United States Department of Transportation
FY 2020 Annual Modal Research Plans

Cover Page

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Executive Summary

The aviation industry provides opportunities for business, job creation, economic development, personal travel, and leisure, as well as law enforcement and emergency response throughout the world. U.S. leadership is critical to these opportunities and the global aviation community. The U.S. must also respond quickly to changing and expanding aviation-based transportation needs. The Federal Aviation Administration (FAA) supports this system through the introduction of new technologies and procedures, innovative policies, and advanced management practices that promote safety and environmental sustainability.

The FAA uses its performance-based National Aviation Research Plan (NARP) to ensure that Research and Development (R&D) investments are managed to deliver results and sufficiently address national aviation priorities. The NARP presents the FAA's R&D programs in a portfolio consisting of six domain areas. As shown in Figure 1, these domain areas consist of Airport Technology, Aircraft Safety Assurance, Digital Systems & Technologies, Environment & Weather Impact Mitigation, Human and Aeromedical Factors, and Aviation Performance and Planning.

FAA research across each domain area is focused on the integration of emerging technologies and new aircraft systems to meet the growing demand of air travel, new entrants, and technological capabilities while ensuring the continued safety record that the US aviation system is known for. The FAA research portfolio addresses critical aviation research needs in the near, mid, and far-term (5-year) timeframes. Some examples of near and mid-term aviation research include ensuring continued airworthiness of aircraft, efficient preventative measures and suppressant systems for inflight fires, aircraft/engine icing, and continued development of NextGen systems. Bridging current and future needs includes the integration of Unmanned Aircraft Systems (UAS) and other new entrant technology, such as commercial spaceflight, into the National Airspace System (NAS). Additionally, research to evaluate the certification of new aircraft technologies and materials, such as the use of additive manufacturing and fiber-reinforced composite material, is needed to ensure that cost-saving and innovative technologies are implemented without sacrificing the continued safe operation of aircraft.

The NARP features the FAA's framework of R&D goals, objectives, and outputs that together support the strategic visions laid out by the President, Secretary of Transportation, and the FAA Administrator concerning governance, safety, innovation, infrastructure, and accountability. This approach enables the FAA to address the current challenges of operating the safest, most efficient air transportation system in the world – while building a foundation for the future system in an environmentally responsible manner.

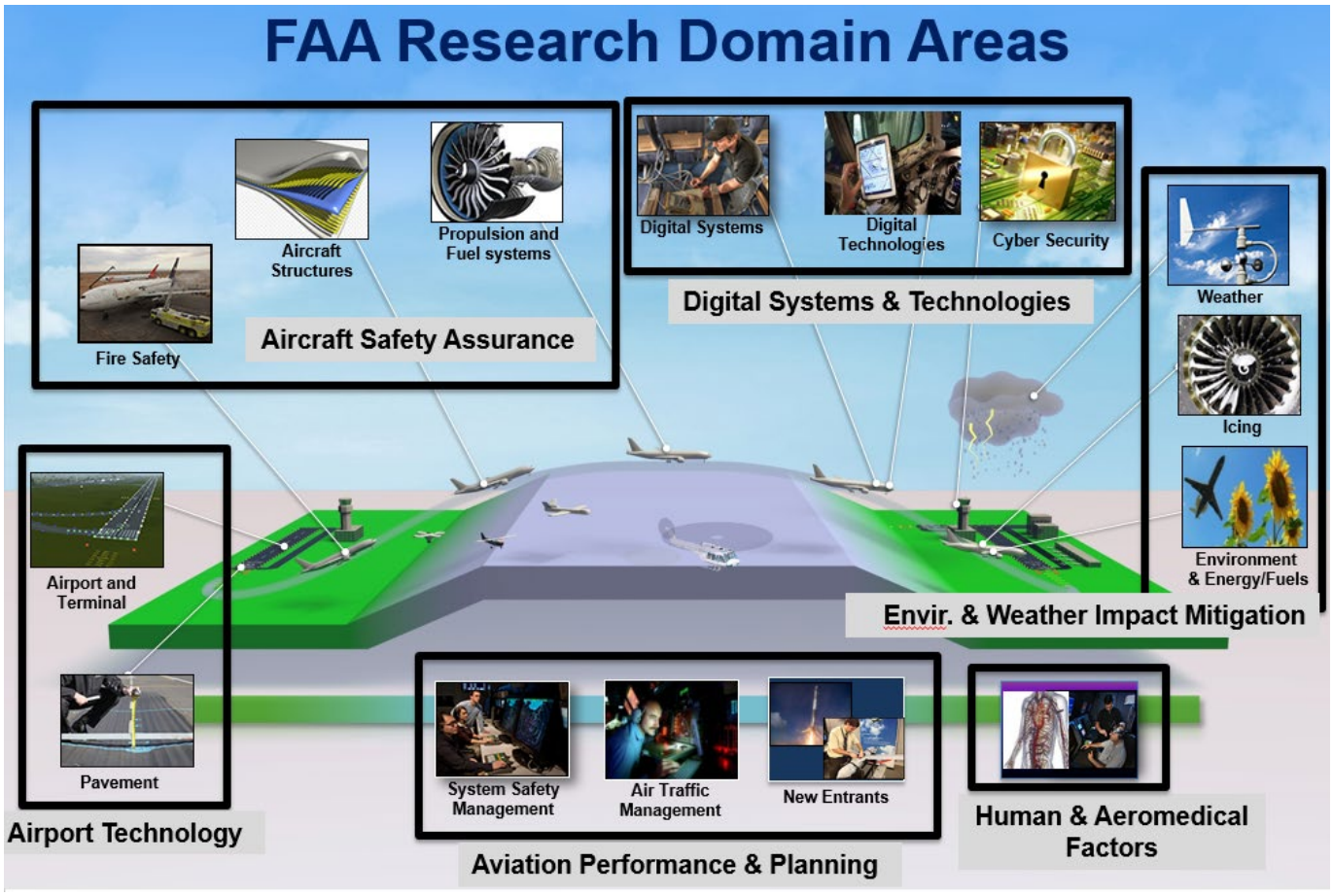

Figure 1. FAA Research Domain Areas

There are several successful outputs and activities planned for FY20 and FY21. For example, there is the anticipated development of air traffic operational concepts to optimize airspace and airport capacity in support of addressing the high traffic congestion along the northeast corridor of the US. Another example is the Design Assessment of Reliability with Inspection (DARWIN) software, a fracture mechanics and reliability assessment software that will be updated to allow for further capabilities, including improved user interfaces for 2D and 3D models, and the ability to analyze additional components. Additional tools will be developed to evaluate spaceport site locations, predict traffic effects on extended pavement life performance, and evaluate methodologies for making UAS highly visible to manned pilots.

In keeping with the priority of maximizing interagency collaboration, the FAA portfolio of research projects includes successfully established partnerships with other DOT agencies, U.S. government agencies (e.g., NASA, USDA, etc.), state and local governments, private industry, academia, and international partners. Further partnership opportunities include active participation in each of the twelve Topical Research Working Groups (TRWG) established by the DOT, and a leadership role in the Systemic Safety Approach TRWG. Through this participation, the FAA continues to collaborate with other transportation modes in an effort to eliminate duplicative research and ensure the sharing of data where possible.

As an example of this cross-modal collaboration, the FAA and the Pipeline and Hazardous Materials Safety Administration (PHMSA) are currently coordinating on a research initiative to define requirements that support the United Nations (UN) Subcommittee on the Transport of Dangerous Goods. The purpose of this effort is to define a new lithium battery classification system applicable to all modes of transport. An additional effort is underway with the Federal Highway Administration (FHWA) to evaluate potential research collaboration with the FAA Airports staff to evaluate Alkali Silica Reaction (ASR) susceptibility test methods

for pavement materials and aggregates. These partnerships help the FAA leverage critical resources and capabilities to ensure that the Agency can achieve its goals and objectives. Collaboration with other organizations allows the FAA to gain 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.

Chapter 1. Introduction/Agency-Wide Research Approach

The FAA's Mission is to provide the safest and most efficient aerospace system in the world. In support of this mission, the FAA uses R&D to support policymaking and planning, regulation, certification, standards development, and modernization of the NAS. The FAA R&D portfolio supports both the day-to-day operations of the NAS, and balances between near-term, mid-term, and far-term aviation needs. The FAA has defined a research-planning framework to help align and plan its R&D portfolio to best support this mission. This framework consists of three overarching R&D Outcomes that map to the DOT Strategic Plan Goals of Safety, Infrastructure, Innovation and Accountability as demonstrated in Table 1.

Table 1: FAA R&D Outcomes

FAA Goal	Alignment with DOT Strategic Plan Goals	Description
Improve Aerospace Safety	Goal of Safety	Systematically expand and apply knowledge to produce useful materials, devices, systems, and methods that will improve aerospace safety and achieve the lowest possible accident rate.
Improve Operational Effectiveness	Goals of Safety, Infrastructure, Innovation, & Accountability	Systematically expand and apply knowledge to produce useful materials, devices, systems, and methods that will improve access to and increase the capacity and operational efficiency of the Nation's aerospace system.
Reduce Environmental Impact	Goals of Safety & Infrastructure	Systematically expand and apply knowledge to produce useful materials, devices, systems, and methods that will reduce aerospace environmental impacts.

The FAA focuses its investments on applied research and development projects that aim to innovate solutions from an initial body of knowledge, or proposed concept, to viable applications that address known aviation problems, mission shortfalls, and increase the safety of operations. This focus is distinctly different from that of basic research – a far-sighted emphasis on advancing the state of knowledge or technological progress, often without a known practical application or use. While the FAA's primary goal is to ensure the overall safety and operational effectiveness of the NAS, the FAA's research also seeks to reduce certification timelines and burdensome regulations.

The FAA is committed to funding research that focuses on maintaining or improving safety, improving the effectiveness of NAS operations, and reducing environmental impact. The FAA strives to do this while standardizing the approach industry can use to show compliance to safety regulations and developing a better understanding of industry's use of innovative technologies. This standardization ensures consistency in component testing and certification requirements, while enabling the FAA policy offices to develop safety regulations and/or identify areas where it may be appropriate to modify existing regulations and standards,

which may be too conservative or restrictive in light of new technologies. The FAA leverages research – wherever possible – to streamline certification, minimize cumbersome regulations, and improve system throughput. This positively affects both the industry and the flying public.

The FAA must continue to fund and actively engage in research activities to ensure that the innovations brought about by the aviation industry are safely integrated into the NAS. This includes continued updates to existing regulations and certification practices. The aviation industry is evolving at a rapid pace through an abundance of emerging technologies and operations. This includes advances in software, materials, fuels and propulsion technology. Additionally, new mission types including supersonic flight, urban air mobility, and commercial space operations are rapidly developing within the industry. The FAA possesses a unique and robust collection of researchers, scientists, engineers, and subject matter experts (SMEs) that work collaboratively to address the challenges posed by the changing aviation landscape. Without the existence of FAA programs and leadership, these emerging and disruptive technologies and innovative operations may cause degradation of our safety record and limit integration into the NAS.

The research conducted through FAA's R&D investments is required by statute and necessary to inform the safe and efficient evolution of aviation domestically and globally. Since pilots operating in the NAS are from around the world, having a common approach to air traffic procedures at the global level directly impacts foreign operators while in the NAS. This not only increases effective communication, but also aids in familiarity with new procedures that are more widely disseminated. Influencing global aviation standards is highly dependent on the knowledge base of FAA representatives/researchers who are on global harmonization and standards-setting bodies – many whom are world-renowned experts - and often called upon as SMEs. This knowledge-base enables the U.S. to be a global leader in influencing and driving international standards that affect our aviation economic advantage.

The FAA's R&D is critical and relevant to industry and the flying public. An example of this is the use of Eddy Dissipation Rate (EDR) algorithms to predict the location of turbulence along an aircraft's route and altitude of flight, and measure the impact of turbulence on the aircraft if it is encountered. From a passenger's perspective, turbulence can be an uncomfortable and often terrifying experience; it can also cause in-flight injuries along with structural damage to an aircraft that encounters it, if the turbulence is severe enough. For these reasons, predicting and avoiding turbulence is a primary concern for any flight.

The FAA's Weather Program and Weather Technology in the Cockpit (WTIC) program jointly developed an EDR algorithm, EDR cockpit viewer, and EDR Technical Transfer package in collaboration with Delta Airlines, United Airlines, Boeing, and Teledyne. In late 2017, Delta Airlines began using this technology with great success and is actively engaging airlines collaboratively in the use of this open-source algorithm. Delta's ultimate goal is to continually enhance the algorithm, thereby improving the benefits it provides, through use of a greater set of EDR data generated by Delta and the partnering airlines. This will increase safety and passenger comfort, and reduce risk of aircraft damage through more efficient flight operations resulting from turbulence avoidance. This is just one example of FAA (i.e., federally-developed) research being conducted in collaboration with industry, transferred to industry for safer and more efficient travel with less impact to the environment, and ultimately enhanced by industry using its own resources.

In FY2020, FAA R&D has no new programs; however, there are new projects within the ongoing programs. These projects are discussed in Chapter 3.

Research Portfolio Information

FAA organizations with R&D program performance responsibility are working towards increased public access to results of federally funded scientific research. For example, the Air Transportation Centers of Excellence (COE) Program has implemented Public Access Plan and Data Management Plan requirements for

external DOT-funded research projects as terms and conditions of grant awards. The terms and conditions include obtaining an Open Researcher and Contributor ID (ORCiD), submission/approval of a Data Management Plan (DMP), and submission and maintenance of project information in the Transportation Research Board's (TRB) Research in Progress (RiP) database. Within two months of project completion, researchers are required to submit project information (to include any project outputs) to TRB, ROSA-P via the National Transportation Library (NTL), and Research Hub. Additionally, through our partnership with the DOT TRWGs, the FAA is working with the other modes to establish consistent guidance related to data management plans, data discoverability, and technical assistance for project managers and their research teams.

Acquisition/Assistance

FAA programs utilize competitive procurement processes through multiple contracting vehicle types and grants to acquire and conduct R&D activities. The FAA's Acquisition Management System (AMS) offers research programs omnibus contract vehicles and Blanket Purchase Agreements (BPAs) where vendors compete for Task Orders (TOs) and BPA calls. Similarly, the Broad Agency Announcement (BAA) is another competitive process the FAA utilizes for awarding basic research contracts. Outcome-oriented specialized research tasks are handled through Federally Funded Research and Development Centers (FFRDC) (e.g., MITRE, MITLL). The FAA also leverages research partnerships through various interagency agreements with other Federal laboratories (e.g. NSF, NOAA/ESRL). 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 COE is one example of a grant-based program that uses a competitive process to select academic institutions 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 (T2) happens when existing knowledge, facilities or capabilities developed with federal R&D funding are transferred and utilized to fulfill public and private needs. The FAA achieves this process through collaboration with stakeholders within academic, industry, other government entities, utilizing FAA SMEs, and state-of-the-art research laboratories. The solutions further enhance the FAA's mission of having the safest and most efficient aerospace system, and address advancements for the U.S. marketplace and the world. The FAA has a diverse and broad-reaching research portfolio, with a strong emphasis on T2.

The FAA depends on relationships with domestic and international research partners and organizations – internal and external to the FAA – in its mission to transfer knowledge, data, and technology, to data consumers and private industry. FAA research program managers have the responsibility to disseminate the results to stakeholders throughout the aviation community. The FAA accomplishes this through a number of vehicles, including:

- Informing Smart Regulations, Advisory Circulars (ACs), 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 advance research knowledge more broadly;
- Performing as contributing members of aviation related working groups and forums;
- Serving as SMEs to those requiring developmental aid;
- Serving as product function validators to vendors looking to advance their products; and
- Facilitating the transfer of new technology.

T2 partners include interagency offices, aviation industry members, and academia working towards the advancement of transformative technologies for a safer, more efficient, and economically accessible NAS. Private organizations provide industry perspectives and insights essential to economically prudent regulation processing as they evaluate and provide feedback on new requirements. This participation and feedback aids in reducing burdensome regulation. Additionally, industry partners sponsor research performed through established FAA COEs.

The COE program was created through the FAA RE&D Authorization Act of 1990, Public Law 101-508 for the purposes of conducting and transferring research in specific mission-critical areas. 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-sharing 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 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 Science Technology Engineering and Math (STEM) initiatives.

The T2 leadership comes from the Office of Research and Technology Applications (ORTA) located at the William J. Hughes Technical Center. The FAA's T2 Program serves to ensure the practical application of FAA Federal research by transferring knowledge, facilities, equipment, and capabilities developed by Federal laboratories and R&D programs to non-federal entities such as private business, academia, and state and local governments.

The items that are subject to T2 are as diverse as the manner in which T2 is conveyed. FAA research items that undergo T2 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;
- Raw data produced from experiments made publically available;
- Analytical and processing tools to ensure private industry modeling capabilities, and for flight-related decision making; and
- New technologies, capabilities, and prototypes for industry to integrate into production.

The mechanisms associated with the transfer of the information above are diverse. Some of the methods for information propagation and dissemination include:

- 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 expert;
- Databases – research results entered into second party databases for 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; and
- Licensing authorization – authorizations to use technology resultant from FAA research.

Evaluation/Performance Measurement

The FAA R&D portfolio is developed to maximize the benefits to the aviation stakeholder 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 portfolio aligns with the DOT Strategic Plan, and provides the mechanism to achieve DOT performance goals, while ensuring its own statutory requirements are met.

The FAA Research and Development Management Division tracks and reports on FAA conducted research in several ways, including the NARP, Annual Review (AR), Annual Modal Research Plan (AMRP), and the Technology Transfer Annual Congressional Report. The NARP presents over 200 planned outputs for 31 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. This world-class research is often further captured in journals, reports, and articles. The Technology Transfer Congressional Report is the vehicle used to report tracked T2 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. In consideration of the nine DOT investment topic areas, these programs provide impact to the following five areas:

- Economic Impact of Regulatory Reform,
- Performance Based Regulations and Safety,
- Improving the Mobility of Freight,
- Improving Mobility for Underserved Communities, and
- Cybersecurity.

In addition to the agency-wide tracking and reporting systems discussed above, programs perform internal tracking and assessment using project management practices of tracking stakeholders, requirements, risks, costs, and schedules, to ensure objectives are met, and cost and schedule are not compromised.

Chapter 2. High Priority Project Descriptions

New High Priority Projects for FY 2020

Project #1: Integrating Expanded and Non-Segregated UAS Operations into the NAS: Impact on Traffic Trends and Safety

The primary purpose of this research is to provide further coordination of internal FAA activities with the goal of safe integration of UAS operations into the NAS. This research will provide valuable data and forecasts of expanded and non-segregated operations facilitating UAS integration, and enhance the FAA's incremental risk-based approach towards safety rules, regulations, and revising Safety Management Systems (SMS) to incorporate UAS operational needs and characteristics.

The FAA will leverage data from on-going integration activities such as the Integrated Pilot Program (IPP), Low Altitude Area Navigation Capability (LAANC), Unmanned Traffic Management (UTM), UAS Facility Maps (UASFM), Certificate of Authorizations (COA)/COA Application Process (CAPS), and Special Government Interest (SGI) to understand issues at the forefront of UAS-NAS integration. Specifically, this research aims to:

- understand the emerging usage patterns and missions leading to expanded operations;
- scope operations and characteristics of non-segregated operations and potential traffic patterns;
- understand and describe likely conflict and safety risks;
- describe risk profiles in busy terminal areas and in lower altitudes elsewhere;
- describe need for safety and certification regulations emanating from integrations; and
- underscore revisions of SMS incorporating emerging needs of expanded and non-segregated operations.

Successful completion of this research will provide important insights into interactions between human factors, technology, procedures, and further regulatory considerations pertinent to UAS integration into the NAS.

Project #2: Investigate the Cumulative Risk of Comorbidities in Aircrew, Identifying Areas to Improve the Determination of Medical Certification to Improve Aviation Safety

This research performed by the Civil Aerospace Medical Institute (CAMI) will improve our determination for medical certificates for pilots, and lead to better evidence-based decisions. This will allow the FAA to selectively restrict pilots whose disease pathologies have been shown to increase the risk of being in fatal aviation accidents, while allowing those whose pathologies show no evidence of increased risk to continue to fly.

This project responds to the Aeromedical Technical Community Representative Group (TCRG) request of 6/26/2018 to conduct research regarding the cumulative risk of comorbidities. Specifically, How many diseases are too many; What are the interactions between multiple medical conditions and multi-system diseases; and Is there a way to examine air mishap databases or performance databases to assess when the presence/interaction between multiple medical conditions exceeds acceptable risk, even if these conditions are appropriately clinically managed? Most suspected comorbidities become deferred bases, which may be addressed by a panel of physicians today. This research will use evidence to make the determination, and will likely reduce the use of panels of physicians to make these decisions.

This research aligns DOT Strategic goals and/or DOT research priorities from The DOT Strategic Plan 2018-2022. Specifically:

- Goal 1 – Safety (Obj. 1) Systemic Safety Approach (data, risks, collaboration, leadership, evaluation, performance)
- Goal 2 – Infrastructure (Obj. 1) Project Delivery, Planning, Environment, Funding and Finance (partnerships), and (Obj. 4) Economic Competitiveness and Workforce (workforce development)
- Goal 3 – Innovation (Obj. 1) Development & Innovation (coordination, research, partnerships, data), and (Obj. 2) Deployment of Innovation (technology integration & collaboration)
- Goal 4 – Accountability (Obj. 2) Mission Efficiency & Support (workforce, information systems).

Project #3: Alternatives to Aqueous Film Forming Foams (AFFF) in Firefighting Agents

This project, conducted by the Airports Technology Research Program, is designed to meet requirements established by The FAA Reauthorization Act of 2018, Section 332(a) – Firefighting Foam.

This research is driven by increasing concern regarding the potential health and environmental impacts of aqueous film-forming foams (AFFF) used by Aircraft Rescue and Fire Fighting (ARFF) Departments at airports and surrounding communities. Perfluoroalkyl and polyfluoroalkyl substances, commonly referred to as PFAS, are a toxic group of chemicals that are found in AFFF concentrates used at airports. Specifically, of concern are perfluorooctane sulfonate (PFOS) and perfluorooctanoic acid (PFOA). Both PFOS and PFOA are considered persistent, bio-accumulative, and toxic by United States (US) Environmental Protection Agency (EPA) standards. Though foam manufacturers have worked diligently to reduce the presence of PFAS in their AFFF concentrates, the environmental concerns still linger. There are also several other PFAS compounds in the current AFFF formulas whose environmental and health hazards are not yet known. The US Navy and Air Force have also initiated programs for eliminating fluorine from foams in FY2019, however they lack the facilities to perform the fire extinguishing performance testing.

The objectives of this project are to identify potential FFF (Film-Forming Foam) candidates that could replace AFFF at airports and determine the fire extinguishing performance of FFF candidates. Once identified, the project will seek to provide a process for integration of suitable FFFs as alternatives for current AFFFs into airports.

Planned activities in support of this research are:
- Health and Environmental Hazards Gaps Analysis,
- Selection of FFF Candidates,
- FFF Literature Review,
- FFF Chemical Analysis,
- Final Selection of FFF Candidates,
- FFF Evaluations, and
- Fire Test Evaluations.

The project funding in FY-2020 is $750k and there is no non-federal contribution.

Project #4: Use of Geosynthetics in Airport Pavement Structures

This research supports the FAA Reauthorization Act of 2018 signed on October 5, 2018, Section 525 - Geosynthetic Material, which states, “The Administrator of the Federal Aviation Administration, to the extent practicable, shall encourage the use of durable, resilient, and sustainable materials and practices, including the use of geosynthetic materials and other innovative technologies, in carrying out the activities of the Federal Aviation Administration.”

An airport pavement is a complex engineering structure and conventional design and construction practices present growing challenges to pavement engineers, contractors, and airport owners. The increasing cost and use of high quality local materials is an increasing concern in a variety of geographic areas. This issue is driving

industry designers and airport owners to develop and incorporate alternative solutions and will present greater challenges in the future as the FAA moves toward a 40-year pavement design life.

Through FAA collaboration with Geosynthetics Material Association (GMA), numerous airports were identified that have incorporated geosynthetics within their pavement structures as a solution with limited guidance and oversight. Although used in highway pavement applications for years, knowledge regarding the use of geosynthetics in airfield pavements is limited. Therefore, to meet industry demand the FAA will conduct research to establish guidance for quality oversight to ensure proper design, construction, and installation of geosynthetic materials within airport pavements. Incorporating geosynthetics within pavements is not a new concept, as academia, state department of transportation agencies, and the Department of Defense have been researching the concept for over 30 years. The Federal Aviation Administration has previously invested in this topic through an interagency agreement with the Department of Defense (U.S. Engineering Research & Development Center, ERDC). Medium-scale laboratory studies have confirmed various findings from previous research related to highway pavement and loading conditions are applicable to airport pavements and loading conditions. The FAA and ERDC believe geosynthetics are a practicable solution to improving the life of airport pavement structures.

The FAA's Airport Technology Research Program will conduct full-scale accelerated pavement testing at the National Airport Pavement Test Facility on flexible airport pavement structures under simulated aircraft loading conditions. This will further evaluate airport pavement performance constructed with geosynthetics.

This research aligns with the following DOT Strategic goals of Infrastructure and Innovation with an expected project cost for FY20 of 250k. At this time there is no non-Federal financial contribution, however there is significant in-kind contribution from the GMA, an industry organization comprised of representatives of the manufacturers and industry experts of geosynthetics.

Project #5: Safe integration of Urban Air Mobility (UAM) in the NAS

This project will develop requirements and use cases to allow the safe integration of Urban Air Mobility operations into the NAS. The rapid development of technology has introduced new entrants with the potential to provide transportation services to users within urban environments. Urban Air Vehicles may need to operate within both the UTM and Air Traffic Modernization (ATM) environments, requiring information exchange models between other occupants of the airspace. This program will identify applications for Urban Air Mobility (UAM).

Urban environments lack traditional ATC surveillance systems and pose unique separation challenges. Communications, navigation, and surveillance requirements necessary for operations in low altitude environments and Class E/G airspace will be investigated. This program will analyze airspace for UAM operations including potential special purpose corridors. The UAS programs play 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 as or safer than they are today. Government cost of allowing UAS operations will decrease due to the reduction of "exception handling" of UAS flights, and improvements to NAS capabilities and operations will be made cost effective due to the integrated framework approach to addressing needs and solutions. The total project cost is approximately $30M, while the expected funding for FY2020 is currently at $6 Million. There is currently no non-Federal financial contribution.

High Priority Projects Completed in FY 2018/2019

Project #1: Catastrophic Failure Prevention Program

The Propulsion and Fuel Systems Program completed the Large Engine Uncontained Debris Analysis High-Bypass Ratio Engine Update effort in support of the Australian Transport Safety Bureau Recommendation

resulting from the A380 uncontained engine failure in Singapore. This work also supported the National Transportation Safety Board Recommendation that followed from the fan blade failure event in Philadelphia resulting in a single passenger fatality. The research report is in final review and will be released shortly in 3QFY19.

This project aligns with the DOT strategic goal of safety and will be used to update AC 20-128, "Design Considerations for Minimizing Hazards From Uncontained Turbine Engine and Auxiliary Power Unit Rotor Failures." This work will update the fragment normalized weight and also the fragment count and trajectory, based upon data from in-service events including recent incidents involving modern high-bypass engines.

Follow-on work is planned to use this new fragment debris model in the updated Uncontained Engine Debris Damage Assessment Model (UEDDAM), which will result in an update to the 2004 report on the use of the model. This work is an ongoing effort to keep the model maintained. The UEDDAM is a collaborative effort with the US Navy and US Air Force who fund core vulnerability modules that UEDDAM leverages. As the military vulnerability codes are improved, UEDDAM must also be upgraded and improved to be able to work on new computing platforms. The latest version of the code includes parallel processing to significantly speed up analysis run times. On-going cost of UEDDAM updates averages $100,000 per year from FAA when updates are needed.

Project #2: Aircraft Structure Research, Development and Testing, and Aircraft Crashworthiness Analysis

In September of 2016, the FAA William J. Hughes Technical Center and NASA Langley Research Center entered into an interagency agreement to conduct research, development and testing of aircraft structures and materials, including a failure analysis of materials and aircraft crashworthiness.

The primary objective of this activity was to obtain information to help establish regulations and standards for aircraft crashworthiness. The information from this test was used by NASA in the area of vertical lift technology (specifically impact dynamics). The research activities included the vertical drop test of two Fokker F-28 aircraft fuselage sections and a swing test of a Fokker F-28 aircraft (typically 65-70 passenger capacity). The FAA used this information to fill the existing data gap concerning the crashworthiness between small part 25 airplanes (regional jets) and large Part 25 airplanes (wide-body airplanes). This data gap made it difficult to establish equivalent levels of safety when considering such items as size, design or materials used.

A second objective was to assess the capabilities of finite element simulations to predict the test response. Results of the two vertical drop tests of the F-28 fuselage section were compared with the results of analytical modeling of both the fuselage and the anthropomorphic test dummies (ATDs) (completed June 2017 at a cost of $416K). The overall results were favorable and subsequent changes improved the model's results. The Fokker F-28 aircraft swing test will occur mid-summer 2019 at NASA Langley (at a cost of $640K). This test will consist of multiple experiments involving the FAA Technical Center, CAMI, NASA, NTSB, NHTSA, Transportation Safety Institute (TSI), DOD Army Research Laboratory (ARL), as well as non-federal stakeholders (e.g., Humanetics, DTS, etc). Services and equipment provided by the non-federal stakeholders were of a volunteer nature and with a value in the tens of thousands of dollars. The tests will involve different seat configurations (forward and side facing seats) and different ATDs. TSI will also conduct a full-post accident investigation.

A valuable outcome of this test is a verified and validated model of the Fokker F-28 aircraft. This model can be used to study water impact scenarios by changing the impact surface and aircraft impact kinematics. This information could be used to help develop water impact regulation and standards.

The total cost of the effort is $1.056M.

Chapter 3 – FY 2020 Program Descriptions

FY 2020 RD&T Program Funding Details

RD&T Program Name	FY 2020 Enacted ($000)	FY 2020 Basic ($000)	FY 2020 Applied ($000)	FY 2020 Development ($000)	FY 2020 Technology ($000)
Fire Research and Safety	7,200		7,200		
Propulsion and Fuel Systems	2,100		2,100		
Alternative Fuels for General Aviation	1,900		1,900		
Aircraft Catastrophic Failure Prevention Research	1,565		1,565		
Advanced Materials/Structural Safety	14,720		14,720		
Aircraft Icing/Digital System Safety	9,000		9,000		
Continued Airworthiness	10,269		10,269		
Flightdeck/Maintenance/System Integration Human Factors	7,300		7,300		
System Safety Management	4,500		4,500		
Air Traffic Control/Technical Operations Human Factors	5,800		5,800		
Aeromedical Research	7,919		7,919		
Airliner Cabin Environment Research	1,000		1,000		
Weather Program	12,911		12,911		
Unmanned Aircraft Systems Research	24,035		24,035		
Commercial Space Transportation Safety	2,500		2,500		
NextGen - Wake Turbulence	5,000		5,000		

NextGen - Air Ground Integration Human Factors	5,300		5,300		
NextGen - Weather Technology in the Cockpit	3,144		3,144		
NextGen Flight Data Exchange	2,675		2,675		
NextGen - Information Security	1,005		1,005		
Environment and Energy	18,013		18,013		
NextGen - Environmental Research - Aircraft Technologies, Fuels, and Metrics	29,174		29,174		
System Planning and Resource Management	12,135		12,135		
William J. Hughes Technical Center Laboratory Facility	3,500		3,500		
William J. Hughes Technical Center Laboratory Sustainment	20,000			20,000	
Advanced Technology Development & Prototyping	40,900			40,900	
NextGen - Separation Management Portfolio	20,500			20,500	
NextGen Traffic Flow Management Portfolio	19,800			19,800	
NextGen - On Demand NAS Portfolio	8,500			8,500	
NextGen - NAS Infrastructure Portfolio	11,500			11,500	
NextGen - Support Portfolio	11,000			11,000	

NextGen Unmanned Aircraft Systems	51,900			51,900	
NextGen Enterprise, Concept Development, Human Factors, & Demonstrations	19,000			19,000	
Center for Advanced Aviation System Development (CAASD)	57,000			57,000	
Airport Cooperative Research Program	15,000		15,000		
Airport Technology Research Program	33,224		33,224		
Totals	**500,989**		**240,889**	**260,100**	

FY 2020 RD&T Program Budget Request by DOT Strategic Goal

RD&T Program Name	FY 2020 Enacted ($000)	SAFETY ($000)	INFRASTRUCTURE ($000)	INNOVATION ($000)	ACCOUNTABILITY ($000)
Fire Research and Safety	7,200	7,200			
Propulsion and Fuel Systems	2,100	2,100			
Alternative Fuels for General Aviation	1,900	1,900			
Aircraft Catastrophic Failure Prevention Research	1,565	1,565			
Advanced Materials/Structural Safety	14,720	14,720			
Aircraft Icing/Digital System Safety	9,000	9,000			
Continued Airworthiness	10,269	10,269			
Flightdeck/Maintenance/System Integration Human Factors	7,300	7,300			
System Safety Management	4,500	4,500			
Air Traffic Control/Technical Operations Human Factors	5,800	5,800			
Aeromedical Research	7,919	7,919			
Airliner Cabin Environment Research	1,000	1,000			
Weather Program	12,911	12,911			
Unmanned Aircraft Systems Research	24,035	24,035			

Commercial Space Transportation Safety	2,500	2,500			
NextGen - Wake Turbulence	5,000			5,000	
NextGen - Air Ground Integration Human Factors	5,300			5,300	
NextGen - Weather Technology in the Cockpit	3,144			3,144	
NextGen Flight Data Exchange	2,675			2,675	
NextGen - Information Security	1,005			1,005	
Environment and Energy	18,013		18,013		
NextGen - Environmental Research - Aircraft Technologies, Fuels, and Metrics	29,174		29,174		
System Planning and Resource Management	12,135				12,135
William J. Hughes Technical Center Laboratory Facility	3,500				3,500
William J. Hughes Technical Center Laboratory Sustainment	20,000			20,000	
Advanced Technology Development & Prototyping	40,900			40,900	
NextGen - Separation Management Portfolio	20,500			20,500	
NextGen Traffic Flow Management Portfolio	19,800			19,800	
NextGen - On Demand NAS Portfolio	8,500			8,500	
NextGen - NAS Infrastructure Portfolio	11,500			11,500	
NextGen - Support Portfolio	11,000			11,000	
NextGen Unmanned Aircraft Systems	51,900			51,900	
NextGen Enterprise, Concept Development, Human Factors, & Demonstrations	19,000			19,000	
Center for Advanced Aviation System Development (CAASD)	57,000		57,000		
Airport Cooperative Research Program	15,000				
Airport Technology Research Program	33,224	17,257	15,967		
Totals	**500,989**	**129,976**	**120,154**	**220,224**	**15,635**

Program Alignment to USDOT Research Priorities

Alignment to DOT Research Priorities					
Research Program	**Economic Impact of Regulatory Reform**	**Performance Based Regulations and Safety**	**Improving the Mobility of Freight**	**Improving Mobility for Underserved Communities**	**Cyber security**
Airport Technology					
Airports Cooperative Research	X	X			X
Airports Technology Research	X	X		X	
Aircraft Safety Assurance					
Fire Research and Safety	X	X	X		
Advanced Materials/Structural Safety	X	X			
Continued Airworthiness		X			
Propulsion and Fuel Systems	X	X			
Alternative Fuels for General Aviation	X	X			
Aircraft Catastrophic Failure Prevention Research	X	X			
Digital Systems and Technologies					
Aircraft Icing/Digital System Safety		X			X
NextGen – Information Security					X
NextGen – Flightdeck Data Exchange		X			X
Environment and Weather Impact Mitigation					
Weather Program	X	X			
NextGen – Weather Technology in The Cockpit	X	X		X	
Environment and Energy	X	X			
NextGen – Environmental Research – Aircraft Technologies, Fuels, & Metrics	X				
Human Performance and Aeromedical Factors					
Flightdeck/Maintenance/Systems Integration Human Factors		X			
Air Traffic Control/Technical Operations Human Factors		X			
NextGen – Air Ground Integration Human Factors		X			
Aeromedical Research	X	X		X	
Airliner Cabin Environment Research	X	X		X	
NextGen Transportation System – Enterprise, Concept Development, Human Factors and Demonstrations Portfolio		X			
Aviation Performance and Planning					
System Safety Management	X	X			
Commercial Space Transportation	X	X			

Alignment to DOT Research Priorities					
Research Program	**Economic Impact of Regulatory Reform**	**Performance Based Regulations and Safety**	**Improving the Mobility of Freight**	**Improving Mobility for Underserved Communities**	**Cyber security**
NextGen – Wake Turbulence		**X**			
Unmanned Aircraft Systems	**X**				
Advanced Technology Development and Prototyping	**X**	**X**			
NextGen Transportation System – Separation Management Portfolio			**X**		
NextGen Transportation System – Traffic Flow Management Portfolio			**X**		
NextGen Transportation System – On Demand NAS Portfolio		**X**			
NextGen Transportation System – NAS Infrastructure Portfolio	**X**				
NextGen Support Portfolio*	**-**	**-**	**-**	**-**	**-**
NextGen Transportation System – Unmanned Airspace Systems (UAS)	**X**		**X**		
System Planning and Resource Management			**X**		
WJHTC Laboratory Facility*	**-**	**-**	**-**	**-**	**-**
WJHTC Laboratory Sustainment*	**-**	**-**	**-**	**-**	**-**

** Facilities used for research purposes, not singularly aligned with any particular research*

Program Alignment to DOT Strategic Goals

DOT Strategic Goal				
Research Program	**Safety**	**Infrastructure**	**Innovation**	**Accountability**
Airport Infrastructure and Technologies				
Airports Cooperative Research	**X**	**X**	**X**	
Airports Technology Research	**X**	**X**		
Aircraft Safety Assurance				
Fire Research and Safety	**X**			
Advanced Materials/Structural Safety	**X**			
Continued Airworthiness	**X**			
Propulsion and Fuel Systems	**X**			**X**
Alternative Fuels for General Aviation	**X**			
Aircraft Catastrophic Failure Prevention Research	**X**			
Digital Systems and Technologies				
Aircraft Icing/Digital System Safety	**X**			
NextGen – Information Security			**X**	
NextGen – Flightdeck Data Exchange			**X**	
Environment and Weather Impact Mitigation				
Weather Program	**X**			
NextGen – Weather Technology in The Cockpit			**X**	
Environment and Energy		**X**		
NextGen – Environmental Research – Aircraft Technologies, Fuels, & Metrics		**X**		
Human Performance and Aeromedical Factors				
Flightdeck/Maintenance/Systems Integration Human Factors	**X**			
Air Traffic Control/Technical Operations Human Factors	**X**			
NextGen – Air Ground Integration Human Factors			**X**	
Aeromedical Research	**X**			
Airliner Cabin Environment Research	**X**			
NextGen Transportation System – Enterprise, Concept Development, Human Factors and Demonstrations Portfolio			**X**	
Aviation Performance and Planning				
System Safety Management	**X**			
Commercial Space Transportation	**X**			

NextGen – Wake Turbulence			**X**	
Unmanned Aircraft Systems	**X**			
Advanced Technology Development and Prototyping			**X**	
NextGen Transportation System – Separation Management Portfolio			**X**	
NextGen Transportation System – Traffic Flow Management Portfolio			**X**	
NextGen Transportation System – On Demand NAS Portfolio			**X**	
NextGen Transportation System – NAS Infrastructure Portfolio			**X**	
NextGen Support Portfolio			**X**	
NextGen Transportation System – Unmanned Airspace Systems (UAS)			**X**	
System Planning and Resource Management				**X**
WJHTC Laboratory Facility				**X**
WJHTC Laboratory Sustainment				**X**

Airport Infrastructure and Technologies

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Airports Cooperative Research Program
Enacted ($15,000,000)

Program Description/Activities/Objectives:

The Airport Cooperative Research Program (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.

The ACRP is an industry driven research program managed by the 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 the National Academy of Sciences to implement the ACRP. The Secretary also appoints the 13 members of the ACRP Oversight Committee (AOC).

The ACRP's mission is to develop near-term, practical solutions to problems faced by airport operators. The ACRP uses contractors, selected in a competitive process, to conduct the research, which is overseen by industry experts and a designated FAA SMEs. The results of the research are published in the form of handbooks and best practices. To date, the vast library of publications include 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.

The 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.

The 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.

Statutory Requirements:

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

The 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, $3M was appropriated in 2003 for the pilot program, and this increased to $10M in 2006, and increased again to $15M in 2011.

Program Alignment with Strategic Goals:

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. Data generated by this research is 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 culminate in assessments. These assessments then provide the information used to improve the infrastructure at airports across the NAS. This research data is also used to provide 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, which are often located in rural communities.

Research Collaboration Partners:

ACRP information regarding published reports, digests, and up-coming events (e.g., webinars, calls for research proposals, etc.) is provided to representatives in industry, academia and the Federal Government via both the report postings and updates on the ACRP and FAA websites. It is also disseminated through the TRB newsletters and the ACRP LinkedIn and Facebook websites.

The DOT Secretary appoints the 13 members of the AOC. The AOC includes representatives from industry, academia, and national associations representing public airport operating agencies, airport executives, State aviation officials, and scheduled airlines. Representatives from both the FAA and the EPA are participants in both the AOC and the project research panels. This enables members to understand the research initiatives and processes, and ensures awareness of the products and results. It also allows members to participate in the research proposal or problem statement drafting and voting In addition, the representatives and stakeholder on the AOC are often 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 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; and/or
- 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.

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Airports Technology Research Program
Enacted ($33,224,000)

Program Description/Activities/Objectives:

The Airport Technology Research Program (ATRP) supports the safe and efficient integration of new technologies into the airport environment through the development and updates of the FAA's Advisory Circulars (ACs). 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.

The program is organized to directly support the development and updates of the FAA's Airports ACs in the areas of airport safety and airport infrastructure. On the airport safety side, in FY-20, the ATR program will remain engaged in a multitude of airport safety areas. Some examples are; development of new specifications for the use of Light Emitting Diode (LED) lighting technologies at airports, analysis of airport safety data, testing of environmentally-friendly firefighting agents, improving airport noise, reducing wildlife strike risks, and integrating UAS operations at airports.

Regarding the Strategic Goal of Infrastructure, 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-20, 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.

Statutory Requirements:

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

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

Program Alignment with Strategic Goals:

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. Data generated by this research is 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 that will improve the infrastructure at airports across the NAS. Data generated by this research is used to provide the baseline information 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.

Research Collaboration Partners:

In addition to the REDAC, the ATRP 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 while helping to 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 hazard 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 on airports.

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

The ATRP has CRADA'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.

OTA with the Boeing Company

ATRP has an "other transaction agreement" or OTA with the Boeing Company to establish a mechanism for funding, studying, researching, planning, developing, demonstrating, evaluating and implementing advanced concepts, technologies and methods in support of the U.S. National Air Transportation System with emphasis on operational safety at airports, and in particular analyzing vast amounts of taxiway centerline deviation data from various aircraft. The overall goal is to possibly revise the numeric wingspan ranges for the existing

airplane design groups (ADG) and separation standards to re-align the aircraft wingspan ranges so that newer aircraft do not hit the upper limits of the allowed wingspan range.

Aircraft Safety Assurance

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Fire Research and Safety
Enacted ($7,200,000)

Program Description/Activities/Objectives:

The purpose of this program is to conduct research to prevent accidents caused by in-flight fire 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) and with the FAA Office of Hazardous Materials (AXH-1).

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 of this program's efforts is demonstrated through the participation in the Society of Automotive Engineering's (SAE) G-27 committee. This is an international committee focused on efforts to develop a packaging standard for the safe shipment of lithium batteries on aircraft. This standard was requested by the International Civil Aviation Organization (ICAO) after they a ban of the carriage of lithium batteries as cargo on passenger aircraft. Following this ban, the Fire Safety and Research Program proposed a test standard and have conducted extensive tests to understand the details and develop pass/fail criteria. The Pipeline and Hazardous Materials Safety Administration (PHMSA) is also participating in the standard development and, if adopted, would have the responsibility to change the hazards materials shipping regulations to mandate its use.

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 Commercial Aviation Safety Team (CAST) Safety Enhancement (SE) SE127 team which 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.

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:

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. Data generated by this research is 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.

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:

ICAO Research results from testing conducted 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 a 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 that will 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. Partnerships also include 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, and the University of Massachusetts. These institutes conduct research through grants to help support this program.

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

Program Description/Activities/Objectives:

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 knowledge before they can cause catastrophic loss of aircraft and lives. This research program is a proactive approach to preventing accidents rather than the reactive approach to preventing the *recurrence* of accidents pursued in the past.

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.

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

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 affect 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.

The output of this research is used by the FAA to develop industry consent standards, 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.

Research on Damage Tolerance of Composite Structures aims to study critical defects and damage threats that affect 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 be analyzed using 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 in guidelines for bond qualification including bonding processes parameters and material compatibility.

Finally, Research on COS and CE 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 NAS, the 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 the 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 being 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.

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:

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. Data generated by this research is 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 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 2020);
- 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 2021);
- Updated maintenance technician training requirements for part 147 (by FY 2020);
- New AC outlining best practices approving modifications to composite structure (by FY 2020);
- Revised AC 21-43 to replace 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 2020);
- 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 2020);
- Revised AC 20-107, "Composite Aircraft Structure," to incorporate advanced composite technologies and lessons learned (by FY 2022).
- A revised edition of the Aircraft Lightning Protection Handbook (by FY2021) which will incorporate material for composite aircraft.

Additionally, the completion of this task is instrumental for FAA's efforts to achieve the following NARP milestone: By 2020, develop background information and data for creation of a Part 21 AC on composite structures. This research improves the overall safety of air travel and therefore affects all communities in the United States including rural communities. Furthermore, much of the research is performed at state universities, in states that are predominately comprised of rural communities, or directly located in rural communities.

Research Collaboration Partners:

Public and stakeholder input is primarily received through two mechanisms. First, there is the close research collaboration 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 REDAC. The REDAC is an advisory committee to the FAA whose members are FAA stakeholders including industry, 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 programs. 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 two full committee meetings and 10 subcommittee meetings annually that produce reports documenting REDAC's input known as REDAC Findings and Recommendations (F&Rs.) The research programs evaluate REDAC F&Rs, 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 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 the FAA Aircraft Certification Service Policy and Innovation Division (AIR-600), Airframe and Cabin Safety Section (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. They 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 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 in this research program as external partners, matching funding and working closely with the individual projects and through various 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 Composite Materials Handbook (CHM-17).

FAA Stakeholders: Transport Airplane, Rotorcraft and Small Airplane Standards offices

Industry Partners: Boeing, 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 provided approximately $5M in matching resources.

United States Department of Transportation
FY 2020 Annual Modal Research Plans

Continued Airworthiness
Enacted ($10,269,000)

Program Description/Activities/Objectives:

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 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 2020, aircraft safety-critical components (a focus of continued airworthiness) are grouped into aviation systems and structures described below:

- Electrical Systems (ES): 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. This may 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.

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 on providing 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 Systems: The *Novel and Unusual Electric Aircraft Systems* research requirement will be conducted to ensure that more electrical airplane (MEA) technology is safely introduced onto traditional, current, and future aircraft electrical architectures. As more electrical based systems replace traditional mechanical and hydraulic systems, standards must be developed to account for this novel technology. This research will provide data to address the safety implications of the increased electrical content of the MEA. It will provide regulatory standards for, and technical expertise in, the use of fuel cells and/or lithium battery systems for power generation aboard civil aircraft. The title of this research requirement has changed from the previous year to reflect the novel and unusual technology being addressed and to address associated safety concerns and prevent in-service events once this technology is implemented and operational.

- Flight Control and Mechanical Systems: 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 and 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 provide significant reduction of Controlled Flight into Terrain and Loss of Control accidents in GA.

  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. The FAA 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, and 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 shared 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 generally smaller operators so the cost of the technology has to be carefully considered, as well as the added weight of the technology. 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 that 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 Design Values for Emerging Materials* research requirement will promote a 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 Small Aircraft Risk Tool (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 FAA engineers, small operators, or private users. Therefore, there is a need for the FAA to develop this software.

Statutory Requirements:

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 Design 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.

Electrical Systems

- The *Novel and Unusual Electric Aircraft Systems* research develops data to assess the technical capabilities of several technologies that may mitigate the risks associated with the installation and certification of new electrical energy generation, electrical storage, electrical power distribution and electrical propulsion.

Program Alignment with Strategic Goals:

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.

Structural Integrity

- 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. The FAA 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 Design 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 that currently have no in-service history. Results from this research will guide standardization of the technology that 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 Aircraft Certification Official (ACO) engineers to improve efficiency.

Rotorcraft Systems

- The *Wire Strike Avoidance* research supports DOT strategic goal of safety. 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 altitudes and are subject to dangers such as power lines, towers and have 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).

Flight Control and Mechanical Systems

- *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 addressing 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 Goals of Safety Innovation, and Accountability. It supports 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.

Electrical Systems

- *Novel and Unusual Electric Aircraft Systems* requirement supports the DOT's Strategic Goal of Safety and innovation and accountability by reducing or mitigating the safety risks introduced by having a higher electrical energy on aircraft by providing FAA with a thorough understanding of the impacts of the more complex, increased voltage, and highly integrated systems being proposed on modern aircraft. In support of the FAA's Continuous Lower Energy, Emissions and Noise (CLEEN) program, FAA research experts have been participating and are key members of: Lithium battery standard development SAE AE-7 and RTCA special committees SC-211, sc-225 and SC-235 (since 2005). Fuel cell standard development SAE AE-7 since 2008 and Advisory Rule Making Committee since 2004. Recently within last year, formed a new sub-committee SAE AE-7 to address the more electric aircraft SAE AE-7.

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 programs. 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 Continued Airworthiness Program participates 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.

The Continued Airworthiness Program also teams 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 (CRADA) or through working groups in standards development organizations (SDO).

Collaborative research with industry includes the areas discussed below.

Structural Integrity

- The *Damage Tolerance and Durability Issues for Emerging Technologies* research is being conducted in close collaboration with industry through cooperative research and development agreements (CRADA). These cost-share agreements leverage resources to address areas of mutual interest that benefit all partners that 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 a 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 providing 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 Next Manufacturing Consortium: this consortium includes 20 active participants giving the FAA access to millions of dollars of research for a small annual fee.

- AmericaMakes: includes198 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. The Government Steering Group includes FAA, NASA, and DOD while the 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 the FAA with access to graduate-level student and faculty 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 the 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. The industry OEM partner is directly involved in development and validation of this tool.

Rotorcraft Systems

- The *Wire Strike Avoidance* prime research stakeholder is the rotorcraft directorate who, 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: 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 reduced technical risks. No funding is received by the FAA from external partners, but cost sharing includes in-kind contributions from industry and academia as part of the collaborative research initiatives.

Flight Control and Mechanical Systems

- The major collaborative partners are the FAA Compliance & Airworthiness Division and the Policy & Innovation Division, Transport Standards Branch. Additional stakeholders include government, industry, and academia partners under contract with the FAA. Government partners include NASA Armstrong, NASA Ames, and NASA Langley. Industry partners currently include; the Adaptive Aerospace Group, Systems Technology Inc., National Test Pilot School, and Flight Level Engineering. Academia partners include Purdue University, and FIT. No funding is received by the FAA from external partners, but cost sharing includes in-kind contributions from other government agencies, industry and academia as part of the collaborative research initiatives.

Electrical Systems

- The major collaborative partners are the FAA Policy & Innovation Division, Transport Standards Branch. Additional stakeholders include government, industry, and academia partners under contract with the FAA. Government partners include Air Force Research Laboratory (AFRL), NavAir, NASA

Johnson, NASA Jet-Propulsion Labs (JPL), and NASA Glenn. Industry partners currently include; Boeing, Saft, Teledyne, Honeywell, Eagle Picher, University of Dayton Research Institute Systems, DNV-GL, Ametek , and Astronics. No funding is received by the FAA from external partners, but cost sharing includes in-kind contributions from other government agencies, industry and academia as part of the collaborative research initiatives.

Do non-government groups partner with this program?

Yes. See description of collaborative research projects above.

United States Department of Transportation
FY 2020 Annual Modal Research Plans

Propulsion and Fuel Systems
Enacted ($2,100,000)

Program Description/Activities/Objectives:

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 (NTSB) safety 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.

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. The FAA and the AIA formed the Rotor Integrity Steering Committee (RISC) as a result of these accidents, 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 that is 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 evaluation (NDE) methods to detect cracks and anomalies prior to fracture. This research, which has industry wide safety implications, is best pursued through government and industry collaboration.

In FY 2020, FAA research within the Propulsion and Fuel Systems Program will continue to develop the final two Advisory Circulars (ACs) and necessary enhancements to the 'DARWIN' software program needed to support Title 14 Code of Federal Regulations part 33.70. These ACs include one on damage tolerance of lathe turned surfaces and one on nickel material anomalies. Funding in FY20 will be used to conduct necessary research to enable the development of these ACs that will provide FAA guidance and a publicly acceptable means to certify designs with these features, and therefore, reduce the risk of failures of these parts.

The lack of additional funds in FY20 will prevent R&D funding of this program to address the recent NTSB safety 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 nondestructive evaluation (NDE) methods to detect anomalies in nickel billet and in-service inspections for cracks in nickel and titanium rotors.

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.

This research specifically supports regulation 14 CFR 33.70, which prescribes new requirements for turbine engine life-limited parts. In addition, advisory circulars and a publicly accessible software program (DARWIN) are being developed by this research that provide an acceptable means for which industry can safely comply with the new regulation. This research will provide certification and inspection standards as well as safety regulatory guidance which 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.

Program Alignment with Strategic Goals:

The turbine research program supports the DOT's Strategic Goal of Safety by developing innovative methods to design and inspect critical rotating components to prevent uncontained turbine engine failures and accidents.

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

Research Collaboration Partners:

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 at periodic meetings. Both groups consist of stakeholders who review and guide the development of the Advisory Circulars that support 14 CFR 33.70 and who provide beta-site testing of the DARWIN software code. This program also coordinates with the Jet Engine Titanium Quality Committee (JETQC) and the Jet Engine Nickel Quality Committee (JENQC) to develop improved methods to produce these super alloys for premium quality critical rotating parts. Minutes and action items from these meetings are shared and tracked with all participants.

Program partners include:

- Aerospace Industries Association (AIA) Rotor Integrity Steering Committee (RISC) and AIA Rotor Manufacturing (RoMan) Team
- Jet Engine Titanium Quality Committee (JETQC)/Jet Engine Nickel Quality Committee (JENQC)
- Department of Defense (USAF, USN)
- NASA
- Foreign Regulators (EASA, Transport Canada)

Do non-government groups partner with this program? Yes

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. The industry also licenses the DARWIN software code from Southwest Research Institute which reinvests the licensing fees into further developing the code. Lastly, several engine manufacturers separately fund DARWIN capabilities which often leverage related efforts funded by the government.

United States Department of Transportation
FY 2020 Annual Modal Research Plans

Alternative Fuels for General Aviation
Enacted ($1,900,000)

Program Description/Activities/Objectives:

The Alternative Fuels for General Aviation research program operates as part of the Piston Aviation Fuel Initiative (PAFI). PAFI was established at the request of a broad cross section of the aviation and petroleum industries and consumer representatives to develop a path forward for the identification, evaluation and deployment of the most promising unleaded replacements for 100 low lead aviation gasoline. Mounting environmental, regulatory and economic pressures both domestically and worldwide, necessitate a transition to unleaded fuel. Unfortunately, the aviation and petroleum marketplace, in concert with existing government regulations and policies, do not support a safe, orderly and economically viable fleet-wide transition to a new fuel or fuels, hence the need for the joint government and industry collaborative initiative known as PAFI. The Alternative Fuels program collaborates with 40 different entities in this program as further detailed below.

The research that the FAA and its Collaborative Partners will perform include laboratory materials and performance testing, rig simulations, ground based test beds, altitude simulations, and in-flight operations at state-of-the-art laboratories. Engine testing will be conducted in engine test cells at ground level and using altitude simulation capabilities as required by specific test plans to measure engine performance, detonation, durability and other operating characteristics showing if unleaded fuels meet the applicable requirements of FAA 14 CFR Parts 33.45, 33.47, 33.49, 33.55, and 33.57. Engine tests will be performed on fleet representative engine models and may include development and evaluation of engine modifications that will mitigate any limitations of PAFI fuels.

Materials research testing will include cooperative research in the areas of laboratory rig and materials compatibility testing with the novel fuels and potential fuel additives. Research will be comprised of tests to simulate a variety of conditions and include testing for materials degradation, aging conditions, performance characteristic changes, and property changes from exposure to heat and cold. We will be assess materials after exposure to the novel fuels for conformance to FAA Technical Standard Orders (TSO), ASTM test criteria and compatibility with Parts Manufacturer Approval (PMA) engine and fuel system components including elastomeric materials, bladders, seals, and other fuel system materials. Individual tests range from a few weeks to over 6 months in duration.

Candidate fuels and lube oils used in the engine, aircraft and flight-testing will be subject to chemical and physical properties analysis in accordance with ASTM International test standards. We will also perform laboratory analysis on fuel deliveries for the engine, aircraft, and materials test segments to verify that fuel elemental compositions are consistent with proposed fuel formulation specifications.

The Alternative Fuels program is a collaborative effort between the FAA and industry. Its primary purpose is to serve as a vehicle in which unleaded fuel is broadly and safely introduced to the general aviation fleet if research shows the fuel the same level of safety as the existing leaded aviation gasoline. Another purpose is to facilitate and spur continued private research and development of unleaded fuels for general aviation. The program itself does not develop, formulate, refine, or distribute fuel, the private sector does that.

Statutory Requirements:

This program implements the recommendations of the Unleaded AVGAS Transition Aviation Rulemaking Committee, and directly supports FAA fulfillment of section 504 of the FAA Reauthorization Act of 2018 Public Law No: 115-254.

Program Alignment with Strategic Goals:

The Alternative Fuels program supports DOT's Strategic Goal of Safety by providing systematic research on candidate unleaded fuels to identify, assess, and mitigate safety risks associated with their use in GA engines and aircraft. Current fuels that use Tetraethyl Lead (TEL), are designed to minimize or prevent detonation (engine knock) and to meet operability and other performance characteristics to prevent engine failures and resultant aircraft accidents. Research and testing using standardized methods developed under the fuels and energy program will generate data on the anti-knock and other performance characteristics of candidate fuels as they relate to the safe operation of GA aircraft engines. This data will be used to create and develop new safety standards and new aviation fuels that will be adopted throughout the aviation community.

The program also supports DOT's Strategic Goal of accountability. The FAA initiated PAFI 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. These same groups sought a single, unified, assessment and regulatory program at the federal level. The PAFI initiative created a public/private partnership to develop a unique regulatory approach in which the FAA would issue a fleet authorization for a new fuel; this has never been done before. The FAA and aviation fuel manufacturers are learning important research data on the anti-knock and performance characteristics of the candidate fuels vs. current industry standards as well as important characteristics with co-mingled fuels. When the research is completed, this information will form the basis for the FAA to issue a fleet authorization in accordance with Public Law No: 115-254 as well as establishing a process for authorization of future unleaded fuels into public use.

Research Collaboration Partners:

The Alternative Fuels program has always been a collaborative effort between the FAA, GA community stakeholders, fuel industry partners, and educational intuitions including Centers Of Excellence (COEs).

The PAFI Steering Group (PSG) provides overall program guidance and direction. It is comprised of FAA representatives from the Certification Offices and the Technical Center, the Aircraft Owners and Pilots Association (AOPA), Experimental Aircraft Association (EAA), General Aviation Manufacturers Association (GAMA), and the National Air Transportation Association (NATA).

The PAFI Technical Advisory Committee (TAC) is composed of 35 corporations, industry standards bodies and other organizations as listed below, in addition to FAA representatives. The performance based criteria for testing and validating alternative fuels candidates are developed in consensus with the TAC. In addition, TAC members provide In-Kind test support including engine and flight-testing. Select TAC members include fuel companies that perform basic and advanced research into fuel development, provide fuel for testing, and contribute other test resources.

FY20 Active TAC members (excluding FAA organizations):

- Afton Chemical
- Air BP
- Air Repair
- ASTM
- AVFUEL Corp
- Calumet Specialty Products
- Cape Air

- Chevron
- Cirrus Aircraft
- Commemorative Air Force
- Continental Motors
- Dixie Services
- Enstrom Helicopter
- Epic Aviation
- Ethyl Corp
- Everts Air
- Exxon Mobil
- Haltermann Solutions
- Hartzell Propeller
- Lycoming Engines
- LyondellBasell
- McCauley Propeller
- Meggitt Polymers & Composites
- National Research Council Canada (NRC)
- Phillips 66
- Piper Aircraft
- Precision Airmotive
- Precision Engines
- Robinson Helicopter Company
- Rotax Engines
- Shell Oil Products US
- Swift Fuels LLC
- Textron Aviation
- TOTAL
- Transport Canada

For FY20, the Purdue University Center of Excellence will continue to be a collaborative partner as well. Past educational and non-profit partners have included Embry Riddle Aeronautical University and Southwest Research Institute (SwRI) in addition to Purdue.

Do non-government groups partner with this program? Yes
Yes. The vast majority of the Research Collaboration Partners listed above are non-government entities.

United States Department of Transportation
FY 2020 Annual Modal Research Plans

Aircraft Catastrophic Failure Prevention Research
Enacted ($1,565,000)

Program Description/Activities/Objectives:

The FAA establishes rules for the certification and operation of aircraft engines that enhance the airworthiness, reliability, and performance of aircraft propulsion systems and installations. 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.

Aircraft Catastrophic Failure Prevention 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 rare but hazardous uncontained engine failure impact events. This research program develops 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 Transport Safety Bureau 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."

The most 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.

Today, certification of fan blade off to 14 CFR 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. FAA Experts will continue to support the user community for 'LSDYNA' Aerospace Working Group and the Uncontained Engine Debris Damage Assessment Model (UEDDAM).

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's 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 (FAR) 25.903 (d) 1 requires that OEM's minimize the threat to uncontained engine failure. After the Sioux City event in 1989, 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.

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 biweekly meetings has resulted in four 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 needed for certification by analysis. Research results are coordinated with industry during working group meetings.

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.

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. The FAA developed predictive models, model validation and user guidance under the LSDYNA Aerospace Working group which documents the current state of the art. The research to provide safety regulatory guidance and standardized certification methods are inherently governmental functions.

Program Alignment with Strategic Goals:

Safety: The Aerospace Working Group includes industry partners from both engine and airframe manufacturers working to improve the quality and increase the use of computational modeling of engine related impact failure events. Robust models and certification by analysis guidance help ensure safe engine designs and reduce the likelihood of uncontained failures. (This could also map to the Safety goal through collaboration with stakeholders).

Accountability: Regulatory Reform: Standard material models suitable for metal and composite impact and associated guidance will increase the acceptable use of analysis in the certification process. This will reduce regulatory burden and cost by reducing the number of expensive and destructive blade containment tests. The current 33.94 rule is prescriptive that physical tests must be conducted in which an engine asset on the order of 20 million dollars is destroyed. In the event of a failure, industry will not want to destroy another asset through re-test. The FAA is often presented with analysis in lieu of a re-test. However, current analyses have proven insufficient as evidenced by the loss of inlet cowlings in three recent occurrences (1 resulting in a fatality) which relied heavily upon analysis for certification following initial test failures.

Research Collaboration Partners:

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.

Program partners include:

- Aerospace Industries Association (AIA) Rotor Integrity Steering Committee (RISC)
- National Transportation Safety Board (NTSB)
- LS-DYNA Aerospace Working Group – Engine Related Impact and Failure (ERIF)
    - Arizona State University (ASU)
    - - Boeing
    - - Central Connecticut State University (CCSU)
    - - Federal Aviation Administration (FAA)
    - - General Electric Aviation
    - - George Mason University (GMU)
    - - Honda Aircraft Engine
    - - Honeywell
    - - Livermore Software Technology Corporation (LSTC)
    - - National Aeronautics and Space Administration (NASA)
    - - Northrop Grumman
    - - Ohio State University (OSU)
    - - Pratt & Whitney
    - - Pratt & Whitney Canada
    - - Rolls-Royce
    - - University of Akron
    - - United Technologies Aerospace Systems (UTAS)
    - - Williams International
- NASA
- Naval Air Warfare Center, Weapons Survivability Laboratory, China Lake
- Livermore Software Technology Corporation
- Honda R&D America

Do non-government groups partner with this program? Yes

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. The FAA has 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. The FAA also leverages facilities at the Naval Air Warfare Center Weapons Survivability Laboratory during testing at the Laboratory.

Digital Systems and Technologies

United States Department of Transportation
FY 2020 Annual Modal Research Plans

Aircraft Icing/Digital System Safety
Enacted ($9,000,000)

Program Description/Activities/Objectives:

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 small and 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

- 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. This also includes research on Ice Crystal Icing Conditions to Support Means of Compliance.

- Research on Ice Crystal Icing to Support Means of Compliance - Testing with two stage 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 - Complex Digital Systems

- Develop a refined alternative assurance process and overarching properties by leveraging collaborative agreements with aviation industry partners and NASA to understand how certification authorities and industry can adequately assess systems for overarching compliance safely within the framework of global harmonization.

- Develop use cases and analyze the cases to come up with recommended criteria for the validation and verification of Artificial Intelligence (AI)/Machine Learning (ML) implementations in airborne systems and recommend safety architectures for such implementations.

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

Aircraft Icing

The main goal in Aircraft Icing research is to improve aviation safety related to aircraft icing by developing a better understanding of the effects of environmental icing, the development of data in support of new regulations and guidance materials, the support for improvements to engineering tools for certification and operations, and improving icing weather information for decision-making in terminal areas and for in-flight avoidance of high ice water content ice crystal conditions. 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'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.

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 analyze airworthiness and certification assurance aspects of highly integrated, complex digital aircraft systems, including: systems development processes, requirements validation and integration; use of Commercial Off The Shelf (COTS) devices; new and novel electronic hardware and software implementation techniques, tools, methods, and processes; streamlining approaches to development assurance and aircraft certification. 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 to 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.

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 performers need to research ways to make the 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, Digital System Safety will research alternative methods to reduce the FAA certification footprint in the applicant's critical path while maintaining the same level of safety. In addition, the traditional lines of identifying issues, gaps, and assurance process approaches for aircraft systems and system element implementation continue to blur. Issues may affect both aircraft systems and system element development such that identifying and mitigating them may need to be addressed in both areas, rather than individually. That is, research will need to be done in multiple domains (systems, software, and electronic hardware) to address issues because they can affect more than one domain.

Program Alignment with Strategic Goals:

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. Data generated by this research is used to create and develop new safety standards that will be adopted throughout the aviation community.

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. This may take the form of collaboration, support for development of new standards, or establishment of new policy, guidance or regulation (if required).

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.

Aircraft Icing

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), Transport Canada (by means of international agreement), 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 their 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 of software and hardware. Work is also done with NASA (Langley), National Resource Council of Canada, Aerospace Vehicle Systems Institute (AVSI, a consortium of industry OEMs (Boeing, Airbus, Embraer, Honeywell, GE, and Collins Aerospace), other government agencies, and academia), RTCA, SAE International, and Carnegie Mellon University. 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 industry's 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 and academia, as well as a more intense collaboration directly with aviation industry Original Equipment Manufacturers (OEMs) and suppliers through Cooperative Research and Development Agreements (CRADAs). Benefits from this collaboration include faster industry response to potential threats, more accurate collaborative FAA/industry safety risk assessments for promotion of aviation safety through reduced regulation and more efficient use of Government resources.

In Phases 2 & 3, the FAA is working with some airlines, OEMs and suppliers to leverage their facilities, equipment and subject-matter expertise in the conduct of safety risk assessments. The number of industry participants is anticipated to expand as the program proceeds to phase 4.

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 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.

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NextGen - Information Security
Enacted ($2,675,000)

Program Description/Activities/Objectives:

The NextGen Information Security R&D objective is to prevent and predictively determine the potential of cyber events such as unauthorized access, destruction, disclosure, or modification of information or data, and/or denial of service. FAA's NAS traffic is growing with Air/Ground and Ground/Ground networks that provide communication between different users including: FAA staff, service providers, private aviation, commercial passenger, freight carriers, and partner governments. In addition to increases in traditional air traffic, the NAS will undergo significant changes to mission requirements over time. Examples of significant potential changes to the NAS include Unmanned Aircraft Systems [UAS], emerging technologies, open architectures, cloud computing, and shared aviation information. Other kinds of changes that may happen at run time, include 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.

This program conducts research on cyber data science methodologies using Machine Learning (ML) and Artificial Intelligence (AI) addressing cyber security parameters such as data volume, data velocity, data variety, data veracity, behavioral data, and a variety of other parameters. This helps to prevent disruptive cyber incidents that may impact NextGen 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 NextGen future traffic that will include digital and flexible communication in future Air Traffic Control (ATC) missions, and improve big data cyber security within Air Traffic Management Operations, Net-Centric Operations, and NAS Infrastructure (communication, and information management) resilience through:

- 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

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 when 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. These threats may focus 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 the Transportation Systems Sector as one of the 16 critical infrastructure sectors, and aviation as an essential sub-sector.

The program will take a proactive and collaborative approach to work with other Federal agencies, NAS stakeholders, and academic institutions to identify, develop, and implement methods, tools, 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 are 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 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 assessments, 2) A common framework applicable across all FAA domains – configurable to meet unique requirements within each domain, 3) methodology for prioritizing cybersecurity testing provides tangible results and outcomes that validate threat and risk, and 4) supports data-driven risk based decision making across the FAA enterprise.

Statutory Requirements:

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

This research supports FAA Cybersecurity Strategy 2019 - 2024 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. This strategy allows the FAA to 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:

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 NAS. The data generated by this research will allow the assessment of regulatory approaches, foster information sharing and facilitate coordination, collaboration with industry and other stakeholders, and allow the FAA to test and adopt new technologies throughout the NAS. This program has no specific impact on rural communities.

Research Collaboration Partners:

The program will take a proactive and collaborative approach to work with other Federal agencies, NAS stakeholders, and academic institutions to identify, develop, and implement methods, tools, 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;
- MIT/LL – Cyber data science methodologies using Machine Learning and Artificial Intelligence;
- Carnegie Mellon University/SEI – Self-adaptive Network, Strong Authentication and integrity in mixed trust environments.

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NextGen - Flightdeck Data Exchange
Enacted ($1,005,000)

Program Description/Activities/Objectives:

The Flight Deck Data Exchange Requirements (FD-DER) program addresses the data exchange format and performance requirements that enable enhanced data exchange between onboard avionics systems and ground systems for Collaborative Decision Making (CDM). Recent advancements in flight deck automation such as Electronic Flight Bags (EFBs), Aircraft Interface Devices (AIDs), and the availability of on-board Internet Protocol (IP) data links have introduced an opportunity for flight operators to leverage these technologies in the collaborative decision-making process. There is an ongoing effort to evaluate the feasibility of utilizing connected aircraft technologies to enable operational functions like downlink of aircraft specific intent data to synchronize trajectories with ground automation, but it focuses primarily on improving the ground automation capabilities. Therefore, 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 and non-certified avionics such as Flight Management Computer (FMC), EFBs, AIDs and the FAA ground automation systems using IP data links. Specifically, this research will evaluate the current cybersecurity requirements and state-of-the-art cybersecurity standards that can be imposed on the new FD data exchange architecture, and identify any additional requirements needed to achieve a secured data exchange environment. It will also define performance standards required to enable operational information exchange like taxi instructions, clearances, and trajectory negotiations, and establish data exchange protocols to enable seamless integration between airborne and ground systems.

For FY 2020, the requested funding will be used to develop a research plan, identify technical and operational needs, and conduct cybersecurity risks assessments for existing and emerging connected aircraft technologies. The project team will also conduct a stakeholders engagement exercise (e.g., table-top or similar) to engage both government and industry stakeholders, which will help to further refine the concept and requirements, and develop scenarios and use cases for flight deck data exchange.

The main goal that the NextGen – TFD-DER program addresses is the ability to exchange extensive information between the flight operator and the Air Navigation Service Provider (ANSP) in a secure manner. The current voice-based information exchange mechanisms are not adequate to enable the rich data exchange requirements to achieve full potential of CDM. The implementation of Data Communications (DataComm) Aeronautical Telecommunications Network (ATN) Baseline 2 (ATNB2) is not expected to fully address these requirements due to mixed equipage in data communication capabilities driven by cost factor of ATNB2. The resulting mixed equipage will leave a gap in the potential benefits pool for the remaining portion of the NAS operations. 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 CDM, 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, data exchange service providers, and 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.

Statutory Requirements:

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

Program Alignment with Strategic Goals:

Flight Deck Data Exchange Requirements (FD-DER) program supports the DOT's Strategic Goal of Innovation by leveraging emerging Internet of Things (IOT) technologies in aviation to improve mobility through new NAS concepts and identify potential cybersecurity risks associated with connected aircraft technology. 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 component to achieving greater efficiency of NAS 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 capabilities among non-DataComm equipped aircraft 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.

Research Collaboration Partners:

NextGen 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 a table top exercise, or similar event, and invites all relevant stakeholders from the industry and public to participate in program. The stakeholder input metrics are generally captured in meeting minutes and result in improvement in the program based on industry feedback. Another metric 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 the flight deck via System Wide Information Management System (SWIM) to overcome the information exchange challenges in creating a CDM 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 CDM environment. Aircraft OEMs will benefit from gaining flexibility in configuring and optimizing flight deck designs.

Do non-government groups partner with this program? No

Environment and Weather Impact Mitigation

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Weather Program
Enacted ($12,911,000)

Program Description/Activities/Objectives:

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 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.

The main goals of the FAA's Weather Program are to mitigate the impact of weather on the 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 mandated by FAA regulatory guidance and/or international agreements. This program addresses these goals in the following described requirements.

- *Terminal Area Icing Weather Information for NextGen (TAIWIN)* 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 Decision-Support Processes (DSPs), dispatchers and pilots
    - Benefits resulting: Improved safety, increased capacity, and reduced atmospheric emissions within the NAS

- *Convective Storms* 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) contribute to 30% of all GA accidents
    - IMC is the leading cause of fatal GA accidents in Alaska
  - Reduced 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:
  - Outcomes 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

- *In-Flight Icing* research requirement:
  - Outcome supported: High resolution diagnoses and forecasts of aircraft icing conditions to support ATM DSPs, dispatchers and pilots
  - Diagnoses and forecasts up to and beyond 18 hours over the CONUS and Alaska
  - Benefits resulting: Improved safety, capacity, and efficiency of the NAS

- *Model Development* research requirement:

- Outcome supported: Improved operationally available numerical weather prediction model resolution and refresh rates to enhance the forecast of aviation weather hazards including inflight icing, turbulence, convective storms, and low ceilings and restricted visibility
  - 0-36 hour high resolution rapid refresh capability to include forecasts over oceanic airspace
  - Global model with hourly output compatible with suite of NOAA models
  - Benefits resulting: Improved safety, capacity, and efficiency of the NAS

- *Radar Techniques Development* research requirement:
  - Outcome supported: Improved and increased weather radar systems' detection of aviation-impacting weather conditions including turbulence, icing, and convection
  - High-resolution, high quality, three-dimensional weather radar data analysis form national and international data networks
  - Capabilities integrated into the NWS Multi-Radar, Multi-Sensor (MRMS) System
  - Benefits resulting: Improved safety, capacity, and efficiency of the NAS

- *Unmanned Aerial Systems (UAS)* weather research requirement:
  - Outcome supported: Standards, requirements, capabilities and systems for weather information robustness, resiliency and effectiveness for UAS operations
  - Survey current weather research to determine alignment with gaps
  - Investigate accessibility of existing weather technology and data to UAS operators
  - Benefits resulting: Integration of UAS into civil airspace while ensuring the safety and efficiency of the NAS

- Weather Requirements for Wake Mitigation research requirement:
  - Outcome supported: Development of an airport wind and weather-based wake vortex separation advisory system
  - Incorporate weather information to calculate statistical prediction bounds on the transport and decay of aircraft wake
  - Benefits resulting: Information/Analyses to develop procedures and systems to improve NAS safety and efficiency

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 initiate or 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.

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, v13.

Program Alignment with Strategic Goals:

This program supports the DOT's Strategic Goal of Innovation by providing focused applied research and development to mitigate weather-related NAS safety, capacity, and efficiency issues. This research will also support the evolution of legacy weather capabilities that meet the weather information needs of today's NAS users into capabilities being deployed as NextGen (DSPs).

This program does impact rural communities. 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.

Research Collaboration Partners:

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 research 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, and
- National Research Council of Canada (NRC).

Do non-government groups partner with this program? Yes

The Weather Program has on-going partnerships with Delta Air Lines, American, Southwest, and United Airlines, as well as Airlines for America (A4A), Aircraft Owners and Pilots Association (AOPA), Airline Pilots Association (ALPA), and the International Civil Aviation Organization (ICAO) to determine the suitability of Weather Program capabilities for use by airline flight operations. Airline flight crews, dispatchers, and in-house meteorologists evaluate capabilities that provide timely and accurate observations and forecasts of turbulence. Feedback from these evaluations enable the FAA to refine 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.

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NextGen - Weather Technology in the Cockpit
Funding Request ($3,144,000)

Program Description/Activities/Objectives:

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, and
- 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.

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, gaps in cockpit MET information, and gaps 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 shortfalls, 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 and thus lack this 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. This information will also enhance access to underserved communities by enabling more Visual Flight Rules (VFR) flights due to the availability of accurate visibility and ceiling information.

- 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 are 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 that identified that many MET displays on the market lack the proper salience for pilots to notice a state change (i.e., VFR to IMC conditions) 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. Ths means that even 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 recommendations to

pilots and industry. Users 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 research requirements as applicable 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, and
- NTSB safety alerts identify critical gaps identified as causal factors in accidents that require research to resolve.

Statutory Requirements:

Is this program statutorily mandated (Y/N): Yes, as listed below.

- 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:

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 NAS. The data obtained by this research will inform the assessment of regulatory approaches, foster information sharing, facilitate coordination and collaboration with industry and other stakeholders, and provide 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; 1) resolve identified safety hazards and risks (identified by the WTIC program or stakeholders including NTSB, AOPA, and the Alaska Air Carriers Association), identify performance gaps linked to safety hazards and risks, and 3) 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 decisions, weather delivery applications, and pilot education." Consistent with this stakeholder input, the WTIC program is performing research to increase 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 rely 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 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 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 identifies 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's 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 provide 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.

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.

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Environment and Energy
Enacted ($18,013,000)

Program Description/Activities/Objectives:

The Environment and Energy (E&E) Program is key to the FAA's strategy to achieve environmental protection that allows sustained aviation growth. The Program advances understanding of civil aviation noise and emissions at their source, how noise and emissions propagate and are modified in the atmosphere, and their ultimate health and welfare impacts. A central part of the program is the continued development of an integrated aviation environmental tools suite that can be used to evaluate a wide range of environmental mitigation solutions. The suite is built upon a sound scientific understanding of aviation noise and emissions as well as their environmental, health, and welfare impacts. The tools analyze and inform decision-making on technology development, operational procedures, regulatory compliance, and international and domestic standards and policies relating to civil aviation's energy use and environmental impacts.

Aviation noise and emissions are a considerable challenge to the continued growth of the NAS. Despite the technological advancements achieved during the last four decades, and the resultant 95 percent 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 through the Part 150 Program. 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. Technologies that reduce noise and emissions are regulated at the vehicle level as a part of airworthiness certification. These environmental standards are harmonized internationally through the International Civil Aviation Organization's (ICAO) Committee on Aviation Environmental Protection (CAEP). A significant portion of this Program is devoted to informing decision making at ICAO CAEP. Further, this Program supports domestic policy and regulatory considerations in the absence of timely consensus on international policies and standards.

NOISE INNOVATION. The E&E Program is producing data and knowledge that are the scientific and technical foundation for decision making and mitigations development for aviation noise. Through the Aviation Noise Research Roadmap, the Program is advancing our understanding of the impacts of aviation noise on community annoyance, sleep, health, and children's learning. The Program also supports noise measurements of existing air vehicle types and new entrants for the airworthiness noise certification requirement. The E&E Program, in close collaboration with industry, National Aeronautics and Space Administration (NASA), and international partners through ICAO CAEP, 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 transportation. Additional work will be initiated on the development of the data, techniques, and tools that will be necessary to enable the FAA to respond to potential noise concerns associated with the introduction of Unmanned Aircraft Systems (UAS) and Urban Air Mobility (UAM) vehicles operations into the national airspace system (NAS). This includes the development of tools to understand their noise to enable cost effective noise certification, which is required as a part of air worthiness, and identification of means to reduce their noise impact.

EMISSIONS INNOVATION. The E&E Program is also producing data and knowledge that are the scientific and technical foundation for decision making on aviation emissions. Through the Aviation Emissions Characterization Research Roadmap, the Program is advancing our understanding of how aviation emissions form and are dispersed in the atmosphere. Because of their adverse health impacts, the current focus of emissions research is on aircraft particulate matter emissions, a regulated criteria pollutant in the United States, and the development of an engine particulate matter emissions standard in ICAO CAEP. The Program is also supporting the development of aviation emissions standards for supersonic aircraft and laying the groundwork to understand the emissions impacts from other new entrants.

AVIATION ENVIRONMENTAL TOOLS SUITE. The E&E Program is developing a comprehensive suite of analytical tools to quantify the environmental consequences and impacts of aviation. These analytical tools provide 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 market, policy, technology, and operational scenarios. At the center of these analytical tools is the Aviation Environmental Design Tool (AEDT), which can quantify the noise, fuel burn and emissions resulting from aircraft operations from the airport gate through ground movements, takeoff, climb-out, cruise, approach, and landing at the aircraft's final destination. Research continues to improve the ability of AEDT to model noise at lower levels to address community concerns in areas at relatively large distances from airports including supersonic aircraft. These new capabilities will enhance our ability to design effective options to mitigate noise and emissions impacts of aircraft operations. The Program also supports the development of analytical tools that quantify the costs and benefits of varied solutions to reduce aviation noise and emissions. Additional work will be initiated on the development of the data, techniques, and tools that will be that will have to be integrated into the suite in order to begin assessing the noise impact associated with the introduction of UAS and UAM vehicles operations into the NAS.

STREAMLINING ENVIRONMENTAL APPROVALS. The E&E 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. The new tool will enable the FAA to perform effective screening analysis and provide users with powerful analytics to improve the communication of results to the public. Additionally, further efficiencies will be realized with the support of two additional parallel development activities. The first is the development of a standard automated process for the generation of the baseline trajectory and operational data used as the starting point of the review analysis. The second is the creation of a web-based visualization tool that provides the infrastructure needed to easily generate consistent and standardized visual information for reporting and communication.

ANALYSIS. The E&E Program uses the aforementioned models and knowledge to inform decision-making on technology, fuels, operational procedures, and policies relating to aviation's energy use and environmental impacts. Efforts under this project support the development of operational procedure concepts to reduce noise, emissions and fuel use from aircraft and helicopters. Efforts also support the development of standards, market-based measures, and policies within ICAO CAEP for subsonic and supersonic civil aircraft. The CAEP 12 work program includes a task focused on performing an exploratory study for supersonic aircraft that will provide the foundation for the development of an intentional standard for supersonic aircraft noise. Such a standard will ensure that the industry will have a consistent international regulatory framework that will enable the development and growth of supersonic air transportation.

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:

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. 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 a specific impact on rural communities.

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, Department of Energy (DOE), Environmental Protection Agency (EPA), and Department of Defense (DOD), most of which are 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 Center of Excellence for Alternative Jet Fuels and Environment (ASCENT), 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 on 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 DOD, Department of the Interior (DOI), DOT, EPA, NASA, and the Department of Housing and Urban Development (HUD). The National Institutes of Health (NIH) 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 and supporting the development of reduced noise procedures. Entities in Europe are funding work on the impact of noise on sleep that is aligned with the FAA work. Massachusetts Port Authority (Massport) is contributing support to the development of new reduced noise procedures for subsonic aircraft at Boston Logan Airport.

Work on emissions 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.

ACRP 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.

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.

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NextGen - Environmental Research - Aircraft Technologies and Fuels
Enacted ($29,174,000)

Program Description/Activities/Objectives:

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. This Program also provides test data, analyses, and methodologies to ensure that alternative jet fuels that are drop-in compatible with today's fleet of aircraft are certified as being safe for use and are being appropriately credited under the ICAO Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA).

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

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 third phase of the CLEEN Program, 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 third phase of the CLEEN Program are to develop and demonstrate certifiable engine technology that reduces:

- Noise levels by 25 decibels cumulative, relative to the Stage 5 standard and/or reduces community noise exposure,
- Aircraft fuel burn by 20% below the International Civil Aviation Organization standard adopted in 2016,
- 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 begin product development for entry into service.

This Program also provides funding for alternative jet fuel testing and analysis efforts of the Aviation Sustainability Center (ASCENT), the FAA Center of Excellence (COE) for Alternative Jet Fuels and Environment, a cooperative aviation research organization co-led by Washington State University and Massachusetts Institute of Technology (http://ascent.aero). This Program also supports the Commercial Aviation Alternative Fuels Initiative (CAAFI) and its effort to engage with both the commercial aviation and emerging alternative fuels industries (http://caafi.org). The continuing work of CLEEN, CAAFI and ASCENT to develop alternative jet fuels via fuel testing, integrated analysis and coordination will help to ensure that aviation has a wide range of energy options for decades to come.

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, 47511, and 48102.

Program Alignment with Strategic Goals:

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 a specific impact on rural communities.

Research Collaboration Partners:

All three of the programs, CLEEN, CAAFI and ASCENT, are conducted in partnership with a wide range of aviation stakeholders that leverage resources from the private sector. CLEEN is a public private partnership where industry contributes cost share that matches or exceeds that provided by the FAA. CAAFI is a coalition among the FAA, airlines, aircraft and engine manufacturers, and industry where each entity contributes staff

resources to focus the efforts of commercial aviation to engage the emerging alternative fuels industry. ASCENT, like all FAA COEs, has a 100% cost share requirement from non-federal sources and an Advisory Committee that has robust participation from a wide range of aviation stakeholders, including industry.

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 had 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.

As noted previously, the work on alternative jet fuels is coordinated with industry and academia through CAAFI and ASCENT. We also coordinate across the U.S. Federal Government as well with local authorities and international organizations and nations.

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 in operation through 2020. The third phase of CLEEN is expected to begin operation in 2020.

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.

Human Performance and Aeromedical Factors

United States Department of Transportation
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Flightdeck / Maintenance / Systems Integration Human Factors
Enacted ($7,300,000)

Program Description/Activities/Objectives:

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.

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 2020, four different research areas are planned to be addressed. The first one is *Human Factors to Support Risk Based Decision Making.* 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 2020 is *Advanced Vision Systems – Enhanced Flight Vision System, Enhanced Vision Systems, Synthetic Vision Systems, Combined Vision Systems, Heads Up Displays, Helmet Mounted Displays – Certification and Ops Approval Criteria.* This research evaluates human performance while using these systems in various conditions including low visibility operations. 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 third research area 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).

The fourth research area is *Pilot Training, Qualification, Procedures and Flight Operations.* This research will focus on the development of data-driven guidance for inspectors and operators on training methodologies, as well as qualification and operational procedures. Research will also aim to provide data-driven recommendations to address emerging risks, including that of the upcoming pilot workforce and risks introduced by generational differences. The results of this research are directly applicable to updating regulations and guidance material related to pilot training and operations for flight standards inspectors and

operators, including but not limited to 14 CFR Parts 60, 65, 119, 121 (Subparts N, O, & Y), 135, 142 and FAA Order 8900.1. Upgrades to traditional and AQP training and checking guidance will keep the FAA in a continuous improvement process for safety. The development of recommended practices for different training methods will enable operators to develop, and inspectors to evaluate training methods that will utilize new capabilities, such as interactive mobile technology and augmented reality.

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. 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 of and generalizable to the current pilot population. 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.

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 human performance, safety risks, and aviation accidents. Our research lab is a world leader in assessing human performance in aviation, identifying unintended risks from new technologies, and developing corrective methodologies or mitigations to maintain our aviation safety performance and improve efficiency of the NAS.

U.S.C. Title 49 § 44507 Regions and centers

(a) Civil Aeromedical Institute. – The Civil Aeromedical Institute established by section 106(j) of this title may –

(1) conduct civil aeromedical research, including research related to –

(F) 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;

(G) agency work force optimization, including training, equipment design, reduction of errors, and identification of candidate tasks for automation;

(2) make comments to the Administrator of the Federal Aviation Administration on human factors aspects of proposed air safety regulations;

(3) make comments to the Administrator on human factors aspects of proposed training programs, equipment requirements, standards, and procedures for aviation personnel;

(4) 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 Human factors program

(a) Human Factors Training.

(2) 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. They are 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:

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 data from this research is used to create and develop new safety standards that will be adopted throughout the aviation community.

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, percentage 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. Examples of partnerships include:

- 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, Universal Avionics, Sirius XM;

- 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; and

- International - ICAO, EASA, CAA, SAE, and International Air Transport Association (IATA), North Atlantic Treaty Organization (NATO).

The FAA's strategy is to work closely with all vested stakeholders to ensure our research is timely and has buy-in from the potentially impacted parties. The FAA frequently hosts international research summits and representation always includes FAA, academia, industry, and labor. The chief scientists and lead researchers coordinate with respective international counterparts to ensure knowledge sharing and knowledge building. The FAA collaborates 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.

United States Department of Transportation
FY 2020 Annual Modal Research Plans

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

Program Description/Activities/Objectives:

The purpose of this Air Traffic Control/Technical Operations (ATC/ATO) Human Factors program is to provide scientific and technical information that our Air Traffic Organization technical sponsors will apply in their work to improve the safety and efficiency of complex ATC systems. The research that we conduct produces information supporting the ATO's needs by measuring and enhancing the performance of individual controllers and specialists, improving the integration of NAS technologies for controllers and technicians, addressing the human contribution to safety in air traffic control operations, and supporting data-driven decisions related to the workforce, including selection methods, job placement, performance measurement, and training.

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) guidance to reduce air traffic controller and technician errors and improve safety, (2) methods and data to optimize the controller and technical operations workforces, (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 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). The 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. The FAA will also oversee 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 2020 will enable us to help our ATO customers improve the efficiency with which they can hire and train these aviation professionals.

In FY 2020 the program will continue to generate standards and guidance to enable ATO program offices to comply with 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.' In support of system acquisitions that are managed within the ATO Program Management Office, the R&D program in FY 2020 will provide guidance and scientific information to address key issues in user-system interface 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 ATO's Program Management Office (AJM) and Mission Support Services (AJV) coordination, provides useful human factors R&D results including human factors design guidance and data that support the development and implementation of new technologies and procedures in the National Airspace System. The program's research results and guidance enables ATO technical sponsors to adopt personnel selection and training policies and practices to give the proper roles and responsibilities to the ATO workforce, and to ensure that controller and technician capabilities are compatible with the advanced technology they use in their jobs. The ATC/TO 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;
- Evaluate the controller selection process in relation to predictors of FAA Academy and field training success;
- 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;
- Assess controller use of advanced ATC automation capabilities and identify human factors considerations that could be affecting their use;
- Conduct research to optimize the presentation of air traffic control information in the controller's display;
- Develop a strategy and supporting demonstrations and training materials to enable the ATO's program management offices to implement the updated color palette in air traffic controller displays;
- Identify applicable human factors guidance for ATC and Technical Operations displays and printers and incorporate this into the Human Factors Design Standard;
- Develop handbooks providing program offices with guidance about how to best integrate decision support tools and alarms and alerts into air traffic systems;
- Develop controller performance measures to inform the ATO's assessment of the effectiveness of new controller procedures and job responsibilities in managing air traffic flows as part of trajectory based operations;
- Evaluate the suitability of proposed dynamic controller aptitude tests for assessing candidate new hires;
- Identify and conduct human-in-the-loop simulation studies to validate the effectiveness of controller visual scanning instructional methods; and
- Evaluate available data on controller performance following unexpected operational events and the effectiveness of proposed approaches for facilitating recovery to normal operations.

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 to 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 FAA employees.

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;

(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.

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 for use 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.

Note: In "The Future of Air Traffic Control," the National Research Council made 49 recommendations for FAA human factors research in the following topic areas:

- Levels of automation
- Adaptable automation
- Recovery
- Locus of authority
- Teamwork
- Cross-cultural issues
- Communication: Data Link
- Flight Management System
- Flight data
- Traffic Alert and Collision Avoidance System
- Converging Runway Display Aid
- Precision Runway Monitor
- Avoiding collisions on the ground
- Center TRACON Automation System
- Conflict Probe and interactive planning
- Four-dimensional contracts
- Surface Movement Advisor
- Support functions
- The future National Airspace System
- Development and installation of advanced systems
- Long-range planning

These recommendations provide supporting rationale for ATO research requirements that support integration of human factors in ATC system automation, such as the use of human-in-the-loop simulations to

identify human-system integration challenges and potential mitigations. These feed into the planning and requirements for the ATO's Program Management Office to use on its acquisition programs. For example, under the headings "Development and Installation of Advanced Systems" and "Long-Range Planning," the National Research Council made these recommendations, which remain central to safe and efficient operations in the NAS, with the introduction of new ATC capabilities.

- "Recommendation 7: The panel recommends proceeding gradually with the *introduction* of automated tools in the workplace, giving adequate attention to user training, to facility differences, and to user requirements, and carefully monitoring the *operational experience* from initial introduction, putting mechanisms in place to respond rapidly to both positive and negative lessons learned from those experiences."

- "Recommendation 1: During development of each automation function, system developers should consider possible interactions with other automation functions (under development or already existing), tools, and task requirements that form (or will form) the operational context into which the specific automation feature will be introduced."

R&D efforts that include analysis and human-in-the-loop simulations provide the necessary data to guide the program offices in the development and implementation of these new automated tools, procedures, and capabilities.

Program Alignment with Strategic Goals:

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 data generated by this research is used to create and develop new safety standards that will be adopted throughout the aviation community.

The Air Traffic/Tech Ops human factors FY 2020 research program supports 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.

Research Collaboration Partners:

Public input about research requirements is provided by the REDAC, in particular by the Human Factors REDAC subcommittee. While the work contributes to improve NAS performance, safety, and efficiency and thus ultimately benefits users of the NAS and the public, the sponsors and stakeholders on this research program are not members of industry, but primarily managers and employees of ATO organizations. This is true because the ATC/TO Human Factors program research requirements are provided by the ATO research sponsors and then the ATO sponsors and the Deputy Vice Presidents for the ATO's Service Units concur with the allocation of resources through the ATO's Human Factors Research Roundtable.

Nevertheless, we respond to requests and questions submitted to us through the FAA.Gov web site. As an ISO organization , ATC/TO Human Factors program records 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 NextGen Human Factors Division employees and internal FAA human factors research team members 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. 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
- Mike Monroney Aeronautical Center NextGen Integration Committee
- Wright State University., 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 the ATC/TO Human Factors program 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.

United States Department of Transportation
FY 2020 Annual Modal Research Plans

NextGen – Air Ground Integration Human Factors
Enacted ($5,300,000)

Program Description/Activities/Objectives:

The NextGen – Air Ground 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 future aircraft operations. Functionally, human factors research products support Aircraft Certification and Flight Standards personnel who evaluate and approve emerging flight deck displays, devices, procedures, and operations that leverage FAA investments in NextGen changes.

The primary goal of the NextGen - Air Ground Integration Human Factors Program is enhanced safety and operational efficiency. In FY2020 two research areas are planned to be addressed. The first one is *NextGen Human Error Mitigation Research.* This research aims to proactively detect and respond to NextGen flight deck technology shortfalls/gaps that could increase the opportunity for human error in future NAS operations. Potential FY2020 focus areas include addressing the pilot performance impact(s) of NextGen automated systems, evaluating the human factors system resiliency impacts introduced by initial and full Trajectory Based Operations (TBO), and identifying far-term flight crew task management needs. FAA stakeholders may apply research outputs to conduct technology design reviews, evaluate system design alternatives, and respond to emerging human-system interface issues. Stakeholders may also apply research outputs to update FAA regulations (e.g. 14 CFR Part 121, Subparts N, O, Y (AQP); 14 CFR Parts 2X.1301, 25.1302), corresponding guidance materials, and best practices that are used to assess NextGen technologies/systems for human error tolerance.

The second research area is *NextGen Flightcrew Readiness Research.* This research will respond to strategic 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. Potential FY2020 focus areas include the human factors identification of new NextGen normal and non-normal situations and how those situations compare to current day operations, the identification of changes in pilot competencies (e.g. tasks, procedures), and the development of data-driven recommendations to support future training and assessment needs. FAA stakeholders may 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 (e.g. 14 CFR Part 121, Subparts N, O & Y, AC 120-54 Advanced Qualification Program, AC 120-71 Standard Operating Procedures, AC 120-51 Crew Resource Management, and AC 120-35 Line Operational Simulation).

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.

U.S.C. Title 49 § 44507 Regions and centers

(a) Civil Aeromedical Institute. – The Civil Aeromedical Institute established by section 106(j) of this title may –
(1) conduct civil aeromedical research, including research related to –
(F) 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;
(G) agency work force optimization, including training, equipment design, reduction of errors, and identification of candidate tasks for automation;
(2) make comments to the Administrator of the Federal Aviation Administration on human factors aspects of proposed air safety regulations;
(3) make comments to the Administrator on human factors aspects of proposed training programs, equipment requirements, standards, and procedures for aviation personnel;
(4) 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:

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 NAS. Data generated by this research will allow the assessment of regulatory approaches, foster information sharing, and facilitate coordination and collaboration with industry and other stakeholders. This research also provides 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.

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.

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.

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Aeromedical Research
Enacted ($7,919,000)

Program Description/Activities/Objectives:

The FY 2020 budget allocated to the Aeromedical Research Program will support research in the following areas:

- AM-1: Aerospace Medical Systems Analyses,
- AM-2: Aerospace Medical Accident Prevention & Investigation,
- AM-3: Human Protection & Survival,
- RS-1: Occupant Protection for Legacy Rotorcraft, and
- FCS-8: Expanded Use of Analytical Modeling in Cabin Safety Applications.

These activities concern a component of the Aeromedical Accident Investigation & Prevention requirement (A11.J.AM-1, A11J.AM-2, A11.J.AM-3, A11J.RS.1, and A11.J.FCS.8).

The program is formulated to keep abreast of emerging human safety risk issues such as those brought by the aging pilot population with changes in their health condition and accompanying therapeutic solutions. It also concerns aircraft materials, equipment, cabin configurations, life support systems, and evacuation procedures that may affect survival from an aircraft accident. The program is also designed to address the complexity of software, technology, and systems integration practices as these continue to evolve. Advances in computational biology, omics sciences, modeling & simulation, and tools to facilitate the integration of very large aeromedical data sets containing disparate information will lead to improved knowledge management and decision-making processes in aerospace medicine.

Aeromedical research is performed by in-house personnel of the Aerospace Medical Research Division of CAMI. The division has two branches, Bioaeronautical Sciences and Protection & Survival, each with five research teams. The Forensic Toxicology and Biochemistry research teams serve as the primary national site for toxicology testing for federal agencies. The Functional Genomics research team is the pioneer in biomarker research pertinent to aviation safety, and the Knowledge Management research team supports all research efforts involving information technology. Protection & Survival personnel provide state-of-the-art information, procedures, and equipment evaluations relative to aircraft accident investigation, survivability, atmospheric and radiation risk, health, and security of passengers and crewmembers during normal operations and emergency events. The Cabin Safety, Biodynamics, and Environmental Physiology research teams are key contributors to the development of national and international safety equipment standards and survival procedures. The Medical research team and the Autopsy Program team maintain unique databases that facilitate the aeromedical review of aircraft accidents; and the Numerical Sciences research team is the national source of expertise for cosmic radiation events of aeromedical concern (maintaining the only repository of integrated civil aeromedical information that pre-dates safety management system concepts).

Statutory Requirements:

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

The FY 2020 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 2020 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. CAMI focuses 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. CAMI hosts high school/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 the STEM program.

Program Alignment with Strategic Goals:

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. Data generated by this research is used to create and develop new safety standards that will be adopted throughout the aviation community.

The FY 2020 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 specifically impact rural communities.

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 programs. 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 two 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&Rs and associated Agency responses.

(2) Stakeholder input pertinent to the FY 2020 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 eight 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 2020 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. We currently have a medical resident who is assisting internal Medical Research Team by analyzing the publicly available NTSB accident database, with parameters set jointly with internal Medical Doctors and Mathematicians.

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Airliner Cabin Environment Research
Enacted ($1,000,000)

Program Description/Activities/Objectives:

There are frequent reports of air contaminant events on commercial airplanes. Some of these events are attributed to leaks from engine/APU oil or other fluids being distributed throughout the cabin and flight deck. However, no airplane level research has been done to determine the actual contaminants present when engine/APU oil enters the engine/APU bleed port and travels through the airplane environmental control system.

Statutory Requirements:

In FAA 2018 Reauthorization Section 326 US Congress mandated FAA to commission the Airliner Cabin Environment Research (ACER) Center of Excellence (COE) to conduct research to determine the safety impact of air contaminants in the cabin and flight deck and to define the threat from these contaminants on commercial airplanes.

Program Alignment with Strategic Goals:

As required in the operating regulations, airline operators have reported the presence of fumes/smoke in the flight deck and cabin during revenue flights. They report symptoms that could indicate the presence of certain contaminants that can impair the performance of their duties and lead to long-term health effects. In a few instances, pilots and flight attendants have declared themselves unfit to continue their duties and have sought aid from medical personnel. There is no data on how the chemistry of air contaminants may change as they enter the environmental control system of an airplane. Laboratory testing on the pyrolysis of oil or hydraulic fluid shows that these can release toxic chemicals. But no testing has been accomplished to see how these chemicals may be altered by the temperature and pressure changes in the ECS, prior to delivery into the flight deck and cabin. Successful completion of this research could lead to regulatory guidance requiring sensors that warn of dangerous contaminants.

This research aligns with the DOT RD&T Strategic Plan in two areas, Safety (i.e., *Reduce transportation-related fatalities and serious injuries across the transportation system*) and Innovation (i.e., *Lead in the development and deployment of innovative practices and technologies that improve the safety and performance of the nation's transportation system.*). Many flight diversions and air-turn backs are the result of smoke/fume events. This research could lead to a reduction in unnecessary diversions and improve aviation safety.

Research Collaboration Partners:

This project will be worked jointly by several internal partners, including ANG, AIR, AFS, and AAM, plus external collaboration with the primary groups who were involved in the former ACER RITE CoE that is specified in the legislation. External collaborators will very likely include Kansas State University, but may include different groups from the aviation industry and academia, for specific task performance, as necessary.

Do non-government groups partner with this program? Yes

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NextGen Transportation System – Enterprise, Concept Development, Human Factors & Demonstrations Portfolio
Enacted ($19,000,000)

Program Description/Activities/Objectives:

Enterprise Concept Development, Human Factors, and Demonstration Portfolio 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 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

Program Alignment with Strategic Goals:

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 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 specifically impact rural communities.

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.

This program utilizes input from FAA stakeholders and industry partners through the participation in several collaborative communities and workgroups. These partnerships provide advice, recommendations, identify high benefit capabilities and ensure international harmonization.

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 implementating this plan.
International Civil Aviation Organization (ICAO) (external)	Partnership with ICAO ensures FAA's part in 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 collaborates 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

Aviation Performance and Planning

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System Safety Management
Funding Request ($4,500,000)

Program Description/Activities/Objectives:

This Budget Line Item funds two programs: System Safety Management and Terminal Area Safety research. The main goals of the these programs are to effect overall improvements in the safety of flight for operational areas such as air traffic control, commercial aviation, general aviation and rotorcraft, as well as safety improvements at, or near, airports.

Some of the projects within this program:

- Are designed to improve safety through addressing systematic safety issues including emerging safety issues across the 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, the FAA has developed 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 braking 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).

The System Safety Management (SSM) program, more specifically, 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 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 2020 funds will support the FAA Administrator's strategic initiative of improved risk-based decision-making. Loss of separation is a major safety concern for 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. In addition, FY2020 funds will also support 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.

Furthermore, the general aviation (GA) research improves the safety of GA operations. FAA guidance (Handbooks and Advisory Circulars) and testing standards (Airman Certification Standards/Practical Test Standards or ACS/PTS) include required flight maneuvers to evaluate airman skills to control the aircraft. However, many of these required flight maneuvers date back to pre-World War II. For example, the first known use of the Chandelle, an abrupt climbing turn of an airplane 180 degree in which the momentum of the airplane is used to attain a higher rate of climb, was 1918. The FY20 funds will support the research to gather technical information to develop and purpose appropriate revision to the required flight maneuvers, which will help to mitigate the LOC in flight, that GA pilots will be trained and tested on.

The Terminal Area Safety (TAS) program, more specifically, 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 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) as well as the leading cause of rotorcraft fatal accidents as detailed over the most recent five-year reporting period per the United States Helicopter Safety Team (USHST).

Recent landing overruns on wet runways have raised questions regarding the validity of current wet runway stopping performance requirements and methods documented in 14 CFR Part 25.109(c) and AC-25-7C, which were developed based on analyses of data by the Engineering Sciences Data Unit and collected during NASA's flight tests in the 1960s and 1970s. The touchdown speed of commercial aircraft back then was around 100 knots; however, modern aircraft landing speeds could be as high as 160 knots. Lack of action risks that the increasing operations of the modern jet transport fleet expanding into more marginal airports – at heavier weights and higher approach speeds – may increase the number of landing overruns and casualties following approaches to wet or contaminated runways. 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 braking friction and recommend next steps for the government and industry such as updating aircraft landing performance standards, which in turn, will promote aviation safety.

FY 2020 funding will support the current plan for wet runway stopping performance project, which includes three primary efforts: physical flight-testing, drainage experiments, and big data analytics/machine learning. Flight-testing is planned to be conducted at a designated facility, such as NASA Wallops Flight Facility, using a test aircraft from either the FAA, NASA, or a third-party contractor. It will be performed in controlled conditions while measuring the significant factors affecting wet runway wheel braking effectiveness and aircraft hydroplaning. Drainage and water depth experiments are also planned to be conducted at Atlantic City International Airport and/or other facilities such as NASA Wallops Flight Facility. This work would involve measuring pavement texture and using a variety of equipment in natural or simulated rainfall conditions to

draw correlations to predict water depths on runways during rainfall. Finally, the big data analytics/machine learning work is in collaboration with academia and industry and involves obtaining large amounts of data from a variety of sources and applying machine learning methods to identify degraded braking conditions and predict when an aircraft has an increased risk of experiencing degraded braking prior to landing on a wet or snow-covered runway.

Hazards associated with go-arounds have been documented in reports by the Bureau d'Enquetes et d'Analyses (BEA), the FSF, and the Commercial Aviation Safety Team (CAST). BEA published "Study on Aeroplane State Awareness during Go-Around" which documents at least 25 airplane-state-awareness-during-go-around accidents or incidents that occurred between 1985 and 2010. Based on the analysis of the accidents, the BEA report includes 14 recommendations for improving go-around safety such as developing more realistic go-around training scenarios, improving crew resource management, and simplifying aircraft management during go-arounds. In 2013, the Flight Safety Foundation held a Go Around Safety Forum which resulted in eight strategies for improving go-around safety such as improving crew dynamics, simplifying the go-around decision and properly communicating go-around risks to the industry.

In 2014, CAST issued a safety enhancement (SE 198) to develop scenario-based training for go-arounds to include scenarios for go-arounds at other than the decision height, somatogravic illusions (false sensation of pitching up during a forward acceleration), extreme pitch trim configurations, such as nose up trim resulting from flight at speeds below the landing reference speed with the autopilot engaged. To that end, the FAA has been conducting research and seeking training solutions that improve go-around safety for transport category airplanes by mitigating potential risks during go-arounds such as loss of situational awareness, poor crew resource management, aircraft management mistakes, and the somatogravic illusion. FY20 funds will support the continuation of this research by the FAA. Pending the outcome of the research, the FAA may develop and publish policy and guidance material regarding go-around safety.

In the helicopter community, recent accidents and incidents related to helicopter loss of control have highlighted the need to focus on improved training to allow pilots to avoid these conditions. These include examining the methods for improved simulator/flight training device mathematical models for helicopter flight dynamics. These models are not accurate at edge-of-the envelope and outside-of-the envelope flight regimes and this is leading to inaccurate control inputs for pilots seeking to recover from a loss-of-control condition. A review of recent accidents indicated that the majority of accidents that occurred from this condition were due to the pilot's loss of situational awareness as well as their ability to effectively control the helicopter during basic maneuvers (e.g., Hover, Quick Stop, etc.) and recover from potentially unsafe conditions (e.g.,. Loss of Tail Rotor Effectiveness, Settling with Insufficient Power, etc.). This research project seeks to develop more accurate full flight simulators (FFS)/aviation training devices/flight training devices for all segments of the helicopter community by developing better mathematical/physics based models for helicopter flight dynamics and eliminating unrealistic simulation of catastrophic events (e.g., low main rotor rpm during autorotation) through better, higher-fidelity, and more realistic simulator models.

Another safety-related issue facing the FAA today are helicopter fatal accidents, primarily those related to low visibility conditions at low altitude in marginal or inclement weather. To insure the safety of the NAS, the FAA is looking at several technology/equipment solutions. A recent review by the United States Helicopter Safety Team (USHST) of the fatal accidents from 2009-2013 indicated that the majority of UIMC accidents that occurred were due to the pilot's loss of situational awareness, visual cues, and spatial disorientation; often due to visibility issues that limited the pilot's ability to see and remain well clear of wires. Thus, the FAA needs to examine operational concepts and develop criteria for approving new vision-enhancing technologies and develop the regulatory basis (i.e. policy, guidance, rulemaking, etc.) to enable their use as part of an improved low-level helicopter infrastructure. Helicopter Vision Systems research is required to assess new operational concepts for the use of vision systems in all-weather conditions and varied mission environments during critical phases of flight (approach, departure, takeoff, landing, and hover). This research project on Enhanced

Helicopter Vision Systems (EHVS) examines performance criteria that will allow helicopters to achieve higher levels of safety and efficiency by using Vision enhancing technologies.

Using FY 2020 funds, the research team will review current simulator/flight training device models for fidelity and gaps in model data for outside-of-the-envelope flight regimes (e.g., Hover, Quick Stop, LTE, VRS, Autorotations, etc.). In addition, the team will examine the role of Vision Systems Technology and interoperability with other helicopter navigation and surveillance systems for Head-Worn/Helmet-Mounted/Heads-Up Displays and explore the feasibility of landing system technologies and augmented reality concepts with Enhanced/Synthetic/Combined Vision for helicopter pop-up landing zone operational concepts for HAA scene pickup, commercial transport, and search and rescue mission segments.

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 (b) (7) which states "…to develop technologies and methods to assess the risk of and prevent defects, failures, and malfunctions of products, parts, processes, and articles manufactured for use in aircraft, aircraft engines, propellers, and appliances that could result in a catastrophic failure of an aircraft."

Program Alignment with Strategic Goals:

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. Data generated by this research is 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. In addition, 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) plans 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 impacts the flying public no matter where they live including rural communities. In particular, the helicopter safety research being conducted in FY 2020 that focuses on improving the fidelity of models for helicopter simulator/flight training devices and enhanced helicopter vision systems offers benefits for increased all-weather operations to rural communities by enabling life-saving Helicopter Air Ambulance operations. These operations would otherwise not be flown safely as they occur in areas where minutes count and transportation by vehicle would result in subsequent loss of life when not located in close proximity to a hospital.

Research Collaboration Partners:

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, 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 two 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.

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. The research team lead will present the Stabilized Approach research findings during the April 2019 Infoshare meeting.

Helicopter safety research project team members for the Simulator Fidelity and Vision Systems Technology projects participate in industry safety teams/working groups (e.g., SAE G10/A4 Committee on Head-Worn/Heads-Up Displays, EUROCAE Working Group 79 & RTCA SC-213 on Enhanced/Synthetic/Combined Vision Systems) to develop and validate concept of operations, standards, and advisory materials. The project also supports the United States Helicopter Safety Team (USHST), through several active Helicopter Safety Enhancements that utilize the work being done under these research project areas.

The helicopter safety research team has established a vast multitude of partnerships within the rotorcraft industry. These partnerships have included Cooperative Research and Development Agreements (CRADA's) and Other Transaction Agreements (OTA's) with vision systems manufacturers such as Thales, Elbit Systems, Astronics-MaxVis, Rockwell Collins, Honeywell, Hensoldt, CMC, and others contributing time, engineering resources, and sensors/displays for testing as part of the research effort. In addition, the program has also had partnerships with several OEM's (Sikorsky, Leonardo, Airbus Helicopters, Bell, Robinson, etc.). Further, the program has established partnerships with the DOD for Degraded Visual Environment Laboratories, NASA, various institutions of academia (Rowan University, Iowa University Operator Performance Laboratory), and several other stakeholders (i.e. HAI) to achieve a common goal. All of these entities have contributed significantly towards these efforts in order to assist with progress towards the common goals of the research and reduction of the fatal accident rate. This benefits the travelling public and saves the FAA and industry considerable money while establishing mechanisms to share information between all of the various entities involved in the research activities.

With regards to the wet runway wheel braking testing research project, partnerships are being established with academic and industry organizations primary for the big data analytics/machine learning effort. This work involves obtaining digital flight data recorder (DFDR) data and applying machine learning methods (e.g., clustering, random forests, neural networks, etc.) to first identify degraded braking conditions and then to predict when an aircraft on approach has an increased risk of experiencing degraded braking prior to landing on a wet or snow-covered runway. The logistics of these collaborations and partnerships are still in the early stages; the research team is hopeful they will strengthen the machine learning aspect of the overall project through increased access to machine learning expertise as well as availability of data.

Do non-government groups partner with this program? Yes

This program plans to establish Cooperative Research and Development Agreements (CRADAs) to collaborate with aviation industry.

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Commercial Space Transportation
Enacted ($2,500,000)

Program Description/Activities/Objectives:

Commercial Space Transportation (CST) research focuses on four priorities, which are aligned with DOT and National Space Council priorities. These include safe integration of commercial space operations into the NAS, spaceport infrastructure, systemic safety initiatives, and regulatory reform.

Examples include the definition of separation standards between operations of commercial space systems to ensure safe integration of air traffic management during space vehicle operations, and refining collision avoidance analysis methods. Other tasks, such as studying spaceport industry trends and assessing spaceport policy goals, focus on the priority of improving spaceport infrastructure. Tasks supporting the priority of overall systemic safety of commercial space include the creation of a launch vehicle breakup database to determine aircraft debris vulnerability. Finally, the priority of regulatory streamlining includes developing leading-edge methodologies in performance-based regulations (PBRs), and investigating new standards that improve fidelity and reduce overly burdensome or conservative regulatory approaches. Through this approach, the industry can be regulated to the least extent necessary while maintaining safe operations.

The primary mission of the FAA Office of Commercial Space Transportation (AST) is to regulate commercial space launch and reentry operations. This is 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.

Commercial space transportation provides direct benefits to the nation. Some benefits directly support U.S. Government (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 in December 2014, 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. An impressive list of U.S. rockets all made their maiden flights with an FAA-issued commercial launch license, including Atlas V, Delta IV, Antares, the Falcon-9-Heavy, and all previous Falcon's.

AST will use FY 2020 funds to facilitate U.S. global leadership in CST by researching solutions that optimize safety and efficiency through innovation, collaborative research, and prototype development. AST's FY 2020 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. The funding supports regulatory research to address lessons learned and to keep pace with the dynamic CST industry, and industry development research that benefits all actors within different commercial space industry segments.

Current R&D priorities are:

1. Safe Integration of Commercial Space into the NAS: 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, and quickly release airspace.

2. Spaceport Infrastructure: develop policies and methods to understand and assess the effect of spaceport operations on the public, airspace/airport operations, safety of population centers, and critical national assets.

3. Systemic Safety Initiatives: risk-based approach to human safety (e.g. research practices for crew human factors, develop airspace separation standards).

4. Regulatory Reform: create consolidated, performance-based regulations to ensure public safety, reduce regulatory burdens, and enable rapid industry growth/launch cadence.

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 improvements to the investigation of conditional risk, of past and other foreseeable launch and reentry operations, including uncertainties. This work will become the basis for draft guidance on valid methods to compute conditional risks and provide examples that could be included in a future advisory circular.

- Advanced safety assessment methods include the determination of the vulnerability of aircraft to fragments from the breakup of the vehicle. Since explicitly developing test data and models for each combination of target material and impactor would be extremely time-consuming and expensive, it is desirable to develop a reduced parameter model that is more flexible and encompasses a range of targets and impactors. A small, but sufficient parameter set will be used to characterize the particular target and impactor and to predict penetration.

- Advanced vehicle safety technologies involves aircraft vulnerability testing and modeling with the goal of improving current models. This activity tests debris of varying material properties (such as density, ductility, etc.), geometries (including complex shapes of rods, plates, “corn flakes”, etc., beyond simple shapes of spheres and cubes), and target materials (other than aluminum, such as composites).

- 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.

Additionally, FAA AST research focuses on activities that provide benefits to inherently governmental functions. 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 total requested commercial space transportation safety research budget in FY 2021 is $TBD-M.

The main goal of AST is protecting the safety of the uninvolved public and property from the potential consequences of commercial space launches and reentries. In addition, the FAA needs to 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 AST’s research programs to deliver on organizational goals 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 Reporting System 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.). The FAA/AST R&D program does addresses the common "market failure" of observed under-investment by the private sector into research topics that can benefit the public at-large, due to the typical inability to sufficiently protect the proprietary gains that would justify the level of initial investment (i.e., the "spill-over" or "free-rider" effect).

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 Investment Topic Areas (safety,

infrastructure, innovation, and accountability). 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 (university investigators, students, and independent contractors), the supporting research organization members, associated executive and legislative branch offices, and other external entities.

Program Alignment with Strategic Goals:

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. Data generated by this research is used to create and develop new safety standards that will be adopted throughout the aerospace community. The program also supports the DOT Strategic Goal of Infrastructure by developing analytical capabilities for the development and growth of spaceports and their related supplier-distribution networks. The Strategic Goal of Innovation is generally supported by all the research work conducted, and Accountability is supported through the collection and dissemination of research data as per Federal and Departmental requirements.

Research Collaboration Partners:

The AST safety research program has multiple forms of stakeholder interaction that helps inform the content of the research program. These include organizations such as the Commercial Space Transportation Advisory Committee (COMSTAC), the Commercial Spaceflight Federation, and the COE CST Affiliate and Associate members.

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 partners almost exclusively with non-government groups (listed above) to conduct research. They participate by providing matching contributions to COE CST research, both in-kind as well as cash. For example, the National Aerospace Training and Research Center (NASTAR) 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.

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NextGen – Wake Turbulence
Enacted ($5,000,000)

Program Description/Activities/Objectives:

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 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.

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 in 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 that occur at or near an airport.

Statutory Requirements:

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

This project is committed to research new aircraft types in support of the National Transportation Safety Board (NTSB). 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:

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 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 Collaboration Partners:

NextGen capabilities continue to bring positive effects to the aviation industry and the flying public all across the 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 the 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

New aircraft analysis is performed 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.

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Unmanned Aircraft Systems
Enacted ($24,035,000)

Program Description/Activities/Objectives:

The Unmanned Aircraft Systems (UAS) Research program supports the FAA's implementation of the Next Generation Air Transportation System (NextGen) by studying safety implications of new aircraft operational concepts and technology to the National Airspace System (NAS) and by supporting the development of new and modified regulatory standards. The program's research activities focus on UAS that are fundamentally shifting the aviation landscape and have the potential to provide a wide range of benefits to society. However, there are technical and regulatory challenges that must be overcome as the FAA works to safely integrate these new technologies into the NAS.

Safe, efficient, and timely integration of UAS into the NAS poses substantial technical challenges not only to the FAA but also to the aviation industry. UAS often use new or novel technologies to achieve unique operational capabilities that challenge the expectations of current NAS users. These unique capabilities have demonstrated potential to address commercial applications as well as scientific research needs. Integrating UAS into the NAS potentially affects the entire NAS due to various sizes of UAS (less than a foot up to the size of a commercial jet), a wide range of maximum take-off weight (less than a pound to the weight of a large jet), large performance disparities compared to existing certificated aircraft, and capabilities of operating in all classes of airspace. Even UAS weighing less than 100 pounds may be capable of operating in Class A airspace and the integration of a significant volume of UAS air traffic could potentially disrupt normal aircraft traffic flow and induce unknown safety hazards.

Research is the key to solving integration challenges and unlocking the potential of UAS societal benefits. FAA-sponsored research results are being used to shape rulemaking, guide decision-making, and grow the UAS industry. Applied research will continue to be critical to safe integration of UAS into the NAS, and to reaping their potential societal benefits. Activities within the UAS research program are aligned with the FAA's UAS integration strategy. The UAS research program must remain agile and adaptive in order to keep up with the pace of industry innovation and to respond to FAA, DOT, and White House executive priorities and those mandated by Congress.

Research results will continue to drive the FAA's decision-making process, inform rulemaking, enhance operational procedures, air traffic management, and maintain safety. UAS research and analysis yields data and results to inform decision-making processes. Research generates technical information to support development of rules, policies, guidance materials, advisory circulars, and FAA Safety Management System.

The FY 2020 portfolio of UAS research will focus on standards to enable beyond visual line of sight operations, safety data collection and risk-based assessments, advancing UAS concepts and applications, enhanced security, and other research that will support the safe, efficient, and timely integration of UAS in the NAS within the 14 Code of Federal Regulations (CFR) regulatory framework. Additionally, funding will provide for engineering, technical, and management support of overall research activities and support the integration of UAS into the NAS by studying new operational concepts and technology, and providing information that supports the development of new rules and regulatory standards. Outcomes of this research may also lead the development of new procedures or modifications to NAS equipment.

FY2020 research activities may be categorized according to key thrust areas that directly support FAA Aviation Safety strategic goals:

UAS standards research supports the strategic goal of safety through the achievement of performance standards. FY2020 research will inform the development and validation of UAS standards related to:

- Detect and Avoid performance for both small (below 55 lbs) and large UAS, to enable beyond visual line of sight operations
- Command and Control link performance
- UAS standards analysis to track and map existing standards, and to identify gaps in UAS standards
- Severity of small UAS impacts with commercial transportation aircraft engines
- Test methodologies to validate operational safety cases and to certify small UAS

Research on data collection and risk-based assessments supports the strategic goal of safety through the improvement of data collection methods and analyses. FY2020 research includes:

- Development and enhancement of UAS safety data collection and reporting processes in support of the UAS regulatory framework
- Collection and analysis of UAS data to identify safety risks for industry and government partners within the UAS Safety Team

Research on advanced UAS concepts and applications (including Urban Air Mobility) supports the strategic goals of safety, innovation, an infrastructure. The expanding set of UAS use cases brings integration challenges that must ensure the safety of the NAS. These new use cases also promote new technologies and practices into transportation systems, and the NAS systems, equipment, and procedures must be robust and resilient in order to support these operations safely. FY2020 research in these areas include:

- Evaluations of UAS operations for wake turbulence considerations with emphasis on Urban Air Mobility
- Evaluations of the demand and safety impacts, focusing on increased UAS autonomy for large UAS cargo and passenger transport operations
- Exploring Air Carrier Operations for UAS to inform requirements and regulatory efforts
- Investigating the use of UAS in response to natural disaster and emergencies, focusing on coordination between federal agencies and state/local governments

Research on UAS security supports the strategic goals of infrastructure and innovation, through the need to protect critical infrastructure, data, and aviation systems. Security research in FY2020 includes:

- Identification of risks and proposed mitigations related to UAS security, including cybersecurity
- Exploring Counter UAS detection technologies and their potential impacts on airport operations

Statutory Requirements:

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

The safe integration of UAS into the NAS is an important objective for the FAA, as evidenced in the 2018 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 2018 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:

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. Data generated by this research is 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 NAS. UAS in the NAS will affect urban, suburban, and rural communities.

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? Yes

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).

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Advanced Technology Development & Prototyping
Enacted ($40,900,000)

Program Description/Activities/Objectives:

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 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.

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.

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:

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 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.

Research Collaboration Partners:

The ATDP program contributes to the FAA's support for the RTCA, a non-profit association that develops standards based on manufacturers, 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 as 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

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.

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Next Generation Transportation System - Separation Management Portfolio
Enacted ($20,500,000)

Program Description/Activities/Objectives:

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 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.

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.

Statutory Requirements:

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

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 NAS. This work is critical to the success of NextGen.

Program Alignment with Strategic Goals:

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 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 results 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 a specific impact on rural communities.

Research Collaboration Partners:

NextGen capabilities continue to bring positive effects to the aviation industry and the flying public all across the NAS. The FAA and the aviation industry work together through the NextGen Advisory Committee (NAC), which includes carriers such as United Airlines, FedEx, and 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.
NextGen Advisory Committee (NAC) – Federal advisory committee	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 implementing this plan.
FAA Lines of Business	NextGen collaborates 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 and the NAC as described in the table above. The efforts within this portfolio include collaboration with international partners, and the NAC. The INDP PBN program integrates industry's priorities via the NextGen Advisory Committee / NextGen Integration Work Group (NAC/NIWG), Northeast Corridor (NEC), and agency efforts to improve efficiency by taking advantage of aircraft performance capabilities, Standard Terminal Arrivals, and Optimum Profile Descents. The Wake RECAT and CSPO program coordinate long term plans for research and short term plans for implementations with the NAC/NIWG. These efforts support operational improvements in the field and further concept development.

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Next Generation Transportation System - Traffic Flow Management Portfolio
Funding Request ($19,800,000)

Program Description/Activities/Objectives:

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 includes technology development activities for departure scheduling at smaller community airports, improved strategic flow services and capabilities that will capitalize on future DataComm capabilities, further integrated traffic flow management and metering operations, advanced trajectory-based operations leveraging the technologies of NASA's Airspace Technology Demonstration 3 (ATD-3), and exploring technologies, infrastructure enhancements, and procedural changes for future traffic management needs.

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.

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:

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 NAS. By providing the necessary research to gather information, this will allow the assessment of regulatory

approaches, foster information sharing and facilitate coordination, allow collaboration with industry and other stakeholders, and provide 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 NAS.

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

Research Collaboration Partners:

NextGen capabilities continue to bring positive effects to the aviation industry and the flying public all across the 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.
NextGen Advisory Committee (NAC) – Federal advisory committee	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 implementing 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. Under the Surface Tactical Flow project within the TFM portfolio, 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.

United States Department of Transportation
FY 2020 Annual Modal Research Plans
Next Generation Transportation System - On Demand NAS Portfolio
Enacted ($8,500,000)

Program Description/Activities/Objectives:

The On Demand 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.

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 simplify 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 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.

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:

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 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 specific impacts on the rural communities**.**

Research Collaboration Partners:

Public stakeholder input is also received through the NextGen Advisory Committee (NAC). The NAC is an industry partnership with the 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 programs, and reviews and comments on the aviation research programs.
NextGen Advisory Committee (NAC)	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 implementing this plan.
FAA Lines of Business	NextGen collaborates with multiple internal lines of business such as the air traffic, program management office and aviation safety office 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

Do non-government groups partner with this program? Yes

REDAC, RTCA, and NAC are non-government groups this program partners with as detailed in the table above.

United States Department of Transportation
FY 2020 Annual Modal Research Plans

Next Generation Transportation System - NAS Infrastructure Portfolio
Enacted ($11,500,000)

Program Description/Activities/Objectives:

The 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.

The NAS Infrastructure (NI) Portfolio contains key transformational and infrastructure sustainment capabilities that are critical to the success of NextGen. This program supports the NextGen goal of expanding capacity by conducting pre-implementation activities geared toward the development of decision support tools that improve the strategic management of operations in the NAS. The main goal of the NextGen – NAS Infrastructure Portfolio is to support the NextGen goals of improved capacity, efficiency, and safety.

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 portfolio 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:

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 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 specific impacts on rural communities.

Research Collaboration Partners:

NextGen capabilities continue to bring positive effects to the aviation industry and the flying public all across the 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 the aviation research programs, and reviews and comments on the aviation research programs.
International Civil Aviation Organization (ICAO) (external)	Partnership with ICAO ensures 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 (AEEC) (external)	Partnership with AEEC support standards development to inform air/ground communications between FAA and airspace users in the future.
FAA Lines of Business (internal)	NextGen collaborates 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, ICAO, and AEEC as described in the table above.

United States Department of Transportation
FY 2020 Annual Modal Research Plans

Next Generation Support Portfolio
Enacted ($11,000,000)

Program Description/Activities/Objectives:

The NextGen Support Portfolio provides the 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. The 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 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:

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 NAS. Data generated by this program will allow for the assessment of regulatory approaches, foster information sharing and facilitate coordination and collaboration with industry and other stakeholders. Most importantly this program facilitates the testing and adoption of new technologies throughout the NAS. There is no specific impact on rural communities.

Research Collaboration Partners:

This program is 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 exercises or adoption/implementation.

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 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 involving key stakeholders.

United States Department of Transportation
FY 2020 Annual Modal Research Plans

Next Generation Transportation System - Unmanned Aircraft Systems (UAS)
Funding Request ($51,900,000)

Program Description/Activities/Objectives:

The UAS projects play a critical role in enabling UAS operations in the National Airspace System (NAS). The activities in this program support research that allows 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 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.

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 (e.g., 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.

Statutory Requirements:

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

This program addresses 2016, 2017, and 2018 Congressional Reauthorizations mandate 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:

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 NAS. Data generated by this research will allow the assessment of regulatory approaches, will foster information sharing and facilitate coordination and collaboration with industry and other stakeholders, and provide the ability to test and adopt new technologies throughout the NAS. This program may impact rural communities. Potential small UAS applications include agricultural applications, geological surveys, etc.

Research Collaboration Partners:

Additional public stakeholder input is obtained through the 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 the FAA and key decision-makers supporting the safe introduction of UAS into the 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 programs, and reviews and comments on the aviation research programs.
Drone Advisory Committee (DAC) –	FAA and key decision-makers supporting the safe introduction of UAS into the 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 collaborates 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 the necessary knowledge and operational and technical subject matter expertise to conduct research efforts.
UAS Test Sites	Provides the necessary knowledge and operational and technical subject matter expertise to conduct research efforts.
UAS Center of Excellence (COE)	Provides 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 the necessary knowledge and operational and technical subject matter expertise to conduct research efforts.

Do non-government groups partner with this program?

Yes. REDAC and DAC as demonstrated in the table above.

United States Department of Transportation
FY 2020 Annual Modal Research Plans

System Planning and Resource Management
Enacted ($12,135,000)

Program Description/Activities/Objectives:

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 RE&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.

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.

Additionally, SPRM will provide funding and support of programs to provide grants supporting the education of future aircraft pilots, development of the aircraft pilot workforce, as well as the education, recruitment and development of the aviation maintenance workforce. This work is as per guidance specified in Section 625 of the FAA Reauthorization Act of 2018 (Pub. L. No. 115-254). Funding will also provide for engineering, technical, and management support of overall research activities.

The support planning and resource management activities conducted by this program do not address market failures.

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.
- FAA Reauthorization Act of 2018, Section 625 (Pub. L. No. 115-254) – requires the establishment of programs to provide grants for the education of the future aviation pilot and maintenance workforce.

Program Alignment with Strategic Goals:

This program supports the DOT's Accountability Strategic Goal. 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 specific impact on rural communities.

Research Collaboration Partners:

The development and submission of all SPRM 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, research management and accountability, and serves as the 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; and

- Air Traffic Organization – Advisory Member of the REB.

Do non-government groups partner with this program? No.

United States Department of Transportation
FY 2020 Annual Modal Research Plans

William J. Hughes Technical Center Laboratory Facility
Enacted ($3,500,000)

Program Description/Activities/Objectives:

This program sustains research facilities located at the William J. Hughes Technical Center Laboratory (WJHTC) to support Research and Development (R&D) program goals. These programs require specialized facilities to emulate and evaluate field conditions. The R&D laboratories are comprised of the Cockpit Simulation Facility (CSF), Target Generation Facility (TGF), Research Development and Human Factors Laboratory (RDHFL) and The NextGen Prototyping Network (NPN). R&D programs require specialized facilities which provide flexible, high-fidelity environments to conduct research and perform Human-in-the-Loop (HITL) simulations which evaluate advanced air traffic concepts. Researchers measure baseline human performance using existing air traffic controller configurations and determine changes in performance when new systems or procedures are introduced to identify and evaluate human factors (HF) issues. These laboratories include integrated cockpits, air traffic controller workstation capabilities (simulated and real), and specialized biometric data collection systems to evaluate the system and human components that can only be addressed in a full mission end-to-end simulation environment. The R&D laboratories are fully integrated with the other WJHTC capabilities which allows for an extremely high fidelity environment supporting R&D research. This research encompasses capabilities of the current day systems, NextGen, and the transition (e.g., mixed equipage, adjacent site deployment, etc.). The funding provides for existing infrastructure support, project support, engineering support, R&D facility modifications and improvements, equipment and software/hardware licenses, and support tools.

The main goal of the William J. Hughes Technical Center Laboratory Facility is the provision of a laboratory environment that is fully integrated, extremely high fidelity, and that encompasses capabilities of current day systems, the NextGen system, and the transition between the two. Simulation Facilities goals include developing capabilities to enable the research of complex problems due to weather, UAS, and commercial space flight in a controlled laboratory environment. The fully integrated facilities will enable research from the ground and airborne elements for a complete simulation capability. Concepts and Systems Integration RDHFL goals include doing proactive HF research on proposed changes to the NAS that identify human performance issues early in the concept development phase. Network Infrastructure – NPN goals are to maximize shared resources, relieve the need to establish separate connections, and minimize duplication of efforts and the resources to manage these extra connections and efforts. The NPN provides a common network approach that affords distributed access to NextGen and R&D laboratories, and a distributed set of capabilities.

Statutory Requirements:

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

The William J. Hughes Technical Center Laboratory Facilities are not statutory mandated by law; however, these laboratories support many research programs that are required by law. U.S.C. Title 49, section 44505: The laboratory facilities support studies on the ability of UAS to comply with Air Traffic Control visual separation clearances. The laboratory facilities support numerous human factors studies on the effects of new technologies on air traffic controllers, flight crews and the NAS as a whole.

Program Alignment with Strategic Goals:

This program supports the DOT's Strategic Goal of Accountability.

This program is utilized to sustain and improve the laboratory infrastructure, which in turn, supports programs that directly contribute to DOT Strategic Goals and Objectives. This program does not have a specific impact on rural communities.

Research Collaboration Partners:

This program has the following partners:

- **Academia:** Drexel University, George Mason University, Georgia Tech University, MIT Lincoln Labs, Rowan University, University of North Dakota;
- **FFRDC:** MITRE;
- **Government:** DOD Naval Air Station - Patuxent River, DOD Research & Engineering Network, Federal Air Marshals Service, Mike Monroney Aeronautical Center, NASA, National Weather Service, US Army Corp of Engineers, US Navy - Dahlgren, Volpe, Warren Grove Bombing Range;
- **Industry**: Various.

These partnerships are beneficial because they enable the achievement of efficient solutions by eliminating duplicative efforts; filling capability gaps; and sharing technical knowledge.

Do non-government groups partner with this program?

Yes. These partnerships listed above are beneficial because they enable the achievement of efficient solutions by eliminating duplicate efforts; filling capability gaps; and sharing technical knowledge.

United States Department of Transportation
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William J. Hughes Technical Center Laboratory Sustainment
Enacted ($20,000,000)

Program Description/Activities/Objectives:

This program sustains the William J. Hughes Technical Center laboratories. This centralized set of laboratories is depended on to support the Acquisition Management System (AMS) lifecycle from concepts and requirement definition to In-Service decision. These laboratories are the only location where it is possible to realistically simulate the NAS and it is necessary to maintain the laboratory systems with capabilities that match field sites that currently exist or are planned for the future. These test beds can be altered to replicate desired field configurations and traffic scenarios providing stakeholders with an understanding of how upgraded systems will perform prior to operational deployment. These labs also provide a flexible high-fidelity environment to conduct research and perform Human-In-The-Loop (HITL) simulations that evaluate advanced air traffic concepts and are fully integrated with the other WJHTC capabilities.

The goal of this program is to modernize the equipment and infrastructure necessary for the FAA's centralized NAS laboratory facilities so that F&E programs can deliver products that result in a safe, reliable, and efficient NAS. The WJHTC centralized labs eliminate the need for each acquisition program to establish and sustain separate laboratory facilities to support their individual programs and fielded systems. The capabilities developed in these laboratories reduce overall cost of NAS and NextGen development while increasing traveler safety and decreasing travel times by reducing airspace congestion. This program is necessary to sustain the WJHTC laboratory test facility which provides direct field support for Operational NAS systems. Problems identified at various field locations are quickly transmitted to the appropriate laboratory where solutions are developed and tested. The test beds are used by acquisition programs and partner agencies for development, test, evaluation, integration, transition testing, and first and second level support to the field. This program is further necessary to maintain these laboratory systems in configurations and capabilities that match field sites that currently exist or are planned for the future.

Statutory Requirements:

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

Program Alignment with Strategic Goals:

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 NAS. Funding the sustainment of WJHTC laboratories will allow for the assessment of regulatory approaches, 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 have a specific impact on rural communities.

Chapter 4 – FY 2021 Program Descriptions

Airport Infrastructure and Technologies

FY 2021 Program Descriptions
Airports Cooperative Research Program

Program Description/Activities/Objectives:

The purpose of the Airport Cooperative Research Program (ACRP) is to conduct applied research on problems shared by airport operating agencies that are not adequately addressed by existing Federal research programs. March 2020 is the deadline to receive research problem statements for the FY2021 cycle from airport operators, industry associations, the FAA, and other interested parties.

The ACRP Oversight Committee (AOC) will select the highest rated topics at the July 2020 bi-annual meeting from this list covering research topics of aviation administration, environmental planning & policy, human resources, safety, design, construction, operations and maintenance – subject to availability of funds. The AOC examines the submissions to ensure that the proposed studies will not duplicate other federal research.

Typically, 12-15 projects are selected each year. The TRB appoints expert technical panels for each selected project. The technical panels convert the topics into requests for proposals to select contractors to perform the research. The panels also monitor each project to ensure it stays on track and meets project deliverables.

Due to the established ACRP process described above, a description of FY 2021 RD&T Program cannot be provided at this time.

Program Alignment with Strategic Goals:

This program supports the DOT Strategic Goals of: Safety and Infrastructure

This program supports the DOT 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. Data generated by this research is 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 NAS. Data generated by this research is 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.

FY 2021 Program Descriptions
Airports Technology Research Program

Program Description/Activities/Objectives:

The Airport Technology Research (ATR) 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 (ACs). 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.

The program is organized to directly support the development and updates of the FAA's Airports ACs in the areas of airport safety and airport infrastructure. On the airport safety side, in FY-20, the ATR program will remain engaged in a multitude of airport safety areas. Some examples are; development of new specifications for the use of Light Emitting Diode (LED) lighting technologies at airports, analysis of airport safety data, testing of environmentally-friendly firefighting agents, improving airport noise, reducing wildlife strike risks, and integrating UAS operations at airports.

Regarding the Strategic Goal of Infrastructure, 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-21, the ATR program will continue:

- collecting long-term pavement performance data from airports;
- conducting full-scale accelerated pavement tests at its facility to study application of sustainable and eco-friendly pavement materials;
- studying if state highway specification materials can perform satisfactorily at non primary public use airports serving aircraft less than 60,000 pounds gross weight;
- developing performance related specifications for acceptance of pavement materials;
- developing alternate ways of characterizing in-situ properties of layer materials during airport pavement construction; and
- continue to work with the pavement industry on pavement design, materials and evaluation methods.

The overall goal of the program is to conserve airport funds and reduce the downtime of runways from construction and maintenance.

In terms of the Strategic Goal of Innovation, Vertical Take-Off and Landing (VTOL) manufacturers will have ready-to-test prototypes, and ATR plans to test the compatibility of these prototype vehicles against current FAA design standards.

Program Alignment with Strategic Goals:

This program supports the DOT Strategic Goal of Safety and Infrastructure.

This program supports the DOT 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. Data generated by this research is 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 NAS. Data generated by this research is 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 is specific to the development of technical standards that are primarily, and sometimes solely, applicable to airports. There is no other domestic federal, state, local or private program of this nature that focuses on improving safety and capacity at U.S. civilian airports. The ATR program continues to interact with other agencies (DOD, federal, state, industry-led) to leverage their efforts. However, this program is specific to meeting the needs of civilian airports and no other research entities are duplicating this program's work. Only the DOD carries out similar research but it is solely focused on the needs of the military. Research between this program and the DOD research programs are coordinated and leveraged as appropriate.

Aircraft Safety Assurance

FY 2021 Program Descriptions
Fire Research and Safety

Program Description/Activities/Objectives:

This program supports all areas of aircraft fire safety. New materials and systems are continuously introduced by airframe and engine manufacturers and the applicability of existing regulations, policy, and guidance for the certification of changing technologies requires support from this program as issues arise. This program will address the proliferation of hazardous materials in aircraft from passenger personal electronic devices, aircraft installed equipment, and transport of hazardous materials as cargo starting in FY20 and continuing into FY21.

A systems safety risk based approach will be used to assess hazards on an individual operator basis and specific mitigations techniques applicable to the operator will be introduced. Testing will be required to document the effectiveness of proposed mitigations.

Program Alignment with Strategic Goals:

This program supports the DOT Strategic Goal of: Safety

This program supports the DOT 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. Data generated by this research is used to create and develop new safety standards that will be adopted throughout the aviation community.

FY 2021 Program Descriptions
Advanced Materials/Structural Safety

Program Description/Activities/Objectives:

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 interfaces, 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 analyze procedures used by 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 Structural Safety program also identifies limitations associated with structural scale and boundary effects, and develops crashworthiness safety awareness training materials.

In this context, the Advanced Materials/Structural safety 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.

Program Alignment with Strategic Goals:

This program supports the DOT Strategic Goal of: 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. Data generated by this research is 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 2020),
- 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 2020),
- New AC outlining best practices approving modifications to composite structure (by FY 2020),
- 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 2020),
- 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 2020), and
- 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 2020, develop background information and data for creation of a Part 21 Advisory Circular on composite structures.

FY 2021 Program Descriptions
Continued Airworthiness

Program Description/Activities/Objectives:

Structural Integrity

- The Damage Tolerance and Durability Issues for Emerging Technologies research will assess structural performance of new aviation alloy systems prior to use in aircraft manufacturing. Results of this research will quantify the limits of structural strength of new materials along with repair procedures necessary to maintain original load carrying capability. Scientific tests will be conducted using the FAA's Full-Scale Aircraft Structural Test Evaluation and Research (FASTER) Lab and the FAA's Airframe Beam Structure Test (ABST) facility to assess bonded repair technology to composite panels representative of transport aircraft structures.

- The MMPDS Support and Design Values for Emerging Materials project will continue to index material standards used in aircraft construction.

- The Active Flutter Suppression (AFS) research will continue to develop data to support system approval methodology for certification of new aircraft designs.

- The Probabilistic Damage Tolerance Based Fleet Risk Management for Small Airplanes research will provide additional updates covering a broader range of General Aviation aircraft structural data to maintain airworthiness of aircraft into the future.

Electrical Systems

This research will build upon the Novel and Unusual Aircraft Systems research in previous years and will investigate applications and associated risks with electrical primary propulsion systems, hybrid aircrafts and More Electric Aircraft (MEA). The research will identify acceptable test methods to validate and certify the safe generation and distribution of high voltage and energy storage devices on aerospace vehicles. It will quantify the short term and long-term risks to current and future operations associated with MEA for aerospace applications (e.g., electric propulsion, electric deicing, electric taxi, full electrical flight controls, etc.) including potential failure modes and effects. It will describe mitigating factors (including test methods) that will constitute a safe electrical energy storage and electrical system installation for aerospace and will identify possible sources of electrical energy generation and specific applications for current and proposed aircraft systems and sub-systems. Some examples of technology are hydrogen fuel cells, voltage over 600VDC, variable frequency drives, and solid-state primary and secondary distribution networks.

The research conducted under the Large Electric Energy Storage System requirement will provide data to identify the best possible configuration of the large electric Storage System for helicopters and airplanes and large transport airplanes. These will require megawatt-range power consumption and MW-hr. storage capacity. Safe design, validation and maintenance will be a new challenge. These systems may include several modules up to 200 cells of batteries or energy storage that that have to be modularized and designed/validated in a practical method that will ensure safe installation and containment of possible failures. This effort will

provide data on the feasibility and advantage of modularizing the large electric storage system. The data will be used for certification and industry standards to maintain or increase the current level of safety.

This data would apply to unmanned aerial vehicles, small airplanes, rotorcraft, and transport aircraft. In the United States and abroad, experimental prototypes are pushing the envelope of electric propulsion to new limits in hopes of understanding more about its potential and capturing greater market appeal. Among some of today's key players with commercial availability are Pipistrel's Taurus Electro G2 electric-powered motor glider, Yuneec International's e430 twin seat Light-Sport Aircraft (LSA), and Lange Aviation's Antares 20E self-launching sailplane. There is also a growing variety of electric powered weight-shift control trikes, powered parachutes, and hang gliders surfacing in the market. Hybrid-electric part 23 commuter airplanes and transport category regional airplanes are in conceptual design.

The data from the electrical systems research will inform recommendations for the safe implementations of new electrical energy generation, storage, and distribution technologies. This research aligns with M-17-30 and supports American Prosperity (emerging technologies - early stage basic research) and American Energy Dominance (clean and renewable energy sources).

Flight Control and Mechanical Systems

Integrated Flight Path Control to Address GAJSC/FAA GA Safety Interventions. This research will build upon the FY20 activities and 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 light GA flight path control autopilots. The resulting papers, reports, and technical guidance can be used by the FAA and industry to design systems, create industry standards, field new designs similar to those already fielded in complex UAVs that refuse to crash, and in fly-by-wire aircraft – but at lower costs.

Program Alignment with Strategic Goals:

This program supports the DOT Strategic Goal of: Safety.

The Continued Airworthiness program supports initiatives in DOT/FAA Strategic guidelines published in February 2018, specifically:

- 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:

Structural Integrity

- The *Damage Tolerance and Durability Issues for Emerging Technologies* research requirement supports 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 that the fatigue, durability, and damage tolerance performance of new material systems is well understood prior to introduction it into service. This is accomplished through fracture mechanics test and analysis, obtaining material system data, and analytical tool validation data 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 Design 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 that 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 *Helicopter Fuel System Drop Test* research supports the DOT Strategic goal of Safety and Accountability. This research should determine the relevance and standardize the use of different materials used in helicopter fuel cell drop tests as prescribed in Fuel Cell Crash Resistance § 27/29.952.

When applicants certify a rotorcraft they have to prove the fuel system is crash resistant, by showing the system is capable of sustaining the static and dynamic deceleration loads without leaking. The drop height must be 50 feet. The tanks must be filled to 80% of the normal, full capacity and the tank must be enclosed in a surrounding structure representative of the installation unless it can be established that the surrounding structure is free of projections or other design features likely to contribute to rupture of the tank. Applicants can get creative when fabricating the "surrounding structure" of the fuel system for a drop test, including using wood and plastic to enclose the tank and simulate helicopter structure. Currently it is unclear how these materials behave with respect to authentic helicopter structure. According to NTSB records, since the 1994 Crash Resistant Fuel tank rule change, there have been 202 helicopter crashes, in airframes from multiple manufacturers that suffered post-crash fires – 78 of those resulted in post-crash fire deaths. This research supports the DOT goal of Safety and Accountability by seeking to determine if differing materials would absorb more load than the real structure and therefore give erroneous results.

- The *Integrated Flight and Propulsion Control* supports three of the DOT Strategic Goals, Safety, Innovation, and Accountability. The research will investigate the flight characteristics of multiple rotor vehicles (e.g., quad copter, quad copter plus). Since multiple applicants are pursuing new and novel ways of integrating propulsion flight controls to simultaneously produce lift, thrust and directional control for electric vertical takeoff and landing aircraft, some of the existing airworthiness standards and associated means of compliance are not applicable or need modification. This research will identify unknown airworthiness issues with electric vertical take-off and landing aircraft. Unlike rotorcraft with its rotor head that changes the rotor blade pitch as it rotates to provide directional control, an electric prop rotor aircraft (quad) varies the RPM on different prop rotors to create differential thrust for directional control. An electric prop rotor aircraft will have different flight dynamics, stability, and control characteristics than helicopters. Most electric prop-rotor aircraft will not have the capability to auto rotate but will have other alternate means to safely control and descend after a failure. This technology is new and/or novel and has an unknown significant potential for accidents/injuries.

<u>Flight Control and Mechanical Systems</u>

- *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 addressing 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.

<u>Electrical Systems</u>

- The *Novel and Unusual Electric System* requirement will support the DOT's Strategic Goal of safety by reducing or mitigating the safety risks introduced by having a higher electrical energy on aircraft by providing the FAA with a thorough understanding of the impacts of the more complex,

increased voltage, and highly integrated systems being proposed on modern aircraft. The Boeing 787, the earliest appearance of a more-electric airplane, suffered a serious malfunction and inflight fire in its unique electrical distribution computing cabinets during flight test. Protective modifications to that system before certification were not sufficient for durability nor unrestricted operations at its 270 volts, so the early-certified airplanes had their cabinets replaced after service entry with new designs that included systems created to follow revised, improvised electrical specifications. DOD has encountered new electromagnetic interference modes in their recent 270-volts military aircraft and ships. These failures are precursor events indicating vulnerabilities that will increase as higher distribution voltage, higher stored energy, and additional electric powered systems are introduced in the near future. The 787 also experienced several failures and fires in its novel battery systems. Present electrical standards and design practices are based on 28V and 115V systems with standard wiring gauges and methods. Future systems are expected to alter the entire electrical distribution scheme to reduce weight with 540V in the near term, possibly as high as 5000 volts thereafter in hybrid systems, with lighter-gauge wires and varying load distributions. These aircraft will require larger generators, larger new/novel storage devices, hybrid electric systems, hydrogen fuel cell generators, new/novel distribution control systems, and new wiring practices. These innovations each present novel (for aviation) modes of future accidents due to the hazards of fires from various sources, electrical function loss as more systems rely on electric power, electromagnetic Interference (EMI), electrical malfunction and shock, and loss of propulsion. This research is expected to provide quantitative data for risk assessment and design assurance that will prevent accidents that could stem from new hazards and failure modes associated with additional novel more-electric aircraft technologies.

- The *Large Electric Energy Storage System* requirement will provide data to identify the best possible configuration of the large electric Storage System for helicopters and airplanes and large transport airplanes. These will require megawatt-range power consumption and MW-hr storage capacity. Safe design, validation, and maintenance will be a new challenge. Energy Storage systems will be critical components for Full Electric Aircraft. To meet the need for full electric aircraft OEMs are going to higher voltages and increasing electrical energy storage devices. Safety assessment of the higher voltage is required to meet the current level of safe energy transmission on the aircraft.

FY 2021 Program Descriptions
Propulsion and Fuel Systems

Program Description/Activities/Objectives:

Aircraft Turbine Engines: Regarding turbine engine damage tolerance design, the FAA will continue to work with industry and build upon its FY2020 efforts to enhance the DARWIN code to analyze rotor turned surfaces and to develop a corresponding advisory circular.

In addition, a new activity in FY2021 will focus on addressing the two NTSB recommendations from the AA Flight 383 uncontained failure. These NTSB recommendations call for the FAA to conduct research to evaluate better ways to detect anomalies in nickel alloys, both during production and in-service inspections. This research would be similar to, and build on, technology from prior FAA efforts that developed multi-zoned ultrasonic inspections for titanium. New advisory material and a revision of existing policy regarding inspection of critical nickel parts would be an output from this research.

Catastrophic Engine Failure:

In FY2021 the catastrophic failure prevention program plans to complete revision of AC 20-128 with an updated debris fragment model published in the FY19 FAA report *Large Engine Uncontained Debris Analysis High-Bypass Ratio Engine Update*. The program will also use this new fragment debris model in the updated Uncontained Engine Debris Damage Assessment Model (UEDDAM), which will result in an update to the 2004 report on the use of the model. The program will also be ready to conduct research in response to anticipated NTSB recommendations from the ongoing investigation of the fatal SW 1380 fan blade failure. Development, verification, and validation of predictive impact modeling capability will continue to support certification by analysis efforts for metal and composite materials. AWG collaboration between government, industry, and academia will also continue to support accurate and consistent computational modeling in LS-DYNA and provide standardized tools and methods to industry and FAA certification engineers.

Fuels and Energy:

Certification challenges are arising due to the continual proposal of new fuel and energy propulsive technologies. The FAA faces considerable challenges in both applying existing, and creating new regulations, policy, and guidance for new fuel, energy, and propulsive disruptive technologies. Further, approving the existing fleet for use with new fuel and energy sources creates a unique set of challenges. The impact on performance, operability, and compatibility with existing aircraft and engine propulsion systems needs careful evaluation before approving an alternative fuel or energy source.

A goal of the 2020 research activities is to provide research data needed by the FAA Certification and Rulemaking organizations as part of the safety evaluation and development of a process to authorize an unleaded aviation gasoline for use in a majority of General Aviation (GA) aircraft. This portion of the overall GA fleet is referred to as the 'authorized fleet.' Due to the wide variety of types and ages of aircraft engines, a segment of the GA aircraft fleet is not expected to be able to operate on the authorized fuels as a 'drop-in' replacement for leaded avgas, this is referred to as the non-authorized fleet. Starting in 2021, this additional research for the non-authorized fleet will assess engine and aircraft modifications, newer fuels as well as potential additives presented by industry to support additional authorization(s) of these non-authorized fleet aircraft. In addition, continued studies are required to support the evaluation of new and emerging fuel and energy performance specifications, the safety evaluation of emerging propulsive technologies, the safe transition to more environmentally friendly fuels, and the development of regulatory and guidance materials.

Program Alignment with Strategic Goals:

This program supports the DOT Strategic Goal of: 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. Data generated by this research is used to create and develop new safety standards and new aviation fuels that will be adopted throughout the aviation community.

The Aircraft Turbine Engines program will continue to develop probabilistic damage tolerance design methods to analyze critical features of engine rotors, specifically turned surfaces, which will help ensure the structural integrity of these parts and prevent uncontained engine failures and accidents. These methods will provide guidance that enables industry to satisfy the safety intent of rule 33.70 regarding rotor life prediction. The DOD USAF, USN, and NASA have contributed to funding for the development of the DARWIN software although only the FAA specifically addresses rule 33.70. Previous funding of DARWIN has resulted in three advisory circulars that addressed rotor titanium anomalies, circular holes, and axial blade slots. A version of DARWIN that is able to analyze rotor turned surfaces, along with an accompanying AC will be produced by 2021.

The Aircraft Turbine Engine program will also conduct research to address NTSB recommendations to improve inspection methods to better detect anomalies in nickel alloys. The FAA will build on results from a prior program conducted by the Engine Titanium Consortium (ETC) that developed improved inspections using multizone ultrasonic for titanium alloys. Industry will also assist with this research by way of the Jet Engine Nickel Quality Committee. The projected timeframe for this research is five years.

Catastrophic Engine Failure:

This research addresses the overlap between aircraft certification (Part 25) and engine certification (Part 33), known as engine installation. Uncontained engine failures continue to pose an aviation safety risk as evidenced by several recent events including most notably the occurrence on Southwest Airlines flight 1380 in April 2018. This event 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. 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 catastrophic failure prevention program leverages the industry and DOD investment in computing and modeling capability and promises to provide the opportunity to improve the accuracy of failure analysis and minimize aircraft vulnerability for the rare but hazardous uncontained engine failure impact events. This research program develops 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. Industry representatives, along with government and academic partners, participate in the Aerospace Working Group to ensure that consistent and accurate modeling practices are developed under this program. This will improve safety and reduce the cost of producing new engine and aircraft designs. To date, this program has created four new predictive material models along with modeling guidelines to support standardized certification methodologies. The research is ongoing and the model fidelity increase with advances in high performance computing, and new developments in numerical and experimental methods. The program continues to produce composite and metal material characterizations for impact analysis, improvements in finite element analysis, and publishing modeling guidance and publicly available reports on an annual basis. There is strong industry support for these high quality research deliverables.

Fuels and Energy:

The fuels and energy 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 associated with the authorization, certification and deployment of new and alternative fuels, energy sources, and propulsive technologies. By providing the research necessary to assess that performance and operating characteristics are in accordance with current and proposed regulatory requirements, the agency will be able to authorize and/or certify new fuels, energy sources and propulsive technologies that will operate safely within the National Airspace System.

The fuels and energy program also supports the DOT's Strategic Goal of Accountability. The PAFI program was 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 authorization for a new fuel. The FAA and aviation fuel manufacturers learned important research data on the anti-knock and performance characteristics of the test fuels vs industry standards, as well as important characteristics with co-mingled fuels.

As of FY19, commercial entities have invested over $20M in collaborative research to support the fuels and energy program. Some smaller commercial entities are also investing in related research activities, however that generally applies only to limited aircraft models and modifications issued under 14 CFR § 21 Supplemental Type Certificates. This program addresses industry and fleet-wide issues and concerns at the request of industry groups to the FAA Administrator.

Current timelines for alternative fuels call for various stages of completion of program elements leading up to a 2024 finish in accordance with section 504 of the FAA Reauthorization Act of 2018. Research in the areas of novel propulsive technologies including electrical, turbines, and alternative energy sources, including fuel cells, is expected to continue through 2027.

Digital Systems and Technologies

FY 2021 Program Descriptions
Aircraft Icing/Digital System Safety

Program Description/Activities/Objectives:

Aircraft Icing Program

The Aircraft Icing Program will undertake new research activities with the objective of developing information for means of compliance for both SLD structural icing and engine ICI. This research will build upon research done in FY20 in both these areas.

Digital Systems Safety

In FY21, the Digital Systems Safety Program will undertake new research activities with the objective of developing information for a means of compliance to improve the certification methods for complex digital systems. Aviation manufacturers may develop, integrate, or verify their complex systems using novel and unproven processes and techniques; this may contain machine learning and artificial intelligence and/or other methodologies that could introduce a safety risk for undetected errors with failure manifested at the aircraft level when installed in the cockpit. This research builds upon research conducted in prior years that is working towards assurance standards and guidance that is focused on flexibility (less prescriptive) that does not compromise safety, or ignore rules. The research will leverage collaborative agreements with other government agencies, academia, and industry OEMs and suppliers to identify safety issues in complex digital systems before they are installed on-board aircraft and develop an acceptable means for compliance within the framework of global harmonization.

Aircraft Cyber

FY21 brings the first full-year effort on the new ASISP Phase IV. This is based on guidance from AVS to build upon the ASISP Phase II processes and the Phase III (FY19-20) test cases as defined by AVS requirements. ASISP will include work directly with industry OEMs and suppliers to identify a means for establishing an operational trust environment for ASISP/cyber assessments that are non-attributional, to promote aviation safety. Trust environment envisioned to be modeled upon existing Commercial Aviation Safety Team (CAST), but extended to include cyber security impact to safety. This will require research to further refine and adapt the initial ASISP Safety Risk Assessment methodology for use with/by industry. The result of Phase IV research will be an implementable ASISP methodology integrated within a trust environment and validated through a Government-Industry partnership, to include research into various SRA subjects and potential industry use cases, resulting in safety risk assessments.

Program Alignment with Strategic Goals:

This program supports DOT's Strategic Goal of Safety.

Aircraft Icing Program

The Aircraft Icing program supports DOT's Strategic Goal of Safety by addressing the problem of aircraft icing, both on the ground and in flight. In ground icing, new issues are raised by industry relating to possible relaxation of current practices. For in flight icing, industry favors the expanded use of certification by analysis. Research is needed to assure that these changes will not result in any diminution in safety. Aircraft icing research complementing FAA research is supported by Transport Canada, ONERA in France, and CIRA (in

Italy). Investment in the past has led to new rules and guidance for safe operations in aircraft icing conditions. Tangible outcomes have already been achieved, and major tangible outcomes are anticipated in FY2021.

Digital Systems Safety

This research supports the DOT's Strategic Goal of Safety by providing systematic software and hardware research within the FAA that will lead to the identification, assessment and mitigation of safety risks. Data generated by this research is used to create and develop new safety standards that will be adopted throughout the aviation community. The research will address problems with complex digital systems that are developed, integrated, validated, or verified using unproven processes, techniques, and methodologies including commercial-off-the-shelf products, and streamlining processes that could introduce a safety risk for undetected errors with failure manifestation at the aircraft level. For example, industry is actively looking into introducing Artificial Intelligence/ Machine Learning applications and very little is known about the validation and verification of these applications in safety critical environments. These applications could introduce unknown risk if not properly addressed early in the design process. Prescriptive processes for development assurance have been used to address non-federated systems for years. These processes were initially able to accommodate technologies, tools, and methodologies in approximately the first two decades of use. The introduction, however, of products and approaches used in the commercial, non-aviation, non-safety sector has made the applicability of these prescriptive processes obsolete and introduced the need for new processes that allow flexibility in a safety critical, risk-based environment. These new processes are entering use now or will do so in the near term. The current systems, software, and electronic hardware assurance processes are based on explicit, somewhat invariable, detailed, prescriptive approaches using "objectives" that must be satisfied to demonstrate compliance with applicable regulations for aircraft certification. These processes do not easily address new techniques, methodologies, tools, and COTS products proposed for use in civil aircraft development. Further, the aircraft certification service is using a risk-based approach to certify products. The existing prescriptive standards do not adapt easily to allow such a risk-based approach.

Digital Systems Safety research has had funding cuts in previous years and is zero in FY20. In 2015, an FAA internal software and airborne electronic hardware questionnaire revealed that software assurance processes and complex COTS electronic component assurance processes contributed to service difficulties, ADs, and design error escapes. Some of these service difficulties were due to additional complexity of today's designs and the lack of standards for highly complex designs that use the latest tools, design methods and techniques developed for the commercial sector and not for safety critical applications. For example, AD 2014-17-10 addressed a software error in TCAS which could affect Traffic Alert & Collision Avoidance System (TCAS), Mode S transponder, Terrain Awareness Warning System (TAWS), and Automatic Dependent Surveillance-Broadcast (ADS-B) functionality in an Airbus A320.

This research should be pursued since it will analyze and identify issues with system development processes and implementation techniques. This includes streamlined approaches and allowing applicants and aircraft manufacturers to comply with the regulations when using adaptive and distributed systems and architectures in highly integrated and complex systems. The outcome of this requirement can have a positive impact on the prevention of accidents/incidents by updating the guidance and standards with mitigation approaches to detect errors affecting aircraft-level airworthiness. The FAA and NASA have an interagency agreement and have been collaboratively researching (according to the years funding was received) overarching properties, streamlining assurance techniques, and other methods for verifying and validating complex digital systems. The FY21 research will be based off the interim findings of this collaboration.

Digital Systems Safety research for FY21 is scheduled to be completed in FY24 but that date is based on receiving full funding from (FY20-FY24) and funding in FY20 is zero.

Aircraft Cyber

On 8/17/2017, OMB issued memorandum M-17-30, identifying Presidential priorities for R&D federal funding. The ASISP program addresses "American Security," one of the four "R&D Priority Areas." Specifically, ASISP is responsive to "Emerging threats. [that] compel the Federal Government to develop the technologies necessary to prevent terrorist attacks, mitigate the effects of… adversarial threats and hazards. Agencies should invest in R&D to increase the security and resilience of the Nation's critical infrastructure from… cyber-attacks." Of the three "R&D Priority Practices", ASISP addresses two. The first is "Supporting Innovative Early Stage Research - agencies should give priority to funding basic and early-stage applied research that, supplemented by private sector financing of later-stage R&D, can result in the development of transformative commercial products…. Strong partnerships with the private sector will be critical to maximizing the efficacy of Federal funding. Furthermore, agencies should take advantage of innovation from the private sector, where possible, to adapt to Federal needs." The second is "Maximizing Interagency Coordination - Agencies should support ongoing interagency initiatives and participate in applicable interagency coordination groups. The interagency process is encouraged to avoid duplicative efforts and maximize collaboration…." Of the two "R&D Workforce and Infrastructure" areas, ASISP supports "Modernizing and Managing Research Infrastructure - Innovative partnership models involving other agencies, state and local governments, the private sector, academia, and international partners can help maximize utilization of underused facilities and lead to sharing the costs of new R&D facilities."

FY 2021 Program Descriptions
NextGen - Information Security

Program Description/Activities/Objectives:

The NextGen Information Security R&D objective is to prevent and predictively determine the potential of cyber events such as unauthorized access, destruction, disclosure, or modification of information or data, and/or denial of service. FAA's NAS traffic is growing with Air/Ground and Ground/Ground networks that provide communication between different users including: FAA staff, service providers, private aviation, commercial passenger, freight carriers, and partner governments. In addition to increases in traditional air traffic, the NAS will undergo significant changes to mission requirements over time. Examples of significant potential changes to the NAS include Unmanned Aircraft Systems [UAS], emerging technologies, open architectures, cloud computing, and shared aviation information. Other kinds of changes that may happen at run time, include 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.

In support of these efforts, the Information Security program has the following activities planned for FY 2021:

- Cyber Data Science Algorithms to detect Advanced Persistent Threats (APTs)
- Demonstrate Cyber applications of Self-Healing networks
- Concept exploration study of Virtual Dispersive Networks (VDN) capabilities
- Concept exploration study of Context-aware behavioral analytics capabilities
- Analysis of Cloud based integrity improvement methods

Program Alignment with Strategic Goals:

This program supports the DOT Strategic Goal of Innovation.

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 NAS. Data gathered through this research will allow the assessment of regulatory approaches, foster information sharing and facilitate coordination and collaboration with industry and other stakeholders, and the ability to test and adopt new technologies throughout the NAS.

What problem will be addressed?

This research will address issues related to FAA Mission Support, and NAS infrastructure.

The Cyber Security Research and Development (R&D) program will continue the research, analysis, demonstration, evaluation and operational transition of tools, technologies and methods to detect, prevent and mitigate the effects of disruptive cyber incidents to include innovative concepts such as using Machine Learning and Artificial Intelligence in the National Airspace System (NAS) and Mission Support domains. Recognizing the need to protect, defend and enhance the resiliency of the national air transportation

infrastructure and pursuant to congressional direction specified in the FAA Extension, Safety and Security Act of 2016, the FAA established FAA Cybersecurity R&D Plan. The R&D program is also consistent with the goals specified in the FAA Cybersecurity Strategic Plan (2019-2024) and with the four major research project initiatives specified below. Within each initiative, the program will establish research, analysis and exploratory development activities, which will be pursued to discover and validate improved capabilities to enhance the cybersecurity posture of the NAS and Mission Support domains with the following goals:

- By 2022, transition of cyber data science analytical capabilities and research findings to operational implementation.

- By 2023, maturation of Self Adaptive Systems and Networks principles, technologies and Design Assurance methods for mixed trust environments for implementation into FAA networks.

- By 2024, a.) Demonstrate Cyber applications of Self-Healing networks within the NAS, b.) Demonstrate Cloud based integrity improvements methods for self-healing networks, c.) Demonstrate Virtual Dispersive Networks within a NAS domain and d.) Demonstration of multiple layered approach of Context-aware behavioral analytics with improved visualization techniques.

- By 2025, a.) Update algorithms for emerging Cyber applications of Self-Healing networks, b.) Cyber Data science Algorithms to detect APTs, c.) Demonstrate baseline performance of Virtual Dispersive Networks, d.) Demonstration and Integration of Context-aware behavioral analytics with mobile devices, and e.) Final analysis of Cloud based integrity improvements methods into the NAS.

Why should the FAA pursue (or invest in) this research?

(a)- American Security

- Agencies should invest in R&D to secure the resilience and increase the Nation's critical infrastructure from both physical threats and cyber-attacks, which have increased rapidly in number and complexity in recent years.

(b)- American Prosperity

- Federal investment in R&D plays an important supporting role in America's economic growth. Emerging technologies such as autonomous systems, biometrics, energy storage, machine learning, and quantum computing, have the highest potential to drive the economy and create entirely new industries.

(c)- Supporting Innovative Early Stage Research

- Agencies should give priority to funding basic and early-stage applied research that, supplemented by private sector financing of later-stage R&D, can result in the development of transformative commercial products and services.

(d)- Maximize Interagency Coordination

- Agencies should support ongoing interagency initiatives and participate in applicable interagency coordination groups.

(d)- Modernize and Manage Research Infrastructure

- Agencies should support ongoing interagency initiatives and participate in applicable interagency coordination groups.

In addition, the research outcomes shall also align with the following strategic objectives outlined in the National Strategy for Aviation Security (NSAS) document, December 2018.

- ✓ Protect the United States and its global interests in the aviation ecosystem
- ✓ Maximize aviation ecosystem security while maintaining aviation safety and balancing United States economic impact.
- ✓ Enhance Resilience, mitigate damage and expedite recovery

Who else is researching this issue?

Department of Defense (DOD) and FFRDC's are currently researching this issue and we are leveraging those efforts in support of ongoing research.

Have we invested in this topic in the past and what have we learned to date?

No, this topic is an emerging research area

What is the projected time of completion for a tangible outcome?

- By 2022, transition of cyber data science analytical capabilities and research findings to operational implementation.

- By 2023, maturation of Self Adaptive Systems and Networks principles, technologies and Design Assurance methods for mixed trust environments for implementation into FAA networks.

- By 2024, a.) Demonstrate Cyber applications of Self-Healing networks within the NAS, b.) Demonstrate Cloud based integrity improvements methods for self-healing networks, c.) Demonstrate Virtual Dispersive Networks within a NAS domain and d.) Demonstration of multiple layered approach of Context-aware behavioral analytics with improved visualization techniques.

- By 2025, a.) Update algorithms for emerging Cyber applications of Self-Healing networks, b.) Cyber Data science Algorithms to detect APTs, c.) Demonstrate baseline performance of Virtual Dispersive Networks, d.) Demonstration and Integration of Context-aware behavioral analytics with mobile devices, and e.) Final analysis of Cloud based integrity improvements methods into the NAS.

FY 2021 Program Descriptions
NextGen - Flightdeck Data Exchange

Program Description/Activities/Objectives:
FD-DER effort will continue into FY 2021 to finalize the prototype environment to enable exchange of information among EFB (certified and non-certified), AID, and FMS. Based on the exchanges in the prototype environment, the project team will identify and evaluate threats and vulnerabilities associated with current avionics and onboard aircraft systems and provide recommendations to add or tailor security controls to meet the security needs. The efforts in FY2021 will also identify current operational limitations that can be overcome by security measures identified through cybersecurity risk assessments, and further refine operational limitations.

Program Alignment with Strategic Goals:

This program supports the DOT Strategic Goal of Innovation.

FD-DER program supports the DOT's Strategic Goal of Innovation by leveraging emerging Internet of Things (IOT) technologies in aviation to improve mobility through new NAS concepts and identify potential cybersecurity risks associated with connected aircraft technology. The FD-DER program assesses the data exchange format, security, and performance requirements to enable enhanced data exchange between onboard avionics systems and ground systems. Recent advancements in flight deck automation, such as the development of EFB, AID, and on-board data links have allowed flight operators to leverage these technologies in the collaborative decision-making process. This research will assess and evaluate the cyber security risks in emerging technologies that enable exchange of data between AIDs, EFBs, and ground systems via IP data-links. This research will focus on identifying threats and recommending mitigation strategies for Identity management, confidentiality, integrity, and authenticity of exchanges. This research will evaluate the security and performance requirements as well as global standards to enable safe data exchange systems. The FD DER effort is expected to produce both notional and real cybersecurity threat mitigation strategies and network architectures for assured security and quality of service to enable future connected aircraft technologies.

The FD-DER program compliments the DataComm objective of transitioning from the current voice-based information exchange mechanisms to enable the rich data exchange for 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.

For FY19, the FD-DER program will complete initial concept development, operational and technical related assessments, as well as cybersecurity assessments for flight deck data links technologies. The FY20 effort will provide a groundwork for prototype development and concept refinement in the follow-on FY21.

Environment and Weather Impact Mitigation

FY 2021 Program Descriptions
Weather Program

Program Description/Activities/Objectives:

In FY2021, the Weather Program will continue to develop and enhance diagnosis and forecast capabilities that will benefit the American public. The Program will perform applied research on naturally occurring atmospheric aviation hazards including turbulence, convective activity, and restricted ceilings and visibility. The FAA will leverage partnerships with several NOAA and other national research laboratories to mitigate the impacts of these aviation hazards on the NAS. The FAA will either deploy these capabilities on new or existing FAA platforms and systems or transition them to National Weather Service platforms for operational use. Benefits of Weather Program research in FY2021 will 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 safety and efficiency of flights; and
- Enhancements of turbulence analyses and forecasts to increase passenger comfort, safety of passengers and crew, safety of GA operations, increased capacity in the NAS, and reduction in environmental impacts.

Program Alignment with Strategic Goals:

This program supports the DOT Strategic Goal of: Safety.

This program supports the DOT's Strategic Goal of Safety by focusing applied weather research on mitigating weather-related NAS safety issues focused on operational implementation. The research also supports the evolution and enhancement of legacy weather capabilities that meet the weather information needs of today's NAS users into the capabilities that are being deployed as NextGen decision-support weather processes. These efforts are frequently conducted in collaboration with the FAA's designated weather provider, the National Weather Service. As a result of the development of in-flight icing, turbulence, restricted ceiling and visibility, and convective weather algorithms, forecast and nowcast capabilities have been transitioned into operational or experimental use and have led to improved short-term and mid-term forecasts of these naturally occurring atmospheric hazards. Specific research within these areas is needed to further enhance the capabilities of the transitioned algorithms that will contribute to attaining further safety enhancements, especially for General Aviation, as well as the NextGen vision for the NAS. The key is to be able to provide high quality weather nowcasts and forecasts uniquely designed to allow for rapid and effective decision making by FAA Air Traffic Management, Air Traffic Control, airline operations centers and pilots to be able to select safe and optimal routes and reroutes proactively.

Research in the following areas will continue in FY 2021:

- Terminal Area Icing Weather Information for NextGen research:
    - Continue to conduct analysis of research flight test results to quantify the ability to diagnose and forecast detection/discrimination of freezing drizzle from freezing rain aloft.
    - Assess and validate meteorological data from numerical weather prediction models, weather radars, and other icing weather tools with research flight test data collected.
    - Use available results from research flight test data analysis to continue improving model microphysics and icing weather tools with an emphasis on supercooled large drops.
    - Tangible outcome anticipated in FY22 with a demonstration of the Terminal Area Icing Weather Information for NextGen (TAIWIN) capabilities.

- Mitigating the Ice Crystal Weather Threat to Aircraft Turbine Engines research:
    - Prepare for and conduct an engine ice crystal icing (ICI) flight test campaign close to an industrial area, where "non-pristine" environments exist, containing a larger variety and concentration of aerosols.
    - Tangible outcomes anticipated by FY24 with the modification of Part 33, Appendix D, include the development of airborne radar techniques and nowcasting and forecasting tools for use in detecting and avoiding ICI conditions.

- Turbulence research:
    - Commence development of a probabilistic turbulence forecast capability.
    - Commence development of a high-resolution turbulence nowcast capability
    - Incorporate automated turbulence translation technique into traffic flow management
    - Tangible outcomes anticipated in the FY2022 timeframe are research and development on probabilistic turbulence forecast, high-resolution turbulence nowcast, and automated translation technique will undergo quality assessment and operational suitability evaluations.

- Convective Weather research:
    - Development and transition of expanded geographical domain for the Offshore Precipitation Capability to NWS and/or FAA/AJM for incorporation into the NextGen Weather Processor (NWP).
    - Development and transition of enhanced Convective Weather Avoidance Model to AJM for incorporation into NWP.
    - Transition the Ensemble Prediction of Oceanic Convective Hazards capability to operations at NOAA for use by the Washington World Area Forecast Center.
    - Development of high resolution nowcasts (0-2 hours) of convection for UAS and commercial space application.
    - Tangible outcomes of this research anticipated to be available in the FY22-23 timeframe.

- Ceiling and Visibility (C&V) research:
    - Development of techniques to translate C&V analysis and prediction information into ATM decision support processes.
    - Commence transition of camera-based visibility estimates into operational use.
    - Improve ceiling & visibility weather prediction models and post-processing algorithms.
    - Develop tools and processes that advance the concept of a common operating picture for all aviation decision makers.
    - Tangible outcomes are anticipated to be available in the FY21-22 timeframe.

- Quality Assessment (QA) research:
    - Conduct quality assessments of weather research capabilities for high resolution turbulence and Alaska C&V using camera images.
    - Perform analysis of new techniques and data sources.
    - Investigation of techniques for assessments in support of weather capabilities for UAS.
    - The QA efforts will provide independent verification and assessment of forecast quality and skill of research capabilities that are either in development or being considered for transition to operations. QA is required to ensure that new aviation weather capabilities provide accurate and reliable info to support NAS user decision-making. Meteorological accuracy is critical to ensure safe and efficient operations in the NAS during weather events. Tangible outcomes are provided annually via evaluation outcome reports and briefings.

- Aviation Weather Demonstration and Evaluation (AWDE) Services research:

- Conduct assessments of weather diagnosis and forecast capabilities including turbulence, C&V, and convective weather forecast statements.
- Advance the AWDE concept and product capability for the integration, evaluation, and demonstration of future NextGen concepts and technologies.
- AWDE services provides assessments of weather research capabilities to reduce programmatic risk by ensuring that the weather data meets user needs and are suitable and usable in an operational environment. It is critical to the successful maturation of research concepts prior to transition into the NAS. Tangible outcomes are provided annually via evaluation outcome reports.

FY 2021 Program Descriptions
NextGen - Weather Technology in the Cockpit

Program Description/Activities/Objectives:

The main goal of the 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, gaps in cockpit MET information, and gaps 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 shortfalls, 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, Part 91/135 MinWxSvc, and enhanced pilot training are as follows.

- 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 and traditional weather sensor 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 with poor visibility being another leading cause of fatalities for general aviation. This information will resolve multiple gaps associated with these safety issues. This information will also enhance access to underserved communities by enabling more Visual Flight Rules (VFR) flights due to the availability of accurate visibility and ceiling information.

- Helicopter Gap Resolutions
  - Outcome Supported: Based on WTIC gap analyses and inputs from stakeholders, the WTIC program will perform research to resolve identified gaps in weather information in the cockpit to support safe helicopter operations. The gap analyses focuses on three operational scenarios for helicopters: Surveillance, Medical and Rescue, and Air Tour.
  - Benefits Supports: The project will enhance safety by resolving gaps that are attributable to previous accident and incidents, or safety hazards and risks identified by stakeholders that are confirmed via the gap analyses. Due to the large variety of services provided by helicopter operations, addressing these gaps will have a broad benefit to the public by enhancing safety and access.

- Three Dimensional Rendering of Icing Information
  - Outcome Supported: Currently icing information in cockpits does not provide a stratified view so pilots need to vary flight plans laterally to avoid areas of icing. This project is intended to

assess the capability of Multi-Radar Multi-Sensor (MRMS) composites to provide sufficient resolution to present stratified icing information in Part 135 and Part 91 aircraft. The project will also assess the applicability of adapting a WTIC developed 3-D display of turbulence for the icing display.
    - Benefits Supports: Icing is a significant hazard for Part 91 and many Part 135 aircraft. In areas with more severe terrain the ability to only avoid areas of icing with lateral alterations can be inefficient and in many cases risky. By providing a 3-D view of areas of icing, pilots will have increased options to avoid icing efficiently and safely which will provide increased access to many areas.

- Pilot Reports (PIREPs)
    - Outcome Supported: PIREPs are the primary method for pilots to provide safety related information on weather to other pilots and to provide weather observations for ingest into weather models to enhance forecasting. A lack of PIREPs and errors in PIREPs has been identified as a significant gap by stakeholders including AOPA and the National Weather Service. WTIC research is being done to address causal factors in PIREP errors and to make submittal of PIREPs much easier for pilots to increase the number of PIREPs and the quality/accuracy of them.
    - Benefits Supports: The outcome supports all part aircraft by providing accurate information on adverse weather encountered by other pilots for use in adverse weather decision making. Additional and higher quality PIREPs will also benefit weather forecasts which enhances safety and efficiency in operations in adverse weather.

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.

Program Alignment with Strategic Goals:

This program supports the DOT Strategic Goal of: Innovation.

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 NAS. Data generated by this program will allow the assessment of regulatory approaches, foster information sharing,

facilitate coordination and collaboration with industry and other stakeholders, and provide 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 decisions, 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 rely 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.

FY 2021 Program Descriptions
Environment and Energy

Program Description/Activities/Objectives:

In FY 2021, this Program will continue to advance 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. Work will continue on evaluating innovative solutions to reduce the environmental impacts of aviation, including novel operational procedure concepts to reduce community noise. Efforts will also continue on further expanding the AEDT capabilities and on developing screening tools, both of which are necessary to support community acceptance of new procedures. Finally, the Program will continue to leverage its advancements in knowledge and tools to support the development of the international standards, including standards for supersonic aircraft landing and takeoff noise, on which global aviation depends for continued development and growth.

Program Alignment with Strategic Goals:

This program supports the DOT Strategic Goal of: Infrastructure.

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 the continued mobility and economic growth that accompanies the air transport sector. Innovation is required in developing the technological and operational measures needed to reduce aviation's impacts on the environment. These measures 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.

FY 2021 Program Descriptions

NextGen - Environmental Research - Aircraft Technologies, Fuels, and Metrics

Program Description/Activities/Objectives:

In FY 2021, the NextGen Environmental Research 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, 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.

Program Alignment with Strategic Goals:

This program supports the DOT Strategic Goal of: Infrastructure.

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.

Human Performance and Aeromedical Factors

FY 2021 Program Descriptions
Flightdeck / Maintenance / System Integration Human Factors

Program Description/Activities/Objectives:

The Flightdeck/Maintenance/System Integration Human Factors Program will provide 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. This program will develop human performance information that the Agency could provide to industry for use in the design and routine operation of aircraft, and the training of pilots and aviation maintenance personnel.

The main goal for the Flightdeck/Maintenance/System Integration Human Factors program is flight operations safety. This program will support this 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 will address some of the most critical areas of flight safety, as described below. In FY2021, there are six planned research areas that this program may address.

The first area is *Emerging Flight Deck Technologies.* This human factors research will focus on the integration of flight deck systems, software, and human factors considerations to understand the implications of emerging technologies from a systems perspective. This research will address new display concepts and advanced control interfaces. This research will provide human factors data to support the certification of these technologies.

The second area is *Advanced Vision Systems, Head-Up Displays (HUD), and Head Mounted Displays (HMD): Operational Standards & Approval Criteria.* This research will focus on the characterization of human factors/pilot performance considerations when using Advanced Vision Systems, HUD, and HMD for new low visibility concepts of operation. This research will inform the development of operational requirements, standards, conditions, limitations, mitigations, and authorizations for the use of these technologies. Potential FY2021 focus areas may include the development of evaluation tools to help AEG pilots evaluate new EFVS, SVGS, and CVS/CVGS systems for operational suitability during certification. FY2021 research may also result in the identification of special emphasis items and recommended training items for EFVS, SVGS, and CVS/CVGS systems.

The third area is *Fatigue Mitigation in Flight Operations*. This research will build upon past accomplishments and continue to evaluate pilot fatigue data and the effectiveness of fatigue risk management approaches utilized by Part 121 and Part 117 certificate holders. This research will aim to improve flightcrew member alertness through policy updates and educational materials associated with FRMP and FRMS. Potential FY2021 focus areas may include the analysis of the FAA FRMS database to further understand pilot performance and fatigue under operational conditions associated with extended flight duty periods and flight times; characterization of human factors/pilot performance considerations in flight operations involving short haul multiple segment workload and cumulative sleep loss across trip pairings; and the evaluation of the behavioral adaptation of pilots to multiple time zone shifts associated with long-haul and ultra long-range flight operations. This research will better inform the development of operational requirements, standards, conditions, limitations, mitigations, and FRMS authorizations relevant to these flight operations issues.

The fourth area is *Maintenance Human Factors to Support Risk-Based Decision Making and Maintenance Safety Culture***.** This research will focus on the integration of human factors into required maintenance safety management systems (SMS). This research will provide AFS-300, industry, and the Administrator with the information needed for appropriate action to address multiple issues that have been prioritized by the NTSB, AVS infoshare, and the Office of the Secretary of Transportation/FAA/Industry in July 2018. Potential FY2021 focus areas may include the finalization of Safety Culture reports and support tools that were developed during

previous years of research; validation and finalization of a RBDM tool for assessing schedule-based fatigue risk; validation and finalization of human factors SMS reports that were developed during previous years of research; and the validation and finalization of General Aviation Maintenance Error reports and support tools developed during previous years of research.

The fifth area is *Pilot Training, Qualification, Procedures and Flight Operations.* This research will focus on the development of data-driven guidance for inspectors and operators on training methodologies (especially concerning use of technologies in training, such as distance learning and virtual reality), as well as qualification and operational procedures. Research will also aim to provide data-driven recommendations to address emerging risks, including that of the upcoming pilot workforce.

The sixth area is *Human Factors Considerations and Emerging Trends Associated with Helicopter Air Ambulance Operations.* This research will focus on the characterization and evaluation of human factors and human performance considerations associated with helicopter air ambulance operations. This research will provide information that can be used to enhance the FAA's understanding of current industry risks, emerging issues, and trends to inform policy, operational requirements, standards, procedures, limitations, mitigations, and guidance materials pertaining to helicopter air ambulance operations.

Program Alignment with Strategic Goals:

This program supports the DOT Strategic Goal of: 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.

FY 2021 Program Descriptions
Air Traffic Control / Technical Operations Human Factors

Program Description/Activities/Objectives:

The purpose of this Air Traffic Control/Technical Operations (ATC/ATO) Human Factors program is to provide scientific and technical information that Air Traffic Organization technical sponsors will apply in their work to improve the safety and efficiency of complex ATC systems. The research that we conduct produces information supporting the ATO's needs by measuring and enhancing the performance of individual controllers and specialists, improving the integration of NAS technologies for controllers and technicians, addressing the human contribution to safety in air traffic control operations, and supporting data-driven decisions related to the workforce, including selection methods, job placement, performance measurement, and training.

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.

The FY2021 research program will address ongoing needs for scientific and technical information to support ATO technical sponsors in each of the major focus areas.

Workforce optimization research in FY2021 includes studies to:

- Identify training best practices for improved ATC field training effectiveness,
- Analyze field training success as a function of performance in training at the Academy and measures of cognitive skill and personality,
- Evaluate and recommend improvements to student performance evaluations at the Academy's ATC laboratory, focusing on reliability of instructor ratings,
- Analyze ATSS training data to identify potential criterion measures for success in training, including performance and time to achieve certification.

Research to address human factors in safety in FY2021 includes studies to:

- Model human performance to identify potential controller workload impacts when UAS are operating in controlled airspace for a variety of UAS missions and number of UAS that are simultaneously operating, beginning in the TRACON environment (an air traffic human factors research requirement that was coordinated through AJI and in accord with the AUS R&D Plan);

- Use surveys to determine the extent to which perceived controller workload contributes to perceptions of fatigue; and
- Evaluate operational safety data and research literature to identify and address knowledge gaps regarding ATC human performance contributions to wrong surface runway safety events.

Human factors research to support integration of technology into the NAS in FY2021 includes studies to:

- Identify terminal radar air traffic control (TRACON) user interface characteristics that are inconsistent with human factors design requirements, probable impacts on controller performance, and recommended mitigations;
- Review and analyze human factors literature to identify relevant findings, and propose new and revised requirements for design characteristics of automation in ATC systems, as an update to the Human Factors Design Standard (HF-STD-001B) section 5.1 Automation;
- Research to improve human performance in FY2021 includes studies to:
- Identify time-based metering skills for traffic-flow management personnel, within their roles and responsibilities in coordinating time-based flows with facilities throughout the NAS to inform requirements for scenario-based training and personnel selection; and
- Identify age-related cognitive skills and abilities that predict success or failure in the ATC occupation, and make recommendations for future training and selection research

Program Alignment with Strategic Goals:

This program supports the DOT Strategic Goal of: 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. Data generated by this research are used to create and develop new safety standards that will be adopted throughout the aviation community. No one outside the FAA has the charter to research these safety issues, although we will leverage other FAA, NASA, and industry research efforts that have been conducted in relevant safety-critical domains. The FAA and NASA Ames Research Center collaborated on a study of controller fatigue several years ago, and the FAA made policy changes to extend the minimum time between work shifts and the minimum number of controllers on duty during the night shift. However, subjective fatigue effects following experience with high workload (i.e., high traffic density operations) has not been evaluated, and this FY2021 work is therefore deemed critical to safety.[1]

The Air Traffic Control/Technical Operations human factors FY 2021 research program supports the DOT's Safety Strategic Goal. By conducting research to model human performance and thus identify potential controller workload impacts when UAS are operating in controlled airspace, the program will be able to support ATO sponsors who are engaged in addressing the challenges involved in safely integrating UAS operations into the NAS. Other research that will determine the extent to which perceived controller workload contributes to perceptions of fatigue will enable the ATO to develop policies and management practices that will limit fatigue and also provide recuperative breaks after particularly taxing (high workload) situations, using appropriate data in the controller staffing model. Finally, key safety research will help to address human factors aspects of wrong surface runway safety events and to develop potential mitigations involving controller communications and procedures. This work is motivated by recent high-profile events such as Air

[1] https://www.faa.gov/data_research/research/media/NASA_Controller_Fatigue_Assessment_Report.pdf

Canada 759 and an FAA Call to Action meeting to develop actionable recommendations to address the factors involved in wrong surface events.[2]

Due to the time required to initiate research agreements such as research grants and cooperative agreements it is anticipated that tangible results will be available after approximately two years.

[2] https://www.ntsb.gov/investigations/pages/dca17ia148.aspx

FY 2021 Program Descriptions
NextGen – Air Ground Integration Human Factors

Program Description/Activities/Objectives:

The NextGen – Air Ground 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 future aircraft operations. Functionally, human factors 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.

The primary goal of the NextGen - Air Ground Integration Human Factors Program is enhanced safety and operational efficiency. In FY2021 four research areas are planned to be addressed. The first one is *NextGen Aircraft Systems & Controls Research*. This research will evaluate the human-system performance benefits and limitations of emerging flight deck displays, technologies, systems, and controls. Potential FY2021 focus areas include characterizing pilot performance when using sensor based technologies (e.g. IR, MMW, LIDAR) for advanced vision systems (e.g. EFVS, SVGS, CVS) during low visibility flight operations (e.g. SA CAT II, III), and characterizing pilot performance when using novel displays, including HWD/HMDs, during low visibility conditions that require independent verification of visual reference points. FAA stakeholders may 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 may apply outputs from this research to close strategic regulatory and guidance material gaps (e.g. Ops Specs, MSpecs, LOAs, AEG evaluation criteria, etc.).

The second research area is *NextGen Human Error Mitigation Research.* This research aims to proactively detect and respond to NextGen flight deck technology shortfalls/gaps that could increase the opportunity for human error in future NAS operations. Potential FY2021 focus areas include addressing the pilot performance impacts of information automation (e.g. enabling NextGen technologies), evaluating the human factors resiliency impacts introduced by Full TBO and Dynamic TBO, and responding to far-term flight crew task management needs. FAA stakeholders may apply research outputs to conduct technology design reviews, down-select potential design alternatives, and respond to emerging human-system interface issues. Stakeholders may also apply research outputs to update FAA regulations (e.g. 14 CFR Part 121, Subparts N, O, Y (AQP); 14 CFR Parts 2X.1301, 25.1302), corresponding guidance materials, and best practices that are used to assess NextGen technologies/systems for human error tolerance.

The third research area is *NextGen Flightcrew Readiness Research.* This research will respond to strategic 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. Potential FY2021 focus areas include the conduct of an instructional requirements analysis of all relevant job tasks for pilots in a TBO environment to include individual, crew, and team tasks, and the test and evaluation of new training methods to help drive future FAA training and checking guidance. FAA stakeholders may 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.

The fourth research area is *NextGen NAS and Flightcrew Procedures Research.* This research will proactively identify and address operational integration issues that could result from the implementation of future NAS procedures, pilot procedures, and advanced flight deck separation management concepts. Potential FY2021 focus areas include the development of data-driven human factors mitigations to address emerging flightpath management and monitoring needs, and human factors mitigations to address the impacts of increasingly complex NAS and flight crew procedures in a TBO environment. FAA stakeholders apply research outputs to develop NextGen 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 procedures and NextGen concepts on flightcrew performance. Research may also inform future updates to FAA Orders (e.g. 8900.1, 8260 series as needed including 8260.19, 8260.46, and 8260.58) and guidance materials (e.g. AC 90-105A, AC 90-100A, & AC 90-101A, etc.).

Program Alignment with Strategic Goals:

This program supports the DOT Strategic Goal of: Safety and Innovation.

This program supports the DOT's Strategic Goal of Innovation by providing targeted R&D within the FAA that will lead to new technology development and deployment in the NAS. Data generated by this research will allow the assessment of regulatory approaches, foster information sharing, and facilitate coordination and collaboration with industry and other stakeholders. This also provides 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 specifically impact rural communities.

FY 2021 Program Descriptions
Aeromedical Research

Program Description/Activities/Objectives:

Program descriptions, activities, and objectives for FY2021 are presented by research area in the proceeding sections.

AM-1 (Aerospace Medical Systems Analyses)

- By 2021, BASICMED: describe the effect on aviation safety of the BASICMED regulations issued by H.R. 636/S. 571/PL 114-190 of July 15, 2016 (Sec. 2307 h, Medical Certification of Certain Small Aircraft Pilots).
- By 2021, Explore the characteristics of airline inflight medical events; the differences between those reported to the FAA compared to other entities; obtain accurate estimates of the numbers, causes, and operational consequences of these events; and provide recommendations to reduce them.
- By 2022, Use modern data analysis techniques to update the primitive FAA reports from the 1960's and 1970's that considered the association of aircraft accidents with a broad range of health conditions as defined by FAA pathology codes (path codes).
- By 2021, Investigate the cumulative risk of comorbidities in aircrew, identifying areas to improve the determination of medical certification to improve aviation safety.
- By 2021, Use high powered computing to generate improved response functions for aircraft/spacecraft exposure to galactic cosmic rays.

AM-2 (Aerospace Medical Accident Prevention and Investigation)

- By 2022, Prevalence of drug use in the pilot population by testing the urine samples that pilots provided for medical screening.
- By 2022, Develop and validate a forensic toxicology laboratory methodology to perform analysis of novel psychoactive substances in postmortem fluids.
- By 2021, Determine the prevalence of synthetic opioids in aviation fatalities.
- By 2021, Develop and validate a Gas Chromatography-Tandem Mass Spectrometry (GC/MS/MS) method for the simultaneous detection and quantitation of antihistamines in biological matrices.
- By 2024, Compare biomarker patterns across groups with varying levels of fatigue susceptibility, when exposed to sleep deprivation.
- By 2021, Examine gene expression patterns in response to using Modafinil as a countermeasure to sleep deprivation.

AM-3 (Human Protection and Survival)

- By 2021, Determine the effect of minimum seat pitch and width, and alternative seat configurations on cabin safety evacuations.
- By 2022, Identify procedures to gather pertinent crash and injury information to support the aircraft certification organization's effort to correlate rotorcraft design features with mechanism of occupant injuries.
- By 2021, Modernization of the apparel for use in standardized biodynamics crash testing, ensuring that the dynamic response of the Anthropomorphic Test Device (ATD) is not unacceptably altered by the change to modern clothing.

- By 2021, Test the worst-case scenarios using low-flow passenger oxygen systems, to determine the impact of requested deviation requests, and to assist the aircraft certification organization in updating the related Technical Standard Order (TSO).

Program Alignment with Strategic Goals:

This program supports the DOT Strategic Goal of: 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. Data generated by this research is used to create and develop new safety standards that will be adopted throughout the aviation community.

- AM-1, AM-2, and AM-3 align with multiple DOT Strategic Plan 2018-2022 Goals and Objectives.

    - Goal 1 – Safety (Obj. 1) Systemic Safety Approach (data, risks, collaboration, leadership, evaluation, performance): All AM-1, AM-2, and AM-3 research is focused on the human element of the aviation and aerospace system. Forensic toxicology examines the remains of humans involved in aerospace accidents in order to assist the NTSB in their determination of causation and to make recommendations to prevent the next accident from occurring. Genomics research is working to create an individualized test for fitness for duty, to protect the aircrew, their passengers, and those on the ground near them. Numerical sciences research is trying to protect humans in aerospace from radiation hazards. Medical research is trying to ensure that our medical certification decisions are not too stringent, and not too lax, based upon empirical evidence. Chemistry research identifies the analyses for new drugs as they emerge. Environmental physiology research is trying to ensure the continued health and well-being of passengers and aircrew alike, as they function in the aerospace environment, and to ensure that they will be protected even in the unlikely event of a rapid decompression event, by ensuring the safety equipment on-board provides adequate protection. Biodynamics crash research focuses on ensuring that the seat structures, cushions, safety harnesses, air bags, etc. provide adequate protection for passengers and aircrew to survive an aviation accident or incident that occurs at low enough g-forces to be humanly survivable. Cabin safety research focuses on life vests, evacuation slides, passenger briefing cards, and other safety equipment, to ensure that passengers and aircrew can escape following an aircraft accident or incident that they survived, prior to being consumed by a post-crash fire.

    - Goal 2 – Infrastructure (Obj. 1) Project Delivery, Planning, Environment, Funding and Finance (partnerships) and (Obj. 4) Economic Competitiveness and Workforce (workforce development). Aeromedical research is performed by internal FAA personnel of the Aerospace Medical Research Division of CAMI. This allows CAMI to create and retain this knowledge – base of world-renowned expertise, which is of significant benefit to the flying public. CAMI partners with the Department of Defense, academic institutions, other international researchers, and aviation industry experts to share knowledge and data for the mutual benefit of all. Most of our research projects are completed with little more than the cost of the salaries of our researchers, which allows us to produce more results with less financial outlay per

project than organizations who have financial profit worked into their overhead costs. We share our knowledge with those in the aerospace industry and international safety researchers, to promote aerospace safety and best practices globally. We host symposiums to cover our current research, and provide Cabin Safety Workshops and Impact Workshops annually.

- Goal 3 – Innovation (Obj. 1) Development & Innovation (coordination, research, partnerships, data) and (Obj. 2) Deployment of Innovation (technology integration & collaboration). According the "Worldwide Threat Assessment" published last year by the Office of the Director of National Intelligence, the only area in which the USA is still in the lead, when compared to the People's Republic of China is in medical science. CAMI is proud to be a part of creating and maintaining this lead. CAMI's Functional Genomics research laboratory is recognized as one of the global leaders in their field of research, having identified approximately 200 biomarkers for sleep deprivation and other biomarkers identifying attention lapses. This has been recognized by the DOD, who is interested in tracking CAMI's research, and working in collaboration with CAMI's laboratory. CAMI's laboratories are state-of-the-art facilities which are continuously upgraded and maintained. CAMI currently has a high powered computational laboratory, which is used to process the data from the neutrino monitors on satellite systems to predict radiation dosimetry. They are also being expanded for use in functional genomics, and to mine our medical, toxicology, and aerospace accident information, using big data techniques to identify trends that can be used to improve the safety of the National Airspace System, and the humans that use it.

- Goal 4 – Accountability (Obj. 2) Mission Efficiency & Support (workforce, information systems). Since CAMI's research is performed in-house, CAMI creates and retains expertise in respective areas of research. This provides significant and continuing value for the flying public, and improves the safety of the National Aerospace System. It allows CAMI to create standardized tests for vendors to use to test their products, without worrying that there is an ulterior financial motivation in determining recommendations, and without worrying that CAMI is too close to the operators or manufacturers to make objective decisions and recommendations. CAMI partners with the Department of Defense, academic institutions, other international researchers, and aviation industry experts to share knowledge and data for the mutual benefit of all. Most of CAMI's research projects are completed with little more than the cost of the salaries of internal researchers, which allows CAMI to produce more results with less financial outlay per project than organizations who have financial profit worked into their overhead costs. CAMI shares knowledge with those in the aerospace industry and international safety researchers, to promote aerospace safety and best practices globally. CAMI hosts symposiums to cover current research, and provide Cabin Safety Workshops and Impact Workshops annually.

- What problem will be addressed?

  - The program is formulated to keep abreast of emerging human safety risk issues such as those brought by the aging pilot population with changes in their health conditions and accompanying therapeutic solutions. It also concerns aircraft materials, equipment, cabin

configurations, life support systems, and evacuation procedures that may affect survival from an aircraft accident. The program is also designed to address the complexity of software, technology, and systems integration practices as these continue to evolve. Advances in computational biology, omics sciences, modeling & simulation, and tools to facilitate the integration of very large aeromedical data sets containing disparate information will lead to improved knowledge management and decision-making processes in aerospace medicine.

- Why should we pursue (or invest in) this research?

    - The research performed by CAMI provides high value. Specifically, it improves safety, reduces risk, and saves lives. CAMI uses evidence to determine recommendations to improve or maintain the current safety level of aerospace travel, through continuous technological advances. Aircraft systems are complex and changes (advances, disruptions, etc.) in one area can affect other important areas like survivability. As technologies advance, CAMI's job is to maintain awareness and ensure that the humans involved remain safe and/or are exposed to less risk.

- The results of aeromedical research benefit the American public by providing:

    - Continued Operational Safety – Results of research maximize the strengths of the human link in the NAS by improving human safety through evidence-based medicine;

    - Enhanced Standards and Policy – Investigation and analysis of injury and death patterns in civilian flight accidents and incidents enable the development of preventive strategies including language for aeromedical and engineering standards and policies, educational materials, and criteria concerning equipment, technology, and procedures for human protection and survival from stressful environments and emergency events; and

    - Risk Management – The results of this research support accident investigation, aircraft certification, flight standards, and medical certification processes to identify hazards and augment aeromedical safety information systems towards an Aeromedical Safety Management System. This system in turn proactively addresses emerging safety risks to humans in the NAS by using consistent, data-informed approaches to make smarter, system-level, risk-based decisions.

- Who else is researching this issue?

    - CAMI is the global leader in aeromedical research, and most of CAMI's projects are individually so small in budget, that they are not attractive to business enterprises. CAMI collaborates with the DOD, other federal agencies, academic institutions, and other health organizations. However, the results are mixed and relatively unpredictable when relying on grants to academic institutions and outside entities. Compared to the DOD, CAMI's focus is different. For example, while the DOD will test seat structures and cushions to find the best fit for a particular mission, they can typically afford to use more expensive options than what is used for civil operations, and when they find the best fit for their mission, their research ends. CAMI has to continue our research to discover the most relevant performance criteria, to accommodate a much broader variety of and much less expensive choices. We must develop standardized and repeatable tests, based upon the critical performance characteristics, so that aircraft certification and flight standards organizations can publish these tests for vendors to follow, such that they can test their own products, to see if they will meet our requirements.

- Have we invested in this topic in the past and what have we learned to date?

    - Yes, the Civil Aerospace Medical Institute has been performing research since at least the 1960s. CAMI's research is important and it saves lives. For example, CAMI's research can help take a horrific accident like that of Asiana Airlines 214, in July, 2013, a large jet did a cartwheel after striking the seawall, broke into pieces, and was consumed in a post-crash fire, and make it survivable by 99% of the occupants, with 98% of the passengers being able to self-evacuate, and 83% of the occupants sustaining minor or no injuries. The aircraft sustained multiple impacts throughout the accident sequence, and the structures and seats absorbed a tremendous amount of energy. According to the data, this would not have occurred with the seat structures back in the 1970s and 1980s. There are also changes on the horizon, where there is great interest in more autonomous flight. With fewer or no flight crew on board, CAMI's safety evacuation instructions and safety equipment will need to change too. CAMI is also looking to the needs associated with the space tourism plans in the future. For example, what will need to be evaluated to determine who is medically fit to participate in space flight? What types of safety and medical equipment will need to be on-board these flights, and who will be trained to use them? CAMI plans to be involved in providing these and many more answers, through research.

- What is the projected time of completion for a tangible outcome?

    - There are many tangible outcomes, each and every year. The Advisory Circular 121-24D, released on 3/5/2019, contains the new recommended brace position for aerospace accidents that was determined through our research, and it contains data on the evaluation of Serious Games for passenger education, which were developed with the guidance of and a grant from our Cabin Safety Research Team to the University of Udine. Our forensic toxicology results are used to determine the causation of aviation accidents on a continuous and ongoing basis.

FY 2021 Program Descriptions

NextGen Transportation System – Enterprise, Concept Development, Human Factors & Demonstrations Portfolio

Program Description/Activities/Objectives:

Enterprise Concept Development, Human Factors, and Demonstration Portfolio 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 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.

The program will continue to validate operational concepts to identify technical and operational requirements. Through stakeholder demonstrations, the program will collaborate with users, operators, and other partners on emerging technologies, NAS-wide concepts, and human factors considerations to transform Trajectory-Based, Unmanned Aircraft Systems operations (e.g. TBO and UAS) and emerging operational concepts.

- ETM (FY2020-21) – Class E Upper Airspace Trajectory Management Demonstration and Safety Assessments that will demonstrate the feasibility of integrating new entrants into NAS Class E airspace above flight level 600.

- UAM (FY2020-21) – Urban Air Mobility concept of operations, scenarios and demonstrations. The objective will be to develop a concept for immediate and flexible air transportation within a metropolitan area consisting of passenger-carry operations.

- Innovative Airports (FY2020-21) – The Innovative Airports demonstration will plan and execute capabilities to showcase potential application of low cost technologies to improve airport operations.

- AI (FY2021) – The Artificial Intelligence for the NAS will evaluate how various AI methods can be leveraged to improve the management of the NAS. Potential applications in the aviation industry include leveraging AI to support ATC, GA and NOTAMs.

Program Alignment with Strategic Goals:

This program supports the DOT Strategic Goal of: Innovation.

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 NAS. Data generated by this research will allow the assessment of regulatory approaches, will foster information sharing and facilitate coordination and collaboration with industry and other stakeholders, and provide the ability to

test and adopt new technologies throughout the NAS. This program does not specifically impact rural communities.

Aviation Performance and Planning

FY 2021 Program Descriptions
System Safety Management

Program Description/Activities/Objectives:

In FY 2021, the wet runway wheel braking testing project will be primarily focused on continuation of flight testing efforts, continuation of big data analytics/machine learning efforts, data analysis from flight testing, and documentation of results and conclusions. Based on lessons learned from initial flight test experiments conducted in FY19 and FY20, additional and more comprehensive flight tests will be conducted with different aircraft types and in a wider variety of pavement and environmental conditions, increasing the robustness of future predictive models. Analysis of big data from a variety of sources and the use of machine learning methods will also likely have a significant positive impact on the research project. It is expected that the results obtained from both flight testing and machine learning will complement each other and serve to close numerous gaps of knowledge with regards to the wheel braking capability for aircraft landing on wet and contaminated runways. This will lead to more accurate assumptions, better standards and guidance material, and reduced risk of runway overruns in poor weather conditions.

In FY2021, rotorcraft safety research projects on Vision Systems Technologies, Helicopter Flight Data Monitoring to Improve Rotorcraft Safety, and Simulator Modelling for Improved Fidelity will focus on extending aspects of previous research to new examine new capabilities, data elements, and simulator models. Following on from research conducted in previous years, the research team will examine the role of Vision Systems Technology and interoperability with other helicopter navigation and surveillance systems for Head-Worn/Helmet-Mounted/Heads-Up Displays (i.e. for IFR/VFR flights look at systems like ADS-B, navigation, and complex route structures displayed on and interfaced to Vision Systems technologies). The team will also explore the feasibility of landing system technologies and augmented reality concepts with Enhanced/Synthetic/Combined Vision for Helicopters for both onshore and offshore operations as well as visual cueing to mitigate obstacles, and, in conjunction with these other systems, allow helicopters to be able to operate closer to the rig/hospital and assure landing or takeoff with minimal risk to persons or property. In addition the research team will collect simulation data from various helicopter types and operators from existing simulator/flight training devices (i.e. Flight Safety, CAE, ELITE, FRASCA, X-Plane, Microsoft Flight Simulator, etc.) and helicopter flight test data from multiple helicopter types and operators performing candidate maneuvers across various mission segments (i.e. HAA, OGP, Flight Training, Aerial Application, Air Tour, etc.). Data from these flights and simulator trials will be used to begin to develop improved mathematical/physics-based flight dynamics simulator models which capture non-linear behavior of rotorcraft flight dynamics, particularly, mapping rotor rpm within an allowable range within the simulation. All of these efforts, should help the FAA develop policy, guidance, and regulatory materials that will support United States Helicopter Safety Team's (USHST) helicopter safety enhancements for the rotorcraft community; a result that will hopefully lead to a reduction in the helicopter fatal accident rate.

Program Alignment with Strategic Goals:

This program supports the DOT Strategic Goal of: 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. Data generated by this research is used to create and develop new safety standards that will be adopted throughout the aviation community.

The FAA's Office of Aviation Safety (AVS) plans 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. We have invested in this topic in FY2019 and FY2020. The anticipated time of completion is 2022.

The FAA's Office of Aviation Safety (AVS) plans to use the results of the research for the improved simulator fidelity modelling to be able to reduce the helicopter fatal accident rate by developing improved models for helicopter flight dynamics for the rotorcraft industry. These models, in turn, will be used by the industry to enable more realistic training and facilitate the development of basic skills in a low-risk and safe operational environment. Research activities for this effort will contribute to the development of revisions to FAA policy (FAA Orders), guidance (Advisory Circulars), and regulatory material (i.e. rule changes to 14CFR Part 60) related to ATD's, AATD's, and FFS's for helicopters. To help prevent fatal rotorcraft accidents due to Loss of Control (LOC), the rotorcraft community needs to improve the fidelity of simulator/flight training device mathematical models for helicopter flight dynamics. These models are not accurate at edge-of-the envelope and outside-of-the envelope flight regimes and this is leading to inaccurate control inputs for pilots seeking to recover from a loss-of-control condition. By investing in this research, the FAA directly addresses this problem at its root cause, the helicopter pilot's training environment where maneuvers and recovery techniques can be taught in a safe, controlled environment. The FAA is working with industry partners who are also examining this issue and leveraging past research work from the Helicopter Flight Data Monitoring (HFDM) for ASIAS effort that has developed several models for outside of the envelope conditions. Even though this effort does not start until FY2020, the research team can leverage lessons learned from the HFDM for ASIAS project as well as several flight tests and simulations that highlighted the limitations of current simulator modelling methodologies. This foundational knowledge base will enable the research team to achieve a meaningful outcome on the project by 2024 at which point we expect to begin affecting policy and operational changes to allow for the use of improved fidelity helicopter flight dynamics models in helicopter full flight simulators/Aviation Training Devices (AATD's/Basic).

The FAA's Office of Aviation Safety (AVS) plans to use the data obtained from the Helicopter Vision Systems research project to address one of the main safety-related problems facing the FAA today: helicopter fatal accidents; primarily those related to low visibility conditions at low altitude in marginal or inclement weather. By examining operational concepts and developing criteria for approving new vision-enhancing technologies, the AVS plans to develop the regulatory basis/framework (i.e. policy, guidance, rulemaking, etc.) to enable the use of EHVS systems as part of improved low-level helicopter infrastructure. This will increase helicopter operations in low visibility conditions, enable improvements for low level infrastructure used by helicopters, general aviation, and unmanned aircraft/eVTOL, and ultimately save lives by reducing or preventing fatal accidents. This is a key area of emphasis within the helicopter industry as well as the United States Helicopter Safety Team, and enables collaboration with other regulatory agencies including EASA. Other entities that this project routinely collaborates with include the DOD and standards groups such as RTCA SC-213, EUROCAE WG-79, and others that are examining the issue from a Degraded Visual Environment perspective. However, the FAA (with industry partners) is the only entity performing this research for the purpose of developing/modifying the criteria to allow this type of operation for helicopters. The FAA has invested in this topic area and has obtained corporate knowledge having flight tested several systems and technologies in the FAA's S76 helicopter. These tests have yielded findings on such areas as sensor field of view/regard, display requirements, performance issues, and other characteristics that are critical to understand in order to develop effective criteria for policy, guidance, and rulemaking. It is expected that the FAA's research will yield noticeable benefits by 2021 with eventual completion draft criteria for possible rulemaking by 2024. This is dependent on the maturity and viability of the technologies that exist today, as well as the timeline for operational approvals and certification which took over 10 years for similar efforts in the fixed-wing community.

FY 2021 Program Descriptions
Commercial Space Transportation

Program Description/Activities/Objectives:

In FY2021, the FAA AST research priorities will continue to focus on the four DOT Strategic Goals (SG), including safe integration of commercial space into the NAS, spaceport infrastructure, systemic safety initiatives, and regulatory reform. To ensure safe integration of air traffic management during space vehicle operations, improvements in launch collision avoidance analyses will be researched. Other tasks, such as the refinement of spaceport siting tools, will focus on improving spaceport infrastructure. Both these priorities support the DOT SG of Infrastructure. Overall systemic safety of commercial space includes the continued evolution of the launch vehicle breakup database (supporting the DOT Strategic Goal of Safety). Finally, regulatory streamlining and research will include improved methodologies of Performance Based Regulation development, and investigating refinements to spaceport policies (supporting the DOT Strategic Goal of Accountability). The DOT Strategic Goal of Innovation is supported by all of the FAA AST research priorities.

Program Alignment with Strategic Goals:

The FAA AST research programs of safe integration of commercial space into the NAS and spaceport infrastructure both support the DOT Strategic Goal of Safety. The FAA AST research programs within systemic safety support the DOT Strategic Goal of Safety. The FAA AST research program of regulatory streamlining support the DOT Strategic Goal of Safety.

FY 2021 Program Descriptions
NextGen – Wake Turbulence

Program Description/Activities/Objectives:

The program will continue assessments of new aircraft types for wake separation recommendations using a proven data-driven methodology, continue to develop wake encounter mitigation technology aided concepts/procedures developed for piloted en-route aircraft, and develop wake mitigation concepts/procedures for UAS operating in the NAS. The main goal of the program is to maintain wake separation as safe, or safer than, current operations in the NAS. The FAA accomplishes this goal through data collection and analysis along with modeling and simulations to provide the basis for innovations. This provides increased airspace and airport runway throughput by the use of more aircraft type specific wake separations that have been validated as safe by the NextGen Wake analyses through collected statistical aircraft wake transport and decay data. Continuation of this wake turbulence research is required to provide wake separation recommendations for new aircraft that will begin operations and for statistically determining wake separations for controllers to apply between aircraft for all phases of flight.

Program Alignment with Strategic Goals:

This program supports the DOT Strategic Goal of: Innovation.

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 NAS. Data from this research will allow the assessment of regulatory approaches, foster information sharing, facilitate coordination and collaboration with industry and other stakeholders, and provide the ability to test and adopt new technologies throughout the NAS to reduce wake separation.

Reducing wake separation allows increased capacity at Core airports in the NAS. This research is conducted solely by the NextGen Wake program, and has been funded in the past. The research continues to build upon past successes on reduced wake separations and procedure development introducing improvements to NAS infrastructure. New aircraft wake separation recommendations are introduced each year and will reoccur as aircraft types enter service. Concept development is ongoing with updates to previous implemented procedures, and new implementations being proposed in the near-term.

FY 2021 Program Descriptions
Unmanned Aircraft Systems

Program Description/Activities/Objectives:

The UAS Research program supports FAA efforts in implementing the Next Generation Air Transportation System (NextGen) by studying safety implications of new aircraft operational concepts and technology to the NAS and supporting the development of new 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.

Research activities within the UAS Research program will generate technical information to support development of policies, guidance materials, and advisory circulars on using new or novel technologies to demonstrate regulatory compliance while operating UAS in the NAS. UAS-specific technical issues such as detect and avoid, datalink aircraft control and communications with air traffic control, and emergency response requirements, will also require research. UAS will also be integral to NextGen development and will help validate UAS Concept of Operations (CONOPS) integration requirements and meet UAS Roadmap goals.

FY 2021 funding will support the UAS program in conducting research on UAS technologies that directly impact the safety of the NAS. The FY 2021 portfolio of work will be focused on safety data collection, unmanned air carrier operations, beyond visual line of sight operations (BVLOS), and other research that will support the safe, efficient, and timely integration of UAS in the NAS within the 14 Code of Federal Regulations (CFR) regulatory framework. Additionally, funding will provide for engineering, technical, and management support of overall research activities.

Program Alignment with Strategic Goals:

This program supports the DOT Strategic Goal of: Safety.

- Advance the safe integration of UAS into the National Airspace.
    - Support the development of regulations, policies, procedures, guidance, and standards for UAS operations.
    - Develop UAS detection and avoidance technologies.
    - Explore applications of UAS to improve the efficiency and effectiveness of the construction, operation, and maintenance of infrastructure.

This program supports the DOT's Strategic Goal by providing systematic research and development within the FAA that will lead to the identification, assessment and mitigation of safety risks. Data generated by this research is 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 NAS.

FY 2021 Program Descriptions
Advanced Technology Development & Prototyping

Program Description/Activities/Objectives:

Individual projects under the ATDP Program develop and maintain models that 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.

FY2021 work expected includes the following:

- The prior year's work on the System Wide Analysis Capability (SWAC) and the Airfield Delay Simulation Model (ADSIM) will continue,
- Benchmarking activities with the European Union and Civil Aviation Authority of Singapore will be initiated to improve traffic flow initiatives and maximize performance with the Caribbean and Asia Pacific Region, and
- Major Airspace Redesign work will continue in FY21 and will coordinate and fund physical changes in facilities that are necessary to accommodate airspace redesign.
- The Runway Incursion Reduction work will continue and two new projects will begin in FY21:
    - The Speech Recognition for Situational Awareness initiative will assess the feasibility of using information derived from real-time speech recognition to enhance RIPSA capabilities for surface safety, and
    - The Wrong Surface Landing (WSL) Prevention initiative will develop a long-term plan for air traffic and cockpit technologies to allow ATC and pilots to detect alignment problems that could result in Wrong Surface Landing (WSL) incidents.

Program Alignment with Strategic Goals:

This program supports the DOT Strategic Goal of: Innovation

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 NAS. Data generated by this research will allow for the assessment of operational and safety data, will foster information sharing and facilitate coordination and collaboration with industry and other stakeholders, and provide 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.

FY 2021 Program Descriptions

Next Generation Transportation System - Separation Management Portfolio

Program Description/Activities/Objectives:

Separation Management Portfolio enhancements will provide controllers with tools and procedures to manage aircraft in a mixed environment of varying navigation equipment and wake performance capabilities. The Multiple Airport Route Separation (MARS) concept will continue efforts from FY20 to model the expanded usage of Established on Required Navigation Performance (RNP) to separate traffic flows to multiple airports in close proximity. Closely spaced parallel operations work will mature the optimization of the terminal airspace by applying advanced surveillance capabilities for the purpose of enhanced deviation detection methods. Additional airport throughput capacity for NAS users will be researched through the development of terminal dynamic wake solution. Capabilities in this portfolio 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.

Program Alignment with Strategic Goals:

This program supports the DOT Strategic Goal of: Innovation.

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 NAS. Data generated by this research will allow the assessment of regulatory approaches, will foster information sharing and facilitate coordination and collaboration with industry and other stakeholders, and provide 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.

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 NAS. The FAA forecast calls for substantial growth in the commercial air travel segment in the next two decades. The research efforts being pursued in these projects look to safely reduce separations to gain throughput and capacity in the terminal and en route environments by leveraging advanced technologies and data analyses. The efforts within this portfolio include collaboration with international partners, and the NAC. These efforts rely on past research into Established on RNP (EoR) and Wake RECAT Phase I & II. The research is matriculating towards updated procedure standards for MARS, CSPO Departures, and dynamic wake separation standards.

FY 2021 Program Descriptions
Next Generation Transportation System - Traffic Flow Management Portfolio

Program Description/Activities/Objectives:

The TFM portfolio will continue to explore applications of innovative technologies and conduct research activities to improve flight efficiency and throughput. In FY21, efforts to utilize innovative technologies, such as speech recognition, machine learning, and artificial intelligence in Traffic Flow Management, will be explored as an initial prototype – continuing FY20 efforts exploring potential uses for advanced automation. Research into mobile technologies in support of ATD-2 will continue into FY21 in an effort to relay the technology demonstration into potential operational capabilities. Further efforts to improve traffic flow management operations, including integration of ATM systems, post operational analysis, and participation in departure scheduling at smaller community airports, will continue to be matured.

Program Alignment with Strategic Goals:

This program supports the DOT Strategic Goal of: Innovation.

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 NAS. Data generated by this research will allow for the assessment of regulatory approaches, foster information sharing and facilitate coordination and collaboration with industry and other stakeholders, and provide 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 NAS.

The TFM portfolio researches and implements capabilities that are expected to improve both the efficiency of individual flights and optimization of 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. These support systems include and flexibility to avoid airspace constraints, better predict capacity demands and ensure efficient utilization of NAS capacity. This research is necessary to enhance flight efficiency and provide operational flexibility through increased user collaboration. The FAA coordinates research with NASA and industry and will receive a technology transfer to be matured into operational concepts for NAS systems. Efforts to provide new capabilities out of this research are targeted to be operational in the 2025-2030 timeframe.

FY 2021 Program Descriptions
Next Generation Transportation System - On Demand NAS Portfolio

Program Description/Activities/Objectives:

There are no research activities planned for this portfolio in 2021.

FY 2021 Program Descriptions
Next Generation Transportation System - NAS Infrastructure Portfolio

Program Description/Activities/Objectives:

The 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.

The NAS Infrastructure (NI) Portfolio contains key transformational and infrastructure sustainment capabilities that are critical to the success of NextGen. This program supports the NextGen goal of expanding capacity by conducting pre-implementation activities geared toward the development of decision support tools that improve the strategic management of operations in the NAS. The main goal of the NextGen – NAS Infrastructure Portfolio is to support the NextGen goals of improved capacity, efficiency, and safety.

Program activities and objectives are summarized below.

- New Air Traffic Management (ATM) Requirements: This program identifies new opportunities to improve the efficiency and effectiveness of air traffic management operations.
    - Future Collision Avoidance System (CAS): Research will be conducted to develop requirements for new classes of users to ensure future collision avoidance systems are interoperable within the NAS.
    - Weather Transition: Ensures that aviation weather research concepts are matured and technically developed under FAA guidelines to a level of readiness for allocation to implementation (such as implementation by NWS) to support operational use in the NAS.
    - Synchronization of Air/Ground Procedures: The Air/Ground Procedure Synchronization activity will explore the aircraft trajectory synchronization concept of use and validate proposed solutions in collaboration with industry partners and operational stakeholders through simulations and potential flight trials.
    - Advanced Air/Ground Communications: In collaboration with international partners, this activity will support the development of advanced communication technologies such as the Aeronautical Telecommunications Network (ATN) Internet Protocol Suite (IPS) standards for operational usage. This activity will result in the development and validation of Standards for Future Communications Infrastructure technologies.
    - Command and Control in the Cloud Environment: The project will evaluate technical assumptions based on safety, mission criticality, and the ability of current and planned cloud architectures to provide NextGen services in the future, with a focus on command and control services.
    - Common Displays/COTS: Defines requirements for displaying strategic decision data and develops a transition strategy for the possible use of COTS displays as Common Displays in the NAS.
    - Next Generation Input Devices: Supports the definition of requirements and concept development for an enterprise solution to next generation input devices for automation systems in the NAS.

Program Alignment with Strategic Goals:

This program supports the DOT Strategic Goal of: Innovation.

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 NAS. Data generated by this program allows for the assessment of regulatory approaches, fosters information sharing, and facilitates coordination and collaboration with industry and other stakeholders, and provides the ability to test and adopt new technologies throughout the NAS.

FY 2021 Program Descriptions
Next Generation Support Portfolio

Program Description/Activities/Objectives:

New capabilities are required to support emerging NextGen operational improvements related to Collaborative Air Traffic Management, Seamless Integration of Information, Integration of 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 NAS, and reducing overall risk and cost to the taxpayer.

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 that 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), UAS, Space Operations, and many others. These activities help reduce passenger delays, increase the capacity or 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, Performance Panel standards, and guidance documents for International Civil Aviation Organization, which will provide guidelines to ensure the safety of the flying public.

Program Alignment with Strategic Goals:

This program supports the DOT Strategic Goal of: Innovation.

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 NAS. Data generated by this program will allow the assessment of regulatory approaches, will foster information sharing and facilitate coordination and collaboration with industry and other stakeholders, and provide the ability to test and adopt new technologies throughout the NAS.

FY 2021 Program Descriptions
Next Generation Transportation System - Unmanned Aircraft Systems (UAS)

Program Description/Activities/Objectives:

The UAS projects play a critical role in enabling UAS operations in the National Airspace (NAS). The activities in this program support research that allows 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-implementation tasks: 1) UAS Concept Validation and Requirements 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.

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.

Program Alignment with Strategic Goals:

This program supports the DOT Strategic Goal of: Innovation.

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 NAS. Data generated by this research will allow for the assessment of regulatory approaches, foster information sharing and facilitate coordination and collaboration with industry and other stakeholders, and provide the ability to test and adopt new technologies throughout the NAS. 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. There has been significant pressure from industry regarding the integration of UAS into the NAS. There is a large economic potential from package delivery, to passenger operations, etc. Use of UAS in hazardous environments reduces human risk. Other federal agencies and many private entities around the globe are interested in the integration of UAS. An initial investment was made in 2012 regarding the viability of UAS integration into the NAS. The initial Concept of Operations (CONOPS) and implementation plan serve as the initial strategy. Periodic user needs assessments inform the forecasted demand and help revise requirements. One UTM service is currently available to the public in the Low Altitude Authorization and Notification Capability (LAANC) and more services are planned to be available in 2021.

FY 2021 Program Descriptions
System Planning and Resource Management

Program Description/Activities/Objectives:

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.

Program Alignment with Strategic Goals:

This program supports the DOT Strategic Goal of: Accountability.

This program supports the DOT's Accountability Strategic Goal. This program supports mission requirements by effectively and efficiently planning for and reporting on the FAA's entire research portfolio.

FY 2021 Program Descriptions
William J. Hughes Technical Center Laboratory Facility

Program Description/Activities/Objectives:

This program sustains research facilities located at the William J. Hughes Technical Center Laboratory (WJHTC) to support Research and Development (R&D) program goals. These programs require specialized facilities to emulate and evaluate field conditions. The R&D laboratories are comprised of the Cockpit Simulation Facility (CSF), Target Generation Facility (TGF), Research Development and Human Factors Laboratory (RDHFL) and The NextGen Prototyping Network (NPN). R&D programs require specialized facilities that provide flexible, high-fidelity environments to conduct research and perform Human-in-the-Loop (HITL) simulations that evaluate advanced air traffic concepts. Researchers measure baseline human performance using existing air traffic controller configurations and determine changes in performance when new systems or procedures are introduced to identify and evaluate human factors (HF) issues. These laboratories include integrated cockpits, air traffic controller workstation capabilities (simulated and real), and specialized biometric data collection systems to evaluate the system and human components that can only be addressed in a full mission end-to-end simulation environment. The R&D laboratories are fully integrated with the other WJHTC capabilities which allow for an extremely high fidelity environment supporting R&D research. This research encompasses capabilities of the current day, NextGen, and the transition - for example mixed equipage and adjacent site deployment. The funding provides for existing infrastructure support, project support, engineering support, R&D facility modifications and improvements, equipment and software/hardware licenses, and support tools.

Program Alignment with Strategic Goals:

This program supports the DOT's Strategic Goal of Accountability.

This program is utilized to sustain and improve the laboratory infrastructure, which in turn, supports programs that directly contribute to DOT Strategic Goals and Objectives.

FY 2021 Program Descriptions
William J. Hughes Technical Center Laboratory Sustainment

Program Description/Activities/Objectives:

This program sustains the William J. Hughes Technical Center laboratories. This centralized set of laboratories is depended on to support the Acquisition Management System (AMS) lifecycle from concepts and requirement definition to In-Service decisions. These laboratories are the only location where it is possible to realistically simulate the NAS and it is necessary to maintain the laboratory systems with capabilities that match field sites that currently exist or are planned for the future. These test beds can be altered to replicate desired field configurations and traffic scenarios providing stakeholders with an understanding of how upgraded systems will perform prior to operational deployment. These labs also provide a flexible high-fidelity environment to conduct research and perform Human-In-The-Loop (HITL) simulations that evaluate advanced air traffic concepts and are fully integrated with the other WJHTC capabilities.

Program Alignment with Strategic Goals:

This program supports the DOT Strategic Goal of: Innovation.

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 NAS. This program allows for the assessment of regulatory approaches, fosters information sharing and facilitates coordination, collaboration with industry and other stakeholders, and the ability to test and adopt new technologies throughout the NAS.

LIST OF ACRONYMS

ACRONYM	DEFINITION
A	
AAAE	American Association of Airport Executives
AAM	Office of Aerospace Medicine
AASR	Aging Aircraft Safety Rule
ABST	Airframe Beam Structure Test
AC	Advisory Circular
ACI	Aircraft Cyber Initiative
ACI-NA	Airports Council International–North America
ACO	Aircraft Certification Official
ACRP	Airport Cooperative Research Program
ACS/PTS	Airman Certification Standards/Practical Test Standards
AD	Airworthiness Directive
ADG	Airplane Design Groups
ADS-B	Automatic Dependent Surveillance-Broadcast
ADSIM	Airfield Delay Simulation Model
AEDT	Aviation Environmental Design Tool
AFA	Association of Flight Attendants
AFFF	Aqueous Film-Forming Foams
AFRL	Air Force Research Lab
AFS	Active Flutter Suppression
AGC	Office of the Chief Council
AI	Artificial Intelligence
AIA	Aerospace Industries Association
AID	Aircraft Installed Devices
ALPA	Air Line Pilots Association
AMRAC	Aerospace Medicine Research Alignment and Collaboration
AMRP	Annual Modal Research Plan
AM	Additive Manufacturing
AMS	Acquisition Management System
ANG	Office of NextGen
ANSI	American National Standards Institute
ANSP	Air Navigation Service Provider
AOPA	Aircraft Operators and Pilots Association
AOC	ACRP Oversight Committee
AOV	Air Traffic Safety Oversight Office
AR	Annual Review
ARL	Army Research Lab
ARAC	Aviation Rulemaking Advisory Committee

ACRONYM	DEFINITION
ARFF	Aircraft Rescue and Firefighting
ARTCCs	Air Route Traffic Control Centers
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
ASR	Alkali Silica Reaction
ASRS	Aviation Safety and Reporting System
AST	Office of Commercial Space Transportation
ASTM	American Society for Testing Materials
ATA	Air Transport Association
ATC	Air Traffic Control
ATCA	Air Traffic Control Association
ATC/ATO	Air Traffic Control/Technical Operations
ATD	Anthropomorphic Test Device
ATDP	Advanced Technology Development and Prototyping
ATDP-3	Airspace Technology Demonstration 3
ATM	Air Traffic Management
ATN	Aeronautical Telecommunications Network
ATO	Air Traffic Organization
ATNB2	Aeronautical Telecommunications Network Baseline 2
ATRP	Airport Technology Research Program
AVP	Accident Investigation and Prevention
AVS	Aviation Safety
AWDE	Aviation Weather Demonstration and Evaluation
B	
BAA	Broad Agency Announcement
BEA	Bureau d'Enquetes et d'Analyses
BLI	Budget Line Item
BPA	Blanket Purchase Agreement
BOM	Bureau of Meteorology
C	
C2	Command and Control
CAASD	Center for Advanced Aviation System Development
CAEP	Committee on Aviation Environmental Protection
CAMI	Civil Aerospace Medical Institute
CANSO	Civil Air Navigation Services Organization
CAPS	Certificate of Authorizations Application Process
CAS	Collision Avoidance System
CAST	Commercial Aviation Safety Team

ACRONYM	DEFINITION
CDO	Convective Diagnosis Oceanic
CE	Certification Efficiency
CFR	Code of Federal Regulations
CLEEN	Continuous Lower Energy, Emissions and Noise
COA	Certificate of Authorizations
COE	Centers of Excellence
COMSTAC	Commercial Space Transportation Advisory Committee
ConOps	Concept of Operations
CONUS	Continental United States
COS	Continued Operational Safety
COTS	Commercial off-the-shelf
CRADAs	Cooperative Research and Development Agreements
CSC	Cyber Steering Committee
CSF	Cockpit Simulation Facility
CSFF	Cold Soaked Fuel Frost
CST	Commercial Space Transportation
CTA	Consumer Technology Association
CTH	Cloud Top Height
C&V	Ceiling and Visibility
CVRD	UAS Concept Validation and Requirements Development
D	
DAA	Detect and Avoid
DARWIN®	Design Assessment Of Reliability With Inspection
DAC	Drone Advisory Committee
DFDR	Digital Flight Data Reorder
DHS	Department of Homeland Security
DMP	Data Management Plan
DOC	Department of Commerce
DOD	U.S. Department of Defense
DOE	Department of Energy
DOI	Department of Interior
DOJ	Department of Justice
DOT	U.S. Department of Transportation
DSTs	Decision Support Tools

ACRONYM	DEFINITION
E	
E&E	Environment and Energy
EAA	Experimental Aircraft Association
ECCC	Environment and Climate Change Canada
EDR	Eddy Dissipation Rate
EFB	Electronic Flight Bags
EMAS	Engineered Material Arresting System
EHVS	Enhanced Helicopter Vision Systems
EMST	Emerging Metallic Structures Technologies
EMI	Electromagnetic Interference
EO	Executive Order
EPA	Environmental Protection Agency
ERAU	Embry Riddle Aeronautical University
ERDC	U.S. Army Engineer Research and Development Center
ES	Electrical Systems
ESRL	Earth System Research Laboratory
ETC	Engine Titanium Consortium
EuroCAE	European Organization for Civil Aviation Equipment
EXCOM	Executive Committee
F	
F&E	Facilities and Equipment Appropriation
F&Rs	Findings and Recommendations
FAA	Federal Aviation Administration
FACA	Federal Advisory Committee Act
FAR	Federal Aviation Regulations
FAST	Fixing America's Surface Transportation
FASTER	Full-Scale Aircraft Structural Test Evaluation and Research
FCMS	Flight Controls and Mechanical Systems
FD-DER	Flight Deck Date Exchange Requirements
FFF	Film-Forming Foam
FFRDC	Federally Funded Research and Development Center
FFS	Full Flight Simulators
FHWA	Federal Highway Administration
FICAN	Federal Interagency Committee on Aviation Noise
FIMS	UAS Flight Information Management System
FINAS	Flight in Non-Segregated Airspace
FLS	Field-Loadable Software
FMC	Flight Management Computer
FMS	Flight Management Systems
FSF	Flight Safety Foundation

ACRONYM	DEFINITION
FTB	Florida NextGen Test Bed
FY	Fiscal Year
G	
GA	General Aviation
GAJSC	General Operations Joint Steering Committee
GAMA	General Aviation Manufacturers Association
GAO	Government Accountability Office
GMA	Geosynthetics Materials Association
H	
HDD	Head-Down Display
HEMS	Helicopter Emergency Medical Services
HF	Human Factors
HFDM	Helicopter Flight Data Monitoring
HF-STD	Human Factors Design Standard
HITL	Human In The Loop
HRRR	High Resolution Rapid Refresh
HUD	Head-Up Display (also, Department of Housing and Urban Development
I	
IATA	International Air Transport Association
ICAO	International Civil Aviation Organization
ICI	Ice Crystal Icing
ID-SRET	Integrated Domain Safety Risk Evaluation Tool
IEEE	Institute of Electrical and Electronics Engineers
IFR	Instrument Flight Rules
IMC	Instrument Meteorological Conditions
InFOs	Information for Operators
IOT	Internet of Things
IP	Intellectual Property (also, Internet Protocol)
IPP	Integrated Pilot Program
IPS	Internet Protocol Suite
IRB	FAA Institutional Review Board
ISO	International Organization for Standardization

ACRONYM	DEFINITION
J	
JAMS	Joint COE for the Advanced Materials and Structures
JARUS	Joint Authorities for Rulemaking on Unmanned Systems
JAT	Joint Analysis Team
JCAB FATS	Japan Civil. Aviation Bureau Future Air Transportation System
JENQC	Jet Engine Nickel Quality Committee
JETQC	Jet Engine Titanium Quality Committee
JPL	Jet-Propulsion Labs
K	
KART	Kansas Aviation Research & Technology
L	
LAANC	Low Altitude Authorization and Notification Capability
LWE	Liquid Water Equivalent
LOAs	Letters Of Authorizations
LOC	Loss of Control
LTO	Land and Takeoff
M	
MARS	Multiple Airport Route Separation
MEA	More Electric Aircraft
MET	Minimum Cockpit Meteorological
METAR	METeorological Aerodrome Report
MinWxSvc	Minimum Weather Service
MIT	Massachusetts Institute of Technology
ML	Machine Learning
MMPDS	Metallic Materials Properties Development and Standardization
MOPS	Minimum Operational Performance Standards
MRMS	Multi-Radar Multi-Sensor
MSpecs	Management Specifications
N	
NAC	NextGen Advisory Committee
NAC/NIWG	NextGen Advisory Committee / NextGen Integration Work Group
NAFI	National Association of Flight Instructors
NARP	National Aviation Research Plan
NAS	National Airspace System
NASA	National Aeronautics and Space Administration
NASAO	National Association of State Aviation Officials
NATA	National Air Transportation Association
NATO	North Atlantic Treaty Organization
NBAA	National Business Aviation Association
NEC	Northeast Corridor

ACRONYM	DEFINITION
NextGen	Next Generation Air Transportation System
NEXRAD	Next Generation Radar
NI	NAS Infrastructure
NIA	National Institute of Aerospace
NIAR	National Institute for Aviation Research
NIEC	NextGen Integration and Evaluation Capability
NIH	National Institute of Health
NIWG	NextGen Integration Working Group
NIST	National Institutes of Standards and Technology
NOAA	National Oceanographic and Atmospheric Administration
NOx	Nitrogen Oxide
NPN	NextGen Prototyping Network
NPS	NextGen Performance Snapshots
NRC	National Research Council
NSF	National Science Foundation
NSIP	NextGen Segment Implementation Plan
NSTC	National Science and Technology Council
NTL	National Transportation Library
NTSB	National Transportation Safety Board
NWP	NextGen Weather Processor
NWS	National Weather Service
O	
ODNI	On Demand National Airspace System (NAS) Information
OEM	Original Equipment Manufacturers
OMB	Office of Management and Budget
OpSpecs	Operations Specifications
ORTA	Office of Research and Technology Applications
ORCiD	Open Researcher and Contributor ID
OST	Office of the Secretary
OTA's	Other Transaction Agreements
P	
PAFI	Piston Aviation Fuels Initiative
PAFI TAC	PAFI Technical Advisory Committee
PAMA	Professional Aviation Maintenance Association
PEGASAS	Partnership to Enhance General Aviation Safety, Accountability and Sustainability
PBN	Performance Based Navigation
PBRs	Performance Based Regulations
PFAS	Perfluoroalkyl and Polyfluoroakyl Substances
PFOA	Perfluorooctanoic Acid

ACRONYM	DEFINITION
PFOS	Perfluorooctanoic Sulfonate
PHMSA	Pipeline and Hazardous Materials Safety Administration
PIREPs	Pilot Reports
PMO	Program Management Organization
PPD	Presidential Policy Directive
Q	
QA	Quality Assessment
R	
R&D	Research and Development
RBDM	Risk-Based Decision Making
RDHFL	Research Development and Human Factors Laboratory
RD&T	Research, Development, and Technology
REB	Research Executive Board
R,E&D	Research, Engineering and Development Appropriation
REDAC	Research, Engineering, and Development Advisory Committee
RiP	Research in Progress
RISC	Rotor Integrity Steering Committee
RNP	Required Navigation Performance
ROMIO	Remote Oceanic Meteorological Information
RTCA	Radio Technical Commission for Aeronautics
RTT	Research Transition Team
RVR	Runway Visual Range
S	
SA CAT	Special Authorization Category
SAE	Society of Automotive Engineers International
SAFOs	Safety Alert for Operators
SDO	Standards Development Organizations
SG	Strategic Goals
SGI	Special Government Interest
SI	Structural Integrity
SLD	Super Cooled Large Droplets
SMART	Small Aircraft Risk Tool
SME	Subject Matter Expert
SMS	Safety Management System
SOMS	Safety Oversight Management System
SPRM	System Planning and Resource Management
SRM	Safety Risk Management
SRA	Safety Risk Assessment
SSI	Sensitive Security Information
STEM	Science Technology Engineering and Math

ACRONYM	DEFINITION
SVGS	Synthetic Vision Guidance Systems
SWAC	System Wide Analysis Capability
SWIM	System Wide Information Management
T	
3D	Three Dimensional
TAIWIN	Terminal Area Icing Weather Information for NextGen
TAS	Terminal Area Safety
TAWS	Terrain Awareness Warning System
TBFM	Time Based Flow Management
TCRG	Aeromedical Technical Community Representative Group
TT/T2	Tech Transfer
TBO	Trajectory Based Operations
TCAS	Traffic Alert & Collision Avoidance System
TCRG	Technical Community Representative Group
TEL	Tetraethyl Lead
TFM	Traffic Flow Management
TGF	Target Generation Facility
TO	Task Order
TRACON	Terminal Radar Air Traffic Control
TRB	Transportation Research Board
TRWG	Topical Research Working Groups
TSI	Transportation Safety Institute
TSO	Technical Standards Order
U	
UAM	Urban Air Mobility
UAS	Unmanned Aircraft System
UASFM	Unmanned Aircraft System Facility Maps
UEDDAM	Uncontained Engine Debris Damage Assessment Model
UN	United Nations
U.S.	United States
USAF	United States Air force
USDA	United States Department of Agriculture
USG	US Government
USHST	United States Helicopter Safety Team
UTM	UAS Traffic Management
V	
VDN	Virtual Dispersive Networking
VFR	Visual Flight Rules
VNR	VFR Not Recommended
VTOL	Vertical Take-Off and Landing

ACRONYM	DEFINITION
W	
WJHTC	William J. Hughes Technical Center
WSL	Wrong Surface Landing
WTIC	Weather Technology in the Cockpit
Z	
ZASA	Zodiac Arresting Systems America