United States Department of Transportation
Annual Modal Research Plans

Federal Aviation Administration

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FAA Operating Administration Research Portfolio Summary

Why FAA R&D Matters

American aviation represents 5.1percent of the U.S. Gross Domestic Product, yields $10.6 million U.S. jobs, stimulates $1.6 trillion in U.S. economic activity, and constitutes $59.9 billion of U.S. trade (or 8 percent of all U.S. exports). Aviation is safer than it has ever been, with the latest report from the International Air Transport Association showing a 35 percent decline in the all-accident rate in 2017 alone. This record is the result of a collaborative, data-driven culture that allows government and industry to work together and make proactive safety improvements throughout the National Airspace System (NAS).

Effective research enables the Federal Aviation Administration's (FAA) mission to provide the safest, most efficient aerospace system in the world and to continue to build on this unparalleled safety record, while increasing system efficiency and integrating new airspace users. As new technologies change the aviation industry, the FAA's approach to research must evolve. It must be more strategic in its outlook and identification of emerging issues, opportunities and knowledge gaps. It must also be more deliberate in identifying and leveraging complementary research performed throughout the department and by industry, academic, and government partners.

The United States' global leadership and unparalleled aviation safety record is supported by FAA research and development. The advancement and sharing of knowledge and the development of innovative solutions inform critical decisions the FAA makes to improve safety, increase efficiency and mitigate environmental impacts of aviation. To be successful, the FAA must sustain a robust network of academic and industry partners that complement and augment the Agency's research staff and its state-of-the-art research laboratory resources.

FAA R&D Profile

The FAA funds its R&D portfolio through three separate appropriations: Research, Engineering and Development (RE&D), Facilities and Equipment (F&E), and the Airport Improvement Program (AIP). Research results funded through the (RE&D) appropriation inform standards and regulatory guidance governing the design and operation of aircraft and ground based system components. Research programs funded through the (F&E) appropriation are pre-implementation programs intended to mature new air traffic management operational concepts and technologies for eventual acquisition and deployment. Research programs funded through the (AIP) appropriation discover and evaluate new technologies and methods to enhance safety and efficiency of airport operations and the durability of its infrastructure. The FAA's portfolio of aviation research programs and projects, fortify the four Department of Transportation Safety, Infrastructure, Innovation and Accountability Goals. FAA **Safety** related research focuses on mitigating risks, enabling infrastructure, and behavioral changes in Fire Safety, Advanced Materials Safety, Digital Systems Safety, System Safety Management, Human Safety, and Human Factors. FAA **Infrastructure** research includes Environment and Energy, NextGen Environmental Research, Airport Technology/Capacity, and Airport Cooperative/Environment programs. FAA **Innovation** research programs include

Advanced Technology Development and Prototyping, Traffic Flow Management, On-Demand NAS, Separation Management, and Unmanned Aircraft Systems. The FAA's **Accountability** research program improves the efficiency, effectiveness, and accountability of the FAA's research portfolio through the System Planning and Resource Management Program.

Research Areas

Most projects fall into one of the categories shown in the **FAA Research and Development at a Glance** figure below. This figure highlights aviation elements of the NAS where research is planned. When taken together, these elements comprise the whole of the FAA's aviation research portfolio. Our discussion of the elements of FAA's research areas starts at the left of the graphic and continues clockwise.

Figure - FAA Research and Development at a Glance

Airport Infrastructure and Technologies

Starting at an airport's ground level, there are two essential categories of research; Airport Infrastructure and Airport Technologies, which include runway **Pavement** and **Airport and Terminal** projects. Pavement research focuses on improvements to the computerized runway pavement design program, better and alternative pavement asphalt and concrete construction materials, and enhanced predictive maintenance models, all meant to extend pavement life, reduce cost, and improve service. Airport and Terminal projects focus on both operational and infrastructure elements not associated with pavement. Sample infrastructure projects, are the improvement of airport lighting and airport paint markings, which also have significant safety implications.

Aircraft Safety Assurance

Fire Safety projects address in-flight fires by studying the behavior of aircraft materials in realistic conditions to improve post-crash survivability. Notable research in this category are the continued efforts in testing the effects of lithium batteries when transported as cargo. The FAA must also safely integrate the new types of aircraft that are entering the system such as **Unmanned Aircraft Systems (UAS)**. Research necessary to meet the forecasted continued growth of UAS operations in the NAS includes UAS detection and avoidance technologies, UAS visibility enhancement, and the development of operational performance standards. For developing safety certification standards the FAA must have an understanding of the **Aircraft Structures** and materials that make up various aircraft. Projects here include the evaluation of varied composites, alloys, and their fabrication techniques (such as additive manufacturing); analysis of environmental and aging effects on aircraft structures, and modeling bird strike impacts to aircraft structures and engines, all helpful in promoting continued airworthiness. Finally, **Propulsion and Fuel Systems** studies include the impact of uncontained engine fragments, the development of improved engine containment systems, and effects of volcanic ash on propulsion systems.

Digital Systems and Technologies

As modern avionics and control systems become increasingly network accessible, they can also become more vulnerable. **Digital systems** research looks to mitigate those vulnerabilities by developing methodologies for analysis of cyber threats to aircraft safety in an airborne network environment. **Cyber Security** research prevents disruptive cyber incidents and improves resiliency from potential cyber-attacks across the NAS. Significant work in this area includes developing a FAA Cyber Security Research and Development Plan that includes research on identifying aircraft cyber safety risks and identifying advanced analytical and visualization methods for predicting and responding to cyber events. **Digital Technologies** are the introduction of technologies into the NAS, such as alternate means of data exchange and ensuring appropriate level of security protocols and data exchange standards exist.

Environment and Weather Impact Mitigation

The FAA also researches mitigations for environmental and weather impacts. Because weather can negatively affect aircraft, airport operations, and/or air traffic management, various research projects are included in both the **Weather** and **Icing** categories. Research planned by both the Weather and NextGen Weather programs will include a Continental United States (CONUS) in-flight icing analysis and forecast capability, an automated Offshore Precipitation Capability, and standards for real-time broadcasting of aircraft-observed weather data, amongst others. **Environment & Energy/Fuels** research focuses on environmental impact mitigation strategies for the aviation industry. Along with industry cost-share partners, the FAA is accelerating the maturation of aircraft and engine technologies that will reduce noise, emissions, and fuel burn from the aircraft fleet. The FAA is also working with a myriad of partners across government, industry and academia to advance the development of alternative jet fuels and an unleaded replacement for general aviation gasoline.

Human Performance and Aeromedical Factors

An evolving NAS requires research on various aspects of human interaction with the system. This research takes a human engineering perspective and looks at a breadth of issues including performance assessment, training, certification, health, equipment interaction, and more. Examples of key **Aeromedical** and **Human Factors** projects include minimizing inherent human weaknesses to prevent accidents through evidence-based medicine, identifying operational uses of advanced

vision systems and head-up/head-mounted displays, and developing Graphic User Interface (GUI) style guides.

Aviation Performance & Planning
Planning how we manage the vehicles that fly is critical to aviation safety and the operational performance of the NAS. The recent rapid introduction of **Commercial Space** vehicles has made airspace management more complex. Commercial Space research projects improve vehicle safety and risk management by predicting environmental conditions for launch, developing launch-siting tools, and developing rocket trajectory envelopes to minimize impact on air traffic management operations during vehicle launch and reentry. **Air Traffic Management** manages air traffic both on the ground and in the air. In this category, research projects center on separating aircraft departures and approaches, improving simultaneous runway operations, and delivering air traffic control decision support tools like air-to-ground trajectory synchronization to support Trajectory Based Operations (TBO).

The FAA's research facilities at the FAA William J Hughes Technical Center (WJHTC) and the Civil Aerospace Medical Institute (CAMI), provide the necessary platforms necessary for supporting the FAA's R&D and sustainment of a safe system includes advancing safety data collection and performing risk analysis and prototyping risk-based decision-making capabilities through the FAA's **System Safety Management** research.

Collaboration Efforts

The FAA enhances and expands its R&D capabilities through partnerships with other government, industry, academic, and international organizations. Such partnerships help the FAA leverage critical resources and capabilities to ensure that the Agency can achieve its goals and objectives. By collaborating with other organizations, the FAA gains access to both internal and external innovators, promotes the transfer of FAA technologies to the private sector for other civil and commercial applications, and expands the U.S. technology base. In addition to our DOT partners, examples of current interagency partnerships include the National Aeronautics and Space Administration (NASA) and the National Oceanic and Atmospheric Administration (NOAA); the U.S. Global Change Research Program; the Federal Interagency Committee on Aviation Noise; the Interagency Planning Office for NextGen; the General Aviation Joint Steering Committee; and the Aviation Vehicle Systems Institute. Examples of international partnerships include the European Organization for the Safety of Air Navigation; the Single European Sky Air Traffic Management Research Joint Undertaking; the Japan Civil Aviation Bureau; and Transport Canada. Through the FAA's Centers of Excellence (CoE) program the FAA partners with more than 70 academic institutions comprised of universities, colleges, and institutes.

The FAA further enhances and expands its R&D capabilities through partnerships with the public. Public stakeholder input is primarily received through the congressionally mandated Research, Engineering, and Development Advisory Committee (REDAC). The REDAC is an advisory committee to the FAA whose members are FAA stakeholders including industry, Federally Funded Research and Development Centers (FFRDCs), and academia. The REDAC provides advice and recommendations to the FAA Administrator on the needs, objectives, plans, approaches, content, and accomplishments of aviation research program. The committee reviews and comments on the aviation research

programs including Centers of Excellence and other grants. The REDAC considers aviation research needs in five areas; (a) NAS operations, (b) airport technology, (c) aviation safety, (d) human factors, and (e) environment and energy. The REDAC holds 2 full committee meetings and 10 subcommittee meetings annually from which come reports documenting REDAC's input known as REDAC Findings and Recommendations (F&Rs.) The research programs evaluate REDAC findings and recommendations, and the FAA responds with adjudications and where appropriate, action plans commensurate with the recommendations. The FAA Research Portfolio Division and the research performers track all F&R and associated Agency responses.

Further descriptions of the strategic program specific research collaboration partnerships are identified under each of the programs highlighted in this document.

Research Portfolio

To affect the research in each of the previously described research areas, the FAA research portfolio contains 32 budget line items listed below by research area and with the associated financial appropriation. The remainder of this document describes in detail each of these research programs.

Appropriation	Research Program
Airport Infrastructure and Technologies	
AIP	Airports Cooperative Research
AIP	Airports Technology Research
Aircraft Safety Assurance	
RE&D	Fire Research and Safety
RE&D	Unmanned Aircraft Systems
RE&D	Advanced Materials/Structural Safety
RE&D	Aircraft Catastrophic Failure Prevention
RE&D	Continued Airworthiness
RE&D	Propulsion and Fuel Systems
Digital Systems and Technologies	
RE&D	Aircraft Icing/**Digital System Safety**
RE&D	NextGen – Information Security
RE&D	NextGen – Flightdeck Data Exchange
Environment and Weather Impact Mitigation	
RE&D	Weather Program
RE&D	NextGen – Weather Technology in The Cockpit
RE&D	**Aircraft Icing**/Digital System Safety
RE&D	Environment and Energy
RE&D	NextGen – Environmental Research – Aircraft Technologies, Fuels, & Metrics
Human Performance and Aeromedical Factors	
RE&D	Flightdeck/Maintenance/Systems Integration Human Factors
RE&D	Air Traffic Control/Technical Operations Human Factors

Appropriation	Research Program
RE&D	NextGen – Air Ground Integration Human Factors
RE&D	Aeromedical Research
F&E	NextGen Transportation System – Enterprise, Concept Development, **Human Factors and Demonstrations** Portfolio
Aviation Performance and Planning	
RE&D	System Safety Management
RE&D	Commercial Space Transportation
RE&D	NextGen – Wake Turbulence
F&E	Advanced Technology Development and Prototyping
F&E	NextGen Transportation System – Separation Management Portfolio
F&E	NextGen Transportation System – Traffic Flow Management Portfolio
F&E	NextGen Transportation System – **Enterprise, Concept Development**, Human Factors and Demonstrations Portfolio
F&E	NextGen Transportation System – On Demand NAS Information Portfolio
F&E	NextGen Transportation System – NAS Infrastructure Portfolio
F&E	NextGen Support Portfolio
F&E	NextGen transportation System – Unmanned Airspace Systems (UAS)
RE&D	System Planning and Resource Management

OST-R Review Responses

1. How does the FAA treat Economic Impact of Regulatory Reform?

The Federal Aviation Act of 1958 empowered the Federal Aviation Administration (FAA) to oversee and regulate civil aviation safety. Pursuant to its statutory obligation the FAA issues and enforces regulations and minimum standards covering manufacturing, operation and maintenance of aircraft as well as certification of airmen and airports that serve air carriers. Consistent with Regulatory Reform objectives, FAA research programs continually explore and develop improved methods of safety assurance compliance, demonstration and certification. Analytical and model based methods of safety assurance compliance are continually sought and emphasized over more costly and lengthy destructive methods such that the FAA can meet its safety assurance mission without retarding beneficial innovation in the aerospace industry. When coupled with the FAA's safety assurance mission, the increasing pace of industry-driven technology advancement requires a robust, flexible and agile research capability. Collaborating with industry proponents of new aviation technologies to inform smart safety assurance regulation has and will continue to be a major thrust in FAA research programs.

Additional responses on this topic are presented in the Program Descriptions FY19 section of this document, for each specific program, under the heading "Economic Impact of Regulatory Reform".

2. **How does the FAA treat economic impact of permitting reform:**

The FAA's aviation research portfolio does not engage in activities associated with or impactful to permitting and associated permitting reform.

3. **How does the FAA treat Performance-Based Regulations and Safety?**

In managing FAA's research portfolio, we recognize and endorse the need to focus regulation efforts on desired, measurable, defined results, rather than prescriptive-based rules and procedures that do not compromise safety. The knowledge and information produced through FAA research have directly supported a wide range of performance-based regulations and safety activities including; updates to existing regulations, minimum performance standards, rules, advisory circulars, as well as guidance materials. Additional information on this topic can be found under the Performance-Based Regulations header for specific programs within the FY 2019 Program Description section of this document.

4. **Discuss how the research programs in the FAA Research Portfolio treats the potential impact of Asset Recycling:**

Asset recycling is a funding activity that enables the government to fund necessary infrastructure investments through proceeds made from the sale or lease of public assets, typically fixed assets, to the private sector. There is no link between FAA R&D funds and asset recycling.

5. **Discuss how the research programs in the FAA Research Portfolio treats the potential impact of Value Capture:**

Value Capture is a type of public financing that recovers some or all of the value that public infrastructure generates for adjacent private landowners. There is no link between FAA R&D funds and building infrastructure or facilities that yield the potential to increase adjacent privately owned land values.

6. **Discuss how the research programs in the FAA Research Portfolio treats improving the mobility of freight:**

The movement of freight via air carriers in the National Airspace System (NAS) is an essential component of aviation in the United States. The air carrier's ability to successfully move freight, efficiently and economically, inside and outside our country's borders, is directly linked to the FAA's successes in improving the efficiency and safety of the NAS. FAA aviation research is a key to ensuring a safer and more efficient NAS, leading directly to the economic success of the aviation industry in the United States (US). American aviation represents 5.1% of the US Gross Domestic Product, provides 10.6M US jobs, stimulates $1.6T in US economic activity, and constitutes $59.9B of US trade (or 8% of US exports).

7. **Discuss how the research programs in the FAA Research Portfolio treats the potential impact of Micro-Transit:**

Micro Transit is a form of ground public transportation characterized by flexible routing and scheduling of small/medium vehicles, (i.e. minibus) operating in shared-ride mode between pick-up

and drop-off locations according to passenger needs. The FAA research Portfolio does not include research into the feasibility of ground Micro-transit. Therefore, there is no link between FAA R&D and Micro Transit, as currently defined.

8. How does the FAA treat Improving Mobility for Underserved Communities?

The FAA R&D portfolio supports improving mobility for underserved communities' with a focus on safety standards to enable General Aviation (GA). With over 5,000 airports across the United States, General Aviation contributes over $219 billion to the U.S. economy. In certain remote communities, such as those in Alaska and rural Maine, there is considerable dependence on general aviation for the transport of goods, postal service mail, and emergency medical services. For example, the FAA R&D program, Weather Technology in the Cockpit (WTIC), directly supports rural and remote areas by performing applied research to produce weather information using innovative techniques for areas that lack the infrastructure and economy to use traditional weather systems. The WTIC program is researching using Alaska weather cameras to produce ceiling and visibility information in areas that lack weather technology, such as ceilometers, to produce this information. As documented in a February 26, 2018 letter from the President and the Director of the Alaska Air Carriers Association, "Alaska is deficient in infrastructure yet over 82% of communities relay entirely on aviation for transportation." Additionally, the FAA Center of Excellence of Partnership to Enhance General Aviation Safety, Accessibility and Sustainability (PEGASAS) leverages its partnership with a national network of researchers to focus on increasing safety by mitigating the risk facing GA pilots, passengers, and property. FAA aviation research, when transferred and applied, helps ensure that General Aviation service to all communities, and especially remote areas, continues to improve and remains uninterrupted.

9. How does the FAA treat Cybersecurity?

The Federal Aviation Administration (FAA) Order 8000.369, Safety Management System (SMS) and Federal Aviation Administration (FAA) Order 8040.4B Safety Risk Management (SRM) policy for the Federal Aviation Administration (FAA) establishes common terms and processes used to analyze, assess, mitigate, and accept safety risk in the aerospace system. The Aircraft System Information Security Protection research program promotes aviation safety against cyber threats via systematic processes and cross-agency and industry collaboration. Stakeholders include FAA's certification and continued air-worthiness organizations, avionics manufacturers, aircraft integrators, airlines and other Government agencies such as DoD and DHS.

The Cybersecurity risk model-working group's use of FAA's Enterprise Cybersecurity Risk Model addresses future investment and planning informed by end-to-end threat, risk and impact. The model provides a common framework applicable across all FAA domains – tailorable to meet unique requirements within each domain, a methodology for prioritizing cybersecurity testing and supports data-driven risk based decision making across the FAA enterprise.

Evaluation / Performance Measurement

The FAA Research Portfolio Management Division tracks, evaluates, and reports on FAA conducted research in several ways, including the National Aviation Research Plan (NARP), the Annual Review (AR), Annual Modal Plan Report (AMRP), and the Technology Transfer Annual Congressional Report. The NARP presents over 200-research project planned outcomes for 36 separate and independent programs. The Annual Review reports on significant research accomplishments tracked in any given year, and provides status on research projects previously identified in the NARP. The quality of the research work and performance associated with the research is often further captured in journals, reports, and articles. The Technology Transfer Congressional Report is the vehicle used to report tracked tech transfer performance metrics including the number and status of Cooperative Research and Development Agreements, Invention Disclosures, Patent submittals, License Agreements, COE grant awards, and associated funding. These externally reported programs, when considered together, apply to DOT Strategic Plan Safety, Innovation, Infrastructure, and Accountability goals, and most of the nine associated objectives. Programs perform internal tracking and assessment using the classical project management practices of tracking stakeholders, requirements, risks, costs, and schedule, to ensure objectives are met, and cost and schedule are not compromised.

How we track and address Strategic Objective Performance Goals (from the DOT Strategic Plan)

The FAA R&D program is developed to evaluate and perform research across all phases of aviation technology and human performance issues. Results are utilized to correct or improve existing systems, develop new technologies, and mitigate risks in future demand such as UAS and commercial space operations.

The FAA R&D program is developed to maximize the benefits to the aviation community, using resulting knowledge from R&D activities to reduce burdensome regulation, improve safety, and improve the efficiency of the NAS. The FAA R&D program aligns with the DOT Strategic Plan, and provides the mechanism to achieve DOT performance goals, while ensuring its own statutory requirements are met. Specific DOT performance goals to which the FAA R&D program are captured in the DOT Strategic Goals of Safety and Infrastructure.

DOT Safety Strategic Objective Performance Goal - Reducing Aviation-Related Fatalities

Continuing advancements in aerospace operations and technology require FAA research to predict and mitigate risks of accidents and fatalities that may result from operational implementation of such advancements. Unmanned Aircraft Systems, commercial space vehicles, and hypersonic transport aircraft are examples of emergent aerospace technologies and operations requiring continued research and risk analysis. In all cases, FAA applies Safety Management System (SMS) principles to assure safety through the establishment of minimum standards and appropriate regulatory guidance. Research programs within the FAA's portfolio inform are an integral and necessary component of the safety assurance process.

DOT Infrastructure Strategic Objective Performance Goal – Simplify and Enhance Environmental Review Process for Major Transportation Projects

A critical component of FAA Infrastructure projects is the potential to impact the environment. Any proposed research or improvement projects that can impact the environment must undergo an environmental review, and streamlining the review process will deliver projects more quickly and efficiently.

One example of the FAA's completion of this goal is delivered by the Environment & Energy Program, which is providing knowledge and tools to improve and streamline the required environmental review processes for infrastructure projects and other Federal actions. Given the sensitivity and high visibility of such activities in today's environment, the Program is developing an improved screening tool that will allow users to rapidly and conclusively identify Federal actions that do not require further environmental review, thus reducing the time and costs for environmental reviews.

DOT Infrastructure Strategic Objective Performance goal - Increase Airport Capacity

The ability to increase airport capacity is impacted by numerous factors. Environmental and community concerns often delay or cancel proposed expansion projects, airports are aging and may require surface closures for repairs, existing airport planning and design standards, and traffic flow management procedures. Improving efficiencies in these areas will meet the DOT strategic goal of increasing airport capacity and cross many research boundaries.

Advanced Technology Development and Prototyping will use pertinent information on NAS performance that, allows experts from the FAA, academia, and industry collaborate to analyze and develop recommendations for improving safety, capacity and system efficiency, and reducing delays in the NAS. The Airport Technology Research Program (ATRP) has developed a 10-year research plan that will enable the development of several quantitative tools to enhance airport planning, design methodologies and provide more data driven design criteria. NextGen will deliver advanced traffic flow procedures that increase passenger throughput, and Flight Deck/Maintenance/Human Factors will deliver Enhanced Flight Vision Systems to reduce delays, thereby increasing capacity.

DOT Infrastructure Strategic Objective Performance Goal – Decrease Average Flight Wait Time

According to the Bureau of Transportation Statistics, the top three factors affecting National Aviation System Delays between May 2017, and April 2018 were: Weather – 51.84%; Volume – 34.22%; and Closed Runway - 10.55%

The FAA has aligned its research to decrease wait times in all of these areas. It includes a dedicated Weather Program that performs applied research to minimize the impact of weather on the NAS; Traffic Flow Management (TFM) program that provides greater flexibility to the flight planners, and makes the best use of available airspace and airport capacity; and Human Factors research to improve approach and departure procedure operations in low visibility environments.

Additional information on how we track and address Strategic Objective Performance Goals

The information provided above summarizes how we address specific DOT Strategic Plan Strategic Objective Performance Goals. Additional information on this topic can be found in the

Evaluation/Performance section of specific programs within the FY 2019 Program Description section of this document.

Technology Transfer

Technology transfer happens when existing knowledge, facilities or capabilities developed with federal research and development funding are transferred and utilized to fulfill public and private needs. The FAA achieves this process by bringing together academia, industry, other government entities, FAA experts and state-of-the-art research labs to develop products, services and solutions that not only further enhance the FAA's mission of having the safest and efficient aerospace but bring and address exciting advancements for the U.S. marketplace and the world. The FAA has a diverse and broad-reaching research portfolio.

The People and Organizations Involved in TT and their roles

The FAA enjoys, and depends on, relationships with several research programs, and organizations – internal and external to the FAA - in its mission to transfer knowledge, data, and technology, in their many forms, to data consumers and to private industry. Our FAA research programs have the responsibility to disseminate the results throughout the aviation community. Their roles include, amongst many others the following:

- Informing Smart Regulations, Advisory Circulars, and other governance; that reduces onerous regulation and guidance
- Authoring meaningful publications for broad release to ensure wide accessibility;
- Training targeted communities on new technologies that lessen dependence on FAA SMEs;
- Presenting at conferences and forums that advances research knowledge more broadly;
- Perform as contributing members of aviation related working groups and forums;
- Serving as subject matter experts to those requiring developmental aid;
- Serving as product function validators to vendors looking to advance their products; and
- Facilitating the transfer of new technology.

External to FAA, TT partners include interagency offices, aviation industry members and Academia, all looking to do their part in the advancement of transformative technologies for a safer, more efficient, and economically accessible NAS. Private Industry provide industry-perspectives and insights essential to economically prudent regulation processing, as they evaluate new requirements and provide feedback. This participation and feedback aids in reducing burdensome regulation. Another TT role for our industry partners is their sponsorship of research performed through the Centers of Excellence.

Through the FAA RE&D Authorization Act of 1990, Public Law 101-508, the Centers of Excellence program was created, to conduct and transfer research in specific mission-critical topics. The COEs are established through cooperative agreements with the Nation's premier universities, members and affiliates to conduct focused R&D and related activities over a period of five to ten years. The COE program facilitates collaboration and coordination between government, academia, and industry to

advance aviation technologies and expand FAA research capabilities through Congressionally required matching contributions. COE members and affiliates match FAA grant awards, dollar-for-dollar, with contributions from Non-Federal sources, and may also provide additional contributions through cost-share contracts. Over the life of the program, the COE universities with their Non-Federal affiliates have provided more than $300 million in matching contributions to augment FAA research efforts. Through long-term cost-sharing activities, the government joins with our university-industry teams to leverage resources and advance the technological future of the Nation's aviation industry while educating and training the next generation of aviation scientists and professionals in support of STEM initiatives.

The TT leadership comes from Office of Research and Technology Applications (ORTA) located at the William J. Hughes Technical Center. The FAA's Technology Transfer Program serves to ensure the practical application of FAA Federal research. It does so by moving knowledge, facilities, equipment, and capabilities developed by its Federal laboratories and R&D programs out to Non-Federal entities such as private business, academia, and state and local governments.

Technology Transfer Activities and Results

The items that are subject to TT are as diverse as the manner in which TT is conveyed. FAA research items that undergo technology transfer include the following:

- Knowledge gained through experimentation and analytical research that are the scientific and technical foundation for FAA, academia, private industry and general public decision making
- Experimentation-produced raw data made publically available
- Developed analytical and processing tools to ensure private industry modeling capabilities, and for flight related decision making
- New technologies, capabilities, and prototypes for industry to integrate into production

The activities associated with the transfer of the items just discussed, as previously stated are diverse, and can be effected by any combination of the following possible means:

- Publications – peer review journals and articles; process description documents; engineering reports; book chapters; Forensic Toxicology Reports and Aeromedical Review Reports of all U.S. fatal aircraft accidents
- Conferences/forums – technical material submissions or serving as subject matter presenter
- Databases – research results entered into second party databases for broad yet focused community access
- Software – regular software updates to users of FAA research based software tools
- Training workshops and working groups – where program members facilitate and conduct training on core research subject areas, or participate with professionals from industry, government, and academia to discuss safety concerns and best practices in a protected environment
- Licensing authorization – authorizations to use technology resultant from FAA research.

Measuring Technology Transfer Performance

All FAA research programs measure Technology Transfer performance in differing ways.

The primary tool of the Office of Research Technology Applications (ORTA) is the Cooperative Research and Development Agreement (CRDA), which governs the relationships and outputs of collaborating research partners. As such, ORTA measures TT performance based on CRDA development and management activities. To increase CRDA partnerships, the ORTA office conducts outreach activities to highlight FAA's state-of-the-art technical resources, both the physical facilities and human capital (subject matter experts). ORTA office performance measures include a) conducting at least one outreach activity per month and b) targets an increase of new CRDA participations of 5% annually. The COE office performance measures include tracking the number of publications and reports produced, public presentations, which comply with information dissemination requirements, the education and training of students prepared to enter the aviation workforce, generation of industry support and matching contributions. FAA programs actually conducting research, like that of the Weather Program, use alternate means to gauge Tech Transfer performance.

In addition to the CRDAs developed and managed within the ORTA, the transfer of technology occurs within the purview of each research program as identified above. Measurement of the success occurs when the program objectives are completed as defined, and the results of the research are collaborated with industry. Each goal is unique to the program, and leads to the development of new patents, aircraft and system design criteria, and human performance specifications.

Additional Technology Transfer information

The information provided above characterizes Technology Transfer participants, roles, transfer activities, and performance for the whole of the FAA Research Portfolio. Additional information on these aspects of Technology Transfer are presented in the Technology Transfer section of each individual research program within the FY 2019 Program Description section of this document.

New High Priority Research Projects for FY 2019

Project #1: Fire Detection, Containment, and Suppression Technology Testing

The Fire Research and Safety Program, project plans to conduct testing with fire detection, containment, and suppression technologies capable of improved detection of fires involving cargo and hazardous materials inside Unit Load Devices and/or safety packaging. This research is necessary to ensure that the evolving fire resistant methods of transporting hazardous materials do not reduce the timely detection of fires inside of these new packaging and/or containment methods. This research is not being conducted by anyone else and is specifically requested to be conducted by the FAA William J. Hughes Technical Center (WJHTC) by the Commercial Aviation Safety Team (CAST) recommendation in Safety Enhancement SE 127. This research is entirely new and has not previously been conducted. The evolving methods of transporting declared hazardous materials include fire resistant cargo containers and fire resistant packaging standards. These developing methods have an improved capability to contain fires that might occur within the containers and limit the escape of products of combustion. While the increased capability to contain fires is an improvement to overall fire safety, the containment of smoke potentially has a negative effect on the ability of aircraft based detection systems to alarm and alert the flight crew to the presence of an inflight fire. The research will examine alternatives to traditional aircraft based smoke detection systems to improve detection response times. The research aligns with the DOT Safety strategic goal. The total cost of this research is estimated at $2,250K over the three-year duration. The FY 2019 funding is $750K. There is not any expected non-Federal financial contribution.

Project #2: Air Carrier Operational Considerations for Unmanned Aircraft Systems

This research, performed by the Unmanned Aircraft Systems Research program, addresses safety concerns specific to Air Carrier Operations for UAS to include air carrier staffing, training, testing, duty and rest requirements. The objective of this research is the establishment of a separate rulemaking activity specific to air carrier operations. The goal of this research is to standardize the issuance of UAS air carrier operating certificates, UAS air carrier remote pilot and crew requirements, training and testing requirements, duty and rest requirements, to include fatigue, to help safely integrate UAS air carrier operations into the National Airspace System (NAS). Activities associated with this research include: experiments on UAS air carrier remote pilot knowledge and skills; experiments on UAS operator duty and rest intervals; and perform a gap analysis of existing regulations/guidance. The results of this research will provide input to help develop FAA regulations, standards, and guidance for the design and operational approval of Unmanned Aircraft Systems (UAS) air carrier operations in the NAS to support the safe, efficient, and timely integration of UAS into the NAS. Performing sound research will lead to preventative measures in reducing incident and accident rates due to human factors in UAS air carrier operations. These objectives are an outflow of the FAA/DOD-developed NAS Access Plan for public UAS, directed by the National Defense Authorization Act of 2010. The safe integration of UAS into the NAS is an important objective for the FAA, which aligns with the DOT Safety Strategic Goal. Expected project costs for FY 2019 is $574K.

Project #3: High Visual Contrast for Unmanned Aircraft Systems

With the looming proliferation of UAS in the NAS, it is critical to reduce the risk of collision between manned and unmanned aircraft. The Unmanned Aircraft Systems Research program will pursue a

collision risk reduction method aimed to make Unmanned Aircraft (UA) easier for the pilots of manned aircraft to see and avoid UAS. A primary objective of this research is to incorporate research-informed design strategies into future airworthiness approval guidance (i.e. new advisory circulars) to address the minimum standards required to make unmanned vehicles easily visible to other aircraft and individuals on the ground. Research activities and outputs include High Visual Contrast for UAS experiments; analysis of the experimental data addressed by research questions of this study; and identifying implications of the research results for supporting regulatory guidance for UAS integration into the NAS. Further, research performed under this requirement would review current regulations and standards, and recommend changes for the enhancement of UA visibility that will lead to reducing collision risks. This will help to provide the regulatory basis for the safe, efficient, and timely integration of UAS into the NAS. As soon as the research has defined sponsor-acceptable recommendations for making unmanned aircraft more visible to other operators, activities will move to the implementation phase. The research plans expect implementation of recommended design strategies and associated updates to the certification guidelines to occur in 2020. This research objective, to provide input to FAA standards and advisory circular material to support the safe, efficient, and timely integration of UAS into the NAS, aligns with the DOT Safety Strategic Goal. Performing sound research will lead to preventative measures in reducing incident and accident rates due to mid-air collisions between UAS and other aircraft and collisions with people on the ground. The Office of Aviation Safety (AVS) Strategic Guidance identifies UAS as a new user technology that must be further researched and analyzed due to being considered as an emerging risk. Expected project costs for FY 2019 is $163K.

Project #4: Flight-Deck Data Exchange Requirements (FD-DER)

The FD-DER program supports the DOT's Innovation Strategic Goal by leveraging emerging Internet of Things (IOT) technologies in aviation to improve mobility by developing new NAS concepts such as Trajectory-Based Operations (TBO). Through a detailed data driven research of the data exchange performance and security requirements to meet operational needs, this research will expand the ability of flight operators to exchange information between their aircraft and FAA automation systems. This research is necessary because the current voice-based information exchange mechanisms are not adequate to enable the rich data exchange requirements of TBO. The implementation of Data Communications (DataComm) Aeronautical Telecommunications Network (ATN) Baseline 2 (ATNB2) is expected to address these requirements, however, equipage of ATNB2 capabilities will be limited among non-scheduled air carriers and business jet operators and retrofit of older equipment among large air carriers will be limited due to the costs of equipage. The ability to utilize emerging technologies such as electronic flight bags (EFBs) and aircraft interface devices (AIDs) will enable aircraft not equipped with expensive DataComm capabilities to exchange information through alternative means, which supports increased participation without additional equipage while providing redundant data exchange mechanism to those equipped with DataComm.

For FY 2019, the planned activities include: develop a research plan; evaluate and develop an initial technical and operational assessment; define a security framework to assess technologies; initiate and maintain coordination with key industry stakeholders and organizations; and develop concept and use cases for flight deck data exchange. The outputs of these research activities will improve the FAA's understanding of safety and performance implications on the use of new technologies and inform the development of a regulatory framework on the utilization of emerging and readily available technologies to support flight operations. FD-DER is a new program for the FAA. External to the FAA, aviation industry including aircraft original equipment manufacturers, avionics

manufacturers, and datalink providers and data management service providers are creating innovative EFBs, AIDs and datalink technologies that FAA can leverage to make significant progress in the FD-DER research project. Additionally, International Civil Aviation Organization (ICAO) and Air Navigation Service Providers (ANSPs) in Europe and Asia are also promoting and researching concepts that would make flight-deck a fully connected node for seamless data exchange between relevant stakeholders. There is no non-Federal funding expected for this program. Expected FY 2019 costs to do this research is approximately $2.0 million.

Project #5: Noise-Power-Distance-Configuration (NPDC) Capability Development for AEDT

The noise modeling capability in the Aviation Environmental Design Tool (AEDT) was initially designed to predict aircraft noise in the vicinity of airports, but increasingly the modeling capability is being stretched to predict noise in areas at relatively large distances from airports. At those further distances aircraft flight patterns, flap settings and configurations, thrust, speed, altitude and other performance parameters can be significantly different from the close-in case. Additionally airframe noise is a dominant due to the very significant decrease in engine noise brought about by modern engine design. This project, conducted by the Environment and Energy research program, will allow for the explicit prediction of airframe noise (in addition to engine noise) using an update to the current Noise-Power-Distance (NPD) database in AEDT to include configuration-specific data. This new NPD-C functionality will enable more accurate modeling of aircraft noise for advanced operational procedures, particularly during approaches. This work will support the development of AEDT Version 4. The FAA is coordinating on this work both nationally and internationally to ensure a consistent and accepted approach to this improvement in noise modeling methodology. This work aligns with the Infrastructure and Accountability DOT Strategic goals as it improves the FAA's ability to quantify and account for the potential noise consequences of any infrastructure project, and this improves our efficiency to conduct any required environmental reviews for compliance with the National Environmental Policy Act. The expected total project cost will be $1,000,000 with $250,000 funded in FY 2019. This work will then feed into the larger development work for AEDT Version 4. The project builds on many years of AEDT development work and efforts to better quantify aircraft noise. Additionally the work is to be completed through the Aviation Sustainability Center of Excellence (ASCENT) and therefore will utilize the grants 100% cost-share match requirement.

High Priority Completed Projects in FY 2017/2018

Project #1: Develop infrared (IR) specifications for night vision goggle-compatible light-emitting diode

In FY17, the Airport Technology Research and Development Branch (ATRDB) was tasked with a highly visible project to develop infrared (IR) specifications for night vision goggle-compatible light-emitting diode (LED) FAA Type L-810 and L-864 Obstruction Light Fixtures. Night vision goggles (NVG) are now increasingly utilized by civilian pilots to conduct search-and-rescue, emergency medical transport, and other flight operations. However, with the use of LEDs in place of incandescent fixtures for obstruction lighting, the FAA has found that some pilots using NVGs are unable to see red LED obstruction lights because the light generated falls outside the visible spectrum of certain classes of NVG lens filters. In response to this issue, the FAA Office of Airport Safety and Standards–Airport Engineering Division (AAS-100) tasked the ATRDB with conducting research to determine performance specifications (output wavelength, minimum vertical beam spread, and minimum radiant intensity) for infrared (IR) emitters to be incorporated into L-810 and L-864 LED obstruction light fixtures to ensure compatibility with NVGs currently in use.

Researchers from the ATRDB and Rensselaer Polytechnic Institute conducted this research effort in three phases. Phase 1 consisted of a literature review to determine suitable IR wavelength and minimum vertical beam spread specifications. Phase 2 consisted of conducting laboratory testing of commercially available incandescent and LEDs with IR L-810 and L-864 fixtures. Phase 3 consisted of conducting flight evaluations to determine the minimum level of radiant intensity needed for pilots to acquire the obstruction lights.

Based on the research conducted, specifications were developed for the L-810 and L-864 fixtures that AAS-100 have adopted and included in current engineering guidance documents. The results of the ATR effort were documented in a Final Report titled, "DOT/FAA/TC-17/69, Development of Infrared Specifications for Night Vision Goggle-Compatible Light Emitting Diode L-810 and L-864 Obstruction Light Fixtures".

This activity supports DOT Strategic Goal - Safety, Strategic Objective 1: Systemic Safety Approach, and provided answers to a very technical question that had never been answered before. At the present time, ATRDB considers this task complete with no further research required. Researchers will be on standby to respond to future research requests should issues be identified after the new specifications are implemented in the field. This effort cost the FAA approximately $175K, which was funded entirely through ATRDB's FY 2017 budget. There were no other funds leveraged against this project.

Project #2 UAS Airborne Collision Hazard Severity

The purpose of this research, performed by the UAS Center of Excellence under the auspices of the Unmanned Aircraft Systems research program, was to analyze a small quadcopter and a small fixed-wing UAS configuration impacting on a typical commercial transport jet and a typical business jet aircraft. This research will support airworthiness requirements for unmanned aircraft based on their potential hazard severity to other, already certified, airspace users in the NAS. The safe integration

of UAS into the NAS is an important objective for the FAA, as evidenced in the 2016 Reauthorization Act.

UAS impacts are likely to cause more damage than bird strikes with an equivalent initial kinetic energy (mass and velocity). Since birds behave like a fluid during high velocity impacts, density is the main parameter that drives the magnitude of the damage in the target structure. In contrast, UASs do not exhibit this behavior. Structural rigidity (a combination of the structural geometry and material properties) drives the magnitude of the damage in the target structure.

Numerical analysis showed fixed-wing UASs typically caused greater damage levels on air carrier and air taxi aircraft versus those produced by quadcopter UASs of the same mass and velocity. This indicates that the layout of the main UAS components is critical to the energy transfer during an airborne collision. The predicted critical damage occurred when the majority of the masses were aligned with the impact direction. Follow-on research will evaluate collisions with General Aviation aircraft and helicopters. The research was performed by the UAS Center of Excellence for $1M with a one-for-one cost share.

Section 1 – Program Descriptions, FY 2019

FY 2019 RD&T Program Funding Details

RD&T Program Name	FY 2019 Pres. Budget ($000)	FY 2019 Basic ($000)	FY 2019 Applied ($000)	FY 2019 Development ($000)	FY 2019 Technology ($000)
Fire Research and Safety	7,200		7,200		
Propulsion and Fuel Systems	4,000		4,000		
Advanced Materials/Structural Safety	14,720		14,720		
Aircraft Icing/Digital System Safety	9,253		9,253		
Continued Airworthiness	11,269		11,269		
Flightdeck/Maintenance/System Integration Human Factors	7,305		7,305		
System Safety Management	5,500		5,500		
Air Traffic Control/Technical Operations Human Factors	5,800		5,800		
Aeromedical Research	9,080		9,080		
Weather Program	15,476		15,476		
Unmanned Aircraft Systems Research	24,035		24,035		
Commercial Space Transportation Safety	2,500		2,500		
NextGen - Wake Turbulence	6,831		6,831		
NextGen - Air Ground Integration Human Factors	6,757		6,757		
NextGen - Weather Technology in the Cockpit	3,644		3,644		
NextGen Flight Data Exchange	1,035		1,035		
NextGen - Information Security	1,232		1,232		
Environment and Energy	18,013		18,013		
NextGen - Environmental Research - Aircraft Technologies, Fuels, and Metrics	29,174		29,174		
System Planning and Resource Management	2,135		2,135		
William J. Hughes Technical Center Laboratory Facility	4,571		4,571		
Advanced Technology Development & Prototyping	33,000			33,000	
NextGen - Separation Management Portfolio	16,000			16,000	
NextGen Traffic Flow Management Portfolio	14,000			14,000	
NextGen - On Demand NAS Portfolio	20,500			20,500	
NextGen - NAS Infrastructure Portfolio	20,000			20,000	
NextGen - Support Portfolio	12,800			12,800	
NextGen Unmanned Aircraft Systems	25,000			25,000	
NextGen Enterprise, Concept Development, Human Factors, & Demonstrations	16,500			16,500	
Center for Advanced Aviation System Development (CAASD)	57,000			57,000	
Airport Cooperative Research Program	15,000		15,000		
Airport Technology Research Program	33,210		33,210		
Totals	**452,540**		**237,740**	**214,800**	

FY 2019 RD&T Program Budget Request by DOT Strategic Goal

RD&T Program Name	FY 2019 Pres. Budget ($000)	SAFETY ($000)	INFRASTRUCTURE ($000)	INNOVATION ($000)	ACCOUNTABILITY ($000)
Fire Research and Safety	7,200	7,200			
Propulsion and Fuel Systems	4,000	4,000			
Advanced Materials/Structural Safety	14,720	14,720			
Aircraft Icing/Digital System Safety	9,253	9,253			
Continued Airworthiness	11,269	11,269			
Flightdeck/Maintenance/System Integration Human Factors	7,305	7,305			
System Safety Management	5,500	5,500			
Air Traffic Control/Technical Operations Human Factors	5,800	5,800			
Aeromedical Research	9,080	9,080			
Weather Program	15,476	15,476			
Unmanned Aircraft Systems Research	24,035	24,035			
Commercial Space Transportation Safety	2,500	2,500			
NextGen - Wake Turbulence	6,831			6,831	
NextGen - Air Ground Integration Human Factors	6,757			6,757	
NextGen - Weather Technology in the Cockpit	3,644			3,644	
NextGen Flight Data Exchange	1,035			1,035	
NextGen - Information Security	1,232			1,232	
Environment and Energy	18,013		18,013		
NextGen - Environmental Research - Aircraft Technologies, Fuels, and Metrics	29,174		29,174		
System Planning and Resource Management	2,135				2,135
William J. Hughes Technical Center Laboratory Facility	4,571				4,571
Advanced Technology Development & Prototyping	33,000			33,000	
NextGen - Separation Management Portfolio	16,000			16,000	
NextGen Traffic Flow Management Portfolio	14,000			14,000	
NextGen - On Demand NAS Portfolio	20,500			20,500	
NextGen - NAS Infrastructure Portfolio	20,000			20,000	
NextGen - Support Portfolio	12,800			12,800	
NextGen Unmanned Aircraft Systems	25,000			25,000	
NextGen Enterprise, Concept Development, Human Factors, & Demonstrations	16,500			16,500	
Center for Advanced Aviation System Development (CAASD)	57,000		57,000		

Airport Cooperative Research Program*	15,000	950	1,780		
Airport Technology Research Program	33,210	16,407	16,803		
Totals	**452,540**	**133,495**	**122,770**	**177,299**	**6,706**

*During FY19, ACRP plans to spend $2.27m in safety, capacity and environment related research projects. The remaining funds will be used for research projects in other areas. FAA funds ACRP $15m annually as mandated by US 49 USC Section 44511.

Airport Infrastructure and Technologies

Airport Cooperative Research Program
Funding Request ($15,000,000)

Program Description/Activities:

The Airport Cooperative Research Program (ACRP) is an industry driven research program managed by the Transportation Research Board (TRB) of the National Academies of Sciences, Engineering, and Medicine. It was authorized by section 712 of Vision 100 – Century of Aviation Reauthorization Act. The Secretary of Transportation maintains a Memorandum of Agreement among DOT, FAA, and National Academy of Sciences to implement the ACRP. The Secretary also appoints the 13 members of the ACRP Oversight Committee.

The ACRP's mission is to develop near-term, practical solutions to problems faced by airport operators. ACRP uses contractors, selected in a competitive process, to conduct the research, which is overseen by industry experts and a designated FAA subject matter expert. The results of the research are published in the form of handbooks and best practices. To date, the vast library of publications includes areas of safety, airport management, airport financing, airport environmental quality, airport compliance, and airport planning. These publications are available to the general public on the ACRP website and for purchase in hard copy.

ACRP is designed to address needs that are not being addressed by other Federal research programs and that cannot be undertaken cost-effectively by individual airports.

Statutory Requirements:

Is this program statutorily mandated (Y/N): Y

ACRP was authorized by section 712 of Vision 100 – Century of Aviation Reauthorization Act, as a 4-year, research pilot program. Not later than 6 months after the expiration of the pilot program, the Secretary was required in US Code Title 49, Sections 44501 and 44511 to transmit to the Congress a report on the program, including recommendations for establishing a permanent airport cooperative research program. This program is now a permanent research program. Initially, $3 Million was appropriated in 2003 for the pilot program, and this increased to $10 Million in 2006, and increased again to $15 Million in 2011.

Program Alignment with Strategic Goals:

DOT Strategic Goal	DOT RD&T Critical Transportation Topic
Safety Infrastructure	Promoting safety Improving mobility

This program supports the DOT's Strategic Goal of safety by providing systematic research and development within the FAA that will lead to the identification, assessment and mitigation of safety risks. By providing the research necessary to generate data, this data is then used to create and develop new safety standards that will be adopted throughout the aviation community.

This program also supports the DOT's Strategic Goal of infrastructure by providing systematic research and development within the FAA that will lead to assessments, which will improve the infrastructure in airports across the National Airspace System (NAS). By providing the research necessary to generate data, this data is then used to provide the baseline information that will be used to evaluate and advance the safety and capabilities of the infrastructure at airports and air traffic facilities throughout the NAS.

The research conducted through the ACRP does affect rural communities as some of the research is conducted for general aviation airports, where the locations are in rural communities.

Program Objectives:

ACRP is a national resource for the airport industry, providing valuable information, guidance and practical tools to airport owners and operators (as well as consultants and contractors) by performing industry-driven research identified as critical or crucial by airport operators, industry, and users.

ACRP's main goal is to provide resources to support applied research on a wide variety of issues faced by airport practitioners, including all levels of professional staff within the airport community, from CEOs, airport managers, executive directors to mid-level managers, nonsupervisory technical and professional staff, trainees, students, and interns. These professionals represent airports, suppliers, public safety agencies, airlines, airport tenants, local and regional government authorities, industry associations, and many other stakeholders in the airport community. Each of these practitioners has different interests and responsibilities, and each is an integral part of this cooperative research effort.

ACRP is designed to address needs that are not being addressed by other Federal research programs and that cannot be undertaken cost-effectively by individual airports.

Economic Impact of Regulatory Reform:

As a research and development (R&D) program, ACRP creates guidance and best practice reports, so no regulation is generated from this program. In addition, the goal in the FAA strategic plan is to make aviation safer and smarter, which aligns with ACRP's strategic priorities #2: To align program products with the interests of key audiences, and priority #4: To implement and monitor quality, relevance and timeliness of research products.

Research Collaboration Partners:

ACRP information regarding published reports and digests and up-coming events, such as webinars and calls for research proposal is provided to representatives in industry, academic and the Federal Government via both the report postings and updates on the ACRP and FAA websites and through the Transportation Research Board (TRB) emailed newsletters and ACRP LinkedIn and Facebook websites.

The DOT Secretary appoints the 13 members of the ACRP Oversight Committee (AOC). In addition, representatives from industry, academia are members of the AOC, along with representatives from national associations representing public airport operating agencies, airport executives, State aviation officials, and scheduled airlines, and representatives from both the FAA and the

Environmental Protection Agency (EPA) are participants in both the AOC and the project research panels. Having this connection allows all to understand the research initiatives and process and be aware of the results and products underway as well as participate in the research proposal, or problem statement drafting and voting. In addition, the representation on the AOC have members and stakeholders who many times are the end users of the research products distributed.

The AOC shall initially be composed of thirteen (13) voting members and shall include seven (7) members who are chief executive officers, managers, or members of the governing boards of airports (3 from large hubs, 2 from medium-size hubs, and 2 from small hubs, non-hubs, or general aviation airports); five (5) members who are officers or officials of universities, or private entities that are air carriers, shippers, suppliers, researchers, or consultants engaged in providing airport equipment or services; and the Administrator of the FAA or his/her designee. Any such entity shall have no more than one member on AOC.

In addition, upon the request of the Secretary, the following individuals shall serve as "ex-officio," non-voting, members of AOC:

- The Administrator of the Environmental Protection Agency (EPA) or his/her designee.
- The Administrator of the National Aeronautics and Space Administration (NASA) or his/her designee.
- The chief executive of the Airports Council International–North America (ACI-NA) or his/her designee.
- The chief executive of the American Association of Airport Executives (AAAE) or his/her designee.
- The chief executive of the National Association of State Aviation Officials (NASAO) or his/her designee.
- The chief executive of the Air Transport Association (ATA) or his/her designee.
- The Executive Director of the Transportation Research Board or his/her designee.

Do non-government groups partner with this program?

Yes. As stated above, representatives from industry and academia are members of the AOC, and include representatives from national associations representing public airport operating agencies, airport executives, scheduled airlines, and representatives as well as faculty from aviation and transportation departments at universities.

Acquisition/Assistance:

Does this program utilize competitive procurement processes? Yes.

FAA programs in the research portfolio employ competitive contracting vehicle types and grants to acquire Conduct, Research, and Development activities. The FAA's acquisition management system offers researchers omnibus contract vehicles such as the SE2020, SE2025, and eFAST Blanket Purchase Agreements (BPAs) in which vendors competitively compete for Task Orders (TOs) and BPA calls. The Broad Agency Announcement is another competitive process the FAA utilizes for awarding basic research contracts. Grants are used to execute a portion of the FAA's research budget and where the FAA has the statutory authority to issue grants pursuant to the Aviation Research

Grants Program. The FAA's Centers of Excellence (COE) is one example of a grant-based program that uses competition to select from among members of academia for COE participation. In the specific case of the COE grant program, it receives matching funds from industry sponsors.

In general, the FAA Research Portfolio includes Research Programs that use multi-year acquisitions.

Does this program leverage non-Federal funds? (Y/N). No

Technology Transfer (T2):

In addition to the total number of projects, reports and webinars completed, as listed in the ACRP Annual Review publications, along with the corresponding project topics, the FAA is able to link the outputs of ACRP research reports to FAA policy. For example, the ACRP findings in Report 29, "Developing Improved Civil Aircraft Arresting Systems", have helped shape the successful initiatives of the Engineered Material Arresting System (EMAS) program. In addition, recent guidance for the Advisory Circular, AC 150/5360-12F, Airport Signing and Graphics, incorporated the recommendations and guidelines from ACRP Report 52, "Wayfinding and Signing Guidelines for Airport Terminals and Landside". In addition, the program looks at business cases were airport operators have applied the research outputs to their planning and policy. An example of this can be seen in the ACRP 2016 Annual Review where the Management Administrator for Jacksonville Aviation Authority (JAA) is quoted as saying, "I rely on the findings in ACRP reports for insight as I develop policies and procedures for JAA." Also, the ACRP publishes a report titled, Impacts on Practice, where individuals are interviewed and explain their use of the ACRP findings for their policy and planning initiatives and this can be seen in the Annual Review Reports 2015 and 2016 where 3 business case applications are explained in each report for a total of 6 cases. The program is not represented in the USDOT Research Hub and the National Transportation Library (NTL), including project descriptions, funding amounts, links to final reports, datasets, and summary descriptions of research outputs, outcomes, and impacts, but can be viewed at the ACRP and FAA websites where this information is provided.

At this time, both ACRP and the FAA staff are gathering information and conducting interviews on the number of research reports, and the topics of research reports that have assisted in the development of FAA's Advisory Circulars (ACs), to both measure Technology Transfer performance and provide a baseline to strategize the future planning of ACs.

Evaluation / Performance Measurement:

The program, ACRP, has strategic objectives that align to the Department of Transportation's strategic plan. This includes DOT's Strategic Objective 1 Performance Goal of Reducing aviation – related fatalities. ACRP's objective is to provide research to ensure that transportation infrastructure and operations are planned, constructed, and managed using best operational and risk management practices dissemination to the airport industry. This benefits all DOT's strategic goals by conducting research projects that benefit safety with designs and practices that reduce injuries and fatalities, and improves infrastructure and operations. This aligns with ACRP strategic priorities. This strategy document is utilized for planning and tracking ACRP research projects and initiatives. Each research project is also tracked and compared against its project scope, plan, schedule and deliverables, by a project panel team.

ACRP addresses specific and existing problems and needs for improving airport planning, design, operation, and integration for safe aviation operations. The ACRP covers the research topics of aviation administration, environmental planning and policy, safety, design, construction, and operations, all which affects airport capacity. The ACRP Oversight Committee (AOC) is responsible for reviewing the research needs that are solicited from airport operators, industry associations, FAA, and other interested entities, and for reviewing, evaluating and recommending the research topics and setting project priorities and recommending funding levels, of which 1/3 is allocated to the environmental research topics. The remainder of the funding is allocated towards safety, planning, design, and operations, which addresses capacity. The ACRP strategy document is utilized for planning and tracking ACRP research projects and initiatives, along with each project scope, plan, schedule and deliverables.

The program has appropriately addressed predefined goals. These are based on historical data and outcomes from past research projects. The Annual Review reports (2015 and 2016) note the program and project goals and status of the research projects. For example, in the 2016 Annual Review, there were 15 webinars conducted during 2016, 18 research reports published of which 8 reports include tools, spreadsheets, videos, 10 synthesis reports, 1 research results digest, 4 legal research digests, and 3 web-only documents. In addition, the AOC has an annual meeting at the beginning of each year to discuss the program's and projects' progress and statuses and vote on any changes. The measures are defined in the strategy document released in 2015 and include measuring the market penetration of existing ACRP research products. This is the number of research outputs distributed annually, to be collected annually but compared across the years, to observe any trends or improvements. It has been observed that the work completed has increased each year, which is a baseline requirement for the program. The tracked outputs are totals and downloads (Distribution of outputs and number of downloads). The ACRP Annual Review reports show the total number of products produced yearly, and include reports, digests and webinars (the various products) since the program's inception from 2008 to 2017, as well as lists the downloaded report percentages by product series.

Airport Technology Research Program
Funding Request ($33,210,000)

Program Description/Activities:

The Airport Technology Research Program supports the safe and efficient integration of new technologies into the airport environment through the development and updates of the FAA's Advisory Circulars. Examples of these programs include airfield pavement testing, new airfield lighting technology, UAS operations, foreign object detection, and airport design standards to accommodate new aircraft.

Statutory Requirements:

Is this program statutorily mandated (Y/N): No

There no statute requirement for the program. The program is funded yearly through annual appropriations under the FAA's Airport Improvement Program.

Program Alignment with Strategic Goals:

DOT Strategic Goal	DOT RD&T Critical Transportation Topic
Safety Infrastructure	Promoting safety Improving mobility

This program supports the DOT's Strategic Goal of safety by providing systematic research and development within the FAA that will lead to the identification, assessment and mitigation of safety risks. By providing the research necessary to generate data, this data is then used to create and develop new safety standards that will be adopted throughout the aviation community.

This program also supports the DOT's Strategic Goal of infrastructure by providing systematic research and development within the FAA that will lead to assessments which will improve the infrastructure in airports across the National Airspace System (NAS). By providing the research necessary to generate data, this data is then used to provide the baseline information that will be used to evaluate and advance the safety and capabilities of the infrastructure at airports and air traffic facilities throughout the NAS.

The program supports the safe development of airports of all sizes in the nation. As such, the program does have an impact on rural communities as small airports are critical components of the transportation infrastructure providing access to and from rural and far away communities.

Improving Mobility for Underserved Communities:

This program supports the DOT RD&T critical transportation topic of Improving mobility for underserved communities by providing research results that permits the development of airport related- technical specifications used by rural and local airports. These rural airports are important to Americans, particularly those 80 plus million people living in rural areas where a general aviation airport may provide the only means of transportation providing critical community access for

aeromedical flights, disaster relief, search and rescue, aerial application of agricultural agents, time-critical delivery of medicine, tools, mail and other documents, and other key functions.

As an example, the Airport Technology Research (ATR) branch was involved in the development of the "Community Service Airports Visual Aids Handbook", which is a document designed to generate awareness of commercially available visual aid devices (lighting and signage) that offer comparable performance to certified products that are used at larger airports, at a fraction of the cost. This handbook was developed as a joint effort between the Illumination Engineering Society (IES) Subcommittee on General Aviation Lighting, the Center of Excellence for General Aviation Research (CGAR), and ATR, and is available electronically via the download section via the following link: http://www.airporttech.tc.faa.gov/

Program Objectives:

The program is organized to directly support the development and updates of the FAA's Airports Advisory Circulars (AC's) in the areas of airport safety and airport infrastructure. On the airport safety side, in FY-19, the ATR program will remain engaged in a multitude of airport safety areas. Some examples are; development of new specifications for the use of LED lighting technologies at airports, analysis of airport safety data, testing of environmentally-friendly firefighting agents, improved airport noise, reducing wildlife strike risks, and integrating UAS operations at airports.

On the infrastructure side, the long-term goal is to augment the life expectancy of airport pavements beyond the currently accepted term of 20 years. Airports of all sizes support this long-term objective as any pavement construction at an airport is extremely expensive and very disruptive. To achieve this objective, in FY-19, the ATR program will keep collecting long-term performance data from airports, will conduct full-scale annual tests at its facility and will continue to work with the pavement industry on pavement design, materials and evaluation methods.

The program does not address a particular market failure. Rather, the program provides an environment where companies of all sizes can test new ideas and products to meet FAA standards. This in turn spurs companies to be innovative in their product development and competitive at the global level.

Economic Impact of Regulatory Reform:

The Airport Technology Research program (ATR) produces research results that support the development and update of FAA Airport-related Advisory Circulars (AC's). These AC's are technical standards that are used by airports nationwide when using Airport Improvement Program (AIP) funds. Since these AC's are used across the airport industry, and together with regular updates provided by FAA, these AC's lessen the needs for new regulations. This is demonstrated by data that shows the US has the safest aviation system in the world.

Research Collaboration Partners:

In addition to the REDAC, the ATR program has direct interactions with airport consultants, airport authorities, academia, airport contractors and the paving industry (Airport Concrete Paving Association, Asphalt Institute & National Asphalt Paving Association). These stakeholders provide

direct inputs into current needs, future trends, and FAA AC deficiencies and these stakeholders help shape the ATR program's research needs today and into the future.

Interagency Agreements with:

U.S. Army Engineer Research and Development Center (ERDC): Collaboration and technical exchanges in airport and airfield pavement research. This collaboration benefits both organizations in the sharing of critical technical information.

Tyndall U.S. Air Force Base: Collaboration between FAA and the U.S. Air Force on Aircraft Rescue Firefighting (ARRF) research, using the ARRF training facility located at Tyndall Air Force Base This collaboration provides FAA with access to a state of the art facility.

United States Department of Agriculture (USDA): Collaboration between FAA and USDA on the development of wildlife hazards assessment and risk mitigation plans at and near airports. This collaboration provides FAA with access to USDA expertise.

Smithsonian Institution (SI): Collaboration between FAA and SI on the processing of bird remains that are collected after a collision with an aircraft. This collaboration supports better understanding of bird strike risks near and at airports.

Do non-government groups partner with this program? (Yes/No): Yes

The ATR program has Cooperative Research Development Agreements (CRDA)'s with **ATECH Inc.**

Zodiac Arresting Systems America (ZASA)
The FAA and ZASA have entered into these two separate agreements to share intellectual knowledge and perform research and development activities on engineered material arresting system (EMAS) that safely arrest aircraft that overrun runways.

French Civil Aviation Authority (called Direction Generale de l'Aviation Civil or DGAC)
Agreement supports technical information exchanges in airport pavement design. This collaboration benefits both organizations in the sharing of critical technical information.

Acquisition/Assistance:
Does this program utilize competitive procurement processes? Yes.

FAA programs in the research portfolio employ competitive contracting vehicle types and grants to acquire Conduct, Research, and Development activities. The FAA's acquisition management system offers researchers omnibus contract vehicles such as the SE2020, SE2025, and eFAST BPAs in which vendors competitively compete for TOs and BPA calls. The Broad Agency Announcement is another competitive process the FAA utilizes for awarding basic research contracts. Grants are used to execute a portion of the FAA's research budget and where the FAA has the statutory authority to issue grants pursuant to the Aviation Research Grants Program. The FAA's Centers of Excellence (COE) is one example of a grant-based program that uses competition to select from among members of academia for COE participation. In the specific case of the COE grant program, it receives matching funds from industry sponsors.

The ATR program uses a main support research contractor under a competitively bid 5-year support contract.

The program rarely uses "sole source" acquisitions in its research portfolio. When sole source is used for research projects, it is for the few instances where the technology is unique, and the program needs to access that particular technology in order to meet the goals and objectives of the research.

In general, the FAA Research Portfolio includes Research Programs that use multi-year acquisitions.

Does this program leverage non-Federal funds? (Y/N): Yes

The program makes uses of the FAA's Center of Excellence (COE's), which are selected consortiums of U.S. universities. For research projects conducted with the COE's, the universities are matching Federal funds with non-Federal funds.

Technology Transfer (T2):

Although the Airport Technology Research program (ATR) is not directly involved in T2, the program substantially contributes to the transfer of technology to airports and private industry on a regular basis. Throughout its activities, the ATR program has contractual relationships, partnerships, agreements with multiple and diverse private industry innovators that develop products for airports. To name a few, these are in the areas of radar development for airport safety, aircraft overrun systems, LED-based airport lighting, aircraft rescue firefighting agents, and innovative airport pavement materials to make pavements last longer. The ATR program also works directly with airports when testing and evaluating these new products and by default, ATR serves as a conduit for the transfer of technology between private industry and airports. One key role that ATR serves is that, in its function, the ATR program is neutral in its evaluation of new airport products and therefore airports are more receptive to experiment with innovative products.

Evaluation / Performance Measurement:

The ATR program meets all its annual performance goals, and in addition the ATR program has been able to quickly deliver on urgently needed research, such as prototyping innovative LED runway edge lights, and conducting safety assessments at airports. On a regular basis the program is reviewed by the FAA's Office of Airports, the research sponsoring office, and a few select ATR's performance goals are regularly entered and tracked in the office of Airports Business Plan.

Examples of annual performance goals that were met from previous years are:

- Develop prototype LED high intensity runway edge light fixture with Infrared Signature. ATR partnered up with industry to develop two prototypes of LED-based runway edge light fixtures using some additional Infrared Signatures. These were developed to replicate the visual spectrum displayed by incandescent lights, that can be seen by Head-up Displays in low visibility environments.

- Setup and lead a FAA-led Aircraft Braking Friction Technical Working Group

An expert group was formed with representation from industry to review past research Aircraft Braking on Friction limited runways and formulate current and future research needs. An action plan in the form of a white paper was developed.

- Complete Cape May Taxiway Project Construction Project
  The rehabilitation construction of Taxiway C at Cape May, NJ, was completed. The taxiway will be used as a test bed for new airfield lighting technologies and equipped with State of the Art Lighting Control System, as well as, be a used to monitor the effects of the environment on the performance of four different asphalt surface mix designs.

- Complete Installation of Instrumented Site at the Boston Logan Airport
  Instruments such as strain gages were installed in asphalt overlays at Taxiways M & B. The purpose of field instrumentation is to determine the effects of the environment; material properties, and the variability of construction quality on pavement response and performance in the field rather inside the National Airport Pavement Test Facility (NAPTF) facility for a better understanding of airport pavements.

- Life-cycle cost analysis was added to FAA pavement program (aka PAVEAIR)
  A pavement rehabilitation life cycle cost analysis module was added to FAA's wed-based airport pavement management system, FAA PAVEAIR, so Engineers can determine which pavement rehabilitation is the most cost effective over the life of the rehabilitation alternative selected.
- Develop pavement rutting criteria for inclusion into in new FAA AC 150/5370-10H
  A maximum rutting criteria (10 mm of rutting after 4,000 passes) for asphalt pavement samples was developed using test equipment called the Asphalt Pavement Analyzer (APA). This maximum rutting criteria was developed to help determine if asphalt pavement designs would be usable on airfield runways and taxiways. If the samples rut more than 10 mm then the material will be deemed unsuitable for airfield asphalt pavements.

The ATR program portfolio sustains several areas that are directly related to the DOT safety Strategic Objective Performance Goal of reducing aviation-related fatalities. These areas are all grouped under the subject of Airport Safety with the specific focus of improving safety (i.e. minimizing risks and reducing fatalities) at airports. One such key research area is the continuing research and development support for Engineering Material Arrestor Systems (EMAS) technologies. Over the last few years EMAS systems have been installed at 63 airports, have arrested 13 aircraft and saved 288 lives. The data is tracked by FAA and is published on the FAA EMAS Fact Sheet, available online. The ATR program also supports the development of various technologies and activities to reduce fatalities in the airport environment. Examples of such activities are the tracking of wildlife strikes at airports by maintaining an active "wildlife strikes" database and using the data to implement wildlife control techniques at airports. Other examples of using data to track activities specifically related to the reduction of aviation-related fatalities are the Runway Incursion Mitigation (RIM) database and the Foreign Object Debris (FOD) database. Over the years, the ATR portfolio has had a direct impact on improving safety at airports and has data to validate to its activities.

The Airport Technology Research (ATR) program has several activities that supports the DOT Strategic Performance goal to Increase Airport Capacity. One set of activities is in the Airport Planning and Design area. ATR recently completed a comprehensive plan that will guide a portfolio of research

needs for the next 10 years. This plan enables the development of several quantitative tools to enable enhanced airport planning and more data driven decision-making in airport development by airports and their consultants. In the infrastructure area, ATR sustains current research to extend the service life of airport pavements from the current design life of 20 years to 30 or even 40 years. Extending pavement life contributes directly to increased airport capacity by minimizing disruption at the airport, and by allowing AIP funds to be used potentially to fund another infrastructure project at an additional airport. These research activities are fairly new and, if successful, will result in increased capacity.

Aircraft Safety Assurance

Fire Research and Safety
Funding Request ($7,200,000)

Program Description/Activities:

The purpose of this program is to conduct research to prevent accidents caused by in-flight fire (main emphasis of the current program) and to improve survivability during a post-crash fire. The program supports the FAA's Associate Administrator for Aviation Safety, which is responsible for issuing regulations, standards and guidance material to ensure the highest level of safety in commercial aviation. Research efforts specific to hazardous material transports are completed in coordination with DOT's Pipelines and Hazardous Materials Safety Administration (PHMSA).

The program benefits the aviation industry by developing, validating and transferring cost-effective aircraft fire safety technology. This program is necessary because of the catastrophic consequences of an uncontrollable aircraft fire including loss of life and the destruction of the aircraft. An example being our participation in an international committee's (SAE-G27) efforts to develop a packaging standard for the safe shipment of lithium batteries on aircraft. The standard was requested by ICAO after they implemented the ban on passenger aircraft. We proposed a test standard and have conducted extensive tests to work out the details and develop pass/fail criteria. PHMSA is also participating in the standard development. If it were adopted, PHMSA would have the responsibility to change the hazards materials shipping regulations to mandate its use.

Statutory Requirements:

Is this program statutorily mandated (Y/N): Yes

Research is required by U.S.C. Title 49, Subtitle VII, Part A, Subpart iii, Chapter 445, Section 44504, Parts b(3), b(4), and b(5) which states "… to assess the fire and smoke resistance of aircraft materials; to develop improved fire and smoke resistant materials for aircraft interiors; to develop and improve fire and smoke containment systems for inflight aircraft fires".

Program Alignment with Strategic Goals:

DOT Strategic Goal	DOT RD&T Critical Transportation Topic
Safety	**Promoting safety**

This program supports the DOT's Strategic Goal of safety by providing systematic research and development within the FAA that will lead to the identification, assessment and mitigation of safety risks. By providing the research necessary to generate data, this data is then used to create and develop new safety standards that will be adopted throughout the aviation community.

This program does not have any specific impact on rural communities.

Program Objectives:

The primary goal of this research is the prevention of catastrophic aircraft accidents caused by in-flight fires and increased survivability during a post-crash fire. Other benefits derived from this program include: 1) the introduction of enabling technologies to prevent accidents caused by fire in freighter aircraft and hidden in-flight fires in passenger-carrying airplanes, and 2) the development, validation, and transfer of cost-effective aircraft fire safety technology to the aviation industry.

The Fire Safety Branch at the FAA WJHTC has unique aircraft fire testing capabilities that do not exist anywhere else in the world. This fact was recognized by the CAST Safety Enhancement (SE) SE127 team that recommended that the research be conducted by the FAA Fire Safety Branch. The FAA Associate Administrator for Aviation Safety relies on objective research results to make decisions on required changes to certification methods as aircraft manufacturing incorporates new materials and processes that may have unforeseen consequences with respect to aircraft fire safety. Global aircraft manufacturers have no incentive to conduct research that might limit the safe use of these new materials and processes.

Economic Impact of Regulatory Reform:

The Fire Research and Safety program supports the FAA Aircraft Certification office goal of rewriting the regulations involving aircraft material fire test requirements. The testing and research results will enable the FAA to reduce unnecessary and/or redundant requirement that will reduce the industry certification burden while maintaining the current safety levels. This support is provided with active industry involvement through the International Aircraft Materials Fire Test Forum which meets three times per year. The material fire testing requirements are performance based and do not specify any particular required material construction. Planned FY19 research also supports the Commercial Aviation Safety Team. This team consists of aircraft industry and regulators and the goal is to establish objectives agreed to by the team members on a volunteer basis without the formal regulation process. The specific research requested by the CAST team is the improved detection and suppression of hazardous material fires.

Research Collaboration Partners:

The FAA Fire Safety Branch conducts regular public meetings and conferences that are well attended by aircraft and aviation system manufacturers, operators, foreign regulatory authorities, and other research institutes and universities. Current FAA research projects and results are presented and industry input is encouraged. Aircraft fire safety research conducted by others is also presented at the meetings.

The following are program partners:

International Civil Aviation Organization (ICAO) Research results from testing to document the fire hazards involved in the air transport of lithium batteries has been presented to the ICAO Dangerous Goods Panel and Airworthiness Panel as part of their decision making process that led to a ban on the shipment of these types of batteries on passenger aircraft until a safe shipping method is developed. Research has also been conducted to support the development of the safe shipping method through contributions to the Society of Automotive Engineers, International (SAE) committee tasked with developing the new standard.

Boeing Commercial Airplanes. Testing has been conducted at the FAA Fire Safety Branch facilities in partnership with Boeing and one of their suppliers to evaluate a proposed Halon replacement fire suppression system for cargo compartments. The benefit of this partnership is the data generated to allow the certification of such a system to progress within the FAA.

Do non-government groups partner with this program? Yes

Non-government groups routinely partner with this program. The partnerships involve the supply of proposed new fire suppression agents or systems that are evaluated in full scale testing to determine their suitability and effectiveness. It also includes suppliers of fire detection technology and aircraft materials suppliers. Long lasting partnerships are also in place with higher education institutes such as University of Maryland, Rutgers University, University of Massachusetts, and University of Cincinnati. These institutes conduct research through grants to help support this program.

Acquisition/Assistance:

FAA programs in the research portfolio employ competitive contracting vehicle types and grants to acquire Conduct, Research, and Development activities. The FAA's acquisition management system offers researchers omnibus contract vehicles such as the SE2020, SE2025, and eFAST BPAs in which vendors competitively compete for TOs and BPA calls. The Broad Agency Announcement is another competitive process the FAA utilizes for awarding basic research contracts. Grants are used to execute a portion of the FAA's research budget and where the FAA has the statutory authority to issue grants pursuant to the Aviation Research Grants Program. The FAA's Centers of Excellence (COE) is one example of a grant-based program that uses competition to select from among members of academia for COE participation. In the specific case of the COE grant program, it receives matching funds from industry sponsors.

This program typically does not use sole source acquisitions except for highly specialized equipment that is essential for the conduct of fire testing projects. *I*n general, the program uses multi-year acquisitions (please see description above). This program typically does not leverage non-Federal funds.

Technology Transfer (T2):

The Fire Safety Branch at the William J. Hughes Technical Center is recognized as a world leader in the conduct of aviation fire related research and testing. Members of the branch are active participants in U.S. and international bodies related to aircraft fire. Participation includes accident investigation, SAE/ISO/RTCA standards committees, and ICAO Dangerous Goods panel. In addition, the branch plans and chairs five international forums annually relating to aircraft materials fire testing and aircraft system fire protection. The forums are well attended by aircraft manufacturers, U.S. and foreign regulatory authorities, aircraft system component and materials manufacturers, airlines, other research institutes, and aircraft industry union representatives. The status and results of the FAA fire safety research is presented to the aviation industry at these forums and research by other attendees is also presented. All of the presentations from these forums are publicly available on the Fire Safety Branch website at: www.fire.tc.faa.gov. Reports are published for all research projects and are also available on the website. The Fire Safety Branch also organizes and conducts an international aircraft fire and cabin safety conference every three years. The conference is typically attended by over 500 people from all aspects of the international aviation community.

Evaluation / Performance Measurement:

The progress of this program is tracked through the annual Performers Research Execution Plan which contains milestones for the research activities. The progress of each activity is reported monthly through the Simplified Program Information Reporting and Evaluation (SPIRE) reporting system and quarterly in the Executive Quarterly Reporting System. The program supports the overall DOT Strategic Plan of improved safety but there are not specific metrics that apply to the aircraft fire safety program. The program is performing well as evidenced by meeting the sponsor requirements.

Fire Research and Safety contributes to the DOT Strategic Objective Performance Goal of reducing aviation-related fatalities through the knowledge gained from the research testing conducted. The specific research planned for FY19 includes: assessing the ramifications of the transport of hazardous materials; improved understanding of the contribution to overall fire safety of new materials used in the construction of aircraft; improved detection and suppression capabilities for cargo containers; and the development of an integrated aircraft fire protection system. The outcome of the research could lead to new regulations, improved guidance and training, and new standards for fire safety related improvements implemented on a voluntary basis. Aircraft fire related fatalities have been reduced to a very low level, partially due to past research results from this program. The planned research addresses emerging trends in an effort to maintain the fire related fatality rate at the present low level.

Unmanned Aircraft Systems Research
Funding Request ($24,035,000)

Program Description/Activities:

The UAS Research program supports the FAA efforts in integrating UAS into the NAS. By studying safety implications of unmanned aircraft operational concepts and technology, this research program supports the development of minimum operational performance standards and modified regulatory standards. The program's research activities focus on new technology assessments, methodology development, data collection and generation, laboratory and field validation, and technology transfer.

Statutory Requirements:

Is this program statutorily mandated (Y/N): Y

The safe integration of UAS into the NAS is an important objective for the FAA, as evidenced in the 2016 Reauthorization Act. Current regulations, system safety policy, and certification processes are deficient in their ability to address advanced flight path control technologies (automation) even though it has been proven that they can provide for safer control of a vehicle's flight path than the pilot can accomplish alone. This level of flight path control is not currently covered in autopilot guidance for existing fixed wing and rotary wing aircraft for compliance to 23.1329, 23.1309, and other regulations, yet is widely used in other aircraft markets. The 2016 Congressional Reauthorization includes specific requirements on UAS research. Furthermore, Congress directs funds for UAS research to the ASSURE COE and to the WJHTC/other FAA facilities.

Program Alignment with Strategic Goals:

DOT Strategic Goal	DOT RD&T Critical Transportation Topic
Safety	**Promoting safety**

This program supports the DOT's Strategic Goal of safety by providing systematic research and development within the FAA that will lead to the identification, assessment and mitigation of safety risks. By providing the research necessary to generate data, this data is then used to create and develop new safety standards that will be adopted throughout the aviation community. The implementation of the research from this program will assist the integration of UAS into the National Airspace System (NAS). UAS in the NAS will affect urban, suburban, and rural communities.

Program Objectives:

The Unmanned Aircraft Systems Research program goal is the safe integration of unmanned aircraft into the NAS. UAS research contributes and informs technical and regulatory standards, policy guidance, and operational procedures on which successful UAS integration depends. These research efforts significantly contribute to addressing the challenges of integrating UAS into the NAS by leveraging studies of UAS operations and associated technologies. These research programs help develop unmanned aircraft systems, training, technology, and procedures that increase the safety of UAS operations and increase the confidence of the American public that UAS flights can be safely and

efficiently integrated into national airspace. The research facilitates approval and use of systems that prevent accidents and help reduce the severity of UAS accidents in the NAS. This research also develops standards to mitigate human factor causes of incidents and accidents due to control station or pilot training design deficiencies. Descriptions of the several research requirements associated with this central goal follows.

- High Visual Contrast for UAS
  With the looming proliferation of UAS in the NAS, it is critical to reduce the risk of collision with manned aircraft. One risk reduction method will be to make Unmanned Aircraft (UA) easier for the pilots of manned aircraft to see and avoid the UA. This research will help mitigate safety risks by making UA more salient to operators and pilots of manned aircraft therefore aiding with see and avoid.

- UAS Flight Data Research in supporting of the Aviation Safety Information and Analysis Sharing (ASIAS) Program
  This research will aggregate high quality UAS flight data with commercial and general aviation flight data and surveillance data, in order to develop enhanced safety analyses for NAS stakeholders and to support UAS integration in the NAS.

- Air Carrier Operational Considerations for Unmanned Aircraft Systems
  This research addresses safety concerns specific to Air Carrier Operations for UAS to include air carrier staffing, training, testing, duty and rest requirements. It could help establish a separate rulemaking activity specific to air carrier operations.

- Minimum Detect and Avoid Display and Flight Path Information
  This research supports the development of minimum requirements for Detect and Avoid (DAA) display and flight path guidance information required for UAS pilots to execute a maneuver to remain well clear.

- UAS Automation/Autonomy
  This research will examine the interaction between UAS pilots and automated UAS to provide data for developing standards and best practices for pilot information management of UAS and address automation issues (e.g., mode awareness).

The FAA is partnering with industry to establish standards that support UAS operations in an expanding set of missions, platforms, and capabilities. The UAS community needs standards to address all aspects of UAS production and operation, including UAS design and airworthiness, software assurance, operations and mission requirements, pilot training, and maintenance. UAS standards needed to support operations include standards for Command & Control systems (C2), Detect-And-Avoid technology, and identification & tracking capabilities. The FAA has committed to an annual opportunity for the broader stakeholder community to raise issues, concerns, and to provide input to the FAA.

Improving Mobility for Underserved Communities:

The Unmanned Aircraft Systems (UAS) Research Program includes an initiative focused on providing UAS Science, Technology, Engineering, and Mathematics (STEM) outreach to K-12 students in

underserved communities. The FAA, through partnership with the FAA's UAS ASSURE Center of Excellence, aims to make STEM opportunities more accessible to underrepresented groups and to contribute to creating the next generation's interest in the UAS field. Activities such as summer camps and UAS roadshows use UAS as the central learning platform to demonstrate physics of flight, flight simulator exercises, hands-on activities, and team research projects. This STEM initiative falls within the COE's mandate to educate and strategically facilitate outreach. The long-term goal of the project is to ignite an interest in UAS and STEM and, therefore, nurture part of the possible future UAS workforce.

Economic Impact of Regulatory Reform:

The Unmanned Aircraft Systems (UAS) research program currently includes efforts to study the economic impacts of the integration of UAS into the NAS. This research is based on the gathering and analysis of market and business intelligence, as well as existing data sources for UAS. The data is being compiled to support risk and hazard analysis for safety goals of the agency as new business models are incorporated. This research is providing valuable data to facilitate safe UAS integration and enhance FAA's incremental risk-based approach towards safety rules and regulations.

The Unmanned Aircraft Systems (UAS) research program supports the reform of the National Airspace System (NAS), as UAS are new entrants to the NAS, and introduce new challenges in terms of interacting with other aircraft, with Air Traffic Control, and with the general public. To realize the full potential and economic benefits this innovative technology can have, UAS integration must be done safely. UAS research is needed to develop and validate of UAS standards, policy, and regulation to ensure that UAS are integrated safely into the National Airspace System (NAS). Safe integration includes ensuring the safety of people in the air and on the ground. To do this, we must understand key challenges such as unique UAS performance characteristics and the risks of UAS operations. Several UAS research projects have delivered results that have directly informed performance-based standards, specifically RTCA Special Committee 228's minimum performance standards for UAS Detect-And-Avoid, and standards to ensure safe performance of UAS Command and Control. UAS research will continue through FY19-20 to address these critical safety issues needed to continue the development of performance-based standards to ensure UAS are integrated safely into the NAS.

Research Collaboration Partners:

FAA is leveraging a wide spectrum of UAS research being conducted across agencies, within industry, across academia, and internationally. It is collaborating with industry partners, standards bodies, and independent research organizations to inform rulemaking and operational changes that will enable full UAS integration into the NAS. The FAA is leveraging the UAS technical and operational expertise across Federal agencies. The UAS Executive Committee (EXCOM) was established to act as a focal point for resolution of issues on matters of policy and procedures relating to UAS access to the NAS, and to identify solutions to the range of technical, procedural, and policy concerns arising from the integration of DoD UAS into the NAS.

Program partners include:

- Department of Defense (DOD)
- Department of Homeland Security (DHS)

- National Aeronautics and Space Administration (NASA)
- Department of Interior (DOI)
- Department of Justice (DOJ)Department of Commerce (DOC)
- Department of Energy (DOE)
- Department of Transportation (DOT)
- National Academies of Science/ Transportation Research Board (TRB) and Aeronautics and Space Engineering Board (ASEB)
- National Science Foundations' Center for UAS
- National Institutes of Standards and Technology (NIST)
- Air Force Research Lab (AFRL)
- UAS Center Of Excellence

Do non-government groups partner with this program?

Non-government groups contribute to the rapid advances in technology presented across the UAS industry. These organizations bring a different perspective to helping solve complex problems and challenges. The FAA works with the below Independent Research Organizations to ensure they are part of the cutting edge of new and innovative approaches for safety UAS operations.

- Massachusetts Institute of Technology (MIT) Lincoln Labs
- Radio Technical Commission for Aeronautics (RTCA) International
- American Society for Testing Materials (ASTM) International
- Society of Automotive Engineers International (SAE)
- American National Standards Institute (ANSI)
- Institute of Electrical and Electronics Engineers (IEEE)
- Consumer Technology Association (CTA)
- Joint Authorities for Rulemaking on Unmanned Systems (JARUS)
- European Organization for Civil Aviation Equipment (EuroCAE)
- Civil Air Navigation Services Organization (CANSO), North Atlantic Treaty Organization (NATO)/Flight in Non-Segregated Airspace (FINAS)

Acquisition/Assistance:

FAA programs in the research portfolio employ competitive contracting vehicle types and grants to acquire Conduct, Research, and Development activities. The FAA's acquisition management system offers researchers omnibus contract vehicles such as the SE2020, SE2025, and eFAST BPAs in which vendors competitively compete for TOs and BPA calls. The Broad Agency Announcement is another competitive process the FAA utilizes for awarding basic research contracts. Grants are used to execute a portion of the FAA's research budget and where the FAA has the statutory authority to issue grants pursuant to the Aviation Research Grants Program. The FAA's Centers of Excellence (COE) is one example of a grant-based program that uses competition to select from among members of academia for COE participation. In the specific case of the COE grant program, it receives matching funds from industry sponsors.

In general, the FAA Research Portfolio includes Research Programs that use multi-year acquisitions.

Does this program leverage non-Federal funds?

Yes. The FAA's Centers of Excellence (COE) matches funds for research grants.

Technology Transfer (T2):

Not Applicable, because this program focuses on development of new concepts and potential subsequent demonstrations to support NextGen capabilities for continued improvement of the NAS.

Evaluation / Performance Measurement:

The Unmanned Aircraft Systems (UAS) research program supports the development and validation of UAS standards, policy, and regulation to ensure that UAS are integrated safely into the National Airspace System (NAS). Safe integration includes ensuring the safety of people in the air and on the ground. This work pertains to the DOT Safety Performance Goal of reducing aviation-related fatalities. To do this, we must understand key challenges such as unique UAS performance characteristics and the risks of UAS operations. Several UAS research projects have delivered results that have directly informed RTCA Special Committee 228's minimum standards for UAS Detect-And-Avoid, and standards to ensure safe performance of UAS Command and Control. Additional UAS research has yielded results to classify the severity of UAS collisions – both with people on the ground, and with airborne manned aircraft, to support safe UAS operations over people and beyond visual line of sight. UAS research will continue to FY19-20 to address these critical safety issues to ensure UAS are integrated safely into the NAS.

Advanced Materials/Structural Safety
Funding Request ($14,720,000)

Program Description/Activities:

Throughout most of the history of civil aviation, aircraft have evolved slowly with little change to the basic aluminum materials or design concepts. A vast body of knowledge about such aircraft has been gained, often at the expense of fatal crashes. As this knowledge has grown, the safety record of civil aviation has steadily improved to the near perfect record of the past few years. Over the last decade, the pace of evolution of civil aircraft has increased dramatically. One of the most important changes has been the widespread adoption of composites in critical structures. This represents the first significant change in aircraft materials, design concepts, and fabrication techniques since the introduction of the first modern airliners in the 1930's. The current certification process for many advanced materials and structures was established for smaller, and in some cases, less critical components and service conditions. The difference in the structural characteristics, loading conditions, system interface issues, and increased scale of these components must be understood and incorporated into certification and operational plans to assure safety. In many cases, the body of knowledge accumulated for traditional aluminum aircraft does not apply. The long-term effects of aging, environmental factors, flight loads, damage, manufacturing defects, and many other aspects of the intensely complex operating environment of transport aircraft are not fully understood. The Advanced Materials and Structural Safety Program seeks to fill these gaps in our knowledge before they can cause catastrophic loss of aircraft and lives.

The Structural Safety program performs research to evaluate test and analysis procedures used by the industry to meet crashworthiness regulations. These regulations are evolving and are supplemented with special conditions for transport aircraft with composite fuselage and wing structures. The program ensures new aircraft structures demonstrate levels of safety equivalent to existing aircraft structures subjected to survivable crash conditions. The program develops dynamic test methods to determine composite material properties, loading rates for emergency landing conditions including strain rates, typical material response rates at the component and system level, and occupant survivability. The program also identifies limitations associated with structural scale and boundary effects, and develops crashworthiness safety awareness training materials.

In this context, this program will perform research in the following focus areas: 1) Research will be performed to study critical defects and damage threats that effect the damage tolerance of composite airframe structures not fully understood today. This research will evaluate methods to better characterize behavior of damaged composite materials as applied by industry to support certification of composite aircraft. 2) Additionally, research will evaluate composite repair, inspection and other maintenance practices that are in use to ensure that the industry adopts composite maintenance practices that are safe and consistent with continued airworthiness regulations. 3) Issues related to structural integrity of adhesive joints will be investigated. These include quality control of critical processes for bonded aircraft structures substantiation of bonded structures for aircraft, and evaluation of composite material and process conditions that affect structural bonding. 4) Research will be performed to improve continued operational safety (COS) and certification efficiency (CE) for emerging composite technologies. This research area will focus on post-crash fire-related forensic investigation of composites, effects of lightning strike on composites, and evaluation of new composite materials and manufacturing processes.

At the requested funding level, research cannot be performed on the following three areas listed above: 1) Damage Tolerance of Composite Structures, 2) Structural Integrity of Adhesive Joints, and 3) Composite Maintenance Practices.

Advanced Materials and Structural Safety research requirements are driven by industry advancements in construction of airframes and related components presented for certification. The FAA must assure that the changes maintain an equivalent or improved level of safety compared to that achieved with current operational aircraft. Requests from the aircraft certification offices and from the aircraft manufacturers seeking 'type certification' approval are major influences that shape research requirements. Additional requirements are developed from assessments of existing techniques, protocols, and service histories. These are examined to determine if modifications to certification compliance methods are required for novel materials, processes, and forms. The National Transportation Safety board review of accidents involving these structures provides additional impetus for research required to understand these emerging technologies. Sample reports can be viewed at:

- http://www.ntsb.gov/investigations/AccidentReports/Pages/AAR0404.aspx
- https://www.atsb.gov.au/publications/investigation_reports/2007/aair/aair200701625.aspx

Statutory Requirements:

Is this program statutorily mandated (Y/N): Yes

"Research is required by the U.S.C. TITLE 49 - TRANSPORTATION/SECTION 44504 - Improved Aircraft, Aircraft Engines, Propellers, And Appliances; "to develop technologies and analyze information to predict the effects of aircraft design, maintenance, testing, wear, and fatigue on the life of aircraft, including nonstructural aircraft systems, and air safety; to develop methods of analyzing and improving aircraft maintenance technology and practices, including nondestructive evaluation of aircraft structures"

Program Alignment with Strategic Goals:

DOT Strategic Goal	DOT RD&T Critical Transportation Topic
Safety	**Promoting safety**

This program supports the DOT's Strategic Goal of safety by providing systematic research and development within the FAA that will lead to the identification, assessment and mitigation of safety risks. By providing the research necessary to generate data, this data is then used to create and develop new safety standards that will be adopted throughout the aviation community.

This research program is structured in accordance with the strategic goals; internal FAA deliverables and associated timetable outlined by the Aviation Safety (AVS) Strategic Composite Plan and supports all of its three key initiatives. In support of the FAA AVS composite plan, the research output

produced by this program will be used by the FAA to develop and publish guidance for the aviation industry. This guidance material includes:

- New Advisory Circular (AC) for bonded repair best practices (by FY 2021),
- New AC for composite sandwich structure design, manufacturing, and maintenance that supports the unique considerations of "bonded" sandwich (by FY 2020),
- FAA Failure Analysis Handbook for Composites (by FY 2021)
- Publication of an FAA policy on interpretation of § 25.571 for existing rule in coordination with the established FAA ARAC (by FY 2019)
- A new rule (a modified § 25.571 or new subpart to part 25) defining damage tolerance requirements for the certification of composite transport aircraft (by FY 2020)
- Updated maintenance technician training requirements for part 147 (by FY 2019)
- New AC outlining best practices approving modifications to composite structure (by FY 2019)
- Revised AC 21-43 to replace to AC 21-26, "Quality System for the Manufacture of Composite Structures" and AC 21-31A, "Quality Control for the Manufacture of Non-Metallic Compartment Interior Components" (by FY 2019)
- New AC that incorporates guidance on material and process specifications from AC 21-26, AC 21-31, and small airplane directorate policy PS-ACE 100-2002-006 (by FY 2019)
- Revised AC 20-107, "Composite Aircraft Structure," to incorporate advanced composite technologies and lessons learned (by FY 2022)

Additionally, the completion of this task is instrumental for FAA's efforts to achieve the following National Aviation Research Plan (NARP) milestone: By 2019, develop background information and data for creation of a Part 21 Advisory Circular on composite structures. This research improves the overall safety of air travel and therefore affects all communities in the United States included rural communities. Furthermore, much of the research is conducted in state universities of states predominately comprised of rural communities, and often located in rural communities.

Program Objectives:

Recent increase in the use of composite materials in commercial and civil aircraft require a proactive approach to maintain safe operations in the National Aviation System. Approaching a century of experience with metals in aircraft, there have been many lessons learned about the behavior of these materials. Without the benefit of that history for composites, the main goal of this program is to conduct research that addresses this gap and adds to the knowledge base of composite materials. The output of this research is used by the FAA to develop regulations, policy and guidance material which guide FAA employees and the aircraft industry towards the highest levels of safety. Additionally, as a major research output, this program supports publication of the Composite Materials Handbook-17 (CMH-17), the authoritative worldwide focal point for technical information on composite materials and structures. As an industry-wide global standard, it provides information and guidance necessary to design and fabricate end items from composite materials. Through publication of the research program's output, this handbook aims to standardize testing and engineering data development methodologies for current and emerging composite materials.

Within the scope and central goal outlined above, the Advanced Materials and Structural Safety research program conducts research on the following topics to endure the safe use of composite materials in aircraft products: 1) Damage Tolerance of Composite Structures, 2) Composite

Maintenance Practices, 3) Structural Integrity of Adhesive Joints, and 4) Continued Operational Safety (COS) and Certification Efficiency (CE) for Emerging Composite Technologies, including Composite Additive Manufacturing.

Research on Damage Tolerance of Composite Structures aims to study critical defects and damage threats that effect the damage tolerance of composite airframe structures not fully understood today. Research also includes the evaluation of methods to better characterize behavior of damaged composite materials as applied by industry to support certification of composite aircraft. Current regulations and associated guidance for transport airplanes in this area have been based on metallic construction. Damage tolerance behavior of composite structures differs substantially from metallics. The FAA will perform research to characterize, prioritize and simplify damage criteria used during certification.

Research on Composite Maintenance Practices will analyze data produced in prior years of this ongoing task to evaluate the variability in bonded repairs as related to human factors and to examine issues related to specific design and processing details of composite repairs. This research will also investigate the strength of bonded repairs to in-service aged composites. As part of this research, training issues will be identified in coordination with the industry and a training course will be developed to support safe maintenance for composite transport airplanes, small aircraft and rotorcraft in the field.

Research on Structural Integrity of Adhesive Joints will focus on establishing requirements working with industry for environmental durability tests standards for bonded joints and document related guidance. As part of this task, research will be performed in-house at the FAA William J. Technical Center to validate approaches to such standards. This research task will also investigate issues to be addressed by guidelines for bond qualification including bonding processes parameters and material compatibility.

Finally, Research on Continued Operational Safety and Certification Efficiency for Emerging Composite Technologies will investigate the effects of fire on composite failure analysis methods and conduct research on effects of lightning strike on composite aircraft structures. This task will perform research to identify key characteristics of carbon fiber production. Additionally, new research will be started to investigate the sensitivity of composite materials to new fuels.

This program does not address a market failure; rather, it serves the needs of FAA's regulatory roles and responsibilities that are distinct from the pursuits of industry. To effectively regulate the National Aerospace System, FAA must have its own, independent knowledge of the issues involved. To simply accept analyses, findings, claims, etc. of applicants without understanding them is to abrogate FAA's duties and blindly accept the plans of industry rather than regulate. There is a recognition of this by industry, leading to the close cooperation between the Advanced Materials and Structural Safety program and its industry partners. This is evidenced by the 50/50 cost share of virtually all the projects in this program. By working with industry, FAA is able to build consensus and efficiently certify industry applications while ensuring the continuing safety of the flying public.

Some of the issues not independently addressed by the industry but addressed by the Advanced Materials and Structural Safety research collaborations with industry are listed below:

- Bonded repairs (metallic and composite) are being performed without proper engineering substantiation or maintenance techniques, manufacturing defects have not been properly identified, and there is a lack of shared information on lessons learned within the industry.
- Policy/guidance recently released to mitigate the potential safety risk from ground damage on composite aircraft structure. Additional educational efforts are necessary
- Policy/guidance/technology currently does not exist for performing forensic failure analysis of composite surfaces subjected to fire/heat damage.
- Title 14 CFR part 147 appendix B requires that composite materials be included in the curriculum, however, no guidance exists to define the level of detail or application.
- Guidance currently does not exist to define the expectations for certifying a modification to critical composite structure, such as Boeing 787 and Airbus A350 pressurized fuselages.
- Guidance does not currently address process control for advanced composite designs, which may be considered one of the primary engineering concerns for composite products.
- Standardize certification methods for sandwich construction and bonded structure and evaluate the effects of the removal of the prescriptive §23.573 rule.
- With the evolving/advancing composite technology and expanding composite applications, AC 20-107 "Composite Aircraft Structure" will require revision.
- Guidance does not currently exist for use of composite materials in engine applications.

Economic Impact of Regulatory Reform:

Because use of composites in critical (primary) aircraft structure is relatively new, several directives have been issued to cover aspects that had not been an issue with traditional aviation materials. Some of the research of the Advanced Materials Program is aimed at ensuring that those directives are not overly stringent and do not place an undue burden on industry. One example of this is the requirement for bonded joints that limits the maximum temperature that can be experienced by the structure. Because we had no data, and because the primary objective is to ensure safety, a conservative approach was taken. A research program is starting that will examine this directive and determine whether the requirement can be relaxed.

Research Collaboration Partners:

Public and stakeholder input is primarily received through two mechanisms. First is through the close collaboration of the joint research with industry that comprises the great majority of the program. Such input is inherent in identifying research areas that are of sufficient interest for industry to commit substantial research resources to the projects. In addition, the close collaboration affords extensive contacts and discussions on priorities, industry direction, and future plans. A second forum is the congressionally mandated Research, Engineering, and Development Advisory Committee (REDAC). The REDAC is an advisory committee to the FAA whose members are FAA stakeholders including industry, Federally Funded Research and Development Centers (FFRDCs), and academia. The REDAC provides advice and recommendations to the FAA Administrator on the needs, objectives, plans, approaches, content, and accomplishments of aviation research program. The committee reviews and comments on the aviation research programs including Centers of Excellence and other grants. The REDAC considers aviation research needs in five areas; (a) NAS operations, (b) airport technology, (c) aviation safety, (d) human factors, and (e) environment and energy. The REDAC holds 2 full committee meetings and 10 subcommittee meetings annually from which come reports documenting REDAC's input known as REDAC Findings and Recommendations

(F&Rs.) The research programs evaluate REDAC findings and recommendations, and the FAA responds with adjudications and where appropriate, action plans commensurate with the recommendations. The FAA Research Portfolio Division and the research performers track all F&R and associated Agency responses.

The FAA Aviation Safety (AVS) is a key stakeholder of this research program. AVS input is primarily elicited through monthly technical status review and coordination meetings between the AVS program sponsors located at various certification offices including the FAA Chief Scientist and Technical Advisor on Composites and the research program management team located at the FAA William J. Hughes Technical Center. The progress is tracked through the deliverables and due dates outlined by the AVS Composites Strategic Plan.

Internal program partners include AIR-600, AIR-675, and other interested AVS offices including Rotorcraft and Small Airplane Standards. These FAA offices are sponsors of various research projects performed under this this program. There are also the end user of the output produced by this research program.

- Other government entities include the National Aeronautics and Space Administration (NASA), the Department of Defense, Department of Interior, and other government laboratories.

- The majority of the research performed by this program is funded through and managed by the congressionally mandated Joint Centers of Excellence (COE) for the Advanced Materials and Structures (JAMS). Under the leadership of the University of Washington and Wichita State University, the following serve as core members of the COE JAMS and external partners of this research program: Edmonds Community College, Florida International University, Northwestern University, Oregon State University, Purdue University, and University of California at Los Angeles, University of Delaware, University of Utah, Tuskegee University and the Washington State University. Mississippi State University is in the process of joining this list. The COE JAMS universities act as vehicles for workforce education and technology transfer as most students participating in the program research projects are offered engineering and technology positions in the aviation industry and continue working on composite design and manufacturing.

- Additional external partners include NASA, Wichita State University - National Institute for Aviation Research (NIAR), and National Institute of Aerospace (NIA)

- Finally a broad range of main aircraft and composite material OEMs, including Boeing, Lockheed, 3M, Airbus, Bombardier, and Embraer, among others also participate to this research program as external partners, matching funding and working closely with the individual projects and through various Composite Material Handbook (CMH-17) industry steering committees. The technology transfer of the research output and data generated by this research program is achieved through direct communication, FAA reports, and the CHM-17.

FAA Stakeholders: Transport Airplane, Rotorcraft and Small Airplane Standards offices Industry Partners: Boeing, Composite Materials Handbook – 17 (CMH-17) Steering Committee with

contribution/collaboration from major OEMs, maintenance repair organizations and airlines across the aviation industry.

Do non-government groups partner with this program? Yes

As outlined above, non-government groups partner with this research program primarily via the congressionally mandated Joint COE for Advanced Materials and Structures. The COE universities contribute to this research program by providing research facilities, tools, and test equipment in addition to domain knowledge, background and research experience. In FY 2017, the COE members, their Industry partners and other affiliates generated provided approximately $5 million in matching resources.

Acquisition/Assistance:

FAA programs in the research portfolio employ competitive contracting vehicle types and grants to Conduct, Research, and Development activities. The FAA's acquisition management system offers researchers omnibus contract vehicles such as the SE2020, SE2025, and eFAST BPAs in which vendors competitively compete for TOs and BPA calls. The Broad Agency Announcement is another competitive process the FAA utilizes for awarding basic research contracts. Grants are used to execute a portion of the FAA's research budget and where the FAA has the statutory authority to issue grants pursuant to the Aviation Research Grants Program. The FAA's Centers of Excellence (COE) is one example of a grant-based program that uses competition to select from among members of academia for COE participation. In the specific case of the COE grant program, it receives matching funds from industry sponsors.

In general, the FAA Research Portfolio includes Research Programs that use multi-year acquisitions. This research program utilizes the Aviation Research Grants Program and issues the bulk of its grants through the congressionally mandated Joint Centers of Excellence for Advanced Materials and Structures. As a requirement, all COE research grants receive matching contributions from industry partners and sponsors. In FY 2017, 13 grant projects received nearly $4.9 million to support related research. The COE members, their Industry partners and other affiliates generated matching contributions.

Technology Transfer (T2):

Within the context of this research program, technology transfer activities include: 1) Publication of policy and guidance material by the FAA about industry's usage of composite materials in aircraft structures. 2) Publication of research data and other output by the program research partners in the Composite Materials Handbook (CMH-17). 3) Training courses and workshops to inform industry about research results. 4) Presentations of the research output by researchers in technical conferences. Publication of research results in technical journals. 5) Direct contact with research partners.

In most cases, AVS sponsors and FAA research program technical management staff lead the technology transfer activities. In others, performers of the research projects coordinate the tech transfer effort. In every tech transfer activity, industry partners are involved in the process either by a steering committee of workshop where potential approaches for outreach is discussed.

All work done under this program is performed with industry partners and 100% cost matching. Results are shared with partners in real time, with both parties receiving them as they come available. In addition, all personnel are involved in publishing research reports to share all data with the widest possible audience, making the complete raw data set available upon request. Finally, and perhaps most importantly, the data produced by the Advanced Materials and Structural Safety Research Program is used by the research sponsors to create guidance, directives, and other written instruments. This shares not only the knowledge gained, but also the implementation strategies, improving both aviation safety and regulatory efficiency.

Evaluation / Performance Measurement:

Progress at the individual research project level is tracked by detailed project plans reviewed and approved by the project technical monitors and AVS sponsors submitted at the proposal level by the performers. Detailed projects plans identify and describe specific milestones and deliverables for the research project and assign target dates for each activity. The FAA technical monitor on monthly teleconferences and quarterly in-person meeting reviews the project progress and keeps the AVS sponsors informed about the status of the projects and its deliverables.

At the program level, the AVS Strategic Composite Plan is used as the primary tool to keep track of program milestones and deliverables. AVS Composite Plan outlines key initiatives for which additional research is need to develop rulemaking, policy, and guidance to ensure continued operational safety, promote certification efficiency, and provide workforce education. FAA William J. Hughes Technical Center personnel tasked with the management and technical monitoring of this research program briefs the AVS sponsors on a quarterly basis about the progress of research according to the timetable determined by the Composite Plan.

In support of the DOT Performance Goal of Reducing aviation-related fatalities, several potentially fatal incidents involving composites on commercial aircraft have occurred. To ensure that a recurrence does not cause loss of life, the Advanced Materials and Structural Safety program is conducting research projects to better understand the underlying issues and prevent such a recurrence. One group of such incidents is the delamination of composite honeycomb flight control surfaces, an issue that has caused the loss of a rudder from an Airbus A310 aircraft as well as tear-out of the rudder control mechanism on an Airbus A300. Either of these incidents could have resulted in the loss of the aircraft. Research by the Advanced Materials Program has led to a much greater understanding of the issues involved and program personnel are leading an international effort to write standards to prevent such a fatal recurrence of this issue.

Continued Airworthiness
Funding Request ($11,269,000)

Program Description/Activities:

The Continued Airworthiness Program promotes the development of technologies, procedures, technical data, and performance models to prevent accidents and mitigate accident severity related to civil aircraft failures as a function of their continued operation and usage. The program focuses on longer-term maintenance of the structural integrity of fixed-wing aircraft and rotorcraft, continued safety of aircraft engines, development of inspection technologies, and the safety of electrical wiring interconnect systems and mechanical systems.

The Continued Airworthiness research program supports the FAA aviation safety oversight responsibility to ensure that aircraft maintain operational safety as they age. The FAA accomplishes this in two ways: first, by anticipating ageing issues during the certification process and ensuring that they are adequately covered in the operations of the application; and, second, by monitoring the in-service data as it is accumulating, finding issues at the earliest possible point, and ensuring that they are managed through Advisories, Directives, regulation, or other guidance.

Since its establishment, the program has led extensive studies on the in-service behavior of airframe structures and aircraft systems. The knowledge and information produced directly supported a wide range of FAA safety rulemaking including: the Aging Aircraft Safety Rule (AASR) 2005; the Widespread Fatigue Damage Rule (WFD) 2010, the Damage Tolerance Data for Repairs and Alterations rule under 14 CFR Part 26, 2007; Order 8110.104, Responsibilities and Requirements for Implementing Part 26 Safety Initiatives, 2007, as well as related guidance materials and advisory circulars.

Recent years have seen rapid evolution in every aspect of aircraft. Composites and new metallic alloys are being used extensively in primary structures. Large-scale integration techniques are being applied to combine the many diverse existing electronic systems - as well as entirely new systems driven by NextGen implementation into a few digital electrical systems. Hydraulic and other mechanical systems are being replaced by electro-mechanical and electro-hydraulic systems, which in turn require radical changes to the electrical power system. Finally, propulsion technology is rapidly evolving as manufacturers seek and incorporate new technologies to increase fuel efficiency. These developments present unprecedented challenges to the FAA's safety oversight role. In the past, the oversight of continued airworthiness has been balanced between efforts in the certification process and during the service life. The introduction of so many new technologies in a short period requires a proactive research program to ensure that the certification standards are updated or created as necessary in response to new designs.

Research conducted through this program is extraordinarily complex and multidisciplinary, as it spans every aspect of the aircraft (i.e., everything that becomes airborne) as well as the interactions between components. The research program anticipates and solves problems that require in-depth knowledge of every component of the aircraft and the compilation of in-service data of every safety critical system, subsystem, and component in the airframe, propulsion systems, and electronic and electromechanical systems. The program also supports the FAA's 1) role in reviewing operating and repair manuals as part of the certification process and 2) oversight of operational safety.

For FY 2019, aircraft safety-critical components (a focus of continued airworthiness) are grouped into aviation systems and structures described below:

- Aircraft Electrical Systems: To improve aircraft efficiency, reliability, and maintainability, the aerospace world has found that progressive electrification of on-board services reduces or removes the need of the hydraulic, mechanical and the bleed air/pneumatic systems. As technology advances, more electric aircraft architecture will offer advantages that cannot be ignored. Installation and reliability issues may be experienced due to the large volume of installed electronics. Fast progress in semiconductors and materials will result in power density and efficiency improvements in the future. Architectural solutions further improve overall aircraft performance, multiple use, energy-optimized aircraft coupled with high level of integration and interaction between systems will continue to grow exponentially. The output of this research will be used to develop and publish FAA regulations and guidance addressing safe certification of airplanes utilizing more electric aircraft concepts and technologies.

- Flight Controls and Mechanical Systems (FCMS*):* The small airplane directorate's number one safety goal is to reduce general aviation fatal accidents due to loss of control. FCMS research will address Integrated Flight Path Control to address General Aviation Joint Steering Committee/FAA General Safety Interventions that feeds the design and certification of an advanced flight path control system to enhance general aviation safety. Research will be conducted to address transfer of unmanned aircraft system (UAS) technologies for enhancement of general aviation.

- Rotorcraft Systems*:* Wires represent a significant hazard for low-flying helicopters. Collisions with unobserved wire obstacles can result in helicopter or wire damage, or even injuries or fatalities. Because wires are thin, long objects, they may be difficult to detect in various backgrounds. Even if wire obstacles are visible, the human eye has difficulty in gauging the distance and range, and could lead to incorrectly estimating the time available to avoid them. This research will investigate numerous ways to help mitigate wire strikes by providing the pilot with the location of wires near the rotorcraft so they can be avoided.

- Structural Integrity (SI): Many of the new metallic materials being introduced are much more process intensive than more traditional materials. Others are alloys, which are being tailored for specific structural applications. In either case a good understanding of their mechanical behavior and long-term durability is needed to provide the appropriate regulatory guidance and to properly update the Metallic Materials Properties Development and Standardization (MMPDS). SI research will address both air transport and small airplanes and will focus on emerging technologies such as damage tolerance and durability issues of new aluminum-lithium alloys, Additive Manufacturing (AM), and other "tailored" alloys and hybrid fiber metal laminates such as GLARE. Risk management methods will also be developed to support the Aircraft Certification Services Monitor Safety/Analyze Data initiative, which is a data-driven, risk-based continued operational safety decision-making process. SI research will focus on developing probabilistic tools required for risk assessment and risk management of aircraft structures. Additionally, research to characterize flight loads of aircraft operated according to Parts 91, 121 and 135 will be conducted to identify potential safety hazards.

Statutory Requirements:

Is this program statutorily mandated (Y/N): Yes

Research within Continued Airworthiness directly supports §44504 of the FAA Research Legislation, in U.S.C. Title 49, and Executive Order 13419—National Aeronautics Research and Development. Outcomes from research within Continued Airworthiness address these statuary requirements as described below:

Structural Integrity

- The *Damage Tolerance and Durability Issues for Emerging Technologies* research develops data to assess the risk of and prevent defects, failures, and malfunctions of new emerging metallic structures technologies (EMST) including additive manufacturing, metal-composite hybrids, and advanced alloys, repairs and construction methods for use in aircraft that could result in a catastrophic failure of an aircraft.

- The *Metal Additive Manufacturing (AM) for Aircraft, Engine, and Propeller Applications* research produces data that will assess the certification and continued airworthiness issues associated with AM that will ensure the safe operation of an aircraft over its' lifespan, prevent catastrophic failure due to defects or anomalies, and address the need for new inspection techniques.

- The *MMPDS Support and Decision Values for Emerging Materials* research develops data that supports performance based approaches to developing regulations and standards to ensure safety.

- The *Active Flutter Suppression* (AFS) research develops methodologies and analyzes information to predict the effects of aircraft AFS design in the life of the aircraft to prevent catastrophic failure of an aircraft AFS malfunction.

- The *Probabilistic Damage Tolerance Based Fleet Risk Management for Small Airplanes* research develops a technology, SMART, to analyze information to predict the effects of aircraft design, maintenance, and fatigue on the life of aircraft under different usages.

Rotorcraft Systems

- The *Wire Strike Avoidance* research develops data to assess the technical capabilities of several technologies that may mitigate wire strikes on rotorcraft including a novel mechanical wire cutter for part 27 rotorcraft, and sensor packages to detect wires and notify pilots for avoidance

Flight Control and Mechanical System

- The *Integrated Flight Path Control* research develops requirements and guidance for the certification of augmented flight path control (Fly-by-Wire) for Part 23 and Hybrid Vehicles that accommodates advances in sensors, processors and technology

- The *Transfer of UAS Technology for Enhancement of GA Safety* research transfers advanced flight path control technology from the UAS and experimental aircraft markets to immediately deal with a majority of GA fatalities

Program Alignment with Strategic Goals:

DOT Strategic Goal	DOT RD&T Critical Transportation Topic
Safety	**Promoting safety**

The Continued Airworthiness program supports initiatives in DOT/FAA Strategic guidelines published Feb. 2018:

- Safety: Reduce Transportation-Related Fatalities and Serious Injuries Across the Transportation System. Safety is the primary focus of this research.

The program provides systematic research and development within the FAA that will lead to (1) identification, assessment and mitigation of safety risks, (2) promotion of emerging technologies and industry advances that improve safety, and; (3) streamline certification processes, as described below:

<u>Structural Integrity</u>

- The *Damage Tolerance and Durability Issues for Emerging Technologies* research requirement supports both safety, innovation and accountability DOT Strategic Goals. This research fills knowledge gaps associated with the assessment of emerging metallic structures technologies (EMST) and will have a high impact in preventing and mitigating safety risk in the implementation of these new technologies in airplane products. Results will provide a better understanding of the key failure mechanisms and processes that can occur while in-service and allow these new EMST to be safely introduced to certified aircraft. In this proactive research, the FAA is collaborating with industry to ensure the fatigue, durability, and damage tolerance performance of new material systems is well understood prior to introduction into service through fracture mechanics test and analysis, and obtain /material system data, analytical tool validation data, etc. necessary to assess if new regulatory material is required. We will also support certification (including validation of advanced computational methods and analytical simulations) of new products and maintenance of legacy aircraft where new technologies are being implemented. Understanding these new technologies will yield streamlined EMST certification efforts and ensure continued airworthiness.

- The *MMPDS Support and Decision Values for Emerging Materials* research requirement supports safety, innovation and accountability DOT Strategic Goals. This project leverages FAA resources through government – industry consortia in the development of the Metallic Materials Properties Development and Standardization handbook, recognized worldwide as the premier source of metallic allowables. The expected result from this research is a consistent and uniform level of safety throughout the aviation industry through standardization efforts for acceptable design and certification compliance data and tools. This will enable the FAA to operate more efficiently. This research also fulfills commitments to

manage and develop metallic material and joint design standards on which aerospace industry depends through the coordination with NASA, DoD and Industry.

- The *Metal Additive Manufacturing (AM) for Aircraft, Engine, and Propeller Applications* research requirement supports both safety and innovation DOT Strategic Goals. The project will generate data that fills a fundamental knowledge gap and allows FAA regulators to proactively draft policy and guidance needed for the safe implementation of metal AM applications which currently has no in-service history. Results from this research will guide standardization of the technology which will help streamline industries certification efforts.

- The *Probabilistic Damage Tolerance Based Fleet Risk Management for Small Airplanes* supports three of the DOT Strategic Goals, Safety, Innovation, and Accountability. This program supports safety and innovation by providing a new technology, SMART software, which could be used to asses and manage the risk associated with fatigue failure of general aviation aircraft. Moreover, SMART software will be provided to ACO engineers to improve efficiency.

Rotorcraft Systems

- The *Wire Strike Avoidance* research supports safety DOT strategic goals. This research will help to decrease the general aviation fatal accident rate by incorporating the safety technology described above (wire detection and avoidance hardware, wire cutters, etc.). This research will also help remedy an item that is listed in the AVS Strategic Guidance (Low Altitude Operations category). Rotorcraft routinely operate at low level and are subject to the dangers there such as power lines, towers and short reaction times if they have an inflight emergency. This program does impact rural communities. Many of the rotorcraft wire strike accidents occur in rural areas which include agricultural and Helicopter Emergency Medical Services (HEMS) and any improvement of safety will impact rural communities.

Flight Control and Mechanical System

- *Integrated Flight Path Control to Address General Operations Joint Steering Committee (GAJSC)/FAA GA Safety Interventions* supports the DOT's Strategic Goal of safety and the DOT's RD&T Critical Transportations Topic of promoting safety by specifically addresses the Small Airplane Directorate's #1 safety goal to reduce GA fatal accidents due to loss of control.

- *Transfer of UAS Technology for Enhancement of GA Safety* supports the DOT's Strategic Goal of safety and the DOT's RD&T Critical Transportations Topic of promoting safety by transferring advanced flight path control technology from the UAS and experimental aircraft markets to immediately deal with a majority of GA fatalities, potentially eliminating 70% of GA accidents and 300+ fatalities per year.

Program Objectives:

The main goal of the Continued Airworthiness research program is FAA aviation safety oversight to ensure that aircraft maintain operational safety as they age. FAA research accomplishes this in two ways: by anticipating ageing issues during the certification process and ensuring that they are adequately covered in the operations of the application, and secondly, by monitoring the in-service

data as it is accumulating, finding issues at the earliest possible point, and ensuring that they are managed through Advisories, Directives, regulation, or other guidance. The research conducted under the Continued Airworthiness program is done in collaboration with industry and other government agencies to address FAA specific issues addressing new technology, materials and procedures while maintaining or increasing current safety levels. Industry research focus is typically on the development of new technologies that improve efficiency and reduce cost, while the FAA research is focused to provide data to ensuring safe implementation and certification of the those technologies. The program main sponsor is the regulatory community, which can be hindered by proprietary and intellectual property rights. Descriptions of the several research requirements associated with this central goal follows.

Electrical System

The *Fuel Cell Systems for Aircraft Applications* research requirement provides regulatory standards for, and technical expertise in, the use of fuel cells for power generation aboard civil aircraft. The *Rechargeable Lithium Batteries and Battery Systems for Aircraft Applications* research requirement will provide regulatory standards for, and technical expertise in, the use of Lithium battery systems aboard civil aircraft.

Flight Control and Mechanical System

The *Preventing Loss of Control in Part 23 by Safer Automation using Envelope Protection* research requirement will provide standards and performance requirements for automated systems that directly control flight path; promote the appropriate use of simple angle of attack (AOA) sensing equipment. This requirement will also provide policy, guidance, and information to the public to communicate the potential benefit of using low-cost sensed and derived angle of attack systems to increase low speed awareness and stall protection; and provides significant reduction of Controlled Flight into Terrain and Loss of Control accidents in GA.

The *Tire Failure Characteristics* research requirement will provide tire failure and burst models used by industry and authorities to support improved application of safety standards.

Integrated Flight Path Control to Address GAJSC/FAA GA Safety Interventions. The FAA is performing research to develop requirements and guidance for the certification of augmented flight path control for Part 23 and Hybrid Vehicles that accommodates advances in sensors, processors and technology. This research will help the FAA identify design and certification requirements for flight path control autopilot technology in GA, and will initially promote the design and certification of fielded systems through articles, policy, public venues, etc. We will subsequently promote fully integrated flight path control through properly assured automation technology. The research will focus on specific design and architectural mitigations that provide an acceptable level of safety for flight critical systems with non-traditional design assurances. These include the use of formal methods for certification, demonstrating system utility and feasibility. The outcome will be design and certification requirements for a flight path control autopilots for light GA purposes. The resulting papers, reports, and technical guidance can be used by the FAA and industry to design systems, create industry standards, and field new designs similar to those already fielded in complex UAVs that refuse to crash, and in fly-by-wire aircraft.

Transfer of UAS Technology for Enhancement of GA Safety will demonstrate device integration on manned aircraft, validate the intended safety function is met, and develop streamlined certification compliance requirements. This research will result in publishing at least one advisory circular and share results with ASTM and other industry group for incorporation into industry standards. Current regulations, system safety policy, and certification processes are deficient in their ability to address advanced flight path control technologies even though it has been proven they can provide for safer control of a vehicle's flight path than the pilot can accomplish alone. This level of flight path control is not currently covered in autopilot guidance for existing fixed wing and rotary wing aircraft for compliance to 23.1329, 23.1309, and other regulations, yet is widely used in other aircraft markets

Rotorcraft Systems

The *Wire Strike Avoidance* research requirement provides data that will diminish wire strikes and fatalities by implementing procedures and/or improving the certification basis for new helicopters and/or revealing new technology to alert pilots to the proximity of wires. Implementation is planned through the publication of guidance materials to promote mitigation of risk of wire strikes, to include the use of electronics to detect wires and physical wire cutting technology for low weight rotorcraft. Wire Strike Avoidance is primarily a part 27 helicopter problem and the current rules/regulations are inadequate for these aircraft. Part 27 aircraft are smaller operators focus on cost and any rules are weighed heavily against weight and cost. This research program will provide data for proper certification development and provide public data for any operator/rotorcraft OEM to consider.

Structural Integrity

The *Continued Airworthiness of Composite Structures* research requirement will provide technical data to support the revision of Advisory Circular (AC) 65-33.

The *Active Flutter Suppression* (AFS) research aims at correcting the inadequacy of current regulations with regard to AFS systems. Currently, an Airworthiness Directive (AD) was issued for an AFS system which was certified under special conditions. This research will provide the data and methodology required for the FAA to update the regulations to allow for safe integration of these systems. Since the research will be used for preparation of regulation and guidance material, this research is required to be performed by the FAA and not the industry.

The *MMPDS Support and Decision Values for Emerging Materials* research requirement will promote uniform level of safety in developing and maintaining safety standards; standardize acceptable design and certification compliance data and tools; fulfill commitments to manage and develop metallic material and joint design standards; and seek coordination with NASA, DoD and Industry to develop acceptable material allowables. Government role is to provide oversight and guidance to industry to ensure appropriate output of data.

The *Damage Tolerance and Durability Issues for Emerging Technologies* research is being conducted to provide an independent assessment of technologies industry is developing in regards to safety regulations and standards. The program generates data needed to address gaps in regulations and guidance that only the FAA can address. The FAA is leveraging resources with industry through cost-share arrangements to obtain required data.

The *Metal Additive Manufacturing (AM) for Aircraft, Engine, and Propeller Applications* research addresses industry standardization needs and is providing data required by regulators to create new policy and guidance to show compliance to existing regulations. This research includes industry participation through consortia and cost-share arrangements and features tasks tailored to FAA-specific needs.

The *Probabilistic Damage Tolerance Based Fleet Risk Management for Small Airplanes* research develops the SMART software providing the FAA with a probabilistic tool to estimate the structural fatigue failure risk for a fleet of aircraft, and will improve fatigue evaluations and risk analysis and risk management for in-service findings in general aviation fleet when the software is completed. It will be used by the FAA to revise Airworthiness Directives and for certification purposes. The majority of General Aviation (GA) users are private users or small operators who do not have the resources for developing such tools. Moreover, the OEMs have their own proprietary software (not probabilistic tools) that are not available to the FAA engineers, small operators or private users. Therefore, there is a need for the FAA to develop this software.

Economic Impact of Regulatory Reform:

The Continued Airworthiness research program conducts research to fulfill knowledge gaps associated with certification and continued airworthiness emerging technologies and will have a high impact in preventing and mitigating safety risk in their implementation in airplane products. Results will provide a better understanding of the key failure mechanisms and processes that can occur while in-service and allow these new technologies to be safely introduced to certified aircraft. In this proactive research, the FAA is collaborating with industry to understand these new technologies to help streamline certification efforts and to ensure their continued airworthiness.

Much of the work of the SIM program is performed in cooperation with industry under cost-share agreements. These programs focus on emerging manufacturing and repair techniques and materials being adopted because they are a benefit to industry. While FAA's primary goal is to ensure that these improvements are adopted safely, industry invests in FAA's research because it also ensures that certification can proceed in a timely fashion and that unnecessary regulations are not written and that certification requirements are appropriate and not overly restrictive.

Performance-Based Regulations and Safety:

Since its establishment, the Continued Airworthiness program has led extensive studies on the in-service behavior of airframe structures and aircraft systems. The knowledge and information produced have directly supported a wide range of FAA performance-based regulations and safety activities including: the Aging Aircraft Safety Rule (AASR) 2005, the Widespread Fatigue Damage Rule (WFD) 2010, the Damage Tolerance Data for Repairs and Alterations rule under 14 CFR Part 26, 2007; the Enhanced Airworthiness Program for Airplane Systems/Fuel Tank Safety (EAPAS/FTS) Rule, 2007, as well as related guidance materials. Efforts to support future performance-based regulations and guidance will continue.

Research Collaboration Partners:

The main source of public and stakeholder input is from Technical Community Representative Groups (TCRG). TCRG members routinely participate in both FAA and industry activities, such as

Aviation Rulemaking Advisory Committees (ARAC), Commercial Aviation Safety Team (CAST), SAE, RTCA and other aerospace standard organizations. Through these venues, the members gather input from those most affected by the research and present ongoing programs

Public stakeholder input is primarily received through the congressionally mandated Research, Engineering, and Development Advisory Committee (REDAC). The REDAC is an advisory committee to the FAA whose members are FAA stakeholders including industry, Federally Funded Research and Development Centers (FFRDCs), and academia. The REDAC provides advice and recommendations to the FAA Administrator on the needs, objectives, plans, approaches, content, and accomplishments of aviation research program. The committee reviews and comments on the aviation research programs including Centers of Excellence and other grants. The REDAC considers aviation research needs in five areas; (a) NAS operations, (b) airport technology, (c) aviation safety, (d) human factors, and (e) environment and energy. The REDAC holds 2 full committee meetings and 10 subcommittee meetings annually from which come reports documenting REDAC's input known as REDAC Findings and Recommendations (F&Rs.) The research programs evaluate REDAC findings and recommendations, and the FAA responds with adjudications and where appropriate, action plans commensurate with the recommendations. The FAA Research Portfolio Division and the research performers track all F&R and associated Agency responses.

We participate in various inter agency groups that include NASA, DoD, Coast Guard. The benefit is leveraging and collaborating (when possible) to provide our sponsor and the aviation community the best research products.

We also team with OEMs and Tier one manufactures such as Boeing, Bombardier, Bell, Sikorsky, AirBus, Gulf Stream, Dassault, Embraer Honeywell, Teledyne, Astronics, Ametek GE and various others through direct contracts, cooperative research and development agreements (CRDA) or through working groups in standards development organizations (SDO).

Collaborative research with industry includes:

<u>Structural Integrity</u>

- The *Damage Tolerance and Durability Issues for Emerging Technologies* research is being conducted in close collaboration with industry through cooperative research and development agreements (CRDA). These cost-share agreements leverage resources to address areas of mutual interest that benefit all partners which include cost savings, utilization and sharing of available facilities, and expansion of general knowledge base. For each project, roles, responsibilities and tasking are identified, and schedule of milestones and deliverables are monitored to track performance. Current cost-share projects include:

- Partnership with Bombardier, Arconic (formerly ALCOA), Constellium and Embraer, to assess emerging metallic structures technology (EMST) through testing and analysis of advanced fuselage configuration using the FAA's Full-Scale Aircraft Structural Test Evaluation and Research (FASTER) Lab. Industry contributions include material and fuselage panels for testing, engineering time for analysis, and provide supporting data.

- Partnership with Boeing, use the FAA's in-house Airframe Beam Structure Test (ABST) facility to assess bonded repair technology to composite panels representative of transport aircraft wings. Boeing contributions include funds to support in-house FAA staff, material and composite wing panels for testing, installation of repairs to test articles, engineering time for analysis, and testing equipment.

- Partnership with Bombardier and Constellium to characterize the durability and damage tolerance performance of advanced aluminum-lithium alloys. Industry contributions include material and panels for testing and engineering time for analysis.

- The *Metal Additive Manufacturing (AM) for Aircraft, Engine, and Propeller Applications* research leverages resources with industry and academia to address certification and flight standards regulatory gaps associated with the large variability in metal additive manufacturing (AM), including:

    - Kansas Aviation Research & Technology (KART): Led by Wichita State University's National Institute for Aviation Research (NIAR) and includes Airbus, Textron Aviation, Spirit AeroSystems, and Bombardier. This Consortium provides the FAA a 4:1 multiplier on funds contributed.

    - Carnegie Mellon University's NextManufacturing Consortium: 20 active participants giving the FAA access to millions of dollars of research for a small annual fee.

    - AmericaMakes: 198 members giving the FAA access to more than $100 million worth of public and private research activities.

- The *MMPDS Support and Design Values for Emerging Materials* project leverages FAA resources and funding through government – industry consortia in the development of the Metallic Materials Properties Development and Standardization (MMPDS) handbook, recognized worldwide as the premier source of metallic allowables. Government Steering Group include FAA, NASA, and DoD.. Industry Steering Group consists of 35 companies representing the major material suppliers and users (manufacturers of aircraft/aerospace vehicles) worldwide.

- The *Active Flutter Suppression* (AFS) research is conducted in collaboration with academia, mainly, the University of Washington, which provides us with access to graduate-level student and faculties expertise. The research plan for this activity was prepared after a state-of-the-industry survey, which included direct inputs from representatives from Lockheed-Martin, NASA Armstrong Flight Test Center, NASA Langley Research Center, and United States Air Force Research Laboratory.

- The *Probabilistic Damage Tolerance Based Fleet Risk Management for Small Airplanes* research is conducted under a partnership with University of Texas at San Antonio, St. Mary's University and Textron Aviation. This has provided the FAA with academic and OEM expertise. Industry OEM partner is directly involved in development and validation of this tool.

<u>Rotorcraft Systems</u>

- The *Wire Strike Avoidance* research prime stakeholder is the rotorcraft directorate and along with the industry partners under contract to the FAA, will benefit from this research. Industry partners include the Center of Excellence Partnership to Enhance General Aviation Safety, Accessibility and Sustainability (PEGASAS) which include the following schools: Purdue University, Georgia Institute of Technology, Iowa State University and Florida Institute of Technology. PEGASAS was leveraged based on the past experience with rotorcraft research at Georgia Institute of Technology and the sensor development at Iowa State. This experience will provide a more cost effective program with a reduced technical risk.

Do non-government groups partner with this program?

Yes. See description of collaborative research project above.

Acquisition/Assistance:

FAA programs in the research portfolio employ competitive contracting vehicle types and grants to acquire Conduct, Research, and Development activities. The FAA's acquisition management system offers researchers omnibus contract vehicles such as the SE2020, SE2025, and eFAST BPAs in which vendors competitively compete for TOs and BPA calls. The Broad Agency Announcement is another competitive process the FAA utilizes for awarding basic research contracts. Grants are used to execute a portion of the FAA's research budget and where the FAA has the statutory authority to issue grants pursuant to the Aviation Research Grants Program. The FAA's Centers of Excellence (COE) is one example of a grant-based program that uses competition to select from among members of academia for COE participation. In the specific case of the COE grant program, it receives matching funds from industry sponsors.

In general, the FAA Research Portfolio includes Research Programs that use multi-year acquisitions.

Technology Transfer (T2):

Technology transfer of research results to practitioners of the aerospace engineering community worldwide occur on an annual basis at international industry forums including International Committee on Aeronautical Fatigue, Aircraft Airworthiness & Sustainment Conferences, International Conference on Fatigue, and the American Institute of Aeronautics and Astronautics. In addition, research results are published in peer review journals, industry conference proceedings, and as FAA Final Reports available to the public via the FAA WJHTC Library Website, Updates of research results are provided to FAA sponsor organizations and practitioners on a quarterly basis each year. FAA-TC labs are used to generate data in this research in an efficient and cost-effective manner.

<u>Rotorcraft Systems - Wire Strike Avoidance</u>

There is a research task to develop a mechanical wire strike device capable of being used on Part 27 rotorcraft. The design will be prototyped and tested to test its capabilities to work in the Part 27 environment. The FAA program will own the design but will most likely allow the institute that designed it to license it and find a path of tech transfer to a production capability if the test results indicate it is a viable option.

Most structural work done under Structural Integrity Metallic is performed with industry partners and cost sharing. Results are shared with partners in real time, with both parties receiving them as they come available. In addition, all personnel are involved in publishing research reports to share all data with the widest possible audience, making the complete raw data set available upon request. The FAA works actively with industry to publish its results in a wide variety of publicly available forums such as ASTM and other specifications and the Metallic Materials Properties Development and Standardization (MMPDS) database. Finally, and perhaps most importantly, the data produced by the Structural Integrity of Metals Program is used by the research sponsors to create guidance, directives, and other written instruments. This shares not only the knowledge gained, but also the implementation strategies, improving both aviation safety and regulatory efficiency.

The research in the Flight Controls and Mechanical Systems (FCMS) Program typically aims to enhance flight safety by developing new technology and ensuring the continued safe operation of flight controls and mechanical systems to address safety issues unique to the FAA's oversight capabilities and systematic safety issues across industry through providing necessary technical data to the FAA's Office of Aviation Safety (AVS) to prepare meaningful advisory and guidance material for use by industry. For those projects that address safety issues unique to the FAA's oversight capabilities, technology transfer is internal to the FAA. For those projects that address systematic safety issues across industry, technology transfer is executed through publication of advisory and guidance material by the Office of Aviation Safety. Technical publications documenting research results are available to the public at:

- https://www.faa.gov/about/office_org/headquarters_offices/ang/offices/tc/library.

A specific example of technology transfer in this area is the flight control automated interventions research project. Findings and recommendations may be used by AVS to publish new guidance and streamlined certification methodologies that will encourage applicants to take advantage of automated intervention technology such as envelope protection, structural envelope protection, automatic resolutions to ground proximity warning systems and be a significant step in developing refused to crash technology. For example, 14 CFR 25.207 – Code of Federal Regulations (CFR) requires a stall warning. Yet there have been recent accidents where pilots, contrary to training, ignored stall warning (AA587, Air Algiers, Air Asia). If the airplanes had been designed to prevent stall departure these accidents might have been prevented. Depending on the research results, this information will be presented at international conferences and will support standards initiatives and incentives to incorporate automated safety intervention technologies into transport category airplanes. Increased use of automated interventions such as envelope protection, auto Traffic Collision Avoidance System (TCAS) and Enhanced Ground Proximity Warning System (EPGWS) or others will be measured by a decrease in the transport accident rate.

Evaluation / Performance Measurement:

The Provider Research Execution Plan (PREP) identifies requirement-specific research activities with a schedule of milestones, deliverables, and anticipated spend plan.

Metrics for each program are defined and agreed to by the sponsor of the research (typically the designated safety professional in the FAA Aviation Safety Office) and provided and used to monitor the program progress in regular program management reviews and status meetings.

In addition, the research and the outcome are externally reported to the REDAC subcommittee on Aircraft Safety (SAS). The progress is internally reported in multiple ways, i.e., Significant Activity Reports, Quarterly Internal Reviews, Executive Quarterly Status Reports, SIM-TCRG RE&D Plan, SIM-TCRG Accomplishments, and Annual Division-level Review.

Through the requirements development process in the Technical Community Representative Group (TCRG) all strategic guidance and industry trends are analyzed and incorporated into the requirements process. The associated benefits to the FAA and flying public are evaluated during this process.

These metrics are a part of the initial requirement selection and incorporated into the Performer Research Execution Plans (PREPs) in accordance with NextGen Office (ANG) processes, with cost, performance, and schedule data as requested by the Sponsor.

As stated above, the Provider Research Execution Plan (PREP) identifies requirement-specific research activities with a schedule of milestones, deliverables, and anticipated spend plan, which is later baselined and tracked using standard program management techniques. More specifically, the requirement-specific research activities are structured in several phases and monitored using monthly reporting. Each phase will have a structured goal which must be met and have Sponsor concurrence before moving on to the next phase.

The FAA Research Portfolio Management Division tracks, evaluates, and reports on FAA conducted research in several ways, including the National Aviation Research Plan (NARP), the Annual Review (AR), Annual Modal Plan Report (AMRP), and the Technology Transfer Annual Congressional Report. The NARP presents over 200-research project planned outcomes for 36 separate and independent programs. The Annual Review reports on significant research accomplishments tracked in any given year, and provides status on research projects previously identified in the NARP. The quality of the research work and performance associated with the research is often further captured in journals, reports, and articles. The Technology Transfer Congressional Report is the vehicle used to report tracked tech transfer performance metrics including the number and status of Cooperative Research and Development Agreements, Invention Disclosures, Patent submittals, License Agreements, COE grant awards, and associated funding. These externally reported programs, when considered together, apply to DOT Strategic Plan Safety, Innovation, Infrastructure, and Accountability goals, and most of the nine associated objectives. Programs perform internal tracking and assessment using the classical project management practices of tracking stakeholders, requirements, risks, costs, and schedule, to ensure objectives are met, and cost and schedule are not compromised.

The Continued Airworthiness research program meets the DOT Strategic Safety Performance Goal of reducing aviation related fatalities by supporting FAA aviation safety oversight responsibility to ensure aircraft are safely certified and maintained throughout their operational service life. The FAA accomplishes this in two ways: first is by anticipating ageing issues during the certification process and ensuring that they are adequately covered in the operations of the application; and, second, by monitoring the in-service data as it is accumulating, finding issues at the earliest possible point, and ensuring that they are managed through Advisories, Directives, regulation, or other guidance.

One of the greatest sources of fatalities in aviation is small airplanes. This is due in large part to the age of the fleet, with average of approximately 30 years. Management and maintenance of such

aircraft is often a delicate balance of safety and economy, with too many operators delaying costly inspections and repairs. Tools are needed to better track risk and target problem areas, allowing the most effective use of limited resources. The Probabilistic Risk Management program does just that. It has created and is improving a software tool to predict risk of failure and the impact of different repairs and modifications to minimize the risk of failure and accidents.

Other Structural Integrity of Metals (SIM) programs are focused on anticipating issues that might arise before they result in fatalities. As new structural materials and manufacturing techniques are deployed, the certification process seeks to anticipate and eliminate any potentially fatal aging issues. However, due to the enormous complexity of aviation structures and the operating environment, unforeseen issues inevitably arise. Other programs under this BLI focus on ensuring that as few unforeseen issues occur as possible and mitigating those that do before they result in accidents.

Propulsion and Fuel Systems
Funding Request ($4,000,000)

Program Description/Activities:

The FAA establishes rules for the certification and operation of aircraft engines, fuels, and fuel management systems that enhance the airworthiness, reliability, and performance of aircraft propulsion and fuel systems. The Propulsion and Fuel Systems Program conducts research on advanced damage-tolerance and risk assessment methods that provide the Office of Aviation Safety (AVS) with the basis for new or revised engine certification and continued airworthiness standards. This research also supports FAA actions in response to National Transportation Safety Board recommendations and supports preparation of Advisory Circulars that provide industry with technical information on acceptable means of compliance with regulations. Benefits will accrue in the form of a reduced risk of engine failures and fewer accidents, which in turn will lead to fewer injuries and fatalities.

In FY 2019, the three previous FY 2018 Budget Lines A11.b, A11.f, and A11.m are merged into A11.b. Research areas targeted are Aircraft Turbine Engines, Catastrophic Engine Failure, and Alternative Fuels for General Aviation.

Aircraft Turbine Engines:

In FY 2019, due to the limited available budget, research within the Propulsion and Fuel Systems Program will not be conducted as planned. The final two Advisory Circulars and the corresponding enhancement to the 'DARWIN' software program needed to support Title 14 Code of Federal Regulations part 33.70 –one on damage tolerance of lathe turned surfaces and one on nickel anomalies will not be completed. Failure to complete these AC's will leave industry without FAA guidance on a publicly acceptable means to certify designs with these features, and therefore, an increased risk of failure.

The lack of additional funds will furthermore prevent R&D funding of this program to address the recent National Transportation Safety Board (NTSB) recommendations pertaining to the uncontained engine failure of American Airlines Flight 383 in Chicago. Two of these recommendations are for the FAA to lead a research program to develop improved inspection methods to detect anomalies in nickel billet and in-service inspections for cracks in nickel rotors.

Catastrophic Engine Failure:

This research addresses the overlap between aircraft certification (Part 25) and engine certification (Part 33), known as engine installation. The program leverages the industry and DoD investment in computing capability and promises to provide the opportunity to improve the accuracy of failure analysis for the rare but hazardous uncontained engine failure impact events. Develop predictive analysis methods for assessing engine fragment impact into engine and fuselage materials to determine the containment and shielding capabilities of each for safety assessments and certification by analysis. This will improve safety and reduce the cost of producing new engine and aircraft designs. The work is developing metal and composite material models that can predict multiple failure modes from a single input deck, which is an industry first. All previous material models were

tuned to a failure condition identified posttest. Anisotropic composite materials are the current focal area of interest in impact analysis.

The research also is responding to multiple safety recommendations from uncontained engine failure events. The Qantas A380 Australian Transportation Safety Board Recommendation is "The Australian Transport Safety Bureau recommends that the US Federal Aviation Administration, in cooperation with the European Aviation Safety Agency, review the damage sustained by Airbus A380-842, VH-OQA following the uncontained engine rotor failure over Batam Island, Indonesia, to incorporate any lessons learned from this accident into the advisory material. (ATSB A0-2010-089-SR-040)". The Chicago O'Hare 767 uncontained engine failure and resultant fire prompted the National Transportation Safety Board to recommend A-18-005: "Revise Advisory Circular (AC) 20-128A, "Design Considerations for Minimizing Hazards Caused by Uncontained Turbine Engine and Auxiliary Power Unit Rotor Failure," based on an analysis of uncontained engine failure data since the time that the AC was issued, to minimize hazards to an airplane and its occupants if an uncontained engine failure were to occur. The revised AC should include modifications to the accepted design precautions for fuel tanks given the fires that have occurred after uncontained engine failures.

Today, certification of fan blade off to 33.94 requires engine manufacturers to run a test that can cost upwards of $20 million. Predictive analysis will improve the design capability - allowing for a more thorough evaluation that improves safety of aircraft - and significantly reduce the cost of certification. The safety benefits from this research are a reduction in the number of accidents related to engine failures, and mitigation of fatalities and injuries if an accident occurs. The challenge of new emerging designs like the Open Rotor Engine are also addressed.

Future work at external organizations like DoD and Universities will be placed in moratorium due to the cancelation of the BLI and reduced funding available in A11.B. FAA Experts will continue to support the user community for 'LSDYNA' Aerospace Working Group and the Uncontained Engine Debris Damage Assessment Model (UEDDAM).

Alternative Fuels for General Aviation:

In FY 2019, contractual funding was not planned for this program. To date, more than $30 MM dollars have been spent on the Piston Aviation Fuels Initiative (PAFI) program and testing with in-house personnel will conclude in FY 2020. The FAA General Aviation Fuels funding requested in this program is necessary to address the recommendations of the 2012 Unleaded Aviation Gasoline Transition Advisory Rulemaking Committee final report, to provide the necessary support to the PAFI, and to comply with section 910 of the 2012 FAA Modernization and Reform Act. The primary focus of the alternative fuels for General Aviation (GA) program is to support PAFI and provide data to support the fleet wide authorization of unleaded aviation fuels to replace the current leaded aviation gasoline, 100 low-lead (100LL). Approximately 167,000 GA aircraft in the U.S. and 230,000 worldwide rely on 100LL Aviation Gasoline (avgas) for safe operation. 100LL is also the only remaining transportation fuel in the U.S. that contains the additive Tetraethyl Lead (TEL). There is only one remaining manufacturer of TEL worldwide remaining, and it creates the very high octane levels required to prevent detonation damage (engine knock) in high power aircraft engines. Previous research attempted to find an unleaded replacement fuel with no impact to the existing fleet. No such fuel solution was found. Due to the significant changes to the fuel composition that are necessary to minimize the impact to the general aviation fleet, all aspects of the entire general

aviation industry, from fuel production to aircraft use and maintenance, will be impacted. This impact includes fuel production, fuel distribution and handling, fuel storage, fuel aircraft performance, fuel engine performance, fuel system materials compatibility, user handling and operations, fuel airport operations, and GA economics. This program provides testing and evaluation on representative engine and aircraft and is the proving ground for the feasibility of the use of unleaded replacement aviation gasoline fuels in aircraft and engines that minimizes the impact to the fleet.

General aviation is a significant and integral part of the U.S. economy creating millions of jobs and making a positive impact on the U.S. balance of trade. Directly or indirectly, GA accounted for over 1.1 million high-skill, high-wage jobs in professional services and manufacturing in 2015 and contributed over $219 billion to the U.S. economy. This industry segment is at risk unless the GA fleet transitions to safe unleaded fuels.

Statutory Requirements:

Is this program statutorily mandated (Y/N): Yes

This work supports §44504 of the FAA Research Legislation, in U.S.C. Title 49, and aligns with the safety initiatives in DOT/FAA Strategic guidelines published Feb. 2018.

Aircraft Turbine Engines: This research specifically supports regulation 14 CFR 33.70, which prescribes new requirements for turbine engine life-limited parts. In addition, advisory circulars and publicly accessible software (DARWIN) are being developed by this research that provide an acceptable means for which industry can safely comply with the new regulation. The research to provide safety regulatory guidance as well as inspection and certification methods are both inherently governmental functions. This research has been conducted collaboratively with multiple stakeholders including the Aerospace Industries Association (AIA) and all US turbine engine manufacturers.

Catastrophic Engine Failure: This research supports regulation 14CFR 25.903 which prescribes details for minimizing the hazard of uncontained engine failures to the aircraft. It also supports ANE Policy 33.94 which is used to handle request for use of certification by analysis in place of required full scale engine testing in 14 CFR 33.94. FAA developed predictive models, model validation and user guidance under the LSDYNA Aerospace Working group documents the current state of the art. The research to provide safety regulatory guidance and standardized certification methods are inherently governmental functions.

Alternative Fuels for General Aviation: The general aviation fuels work supports regulations 14 CFR parts 23, 25, and 33, the recommendations of the Unleaded Aviation Transition Aviation Rulemaking Committee final report, and the Piston Aviation Fuels Initiative.

Program Alignment with Strategic Goals:

DOT Strategic Goal	DOT RD&T Critical Transportation Topic
Safety	**Promoting safety**

This program supports the DOT's Strategic Goal of safety by providing systematic research and development within the FAA that will lead to the identification, assessment and mitigation of safety risks. By providing the research necessary to generate data, this data is then used to create and develop new safety standards and new aviation fuels that will be adopted throughout the aviation community.

The turbine research program does not have any special impact on rural communities.

Improving Mobility for underserved communities

With over 5,000 airports across the United States, General Aviation contributes over $219 billion to the U.S. economy. In certain remote communities, such as those in Alaska and rural Maine, there is considerable dependence on general aviation for the transport of goods, postal service mail, and emergency medical services. Impacts of this program affect the vast majority of these airports, which are in suburban and rural areas. In these areas, GA operations include everything from providing basic access, as in Alaska where there are over 150 communities whose only means of access is air travel, to the agricultural aviation industry, which treats 71 million acres of cropland. General Aviation is a critical segment of the aviation industry supporting police and firefighting activities as well as other critical missions.

General Aviation is a particularly critical resource in rural and remote parts of the nation where surface transportation is limited or non-existent. In the State of Alaska for example, General Aviation is often the only means of transporting food, clothing, fuel, and all other forms of life sustaining supplies throughout the state. The Alaska Department of Transportation Aviation Division estimated that in 2007 aviation contributed $3.5 billion directly and indirectly to the state economy and supported 47,000 jobs. This accounts for 8 percent of state GDP and 10 percent of average employment, making aviation the 5th largest employer in the state. General Aviation makes up by far the vast majority of aviation activity in the State of Alaska. While Alaska is the most extreme example of dependence on General Aviation, other rural and remote areas of the country in the other 49 states also depend heavily on General Aviation for their transportation and supply needs.

Program Objectives:

Three main goals exist for this program in the areas of aircraft turbine integrity, catastrophic engine failure, and general aviation alternative fuels. The challenges addressed in aircraft turbine integrity include engine failures associated with turbine engine rotors containing undetected material anomalies, and better nondestructive testing methods to characterize rotor material conditions that can compromise its integrity. The problems addressed in Catastrophic Engine Failure includes the proposed open-rotor engine concept; the need for more robust and accurate non-destructive analytical methods and predictive tools to assess safety risks to the aircraft to minimize or replace non-destructive tests; and the move away from the traditional aluminum and into composite aircraft structures. In the area of GA Alternative gasolines in the current GA infrastructure and aircraft, while maintaining the current level of safety is the central problem addressed.

<u>Aircraft Turbine Engines:</u>

All gas turbine engines used in commercial aviation rely on high quality "rotor-grade" super alloys such as nickel and titanium to withstand extreme operational stresses and temperatures. Critical

high-energy rotating parts, such as fan, compressor, and turbine rotors must be carefully manufactured and serviced to avoid the introduction of anomalies and defects that could grow under stress and result in an uncontained engine failure such as those exhibited by the Sioux City and Pensacola accidents. Resulting from these accidents, the FAA and the AIA formed the Rotor Integrity Steering Committee (RISC), which called for a change to how critical life limits should be determined. This change proposed that the engine industry switch from a safe-life approach to one augmented with a probabilistic design methodology to account for extremely rare anomalies. This revolutionary change resulted in the FAA issuing rule 33.70. In order for the FAA to ensure that the industry would be able to comply with the new rule, a series of FAA advisory circulars and a public domain probabilistic software code were planned to be developed. Both of these initiatives required significant research and development best undertaken jointly by an industry and government team working in collaboration. An additional avenue to prevent uncontained engine failures is to develop improved nondestructive inspection methods to detect cracks and anomalies prior to fracture. Again, this research, which has industry wide safety implications, is best pursued through a government and industry collaboration.

Catastrophic Engine Failure:

Industry and government engineers need publicly available tools to standardize the analysis of engine and aircraft for rotor burst and fan blade containment. An increasing number of engine and aircraft projects are relying on proprietary analysis tools to show compliance, complicating the FAA task of making compliance findings and allowing a potential variation in the standard of safety.

Uncontained engine failure poses a risk to flight critical systems and passengers during commercial travel. Federal Aviation Regulation (FARr) 25.903 (d) 1 requires that OEM's minimize the threat to uncontained engine failure. After the Sioux City event, the FAA and industry worked on a two-phase effort to provide guidance for uncontained engine failures. The first phase produced AC20-128A in 1997. The second phase was to provide a means of compliance for the multiple fragment threat from small fragments. This phase was not completed as the work was placed in moratorium in 2003. The above cited NTSB recommendations and report highlight the current deficiencies in the regulations. At current funding levels, the FAA DoD dual use technology effort will be placed on hold.

To minimize uncontained engine failure, the FAA requires that any single blade in a turbine engine that fails must be contained within the engine containment structure in 33.94. A full-scale test is required to prove that, in the worst case stage of the engine, typically the fan successfully contains a blade off event. ~~The~~ Single test can cost upwards of 20 million dollars for industry to perform, which results in destruction of a full scale engine. Research to advance certification by analysis has been pursued by the FAA, NASA, industry and academia through the LSDYNA Aerospace Working Group. Significant progress has been made in testing development and material model development to advance the state of the art in predicative material models. The unique teaming of FAA, NASA and multiple universities all sharing information in bi weekly of monthly meeting has resulted in 4 new predictive material models being added to LSDYNA. Significant verification and validation work is still needed to improve the models and populate the failure surfaces well enough to demonstrate truly predictive modeling that is needed for certification by analysis. Research results are coordinated with industry during working group meetings. At current funding levels, all university research will be terminated.

Alternative Fuels for General Aviation:

Market forces have not supported the development of and transition to a replacement unleaded aviation gasoline (AVGAS). This is expected considering that no unleaded fuel to date has been able to match the characteristics of 100LL in performance and handling and thus compete naturally in the market. Couple this with the many challenges and business risks, including the relatively small size of the market, diminishing demand, certification challenges, specialized nature of AVGAS and liability issues, impact on entire general aviation industry from introduction of novel fuel compositions, and it becomes apparent that the market alone cannot drive this change. Recognizing that an unleaded AVGAS will not be a drop-in replacement for 100LL, there is going to be some adverse impact upon the existing fleet and GA fuel infrastructure.

Since the 1970's, 100LL has been the primary fuel used in General Aviation piston aircraft. There is only one remaining manufacturing plant of tetraethyl lead, the main octane component of 100LL. The industry and market have developed in a way that not only relies on this fuel, but has evolved in a way that has maximized the value and efficiencies of the production, distribution, and performance of aviation fuel and engines that operate on this fuel. This is because market forces strongly support 100LL as the best aviation gasoline in terms of performance and cost. The pressures to replace 100LL are not market driven but are extraneous to the markets. Current pressures include the threats of legal action at the state level, and EPA consideration of potential regulatory actions at the Federal level driven by the Clean Air Act.

The current situation surrounding AVGAS has generated uncertainty and concern among piston aircraft owners and operators regarding (a) the future utility and value of their current assets, (b) the availability and price of aviation gasoline to maintain viable operations and (c) the uncertainty of justifying new aircraft purchases. With the average age of the current fleet being more than 40 years and the fleet size being more than 200 times larger than annual new production, sales of new aircraft stagnating and the resulting overall economic condition of the industry deteriorating, a sense of urgency has evolved regarding the development and deployment of an unleaded AVGAS.

Economic Impact of Regulatory Reform:

In FY19, the Propulsion and Fuels BLI will produce data and a version of the DARWIN engine life prediction design code that provides the basis for a new Advisory Circular dealing with how to design and life fan blade attachment slots in engine disks. This AC provides an acceptable means to comply with regulation 14CFR 33.70 regarding critical life limited engine parts. Research also supports regulation 14CFR 25.903 which prescribes details for minimizing the hazard of uncontained engine failures to the aircraft. It also supports ANE Policy 33.94 which is used to handle request for use of certification by analysis in place of required full scale engine testing in 14 CFR 33.94.

General aviation is a significant and integral part of the U.S. economy creating millions of jobs and making a positive impact on the U.S. balance of trade. Directly or indirectly, GA accounted for over 1.1 million high-skill, high-wage jobs in professional services and manufacturing in 2015 and contributed over $219 billion to the U.S. economy. This industry segment is at risk unless the GA fleet transitions to safe unleaded fuels.

Research Collaboration Partners:

Aircraft Turbine Engines: In addition to the REDAC, FAA researchers work extensively with the major turbine engine manufacturers who comprise the Aerospace Industries Association (AIA), Rotor Integrity Steering Committee (RISC) and the Rotor Manufacturing (RoMan) team. Both groups consist of stakeholders who annually review and guide the development of the Advisory Circulars that support 33.70 and who provide beta-site testing of the DARWIN software code.

Catastrophic Engine Failure: This work is responsive the NTSB recommendations and works with industry through the LSDYNA Aerospace Working group. Research products are shared with industry through an internal version of the Aerospace Working Group website and completed work is made public through the FAA Technical Center library and the working group website

Alternative Fuels General Aviation: The alternative fuels for GA program collaborates with industry and government under the Piston Aviation Fuels Initiative (PAFI), created in response to the FAA's Unleaded Aviation Gasoline Transition Rulemaking Committee recommendations. PAFI provides in-kind support via testing, expertise, equipment, documentation, and industry test plan support. The PAFI steering group is comprised of the Aircraft Owners and Pilots Association (AOPA), Experimental Aircraft Association (EAA), General Aviation Manufacturers Association (GAMA), National Business Aviation Association (NBAA), National Air Transportation Association (NATA), specific aircraft and engine manufacturers, and petroleum and other fuel producers.

Program partners include:

- Aerospace Industries Association Rotor Integrity Steering Committee (RISC)
- Department of Defense
- National Transportation Safety Board
- LS-DYNA Aerospace Working Group
- NASA
- Naval Air Warfare Center, Weapons Survivability Laboratory, China Lake
- Livermore Software Technology Corporation
- Honda R&D America
- Ohio State University
- Piston Aviation Fuels Initiative provides in-kind support via expertise, oversight, documentation, and testing.
- National Resources Canada – provide in-kind test support and data sharing for aircraft in the testing program.

Do non-government groups partner with this program? Yes

Aircraft Turbine Engines: non-government groups partner with the FAA to conduct this research and they contribute in several important ways. For the rotor integrity program, engine manufacturers provide in-kind engineering support to review test matrices; beta-test DARWIN software; conduct validation tests; provide realistic defect parts for nondestructive inspection tests; and generally ensure that proposed research products are practical and useful.

Catastrophic Engine Failure: the program is partnered with Industry and academia through the LSDYNA Aerospace Working Group. Most universities are providing some cost share as partners in the research. We have a cooperative research and development agreement with Livermore Software to develop new models for the industry that are available in the industry code of choice, LSDYNA. The models are publicly available to others and documented in FAA reports.

Alternative Fuels for General Aviation: general aviation fuels research non-government industry partners, through PAFI, provide in-kind testing, engineering expertise, materials, documentation, test fuels, test plan development, data review and analyses, and fleet impact assessment.

Acquisition/Assistance:

FAA programs in the research portfolio employ competitive contracting vehicle types and grants to acquire Conduct, Research, and Development activities. The FAA's acquisition management system offers researchers omnibus contract vehicles such as the SE2020, SE2025, and eFAST BPAs in which vendors competitively compete for TOs and BPA calls. The Broad Agency Announcement is another competitive process the FAA utilizes for awarding basic research contracts. Grants are used to execute a portion of the FAA's research budget and where the FAA has the statutory authority to issue grants pursuant to the Aviation Research Grants Program. The FAA's Centers of Excellence (COE) is one example of a grant-based program that uses competition to select from among members of academia for COE participation. In the specific case of the COE grant program, it receives matching funds from industry sponsors. Broad Agency Announcements are a competitive contracting vehicle often used to solicit research ideas for a particular topic, for example, innovative nondestructive methods to inspect engine rotors.

Aircraft Turbine Engines: The DARWIN probabilistic engine design software has been developed under a series of grants awarded to Southwest Research Institute (SwRI). The initial grant was issued based upon the experience SwRI had in developing the NASGRO fracture mechanics software and for its long reputation as an independent broker of technology. The development of DARWIN has progressed through a series of software versions and is nearing its goal to address all of the Advisory Circulars identified by the FAA and RISC to support 33.70. At this point, no other organization could possibly step in to continue this work without incurring significant and duplicative startup costs.

Alternative Fuels for General Aviation: The program uses, as necessary, sole source acquisitions when the test article conformity is necessary for the data to be used in a fleet-wide authorization. There are other occasions when the testing performed must be performed to FAA certification standards so the data can be used by the FAA for fleet authorization.

In general, the FAA Research Portfolio includes Research Programs that use multi-year acquisitions.

Aircraft Turbine Engines: Throughout the development of the DARWIN software, non-Federal funds were used to enhance its capabilities and life prediction accuracy. These funds have been provided by engine manufacturers directly to Southwest Research Institute and through a DARWIN licensing fee. One example of a capability the FAA was able to leverage and build upon was a fleet risk assessment module developed initially for an engine manufacturer.

Catastrophic Engine Failure: The program leverages cost share from universities and also significant cost share from Livermore Software Technology Corporation and Honda R&D America that are teamed with FAA to develop material modeling improvements.

Alternative Fuels for General Aviation: General Aviation fuels research is supported with extensive in-kind company testing on engines, aircraft, materials, and all of the fuels have been provided by industry. Significant engineering expertise has been provided to support the test plan development, testing oversight, test data review and analyses and fleet impact assessments. There has been considerable industry contributions to this program.

Technology Transfer (T2):

Aircraft Turbine Engines: In the area of rotor integrity research, technology transfer is accomplished in several ways.

First, the FAA produces Advisory Circulars (ACs) which provide an acceptable means to comply with Part 33.70. Although intended for the manufacturers of turbine engines, these ACs are also available to the general public on the FAA's website. Second, the DARWIN software is publicly available for licensed use. To date, 15 engine manufacturers have licenses and are using the DARWIN software. Lastly, the FAA periodically sponsors DARWIN Tech Transfer Workshops which also provide a chance to demonstrate and transfer the software to industry. The last workshop occurred in March 2018.

Catastrophic Engine Failure: All research performed is reported in FAA reports, journal articles, and conference papers and is made available to the public. FAA reports provide the supporting data for aircraft certification to develop revised advisory material. The UEDDAM code is available from the FAA and LSDYNA products are available on the LSDYNA AWG Website.

Alternative Fuels for General Aviation: In the area of general aviation alternative fuels, Cooperative Research and Development Agreements (CRDAs) are used with the candidate aviation fuel providers. These CRDAs allow access and proprietary protections of intellectual property and data for up to five years to foster cooperative research that benefits the entire GA industry.

For Turbine Engine research, results are transferred to industry and the military through the issuance of advisory circulars, journal papers, workshops, and annual DARWIN software releases. A DARWIN training workshop, held in April 2018, was attended by over 100 participants from the aviation industry and multiple government agencies.

The Aircraft Catastrophic Failure Prevention Program primarily receives feedback from industry through the LS-DYNA Aerospace Working Group which includes Boeing, General Electric, Rolls Royce, and Pratt and Whitney. Advanced material models are developed in LS-DYNA and implemented into the software with each release. The material modeling methodology is documented in publicly available FAA reports and the material models for several aerospace materials are freely available from the LS-DYNA Aerospace Working Group AWG website. Additionally, beta testing of new composite material models such as MAT_213 is being coordinated with NASA Advanced Composites Program and industry partners including Boeing and Pratt and Whitney before release. The research is also published in the form of peer reviewed journals and presented at conferences.

In the Fuels Program, data generated under cooperative research and development agreements is provided to the private collaborating partner for their use in certificating, or approving for use, new commercial products or technologies. These commercial products and technologies include novel unleaded fuel chemistries that replace an existing leaded aviation fuel. This helps ensure that environmental regulations restricting the use of leaded aviation gasoline do not negatively impact the General Aviation Industry.

The Advisory Circulars that support Part 33.70 on critical life limited engine parts are issued approximately every two to three years due to the necessary time to conduct the research and coordination with industry. Updates of the publicly available DARWIN software code occur annually.

Evaluation / Performance Measurement:

Aircraft Turbine Engines: The AIA RoMan "lessons learned database" shows that failures from manufacturing processes has declined steadily over the past 10 year period.

Catastrophic Engine Failure: The Executive Quarterly Report and the Business plan internally at FAA track Milestones. Research results are presented to industry through the Aerospace Working Group at the yearly working group meeting. It is also presented to the broader LSDYNA community during the Bi-Annual Users Conference in Detroit during dedicated Aerospace research sessions. Researchers also present their work at other conferences and much of the work is in journals. Feedback from industry users and requests for modification to the models from industry are handled through the working group.

Alternative Fuels for General Aviation: In addition to the above, the Alternative fuels for GA program has quarterly internal FAA program management reviews, and has had several OMB examiner briefs. The GA program schedules, milestones and timelines are jointly developed with the aviation industry, PAFI technical advisory committee and steering groups and progress is reported on a quarterly basis. Bi-weekly status meetings are held between the different lines of business within FAA that are involved in this research to track budget and milestone progress.

The Propulsion and Fuels BLI will produce data and a version of the DARWIN engine design and life prediction code that supports Advisory Circular 33.70-4 which deals with how to design fan blade attachment slots in engine disks. Improved life prediction allows timely inspection planning and reduces the risk of premature uncontained engine failures and aviation related fatalities. A recent occurrence on Southwest Airlines flight 1380 in April 2018 resulted in the first fatality in 9 years on a major US airline when a fan blade fractured at high altitude resulting in the loss of the engine inlet and cowling which struck a passenger window. Single fan blade failures are designed to be benign events and engines are required by 14 CFR 33.94 to demonstrate by test that the damage from a fan blade off event is contained. Computational analysis is used extensively by industry in the development and design phase to be confident that containment is achieved and can be presented as part of the certification effort to satisfy FAA regulatory requirements. However, acceptance of certification by analysis has previously been limited by the lack of truly predictive models. This research is focused on developing better material models and a standardized methodology for engine related impact failures to improve analysis fidelity thereby benefitting aviation safety. The fuel and propulsion Systems program addresses the DOT Safety Strategic Performance Goal of reducing aviation-related fatalities.

Digital Systems and Technologies

Aircraft Icing/Digital System Safety
Funding Request ($9,253,000)

Program Description/Activities:

The FAA establishes rules for the certification and operation of aircraft in icing conditions and for the use of digital systems. The agency uses research results to generate Advisory Circulars (ACs) and other forms of technical information to guide certification and airworthiness specialists and inspectors on acceptable means for meeting requirements. The Aircraft Icing program will improve existing capabilities and develop new engineering tools to support improved means of compliance and new guidance material for engine and airframe certification and operations in super cooled large drops, mixed-phase, and ice crystal icing conditions. The outputs will support new guidance materials for advisory circulars.

Aircraft Icing - SLD Engineering Tools Development and Validation

- Continued development and validation of facilities or software acceptable for compliance. Safe Operations and Take-off in Aircraft Ground Icing Conditions

- Data package supporting annual guidance to airline industry for update of the ground deicing programs. Research on Ice Crystal Icing Conditions to Support Means of Compliance

- Testing with 2 phase rotating rig in pressure controlled facility and analysis of results to evaluate model of compressor icing in high ice water content conditions.

Digital Systems Safety - Development of Assurance Techniques for Systems Elements

- Leverage collaborative efforts with government, academia and aviation industry partners to identify and evaluate the risks associated with using lead free materials in airborne electronic hardware.

- Continue to leverage collaborative agreements with aviation industry partners and NASA to refine the alternative assurance processes and overarching properties to understand how certification authorities and industry can adequately assess systems for overarching compliance safely within the framework of global harmonization.

Aircraft Cyber - Aircraft Systems Information Security Protection

- Continue to leverage collaborative efforts with Federally funded research and development centers, aviation industry partners and Department of Homeland Security to refine the ASISP research processes.

- Execute the Mitigation, Identification, and Evaluation Process for specific identified aircraft cyber safety risks to identify and evaluate potential mitigations for the purpose of understanding how the aviation industry might reasonably respond to associated cyber threats.

The Aircraft Systems Information Security/Protection (ASISP) program activities include the development of an ASISP Safety Risk Assessment (SRA) Methodology, to include the identification of vulnerabilities, cyber threats, risks, potential safety impacts and mitigation strategies. ASISP activities also include partnering with industry and other Government agencies.

Statutory Requirements:

Is this program statutorily mandated (Y/N): Yes

The research aligns with FAA strategic guidance concerning expansion of operations in various weather conditions with no diminution in safety. FAA certification authorities, aircraft manufacturers, ice protection manufacturers, and ice detection manufacturers are stakeholders for this research. PUBLIC LAW 114–190 known as the "FAA Extension, Safety, and Security Act of 2016", in section 2111 (Aviation Cybersecurity) requires identification of "research and development needs to determine any cybersecurity risks of cabin communications and cabin information technology systems on board in the passenger domain". The ASISP research will enable the implementation of this public law requirement. This research also specifically addresses AVS needs expressed by one of the four FAA Administrator strategic initiatives (RBDM - Risk-Based Decision Making RBDM), and outlined in broader FAA requirements from FAA Order 8000.369 (SMS - Safety Management System, May 2013) and FAA Order 8040.4b (SRM - Safety Risk Management, May 2017). The end result is to promote aviation safety against cyber threats via systematic processes and cross-agency and industry collaboration. In addition to the certification and continued air-worthiness organizations within AVS, other important stakeholders include avionics manufacturers, aircraft integrators, airlines and other Government agencies such as DoD and DHS. The most important stakeholder is the flying public.

To address the Modernization and Reform Act of 2012, Aircraft Certification needs to research ways to make its certification processes more efficient through the use of safety risk management. Similar proposals were made in a GAMA AD Hoc report submitted to the FAA in 2016. AIR-1 has initiated certification streamlining initiatives. As part of this streamlining, SDS will research alternative methods to reduce the FAA certification footprint in the applicant's critical path while maintaining the same level of safety.

Program Alignment with Strategic Goals:

DOT Strategic Goal	DOT RD&T Critical Transportation Topic
Safety	**Promoting safety**

This program supports the DOT's Strategic Goal of safety by providing systematic research and development within the FAA that will lead to the identification, assessment and mitigation of safety risks. By providing the research necessary to generate data, this data is then used to create and develop new safety standards that will be adopted throughout the aviation community.

Program Objectives:

Aircraft Icing

The main goal in Aircraft Icing research on structural airframe icing in flight, ground deicing, and anti-icing prior to takeoff, and engine compressor icing due to the ingestion of ice particles into the engine core. Descriptions of the several research requirements associated with this central goal follows. The *Ice Crystal Icing Conditions to Support Means of Compliance* research requirement will mitigate the hazardous impact of ice accretion on engine core components, such as compressors, due to ice crystal ingestion; provide better wind tunnel, cold chamber, and outdoor winter weather (snow) test methods and analysis tools; and provide high quality, cold soaked fuel frost (CSFF) data. The *Simulation Methods Development I Validation to Support Appendix C Icing Certification and Continued Operational Safety* research requirement will provide new test methods, analysis tools, and a 3-D ice accretion database to support validation of computer codes and means of compliance for certification; and also provide a better understanding of 3-D ice accretion physics, 3-D iced aerodynamics, and ice shape features for modern, swept wing airfoils. The *Super cooled Large Drop (SLD) Engineering Tools Development and Validation* research requirement will provide new test capabilities and test methods to support improved means of compliance that can be used for certification, and new guidance materials for advisory circulars.

The research conducted under this BLI differs from industry research the main focus is considering new technology, materials and procedures while maintaining or increasing current safety levels. The program main sponsor is the regulatory community which can be hindered by proprietary and intellectual property rights. The programs under this BLI provide the aviation community with publicly available data and insight for consistent aircraft certification safety.

The Aircraft Icing Program focuses primarily on providing the information needed by the FAA to ensure that industry complies with certification and operational requirement. Much of this information is also useful to industry in its efforts to ensure safety. The Aircraft Icing Program seeks and receives valuable input and insights from industry through meeting with industry working groups and committees and participation in national and international conferences.

Digital Systems Safety

Airborne systems' designs have become increasingly dependent on highly integrated software and hardware architectures that share power, computing, networking, input/output, and other resources to support the needs of multiple aircraft functions. The main goal in Digital Safety Research is to address the evolution of these highly complex architectures especially as they begin to integrate with ground systems and place Performance Based Navigation (PBN) systems in the cockpit for NextGen implementation. The other goal of this research is to develop, validate, streamline and improve certification methods and to reduce time and cost to both FAA and industry in certifying aircraft employing advanced digital airborne systems.

The research requirement will provide additional insights into safety vulnerabilities of complex digital systems that are developed, integrated, or verified using unproven processes, techniques, and methodologies that could introduce a safety risk for undetected errors with failure manifested at the aircraft level. The *System Considerations for Complex Software Intensive Systems* research requirement will develop policy, guidance and training for new technologies and techniques to

promote their safe use in aircraft systems; develop processes and training material used to streamline the certification of complex digital systems and seek to understand, address, and provide an annual measurement indicator of SDS related continued operational safety issues.

The research conducted under this BLI differs from industry research the main focus is considering new technology, materials and procedures while maintaining or increasing current safety levels. The program's main sponsor is the regulatory community, which can be hindered by proprietary and intellectual property rights. The programs under this BLI provide the aviation community with publicly available data and insight for consistent aircraft certification safety.

Aircraft Cyber

The Aircraft Systems Information Security/Protection (ASISP) research requirement will provide additional insights into cybersecurity vulnerabilities and threats of aircraft systems, components, networks, interfaces, and maintenance strategies that would provide a basis to develop rulemaking, policy, guidance, standards, training, and tools for cybersecurity.

Industry's development of aviation systems, from at least the 1990s through the more modern networked avionics of today, has been focused on size, weight and performance. This focus placed no emphasis on, and limited planning for, information security and associated potential safety impacts. The ASISP research program addressees the safety need for the FAA to conduct independent systematic aircraft cyber vulnerability and risk assessments to ensure the safety of the flying public. The market does not have an industry-wide systematic approach for assessing aircraft cyber risks.

Economic Impact of Regulatory Reform:

Digital Systems Safety

This program does not aim to recommend new regulations based on its FY19 portfolio; however, it may provide technical data to AC-20-1152a and AC20-152a. In general, the digital system safety research is striving to update the standards/guidance/regulation to meet with an ever-changing environment and to meet the safety goals. In addition, streamlining certification is centric to several research tasks that are geared towards reducing the certification cost and time. However, in the area of aircraft digital systems, the technology is changing at a rapid pace and older technologies are getting outdated. The research tasks and outcomes will support the development of policy, guidance, standards, and training associated with certification of new/novel approaches for complex system development assurance. In addition, the research task on Generic Framework will investigate certification streamlining and the results from this research will be used to update policy in Orders 8110.49 Chg. 1 and 8110.105 Chg. 1, to create new policy for the FAA. This research aligns with M-17-30 and supports American Security (safe and secure integration) and American Prosperity (emerging technologies, machine learning and autonomous systems- early stage research). The results of the research used by the FAA and industry to streamline the regulations which will lessen the economic impact and remove outdated regulations while addressing the gaps in the current assurance standards/guidance, such as DO-178C, DO-254, AC 20-115C, AC 20-152.

Performance-Based Regulations and Safety:

Since its establishment, the Digital System Safety program has led extensive studies on the in-service behavior of aircraft systems addressing the streamlining of certification while working to remove the deficiencies and gaps with the existing standards, guidance, and policy. The knowledge and information produced have directly supported a wide range of FAA performance-based regulations and safety activities including: updates to existing regulations (e.g. 23.1309, 25.1309, 27.1309, 29.1309), standards (e.g. SAE ARP 4761, SAE ARP 4754A), and AC 20-174 as well as identifying training gaps in related guidance materials.

Evidence shows that complex systems have non-deterministic behavior and are becoming more complex to certify, and that warnings and pilot training are inadequate preventions for accidents. This program provides increased safety for the public by developing requirements and guidance for the certification efforts to support future performance-based regulations, and by implementing automated systems that prevent accidents.

Research Collaboration Partners:

The main source of public and stakeholder input is from Technical Community Representative Groups (TCRG). TCRG members routinely participate in both FAA and industry activities, such as Aviation Rulemaking Advisory Committees (ARAC), Commercial Aviation Safety Team (CAST), SAE, RTCA and other aerospace standard organizations. Through these venues, the members gather input from those most affected by the research and present ongoing programs.

Public stakeholder input is also received through the congressionally mandated Research, Engineering, and Development Advisory Committee (REDAC). The REDAC is an advisory committee to the FAA whose members are FAA stakeholders including industry, Federally Funded Research and Development Centers (FFRDCs), and academia. The REDAC provides advice and recommendations to the FAA Administrator on the needs, objectives, plans, approaches, content, and accomplishments of aviation research program. The committee reviews and comments on the aviation research programs including Centers of Excellence and other grants. The REDAC considers aviation research needs in five areas; (a) NAS operations, (b) airport technology, (c) aviation safety, (d) human factors, and (e) environment and energy. The REDAC holds 2 full committee meetings and 10 subcommittee meetings annually from which come reports documenting REDAC's input known as REDAC Findings and Recommendations (F&Rs.) The research programs evaluate REDAC findings and recommendations, and the FAA responds with adjudications and where appropriate, action plans commensurate with the recommendations. The FAA Research Portfolio Division and the research performers track all F&R and associated Agency responses.

<u>Aircraft Icing</u>

The Aircraft Icing Program attends industry working groups and committees in order to get input directly from those most affected by the issues it is researching. In addition, it meets regularly with Flight Standards and industry representatives at meetings arranged by Flight Standards, often in response to requests from industry representatives.

The Aircraft Icing Program works with the following partners and benefits from the resources and expertise they contribute: NASA (by means of Interagency Agreements), National Resource Council

(NRC) of Canada (by means of memoranda of cooperation), Environment and Climate Change Canada (ECCC) (by means of memoranda of cooperation), and Australian Bureau of Meteorology (BOM) (by means of international agreement).

The Aircraft Icing Program partners with aircraft manufacturers and airline operations. Manufacturers contribute mainly through expert input, and sometimes by the participation of company personnel in projects. For example, Boeing personnel played a very important role in the planning and conduct of recent flight campaigns.

In cooperation with Flight Standards, the Aircraft Icing Program meets regularly with airline representatives, receiving the expert input. Also, some airlines have made their own aircraft available for some recent testing.

Digital Systems Safety

Industry, academia, and other agencies are actively involved in cooperative research tasks to conduct research and develop consensus standards for digital systems assurance. Work is also done with NASA (Glenn, AMES, Langley), National Resource Council of Canada, Aerospace Vehicle Systems Institute (AVSI, a consortium of industry OEMs (Boeing, Airbus, Embraer, Honeywell, GE), other government agencies, and academia), RTCA, Aerospace Valley, MIT and Carnegie Mellon. This research will benefit the safety initiatives of incorporating complex digital systems as we move towards a more electric aircraft and will provide the FAA with a unique capability that protects industries Intellectual Property (IP), does not duplicate test facilities that already exist in the US and can leverage the results across industry, government and academia.

Aircraft Cyber

Cyber collaboration includes industry (aviation OEMs, airlines, DHS and DoD. Other partners anticipated in the near future include other Government threat-related agencies, academia and aviation integrators. Benefits from this collaboration include faster industry response to potential threats, more accurate FAA safety risk assessments and more efficient use of Government resources.

Initially, the FAA is working with some airlines and OEMs to leverage their facilities, equipment and subject-matter expertise in the conduct of safety risk assessments. The number of industry participants is anticipated and intended to expand as the program proceeds to phase 3.

The Aviation Cyber Initiative (ACI) is the collaborative body for the cyber R&D efforts, which includes the Department of Homeland Security (DHS), the Department of Defense (DoD), and the Department of Transportation (DOT), who will collaborate and cooperate on a consensus basis. The aviation ecosystem is an extensive multi-layered network of intersecting elements with integral roles in the Air Domain and involves six primary entities: airports, airlines, aircraft, airlift, actors, and aviation management. The National Airspace System (NAS) falls under aviation management within the aviation ecosystem. The ACI mission is to reduce cybersecurity risk to the Nation's aviation ecosystem, and to support safe, secure, and efficient flight operations. The ACI will provide a U.S. Government collaborative forum for cybersecurity risk reduction affecting military and civil aviation. The ACI will recognize the differences between departments' and agencies' cyber risk management approaches and support effective stakeholder aviation cybersecurity risk management processes

through collaboration and cooperation among federal interagency partners, as well as with private industry and other non-federal aviation community stakeholders.

Acquisition/Assistance:

FAA programs in the research portfolio employ competitive contracting vehicle types and grants to acquire Conduct, Research, and Development activities. The FAA's acquisition management system offers researchers omnibus contract vehicles such as the SE2020, SE2025, and eFAST BPAs in which vendors competitively compete for TOs and BPA calls. The Broad Agency Announcement is another competitive process the FAA utilizes for awarding basic research contracts. Grants are used to execute a portion of the FAA's research budget and where the FAA has the statutory authority to issue grants pursuant to the Aviation Research Grants Program. The FAA's Centers of Excellence (COE) is one example of a grant-based program that uses competition to select from among members of academia for COE participation. In the specific case of the COE grant program, it receives matching funds from industry sponsors.

Sole source acquisitions are not used at all or very rarely. They are only used when the expertise needed is unique to a particular company or individual. All of the programs makes use of multi-year agreement with collaborating organizations. For ASISP, a research Broad Agency Announcement (BAA) also was used to identify multiple potential research partners, of which two were selected and funded. Additionally, all programs make significant use of non-Federal resources. Details are provided in answers to questions above.

Also, as part of the BAA process, all proposals were requested to identify cost-sharing opportunities. This was heavily leveraged on one contract in the form of facilities, test equipment and access to industry participants (SMEs, facilities and equipment) at lower cost. These non-Federal funds are estimated to be equivalent to between 10%-20% of the Federal funds.

Technology Transfer (T2):

<u>Aircraft Icing</u>

All technical transfer in FY19 will be in the form of knowledge to the public. This knowledge is provided in reports, conference papers, and journal papers. Approximately five such publications are anticipated in FY19. Some of the publications are produced in-house, and two or sometimes three of the icing personnel are involved in these activities. Much of the information in these publications is incorporated into advisory circulars. Aircraft icing cannot provide adoption/implementation rates for its obligations. However, since some of the information is used in advisory circulars, it is implemented in that way and brought to the attention of industry.

<u>Aircraft Cyber</u>

The ASISP Program transfers technology in the form of information, by means of process description documents and technical reports. This information is intended to be used by industry to strengthen their aircraft systems against cyber threats and intended to be used by AVS to promote aviation safety.

Digital Systems Safety

Digital System Safety research projects typically aim to address either safety issues unique to the FAA's oversight capabilities or systematic safety issues across industry through providing necessary technical data to the FAA's Office of Aviation Safety (AVS) to prepare meaningful advisory and guidance material for use by industry. For those projects that address safety issues unique to the FAA's oversight capabilities, the T2 is internal to the FAA. For those projects that address systematic safety issues across industry, T2 is executed through publication of advisory and guidance material by the Office of Aviation Safety. Technical publications documenting research results are available to the public at:

- https://www.faa.gov/about/office_org/headquarters_offices/ang/offices/tc/library/

Digital System Safety research results are shared with the standards bodies such as RTCA and SAE. Also, various certification authorities such as FAA, CAA, and EASA use the results in updating the guidance and developing humanized position papers. Some of the Handbooks and Specifications developed by the research are shared with the industry in developing newer technologies and products for airborne applications. Internally, FAA's Office of Aviation Safety uses the results of the research in developing training material for certification engineers. The published handbooks and reports of the research are available to public on the FAA AIR website.

A specific example of T2 in this area is the multi-core processor research and issue paper and EASA certification review item used the safety net concept and definition from DOT/FAA/AR-11/5.

Other examples of T2 in this area are published handbooks from the SDS research:

- DOT/FAA/AR-11/2 (PDF) Handbook for the Selection and Evaluation of Microprocessors for Airborne Systems
- DOT/FAA/AR-09/24 (PDF) Data Network Evaluation Criteria Handbook
- DOT/FAA/AR-08/35 (PDF) Handbook for Networked Local Area Networks in Aircraft
- DOT/FAA/AR-08/32 (PDF) Requirements Engineering Management Handbook
- DOT/FAA/AR-07/48 (PDF) Handbook for Real-Time Operating Systems Integration and Component Integration Consideration in Integrated Modular Avionics Systems
- DOT/FAA/AR-05/54 (PDF) Handbook for Ethernet-Based Aviation Databases: Certification and Design Considerations
- DOT/FAA/AR-01/116 (PDF) Software Service History Handbook

Evaluation / Performance Measurement:

The Provider Research Execution Plan (PREP) identifies requirement-specific research activities with a schedule of milestones, deliverables, and anticipated spend plan.

Metrics for each program are defined and agreed to by the sponsor of the research (typically the designated safety professional in the FAA Aviation Safety Office) and provided and used to monitor the program progress in regular program management reviews and status meetings. Through the requirements development process in the Technical Community Representative Group (TCRG) all strategic guidance and industry trends are analyzed and incorporated into the requirements process. The associated benefits to the FAA and flying public are evaluated during this process. These metrics

are a part of the initial requirement selection and incorporated into the Performer Research Execution Plans (PREPs) in accordance with NextGen Office (ANG) processes, with cost, performance, and schedule data as requested by the Sponsor.

As stated above, the Provider Research Execution Plan (PREP) identifies requirement-specific research activities with a schedule of milestones, deliverables, and anticipated spend plan, which is later baselined and tracked using standard program management techniques. More specifically, the requirement-specific research activities are structured in several phases and monitored using monthly reporting. Each phase will have a structured goal that must be met and have Sponsor concurrence before moving on to the next phase.

To evaluate effectiveness of Software Digital Systems research outcomes, the Office of Aviation Safety (AVS) tracks annually the operational safety issues such as airworthiness directives (AD), incidents and accident where software digital systems were identified as the root causes. The ADs related to software dropped from 16 in 2005 to five in 2016, providing one indicator of the research's positive impact.

Aircraft Icing Program

Industry leaders believe that analysis using computational fluid dynamics (CFD) computer software is now sufficiently mature that aircraft icing certification can rely more on Certification by Analysis (CBA), and have asked the FAA to consider expanding the use of this approach. Use of CBA has the potential to increase icing certification efficiency, thus saving costs, while maintaining or enhancing the safety of the flying public. This program is necessary to establish a sufficient database for evaluation and validation of CFD software for icing certification of swept wing aircraft that predominate among transport aircraft.

Certification of aircraft under the new rule for super cooled large drop (SLD) conditions requires improved and validated means of compliance, ensuring safety of the flying public on these aircraft in SLD conditions. This program is necessary for development of needed methods for certification to the new rule.

FAA ground icing research enables the FAA to provide industry timely guidance to airlines each winter on safety issues that have arisen, and also to provide international leadership in this area through its role in the international SAE Ground Deicing Committee. In this way it promotes uniformity and safety in ground deicing and anti-icing practices not only in the U.S. but around the world, including the growing markets in Southeast Asia. This program is necessary for the FAA to continue to play this role both domestically and internationally.

Engine power loss and other icing events in high ice water content (HIWC) ice crystal conditions pose a significant risk to the flying public. Research into the complex physical causes of these events in controlled environments provides information essential to industry in minimizing the risk through engine design and modification. This program is necessary to continue the research.

Digital Systems Safety

To evaluate effectiveness of Software Digital Systems research outcomes, Aviation Safety (AVS) tracks annually the operational safety issues such as airworthiness directives (ADs), incidents and

accidents where software digital systems were identified as the root causes. The ADs related to software dropped from 16 in 2005 to 5 in 2016, providing one indicator of the research's positive impact.

The ground icing research most directly addresses "reduced aviation-related fatalities." The safety record for ground icing is outstanding, in contrast to the record from 1982 to 1992, when there were more than five accidents claiming more than 100 lives. The regulations, guidance, and procedures put in place by the FAA in 1992 following an FAA-sponsored international conference continue to be followed, with some modification, today. However, questions have been raised by industry as to whether the procedures are overly conservative, and with the transparency policy of Flight Standards, such issues are first addressed with research. The key issue is whether relaxing current procedures will reduce safety margins to the extent that there will be a danger of accidents and fatalities occurring once more as they did from 1982 to 1992. In FY19 FAA research will examine the procedures used for the determination of holdover times in snow.

An example of research in the Digital System Safety Program area that reduces aviation related fatalities/improves safety is in the identification of critical system design errors that could lead to unsafe situations similar to Malaysian Airlines Boeing 777 incident on August 1, 2005 and Boeing 787 (e.g., October 29, 2014 Australian registered B787) transmitting inaccurate ADS-B positional data due to improper software logic used for extrapolation of longitude and latitude. These incidents have raised the question regarding inadequate and misunderstood integration, validation, and verification techniques for complex components that leave potential for faults to exist with failure manifestation at the aircraft level, after the on-board system has been certified. Most standards and regulations address development and safety requirements for individual components. Little exists for complex, highly integrated components and resulting systems, particularly using commercial-off-the-shelf equipment developed for a non-aviation (non-safety) market. As technology continues to change and become more complex, the verification and validation processes must change to adequately assess systems for compliance to the regulations and to minimize risk to the public. United States Federal Aviation Regulation (FAR) Parts 23, 25, 27, and 29, all have an airworthiness standard that states, "the equipment, systems, and installations must be designed and installed to ensure they perform their intended functions under all foreseeable operating conditions." If machine learning is used, for example, to increase the level of flight control autonomy, these current standards imply the applicant must demonstrate the autonomous flight control function performs its intended function under all foreseeable operating conditions. The operating conditions can be infinite and may need to include rain, snow dust, viewing angles, sensor imperfections, lighting changes, system failures, etc. The research results will be used to directly address the FAA's commitment to certification process efficiencies as mandated by the 2012 Modernization and Reform Act. These efficiencies will reduce the FAA's footprint in the certification critical path while, at the same time, not affect continued operational safety. The approach will use risk-based concepts and oversight, and less prescriptive guidance than that currently based on detailed industry standards such as DO-178B/C and DO-254. This research will be used to provide recommendations for updating guidance and training standards to the FAA's Office of Aviation Safety to improve safety in this area

Aircraft Cyber

The ASISP program establishes exit criteria for each fiscal year in the annual requirements document, generally in the form of products to be completed, including process description documents and safety risk assessment reports. Through FY17, the exit criteria have been met.

NextGen - Information Security
Funding Request ($1,232,000)

Program Description/Activities:

This program conducts research on big data methodologies addressing cyber security parameters such as data volume, data velocity, data variety, data veracity, behavioral data, and a variety of other parameters to help prevent disruptive cyber incidents that may impact NextGen future air traffic operational data which includes the NAS, R&D, and mission support domains. The research includes Air Traffic Management Operations, Net-Centric Operations, and NAS Infrastructure. The big data research will include various communications such as Internet Protocol (IP) traffic, big data in the cloud (public, private, community, and hybrid), and various application data within FAA systems and external aviation partners' systems communicating with FAA systems. The long- term goal is to help prevent disruptive cyber incidents within the NextGen future traffic which will include digital and flexible communication in future Air Traffic Control (ATC) mission and improve big data cyber security within Air Traffic Management Operations, Net-Centric Operations, and NAS Infrastructure (communication, and information management) resilience in:

- Big Data Cyber Analytics – to effectively compile and correlate data volume, data velocity, data variety, data veracity, behavioral data large volumes of data, new technologies, and algorithms.

- Visualization tools – related to big data to develop visualization techniques: creative visual presentations of data that quickly differentiate warning signs from normal operating behaviors.

- Exploratory Research topics: Self-Adaptive Networks and Systems and Design Assurance Methods for Mixed Trust Environments

Statutory Requirements:

Is this program statutorily mandated (Y/N): Yes

This research supports FAA Cybersecurity Strategy 2016-2022 Goal 5 - specifically, the FAA's overall cyber security capability development - by researching advanced tools, techniques and processes that can be adapted for use in the NAS. Build and maintain relationships with external partners in government and industry to sustain and improve cybersecurity in the aviation domain.

The program also directly supports the Executive Order (EO) 13636 Improving Critical Infrastructure Cybersecurity and the Presidential Policy Directive (PPD)-21 Critical Infrastructure Security and Resilience, which defines Transportation Systems Sector as one of the 16 critical infrastructure sectors and aviation as an essential sub-sector. The research will follow the strategic guidance of the Federal Cybersecurity Research and Development Strategic Plan published by the National Science and Technology Council, February 2016 to support the specific FAA cybersecurity goals: Protect and Defend FAA mission; Data Driven Risk Management; and Collaboration with external partners.

Program Alignment with Strategic Goals:

DOT Strategic Goal	DOT RD&T Critical Transportation Topic
Innovation	**Improving Mobility**

This program supports the DOT's Strategic Goal of innovation by providing targeted research and development within the FAA that will lead to new technology development and deployment in the National Airspace System (NAS). By providing the necessary research to gather information, this will allow the assessment of regulatory approaches, it will foster information sharing and facilitate coordination, collaboration with industry and other stakeholders, and the ability to test and adopt new technologies throughout the NAS. This program has no impact on rural communities.

Program Objectives:

The main goal of the NextGen Information Security program is the prevention and deterrence of disruptive cyber incidents that affect the ATC mission and improve resiliency in the event an incident does occur. The program directly supports the FAA Cyber Security Strategic plan to research advanced tools, techniques and processes that can be adapted for use in the NAS. The Cyber Steering Committee (CSC) identified the need to explore cyber-data science concepts that go beyond traditional cyber methods, which depend on firewalls, and malware detection methods. The requirement is based on the increased capabilities of advanced persistent threats (APTs) which are characterized by more sophisticated and concentrated efforts and discrete coordinated attacks focused on single or multiple targets within critical infrastructure systems such as the NAS. The attacks aim to infiltrate a sensitive system, remain undetected for as long as possible, and leave few traces of their success of placing and using malware with the system under attack. APTs are a favorite approach for those who aim to conduct cyberattacks. The research goals include the ability to detect and counter these sophisticated APT threats with a more holistic approach using advanced data science and data analytical techniques. The CSC also identified the need to explore Self-adaptive systems and networks and Design assurance methods for mixed trust environments.

The program also directly supports the Executive Order (EO) 13636 Improving Critical Infrastructure Cybersecurity and the Presidential Policy Directive (PPD)-21 Critical Infrastructure Security and Resilience, which defines Transportation Systems Sector as one of the 16 critical infrastructure sectors and aviation as an essential sub-sector.

The program will take proactive and collaborative approach to work with other Federal agencies, NAS stakeholders, and academic institutions to identify, develop, and implement methods, tolls, and technologies to meet the research requirements of FAA Cyber-security Strategic Plan goals and objectives.

The market for data science applied to cyber security in industrial control systems is a new topic area in academia and industry and there is very limited efforts to apply these technologies to the aviation industry. The research program has intentionally collaborated with the FFRDC's to allow collaborating and transitioning of the data science technology and products to aviation stakeholders and in industry partners.

The Aircraft System Information Security Protection research program addresses the DOT requirement for "strategies for the integration of cybersecurity risk management into safety management programs".

The Federal Aviation Administration (FAA) Order 8000.369, Safety Management System (SMS) and Federal Aviation Administration (FAA) Order 8040.4B Safety Risk Management (SRM) policy for the Federal Aviation Administration (FAA) establishes common terms and processes used to analyze, assess, mitigate, and accept safety risk in the aerospace system. The Aircraft System Information Security Protection research program specifically addresses AVS needs expressed by one of the four FAA Administrator strategic initiatives (RBDM - Risk-Based Decision Making RBDM), and outlined in broader FAA requirements from FAA Order 8000.369 (SMS - Safety Management System, May 2013) and FAA Order 8040.4b (SRM - Safety Risk Management, May 2017). The result is to promote aviation safety against cyber threats via systematic processes and cross-agency and industry collaboration. In addition to the certification and continued air-worthiness organizations within AVS, other important stakeholders include avionics manufacturers, aircraft integrators, airlines and other Government agencies such as DoD and DHS. The most important stakeholder is the flying public.

The second DOT requirement "modal cyber threat models for transportation critical infrastructure to enhance integrated cybersecurity and safety research priorities" is addressed by the FAA's Enterprise Cybersecurity Risk Model and the Cybersecurity risk model-working group. The Enterprise Cybersecurity risk model includes 1) future investment and planning informed by end-to-end threat, risk and impact. 2) A common framework applicable across all FAA domains – tailorable to meet unique requirements within each domain, 3) methodology for prioritizing cybersecurity testing providing tangible results and outcomes of validating threat and risk 4) supports data-driven risk based decision making across the FAA enterprise.

Economic Impact of Regulatory Reform:

The Data Science/ Big Data analytics for Cyber security program is not meant to generate additional regulations; hence, there is no impact from regulatory reform.

Research Collaboration Partners:

The program will take proactive and collaborative approach to work with other Federal agencies, NAS stakeholders, and academic institutions to identify, develop, and implement methods, tolls, and technologies to meet the research requirements of FAA Cyber-security Strategic Plan goals and objectives.

Collaborators are:

- Department of Homeland Security (DHS)– NPPD: Potential to leverage the National Cybersecurity and Communications Integration Center data science algorithms
- Department of Defense (DOD) – Air Force Research Lab (AFRL) : Potential to leverage cyber tools developed by the Air Force
- Aircraft Cyber Initiative (ACI): Potential for multi-agency partnerships
- National Aeronautics and Space Administration (NASA): Potential to utilize the ongoing Data science efforts and subject matter expertise.

Acquisition/Assistance:

Does this program utilize competitive procurement processes? Yes.

FAA programs in the research portfolio employ competitive contracting vehicle types and grants to acquire Conduct, Research, and Development activities. The FAA's acquisition management system offers researchers omnibus contract vehicles such as the SE2020, SE2025, and eFAST BPAs in which vendors competitively compete for TOs and BPA calls. The Broad Agency Announcement is another competitive process the FAA utilizes for awarding basic research contracts. Grants are used to execute a portion of the FAA's research budget and where the FAA has the statutory authority to issue grants pursuant to the Aviation Research Grants Program. The FAA's Centers of Excellence (COE) is one example of a grant-based program that uses competition to select from among members of academia for COE participation. In the specific case of the COE grant program, it receives matching funds from industry sponsors.

The program is in preliminary discussions of collaborating with NASA, NSF and Department of Homeland Security.

The program utilizes Federal Funded Research Development Centers (FFRDC) to conduct research, software engineering, and/or technical analyses.

The program is Multi-Year acquisitions to support work plan. The acquisition supports research in the use of data science methodologies to develop, integrate, and demonstrate big data cyber capabilities to address the research objectives. Efforts will focus on the Mission Support domain; follow-on research will demonstrate the application of these capabilities to the NAS domain.

Does this program leverage non-Federal funds? (Y/N). No

Technology Transfer (T2):

To maximize the potential for T2, two FFRDC's will conduct this R&D activity. The stakeholders include the entire aviation community, NAS infrastructure and aircraft system developers. The research products will mature to be considered for Technology transfer. Once the research matures to the appropriate Technology readiness level and demonstrated in a relevant environment, then develop a Technology transfer plan between stakeholders within the aviation community. This program will not report classified activities for T2 Annual Performance.

The Data Science/ Big Data analytics for Cyber security program has interfaced with the Senior Patent Counsel, Office of the Center Counsel in regards to technology transfer and also with Research and Development Management Division ANG-E4, which manages Cooperative Research and Development Agreements (CRDACRDAs) for the technical center. Discussions have already taken place with an industry partner on technology transfer from this program.

Evaluation / Performance Measurement:

FAA will coordinate the planning, implementation, and delivery of the support-defined activities as defined in the contract using project management best practices to include the following:

- Provide on-going customer interface, coordination, planning and support to ensure services and products are satisfactorily delivered
- Keep track of technical expertise, knowledge transference, and applicable technology applications on subject matter to support the FAA.
- Monthly status and progress briefings/reports.
- Track deliverables and progress against plans, and track the expenditure of funds against schedules, milestones, and deliverables.

Schedule, cost and technology performance are the three program metrics to track performance. Additionally, this program receives oversight from FAA's Cyber Steering Committee Quarterly PowerPoint status brief for FAA Cyber Security Steering Committee.

NextGen - Flightdeck Data Exchange
Funding Request ($1,035,000)

Program Description/Activities:

The Flight Deck Data Exchange Requirements program addresses the data exchange format and performance requirements, which enable enhanced data exchange between onboard avionics systems and ground systems to enable trajectory-based operations (TBO). Recent advancements in flight deck automation such as electronic flight bags (EFBs), aircraft interface devices (AIDs), and the availability of new on-board data links have introduced an opportunity for flight operators to leverage these technologies in the collaborative decision-making process. There is ongoing work to evaluate the feasibility of utilizing these technologies to enable operational functions like trajectory negotiation and downlink of aircraft specific intent data to synchronize trajectories with ground automation with extensive work in improving the ground automation capabilities, but further research is required on the flight deck automation performance and information security requirements.

This program evaluates the emerging technologies that enable the exchange of data between certified avionics such as Flight Management Computer (FMC), and non-certified avionics like EFBs through AIDs. The research will evaluate the current security requirements and state-of-the-art security standards that can be imposed on the new FD data exchange architecture. This will enable safe data exchange between certified and non-certified systems, the performance standards required to enable operational information exchange like intent downlink and trajectory negotiations, and the data exchange protocols to enable seamless integration between airborne and ground systems. The project will also seek to evaluate and address the security requirements for information exchange and interaction between certified and non-certified avionics, and between airborne and ground automation systems to maintain the integrity of systems that are safety critical to flight operations while enhancing data exchange capabilities.

For FY 2019, the requested funding will be used to develop a research plan, evaluate and develop an initial technical and operational assessment, define a security framework to assess technologies, initiate, and maintain coordination with key industry stakeholders and organizations, and develop concept and use cases for flight deck data exchange.

Statutory Requirements:

Is this program statutorily mandated (Y/N): No

Program Alignment with Strategic Goals:

DOT Strategic Goal	DOT RD&T Critical Transportation Topic
Innovation	**Improving Mobility**

FD-DER program supports the DOT's Strategic Goal of innovation by leveraging emerging Internet of Things (IOT) technologies in aviation to improve mobility by developing new NAS concepts such as Trajectory-Based Operations (TBO). The FD-DER program will examine requirements for enhancing

the secure exchange of data between onboard avionics systems and ground systems. Supplementing the Data Communications initiatives, alternative means of obtaining and exchanging information between aircraft and ground systems will be explored. Enhanced data exchange to support applications such as complex and efficient trajectory negotiations is a critical part of achieving trajectory-based operations. Enabling alternative means of digital data exchange will expand the benefits of transitioning from traditional voice communications to digital information exchanges by allowing significantly more aircraft to participate in digital data exchange in the near-term.

FD-DER program compliments the DataComm objective of transitioning from the current voice-based information exchange mechanisms to enable the rich data exchange requirements of TBO by enabling aircraft not equipped with DataComm to participate in the data exchange in a mixed equipage environment while providing redundant data exchange mechanisms for those that are equipped. Success of the effort requires collaboration with various stakeholders. These stakeholders include flight operators and air traffic management that need to coordinate their operational objectives, the OEMs that provide the systems that generate and leverage the data exchanged, the supplemental hardware providers that will implement the system architecture, the data exchange service providers that provide the data links, and application developers that design and implement the EFB applications, and the FAA and global regulatory bodies that establish the standards.

Program Objectives:

The main goal that the NextGen – Flight Deck Data Exchange Requirements program addresses is the ability to exchange extensive information between the flight operator and the Air Navigation Service Provider (ANSP) in a secure manner, for successful implementation of Trajectory Based Operations (TBO) in the NAS. The current voice-based information exchange mechanisms are not adequate to enable the rich data exchange requirements of TBO. The implementation of Data Communications (DataComm) Aeronautical Telecommunications Network (ATN) Baseline 2 (ATNB2) is expected to address these requirements, however, equipage of ATNB2 capabilities will be limited among non-scheduled air carriers and business jet operators and retrofit of older equipment among large air carriers will be limited due to the costs of equipage. The resulting mixed equipage in Data Communication capabilities will result in less than optimal realization of the efficiency benefits envisioned through TBO. To supplement the ATNB2 equipped aircraft, alternate means of data exchange capabilities are possible by leveraging emerging technologies that are already being implemented by flight operators. Technologies such as Electronic Flight Bags (EFBs) and Aircraft Interface Devices (AIDs) coupled with data link capabilities can provide a subset of the capabilities of ATNB2 to enable increased participation in TBO, benefiting the NAS. It is imperative that these new capabilities have robust security protocols and exchange mechanisms that ensure that safety critical systems onboard the aircraft and NAS automation systems on the ground are not compromised.

The innovations and applications of emerging IOT technologies in aviation are being aggressively pursued by the aviation industry to improve air mobility. However, the market has not addressed the feasibility issues related to standards, policy and security issues. The outcome of this research will directly inform the development of standards and guidance for the implementation of the necessary data exchange protocols and security requirements for the use of EFB and AID to support alternative data exchange mechanisms. This includes the data driven requirements that will be implemented by FAA regulatory bodies including the necessary global standards alignment. Through stakeholder engagement, the role of industry including the original equipment manufacturers, avionics and

supplemental hardware providers, the data exchange service providers, and the application developers will inform the development of implementation guidance to meet the domestic and international regulatory standards and provide the US industries economic competitiveness on a global scale.

Economic Impact of Regulatory Reform:

Not applicable. The findings of this research project in conjunction with other research projects related to connected aircraft concepts, may inform future research and development of certification standards for connected aircraft. Development of the standards is out of scope of this project.

Research Collaboration Partners:

NextGen Flight Deck Date Exchange Requirements (FD-DER) program will be developed in collaboration with all relevant aviation industry stakeholders including the airspace users, manufacturers and service providers. The FAA has various options for industry stakeholders to participate in the research, which allows FAA and industry flexibility in determining the scope of the program. Invariably, for programs like FD-DER, the FAA holds industry day workshops to invite all the relevant stakeholders from the industry and public to participate in program. The stakeholder input metrics is generally captured in workshop minutes and improvement in the program based on industry feedback. Another metrics to consider would be the extent of cost-sharing that the industry is willing to support.

Air Navigation Service Provider (ANSP) and Air Traffic Management (ATM) ground automation providers, such as the FAA, will be able to securely communicate with flight deck via System Wide Information Management System (SWIM) to overcome the information exchange challenges in creating Trajectory Based Operations (TBO) collaborative decision-making environment in the NAS.

Avionics manufacturers and datalink service providers will benefit from the standards and requirements that they need to meet to bring their feasible innovations to the market.

Commercial and general aviation flight operators will gain access to standardized, secure and inexpensive technologies that would allow them to participate in TBO environment.

Aircraft OEMs will benefit from gaining flexibility in configuring and optimizing flight deck designs.

Do non-government groups partner with this program? No

Acquisition/Assistance:

Does this program utilize competitive procurement processes? Yes.

FAA programs in the research portfolio employ competitive contracting vehicle types and grants to acquire Conduct, Research, and Development activities. The FAA's acquisition management system offers researchers omnibus contract vehicles such as the SE2020, SE2025, and eFAST BPAs in which vendors competitively compete for TOs and BPA calls. The Broad Agency Announcement is another competitive process the FAA utilizes for awarding basic research contracts. Grants are used to

execute a portion of the FAA's research budget and where the FAA has the statutory authority to issue grants pursuant to the Aviation Research Grants Program.

The FAA has various contracting options, which allows FAA and industry flexibility in determining the scope of the participation. These contracting options include existing Indefinite Delivery/Indefinite Quantity (IDIQ) contracts, Federally Funded Research and Development (FFRDC) Center, Other Transaction Agreement (OTA) that allows any number of entities to participate, or establishing a new contract using FAA Acquisition Management System (AMS). Invariably, for programs like FD-DER, the FAA holds industry day workshops to identify and invite all the relevant stakeholders from the industry and public to participate in program.

For a program that requires extensive industry participation, FAA could use Embry Riddle Aeronautical University OTA that allows any relevant industry stakeholders to participate. For preliminary information gathering and gap analysis research, FAA also has options to use an existing FFRDC such as MITRE Corporation.

In general, the FAA Research Portfolio includes Research Programs that use multi-year acquisitions.

Does this program leverage non-Federal funds? No

Technology Transfer (T2):

Flight Deck Data Exchange Requirements research is not intended to develop a technology that will be transferred to industry or government stakeholders. However, the research will lead to a development of flight deck data exchange prototype that will allow the project team to conduct operations evaluations and collect data on information exchange performance between certified and non-certified flight deck and ground systems. The findings of the research will be published that may inform future research and technology development work.

Evaluation / Performance Measurement:

FD-DER Program contracts, risks, costs and deliverables quality and schedule is governed by project management M principles and oversight established between the portfolio management division and project manager, which will be established after the funding is secured. For FY 2019, the goals and deliverables include: develop research plan for flight deck data exchange requirements; develop initial technical and operational assessment report; identify key stakeholders and organization; and develop initial concept, scenarios, and use cases. FD-DER is a new program and the performance metrics are yet to be formulated.

Environment and Weather Impact Mitigation

Weather Program
Funding Request ($15,476,000)

Program Description/Activities:

The Weather Program performs applied research to minimize the impact of weather on the NAS. It consists of specific initiatives that support NextGen weather Operational Improvements as well as the FAA Strategic Goals related to Efficiency, Capacity, Safety, and Environmental Impacts. It facilitates the transition of legacy capabilities to meet NextGen requirements, often through collaborative and complementary initiatives with National Weather Service (NWS); as well as focused initiatives to help mitigate safety and/or efficiency issues associated with well-documented weather problems. The National Oceanic and Atmospheric Administration (NOAA)/ NWS platforms and forecasters also use algorithms developed by the Weather Program to provide regulatory forecast products and NAS decision aids. This research is an integral element in providing advanced forecast information that can be integrated into aviation decision-support capabilities.

Statutory Requirements:

Is this program statutorily mandated (Y/N): Yes

Aviation Investment and Modernization Act of 2007, Sec. 606 Weather Research

- Code of Federal Regulations (CFR) Title 14 Parts 25 and 33, Airplane and Engine Certification Requirements in Super cooled Large Drop, Mixed Phase, and Ice Crystal Icing Conditions
- National Weather Service Organic Act, 15 US Code 9
- National Transportation Safety Board (NTSB) 2014 Most Wanted List to improve transportation safety: "GENERAL AVIATION: IDENTIFY AND COMMUNICATE HAZARDOUS WEATHER"
- NextGen Segment Implementation Plan (NSIP) Lite
- NAS Enterprise Architecture Infrastructure RoadMaps, v11.6

Program Alignment with Strategic Goals:

DOT Strategic Goal	DOT RD&T Critical Transportation Topic
Safety	**Promoting safety**

This program supports the DOT's Strategic Goal of safety by providing systematic research and development within the FAA that will lead to the identification, assessment and mitigation of safety risks. By providing the research necessary to generate data, this data is then used to create and develop new safety standards that will be adopted throughout the aviation community.

In many cases aviation is the only transportation method available to reach rural communities and villages in Alaska. Weather Program research includes projects to improve cloud ceiling and visibility observations and forecasts used by General Aviation pilots flying in these remote regions, including mountain passes, valleys and landing strips where little or no weather observations are currently available.

Program Objectives:

The main goals of the FAA's Weather Program are to mitigate the impact of weather on the National Airspace System (NAS); mitigate weather related NAS safety and/or traffic flow efficiency issues; support the evolution of legacy weather capabilities into the capabilities developed and deployed as NextGen decision-support weather processes; and to improve the accuracy and relevancy of legacy weather products and services still mandated by FAA regulatory guidance and/or international agreement. This program addresses these goals in addressing the following described requirements.

- *Terminal Area Icing Weather Information for NextGen* research requirement:
  - Outcome supported: Manage terminal area icing weather information for operational decision making for ground and in-flight icing conditions, combining products of liquid water equivalent (LWE) research, winter weather ground icing research, and remote sensors and other new technology developments into a comprehensive terminal area icing weather product.
  - Benefits resulting: capability within the terminal area that provides users information on icing conditions with respect to their aircraft certification for safe operation.

- *Mitigating the Ice Crystal Weather Threat to Aircraft Turbine Engines* research requirement:
  - Outcome supported: Data archives that can be used to evaluate Part 33, Appendix D, provide a basis for the development of facility and analytical simulation methods for design and certification, and develop and evaluate the new ice crystal weather diagnosis and forecast tool ALPHA.
  - Benefits resulting: determination if current generation of airborne weather radar can be modified with no change to its "footprint" for avoidance of potentially hazardous icing conditions at en route flight levels.

- *Turbulence* research requirement:
  - Outcome supported: High resolution global detection and probabilistic forecasts of turbulence (clear-air, mountain wave, & convectively-induced) to support ATM DSTs, dispatchers and pilots.
  - Benefits resulting: Improved safety, increased capacity, and reduced atmospheric emissions within the NAS.

- *Convective Weather* research requirement:
  - Outcomes supported: Improve forecasting of thunderstorms and/or mitigate the impacts of thunderstorm occurrence on NAS efficiency and safety.
  - Provide offshore precipitation detection capabilities that compare satisfactorily in accuracy to current CONUS products, displayed for En Route and Oceanic controllers.
  - Develop high resolution frequently-updated CONUS and oceanic probabilistic convective storm forecasts to provide more accurate storm structure depiction.
  - Standardized probabilistic NextGen weather products utilized by NAS operators on a consistent basis, regardless of skill level, to increase ATM operational efficiency, enhance capacity, and improve safety.
  - Benefits resulting: Improved safety and capacity of the NAS.

- *Ceiling and Visibility* research requirement:
    - Outcome supported: High resolution, frequently-updated CONUS and Alaska analyses of low ceilings and restricted visibility conditions.
    - Increased General Aviation (GA) safety:
        - Instrument Meteorological Conditions (IMC) contributes to 30% of all GA accidents.
        - IMC is leading cause of fatal GA accidents in Alaska.
    - Reduce disruptions to terminal operations, such as low arrival rates and airport closures.
    - Benefits resulting: Increased safety of the NAS especially for GA.

- *Quality Assessment* research requirement:
    - Outcome supported: Scientific meteorological verification of aviation weather forecasts and analyses; increased weather information accuracy (i.e. greater forecast skill) and increased weather information relevance.
    - Benefits resulting: Data supporting decisions related to the transition of aviation weather forecast and analysis products based on their accuracy and quality for informing air traffic weather related operations, thereby enhancing airspace safety, capacity and efficiency.

- *Aviation Weather Demonstration and Evaluation (AWDE) Services* research requirement:
    - Outcome supported: Improved delivery of capabilities developed within the Weather Program.
    - Conduct user evaluations to ensure new products and techniques meet user requirements and needs.
    - Provide data and analysis to reduce programmatic risks, aid in the definition and validation of requirements , and inform Acquisition Management System (AMS) lifecycle management activities.
    - Develop a capability within the Aviation Weather Division to provide technical services to organizations advancing NextGen Aviation Weather Initiatives.
    - Benefits resulting: A well-defined approach for the identification, cost estimation, planning and conduct of operational suitability evaluations; coordination, planning and/or support of aviation weather activities associated with concept exploration, demonstrations and evaluations.

Market Surveys conducted by the Weather Program have shown that industry has little experience, expertise and incentive to perform applied aviation weather research. The investment (computer processing equipment, data retrieval, specialized personnel, etc.) required upfront and the fact that airlines and other users have limited budgets to spend on weather information leads to a low ROI that is not enough to sustain an industry effort. In cases where industry does develop new products, data or techniques, the resulting output is usually proprietary. Without oversight and the ability to test the output for accuracy and conformity to standards and safety regulations, it is generally not suitable for use by NextGen or NWS. Therefore the only viable option is for the Weather Program to conduct and manage research to meet FAA requirements.

Economic Impact of Regulatory Reform:

The applied research of the Weather Program supports NextGen Weather Operational Improvements, as well as the DOT Strategic Goal of Safety and the FAA Strategic Goals related to Efficiency, Capacity Safety and Environmental Impacts. The Weather Program does not conduct research that establishes policy.

Research Collaboration Partners:

Additionally, annual Weather Research Workshops are conducted, and recommendations from attendees including airlines, General Aviation, National Weather Service and FAA Air Traffic Management (ATM) are considered in developing the Weather Program Portfolio. Guidance from Research Evolution Plans developed with inputs from airlines, NOAA, FAA ATM have also been utilized to facilitate the identification and selection of research in the Weather Program portfolio. Finally, Weather Program personnel attend scientific conferences and symposia to learn about the latest aviation weather advances, new techniques, shortfalls in weather support and services, and emerging concerns, as well as to meet with other aviation and weather subject matter experts for exposure to discuss and gather inputs from both national and international user and research perspectives.

Program partners include:

- NOAA
- NASA
- Australia Bureau of Meteorology (BOM)
- Environmental and Climate Change Canada (ECCC)
- USAF
- Volpe National Transportation System Center
- National Resource Council (NRC)

Do non-government groups partner with this program?

The Weather Program has on-going partnerships with Delta Air Lines and United Airlines to determine the suitability of Weather Program capabilities for use by airline flight operations. Capabilities that provide timely and accurate observations and forecasts of turbulence are evaluated by the airline flight crews, dispatchers, and in-house meteorologists. Feedback from these evaluations enable the FAA to refine the products, ensuring successful implementation into airline operations. The airlines routinely provide resources in-kind, to include the expertise of the flight crews and aircraft flight time."

Acquisition/Assistance:

FAA programs in the research portfolio employ competitive contracting vehicle types and grants to acquire Conduct, Research, and Development activities. The FAA's acquisition management system offers researchers omnibus contract vehicles such as the SE2020, SE2025, and eFAST BPAs in which vendors competitively compete for TOs and BPA calls. The Broad Agency Announcement is another

competitive process the FAA utilizes for awarding basic research contracts. Grants are used to execute a portion of the FAA's research budget and where the FAA has the statutory authority to issue grants pursuant to the Aviation Research Grants Program. The FAA's Centers of Excellence (COE) is one example of a grant-based program that uses competition to select from among members of academia for COE participation. In the specific case of the COE grant program, it receives matching funds from industry sponsors.

Market surveys are conducted to determine if there are qualified vendors, beyond the government agencies and national laboratories currently utilized, to perform applied weather research in support of Weather Program objectives. Using AMS clause T3.2.1.2 as guidance, web-based research and vendor phone interviews are conducted to gather vendor-specific capability and experience information related to Weather Program research areas. Weather Program requirements are compared with the vendors' experience and expertise; and subject matter expert feedback is solicited to make the determination as to whether the vendors demonstrate the capability to support Weather Program requirements. This analysis assesses vendors with aviation weather R&D and forecasting experience. When Market Survey findings demonstrate that no commercial vendors possess the expertise and/or experience to support Weather Program objectives, and existing FAA contractual vehicles including SE2025 are not viable from a capability standpoint, the non-competitive approach is utilized. Additionally, the FAA NextGen Service Acquisition Review Committee provides a recommendation on the approach to follow.

In general, the FAA Research Portfolio includes Research Programs that use multi-year acquisitions. It does not leverage non-Federal funds.

Technology Transfer (T2):

The Weather Program has transferred advanced weather prediction models with high resolution and rapid updates as well as radar applications that enhance the forecast of aviation weather hazards, for implementation into NWS operations. Additionally, enhanced forecast capabilities in the areas of turbulence, in-flight icing, and ceiling and visibility have been transferred to the NWS Aviation Weather Center where they are available for use by NWS weather forecasters, airlines, GA, aircraft dispatchers, and FAA ATM.

The objective of the Weather Program is to develop and provide accurate and accessible weather forecasts and weather information to improve the safety, capacity, and efficiency of the National Airspace System (NAS). To support the achievement of this objective, a disciplined and rigorous approach is applied, to transfer enhanced forecast capabilities for hazardous weather including turbulence, in-flight icing, restricted ceilings and visibility, and convection, to both FAA and National Weather Service (NWS) platforms. This approach includes a Quality Assessment (QA) of performance, a Technical Review Panel (TRP) assessment to determine scientific validity, a Safety Risk Management (SRM) assessment to ensure that any risks are analyzed, assessed and mitigated, and an Operational Suitability Evaluation (OSE) to evaluate the research capability from a user perspective to determine suitability for operational decision-making.

QAs are performed by a skilled team of meteorologists, mathematicians, software engineers, and system analysts at the National Oceanic and Atmospheric Administration (NOAA) Earth System Research Laboratory (ESRL) who provide assessments, verifications, and detailed reports of the results.

NOAA ESRL staff conducting the QA activities provide verification and assessment of forecast quality and independent assessments of quality and skill of research capabilities that are in development or being considered for transition to operations. Two foundational elements form the basis for all quality assessments: verification techniques and measures that quantify characteristics and features of the weather forecast relative to its intended use and robust engineering to support the execution of the assessments. NOAA ESRL has developed and maintains an automated capability known as the Verification Requirements and Monitoring Capability (VRMC). The VRMC incorporates verification techniques and provides data processing and visualization capabilities to support assessments and provide ongoing performance monitoring of Weather Program capabilities. Results of QA activities include assessment reports, evaluation reports, reports on methodologies, and data analysis results.

TRPs consist of a meteorologist from the FAA Aviation Weather Division, a meteorologist from the NWS Office of Science and Technology Integration, and a subject matter expert (usually a meteorologist either from a University or another government agency). The TRP reviews the QA and evaluation reports as well as research capability Technical Description Documents and receives detailed briefings from both the QA team on the results of their evaluation and assessment and the Weather Program researchers who developed the capability. After a meeting to discuss/deliberate the research capability and its assessment, the TRP renders a recommendation as to whether the specific capability is both scientifically valid and ready for transitioning to operational use.

SRM assessments are required for proposed changes that affect NAS operations. It is a review process used to evaluate proposed changes to ensure any hazards that might be introduced into operations are identified and unacceptable risks are properly mitigated before the changes are implemented. It is performed by all affected stakeholders and other interested parties including FAA Air Traffic Control specialists, general engineers, aviation safety inspectors, dispatch safety inspectors, aviation safety analysts, NWS meteorologists, and Air Force Weather personnel. The process involves convening a meeting with the above personnel to review and analyze the proposed changes, identifying the hazards (if applicable) and defining a mitigation strategy for unacceptable risks. If identified risks cannot be mitigated to an acceptable level, the proposed change(s) will not be implemented. All assessments are documented with either a Safety Risk Management Decision Memorandum (used to document analyses when hazards are not identified) or a Safety Risk Management Document (used to document identified hazards and the mitigation strategy for unacceptable risks). Both documents are approved and signed by the "authority" proposing the change as well as the "authority" accepting the associated risk(s) (if applicable) due to the change.

OSEs are performed by the Aviation Weather Demonstration and Evaluation (AWDE) services team at the William J Hughes FAA Technical Center (WJHTC), who conduct programmatic liaison with the Weather Program project leads and research teams. The AWDE team consists of the following types of personnel: human factors, meteorologists, engineers, computer scientists, configuration management specialists, and network/system administration support. The AWDE team also has access to pilots, FAA air traffic controllers, and dispatchers as needed. This enables the identification, planning, and coordination necessary to conduct demonstration and evaluation services necessary to perform a comprehensive OSE. OSE activities include the conduct, lead, and participation in: Human-In-The-Loop evaluations; meteorological evaluations; software evaluations; exploring, integrating, and evaluating NextGen aviation weather concepts; and prototyping, demonstrating, and conducting other risk reduction activities leading to Investment Analysis Readiness Decisions. The AWDE team utilizes a dedicated lab located at the WJHTC providing the ability to access, archive, and

retrieve weather data, and a flexible, highly configurable, and managed environment with hardware and software allocated for OSEs. Demonstrations and evaluations can also take place in operational environments including: FAA Terminal Radar Approach Control Facilities, Towers, and Air Route Traffic Control Centers; airline and NWS facilities; and any other field location as applicable. OSE undertakings include leading efforts to provide human factors support, ensuring developments are meeting human factors standards and guidelines, and ensuring projects are meeting FAA Acquisition Management System lifecycle processes. Results of these efforts are documented in reports, briefings, and recommendations.

T2 performance is measured by the ability to transition weather research capabilities, whose development is driven by the execution of the goals, objectives, deliverables, schedules and cost estimates of detailed project plans, into operations via either an FAA or NWS platform. It is also measured by feedback received from users including airline dispatchers and pilots, General Aviation, FAA Air Traffic Management, and NWS weather forecasters.

Evaluation / Performance Measurement:

The Weather Program requires detailed Project Plans for all research efforts. These Project Plans provide the goals, objectives, deliverables, schedules and cost estimates for all research to be conducted. These Project Plans are the basis for technical directions/task orders provided to all vendors. Monthly status and financial reports, coupled with Program Management Reviews, Technical Interchange Meetings and deliverable reviews are utilized to assess plans and progress toward accomplishing project milestones and activities as well as to identify problems encountered and their attendant risks, mitigations, and issues. Program performance is also assessed based upon transition of research results to operational entities including FAA and NWS platforms. Weather program research results undergo a rigorous process prior to operational transition. Quality assessment of performance quality, technical review panels to determine scientific validity, safety risk management to ensure that any risks are analyzed, assessed and mitigated and an Operational Suitability Evaluation to evaluate the research capability from a user perspective to determine suitability for operational decision-making are all accomplished prior to transition. The Weather Program also coordinates with other government agencies including NOAA, NASA, and the USAF with the attendant benefits of reduced infrastructure costs, synergy with similar efforts, avoiding duplication of research, enhanced research transition effectiveness and enhanced gap identification.

It is extremely difficult to directly tie the integration of new techniques and algorithms developed via the Weather Program to the reduction of aviation-related fatalities. However, commercial aviation accidents in the US due to weather that involve fatalities have become very rare over the last 10 years. The fatal accident rate for General Aviation (GA) has remained somewhat stable with only minor reductions and remains a priority for the Weather Program. Therefore, the Weather Program conducts aviation weather research to increase the safety of flight for all types of aviation. Safety-related research areas include icing, cloud ceiling and visibility, turbulence, and convective weather. With the disproportionate accident rate in Alaska, the Weather Program also has a focus on Alaska hazardous weather targeted research especially in the areas of in-flight icing and restricted ceilings and visibility. Research program leads work with national “labs”, airlines, pilot associations, operators, air traffic managers, other meteorologists and the National Transportation Safety Board to determine shortfalls in aviation weather that lead to aviation accidents and fatalities. Additionally, the Weather Program conducts annual Weather Research Workshops, and collect research recommendations from attendees including airlines, GA, NWS, and FAA Air Traffic Management.

These shortfalls and recommendations are included in developing the basis for research topics to be considered for inclusion into the Weather Program Portfolio.

NextGen - Weather Technology in the Cockpit
Funding Request ($3,644,000)

Program Description/Activities:

The Weather Technology in the Cockpit (WTIC) program addresses NextGen Implementation Plan (NGIP) weather-related goals including reducing weather delays via increasing capacity and efficiency under adverse weather conditions, enhancing air traffic management (ATM) and aircraft re-routing flexibility to avoid adverse weather, enhancing safety in and around areas of adverse weather (i.e. reducing the number of weather-related accidents and incidents), and reducing greenhouse gas emissions through lower fuel consumption resulting from optimized routing and rerouting during adverse weather.

WTIC research projects are conducted to develop, verify, and validate recommendations for incorporation into Minimum Weather Service (MinWxSvc) standards and guidance documents to enhance safety and efficiency of commercial, business, and general aviation operations. For the WTIC program, a MinWxSvc is defined as:

- Minimum cockpit meteorological (MET) information
- Minimum performance standards (e.g. accuracy) of the MET information
- Minimum rendering standards
- Enhanced weather training
- Minimum cockpit technology capability recommendations

Further, projects are conducted in compliance with requirements originated by any combination of the following sources:

- National Transportation Safety Board (NTSB) 2014 Most Wanted List to improve transportation safety in the category: "GENERAL AVIATION: IDENTIFY AND COMMUNICATE HAZARDOUS WEATHER"
- Aircraft Operators and Pilots Association (AOPA) which identifies critical gaps for resolution to enhance General Aviation safety
- NTSB safety alerts which identify critical gaps that were causal factors in accidents that require research to resolve
- Alaska Air Carriers Association which identifies weather related gaps to enhance safe IFR and VFR flight operations in Alaska
- Flight Service Stations need for objective criteria to consistently determine 'VFR not recommended' (VNR) conditions
- NEXTGEN Segment Implementation Plan (NSIP)

To accomplish the program objective, the WTIC program performs research to identify causal factors in weather-related safety hazards/risks and NAS operational inefficiencies, and then applied research is performed to resolve the identified causal factors or gaps. The WTIC program also develops training enhancements as part of gap resolution.

Statutory Requirements:

Is this program statutorily mandated (Y/N): Yes

- Aviation Investment and Modernization Act of 2007, Sec. 606 Weather Research
- National Weather Service Organic Act, 15 US Code 9

Program Alignment with Strategic Goals:

DOT Strategic Goal	DOT RD&T Critical Transportation Topic
Innovation	**Improving Mobility**

This program supports the DOT's Strategic Goal of innovation by providing targeted research and development within the FAA that will lead to new technology development and deployment in the National Airspace System (NAS). By providing the necessary research to gather information, this will allow the assessment of regulatory approaches, it will foster information sharing and facilitate coordination, collaboration with industry and other stakeholders, and the ability to test and adopt new technologies throughout the NAS. Additionally, WTIC research focuses on adapting and enhancing existing weather products, information, and technology through innovative applications to foster safety and enhance mobility.

This is accomplished by performing applied research to resolve identified safety hazards and risks (risks are identified by the WTIC program or stakeholders including NTSB, AOPA, and the Alaska Air Carriers Association), and performance gaps linked to safety hazards and risks, to enhance aviation safety for commercial, business, and general aviation. Efforts include developing enhanced training for pilots, updated weather questions for the pilot written exam, producing visibility and ceiling information in remote areas that lack this information, and crowd sourcing aircraft weather-related information (winds, weather radar, etc.) for remote/rural areas that lack weather radar coverage and other weather infrastructure. As noted in a December 16, 2016 letter from the AOPA Director of Airspace and Air Traffic, they "believe WTIC should make it a priority to evaluate VNR given the research could influence FAA policy, decision, weather delivery applications and pilot education." Consistent with this stakeholder input, the WTIC program is performing research to enhance the utility and objectivity of the VNR statement to enhance safety for pilots flying under Visual Flight Rules (VFR).

The WTIC program directly supports rural and remote areas by performing applied research to produce weather information using innovative techniques for areas that lack the infrastructure and economy to use traditional weather systems. As an example, the WTIC program is researching using Alaska weather cameras to produce ceiling and visibility information in areas that lack weather technology, such as ceilometers, to produce this information. As documented in a February 26, 2018 letter from the President and the Director of the Alaska Air Carriers Association, "Alaska is deficient in infrastructure yet over 82% of communities relay entirely on aviation for transportation." The letter also states that they are "thrilled" at the prospect of the weather information that may be able to be produced from the WTIC crowd sourcing research without the need for any new infrastructure. The US Helicopter Safety Team has also identified this research as applicable in the Gulf of Mexico

due to the lack of weather radar coverage and other weather information in this region needed to enhance the safety of helicopter flights to oilrigs.

Program Objectives:

The main goal of the Weather Technology in the Cockpit (WTIC) research program is to develop MinWxSvc recommendations that address the need for additional or higher quality meteorological (MET) information in the cockpit or integrated with decision support tools (DSTs) as identified in the NAS mid-term Concept of Operations. This MET information will enable NextGen operations and performance based navigation to achieve planned benefits in adverse weather conditions.

WTIC Program research will identify adverse-weather related operational shortfalls, operational safety hazards/risks, shortfalls in cockpit MET information, and shortfalls in pilot understanding and proper use of MET information. The identified risks, gaps, and shortfalls will be reviewed with stakeholders (pilots, weather information providers, weather technology manufacturers, NTSB, etc.) to assess the need and prioritization for resolving them. Based on the review of the risks, gaps, and shortfall, WTIC will perform applied research to identify resolutions that will be incorporated into the WTIC MinWxSvc recommendations for Part 121/135 and Part 91/135 aircraft. The resolution of the operational shortfalls and safety hazards/risks support NextGen goals for improved NAS efficiency and safety. Examples of WTIC research projects to develop a Part 121/135 MinWxSvc, a Part 91/135 MinWxSvc, and enhanced pilot training are as follows.

- Remote Oceanic Meteorological Information (ROMIO)
  - Outcome supported: Reduce the lack of convective information in oceanic regions by providing outputs from the Cloud Top Height (CTH) product and the Convective Diagnosis Oceanic (CDO) product to cockpits in the oceanic region.
  - Benefits resulting: These two products when used together provide a good characterization of convective storms with CTH providing the full extent of cloud cover and height, and CDO showing the location of updrafts and lightning hazards. This information will enhance safety by improving convective storm avoidance and it will enhance efficiency since pilots will have more detailed information and the information will be provided earlier than onboard weather radar.

- Crowd Sourcing
  - Outcome supported: Using FAA and non-FAA cameras produce visibility, ceiling, and surface wind information in rural and remote areas and at uncontrolled airports. Crowd sourcing will use a combination of human and automation inputs to evaluate images from cameras to produce this critical information in areas that lack infrastructure thus this lack of information.
  - Benefits supported: This project will enhance safety by providing weather information not currently available. Per NTSB statistics, wind is by far the leading cause of accidents for general aviation and poor visibility is one of the leading causes of fatalities for general aviation. This information will resolve multiple gaps associated with these safety issues.

- VNR Objective Criteria
  - Outcome supported: AOPA and other stakeholders have identified that the utility of VNR issuance has been greatly reduced due to its subjective criteria that makes it only available

by voice. This research is attempting to develop objective criteria for its issuance to enhance its utility and to make it available on self-assisted services versus only through calls to a Flight Service Station.
    - Benefits supported: Based on previous research in 2006, VNR issuance was found to influence VFR pilots to delay, cancel, or look for alternate airports/routes approximately 77% of the time. However, since that study, pilots now regularly use self-assisted briefing services versus calling Flight Service stations so the utility of VNR has been significantly reduced since VNR currently is only able to be issued by a flight service specialist. If successful, the WTIC research will significantly enhance the utility of VNR to VFR pilots by making it more objective and compatible for issuance by automated systems.

- Slant Ranging
    - Outcome supported: Enhance the capability of GA pilots to judge distances and visibility. The inability of VFR pilots to accurately assess visibility has been identified as a causal factor of inadvertent flight into Instrument Meteorological Conditions (IMC). This research evaluated the benefits of pilots using a slant ranging technique in their cockpits that requires no additional equipage or any associated costs, but is rarely included in training. The results of the study showed over a 50% improvement in pilot accuracy in judging out the window visibility and distance judgements.
    - Benefits supported: By training pilots on the slant ranging technique it will resolve one of the identified causal factors of inadvertent flight into IMC which per NTSB is one of the highest causes of GA fatalities.

The WTIC program performed numerous gap analyses to identify issues and market failures based on operational shortfalls in commercial, business, and general aviation. For commercial aviation, most market failures related to the lack of MET information in the cockpit to enable safe and efficient pilot decision making. In cases where industry does develop new products, data or techniques, the resulting output is usually proprietary. Without oversight and the ability to test the output for accuracy and conformity to standards and safety regulations, it is generally not suitable for use by NextGen or NWS. Therefore the only viable option is for WTIC or other FAA programs to conduct research to meet FAA requirements. In addition, commercial entities typically perform research when there is strong potential to get a return on investment so these gaps in MET information exist due to industry not performing the necessary research to fill them.

For General Aviation, a market failure is the lack of research to identify performance limitations of current systems. Industry provides manuals on the use of their systems, but they do not perform research to identify limitations of their systems/information. An example is that a weather service provider typically identifies the latency induced by their data link system, but they do not perform research to determine the total latency of the MET information that includes the latency in NEXRAD mosaics as well as the data link resulting in pilot misperceptions. The cost to consumers is much lower if the FAA performs this type of research since the results are available to industry without duplication of research efforts. The other market failure is in performing Human Factors analyses on the rendering of MET information in the cockpit. Industry providers may perform research to determine display characteristics that will result in increased sales, but the cost of performing research to identify safety issues and cockpit compatibility issues is too high so they "look" to the FAA to provide these guidelines. An example of this limitation is WTIC research identified an issue that many MET displays on the market lack the proper salience for pilots to notice a state (i.e., VFR to IMC conditions) change on the displays in flight. For example, METARs that changed from indicating VFR

to IMC were typically observed by pilots only 30% to 50% of the time on popular displays currently on the market so though the information was being provided, it was not being noticed by pilots due to poor human factors research and design. The delay or lack in GA pilot recognition of changing weather conditions is a gap associated with inadvertent flight into IMC. Industry relies on WTIC research to provide standards and guidance on human factors designs to achieve a desired level of safety. Industry then performs research to obtain competitive advantages and to implement the WTIC safety-related standards and guidance. The final market failure is that industry does not perform research on accidents and incidents to identify safety related issues since this research rarely provides a return on investment for industry. The WTIC program looks for additional capabilities needed in cockpit MET technology and information to resolve causal factors in reported accidents and incidents. Once the FAA endorses the need for these capabilities to enhance safety, industry performs the research to incorporate them into their products. WTIC research produced numerous recommendations for Mobile MET applications to enhance safety and provided these to pilots and industry. Users will then drive the market to adapt the WTIC endorsed enhancements. Another example of a safety related capability being researched by WTIC is a Time to Contact display. This display may resolve the gap of GA pilots taking too long in making adverse weather avoidance decisions resulting in inadvertent flight into IMC. Industry would not perform this type of research since it is not likely to provide a significant return on investment, but if the capability is found to provide benefit, they typically perform the necessary research to incorporate the recommendation into their systems.

Additionally, WTIC adheres to requirements as necessary from the following groups:

- Alaska Air Carriers Association identifies weather related gaps to enhance safe IFR and VFR flight operations in Alaska
- Flight Service Stations need for objective criteria to consistently determine VFR not recommended (VNR) conditions "
- NEXTGEN Segment Implementation Plan (NSIP)
- Aircraft Operators and Pilots Association (AOPA) identifies critical gaps for resolution to enhance GA safety
- NTSB safety alerts identify critical gaps that were causal factors in accidents that require research to resolve.

Economic Impact of Regulatory Reform:

The research performed by the WTIC Program and the format of the MinWxSvc recommendations is intended to prevent the need to develop new regulation and policy. By providing compelling research data to support recommendations, providing details on a method to incorporate the recommendations, and allowing industry to adapt the recommendations to their technology, there is no need for additional regulations. Industry is supportive of WTIC research since it enhances safety and the benefits of commercial products in areas that typically do not provide a return on investment so the needed research is rarely performed by industry. In addition, by the WTIC program developing recommendations for pilots and other users on capabilities and performance that are achievable and desirable, the educated consumers create a business case for industry to advance their products to incorporate the recommendations for safety and efficiency enhancements. Overall, the research performed by the WTIC program supports NextGen Weather Operational Improvements as well as

DOT Strategic Goal of Safety and the FAA Strategic Goals related to Efficiency, Capacity, Safety, and Environmental Impacts.

Research Collaboration Partners:

A metric of the utilization of REDAC inputs and alignment with their views can be noted in the minutes from the Fall 2017 NAS Ops REDAC review which states, "The subcommittee emphasized that the WTIC program is of high value and a beneficial activity as it is transitioning into commercial applications."

WTIC Program personnel attend scientific conferences, symposia, and General Aviation events/fly-ins to learn about the latest aviation weather advances, new techniques, shortfalls in weather support and services, and emerging concerns, as well as to meet with stakeholders and weather subject matter experts for exposure to discuss and gather inputs from both national and international user, industry, and research perspectives.

Rockwell Collins – Through a partnership agreement where research is jointly performed by the WTIC program and Rockwell Collins, contractor support is provided at a reduced rate and the research benefits by the increased resources. This partnership has been performing the Crowd Sourcing research that has identified initial methods to produce ceiling and visibility information using camera images and commercial crowd sourcing resources. It has also demonstrated the capability to produce weather radar outputs from photos of commercial aircraft weather radar, processing them through commercial optical character recognition software to digitize the information, and then recreate the original image georeferenced. These innovative techniques have the potential to produce critical MET information in remote and rural areas without the need for new and costly infrastructure.

FAA Future Flight Services and Flight Services, - Future Flight Services is working to lower the cost of providing their services by increasing the use of automation and pilot self-assisted services. The WTIC program performs research to ensure that the resulting services still meet MinWxSvc recommendations and research to identify methods to automate while still meeting pilot needs. The VNR project is an example of a WTIC program that provides outputs to support Future Flight Service need to automate VNR and WTIC's development of MinWxSvc recommendations.

Aircraft Owners and Pilot's Association (AOPA) – The partnership with AOPA has two benefits. First, AOPA identifies gaps and issues identified by their membership. Gaps identified by AOPA include the reduced utility of VNR and the number of Pilot Reports (PIREPS) generated and their accuracy. WTIC uses these inputs to identify gaps and operational shortfalls that need to be resolved and then performs the research to resolve them. The second benefit is that AOPA assists with the outreach of the research results that reduce/resolve issues that their membership has identified. In addition, due to their large membership, AOPA is able to provide market pressure on manufacturers to implement WTIC recommendations to resolve the issues. AOPA is highly motivated to support WTIC recommendations since they recognize that the cost to implement these recommendations is much lower if driven by the market versus excessive standards and regulations. AOPA also publishes recommendations to their pilots to make them educated consumers that also drives the market to incorporate WTIC recommended enhancements.

National Association of Flight Instructors (NAFI) - NAFI participates in WTIC research to assess the quality of their instructors in teaching aviation weather. Based on WTIC research that showed private pilots scores on weather knowledge exams ranged from approximately 50% to 60%, they want to enhance their weather training and ensure that their instructors are also satisfactorily knowledgeable in aviation weather. NAFI has also requested that WTIC program personnel provide seminars to their instructors on ways to enhance weather training, weather areas that research has shown are deficient and providing information on WTIC MinWxSvc recommendations. NAFI instructors are also able to provide inputs to WTIC research by identifying weather related issues they observe with their students.

FAA Flight Standards – FAA Flight Standards works with WTIC on a number of research projects to identify safety issues. They also are a consumer of WTIC MinWxSvc recommendations by incorporating them into standards, guidance documents, and handbooks.

RTCA – RTCA has a similar role as FAA Flight Standards except they are a commercial body that produces standards and guidance documents. Since RTCA is primarily a commercial organization, their requests for research help align WTIC research with industry needs (areas that they will not research due to lack of return on investment (ROI)). They are also a consumer of WTIC research since they produce standards and guidance documents that incorporate WTIC recommendations.

FAA GA Center of Excellence (COE) (named PEGASAS) grant – The GA COE performs much of the WTIC GA related research with in-kind matching for each dollar in the grant resulting in significant savings in the cost of doing the research. In addition, the industry partners of the COE provide efficient transition paths to implementation.

Embry Riddle (ERAU) grant – ERAU is performing research to enhance pilot training and identify pilot deficiencies in weather knowledge. Under the terms of the grant, ERAU provides in-kind matching for each dollar in the grant resulting in significant savings in the cost of doing the research.

NTSB – NTSB provides inputs to the WTIC program by assisting with identifying causal factors in aviation accidents. These details highlight gaps that require resolution to enhance safety. NTSB also reviews and provides inputs on WTIC research projects to resolve these gaps based on their expertise and knowledge of accident casual factors.

NASA – NASA maintains the Aviation Safety and Reporting System (ASRS) and performs callbacks to pilots on weather related accidents and incidents that are reported to ASRS. These detailed callbacks provide insights into gaps, risks, and other attributable factors to the reported accident/incident. This work is funded and being performed under an interagency agreement with the WTIC program.

United, Delta, and American Airlines – These commercial airlines perform operational demonstrations of WTIC MinWxSvc recommendations under Other Transactional Agreements (OTAs) where the WTIC program is only charged for WTIC specific activities so the demonstrations "piggyback" on airline operations to reduce costs. In addition to reduced costs in performing the demonstrations, having airline participation has enhanced the ability to transition research to implementation and the ability of the airlines to internally plan to be aligned with the WTIC MinWxSvc recommendations and associated/linked NextGen concepts. As an example, Delta Airlines incorporated up-linking EDR and the EDR viewer immediately after the successful demonstration and benefits analysis.

Do non-government groups partner with this program?

Yes. In the list above, only FAA Flight Standards, FAA Future Flight Services, NASA, and NTSB are government partners. The non-government partners and their contributions are listed above.

Acquisition/Assistance:

Does this program utilize competitive procurement processes? Yes

FAA programs in the research portfolio employ competitive contracting vehicle types and grants to acquire Conduct, Research, and Development activities. The FAA's acquisition management system offers researchers omnibus contract vehicles such as the SE2020, SE2025, and eFAST BPAs in which vendors competitively compete for TOs and BPA calls. The Broad Agency Announcement is another competitive process the FAA utilizes for awarding basic research contracts. Grants are used to execute a portion of the FAA's research budget and where the FAA has the statutory authority to issue grants pursuant to the Aviation Research Grants Program. The FAA's Centers of Excellence (COE) is one example of a grant-based program that uses competition to select from among members of academia for COE participation. In the specific case of the COE grant program, it receives matching funds from industry sponsors.

Market surveys determine if there are qualified vendors, beyond the government agencies and national laboratories currently utilized, to perform applied weather research in support of WTIC objectives. Using AMS clause T3.2.1.2 as guidance, web-based research and vendor phone interviews gather vendor-specific capability and experience information related to WTIC research areas. WTIC Program requirements are compared with the vendors' experience and expertise; and subject matter expert feedback is solicited to make the determination as to whether the vendors demonstrate the necessary capabilities. When Market Survey findings demonstrate that no commercial vendors possess the expertise and/or experience to support WTIC Program objectives, and existing FAA contractual vehicles including SE2025 are not viable from a capability standpoint, the non-competitive approach is utilized. Additionally, the FAA NextGen Service Acquisition Review Committee provides a recommendation on the approach to follow.

In general, the FAA Research Portfolio includes Research Programs that use multi-year acquisitions.

The WTIC program does not leverage non-Federal funds.

Technology Transfer (T2):

Additionally, WTIC Program personnel outreach WTIC research results to targeted stakeholders that consist of pilots, weather service providers, MET technology and application manufacturers, flight instructors and other training organizations, and organizations that produce aviation related standards and guidance documents. Outreach is accomplished by providing research results and MinWxSvc recommendations directly to stakeholders, to public, private, and trade magazines and periodicals for publication, and to conference, seminar, fly-in, and weather workshop attendees.

The objective of the Weather Technology in the Cockpit (WTIC) Program is to develop, verify, and validate recommendations for incorporation into Minimum Weather Service (MinWxSvc)

standards/guidance documents. A MinWxSvc is defined for this program as being the minimum cockpit meteorological (MET) information, minimum performance standards (i.e. accuracy) of the MET information, minimum rendering standards, enhanced weather training, and minimum cockpit technology capability recommendations. The WTIC Program is developing one MinWxSvc for Part 121 and 135 aircraft and another for Part 91 aircraft. Each MinWxSvc (Part 121/135 and Part 91) is the compilation of individual MinWxSvc recommendations. To enable the program's objectives, transfer of the MinWxSvc recommendations to standards, guidance, or implementation involves various organizations and processes that vary based on the content of the specific MinWxSvc recommendation and the part type aircraft (Part 91, 121, or 135) being addressed. Below is a list of the primary organizations involved in the WTIC T2 process, their roles, the results, and how performance is measured.

FAA (Flight Standards) and non-FAA Standards Development Organizations (i.e. RTCA, SAE) receive MinWxSvc recommendations with a transition path to standards, advisory circulars, and other formal guidance documents. The organization that receives the MinWxSvc recommendation is based on the content of the recommendation and the impacted aircraft (Part 91, 135, or 121). The FAA and non-FAA standards development organizations perform an assessment of the recommendations by evaluating the overall recommendation, supporting and compelling research which is part of the MinWxSvc recommendation, and gaps being addressed for resolution by the recommendation that are also detailed in the MinWxSvc recommendation. Based on their evaluation and acceptance of a MinWxSvc recommendation, a non-FAA standards organization will incorporate the recommendation into the appropriate standard or guidance document for use by industry. Since MinWxSvc recommendations include compelling research data to support the recommendation as well as identifying the gap being resolved, industry is provided a business case to compel adoption of the resulting standard without the need to mandate new policy or requirements. For this category of MinWxSvc recommendation, the WTIC program measures performance and success by monitoring the number of recommendations that are incorporated into official standards and guidance documents. The result of this overall activity is to provide a means to implementation with minimum industry cost and risk, and to encourage competition and innovation while ensuring that cockpit MET information and technology meet minimum standards to support safe and efficient flight operations and pilot decision-making during adverse weather.

Industry receives MinWxSvc recommendations that have a transition path to specific MET data-linked information services that include necessary weather information parameters or cockpit weather technology products that produce services specifically for cockpit use. These MinWxSvc recommendations are provided to industry with the objective of influencing them to incorporate the recommendations into their existing services or technologies to ensure pilots receive the minimum cockpit MET information necessary to support safe and efficient flight in adverse weather conditions. These MinWxSvc recommendations include details of the recommendation, research results supporting the recommendation, minimum performance assessments necessary to achieve the desired benefits, and a method to incorporate the recommendation. For this category of MinWxSvc recommendation, the WTIC program measures performance and success by the number of companies or products that incorporate the recommendation. These recommendations are intended to resolve confirmed gaps in pilot cockpit MET information or technology while still fostering innovation and competition by allowing industry to implement the recommendations into their own processes and designs or to use the methodology or product detailed in the MinWxSvc recommendation. The recommendations also allow them to exceed the minimum standards. An

additional performance measure is feedback from industry on the value of the recommendation to help them align their new products and development efforts to achieve FAA objectives and goals.

Pilots receive the third type of MinWxSvc recommendation via pilot organizations such as Aircraft Owners Pilot Association (AOPA) and National Association of Flight Instructors (NAFI), and via trade magazines. These recommendations are written to inform pilots of specific MET information and technology features or capabilities that they should purchase to obtain the safety benefits they anticipate relative to adverse weather decision-making. The philosophy of using pilot oriented MinWxSvc recommendations is to make pilots educated consumers that will push the market to incorporate safety enhancements that reduce or resolve gaps that are attributable to safety related risks and hazards. This methodology also provides business cases for industry to incorporate MinWxSvc recommendations or meet recommended performance levels being recommended since the market is demanding these enhancements. This methodology avoids the use of over regulating the industry, prevents reducing competition, and allows for industry innovation while still resolving known safety related gaps associated with adverse weather. The WTIC Program monitors performance for this category of MinWxSvc recommendations by tracking the number of published articles and pilot organizations endorsing the recommendations and the number of products advertised as meeting the recommendations.

With all three types of MinWxSvc recommendations, quality is achieved using manufacturers' internal processes while yielding products that they demonstrate meet the MinWxSvc recommendations. This enables MET services to achieve desired quality levels without including specific testing or demonstration in the recommendations.

Evaluation / Performance Measurement:

The WTIC Program monitors success of outreach by the number of standards and guidance documents that reference WTIC research or invoke WTIC MinWxSvc recommendations. Other metrics are the number of airlines and commercial products that incorporate MinWxSvc recommendations, feedback from stakeholders via meetings, conferences, and letters, number of articles published by private and trade magazines, and the incorporation of training recommendations into training curriculums. Another metric is the reduction or elimination of resolved gaps being causal factors in aviation accidents and incidents. Benefits analyses to monitor safety and efficiency improvements are performed as part of WTIC research and as part of monitoring transition success, or benefits are solicited from stakeholders, typically commercial airlines, incorporating MinWxSvc recommendations. As an example, Delta Airlines provided proprietary feedback on the benefits of up-linking EDR to cockpits as part of the partnership agreement.

Environment and Energy
Funding Request ($18,013,000)

Program Description/Activities:

The Environment and Energy (E&E) Program is a key component of the FAA's environment and energy strategy. This Program advances our understanding of aviation noise and emissions at their source, how they propagate and are modified in the atmosphere, and their ultimate health and welfare impacts on the population – both near airports and much farther afield. This knowledge is then incorporated into an integrated aviation environmental tool suite that can be used to evaluate the full breadth of environmental mitigation solutions that are being developed. The aviation environmental tool suite is built upon a sound scientific understanding of aviation noise and emissions as well as their environmental, health, and welfare impacts. The Program uses these models and knowledge to inform decision-making on technology development, operational procedures, and policies relating to aviation's energy use and environmental impacts.

Statutory Requirements:

Is this program statutorily mandated (Y/N): Yes

This program is required to inform decision making related to Title 49 Sections 301, 40101, 44714, 44715, 47502, and 47508 as well as Title 42 Section 7571 and 7572.

Program Alignment with Strategic Goals:

DOT Strategic Goal	DOT RD&T Critical Transportation Topic
Infrastructure	**Preserving the environment**

The program's goals are in line with the DOT strategic goals in Infrastructure. Achieving our environmental and energy goals will allow the nation's air transportation system to grow thereby ensuring continued mobility and economic growth that accompanies the air transport sector. Innovation is required in developing the technological and operational measures to reduce aviation's impacts on the environment, which will also improve the efficiency of the airspace system and promote growth of the sector to new entrants such as unmanned vehicles, supersonic transport aircraft, and commercial space vehicles. Updated policies and regulatory framework that better reflect our improved understanding of environmental and energy impacts, and the innovations in aircraft and engine technologies are necessary to improve the efficiency, effectiveness and accountability of the airspace system to our aviation users and stakeholders.

This program does not have an impact on rural communities.

Program Objectives:

The main goal of the Environment and Energy program is advancing the understanding of aviation noise and emissions at their source, how they propagate and are modified in the atmosphere, and

their ultimate health and welfare impacts on the population – both near airports and much farther afield.

This program is producing data and knowledge that are the scientific and technical foundation for decision making on aviation noise. Research that is several decades old provides the foundation for the current definition of aircraft noise significance, land use compatibility guidelines, and Federally funded noise mitigation programs. The project supports the Aviation Noise Research Roadmap that is advancing our understanding of the impacts of aviation noise on community annoyance, sleep, health, and children's learning. This effort considers the noise from commercial aircraft and helicopters that are currently in operation. The project also supports noise measurements of existing air vehicle types and new entrants such as commercial supersonic aircraft, unmanned aerial systems, and commercial space vehicles to support noise certification, a requirement for airworthiness. Additionally, the project provides the scientific foundation for FAA's noise-related analytical tool capabilities and functionality.

This program is producing data and knowledge that are the scientific and technical foundation for decision making on aviation emissions. The project supports FAA's Aviation Emissions Characterization Research Roadmap that is advancing our understanding of how aviation emissions form and are dispersed in the atmosphere. Due to their adverse health impacts, the focus of the research is on aviation particulate matter emissions, a regulated criteria pollutant in the United States. This effort considers the emissions from commercial aircraft and helicopters that are currently in operation. It is also laying the groundwork for the future consideration of aviation emissions from new entrants. Additionally, the project provides the scientific foundation for FAA's emissions–related analytical tool capabilities and functionality.

This program is developing a comprehensive suite of analytical tools, known as the Aviation Environmental Tool Suite, to quantify the environmental consequences and impacts of aviation. These analytical tools provide the FAA with the ability to characterize and quantify the interdependencies among aviation-related noise and emissions, impacts on health and welfare, and industry and consumer costs, under different policy, technology, operational, and market scenarios. At the center of these analytical tools is the Aviation Environmental Design Tool (AEDT), which can model the noise, fuel burn and exhaust emissions that result from aircraft operations from the airport gate through ground movements, takeoff, climb-out, cruise, approach, and landing at the aircraft's final destination. AEDT has replaced several legacy tools for environmental compliance. This project is also supporting the development of analytical tools that quantify the costs and benefits of varied solutions to reduce aviation noise and emissions as well models that assess aircraft performance.

This program is using the Aviation Environmental Tool Suite to inform the development of solutions to mitigate the environmental consequences and impacts of aviation. Efforts under this project support the development of standards, market-based measures, and policies within ICAO Committee on Aviation Environmental Protection (CAEP) for subsonic and supersonic civil aircraft. Efforts also support the development of operational procedure concepts to reduce noise from aircraft and helicopters.

The negative impacts of aviation noise and emissions on public health and welfare are not priced into the market. In other words, aircraft operators do not have a return on investment for the use of quieter aircraft that produce fewer emissions. To compensate for this market failure, noise and emissions are regulated at the vehicle level as a part of air-worthiness standards. Further, the

cumulative noise exposure caused by aviation is regulated through the Part 150 and Part 161 programs. Finally, aviation noise and emissions are regulated through the National Environmental Policy Act (NEPA). This R&D program informs the development of new vehicle noise and emissions standards and other policy measures through ICAO CAEP; the metrics, tools, and methods that are used to regulate cumulative noise exposure and meet NEPA requirements; and the science that underlies all of these.

Economic Impact of Regulatory Reform:

The analytical tools that are being developed by the Environment and Energy Program allow us to inform the development of regulations to ensure that they are cost-effective, reasonable, and will support continued aviation growth. The aviation industry relies on international harmonization of regulations to ensure they can sell and use their products globally. It is thus in the national interest to work internationally to develop them, and to ensure that solutions exist that could cost-effectively meet the desired outcome of interest without impacting aviation growth. The tools being developed by the Environment and Energy Program are able to analyze a broad range of technological innovations in an integrated fashion to efficiently consider the relative merits of a wide range of potential solutions that could meet the desired outcomes of interest.

The efforts of the Environment and Energy Program work in concert with the technology maturation of the NextGen Environment Program. Through the CLEEN Program, technologies are being matured that will help industry to meet, and potentially exceed, noise and emissions regulations that could come in the future.

Economic Impact of Permitting Reform

While the Environment and Energy Program is developing tools to help streamline the environmental approval process, it is not directed toward permitting reform per se.

Performance-Based Regulations and Safety:

The Environment and Energy Program is developing tools and data to inform the development of cost-effective technological solutions that could be used to meet desired, measurable outcomes in terms of noise and emissions. The Program is considering the full breadth of technological innovations being considered by the aviation industry. As such, it is helping industry identify a broad array of solutions to enable both aviation growth and continued reductions in noise and emissions.

Research Collaboration Partners:

The program incorporates inputs received from stakeholders, such as industry and non-governmental organizations, as well as those from other agencies, including NASA, DOE, EPA, and DOD, most of which is collected during formal review processes conducted during rulemaking comment periods, program reviews, and interagency processing of agency positions and decision documents. The program also takes into consideration the input received from experts, such as the members of the ASCENT Center of Excellence, the Continuous Lower Energy, Emissions and Noise (CLEEN) Consortium, ICAO CAEP meetings, and those that participate at FAA and industry events such as the annual Aviation Emissions Characterization Roadmap meeting and the semi-annual FAA-hosted noise research meetings. Those involved in the program are heavily engaged internationally

and seek input from overseas stakeholders. The program relies on the input and feedback provided by the Research, Engineering, & Development Advisory Committee (REDAC). Finally, direct feedback from the AEDT software from its user base is obtained through the AEDT support website.

The program has many partners and stakeholders including industry, airport communities, environmental non-governmental organizations, foreign governments, ICAO CAEP, the ASCENT COE, and the DOT Volpe Center. The program benefits from these varied partners by ensuring that the research is well-balanced, relevant, and addresses the needs of a broad range of stakeholders. Specific partnerships are listed below.

The Aviation Noise Research Roadmap effort is coordinated through the Federal Interagency Committee on Aviation Noise (FICAN), which includes the Department of Defense, Department of the Interior, Department of Transportation, Environmental Protection Agency, NASA, and the Department of Housing and Urban Development. The National Institutes of Health are co-funding the research to quantify the health impacts of aviation noise that is being done by the ASCENT COE. The Airport Cooperation Research Program (ACRP) of the National Academies is funding research on the impacts of aviation noise on children's learning. The FAA was a part of the ACRP Panel overseeing the work. ACRP funded the pilot study on community annoyance to aircraft noise, which led to a subsequent FAA-funded project. The FAA was a part of the ACRP Panel overseeing the work. NASA is co-funding efforts to measure helicopter noise with FAA. Entities in Europe are funding work on the impact of noise on sleep that is aligned with the FAA work.

This project is coordinated through the Aviation Emissions Characterization Roadmap effort, which includes many participants from the private sector and Government Agencies as well as Transport Canada. The Airport Cooperation Research Program (ACRP) of the National Academies is funding research on emissions from commercial space vehicles. NASA is co-funding efforts to measure emissions from aircraft operations during cruise. Entities in Europe are funding work to measure the emissions from aircraft engines.

NASA is developing analytical tools to evaluate aircraft performance, including fuel burn and noise. These tools have been integrated through FAA funding into the Environmental Design Space, which is used by both NASA and the FAA to evaluate aircraft and engine technologies.

Massport is contributing support to the development of new reduced noise procedures for subsonic aircraft at Boston Logan Airport. NASA is supporting the development of reduced noise procedures for helicopters.

As mentioned, research conducted by ASCENT is reviewed twice per year by the ASCENT Advisory Committee, which has more than 60 private sector stakeholders. As a result legislative matching contribution requirements for all COE research, ASCENT currently has roughly 70 industry partners involved in conducting their research.

Do non-government groups partner with this program?

Yes. Non-government groups contribute cost-share to the work performed by the ASCENT COE. Further, they provide feedback on the work of the program through the various meetings listed previously.

Acquisition/Assistance:

Does this program utilize competitive procurement processes? Yes.

FAA programs in the research portfolio employ competitive contracting vehicle types and grants to acquire and conduct, Research, and Development activities. The FAA's acquisition management system offers researchers omnibus contract vehicles such as the SE2020, SE2025, and eFAST BPAs in which vendors competitively compete for TOs and BPA calls. The Broad Agency Announcement is another competitive process the FAA utilizes for awarding basic research contracts. Grants are used to execute a portion of the FAA's research budget where the FAA has the statutory authority to issue grants pursuant to the Aviation Research Grants Program. The FAA's Centers of Excellence (COE) is one example of a grant-based program that uses competition to select from among members of academia for COE participation. In the specific case of the COE grant program, it receives matching funds from industry sponsors. This program also conducts work with the Volpe Center through Inter-Agency Agreements.

The program uses competitive awards.

In general, the FAA Research Portfolio includes Research Programs that use multi-year acquisitions.

Does this program leverage non-Federal funds? (Y/N): Yes

The research conducted through the ASCENT COE requires a 100% cost-share match.

Technology Transfer (T2):

The results from this project result in improved knowledge for decision makers at FAA as well as the general public. Results from the work are made available as they are finalized through websites for the FAA, ASCENT COE, and Volpe Transportation Center (in addition to the NTL).

Students who receive funding through the ASCENT COE graduate every year and enter the workforce. There are over 100 students currently supported by the ASCENT COE. Over its duration from 2003 to 2013, the Partnership for Air Transportation Noise and Emissions Reduction (PARTNER) COE supported over 280 students who have now entered the work force with knowledge about how aviation could overcome the challenges posed by aviation noise and emissions. Several of these individuals currently work at FAA.

The results from this project also result in improved analytical tools for decision makers at the FAA. AEDT is available for purchase by the general public through the AEDT website - https://aedt.faa.gov. Updates to AEDT that improve the usability and accuracy of the tool are provided every six months. Updates to cost benefit analysis and aircraft performance assessment tools are available to FAA and contractors as they are developed.

Finally, the results from this project result in analyses that inform decision makers at the FAA. Most of the work is made available within 1 year. The analyses also inform decisions that are needed for ICAO CAEP Meetings.

Evaluation / Performance Measurement:

DOT Infrastructure Performance Goal - SO1 – Simplify and enhance environmental review process for major transportation projects:

The Environment & Energy Program is providing knowledge and tools to improve and streamline the required environmental review processes for infrastructure projects and other Federal actions. Given the sensitivity and high visibility of such activities in today's environment, the Program is developing an improved screening tool that will allow users to rapidly and conclusively identify Federal actions that do not require further environmental review, thus reducing the time and costs for environmental reviews.

DOT Infrastructure Performance Goal – SO3 – Decrease average flight wait time:

Environmental impacts, especially aircraft noise, are often the number one cause of opposition to airport capacity expansion and airspace redesign (http://www.gao.gov/assets/310/309622.pdf). The implementation of precision navigation over the last few years has contributed to increased airport community concerns regarding noise. This challenge is anticipated to grow with new entrants such as unmanned aerial systems, urban air mobility, civil supersonic aircraft, and commercial space vehicles. The ability to manage this growth will partly depend on the extent to which we address the effects of noise and emissions. The Environment and Energy Program is using tools and knowledge to inform decision-making on technology development and operational procedures to ensure that efficient, cost-effective innovations are developed to reduce aviation's energy use and environmental impacts thus ensuring continued growth in aviation.

NextGen - Environmental Research - Aircraft Technologies, Fuels, and Metrics
Funding Request ($29,174,000)

Program Description/Activities:

The NextGen Environmental Research project is developing solutions to reduce the environmental impacts of aviation by accelerating the maturation of engine and airframe technologies to reduce aircraft noise, fuel use, and emissions. This project is being done in partnership with industry through the Continuous Lower Energy, Emissions and Noise (CLEEN) program. With the support of the CLEEN Program, the aviation industry is able to expedite the integration of technologies that lower noise, emissions and fuel use into current and future aircraft. CLEEN helps accelerate technologies through a crucial phase in their maturation, culminating in full-scale ground and flight test demonstrations and showing technology readiness for product implementation.

Once entered into service, the CLEEN technologies will realize their noise, fuel burn, and emissions benefits throughout the fleet for years to come. Since its inception in 2010, the CLEEN Program has been successful in maturating technologies to enter into service sooner than what the industry had anticipated. For example, the low emissions engine combustor has met and exceeded the original CLEEN goal for nitrous oxide reductions. This combustor has been introduced into service in 2016. Other demonstrated CLEEN technologies have shown significant progress toward the fuel burn and noise reduction goals.

The work of the program results in technologies that have been matured to the point wherein they are ready for consideration by industry for use in new aircraft and engines. Some of the technologies could also be retrofitted onto existing aircraft and engines.

Additional information on the CLEEN Program is available through the FAA CLEEN Fact Sheet at https://www.faa.gov/news/fact_sheets/news_story.cfm?newsId=22534

Statutory Requirements:

Is this program statutorily mandated (Y/N): Yes

This research project is required under Title 42 Sections 7571 and 7572 as well as Title 49 Sections 301, 40101, 44715, and 48102.

Program Alignment with Strategic Goals:

DOT Strategic Goal	DOT RD&T Critical Transportation Topic
Infrastructure	**Preserving the environment**

The program's goals are in line with the DOT strategic goal of Infrastructure. Achieving our environmental and energy goals will allow the nation's air transportation system to grow thereby ensuring continued mobility and economic growth that accompanies the air transport sector. This program provides the innovation in terms of technological and operational measures to reduce aviation's impacts on the environment, which will also improve the efficiency of the airspace system

and promote growth of the sector. The result is an improved national aerospace system that is able to provide the mobility that society demands with sufficient environmental protection to ensure continued growth in the future.

The program does not have an impact on rural communities.

Program Objectives:

The main goal of the NextGen – Environmental Research-Aircraft Technologies and Fuels program is the development of aircraft and engine technologies that reduce noise, fuel burn, and emissions. Technologies developed by this program result in a fleet of aircraft that have lower noise, use less fuel and produce fewer emissions, thus supporting the overarching environmental performance goal for NextGen to achieve environmental protection that allows sustained aviation growth.

This program will enable the FAA, through the second phase of the CLEEN Program (CLEEN II), to partner with industry to mature technologies with the result being a fleet of aircraft with lower noise, emissions and fuel burn. Specifically, the technology goals of this second phase of the CLEEN Program are to develop and demonstrate certifiable engine technology that reduces:

- Noise levels by 32 decibels cumulative, relative to the Stage 4 standard.
- Aircraft fuel burn by 40% relative to year 2000 best-in-class in-service aircraft
- Landing and Take Off (LTO) cycle, Nitrogen Oxide (NOx) emissions by 70% below the International Civil Aviation Organization standard adopted in 2011.

By reducing the environmental impact of aviation through new technologies this program helps to ensure the continued growth of aviation while also reducing the impacts of aviation noise and emissions on airport communities as well as on the public at large.

Aircraft and engine manufacturers are required to meet minimum standards for noise and emissions as a part of their airworthiness requirements. However, there is no return on investment for manufacturers for exceeding the existing noise and emissions standards. The CLEEN Program provides an incentive to industry to develop technologies that will help manufacturers create aircraft and engines with lower noise, emissions, and fuel burn. Further, the technologies being accelerated by the CLEEN Program have relatively large technological risk; as such, industry is hesitant to invest their limited research and development dollars into their development. By cost-sharing the development with the FAA, industry is willing to accept the greater risk associated with this technological development. The CLEEN Program helps accelerate technologies through a crucial phase in their maturation, culminating in full scale ground and flight test demonstrations and showing readiness for product implementation. At the conclusion of the development effort for a CLEEN technology, each company, having cost shared the development with FAA, is invested in the technology's success and confident in its maturity to enter product development for entry into service.

Economic Impact of Regulatory Reform:

The efforts of the Environment and Energy Program work in concert with the technology maturation of the NextGen Environment Program. Through the CLEEN Program, technologies are being matured

that will help industry to meet, and potentially exceed, noise and emissions regulations that could come in the future.

Research Collaboration Partners:

The program also incorporates inputs received from stakeholders, such as industry and non-governmental organizations, as well as those from other agencies, including NASA and the Department of Defense. The program gets this expert feedback through the REDAC, the CLEEN Consortium, the ASCENT Center of Excellence, as well as other FAA and industry events.

The CLEEN Program has eight industry cost-share partners: Aurora Flight Sciences; Boeing; Delta Tech Ops, America's Phenix, MDS Coating Technologies; General Electric (GE) Aviation; Honeywell Aerospace; Pratt & Whitney; Rolls-Royce; and Rohr, Inc. / UTC Aerospace Systems. The CLEEN Program is also conducted in a collaborative manner with NASA and the Department of Defense. The industry and government partners benefit from the acceleration of technologies that is made possible by the CLEEN Program. The ASCENT COE also provides an independent review of the technologies that are being matured by the CLEEN Program, at both the aircraft and fleet levels.

Do non-government groups partner with this program? (Yes/No): Yes

The CLEEN Program is a public-private partnership wherein industry provides more than 100% cost share. There were five industry partners in the first phase of CLEEN, which was in operation from 2010 to 2015, and there are eight industry partners in the second phase of CLEEN, which started in 2015 and is currently in operation.

Acquisition/Assistance:

Does this program utilize competitive procurement processes? Yes.

FAA programs in the research portfolio employ competitive contracting vehicle types and grants to acquire Conduct, Research, and Development activities. The FAA's acquisition management system offers researchers omnibus contract vehicles such as the SE2020, SE2025, and eFAST BPAs in which vendors competitively compete for TOs and BPA calls. The Broad Agency Announcement is another competitive process the FAA utilizes for awarding basic research contracts. Grants are used to execute a portion of the FAA's research budget and where the FAA has the statutory authority to issue grants pursuant to the Aviation Research Grants Program. The FAA's Centers of Excellence (COE) is one example of a grant-based program that uses competition to select from among members of academia for COE participation. In the specific case of the COE grant program, it receives matching funds from industry sponsors.

The CLEEN Program uses an Other Transaction Agreement that is competitively awarded.

In general, the FAA Research Portfolio includes Research Programs that use multi-year acquisitions.

Does this program leverage non-Federal funds?

Yes, the CLEEN Program requires 100% cost share from industry partners. Industry have more than matched the amount of funding provided by the FAA to the CLEEN Program.

Technology Transfer (T2):

Technologies are matured under CLEEN within a 5 year cycle, but the timeframe for technology introduction depends on many factors outside of the FAA's control. Early on in their product development cycle, aircraft and engine manufacturers examine technologies that could be incorporated into their systems. Through trade studies and analyses, the companies select a fixed set of technologies that will be used in the final design. They then integrate the myriad systems that comprise an engine and/or aircraft around this frozen set of technologies. After this point, no new technologies are introduced into that particular aircraft or engine product and new technologies will need to wait for the next product development cycle to be introduced into the fleet. The overall product development cycle starts when a company realizes there is a need for a new product and the cycle spans the course of years. Due to the large development costs, it can be many years or decades between product updates. Because of these factors, there will be many future opportunities for the technologies that were matured by the CLEEN program to be introduced into the fleet.

Through the CLEEN Consortium and the NextGen Environment Program, the FAA works with industry to track the introduction of CLEEN technologies into the fleet. For example, the CLEEN Program matured a low emission combustor technology, the GE Twin Annular Premixing Swirler (TAPS) II combustor, which entered into service in 2016 in a CFM International engine. This engine is being used on the Boeing 737 MAX and Airbus 320 aircraft with almost 8,000 orders already placed. The combustor technology reduces landing and takeoff emissions by 55% relative to current standards and reduces particulate matter by 90% relative to the current international visibility limit. Further, industry anticipates that additional CLEEN technologies will enter into service in the next several years as opportunities arise for their insertion into new aircraft and engine designs. The CLEEN Program anticipates another CLEEN engine technology will have more than 4,000 orders placed after 2020. As additional new aircraft and engine products are announced by industry, there will be many more orders placed for products that were matured via the CLEEN Program.

Evaluation / Performance Measurement:

The outputs from this program are tracked by the NextGen Office though Project Level Agreements and multi-year plans.

Human Performance and Aeromedical Factors

Flightdeck/Maintenance/System Integration Human Factors
Funding Request ($7,305,000)

Program Description/Activities:

The Flightdeck/Maintenance/System Integration Human Factors Program provides the research foundation for FAA guidelines, handbooks, orders, advisory circulars (ACs), Technical Standards Orders (TSOs), and regulations that help ensure the safety and efficiency of aircraft operations. It also develops human performance information that the agency provides to the aviation industry for use in designing and operating aircraft, and training pilots and maintenance personnel.

The program focuses on the needs of pilots, inspectors, and aircraft maintainers. The revolution in digital avionics has changed flightdeck design and operational practices and enabled new advanced vision system technologies, surface moving maps, electronic flight bags, advanced controls, communications, navigation, surveillance systems, and tools for aircraft system management. With these advances come important human performance and human factors implications which must be understood and applied in the appropriate guidance material developed for policy, procedures, operations, and training. The research supports AVS in regulating the development of these products. Human error continues to be a major contributor to aircraft accidents and incidents both in commercial and general aviation. Current research is proactive in identifying error tendencies and thereby enhancing the safe and effective introduction of new technologies and procedures into the NAS.

Statutory Requirements:

Is this program statutorily mandated (Y/N): Yes

U.S.C. Title 49 § 44505 Systems, procedures, facilities, and devices
(b) Research on Human Factors and Simulation Models. — The Administrator shall conduct or supervise research—
(1) to develop a better understanding of the relationship between human factors and aviation accidents and between human factors and air safety;
(2) to enhance air traffic controller, mechanic, and flight crew performance;
(3) to develop a human-factor analysis of the hazards associated with new technologies to be used by air traffic controllers, mechanics, and flight crews;
(4) to identify innovative and effective corrective measures for human errors that adversely affect air safety; and
(c) Research on Developing and Maintaining a Safe and Efficient System. — The Administrator shall conduct or supervise research on—
(3) human performance in the air transportation environment;
(6) other aviation issues related to developing and maintaining a safe and efficient air transportation system.

Each of the research initiatives conducted in the Flight Deck Human Factors Research lab is focused on developing a better understanding of the relationship between HF, safety, and aviation accidents. Our research lab is a world leader in assessing human factors in aviation and developing corrective methodologies or mitigations.

U.S.C. Title 49 § 44507
"Human Factors: of flight crews, air traffic controllers, mechanics, inspectors, airway facility technicians, and other individuals involved in operating and maintaining aircraft and air traffic control equipment; Human Factors: agency work force optimization, including training, equipment design, reduction of errors, and identification of candidate tasks for automation; Human Factors: make comments to the Administrator of the Federal Aviation Administration on human factors aspects of proposed air safety regulations; make comments to the Administrator on human factors aspects of proposed training programs, equipment requirements, standards, and procedures for aviation personnel; advise, assist, and represent the Federal Aviation Administration in the human factors aspects of joint projects between the Administration and the National Aeronautics and Space Administration, other departments, agencies, and instrumentalities of the United States Government, industry, and governments of foreign countries."

Each of the research initiatives funded under this BLI has been highly prioritized external and internal to the agency via accident investigations, NTSB recommendations, and industry concerns. The scientists funded under the BLI are international leaders and provide advice to the administrator for collaborations with external agencies and response to open human factors issues.

U.S.C. Title 49 § 44516
"Pilots and flight crews. The administrator shall work with representatives of the aviation industry and appropriate aviation programs association with universities to develop specific training curricula to address critical safety problems, including problems caused by pilots – a) in recovering from loss of control of an aircraft, including handling unusual attitudes, and mechanical malfunctions; b) in deviating from standard operating procedures, including inappropriate responses to emergencies and hazardous weather; c) in awareness of altitude and location relative to terrain to prevent controlled flight into terrain; and d) in landing and approaches, including non-precision approaches and go-around approaches."

The scientists in the Flight Deck Human Factors research division serve as leaders of research in collaboration with industry and academia to approach critical human factors training issues. The enhancing aviation safety through procedures, training and methodologies and the maintenance human factors research program both address this public law.

Program Alignment with Strategic Goals:

DOT Strategic Goal	DOT RD&T Critical Transportation Topic
Safety	**Promoting safety**

This program supports the DOT's Strategic Goal of safety by providing systematic research and development within the FAA that will lead to the identification, assessment and mitigation of safety risks. By providing the research necessary to generate data, these data are then used to create and develop new safety standards that will be adopted throughout the aviation community.

This research informs operations internationally in both urban and rural communities.

Program Objectives:

The main goal for the Flightdeck/Maintenance/System Integration Human Factors program is flight operations safety. This program supports that goal by providing scientific and technical information to those responsible for regulations and guidance that ensure safe pilot and maintainer performance. While many human errors warrant research, this program addresses some of the most critical areas of flight safety, as described by the following requirements.

In FY 2019, three different research areas are planned to be addressed. The first one is the *Human Factors Maintenance Risk Management.* This research requirement supports the regulation requiring 14 Code of Federal Regulations (14 CFR) part 121 airlines to implement a Safety Management System (SMS). This proposed plan takes a programmatic approach to maintenance safety with a new focus on critical topics related to organizational culture, safety management, and risk based decision-making. There is also tasking focused on maintenance error in the General Aviation environment. There remains one task associated with the critical ongoing impact assessment of past and current maintenance human factors R&D products and outcomes. The tasking is interwoven in that each is related to the process of making decisions based on the formal process of risk assessment. The result will be applied products, based on sound human factors principles that support FAA Inspectors and industry. The sponsor places high priority on the applied nature of the R&D outcomes.

This research is important because reduction in maintenance-related accidents remains a high value safety target. It is generally accepted that human factors contribute to about 80% of accidents and events. In a recent analysis it was shown that as little as a 10% reduction of maintenance related accidents could save the combined GA and Airliner industry about $2B dollars in a five-year period (Johnson, 2014). That savings is calculated based only on damaged or totaled aircraft and human injuries or fatalities. The total lives saved are estimated at 80 over the five-year period.

The second research area planned for FY 2019 is *Advanced Vision Systems – Enhanced Flight Vision System, Enhanced Vision Systems, Synthetic Vision Systems, and Combined Vision System, Heads Up Displays, Helmet Mounted Displays – Certification and Ops Approval Criteria. This* research requirement evaluates these systems for use during low visibility conditions. Research of these systems will be used to develop and update:

- Operating rules, conditions, limitations, and mitigations;
- Flight Standards policy; Operational approval processes and job aids for Principal Inspectors;
- Training, recent flight experience, and proficiency requirements for pilots, dispatchers;
- FAA orders and ACs; Operations Specifications (OpSpecs), Management Specifications (MSpecs), and Letters of Authorization (LOAs);
- Charting standards;
- Airmen information publications;
- Safety Alert for Operators (SAFOs) and Information for Operators (InFOs); and
- Pilot performance considerations, conditions, and limitations associated with applications for waiver and petitions for exemption from operating rules.

The final research requirement is *Fatigue Mitigation in Flight Operations.* The objective of this research is to reduce the accidents and incidents caused by flightcrew fatigue. The primary activity is to determine and develop measures/data criteria to be acquired, maintained, and analyzed for the

on-going evaluation of the effectiveness of both Fatigue Risk Management Programs (FRMP) and Fatigue Risk Management Systems (FRMS) OpSpecs (A317 and A318) to mitigate flightcrew member fatigue and for the evaluation of improvements offered by 14 CFR Part 117. Additionally, information, recommendations, and best practices need to be developed for updating fatigue mitigation guidance and educational materials.

This research will produce detailed information regarding the effectiveness of fatigue mitigation separately for day to day operations (FRMP A317 outcomes) and for the specific flight operations requiring an FRMS (A318) as an alternative means of compliance to the rule. Also, recommendations will be made for updates to relevant AC guidance and/or educational materials (e.g., AC 120-100, Basics of Aviation Fatigue; AC 120-103A, Fatigue Risk Management Systems for Aviation Safety; AC 117-1, Flightcrew member Rest Facilities; AC 117-2, Fatigue Education and Awareness Training Programs; AC 117-3, Fitness for Duty).

Our human factors research is used to develop performance standards for aircraft systems and flight operations. The industry does not typically share its internal proprietary data developed through its independent research. While we work with industry partners and academia, the FAA has to formulate the science necessary to empirically derive safety standards. These standards are inherently governmental. Industry consensus is derived through organizations such as RTCA International, to inform FAA standards.

Much of this work is done in collaboration with industry to develop human-centered safety standards for operations, technologies, training, and safety management. The market failure occurs because the research is inherently governmental. The FAA research is not designed to benefit one manufacturer or operator. The research informs safety standards and safety minimums with the public's safety as the basis.

Often, each company is unwilling to share their data or technology with other companies to maintain their competitive advantage.

Many companies do in-house research and present it to the FAA in their requests for operational credit or certification. However, much of the corporate research is designed to sell a system and is based on flight test data rather than experimental data that is representative and generalizable. Often the data that is provided by a company has been collected in a way that is in the best interest of the company and cannot be replicated.

Economic Impact of Regulatory Reform:

As technological advances enable our commercial aircraft to fly longer distances, human fatigue research conducted in our lab provides the supporting data and mitigation strategies to inform the regulatory requirements for operations and training to enable ultra-long range flights. This makes new City-Pairs possible that were not possible under existing duty time regulations.

Critical research has enabled several regulatory changes to permit an Enhanced Flight Vision System to be used in approach and landing operations when the visibility is too low for pilots to see outside using natural vision. This technology enabled low visibility approach operations that were not possible before on more than 11,592 instrument approach procedures. This means increased landings and decreased delays – all while maintaining our global leadership in aviation safety.

Research Collaboration Partners:

The productivity of the scientists funded under this BLI is measured under the ISO-9001:2015 standard. Goals are set each year and reviewed quarterly for the division. Metrics include number of research products, number of research services, % favorable sponsor/stakeholder feedback, ISO workflow status, number of continuing education events, number of international research activities, number of collaborative activities, number of industry/supplier relationships, number of organizational relationships, and staffing levels.

Each research project and its status are briefed quarterly to the senior executive team. Study findings are briefed annually to internal and external stakeholders.

This program maintains inter-agency partnerships with NASA and the DOT Volpe National Transportation System Center (NTSC). The partnership with NASA provides this program with unique access to expertise in flight deck human factors. The partnership with Volpe enables this program to harmonize research results with International Civil Aviation Organization (ICAO) standards, as well as FAA and industry work groups, like RTCA.

- Operators - A4A, Southwest, American Airlines, JetBlue, UPS, AAR, United, Delta, Alaska, Spirit, FedEx, NetJets, Arab Emirates, Air Evac, Piedmont Air, Frontier

- Manufacturers -Boeing, Airbus, Gulfstream, Thales, Cessna, Bombardier, Embraer, Jeppeson, Elbit, Honeywell, Rockwell Collins, Sierra Nevada

- Labor – Transport Workers Union (TWU), IAM, Teamsters, Aircraft Operators and Pilots Association (AOPA), Air Line Pilots Association (ALPA), Association of Flight Attendants (AFA), Professional Aviation Maintenance Association (PAMA)

- Academia – PEGASAS Center of Excellence, University of Oklahoma, Oklahoma State University, Texas A&M, Georgia Institute of Technology, Purdue, Florida Institute of Technology, Embry Riddle Aeronautical University, Ohio State, Iowa State, Wichita State University, Massachusetts Institute of Technology

- Government – US Navy, US Air Force, NTSB, NASA, NOAA, NHTSA, Department of Homeland Security, Transportation Safety Institute, Aerospace Medicine Research Alignment and Collaboration (AMRAC) working group, Army, Volpe

- International - ICAO, EASA, CAA, SAE, and International Air Transport Association (IATA)

Our strategy is to work closely with all vested stakeholders to ensure our research is timely and has buy-in from the potentially impacted parties. We frequently host international research summits and our representation always includes FAA, academia, industry, and labor. Our chief scientists and lead researchers coordinate with our international counterparts to ensure knowledge sharing and knowledge building. We collaborate with other government institutions on topics that are of shared interest (e.g., military –laser eye protection, DOT – fatigue, NASA – combined vision systems). This strategy has proven to be successful with the wide utilization and adoption of research findings.

Do non-government groups partner with this program?

Yes. Non-government groups partner/contribute via subject matter expertise personnel hours, facilities or equipment, travel funding, data entry, and data sharing.

This program teams with multiple US Operators (FedEx, Delta), aircraft and avionics manufacturers, labor (TWU, IAM, Teamsters, ALPA) and academia (Texas A&M University, University of Iowa, University of Central Florida) and the Department of Defense. These partners provide current, relevant input on the latest research, the important operational issues, and the latest flight deck technologies. Forums for exchange of this information include Info Share, the Communication, Navigation, and Surveillance Task Force, the Aeronautical Charting Forum, and the DoD Human Factors Engineering Technical Advisory Group.

Acquisition/Assistance:

FAA programs in the research portfolio employ competitive contracting vehicle types and grants to acquire Conduct, Research, and Development activities. The FAA's acquisition management system offers researchers omnibus contract vehicles such as the SE2020, SE2025, and eFAST BPAs in which vendors competitively compete for TOs and BPA calls. The Broad Agency Announcement is another competitive process the FAA utilizes for awarding basic research contracts. Grants are used to execute a portion of the FAA's research budget and where the FAA has the statutory authority to issue grants pursuant to the Aviation Research Grants Program. The FAA's Centers of Excellence (COE) is one example of a grant-based program that uses competition to select from among members of academia for COE participation. In the specific case of the COE grant program, it receives matching funds from industry sponsors.

FAA research performing organizations use the FAA grants office and competitive acquisition under the FAA's Acquisition Management System (AMS) to obtain contractor support for conducting in-house research.

Sole source acquisitions are rarely used and typically are for support of research systems in which a company has histrionic experience and is the only qualified provider.

In general, the FAA Research Portfolio includes Research Programs that use multi-year acquisitions.

This program leverages non-Federal funds in the form of collaborative agreements, interagency agreements, and memorandums of agreement. Most often this cost sharing is in terms of personnel time, facilities or equipment, travel funding, data entry, and data sharing.

This program includes university and industry partners in its research efforts. When able, this program uses in-kind contributions from those partners as a partial match that supplements its research investment. This program involves university researchers through the FAA's Regional Air Transportation Centers of Excellence (COE) that requires a 1-to-1 match on the program's investments. As the program develops consensus on standards through participation in government-industry working groups such as the RTCA and SAE G-10 committees, the non-governmental participants cover their own costs. Research, Engineering, and Development Advisory Committee (REDAC) members from industry and academia also fund their own time and expenses for biannual meetings convened to review and provide feedback on our research plans and progress.

Technology Transfer (T2):

System Safety research projects typically aim to address either safety issues unique to the FAA's oversight capabilities or systematic safety issues across industry through providing necessary technical data to the FAA's Office of Aviation Safety (AVS) to prepare meaningful advisory and guidance material for use by industry. For those projects that address safety issues unique to the FAA's oversight capabilities, the T2 is internal to the FAA. For those projects that address systematic safety issues across industry, T2 is executed through publication of advisory and guidance material by the Office of Aviation Safety. Technical publications documenting research results are available to the public at: https://www.faa.gov/about/office_org/headquarters_offices/ang/offices/tc/library/. A specific example of T2 in this area is the wet runway wheel barking testing research project. Findings and recommendations may be used by the Office of Aviation Safety to update wet runway braking performance standards, i.e., 14 CFR Part 25.109(c) and AC-25-7C using the research findings. Other examples of T2 in this area are published findings presented at conferences such as: "Human-in-the-Loop Study on Angle-of-Attack Indicator Effectiveness for Transport Category Airplanes" available at https://arc.aiaa.org/doi/abs/10.2514/6.2018-2938, "Development of Possible Go-Around Criteria for Transport Aircraft" available at https://arc.aiaa.org/doi/abs/10.2514/6.2018-3198, "Analyzing Pilot Decision-Making Using Predictive Modeling" available at http://www.icrat.org/icrat/ and the conduct of a "Stabilized Approach and Go-Around Safety" workshop during March 2018 Aviation Safety InfoShare meeting. InfoShare meeting allows aviation safety professionals from industry, government, and academia to share their safety concerns and best practices in a protected environment. No adoption/implementation rates are available. In this way, the knowledge gained from the research is transferred to the aviation industry.

- AAM-500 representatives: Dr. Daniela Kratchounova (Research Psychologist) and Ashley Awwad (Management and Program Analyst) of AAM-510 are working with Lise Rode (Senior Patent Counsel) on the Cooperative Research and Development Agreement process.
- AAM-500 hosts national and international research summits, workshops, and symposia to collaborate with industry, academia, as well as other government agencies to evaluate innovative technologies and their potential safe integration into the National Aerospace System
- We have transferred knowledge to the Human Factors community (e.g., via publication of methodologies and findings)
- We evaluate new technologies from vendors in our facilities (e.g., in multimodal lab and weather applications)
- We transfer knowledge (and software) with military, academia, and industry (and vice-versa).
- Collaborate and fund research with local universities and industry leaders in aviation technologies. We collaborate across the entire industry including operators, manufacturers, labor, academia, government institutions, international entities, and other organizations like AOPA. We typically cost share projects with industry to achieve the best value for the government. The cost shares range from 30 to 60% typically.

Our specific collaborative relationships include:

- **Operators** – Airlines for America (A4A), SouthWest, American Airlines, Jet Blue, UPS, AAR, United, Delta, Alaska, Spirit, Fedex, NetJets, Air Evac, Piedmont Air, Frontier
- **Manufacturers** -Boeing, Airbus, Gulfstream, Cessna, Bombardier, Embraer, Jeppeson, Elbitt, Honeywell, Rockwell Collins, Sierra Nevada

- **Labor** - TWU, IAM, Teamsters, Air Line Pilots Association, Association of Flight Attendants, PAMA
- **Academia** – Centers Of Excellence, Oklahoma University, Ohio State University, Texas A&M, Georgia Institute of Technology, Purdue, Florida Institute of Technology, Embry-Riddle Aeronautical University, Washington State University
- **Gov't** – US Navy, US Air Force, US Army, National Transportation Safety Board, NASA, National Oceanic and Atmospheric Administration, National Highway Transportation Safety Administration, Department of Homeland Security, Transportation Safety Institute, NASA Aerospace Medicine Research Alignment and Collaboration Working Group, Volpe
- **International** – International Civil Aviation Organization, European Aviation Safety Agency, Civil Aviation Authority, Society of Automotive Engineers, International Air Transport Association

Evaluation / Performance Measurement:

Human factors issues, specifically human errors, contribute to 88% of aircraft incidents and accidents. Human errors include errors by the flight crew, maintenance personnel, air traffic controllers, and others who have a direct impact on flight safety.

Core research areas include advanced vision systems and sensor based technologies, avionics and new technologies, bio-physiological delimiters, risk mitigation and advanced cognition, and weather systems and displays. These core research areas are consistent with the DOT Safety Performance Goal of reducing aviation-related fatalities.

As technological advances enable our commercial aircraft to fly longer distances, human fatigue research conducted in our lab provides the supporting data and mitigation strategies to inform the regulatory requirements for operations and training to enable ultra-long range flights. This makes new City-Pairs possible that were not possible under existing duty time regulations.

It is estimated that weather-related flight delays cost air carriers $8 billion dollars and passengers $17 billion dollars a year. Advanced vision systems can enable airlines to conduct terminal operations in low visibility conditions at airports with limited navigational and lighting infrastructure. Our research has informed the adoption and operational credit for the use of synthetic vision systems and enhanced flight vision systems to safely allow taxi, take-off, approach, and landing operations in low visibility conditions thereby increasing the efficiency and safety of aviation operations.

Unmanned Aircraft Systems (UAS) operations involving small and large unmanned aircraft with increasing amounts of automation and levels of autonomy are expanding worldwide and present significant unique human factor issues to the UAS pilots who are operating the aircraft from a remote "cockpit", as well as new potential hazards for seeing and avoiding manned aircraft and persons on the ground. Our research has informed the minimum information requirements that UAS pilots need to safely operate in the NAS.

Management Controls

We track performance with Business Plan Goals, Activities, and Targets. We report status against plans in the quarterly Program Management Reviews, and the biannual meetings of the REDAC SAS and Human Factors subcommittees. We manage our research through Program Descriptions and

Level-of-Effort Agreements with CAMI and the FAA's Technical Center research performers. We conduct monthly Program Financial Management Reviews to monitor obligations and expenditures.

Measures of Program Effectiveness

The AVS sponsors apply the results of our research program through policy, procedures, training, equipment design, safety analysis, and other types of applications. The AVS sponsors determine the effectiveness of the research for meeting their needs. We measure our performance against the plan for funding and program timing of deliverables as established by the AVS sponsors and approved through the Provider Execution Plans for each area of research.

Air Traffic Control/Technical Operations Human Factors
Funding Request ($5,800,000)

Program Description/Activities:

The purpose of this Air Traffic Control/Technical Operations (ATC/ATO) Human Factors program is to focus on improving the safety and efficiency of complex ATC systems by measuring and enhancing the performance of individual controllers and specialists, improving the integration of NAS technologies for controllers and technicians, and supporting data-driven decisions related to the workforce, including selection methods, job placement, performance measurement, and training.

ATO human factors challenges currently center on evolution of the workforce and the advancing technologies and associated procedures that are expected to be implemented in the NAS over the next several years. The workforce challenges are especially acute in the large terminal radar air traffic control facilities (TRACONs) and in several of the busy air route traffic control centers (ARTCCs). FAA is challenged to hire, place, and train several thousand new air traffic controllers in the coming years, while continuing to provide safe and efficient air traffic services to the users of the National Airspace System. We will also see hiring and training of several hundred technical operations specialists, who are essential for maintaining and certifying systems and services for use in the air traffic control system. Funding in FY 2019 will enable us to help our ATO customers improve the efficiency with which they can hire and train new aviation professionals.

In support of system acquisitions that are managed within the ATO Program Management Office, the R&D program in FY 2019 will further limit the focus to integration of human considerations to enhance user-system design. Human performance is a key factor in total system performance, and enhancements to human performance will contribute to enhancing the total system's performance, reducing errors, and helping reduce life cycle ownership costs. The program, through the FAA's Program Management Office (PMO) coordination, strives to provide useful human factors R&D results that support the development and implementation of new technologies and procedures in the National Airspace System. In FY 2019 the program will increasingly rely on offices in the ATO for implementation of the requirements in FAA Order 9550.8 Human Factors Policy, specifically, that 'Human factors shall be systematically integrated into the planning and execution of the functions of all FAA elements and activities associated with system acquisitions and system operations. FAA endeavors shall emphasize human factors considerations to enhance system performance and capitalize upon the relative strengths of people and machines. These considerations shall be integrated at the earliest phases of FAA projects. The program assures that the proper roles and responsibilities are assigned to the ATO workforce to assure that controller and technician capabilities are compatible with the advanced technology they use in their jobs, and that the resulting level of air traffic system performance meets operational requirements and fulfills the safety and efficiency objectives. Our headquarters human factors team also continues to provide human factors subject matter expertise to the Joint Resources Council and will coordinate with the PMO human factors office to review how acquisitions have complied with human factors design requirements through the In-Service Decision review checklist process.

The ATC/TO Human Factors program currently includes the following research activities:

- Conduct analyses and develop recommended practices for facility managers to increase the likelihood that controller trainees will succeed in field training, such that trainees are not lost due to factors other than their ability to control air traffic.
- Conduct targeted analyses to support data-driven decision making at the FAA Academy's Air Traffic Division, to document and provide recommendations for improving the reliability of raters who evaluate ATC student performance.
- Develop data mining methods to obtain and evaluate controllers' use of new equipment and system functions that provide additional air traffic control capabilities, and develop an approach for analyzing the data that will provide insights to acquisition programs and operational evaluation teams about which capabilities have been under-used as well as some of the operational human factors aspects that may limit their use.
- Identify and analyze elements of air traffic control system user interfaces that may introduce human error potential in ATC operations, and recommend candidate elements for additional evaluations through high fidelity human-in-the-loop simulations that include multiple new systems and functions.

The purpose of CAMI's "Evaluation of ATC Hiring and Training Processes" research program is to evaluate ATC hiring processes to assess their fairness and validity in predicting the success of new hires in Academy and field training. A longitudinal database, containing controller background information, selection test scores, and training performance measures, was developed by CAMI researchers to evaluate the validity of ATC selection procedures and analyze relationships between selection test scores, education, prior experience, and other non-cognitive factors with success in training and on the job. The research program has expanded to examine the effectiveness of ATC training programs. Evaluation of current and potential selection and training programs will be conducted.

CAMI's FY 2019 "Evaluation of ATC Hiring and Training Processes" research program includes the following individual research tasks: "Investigation of Attributes that Predict ATCS Training Success Using a Longitudinal Database," "Understanding Why Some Developmental Controllers Fail to Succeed in Field Training/ATC Field Training Effectiveness," "Data-Driven Decision Support for AJI and the FAA Academy Air Traffic Division," and "Evaluation of ATCS Selection Process in relation to Predictors of FAA Academy and Field Training Success."

The purpose of CAMI's "Safety Aspects of Air Traffic Controller Performance" research program is to identify scanning patterns used most often by tower and en route air traffic controllers and provide information about which scanning methods are better than others. Additional project activity can indicate how easily scanning techniques might be taught to new or Certified Professional Controllers (CPCs). The program also involves identification of potential human factors safety-related problems associated with how controllers perform in proposed Remote Tower (RT) configurations. The FY 2019 "Safety Aspects of Air Traffic Controller Performance" research program includes the following research tasks: "Visual Scanning Techniques Research Study" and "Remote Tower Services (RTS) Human Factors Support."

A third research program, "Projecting the Jobs of Future Technical Operations Specialists," that included the following research tasks: "Strategic Work Analysis for Technical Operations NAS

Security and Enterprise Operations (NASEO), "Capitalize on ATSS 2101 Job Task Analysis Findings," and "Strategic Job Analysis for Engineering Services," has been eliminated from consideration in FY 2019 because of additional funding and staffing cuts, over and above the 50% cuts that had previously been projected. No research addressing hiring and training of Technical Operations personnel can be conducted if the 50% cuts persist.

Statutory Requirements:

Is this program statutorily mandated (Y/N): Yes

Research is required by U.S.C. Title 49, Subtitle VII, Part A, Subpart iii, Chapter 445, Section 49 USC § 44505, 44506, and 44516:

49 USC § 44505 Systems, procedures, facilities, and devices

(b) Research on Human Factors and Simulation Models.— The Administrator shall conduct or supervise research—

(1) to develop a better understanding of the relationship between human factors and aviation accidents and between human factors and air safety;

(2) to enhance air traffic controller, mechanic, and flight crew performance;

(3) to develop a human-factor analysis of the hazards associated with new technologies to be used by air traffic controllers, mechanics, and flight crews;

(4) to identify innovative and effective corrective measures for human errors that adversely affect air safety; and

(c) Research on Developing and Maintaining a Safe and Efficient System.— The Administrator shall conduct or supervise research on—

(3) human performance in the air transportation environment;

(6) other aviation issues related to developing and maintaining a safe and efficient air transportation system.

Research associated with the "Safety Aspects of Air Traffic Controller Performance" program is required by USC §44505 because it addresses research on human factors to enhance air traffic controller performance, to develop a human-factors analysis of the hazards associated with new technologies to be used by air traffic controllers. This project is also required by USC §44505 because it involves conducting research on human performance in the air transportation environment.

49 USC § 44506. Air traffic controllers

(a) Research on Effect of Automation on Performance.— To develop the means necessary to establish appropriate selection criteria and training methodologies for the next generation of air traffic controllers, the Administrator of the Federal Aviation Administration shall conduct research to study the effect of automation on the performance of the next generation of air traffic controllers and the air traffic control system. The research shall include investigating—

(1) methods for improving and accelerating future air traffic controller training through the application of advanced training techniques, including the use of simulation technology;

(2) the role of automation in the air traffic control system and its physical and psychological effects on air traffic controllers;

(3) the attributes and aptitudes needed to function well in a highly automated air traffic control system and the development of appropriate testing methods for identifying individuals with those attributes and aptitudes;
(4) innovative methods for training potential air traffic controllers to enhance the benefits of automation and maximize the effectiveness of the air traffic control system; and
(5) new technologies and procedures for exploiting automated communication systems, including Mode S Transponders, to improve information transfers between air traffic controllers and aircraft pilots.

Research associated with the "Evaluation of ATC Hiring and Training Processes" program is required by USC § 44506, Investigate the attributes and aptitudes needed to function well in a highly automated ATC environment and development of appropriate testing methods for identifying individuals with those attributes and aptitudes. Also, under USC § 44506, the program will investigate air traffic controller performance measures, including the development of predictive models. This project also supports the Administrator's Priority Initiative of developing the Workforce of the Future by addressing the related sub-initiative of Skill Identification.

49 USC § 44516. Human factors program
(a) Human Factors Training.
(1) Air traffic controllers. — The Administrator of the Federal Aviation Administration shall—
(A) address the problems and concerns raised by the National Research Council in its report "The Future of Air Traffic Control" on air traffic control automation; and
(B) respond to the recommendations made by the National Research Council.

Program Alignment with Strategic Goals:

DOT Strategic Goal	DOT RD&T Critical Transportation Topic
Safety	**Promoting safety**

This program supports the DOT's Strategic Goal of safety by providing systematic research and development within the FAA that will lead to the identification, assessment and mitigation of safety risks. By providing the research necessary to generate data, these data are then used to create and develop new safety standards that will be adopted throughout the aviation community.

Both Air Traffic/Tech Ops HF BLI FY 2019 research programs listed above support the DOT's Safety Strategic Goal. The "Evaluation of ATC Hiring and Training Processes" research program, in particular, is consistent with Strategic Objective 1: Systemic Safety Approach, because the research uses a data-driven systemic safety approach to enhance standards and programs, and evaluate program effectiveness. The "Safety Aspects of Air Traffic Controller Performance" research program is also consistent with Strategic Objective 1: Systemic Safety Approach, but focuses more on identifying risks and enhancing training programs.

Neither of these research programs has any differential effect on rural communities.

Program Objectives:

The Air Traffic Control/Technical Operations (ATC/TO) Human Factors program responds to research and development (R&D) requirements defined by offices in ATO and other FAA headquarters technical sponsors. The program provides timely R&D products and consultation services that focus on improving the safety and efficiency of complex ATC systems. This program addresses ATO challenges in four human factors R&D focus areas: (1) methods and data to optimize the controller and technical operations workforces, (2) guidance to reduce air traffic controller and technician errors and improve safety, (3) efforts to support integration of technology into the NAS; and (4) development of recommendations and methods for enhancing human performance, including individual and team performance.

We address human factors and training challenges through targeted research that yields understanding of human performance, and those factors that contribute to facility-specific impacts, especially for high-impact facilities. In the training domain, we conduct research to evaluate the effectiveness of realistic simulation capabilities that provide a medium for training complex task performance where ATC system safety depends on job task performance. Effective use of simulation may reduce the time required for controllers to reach certification.

ATO human factors challenges currently center on evolution of the workforce and the advancing technologies and associated procedures implemented in the NAS over the next several years. FAA is challenged to hire, place, and train several thousand new air traffic controllers in the coming years, while continuing to provide safe and efficient air traffic services to the users of the National Airspace System. Considerable hiring and training of several hundred technical operations specialists, essential for maintaining and certifying systems and services for use in the air traffic control system, are additional challenges. This program will help our ATO customers improve the efficiency with which they can hire and train new aviation professionals.

In support of system acquisitions that managed within the ATO Program Management Office, this program will focus on integration of human considerations to enhance user-system design. Research in enhancements to human performance will contribute to enhancing the total system's performance, reducing errors, and helping reduce life cycle ownership costs. The program, through the FAA's Program Management Office (PMO) coordination, provides human factors R&D results that support the development and implementation of new technologies and procedures in the National Airspace System. The program assures that the proper roles and responsibilities are assigned to the ATO workforce to assure that controller and technician capabilities are compatible with the advanced technology they use in their jobs, and that the resulting level of air traffic system performance meets operational requirements and fulfills the safety and efficiency objectives. This program continues to provide human factors subject matter expertise to the Joint Resources Council and will coordinate with the PMO human factors office for reviewing how acquisitions have complied with human factors design requirements.

The FY 2019 "Evaluation of ATC Hiring and Training Processes" research program and its component tasks, "Investigation of Attributes that Predict ATCS Training Success Using a Longitudinal Database," "Understanding Why Some Developmental Controllers Fail to Succeed in Field Training/ATC Field Training Effectiveness," "Data-Driven Decision Support for AJI and the FAA Academy Air Traffic Division," "Evaluation of ATCS Selection Process in relation to Predictors of FAA Academy and Field

Training Success," were approved by the 2018 ATO Research Roundtable participants because they addressed problems that the ATO believes are of sufficient importance to warrant research.

The research project "Evaluation of ATCS Selection Process in relation to Predictors of FAA Academy and Field Training Success" is addressing the following ATO research issue: "Air traffic control specialist (ATCS) selection processes underwent significant change between 2014 and 2016. The effect of these changes on success rates in FAA Academy and field training is unknown."

The research project "Understanding Why Some Developmental Controllers Fail to Succeed in Field Training/ATC Field Training Effectiveness" is addressing the following ATO research issue: "Failures from selection and training programs are costly both to the FAA and the employee. The FAA needs information that can help ATO officials develop strategies to increase the probability that new ATC hires will succeed in both Academy and field training at their first facility."

The research project "Investigation of Attributes that Predict ATCS Training Success Using a Longitudinal Database" is addressing the following ATO research issue: "The FAA's Air Traffic Organization regularly makes decisions about policies regarding the placement, training, and promotion of air traffic controllers. Analyses of a longitudinal database containing background information and training performance of developmental controllers have been used to provide information to support these decisions. Researchers previously found differences in the ability of aptitude and experience of newly hired controllers predicted the likelihood that they would succeed in training at their first facility. Additional research might help determine whether these or other attributes could be used to place controllers by option or if a controller who had been successful at a lower level tower should be promoted to a higher level or type of facility."

The research project "Data-Driven Decision Support for AJI and the FAA Academy Air Traffic Division" is addressing the following ATO research issue: "The Office of Safety and Technical Training and the FAA Academy's Air Traffic Division need to obtain information that can improve the evaluation of controller trainees. Currently, two issues about the Academy's tower and En route initial qualification training courses are raising questions: (1) the reliability of trainee performance assessments, and (2) declining class pass rates in both courses. Analysis of the longitudinal database will be conducted to investigate these questions."

The FY 2019 "Safety Aspects of Air Traffic Controller Performance" research program and its component tasks, "Visual Scanning Techniques Research Study" and "Remote Tower Services (RTS) Human Factors Support," were approved by the 2018 ATO Research Roundtable participants because they addressed problems that the ATO believes are of sufficient importance to warrant research.

The research project "Visual Scanning Techniques Research Study" is addressing the following ATO research issue: "Investigations of aircraft separation losses occurring at towers often attribute the incident to a failure in scanning, an effort to acquire information needed to build an awareness of activities that may affect controllers' areas of responsibility. Scanning errors have been repeatedly included among the FAA's Top 5 Safety Issues, yet little is known about scanning patterns used by tower controllers or if certain scanning patterns are better than others."

The research project "Remote Tower Services (RTS) Human Factors Support" is addressing the following ATO research issue: "Remote tower systems are a new technology being brought into the

National Airspace System (NAS). Much needs to be learned about the impact of this new technology on controller performance."

Private industry does not conduct human factors research for air traffic control or technical operations, unless funded by FAA under contract. Industry may make investments in technical products for marketing and other purposes in conjunction with demonstrations at trade shows, such as the ATCA conference.

No other entity exists in the U.S. that performs selection and training research localized to the United States Air Traffic population. The effort required to build and maintain a training database that contains information about selection test scores, experimental tests, biographical information, Academy test scores, and field training records, has required a decade of efforts by trained, educated government personnel. Other agencies and industries collect data and measure training and job performance to assess the validity and fairness of their selection procedures, as required by law. However, these predictive tests and criterion performance measures are relevant only to specific occupations. We strive to maintain awareness of the research on selection procedures and performance measurement techniques used by other agencies and organizations so that we can apply their findings to our research. We communicate with other researchers to share information. Knowledge of the ATO selection and training processes is required to understand what kind of information to collect and interpret results of statistical analyses. Having a group of external employees develop and maintain that kind of knowledge base would require a long-term investment that is not relevant to other occupations. Currently, most of the work being done on these projects is provided by in-house employees.

Economic Impact of Regulatory Reform:

The program does not tie directly to regulations, but program outputs provide important information and data supporting ATO policy, procedures, design standards, training, and operational practices.

The program's primary sponsor and beneficiary is the ATO. The program maintains a high level of discipline working with individual sponsors from different ATO offices for each research project using the ATO Roundtable process. A key part of this process is called Research to Reality. This process provides a mapping beginning with the ATO identifying a research need and its priority, the ANG-C1 program manager designating how the project will be executed, how the ATO uses the research output, and future activities.

Program projects include supporting the development of the workforces for ATC and Technical Operations. For example, research outputs on training support data-driven decision-making on field training success for air traffic control developments.

Research Collaboration Partners:

As mentioned above, public input about research requirements is provided by the REDAC, in particular by the Human Factors REDAC subcommittee. Our stakeholders are not members of industry, but primarily managers and employees of ATO organizations. This is true because our research requirements are provided by our ATO research sponsors and the funding we expend on projects is approved in advance by ATO Research Roundtable participants (a group of ATO research sponsors).

Nevertheless, we respond to requests and questions submitted to us through the FAA.Gov web site. We also, as an ISO organization, record stakeholder feedback using an electronic reporting system. We respond to questions and comments submitted through that system. We also provide statistics about stakeholder satisfaction to our management using Analysis of Data reports, produced quarterly.

Below is a list of some of the work groups in which division employees participate. All of these groups involve other FAA organizations, though some include non-FAA government employees. The advantages of these partnerships include the opportunity to interact with individuals who have different expertise than that of our employees and learn about other projects that may be relevant to our own. Interaction may provide opportunities for working together to accomplish similar research or other goals.

- AJI OJTI Safety and Technical Training Workgroup
- AJI Air Traffic Training Summit
- AJI Collegiate Training Institution Training Summit
- DoD/FAA/NASA Aerospace Medicine Research Alignment and Collaboration Working Group (AMRAC)
- FAA Institutional Review Board (IRB)
- FAA Research Engineering and Development Advisory Committee (REDAC) – HF - observer
- ATO Research Roundtable - observer
- MMAC NextGen integration Committee
- Wright State Univ., University of Oklahoma, and Eurocontrol Coordination Plan 1.7

We also have partnerships with grant recipients, COE participants, and FFRDC employees. We have provided support to COE participants and FFRDC employees by providing them access to our simulation or testing equipment, designing scenarios for them, helping them gain access to research participants, collecting data for them, providing output files for their use, and sometimes analyzing their data.

Do non-government groups partner with this program? Yes

Universities partner with us in performing human factors R&D when we fund their work through the FAA grants program. We work with the military as research partners as they examine air traffic controller selection and training. We work with universities domestically and internationally as they examine personnel selection. We collaborated in research meetings with representatives of DLR German Aerospace Center and edited a book together. We partnered with researchers from the US Navy to exchange information about Air Traffic selection. Our personnel have collaborated with academic researchers via Collaborative Agreements (related to grants). We have also supported research being conducted by faculty members at universities associated with the Center of Excellence for Technical Training and Human Performance.

Acquisition/Assistance:

FAA programs in the research portfolio, use the FAA grants office and competitive acquisition under the FAA's Acquisition Management System (AMS) to employ a range of contracting vehicle types and

grants to conduct Research and Development activities. The FAA's acquisition management system offers researchers a plethora of contract vehicles. These include omnibus contract vehicles such as the SE 2020/25 Contracts and eFAST Indefinite Delivery/Indefinite Quantity (IDIQ) Contract Vehicles in which participating vendors competitively bid to earn status as vetted service providers for term, single and multiyear contracts. Local Contracting Offices also support sole source, directed awards to Veteran Owned Small Business (VOSB), 8A and competitive acquisitions through simplified acquisition processes announced on Federal Aviation Administration Contracting Opportunities (FAACO) website. Local grants are used to execute a portion of the FAA's research budget in line with the FAA's statutory authority to issue grants pursuant to the Aviation Research grants Program. The FAA's Center of Excellence (COE) is one example of a successful- grant-based program that uses competition to select from among member of academia for CO participation.

The Human Factors and Engineering Group (ANG-C) may obtain specific university capabilities to support the research program from Wright State University and University of Oklahoma through the FAA grants office.

The only time sole source acquisitions are used at CAMI is if the product or service being acquired is related to a previous proprietary acquisition. For example, in some cases, the original vendor may be the best source for providing maintenance for certain kinds of proprietary equipment that are not commonly available. If a certain vendor developed some software, the best source for modifying/updating/expanding the software may be the original developer. However, we rely on competitive awards when possible.

In general, the FAA Research Portfolio includes Research Programs that use multi-year acquisitions.

Does this program leverage non-Federal funds? Yes

The Human Factors and Engineering Group (ANG-C) receives in-kind contributions from university administration staff in the performance and management of FAA grants. Research, Engineering, and Development Advisory Committee (REDAC) members from industry and academia fund their own time and expenses for biannual meetings convened to review and provide feedback on our research plans and progress.

CAMI uses in-kind contributions provided by recipients of grants/Cooperative Agreements or COE participants. The in-kind contributions we have typically seen provide a non-monetary advantage, such as contributing the time of scientists, researchers, or administrative staff. We have supported COE participants but have not funded them directly. We work with the military and other labs to leverage each other's expertise and data, if sharing is possible.

Technology Transfer (T2):

The beneficiaries of the Human Factors and Engineering Group (ANG-C) research exist within the FAA, in the ATO, Human Resources, Office of Civil Rights, and Office of the General Counsel. We publish research results in technical reports, peer-reviewed journal articles, and at scientific conferences as papers and presentations, the cost of publication being factored into the research and not separately tracked.

CAMI Technology Transfer products are published in a publicly available format. We typically distribute information either through technical reports, Proceedings Papers associated with scientific meetings, or journal articles. We make the material available on-line.

- AAM-500 representatives: Dr. Daniela Kratchounova (Research Psychologist) and Ashley Awwad (Management and Program Analyst) are working with Lise Rode (Senior Patent Counsel) on the Cooperative Research and Development Agreement process. Dr. Kevin Gildea has communicated with Ms. Rode about Tech Transfer issues related to the recently-developed revised color palette to identify colors used for coding critical information on primary ATC displays. Dr. Jerry Crutchfield has developed a set of standardized scenarios that industry could use to test NextGen concepts and technologies in a standardized way that would allow easier comparison of research results across companies and organizations.
- AAM-500 hosts national and international research summits, workshops, and symposia to collaborate with industry, academia, as well as other government agencies to evaluate innovative technologies and their potential safe integration into the National Aerospace System
- AAM-500 has transferred knowledge to the Human Factors community (e.g., via publication of methodologies and research findings). Publications are publicly available at https://www.faa.gov/data_research/research/med_humanfacs/oamtechreports/. AAM-500 also transfers knowledge (and software) while communicating with military, academic, and other organizations.
- AAM-500 collaborates and funds research with local universities. We collaborate with academia, government institutions, international entities, and other organizations. For example, we have relationships with the MITRE Corporation, US Navy, International Air Navigation Service Providers (ANSPs): German Aerospace Center (DLR), University of Oklahoma, Wright State University, Georgia Tech. University, and the Technical Training & Human Performance Center of Excellence (COE). We participate in Collaborative Agreements that involve cost-sharing between participants. We also support the Human Performance and Technical Training Center of Excellence by providing laboratory facilities and support for the COE entities' research studies.

The program participates in technology transfer to industry through multiple paths. As an invited member to the ICAO Human Performance Task Force, the NextGen Human Factors Division Manager provided unique input for inclusion of human factors as part of Aviation System Block Upgrades (ASBUs) as well as development of the Human Performance Manual. These materials will be used by Regulators and States to ensure the safety of aviation operations, systems, and training.

This also includes giving presentations and participating in the national standards organizations (RTCA and SEA), and the FAA Research, Engineering, and Development Advisory Committee (REDAC) and its Human Factors Subcommittee. The people attending these meetings have roles in which they contribute human factors, operational, engineering, and management expertise. They take away up-to-date information on FAA policy, trends in safety data, and information on research outcomes and outputs.

T2 performance is measured by the number of reports, technical papers, and conference presentations. The overarching report on FAA human factors is the Fiscal Year 2017 Annual Review available at www.hf.faa.gov, and research reports are available on both the Technical Center and CAMI web sites. Technical papers are competitively reviewed and presented at industry conferences

such as the International Symposium for Aviation Psychology, Human Factors and Ergonomics Society, and the Aerospace Medical Association.

Evaluation / Performance Measurement:

Human Factors and Engineering Group (ANG-C) Management Controls

We track performance with Business Plan Goals, Activities, and Targets. We report status against plans in the quarterly Program Management Reviews, and the biannual meetings of the REDAC NAS OPS and Human Factors subcommittees. We manage our research through Program Descriptions and Level-of-Effort Agreements with CAMI and Technical Center (ANG-E25) research performers. We conduct monthly Program financial Management Reviews to monitor obligations and expenditures.

Human Factors and Engineering Group (ANG-C) Measures of Program Effectiveness

The ATO sponsors apply the results of our research program through policy, procedures, training, equipment design, safety analysis, and other types of applications. The ATO sponsors determine the effectiveness of the research for meeting their needs. We measure our performance against the plan for funding and program timing of deliverables as established by the ATO sponsors and approved at the ATO's Human Factors Research Requirements Roundtable, hosted by ATO.

CAMI Management Controls and Performance

Proposals for annual activity and outcomes are prepared for each research task and collected in a document called a Program Directive (PD) that is provided to ANG-C1. (We work at the task level rather than the program level.) PD Task Descriptions are prepared for each task; they provide a research requirements statement from the project sponsor, the objective, the background, a description of previous activity on the project, proposed or planned research for the current year, research questions to be addressed by the project, the technical approach both in the current year and out years, resources required, and a list of milestones and deliverables (both to be accomplished during the current year). The PD includes a funding requirements table (listed by task) and another table specifying the assignment of FTEs to each of the research tasks.

Quarterly Program Management Review meetings are held by ANG-C1 to review the status of individual research projects. If milestones have shifted or deliverables delayed, justifications for these changes must be provided. We provide quarterly reports about activity on the tasks to the Program Manager in ANG-C1. Semi-annual reviews of task status are also conducted by ANG-C1.

Project performance must take into consideration whether circumstances used to justify the requirement for the project have changed or other events may have changed the need for the project. Did any delays result from unnecessary lack of progress or were they the result of external events (e.g., delays related to lengthy coordination of data collection with the union).

Often, one of our projects is placed on the AVS and/or ANG Business Plans. The status of these projects is reported on a monthly basis. Deliverables are submitted to prove that they were completed on schedule. All projects are developed to meet a request by sponsor that is derived to enhance aviation safety.

Human factors issues, specifically human errors, contribute to 88% of aircraft incidents and accidents. Human errors include errors by the flight crew, maintenance personnel, air traffic controllers, and others who have a direct impact on flight safety. AAM-520, in support of Air Traffic Control/Technical Operations Human Factors research, focuses on reducing aviation-related fatalities related to the actions of controllers and Airway Transportation System Specialist maintainers. The goal of the research program "Evaluation of Air Traffic Control Hiring and Training Processes" is to ensure that the controller workforce is capable of maintaining aircraft separation, maximizing efficiency of aircraft movement, and assisting pilots, all of which can result in reducing aviation-related fatalities. The goal of the "Safety Aspects of Air Traffic Controller Performance" research program is to identify and train optimal tower controller scanning patterns, and to contribute knowledge of human factors to the assessment of remote tower services and participate in safety risk management panels associated with two remote tower demonstration projects. Both of these programs will result in increased safety and reduced aviation-related fatalities.

The program has been concentrated using in-house FAA R&D capabilities and staff to address ATO challenges in human factors R&D focus areas including methods, data and guidance to reduce air traffic controller and technician errors and improve safety. The program recommends improvements to controller visual scanning techniques to reduce runway incursions and loss of standard separation at tower-controller airports. In the training domain, we are prepared to conduct research to evaluate the effectiveness of realistic simulation capabilities that will provide a medium for training complex task performance where ATC system safety depends on job task performance. The program assures that the proper roles and responsibilities are assigned to the ATO workforce to assure that controller and technician capabilities are compatible with the advanced technology they use in their jobs, and that the resulting level of air traffic system performance meets operational requirements and fulfills the safety and efficiency objectives. The program assesses controller fatigue data allowing comparisons to the 2011 NASA fatigue study to support the ATO Fatigue Safety Steering Committee to determine whether existing mitigations have been effective in reducing controller fatigue, and if further mitigations are needed.

NextGen - Air Ground Integration Human Factors
Funding Request ($6,757,000)

Program Description/Activities:

This research program produces human factors scientific and technical research products that will benefit multiple pre-implementation programs. FAA sponsors apply these products to develop and update FAA guidelines, Orders, Advisory Circulars, Technical Standard Orders (TSOs), and Federal Aviation Regulations (FAR). Operationally, research products support Aircraft Certification and Flight Standards personnel who evaluate and approve emerging flight deck displays, devices, and procedures that leverage FAA investments in NextGen capabilities and enhancements. Focus areas for this research program include NextGen Aircraft Systems & Controls Research; NextGen Human Error Mitigation Research; NextGen Flightcrew Readiness Research; and NextGen NAS & Flightcrew Procedures Research.

Statutory Requirements:

Is this program statutorily mandated (Y/N): Yes

"49 USC § 44505. Systems, procedures, facilities, and devices
(b) Research on Human Factors and Simulation Models. — The Administrator shall conduct or supervise research—
(1) to develop a better understanding of the relationship between human factors and aviation accidents and between human factors and air safety;
(2) to enhance air traffic controller, mechanic, and flight crew performance;
(3) to develop a human-factor analysis of the hazards associated with new technologies to be used by air traffic controllers, mechanics, and flight crews;
(4) to identify innovative and effective corrective measures for human errors that adversely affect air safety; and
(5) to develop dynamic simulation models of the air traffic control system and airport design and operating procedures that will provide analytical technology—
(A) to predict airport and air traffic control safety and capacity problems;
(B) to evaluate planned research projects; and
(C) to test proposed revisions in airport and air traffic control operations programs.
(c) Research on Developing and Maintaining a Safe and Efficient System.— The Administrator shall conduct or supervise research on—
(1) airspace and airport planning and design;
(2) airport capacity enhancement techniques;
(3) human performance in the air transportation environment;
(4) aviation safety and security;
(5) the supply of trained air transportation personnel, including pilots and mechanics; and
(6) other aviation issues related to developing and maintaining a safe and efficient air transportation system.

44507

- Human Factors: of flight crews, air traffic controllers, mechanics, inspectors, airway facility technicians, and other individuals involved in operating and maintaining aircraft and air traffic control equipment;

- Human Factors: agency work force optimization, including training, equipment design, reduction of errors, and identification of candidate tasks for automation;

- Human Factors: make comments to the Administrator of the Federal Aviation Administration on human factors aspects of proposed air safety regulations; make comments to the Administrator on human factors aspects of proposed training programs, equipment requirements, standards, and procedures for aviation personnel; advise, assist, and represent the Federal Aviation Administration in the human factors aspects of joint projects between the Administration and the National Aeronautics and Space Administration, other departments, agencies, and instrumentalities of the United States Government, industry, and governments of foreign countries;

A U.S. Congress, Office of Technology Assessment report titled 'Safe Skies for Tomorrow' concluded that long-term improvements in aviation safety will come from human factors solutions and that such solutions are established through consistent, long-term support for human factors research and development, analysis, and the application of human factors information.

In addition to internal AVS sponsors, other program stakeholders include commercial airlines, manufacturers, and the general aviation community."

Program Alignment with Strategic Goals:

DOT Strategic Goal	DOT RD&T Critical Transportation Topic
Innovation	**Improving Mobility**

This program supports the DOT's Strategic Goal of innovation by providing targeted research and development within the FAA that will lead to new technology development and deployment in the National Airspace System (NAS). By providing the necessary research to gather information, this will allow the assessment of regulatory approaches, it will foster information sharing and facilitate coordination, collaboration with industry and other stakeholders, and the ability to test and adopt new technologies throughout the NAS.

This program supports the DOT's strategic goal of Safety by producing scientific data, technical information, and targeted FAA human factors solution integration strategies that enable the successful deployment and operational use of NextGen capabilities. This program focuses on the early identification and proactive response to NextGen human factors impacts that will be introduced to pilots, flight planners, and FAA flight standards and certification personnel. The program's outcome is to ensure that system design, procedures, and training support the flightcrew functions, responsibilities, information needs, and interactions necessary for successful implementation of NextGen improvements, which often involve multiple new technologies operating in parallel. This program does not directly impact rural communities.

Program Objectives:

The objective of the NextGen Air-Ground Integration Human Factors program is to provide a data-driven foundation for FAA guidelines, handbooks, orders, Advisory Circulars (ACs), technical standards orders (TSOs), and regulations to enable the successful implementation of NextGen capabilities (increments) and services (operational improvements). Often, NextGen changes are predicated on the implementation of highly automated aircraft systems and increasingly complex NAS and flightcrew procedures. In many cases, current regulatory and guidance materials do not address the interactions of these technological and procedural dependencies. This research program focuses on the early identification and proactive response to NextGen human factors impacts that will be introduced to pilots, flight planners, and FAA flight standards and certification personnel. The program's outcome is to ensure that system design, procedures, and training support the flightcrew functions, responsibilities, information needs, and interactions necessary for successful implementation of NextGen improvements, which often involve multiple new technologies operating in parallel. On-going focus areas for this program include:

NextGen Aircraft Systems & Controls Research: This research evaluates the human-system performance benefits and limitations of emerging flight deck technologies, systems, and controls. FAA stakeholders apply research outputs to support the expanded use of NextGen capabilities while proactively addressing human factors installation and integration issues that could arise when combining NextGen aircraft changes with legacy technologies, systems, controls, and their respective mode(s) of operation. Many existing regulatory and guidance materials do not address the proliferation of new aircraft equipment, functions, and procedures that are required to implement NextGen. FAA stakeholders apply outputs from this research to close validated regulatory and guidance material gaps.

NextGen Human Error Mitigation Research: This research proactively detects and responds to NextGen flight deck technology shortfalls/gaps that could increase the opportunity for human error in future NAS operations. FAA stakeholders apply research outputs to conduct technology design reviews, down-select potential system design alternatives, and respond to emerging human-system interface issues. Stakeholders also apply research outputs to update FAA regulations, guidance materials, and best practices that are used to assess NextGen technologies/systems for human error tolerance.

NextGen Flightcrew Readiness Research: This research responds to gaps in FAA regulatory and training guidance to enable the evaluation of new NextGen pilot knowledge, skills, and abilities. This research proactively identifies air-ground user adaptation needs to support the successful implementation and operational use of NextGen capabilities and procedures. FAA stakeholders apply outputs from this research to address potential task management evolution needs, and update FAA regulatory and training guidance materials that are used to assess compliance.

NextGen NAS & Flightcrew Procedures: This research proactively identifies and addresses operational integration issues that could result from the implementation of future NAS procedures and advanced flight deck separation management concepts. FAA stakeholders apply research outputs to develop NAS procedure design and evaluation criteria, assess the feasibility of procedure design alternatives, and address the human factors impacts (e.g. workload, cognition, usability) of proposed NAS procedures and NextGen concepts on flightcrew performance.

While we work with industry partners and academia, the FAA has to formulate the science necessary to empirically derive safety standards.

Economic Impact of Regulatory Reform:

Research on Human Error & Complex Systems identifies the impact of emerging flight deck technologies on total human-system performance. This includes understanding whether potential technologies will reduce or increase the opportunity for human error. This research will use data-driven recommendations and repeatable human error assessment methods to support the development of guidance for NextGen operational and equipment approvals, training program criteria, and flightcrew procedure development.

The results of this research will support updates to FAA regulations on pilot training including 14 CFR Parts 65, 119, 121, 135, 142 - Air Carrier Certification, and FAA Order 8900.1 - Flight Standards Information Management System (FSIMS).

Research outputs are shared so industry can leverage scientific methods, data, and recommendations for applicant compliance with regulations on human error and complex systems in 14 CFR 25.1302 including AC 25.1302 – Installed Systems and Equipment for Use by the Flightcrew, AC 25.1309 – System Design and Analysis, and a new AC on Fliightpath Management.

Research supports compliance with flight deck systems regulations in RTCA DO-257A – Operational Performance Standards for the Depiction of Navigation Information on Electronic Maps; AC 120-76C - Operational use of Electronic Flight Bags (EFBs), Order 8900.1 - FSIMS, EFB/AMM Job Aid; RTCA SC-186 - **Automatic Dependent Surveillance-Broadcast (ADS-B);** and SC-227 DO-236c Change 1 and DO-257B MOPS for Depiction of Navigation Information on Electronic Maps.

Research Collaboration Partners:

This program maintains inter-Agency partnerships with NASA and the Volpe National Transportation System Center (NTSC). The partnership with NASA provides this program with unique access to advanced human-in-the-loop simulation, modeling, and data analytics capabilities. The partnership with Volpe enables this program to harmonize research results with International Civil Aviation Organization (ICAO) standards, as well as FAA and industry work groups, like RTCA.

Do non-government groups partner with this program? Yes

This program maintains partnerships with the MITRE Corporation, U.S. airlines, aircraft manufacturers, avionics/technology manufacturers, navigational information publishers, and academia. These partnerships enable this program to leverage both public and private sector capabilities to maintain a comprehensive research to reality strategy. This strategy leverages the key intersection points between FAA rule/guidance update needs, NextGen pre-implementation timelines, industry needs and expectations, and global harmonization opportunities. Additionally, these partnerships provide this program improved technical monitoring and a strategic vision that bridges human factors gaps across domains.

Acquisition/Assistance:

Does this program utilize competitive procurement processes? Yes.

FAA programs in the research portfolio employ competitive contracting vehicle types and grants to acquire Conduct, Research, and Development activities. The FAA's acquisition management system offers researchers omnibus contract vehicles such as the SE2020, SE2025, and eFAST BPAs in which vendors competitively compete for TOs and BPA calls. The Broad Agency Announcement is another competitive process the FAA utilizes for awarding basic research contracts. Grants are used to execute a portion of the FAA's research budget and where the FAA has the statutory authority to issue grants pursuant to the Aviation Research Grants Program. The FAA's Centers of Excellence (COE) is one example of a grant-based program that uses competition to select from among members of academia for COE participation. In the specific case of the COE grant program, it receives matching funds from industry sponsors.

This program does not use "sole source" acquisitions.

In general, the FAA Research Portfolio includes Research Programs that use multi-year acquisitions.

Does this program leverage non-Federal funds? Yes.

This program includes university and industry partners in its research efforts. When able, this program uses in-kind contributions from those partners as a partial match that supplements its research investment. This program involves university researchers through the FAA's Regional Air Transportation Centers of Excellence (COE) that requires a 1-to-1 match on the program's investments. As the program develops consensus on standards through participation in government-industry working groups such as the RTCA and SAE G-10 committees, the non-governmental participants cover their own costs. Research, Engineering, and Development Advisory Committee (REDAC) members from industry and academia also fund their own time and expenses for biannual meetings convened to review and provide feedback on our research plans and progress. The program has used Other Transaction Agreements (OTAs) with research partners that require in-kind contributions that enable cost avoidance and add relevant activity at no cost.

Technology Transfer (T2):

Managers from this program lead the transfer of scientific and technical research products to AVS and NextGen program/project sponsors. FAA sponsors apply these products to develop and/or update FAA guidelines, Orders, Advisory Circulars, TSOs, and Federal Aviation Regulations (FARs). Operationally, research products support Aircraft Certification and Flight Standards personnel who evaluate and approve emerging flight deck displays, devices, and procedures that leverage FAA investments in NextGen capabilities and enhancements.

AVS and NextGen pre-implementation programs are the primary beneficiaries of this program's research outputs. Research results are published on the DOT's National Transportation Library (NTL) or on publicly-available websites hosted by the FAA William J Hughes Technical Center, the FAA Civil Aerospace Medical Institute (CAMI), and the US DOT Volpe Center. Scientific papers are published in technical conference proceedings, peer-reviewed journal articles, and in chapters within edited books. This program also facilitates biannual Human Factors Reviews, where current research

investments and results are shared across the community of interest. Metrics for program success include but are not limited to the number of FAA rules and guidance materials impacted by this program's research

The program participates in technology transfer to industry through multiple paths. As an invited member to the ICAO Human Performance Task Force, the NextGen Human Factors Division Manager provided unique input for inclusion of human factors as part of Aviation System Block Upgrades (ASBUs) as well as development of the Human Performance Manual. These materials will be used by Regulators and States to ensure the safety of aviation operations, systems, and training.

This also includes giving presentations and participating in the national standards organizations (RTCA and SAE), industry events (e.g., PCPSI), and the FAA Research, Engineering, and Development Advisory Committee (REDAC) and its Human Factors Subcommittee. The people attending these meetings have roles in which they contribute human factors, operational, engineering, and management expertise. They take away up-to-date information on FAA policy, trends in safety data, and information on research outcomes and outputs.

T2 performance is measured by the number of reports, technical papers, and conference presentations. The overarching report on FAA human factors is the Fiscal Year 2017 Annual Review available at www.hf.faa.gov, and research reports are available on the Volpe web site. Technical papers are competitively reviewed and presented at industry conferences such as the International Symposium for Aviation Psychology, Human Factors and Ergonomics Society, and the Aerospace Medical Association.

Evaluation / Performance Measurement:

Management Controls

We track performance with Business Plan Goals, Activities, and Targets. We report status against plans in the quarterly Program Management Reviews, and the biannual meetings of the REDAC NAS OPS and Human Factors subcommittees. We manage our research through Program Descriptions and Level-of-Effort Agreements with CAMI and Technical Center (ANG-E25) research performers. We conduct monthly Program financial Management Reviews to monitor obligations and expenditures.

Measures of Program Effectiveness

The ATO sponsors apply the results of our research program through policy, procedures, training, equipment design, safety analysis, and other types of applications. The ATO sponsors determine the effectiveness of the research for meeting their needs. We measure our performance against the plan for funding and program timing of deliverables as established by the ATO sponsors and approved at the ATO's Human Factors Research Requirements Roundtable, hosted by ATO.

Aeromedical Research
Funding Request ($9,080,000)

Program Description/Activities:

The FY 2019 budget allocated to the Aeromedical Research Program will support the following activities only: Processing of biological samples from fatal aircraft accidents for forensic toxicology analysis and preparation of forensic toxicology reports describing findings. These activities concern a component of the Aeromedical Accident Investigation & Prevention requirement (A11.J.AM-2).

Statutory Requirements:

Is this program statutorily mandated (Y/N): Yes.

The FY 2019 budget allocated to the Aeromedical Research Program concerns forensic sciences activities established by Public Law (PL) in 1958. PL 85-726 (1958) Sec. 106j, 312 and subsequent PLs/corresponding sections, e.g., PL 100-591 Sec. 5 (1988); PL 103-272 (1994) Sec. 106j, 44505, 44507; PL 112-95 (2012) Sec. 901g10; PL 114-190 (2016) Sec. 2307f, h. The language within these documents specifically describes the type of research to be conducted by CAMI. For example, pertinent to the research supported by the FY 2019 budget: *"The Civil Aeromedical Institute established by section 106(j) of this title… (1) conduct civil aeromedical research, including research related to— … (B) medical accident investigation …; (C) toxicology and the effects of drugs on human performance; (D) the impact of disease and disability on human performance;…".*

Other drivers of the research include:

- OMB/OST M-17-30 Memorandum regarding FY 2019 RE&D Budget Priorities: (1) American Health. By prioritizing biomedical programs that encourage innovation to prevent, treat, and defeat diseases. We focus on solutions for an aging population, combating drug addiction and other public health crises. (2) Increasing Government Accountability and Efficiency. By ensuring that research efforts are based on sound science, do not duplicate existing R&D efforts, and contribute to the public good. (3) Developing a Future-Focused Workforce. Aeromedical research is an active participant of STEM education and other outreach efforts. We host H.S./university students, scientists, and residents in aerospace medicine via internship programs. However, the FY 2019 50% reduction in personnel will eliminate this and other outreach activities. (4) Modernizing and Managing Research Infrastructure. Forensic toxicology and biochemistry research laboratories have been recently modernized with state-of-the-art instruments.

- DOT Strategic Plan 2018-2022: Safety. Explained in the next section.

- FAA Orders that establish aeromedical research activities pertinent to accident investigation and prevention are: 9000.3A. Aviation Drug and Alcohol Testing Program/Drug Abatement; 8025.1D. Medical Responsibilities in Aerospace Incidents and Accidents; and 8020.11C. Aircraft Accident and Incident Notification, Investigation, and Reporting.

- FAA Strategic Priorities & Initiatives. (1) Make Aviation Safer & Smarter – Risk-Based Decision Making - Enhance aeromedical decision making process, accident investigation practices, and human safety criteria; (2) Enhance Global Leadership – Develop an integrated, data-driven approach to international activities – harmonization of aeromedical standards and mentorship of resident physicians and scientists; and (3) Empower & Innovate with the FAA's People – Workforce of the Future by attracting talent and supporting mentorship and STEM program., STEM). Items 2 and 3 will be curtailed given the FY19 budget constraints.

Program Alignment with Strategic Goals:

DOT Strategic Goal	DOT RD&T Critical Transportation Topic
Safety	**Promoting safety**

This program supports the DOT's Strategic Goal of safety by providing systematic research and development within the FAA that will lead to the identification, assessment and mitigation of safety risks. By providing the research necessary to generate data, this data is then used to create and develop new safety standards that will be adopted throughout the aviation community.

The FY 2019 budget allocated to the Aeromedical Research Program supports the strategic goal of Safety by providing: 1. Forensic Toxicology Reports for all U.S. fatal aircraft accidents – from the performance of advanced toxicological and biochemistry methodologies to analyze human biological samples for alcohol, drugs, toxins, and other substances. 2. Aeromedical Review Reports of all U.S. fatal aircraft accidents – integrated evaluation of the accident's operational environment, survival factors, and medical records (e.g., autopsy, toxicology, and airmen's certification data). 3. Scientific Publications – describing (a) trends in the use of drugs, alcohol, and other substances by the pilot population and (b) risk mitigation strategies to combat medical or environmental factors that affect pilot health and performance in-flight; and 4. Maintaining integrated medical information systems and data mining/analytical tools. The Aeromedical Research Program does not impact rural communities.

Program Objectives:

This program does not concern a market failure. The main goal of the research conducted through this program is to elucidate aviation accidents' causes and contributing factors to develop methods to mitigate their occurrence. Focus is on the human component of the National Airspace System (NAS), specifically the aircrew's health and performance in civil aviation operations.

The FAA's Civil Aerospace Medical Institute is the authorized agency to conduct forensic analysis of biological samples proceeding from U.S. fatal aircraft accidents. No other entity exists in the U.S. that performs forensic toxicology research pertinent to civil aviation operations. Any product (e.g., designer illegal drugs and new medications) introduced in the NAS concerns the safety and health of the user of such products (operators) and the customers they serve (public). Even uninhabited air vehicles and sophisticated automated systems ultimately involve human input; the human is invariably subject to physiologic breakdown and, therefore, less than optimal performance. The FAA's Aeromedical Research Program is unique in its expertise regarding this human vulnerability in civil aviation.

Improving Mobility for Underserved Communities:

The FY19-FY20 aeromedical research program does not address mobility for underserved communities. In terms of aeromedical topics relative to passengers, these would refer to cabin safety – wheelchair access, aircraft seating accommodations, and evacuation during emergency events. DOT released disability-related training materials for airlines and passengers for areas subject to the greatest number of complaints: wheelchair and guide assistance; stowage, loss, delay, and damage of wheelchairs and other mobility assistive devices; aircraft seating accommodations; and travel with service animals. Airlines can use them to supplement disability-related training required for employees and contractors under DOT rules. The new materials include companion pieces to provide passengers with disabilities information about their rights under the Air Carrier Access Act (ACAA) and DOT rules [http://www.yklaw.com/WAS-February-2017.pdf]. DOT also issued "Guidance for Airline Personnel on Nondiscrimination in Air Travel" for airline employees and contractors, and "Passengers' Right to Fly Free from Discrimination" for the flying public. The documents replace prior DOT guidance and were developed with airlines and civil rights organizations. Both are available on the DOT website. See the Air Carrier Access Act at either of the following:

- https://www.transportation.gov/airconsumer/passengers-disabilities
- https://www.transportation.gov/airconsumer/disability.

Economic Impact of Regulatory Reform:

Aeromedical research has resulted in increased safety and the elimination of existing costs associated with aeromedical certification standards and sharing of resources with other entities. For example, (1) Relaxation of medical certification standards regarding antidepressant medications, diabetes, and medical conditions that an Aviation Medical Examiner (AME) can issue (e.g., expedite); (2) improvements recently prominent in the media, such as aeromedical standards regarding mental health and the safety of oblique seat cabin configurations; (3) Invited contribution to the Office of Science and Technology (OST) Space Weather Action Plan and participation or our scientists, engineers, and physicians in the investigation of several accidents: Turkish Airlines (2009), Brighton (2012), ASIANA (2013), Space Ship 2 (2014), NY East River (2018); (4) aeromedical research ultimately resulting in Tax-Payer Cost Savings. For example, regulatory guidance concerning passenger safety, Accident Prevention, Drug Abatement, and Personalized Medicine proceeds from the knowledge gained from aeromedical research. Witness the recent international successes wrought by cabin safety and biodynamics research: Air France A-340 Toronto and United Arab Emirates Flight EK521 both resulted in 100% evacuation success. Saving one solitary soul (crew or passenger) from death as a result of aerospace medical research knowledge generates a savings of $9.6 M, the value of a human life as of 8/2016, per DOT's Guidance on Treatment of the Economic Value of a Statistical Life in U.S. Multiply that amount by half of the 416 passengers occupying a 3-class layout of the typical 747-400 flight (e.g., 208 fatalities). This calculation results in a savings of $2 Billion, not counting lesser injured passengers, loss of materiel, or considering the political and moral repercussions of such accidents; (5) Successful resolution of NTSB Recommendations A-14-46 (adequacy of slide and slide/raft certification standards and test methods, ASIANA) and A-10-85 (Life vests, US Airways flight 1549, leading to the revision of TSO-C 13L, Life Preservers); and (6) Significant cost savings in passenger education via the development of Cabin Safety Applications available at Google Play/iTunes: Plane Troubles, Life Vest, Learn to Brace, and Prepare for Impact.

Examples of our impact include this input from stakeholders: (1) "… I would like to take this opportunity to express our appreciation for the excellent product provided by the FAA Civil Aerospace Medical Institute's CARI Program- the computer program developed by CAMI's Radiobiology Research Team- which is used to help air travelers calculate their in-flight exposure to cosmic radiation, Additionally, the Coalition of Airline Pilots Associations (CAPA) which represents 22,000 pilots from five different airlines, would like to express our continued support for the CARI Program and the critically important cosmic radiation exposure research and resultant information that CAMI Radiobiology Research Team provide to the public and our professional aircrew members…" Coalition of Airline Pilots Associations (CAPA) Letter to the FAA Administrator Signed by Captain Gary Boettcher, President, CAPA and (2) "The International Brotherhood of Teamster Airline Division, representing 40,000 aviation employees, urges you to preserve funding for the CARI-6 Program and the FAA's Radiobiology Research Team. This critical program provides much needed research and information on aircrew radiation exposure, which is used not only in the United States, but also throughout the world…The IBT Airline Division strongly supports the funding of the CARI program, and all programs within the FAA that address the occupational safety and health of air crewmembers." International Brotherhood of Teamsters (IBT) Letter to the FAA Administrator Signed by Don Treichler, Director, Airline Division, IBT.

Performance-Based Regulations and Safety

The Aeromedical Research Program provides regulatory language and recommendations to improve safety of civilian air operations by optimizing the health and performance of the most important aspect of the National Airspace System, the human (the operators and the public they serve). Three FY19-FY20 aeromedical research requirements support performance-based regulations and safety: Aerospace Medical Systems Analyses. Topics include: cannabinoids, cognitive issues and clinical follow-up for airmen with chronic neurological disease, reporting accuracy of airmen medical certification applications, Impact of BASICMED (relaxed medical certification regulation – general aviation operations), Impact of CACI (facilitation of medical certification standards for certain pathologies), Definition of medical hazards involved in medical transports by helicopter, Development, verification, and validation of a g-induced loss of consciousness model (aerobatic flight), Criteria for medical certification of airmen with chronic obstructive pulmonary disease, Software with better estimates of radiation levels at neutron monitor locations during solar particle events, and Efficacy of the medical certification process for atrial fibrillation combined with stroke conditions

Aerospace Medical Accident Prevention & Investigation. Topics include: analysis of designer drugs in postmortem fluids and tissues, Chromatographic/mass spectrometry method and report for the analysis of antipsychotic medications in postmortem specimens, Description of the stability of quetiapine. Quetiapine (e.g., Seroquel) is used for the treatment of bipolar disorder, major depressive disorder, and schizophrenia – it is disqualifying for flight operations, Human physiologic response comparison in three hypoxic environments, and Assessment of modafinil as a countermeasure to sleep deprivation – biomarker discovery.

Human Protection & Survival. Topics include: Evaluation of new physical way-finding technology proposed for use on aircraft, Evaluation of serious games (e.g., iPhone apps) for passenger education, Effect of cabin seat pitch and alternative seat configurations on evacuation, Injury criteria for obliquely oriented seats, Evaluation of replacement cushions in energy absorbing seats, Predicting occupant unconsciousness and leg injuries that can occur during a survivable crash, New standards

necessary to ensure a similar level of safety is afforded smaller occupants, Correlation of rotorcraft design features with mechanism of occupant injuries, and Evaluation of new safety equipment/technology that can be retrofitted onto legacy rotorcraft.

For example, appropriate flight attendant emergency procedures and restraint systems that meet injury criteria thresholds are a result of aerospace medical research. See the successful USAir A-320 ditching in the Hudson River – this is a result of aeromedical research findings in evacuation and crash survival specific to the activities of flight attendants and cabin safety strategies. The impact of the forensic sciences aspect of the aeromedical program is reflected by the following statement: "The NTSB is fortunate to benefit from the resources of the FAA toxicology laboratory at the Civil Aerospace Medical Institute, likely the finest toxicology laboratory in the world for analysis of specimens from accident investigations." Testimony of Mitchell A. Garber, M.D., NTSB to the Committee on Transportation and Infrastructure, Subcommittee on Aviation, U.S. House of Representatives. The FAA's Civil Aerospace Medical Institute is the authorized agency to conduct forensic analysis of biological samples proceeding from U.S. fatal aircraft accidents.

No other entity exists in the U.S. that performs forensic toxicology research pertinent to civil aviation operations. Any product (e.g., designer illegal drugs and new medications) introduced in the NAS concerns the safety and health of the user of such products (operators) and the customers they serve (public). Even uninhabited air vehicles and sophisticated automated systems ultimately involve human input; the human is invariably subject to physiologic breakdown and, therefore, less than optimal performance. The FAA's Aeromedical Research Program is unique in its expertise regarding this human vulnerability in civil aviation.

Research Collaboration Partners:

Public stakeholder input is primarily received through:

(1) The congressionally mandated Research, Engineering, and Development Advisory Committee (REDAC). The REDAC is an advisory committee to the FAA whose members are FAA stakeholders including industry, Federally Funded Research and Development Centers (FFRDCs), and academia. The REDAC provides advice and recommendations to the FAA Administrator on the needs, objectives, plans, approaches, content, and accomplishments of aviation research program. The committee reviews and comments on the aviation research programs including Centers of Excellence and other grants. The REDAC considers aviation research needs in five areas; (a) NAS operations, (b) airport technology, (c) aircraft safety, (d) human factors, and (e) environment and energy. The REDAC holds 2 full committee meetings and 10 subcommittee meetings annually from which come reports documenting REDAC's input known as REDAC Findings and Recommendations (F&Rs.) The research programs evaluate REDAC findings and recommendations, and the FAA responds with adjudications and where appropriate, action plans commensurate with the recommendations. The FAA Research Portfolio Division and the research performers track all F&R and associated Agency responses.

(2) Stakeholder input pertinent to the FY 2019 budget allocated to the Aeromedical Research Program was primarily obtained from NTSB Recommendations, Public Law, the FAA's Office of Aviation Safety's (AVS) Aeromedical Technical Community Representative Group (TCRG), and FAA's Orders related to accident investigation & prevention. Program Performance metrics are reported periodically to the REDAC, the TCRG, and multiple research,

management, and financial forums. These metrics may be summarized as those related to requirements, budget, infrastructure, schedule, and output. Public input is managed through processes governed by the AVS Quality Management System, which is based on the ISO 9011:2015 standard. Customer and stakeholder satisfaction is tracked by 8 processes that assess metrics such as efficiency, effectiveness, productivity, and quality of the program's output. The FAA's Aeromedical Research laboratories and test facilities are audited periodically and are certified by the American Board of Forensic Toxicology -- compliance with numerous metrics is required for such certification.

The FY 2019 budget allocated to the Aeromedical Research Program supports the following internal sponsors: FAA's Office of Aerospace Medicine (AAM), Office of Accident Investigation and Prevention (AVP), and Office of Chief Council (AGC). It also supports the following external stakeholders: NTSB, Department of Justice, US Medical Examiners/Coroners, and several professional organizations (toxicology and chemistry specialties). These partnerships are described in FAA Orders pertinent to accident investigation and prevention, listed earlier in this document. The benefits of these partnerships include: (a) Data-Driven Continued Operational Safety – by maximizing the strengths of the human link in the NAS and minimizing inherent human weakness to prevent accidents and improve safety through evidence-based medicine; (b) Risk Management – by identifying hazards and investigating injury and death patterns in civilian flight accidents towards an aerospace medical safety management system; and (c) Streamlined Certification by Analysis/Standards and Policy – by formulating criteria that will lead to improved knowledge management and decision-making processes in aerospace medicine and accident investigation & prevention programs.

Do non-government groups partner with this program?

Yes, while internships in forensic sciences are normally offered to several universities, e.g., students learn numerous laboratory practices and forensic toxicology methods from CAMI scientists, the FY19 budget constraints will not allow this.

Acquisition/Assistance:

FAA programs in the research portfolio employ competitive contracting vehicle types and grants to acquire Conduct, Research, and Development activities. The FAA's acquisition management system offers researchers omnibus contract vehicles such as the SE2020, SE2025, and eFAST BPAs in which vendors competitively compete for TOs and BPA calls. The Broad Agency Announcement is another competitive process the FAA utilizes for awarding basic research contracts. Grants are used to execute a portion of the FAA's research budget and where the FAA has the statutory authority to issue grants pursuant to the Aviation Research Grants Program. The FAA's Centers of Excellence (COE) is one example of a grant-based program that uses competition to select from among members of academia for COE participation. In the specific case of the COE grant program, it receives matching funds from industry sponsors.

Sole source acquisitions are rare and may concern, for example, unique forensic toxicology instrumentation or proprietary analytical software.

This program utilizes both single year and multi-year acquisitions. For example, single-year efforts may concern the purchase of forensic toxicology laboratory supplies, reagents, or an analytical instrument; a multi-year acquisition may concern the maintenance of equipment. Research will be

focused on the processing and toxicological analysis of biological samples from fatal aviation accidents. Such activities are conducted independent of any other entity, in a secure environment, and in accordance with strict chain-of-custody procedures.

The FY19 budget allocated to the Aeromedical Research Program does not support leveraging non-Federal funds. Research will be focused on the processing and toxicological analysis of biological samples from fatal aviation accidents. Such activities are conducted independent of any other entity, in a secure environment, and in accordance with strict chain-of-custody procedures.

Technology Transfer (T2):

Research will be focused on the processing and toxicological analysis of biological samples from fatal aviation accidents. Posting of research findings in the USDOT Research Hub is ongoing.

The aeromedical research program is represented by the AAM-612 Section Supervisor in support of the FAA T2 program, managed by personnel at the WJHTC. Her role is to support the program and identify opportunities amenable to the transfer of research knowledge, products, and services amongst the aerospace civilian and military communities. The results of these activities are numerous and focus on outreach, collaborative activities, and knowledge transfer as listed below. T2 performance is evidenced by the cost savings in the leveraging of resources, relaxation of standards without compromising safety, and realizing 100% survival from aircraft mishaps. The aeromedical research program includes processes by which existing knowledge, facilities, or capabilities developed under federal R&D funding are utilized to fulfill public and private needs as follows:

1. Scientific and engineering reports, book chapters, presentations, and other tangible media assessing biological/chemical threats; hypoxia exposure; adequacy of protective technology (oxygen masks, restraints, airbags, rafts, escape slides, exit types /markings), procedures (brace for impact, cabin crew communications); incidence, prevalence, and distribution of medications or illegal drugs in post-mortem specimens; and other factors that influence human performance, physiology, safety, and health in civilian air operations.
2. Recommendations addressing the impact of commercial space transportation (e.g., suborbital flight) including the effects of ionizing and non-ionizing radiation on living systems (e.g., cancer and genetic defects). These efforts include the development of software that calculates radiation dose in-flight and associated warning systems that assist the aircrew and aircraft cabin personnel in monitoring and maintaining their occupational exposure within safe levels.
3. Technical evaluations of emergent biomedical techniques, devices, and screening procedures for their suitability in the aviation environment and their impact on human safety.
4. Guidance to national and international aviation medical examiners, residents in aerospace medicine, accident investigators, and other aviation specialists in support of the harmonization of aeromedical standards and policies across the world.
5. Forensic Toxicology Reports for all U.S. fatal aircraft accidents – from the performance of advanced toxicological and biochemistry methodologies to analyze human biological samples for alcohol, medications, illegal drugs, gases, toxins, and other substances. This activity includes offering expert witness testimony and supporting drug abatement programs.
6. Aeromedical Review Reports of all U.S. fatal aircraft accidents – integrated evaluation of the accident's operational environment, survival factors, and medical records (e.g., autopsy, toxicology, and airmen self-reports).

7. Discovery of biomarkers that signal incapacitation or impairment due to stressors posed by the flight environment (e.g., altitude, radiation, and acceleration forces) or inherent condition of the human operator (e.g., fatigue, drug, alcohol, or disease).
8. Comprehensive and Integrated Medical Information Systems, Biomarker Libraries, Data Mining/Analytical Tools (including high performance computing/big data analyses), and Data Visualization Tools to support epidemiological, data-mining, and probabilistic risk analyses towards the realization of aerospace medical safety management systems.
9. Regulatory language for flight standards and aircraft certification addressing: aircraft seat cushions and restraint systems, evacuation equipment and procedures, fire safety systems and procedures, post-crash survival, water survival, emergency equipment and procedures, and passenger information media.
10. Criteria and methods to define injury potential of new aircraft configurations and structures by utilizing advanced computational (modeling & simulation) and impact test techniques under simulated crash environments.
11. Didactic programs that include safety brochures, cabin safety research workshops, biodynamics engineering procedures seminars, emergency egress methodologies, student internships, and other strategies (media events/public relations and outreach efforts) to enhance human safety.
12. Service as an advisory resource to the national and international public, government, academia, and industry communities.

T2 activities include collaboration with several organizations, some listed below, several via contract, agreements (MOA/MOU/IAA/OTA), or grants.

1. Government: USN, USA, USAF, NTSB, NASA, NOAA, DOJ, NHTSA, DHS CBP/ICE, TSI, NSC, US Medical Examiners/Coroners, local Law Enforcement/Emergency Response agencies
2. Industry: Boeing, Cleveland Clinic Foundation, OMRF, FAMRI
3. Academia: SWRI, OSU, OU, WSI, MCW, UMTRI, OSSM
4. Professional Organizations: > 50 (science, engineering, medical, ALPA, AOPA)
5. International: EASA, ICAO, SAE, ISR, Airbus, CSRTG, IAAM, IAASM, IATA

DOD= US Navy/Air Force/Army; NTSB= Natl. Transp. Safety Board; NASA= Natl. Aeron. & Space Admin.; NOAA: Natl. Oceanic Atm. Admin.; DOJ= Dept. of Justice; NHTSA= Natl. Highway Traffic Safety Admin.; DHS= Dept. Homeland Security; TSI: Transp. Safety Inst.; NSC= Natl. Safety Council; FAMRI= Flight Attendant Medical Res. Inst.; SWRI= SW Res. Inst.; OSU= OK State U.; OU= U. of OK; WSI= Wichita State U.; MCW= Medical College of Wisconsin; UMTRI= U. Mich. Transp. Res. Inst.; EASA= Europ. Aviat. Safety Agency; ALPA= Airline Pilots Assoc.; AOPA= Aircraft Owners & Pilots Assoc.; ICAO= Intl. Civ. Aviat. Org.; SAE= Intl. Eng. Stds. Assoc.; ISR= Intl. Safety Res.; OMRF= OK Med. Res. Found.; IAAM= Iberoam. Assoc. of Aerosp. Med; IAASM= Int. Academy of Aviat. & Space Med.; IATA= Intl. Air. Transp. Assoc.; OSSM= OK School of Science & Math.; MOA/MOU= Memorandum of Agreement/Understanding; OTA= Other Transaction Agreement; IAA= Interagency Agreement; CSRTG: International Fire and Cabin Safety Research Technical Group; ICE= Immigration and Customs Enforcement; CBP= Customs and Border Protection.

A total of 2,953 products and services were delivered in 2017. T2 activities are supported by our participation in several forums, including: (1) Aerospace Medicine Research Alignment and Collaboration Council (AMRAC: NASA/USA/USN/USAF/FAA), (2) NASA Living with A Star Institutes program, (3) the Inter-Agency Federal Fatigue Management & Research Working Group led by

NHTSA, (4) DOD Blue Team of the Biotechnologies for Health and Performance Council, and (5) the DOJ/HHS/OSTP Medicolegal Death Investigation Working Group.

Evaluation / Performance Measurement:

The Aeromedical Research Program measures its progress via multiple processes that evaluate (A) Management & Program performance, (B) Research Project Technical Requirements & Scientific Rigor, (C) Employee Competency, (D) Customer/Stakeholder Satisfaction, (E) Safety of Laboratory and Test Facility Operations, and (F) Quality of Products and Services. Numerous metrics are tracked within each process. Program Performance metrics may be summarized as those related to research requirements, budget, infrastructure, schedule, and output. Performance baselines are established for each research project, along with the basis for the formulation of the project, its sponsor, the benefits expected of the results, and the projected implementation of findings in regulatory language and aviation safety guidance documents. Research topics are established according to Public Law, DOT/FAA Strategic Guidance Documents, NTSB Safety Recommendations, and other drivers, including emerging advances in science & technology that may impact human safety in civilian air operations. Per the FY 2018-2022 DOT Strategic Plan, *"DOT is launching a new Program Evaluation effort in 2018. OST is working with its OAs to develop a methodology for defining a program that ties organizational units to mission delivery and allows for comprehensive analysis."* Thus, at this time, DOT 2018 metrics have not been published. The Aeromedical Research Program does address the DOT metrics established in 2017 under its Aviation Safety Goal: (1) *"Reduce U.S. commercial aviation air carrier fatalities by 24 percent over a 9-year period (2010–2018), to no more than 6.2 per 100 million persons on board in FY 2018,"* and (2) *"Reduce the general aviation fatal accident rate per 100,000 flight hours to no more than one in FY 2018."* For example, cabin safety and biodynamics research efforts funded in prior years have increased the chance of crash survival and generated cost savings. Appropriate flight attendant emergency procedures and restraint systems that meet injury criteria thresholds are a result of aerospace medical research knowledge. See USAir A-320 ditching in the Hudson River, which resulted in a 100% survival rate. Saving one solitary soul from death generates a savings of $9.6 M, the value of a human life (DOT, 8/2016,). The FAA's 5-year trend data concerning the DOT's Safety goal is available at https://www.transportation.gov/mission/budget/dot-budget-and-performance-documents. The budget assigned to the Aeromedical Research Program has enabled the excellent performance of this effort through FY18 -- we have completed all the program's annual objectives within the budget and timeline constraints provided to date. The FY 2019 budget allocated to the program will only allow the performance of forensic sciences research. The impact of the forensic sciences aspect of the program is reflected by the following statement: *"The NTSB is fortunate to benefit from the resources of the FAA toxicology laboratory at the Civil Aerospace Medical Institute, likely the finest toxicology laboratory in the world for analysis of specimens from accident investigations."* Testimony of Mitchell A. Garber, M.D., NTSB to the Committee on Transportation and Infrastructure, Subcommittee on Aviation, U.S. House of Representatives.

The FY19-FY20 aeromedical research program addresses the DOT Safety Performance Goal of reducing aviation-related fatalities. This program addresses human safety as follows: (a) Data-Driven Continued Operational Safety – by maximizing the strengths of the human link in the NAS and minimizing inherent human weakness to prevent accidents and improve safety through evidence-based medicine; (b) Risk Management – by identifying hazards and investigating injury and death patterns in civilian flight accidents towards an aerospace medical safety management system; and (c) Streamlined Certification by Analysis/Standards and Policy – by formulating criteria that will lead

to improved knowledge management and decision-making processes in aerospace medicine and accident investigation & prevention programs.

The program measures its progress via multiple processes that evaluate (A) Management & Program performance, (B) Research Project Technical Requirements & Scientific Rigor, (C) Employee Competency, (D) Customer/Stakeholder Satisfaction, (E) Safety of Laboratory and Test Facility Operations, and (F) Quality of Products and Services. Numerous metrics are tracked within each process and the research laboratories are ISO 9001 certified since 2006. Forensic laboratories are also audited periodically and certified by the American Board of Forensic Toxicology. Program Performance metrics may be summarized as those related to research requirements, budget, infrastructure, schedule, and output. Performance baselines are established for each research project, along with the basis for the formulation of the project, its sponsor, the benefits expected of the results, and the projected implementation and tracking of findings in regulatory language and aviation safety guidance documents. Research topics are established according to Public Law, DOT/FAA Strategic Guidance Documents, NTSB Safety Recommendations, and other drivers, including emerging advances in science & technology that may impact human safety in civilian air operations. Per the FY18-FY22 DOT Strategic Plan, "DOT is launching a new Program Evaluation effort in 2018. OST is working with its OAs to develop a methodology for defining a program that ties organizational units to mission delivery and allows for comprehensive analysis."

Next Generation Transportation System - Enterprise, Concept Development, Human Factors, & Demonstrations Portfolio
Funding Request ($16,500,000)

Program Description/Activities:

Enterprise Concept Development, Human Factors, and Stakeholder Demonstration program conducts enterprise level activities, including the development of concepts across the NAS, human factors analysis of a NextGen operational environment, and demonstrations of proposed NextGen system improvements ensure operational feasibility and viability within the NAS. These concept development efforts lead to improvements that will provide air traffic controllers with tools and procedures to separate aircraft with technologically advanced navigation equipment and wake performance capabilities to enhance system capacity, efficiency, and ensure safe aircraft separation while reducing workload for controllers and flight crews. Concept development identifies early NextGen concepts and maturation activities that will transform the National Airspace System (NAS) into the Next Generation of the NAS. Human factors activities evaluate concepts for human factors implications, and inform the maturation of these concepts into successful capabilities. Stakeholder Demonstration provides practical application and analysis of proposed NextGen system improvements to validate and prove concept feasibility and determine which initiatives might be accelerated through fast track modeling.

Statutory Requirements:

Is this program statutorily mandated (Y/N): Y

This program is driven by the FAA Modernization and Reform Act 2012 and FAA Reauthorization March 2018 under FAA Title II NextGen Air Transportation System and Air Traffic Control Modernization Section 202 NextGen Demonstrations and Concepts "In allocating amounts appropriated pursuant to section 48101(a) of title 49, United States Code, the Secretary of Transportation shall give priority to the following NextGen activities.

The Enterprise Concept Development, Human Factors, and Demonstration program supports the statutory requirement through development of concepts across the NAS, human factors analysis of NextGen's operational environment, and demonstrations of proposed NextGen system improvements ensure operational feasibility and viability within the NAS that are critical to NextGen.

Program Alignment with Strategic Goals:

DOT Strategic Goal	DOT RD&T Critical Transportation Topic
Innovation	**Improving mobility**

This program supports the DOT's Strategic Goal of innovation by providing targeted research and development within the FAA that will lead to new technology development and deployment in the National Airspace System (NAS). By providing the necessary research to gather information, this will allow the assessment of regulatory approaches, it will foster information sharing and facilitate

coordination, collaboration with industry and other stakeholders, and the ability to test and adopt new technologies throughout the NAS. This program does not impact rural communities.

Program Objectives:

The goal of the Enterprise, Concept Development, Human Factors, and Demonstrations Portfolio is to identify and reduce risk, evaluate concepts, and define operating requirements early in the lifecycle process. This program 1) develops and conducts studies that prove out NAS concepts to ensure feasibility and viability within the NAS, 2) executes research, engineering analysis, demonstrations and evaluations in support of service analysis and strategic planning, 3) provides a vehicle to test concepts and leverage individual transformational program and project technology to create multi-domain cohesive demonstrations to capture the synergies needed to transform the NAS in an expedited manner, and 4) identifies potential human performance issues at the concept development and validation stages is essential to the usability, acceptability, and safety of NextGen concepts and systems.

The concept development efforts in this program lead to improvements that will provide air traffic controllers with tools and procedures to separate aircraft with technologically advanced navigation equipment and wake performance capabilities to enhance system capacity, efficiency, and ensure safe aircraft separation while reducing workload for controllers and flight crews. Validated operational concepts will identify technical and operational requirements (including airspace, procedures, and automation requirements needed to realize the capacity gains. Human factors examines the overall effect of these changes on the system to maximize user acceptance and utilization while minimizing risk, and stakeholder demonstrations provide a vehicle to test concepts and leverage individual transformational program and project technology needed to transform the NAS.

Economic Impact of Regulatory Reform:

Not applicable, because this program focuses on development of new concepts and potential subsequent demonstrations to support NextGen capabilities for continued improvement of the NAS.

Research Collaboration Partners:

This program utilizes input from FAA stakeholders, airspace users, and industry. This program works collaboratively with all of these groups to understand the value and feasibility of new FAA concepts and capabilities to determine which concepts should be transitioned for further development.

Program Partners	Benefits
Research, Engineering, and Development Advisory Committee (REDAC) (external)	Provides advice and recommendations to the FAA Administrator on the needs, objectives, plans, approaches, content, and accomplishments of aviation research program, and reviews and comments on the aviation research programs.

Radio Technical Center for Aeronautics (external)	Provide recommendations on technical and operational standards to achieve the necessary improvements in the safety and efficiency of the air transportation system. Input has deepened FAA understanding of technical maturity and resulted in changes to definitions and timing for operational concepts.
NextGen Advisory Committee (NAC) – Federal advisory committee (subcommittee of RTCA)	FAA and industry partnership to identify high-benefit, high-readiness NextGen capabilities for implementation in the near term. The FAA and industry jointly evaluate the effects off NAC commitments on the NAS through the work of a Joint Analysis Team (JAT) to understand the value of implementations in this plan.
International Civil Aviation Organization (ICAO) (external)	Partnership with ICAO ensure FAA's part of international harmonization of data exchange and management, a key piece of the future of air traffic management and user collaboration.
FAA Lines of Business (internal)	NextGen collaborate with multiple internal lines of business such as air traffic, program management office, and aviation safety for policy development, concept maturation, and technical acceptance of investment capabilities.

Do non-government groups partner with this program? (Yes/No): No

Acquisition/Assistance:

FAA programs in the research portfolio employ competitive contracting vehicle types and grants to acquire Conduct, Research, and Development activities. The FAA's acquisition management system offers researchers omnibus contract vehicles such as the SE2020, SE2025, and eFAST BPAs in which vendors competitively compete for TOs and BPA calls. The Broad Agency Announcement is another competitive process the FAA utilizes for awarding basic research contracts.

Does this program leverage non-Federal funds? (Y/N): No

Technology Transfer (T2):

Internal T2 activities transition from NextGen to other lines of business for policy development and updates to air traffic control (ATC) procedures. Beneficiaries are the flying public and all air caries operating in the NAS. For concepts that are determined to be feasible, benefits analyses are conducted during pre-implementation activities to gauge projected benefits; additionally, benefits are verified

post-implementation through statistical analysis of actual operations utilizing newly implemented procedures.

Evaluation / Performance Measurement:

The FAA NAS Lifecycle Planning Division manages the planning, implementation, and reporting of NextGen portfolios. Portfolio managers use project management best practices to track and evaluate project progress towards defined objectives/outcome goals, ensure agreed to milestones and commitments with NAS planning documents are on track, monitor/control program risk, and monitor program funds to ensure they are expended in a timely manner. Additionally, they evaluate projects with respect to research needs, considering key aspects such as timeframes for when results are needed, alignment to the NAS enterprise architecture and early phase acquisition management system decision points, likelihood of achieving expected benefits, criticality, risk, interdependencies, and available funding. Portfolio managers incorporate results of completed projects into concept planning during periodic evaluations of concept status and progress.

Aviation Performance and Planning

System Safety Management
Funding Request ($5,500,000)

Program Description/Activities:

This Budget Line Item funds two programs: System Safety Management and Terminal Area Safety research.

The System Safety Management (SSM) program is designed to improve safety through developing safety data collection methods, advanced safety data and risk analysis techniques, and prototypes of risk-based decision-making capabilities to identify and analyze emerging safety issues in a cooperative nature with the aviation stakeholders. The program provides an ability to analyze trends across the aviation community that is much more effective than monitoring individual certificated entities, (e.g., air operators and air traffic facilities).

The FY 2019 funding will support the FAA Administrator's strategic initiative of improved risk-based decision-making. Loss of separation is a major safety concern for the aviation safety, and close encounters between Instrument Flight Rules (IFR) and Visual Flight Rules (VFR) aircraft is one of the ATO's top five priorities. The effective identification and mitigation of hazards associated with NAS system changes and Air Traffic Control (ATC) procedure changes are needed to reduce the chance of loss of separation. To that end, through this program, the FAA has developed a methodology and decision-making prototype tool to support the evaluation of risk controls that are proposed by the ATO to mitigate or eliminate potential hazards due to changes in NAS. The scope and capabilities of the decision-making prototype tool, identified as the Integrated Domain Safety Risk Evaluation Tool (ID-SRET), support the evaluation of risk controls proposed by the ATO to mitigate or eliminate potential hazards due to changes in NAS.

FY 2019 funding will also allow the FAA to develop a Safety Oversight Management System (SOMS) capability to support The Air Traffic Safety Oversight Service (AOV) oversight of ATO compliance with safety standards.

The Terminal Area Safety (TAS) program improves the safety of operations near or at an airport. Research projects in the program focus on developing training solutions and identifying effective technologies to mitigate key causes of fatal accidents such as the loss of control, runway excursions, and runway overruns. These are the leading causes of fatalities in the worldwide commercial jet fleet as indicated in the Boeing Annual Summary of Commercial Jet Airplane Accidents that is based on corresponding ICAO, NTSB, and Flight Safety Foundation (FSF) definition of accidents and events (Statistical Summary of Commercial Jet Airplane Accidents Worldwide Operations 1959- 2014).

Recent landing overruns on wet runways have raised questions regarding validity of current wet runway stopping performance requirements and methods documented in 14 CFR Part 25.109(c) and AC-25-7C, which was developed based on analysis of data collected during NASA’s flight tests in the 60s and 70s. The landing speed of commercial aircraft was around 100 knots In the 60s and 70s; however, the modern aircraft landing speed could be as high as 160 knots. Lack of action risks that the increasing operations of the modern jet transport fleet expanding in to more marginal airports at heavier weights and higher approach speeds may increase the number of landing overruns and casualties. This research project aims to conduct a set of comprehensive high speed flight tests on

wet runway conditions in order to provide further insight into the factors affecting wet runway friction and recommend next steps for the government and industry such as updating aircraft landing performance standards, which in turn, will promote aviation safety.

In FY 2019, the plan is to complete a literature survey of safety issues surrounding wet runway barking performance and complete a set of flight test experiment designs that stakeholders, i.e., manufacturers, airlines, regulators, agree upon.

Statutory Requirements:

Is this program statutorily mandated (Y/N): Yes

Per FAA Order 1100.161, AOV is responsible for oversight of ATO compliance with safety standards. Safety Oversight Management System (SOMS) will support AOV to effectively perform a risk-based oversight in various safety standard areas, i.e., Acquisition and Implementation of New Systems, Air Traffic Control Functions, Equipment and Facility Maintenance Functions. SOMS establishes and maintains oversight profiles for ATO organizations, operations, procedures, and systems. Oversight profiles are a set of safety requirements and safety standards with which the ATO must comply and that are traceable to ATO elements. In addition, the Integrated Domain Safety Risk Evaluation Tool (ID-SRET) is a risk-based decision-making support tool to support AOV and ATO in their evaluation and approval processes of NAS changes. The tool achieves the same goal as FAA Risk-Based Decision Making Initiative – improving standardization, data access, and modeling integration; enhancing decision-making process; and redefining oversight model for industry.

Program Alignment with Strategic Goals:

DOT Strategic Goal	DOT RD&T Critical Transportation Topic
Safety	**Promoting safety**

This program supports the DOT's Strategic Goal of safety by providing systematic research and development within the FAA that will lead to the identification, assessment and mitigation of safety risks. By providing the research necessary to generate data, this data is then used to create and develop new safety standards that will be adopted throughout the aviation community.

More specifically, AOV will use SOMS to proactively identify and prioritize emerging safety issues across the NAS, and to develop targeted and risk-based audit plans and allocate oversight resources effectively and efficiently, which in turn will improve aviation safety.

The ID-SRET will support AOV's decision-making in the evaluation and approval of proposed NAS changes and proactively mitigate risk as well as the ID-SRET supports ATO's Safety Risk Management (SRM) process, which in turn will improve aviation safety.

FAA's Office of Aviation Safety (AVS) plan to use the wet runway wheel braking testing project results to update braking friction coefficient models in FAR 25.109 or to prepare advisory or guidance materials, which in turn will improve aviation safety. AVS may use research results to respond to the NTSB Letter to the FAA dated 4 March 2015 regarding wet runway braking performance standards.

This program impact flying public no matter where they live including rural communities.

Program Objectives:

The main goal of the System Safety Management and Terminal Area Safety program is safety improvements in flight operational areas such as air traffic control, commercial aviation, general aviation and rotorcraft, as well as safety improvements at, or near, airports.

Research in system safety management is described by the following requirements.

The mission of the FAA Air Traffic Safety Oversight Service (AOV) is to conduct independent safety oversight of air traffic services, and AOV is facing increasing challenges due to the dynamic National Airspace System (NAS) changes and lack of understanding on interactions and interdependencies among NAS components. A decision support tool is needed to facilitate AOV's evaluation and approval of NAS changes. The ID-SRET is a model-based decision making support tool to assist AOV in evaluating Safety Risk Management (SRM) documents within the context of multiple NAS changes by integrating NAS system, air traffic control (ATC) procedure, and safety data into a single platform. ID-SRET identifies the interactions and interdependencies among NAS systems, ATC procedures, and system safety hazards to allow AOV more effectively evaluate NAS change impacts, identify potential SRM document issues, and evaluate risk control effectiveness.

FAA's Air Traffic Safety Oversight Office (AOV) currently lacks a capability for organizing products of the various oversight activities for planning oversight actions to verify compliance. Thus, the AOV needs a comprehensive integrated assessment tool to indicate if the current safety oversight requirements are effectively implemented by ATO. The Safety Oversight Management System (SOMS) research project will integrate, link, analyze, and evaluate information contained in AOV data repositories, and enable AOV to identify current and developing safety risks in its area of oversight responsibility.

Research in terminal area safety is described by the following requirement. Aircraft braking capability on a wet runway is a relatively complicated issue, being affected by many different factors in terms of the aircraft, tires, pavement surface, and the environment. Over the years, knowledge gaps with regards to the wet runway braking issue were filled through a multitude of research projects aimed at investigating these factors, resulting in the current state of knowledge and various models for the wet runway braking friction coefficient as seen in FAR 25.109. However, since most of research projects were completed in 1960s and 1970s, knowledge gaps still remain and friction coefficient models are laden with assumptions that may not be applicable in all circumstances and with modern aircraft. The wet runway wheel braking testing project aims to conduct a set of comprehensive high speed flight tests in order to provide further insight into the factors affecting wet runway friction and recommend next steps for the government and industry such as updating aircraft landing performance standards.

Some of the projects within this program:

- Are designed to improve safety through addressing systematic safety issues including emerging safety issues across aviation industry in a cooperative nature with the aviation industry. Neither an industry entity nor the FAA alone could address systematic safety issues

across the aviation system effectively. For example, through this program, FAA has developed an infrastructure and capabilities, called Aviation Safety Information and Analysis Sharing (ASIAS), to enable the free sharing and analysis of de-identified safety information derived from government and industry sources. The ASIAS team with collaboration with aviation industry and the Commercial Aviation Safety Team (CAST) have developed safety metrics for monitoring precursors to aviation accidents such as Near Midair Collision, Runway Excursion and Incursion, Loss of Control, and Controlled Flight into Terrain. The ASIAS team regularly monitors safety metrics and uses specific measures to understand the safety enhancements put in place by the CAST to detect changes, if any, in the current levels of safety.

- Address safety issues unique to the FAA's oversight capabilities. For example, the FAA's Air Traffic Safety Oversight Office (AOV) currently lacks a capability for organizing products of the various oversight activities for planning oversight actions to verify compliance. Thus, the AOV needs a comprehensive integrated assessment tool to indicate if the current safety oversight requirements are effectively implemented by ATO. The Safety Oversight Management System (SOMS) research project will integrate, link, analyze, and evaluate information contained in AOV data repositories, and enable AOV to identify current and developing safety risks in its area of oversight responsibility.

- Provide necessary technical data to the FAA's Office of Aviation Safety (AVS) to prepare meaningful advisory and guidance materials. For example, the purpose of wet runway wheel barking testing is to conduct high speed landing flight tests, collect experimental data and gain knowledge and insight into the reasons for significant reduced wet runway wheel braking compared to models defined in FAR 25.109; and provide recommendations for updating wet runway braking performance standards to the FAA's Office of Aviation Safety (AVS).

Economic Impact of Regulatory Reform:

The System Safety Management Program may provide technical data to update 14 CFR Part 25.109(c), which is considered a performance-based regulation as it provides applicable requirements for aircraft accelerate-stop distance rather than a prescriptive accelerate-stop distance. Recent landing overruns accidents on wet runways have raised questions regarding validity of current wet runway stopping performance requirements and methods documented in 14 CFR Part 25.109(c), which was developed based on analysis of data collected during NASA's flight tests in the 60s and 70s. The purpose of the FY19 wet runway wheel barking testing research project is to provide recommendations for updating 14 CFR Part 25.109(c) and associate Advisory Circular (AC) AC-25-7C to the FAA's Office of Aviation Safety (AVS).

Research Collaboration Partners:

In addition, stakeholders' inputs are received through conducting workshops and meetings. For example, the Terminal Area Safety research team conducted and moderated a workshop entitled "Stabilized Approach and Go-Around Safety" during March 2018 Aviation Safety InfoShare meeting in Baltimore, MD from March 20-22. The semi-annual meeting allows aviation safety professionals from industry, government, and academia to share their safety concerns and best practices in a protected environment.

This program does not have any government partners.

Do non-government groups partner with this program? Yes

This program plans to establish Cooperative Research and Development Agreements (CRDAs) to collaborate with aviation industry.

Acquisition/Assistance:

FAA programs in the research portfolio employ competitive contracting vehicle types and grants to acquire Conduct, Research, and Development activities. The FAA's acquisition management system offers researchers omnibus contract vehicles such as the SE2020, SE2025, and eFAST BPAs in which vendors competitively compete for TOs and BPA calls. The Broad Agency Announcement is another competitive process the FAA utilizes for awarding basic research contracts. Grants are used to execute a portion of the FAA's research budget and where the FAA has the statutory authority to issue grants pursuant to the Aviation Research Grants Program. The FAA's Centers of Excellence (COE) is one example of a grant-based program that uses competition to select from among members of academia for COE participation. In the specific case of the COE grant program, it receives matching funds from industry sponsors.

This program does not plan to use sole source acquisitions for FY 2019 research projects. In general, the FAA Research Portfolio includes Research Programs that use multi-year acquisitions.

Does this program leverage non-Federal funds?

Yes it does, when a Cooperative Research and Development Agreement (CRDA) is established between the FAA and industry partner. The details of the CRDA are normally negotiated and agreed upon by both parties throughout the CRDA process. For the wet runway wheel barking testing research project, the plan is to try to establish CRDAs with air operators and/or aviation companies.

Technology Transfer (T2):

System Safety research projects typically aim to address either safety issues unique to the FAA's oversight capabilities or systematic safety issues across industry through providing necessary technical data to the FAA's Office of Aviation Safety (AVS) to prepare meaningful advisory and guidance material for use by industry. For those projects that address safety issues unique to the FAA's oversight capabilities, the T2 is internal to the FAA. For those projects that address systematic safety issues across industry, T2 is executed through publication of advisory and guidance material by the Office of Aviation Safety. Technical publications documenting research results are available to the public at: https://www.faa.gov/about/office_org/headquarters_offices/ang/offices/tc/library/.

A specific example of T2 in this area is the wet runway wheel barking testing research project. Findings and recommendations may be used by the Office of Aviation Safety to update wet runway braking performance standards, i.e., 14 CFR Part 25.109(c) and AC-25-7C using the research findings. Other examples of T2 in this area are published findings presented at conferences such as: "Human-

in-the-Loop Study on Angle-of-Attack Indicator Effectiveness for Transport Category Airplanes" available at https://arc.aiaa.org/doi/abs/10.2514/6.2018-2938, "Development of Possible Go-Around Criteria for Transport Aircraft" available at https://arc.aiaa.org/doi/abs/10.2514/6.2018-3198, "Analyzing Pilot Decision-Making Using Predictive Modeling" available at http://www.icrat.org/icrat/ and the conduct of a "Stabilized Approach and Go-Around Safety" workshop during March 2018 Aviation Safety InfoShare meeting. InfoShare meeting allows aviation safety professionals from industry, government, and academia to share their safety concerns and best practices in a protected environment. No adoption/implementation rates are available. In this way, the knowledge gained from the research is transferred to the aviation industry.

Evaluation / Performance Measurement:

The Provider Research Execution Plan (PREP) identifies requirement-specific research activities with a schedule of milestones, deliverables, and anticipated spend plan.

Metrics for each program are defined and agreed to by the sponsor of the research (typically the designated safety professional in the FAA Aviation Safety Office) and provided and used to monitor the program progress in regular program management reviews and status meetings.

Through the requirements development process in the Technical Community Representative Group (TCRG) all strategic guidance and industry trends are analyzed and incorporated into the requirements process. The associated benefits to the FAA and flying public are evaluated during this process.

These metrics are a part of the initial requirement selection and incorporated into the Performer Research Execution Plans (PREPs) in accordance with NextGen Office (ANG) processes, with cost, performance, and schedule data as requested by the Sponsor.

As stated above, the Provider Research Execution Plan (PREP) identifies requirement-specific research activities with a schedule of milestones, deliverables, and anticipated spend plan, which is later baselined and tracked using standard program management techniques. More specifically, the requirement-specific research activities are structured in several phases and monitored using monthly reporting. Each phase will have a structured goal which must be met and have Sponsor concurrence before moving on to the next phase.

Commercial Space Transportation
Funding Request ($2,500,000)

Program Description/Activities:

The primary mission of the Commercial Space Transportation Office (AST) is to regulate commercial space launch and reentry operations, only to the extent necessary to ensure compliance with international obligations of the U.S. and to protect the public health and safety, safety of property, and national security and foreign policy interests of the United States. AST's secondary mission is to encourage, facilitate, and promote commercial space launches and reentries performed by the private sector. More recently, Congress tasked AST with promoting the continuous improvement of the safety of launch vehicles designed to carry humans.

All commercial space transportation directly benefits the American people, and some directly supports USG missions such as delivering National Security payloads to orbit and transporting cargo to and from the International Space Station. The first flight test of the Orion capsule, America's next generation spaceship to transport humans beyond Earth orbit, was a good example of an FAA licensed launch and reentry that directly supported a USG mission. A more recent example of the power of Commercial Space Transportation (CST) was the debut of Falcon 9 Heavy, now the most powerful rocket in the world. The F9-Heavy joins the host of US rockets that all made their maiden flights with a commercial launch license (e.g., Atlas V and Delta IV, Antares, as well as all previous Falcon's flew first under the FAA's authority). One thing unique about the Falcon 9 Heavy: it was developed and launched safely and successfully, without any direct government funding. Flying two boosters back to land in formation, with a sonic boom-boom that silenced the skeptics about the role CST is now playing as the US leads in the world of rocket science and innovation.

The FAA Office of Commercial Space Transportation (AST) will use FY 2019 funds to facilitate US global leadership CST by finding practical solutions that optimize safety and efficiency through innovation, collaborative research, and prototype development. AST's FY 2019 RD&T portfolio, which includes all funds allocated to the A11.n budget line item account, is designed to optimize AST's mission execution through the development of improved regulations, safety assessment tools, and public safety technologies. AST's portfolio includes a near 50-50 balance of research activities conducted by grants to the Center of Excellence for Commercial Space Transportation (COE CST) and contracts. The funding supports regulatory research, to address lessons learned and to keep pace with the dynamic CST industry, and industry development research, to benefit all commercial space industry actors.

Our current R&D priorities are:

1. Regulation Streamlining and Innovation: create consolidated, performance-based regulations to ensure public safety, reduce regulatory burdens, and enable rapid industry growth/launch cadence.

2. Deployment of Innovation: research safe integration of CST into the NAS with improved safety analyses and tools (e.g. automation and advanced Automatic Dependent Surveillance-Broadcast (ADS-B)) to safely reduce airspace closed to other stakeholders, develop rapid response capabilities to off-nominal scenarios, quickly release airspace.

3. Spaceport Infrastructure Research: develop methods to assess the effect of spaceports on the public, including airspace/airport operations, safety of population centers, and critical national assets.

4. Systemic Safety: risk-based approach to human safety (e.g. research practices for crew human factors, develop airspace separation standards)

Some select details on the types of research included in these four priority areas:

- Research to facilitate safe and efficient integration of increased CST into the NAS includes the development of methods to supplement data derived from telemetry with data from existing overhead assets and other sensors to track launch/reentry vehicles, and to identify in real-time the airspace within which debris would fall in the event of a malfunction.

- Advanced safety assessment methods include recent improvements in the Multiple Probable Loss methodology used to establish the amount of insurance an operator must have to reimburse any third party of USG losses. AST will use FY 2019 funds for additional research needed to improve ways to evaluate and mitigate property damage, including third party property and high value USG assets on a launch site.

- Advanced vehicle safety technologies involves the development of improved mission rules that use autonomous flight safety systems to prevent high consequence events and minimize launch constraints (by removing the delays associated with human reaction time).

- Human spaceflight safety research is underway to identify candidate recommended practices for crew human factors for suborbital winged commercial spaceflight vehicles to support licensing and permit evaluations.

Prior investments by FAA AST since FY 2010 have resulted in significant results and improvements in all these research areas. All research results have been published in peer-reviewed journals, and these have been publicized to many different communities. The four research areas described above address the four major DOT strategic goals of Safety (of the traffic system, vehicle, and human spaceflight participants), Infrastructure (spaceport interoperability), Innovation (space vehicle technologies), and Accountability (regulatory reform). The total requested commercial space transportation safety research budget in FY 2019 is estimated $2.5M. A major fraction of this research (i.e., no less than $1M) is conducted through the FAA Center of Excellence for Commercial Space Transportation (COE CST), and as with all COEs, each Federally-funded research grant requires a 1:1 matching contribution, either in-kind or in cash. The COE CST has exceeded the minimum requirement by soliciting and receiving over 2:1 matching contributions for the research funded by the FAA AST.

Statutory Requirements:

Is this program statutorily mandated (Y/N): Yes

Although, the R&D conducted to support commercial space transportation is not specifically mandated by statute, the mission of the FAA/AST is directed by statute. Title 51 of the USC in §50901 states:

1. "the United States should encourage private sector launches, reentries, and associated services and, only to the extent necessary, regulate those launches, reentries, and services to ensure compliance with international obligations of the United States and to protect the public health and safety, safety of property, and national security and foreign policy interests of the United States."

2. "providing launch services and reentry services by the private sector is consistent with the national security and foreign policy interests of the United States and would be facilitated by stable, minimal, and appropriate regulatory guidelines that are fairly and expeditiously applied."

3. "the goal of safely opening space to the American people and their private commercial, scientific, and cultural enterprises should guide Federal space investments, policies, and regulations."

4. "private applications of space technology have achieved a significant level of commercial and economic activity and offer the potential for growth in the future, particularly in the United States."

This research program is aligned with the three FAA NARP Outcomes (improve aerospace safety, reduce environmental impact, and improve operational effectiveness), the DOT RD&T Strategic Goals (making aviation safer and smarter, and deliver benefits through technology and infrastructure), and goals of the "Moving Ahead for Progress in the 21st Century" (MAP-21) Act, P.L. 112-141 (safety, environmental sustainability, and livable communities). This R&D addresses OMB priority areas of (1) "American prosperity" by providing the fundamental building block of new technology advances to promote the nation's economic growth, and (2) safety by improving space safety; providing research data and analyses for aerospace policy, regulation, guidance, standards development, and new aviation technologies; evaluating and/or validating aerospace requirements, procedures, and methods. Stakeholders of the Commercial Space Transportation - Air/Space Traffic Management research program include the sponsoring organization (FAA AST), the executing research entities (COE CST universities, their students, and independent contractors), the supporting members (Affiliate and Associate members of the COE CST), associated executive and legislative branch offices, and other external entities."

Program Alignment with Strategic Goals:

DOT Strategic Goal	DOT RD&T Critical Transportation Topic
Safety	**Promoting safety**

This program supports the DOT's Strategic Goal of Safety by providing systematic research and development within the FAA that will lead to the identification, assessment and mitigation of safety

risks. By providing the research necessary to generate data, this data is then used to create and develop new safety standards that will be adopted throughout the aerospace community.

In addition to supporting the DOT RD&T critical transportation topic of Promoting Safety, the commercial space transportation Safety research program also supports the remaining topics of Improving Infrastructure, Improving Mobility, and Accountability (in the form of regulatory reform and streamlining). Research projects on the topics of spaceport interoperability and air-space traffic integration within the NAS all help promote improvements in infrastructure efficiency and effectiveness. Research projects on the development of improved mission rules for automated flight safety systems, as well as new sensors and materials that are easier to fabricate, and integrate into the assembly process all promote technical innovation in the emerging and evolving commercial space transportation industry segments. Finally, all the research projects contribute to the development and evolution of more effective and streamlined regulations, thereby ensuring that AST "regulates on to the extent necessary."

Program Objectives:

The main goal of the Commercial Space Transportation (CST) program is protecting the safety of the uninvolved public and their property from the potential consequences of commercial space launch and reentry demands, and the goal that the FAA keep pace with emerging technologies and operational concepts coming from a diverse and exponentially growing industry. The areas discussed below highlight critical topics that must be addressed for this program to achieve its goal and statutory missions.

First, the CST research program supports the development of improved regulations and industry guidance material to address lessons learned and to keep pace with the dynamic commercial space transportation industry. R&D in this area will provide industry with maximum flexibility to innovate by regulating only to the extent necessary and building a performance-based regulatory framework to the maximum extent feasible. Research will improve regulations that govern launch and reentry, and launch and reentry sites, as well as industry guidance to support industry compliance with AST regulations.

Second, the CST research program will improve safety analyses and other tools to facilitate the safe and efficient integration of space traffic through the NAS, a component of the FAA Administrator's Strategic Initiatives. Research will advance this initiative with a detailed understanding of man-made and naturally-occurring hazards in the space environment to increase safety and efficiency while getting into and out of the NAS. State-of-the-art theoretical, analytical, and computational investigations will result in improved assessment methods: results that are easier to understand, easier to execute, require fewer input data, and/or require data that are easier to collect. Specific research efforts include the development of a voluntary reporting program similar to the Aviation Safety Action Program so that employees can self-report safety concerns and events.

Third, the CST research program will focus on advanced vehicle safety technologies, human spaceflight and physiological safety guidelines that provide a direct benefit to the strategic needs of industry (e.g., improved preparation and operations, and ensuring safety of human spaceflight occupants). Specific areas of research include the development of recommended practices for crew human factors for suborbital winged commercial space flight vehicle, and the demonstration of

advanced surveillance technology, including cockpit displays, capable of improving airspace management during launch or reentry.

The research and development activities directly support AST's statutory missions, which are inherently governmental functions (such as the development of regulations, safe and efficient integration of CST into the NAS, and evaluation of compliance with safety criteria, etc.). Therefore, the FAA/AST R&D program does not address any market failure.

Economic Impact of Regulatory Reform:

FAA's Office of Commercial Space (FAA/AST) has leveraged its R&D program in direct and indirect ways to lessen the economic impact of its regulations. The most impactful example of this is in the transformation of its regulatory regime. The DOT has been tasked by the President to develop a streamlined approach to its launch and reentry licensing regime for Commercial Space Transportation. This includes removing outdated "prescriptive" regulatory approaches with more performance-based regulations designed to reduce barriers for industry and ensure global competitiveness. AST R&D efforts included the conduct of an in-depth analysis of performance-based regulations (PBRs), including a review of academic literature, historical applications, and implementation of PBRs in a variety of sectors. The initial activity culminated in an evaluation of published best practices, and the first "Adaptive Toolkit" for PBRs in Commercial Space Transportation that were directly applied to the new streamlined licensing rule to reduce economic burdens for industry. FAA AST is also leveraging its R&D program in ways that indirectly impact future regulatory activities in Commercial Space Transportation and reduce economic burdens for industry. For example, AST is researching the development of a spaceport assessment tool that will quickly and efficiently identify suitable sites, and eliminate the need for wasteful data collection and pre-application analyses that can be contentious, costly, and time-consuming for industry. Finally, R&D efforts investigate the boundaries of training for suborbital spaceflight crews in aerobatic aircraft (to simulate the repeated g-forces these pilots would expect to experience). The results of this research will minimize overly conservative training requirements that could prove burdensome to industry.

Performance Based Regulation and Safety:

The President asked DOT to develop a streamlined approach to its launch and reentry licensing regime for Commercial Space Transportation. This included removing outdated "prescriptive" regulatory approaches, and replacing them with more performance-based regulations. The goal is to lessen the economic impact of existing regulations through regulatory regime transformation, reducing barriers for industry, and ensuring global competitiveness. AST and its R&D partners conducted an in-depth analysis of performance-based regulations (PBRs), including a review of academic literature, historical applications, and the implementation of PBRs in a variety of sectors. The initial activity culminated in an evaluation of published best practices, and the first "PBR Adaptive Toolkit" for Commercial Space Transportation.

Research Collaboration Partners:

The Commercial space transportation safety research program has multiple forms of stakeholder interaction that helps inform the content of the research program. These include organizations such

as COMSTAC, the Commercial Spaceflight Federation, the COE CST Affiliate and Associate members, etc.

Program partners include:

- ACTA, Incorporated
- Aerospace
- CST-COE (Universities)
- CSSI Inc.
- MITRE/ Center for Advanced Aviation System Development (CAASD)
- NASA

Other program partners are listed in the COE CST Annual Report Executive Summary, and have included as many as 50-60 external industry and academic partners.

Do non-government groups partner with this program? Yes

AST research partners almost exclusively with non-government groups (listed above). They participate by providing matching contributions to COE CST research, both in-kind as well as cash. For example, the NASTAR Center contributed over $1M of centrifuge time for human spaceflight participant safety research, conducted by a COE CST member university, the University of Texas Medical Branch at Galveston.

Acquisition/Assistance:

FAA programs in the research portfolio employ competitive contracting vehicle types and grants to acquire Conduct, Research, and Development activities. The FAA's acquisition management system offers researchers omnibus contract vehicles such as the SE2020, SE2025, and eFAST BPAs in which vendors competitively compete for TOs and BPA calls. The Broad Agency Announcement is another competitive process the FAA utilizes for awarding basic research contracts. Grants are used to execute a portion of the FAA's research budget and where the FAA has the statutory authority to issue grants pursuant to the Aviation Research Grants Program. The FAA's Centers of Excellence (COE) is one example of a grant-based program that uses competition to select from among members of academia for COE participation. In the specific case of the COE grant program, it receives matching funds from industry sponsors.

The FAA AST research program does not utilize sole source acquisitions. In general, the FAA Research Portfolio includes Research Programs that use multi-year acquisitions.

Does this program leverage non-Federal funds? Yes

As mentioned above, the research conducted by the COE CST require a 1:1 matching of all awarded Federal funds.

Technology Transfer (T2):

In 2018, FAA Office of Commercial Space Transportation (AST) formed the Directorate of Advanced Programs and Innovation in order to support National Space Council and DOT strategic objectives, in

particular through the development and deployment of innovation through R&D. FAA AST's R&D program supports T2 in two ways: The first method is through the Center of Excellence for Commercial Space Transportation (COE CST). The COE CST conducts leading-edge research to support Commercial Space Transportation through a consortium of 10 different universities located across the nation. Activities take the form of annual presentations of research results, and publication in peer-reviewed journals representing the space community. For example, the results of centrifuge testing of human subjects (non-astronaut) that simulate suborbital flight trajectories have been used to define medical limits and training protocols for commercial space tourism. Additionally, research on the use of aerobatic aircraft, flown by suborbital vehicle pilots, are shaping the training protocols for the commercial operators. Metrics include number of TIM presentations and publication of journal articles. The second method of supporting T2 is through R&D innovations developed internally within AST. Innovations take the form of low-investment, high payoff capabilities designed for fielding of critical solutions. For example, the Spaceport Assessment Tool was an internally developed concept designed to improve both industry and government assessments of potential launch sites. R&D investment will support proof of concept demonstration. Low investment, high payoff innovative technologies that emerge in this process are incubated through a special projects office within the Directorate that evaluates the research and determines the viability of the innovation to further advance to a concept demonstration.

Evaluation / Performance Measurement:

The Commercial Space Transportation RE&D program addresses the strategic goal of reducing aviation-related fatalities by researching safety risks posed by the increasing proximity of commercial space and aviation operations. By conducting research into new or enhanced methods for assessing the hazards attributable to commercial space transportation operations in the National Airspace System (NAS), mitigation strategies are developed that foster a systemic safety culture within the rapidly growing commercial space sector. Research activities include advanced methods of dynamic population cluster analyses, spaceport flight hazard corridor assessment, launch vehicle probability of failure, vehicle breakup analyses, and structural damage model improvement. These R&D activities are collectively designed to improve fidelity and understanding of the risks involved with integration of aircraft and launch vehicles. This will improve in airspace access and capacity within the NAS and will reduce the risk of aviation fatalities as commercial space and aviation operations increase.

NextGen - Wake Turbulence
Funding Request ($6,831,000)

Program Description/Activities:

This program provides aircraft generated wake turbulence research that matures wake mitigation operational concepts to the point they can be directly implemented by FAA orders. Concepts are developed to the point that they can enter the FAA F&E development and implementation process, to meet National Airspace System (NAS) infrastructure enhancement requirements. This program supports the NextGen objective to accommodate increased demand (flights) during peak demand periods. The program provides increased access to airport runways and airspace through modifications to ATC wake separation standards and procedures while maintaining or enhancing the safety of the NAS.

Statutory Requirements:

Is this program statutorily mandated (Y/N): No

This project is committed to the National Transportation Safety Board (NTSB) to research new aircraft types. The current structure of the program allows for a non-biased approach to application of new aircraft wake separation standards. The Wake team conducts the data collection and analysis of a new aircraft type and presents the findings to Aviation Safety and Air Traffic offices. The agency is therefore in the position to conduct the research and inform industry of the appropriate separation standard.

Program Alignment with Strategic Goals:

DOT Strategic Goal	DOT RD&T Critical Transportation Topic
Innovation	**Improving Mobility**

This program supports the DOT's Strategic Goal of innovation by providing targeted research and development within the FAA that will lead to new technology development and deployment in the National Airspace System (NAS). By providing the necessary research to gather information, this will allow the assessment of regulatory approaches, it will foster information sharing and facilitate coordination, collaboration with industry and other stakeholders, and the ability to test and adopt new technologies throughout the NAS.

Program Objectives:

The main goal of the NextGen Wake Turbulence research program is wake mitigation separation. NextGen - Wake Turbulence research analyzes and collects the data to establish the wake mitigation separations that are to be applied by ATC to new series of aircraft entering operational service. The program's analysis capability was used to establish separations for the Airbus A380, Boeing 747-800, Boeing 787 and the Airbus A350 series aircraft. Analysis work and international coordination has been completed on standards for the Airbus A320-Neo series of aircraft. The project provided wake separations for ATC's use for the Boeing 737 MAX which began operations in the NAS August 2017.

This project also determined the wake separations to be applied to other manufacturers' (e.g. Bombardier CS100 and CS300) newly developed aircraft that will be entering the NAS and is working on separation standards for a new Embraer series of aircraft. Without this work, FAA will not be able to execute its regulatory role in establishing ATC wake separation standards for new aircraft designs/series that begin operations in the NAS.

NextGen – Wake Turbulence research also addresses the role of wake separation standards will play in NextGen era ATC operations. The project's research has produced validated concepts for applying aircraft performance characteristics and runway crosswind information to reduce the required wake mitigation separations applied to aircraft arriving to and departing from an airport's runways. The research products have been transitioned into the FAA F&E projects: Wake Re-Categorization, Wake Turbulence Mitigation for Departures, and Wake Turbulence Mitigation for Arrivals. Standards, processes and decision support tool products from these projects have been demonstrated operationally and some are now being implemented nationally. These products, when implemented, will provide ATC with the tools that allow them to safely increase an airport's runway throughput for both arrival and departure operations when an airport is busiest. Aircraft manufacturers, airport authorities and air carriers agree that squeezing in more operations onto an airport's existing runways results in major reductions of flight delays during and after a bad weather event occurs at an airport. RTCA has requested that the FAA continue to progress in the development of the wake products as documented in RTCA requested Operational Improvements 102137, 102140, 102141, 102142 and 102144, 102145, 102151 and 102152.

The Wake Turbulence Research program focuses on increasing the throughput capacity of airports and congested air corridors. Increased airport throughput capacity allows airports to achieve more arrivals and departures per hour during periods of heavy demand by the airport's major users thereby increasing the average daily capacity for the core airports.

Research Collaboration Partners:

NextGen capabilities continue to bring positive effects to the aviation industry and the flying public all across the National Airspace System (NAS). The Federal Aviation Administration (FAA) and the aviation industry work together through the NextGen Advisory Committee (NAC), which includes carriers such as United Airlines, FedEx, Delta Airlines, to identify high-benefit, high-readiness NextGen capabilities for implementation in the near term.

This project interacts with numerous third-party stakeholders and aircraft manufacturers. As an example, the current structure of the program allows for a non-biased approach to application of new aircraft wake separation standards. The Wake team conducts the data collection and analysis of a new aircraft type and presents the findings to the Safety office without private sector involvement. The agency is therefore in the position to conduct the research and recommend the appropriate separation standard without bias.

Do non-government groups partner with this program? (Yes/No): Yes

The wake research program contracts with university organizations such as NEXTOR. New aircraft analysis is performed via modeling and analysis by the FAA to determine wake separation standards. If aircraft manufacturers would like more refined results, dedicated flight testing can be executed to allow for data collection that supports a data driven assessment of aircraft wake characteristics. In

this scenario, the manufacturer would contribute via the execution of flight test procedures to allow the FAA to collect lidar data to support this analysis.

Acquisition/Assistance:

Does this program utilize competitive procurement processes? Yes.

FAA programs in the research portfolio employ competitive contracting vehicle types and grants to acquire Conduct, Research, and Development activities. The FAA's acquisition management system offers researchers omnibus contract vehicles such as the SE2020, SE2025, and eFAST BPAs in which vendors competitively compete for TOs and BPA calls. The Broad Agency Announcement is another competitive process the FAA utilizes for awarding basic research contracts. Grants are used to execute a portion of the FAA's research budget and where the FAA has the statutory authority to issue grants pursuant to the Aviation Research Grants Program. The FAA's Centers of Excellence (COE) is one example of a grant-based program that uses competition to select from among members of academia for COE participation. In the specific case of the COE grant program, it receives matching funds from industry sponsors.

In general, the FAA Research Portfolio includes Research Programs that use multi-year acquisitions.

Does this program leverage non-Federal funds? (Y/N): No

Technology Transfer (T2):

The Wake Research Team develops requirements and concepts for wake mitigations that are tech transferred to the ATO for inclusion in the NAS. The wake program also develops wake separation standards for new aircraft types in collaboration with the FAA Flight Standards organization.

Evaluation / Performance Measurement:

The FAA NAS Lifecycle Planning Division manages the planning, implementation, and reporting of NextGen portfolios. Portfolio managers use project management best practices to track and evaluate project progress towards defined objectives/outcome goals, ensure agreed to milestones and commitments with NAS planning documents are on track, monitor/control program risk, and monitor program funds to ensure they are expended in a timely manner. Additionally, they evaluate projects with respect to research needs, considering key aspects such as timeframes for when results are needed, alignment to the NAS enterprise architecture and early phase acquisition management system decision points, likelihood of achieving expected benefits, criticality, risk, interdependencies, and available funding. Portfolio managers incorporate results of completed projects into concept planning during periodic evaluations of concept status and progress.

Advanced Technology Development & Prototyping
Funding Request ($33,000,000)

Program Description/Activities:

The FAA's mission is to provide the safest and most efficient aerospace system in the world. To accomplish this mission, FAA's Advanced Technology Development and Prototyping (ATDP) program, develops and validates technology and systems that support air traffic services. These initiatives support the requirements associated with the evolving air traffic system architecture and improvements in airport safety and capacity. A key element of this program is to promote safe and efficient airspace, provide the means to recognize and respond to needs, and evaluate the results.

Individual projects under the ATDP Program develop and maintain mathematical & simulation software models of the National Airspace System (NAS). These models evaluate system wide benefits associated with the implementation of various solutions. These models are particularly useful in evaluating mid-term and long-term benefits associated with NextGen. These models aid organizations throughout FAA with analyses of proposed new investments, trade-off studies, enterprise-wide shortfall analyses, and the operational analyses of new entrants on NAS Performance. Recent examples of this work include the development of the System Wide Analysis Capability (SWAC) and the Airfield Delay Simulation Model (ADSIM).

Another key component of ATDP are the projects that develop and improve FAA systems that meet the regulatory requirement for reporting traffic operations, counts, delays, and safety information. These systems must continue to support the growing demands of the NAS. Work under the ATDP program improves the efficiency and integration of data processing and improves NAS reporting capabilities. This work aids in the assessment of performance of airline operations and provides the objective data to support the need for improved traffic flow and efficiency measures within the NAS.

Two individual projects under the ATDP program are responsible for oversight of the pre-implementation planning for the improved traffic flow and efficiency measures identified through the operational reporting and simulation activities. Major Airspace Redesign work is critical for enhanced capacity under the ATDP budget line. The program coordinates and funds physical changes in facilities that are necessary to accommodate airspace redesign. The program prioritizes redesign projects that provide the most benefits and develops criteria for assessing a projects system wide impact. The Runway Incursion Reduction work under ATDP continually discovers researches, and implements technologies that will detect the incorrect presence of an object in the Runway Safety Area at every airport and deliver a directive cue to the individual who can take corrective action. The focus of the program is to provide direct safety indications and alerts to pilots and aircrews. This work has created successful runway innovations like Airport Surface Detection Equipment and Runway Status Lights.

Statutory Requirements:

Is this program statutorily mandated (Y/N): Yes

The FAA Modernization and Reform Act of 2012 directed the FAA to track and publish NAS performance metrics (section 214) and Routinely monitor air carriers' scheduled operations (section

413). This program supports that requirement by ensuring the infrastructure for that reporting is sustainable, efficient, and enhanced as new technology emerges.

Program Alignment with Strategic Goals:

DOT Strategic Goal	DOT RD&T Critical Transportation Topic
Innovation	**Improving mobility**

This program supports the DOT's Strategic Goal of innovation by providing targeted research and development within the FAA that will lead to new technology development and deployment in the National Airspace System (NAS). By providing the necessary research to gather information, this will allow the assessment of operational and safety data, it will foster information sharing and facilitate coordination, collaboration with industry and other stakeholders, and the ability to test and adopt new technologies throughout the NAS. In addition, this program supports rural communities through enhanced monitoring of operations data and the implementation of improved runway situational awareness for controllers and pilots at small to medium airports.

Program Objectives:

The main goals for the Advanced Technology Development and Prototyping budget line item include:

- Ensure efficient gathering of information on NAS performance, airport capacity, and safety information. This information allows experts from the FAA, academia, and industry collaborate to analyze and develop recommendations for improving safety, capacity and system efficiency, and reducing delays in the NAS. The ATDP program enhances and upgrades data collection across multiple tool sets to ensure the means of collecting and disseminating the data are efficient and sustainable.

- Assess changing roles and responsibilities of NAS service providers and pilots, airspace changes, procedural changes and new automation systems for distributing weather, traffic and other flight related information. This information allows FAA to develop/validate shortfalls, explore/develop concepts, and ensure any new concept can be integrated within the NAS to provide positive benefits.

- ATDP promotes efficient coordination and collaboration with objective information for Airspace Redesign priorities and Runway Incursion Reduction work to increase system efficiency and safety.

Economic Impact of Regulatory Reform:

The purpose of the work performed under the ATDP budget line item is to develop an understanding of potential gaps and inefficiencies that must be addressed before problems occur that might impact NAS capacity and efficiency. The program is actively reviewing emerging technology and evaluating the use of that technology for the collection and evaluation of operational information on NAS performance and safety Regulations are not produced as a result of the work produced under this program.

Research Collaboration Partners:

The ATDP program contributes to the FAA's support for the RTCA, a non-profit association that develops standards based on manufactures, government, and aviation operator inputs. RTCA recommends operational improvements to increase the efficiency of air transportation.

In addition, the program works with the European Union and Civil Aviation Authority of Singapore under memorandums of agreement in an effort to improve traffic flow initiatives in the Asian Pacific region and well as assess performance and develop business cases for International Civil Aviation Organization in the North Atlantic.

Do non-government groups partner with this program? (Yes/No)

Yes, the ATDP program participates with commercial airlines to collaborate on operational performance, evaluate/discuss airline objectives and the results obtained from initiatives that were implemented to improve operations.

Acquisition/Assistance:

Does this program utilize competitive procurement processes? Yes.

FAA programs in the research portfolio employ competitive contracting vehicle types and grants to acquire Conduct, Research, and Development activities. The FAA's acquisition management system offers researchers omnibus contract vehicles such as the SE2020, SE2025, and eFAST BPAs in which vendors competitively compete for TOs and BPA calls. The Broad Agency Announcement is another competitive process the FAA utilizes for awarding basic research contracts. Grants are used to execute a portion of the FAA's research budget and where the FAA has the statutory authority to issue grants pursuant to the Aviation Research Grants Program. The FAA's Centers of Excellence (COE) is one example of a grant-based program that uses competition to select from among members of academia for COE participation. In the specific case of the COE grant program, it receives matching funds from industry sponsors.

In general, the FAA Research Portfolio includes Research Programs that use multi-year acquisitions.

Does this program leverage non-Federal funds? (Y/N). No

Technology Transfer (T2):

The products from this program are used by FAA and are not transferred to industry.

Next Generation Transportation System - Separation Management Portfolio
Funding Request ($16,000,000)

Program Description/Activities:

The Separation Management Portfolio conducts pre-implementation activities to reduce risk, and implementation activities supporting the safe and efficient separation of aircraft and other vehicles in the National Airspace System (NAS). Risk reduction activities may include validation of concepts or technologies; demonstration and integration of operational capabilities; and an understanding of the role of the human through cognitive engineering experiments. This portfolio evaluates and matures concepts and capabilities that focus on the enhancement of separation assurance using both ground based automation and aircraft technology enhancements. This portfolio will develop flight-deck interval management minimum operational performance standards and safety performance requirements, identify improvements to runway access through use of improved aircraft technology, updated standards, safety analysis, and modifications to air traffic monitoring tools and operating procedures that will enable more arrival and departure operations.

Statutory Requirements:

Is this program statutorily mandated (Y/N): Y

This program is driven by the FAA Modernization and Reform Act 2012 and FAA Reauthorization March 2018 under FAA Title II NextGen Air Transportation System and Air Traffic Control Modernization Section 202 NextGen Demonstrations and Concepts "In allocating amounts appropriated pursuant to section 48101(a) of title 49, United States Code, the Secretary of Transportation shall give priority to the following NextGen activities."

The Separation Management program supports the statutory requirement through pre-implementation activities conducted to reduce risk, and implementation activities supporting the safe and efficient separation of aircraft and other vehicles in the National Airspace System (NAS) that are critical to the success of NextGen.

Program Alignment with Strategic Goals:

DOT Strategic Goal	DOT RD&T Critical Transportation Topic
Innovation	**Improving mobility**

This program supports the DOT's Strategic Goal of innovation by providing targeted research and development within the FAA that will lead to new technology development and deployment in the National Airspace System (NAS). By providing the necessary research to gather information, this will allow the assessment of regulatory approaches, it will foster information sharing and facilitate coordination, collaboration with industry and other stakeholders, and the ability to test and adopt new technologies throughout the NAS.

This program promotes transportation policies and investments that bring lasting and equitable economic benefits to the nation and its citizens. Information resulting from research activities in the

Separation Management Portfolio result in enhanced aircraft separation assurance by safely reducing separation between aircraft, and as a result improve capacity, efficiency and safety in the National Airspace System. This program does not have an impact on rural communities.

Program Objectives:

The main goal of the NextGen Separation Management Portfolio is to provide recommendations through research and technology development activities to improve the tools, standards, and procedures that air traffic controllers use to separate aircraft. Pre-implementation activities conducted under this program reduce risk, define requirements and demonstrate operational feasibility to support these recommendations.

As the demand for flights increase, concepts and capabilities that focus on enhancing separation assurance using ground based automation and aircraft technology enhancements are critical. The Separation Management program supports the FAA's mission to provide the safest, most efficient aerospace system in the world by conducting research that will enhance aircraft separation assurance by safely reducing separation between aircraft, and as a result improve capacity, efficiency and safety in the National Airspace System.

Economic Impact of Regulatory Reform:

Not applicable because the program does not directly tie to regulations but program outputs provide important information and data supporting ATO policy, procedures, design standards, training, and operational practices.

Research Collaboration Partners:

NextGen capabilities continue to bring positive effects to the aviation industry and the flying public all across the National Airspace System (NAS). The Federal Aviation Administration (FAA) and the aviation industry work together through the RTCA and NextGen Advisory Committee **(**NAC), which includes carriers such as United Airlines, FedEx, Delta Airlines, to identify high-benefit, high-readiness NextGen capabilities for implementation in the near term.

Program Partners	Benefits
Research, Engineering, and Development Advisory Committee (REDAC) (external)	Provides advice and recommendations to the FAA Administrator on the needs, objectives, plans, approaches, content, and accomplishments of aviation research program, and reviews and comments on the aviation research programs.
Radio Technical Commission for Aeronautics (RTCA) (external)	Provide recommendations on technical and operational standards to achieve the necessary improvements in the safety and efficiency of the air transportation system. Input has deepened FAA understanding of technical maturity and resulted in changes

	to definitions and timing for operational concepts.
NextGen Advisory Committee (NAC) – Federal advisory committee (subcommittee of RTCA)	FAA and industry partnership to identify high-benefit, high-readiness NextGen capabilities for implementation in the near term. The FAA and industry jointly evaluate the effects off NAC commitments on the NAS through the work of a Joint Analysis Team (JAT) to understand the value of implementations in this plan.
FAA Lines of Business	NextGen collaborate with multiple internal lines of business such as air traffic, program management office, and aviation safety for policy development, concept maturation, and technical acceptance of investment capabilities.

Do non-government groups partner with this program?

Yes. FAA partners with Industry through REDAC, RTCA and the NAC as described in the table above.

Acquisition/Assistance:

Does this program utilize competitive procurement processes? Yes.

FAA programs in the research portfolio employ competitive contracting vehicle types to acquire Conduct, Research, and Development activities. The FAA's acquisition management system offers researchers omnibus contract vehicles such as the SE2020, SE2025, and eFAST BPAs in which vendors competitively compete for TOs and BPA calls. The Broad Agency Announcement is another competitive process the FAA utilizes for awarding basic research contracts.

In general, the FAA Research Portfolio includes Research Programs that use multi-year acquisitions.

Technology Transfer (T2):

Not applicable, because this program focuses on development of new concepts and potential subsequent demonstrations to support NextGen capabilities for continued improvement of the NAS.

Evaluation / Performance Measurement:

The FAA NAS Lifecycle Planning Division manages the planning, implementation, and reporting of NextGen portfolios. Portfolio managers use project management best practices to track and evaluate project progress towards defined objectives/outcome goals, ensure agreed to milestones and commitments with NAS planning documents are on track, monitor/control program risk, and monitor program funds to ensure they are expended in a timely manner. Additionally, they evaluate

projects with respect to research needs, considering key aspects such as timeframes for when results are needed, alignment to the NAS enterprise architecture and early phase acquisition management system decision points, likelihood of achieving expected benefits, criticality, risk, interdependencies, and available funding. Portfolio managers incorporate results of completed projects into concept planning during periodic evaluations of concept status and progress.

Next Generation Transportation System - Traffic Flow Management Portfolio
Funding Request ($14,000,000)

Program Description/Activities:

The Traffic Flow Management (TFM) portfolio involves NAS operators and FAA traffic managers, along with advanced automation, in managing daily flight and flow decision-making, airspace and airport capability issues, such as special activity airspace and weather to improve overall efficiency of the National Airspace System. Pre-implementation research conducted under this portfolio include technology development activities for departure scheduling at smaller community airports, improved strategic flow services and capabilities that will capitalize on future DataComm capabilities, further integrate traffic flow management and metering operations, advanced trajectory-based operations leveraging the technologies of NASA's Airspace Technology Demonstration 3 (ATD-3), and explore technologies, infrastructure enhancements, and procedural changes for future traffic management needs.

Statutory Requirements:

Is this program statutorily mandated (Y/N): Y

This program is driven by the FAA Modernization and Reform Act 2012 and FAA Reauthorization March 2018 under FAA Title II NextGen Air Transportation System and Air Traffic Control Modernization Section 202 NextGen Demonstrations and Concepts "In allocating amounts appropriated pursuant to section 48101(a) of title 49, United States Code, the Secretary of Transportation shall give priority to the following NextGen activities."

The TFM Portfolio will evaluate trajectory negotiation and collaborative decision making between NAS operators and FAA traffic managers, along with advanced automation, in managing daily flight and flow decision-making, airspace and airport capability issues, such as special activity airspace and weather to improve overall efficiency of the National Airspace System that are critical to NextGen.

Program Alignment with Strategic Goals:

DOT Strategic Goal	DOT RD&T Critical Transportation Topic
Innovation	**Improving mobility**

This program supports the DOT's Strategic Goal of innovation by providing targeted research and development within the FAA that will lead to new technology development and deployment in the National Airspace System (NAS). By providing the necessary research to gather information, this will allow the assessment of regulatory approaches, it will foster information sharing and facilitate coordination, collaboration with industry and other stakeholders, and the ability to test and adopt new technologies throughout the NAS.

This program promotes transportation policies and investments that bring lasting and equitable economic benefits to the nation and its citizens. Information resulting from research activities in the

Traffic Flow Management Portfolio provides greater flexibility to the flight planners, and makes the best use of available airspace and airport capacity in the National Airspace System (NAS).
This program does not have an impact on rural communities.

Program Objectives:

The main goal of this NextGen – Traffic Flow Management (TFM) Portfolio is to improve both the efficiency of individual flights while optimizing throughput. This work will make travel safer for the traveling public, help reduce passenger delays leading to a better traveling experience, and contribute to less pollution as the result of improved prediction performance for TFM decision support systems and flexible TFM around weather constraints.

The TFM provides greater flexibility to the flight planners, and makes the best use of available airspace and airport capacity to make travel safer for the traveling public, help reduce passenger delays leading to a better traveling experience, and contribute to less pollution as the result of improved prediction performance for TFM decision support systems and flexible TFM around weather constraints.

Economic Impact of Regulatory Reform:

Not applicable because this portfolio does not directly tie to regulations but portfolio outputs provide important information and data supporting ATO policy, procedures, design standards, training, and operational practices.

Research Collaboration Partners:

NextGen capabilities continue to bring positive effects to the aviation industry and the flying public all across the National Airspace System (NAS). The Federal Aviation Administration (FAA) and the aviation industry work together through the RTCA and NextGen Advisory Committee (NAC), which includes carriers such as United Airlines, FedEx, Delta Airlines, to identify high-benefit, high-readiness NextGen capabilities for implementation in the near term.

Program Partners	***Benefits***
Research, Engineering, and Development Advisory Committee (REDAC) (external)	*Provides advice and recommendations to the FAA Administrator on the needs, objectives, plans, approaches, content, and accomplishments of aviation research program, and reviews and comments on the aviation research programs.*
Radio Technical Commission for Aeronautics (RTCA) (external)	*Provide recommendations on technical and operational standards to achieve the necessary improvements in the safety and efficiency of the air transportation system. Input has deepened FAA understanding of technical maturity and resulted in changes to definitions and timing for operational concepts.*

NextGen Advisory Committee (NAC) – Federal advisory committee (subcommittee of RTCA)	*FAA and industry partnership to identify high-benefit, high-readiness NextGen capabilities for implementation in the near term. The FAA and industry jointly evaluate the effects off NAC commitments on the NAS through the work of a Joint Analysis Team (JAT) to understand the value of implementations in this plan.*
FAA Lines of Business • Program Management Office (PMO) • NATCA	*NextGen collaborate with multiple internal lines of business such as air traffic, program management office, and aviation safety for policy development, concept maturation, and technical acceptance of investment capabilities.*
NASA	*Collaboration to leverage cooperative research in an FAA operational environment*
DOT Volpe Center	*Safety Management System support*
MITRE	*Leverage research integration and data exchange and assist with the tech transfer*
Airlines	*Cooperative evaluations and development of airline tools to enable FAA*
Airport Authorities	*Support of research activities and access to operational subject matter experts*

Do non-government groups partner with this program? (Yes/No): Y

Yes, many non-governmental groups are stakeholders and contribute in many key areas. Key partners are American Airlines and the Charlotte Airport Authority. American is designated "lead carrier" for the ATD-2 Demonstration and leads coordination efforts with other flight operators. American is also sharing new data elements to enable new technologies under evaluation. Additionally, the American Airlines Ramp Tower is utilizing the ATD-2 system daily to execute the ATD-2 departure management strategy. The Charlotte Airport Authority contributes space to host the ATD-2. Charlotte Laboratory, networking capabilities, and airport operations subject matter experts. NATCA supports the effort with a dedicated representative and coordinates subject matter experts for evaluations. MITRE leverages previous FAA work with the integration of FAA scheduling systems and incorporates new research to allow pilots to submit data to improve departure scheduling. MITRE, a non- government organization, has been involved on the NextGen side of this collaboration assisting with the tech transfer.

Acquisition/Assistance:

Does this program utilize competitive procurement processes? Yes.

FAA programs in the research portfolio employ competitive contracting vehicle types and grants to acquire Conduct, Research, and Development activities. The FAA's acquisition management system offers researchers omnibus contract vehicles such as the SE2020, SE2025, and eFAST delivery-order based contracts in which vendors competitively bid to earn status as vetted service providers for both single year and multiyear contracts.

In general, the FAA Research Portfolio includes Research Programs that use multi-year acquisitions.

Technology Transfer (T2):

Akbar Sultan with NASA and FAA personnel within the NextGen organization work in concert to execute Technology Transfers. NASA Subject Matter Experts and program leads work directly with program managers within the FAA to develop and mature specific technologies and capabilities. Currently, FAA and NASA are collaborating on projects related to improving the efficiency of ground and airborne traffic flow, strategic weather avoidance and other constraints within the National Airspace. Adoption and implementation performance measurements are based on efficiencies realized. The following projects are NASA Technology Transfers in progress:

1. Surface Tactical Flow capabilities (ATD2)
2. Dynamic Reroute Around Weather (ATD3)

Evaluation / Performance Measurement:

The FAA NAS Lifecycle Planning Division manages the planning, implementation, and reporting of NextGen portfolios. Portfolio management reviews (PMRs) held quarterly with program managers track and evaluate progress towards defined objectives/outcome goals, ensure milestones and commitments with planning documents are on track, monitor/control program risk, and monitor program funds to ensure they are expended in a timely manner. Additionally, portfolio managers interact with program managers frequently throughout the year for project status. Project Level Agreements (PLAs) between the sponsor and research performers are created to judge the efficiency and success of a project by identifying distinct milestones and deliverables, and maintaining alignment against agreed upon milestone and deliverable dates, decision points, and success criterion.

Next Generation Transportation System - On Demand NAS Portfolio
Funding Request ($20,500,000)

Program Description/Activities:

The On Demand National Airspace System (NAS) Information (ODNI) portfolio conducts pre-implementation work to reduce risk in supporting the efficient and secure exchange of information within the FAA and between the FAA and other NAS users. The ODNI portfolio examines concepts and matures capabilities through validation activities, demonstrations conducted with stakeholders, and human systems engineering to mitigate adverse impacts to the NAS. This portfolio provides flight planners, Air Navigation Service Providers (ANSP) staff, and flight crews with consistent, complete, and easily processed information on changes of conditions in the NAS, and works toward developing an international data standard allowing more users to share flight information and coordinate various activities concerning a flight to support collaborative decision-making.

Statutory Requirements:

Is this program statutorily mandated (Y/N): Y

This program is driven by the FAA Modernization and Reform Act 2012 and FAA Reauthorization March 2018 under FAA Title II NextGen Air Transportation System and Air Traffic Control Modernization Section 202 NextGen Demonstrations and Concepts "In allocating amounts appropriated pursuant to section 48101(a) of title 49, United States Code, the Secretary of Transportation shall give priority to the following NextGen activities."

The On Demand NAS Information program supports the statutory requirement through pre-implementation activities conducted to reduce risk in supporting the efficient and secure exchange of information within the FAA and between the FAA and other NAS users that are critical to the success of NextGen.

Program Alignment with Strategic Goals:

DOT Strategic Goal	DOT RD&T Critical Transportation Topic
Innovation	**Improving mobility**

This program supports the DOT's Strategic Goal of innovation by providing targeted research and development within the FAA that will lead to new technology development and deployment in the National Airspace System (NAS). By providing the necessary research to gather information, this will allow the assessment of regulatory approaches, it will foster information sharing and facilitate coordination, collaboration with industry and other stakeholders, and the ability to test and adopt new technologies throughout the NAS. There are no impacts on the rural communities**.**

Program Objectives:

The main goal of the NextGen – On Demand NAS Portfolio is the efficient and secure exchange of information within the FAA and between the FAA and other NAS users for collaborative decision-

making to support trajectory based operations (TBO). Improvements in the development of a standard set of flight information will simplifying the flight planning process and provide information that will cross multiple ATC systems and domains with ease, leading to improvements in on-going traffic management initiatives and decision making. System efficiency is maximized through the reallocation of existing resources to address demand and capacity imbalances, as well as creating additional NAS agility in support of contingency operations, The incorporation of aircraft performance, flight intent, and improved flight crew situational awareness will result in increased predictability of future aircraft position, allowing traffic managers to strategically manage the airspace based on where aircraft will be.

Economic Impact of Regulatory Reform:

Not applicable; the NextGen ODNI portfolio does not directly tie to regulations. The ODNI portfolio outputs provide information and data for efficient and secure exchange of information within the FAA and between the FAA and other NAS users to support ATO policy, procedures, and operational practices.

Research Collaboration Partners:

Public stakeholder input is also received through Federal advisory committees: Radio Technical Commission for Aeronautics (RTCA) and the NextGen Advisory Committee (NAC), both are Federal advisory. RTCA provides recommendations on technical and operational standards to achieve the necessary improvements in the safety and efficiency of the air transportation system. Input has deepened FAA understanding of technical maturity and resulted in changes to definitions and timing for operational concepts. The NAC, a subcommittee of RTCA, is an industry partnership with FAA to identify high-benefit, high-readiness NextGen capabilities for implementation in the near term. The FAA and industry jointly evaluate the effects off NAC commitments on the NAS through the work of a Joint Analysis Team (JAT) to understand the value of implementations in this plan.

Program Partners	Benefits
Research, Engineering, and Development Advisory Committee (REDAC) (external)	Provides advice and recommendations to the FAA Administrator on the needs, objectives, plans, approaches, content, and accomplishments of aviation research program, and reviews and comments on the aviation research programs.
Radio Technical Commission for Aeronautics (RTCA) (external)	Provide recommendations on technical and operational standards to achieve the necessary improvements in the safety and efficiency of the air transportation system. Input has deepened FAA understanding of technical maturity and resulted in changes to definitions and timing for operational concepts.

NextGen Advisory Committee (NAC) – Federal advisory committee (subcommittee of RTCA)	FAA and industry partnership to identify high-benefit, high-readiness NextGen capabilities for implementation in the near term. The FAA and industry jointly evaluate the effects off NAC commitments on the NAS through the work of a Joint Analysis Team (JAT) to understand the value of implementations in this plan.
FAA Lines of Business	NextGen collaborate with multiple internal lines of business such as air traffic, program management office, and aviation safety for policy development, concept maturation, and technical acceptance of investment capabilities.
International Civil Aviation Organization (ICAO) (external)	Partnership with ICAO ensure FAA's part of international harmonization of data exchange and management, a key piece of the future of air traffic management and user collaboration.
MITRE	Leverage research integration and data exchange and assist with the tech transfer

REDAC, RTCA, and NAC are non-government groups this program partner's with. Details are in the above table.

Acquisition/Assistance:

Does this program utilize competitive procurement processes? Yes.

FAA programs in the research portfolio employ competitive contracting vehicle types and grants to acquire Conduct, Research, and Development activities. The FAA's acquisition management system offers researchers omnibus contract vehicles such as the SE2020, SE2025, and eFAST BPAs in which vendors competitively compete for TOs and BPA calls. The Broad Agency Announcement is another competitive process the FAA utilizes for awarding basic research contracts.

Technology Transfer (T2):

Internal technology transfer activities transition from NextGen to other lines of business for policy development and updates to air traffic control (ATC) procedures. Beneficiaries are the flying public and all air carriers operating in the NAS. Benefits analyses conducted during pre-implementation gauge projected benefits; additionally, benefits are verified post-implementation through statistical analysis of actual operations utilizing newly implemented procedures.

Evaluation / Performance Measurement:

The FAA NAS Lifecycle Planning Division manages the planning, implementation, and reporting of NextGen portfolios. Portfolio managers use project management best practices to track and evaluate project progress towards defined objectives/outcome goals, ensure agreed to milestones and commitments with NAS planning documents are on track, monitor/control program risk, and monitor program funds to ensure they are expended in a timely manner. Additionally, they evaluate projects with respect to research needs, considering key aspects such as timeframes for when results are needed, alignment to the NAS enterprise architecture and early phase acquisition management system decision points, likelihood of achieving expected benefits, criticality, risk, interdependencies, and available funding. Portfolio managers incorporate results of completed projects into concept planning during periodic evaluations of concept status and progress.

Next Generation Transportation System - NAS Infrastructure Portfolio
Funding Request ($20,000,000)

Program Description/Activities:

The National Airspace System (NAS) Infrastructure portfolio conducts pre-implementation activities to reduce risk for aviation weather-related and cross-cutting engineering issues. This portfolio provides the research, development, and analysis of validation activities, human system engineering, and demonstrations to improve the efficiency and effectiveness of air traffic management. It includes an array of work encompassing emerging issues in communications, weather, information management, trajectory management, collision avoidance, and assessment of requirements for future NAS systems and system enhancements.

Statutory Requirements:

Is this program statutorily mandated (Y/N): Y

This program is driven by the FAA Modernization and Reform Act 2012 and FAA Reauthorization March 2018 under FAA Title II NextGen Air Transportation System and Air Traffic Control Modernization Section 202 NextGen Demonstrations and Concepts "In allocating amounts appropriated pursuant to section 48101(a) of title 49, United States Code, the Secretary of Transportation shall give priority to the following NextGen activities."

The NAS Infrastructure program supports the statutory requirement through pre-implementation activities conducted to reduce risk for aviation weather-related and cross-cutting engineering issues related to communications, weather, information management, trajectory management, collision avoidance, and assessment of requirements for future NAS systems and system enhancements that are critical to the success of NextGen.

Program Alignment with Strategic Goals:

DOT Strategic Goal	DOT RD&T Critical Transportation Topic
Innovation	**Improving mobility**

This program supports the DOT's Strategic Goal of innovation by providing targeted research and development within the FAA that will lead to new technology development and deployment in the National Airspace System (NAS). By providing the necessary research to gather information, this will allow the assessment of regulatory approaches, it will foster information sharing and facilitate coordination, collaboration with industry and other stakeholders, and the ability to test and adopt new technologies throughout the NAS. There are no impacts on rural communities

Program Objectives:

The main goal of the NextGen – NAS Infrastructure Portfolio is to support the NextGen goals of improved capacity, efficiency, and safety through its cross-cutting development programs. These goals are supported by an array of work encompassing emerging issues in communications, weather,

information management, trajectory management, collision avoidance, and assessment of requirements for future NAS systems and system enhancements.

The NAS Infrastructure (NI) Portfolio contains key transformational and infrastructure sustainment capabilities that are critical to the success of NextGen. This program also supports the NextGen goal of expanding capacity by conducting pre-implementation activities that lead to development of decision support tools that improve the strategic management of operations in the NAS.

Economic Impact of Regulatory Reform:

The work in the portfolio is not actively focused on reducing economic impact of needed regulations, nor are its outputs expected to add to regulation. For additional information, please see A12.C RE&D WTIC (Weather Technology in the Cockpit) response; RE&D WTIC is a program in the NAS Infrastructure portfolio.

Research Collaboration Partners:

NextGen capabilities continue to bring positive effects to the aviation industry and the flying public all across the National Airspace System (NAS). The Federal Aviation Administration (FAA) and the aviation industry work together through the NextGen Advisory Committee (NAC), which includes carriers such as United Airlines, FedEx, Delta Airlines, to identify high-benefit, high-readiness NextGen capabilities for implementation in the near term.

Program Partners	Benefits
Research, Engineering, and Development Advisory Committee (REDAC) (external)	Provides advice and recommendations to the FAA Administrator on the needs, objectives, plans, approaches, content, and accomplishments of aviation research program, and reviews and comments on the aviation research programs.
Radio Technical Center for Aeronautics (external)	Provide recommendations on technical and operational standards to achieve the necessary improvements in the safety and efficiency of the air transportation system. Input has deepened FAA understanding of technical maturity and resulted in changes to definitions and timing for operational concepts.
International Civil Aviation Organization (ICAO) (external)	Partnership with ICAO ensure FAA's part of international harmonization of data exchange and management, a key piece of the future of air traffic management and user collaboration.
Airline Electronic Engineering Committee (AEEE) (external)	Partnership with AEEE support standards development to inform air/ground communications between FAA and airspace users in the future

FAA Lines of Business (internal)	NextGen collaborate with multiple internal lines of business such as air traffic, program management office, and aviation safety for policy development, concept maturation, and technical acceptance of investment capabilities.
National Oceanic and Atmospheric Administration (external)	Coordination to identify improvements to aviation weather-observation sensor networks
Department of Defense (external)	Coordination to identify improvements to aviation weather-observation sensor networks

Do non-government groups partner with this program?

Yes. FAA partners with Industry through REDAC, RTCA, ICAO, and AEEC as described in the table above.

Acquisition/Assistance:

Does this program utilize competitive procurement processes? Yes.

FAA programs in the research portfolio employ competitive contracting vehicle types and grants to acquire Conduct, Research, and Development activities. The FAA's acquisition management system offers researchers omnibus contract vehicles such as the SE2020, SE2025, and eFAST BPAs in which vendors competitively compete for TOs and BPA calls. The Broad Agency Announcement is another competitive process the FAA utilizes for awarding basic research contracts.

In general, the FAA Research Portfolio includes Research Programs that use multi-year acquisitions.

Does this program leverage non-Federal funds? (Y/N): No

Technology Transfer (T2):

National Air Space (NAS) Infrastructure programs are involved in two technology transfers. The Information Management (IM) program had developed a concept called NAS Enterprise Repository (NER), an enterprise data storage hub. Upon conclusion of the research and development the program had undertaken, the technology transfer package was delivered to the Office of Information Technology (AIT). AIT's role was to apply the concept to the Enterprise Information Management (EIM) platform, which will provide a unified data layer and enterprise applications across the FAA. AIT has implemented the concept by ingesting aeronautical, flight, and weather data into their platform using the same software leveraged by the NER concept.

The Weather Observation Improvements (WOI) program has completed a technology maturity study on the enhanced Present Weather Sensor (PWS) capable of detecting all phases of precipitation including those used for ground de-icing decision making. The sensor's requirements have been validated by Air Traffic Organization (ATO) Operational Concepts, Validation and Requirements.

Additionally, Flight Standards Service has endorsed the sensor requirements. WOI has completed a technology transfer to the Aviation Surface Weather Observation Network (ASWON) technology refresh (TR) 2 program for inclusion of the sensor into the investment planning. Pending investment analysis and implementation, the success can be measured by the replacement of the legacy sensor with the PWS.

Evaluation / Performance Measurement:

The FAA NAS Lifecycle Planning Division manages the planning, implementation, and reporting of NextGen portfolios. Portfolio managers use project management best practices to track and evaluate project progress towards defined objectives/outcome goals, ensure agreed to milestones and commitments with NAS planning documents are on track, monitor/control program risk, and monitor program funds to ensure they are expended in a timely manner. Additionally, they evaluate projects with respect to research needs, considering key aspects such as timeframes for when results are needed, alignment to the NAS enterprise architecture and early phase acquisition management system decision points, likelihood of achieving expected benefits, criticality, risk, interdependencies, and available funding. Portfolio managers incorporate results of completed projects into concept planning during periodic evaluations of concept status and progress.

Next Generation Support Portfolio
Funding Request ($12,800,000)

Program Description/Activities:

The NextGen Support Portfolio provides the National Airspace System (NAS) laboratory environments required to evaluate, mature, and validate the broad framework of NextGen concepts, technologies, operational functions, and systems before they are introduced into the NAS. This program provides the evaluation platforms at the NextGen Integration and Evaluation Capability (NIEC) and Florida NextGen Test Bed (FTB). These labs facilitate the conduct of NextGen concept demonstrations using research NAS environments without affecting actual NAS operations.

The NextGen Support Portfolio funding is used to continue laboratory operations in support of on-going NextGen programs, as well as, enhance existing NIEC and FTB lab capabilities as required to support the development and evaluation of advanced capabilities associated with evolving NextGen operational improvements and implementation plans. Following is a brief explanation of the work that will be performed as part of each activity.

Statutory Requirements:

Is this program statutorily mandated (Y/N): Y

This program is driven by the FAA Modernization and Reform Act 2012 and FAA Reauthorization March 2018 under FAA Title II NextGen Air Transportation System and Air Traffic Control Modernization Section 202 NextGen Demonstrations and Concepts "In allocating amounts appropriated pursuant to section 48101(a) of title 49, United States Code, the Secretary of Transportation shall give priority to the following NextGen activities."

The NextGen Support Portfolio provides the National Airspace System (NAS) laboratory environments required to evaluate, mature, and validate the broad framework of NextGen concepts, technologies, operational functions, and systems before they are introduced into the NAS.

Program Alignment with Strategic Goals:

DOT Strategic Goal	DOT RD&T Critical Transportation Topic
Innovation	**Improving mobility**

This program supports the DOT's Strategic Goal of innovation by providing targeted research and development within the FAA that will lead to new technology development and deployment in the National Airspace System (NAS). By providing the necessary research to gather information, this will allow the assessment of regulatory approaches, it will foster information sharing and facilitate coordination, collaboration with industry and other stakeholders, and the ability to test and adopt new technologies throughout the NAS. There is no impact on rural communities

Program Objectives:

New capabilities are required to support emerging NextGen operational improvements related to Collaborative Air Traffic Management, Seamless Integration of Information, Integration of Unmanned Aircraft Systems (UAS), Commercial Space Operations, and Trajectory-Based Operations (TBO). The main goal of the NextGen Support Portfolio is to provide an efficient and flexible platform to evaluate future NextGen concepts and technologies that will enhance the safety and efficiency of air travel. The laboratory environments provided by this program are necessary for Air Traffic Management (ATM) enhancements to be assessed at an early stage before implementation decisions or significant investments are made, allowing time to adjust the concepts or technologies, expediting their implementation in the National Airspace System (NAS), and reducing overall risk and cost to the taxpayer.

In the NIEC, NextGen systems and procedures will be developed and integrated into the NIEC to support studies that measure and validate concept feasibility, human performance, usability, changes in workload, and safety. In the FTB, laboratory infrastructure modifications are required to support a NextGen integration platform which will meet project demonstration requirements. The Operational Assessments will support NextGen implementation by performing work in three areas: Systems Analysis, NextGen Performance Snapshots (NPS), and NextGen Segment Implementation Plan (NSIP).

The Laboratory environments supported by the NextGen Support portfolio are critical in evaluating such concepts as the international exchange of standardized ATM messages, Trajectory Based Operations (TBO), Unmanned Aircraft Systems (UAS), Space Operations, and many others. These activities help reduce passenger delays, increase the capacity for number of flights, and allow UAS and space operations to safely and more efficiently interoperate with manned aircraft. Outputs from the projects conducted in the lab environments help to define Air Traffic Management Requirements and Performance Panel standards and guidance documents for International Civil Aviation Organization, which will provide guidelines to ensure the safety of the flying public

Economic Impact of Regulatory Reform:

The Support Portfolio are involved inis not involved in regulatory reform. The programs in this portfolio support tests and demonstrations for other programs. Therefore, this question does not apply to the Labs Support Portfolio.

Research Collaboration Partners:

This program is in and of itself, a pathway to obtaining stakeholder input. Specifically, the NIEC laboratory is used to expose stakeholders in the ATM operational user community to emerging NextGen concepts and capabilities in order to gain their assessment of the potential operational effectiveness and/or suitability of the concept for use in further maturation and development.

The Florida NextGen Test Bed is a facility located at the Embry Riddle Aeronautical University in Daytona Beach, Florida. It supports the integration of new and emerging technologies into the National Airspace System (NAS) through demonstrations and evaluations. One of the main purposes of the Florida NextGen Test Bed is to provide an open-access location for industry, users, and vendors to demonstrate new capabilities and harness NAS architecture solutions. These demonstrations

cultivate government, academia, and industry partnerships and facilitate decision making requiring community buy-in.

Acquisition/Assistance:

Does this program utilize competitive procurement processes? Yes.

FAA programs in the research portfolio employ competitive contracting vehicle types and grants to acquire Conduct, Research, and Development activities. The FAA's acquisition management system offers researcher's omnibus contract vehicles such as the SE2020, SE2025, and eFAST delivery-order based contracts in which vendors competitively bid to earn status as vetted service providers for both single year and multiyear contracts.

Does this program leverage non-Federal funds? (Y/N): No

Technology Transfer (T2):

The Support Portfolio is not directly involved in the Technology Transfer process. This portfolio supports NextGen projects by providing a laboratory environment to perform human-in-the-loop simulations, demonstrations and other technical evaluations.

Evaluation / Performance Measurement:

The FAA NAS Lifecycle Planning Division manages the planning, implementation, and reporting of NextGen portfolios. Portfolio managers use project management best practices to track and evaluate project progress towards defined objectives/outcome goals, ensure agreed to milestones and commitments with NAS planning documents are on track, monitor/control program risk, and monitor program funds to ensure they are expended in a timely manner. Additionally, they evaluate projects with respect to research needs, considering key aspects such as timeframes for when results are needed, alignment to the NAS enterprise architecture and early phase acquisition management system decision points, likelihood of achieving expected benefits, criticality, risk, interdependencies, and available funding. Portfolio managers incorporate results of completed projects into concept planning during periodic evaluations of concept status and progress.

Next Generation Transportation System - Unmanned Aircraft Systems (UAS)
Funding Request ($25,000,000)

Program Description/Activities:

The UAS projects play a critical role in enabling UAS operations in the National Airspace (NAS). The activities in this program support research that allow integration of UAS without impact to manned aircraft operations or creating disruptions or delays, and will ensure NAS operations will be as safe as they are today. The UAS operators will be allowed more operations that cost less, are better for the environment, and have the ability to operate in extreme conditions, lowering risk to human life. This program has two core pre-implementations tasks: 1) UAS Concept Validation and Requirements (UCVR) Development (CVRD), and 2) UAS Flight Information Management System (FIMS). The UAS CVRD project will continue identifying and maturing UAS needs as they relate to air traffic systems and services, and refining operational requirements associated with Air Traffic Management (ATM) automation, airspace management, policies, and procedures. UAS FIMS activities will establish the concepts, use cases, and requirements associated with UAS Traffic Management/FIMS to safely manage UAS operations primarily through operator-operator sharing of flight intent and operator-FAA sharing of flight intent and airspace constraints.

Statutory Requirements:

Is this program statutorily mandated (Y/N): Y

This program addresses 2016 Congressional Reauthorization mandates to research UAS Traffic Management (UTM) and establish an Operational Evaluation for testing and developing a UAS Traffic Management (UTM) data exchange capability and proposed architecture, of which FIMS is a core component.

Program Alignment with Strategic Goals:

DOT Strategic Goal	DOT RD&T Critical Transportation Topic
Innovation	**Improving mobility**

This program supports the DOT's Strategic Goal of innovation by providing targeted research and development within the FAA that will lead to new technology development and deployment in the National Airspace System (NAS). By providing the necessary research to gather information, this will allow the assessment of regulatory approaches, it will foster information sharing and facilitate coordination, collaboration with industry and other stakeholders, and the ability to test and adopt new technologies throughout the NAS. This program does not impact rural communities.

Program Objectives:

UAS operations have increased dramatically in both the public and civil sectors. Air Traffic products, policies, and procedures must be reviewed and refined, or developed through supporting research, to permit UAS operations in the NAS. The UAS research program plays a critical role in enabling UAS

operations in the NAS without impacting manned aircraft operations and creating disruptions or delays and ensuring NAS operations will be as safe or safer than they are today.

Standardized regulations, policy, procedures, guidance material, and training requirements are needed to allow routine UAS operations in the NAS. Additionally, existing Air Traffic Management (ATM) automation systems are not adapted to enable UAS integration. The activities in this program support research that allow integration of UAS without impact to manned aircraft operations or creating disruptions or delays, and will ensure NAS operations will be as safe as they are today.

Economic Impact of Regulatory Reform:

Prior to the creation of new regulations, current regulations are reviewed. New regulations are created with the intention of streamlining the regulatory process which is consistent with maintaining the safest, most efficient aerospace system in the world. Any new investment needed to support a new regulation is vetted through our AMS procurement process which includes investment analysis and a business case. Through these activities, benefits and costs are evaluated to achieve the most economically beneficial solution.

Research Collaboration Partners:

Additional public stakeholder input through Radio Technical Commission for Aeronautics (RTCA) and Drone Advisory Committee (DAC). RTCA provides recommendations on technical and operational standards to achieve the necessary improvements in the safety and efficiency of the air transportation system. Input has deepened FAA understanding of technical maturity and resulted in changes to definitions and timing for operational concepts. DAC is comprised of FAA and key decision-makers supporting the safe introduction of Unmanned Aircraft Systems (UAS) into the National Airspace System (NAS). The Committee seeks to identify and propose actions for the FAA on how best to facilitate the resolution of issues affecting the efficiency and safety of integrating UAS into the NAS.

Program Partners	Benefits
Research, Engineering, and Development Advisory Committee (REDAC) (external)	Provides advice and recommendations to the FAA Administrator on the needs, objectives, plans, approaches, content, and accomplishments of aviation research program, and reviews and comments on the aviation research programs.
Radio Technical Commission for Aeronautics (RTCA) (external)	Provide recommendations on technical and operational standards to achieve the necessary improvements in the safety and efficiency of the air transportation system. Input has deepened FAA understanding of technical maturity and resulted in changes to definitions and timing for operational concepts.

Drone Advisory Committee (DAC) – Federal advisory committee (subcommittee of RTCA)	FAA and key decision-makers supporting the safe introduction of Unmanned Aircraft Systems (UAS) into the National Airspace System (NAS). The Committee seeks to identify and propose actions for the FAA on how best to facilitate the resolution of issues affecting the efficiency and safety of integrating UAS into the NAS.
FAA Lines of Business • ATO Operational Concepts, Validation & Requirements (AJV-7) • UAS Engineering Branch (ANG-C35) • Air Traffic Procedures (AJV-8) • Airspace Services (AJV-1) • Program Management Organization (AJM) • National Air Traffic Controllers Association (NATCA)	NextGen collaborate with multiple internal lines of business such as air traffic, program management office, and aviation safety for policy development, concept maturation, and technical acceptance of investment capabilities.
FAA/NASA UTM Research Transition Team (RTT) Stakeholder Group	Oversees the RTT activities, including efforts by all working groups to develop the necessary requirements, concepts, and infrastructure for low-altitude operations for UAS. UTM RTT Stakeholder support will ensure proper recording and coordination of RTT progress and actions.
FAA-NASA UAS Traffic Management (UTM) Research Transition Team (RTT)	Provides for the necessary knowledge and operational and technical subject matter expertise to conduct research efforts.
UAS Test Sites	Provides for the necessary knowledge and operational and technical subject matter expertise to conduct research efforts.
Japan Civil. Aviation Bureau Future Air Transportation System (JCAB FATS)	Provides for the necessary knowledge and operational and technical subject matter expertise to conduct research efforts.

Do non-government groups partner with this program?

Yes. REDAC, RTCA, DAC. Details are in the table above.

Acquisition/Assistance:

Does this program utilize competitive procurement processes? Yes.

FAA programs in the research portfolio employ competitive contracting vehicle types and grants to acquire Conduct, Research, and Development activities. The FAA's acquisition management system offers researchers omnibus contract vehicles such as the SE2020, SE2025, and eFAST BPAs in which vendors competitively compete for TOs and BPA calls. The Broad Agency Announcement is another competitive process the FAA utilizes for awarding basic research contracts.

In general, the FAA Research Portfolio includes Research Programs that use multi-year acquisitions.

Does this program leverage non-Federal funds? (Y/N): No

Technology Transfer (T2):

Not Applicable, because this program focuses on development of new concepts and potential subsequent demonstrations to support NextGen capabilities for continued improvement of the NAS.

Evaluation / Performance Measurement:

The FAA NAS Lifecycle Planning Division manages the planning, implementation, and reporting of NextGen portfolios. Portfolio managers use project management best practices to track and evaluate project progress towards defined objectives/outcome goals, ensure agreed to milestones and commitments with NAS planning documents are on track, monitor/control program risk, and monitor program funds to ensure they are expended in a timely manner. Additionally, they evaluate projects with respect to research needs, considering key aspects such as timeframes for when results are needed, alignment to the NAS enterprise architecture and early phase acquisition management system decision points, likelihood of achieving expected benefits, criticality, risk, interdependencies, and available funding. Portfolio managers incorporate results of completed projects into concept planning during periodic evaluations of concept status and progress.

System Planning and Resource Management
Funding Request ($2,135,000)

Program Description/Activities:

The System Planning and Resource Management (SPRM) program leads the planning, coordination, development, presentation, and review of the FAA's research and development (R&D) portfolio. Its key programmatic outputs include the National Aviation Research Plan (NARP), the Annual Research and Development Review – both of which are annual statutory deliverables to Congress – and administration of the congressionally mandated (P.L. 100-591 Section 6 Advisory Committee) Research, Engineering and Development Advisory Committee (REDAC) and resultant reports. SPRM also provides program advocacy and outreach and maintains alignment with departmental R&D program planning and performance reporting guidance. SPRM leads the portfolio planning, formulation, presentation and review activity to ensure the FAA meets the President's criteria for R&D, increases program efficiency, sustains and maintains management of the program within operating cost targets, and enables effective program review by the REDAC and the OST Office of Research and Technology.

Established pursuant to the Federal Advisory Committee Act (FACA), the REDAC reviews FAA research commitments annually and provides guidance for future R, E&D investments. The members of this committee and its associated subcommittees are subject matter experts drawn from various associations, user groups, corporations, government agencies, universities, and research centers. Their combined presence in the REDAC fulfills a congressional requirement for FAA R&D to be mindful of aviation community and stakeholder input. SPRM also develops program guidance and conducts compliance reviews to ensure that departmental R&D program planning and performance reporting requirements specified in the Fixing America's Surface Transportation (FAST) Act are satisfied. It also coordinates the establishment and administration of the Air Transportation Centers of Excellence (COE) Program and ensures compliance with related Financial Assistance and Grants Management departmental policy guidance.

Statutory Requirements:

Is this program statutorily mandated (Y/N): Y

- Section 44501(c) of Title 49 of the United States Code (49 U.S.C. § 44501(c)) – requires the annual submission of the NARP and AR.
- Office of Management and Budget Circular No. A-11 – requires the submission of the Budget Narratives to accompany the President's Budget Request
- Public Law 100-591 Section 6 Advisory Committee – requires the administration of the REDAC.
- Public Law 101-508, Section. 9209. Aviation Research and Centers of Excellence
- USC 15 Chapter 63 3710 (f) – requires the submission of Technology Transfer performance metrics for the prior year.
- Fixing America's Surface Transportation Act – requires the submission of the Annual Modal Research Plan.

Program Alignment with Strategic Goals:

DOT Strategic Goal	DOT RD&T Critical Transportation Topic
Accountability	**Preserving the environment**

This program supports the DOT's Accountability Strategic Goal, particularly the Management Objective #2. This program supports mission requirements by effectively and efficiently planning for and reporting on the FAA's entire research portfolio. This program does not have any direct impact on rural communities.

Program Objectives:

The main goal of the System Planning and Resource Management program is planning and program management support for the FAA to formulate its annual RE&D portfolio and submit the mandatory R&D planning documents to Congress each year. Through the management of the FAA REDAC, this program facilitates an independent, expert review of the FAA's R&D portfolio that provides meaningful recommendations for the FAA to refine and improve its portfolio. This results in a more effective research program that will benefit the public by making aviation safer and smarter and enhancing the U.S. global leadership in aviation.

The support planning and resource management activities conducted by this program do not address market failures.

Economic Impact of Regulatory Reform:

Beyond the planning and performance reporting requirements specified in the Fixing America's Surface Transportation (FAST) Act and in Section 44501(c) of Title 49 of the United States Code, there are no new regulations governing the System Planning and Resource Management of the FAA research portfolio, and therefore no associated increase of economic impact resulting from this legislation.

Research Collaboration Partners:

The development and submission of all System Planning and Resource Management products (Annual Review, National Aviation Research Plan, Annual Modal Research Plan, President's Budget Request Budget Narrative, and Technology Transfer Congressional Report) and associated services (REDAC and Research Executive Board (REB) conduct) involve the same stakeholders.

FAA Research Planning and Reporting Stakeholders include:

- Office of the William J. Hughes Technical Center Director – Manages the entire FAA Research portfolio, oversees research funding allocations and disbursements, and research management and accountability, Chair of the Research, Engineering, and Development Executive Board

- Office of the Assistant Administrator for NextGen – Provides Executive oversight of NextGen Research

- Office of the Associate Administrator for Aviation Safety – Manages portfolio of Aviation Safety Research programs, Voting Member of both the REDAC and the REB

- Office of the Associate Administrator for Airports – Manages portfolio of Airport Technology and Cooperative Research Programs, Voting Member of both the REDAC and the REB

- Office of the Associate Administrator for Commercial Space Transportation – Manages portfolio of Commercial Space Research programs, Voting Member of both the REDAC and the REB

- Office of the Assistant Administrator for Policy, International Affairs and Environment - Voting Member of both the REDAC and the REB

- Office of the Assistant Administrator for Finance and Management – Provides all financials associated with the planning and reporting products, serves as financial POC to OST, serves as Advisory Member of the REB

- Air Traffic Organization – Advisory Member of the REB

Do non-government groups partner with this program? No.

Acquisition/Assistance:

Does this program utilize competitive procurement processes? Yes.

FAA programs in the research portfolio employ competitive contracting vehicle types and grants to acquire Conduct, Research, and Development activities. The FAA's acquisition management system offers researchers omnibus contract vehicles such as the SE2020, SE2025, and eFAST BPAs in which vendors competitively compete for TOs and BPA calls. The Broad Agency Announcement is another competitive process the FAA utilizes for awarding basic research contracts. Grants are used to execute a portion of the FAA's research budget and where the FAA has the statutory authority to issue grants pursuant to the Aviation Research Grants Program. The FAA's Centers of Excellence (COE) is one example of a grant-based program that uses competition to select from among members of academia for COE participation. In the specific case of the COE grant program, it receives matching funds from industry sponsors.

Does this program leverage non-Federal funds? No

Technology Transfer (T2):

While this program does not perform any actual research, it includes two functional areas that conduct technology transfers; Office of Research and Technology Applications (ORTA) and Office of Center of Excellence (COE). The ORTA office activities include the development of Cooperative Research and Development Agreements (CRDACRDA) and technology commercialization (patent

executions) in partnership with the non-federal sector, including private firms, research organizations and academia. This office conducts outreach activities to highlight FAA's state-of-the-art technical resources, both the physical facilities and human capital (subject matter experts), to increase CRDACRDA partnerships. ORTA office performance measures include a) conducting at least one outreach activity per month and b) targets an increase of new CRDACRDA participations of 5% annually.

The COE office supports partnerships which conduct long-term cooperative research with academia, industry and other entities. The results of these research efforts are technical publications which are available on the DOT Research Hub as part of technology transfer. Additional COE performance measures include publications and reports produced, public presentations which comply with information dissemination requirements, the education and training of students prepared to enter the aviation workforce, generation of industry support and matching contributions.

Section 2 - Program Descriptions, FY 2020

Airport Infrastructure and Technologies

Airport Cooperative Research Program

Program Description/Activities:

To gain insights from representatives in industry, academic, and the Federal government, and to develop future high quality research proposals and to revise the program's strategy and planning, the program has scheduled Insights events in both 2018 and 2019. The topics include environmental policy and planning as well as airport economic and social sustainability. These events will allow the program to make sure the needs of the users continue to be of focus and collect their research ideas and feedback on existing products utilized. The REDAC will also host 2 committee meetings and 10 subcommittee meetings annually from which come reports documenting REDAC's input known as REDAC Findings and Recommendations (F&Rs.), which are utilized for further research program planning.

Program Alignment with Strategic Goals:

DOT Strategic Goal	DOT RD&T Critical Transportation Topic
Safety **Infrastructure**	**Promoting safety** **Improving mobility**

This program supports the DOT's Strategic Goal of safety by providing systematic research and development within the FAA that will lead to the identification, assessment and mitigation of safety risks. By providing the research necessary to generate data, this data is then used to create and develop new safety standards that will be adopted throughout the aviation community.

This program further supports the DOT's Strategic Goal of infrastructure by providing systematic research and development within the FAA that will lead to assessments, which will improve the infrastructure in airports across the National Airspace System (NAS). By providing the research necessary to generate data, this data is then used to provide the baseline information that will be used to evaluate and advance the safety and capabilities of the infrastructure at airports and air traffic facilities throughout the NAS.

In 2014, ACRP identified five Hot Topics that pose challenges to airports today, as published in the Annual Review report 2015, pg. 10. The ACRP Oversight Committee (AOC) uses this list when reviewing and selecting research topics for funding.

- The changing aviation industry and airports,
- New models of airport and aviation industry engagement,
- Airports in the transportation system and the customer experience,
- The future of airports, and
- Next Generation Air Transportation System (NextGen) technology.

In addition, ACRP has strategic objectives from the 5-year research plan that align to the Department of Transportation's strategic plan. This includes DOT's Strategic Objective 2: Life Cycle and Preventive Maintenance, which aligns with ACRP's Priority 1: Ensure that Problem Statements Are of the Highest Quality and Greatest Relevance to the Airport Industry; Priority 2: Align Program Products with the Interests of Key Audiences; Priority 3: Expand and Diversify Product Dissemination; Priority 4: Implement Processes to Monitor Product Quality, Relevance, and

Timeliness. This Objective is to provide research, technical assistance, and targeted funding to ensure that transportation infrastructure is planned, constructed, and maintained using best operational and risk management practices. This not only aligns with ACRP's mission but also with the 4 above strategy priorities as high quality problem statements, aligned programs, product dissemination and quality processes all allow the transportation system to be planned, constructed and maintained with best practices dissemination to the airport industry. This benefits all four of DOT's strategic goals by conducting projects that benefit safety with designs and practices that reduce injuries and fatalities, improve infrastructure to stimulate economic growth, demonstrate innovation by introducing new technology, and accountability by allowing the workforce to be more efficient. The research projects are completed on average in 1.5 years with the expectation that many research deliverables (reports, templates, tools and webinars) will culminate within the 5-year strategy period. The program does not overlap with any other Federal or non-Federal efforts. ACRP's mission is to carry out applied research on problems that are shared by airport operating agencies and are not being addressed by existing Federal research programs. This program focuses on airport operations, policy and planning development whereas the Aviation Technical Research Program ATRP is specific to the development of technical standards that are primarily applicable to airports.

Airport Technology Research Program

Program Description/Activities:

In FY 2020, it is expected that over 125 on-going complex projects will be carried on by the ATR program. To support the execution and management of such a large number of projects, the ATR program is organized into 19 research program areas (RPA's). Under these RPA's, research is conducted in airport planning and design, analysis of airport safety data, airport rescue and firefighting, wildlife hazard mitigation, visual guidance, runway surface technology, airport surveillance sensors, aircraft noise issues around airport, airport pavement design, airport pavement long-term performance, and unmanned aircraft systems (UAS) integration at airports.

In the airport pavement research area, the ATR program will continue to use its facilities, and makes use of an advanced airport pavement materials testing laboratory constructed in FY-18-19, to test and conduct research on new pavement design and new pavement materials. The FAA plans to use state-of-the-art material testing laboratory methods to perform material characterization of new pavement materials. Providing realistic material properties and specifications through this material research and testing as design inputs will improve the pavement thickness design procedure and pavement life predictions thus reducing costs and increasing pavement life.

In FY 2020, ATR will continue its multi-year research project to investigate the reduction or elimination of harmful chemicals that may pose either health or environmental hazards. Over the years there has been a growing concern about the potential health and environmental impact that aqueous film-forming foams (AFFF) used by aircraft rescue and firefighting (ARFF) departments can have at airports and surrounding communities. The main concern is that the EPA and other organizations have found that certain chemicals are toxic and have accumulated in land and water around airports. This research will help test new kinds of AFFF for effectiveness without the harmful chemicals. This multi-year research will be accomplished through critical testing at a fire testing facility dedicated to this issue.

In FY 2020, ATR will continue to research, test and evaluate alternatives to Engineered Materials Arresting Systems (EMAS), that can be used at runway safety areas at all airports. The research will focus on life extension of existing in-place EMAS systems along with testing future alternatives.

The ATR branch also manages a number of research databases. In FY 2020, integration and support of the databases (bird strike, FOD detection, Airport Pavement management systems) into one location will continue. This will ensure compliance with FAA standards, to improve the overall functionality of the databases, and promote public access and sharing of the data.

The introduction of UAS's in the airspace system constitutes a challenge for airports, but the use of UAS's can also be very beneficial for airports. In FY 2020, work will continue and expand on UAS research activities started in FY-19 in the detection areas, and in the use of UAS at airports for various safety and infrastructure inspection activities. UAS opportunities will be defined, tested and evaluated in cooperation with airports.

Program Alignment with Strategic Goals:

DOT Strategic Goal	DOT RD&T Critical Transportation Topic
Safety **Infrastructure**	**Promoting safety** **Improving mobility**

This program supports the DOT's Strategic Goal of safety by providing systematic research and development within the FAA that will lead to the identification, assessment and mitigation of safety risks. By providing the research necessary to generate data, this data is then used to create and develop new safety standards that will be adopted throughout the aviation community.

This program also supports the DOT's Strategic Goal of infrastructure by providing systematic research and development within the FAA that will lead to assessments which will improve the infrastructure in airports across the National Airspace System (NAS). By providing the research necessary to generate data, this data is then used to provide the baseline information that will be used to evaluate and advance the safety and capabilities of the infrastructure at airports and air traffic facilities throughout the NAS.

The Airport Pavement research area in FY 2020 RD&T will help to support the Strategic Objective 2: Life Cycle and Preventive Maintenance by continued research into the use of green technologies in both concrete and asphalt airfield pavements with the advance testing developed in the material testing laboratory. This work will help in providing longer life pavements and the reduction of the use of our existing natural resources. Another project is the refinement of the Life Cycle Cost Analysis (LCCA) process to refine and provide prescriptive cost comparison between the pavement alternative so Airports can compare each alternative in an unbiased way. The other program is the development of a framework for Airports to use when performing Life Cycle Assessments (LCA) for their airside features.

The major reason to pursue this research is the reduction of the AIP cost of construction of airside features. Other reasons are the research will reduce the amount of natural resources which will be consumed in the construction of future airport projects and the life of airport pavements will be extended past the current 20 year design life.

Some of this research is currently being under taken by the Federal Highway Administration (FHWA) under highway (Truck and Cars) loading conditions and by the U.S. Army Corp of Engineers, Engineer Research and Development Center (ERDC) under military aircraft loadings. The Airport Pavement R&D section is in communication with both FHWA and ERDC about their research and the outcomes of the work.

The products of this research should become tangible as early as FY 2021 if full scale testing proves the green technologies are viable under commercial aircraft loadings and could be added to the pertinent Advisory Circulars. Other products could become viable in 2022 and beyond as new materials are introduced into the market place. The LCCA and LCA programs could be become viable in 2021 and 2022 respectively

The Airport Safety research area in FY 2020 RD&T will continue to support DOT Strategic Goal - Safety, Strategic Objective 1: Systemic Safety Approach by continuing research in integrating

unmanned aircraft systems into the environment to perform various airport centric operations. Specialized applications that involve UAS being used within the airport environment or on the airport surface itself could be a major safety enhancement to the National Airspace System. Projects being considered include UAS for Airport Inspections, Airport Perimeter Security, Wildlife Mitigation/Detection, Geo-analysis of Obstacle Clearance Surfaces, and Surveillance of Airfield Emergencies.

There are several risks associated with the operation of ground vehicles on airfields, including potential collision with aircraft or inadvertent operations that may cause runway incursions, incidents, or even accidents. The use of UAS could, in many cases, reduce the requirement of ground vehicles to be on the airfield surface, or at least reduce the amount of time they are there. It could also greatly reduce the amount of time required to conduct various inspections that usually require a person in a vehicle several hours to complete. The use of UAS could also increase the reliability and accuracy of the inspection, as it eliminates the potential for human error by using artificial intelligence. For other applications, the use of UAS could be used to greatly improve the methods by which airport operators respond to various emergency or security related events on the airfield by allowing UAS's equipped with high power cameras to provide live, real-time video streams from angles, heights and distances that have never been possible. This can greatly reduce the risk of injury to airport personnel responding to an incident, improve the efficiency of operations, and greatly enhance the safety of the flying public.

At the present time, numerous private vendors are involved in developing technologies that could be used to conduct the above applications. The FAA recognizes that while private industry continues to develop the tools to conduct the operations, a significant amount of research is needed to properly document operational guidance that can be provided to a local airport authority to spell out, in very simple terms, the steps needed to conduct such operations. Material to be covered includes what approvals are necessary to fly UAS, descriptions of concept of operations for each application, integration with manned aircraft, expected capabilities, and baselines for what should be considered acceptable data/results. This guidance is currently missing, and it being sought out by airport operators.

ATR is aware that other government agencies are investigating similar operations to protect other critical infrastructure within the US, but this proposed research effort for FY 202020 will be the first to focus on airport centric UAS operations.

To date, some FY18 funds have been dedicated to this task to begin the early work of conducting literature reviews and surveying airports to better understand any type of UAS operations that are currently being pursued. Thus far, ATR has confirmed that there is a lot of activity in the development of the UAS technology, but nobody has been able to properly document the complexity of the operations or provide clear explanations of what the final operations will look like. Airport authorities contacted thus far have echoed their appreciation for this effort, and have on several occasions, offered their assistance and volunteered to be included in the research program.

The products of this research should be completed and available to the public in early FY21. FY18 and FY 2019 will be spent conducting a significant amount of fieldwork observing the various types of operations that will be documented in final reports and draft guidance documents. FY 2020 will include the launch of numerous pilot programs at numerous airports across the US where researchers will be testing the draft guidance documents in the field to ensure their accuracy and

completeness. With completion of this phase, ATR will be in a good position to issue the documents in final form in early FY21.

Aircraft Safety Assurance

Fire Research and Safety

Program Description/Activities:

Assess the ramifications of carriage of hazardous goods on aircraft fire protection methods and equipment, and consider technical feasibility of addressing such goods at the aircraft level.

This research is a continuation of ongoing research to address the emerging fire hazards from the air transport of hazardous materials. The proliferation of lithium battery production and the volume of such batteries carried as cargo is a particular concern. The research focuses on improved methods for the safe shipment of these materials.

Develop criteria and test methods for improved detection of fires inside Unit Load Devices (ULDs).

This research is a continuation of ongoing research. Recent developments of improved fire resistant containers and packaging methods for declared hazardous materials has led to the possibility of containment of combustion products from fires within these containers/packages. This could effect the response of traditional aircraft based fire detection systems. This continuing research will focus on technologies that can improve the detection time of fires in this scenario.

Additional research activities requested by FAA sponsors will not be conducted during this fiscal year due to funding reductions.

Program Alignment with Strategic Goals:

DOT Strategic Goal	DOT RD&T Critical Transportation Topic
Safety	**Promoting safety**

This program supports the DOT's Strategic Goal of safety by providing systematic research and development within the FAA that will lead to the identification, assessment and mitigation of safety risks. By providing the research necessary to generate data, this data is then used to create and develop new safety standards that will be adopted throughout the aviation community.

The research is needed to address the evolving nature of both the materials used in aircraft manufacturing and the types and quantities of hazardous materials being transported on aircraft. The research addresses the safety implications of these issues and will provide data for the FAA to determine needed changes in the certification of aircraft. The unique fire safety research facilities at the FAA Technical Center have been identified as the most appropriate location to conduct this research. Fire safety research has been conducted at this location for the past 50 years and has led to improvements throughout the entire aircraft and to a significant decrease in aircraft fire related fatalities and injuries. The research is ongoing and the improvements occur through updates to the FAA certification requirements as the aviation industry evolves and new fire hazard threats emerge.

Unmanned Aircraft Systems Research

Program Description/Activities:

The UAS Research program supports the FAA efforts in integrating UAS into the NAS. By studying safety implications of unmanned aircraft operational concepts and technology, this research program supports the development of policy, rulemaking, and standards. The program's research activities focus on new technology assessments, methodology development, data collection and generation, laboratory and field validation, and technology transfer. Below are two FY 202020 research projects.

- UAS Automation and Intelligent Systems
  - This research will develop a long-term automation strategy to work towards approval of intelligent systems. This program proposes a phased approach beginning with UAS and moving toward cargo and passenger carrying aircraft. The intent is to identify considerations for certification, including general human factors.

- UAS High Performance Command and Control (C2) Link Systems and Networks
  - This research supports development of certification guidance and industry standards for C2 Link and Autoflight Interoperability.

Program Alignment with Strategic Goals:

DOT Strategic Goal	DOT RD&T Critical Transportation Topic
Safety	**Promoting safety**

This program supports the DOT's Strategic Goal of safety by providing systematic research and development within the FAA that will lead to the identification, assessment and mitigation of safety risks. The safe integration of UAS into the NAS is an important objective for the FAA, as evidenced in Destination 2025. By providing the research necessary to generate data, this data is then used to create and develop new safety standards that will be adopted throughout the aviation community. The program's research activities focus on new technology assessments, methodology development, data collection and generation, laboratory and field validation, and technology transfer.

Advanced Materials/Structural Safety

Program Description/Activities:

The Advanced Materials/Structural Safety Program supports the goal of improving aviation safety by investigating a broad spectrum of issues related to the use of composite and advanced materials in aircraft structures. In this context, this program will perform research in the following four focus areas:

1) Fatigue and Damage Tolerance of Composite Structures: Research will be performed to identify composite aging mechanisms that span a time that exceeds practical maintenance programs. Additionally research will explore the analysis and test protocol needed to properly address aging phenomena identified in Phase I of this research task. Additionally, research will evaluate composite fatigue & damage tolerance issues for high cycle applications (rotorcraft) considering more realistic damage scenario and loading effects. Finally, research will investigate critical defects & damage threats for emerging composite technology: It will define unique test and analysis protocols for new material forms, fabrication processes and unique design details that do not follow current standards for more common composite performance characteristics. It will perform tests and analyses to characterize the notch sensitivity of chopped fiber composites, considering typical manufacturing defects and service damage. Research will help develop guidelines on unique material behavior & NDI methods that characterize important defect or damage metrics for analyses.

2) *Composite Maintenance Technology:* This research project will establish composite repair design and evaluation criteria for continued operational safety. It will produce data critical to composite bonded repair material and process control, including specification requirements and reliable test standards. Research will develop a composite repair structural substantiation training course to support safe maintenance for composite transport airplanes, small airplanes and rotorcraft in the field. Finally, it will evaluate maintenance practices for new composite technologies and facilitate related technology transfer.

3) *Continued Operational Safety (COS) and Certification Efficiency (CE) for Emerging Composite Technologies:* This research will continue investigating the effects of fire on composite failure analysis procedures and methods. Additional research will be performed to develop a test method for characterizing spark detection and certifying lightning protection of a composite structure; Finally, Phase 2 research will be conducted to investigate the sensitivity of composite materials to new fuel and the adequacy of current screening test.

4) *Certification and Maintenance Protocols for Bonded Joints (new research for FY 2020):* This new research activity will document best practices in qualifying surface preparation techniques for bonded joints in composite aircraft structures. It will also document best practices in quantifying cure process effects, with key characteristics and key process parameters, and identify the limitations of design allowables considering the effects of design features (e.g., single versus double overlaps) for bonded joints. Finally new research will be performed to investigate the residual strength and overall durability of certain bonded joints in general aviation structures to allow a fourth option for certifying bonded joints beyond those currently in 23.573(a)(5).

Program Alignment with Strategic Goals:

DOT Strategic Goal	DOT RD&T Critical Transportation Topic
Safety	**Promoting safety**

This program supports the DOT's Strategic Goal of safety by providing systematic research and development within the FAA that will lead to the identification, assessment and mitigation of safety risks. By providing the research necessary to generate data, this data is then used to create and develop new safety standards that will be adopted throughout the aviation community.

Research activities planned for FY 2020 are structured in accordance with the strategic goals, internal FAA deliverables and associated timetable outlined by the Aviation Safety (AVS) Strategic Composite Plan and supports all of its three key initiatives. In support of the FAA AVS composite plan, the research output produced by this program will be used by the FAA to develop and publish guidance for the aviation industry. This guidance material includes:

- New Advisory Circular (AC) for bonded repair best practices (by FY 2021),
- New AC for composite sandwich structure design, manufacturing, and maintenance that supports the unique considerations of "bonded" sandwich (by FY 2020),
- FAA Failure Analysis Handbook for Composites (by FY 2021)
- A new rule (a modified § 25.571 or new subpart to part 25) defining damage tolerance requirements for the certification of composite transport aircraft (by FY 2020)
- Revised AC 20-107, "Composite Aircraft Structure," to incorporate advanced composite technologies and lessons learned (by FY 2022)

More specifically, research on *Damage Tolerance of Composite Structures* supports key initiatives of the AVS Strategic Composite Plan. This research aims to study critical defects and damage threats that effect the damage tolerance of composite airframe structures not fully understood today. Research also includes the evaluation of methods to better characterize behavior of damaged composite materials as applied by industry to support certification of composite aircraft. Current regulations and associated guidance for transport airplanes in this area have been based on metallic construction. Damage tolerance behavior of composite structures differs substantially from metallics. The FAA will perform research to characterize, prioritize and simplify damage criteria used during certification. FAA invested in this research areas and output of past research supports various ongoing rulemaking and guidance development activities within the AVS. Output of the proposed activities are expected to be available by FY 2021.

Research on Composite Maintenance Technology is essential in supporting outcomes defined in the AVS Strategic Composite Plan. The continued airworthiness of composite aircraft is contingent on sound composite maintenance practices. To date the maintenance workforce, including service engineering has been metal concentric with a long history of designing and installing repairs to metallic aircraft. With the proliferation of composite aircraft there needs to be an increased focus on extremely process dependent composite maintenance. This research will address the need to train and qualify all persons involved in composite maintenance from the engineer, repair technician and quality personnel. Projected output target date is FY 2022.

Research on Continued Operational Safety and Certification Efficiency for Emerging Composite Technologies will continue investigate the effects of fire on composite failure analysis methods and conduct research on effects of lightning strike on composite aircraft structures. Research will also continue on the potential sensitivity of composite materials to new fuels. This research activity support the AVS Strategic Plan and its output will be published as part of the FAA Failure Analysis Handbook for Composites (AVS Composite Plan Deliverable, by FY 2021).

Research on Certification and Maintenance Protocols for Bonded Joints is a new FY 2020 activity. This research will leverage earlier work and expand adhesive research to that of the entire bonded joint. Its objective is to understand and quantify the factors that influence bonded joint quality, and generate guidelines for bonded joint certification and repairs. The FAA has identified bonding as the most critical COS issue related to composites in the AVS Strategic Composite Plan. Bonding is also listed as an initiative for certification efficiency. All product types, from rotorcraft to general aviation to transport aircraft, as well as propellers and now even engines, use bonded structure. While all composite manufacturing is process-critical, bonding is particularly so due to the fact that there are no non-destructive inspection methods to identify understrength bonds. Bonded repairs are performed in less controlled environments than manufacturing, and have their own set of safety risks and mitigating protocols. Outcome target date for this research activity is FY 2023.

Continued Airworthiness

Program Description/Activities:

Structural Integrity - Agricultural Airframe Usage and Operational Loads Monitoring

Agricultural aircraft, or crop dusters, are often also used as single engine air tankers during the fire season. The aircraft are used in both FAA regulated roles, and as public use aircraft for the Department of the Interior. Aircraft used in this dual role have experienced in-flight breakups, sometimes during FAA regulated, agricultural use. These fatalities proved that the existing Airworthiness Directives (AD), which are prepared based on agricultural operation data, are not applicable to firefighting operations. This effort, which has been jointly funded by the Department of the Interior, will provide operational load data for firefighting mission, which will enable the FAA to issue new AD to address this safety concern.

An initial study sponsored by the FAA revealed that there exist differences between operational loads during agricultural and firefighting missions, suggesting that these differences have different impacts on the health of airplanes. However, the brief investigation could not provide enough data for the FAA to update existing ADs or providing guidance material.

The FAA will record the operational loads of Agricultural and Single-Engine Air Tanker aircraft and process the data to address the risk associated with the fatigue cracks commonly found in primary structures of these airplanes. Data collection instruments will be installed on these airplanes and the load data will be collected and processed. The data will then be used by the FAA to update the ADs and introduce guidance materials.

This activity is aligned with DOT first strategic goal for FY 202018-2022 “Safety” since data collected will be used to reduce Transportation-Related Fatalities and Serious Injuries Across the Transportation System.

Effect of Turbulence on Aircraft Structural Loading

This research will address aviation accidents associated with turbulence by better understanding what effect specific values of turbulence have on specific general aviation aircraft and Unmanned Aircraft Systems (UAS).

From 1987 to 2009, at least 864 accidents have been affected by some sort of turbulence, thunderstorm, wind shear or microburst, or a combination thereof. The objective of this research is to address these accidents by developing a data-driven turbulence-risk identification methodology to correlate the structural integrity to a measurable turbulence value. This will enable the FAA to address this safety concern as well as providing guidance material for safe integration of UAS. This activity supports two of the DOT Strategic Plans, Safety and Innovation, by addressing the turbulence-related accidents and providing data and methodology, which will assist in development and integration of UAS. This is a new research; therefore, we have not invested in this topic in the past.

Development of Control Surface and Stabilizer Freeplay Limits

Freeplay-induced vibrations have been categorized as unsafe conditions by the FAA, the FAA has acted reactively and has issued many Airworthiness Directives on many airplane makes and models

to address the safety concern after the incidents have occurred. This research will obtain the data, develop methodology and provide freeplay limits that can be achieved by transport category airplanes to manage the associated risk with freeplay. The FAA will obtain data and develop the methodology and nonlinear models required to establish safe and realistic freeplay limits for transport category aircraft to avoid freeplay-induced vibrations and manage its consequent risks. This research supports the first DOT Strategic Plan, which is Safety, by providing freeplay limits for control surfaces of transport category airplanes. This is a new research; therefore, we have not invested in this topic in the past.

Rotorcraft Systems - Wire Strike Avoidance (will build upon FY 2019 activities)

This research program is intended to help reduce the rotorcraft accident rate by giving the operators the ability to either cut a wire encountered or give the pilot the knowledge of wire close to the aircraft. There will be two technical areas investigated. The first is the development of a mechanical wire strike device and the second is the development of a sensor package capable of detecting wires in the vicinity of the aircraft while flying. Wire strike accidents accounts for 5% of all rotorcraft accidents. To our knowledge, which included literature and market surveys, no one else is researching this issue. This is a new research; therefore, we have not invested in this topic in the past and the program is expected to be completed in FY21 with results provided to the rotorcraft directorate (certification office) via a final report.

Goals for FY 2019 and FY 2020 Funding:

- By 2019, review the NTSB accident reports for rotorcraft wire strikes to determine location of strike, type of industry, type of rotorcraft, phase of flight, etc., which will be used to determine the direction of the wire strike research program.

- By 2021, develop technical data to evaluate non-flammable electrolyte lithium batteries and battery systems for aerospace applications.

- By 2021, develop technical data to evaluate the feasibility of using fuel cell systems for aerospace applications while retaining or improving the current level of safety in commercial transport aircraft.

- By 2020, provide technical data for use in guidance material to mitigate risk of bird strikes to helicopter operators.

- By 2021, develop a process for establishing mechanical property standards (used in FAA certification guidance) for emerging process-intensive metallic materials, including metal additive manufacturing.

- By 2022, provide data relative to active flutter suppression to allow for the review of pertinent regulations and guidance material, and prepare recommendations for new, modified, or otherwise improved criteria.

- By 2023, provide data to assess additive manufacturing technologies.

Program Alignment with Strategic Goals:

DOT Strategic Goal	DOT RD&T Critical Transportation Topic
Safety	**Promoting safety**

This program supports the DOT's Strategic Goal of safety by providing systematic research and development within the FAA that will lead to the identification, assessment and mitigation of safety risks. By providing the research necessary to generate data, this data is then used to create and develop new safety standards that will be adopted throughout the aviation community.

Propulsion and Fuel Systems

Program Description/Activities:

Aircraft Turbine Engines: Current funds for this budget line will preclude the successful completion of the research activities needed to support Part 33.70. It will also prevent the FAA from conducting R&D in support of the recent NTSB recommendations regarding the American Airlines Flight 383 uncontained engine failure in Chicago.

Catastrophic Engine Failure: No funds were provided to continue external interagency agreements of Grants with academia. FAA researchers will utilize the FAA High Performance Computer at the William J. Hughes Technical Center to continue evaluation of the predictive modeling capabilities by testing against previously completed verification and validation tests to evaluate the performance of the existing models. The loss of the academic support staff will significantly delay results publication.

Alternative Fuels for General Aviation: No funds were provided to support the identification and evaluation of the non-transparent fleet authorization. These are the aircraft that would not have been covered under the previous PAFI testing authorization as they would require modifications due to significant fuel impacts. The size of this non-authorized fleet may be significant and would need first to be identified. Until they are modified and approved for use with new fuels they will likely be grounded.

In addition, no funds were provided to support rapidly emerging or disruptive technologies, such as alternative turbine fuels, pure electric and electric hybrid or fuel cell means of propulsion. These areas are rapidly emerging and potentially very disruptive technologies that do not fit easily into the current regulatory framework. In many cases, research needs to be done to support the interpretation and development of advisory material, standards, and rules.

Program Alignment with Strategic Goals:

DOT Strategic Goal	DOT RD&T Critical Transportation Topic
Safety	**Promoting safety**

This program supports the DOT's Strategic Goal of safety by providing systematic research and development within the FAA that will lead to the identification, assessment and mitigation of safety risks. By providing the research necessary to generate data, this data is then used to create and develop new safety standards that will be adopted throughout the aviation community.

At the current proposed funding levels, minimum in-house research will only be possible. Some validation of the advanced computational impact models will be possible on the FAA high performance computing cluster but further material model development necessary to advance the certification by analysis goal will be halted. Development of DARWIN and UEDDAM will be discontinued or significantly delayed. Additionally, the FAA will not be able to respond to outstanding NTSB recommendations and will not be able to revise advisory circulars. Research on the alternative fuels must be placed in moratorium without in-house resources.

This program directly supports and promotes DOT safety goals by serving to reduce the risk of uncontained turbine engine failures, providing a standardized methodology for uncontained aircraft turbine engine failure analysis, advancing certification by analysis capability through development of a standardized methodology.

The alternative fuels project supports the DOT goal of safety and accountability as follows. The search for an unleaded fuel that can meet the antiknock characteristics of current fuels that use Tetraethyl Lead (TEL) requires extensive testing and comparative analysis. The PAFI program initiated at the request of various General Aviation industry groups, who were concerned about the very real prospect of a patchwork of state and local regulations. The PAFI initiative created a public/private partnership to develop a unique regulatory approach in which the FAA would issue a fleet-wide authorization for a new fuel.

Digital Systems and Technologies

Aircraft Icing/Digital System Safety

Program Description/Activities:

Aircraft Icing

The Aircraft Icing Program will continue projects started earlier, building upon FY 2019 activities. A second stage rotor will be added to the first stage rotor for the compressor model and testing undertaken to study the engine ice crystal icing process. Ground icing research will continue from FY 2019, or initiated anew, on issues to be addressed in the annual Flight Standards Notice on ground icing. This notice is necessary for airlines to develop their annual ground icing plans, and for FAA inspectors to evaluate these plans. Research on engineering tools for icing in super cooled large drop conditions will continue.

Digital System Safety (DSS)

The DSS FY 2020 requirements are a continuation of the program. This research is for the second phase of Generic Framework for Software Assurance is to directly address the FAA's commitment to certification process efficiencies as mandated by the 2012 Modernization and Reform Act. The efficiencies resulting from this task will reduce the FAA's footprint in the certification critical path while, at the same time, not affect continued operational safety. This task will explore software and airborne electronic hardware certification streamlining techniques to potentially reduce the certification burden on industry while at the same time improve the level of safety. This task will generate a report that identifies the streamlining approaches. The task will also identify and evaluate development assurance metrics that could be used to assess an applicant's assurance process and the need for additional oversight. The task will continue in FY 2021 and will generate a report that identifies the assurance performance assessment metrics.

The DSS In-Service Reliability research is the continuation of a multi-year research task aiming at the development of guidance for the reliability of newer material in circuits (e.g. lead-free electronics, fluxes, and coatings), develop deployable hardware to test devices/assemblies, and conduct flight tests The research will be used to understand the reliability of newer materials in circuits and the associated safety risks and to update standards, guidance, policy and training applicable to aircraft certification applicants, engineers, and designees. The outputs for this task include design of deployable circuits with the newer material, design of experiments, performance data analysis from flight tests, and a report on the reliability performance of the circuits. Descript

The DSS Use of Model Checking and Formal Methods Property Abstraction research will investigate model checking through formal methods and prove that more properties hold based on a given model design and research how the properties flow down as the models are expanded. The certification issue is to obtain confidence that the properties are complete and that the model checker output can be trusted to demonstrate that the properties do hold in the model. This task will research model checking and formal methods property abstraction as a certification streamlining technique to potentially reduce the certification burden on industry while at the same time improve the level of safety. This research will explore approaches for the certification issues as input to future guidance.

The DSS Commercial off-the-shelf (COTS) Assurance Methods research will focus on safety and certification issues due to technology innovations and the industries request to reduce system

element development cost and time to market. The use of COTS components, may not be suitable for safe use in embedded aircraft equipment or may only be suitable only with new, revised or additional assurance activities. The FAA, AVSI and industry identified research tasks of immediate importance to the participating aircraft manufacturers, OEMs, and other organizations regarding the assurance of safely using embedded COTS components. This research task is to develop guidance supporting material on Single Event Effects (SEE) assurance and mitigation. The outcome of this effort will be report with guidance supporting material on SEE for ARP-4754 standards committee consideration.

Aircraft Cyber

The ASISP FY 2020 requirements include continuation of program phase 3. Phase 3 builds upon the earlier phases by enhancing the risk assessment process, conducting safety risk assessments (SRAs) of additional aircraft systems, broadening collaboration with industry and other Government agencies and identifying appropriate tools to increase efficiency in execution of the SRA process.

Program Alignment with Strategic Goals:

DOT Strategic Goal	DOT RD&T Critical Transportation Topic
Safety	**Promoting safety**

Aircraft Icing

- By 2019, complete study on the use of computational fluid dynamics analysis and of test methods and scaling for iced swept wings. Federal Aviation Administration FY 2019 President's Budget Submission Research, Engineering and Development 25

- By 2019, complete modeling study of compressor icing in high ice water content conditions using rotating rig.

- By 2020, develop engineering tools and icing test facilities for freezing drizzle and potentially freezing rain icing conditions.

- By 2021, develop data package of experimental, test, and analytical results that can be used for the development of guidance materials for means of compliance for certification in SLD conditions.

- In 2022, provide data package supporting annual guidance to airline industry for update of the ground deicing programs.

- In 2023, provide data package supporting annual guidance to airline industry for update of the ground deicing programs.

Digital System Safety

This program supports the DOT's Strategic Goal of safety by providing systematic research and development within the FAA that will lead to the identification, assessment and mitigation of safety risks. By providing the research necessary to generate data, this data is then used to create and develop new safety standards that will be adopted throughout the aviation community.

This research aligns with the DOT's strategic guidance to improve the safety and reduce fatalities and serious injuries and foster the development and deployment of innovative practices that improve the safety and performance of Nation's Transportation System. This research is paramount to understanding the risks associated with the implementation of new technologies and allowing aircraft certification to develop policy and guidance for their safe usage. If this research is not pursued, aircraft airworthiness is impacted and stifles the innovation of newer airborne systems. Wherever possible, the FAA collaborate with other agencies and academia to avoid duplication and seek industry input in developing recommendations to improve guidance and standards. In the past, the results of the research had been used for the revisions to the industry documents or advisory circulars that reference them. e.g., ARP-4754A, AC 20-174, DO-178C, DO-254, AC 20-115D, AC 20-152, DO-297, or into other standards, guidance, and training. Usually, it takes two to five years to develop the guidance after the research is completed.

- By 2022, identify and analyze software digital system issues that could affect aircraft airworthiness.

- By 2022, publish a report that identifies the streamlining approaches that can be used to assure airborne systems through the generic framework and can be applied to systems, software, and hardware.

- By 2022, determine an acceptable means to analyze, integrate, validate, and verify complex airborne digital systems and improve safety.

Aircraft Cyber

This program supports the DOT's Strategic Goal of safety by providing research within the FAA that will lead to the identification and assessment of aviation safety risks potentially jeopardizing aviation safety. Evaluation of the risks also includes assessment of potential mitigation alternatives. The aggregation of this information permits AVS to be informed independently, allowing them to better promote aviation safety based on objective data. Promotion may take the form of collaboration, support for development of new standards, or establishment of new policy, guidance or regulation (if required). By FY 2020, evaluation of risks for initial SRA subjects will be completed, with associated recommendations provided to AVS. By FY21, the full process will be scaled for conduct of multiple SRAs on additional SRA subjects of highest concern to AVS. Through FY21, the FAA will continue strengthening its collaboration with other agencies such as DoD, DHS, NASA and DNI, as well as industry.

NextGen - Information Security

Program Description/Activities:

The NextGen Information Security research will continue to support the FAA's overall cyber security posture through development of advanced tools, techniques and processes that can be adapted for use in the NAS." In addition, this requirement falls under the research area: Data Analytics and Informatics.

Develop analytical capabilities for aggregating and correlating current data with the intent of understanding, predicting, and responding to cyber-attacks for system-wide safety assurance

Program Alignment with Strategic Goals:

DOT Strategic Goal	DOT RD&T Critical Transportation Topic
Innovation	**Improving Mobility**

This program supports the DOT's Strategic Goal of innovation by providing targeted research and development within the FAA that will lead to new technology development and deployment in the National Airspace System (NAS). By providing the necessary research to gather information, this will allow the assessment of regulatory approaches, it will foster information sharing and facilitate coordination, collaboration with industry and other stakeholders, and the ability to test and adopt new technologies throughout the NAS.

The FAA operates the National Airspace System (NAS), one of the most complex aviation systems in the world. The NAS services air travel in the United States as well as over large portions of oceans. The NAS has become increasingly complex, managing more than 5,000 active flights at a time (on average), utilizing more than 65,000 pieces of equipment over 19,600 airports. In addition to increases in traditional air traffic, the NAS will undergo significant changes to mission requirements over time (e.g. Drones) as well changes to technology. Furthermore, there are other kinds of change that may happen at run time, including potential increases in communications traffic due to malicious activity, and changes in network and resource availability. As the NAS grows in mission and complexity the cost of making changes, requiring human interaction becomes prohibitively expensive. In addition, in the case of run-time changing conditions, humans cannot keep up with the pace of system operational changes. Big data collection, storage and processing are critical as they enable the process to keep up with traffic rates. Machine learning and artificial intelligence (AI) technologies can assist the human analyst in automating processing in intelligent ways, automatically building the baseline, detecting anomalies, and taking action to mitigate risk.

FAA must defend its NAS and mission support networks against cyber-attacks that are increasing in both frequency and sophistication. Current defensive security practices will be outpaced by these evolving threats unless more advanced technologies are adopted that enable rapid detection, analysis, response, and prediction of cyber events. Often, the defender does not really know what normal network flows look like, and therefore cannot adequately detect anomalous events. In addition, without sufficiently sophisticated automation and displays, the defenders cannot keep pace with the volume of data.

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DHS, AFRL, DoD are others who are performing similar research.

The FAA has not invested in the use of Data Science Methodologies in Big Data Analytics Methodologies focusing on Cyber security.

The projected time for a tangible outcome will be in FY 202021 and this first useful package will require follow up work in subsequent years.

NextGen - Flightdeck Data Exchange

Program Description/Activities:

The NextGen FD-DER Program will continue to examine requirements for enhancing the secure exchange of data between onboard avionics systems and ground systems. Supplementing the Data Communications initiatives, alternative means of obtaining and exchanging information between aircraft and ground systems will be explored. Enhanced data exchange to support applications such as complex and efficient trajectory negotiations is a critical part of achieving trajectory-based operations. Enabling alternative means of digital data exchange will expand the benefits of transitioning from traditional voice communications to digital information exchanges by allowing significantly more aircraft to participate in digital data exchange in the near-term.

Program Alignment with Strategic Goals:

DOT Strategic Goal	DOT RD&T Critical Transportation Topic
Innovation	**Improving Mobility**

This program supports the DOT's Strategic Goal of innovation by providing targeted research and development within the FAA that will lead to new technology development and deployment in the National Airspace System (NAS). By providing the necessary research to gather information, this will allow the assessment of regulatory approaches, it will foster information sharing and facilitate coordination, collaboration with industry and other stakeholders, and the ability to test and adopt new technologies throughout the NAS. Through a detailed data driven research of the data exchange performance and security requirements to meet operational needs, this research will expand the ability of flight operators to exchange information between their aircraft and FAA automation systems. The ability to utilize emerging technologies such as electronic flight bags (EFBs) and aircraft interface devices (AIDs) will enable aircraft not equipped with expensive DataComm capabilities to exchange information through alternative means, which supports increased participation without additional equipage while providing redundant data exchange mechanism to those equipped with DataComm. The research will improve the FAA's understanding of safety and performance implications on the use of new technologies and inform the development of a regulatory framework on the utilization of emerging and readily available technologies to support flight operations.

External to the FAA, aviation industry including aircraft OEMs, avionics manufacturers, datalink connectivity and data management service providers are creating innovative EFBs, AIDs and datalink technologies that FAA can leverage to make significant progress in the FD-DER research project. Additionally, International Civil Aviation Organization (ICAO) and Air Navigation Service Providers (ANSPs) in Europe and Asia are also promoting and researching related concepts that would make flight-deck a fully connected node for seamless data exchange between relevant stakeholders.

It is expected that feasibility demonstrations will be conducted in FY 202021. The lessons learned and recommendations will inform standards and regulations development process. The demonstration results will also inform the aviation industry on the near-term and long-term feasibility of emerging flight deck technologies.

Environment and Weather Impact Mitigation

Weather Program

Program Description/Activities:

In FY 2020, the Weather Program will continue to develop and enhance diagnosis and forecast capabilities that will benefit the American public. The program will continue to include applied research on naturally occurring atmospheric aviation hazards including turbulence, convective activity, and restricted ceiling and visibility. The FAA will leverage partnerships with several NOAA research laboratories to conduct research to minimize the impacts of these aviation hazards on the NAS. The FAA will either deploy these capabilities on new or existing platforms and systems or transition them to NWS platforms or procedures through FAA regulations. Benefits of Weather Program research in FY 2020 include:

- Increased GA safety in Alaska, as focused efforts target enhancements to turbulence, and restricted ceilings and visibility analyses and forecasts.

- Enhancements to convective weather forecasts that minimize gate-to-gate delays and improve efficiency of flights.

- Enhancements to turbulence analyses and forecasts to increase passenger comfort, safety of passengers and crew, safety of GA operations, and increased capacity in the NAS.

Program Alignment with Strategic Goals:

DOT Strategic Goal	DOT RD&T Critical Transportation Topic
Safety	**Promoting safety**

This program supports the DOT's Strategic Goal of safety by providing systematic research and development within the FAA that will lead to the identification, assessment and mitigation of safety risks. By providing the research necessary to generate data, this data is then used to create and develop new safety standards that will be adopted throughout the aviation community.

Research in the following areas will continue in FY 2020:

- *Terminal Area Icing Weather Information for NextGen* research:
  - Conduct analysis of initial flight test results to quantify the ability to diagnose and forecast the detection/ discrimination of freezing drizzle from freezing rain aloft.
  - Use available results from analysis of flight campaign data collected in FY 2019 to begin improving model microphysics and icing weather tools with emphasis on super cooled large drops.
  - Demonstrate a TAIWIN capability that identifies and distinguishes sizes of Super Cooled Large Drop for icing conditions in the terminal area.

- *Mitigating the Ice Crystal Weather Threat to Aircraft Turbine Engines* research:
  - Plan for additional flight research focusing on continental engine ice crystal icing (ICI) per data requested by the Ice Crystal Icing Working Group (ICIWG).

- *Turbulence* research:
  - High Resolution Rapid Refresh (HRRR) – based Graphical Turbulence Guidance (GTG) forecast product, with Convectively-Induced Turbulence capability: Complete quality assurance evaluation and ready for Safety Risk Management Panel.
  - Ready the Graphical Turbulence Nowcast product for transition to operations.

- *Convective Weather* research:
  - Expand Offshore Precipitation Capability domain to the Pacific; integrate new data sets such as polar satellite imagery into the algorithm
  - Test and integrate new Convective Weather Avoidance Model redesign that incorporates new machine learning techniques, computational capability, and larger volumes of archived weather and traffic data
  - Complete transition of the Ensemble Prediction of Oceanic Convective Hazards algorithm to operations at the NWS for use by the Washington World Area Forecast Center

- *Ceiling and Visibility* research:
  - Evaluation of short-term C&V forecasts in the Helicopter Emergency Medical Services tool
  - Development of advanced techniques to blend multiple models while still maintaining the structure of the clouds.
  - Development and testing of software to blend web cam fields with the CVA-Alaska prototype

- *Quality Assessment research*:
  - Conduct quality assessments of weather research products to address uncertainty information in forecasts of cloud ceiling and visibility, convective weather, and turbulence, along with investigation of new techniques and data sources

- *Aviation Weather Demonstration and Evaluation (AWDE) Services* research:
  - Conduct assessments of diagnosis and forecasting products. Including:
    - Turbulence Forecast and Graphical Guidance
    - Ceiling and Visibility Analysis and Graphical Guidance
    - Convective Weather Forecast Statements & Graphical Guidance
  - Advance the AWDE Concept and Product Capability for the integration, evaluation and demonstration of future NextGen weather concepts and technologies.

- *Safety Driven Weather Requirements for Wake Mitigation*:
  - Develop preliminary procedures and assess the benefits for/of an airport wind-based wake vortex separation advisory system – these requirements will be used by the FAA and industry to develop a Wake Prediction System to safely reduce aircraft separations for arrivals and departures on single and multiple parallel runways.
    - Complete draft procedures based on acquired data
    - Complete a high-level description of the wake vortex prediction/advisory system for departures and/or arrivals
    - Complete a benefits-case study for proposed wake vortex prediction/advisory system

NextGen - Weather Technology in the Cockpit

Program Description/Activities:

In FY 2020, the WTIC Program will continue to develop Part 121/135 MinWxSvc recommendations, Part 91/135 MinWxSvc recommendations, and enhanced training materials to resolve or reduce the impacts of previously or newly identified gaps that are linked to operational shortfalls related to safety issues or operational inefficiencies. Benefits and targeted areas will be comparable to FY 2019 with most efforts being follow-on phases in the areas of research described for FY 2019.

Program Alignment with Strategic Goals:

DOT Strategic Goal	DOT RD&T Critical Transportation Topic
Innovation	**Improving Mobility**

This program supports the DOT's Strategic Goal of innovation by providing targeted research and development within the FAA that will lead to new technology development and deployment in the National Airspace System (NAS). By providing the necessary research to gather information, this will allow the assessment of regulatory approaches, it will foster information sharing and facilitate coordination, collaboration with industry and other stakeholders, and the ability to test and adopt new technologies throughout the NAS.

The program further supports innovation by performing applied research to resolve identified safety hazards and risks (risks are identified by the WTIC program or stakeholders including NTSB, AOPA, and the Alaska Air Carriers Association), and performance gaps linked to safety hazards and risks, to enhance aviation safety for commercial, business, and general aviation. Efforts include developing enhanced training for pilots, updated weather questions for the pilot written exam, producing ceiling and visibility information in remote areas that lack this information, and crowd sourcing aircraft weather-related information (winds, weather radar, etc.) for remote/rural areas that lack weather radar coverage and other weather infrastructure. As noted in a December 16, 2016 letter from the AOPA Director of Airspace and Air Traffic, the "WTIC should make it a priority to evaluate VNR given the research could influence FAA policy, decision, weather delivery applications and pilot education." Consistent with this stakeholder input, the WTIC program is performing research to enhance the utility and objectivity of the VNR statement to enhance safety for pilots flying under Visual Flight Rules (VFR).

The WTIC program directly supports rural and remote areas by performing applied research to produce weather information using innovative techniques for areas that lack the infrastructure and economy to use traditional weather systems. As an example, the WTIC program is researching using Alaska weather cameras to produce ceiling and visibility information in areas that lack weather technology, such as ceilometers, to produce this information. As documented in a February 26, 2018 letter from the President and the Director of the Alaska Air Carriers Association, "Alaska is deficient in infrastructure yet over 82% of communities relay entirely on aviation for transportation." The letter also states that they are "thrilled" at the prospect of the weather information that may be able to be produced from the WTIC crowd sourcing research without the need for any new infrastructure. The US Helicopter Safety Team has also identified this research as applicable in the Gulf of Mexico

due to the lack of weather radar coverage and other weather information in this region needed to enhance the safety of helicopter flights to oilrigs.

Research to develop MinWxSvc recommendations for Part 121/135 aircraft and for Part 91/135 aircraft will continue. Research to develop associated enhanced training will also continue. Specific research projects and the selection of gaps for resolution will are dependent on the results of FY 2019 research efforts. The primary focus in FY 2020 will be to complete MinWxSvc recommendations for gaps selected in FY 2019 where resolutions and MinWxSvc recommendations were not completed. If sufficient funding is available, research to resolve additional gaps in related areas will be accomplished in an effort to fully resolve the associated operational shortfalls. These areas include research to fill gaps in cockpit MET information (typically in rural and remote/oceanic areas), address human factors gaps in current cockpit MET technology, applications, and renderings, and identify additional capability enhancements to resolve gaps that have been identified as causal factors in wind and visibility related GA accidents.

Environment and Energy

Program Description/Activities:

In FY 202020, the program will continue to scientific data and analysis to inform decision making. This includes the development of data and analyses that are used to inform the development of new noise and emissions standards in ICAO CAEP. It will also examine advanced operational procedural concepts that could reduce community noise exposure while maintaining safe flight operations. It will also provide guidance for air space planners on how these concepts could be incorporated. The program will also conduct quantitative analyses through modeling of the change in fuel use and emissions that could result from changes in aircraft technology, operational procedures and alternative fuel use.

The program will continue to examine new entrants with a focus on supersonic aircraft. With FY 202020 funds, the program will examine technologies that could reduce supersonic aircraft noise as well as the public reaction to advanced supersonic aircraft noise. The program will also evaluate procedures needed to certify aircraft noise to create the body of knowledge to support the development of en-route noise standards for airplanes that exceed Mach 1 both domestically and within ICAO CAEP.

With FY 202020 funds, the program will continue to advance our understanding of how aviation noise affects the health and welfare of those living in airport communities. The result will be a reassessment of current metrics relative to community exposure to aircraft noise using the most recent information collected at U.S. airports.

With FY 202020 funds, the program will continue to improve the noise and emissions modeling capabilities of AEDT to have an explicit incorporation of airframe noise and to develop methods to streamline the use of the tool. In older aircraft, the jet exhaust was the dominant noise source; however, in modern aircraft, airframe noise has become a dominant noise source on approach and one that is distinctly heard by some members of the community. AEDT Version 4 will also incorporate both an improved local-scale airport air quality model and capabilities to model civil supersonic aircraft. The capabilities provided by AEDT Versions 4 will improve our ability to evaluate the changes in noise, fuel burn and emissions, including fine particulate matter, that result from the introduction of NextGen as well as greatly improve our ability to design effective options to mitigate noise, fuel burn and emissions. In addition, a streamlined version of AEDT will be developed to support the environmental compliance process. The end result will be tools that aid in the development of an aviation system with increased capacity that also has reduced environmental impacts.

Program Alignment with Strategic Goals:

DOT Strategic Goal	DOT RD&T Critical Transportation Topic
Infrastructure	**Preserving the environment**

The program's goals are in line with the DOT strategic goals in Infrastructure. Achieving our environmental and energy goals will allow the nation's air transportation system to grow thereby

ensuring continued mobility and economic growth that accompanies the air transport sector. Innovation is required in developing the technological and operational measures to reduce aviation's impacts on the environment, which will also improve the efficiency of the airspace system and promote growth of the sector to new entrants such as unmanned vehicles and commercial space. Updated policies and regulatory framework that better reflects our improved understanding of environmental and energy impacts, and the innovations in aircraft and engine technologies are necessary to improve the efficiency, effectiveness and accountability of the airspace system to our aviation users and stakeholders.

This program is providing scientific data, analytical tools, and analyses to inform decision making regarding aviation environmental and energy matters such as noise, emissions, and fuel burn. This work needs to be done by the FAA to ensure that the U.S. maintains its global leadership position in the development of international standards and policies relating to aviation. Aviation is the number one export industry for the U.S. and products made in the U.S. are bought and used by countless countries around the world. As such, harmonized standards are critical for the continued success of the aviation industry.

As outlined above, many entities around the globe are working on matters involving aviation and the environment. This program is leveraging those efforts to reduce the costs of this program to U.S. taxpayers.

The U.S. Federal government has been investing in research on aviation noise since the beginning of the jet age (if not longer). Since that time, aviation noise has changed substantially. Despite the technological advancements achieved during the last 40 years, and the resultant 95% reduction in the population exposure to significant noise, the impact of aircraft noise demands considerable Federal resources and is a constraint on aviation growth. Since 1982 the FAA has provided over $10.5 billion for sound insulation of houses and schools around U.S. airports. Environmental impacts, especially aircraft noise, are often the number one cause of opposition to airport capacity expansion and airspace redesign. A Government Accountability Office (GAO) 2000 survey of the 50 busiest commercial airports in the U.S. found that 72% of delayed work and 25% of project cancellations of airport capacity expansion projects was due to environmental issues (http://www.gao.gov/archive/2000/rc00153.pdf). Further, a 2010 GAO Report found that new runway construction from initial planning to completion takes a median of 10 years, but delays from lawsuits or addressing environmental issues can add an additional 4 years to the median time (http://www.gao.gov/assets/310/309622.pdf). These GAO studies were conducted prior to the implementation of precision navigation, which has been accompanied by increased airport community concerns regarding noise.

Research is also needed to ensure the U.S. response to aviation noise keeps pace with new entrants to the National Air Space such as unmanned aerial systems, civil supersonic aircraft, and commercial space vehicles. The E&E Program is providing the technical basis for a review and possible elimination or modification of existing regulations to enable the development and growth of supersonic air transport. The effort to evaluate supersonic air transport is being done in close collaboration with industry and NASA as well as international partners through the International Civil Aviation Organization (ICAO) Committee on Aviation Environmental Protection (CAEP).

While energy efficiency and local environmental issues have traditionally been primary drivers of aeronautics innovation, the current and projected effects of aviation emissions on our global climate

are a serious long-term environmental issue of concern to the aviation industry. Aside from their associated health and welfare impacts, noise and emissions are a considerable challenge in terms of community acceptance of aviation activities and this challenge is anticipated to grow with new entrants such as unmanned aircraft systems and supersonic aircraft.

NextGen - Environmental Research - Aircraft Technologies, Fuels, and Metrics

Program Description/Activities:

FY 202020 funds will be used to initiate the third phase of the CLEEN Program to demonstrate technologies that can reduce noise, emissions, and fuel use. Like the first two phases of CLEEN, this new phase of the CLEEN Program will have a 100% cost share requirement with industry and will have goals for noise, fuel burn, and emissions. Given the concerns of communities regarding increased aircraft noise due to the concentration of flight paths that accompanies precision navigation, there will be a greater emphasis on reducing community noise within the third phase of CLEEN.

Program Alignment with Strategic Goals:

DOT Strategic Goal	DOT RD&T Critical Transportation Topic
Infrastructure	**Preserving the environment**

The program's goals are in line with the DOT strategic goals of Innovation and Infrastructure. Achieving the NextGen environmental goal will allow the nation's air transportation system to grow thereby ensuring continued mobility and economic growth that accompanies the air transport sector. This program provides the innovation in terms of technological and operational measures to reduce aviation's impacts on the environment, which will also improve the efficiency of the airspace system and promote growth of the sector. The result is an improved national aerospace system that is able to provide the mobility that society demands with sufficient environmental protection to ensure continued growth in the future.

The project will continue to develop solutions to reduce the environmental impacts of aviation by accelerating the maturation of engine and airframe technologies to reduce aircraft noise, emissions, and fuel use. The work of the program results in technologies that have been matured to the point wherein they are ready for consideration by industry for use in new aircraft and engines. Some of the technologies could also be retrofitted onto existing aircraft and engines. By reducing the environmental impact of aviation through new technologies this program helps to ensure the continued growth of aviation while also reducing the impacts of aviation noise and emissions on airport communities as well as on the public at large.

Through 2017, the FAA has invested over $140 million into the first two five year phases of the CLEEN Program. In partnership with industry, these two five year stages of CLEEN will mature over 23 technologies that reduce noise, emissions and fuel use. No other government agency is researching this issue in this manner.

The third five-year phase of CLEEN would utilize funding from 2020 through 2025 with the matured technologies being ready to enter service in roughly 2030.

Human Performance and Aeromedical Factors

Flightdeck/Maintenance/System Integration Human Factors

Program Description/Activities:

The *Advanced Vision Systems – Enhanced Flight Vision System, Enhanced Vision Systems, Synthetic Vision Systems, and Combined Vision System, Heads Up Displays, Helmet Mounted Displays – Certification and Ops Approval Criteria* research requirement will continue to evaluate systems for use during approach procedures.

As FY 2019 activities relevant to low visibility operations develop, efforts in FY 202020 will further investigate advanced vision systems relevant to approach lighting systems. New projects will begin that will focus on the evaluation of Synthetic Vision Guidance Systems (SVGS) operations on less than a MALSR (Medium Intensity Approach Lighting System with Runway Alignment Indicator Lights) Approach Lighting System (ALS). This particular research will be utilized to inform operational standards and approval criteria for specific SVGS operations.

Program Alignment with Strategic Goals:

DOT Strategic Goal	DOT RD&T Critical Transportation Topic
Safety	**Promoting safety**

This program supports the DOT's Strategic Goal of safety by providing systematic research and development within the FAA that will lead to the identification, assessment and mitigation of safety risks. By providing the research necessary to generate data, this data is then used to create and develop new safety standards that will be adopted throughout the aviation community.

There are over 900 Medium-intensity Approach Lighting Systems with Runway Alignment Indicator Lights (MALSR) in the NAS. Facility and equipment (F&E) costs for a single MALSR installation utilized during these operations represent a significant percentage of total F&E costs for category I capabilities. Airports with reduced and/or degraded NAS approach infrastructure, like MALSR, complicate or reduce approaches. As technology evolves, the integration of emergent technologies in flight operations is an often-proposed solution to such issues. However, the introduction of new technologies and operational concepts is not possible without research to understand how they affect pilot performance and operational safety.

The FAA is the first civil aviation authority to authorize synthetic visions systems for specific flight operations and this research could enable the use of synthetic vision guidance systems across a significant number of approach procedures. This research is critical for data-driven and performance based approaches to developing policy as well as operational criteria for the safe introduction of specific synthetic vision guidance system (SVGS) capabilities. By evaluating the quantified performance of pilot's during SVGS operations on less than a MALSR approach lighting system, we can safely integrate technologies that will enable more landings, decrease delays, and reduce our dependence on expensive infrastructure.

Research was recently conducted to evaluate general aviation pilot performance and preferences using head-up and head-mounted synthetic vision displays for category I approaches in flat terrain.

The data has suggested that the presence of synthetic vision can increase the confidence that pilots have and influence the altitude above ground level to which they believe they can descend as additional features are added to the system. As we look to investigate SVGS operations pertaining to approach procedures, we expect the length of time to complete an evaluation of SVGS operations on less than a MALSR approach lighting system to be less than four years.

The *Advanced Vision Systems – Enhanced Flight Vision System, Enhanced Vision Systems, Synthetic Vision Systems, and Combined Vision System, Heads Up Displays, Helmet Mounted Displays – Certification and Ops Approval Criteria* research requirement evaluates these systems for use during low visibility conditions. Research of these systems will be used to develop and update:

- Operating rules, conditions, limitations, and mitigations;
- Flight Standards policy; Operational approval processes and job aids for Principal Inspectors;
- Training, recent flight experience, and proficiency requirements for pilots, dispatchers;
- FAA orders and ACs; Operations Specifications (OpSpecs), Management Specifications (MSpecs), and Letters of Authorization (LOAs);
- Charting standards;
- Airmen information publications;
- Safety Alert for Operators (SAFOs) and Information for Operators (InFOs); and
- Pilot performance considerations, conditions, and limitations associated with applications for waiver and petitions for exemption from operating rules.

The *Fatigue Mitigation in Flight Operations* research requirement will address the ability to measure and monitor the effectiveness of fatigue risk management approaches utilized by certificate holder's operating under 14 CFR parts 121 and 117 to mitigate fatigue and improve flightcrew member alertness.

Air Traffic Control/Technical Operations Human Factors

Program Description/Activities:

The Human Factors and Engineering Group (ANG-C)

In FY 202020 we plan to continue research on the human factors topics that are priorities for our ATO technical sponsors. The planned research will support the ATO, Human Resources, the Office of Civil Rights, and the Office of the General Counsel by providing scientific and technical information to improve controller and technical operations personnel selection, placement, and training performance evaluation, and efforts to improve air traffic controller performance to enhance aviation safety.

Specific ATO requests include:

- Conduct research to identify and mitigate maintainer performance risk posed by ATC automation and provide recommendations to AJM and AJW.

- Provide recommendations to AJI and ATO facility managers to address training environment challenges that adversely affect performance of developmental and CPC-IT controllers during field training.

- Evaluate factors that improve the learning and transfer of training of ATC training games and applications (Apps) to controller knowledge and skills, and recommend to AJI the criteria for selecting and developing future Apps.

- Recommend improvements to controller visual scanning techniques to reduce runway incursions and loss of standard separation at tower-controlled airports.

- Conduct simulation research to identify and recommend mitigations to AJM for operator and maintainer performance risk posed by ATC automation.

CAMI

In FY 2020, the research program "Projecting the Jobs of Future Technical Operations Specialists" will be reactivated. This program will include the individual research projects "Capitalize on ATSS 2101 Job Task Analysis Findings," and "Strategic Job Analysis for Engineering Services" in FY21.

The two FY 2019 research programs, "Evaluation of ATC Hiring and Training Processes" and "Safety Aspects of Air Traffic Controller Performance," (described above) will continue in FY 2020, although changes will be made to some of the individual research tasks.

In FY 2020, the "Evaluation of ATC Hiring and Training Processes" research program will include the following research tasks: "Investigation of Attributes that Predict ATCS Training Success Using a Longitudinal Database," "ATC Field Training Effectiveness," and "Evaluation of ATCS Selection Process in relation to Predictors of FAA Academy and Field Training Success." The research task "Data-Driven Decision Support for AJI and the FAA Academy Air Traffic Division" will end in FY 2019.

In FY 2020, additional criterion performance data will be incorporated into the longitudinal database so that expanded statistical analyses can be performed. Interviews and surveys will be conducted for all employees involved in the field training process (i.e., developmentals, contract instructors, On-the-Job Training (OJTI) instructors, and FAA training managers and staff) about factors related to failure to complete field training. The version of the ATC selection process introduced in FY16 will be evaluated against performance in Academy and field training, taking into account other predictors of ATCS training performance.

In FY 2020, the "Safety Aspects of Air Traffic Controller Performance" research program will include only the "Remote Tower Services (RTS) Human Factors Support" research task. The research task "Visual Scanning Techniques Research Study" will end in FY 2019.

The "Remote Tower Services (RTS) Human Factors Support" research task will expand in FY 2020 to address identification of human factors issues that may occur while planning to integrate Remote Towers into ATC operations.

Program Alignment with Strategic Goals:

DOT Strategic Goal	DOT RD&T Critical Transportation Topic
Safety	**Promoting safety**

This program supports the DOT's Strategic Goal of safety by providing systematic research and development within the FAA that will lead to the identification, assessment and mitigation of safety risks. By providing the research necessary to generate data, this data is then used to create and develop new safety standards that will be adopted throughout the aviation community.

<u>The Human Factors and Engineering Group (ANG-C)</u>
The research addresses problems of human performance within the context of complex ATC automation systems and technologies. We undertake efforts that the ATO technical sponsors identify as the highest priorities, based on their knowledge of current and anticipated operational challenges in the air traffic control system.

We should pursue (invest in) this research because the ATO puts to use our scientific and technical information, and our actionable recommendations that inform policies, procedures, training, and support the workforce. No one else (outside of FAA) researches these topics, unless FAA funds them to do so through grants or contracts.

We routinely apply the full funding for this budget line and the full-time equivalent employees who are engaged in the research at the CAMI and Technical Center laboratories on a yearly basis. We continue to progress in supporting the technical sponsors' needs for the human factors science that informs their policies and provides human factors guidance across system acquisition programs. We have tangible products every fiscal year, and the work is briefed to sponsors, stakeholders, the REDAC oversight committees, and also is presented at technical conferences and symposia. Each year, there are a number of technical reports, scientific articles in peer-reviewed publications, and conference

proceedings papers that are shared with the larger aviation research and human factors research communities.

CAMI

Both Air Traffic/Tech Ops HF BLI FY 2019 research programs that remain in FY 2020 will continue to support the DOT's Safety Strategic Goal. The "Evaluation of ATC Hiring and Training Processes" research program, in particular, is consistent with Strategic Objective 1: Systemic Safety Approach, because the research uses a data-driven systemic safety approach to enhance standards and programs, and evaluate program effectiveness, in spite of the termination of one research task.

In FY 2020, the "Evaluation of ATC Hiring and Training Processes" research program will increase the information available for analysis to be better able to answer questions for sponsors, Congress, and research. Some of those questions concern about how effective the most recent ATCS selection process has been in identifying trainees who can pass Academy and field training. Other research projects will identify reasons other than aptitude why trainees fail field training and will indicate the degree of agreement in responses between those with different roles in the field training process.

This research should be pursued because using the information resulting from the research studies can result in cost savings to the FAA, and therefore to the public. Some of the information produced by the Evaluation of ATC Hiring and Training Processes research program can be used to improve policies concerning the conduct and oversight of ATC selection, Academy training, and field training programs. Other information may improve the quality of personnel selected for the job, resulting in reduced training times and improved job performance.

FAA Human Factors' expertise is essential to the continued technical and scientific discovery that would assure the future of the FAA Air Traffic controller selection and training processes. It is critical to the regulatory mission of the FAA to maintain and enhance its in-house Human Factors research program.

The "Safety Aspects of Air Traffic Controller Performance" research program is also consistent with Strategic Objective 1: Systemic Safety Approach, but the remaining FY 2020 research task in that program, "Remote Tower Services (RTS) Human Factors Support," will focus on identifying risks.

In FY 2020, the "Remote Tower Services (RTS) Human Factors Support" research project will use simulations to test certain human factors issues that might negatively affect the performance of controllers while operating in Remote Towers. This research should be pursued because the information from this study can directly increase safety associated with the use of this new technology.

"Projecting the Jobs of Future Technical Operations Specialists," is consistent with DOT's Safety strategic goal. It is also consistent with Strategic Objective 1: Systemic Safety Approach, because the research uses a data-driven systemic safety approach to enhance standards, identify risks and enhance training programs,

In FY 2020, the "Projecting the Jobs of Future Technical Operations Specialists" research program will close the knowledge gap about the current and future work and requirements for Knowledge/ Skill/Ability/and Other Characteristics in future Tech Ops jobs. The benefit in closing the knowledge

gap is that it provides for an empirical basis for future workforce recruitment, selection, classification, and training. This will ensure that the Tech Ops workforce is able to meet job demands as additional NextGen technologies are integrated into the NAS.

Other organizations, Federal/state/private/academic, conduct research to analyze jobs, improve selection procedures, and make training more effective. Most organizations do this kind of research for particular occupations. Some research findings may generalize across occupations. For that reason, we interact with representatives of other organizations who do that kind of research during scientific and organizational meetings, where we learn about others' research results and establish relationships that may lead to collaborative research activities. But even if the occupations investigated by different organizations are the same, not all research done by other organizations will necessarily generalize to FAA air traffic control and technical operations workforces. Differences in organizational structure, safety culture, and union influence may make it difficult to use findings from other organizations' research at FAA ATC facilities. To the extent that we have sufficient data to be able to provide interim products to sponsors, the time to attain a tangible outcome can be very short.

NextGen - Air Ground Integration Human Factors

Program Description/Activities:

In FY 202020 we plan to continue research on the human factors topics that are the priorities for the AVS and NextGen sponsors This research program produces human factors scientific and technical research products that will benefit multiple pre-implementation programs. FAA sponsors apply these products to develop FAA guidelines, Orders, Advisory Circulars, Technical Standard Orders (TSOs), and Federal Aviation Regulations (FAR). Operationally, research products support Aircraft Certification and Flight Standards personnel who evaluate and approve emerging flight deck displays, devices, and procedures that leverage FAA investments in NextGen capabilities and enhancements. Focus areas for this research program include: NextGen Aircraft Systems & Controls Research; NextGen Human Error Mitigation Research; NextGen Flightcrew Readiness Research; and NextGen NAS & Flightcrew Procedures Research.

Example of a program that will build upon previous FY activities:

Highly automated aircraft systems and complex NAS procedures have resulted in flightcrews inadequately monitoring and maintaining proper Aircraft Energy State Awareness. This lack of awareness has caused flightcrews to initiate delayed or inappropriate responses to low energy events, resulting in fatal accidents. These human factors issues may increase as NextGen improvements with speed guidance dependencies are introduced to the flight deck. Research is needed to identify potential system-based solutions that may help mitigate these risks and support the FAA's response to Commercial Aviation Safety Team (CAST) recommendations SE207 and SE208.

Before the FAA became involved, NASA had begun to address the safety concerns that were identified within the CAST's recommendations. They worked together with industry in the development of prototype technologies, which would greatly reduce the risk from loss of Aircraft Energy State Awareness and provide enhanced Aircraft System State Awareness to the flight crew. The FAA joined this research venture, so that they would be able to certify that the technologies under development meet the safety criteria and were applicable across all aircraft manufacturers.

In FY 2019, after the HITL simulations on both Airbus and Boeing will be completed, an analysis of the technologies and their respective performance will be examined. The most promising prototypes will be identified for the next research phase (AIME 3) of analysis. In FY 2020, after the completion of Phase 3 research (AIME3) a final technical report will be generated that will make recommendations on minimum human factors requirements, as well as design and evaluation criteria for novel technologies. Additionally, it will result in human factors guidance and regulatory literature.

This research is in alignment with the DOT Strategic Goal by increasing the overall safety by increasing the Aircraft System State Awareness of the flight crew. This research contributes to improving the current standard of safety by also increasing the flight crew's Low Energy State Awareness.

Program Alignment with Strategic Goals:

DOT Strategic Goal	DOT RD&T Critical Transportation Topic
Innovation	**Improving Mobility**

This program supports the DOT's Strategic Goal of innovation by providing targeted research and development within the FAA that will lead to new technology development and deployment in the National Airspace System (NAS). By providing the necessary research to gather information, this will allow the assessment of regulatory approaches, it will foster information sharing and facilitate coordination, collaboration with industry and other stakeholders, and the ability to test and adopt new technologies throughout the NAS.

This program supports innovation by proactively producing scientific data, technical information, and targeted FAA human factors solution integration strategies that enable the successful deployment and operational use of NextGen capabilities. These products proactively address the flight deck human factors impacts that will be introduced by NextGen changes, with a focus on the optimization of human performance and safety in complex systems. This program supports the development of new FAA rules and guidance. It also fosters the sharing of emerging human factors information across FAA lines of business, other government Agencies, and across industry stakeholders.

This research is focused on flight deck human factors considerations for NextGen technologies and advanced procedures. The program supports the FAA Aviation Safety certification and operational approval processes by providing guidance and other information on flightcrew procedures, maintenance procedures, training development, and continuous safety monitoring. In FY 2020, this research will focus on the identification of emerging human-system integration (HSI) gaps that could impact the successful transition to full and dynamic TBO. These HSI gaps will be identified in the following areas:

- **Focus Area 1:** Identify and respond to user adaptation/evolution needs (i.e., future knowledge, skills, and abilities) to support the successful development, implementation, and operational use of NextGen technologies/procedures during the iTBO, full TBO, and dynamic TBO transition.

- **Focus Area 2:** Proactively address human factors installation & integration issues that could arise when combining NextGen aircraft changes with legacy technologies, systems, controls, & their respective mode(s) of operation. Research will focus on NextGen capabilities that cite advanced aircraft automation/enabler dependencies to achieve flight specific time-based solutions.

- **Focus Area 3:** Identify & respond to operational integration issues that could arise from the implementation of future NAS procedures & advanced flight deck separation management concepts.

- **Focus Area 4:** Proactively detect & respond to technology shortfalls/gaps that could increase the opportunity for human error in future NAS operations.

Human performance is often the largest contributor to system variability, so the implementation of advanced systems and the implementation of new procedures associated with NextGen will challenge the human components of the aviation system. Reviews of accidents and incidents have identified that human factors and human performance is a major factor in as much as 85% of all civil aviation accidents. This program will develop human factors scientific and technical information to address human performance related to error and automation; avionics, new technologies, and procedures; and air carrier training. As part of this effort, research addresses coordination among pilots and air navigation service providers (air traffic controllers), human system integration, and error management strategies to implement NextGen capabilities. Current FAA rules and guidance for pilots and dispatchers do not address the changes in roles, responsibilities, procedures, and job tasks that will be required as the core technologies of NextGen are sequentially introduced into the NAS. The FAA will need updated standards and guidance materials to oversee the safe transition, over time, of pilots and dispatchers to the NextGen end state. The FAA can leverage the work of other Federal agencies (e.g., NASA, DoD), and includes work from universities and industry partners, but at the end of the day the FAA is uniquely responsible for producing unbiased rules, standards, and guidance that integrate the research and operational results obtained from these sources. That is why the FAA-managed Human Factors program is so important to the success of NextGen.

This research supports important human factors regulatory and guidance material used by the Aircraft Certification and Flight Standards personnel who approve new flight deck displays, devices, and procedures that comprise NextGen capabilities in order to ensure that pilots can conduct operations that leverage NextGen capabilities. Research to assess human performance addressing new NextGen technologies and procedures continues to be necessary for developing updates to standards, FAA orders, RTCA guidance documents, and Federal regulations. Research on NextGen pre-implementation capabilities for the mid-term extends through 2025, and for far-term capabilities extends to 2030. This is new research; therefore, we have not invested in this topic in the past. The projected time of completion for this outcome is 2020.

Aeromedical Research

Program Description/Activities:

The FY 2020 budget allocated to the Aeromedical Research Program does not support new research projects. The FY 2020 budget will continue to support the following activities: processing of biological samples from fatal aircraft accidents for forensic toxicology analysis and preparation of forensic toxicology reports describing findings.

Program Alignment with Strategic Goals:

DOT Strategic Goal	DOT RD&T Critical Transportation Topic
Safety	**Promoting safety**

This program supports the DOT's Strategic Goal of safety by providing systematic research and development within the FAA that will lead to the identification, assessment and mitigation of safety risks. By providing the research necessary to generate data, this data is then used to create and develop new safety standards that will be adopted throughout the aviation community.

The FY 2020 Aeromedical Research Program supports the DOT's Safety goal. Activities will continue to focus on the processing of biological samples from fatal aircraft accidents for forensic toxicology analysis and preparation of forensic toxicology reports describing findings. These activities will elucidate aviation accidents' causes and contributing factors to develop methods to mitigate their occurrence. Focus is on the human component of the National Airspace System (NAS), specifically the aircrew's health and performance in civil aviation operations. No one else in the nation performs this research with respect to civil aviation operations. We have invested on this topic since 1958 (PL 85-726). This activity is intended to continue indefinitely; accident prevention and investigation are fundamental safety practices. Forensic toxicology reports form the basis of FAA and NTSB accident investigation processes that concern the most important safety aspect of the NAS, the human operator and the public s/he serves. FAA aeromedical expertise is essential to the continued technical and scientific discovery that would assure the future of the FAA as a world leader in aviation safety. As such, it is especially critical to the regulatory mission of the FAA to maintain and enhance its in-house aerospace medical research program, unique in the nation for civilian aviation operations, and a model sought by international civil aviation authorities. Indeed, we must not surrender the public's welfare (safety) to others' interests. Academic research priorities are subject to the temporary nature of their mission (graduating students, narrow in focus, limited in continuity of operations). Industry research activities are subject to corporate concerns (remaining competitive and realizing financial profits) and may not be readily inspired to share findings. On the other hand, the FAA's aeromedical research activities (a) promote transparent and collaborative scientific discovery across the world, (b) allow for continuous development and high risk/return, and most importantly, (c) ensure sharing of results and independent science and technology assessments in support of the regulatory mission of the FAA.

Next Generation Transportation System - Enterprise, Concept Development, Human Factors, & Demonstrations Portfolio

Program Description/Activities:

Enterprise Concept Development, Human Factors, and Stakeholder Demonstration program will continue to conduct enterprise level activities, including the development of concepts across the NAS, human factors analysis of a NextGen operational environment, and demonstrations of proposed NextGen system improvements ensure operational feasibility and viability within the NAS. These concept development efforts lead to improvements that will provide air traffic controllers with tools and procedures to separate aircraft with technologically advanced navigation equipment and wake performance capabilities to enhance system capacity, efficiency, and ensure safe aircraft separation while reducing workload for controllers and flight crews.

Program Alignment with Strategic Goals:

DOT Strategic Goal	DOT RD&T Critical Transportation Topic
Innovation	**Improving mobility**

This program supports the DOT's Strategic Goal of innovation by providing targeted research and development within the FAA that will lead to new technology development and deployment in the National Airspace System (NAS). By providing the necessary research to gather information, this will allow the assessment of regulatory approaches, it will foster information sharing and facilitate coordination, collaboration with industry and other stakeholders, and the ability to test and adopt new technologies throughout the NAS.

As NextGen continues to evolve, research and enterprise concept efforts are needed to deliver improved services, enable seamless integration of data, and to address new challenges such as incorporating new entrants into the NAS and cybersecurity. Validated operational concepts will identify technical and operational requirements (including airspace, procedures, and automation requirements needed to realize the capacity gains. Human factors development will identify potential human performance issues at the concept development and validation stages essential to the usability, acceptability, and safety of NextGen concepts and systems. Stakeholder r demos in collaboration with users, operators, and other partners early in the modeling process will provide practical application and analysis of proposed NextGen system improvements to validate and prove concept feasibility.

Aviation Performance and Planning

System Safety Management

Program Description/Activities:

Wet Runway Wheel Braking Testing: This research will start in FY 2019 and will continue into FY 2020 and FY21. Aircraft braking capability on a wet runway is a relatively complicated issue, being affected by many different factors in terms of the aircraft, tires, pavement surface, and the environment. Over the years, knowledge gaps with regards to the wet runway braking issue were filled through a multitude of research projects aimed at investigating these factors, resulting in the current state of knowledge and various models for the wet runway braking friction coefficient as seen in FAR 25.109. However, since most of research projects were completed in 60s and 70s, knowledge gaps still remain and friction coefficient models are laden with assumptions that may not be applicable in all circumstances and with modern aircraft. This research project aims to synthesize work in wet runway braking friction through a set of comprehensive flight tests in order to provide further insight into the factors affecting wet runway friction and recommend next steps for the government and industry such as updating aircraft landing performance standards.

In FY 2019, the plan is to complete a literature survey of safety issues surrounding wet runway braking performance and complete a set of flight test experiment designs that stakeholders, i.e., manufacturers, airlines, regulators, agree upon. In FY 2020, the plan is to conduct flight tests, collect experimental data and complete data analysis. In FY21, the plan is to gain knowledge and insight into the reasons for significant reduced wet runway wheel braking compared to models defined in FAR 25.109; and provide recommendations for updating wet runway braking performance standards to the FAA's Office of Aviation Safety (AVS).

Safety Oversight Management System (SOMS). The FAA has committed resources to this project since FY17 for a total of $716K. FAA's Air Traffic Safety Oversight Office (AOV) currently lacks a capability for organizing products of the various oversight activities for planning oversight actions to verify compliance. Thus, the AOV needs a comprehensive integrated assessment tool to indicate if the current safety oversight requirements are effectively implemented by ATO. SOMS is a comprehensive toolset, risk-based data-driven system, which outlines AOV oversight activities based on emerging safety risks and trends associated with ATC systems at the facility and NAS levels.

In FY 2020, the plan is to present case studies for SOMS use, prepare technology transfer documentation and training materials as well as complete the technology transfer to AVO.

Integrated Domain – Safety Risk Evaluation Tool (ID-SRET): The FAA has committed resources to this project since FY17 for a total of $716K. The ID-SRET, available at http://ida.tc.faa.gov, is a model-based decision making support tool to assist AOV in evaluating Safety Risk Management (SRM) documents within the context of multiple NAS changes by integrating NAS system, air traffic control (ATC) procedure, and safety data into a single platform. ID-SRET identifies the interactions and interdependencies among NAS systems, ATC procedures, and system safety hazards to allow AOV more effectively evaluate NAS change impacts, identify potential SRM document issues, and evaluate risk control effectiveness.

The ID-SRET includes 71 NAS critical systems at this time. The research will continue into FY 2019 and FY 2020 to incorporate ATC procedures into ID-SRET to make ID-SRET fully functional that covers both NAS systems and procedures.

Program Alignment with Strategic Goals:

DOT Strategic Goal	DOT RD&T Critical Transportation Topic
Safety	**Promoting safety**

This program supports the DOT's Strategic Goal of safety by providing systematic research and development within the FAA that will lead to the identification, assessment and mitigation of safety risks. By providing the research necessary to generate data, this data is then used to create and develop new safety standards that will be adopted throughout the aviation community.

Wet Runway Wheel Braking Testing: Existing safety regulations make a number of assumptions about the braking friction available in wet runway conditions that have been shown to be inadequate in certain circumstances based on accident investigation. This research project will provide the necessary knowledge, insight, and data to assist in the modification of existing performance assumptions and models leading to more realistic landing distances on poorly maintained runways and/or during heavy rain. Timely and accurate information about the runway condition on approach could prevent future runway excursions and increased safety due to either improved performance standards or improved runway capability. This research has multiple stakeholders such as airlines, pilots, airports, aircraft manufacturers, the NTSB, and the flying public, among others. The Netherlands Aerospace Centre (NLR) has been conducting research projects related to hydroplaning, flooded runways, and surface texture. The FAA has not invested in this topic. September 2021 is the projected time of completion for this research.

Safety Oversight Management System (SOMS): FAA's Air Traffic Safety Oversight Office (AOV) currently lacks a capability for organizing products of the various oversight activities for planning oversight actions to verify compliance. Thus, the AOV needs a comprehensive integrated assessment tool to indicate if the current safety oversight requirements are effectively implemented by ATO.

SOMS is a comprehensive toolset, risk-based data-driven system, which outlines AOV oversight activities based on emerging safety risks and trends associated with ATC systems at the facility and NAS levels. Per FAA Order 1100.161, AOV is responsible for oversight of ATO compliance with safety standards. SOMS will support AOV to effectively perform a risk-based oversight in various safety standard areas, i.e., Acquisition and Implementation of New Systems, Air Traffic Control Functions, Equipment and Facility Maintenance Functions. No other organization is conducting research in this topic. We have already developed SOMS Concept of Operations. September 2020 is the projected time of completion for this research.

Integrated Domain – Safety Risk Evaluation Tool (ID-SRET): The mission of the FAA Air Traffic Safety Oversight Service (AOV) is to conduct independent safety oversight of air traffic services, and AOV is facing increasing challenges due to the dynamic National Airspace System (NAS) changes and lack of understanding on interactions and interdependencies among NAS components. A decision support tool is urgently needed to facilitate AOV's evaluation and approval of NAS changes.

The ID-SRET is a model-based decision making support tool to assist AOV in evaluating Safety Risk Management (SRM) documents within the context of multiple NAS changes by integrating NAS system, air traffic control (ATC) procedure, and safety data into a single platform. ID-SRET identifies the interactions and interdependencies among NAS systems, ATC procedures, and system safety hazards to allow AOV more effectively evaluate NAS change impacts, identify potential SRM document issues, and evaluate risk control effectiveness.

We learned that traditional Safety Risk Management (SRM) process focusing on individual change cannot meet today's needs. An integrated SRM approach is definitely needed to support NAS safety analysis. The outcomes from this ID-SRET research include a model-based decision making support prototype available at http://ida.tc.faa.gov for AOV use, which includes 71 NAS critical systems.
The research will continue into FY 2019 and FY 2020 to incorporate ATC procedures into ID-SRET to make ID-SRET fully functional that covers both NAS systems and procedures. Only Federal dollars were used for this project because Federal government is sole stakeholder. The total cost for ID-SRET by the end of FY18 is $1.7M. September 2020 is the projected time of completion for this research.

Commercial Space Transportation

Program Description/Activities:

The commercial space transportation safety research program in FY 202020 will continue a majority of work from previous years, since all research programs are cumulative in their pursuit of knowledge. Most activities listed in FY 2019 will be continued into FY 2020. The accuracy and precision of future research activity descriptions are minimized by the uncertainties inherent to the research process, and compounded with funding uncertainties of future fiscal years. Future milestones that are currently projected for achievement in FY 202020 include the implementation of a terrestrial and space weather model that will permit improved prediction of environmental conditions for safe and efficient launch and re-entry operations tailored to commercial space transportation industry needs, and the development of draft separation standards for improved airspace management of launch/reentry vehicles, such as hybrids and manned stratospheric balloons, during non-explosive phases of flight.

Program Alignment with Strategic Goals:

DOT Strategic Goal	DOT RD&T Critical Transportation Topic
Safety	**Promoting safety**

This program supports the DOT's Strategic Goal of safety by providing systematic research and development within the FAA that will lead to the identification, assessment and mitigation of safety risks. By providing the research necessary to generate data, this data is then used to create and develop new safety standards that will be adopted throughout the aviation community.

NextGen - Wake Turbulence

Program Description/Activities:

The Wake program will continue to evaluate en-route aircraft wake turbulence generation fast-time models and analyze potential ATC wake hazard mitigation procedure changes. This work focuses on a current airspace issue, en-route wake encounters. These encounters have the potential to cause incidents during the cruise portion of a flight, and the programs mitigation efforts should allow for more mitigation to maintain an equivalent level of safety in the NAS.

The Wake program will continue to explore the use of aircraft wake transport and decay real time predictions in determining wake mitigation protection to be used by ATC in future NextGen programs. The wake transport decay predications could allow the use of decreased wake separation standards increasing capacity and efficiency in the NAS.

Program Alignment with Strategic Goals:

DOT Strategic Goal	DOT RD&T Critical Transportation Topic
Innovation	**Improving Mobility**

This program supports the DOT's Strategic Goal of innovation by providing targeted research and development within the FAA that will lead to new technology development and deployment in the National Airspace System (NAS). By providing the necessary research to gather information, this will allow the assessment of regulatory approaches, it will foster information sharing and facilitate coordination, collaboration with industry and other stakeholders, and the ability to test and adopt new technologies throughout the NAS.

The NextGen Wake Turbulence research project is driven by FAA operational needs and focused on providing the information needed for the development of more throughput capacity efficient aircraft wake mitigation processes, procedures, and associated decision support tools. The FAA Aviation Safety AOV and AFS organizations utilize the relative wake hazard and wake encounter probabilistic model research information for validating the relative safety of NextGen changes to ATC wake mitigation processes, separation standards, and ATC procedures being developed to meet the goal of increased NAS throughput capacity. These standards and ATC procedures are then published in relevant FAA orders and guidance materials.

Advanced Technology Development & Prototyping

Program Description/Activities:

The FAA will continue to develop and maintain mathematical & simulation software models of the National Airspace System (NAS) and evaluate system wide benefits associated with the implementation of various solutions. These models aid organizations throughout FAA with analyses of proposed new investments, trade-off studies, enterprise-wide shortfall analyses, and the operational analyses of new entrants on NAS Performance. FAA will continue to develop and improve FAA systems that report traffic operations, counts, delays, and safety information. This work supplies objective data supporting performance of airline operations and provides quantitative data to support the need for improved traffic flow and efficiency measures within the NAS.

Major Airspace Redesign work will continue under the ATDP budget line. Future redesign efforts will focus on improvements in the Northeast corridor. The Runway Incursion Reduction work under ATDP will continue to provide direct safety indications and alerts based on emerging technology.

Program Alignment with Strategic Goals:

DOT Strategic Goal	DOT RD&T Critical Transportation Topic
Innovation	**Improving mobility**

This program supports the DOT's Strategic Goal of innovation by providing targeted research and development within the FAA that will lead to new technology development and deployment in the National Airspace System (NAS). By providing the necessary research to gather information, this will allow the assessment of regulatory approaches, it will foster information sharing and facilitate coordination, collaboration with industry and other stakeholders, and the ability to test and adopt new technologies throughout the NAS.

Next Generation Transportation System - Separation Management Portfolio

Program Description/Activities:

The Separation Management Portfolio will continue to conduct pre-implementation activities to reduce risk, and implementation activities supporting the safe and efficient separation of aircraft and other vehicles in the National Airspace System (NAS). This portfolio will develop flight-deck interval management minimum operational performance standards and safety performance requirements, identify improvements to runway access through use of improved aircraft technology, updated standards, safety analysis, and modifications to air traffic monitoring tools and operating procedures that will enable more arrival and departure operations.

Program Alignment with Strategic Goals:

DOT Strategic Goal	DOT RD&T Critical Transportation Topic
Innovation	**Improving mobility**

This program supports the DOT's Strategic Goal of innovation by providing targeted research and development within the FAA that will lead to new technology development and deployment in the National Airspace System (NAS). By providing the necessary research to gather information, this will allow the assessment of regulatory approaches, it will foster information sharing and facilitate coordination, collaboration with industry and other stakeholders, and the ability to test and adopt new technologies throughout the NAS.

As the demand for flights increase, concepts and capabilities that focus on enhancing separation assurance using ground based automation and aircraft technology enhancements are critical. The Separation Management program supports the FAA's mission to provide the safest, most efficient aerospace system in the world by conducting research that will enhance aircraft separation assurance by safely reducing separation between aircraft, and as a result improve capacity, efficiency and safety in the National Airspace System. No other U.S. agency is researching this issue

Next Generation Transportation System - Traffic Flow Management Portfolio

Program Description/Activities:

The Traffic Flow Management (TFM) portfolio involves NAS operators and FAA traffic managers, along with advanced automation, in managing daily flight and flow decision-making, airspace and airport capability issues, such as special activity airspace and weather to improve overall efficiency of the National Airspace System.. Pre-implementation research conducted under this portfolio include technology will continue development activities for departure scheduling at smaller community airports, improved strategic flow services and capabilities that will capitalize on future DataComm capabilities, further integrate traffic flow management and metering operations, advanced trajectory-based operations leveraging the technologies of NASA's Airspace Technology Demonstration 3 (ATD-3), and explore technologies, infrastructure enhancements, and procedural changes for future traffic management needs.

Program Alignment with Strategic Goals:

DOT Strategic Goal	DOT RD&T Critical Transportation Topic
Innovation	**Improving mobility**

This program supports the DOT's Strategic Goal of innovation by providing targeted research and development within the FAA that will lead to new technology development and deployment in the National Airspace System (NAS). By providing the necessary research to gather information, this will allow the assessment of regulatory approaches, it will foster information sharing and facilitate coordination, collaboration with industry and other stakeholders, and the ability to test and adopt new technologies throughout the NAS.

The TFM Portfolio conducts pre-implementations activities introduce innovative concepts and technologies in the air traffic system, and conducts risk reduction activities for implementing programs to address and meet the rapidly changing needs of the aviation industry. The research activities for surface capabilities are expected to improve both the efficiency of individual flights while optimizing runway throughput to allow more efficient use of the airport, and terminal airspace resources, reduce delays on the airport surface and increase NAS throughput/capacity with better utilization of surface resources, and reduce emissions due to less engine run time on the airport surface and to/from the arrival/departure fix.

The research for collaborative air traffic management technologies will increase capacity and flexibility. Increased capacity by integrating strategic flow management with Trajectory Based Operations. This provides a more structured traffic flow so that the airspace capacity is used efficiently meet demand. Advanced Methods research will provide increased safety and flight efficiency/delay reduction through its TFM enhancements. New rerouting concepts will provide controllers, pilots, and flight operators with more choices when negotiating dynamic reroutes for active aircraft thus reducing flight delays.

Next Generation Transportation System - On Demand NAS Portfolio

Program Description/Activities:

The On Demand National Airspace System (NAS) Information (ODNI) portfolio will continue to conduct pre-implementation work to reduce risk in supporting the efficient and secure exchange of information within the FAA and between the FAA and other NAS users.

Program Alignment with Strategic Goals:

DOT Strategic Goal	DOT RD&T Critical Transportation Topic
Innovation	**Improving mobility**

This program supports the DOT's Strategic Goal of innovation by providing targeted research and development within the FAA that will lead to new technology development and deployment in the National Airspace System (NAS). By providing the necessary research to gather information, this will allow the assessment of regulatory approaches, it will foster information sharing and facilitate coordination, collaboration with industry and other stakeholders, and the ability to test and adopt new technologies throughout the NAS.

Next Generation Transportation System - NAS Infrastructure Portfolio

Program Description/Activities:

The National Airspace System (NAS) Infrastructure portfolio will continue to conduct pre-implementation activities to reduce risk for aviation weather-related and cross-cutting engineering issues. This portfolio provides the research, development, and analysis of validation activities, human system engineering, and demonstrations to improve the efficiency and effectiveness of air traffic management. This portfolio includes an array of work encompassing emerging issues in communications, weather, information management, trajectory management, collision avoidance, and assessment of requirements for future NAS systems and system enhancements.

Program Alignment with Strategic Goals:

DOT Strategic Goal	DOT RD&T Critical Transportation Topic
Innovation	**Improving mobility**

The NAS Infrastructure program supports the DOT's Strategic Goal of innovation by providing targeted research and development within the FAA that will lead to new technology development and deployment in the National Airspace System (NAS). By providing the necessary research to gather information, this will allow the assessment of regulatory approaches, it will foster information sharing and facilitate coordination, collaboration with industry and other stakeholders, and the ability to test and adopt new technologies throughout the NAS.

The benefits delivered by the pre-implementation activities in the NAS Infrastructure portfolio to reduce risk for aviation weather-related and cross-cutting engineering issues support operational improvements that will increase the number of arrivals and departures at major airports.

Next Generation Support Portfolio

Program Description/Activities:

The NextGen Support Portfolio program will continue to provide the evaluation platforms at the NextGen Integration and Evaluation Capability (NIEC) and Florida NextGen Test Bed (FTB to facilitate the conduct of NextGen concept demonstrations using research NAS environments without affecting actual NAS operations. This portfolio provides the National Airspace System (NAS) laboratory environments required to evaluate, mature, and validate the broad framework of NextGen concepts, technologies, operational functions, and systems before they are introduced into the NAS.

Program Alignment with Strategic Goals:

DOT Strategic Goal	DOT RD&T Critical Transportation Topic
Innovation	**Improving mobility**

This program supports the DOT's Strategic Goal of innovation by providing targeted research and development within the FAA that will lead to new technology development and deployment in the National Airspace System (NAS). By providing the necessary research to gather information, this will allow the assessment of regulatory approaches, it will foster information sharing and facilitate coordination, collaboration with industry and other stakeholders, and the ability to test and adopt new technologies throughout the NAS.

The NextGen Laboratory Support Portfolio provides an efficient and flexible platform to support the development of NextGen. Concept demonstrations are conducted to evaluate future concepts and ensure that foundational technologies are developed and integrated with emerging technologies, procedures, and embedded automation systems. To conduct these demonstrations, the FAA requires an environment for the evaluation of NextGen concepts and technologies that will not affect day-to-day air traffic operations. The use of this platform supports NextGen demonstrations to be conducted at an early stage without affecting the NAS. This reduces risk by enabling the FAA to evaluate the viability of these new technologies and concepts before making further investments and decisions on potential implementation in operations.

Next Generation Transportation System - Unmanned Aircraft Systems (UAS)

Program Description/Activities:

The activities in the Unmanned Aircraft Systems (UAS) program will continue to support research that allow integration of UAS without impact to manned aircraft operations or creating disruptions or delays, and ensure NAS operations will be as safe as they are today. This program will continue the two core pre-implementations tasks: 1) UAS Concept Validation and Requirements Development (CVRD), and 2) UAS Flight Information Management System (FIMS). The UAS CVRD will continue identifying and maturing UAS needs as they relate to air traffic systems and services, and refining operational requirements associated with Air Traffic Management (ATM) automation, airspace management, policies, and procedures. UAS FIMS activities will establish the concepts, use cases, and requirements associated with UAS Traffic Management/FIMS to safely manage UAS operations primarily through operator-operator sharing of flight intent and operator-FAA sharing of flight intent and airspace constraints.

Program Alignment with Strategic Goals:

DOT Strategic Goal	DOT RD&T Critical Transportation Topic
Innovation	**Improving mobility**

This program supports the DOT's Strategic Goal of innovation by providing targeted research and development within the FAA that will lead to new technology development and deployment in the National Airspace System (NAS). By providing the necessary research to gather information, this will allow the assessment of regulatory approaches, it will foster information sharing and facilitate coordination, collaboration with industry and other stakeholders, and the ability to test and adopt new technologies throughout the NAS.

Research within this portfolio contributes to the successful integration of UAS into the NAS, and provides benefits to both public and civil users when UAS missions relate to agriculture, search and rescue, border protection and pipeline monitoring among other applications. Additionally, the research activities addresses the 2016 Congressional Reauthorization mandate to research UTM and establish an Operational Evaluation for testing and developing a UTM data exchange capability and proposed architecture. Public and civil users, as well as the general public and Commercial and General Aviation, benefit from the work being conducted under this activity which will lead to the safe integration of UAS in the NAS.

System Planning and Resource Management

Program Description/Activities:

As the System Planning and Resource Management (SPRM) program annually leads the planning, coordination, development, presentation, and review of the FAA's research and development (R&D) portfolio, FY 2020 program activities are essentially the same. Planned key programmatic outputs include the National Aviation Research Plan (NARP), the Annual Research and Development Review – both of which are annual statutory deliverables to Congress – and administration of the congressionally mandated (P.L. 100-591 Section 6 Advisory Committee) Research, Engineering and Development Advisory Committee (REDAC) and resultant reports. SPRM will continue to provide program advocacy and outreach and maintain alignment with departmental R&D program planning and performance reporting guidance. SPRM will lead the portfolio planning, formulation, presentation and review activity to ensure the FAA meets the President's criteria for R&D, increases program efficiency, sustains and maintains management of the program within operating cost targets, and enables effective program review by the REDAC and the OST Office of Research and Technology. Similarly, the REDAC with its annualized functions will continue to review FAA research commitments and provide guidance for future R, E&D investments. SPRM will also develop program guidance and conduct compliance reviews to ensure that departmental R&D program planning and performance reporting requirements specified in the Fixing America's Surface Transportation (FAST) Act are satisfied. SPRM will continue to coordinate the establishment and administration of the Air Transportation Centers of Excellence (COE) Program and ensure compliance with related Financial Assistance and Grants Management departmental policy guidance.

Program Alignment with Strategic Goals:

DOT Strategic Goal	DOT RD&T Critical Transportation Topic
Accountability	**Preserving the environment**

This program supports the DOT's Accountability Strategic Goal, particularly the Management Objective #2. The activities planned by this program, are continuations of prior annual requirements to continue to support mission requirements by effectively and efficiently planning for and reporting on the FAA's entire research portfolio. This program, through its varied Plans and Reports will: identify funded Research projects (FY 2020 NARP and FY 202020 AMRP), present research accomplishments (FY 2019 AR), and facilitate the formulation of the research Budget (for FY 202021). Other continued activities planned for FY 2020 include conduct of the FY 2020 REDAC Full and Sub-Committee meetings, Tech Transfer and COE oversight. The projected time of completion for each of the tangible outcomes of this program is 12 months or less.

ACRONYMS

ACRONYM	DEFINITION
A	
A4A	Airlines for America
AAM	Office of Aerospace Medicine
AASR	Aging Aircraft Safety Rule
ABST	Airframe Beam Structure Test
AC	Advisory Circular
ACAA	Air Carrier Access Act
ACI	Aircraft Cyber Initiative
ACRP	Airport Cooperative Research Program
ADS-B	Automatic Dependent Surveillance-Broadcast
ADSIM	Airfield Delay Simulation Model
AEDT	Aviation Environmental Design Tool
AEE	Office of Environment and Energy
AFA	Association of Flight Attendants
AFFF	Aqueous Film-Forming Foams
AFRL	Air Force Research Lab
AFS	Active Flutter Suppression
AI	Artificial Intelligence
AIA	Aerospace Industries Association
AID	Aircraft Interface Devices
AIP	Grants-In-Aid for Airports Appropriation
AIT	Office of Information Technology
ALPA	Air Line Pilots Association
ALS	Approach Lighting System
AME	Aviation Medical Examiner
AMM	Aircraft Maintenance Manual
AMRAC	Aerospace Medicine Research Alignment and Collaboration
AMRP	Annual Modal Research Plan
AMS	Acquisition Management System
ANG	Office of NextGen
ANSI	American National Standards Institute
ANSP	Air Navigation Service Provider
AOC	Airport Cooperative Research Program Oversight Committee
AOPA	Aircraft Operators and Pilots Association
AR	Annual Review
ARFF	Aircraft Rescue and Firefighting
ARP	Aerospace Recommended Practice
ASBU	Aviation System Block Upgrades

ACRONYM	DEFINITION
ASCENT	Aviation Sustainability Center of Excellence
ASEB	Aeronautics and Space Engineering Board
ASIAS	Aviation Safety Information Analysis and Sharing
ASISP	Aircraft Systems Information Security/Protection
ASRS	Aviation Safety and Reporting System
AST	Office of Commercial Space Transportation
ASTM	American Society for Testing Materials
ASWON	Aviation Surface Weather Observation Network
ATC	Air Traffic Control
ATD	Airspace Technology Demonstration
ATM	Air Traffic Management
ATNB	Aeronautical Telecommunications Network
ATO	Air Traffic Organization
ATR	Airport Technology Research
ATRP	Airport Technology Research Program
AVS	Office of Aviation Safety
AWDE	Aviation Weather Demonstration and Evaluation
B	
BLI	Budget Line Item
BOM	Bureau of Meteorology
BPA	Blanket Purchase Agreement
C	
C2	Command and Control
CAA	Civil Aviation Authority
CAASD	Center for Advanced Aviation System Development
CAEP	Committee on Aviation Environmental Protection
CAMI	Civil Aerospace Medical Institute
CAPA	Coalition of Airline Pilots Association
CAST	Commercial Aviation Safety Team
CATMT	Collaborative Air Traffic Management Technology
CBA	Certification by Analysis
CBP	Customs and Border Protection
CEAT	Center of Airport Technology Research
CFD	Computational Fluid Dynamics
CFR	Code of Federal Regulations
CGAR	Center of Excellence for General Aviation Research
CLEEN	Continuous Lower Energy, Emissions and Noise
COE	Center of Excellence
COMSTAC	Commercial Space Transportation Advisory Committee
ConOps	Concept of Operations

ACRONYM	DEFINITION
CONUS	Continental United States
COS	Continued Operational Safety
COTS	Commercial off-the-shelf
CRDA	Cooperative Research and Development Agreement
CSRTG	International Fire and Cabin Safety Research Technical Group
CST	Commercial Space Transportation
CTA	Consumer Technology Association
CVRD	Concept Validation and Requirements Development
D	
DAA	Detect and Avoid
DARWIN®	Design Assessment Of Reliability With Inspection
DAC	Drone Advisory Committee
DHS	Department of Homeland Security
DNL	Day-Night Noise Level
DoD	U.S. Department of Defense
DOE	Department of Energy
DOJ	Department of Justice
DOT	U.S. Department of Transportation
DSS	Digital System Safety
DWR	Dynamic Weather Route
E	
EAPAS	Enhanced Airworthiness Program for Airplane Systems
EASA	Europe Aviation Safety Agency
ECCC	Environment and Climate Change Canada
EFB	Electronic Flight Bags
EIM	Enterprise Information Management
EMAS	Engineered Material Arresting System
EO	Executive Order
EPGWS	Enhanced Ground Proximity Warning System
ERAU	Embry Riddle Aeronautical University
ERDC	U.S. Army Engineer Research and Development Center
ESRL	Earth Systems Research Laboratory
EXCOM	Executive Committee
F	
F&E	Facilities and Equipment Appropriation
F&R	Findings and Regulations
FAA	Federal Aviation Administration
FAMRI	Flight Attendant Medical Research Institute
FAR	Federal Aviation Regulations
FCMS	Flight Controls and Mechanical Systems

ACRONYM	DEFINITION
FD-DER	Flight Deck Date Exchange Requirements
FEMA	Federal Emergency Management Agency
FFRDC	Federally Funded Research and Development Center
FIMS	Flight Information Management System
FMC	Flight Management Computer
FOD	Foreign Object Debris
FSIMS	Flight Standards Information Management System
FTS	Fuel Tank Safety
FY	Fiscal Year
G	
GA	General Aviation
GAJSC	General Operations Joint Steering Committee
GAO	Government Accountability Office
GDP	Gross Domestic Product
GTG	Graphical Turbulence Guidance
GUI	Graphic User Interface
H	
HHS	Health and Human Services
HIS	Human System Integration
HITL	Human In The Loop
HRRR	High Resolution Rapid Refresh
I	
IAA	Interagency Agreement
IAAM	Iberoamerican Association of Aerospace Medicine
IAASM	International Academy of Aviation and Space Medicine
IATA	International Air Transport Association
IBT	International Brotherhood of Teamsters
ICAO	International Civil Aviation Organization
ICE	Immigration and Customs Enforcement
ICI	Ice Crystal Icing
ICIWG	Ice Crystal Icing Working Group
IDIQ	Indefinite Delivery/Indefinite Quantity
ID-SRET	Integrated Domain Safety Risk Evaluation Tool
IEEE	Institute of Electrical and Electronics Engineers
IES	Illumination Engineering Society
IFR	Instrument Flight Rules
IM	Information Management
IMC	Instrument Meteorological Conditions
InFOs	Information for Operators
IOT	Internet of Things

ACRONYM	DEFINITION
IPO	Interagency Planning Office
IR	Infrared
ISO	International Organization for Standardization
ISR	International Safety Research
J	
JAA	Joint Aviation Authority
JARUS	Joint Authorities for Rulemaking on Unmanned Systems
JCAB FATS	Japan Civil. Aviation Bureau Future Air Transportation System
K	
KART	Kansas Aviation Research & Technology
L	
LCA	Life Cycle Assessment
LED	Light Emitting Diode
LOAs	Letters Of Authorizations
LTO	Land and Takeoff
LWE	Liquid Water Equivalent
M	
MALSR	Medium Intensity Approach Lighting System with Runway Alignment Indicator Lights
MCW	Medical College of Wisconsin
MET	Meteorological
MFCR	Multi-Flight Common Route
MinWxSvc	Minimum Weather Service
MIT	Massachusetts Institute of Technology
MMPDS	Metallic Materials Properties Development and Standardization
MOA	Memorandum of Agreement
MOPS	Minimum Operational Performance Standards
MOU	Memorandum of Understanding
MSpecs	Management Specifications
N	
NAC	NextGen Advisory Committee
NAFI	National Association of Flight Instructors
NAPTF	National Aviation Pavement Test Facility
NARP	National Aviation Research Plan
NAS	National Airspace System
NASA	National Aeronautics and Space Administration
NEPA	National Environmental Policy Act
NER	National Airspace System Enterprise Repository
NextGen	Next Generation Air Transportation System
NEXTOR	National Center of Excellence for Aviation Operations Research

ACRONYM	DEFINITION
NHTSA	National Highway Traffic Safety Administration
NIA	National Institute of Aerospace
NIAR	National Institute for Aviation Research
NIST	National Institutes of Standards and Technology
NIWG	NextGen Integration Working Group
NOAA	National Oceanographic and Atmospheric Administration
NOx	Nitrogen Oxide
NPD	Noise Power Distance
NRC	National Research Council
NRCC	National Research Council of Canada
NSC	National Safety Council
NSIP	NextGen Segment Implementation Plan
NSTC	National Science and Technology Council
NTL	National Transportation Library
NTSB	National Transportation Safety Board
NVG	Night Vision Goggles
NWS	National Weather Service
O	
OA	Operating Administration
ODNI	On Demand National Airspace System (NAS) Information
OMB	Office of Management and Budget
OMRF	Oklahoma Medical Research Foundation
OpSpecs	Operations Specifications
OSE	Operational Suitability Evaluation
OSSM	Oklahoma School of Science and Mathematics
OST	Office of the Secretary
OSTP	Office of Science and Technology
OSU	Oklahoma State University
OTA	Other Than Agreement
OU	University of Oklahoma
P	
PAFI	Piston Aviation Fuels Initiative
PAMA	Professional Aviation Maintenance Association
PARTNER	Partnership for Air Transportation Noise and Emissions Reduction
PBN	Performance Based Navigation
PCPSI	Pilot Controller Procedures System Integration
PEGASAS	Partnership to Enhance General Aviation Safety, Accountability and Sustainability
PIREP	Pilot Report
PLA	Project Level Agreements

ACRONYM	DEFINITION
PMO	Program Management Organization
PMR	Program Management Review
PPD	Presidential Policy Directive
PPT	Program Planning Team
PREP	Performer Research Execution Plan
PWS	Present Weather Sensor
Q	
QA	Quality Assessment
R	
R&D	Research and Development
RE&D	Research, Engineering and Development Appropriation
RBDM	Risk-Based Decision Making
RD&T	Research, Development, and Technology
REB	Research Executive Board
REDAC	Research, Engineering, and Development Advisory Committee
RFP	Request for Proposal
RIM	Runway Incursion Mitigation
RISC	Rotor Integrity Steering Committee
ROMIO	Remote Oceanic Meteorological Information
RTCA	Radio Technical Commission for Aeronautics
RTS	Remote Tower Services
RTT	Research Transition Team
S	
SAE	Society of Automotive Engineers International
SAFO	Safety Alert for Operators
SBIR	Small Business Innovation Research
SDO	Standards Development Organizations
SFMA	Strategic Flow Management Application
SIM	Structural Integrity of Metals
SLD	Super Cooled Large Droplets
SMS	Safety Management System
SOMS	Safety Oversight Management System
SRM	Safety Risk Management
STEM	Science, Technology, Engineering, and Mathematics
STF	Surface Tactical Flow
STM	Surface Traffic Management
SVGS	Synthetic Vision Guidance Systems
SWAC	System Wide Analysis Capability
SWIM	System Wide Information Management
SwRI	Southwest Research Institute

ACRONYM	DEFINITION
SWS	System Wide Safety
T	
3D	Three Dimensional
TAPS	Twin Annular Premixing Swirler
TAS	Terminal Area Safety
TBFM	Time Based Flow Management
TBO	Trajectory Based Operations
TCAS	Traffic Collision Avoidance System
TEL	Tetraethyl Lead
TFDM	Terminal Flight Data Manager
TFM	Traffic Flow Management
TO	Task Order
TR	Technology Refresh
TRB	Transportation Research Board
TRP	Technical Review Board
TSI	Transportation Safety Institute
TSO	Technical Standards Orders
TT	Tech Transfer
TWU	Transport Workers Union
U	
U.S.	United States
UAS	Unmanned Aircraft System
UCVR	UAS Concept Validation and Requirements
UEDDAM	Uncontained Engine Debris Damage Assessment Model
ULD	Unit Load Device
UMTRI	University of Michigan Transportation Research Institute
UPS	United Parcel Service
USA	United States Army
USAF	United States Air Force
USDA	United States Department of Agriculture
USG	U.S. Global
USGCRP	U.S. Global Change Research Program
USN	United States Navy
UTM	UAS Traffic Management
UTMB	University of Texas Medical Branch
V	
VFR	Visual Flight Rules
VRMC	Verification Requirements & Monitoring Capability
W	
WFD	Widespread Fatigue Damage Rule

ACRONYM	DEFINITION
WJHTC	William J. Hughes Technical Center
WOI	Weather Observation Improvements
WSI	Wichita State University
WTIC	Weather Technology in the Cockpit
Z	
ZASA	Zodiac Arresting Systems America