United States Department of Transportation
FY 2021 Annual Modal Research Plans

Cover Page

Federal Aviation Administration

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Table of Contents

Chapter 1. Executive Summary

The Annual Modal Research Plan (AMRP) outlines planned research for the upcoming fiscal year and a detailed outlook for the following year. All Department of Transportation (DOT) operating administrations, or modes, must submit this plan annually by the 1st of May to the Assistant Secretary of Research and Technology for review and approval, as statutorily mandated.

The FAA uses Research and Development (R&D) to support policymaking and planning, regulation, certification, standards development, and national airspace system (NAS) modernization to fulfil its mission to provide the safest and most efficient aerospace system in the world. The FAA R&D portfolio supports the day-to-day operations of the NAS and balances near-term, mid-term, and far-term aviation research needs. The FAA has defined a research-planning framework to help align and plan its R&D portfolio to best support this mission.

The FAA focuses investments on applied research and development projects that aim to innovate solutions that address known aviation problems and mission shortfalls, and increase the safety of operations. While the FAA's primary goal is to ensure overall NAS safety and operational effectiveness, our research also seeks to increase efficiencies in certification timelines and reduce aviation's environmental impact.

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 and emerging 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 that work collaboratively to address the challenges posed by the changing aviation landscape. The FAA continues to fund and actively engage in research activities to enable innovations brought about by the aviation industry, while maintaining our world-class safety record. This includes continued updates to existing regulations and certification practices.

The FAA has evaluated its R&D portfolio and certifies that there are no known duplicative R&D activities in the portfolio.

Critical Research, Development, and Technology Programs

The FAA's R&D is critical and relevant to industry and the flying public. This section highlights a few examples of the important research conducted within the FAA's R&D portfolio.

NextGen – Information Security
Cybersecurity is one of the biggest challenges the FAA and our nation face. Although the motivations behind cyber-attacks vary depending on the actor, the goal behind these potential attacks remains the same — to disable, disrupt, and exploit systems through unauthorized access. The FAA must be increasingly vigilant and forward looking in this area due to the critical function of FAA systems, and the critical nature of its mission, which is to provide safe and efficient travel to the flying public. Because of the rapid evolution of these threats, the FAA must position itself to not only prevent known cyber exploits but also to model and forecast future cyber-attacks. This is a challenging endeavor as FAA systems are increasingly interconnected.

The FAA heavily invests in research to prevent the cyber exploitation of the NAS. Development of new and advanced cyber risk analytical tools help the agency prevent, deter, detect, and respond to cyberattacks to ensure continued safe operations. Research includes virtual dispersive networks, a multi-layered approach of context-aware behavioral analytics, and implementation of cloud-based methods to improve NAS integrity. Additionally, FAA research is aimed at understanding and mitigating cyber threats to the flight deck by identifying vulnerabilities, and developing alternate strategies for securing flight deck data exchange.

Unmanned Aircraft Systems
The FAA faces a growing challenge to ensure safe and efficient air traffic management while integrating unmanned aircraft systems (UAS), also known as drones, into an already crowded airspace system. As UAS operations continue to expand, the FAA is conducting crucial R&D to provide the necessary tools, procedures, and requirements to integrate these aircraft into the NAS.

The FAA is currently validating concepts and identifying requirements to ensure all air traffic needs are adequately addressed and implemented to allow UAS and manned aircraft to safely operate in the same airspace. This includes researching safety risks and potential mitigations for UAS operating on and around airports. Findings will be used to create future airport-centric policies and procedures.

Incorporating the growing number of UAS also raises questions about the impact these vehicles will have on the general public. The FAA is conducting research to assess the environmental impacts of UAS operations to establish noise and emissions certification requirements for different types of UAS operations and weight classes.

The FAA is researching human factor concerns unique to UAS operations, in public use and civil operations, by establishing pilot proficiency requirements. Other critical research includes cooperative studies with DoD, DHS, DOJ, and other government agencies researching Counter-UAS technologies for detection and mitigation of UAS around airports and sensitive areas.

Commercial Space
Significant efforts are taken by the FAA towards fulfilling our duty to ensure protection of the public, property, national security, and foreign policy interests of the United States during commercial space launches and reentry activities. The FAA enables American space exploration through efficient regulation of the launch operations of providers of the human-rated launch vehicles and capsules that will launch the first U.S. astronauts into space from American soil since the Space Shuttle was retired in 2011.

FAA research plays a crucial role in encouraging, facilitating, and promoting U.S. commercial space transportation. This research program includes efforts to ensure that regulations are scoped properly and are timely to enable innovation, and provide guidance for regulatory reform. Findings will be used to develop performance based regulations that offer greater flexibility for operators while improving safety analyses and other tools to allow the safe and efficient integration of space vehicle traffic through the NAS.

Additional research will use quantitative methods for evaluating impacts of spaceports on the environment. Findings will be used for spaceport planning and operation. The FAA currently is researching how to integrate all current and future ascent vehicles (e.g., aircraft, balloons, rockets, and space vehicles) seamlessly into the NAS while also preparing for future aircraft and technologies that have yet to be imagined.

Collaboration Efforts

In pursuit of our mission, the FAA maintains partnerships with over 300 stakeholders representing federal agencies, academia, industry, international entities, and technical organizations. Our partners include aircraft and parts manufacturers, design and engineering companies, external testing facilities, domestic and international organizations, and representatives of large and small businesses. Together these relationships support the DOT strategic mission goals promoting safety, infrastructure, innovation, and accountability. Our partnerships include the following groups, associations, and agencies.

Category	Partnership Examples
Federal Agency / State / City	Department of Energy, Environmental Protection Agency, MIT Lincoln Labs, NASA Armstrong Flight Research Center, NASA Ames, NASA Glenn, NASA Johnson, NASA Langley, Port of Seattle, Smithsonian Institution, Transportation Security Administration Federal Air Marshal Service, U.S. Air Force Research Laboratory, U.S. Army, U.S. Marshals Service, U.S. Navy, U.S. Coast Guard, Department of Agriculture Forest Service, and Volpe.
Academia	Clarkson University, Rowan University, George Mason University, Rutgers University, Florida International University, University of California San Diego, University of Utah, University of Washington, Washington State University, Wichita State University, Massachusetts Institute of Technology, Stanford University, University of Colorado Boulder, University of Texas, Embry-Riddle Aeronautical University, Mississippi State University, Ohio State University, University of Alabama Huntsville, Purdue University, Pennsylvania State University, University of Dayton, and New Mexico State University.
Industry	Aircraft Owners and Pilots Association, Alaska Airlines, American Airlines, Boeing, Bombardier, Cirrus Aircraft, Delta Airlines, Embraer, FedEx, Garmin, General Electric, Harris, Honeywell, JetBlue, MOBIL, National Institute of Aerospace, NetJets, Raytheon, Rockwell, Society of Automotive Engineers, Southwest, Spirit, United, and UPS.
International	BlindSquare, CMC International, European Organization for the Safety of Air Navigation, International Civil Aviation Organization, Japan Civil Aviation Bureau, Single European Sky Air Traffic Management Research Joint Undertaking, Team Eagle, Thales, Transport Canada, and Warsaw Institute of Aviation.
Other	Aerospace Vehicle Systems Institute, American Helicopter Society, American Petroleum Institute, American Society of Mechanical Engineers, Battelle Memorial Institute, Flight Attendants Medical Research Institute, MITRE, National Air Transportation Association, National Business Aviation Association, National Fire Protection Association, National Institute for Aviation Research, National Institute of Aerospace and National Safety Council.

Research and Information Sharing
The FAA leverages agreements with federal, academic, industry, and international partners to promote technical innovation, technology transfer, and science, technology, engineering, and math initiatives. The FAA utilizes several mechanisms to accomplish this including Interagency Agreements, Memorandums of Agreement, Centers of Excellence (COE) grants, and Cooperative Research and Development Agreements (CRADAs).

Topical Research Working Groups
The FAA will continue working with DOT's Topical Research Working Groups in FY 2021. The FAA has a representative within each of the 12 working group areas, and is the lead member for the Systemic Safety Working Group. As working group members, FAA representatives share scientific resources, host research tours, provide technical presentations, establish partnerships, and assist with coordinating research agendas to avoid duplication of effort while focusing on critical challenges and maximizing synergies with other Modes.

Research, Engineering, & Development Advisory Committee (REDAC)
The REDAC is an important contributor in the FAA's R&D portfolio development process. The REDAC's primary purpose is to provide a mechanism for industry to participate in FAA program development and contribute their broad perspectives to the FAA's R,E,&D program. The REDAC also assists in ensuring that FAA research activities are coordinated with other government agencies and industry.

The REDAC consists of expert members from industry, academia, other government agencies, and various FAA stakeholder groups who meet regularly to provide advice and recommendations to the FAA Administrator. This includes advice on the needs, objectives, plans, approaches, content, and accomplishments of the aviation research portfolio. The REDAC regularly submits findings and

recommendations to the FAA which are then evaluated by the agency. Formal responses are then generated, distributed, and tracked.

Technology Transfer (T2)/Deployment Activities

The FAA has a diverse cutting edge research portfolio that benefits significantly from technology transfer activities. These collaborations enable federal expertise, knowledge, facilities, and capabilities — developed with federal R&D funding — to fulfill public and private needs. The FAA's Office of Research and Technical Applications (ORTA) fulfills this mission by promoting and enabling collaboration between FAA researchers and stakeholders from a wide array of federal agencies, government, industry, and academic partners. The solutions developed through these partnerships support the FAA's mission of maintaining the safest and most efficient aerospace system, as well as advancing our nation's leadership role in the marketplace and the world.

ORTA Origins
In 1995, in accordance with 15 USC 63 §3710, the FAA established the FAA ORTA program office to promote the transfer of federally-owned technology to state and local governments, as well as to the private sector. Since its formation, the office has successfully implemented more than 100 CRADAs, enabling FAA experts to collaborate with leading industry and academic partners. Currently there are over 40 active agreements.

Deployment Activities
In an effort to enhance the effectiveness of the T2 program, the ORTA is currently developing augmented procedures for the capture and dissemination of technology transfer products across all FAA appropriation streams (i.e., Research Engineering, and Development [RE&D], Facilities and Equipment [F&E], and the Airport Improvement Program [AIP]). The expanded procedures will ensure the identification, capture and when appropriate, public dissemination, of technical products prepared by researchers across the research portfolio.

The FAA is emphasizing the importance of T2 through presentations to members of FAA R&D teams, as well as the inclusion of technology transfer functions in lab personnel job descriptions and performance assessments. Further, the program has initiated steps to increase flexibility in establishing important collaborative relationships by identifying alternative contract vehicles for instances when a CRADA cannot be pursued.

Looking Ahead
The ORTA will continue to expand on relationships with local and state government, and private industry through innovative opportunities afforded through the National Aviation Research and Technology Park (NARTP). This facility promotes innovation by creating and fostering a unique ecosystem of partnerships and collaboration.

The range of FAA technology transfer mechanisms and knowledge is broad, including:

- Publishing FAA technical notes, advisory circulars, regulations, and other guidance, as well as peer reviewed journals and articles, process description documents, engineering reports, book chapters, forensic toxicology reports, and aeromedical review reports of all U.S. fatal aircraft accidents
- Participating as members in forums and technical societies as subject matter experts in several key technical aviation-related working groups and forums
- Providing subject matter expertise for research in fire safety, propulsion, advanced materials, aircraft icing, human factors, aeromedical, weather and other specialized focus areas
- Offering unique innovative laboratories to support independent agency-sponsored, and collaborative research
- Managing patent applications, licenses, and royalties

- Providing regular software updates to users of FAA research-based software tools
- Facilitating training and technical workshops focused on core research subject areas, and participating with professionals from industry, government, and academia to discuss safety concerns and best practices in a protected environment.

Anticipated Outcomes

The FAA continues to conduct research towards a harmonized approach to traffic flow management in the near-term by identifying high priority strategic and tactical operational integration issues and gaps. As traffic demand grows, this R&D supports integrated demand management using Traffic Flow Management Software tools, and examines the operational procedures and automation systems used by air traffic controllers. For example, research into an air/ground trajectory synchronization prototype will leverage the Scheduled Time of Arrival capability to improve accuracy of sector loading and arrival demand prediction in the NAS.

Research also continues to maximize the tactical flow of surface movement at our nation's airports. This research includes application of NASA's Airspace Technology Demonstration 2 (ATD-2), a collaborative arrival and departure research capability in metroplex operations through the FAA's Integrated Departure Scheduling concept.

Research into Trajectory Based Operations (TBO) continues to provide better operational procedures and requirements for the aerospace community. This research includes data and analyses to define a strategy for creating a future traffic flow management operational environment that enables increased en route efficiency and critical FAA mission areas such as new entrants. The FAA also continues to optimize airport and airspace capacity, and relieve the congestion in the Northeast Corridor (NEC) of the United States — the busy airspace between Washington, D.C. and Boston that includes Philadelphia and New York City. This work is of high benefit to the NAS and its users because more than 50% of all delays in the NAS are attributable to the NEC.

The FAA faces challenges incorporating newer aerospace vehicles into an already congested NAS as the aviation industry rapidly evolves. The FAA is conducting research to enable innovations in areas such as UAS, Urban Air Mobility (UAM), and Class E Upper Airspace Traffic Management (ETM). The FAA is developing a Concept of Operations (ConOps) for UAM, which will allow air taxi services in some of our nation's most crowded urban areas. This ConOps describes a vision for emerging flight operations and their interaction with UAS Traffic Management and Air Traffic Management. Similarly, the FAA is developing an ETM ConOps that describes a vision for upper airspace operations.

Through the Continuous Lower Energy, Emissions and Noise (CLEEN) program's public-private partnership (http://faa.gov/go/cleen), the FAA and industry are working together to develop technologies that will enable manufacturers to create aircraft and engines with lower noise and emissions, as well as improved fuel efficiency. The technologies being accelerated by the CLEEN program have relatively large technological risk. Government resources help mitigate this risk and incentivize aviation manufacturers to invest in and develop these technologies. By cost sharing with the FAA, industry partners are willing to accept the greater risk associated with this technological development.

High priority FAA research continues towards the development of analytical tools that provide data to evaluate the environmental, economic, and social sustainability of lower carbon aviation fuel produced from fossil resources, and sustainable aviation fuels, produced from renewable and waste resources. This research is facilitating the evaluation of new fuel pathways for possible inclusion within the International Civil Aviation Organization's Carbon Offsetting and Reduction Scheme for International Aviation. The program is also examining research and test data to support the safe use and integration of electric, hybrid electric, and fuel cell electric propulsion systems, and aircraft into the NAS. This research on novel fuel types also includes new alternative fuels and supporting technologies for general aviation aircraft.

An evolving NAS requires research on various aspects of human interaction with the system. Human Factors research takes a human engineering perspective and looks at a variety of issues, including performance assessment, training, and equipment interaction. Examples of key Human Factors activities include research on improved tower controller methods and training for scanning the terminal environment. Research addresses human performance limitations and associated mitigations for air traffic operations with remote towers, and remotely-sited cameras in air traffic control towers. Related research will focus on air traffic controller and technician selection, and training guidelines to support the integration of the next generation of air traffic control personnel into a highly automated environment.

Evaluation/Performance Measurement Efforts

The FAA Research and Development Management Division collects, analyzes, tracks, and measures FAA-conducted research performance in multiple ways. The FAA actively tracks ongoing and completed products (technical presentations, conference papers, publications, etc.), National Aviation Research Plan (NARP) outputs, and technology transfer activities. These products and activities are tracked and measured through various reporting mechanisms including the NARP, Annual Review (AR), and the Technology Transfer Annual Congressional Report.

The NARP presents over 200 planned outputs for 31 independent programs, while the Annual Review reports on the significant research accomplishments completed in a given year, and provides status on outputs previously identified in the NARP. The Technology Transfer (T2) Congressional Report provides T2 performance metrics including the number and status of CRADAs, invention disclosures, patent submittals, license agreements, COE grant awards, and associated funding.

COVID-19 Impact on Research

COVID-19 has significantly affected the FAA's research activities and its impacts are continuing to evolve. Some of the FAA's research projects in the second half of 2020 have experienced COVID-19 related delays due to a reduced onsite workforce. Critical work has continued where possible and the creativity and agility of the FAA's workforce has allowed a significant amount of work to be conducted virtually. This includes continued collaboration with industry, other government agencies and academia through multiple virtual conferences and working group sessions such as the 2020 REDAC Summer/Fall meetings, Aircraft Fire Test Forums, and the Joint Human Systems Integration Steering Committee. In addition, researchers have been able to remotely connect to FAA servers and access previously collected test data for post-test analysis, synthesis, and reporting. The FAA has also made improvements to the design of test apparatus in the current remote environment. This work will better prepare the FAA for implementation of these new designs for when the workforce can return.

FY 2021 RD&T Program Funding Details

RD&T Program Name	FY 2021 Enacted ($000)	FY 2021 Basic ($000)	FY 2021 Applied ($000)	FY 2021 Development ($000)	FY 2021 Technology ($000)
Fire Research and Safety	7,136		7,136		
Propulsion and Fuel Systems	4,215		4,215		
Advanced Materials/Structural Safety	14,720		14,720		
Aircraft Icing/Digital System Safety	6,426		6,426		
Continued Airworthiness	11,269		11,269		
Aircraft Catastrophic Failure Prevention Research	1,565		1,565		
Flightdeck/Maintenance/System Integration Human Factors	7,469		7,469		
System Safety Management	5,485		5,485		
Air Traffic Control/Technical Operations Human Factors	5,685		5,685		
Aeromedical Research	10,235		10,235		
Weather Program	6,236		6,236		
Unmanned Aircraft Systems Research	24,035		24,035		
Alternative Fuels for General Aviation	2,524		2,524		
Commercial Space Transportation Safety	5,840		5,840		
NextGen - Wake Turbulence	3,698		3,698		
NextGen - Air Ground Integration Human Factors	6,000		6,000		
NextGen - Weather Technology in the Cockpit	1,982		1,982		
NextGen Flight Data Exchange	1,000		1,000		
NextGen - Information Security	4,769		4,769		
Environment and Energy	20,303		20,303		
NextGen - Environmental Research - Aircraft Technologies, Fuels, and Metrics	31,465		31,465		
System Planning and Resource Management	13,022		13,022		
William J. Hughes Technical Center Laboratory Facility	2,921			2,921	
William J. Hughes Technical Center Laboratory Sustainment	16,900			16,900	
Advanced Technology Development & Prototyping	26,600			26,600	
NextGen - Separation Management Portfolio	21,200			21,200	
NextGen Traffic Flow Management Portfolio	8,000			8,000	
NextGen - On Demand NAS Portfolio	10,500			10,500	
NextGen - NAS Infrastructure Portfolio	15,000			15,000	
NextGen Unmanned Aircraft Systems	22,000			22,000	
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	40,666		40,666		
Totals	**449,866**		**307,745**	**142,121**	

FY 2021 RD&T Program Budget Request by DOT Strategic Goal

RD&T Program Name	FY 2021 Enacted ($000)	SAFETY ($000)	INFRASTRUCTURE ($000)	INNOVATION ($000)	ACCOUNTABILITY ($000)
Fire Research and Safety	7,136	7,136			
Propulsion and Fuel Systems	4,215	4,215			
Advanced Materials/Structural Safety	14,720	14,720			
Aircraft Icing/Digital System Safety	6,426	6,426			
Continued Airworthiness	11,269	11,269			
Aircraft Catastrophic Failure Prevention Research	1,565	1,565			
Flightdeck/Maintenance/System Integration Human Factors	7,469	7,469			
System Safety Management	5,485	5,485			
Air Traffic Control/Technical Operations Human Factors	5,685	5,685			
Aeromedical Research	10,235	10,235			
Weather Program	6,236	6,236			
Unmanned Aircraft Systems Research	24,035	24,035			
Alternative Fuels for General Aviation	2,524	2,524			
Commercial Space Transportation Safety	5,840	5,840			
NextGen - Wake Turbulence	3,698			3,698	
NextGen - Air Ground Integration Human Factors	6,000			6,000	
NextGen - Weather Technology in the Cockpit	1,982			1,982	
NextGen Flight Data Exchange	1,000			1,000	
NextGen - Information Security	4,769			4,769	
Environment and Energy	20,303		20,303		
NextGen - Environmental Research - Aircraft Technologies, Fuels, and Metrics	31,465		31,465		
System Planning and Resource Management	13,022				13,022
William J. Hughes Technical Center Laboratory Facility	2,921				2,921
William J. Hughes Technical Center Laboratory Sustainment	16,900			16,900	
Advanced Technology Development & Prototyping	26,600			26,600	
NextGen - Separation Management Portfolio	21,200			21,200	
NextGen Traffic Flow Management Portfolio	8,000			8,000	
NextGen - On Demand NAS Portfolio	10,500			10,500	
NextGen - NAS Infrastructure Portfolio	15,000			15,000	
NextGen Unmanned Aircraft Systems	22,000			22,000	
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	5,070	9,101	603	226
Airport Technology Research Program	40,666	17,774	20,692	2,200	
Totals	**449,866**	**135,684**	**138,561**	**159,452**	**16,169**

Chapter 2 – FY 2021 RD&T Programs

Airport Infrastructure and Technologies

United States Department of Transportation
FY 2021 Annual Modal Research Plans

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

Program Description:

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 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 by airport operators, industry, and users.

Program Objective

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 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 public on the ACRP website and for purchase in hard copy.

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.

Anticipated Program Activities:

The ACRP Oversight Committee (AOC) will be selecting research projects for FY2021 during its summer meeting this year. These projects will focus on the research need of the airports and aviation communities that are not addressed by the Federal research efforts.

Expected Program Outcomes:

Research results from this program supplements our on-going airport research program at the William J. Hughes Technical Center and the needs of the aviation industry.

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.

United States Department of Transportation
FY 2021 Annual Modal Research Plans

Airports Technology Research Program
Funding Enacted ($40,666,000)

Program Description:

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.

Program Objectives:

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-21, 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.

The program provides an environment where companies of all sizes can test new ideas and products to meet FAA standards. This encourages companies to be innovative in their product development and competitive at the global level.

Anticipated Program Activities:

- In FY 2021, an innovation project with an environmental benefit will be the evaluation of solar lighting systems for airports.
- In FY 2021, ATR will complete testing of prototype Photovoltaic (PV) technologies at multiple airports across the United States as part of a program that will include testing at five airports in total.
- In FY 2021, ATR will continue to research how UAS technologies can be utilized in five airport application areas: obstruction analysis, airfield pavement inspections, wildlife hazard management, perimeter security, and aircraft rescue and firefighting.
- In FY 2021, ATR will complete field testing of visual aids to reduce wrong surface landings, including the evaluation of proposed changes to lighted runway closure markers including a new LED lighted "X".
- FY 2021 airport safety and design research, ATR will complete the annual Runway Incursion Mitigation update to include an airfield geometry assessment of all towered airports that may have airport design features that are considered at risk for incursions.
- ATR will also complete the development of "AppMap", which is a scalable, centralized, geospatial tool that will expedite and improve FAA's planning and environmental reviews.
- In FY 2021, the ATR program will continue to research ways to reduce community noise impacts. Research projects include: evaluating and improving the accuracy of noise level reduction testing to develop guidelines for industry standards; and collecting nationally representative data on the relationship between aircraft noise exposure and residential sleep disturbance.

- In FY 2021, the ATR program will complete the full scale testing of Construction Cycle 9. The main objective this testing is to investigate the use of geosythetics on improving the pavement life. A final report will be provided about the full-scale test results.
- In FY 2021 the ATR program will have started investigating new pavement design procedures for cold region areas dealing with permafrost and deep frost penetration. A final report would be expected in FY 22.

Expected Program Outcomes:

- By 2022, develop a comprehensive knowledge base, based on testing and analysis, to fully evaluate AFFF replacement firefighting agents, which will support the reduction/elimination of PFAS chemical byproducts at airports.
- By 2025, support the mitigation of runway incursions at U.S. airports, by leveraging years of documented analyses of data collected at airports. This will result in sustained increases of safety at airports.
- By 2025, support the mitigation of wildlife strikes at U.S. airports by leveraging years of documented analyses of data collected at airports. This will result in sustained increases of safety at airports.
- By 2023, support the use of solar lighting at General Aviation Airports which will represent major cost savings for those airports.
- By 2025, support the use of UAS at airports for multiple applications such as Pavement Inspection, Obstruction surveys, Perimeter security and the dispersion of wildlife at and near airports.
- By 2023, support the development of Vertiport Design standards for Advanced Air Mobility, and support the development of new Vertiport Facilities
- By 2023, support the incorporation of permafrost design into airport pavement design that will result in longer airport pavement life in colder regions affected by permafrost changes.
- By 2023, support the incorporation of geotextile membranes into airport pavement design, resulting in longer airport pavement life.

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 Institute: 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.

The ATRP has a CRADA with ATECH Inc.

The FAA and ATECH Inc. have entered into an agreement 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 (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

United States Department of Transportation
FY 2021 Annual Modal Research Plans

Fire Research and Safety
Funding Enacted ($7,136,000)

Program Description:

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 the ban on 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.

Program Objectives:

The primary goals 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 FAA Fire Safety Branch conduct the research. 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.

Anticipated Program Activities:

- Improve aircraft ability to mitigate fires involving hazardous materials transported as cargo.
- Improve capability for detection of inflight fires.

- Develop standardized methods for evaluating non-metallic aircraft structural and component materials.
- Test and evaluate the fire hazards and mitigation options for lithium battery powered personal electronic devices and other flammable materials on transport aircraft.
- Evaluate the capability of new fire suppression agents and systems.

Expected Program Outcomes:

- By 2025, develop the enabling technology to prevent accidents caused by in-flight fires in cargo and passenger large transport aircraft by improving fire detection and suppression capabilities and upgrading the flammability requirements for materials in inaccessible areas.

- By 2025, enable the introduction of new, lightweight/energy efficient, fire-safe materials, and components into commercial transport aircraft, such as composite structure, additive manufacturing components, magnesium and other metallic alloys, cabin furnishings, and advanced electrical power sources.

- By 2025, support and facilitate the evaluation and replacement of Halon fire extinguishing agents and halogenated cabin material flame-retardants with effective and practical alternatives.

Collaboration Partners:

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

The following are program partners:

International Civil Aviation Organization (ICAO) Research 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 the 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.

European Aviation Safety Agency (EASA)

DOT Pipeline and Hazardous Materials Safety Administration (PHMSA)

Boeing Commercial Airplanes. Testing has been conducted at the FAA Fire Safety Branch facilities in partnership with Boeing and fire suppression suppliers to evaluate proposed Halon replacement fire suppression systems for engines and 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.

Airbus. Testing has been conducted at the FAA Fire Safety Branch facilities in partnership with Airbus and fire suppression suppliers to evaluate proposed Halon replacement fire suppression systems for engines and 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.

United States Department of Transportation
FY 2021 Annual Modal Research Plans

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

Program Description:

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.

Program Objectives:

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

Anticipated Program Activities:

Damage Tolerance of Composite Structures

- Evaluate critical defects & damage threats to understand the damage tolerance of airframe structures representative of General Aviation (GA), rotorcraft, and transport category airplane applications.

Composite Maintenance Technology

- Develop standards for composite repair material properties (both new and aged), process specifications and associated test protocols.

Continued Operational Safety and Certification Efficiency for Emerging Composite Technologies

- Develop and document simplified means of compliance for composite structures to promote adoption of emerging materials into new aviation products including but not limited to UAS and urban mobility platforms.
- Develop certification protocols for polymer Additive Manufacturing (AM) and chopped fiber materials (thermoset and thermoplastic) used in transport category airplanes.
- Update the Composite Failure Analysis Handbook co-developed by the FAA and the AFRL based on results of investigating the effects of fire on composite failure analysis procedures and methods.

Certification and Maintenance Protocols for Bonded Joints:

- Generate guidelines for bonded joint certification and repairs.
- Evaluate aged structural bonds with an emphasis on understanding the mechanism leading to potential bond failure and delamination of rotorcraft blades.

Additive Manufacturing for Aircraft, Engine, and Propeller Applications

- Develop data on various aspects of metal AM that is needed to generate policy, guidance, and industry standards.

Expected Program Outcomes:

- By 2023, provide detailed background on the unique static, fatigue, environmental durability, and impact performance of advanced composite structures.
- By 2023, produce data and share results with industry standardization organizations in a publically available database to help develop guidelines for certification of additively manufactured materials in aviation applications.
- By 2024, provide data for regulatory action to assure reliable processing of adhesively bonded structures. (FAA Strategic Composite Plan Deliverable).
- By 2025, develop a handbook for failure analysis of structures subjected to a fire event after structural malfunction. (FAA Strategic Composite Plan Deliverable).

Collaboration Partners:

In addition to the REDAC, public and stakeholder input is received through close research collaboration with the industry members 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.

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

Internal program partners include 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 the congressionally mandated Joint Center of Excellence (COE) for Advanced Materials and Structures (JAMS). Under the leadership of the University of Washington and Wichita State University, the following universities 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) and AmericaMakes, which includes 198 members giving the FAA access to more than $100 million worth of public and private research activities.

- 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, America Makes, 3M, Toray Advanced Composites, CMH-17 Steering Committee with contribution/collaboration from major OEMs, maintenance repair organizations and airlines across the aviation industry.

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

Program Description:

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.

Program Objectives:

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.

Anticipated Program Activities:

Aircraft Electrical Systems
Novel and Unusual Electric Aircraft Systems
- Provide data for safe installation High voltage systems for electric propulsion.

Large Electric Energy Storage System
- Investigate methods of inducing thermal runaway for large battery validation and certification.

Flight Controls and Mechanical Systems
Integrated Flight Path Control to Address GAJSC/FAA GA Safety Interventions
- Develop specific technology interventions using simple autopilot controls to develop basic envelope protection that will reduce or prevent loss-of-control GA accidents.

Transfer of New Technologies for Enhancement of GA Safety
- Identify and document new technologies to enhance GA safety and on what platforms they could be used.

Rotorcraft Systems

Integrated Flight and Propulsion Control

- Identify, test, and document new technologies that can support the develop standards, rules and guidance for the flight characteristics of multi-rotor vehicles. This research is helping to rewrite Part 27 requirements to support the Urban Air Mobility aircraft that need to be certify.

Strategies for Adoption and Certification of Intelligent Systems

- Development a standards for design, architecture, testing, and certification for intelligent systems and automation.

Structural Integrity

- Assess emerging technologies in partnership with industry to support developing policy, guidance and standards needed for certification and continued airworthiness by testing advanced fuselage panels, composite wing panels, and subscale components using the FAA's Full-Scale Aircraft Structural Test Evaluation and Research (FASTER), Aircraft Beam Structural Test (ABST), and Structures and Materials Labs.
- Collaborate with NASA, DoD and industry to develop tools, methodologies and data to mitigate the risk associated with structural failures and provide updates and distribution of standardized handbooks supporting aircraft certification and continued airworthiness.
- Continue the development of computer software and other tools required to successfully implement probabilistic methods for risk assessment and risk management of structural fatigue issues for general aviation aircraft.

Expected Program Outcomes:

- By 2022, develop a process for establishing mechanical property standards (used in FAA certification guidance) for emerging process-intensive metallic materials, including metal additive manufacturing.
- By 2022, develop technical data to evaluate the use of electronics to detect wires and physical wire cutting technology to reduce rotorcraft wire strikes.
- By 2023, publish advisory circular and/or share results with the American Society for Testing and Materials (ASTM) on new autopilot technology, with advanced flight path control for incorporation into an industry standard.
- By 2024, publish guidance for improving design requirements, architecture, and certification processes for flight path control autopilots in general aviation aircraft.
- By 2024, develop technical data to evaluate the flight characteristics of multi-rotor vehicles that will be used in the development of the certification rules of these vehicles.
- By 2025, develop a certification path for a methodical, systematic approach to the replacement of specific pilot functions that are better served by automated systems and autonomy.

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.

The Continued Airworthiness Program participates in various interagency groups that include NASA, DOD, and the 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 *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 includes 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, The Florida Institute of Technology, and Georgia Tech. 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.

United States Department of Transportation
FY 2021 Annual Modal Research Plans

Propulsion and Fuel Systems
Funding Enacted ($4,215,000)

Program Description:

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 and improved inspection technologies 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 accrue in the form of a reduced risk of engine failures and fewer accidents, which in turn lead to fewer injuries and fatalities.

Program Objectives:

To prevent uncontained engine failures, the FAA and the Aerospace Industries Association (AIA) formed the Rotor Integrity Steering Committee (RISC) to augment the traditional safe-life design approach with one that employs a probabilistic design methodology to account for extremely rare material and service induced anomalies. This revolutionary change resulted in the FAA issuing rule 33.70, which describes the certification of critical life limited engine parts. In order for the FAA to ensure that the industry is able to comply with the new safety rule, a series of FAA advisory circulars and a publicly available probabilistic software code were planned to be developed.

The objective of this research is to develop the damage tolerance framework and supporting data to provide a basis for the necessary advisory materials and a design software code called Design Assessment of Reliability With Inspection (DARWIN) in support of rule 33.70. A further objective of this research is to develop improved nondestructive evaluation (NDE) methods to characterize engine component material conditions that can compromise integrity. This need was highlighted by the NTSB in recommendations A-18-03 and A-18-04 resulting from the 2016 AA Flight 383 uncontained turbine failure event. To accomplish these objectives, research will be pursued through a government and industry collaboration to ensure that a consistent level of safety is widely adopted by the engine industry.

Anticipated Program Activities:

- Develop Nickel Anomaly Mechanical Properties Test Plan with input from the AIA Rotor Integrity Steering Committee.
- Initiate experiments to investigate crack formation and growth from naturally-occurring nickel anomalies.
- Conduct research to improve inspection of nickel billet.

Expected Program Outcomes:

- By 2022, develop an improved nickel billet inspection method.
- By 2024, develop enhanced capabilities within the DARWIN code to conduct fracture and life predictions of nickel rotor components containing inherent anomalies.

Collaboration Partners:

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)
- AIA Rotor Manufacturing (RoMan) Team
- AIA Inspection Team
- Jet Engine Titanium Quality Committee (JETQC)/Jet Engine Nickel Quality Committee (JENQC)
- Department of Defense (USAF, USN)
- NASA
- Foreign Regulators (EASA, Transport Canada)

Alternative Fuels for General Aviation
Enacted ($2,524,000)

Program Description:

Due to a variety of environmental, regulatory, and market forces in the U.S. and worldwide, leaded avgas will be eliminated at a future point in time. 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. 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.

Program Objectives:

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.

Anticipated Program Activities:

- Investigate the fit-for-purpose performance of alternative fuels in conformance with FAA and industry standards.
- Perform testing on alternatives for compliance to FAA regulations and industry standards.
- Investigate material compatibility issues on alternative fuels for safe integration into the GA fleet.
- Acquire test related equipment, and perform testing on alternative energy systems and related propulsive technologies per industry and FAA standards.
- Complete Technology Transfer with one or more Cooperative Research and Development (CRADA) or Memorandum of Understanding (MOU) holders.

Expected Program Outcomes:

- By 2023, complete material compatibility testing on alternative fuels, including Center of Excellence (COE) cooperative research, for safe integration into the GA fleet.
- By 2023, develop engine and aircraft fuel systems and operational modification recommendations for testing to support alternative fuels.

- By 2024, complete the research and Technology Transfer on testing. This includes data for industry to support ASTM Production Specifications.

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.

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

Aircraft Catastrophic Failure Prevention Research

Funding Enacted ($1,565,000)

Program Description:

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.

Program Objectives:

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.

Anticipated Program Activities:

- Support the LS-DYNA Aerospace Working Group, a partnership of government, industry, and academia. This effort is developing predictive analytical models for impact of metal and composite materials in LSDYNA, along with associated test data, quality assurance problems and methods, sample problems, and guidance to advance certification by analysis capability.
- Update the Uncontained Engine Debris Damage Assessment Model (UEDDAM) in conjunction with DoD, as a means of compliance for ducted and open rotor engines.
- Support validation of compliance methods for Draft AC20-128.

Expected Program Outcomes:

- By 2024, validate composite material models with associated guidance for certification.
- By 2025, develop inlet impact modeling test case that includes containment of the blade and load transfer into the inlet and fan cowl structure.

Collaboration Partners:

This work is responsive to NTSB recommendations and works with industry through the LS-DYNA 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:

- 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
    - - ANSYS – LST Livermore Software Technology
    - - National Aeronautics and Space Administration (NASA)
    - - Northrop Grumman
    - - Ohio State University (OSU)
    - - Pratt & Whitney
    - - Pratt & Whitney Canada
    - - Rolls-Royce
    - - University of Akron
    - - University of Dayton
    - - United Technologies Aerospace Systems (UTAS)
    - - Williams International
- NASA
- Naval Air Warfare Center, Weapons Survivability Laboratory, China Lake
- ANSYS – LST Livermore Software Technology
- Honda R&D America

Digital Systems and Technologies

United States Department of Transportation
FY 2021 Annual Modal Research Plans

Digital System Safety/Aircraft Icing
Funding Enacted ($6,426,000)

Program Description:

Airborne systems' designs have become increasingly dependent on highly integrated software and hardware architectures that share power, computing, networking, input/output, and other resources to support the needs of multiple aircraft functions. The main goal in Digital Safety Research is to 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 (such as Artificial Intelligence [AI] and/Machine Learning [ML]), 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 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.

Program Objectives:

The research conducted under this Budget Line Item (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 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 *Complex Digital 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 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.

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.

The research conducted under this BLI differs from industry research. The main focus of this research 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 requirements. 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.

Anticipated Program Activities:

Digital System Safety

- Study the assurance issues of Artificial Intelligence/Machine Learning (AI/ML) implementations in airborne systems and develop assurance criteria for dataset requirements, runtime monitoring, and safety monitoring.
- Develop a Generic Framework (Using Overarching Properties) and metrics for assurance processes and evaluate the assurance metrics using test cases.
- Study airborne electronic hardware vulnerabilities to high altitude environments, environmental regulation, market trends, and transient electromagnetic disturbances and develop recommendations to mitigate the risk.

Safe Operations and Take-off in Aircraft Ground Icing Conditions

- Transfer data package supporting annual guidance to airline industry for updating of airline ground deicing programs.
- Complete geometric and roughness characterization of cold soaked fuel frost.

Expected Program Outcomes:

Digital System Safety

- By 2022, identify assurance issues with the use of new technologies in the development of safety critical systems, analyze digital system safety issues that could affect aircraft airworthiness and develop assurance criteria for safe certification.
- By 2022, develop generic framework for assurance and determine an acceptable means to analyze, integrate, validate, and verify complex airborne digital systems to reduce cost and improve safety.
- By 2022, identify AEH specific vulnerabilities relating to Airborne Electronic Hardware aging, production methods and environmental exposure (natural or manmade), and develop recommendations for mitigation.

Aircraft Icing

- Through 2022, conduct aerodynamic testing of an airfoil with cold soaked fuel frost.
- Through 2022, report on protection of ice contamination of vertical stabilizers in ground icing conditions.

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.

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 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 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.

NextGen - Information Security
Funding Enacted ($4,769,000)

Program Description:

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

Program 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.

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.

Anticipated Program Activities:

- Cyber Data Science Algorithms to detect Advanced Persistent Threats (APTs)
- Identify and evaluate the initial set of data parameters for cyber data analytics across the aviation ecosystem
- Investigate the various data suites for cybersecurity threats across the aviation ecosystem
- Establish proof of concept cyber data distribution models and analytical cells for the aviation ecosystem
- Establish the baseline of event/data logging for information/cybersecurity

Expected Program Outcomes:

- By 2022, initial demonstration of cyber data science algorithms to detect APTs for the NAS domain. Identify and validate data parameters for cyber data analytics across the aviation ecosystem
- By 2023, maturation of **s**elf-adaptive systems and networks principles, technologies and design methods for mixed trust environments for implementation into FAA networks. Develop NAS and data communication service provider data analytics within analytical cells across the aviation ecosystem (e.g., Gatelink, Maintenance, AOC, etc.)
- By 2024, a) Develop AI analytics utilizing event/data logs and establish data distribution models, b) Demonstrate NAS and data communication service provider data analytics for the analytical cells across the aviation ecosystem c.)) Demonstrate multiple layered approach of context-aware behavioral analytics with improved visualization techniques.
- By 2025, a.) Cyber data science algorithms to detect APTs across the aviation ecosystem, b.) Demonstrate and integrate context-aware behavioral analytics

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)– National Protection and Programs Directorate (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.

United States Department of Transportation
FY 2021 Annual Modal Research Plans

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

Program Description:

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.

Program Objectives:

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.

The main goal that the NextGen – FD-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.

Anticipated Program Activities:

- Finalize the FD DER prototype environment to enable exchange of information in a secured environment for EFBs and AIDs applications through the use of IP Data Link.
- Identify and evaluate threats and vulnerability associated with current avionics, on-board aircraft systems, IP Data Link, and their associated data elements, and provide mitigation strategies to address cyber security risks.
- Provide recommendations for performance and cyber security standards for EFBs, AIDs, and Data Link hardware and software applications.
- Refine operational and technical assessments based on results of the cyber security risk assessments exercise.

Expected Program Outcomes:

- By 2021, complete development of the prototype environment and cyber security risk assessments that result in mitigation strategies for EFBs, AIDs, and IP Data Link hardware and software applications. The program is expected to provide recommendations for performance and cyber security standards for such applications.
- By 2025, expand the research to include additional on-board aircraft systems such as Flight Management System (FMS), as well as ground automation systems in order to fully address the cybersecurity needs of the connected aircraft concept.

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.

Environment and Weather Impact Mitigation

United States Department of Transportation
FY 2021 Annual Modal Research Plans

Weather Program
Funding Enacted ($6,236,000)

Program Description:

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.

Program Objectives:

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.

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.

Anticipated Program Activities:

- Complete domain expansion of Offshore Precipitation Capability (OPC) to include CONUS, Hawaii, and portions of Alaska and commence transition to the NWS and/or the PMO.
- Complete development of enhancements to the Convective Weather Avoidance Model (CWAM) and commence transition to the PMO.
- Commence development of probabilistic turbulence and high-resolution turbulence nowcast capabilities.
- Continue the transition of camera-based visibility estimates into operations.

Expected Program Outcomes:

- By FY 2022, complete development of higher resolution ceiling and visibility forecast capability that will be available, via the NWS, for the HEMS Tool as well as other short distance and low-altitude flights, improving safety of operations.
- By 2023, complete development of the OPC 0-12 forecast for offshore thunderstorms and precipitation
- By 2024, complete development of a global-scale probabilistic turbulence forecast capability for implementation (reducing aircraft encounters with unacceptable levels of turbulence, increasing passenger safety and airspace capacity)

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).

United States Department of Transportation
FY 2021 Annual Modal Research Plans

NextGen - Weather Technology in the Cockpit
Funding Enacted ($1,982,000)

Program Description:

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

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

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

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

- National Transportation Safety Board (NTSB) 2014 Most Wanted List to improve transportation safety in the category: "GENERAL AVIATION: IDENTIFY AND COMMUNICATE HAZARDOUS WEATHER,"
- Aircraft Operators and Pilots Association (AOPA) which identifies critical gaps for resolution to enhance General Aviation safety,
- NTSB safety alerts which identify critical gaps that were causal factors in accidents that require research to resolve,
- Alaska Air Carriers Association which identifies weather related gaps to enhance safe IFR and VFR flight operations in Alaska,
- Flight Service Stations need for objective criteria to consistently determine 'VFR not recommended' (VNR) conditions,
- NEXTGEN Segment Implementation Plan (NSIP),
- Federal and private weather providers and pilots' needs for increases in the quantity and accuracy of pilot reports (PIREPs) and airborne observations to enhance weather forecasts, nowcasts, and adverse weather avoidance decision-making,

- National Association of Flight Instructors (NAFI) and commercial flight training schools that identify needs for enhanced pilot weather training materials, experiential learning software, weather training courseware, and current aviation-specific weather knowledge test questions.

Program Objectives:

To accomplish the program objectives, the WTIC program performs research to identify causal factors in weather-related safety hazards/risks and NAS operational inefficiencies, and then conducts applied research to resolve the identified causal factors or gaps. The WTIC program also develops enhanced training materials and courseware 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.

Anticipated Program Activities:

- Demonstrate ability to use crowd sourcing to produce and provide ceiling information from Alaska webcam images.
- Make MinWxSvc recommendations to resolve selected gaps in weather information in helicopter cockpits linked to safety and efficiency operational shortfalls.
- Create objective criteria that are compatible with automating VNR statement issuance for selected adverse weather scenarios.
- Identify algorithms to calculate objective turbulence information from data contained in downlinked ADS-B reports to increase the number of turbulence observations by orders of magnitude. Identify methods to present this new turbulence information in cockpits for enhanced turbulence avoidance decisions.

Expected Program Outcomes:

- By 2023, complete development of objective criteria and associated MinWxSvc recommendations for fully automated VFR Not Recommended (VNR) issuance
- By 2024, resolve cockpit weather related gaps for helicopter operations.
- By 2024, produce Minimum Weather Service recommendations for calculating turbulence information from downlinked ADS-B reports and presenting the resulting turbulence forecast/nowcast information in cockpits to improve turbulence avoidance decision-making.
- By 2025, produce meaningful visibility, ceiling, weather radar, and wind information to remote regions that lack infrastructure, Automated Surface Observing System (ASOS), and weather radars.

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, a part of Collins Aerospace – 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 recreating 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.

United States Department of Transportation
FY 2021 Annual Modal Research Plans

Environment and Energy
Funding Enacted ($20,303,000)

Program Description:

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.

Program Objectives:

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.

Anticipated Program Activities:

- Use advances in scientific understanding to enhance the aviation environmental tool suite to improve our ability to calculate environmental consequences and impacts of aviation.
- Develop innovative, cost-effective solutions to reduce noise, fuel use, and emissions for both fixed wing and vertical takeoff and landing vehicles through technology and operational procedure concepts.
- Conduct analyses to inform decision making on operational procedure concepts, policy measures, and standards that could reduce noise, fuel use, and emissions.
- Develop improved measurement capabilities and airworthiness certification methods for both noise and emissions, for both existing air vehicles and new entrants.

- Conduct analyses and gather data to inform the development of noise and emissions standards to enable the introduction of new entrants, such as Unmanned Aerial Systems, Urban Air Mobility vehicles, and civil supersonic aircraft.

Expected Program Outcomes:

- By 2022, complete analyses to quantify the potential health impacts of aircraft noise.
- By 2022, release noise screening tool to streamline environmental approval process and improve communication on noise matters with communities.
- By 2022, conduct measurements and complete analyses to inform the development of noise standards for unmanned aerial systems and urban air mobility vehicles.
- By 2023, release AEDT Version 4 with improved characterization at lower noise levels where some communities are expressing concerns as well as to include supersonic aircraft.
- Through 2025, complete analyses to support the development of new international standards for supersonic transport aircraft and engines in ICAO CAEP.

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, the program works closely with the ASCENT COE, which is comprised of 16 Universities plus 5 affiliate Universities. The center is supported by 77 industry partners, which provide the one-to-one matching contribution that is legislatively required for all COE research. These private sector stakeholders are also members of the ASCENT Advisory Committee, which reviews the center's research program and progress twice per year. As of the end of FY2019 ASCENT had 30 active research projects involving 236 students and has produced 166 publications, reports and presentations.

United States Department of Transportation
FY 2021 Annual Modal Research Plans

NextGen - Environmental Research - Aircraft Technologies and Fuels
Funding Enacted ($31,465,000)

Program Description:

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 was 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

Program Objectives:

The main goal of the NextGen Environmental Research – Aircraft Technologies and Fuels program is the development of aircraft and engine technologies that reduce noise, fuel burn, and emissions. Technologies developed by this program result in a fleet of aircraft that have lower noise, use less fuel and produce fewer emissions, thus supporting the overarching environmental performance goal for NextGen to achieve environmental protection that allows sustained aviation growth. The program also provides data to evaluate the safety of alternative jet fuels and ensure they are appropriately integrated within international standards.

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.

Anticipated Program Activities:

- Develop aircraft and engine technologies, as well as novel drop-in fuels, for both subsonic and supersonic aircraft, that reduce noise and emissions while increasing fuel efficiency through the CLEEN Program.
- Evaluate innovative technological solutions to reduce noise, emissions and fuel burn from both subsonic and supersonic aircraft through ASCENT.
- Support the approval of novel jet fuel pathways within the American Society of Testing and Materials (ASTM) International certification process via testing and coordination to ensure these fuels are safe for use.
- Support the inclusion of sustainable aviation fuels, created from waste and biomass feedstocks, and lower carbon aviation fuels, created from fossil feedstocks, within the International Civil Aviation Organization (ICAO) Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA).

Expected Program Outcomes:

- By 2022, develop lifecycle greenhouse gas emissions values and sustainability criteria for use in CORSIA.
- By 2022, identify innovative solutions to reduce noise, emissions, and fuel burn through the university research of ASCENT.
- Through 2025, continue activities within the third phase of CLEEN to demonstrate technologies that can reduce energy use, emissions, and noise for both subsonic and supersonic aircraft.
- Through 2025, conduct testing to support the approval of at least one alternative jet fuel type per year and to streamline the ASTM certification process to reduce the time and cost of certification.
- By 2025, assess the benefits of the technologies matured under the third phase of the CLEEN Program.

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.

Human Performance and Aeromedical Factors

United States Department of Transportation
FY 2021 Annual Modal Research Plans

Flightdeck/Maintenance/Systems Integration Human Factors
Funding Enacted ($7,469,000)

Program Description:

The Flight Deck/Maintenance/System Integration Human Factors program addresses research and development (R&D) requirements defined by technical sponsors in the Aviation Safety Organization (AVS). These requirements are driven by the human factors needs of Aircraft Certification (AIR) and Flight Standards (AFS) personnel responsible for the certification, approval, and continued airworthiness of aircraft; as well as the certification of pilots and mechanics. Program outputs provide the research foundation to update and maintain human factors related rules, guidance, procedures, Orders, standards, job aids, and other materials to support aviation safety and productivity. Program outputs also proactively address the human factors impact of rapid changes to current-day technologies, procedures, and emerging issues.

The program focuses on the needs of pilots, inspectors, and aircraft maintainers. The revolution in digital avionics has changed flight deck 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.

Program Objectives:

The main goal for the Flight deck/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.

In FY 2021, three different research areas are planned to be addressed. The first research area is *Advanced Vision Systems – Enhanced Flight Vision System (EFVS), Enhanced Vision Systems (EVS), Synthetic Vision Systems (SVS), and Combined Vision System (CVS), Heads Up Displays, Helmet Mounted Displays – Certification and Ops Approval Criteria.* The objective of this research is to characterize the human factors, pilot performance, and operational considerations related to the expanded use of these technologies during new low visibility concepts of operation. Outputs from this research will inform the development of operational requirements, standards, conditions, limitations, mitigations, and authorizations for their use.

The second research area is *Fatigue Mitigation in Flight Operations.* The objective of this research is to reduce the number of accidents and incidents caused by flight crewmember fatigue. This research will examine the

operational effectiveness of mitigations developed by industry (e.g. Fatigue Risk Management Plans) to manage pilot performance issues (sleep disruption, fatigue, and workload) caused by flight operations that do, and do not, exceed 14 CFR Part 117 limits (Flight And Duty Limitations And Rest Requirements: Flightcrew Members). Human factors scientific and technical information will be used to improve the FAA and industry's understanding of fatigue through training and mitigations, and the effect of short haul, long haul, and ultra-long range flight operations to pilot performance.

The third research area is *Pilot Training, Qualification, Procedures and Flight Operations.* The objective of this research is to inform data-driven guidance for inspectors and operators on training methodologies, such as distance learning and virtual reality, and 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.

Anticipated Program Activities:

<u>Advanced Vision Systems (EFVS, EVS, SVS, CVS), Head-Up Displays (HUD), and Head Mounted Displays (HMD): Operational Standards & Approval Criteria</u>

- Technical report on pilot performance when using flight director, HUD, and SVGS during the instrument segment to inform lowering standard CAT I approach minima.
- Technical report characterizing pilot performance and operational impacts associated with the use of HUDs to conduct CAT II and CAT III approaches using other than ALSF I or ALSF II approach lighting systems.
- Technical report characterizing pilot performance and human factors considerations when using SVGS on an SA CAT I approach with less than a MALSR approach lighting system (in support of the development of operational standards and approval criteria for specific SVS operations).

<u>Fatigue Mitigation in Flight Operations</u>

- Improve the FAA's understanding of pilot fatigue during flight operations exceeding the limitations of the 14 CFR part 117 regulations.
- Provide recommendations for operational guidance and educational materials based on the effects of short haul multi-segment flight operations on pilot workload and cumulative sleep loss across trip pairings.
- Investigate the effects of multiple time zone shifts associated with long-haul and ultra-long-range flight operations on pilots' behavioral and physiological adaptations and provide recommendations for operational guidance and educational materials.

<u>Pilot Training, Qualification, Procedures and Flight Operations</u>

- Assess different training methodologies to enable more cost-effective flightcrew training with similar or superior quality.
- Analyze the upcoming pilot workforce to help adapt training and procedures to address any emerging risks associated with generational differences.

Expected Program Outcomes:

- By 2023, make recommendations for training mechanisms and methodologies based on scientific and technical data.
- By 2024, provide empirical data that may be used by AVS to expand the use of advanced vision systems, HUDs, and HMDs to increase safety, access, efficiency, capacity, and throughput in low visibility conditions.
- By 2024, provide pilot performance data and human factors recommendations that may be used by AVS to inform the development of guidance material for pilots and operators using advanced vision systems, HUDs, and HMDs to conduct low visibility flight operations and for FAA inspectors who approve those operations.

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 leverages technology transfer collaborations with industry including Collins Aerospace, Honeywell, and Universal Avionics to name a few. These collaborations enable research to be conducted at a cost savings to the government while also benefiting industry and contributing to aviation safety across the board. The program also partners 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, Universal Avionics, Honeywell, Collins Aerospace, 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.

United States Department of Transportation
FY 2021 Annual Modal Research Plans

Air Traffic Control/Technical Operations Human Factors
Funding Enacted ($5,685,000)

Program Description:

The purpose of the Air Traffic Control/Technical Operations (ATC/TO) 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 program strives to provide useful human factors R&D results that support the ATO's development and implementation of new technologies and procedures in the NAS, in accordance with FAA Order 9550.8 Human Factors Policy. Specific subject matter identified in 49 USC 445 underpins the human factors R&D program, while ATO human factors research needs are also driven by DOT priorities, evolution of the workforce, and advancing technologies and associated procedures that are expected to be implemented in the NAS over the next several years. Research addresses workforce challenges that are especially acute in the large terminal radar air traffic control (TRACONs) facilities and in several of the busy air route traffic control centers (ARTCCs). The FAA must hire, place, and train thousands of new air traffic controllers and technical operations specialists, while continuing to provide safe and efficient air traffic services to NAS users. In addition, the program provides technical guidance that helps FAA acquisition programs to incorporate human factors requirements and methods that will ensure user acceptance and NAS performance, while avoiding the need for costly and time-consuming rework. The research program is also responsible for proactively identifying the potential for human error, and for recommending mitigations.

This program addresses ATO challenges in five human factors R&D focus areas:

1) Human Factors Research for Improved Safety, Reduced Hazards, and Error Mitigation in ATC

2) Human Factors Research on Automation Effects and Controller Performance

3) Human Factors Research for Improved Design and Operation of ATC Systems

4) Human Factors Research for Improved Controller Selection and Training

5) Human Factors Research for Workforce Optimization.

Program Objectives:

The Air Traffic Control/Technical Operations (ATC/TO) Human Factors program responds to research and development (R&D) requirements defined by offices in ATO and other FAA headquarters technical sponsors.

We address human factors and training challenges through targeted research that yields understanding of human performance, and those factors that contribute to facility-specific impacts, especially for high-impact

facilities. In the training domain, we conduct research to evaluate the effectiveness of realistic simulation capabilities that provide a medium for training complex task performance where ATC system safety depends on job task performance. Effective use of simulation may reduce the time required for controllers to reach certification.

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

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

Anticipated Program Activities:

Human Factors R&D to Support Controller Selection, Placement, and Training Performance Evaluation

- **Research to Support Controller Training for Trajectory Based Operations**. Conduct controller task performance research that identifies metering skills for ATC System Command Center (ATCSCC) personnel and the potential improvements in scenario-based training that result.

Human Factors R&D to Support Air Traffic Control Safety and NAS Technology Integration

- **Research to Address Controller Workload with New Entrant Operations in the NAS**. Conduct human performance modeling research to identify potential controller workload impacts with mixed traffic types operate in controlled airspace, for a variety of aircraft types and missions, beginning in the TRACON environment.
- **Research to Support Safety by Addressing Controller Fatigue.** Conduct controller survey studies to determine the extent to which perceived controller workload contributes to the perception of fatigue.
- **Research to Improve Controller Performance and Safety in the NAS.** Continue research to develop recommended training on best practices for controller visual scanning in a variety of traffic situations and to reduce the likelihood of wrong surface landings.

Expected Program Outcomes:

- By 2022, develop recommendations regarding improved, alternative, more efficient training technologies for newly hired ATC personnel over the next decade.

- By 2024, identify controller best practices for visual scanning in tower facilities, and develop guidance and recommended training to improve controller performance and safety in the NAS.
- By 2025, recommend procedures and best practices to address air traffic controller performance factors contributing to wrong surface runway safety events.

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.

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.

United States Department of Transportation
FY 2021 Annual Modal Research Plans

NextGen – Air Ground Integration Human Factors
Funding Enacted ($6,000,000)

Program Description:

The NextGen Air/Ground Integration Human Factors program addresses research, engineering, and development (RE&D) requirements defined by technical sponsors in the Aviation Safety Organization (AVS). These requirements are driven by the intersection points between FAA policy documents, NextGen changes, and enabling flight deck technologies and procedures. Program outputs are transferred to technical sponsors to develop and maintain human factors-related rules, guidance, procedures, Orders, standards, job aids, and other materials to support the safety, productivity, and efficiency of NextGen flight operations. Functionally, NextGen Air/Ground Integration Human Factors work products benefit Aircraft Certification (AIR) and Flight Standards (AFS) personnel who evaluate and approve emerging flight deck systems, displays, devices, controls, procedures, and operations, which may not be covered by existing human factors documentation.

Program Objectives:

The primary goal of the NextGen/Air Ground Integration Human Factors program is enhanced safety and operational efficiency. In FY 2021 four research areas will be addressed: (1) NextGen Aircraft Systems and Controls, (2) NextGen Human Error Mitigation, (3) NextGen Flightcrew Readiness, and (4) NextGen NAS and Flightcrew Procedures. The scope of each research area is provided below.

1. *NextGen Aircraft Systems and Controls Research* will address the human-system performance benefits and limitations of emerging flight deck technologies, systems, and controls. This research will also 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.

2. *NextGen Human Error Mitigation Research* will proactively address the impact of emerging flight deck technologies and NextGen concepts of operation to pilot performance in future NAS operations, including the effect of anticipated changes to the role, required skillset, and expectations of pilots.

3. *NextGen Flightcrew Readiness Research* will examine the impact of flight deck technologies (i.e. control automation, information automation), pilot procedures, and NextGen concepts of operation to baseline pilot knowledge, skills, and abilities (KSA). Research will enable the evaluation of new NextGen pilot KSAs and the identification of potential training evaluation needs to support the expanded use of NextGen capabilities and procedures.

4. *NextGen NAS and Flightcrew Procedures* will proactively identify and address operational integration issues which could result from the implementation of future NAS procedures and advanced flight deck procedures. Research will enable the development of procedure design and evaluation criteria, assessment of the feasibility of procedure design alternatives, and address the human factors impacts (e.g. workload, cognition, usability) of proposed procedures and NextGen concepts on flight deck operations/pilot performance.

Anticipated Program Activities:

NextGen Aircraft Systems and Controls Research (Avionics Design & Evaluation, Advanced Vision Systems)

- Assess the human factors acceptability and usability of minimum cockpit display of traffic information (CDTI) display requirements during dependent runway operations to inform future avionics standard updates (DO-361A, DO-328B).
- Conduct a longitudinal study to evaluate the FAA's visual advantage concept to enable the effective implementation of the Enhanced Flight Vision System (EFVS) rule, which broadly accommodates current and future EFVS, not yet evaluated.

NextGen Human Error Mitigation Research (Human Error & Complex Systems)

- Evaluate prototype flight deck displays that aim to improve pilot awareness and response to low energy events, high energy events, and potential loss of control (LOC) scenarios (predictive information, alerts, recovery guidance, etc.) to address requirements introduced by CAST SE-207 and to provide human factors criteria for future technology prototypes.
- Examine how an information-intensive flight deck with highly interdependent systems affects pilot performance and workload-based decisions (manual flight vs. automated systems) during normal and non-normal flight operations (i.e. aural clutter).

NextGen Flightcrew Readiness Research (Procedures, Tasks, Skills, and Training)

- Develop a holistic set of human factors mitigations to address at-risk cognitive skills related to the introduction and expanded use of flightpath management (FPM) automation enhancements.
- Identify and evaluate the impact of emerging flight deck technologies, pilot procedures, and flight deck system dependencies to existing pilot flying/pilot monitoring knowledge, skills, and abilities (KSA).

NextGen NAS and Flightcrew Procedures Research (Instrument Procedures)

- Examine the impact of current and planned Terminal instrument flight procedures at high volume facilities to pilot performance and flight deck operations. Develop generalizable opportunities to reduce the human factors impact of operational variation and complex procedures.

Expected Program Outcomes:

- By 2023, reduced accident rates due to human error with airspace procedure design or use as a causal or contributing factor and improved operational implementation of PBN-based airspace procedures, with reduced need for redesign after initial implementation.
- By 2024, create comprehensive human factors guidelines that will assist certification and flight standards personnel. Examples include:
    - Develop guidance and job aids to assist inspectors in the field
    - Collect empirical data for updating FAA guidance and industry standards
    - Support streamlining the certification approval process

Collaboration Partners:

The NextGen Air/Ground Integration research program maintains a diverse research portfolio that capitalizes on robust partnerships with multiple DOT agencies (e.g., FAA CAMI, FAA William J. Hughes Technical Center, Volpe National Transportation System Center), external government agencies (e.g., NASA), federally funded research and development centers (MITRE), academia (e.g. University of MI, UCF), manufacturers (e.g. Honeywell, Collins Aerospace), operators (e.g. domestic/international air carriers), joint working groups (e.g. RTCA, PCPSI, CNS Task Force, Coordination Plan [CP] 1.7), international organizations

(e.g. ICAO, Eurocontrol), labor (e.g. NATCA, ALPA, AOPA, A4A) and industry. These partnerships have contributed significantly to the FAA's mission and achievement of broader NextGen milestones.

The FAA's strategy is to work closely with all vested stakeholders to ensure this program's research is timely and has buy-in from the potentially impacted parties. The FAA frequently hosts international research summits and representation frequently includes FAA, academia, industry, and labor. The chief scientists and lead researchers coordinate with respective international counterparts to ensure knowledge sharing and knowledge building. Whenever possible, the FAA collaborates with other government institutions on topics that are of shared interest. This strategy has proven to be successful with the wide utilization and adoption of research findings.

United States Department of Transportation
FY 2021 Annual Modal Research Plans

Aeromedical Research
Funding Enacted ($10,235,000)

Program Description:

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).

Program Objectives:

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.

Anticipated Program Activities:

<u>CAMI Aerospace Medical Systems Analyses</u>

- Production of technical reports about inflight medical events and improved galactic cosmic radiation dosing
- Delivery of a 5-year report to Congress on the impact of BasicMed policy

<u>CAMI Aerospace Medical Accident Investigation & Prevention</u>

- Production of technical reports related to opioids, toxicology, sleep deprivation, and pilot response to sleep schedule disturbances

<u>CAMI Human Protection & Survival</u>

- Creation of a protocol for the effects of medications on human performance at altitude

Expected Program Outcomes:

- By 2022, provide an assessment of new safety equipment/technology that can be retrofitted onto legacy rotorcraft. Examples are adding four-point harnesses for all occupants, inflatable seatbelts and airbags, including side impact airbags (for rollover phenomena) and dynamic seats/energy absorbers for occupants

Collaboration Partners:

Stakeholder input pertinent to the FY 2021 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 2021 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.

United States Department of Transportation
FY 2021 Annual Modal Research Plans

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

Program Description:

The Enterprise Concept Development, Human Factors, and Demonstration Portfolio conducts enterprise level activities, including the development of concepts across the NAS, human factors analyses of the NextGen operational environment, and demonstrations of proposed NextGen system improvements to ensure operational feasibility and viability within the NAS.

Program Objectives:

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 demonstrations 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.

Anticipated Program Activities:

- Support concept development and validation activities, research, concept engineering, and concept analysis.
- Identify human factors performance considerations of NextGen concepts.
- Support multiple demonstrations in relation to the matured NextGen concepts including, but not limited to:
    - Trajectory Based Operations
    - Class E Upper Airspace Traffic Management (ETM) Demonstration

Expected Program Outcomes:

- Complete initial scenarios, use cases and Concept of Operations for UAM.
- Understand the effects of full TBO on Traffic Management Unit Traffic Managers in terminal and enroute facilities
- Conduct safety assessment for the TBO Demonstration.

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 implementing 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.

Aviation Performance and Planning

United States Department of Transportation
FY 2021 Annual Modal Research Plans

System Safety Management/ Terminal Area Safety
Funding Enacted ($5,485,000)

Program Description:

The main goals of this program is to affect 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.

The Terminal Area Safety (TAS) program improves the safety of operations near or at an airport. Research projects in the program focus on developing training solutions and identifying effective technologies to mitigate key causes of fatal accidents such as the loss of control, runway excursions, and runway overruns. These are the leading causes of fatalities in the worldwide commercial jet fleet.

Program Objectives:

The System Safety Management (SSM) program, is designed to improve safety through developing safety data collection methods, advanced safety data and risk analysis techniques, and prototypes of risk-based decision-making capabilities to identify and analyze emerging safety issues in a cooperative nature with 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).

Through this program, the FAA evaluates potential solutions to reduce fatal accidents through: extending simulator models to allow for better upset training; exploring alternatives to determine runway slipperiness; developing objective motion criteria to minimize inappropriate simulator training; enabling safe helicopter approaches when using advanced vision systems; exploring consistent operational standards for a stable approach to reduce runway excursions; developing a logical go-around training curriculum that mitigates the operational go-around problems that have arose; and performing flight tests on representative domestic and international runways that support turbine-powered airplane operations in order to validate the wet-ungrooved and wet-grooved wheel braking coefficient models in 14 CFR Part 25.109(c). These projects address the principal causes of fatalities in the commercial jet, general aviation, and rotorcraft communities but also fill aviation safety research gaps identified in NTSB's Safety Recommendations such as A-07-003, A-04-62, A-07-64, and A-01-069.

Anticipated Program Activities:

- Analyze the representation of contextual, conditional, and common cause failures across industries to include systems, procedures/processes, technology, and human factors.
- Establish methodology for NAS risk representation focusing on the quantification of risk.
- Identify gaps in runway operations safety monitoring and surveillance.
- Develop Concept of Operations for the runway operations safety monitoring and surveillance tool.

<u>Improving Go Around Safety</u>

- Develop and conduct human-in-the-loop flight simulation experiments to evaluate and refine proposed training or technology solutions for improving go-around safety.

Wet Runway Wheel Braking Testing

- Complete comprehensive flight testing efforts involving the control of numerous variables affecting wet runway wheel braking capability to determine their specific influences on stopping performance.
- Analyze data from flight testing activities, document findings in publicly available reports, and provide technical data for updating wet runway wheel braking standards.

Improved Helicopter Simulation Models

- Collect simulation data from helicopter types and operations via existing simulator/flight training devices and flight test helicopter platforms performing candidate maneuvers to inform model improvements.

Expected Program Outcomes:

- By 2023, enable NAS-wide safety risk analysis with a common baseline to reduce commercial aviation fatalities.
- By 2024, provide risk-based decision-making support prototype tools to enhance Aviation Safety Services' oversight capabilities.
- By 2022, develop and validate models to estimate the wheel braking capability of aircraft based on runway parameters and meteorology data.
- By 2023, provide recommendations for wet runway performance standards as well as runway construction and maintenance standards.
- By 2023, provide recommendations for training or technology solutions to improve go-around safety.
- By 2024 – 2025, provide recommendations for changes in policy, regulations and guidance material for implementing advanced vision systems for helicopter operations.
- By 2026, develop and test higher-fidelity mathematical and performance models of helicopter flight dynamics during various mission segments and phases of flight.

Collaboration Partners:

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 industry, academic, and other governmental partners.

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.

United States Department of Transportation
FY 2021 Annual Modal Research Plans

Commercial Space Transportation
Funding Enacted ($5,840,000)

Program Description

Commercial Space Transportation (CST) research focuses on four priorities, which align 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.

Program Objectives:

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.

AST will use FY 2021 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 2021 RD&T portfolio optimizes 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.

Anticipated Program Activities:

- Develop improved models and methods to reduce over-conservatism applied to airspace keep-out areas used to protect against launch or re-entry failures.
- Initiate multiple, large-scale activities, conducted by teams of industry segment collaborators, investigating questions of common interest to industry and FAA.

Expected Program Outcomes:

- By 2022, develop methods to share data and software tools that estimate aircraft hazard areas suitable for use in early design and mission planning.
- By 2022, provide performance-based regulation recommendations and guidance, to support regulatory reform for commercial space, enabling greater flexibility for operators.

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:

- Contractors (ACTA, CSSI)
- FFRDCs (Aerospace Corp., MITRE/CAASD)
- CST COE (including 10 Member Universities, 11 Associate Members, and 7 Affiliate Members)
- NASA

The COE CST Annual Report Executive Summary lists other program partners.

United States Department of Transportation
FY 2021 Annual Modal Research Plans

NextGen – Wake Turbulence
Funding Enacted ($3,698,000)

Program Description

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.

Program Objectives:

The main goal of the NextGen Wake Turbulence research program is wake mitigation separation. NextGen - Wake Turbulence research analyzes and collects the data to establish the wake mitigation separations that are to be applied by ATC to new series of aircraft entering operational service. The program's analysis capability was used to establish separations for the Airbus A380, Boeing 747-800, Boeing 787 and the Airbus A350 series aircraft. Analysis work and international coordination has been completed on standards for the Airbus A320-Neo series of aircraft. The project provided wake separations for ATC's use for the Boeing 737 MAX which began operations in the NAS 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 more operations onto an airport's existing runways results in major reductions of flight delays during and after a bad weather event that occurs at or near an airport.

Anticipated Program Activities:

- Assess new aircraft types entering service in the NAS for wake separation recommendations.
- Develop wake encounter mitigation technology aided concepts/procedures for manned aircraft en-route trajectories.

Expected Program Outcomes:

- By 2022, determine required wake separations for new aircraft entering service in the NAS.
- By 2023, develop feasible concepts including procedures, processes, and applications of NextGen era capabilities that allow the safe relaxation of the ATC wake encounter hazard mitigation constraint on NAS throughput capacity.
- By 2024, make available algorithms for use by flight deck avionics and ground-based ATC decision support tools that will allow safe and throughput-efficiency, dynamically adjusted wake hazard mitigation separations and operations between aircraft.

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.

United States Department of Transportation
FY 2021 Annual Modal Research Plans

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

Program Description:

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.

Program Objectives:

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.

Anticipated Program Activities:

FY 2021 research activities are 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. FY 2021 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
- UAS pilot and visual observer training and qualification

Research on data collection and risk-based assessments supports the strategic goal of safety through the improvement of data collection methods and analyses. FY 2021 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
- Identification and evaluation of potential risks of UAS operations on and around the airport surface

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. FY 2021 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 FY 2021 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

Expected Program Outcomes:

FY 2021 funding must support the research areas identified above in order to meet FAA objectives for safe UAS integration. As UAS technologies and business cases evolve, so will the demand for increased UAS operations. The FAA must keep up with the UAS community as operations expand, in order to ensure the safety of the NAS and to people on the ground. Research needs that were previously unanticipated may arise due to additional research priorities directed by Congress, as well as the rapid pace of the UAS progression, increased operations, and the associated safeguards and mitigations. Goals for funding include:

- By 2021, determine common risks and additional safety requirements from the BVLOS Concept of Operation (ConOps) and Operational Risk Assessment (ORA).
- By 2021, conduct experiments and related analysis for air carrier UAS remote pilot crew staffing and requirements.
- By 2021, continued operation of the UAS Center of Excellence for UAS research activities.
- By 2021, expose students to current FAA rules and regulations that apply to drones.

- By 2022, conduct designed experiment(s) and related analysis as defined for UAS air carrier remote pilot knowledge and skills testing.
- By 2022, establish the scope of non-segregated operations co-existing, with restrictions, in controlled airspace with manned aircraft.

Collaboration Partners:

The 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

United States Department of Transportation
FY 2021 Annual Modal Research Plans

Advanced Technology Development & Prototyping
Funding Enacted ($26,600,000)

Program Description:

The 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.

Program Objectives:

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.

Anticipated Program Activities:

- Develop and demonstrate a prototype cockpit-based taxi conformance monitoring system to reduce Runway Incursions at controlled airports.
- Provide updates to Common Metrics application for FAA and airlines.
- Develop methodologies and analytical capabilities to assess the operational impact of Trajectory Based Operations.
- Develop technical papers and reports in support of RTCA. These artifacts include safety and performance requirements, operational services and environment definitions, minimum aviation system performance standards, minimum operational performance standards, NextGen implementation progress updates, and other reports as necessary.
- Support NextGen Advisory Committee priorities through various activities that include development of a traffic flow management strategy to maintain capacity during Performance Based Navigation (PBN) operations commensurate with the FAA's implementation of the PBN Navigation Strategy.
- Conduct engineering analysis for candidate airspace redesign projects and implementation.

Expected Program Outcomes:

- Reducing and eliminating runway incursions will increase the safety of surface operations at controlled airports.
- System Capacity deliverables are on schedule.
- Infrastructure changes resulting from airspace redesign at air traffic facilities in the Northeast Corridor will be implemented.

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.

NextGen Transportation System - Separation Management Portfolio
Funding Enacted ($21,200,000)

Program Description:

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.

Program Objectives:

The main goal of the NextGen Separation Management Portfolio is to provide recommendations through research and technology development activities to improve the tools, standards, and procedures that air traffic controllers use to separate aircraft. Pre-implementation activities conducted under this program reduce risk, define requirements, and demonstrate operational feasibility to support these recommendations.

As the demand for flights increase, concepts and capabilities that focus on enhancing separation assurance using ground based automation and aircraft technology enhancements are critical. The Separation Management program supports the FAA's mission to provide the safest, most efficient aerospace system in the world by conducting research that will enhance aircraft separation assurance by safely reducing separation between aircraft, and as a result improve capacity, efficiency and safety in the National Airspace System.

Anticipated Program Activities:

- Develop refined benefit and safety assessments of the wake risk mitigation concept solutions.
- Commence operations of next RNP scenarios to validate PBN operational concept at new developmental site (e.g., EoR TF Duals / Triples).

Expected Program Outcomes:

- Determine required wake separations for new aircraft entering service in the NAS.
- Complete Safety Risk Management artifacts to support separation standard change to allow for more RNP operations in the NAS (e.g., MARS).

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.

United States Department of Transportation
FY 2021 Annual Modal Research Plans

NextGen Transportation System - Traffic Flow Management Portfolio
Funding Enacted ($8,000,000)

Program Description:

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.

Program Objectives:

The main goal of this NextGen – Traffic Flow Management (TFM) Portfolio is to improve both the efficiency of individual flights while optimizing throughput. This work will make travel safer for the traveling public, help reduce passenger delays leading to a better traveling experience, and contribute to less pollution as the result of improved prediction performance for TFM decision support systems and flexible TFM around weather constraints.

The TFM provides greater flexibility to the flight planners, and makes the best use of available airspace and airport capacity to make travel safer for the traveling public, help reduce passenger delays leading to a better traveling experience, and contribute to less pollution as the result of improved prediction performance for TFM decision support systems and flexible TFM around weather constraints.

Anticipated Program Activities:

- Deliver a report applying NASA research efforts to NAS integrated departure scheduling, focusing on metroplex airports.
- Research mobile/Electronic Flight Bag (EFB)-based solutions that enable participation in integrated departure scheduling and enhanced data exchange with other types of flight operators (regional, cargo, international, etc.).
- Complete initial set of concept validation activities for CTOP-related enhancements
- Develop recommendation report detailing training and simulation improvements that can be identified based on Advanced Coordination and TFM Advanced Coordination Analysis lessons learned.

Expected Program Outcomes:

- Assessment of NASA's Final ATD-2 Technical Transfer to the FAA
- Concept of Use and Functional Analysis for CTOP-related enhancements
- Report detailing training and simulation improvements

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

United States Department of Transportation
FY 2021 Annual Modal Research Plans
NextGen Transportation System - On Demand NAS Portfolio
Funding Enacted ($10,500,000)

Program Description:

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.

Program Objectives:

The main goal of the NextGen – On Demand NAS Portfolio is the efficient and secure exchange of information within the FAA, and between the FAA and other NAS users for collaborative decision-making to support trajectory based operations (TBO). Improvements in the development of a standard set of flight information will 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.

Anticipated Program Activities:

- Update Flight Object concept documentation to reflect findings and lessons learned from the Flight Object demonstration activity,
- Development of requirements for machine-to-machine information exchange using an internationally recognized standardized format for aeronautical information
- Complete Demonstrations to assess Dynamic Airspace functionality and capabilities
- Conduct functional analysis for Flight Deck CDM applications
- Complete the Initial program requirements, business case analysis, implementation strategy and planning documents for Common Support Services-Flight Data for CSS-FD

Expected Program Outcomes:

- Standardizing machine-to-machine aeronautical information exchange
- Developing an implementation strategy and tech transfer plan for applicable technologies
- Achieve AMS decision points for CSS-FD, AIMM Enhancement 1
- Contribute US input for FIXM, AXIM, and CSS-FD requirements to Flight and Flow–Information for a Collaborative environment (FF-ICE) document 1.

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

United States Department of Transportation
FY 2021 Annual Modal Research Plans

NextGen Transportation System - NAS Infrastructure Portfolio
Funding Enacted ($15,000,000)

Program Description:

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.

Program Objectives:

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.

Anticipated Program Activities:

- Create, test and evaluate ceiling and visibility information support prototypes and conduct operational demonstrations to display pre-service functionality.
- Conduct trajectory synchronization shadow evaluation, and complete and document analysis.
- Develop prototype command and control instance in the cloud for a selected demonstrator system.
- Identify gaps in current input device capabilities for automation systems in the NAS and complete report.

Expected Program Outcomes:

- Complete ACAS-Xr (rotorcraft) Operational Capability Flight Demonstration of system specified in the SRS.
- Complete implementation activities inflight icing tool using a High Resolution Rapid Refresh-based capability.
- Develop Prototype and Integration Document for synchronization of Air to Ground Procedures.
- Complete initial analysis of command and control performance and security requirements to support the potential use of internet based data exchange for command and control applications

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.

United States Department of Transportation
FY 2021 Annual Modal Research Plans

NextGen Transportation System - Unmanned Aircraft Systems (UAS)
Funding Enacted ($22,900,000)

Program Description:

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.

Program Objectives:

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 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.

Anticipated Program Activities:

- Develop Initial Concept of Operations for Operations Over People.
- Update of UTM Data Exchange Requirements for applications such as Identification and Tracking.
- Conduct initial concept evaluation and simulation activities for UAS Lost Link Procedures.

Expected Program Outcomes:

- Initial Concept of Operations for Operations Over People.
- Complete Update of UTM Data Exchange Requirements for applications such as Identification and Tracking.
- Initial concept evaluation and simulation activities for UAS Lost Link Procedures.

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.

United States Department of Transportation
FY 2021 Annual Modal Research Plans

System Planning and Resource Management
Funding Enacted ($13,022,000)

Program Description:

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 activities 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.

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.

Program Objectives:

The main goal of the SPRM 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 enhance 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.

Anticipated Program Activities:

- Completion of annual Congressional deliverables (NARP, Annual Review).
- Coordination and completion of REDAC reports, guidance and transmittals.
- Development and dissemination of R&D Program Performance Reports.
- Development and submission of R&D investment portfolio.
- Development and coordination of OST R&D management deliverables (including the Annual Modal Research Plan).

- Provide funding and support per Section 625 of the FAA Reauthorization Act of 2018 (Pub. L. No. 115-254)

Expected Program Outcomes:

- For FY 2021, Effective planning, coordination and communication of the FAA's research portfolio.
- For FY 2021, Delivery of Congressional and DOT reporting requirements.
- For FY 2021Expenditures of the REDAC controlled to less than 1/10 of 1 percent of the total RE&D budget.

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.

United States Department of Transportation
FY 2021 Annual Modal Research Plans

William J. Hughes Technical Center Laboratory Facility
Funding Enacted ($2,921,000)

Program Description:

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 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 other WJHTC capabilities allowing 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.

Program Objectives:

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. The goals of these simulation facilities 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.

Anticipated Program Activities:

<u>Simulation Facilities - (CSF & TGF)</u>

- Upgrade the avionics in the CSF A320 simulator.
- Integrate the Intelligent Agent capability of the TGF with synthetic voice.

<u>Concepts and Systems Integration – RDHFL</u>

- Perform HITL simulations to support research into conceptual Four Dimensional Trajectory (4DT) controller interface.

- Enhance the ATC simulation infrastructure with capabilities to support evaluation of coordinated trail planning and Time Based Operations.

Network Infrastructure - NPN

- Conduct initial cybersecurity exercise with Department of Defense (DoD).

Expected Program Outcomes:

Simulation Facilities - (CSF & TGF)

- By 2021, implement intelligent agent-based capability for both En Route & Terminal environments into TGF for CONUS simulations in Tech Center R&D and field support laboratories as well as remotely located simulation facilities.
- By 2021, implement TBO improvements and connectivity capabilities to the B737 simulator to support integrated, high fidelity, multi-lab simulation.

Concepts and Systems Integration – RDHFL

- By 2021, support research into a conceptual 4DT controller interface to research TBO.
- By 2022, develop prototypes within the ATC simulation software that support research into coordinating conflict probe and trial planning with Time Based Operations.

Q22Network Infrastructure – NPN

- By 2021, support cybersecurity exercises and Whole of Nation Exercise with DoD.
- By 2023, integrate FAA and partner networks and facilities into the NPN baseline to expand the collaborative capabilities and position the FAA to best support NextGen research within the FAA, other government agencies, industry and academia partners.

Collaboration Partners:

This program has the following partners:

- **Academia:** Arizona State University, Drexel University, George Mason University, Georgia Tech, Embry Riddle Aeronautical University, Ohio State University, Rowan University, National Aviation Research &Technology Park;
- **FFRDC:** MITRE, MIT Lincoln Laboratories;
- **Government:** Department of Defense, NASA, Volpe
- **Industry**: AvMet, ComSAT, Concepts Beyond, DocuSign, General Dynamics, Harris, KeyPKI, Liberty IT Solutions, Saab Sensis, SAIC, Survice Eng, (FFRDC), Boeing
- **Other Government**: EUROControl

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

United States Department of Transportation
FY 2021 Annual Modal Research Plans

William J. Hughes Technical Center Laboratory Sustainment
Requested ($16,900,000)

Program Description:

This program sustains the William J. Hughes Technical Center laboratories. This centralized set of laboratories supports 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.

Program Objectives:

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.

Anticipated Program Activities:

Not Applicable

Expected Program Outcomes:

Not Applicable

Collaboration Partners:

Not Applicable

Chapter 3 – FY 2022 Program Descriptions

Airport Infrastructure and Technologies

FY 2022 Program Descriptions
Airports Cooperative Research Program

Program Description:

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 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 by airport operators, industry, and users.

Program Objective

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 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 public on the ACRP website and for purchase in hard copy.

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.

Anticipated Program Activities:

ACRP Oversight Committee (AOC) will be selecting research projects for FY2022 during summer meeting this year. These projects will be focus on the research need of the airports and aviation communities that are not addressed by the Federal research efforts.

FY 2022 Program Descriptions
Airports Technology Research Program

Program Description:

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.

Program Objectives:

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-21, 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.

The program provides an environment where companies of all sizes can test new ideas and products to meet FAA standards. This encourages companies to be innovative in their product development and competitive at the global level.

Anticipated Program Activities:

- Public release of AppMap, a geospatial environmental mapping tool for FAA's environmental protection specialists and planners and airport consultants and sponsors
- Several airport planning tools and models for use in airport planning and capacity analysis (Small Aircraft Capacity Model / Aircraft Characteristics Database)
- Fire testing and data collection related to the replacement of fluorinated firefighting foams and evaluations of firefighting effects on thermal balance.
- Reports on the use of UAS for airport applications: Pavement inspection, wildlife hazing, Aircraft Rescue and Firefighting
- Annual Wildlife Strike Data Analysis Report
- Annual Runway Incursion Mitigation Report
- Report on activities at the National Airport Pavement Materials Research Center
- Report on activities at the National Airport Pavement Test Facility

Aircraft Safety Assurance

FY 2022 Program Descriptions
Fire Research and Safety

Program Description:

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 the ban on 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.

Program Objectives:

The primary goals 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 FAA Fire Safety Branch conduct the research. 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.

Anticipated Program Activities:

- Perform tests to support international efforts to classify the fire hazards of electrical power sources, including lithium and other battery chemistries.

- Develop new and/or revised aircraft materials flammability standards. This includes upgraded standards for materials in inaccessible areas, newly introduced structural and component materials, and new manufacturing processes such as additive manufacturing.

- Perform tests to support the development of new standards for the fire containment and fire detection of cargo containers (Unit Load Devices).

- Perform tests to evaluate novel designs for freighter aircraft fire suppression systems.

- Perform tests to evaluate the fire suppression capability of new agents and/or systems for engine and APU applications.

- Develop the capability to verify and validate computational models proposed to the FAA for certification by analysis in lieu of performing fire tests. Develop standardized fire test fixtures simulating aircraft engines, cargo compartments, and hidden spaces to generate experimental data for model validation.

FY 2022 Program Descriptions
Advanced Materials/Structural Safety

Program Description:

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.

Program Objectives:

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

Anticipated Program Activities:

Once program funding values are determined for this year program activities will be identified.

FY 2022 Program Descriptions
Continued Airworthiness

Program Description:

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.

Program Objectives:

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.

Anticipated Program Activities:

<u>Helicopter Fuel System Drop Test</u>

- 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.

- *MMPDS Support and Design Values for Emerging Materials:* Collaborate with NASA, DoD and industry to develop tools, methodologies and data to mitigate the risk associated with structural failures and provide updates and distribution of standardized handbooks supporting aircraft certification and continued airworthiness.

- The *Development of Control Surface and Stabilizer Freeplay Limits* activity focuses on obtaining the data and develop the methodologies and nonlinear models required to establish safe and realistic freeplay limits for control surfaces of transport category aircraft to preclude freeplay-induced vibrations.

FY 2022 Program Descriptions
Propulsion and Fuel Systems

Program Description:

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 and improved inspection technologies 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 accrue in the form of a reduced risk of engine failures and fewer accidents, which in turn lead to fewer injuries and fatalities.

Program Objectives:

To prevent uncontained engine failures, the FAA and the Aerospace Industries Association (AIA) formed the Rotor Integrity Steering Committee (RISC) to augment the traditional safe-life design approach with one that employs a probabilistic design methodology to account for extremely rare material and service induced anomalies. This revolutionary change resulted in the FAA issuing rule 33.70, which describes the certification of critical life limited engine parts. In order for the FAA to ensure that the industry is able to comply with the new safety rule, a series of FAA advisory circulars and a publicly available probabilistic software code were planned to be developed.

The objective of this research is to develop the damage tolerance framework and supporting data to provide a basis for the necessary advisory materials and a design software code called DARWIN in support of rule 33.70. A further objective of this research is to develop improved nondestructive evaluation (NDE) methods to characterize engine component material conditions that can compromise integrity. This need was highlighted by the NTSB in recommendations A-18-03 and A-18-04 resulting from the 2016 AA Flight 383 uncontained turbine failure event. To accomplish these objectives, research will be pursued through a government and industry collaboration to ensure that a consistent level of safety is widely adopted by the engine industry.

Anticipated Program Activities:

Once program funding values are determined for this year program activities will be identified.

FY 2022 Program Descriptions
Alternative Fuels for General Aviation

Program Description:

Due to a variety of environmental, regulatory, and market forces in the U.S. and worldwide, leaded avgas will be eliminated at a future point in time. 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. 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.

Program Objectives:

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 that the fuel has 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 as that is the responsibility of the private sector.

Anticipated Program Activities:

- Engine testing in engine test cells at ground level and using altitude simulation capabilities to measure engine performance, detonation, durability and other operating characteristics showing if unleaded fuels meet the PAFI applicable requirements of FAA 14 CFR Parts 33.45, 33.47, 33.49, 33.55, and 33.57.

- Aircraft flight testing to document ground and flight operational characteristics and to verify if the performance of aircraft on candidate fuels meet the PAFI applicable requirements of FAA 14 CFR Part 23 and ASTM D7826.

- Laboratory rig and materials compatibility testing with the novel fuels and potential fuel additives for materials degradation, aging conditions, performance characteristic, and other property changes to verify conformance to FAA Technical Standard Orders (TSO), ASTM test criteria and compatibility with Parts Manufacturer Approval (PMA) engine and fuel system components.

- 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 to verify that fuel elemental compositions are consistent with proposed fuel formulation specifications.

FY 2022 Program Descriptions
Aircraft Catastrophic Failure Prevention Research

Program Description:

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.

Program Objectives:

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.

Anticipated Program Activities:

Once program funding values are determined for this year program activities will be identified.

Digital Systems and Technologies

FY 2022 Program Descriptions
Digital System Safety/Aircraft Icing

Program Description:

Airborne systems' designs have become increasingly dependent on highly integrated software and hardware architectures that share power, computing, networking, input/output, and other resources to support the needs of multiple aircraft functions. The main goal in Digital Safety Research is to 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 (such as Artificial Intelligence [AI] and/Machine Learning [ML]), 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 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.

Program Objectives:

The research conducted under this Budget Line Item (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 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 *Complex Digital 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 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.

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.

The research conducted under this BLI differs from industry research. The main focus of this research 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 requirements. 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.

Anticipated Program Activities:

Digital System Safety

- Activity 1: Implementation Methodologies for Automation using Artificial Intelligence (AI) – This task will assess the use of artificial intelligence in safety critical airborne systems, non-deterministic methodologies to demonstrate the intended behavior, and develop criteria for various Development Assurance Levels (DAL) across the safety continuum. This activity will begin in FY22 and end in FY24. Research outputs will include interim reports identifying safety issues related to system certification, delineation of mitigation techniques, and validating efficacy of such techniques.

- Activity 2: Pilot Studies to evaluate the concept of Abstraction Layer (AL) for alternate assurance digital systems/Report – This activity will assess the AL , and other approaches for completeness, consistency, and feasibility of use in a certification environment identifying potential improvements, clarifications, gaps, and issues with their use. This activity will begin in FY22 and end in FY23. Research outputs will include draft and interim reports identifying issues in certifying a product using the overarching properties, abstraction layer, or other means in lieu of the current, more prescriptive, system, software, or electronic hardware standards.

- Activity 3: Pilot Studies to evaluate the application of Overarching Properties (OP) for alternate assurance of complex digital systems. This activity will assess the implementation of Overarching Properties (OP), AL, and other approaches for completeness, consistency, and feasibility of use in a certification environment identifying potential implementation issues and possible mitigations to address these issues. This activity will begin in FY22 and end in FY24. Research outputs will include draft and interim reports identifying the implementation issues and mitigations in certifying a product using the overarching properties, abstraction layer, or other means in lieu of the current, more prescriptive, system, software, or electronic hardware standards.

- Activity 4: Integrated Service Reliability – This activity on the will focus on the designing, building, quantifying and certifying of a Flight Test Unit (FTU) prototype. Installing that protoype in an aircraft and conducting test flights to gather the reliability data for the first time on lead free solder alloys, semiconductor device wear out models, gold-alternative wire bonds, and thermal energy atmospheric neutron environments. This activity will begin in FY22 and end in FY24. Research outputs will include Plans, Designs, Reports, Qual/Cert Test Results and Operation Manuals.

Aircraft Icing

- Transfer data package supporting annual guidance to airline industry for updating of airline ground deicing programs.
- Complete geometric and roughness characterization of cold soaked fuel frost. Plan aerodynamic testing.
- Continue investigation of ice crystal icing using rotating rig.

FY 2022 Program Descriptions
NextGen – Information Security

Program Description:

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

Program 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.

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.

Anticipated Program Activities

- Cyber Data Science Algorithms to detect Advanced Persistent Threats (APTs)
- Identify and evaluate the initial set of data parameters for cyber data analytics across the aviation ecosystem
- Investigate the various data suites for cybersecurity threats across the aviation ecosystem
- Establish proof of concept cyber data distribution models and analytical cells for the aviation ecosystem
- Establish the baseline of event/data logging for information/cybersecurity

FY 2022 Program Descriptions
NextGen – Flightdeck Data Exchange

Program Description:

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.

Program Objectives:

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.

The main goal that the NextGen – FD-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.

Anticipated Program Activities:

- Finalize the FD DER prototype environment to enable exchange of information in a secured environment for EFBs and AIDs applications through the use of IP Data Link
- Identify and evaluate threats and vulnerability associated with current avionics, on-board aircraft systems, IP Data Link, and their associated data elements, and provide mitigation strategies to address cyber security risks
- Provide recommendations for performance and cyber security standards for EFBs, AIDs, and Data Link hardware and software applications
- Refine operational and technical assessments based on results of the cyber security risk assessments exercise

Environment and Weather Impact Mitigation

FY 2022 Program Descriptions
Weather Program

Program Description:

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.

Program Objectives:

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.

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.

Anticipated Program Activities:

- Complete transition of Ensemble Prediction of Oceanic Convective Hazards (EPOCH) to operations; complete enhancements to: CWAM including machine learning techniques for improved accuracy and OPC with MRMS data ingest to improve forecast accuracy, and prepare for transition to NWS and/or PMO.

- Develop convectively-induced turbulence forecast capability including improved diagnoses of turbulence categories

- Assess the viability of a super compact, low energy usage, ceilometer for use in remote areas with data gaps to provide analyses for data sparse regions and integration into NWS weather prediction models.

FY 2022 Program Descriptions
NextGen – Weather Technology in the Cockpit

Program Description:

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
- Federal and private weather providers and pilots' needs for increases in the quantity and accuracy of pilot reports (PIREPs) and airborne observations to enhance weather forecasts, nowcasts, and adverse weather avoidance decision-making,
- National Association of Flight Instructors (NAFI) and commercial flight training schools that identify needs for enhanced pilot weather training materials, experiential learning software, weather training courseware, and current aviation-specific weather knowledge test questions,
- NEXTGEN Segment Implementation Plan (NSIP).

Program Objectives:

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.

Anticipated Program Activities:

- Make MinWxSvc recommendations to resolve selected gaps in weather information in helicopter cockpits linked to safety and efficiency operational shortfalls.
- Create objective criteria that are compatible with automating VNR statement issuance for selected complex adverse weather scenarios.
- Complete development of algorithms to calculate objective turbulence information from data in downlinked ADS-B reports and methods to present this turbulence information in cockpits, and develop a demonstration plan to assess the safety and efficiency benefits relative to turbulence avoidance.
- Interim products for providing applicable weather training for new entrant pilots and to resolve identified knowledge gaps.
- To support evolving technological air traffic flow management solutions, begin identification of minimum weather information and associated cockpit presentation for collaborative information exchange to enable aircrews to easily respond and to improve decision-making for changing weather conditions in the NAS.

FY 2022 Program Descriptions
Environment and Energy

Program Description:

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.

Program Objectives:

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.

Anticipated Program Activities:

- Use advances in scientific understanding to enhance the aviation environmental tool suite to improve our ability to calculate environmental consequences and impacts of aviation.
- Develop innovative, cost-effective solutions to reduce noise, fuel use, and emissions for both fixed wing and vertical takeoff and landing vehicles through technology and operational procedure concepts.
- Conduct analyses to inform decision making on operational procedure concepts, policy measures, and standards that could reduce noise, fuel use, and emissions.
- Develop improved measurement capabilities and airworthiness certification methods for noise and emissions for both existing air vehicles and new entrants.
- Conduct analyses and gather data to inform the development of noise and emissions standards to enable the introduction of new entrants, such as Unmanned Aerial Systems, Urban Air Mobility vehicles, and civil supersonic aircraft.

FY 2022 Program Descriptions
NextGen – Environmental Research: Aircraft Technologies and Fuels

Program Description:

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

Program Objectives:

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

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.

Anticipated Program Activities:

- Develop aircraft and engine technologies, as well as novel drop-in fuels, for both subsonic and supersonic aircraft, that reduce noise and emissions while increasing fuel efficiency through the CLEEN Program.
- Evaluate innovative technological solutions to reduce noise, emissions and fuel burn from both subsonic and supersonic aircraft through ASCENT.

- Support the approval of novel jet fuel pathways within the American Society of Testing and Materials (ASTM) International certification process via testing and coordination to ensure these fuels are safe for use.
- Support the inclusion of sustainable aviation fuels, created from waste and biomass feedstocks, and lower carbon aviation fuels, created from fossil feedstocks, within the International Civil Aviation Organization (ICAO) Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA).

Human Performance and Aeromedical Factors

FY 2022 Program Descriptions
Flightdeck / Maintenance / System Integration Human Factors

Program Description:

The Flight Deck/Maintenance/System Integration Human Factors program addresses research and development (R&D) requirements defined by technical sponsors in the Aviation Safety Organization (AVS). These requirements are driven by the human factors needs of Aircraft Certification (AIR) and Flight Standards (AFS) personnel responsible for the certification, approval, and continued airworthiness of aircraft; as well as the certification of pilots and mechanics. Program outputs provide the research foundation to update and maintain human factors related rules, guidance, procedures, Orders, standards, job aids, and other materials to support aviation safety and productivity. Program outputs also proactively address the human factors impact of rapid changes to current-day technologies, procedures, and emerging issues.

The program focuses on the needs of pilots, inspectors, and aircraft maintainers. The revolution in digital avionics has changed flight deck 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.

Program Objectives:

The main goal for the Flight deck/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.

In FY 2021, three different research areas are planned to be addressed. The first research area is *Advanced Vision Systems – Enhanced Flight Vision System (EFVS), Enhanced Vision Systems (EVS), Synthetic Vision Systems (SVS), and Combined Vision System (CVS), Heads Up Displays, Helmet Mounted Displays – Certification and Ops Approval Criteria.* The objective of this research is to characterize the human factors, pilot performance, and operational considerations related to the expanded use of these technologies during new low visibility concepts of operation. Outputs from this research will inform the development of operational requirements, standards, conditions, limitations, mitigations, and authorizations for their use.

The second research area is *Fatigue Mitigation in Flight Operations.* The objective of this research is to reduce the number of accidents and incidents caused by flight crewmember fatigue. This research will examine the operational effectiveness of mitigations developed by industry (e.g. Fatigue Risk Management Plans) to manage pilot performance issues (sleep disruption, fatigue, and workload) caused by flight operations that do, and do not, exceed 14 CFR Part 117 limits (Flight And Duty Limitations And Rest Requirements: Flightcrew Members). Human factors scientific and technical information will be used to improve the FAA

and industry's understanding of fatigue through training and mitigations, and the effect of short haul, long haul, and ultra-long range flight operations to pilot performance.

The third research area is *Pilot Training, Qualification, Procedures and Flight Operations.* The objective of this research is to inform data-driven guidance for inspectors and operators on training methodologies, such as distance learning and virtual reality, and 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.

Anticipated Program Activities:

<u>Advanced Vision Systems (EFVS, EVS, SVS, CVS), Head-Up Displays (HUD), and Head Mounted Displays (HMD): Operational Standards & Approval Criteria</u>

- Research plan to evaluate the pilot performance, human factors, and operational impacts associated with conducting SVGS operations to lower than standard LPV minima (i.e. conditions such as 150'DH, 1400 RVR) and how pilot performance compares to the baseline condition.
- Technical report describing the pilot performance, human factors, and operational impacts associated with conducting EFVS operations to 100 feet above touchdown zone elevation using a head-down display (HDD), and whether pilot performance is sufficiently comparable to pilot performance obtained when using an EFVS head-up display (HUD).

<u>Fatigue Mitigation in Flight Operations</u>

- Technical report describing the effectiveness of techniques used by industry to incorporate lessons learned from unexpected events from operations into pilot training curriculums.
- Create a single-source reference document for human factors – related rules and guidance which pertain to Flight Standard Service (AFS) topic areas. This document will identify human factors issues for FAA personnel to consider in the design and evaluation of current/proposed flight deck operations and pilot procedures.
- Research plan to verify and validate potential indicators of pilot performance in CRM, including cognitive indicators, which may be consistently observed and generalized across industry.

<u>Pilot Training, Qualification, Procedures and Flight Operations</u>

- Develop a rotorcraft human factors analysis framework which could be used to identify issues across the HAA domain, including causal and contributing factors to event outcomes – such as accidents and incidents.
- Develop a draft fatigue risk baseline of the helicopter air ambulance industry using fatigue risk assessment modeling algorithms to inform improvements in the strategic use of rest facilities, fitness for duty requirements, and scheduling practices.

FY 2022 Program Descriptions
Air Traffic Control / Technical Operations Human Factors

Program Description:

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.

Program Objectives:

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.

Anticipated Activities:

Once program funding values are determined for this year program activities will be identified.

FY 2022 Program Descriptions
NextGen – Air Ground Integration Human Factors

Program Description:

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.

Program Objectives:

The primary goal of the NextGen/Air Ground Integration Human Factors program is enhanced safety and operational efficiency. In FY2022 three research areas will be addressed: (1) NextGen Aircraft Systems and Controls, (2) NextGen Human Error Mitigation, and (3) NextGen Flightcrew Readiness. The scope of each research area is provided below.

1. *NextGen Aircraft Systems and Controls Research* will address the human-system performance benefits and limitations of emerging flight deck technologies, systems, and controls. This research will also 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.

2. *NextGen Human Error Mitigation Research* will proactively address the impact of emerging flight deck technologies and NextGen concepts of operation to pilot performance in future NAS operations, including the effect of anticipated changes to the role, required skillset, and expectations of pilots.

3. *NextGen Flightcrew Readiness Research* will examine the impact of flight deck technologies (i.e. control automation, information automation), pilot procedures, and NextGen concepts of operation to baseline pilot knowledge, skills, and abilities (KSA). Research will enable the evaluation of new NextGen pilot KSAs and the identification of potential training evaluation needs to support the expanded use of NextGen capabilities and procedures.

Anticipated Program Activities:

<u>NextGen Aircraft Systems and Controls Research (Avionics Design & Evaluation, Advanced Vision Systems)</u>

- Evaluate the effect of advanced vision systems, emerging sensor-based technologies (i.e. multiple sensor systems), and new display types (e.g. head-worn or head-mounted) to pilot performance, human factors, and flight deck operations in transport category aircraft during low visibility concepts of operation.

<u>NextGen Human Error Mitigation Research (Human Error & Complex Systems)</u>

- Baseline causal and contributing factors to human-system performance vulnerabilities in current-day flight operations to track and measure the impact of NextGen flight deck changes and TBO.
- Evaluate the effect of planned air/ground system enhancements, flight deck system dependencies, and their respective NextGen concept of operation(s) to pilot performance, including unexpected events that may or may not exist in current-day flight operations and Industry responses.

NextGen Flightcrew Readiness Research (Procedures, Tasks, Skills, and Training)

- Identify and address change management barriers that could impact high levels of pilot participation in future time-based flight operations (e.g. pilot acceptance, industry culture, etc.).

FY 2022 Program Descriptions
Aeromedical Research

Program Description:

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).

Program Objectives:

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.

Anticipated Program Activities:

- **Feasibility Study of An Inclusive Aerospace Medicine Data Table**: This will improve the efficiency of our medical research tasks. Current information has many misspellings and other data issues**.** Variety of memoranda, recommendations, presentations, and technical reports, as needed.
- **Best Medical Transport Method Selection Tool:** Research to determine the most effective and safe method of medical transport. Technical report with recommendations.
- **Cystic Fibrosis in Airmen, 5-Year Prognosis:** Technical report on the 5-year prognosis of airmen with Cystic Fibrosis.
- **Intermediate Visual Acuity In Older Third-Class Pilots:** Technical report of the intermediate visual acuity of older third-class pilots, and correlations to safety of flight issues..
- **Acquiring Aviation Data From Textual Analysis Of Social Media:** Tools to gather aviation data from online social media applications, which is used in processing our autopsy toxicology, and aeromedical data.
- **Safety Experience of Pilots Holding Sport Pilot Certificates:** Technical report on the safety experience of pilots holding sports pilot's certificates, versus other pilots, and any inferences that may be made of BasicMed safety experiences.

- **Cognitive Screening Test Categorization and Assessment:** The previous cognitive screening tool was compromised**.** Ideally, several new tools would be identified and validated to provide more options**.** Technical memorandum listing of multiple categories of cognitive screening tests, and a plan to test them.
- **Effects Of Medications On Human Performance At Altitude:** Project plan for completion, and lists of medications to be tested to determine performance at altitude while taking them
- **Passenger Evacuation Review – Wide Body Aircraft Slide Egress:** Investigating ways to mitigate injuries associated with slide egress from wide-body aircraft. Project plan and brief outline of wide-body aircraft slide egress injury reports to be studied.
- **ATD Construction Harmonization Phases I – II:** Technical reports that provide providing consistent measurement of pelvis load and an accurate assessment of spinal injury risk. These will be used to modify the regulations and standards for crash testing.
- **Passenger evacuation from Alternative Horizontal Cabin Configurations:** Determining if the alternative cabin configurations proposed by some airlines will meet the same level of safety as existing configurations. Technical report describing the impact of alternative horizontal cabin configurations on passenger egress times.
- **Effects of Cabin Seat Pitch and Alternative Seat Configurations on Evacuations:** Draft technical report, and recommendations for the Evacuation Aviation Rulemaking Committee (ARC).
- **Passenger Retention of Cabin Safety Information:** Approved project plan for this work will be available by the end of FY22.

FY 2022 Program Descriptions

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

Program Description:

The Enterprise Concept Development, Human Factors, and Demonstration Portfolio conducts enterprise level activities, including the development of concepts across the NAS, human factors analyses of the NextGen operational environment, and demonstrations of proposed NextGen system improvements to ensure operational feasibility and viability within the NAS.

Program Objectives:

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 demonstrations 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.

Anticipated Program Activities:

- Finalize scenarios, use cases and UAM Concept of Operations.
- Conduct TBO Demonstration.
- Complete ETM I Demonstration final report.
- Identify human factors performance considerations of NextGen concepts.

Aviation Performance and Planning

FY 2022 Program Descriptions
System Safety Management/Terminal Area Safety

Program Description:

The main goals of this program is to affect 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.

The Terminal Area Safety (TAS) program improves the safety of operations near or at an airport. Research projects in the program focus on developing training solutions and identifying effective technologies to mitigate key causes of fatal accidents such as the loss of control, runway excursions, and runway overruns. These are the leading causes of fatalities in the worldwide commercial jet fleet.

Program Objectives:

The System Safety Management (SSM) program, is designed to improve safety through developing safety data collection methods, advanced safety data and risk analysis techniques, and prototypes of risk-based decision-making capabilities to identify and analyze emerging safety issues in a cooperative nature with 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).

Through this program, the FAA evaluates potential solutions to reduce fatal accidents through: extending simulator models to allow for better upset training; exploring alternatives to determine runway slipperiness; developing objective motion criteria to minimize inappropriate simulator training; enabling safe helicopter approaches when using advanced vision systems; exploring consistent operational standards for a stable approach to reduce runway excursions; developing a logical go-around training curriculum that mitigates the operational go-around problems that have arose; and performing flight tests on representative domestic and international runways that support turbine-powered airplane operations in order to validate the wet-ungrooved and wet-grooved wheel braking coefficient models in 14 CFR Part 25.109(c). These projects address the principal causes of fatalities in the commercial jet, general aviation, and rotorcraft communities but also fill aviation safety research gaps identified in NTSB's Safety Recommendations such as A-07-003, A-04-62, A-07-64, and A-01-069.

Anticipated Program Activities:

<u>System Safety Management</u>

- Identify and document the necessary software changes within ISAM to allow appropriate representation of contextual, conditional, and common cause failures.
- Develop descriptive analytics and proof of concept for safety performance indicators of surface operations.
- Develop concept and model for sector risk profile tool for aeronautical information services.
- Develop tools, techniques, metrics, and provide analytical expertise to the Helicopter Issue Analysis Team (IAT) for examining safety data and methodologies to reduce the fatal accident rate within the vertical lift community.

- Create safety metrics and software prototypes for general aviation using safety data sources such as Surveillance Broadcast Services (SBS) data (i.e. ADS-B) to better analyze risk within the general aviation community.

Terminal Area Safety

Immersive Flight Simulation

- Complete literature survey and identify a virtual reality system and a simulated air traffic control system to evaluate for pilot training

Reducing Human Error Through Cognitive Bias Awareness

- Identify strategies for developing flight simulation scenarios that expose pilots to a variety of human biases in an effort to make pilots aware of those biases and reduce pilot error,
- Create improved mathematical/physics based flight dynamics models representing anomalous helicopter flight states/conditions.
- Explore vision systems technology interoperability and compatibility issues for enhancing safety and identifying concepts for providing operational credit through rotorcraft simulation and flight testing.

Wet Runway Wheel Braking Testing

- Conduct data analysis to determine the influence of runway, meteorological, and aircraft factors on wet runway wheel braking effectiveness of turbine-powered aircraft and provide results and recommendations to stakeholders in publicly available reports.

FY 2022 Program Descriptions
Commercial Space Transportation

Program Description

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.

Program Objectives:

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.

AST will use FY 2021 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 2021 RD&T portfolio 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.

Anticipated Program Activities:

- Develop improved models and methods to reduce over-conservatism applied to airspace keep-out areas used to protect against launch or re-entry failures.
- Initiate multiple, large-scale activities, conducted by teams of industry segment collaborators, investigating questions of common interest to industry and FAA.

FY 2022 Program Descriptions
NextGen – Wake Turbulence

Program Description

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.

Program Objectives:

The main goal of the NextGen Wake Turbulence research program is wake mitigation separation. NextGen - Wake Turbulence research analyzes and collects the data to establish the wake mitigation separations that are to be applied by ATC to new series of aircraft entering operational service. The program's analysis capability was used to establish separations for the Airbus A380, Boeing 747-800, Boeing 787 and the Airbus A350 series aircraft. Analysis work and international coordination has been completed on standards for the Airbus A320-Neo series of aircraft. The project provided wake separations for ATC's use for the Boeing 737 MAX which began operations in the NAS 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 more operations onto an airport's existing runways results in major reductions of flight delays during and after a bad weather event that occurs at or near an airport.

Anticipated Program Activities:

- Assessment of new aircraft types for ATC wake risk mitigating separations: Wake track statistical data base assessments will be done if the aircraft type is similar to another aircraft type already flying in the NAS. If not similar, aircraft performance & design data will be modeled to determine a safe wake separation for ATC's use until wake track data on the aircraft type can be collected to possibly allow reduced separation.
- Collection/analysis of wake track data to build a statistical basis for determining safe, throughput efficient wake separations between aircraft: Data analyses will be accomplished on the collected wake track data.

- Assessment of proposed changes to ATC procedures for wake encounter risk to include the finalized RECAT "Total Wind" (TW) terminal area dynamic wake separation solution: Among others, RECAT TW solution's safety assessment will be provided as a part of the solution's documentation technical transfer package.
- Subset of absolute wake hazard metrics to use where relative metrics are not feasible**.**

FY 2022 Program Descriptions
Unmanned Aircraft Systems

Program Description:

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.

Program Objectives:

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.

Anticipated Program Activities:

FY 2022 research activities are 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. FY 2022 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
- UAS pilot and visual observer training and qualification

Research on data collection and risk-based assessments supports the strategic goal of safety through the improvement of data collection methods and analyses. FY 2022 research includes:

- Collection and analysis of UAS data to identify safety risks for industry and government partners within the UAS Safety Team
- Identification and evaluation of potential risks of UAS operations on and around the airport surface

Research on advanced UAS concepts and applications (including Urban Air Mobility) supports the strategic goals of safety, innovation, and 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. FY 2022 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 FY 2022 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

FY 2022 Program Descriptions
Advanced Technology Development & Prototyping

Program Description:

The 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.

Program Objectives:

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.

Anticipated Program Activities:

- Develop and demonstrate a prototype cockpit-based taxi conformance monitoring system to reduce Runway Incursions at controlled airports.
- Provide updates to Common Metrics application for FAA and airlines.
- Develop methodologies and analytical capabilities to assess the operational impact of Trajectory Based Operations.
- Develop technical papers and reports in support of RTCA. These artifacts include safety and performance requirements, operational services and environment definitions, minimum aviation system performance standards, minimum operational performance standards, NextGen implementation progress updates, and other reports as necessary.
- Conduct engineering analysis for candidate airspace redesign projects and implementation.

FY 2022 Program Descriptions
NextGen Transportation System - Separation Management Portfolio

Program Description:

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.

Program Objectives:

The main goal of the NextGen Separation Management Portfolio is to provide recommendations through research and technology development activities to improve the tools, standards, and procedures that air traffic controllers use to separate aircraft. Pre-implementation activities conducted under this program reduce risk, define requirements, and demonstrate operational feasibility to support these recommendations.

As the demand for flights increase, concepts and capabilities that focus on enhancing separation assurance using ground based automation and aircraft technology enhancements are critical. The Separation Management program supports the FAA's mission to provide the safest, most efficient aerospace system in the world by conducting research that will enhance aircraft separation assurance by safely reducing separation between aircraft, and as a result improve capacity, efficiency and safety in the National Airspace System.

Anticipated Program Activities:

- Develop preliminary requirements and supporting safety assessments for adding the RECAT Phase III wake risk mitigation solution enhancements to ATC decision support tools.
- Conduct concept validation studies based of PBN strategy and document findings to reduce risks/uncertainties of PBN Concepts (e.g., EoR xLS or EoR TF/RF Duals and Triples).

FY 2022 Program Descriptions
NextGen Transportation System - Traffic Flow Management Portfolio

Program Description:

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.

Program Objectives:

The main goal of this NextGen – Traffic Flow Management (TFM) Portfolio is to improve both the efficiency of individual flights while optimizing throughput. This work will make travel safer for the traveling public, help reduce passenger delays leading to a better traveling experience, and contribute to less pollution as the result of improved prediction performance for TFM decision support systems and flexible TFM around weather constraints.

The TFM provides greater flexibility to the flight planners, and makes the best use of available airspace and airport capacity to make travel safer for the traveling public, help reduce passenger delays leading to a better traveling experience, and contribute to less pollution as the result of improved prediction performance for TFM decision support systems and flexible TFM around weather constraints.

Anticipated Program Activities:

- Complete and deliver a report on cloud-based technologies and services required to exchange data from EFB applications in a timely and secure manner
- TFM new capability integration Operational Scenarios and Use Cases
- Develop prototype capability for the advanced automation learning/data mining capability that utilizes historical and real-time data

FY 2022 Program Descriptions
NextGen Transportation System - On Demand NAS Portfolio

Program Description:

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.

Program Objectives:

The main goal of the NextGen – On Demand NAS Portfolio is the efficient and secure exchange of information within the FAA, and between the FAA and other NAS users for collaborative decision-making to support trajectory based operations (TBO). Improvements in the development of a standard set of flight information will 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.

Anticipated Program Activities:

- Develop shortfall analysis, solution concept of operations, functional analysis, and preliminary program requirements, in support of IARD for AIMM Enhancement 2
- Develop the FIXM standard and extensions in support of FF-ICE, as well as addressing the challenges of doing so
- Complete the Initial program requirements, business case analysis, implementation strategy and planning documents in support of Initial Investment Decision (IID) for Common Support Services-Flight Data
- Develop concept for FD CDM Trajectory Negation Application, including use cases and initial architecture design documents

FY 2022 Program Descriptions
NextGen Transportation System - NAS Infrastructure Portfolio

Program Description:

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.

Program Objectives:

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.

Anticipated Program Activities:

- Conduct studies surrounding the operational usage of convective weather information support capabilities, determine the performance level of current weather products and develop report.
- Complete trajectory synchronization flight demonstration/trial and document lessons learned.
- Prepare and deliver a technology transfer package for Command and Control in the Cloud technologies.
- Complete final analysis of performance, security requirements, and risk management analysis to support the potential use of internet based data exchange for command and control applications.

FY 2022 Program Descriptions
NextGen Transportation System - Unmanned Aircraft Systems (UAS)

Program Description:

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.

Program Objectives:

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.

Anticipated Program Activities:

- Develop Final Concept of Operations for Operations Over People.
- Conduct final concept evaluation and simulation activities for UAS Lost Link Procedures.

FY 2022 Program Descriptions
System Planning and Resource Management

Program Description:

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 activities 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.

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.

Program Objectives:

The main goal of the SPRM 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 enhance 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.

Anticipated Program Activities:

- Completion of annual Congressional deliverables (NARP, Annual Review).
- Coordination and completion of REDAC reports, guidance and transmittals.
- Development and dissemination of R&D Program Performance Reports.
- Development and submission of R&D investment portfolio.
- Development and coordination of OST R&D management deliverables (including the Annual Modal Research Plan).

FY 2022 Program Descriptions
William J. Hughes Technical Center Laboratory Facility

Program Description:

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.

Program Objectives:

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.

Anticipated Program Activities:

<u>Concepts and Systems Integration – RDHFL</u>

- Enhance the ATC simulation infrastructure with capabilities to support evaluation of human factor issues associated with new ATC console hardware and advanced information display concepts.

<u>Network Infrastructure – NPN</u>

- Continue to support cybersecurity exercises and Whole of Nation Exercise with DoD.
- Continue to integrate FAA and partner networks and facilities into the NPN baseline to expand the collaborative capabilities and position the FAA to best support NextGen research within the FAA, other government agencies, industry and academia partners.

- Support CyTF Secure Laboratory partner activities investigating cyber threats to the NAS. This is expected to include joint FAA/DoD/DHS activities.

FY 2022 Program Descriptions
William J. Hughes Technical Center Laboratory Sustainment

Program Description:

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.

Program Objectives:

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.

Anticipated Program Activities:

Not Applicable

List of Acronyms

ACRONYM	DEFINITION
A	
A4A	Airlines for America
AAAE	American Association of Airport Executives
AAM	Office of Aerospace Medicine
AASR	Aging Aircraft Safety Rule
ABST	Airframe Beam Structure Test
AC	Advisory Circular
ACAS-Xr	Aircraft Collision Avoidance System for NextGen (rotorcraft)
ACI	Aircraft Cyber Initiative
ACI-NA	Airports Council International–North America
ACRP	Airport Cooperative Research Program
ADG	Airplane Design Groups
ADS-B	Automatic Dependent Surveillance-Broadcast
ADSIM	Airfield Delay Simulation Model
AEEC	Airline Electronic Engineering Committee
AEDT	Aviation Environmental Design Tool
AEH	Airborne Electronic Hardware
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 Interface Devices
AIMM	Aeronautical Information Management Modernization
AIR	Aircraft Certification Service
AJI	Safety and Technical Training Organization
AJM	Program Management Organization
AJV	Aeronautical Information Services Organization
AL	Abstraction Layer
ALPA	Air Line Pilots Association
ALSF	Approach Lighting System with Sequence Flashing
AMRAC	Aerospace Medicine Research Alignment and Collaboration
AMRP	Annual Modal Research Plan
AM	Additive Manufacturing
AMS	Acquisition Management System
ANG	Office of NextGen

ACRONYM	DEFINITION
ANSP	Air Navigation Service Provider
AOPA	Aircraft Operators and Pilots Association
AOC	ACRP Oversight Committee
AOV	Air Traffic Safety Oversight Office
APT	Advanced Persistent Threats
APU	Auxiliary Power Units
AR	Annual Review
ARC	Evacuation Aviation Rulemaking Committee
ARAC	Aviation Rulemaking Advisory Committee
ARRF	Aircraft Rescue Firefighting
ARTCCs	Air Route Traffic Control Centers
ASCENT	Aviation Sustainability Center of Excellence
ASEB	Aeronautics and Space Engineering Board
ASOS	Automated Surface Observing System
ASRS	Aviation Safety and Reporting System
AST	Office of Commercial Space Transportation
ASTM	American Society for Testing Materials
ASU	Arizona State University
ATA	Air Transport Association
ATC	Air Traffic Control
ATC/ATO	Air Traffic Control/Technical Operations
ATD-3	Airspace Technology Demonstration 3
ATDP	Advanced Technology Development and Prototyping
ATM	Air Traffic Management
ATN	Aeronautical Telecommunications Network
ATO	Air Traffic Organization
ATNB2	Aeronautical Telecommunications Network Baseline 2
ATR/ATRP	Airport Technology Research Program
ATSM	American Society for Testing and Materials
AVP	Accident Investigation and Prevention
AVS	Office of Aviation Safety
AVSI	Aerospace Vehicle Systems Institute
AHX-1	FAA Office of Hazardous Materials
AXIM	Aeronautical Information Exchange Model
B	
BLI	Budget Line Item
BOM	Bureau of Meteorology
C	

ACRONYM	DEFINITION
CAA	Civil Aviation Authority
CAAFI	Commercial Aviation Alternative Fuels Initiative
CAASD	Center for Advanced Aviation System Development
CAEP	Committee on Aviation Environmental Protection
CAMI	Civil Aerospace Medical Institute
CAST	Commercial Aviation Safety Team
CAT	Category
CCSU	Central Connecticut State University
CDM	Collaborative Decision Making
CDTI	Cockpit Display of Traffic Information
CFR	Code of Federal Regulations
CHM	Composite Materials Handbook
CLEEN	Continuous Lower Energy, Emissions and Noise
CNS	Communication, Navigation, and Surveillance
COE	Centers of Excellence
COMSTAC	Commercial Space Transportation Advisory Committee
ConOps	Concept of Operations
CONUS	Continental United States
CORSIA	Carbon Offsetting and Reduction Scheme for International Aviation
COTS	Commercial off-the-shelf
CP	Coordination Plan
CRADA	Cooperative Research and Development Agreements
CRM	Crew Resource Management
CSC	Cyber Steering Committee
CSF	Cockpit Simulation Facility
CSS-FD	Common Support Services-Flight Data
CST	Commercial Space Transportation
CTOP	Collaborative Trajectory Options Program
CVRD	UAS Concept Validation and Requirements Development
CVS	Combined Vision System
CWAM	Convective Weather Avoidance Model
D	
DAL	Development Assurance Levels
DARWIN®	Design Assessment Of Reliability With Inspection
DAC	Drone Advisory Committee
DataComm	Data Communications
DGAC	Direction Generale de l'Aviation Civil
DHS	Department of Homeland Security
DO	Domain
DOC	Department of Commerce

ACRONYM	DEFINITION
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
E	
E&E	Environment and Energy
EAA	Experimental Aircraft Association
EASA	European Aviation Safety Agency
ECCC	Environment and Climate Change Canada
EDR	Eddy Dissipation Rate
EDRC	U.S. Army Engineer Research and Development Center
EFB	Electronic Flight Bags
EVS	Enhanced Vision System
EFVS	Enhanced Flight Vision System
EMAS	Engineered Material Arresting System
EMST	Emerging Metallic Structures Technologies
EO	Executive Order
EoR	Established on RNP (Required Navigation Performance)
EPA	Environmental Protection Agency
EPOCH	Prediction of Oceanic Convective Hazards
ERAU	Embry Riddle Aeronautical University
ERDC	U.S. Army Engineer Research and Development Center
ERIF	Engine Related Impact and Failure
ETM	Engineering Test Model
EUROCAE	European Organization for Civil Aviation Equipment
EXCOM	Executive Committee
F	
4DT	Four Dimensional Trajectory
F&E	Facilities and Equipment Appropriation
F&Rs	Findings and Recommendations
FAA	Federal Aviation Administration
FACA	Federal Advisory Committee Act
FAST	Fixing America's Surface Transportation
FASTER	Full-Scale Aircraft Structural Test Evaluation and Research
FD-DER	Flight Deck Date Exchange Requirements
FF-ICE	Flight and Flow – Information Collaborative Environment
FFRDC	Federally Funded Research and Development Center
FICAN	Federal Interagency Committee on Aviation Noise

ACRONYM	DEFINITION
FIMS	UAS Flight Information Management System
FIXM	Flight Information Exchange Model
FMC	Flight Management Computer
FMS	Flight Management Systems
FPM	Flightpath Management
FTB	Florida NextGen Test Bed
FTU	Flight Test Unit
FY	Fiscal Year
G	
GA	General Aviation
GAJSC	General Operations Joint Steering Committee
GAMA	General Aviation Manufacturers Association
GE	General Electric
GAO	Government Accountability Office
GMU	George Mason University
H	
HEMS	Helicopter Emergency Medical Services
HF	Human Factors
HITL	Human In The Loop
HMD	Head Mounted Display
HUD	Heads-Up Display (also, Department of Housing and Urban Development
I	
IAM	Identity and Access Management
IARD	Investment Analysis Readiness Decision
IATA	International Air Transport Association
ICAO	International Civil Aviation Organization
IFR	Instrument Flight Rules
IID	Initial Investment Decision
IOT	Internet of Things
IP	Intellectual Property (also, Internet Protocol)
IRB	FAA Institutional Review Board
ISO	International Organization for Standardization
J	

ACRONYM	DEFINITION
JAMS	Joint COE for the Advanced Materials and Structures
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	
KSA	Knowledge, Skills, and Abilities
L	
LED	Light Emitting Diode
LL	Lincoln Laboratory
LOC	Loss of Control
LPV	Localizer Performance with Vertical guidance
LS-DYNA	An advanced general-purpose multiphysics simulation software package developed by the Livermore Software Technology Corporation
LST	Livermore Software Technology
M	
MALSR	Medium Intensity Approach Lighting System With Runway Alignment Indicator Lights
Massport	Massachusetts Port Authority
MARS	Multiple Airport Route Separation
MET	Minimum Cockpit Meteorological
MI	University of Michigan
MinWxSvc	Minimum Weather Service
MIT	Massachusetts Institute of Technology
ML	Machine Learning
MMPDS	Metallic Materials Properties Development and Standardization
MOU	Memorandum of Understanding
MRMS	Multi-Radar Multi-Sensor
N	
NAC	NextGen Advisory Committee
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
NATCA	National Air Traffic Controllers Association
NATO	North Atlantic Treaty Organization
NDE	Nondestructive Evaluation
NESG	NAS Enterprise Security Gateway

ACRONYM	DEFINITION
NextGen	Next Generation Air Transportation System
NGIP	NextGen Implementation Plan
NHTSA	National Highway Traffic Safety Administration
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
NIST	National Institutes of Standards and Technology
NOAA	National Oceanographic and Atmospheric Administration
NPN	NextGen Prototyping Network
NPPD	National Protection and Programs Directorate
NRC	National Research Council
NSIP	NextGen Segment Implementation Plan
NSTC	National Science and Technology Council
NTSB	National Transportation Safety Board
NWS	National Weather Service
O	
ODNI	On Demand National Airspace System (NAS) Information
OEM	Original Equipment Manufacturers
OP	Overarching Properties
OPC	Offshore Precipitation Capability
ORA	Operational Risk Assessment
ORTA	Office of Research and Technology Applications
OST	Office of the Secretary
OSU	Ohio State University
OTA	Other Transaction Agreements
OTJI	On The Job Training Instructor
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
PCPSI	Pilot/Controller Procedures and Systems Integration
PFAS	Perfluoroalkyl and Polyfluoroakyl Substances
PHMSA	Pipeline and Hazardous Materials Safety Administration
PIREPs	Pilot Reports
PMA	Parts Manufacturer Approval

ACRONYM	DEFINITION
PMO	Program Management Organization
PPD	Presidential Policy Directive
PSG	PAFI Steering Group
PV	Photovoltaic
Q	
R	
R&D	Research and Development
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
RECAT TW	Re-Categorization Total Wind
RISC	Rotor Integrity Steering Committee
RNP	Required Navigation Performance
RoMan	Rotor Manufacturing
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
SBS	Surveillance Broadcast Services
SDO	Standards Development Organizations
SE	Safety Enhancement
SME	Subject Matter Expert
SPRM	System Planning and Resource Management
SSM	System Safety Management
SVS	Synthetic Vision Systems
SVGS	Synthetic Vision Guidance Systems
SWAC	System Wide Analysis Capability
SWIM	System Wide Information Management
T	
TAC	Technical Advisory Committee
TAS	Terminal Area Safety
TCRG	Technical Community Representative Group
TBO	Trajectory Based Operations
TF/RF	Track to Fix/Radius to Fix
TFM	Traffic Flow Management
TGF	Target Generation Facility

ACRONYM	DEFINITION
TRACON	Terminal Radar Air Traffic Control
TRB	Transportation Research Board
TSO	Technical Standards Order
TWU	Transport Workers Union
U	
UAM	Urban Air Mobility
UAS	Unmanned Aircraft System
UCF	University of Central Florida
UEDDAM	Uncontained Engine Debris Damage Assessment Model
U.S.	United States
USAF	United States Air force
USDA	United States Department of Agriculture
USHST	United States Helicopter Safety Team
USN	United States Navy
UTAS	United Technologies Aerospace Systems
UTM	UAS Traffic Management
V	
VDN	Virtual Dispersive Networking
VFR	Visual Flight Rules
VNR	VFR Not Recommended
W	
WFD	Widespread Fatigue Damage Rule
WJHTC	William J. Hughes Technical Center
WTIC	Weather Technology in the Cockpit
Z	
ZASA	Zodiac Arresting Systems America