United States Department of Transportation
FY 2022 Annual Modal Research Plans

Cover Page

Federal Aviation Administration

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Chapter 1. Executive Summary

The Annual Modal Research Plan (AMRP) outlines planned research for fiscal year 2022 (FY 2022) and the outlook for fiscal year 2023 (FY 2023).

The FAA uses Research and Development (R&D) to support policymaking and planning, regulation, certification, standards development, and national airspace system (NAS) modernization to fulfill 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 support this mission accordingly.

The FAA focuses investments on applied research and development projects that aim to innovative 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, research also seeks to increase efficiencies in certification timelines and reduce aviation's environmental impact on underserved populations in an equitable manner.

The FAA will continue to evolve its research portfolio to meet both the challenges and opportunities brought forth by the rapid acceleration of innovation in the aviation and aerospace industry. This includes supporting and enabling advancements in areas like Commercial Space and Advanced Air Mobility (AAM). The FAA must also continue to be a responsible steward of the environment by pursuing alternatives to leaded aviation gas for General Aviation applications, developing tools to understand aviation's environmental impact, and researching ways to alleviate the impact of aviation noise on the general public. As the FAA plans and executes its research portfolio, it will continue its forward leaning approach to prevent and mitigate growing cyber security threats to digital systems.

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 impeccable safety record.

Critical Programs and Alignment to DOT Goals

The FAA's R&D portfolio 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 and their alignment to the Department of Transportation's (DOT) goals.

Alt Fuels for GA *(Climate Solutions)*

This program will be looking at sustainable and renewable fuels as well as other fuels and technologies to reduce emissions and greenhouse gases. Due to a variety of environmental, regulatory, and market forces in the U.S. and worldwide, leaded aviation gasoline will be eliminated in the future. The Alternative Fuels for General Aviation Program provides the critical data necessary for the FAA Administrator to authorize an unleaded replacement fuel in accordance with Section 565 of the 2018 Reauthorization Act, and to support the safe transition of the General Aviation fleet to an unleaded aviation gasoline.

Successful transition to unleaded fuels will reduce lead emissions from the sale and use of 165 million gallons (2018) of leaded aviation gas. This replacement fuel will provide benefit to the General Aviation industry which contributes greatly to American jobs and has a significant positive effect on the balance of trade.

Environment and Energy *(Climate Solutions)*

This research is used to develop a comprehensive suite of analytical tools to quantify the environmental consequences and impacts of aviation. These analytical tools provide the ability to characterize and quantify the interdependencies among aviation-related noise and emissions, impacts on health and welfare, and industry and consumer costs, under different market, policy, technology, and operational scenarios. At the center of these analytical tools is the Aviation Environmental Design Tool (AEDT), which can quantify the noise, fuel burn and emissions resulting from aircraft operations from the airport gate through ground movements, takeoff, climb-out, cruise, approach, and landing at the aircraft's final destination.

Additionally, this program provides knowledge and tools to improve and streamline the required environmental review processes for infrastructure projects and other Federal actions. Given the sensitivity and high visibility of such activities in today's environment, the Program is developing an improved screening tool that will allow users to rapidly and conclusively identify Federal actions not requiring further environmental review, thus reducing the associated time and costs implications.

Aviation Climate Research *(Climate Solutions)*

The Aviation Climate Research (ACR) Program invests in high-risk, accelerated research that has transformative impact potential to reduce greenhouse gas emissions from aviation in support of the 2030 and 2050 U.S. climate change goals. This program will be executed in coordination with the new Advanced Research Projects Agency for Climate (ARPA-C) that will be located within the Department of Energy. This program's research efforts support FAA's timely and safe introduction of advanced technologies that mitigate climate change and provides the framework for directing targeted with high potential to mitigate the impact of aviation operations on the environment. This program will also coordinate high value research initiatives with federal partners to assure benefits are properly aligned and shared in support of national objectives.

Weather *(Climate Solutions)*

The Weather Program is working on a project to develop high resolution and frequently updated probabilistic thunderstorm forecasts that will enable improved observations and forecasting of convection throughout the NAS by improving standards, techniques, and leveraging new types of data to enhance convective initiation forecasts. Advancements include better timing of convective initiation and dissipation, with finer resolution and frequent updates, and developing products for cockpit use and integration into decision support processes to mitigate impacts and improve the efficiency and safety of the NAS. Probabilistic lead times will be out to 36 hours for use with current operations and strategic planning of transoceanic flights.

Specific efforts include the development of an Ensemble Probabilistic Oceanic Convective Hazards (EPOCH) capability combining multiple global ensemble forecasts to generate global probabilistic guidance, and a Convective Weather Avoidance Model to predict the availability of a weather-impacted flight path by providing controllers via Route Availability Planning Tool (RAPT) with status indicators up to 30 minutes in advance.

Unmanned Aircraft Systems *(Safety)*

The vision to revolutionize mobility within metropolitan areas is a new frontier in aviation and the Advanced Air Mobility (AAM) ecosystem, and associated technologies, are likely to be the most complex aviation has

ever encountered. The FAA has an important and emerging role in supporting accessible air transport systems for passengers and cargo by working with the AAM community to identify and address the opportunities and key challenges ahead.

The FAA needs to understand how the AAM environment could emerge and respond in a proactive nature that is informed by assessing and understanding the markets, viability, economics, and challenges that will arise. Anticipated engineering research in FY 2022 will inform unique traffic management requirements, develop initial conceptual architecture, and identify information exchanges needed to enable collaborative, safe, and efficient incorporation of AAM.

Information/Cyber Security *(Safety)*

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.

This research also seeks to leverage advancements in artificial intelligence and machine learning (AI/ML) technology to establish a suite of tools that enable proactive monitoring of NAS and Mission Support networks to detect, prevent, and mitigate effects of disruptive cyber incidents. Recognizing the substantial federal and private sector science and technology investment in AI/ML, this research is designed to discover, evaluate, adapt, and demonstrate emerging sector-independent tools, techniques, and algorithms for potential adoption and application in the aviation system cyber protection problem space. Assessment and maturation of selected tools will culminate in laboratory demonstrations that highlight their potential utility and efficacy in an aviation system context.

Anticipated Outcomes

The FAA's Office of Commercial Space Transportation (AST) plays a crucial role in encouraging, facilitating, and promoting Commercial Space Transportation (CST). Research areas are responsive to the requirements of FAA and industry in the areas of Space Traffic Management and Spaceport Operations, Space Transportation Vehicles, Human Spaceflight, and Space Transportation Industry Viability.

AST's research activities will find innovative solutions through public-private collaborations and prototype development, to increase safety, efficiency, and U.S. global leadership in CST. AST's portfolio optimizes our mission execution through the development of improved regulations, safety assessment tools, and public safety technologies. FY 2022 research supports regulatory research, addressing lessons learned, and keeping pace with the dynamic CST industry.

Performance Based Flow Management (PBFM) research builds on the NextGen Traffic Flow Management System (TFMS) to include all traffic flow management capabilities and expand TFMS operations. The results

of this research will be a PBFM Concept of Operations (ConOps) that captures a comprehensive view of the future Traffic Flow Management (TFM) vision.

Air/Ground Trajectory Synchronization (AGTS) research will improve operational predictability and improve strategic management of air traffic leading to increased efficiency in the overall system. This project will reconcile differences in trajectory data elements between NAS systems and the aircraft to increase common situational awareness and enable more efficient and consistent decision making. AGTS will allow traffic flow management tools like TFMS and TBFM to operate using consistent demand data with knowledge of control actions or planned actions taken across the systems.

In FY 2022, the Flight Deck Data Exchange Requirements project will produce a report that assesses and evaluates cybersecurity risks in current and emerging technologies. Program research will enable exchange of data using Electronic Flight Bag (EFB), Aircraft Interface Device (AID), Internet Protocol (IP) Data Link, and other related avionics. It will also develop mitigation strategies for the identified risks and determine security defense mechanisms to ensure that avionics and data being exchanged are protected from accidental or unauthorized acts that could compromise safety and security of flight operations.

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.

Topical Research Working Groups

The FAA will continue working with DOT's Topical Research Working Groups in FY 2022. The FAA has a representative within each of the working group areas. 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 provides advice and recommendations to the FAA Administrator on the needs, objectives, plans, approaches, content, and accomplishments of the aviation research program.

REDAC members include aerospace professionals from industry, Federally Funded Research and Development Centers, and academia who are best positioned to identify aviation drivers, issues, requirements, and influencing technologies; and understand the level of research investment the aerospace industry is making or willing to make.

Technology Transfer (T2)/Deployment Activities

The FAA is committed to building upon the already successful Technology Transfer (T2) program, which promotes the dissemination of federally funded research and innovations to the commercial marketplace and American public. The agency achieves this by facilitating the exchange of the FAA's knowledge, facilities, and capabilities with industry, academia, and other federal partners. The program fulfills three primary roles:

- Promoting and enabling government-industry collaboration
- Managing intellectual property
- Sharing technical advances resulting from FAA research and development efforts.

The agency recognizes the importance of a robust T2 program to the FAA's mission as a federal laboratory and is motivated to expand the program. The graphic below outlines the agency's roadmap for incremental technology transfer enhancements. Today, the program successfully manages CRADAs, intellectual property, and royalties.

The FAA will begin to implement policies reflecting standard operating procedures and add alternative technology transfer contract vehicles. The agency will expand workforce recognition for technology transfer accomplishments and increase engagement with the federal technology transfer community to identify and leverage lessons learned. Together these enhancements provide a firm foundation for the T2 program and encourage the commercialization of innovative solutions.

The Technology Transfer program office, with the assistance of the FAA's senior patent attorney, secures patents and manages both licenses and royalties. The agency encourages its workforce to patent new inventions and disclose new technology to the world. By utilizing the available FAA legal resources, the workforce can gain valuable knowledge of, and assistance with, the patent filing process, understand his/her

rights as an inventor and patent holder, learn the filing steps, and understand the benefits of a granted "exclusionary right" over a patented invention for a limited time.

Inventions patented by FAA inventors are also available for commercial licensing and can result in royalty revenue shared with the inventor and the agency. The FAA currently maintains a small number of active income-generating license agreements.

The FAA contributes to technical advancement through technical notes and reports, advisory circulars, regulatory guidance, technical findings, participation on technical society panels, membership in international advisory organizations, and several other forums. A key function of the program is tracking the significant near- and far-term advances accomplished through FAA research and development activities.

Exhibit IV-1 FY 2023 Budget Request – RD&T Program Funding Information
Department of Transportation – FY 2023 Budget Federal Aviation Administration RD&T Program Budget

RD&T Program Name	FY 2021 Actual ($000)	FY 2022 Pres. Budget ($000)	FY 2023 Request ($000)	Applied ($000)	Technology Transfer ($000)	Facilities ($000)	Experimental Development ($000)	Major Equipment, R&D Equipment ($000)
Fire Research and Safety	7,136	7,576	8,150	8,150				
Propulsion and Fuel Systems	4,215	3,121	7,042	7,042				
Advanced Materials/Structural Safety	14,720	1,678	3,000	3,000				
Aircraft Icing	6,426	2,472	3,353	3,353				
Digital System Safety	-	3,689	5,287	5,287				
Continued Airworthiness	11,269	8,829	12,430	12,430				
Aircraft Catastrophic Failure Prevention Research	1,565	-	-					
Flightdeck/Maintenance/System Integration Human Factors	7,469	14,301	15,292	15,292				
System Safety Management	5,485	7,898	10,111	10,111				
Air Traffic Control/Technical Operations Human Factors	5,685	5,911	6,100	6,100				
Aeromedical Research	10,235	13,257	14,000	14,000				
Weather Program	6,236	13,786	18,200	18,200				
Unmanned Aircraft Systems Research	24,035	22,077	15,000	15,000				
Alternative Fuels for General Aviation	2,524	4,986	6,000	6,000				
Emerging Technology Accelerator (ETA)	-	8,500	10,000	10,000				
Commercial Space Transportation Safety	5,840	5,708	6,279	6,279				
NextGen - Wake Turbulence	3,698	3,728	3,728	3,728				
NextGen - Air Ground Integration Human Factors	6,000	3,000	-					
NextGen - Weather Technology in the Cockpit	1,982	3,028	3,028	3,028				
NextGen Flight Data Exchange	1,000	1,000	-					
Information/Cyber Security	4,769	4,769	5,500	5,500				
Environment and Energy	20,303	20,336	23,500	23,500				

RD&T Program Name	FY 2021 Actual ($000)	FY 2022 Pres. Budget ($000)	FY 2023 Request ($000)	Applied ($000)	Technology Transfer ($000)	Facilities ($000)	Experimental Development ($000)	Major Equipment, R&D Equipment ($000)
NextGen - Environmental Research - Aircraft Technologies and Fuels	31,465	33,476	45,500	45,500				
System Planning and Resource Management	13,022	4,141	4,500	4,500				
Aviation Workforce Development - Section 625	-	5,752	6,000	6,000				
William J. Hughes Technical Center Laboratory Facility	2,921	5,481	10,500			10,500		
Aviation Climate Research	-	50,000	50,000	50,000				
Advanced Technology Development & Prototyping	26,600	29,000	35,300				35,300	
William J. Hughes Technical Center Laboratory Sustainment	16,900	16,900	16,900			16,900		
William J. Hughes Technical Center Infrastructure Sustainment	10,000	16,000	15,000			15,000		
NextGen - Separation Management Portfolio	21,200	23,500	18,000				18,000	
NextGen Traffic Flow Management Portfolio	8,000	13,000	22,000				22,000	
NextGen - On Demand NAS Portfolio	10,500	9,000	8,500				8,500	
NextGen - NAS Support Portfolio	15,000	10,500	25,500				25,500	
NextGen - NAS Infrastructure Portfolio	8,400	7,000	5,000				5,000	
NextGen Unmanned Aircraft Systems	22,000	24,000	15,000				15,000	
NextGen Enterprise, Concept Development, Human Factors, & Demonstrations	19,000	10,600	11,000				11,000	
Center for Advanced Aviation System Development (CAASD)	57,000	57,000	57,000				57,000	
Airport Technology Research Program	40,666	40,961	41,071	41,071				
Airport Cooperative Research Program	15,000	15,000	15,000	15,000				
Administrative	10,293	16,418	19,492				19,492	
Totals	**478,559**	**547,379**	**597,263**	**338,071**		**42,400**	**216,792**	

Exhibit IV-2 FY 2023 Budget Request – RD&T Program Funding by DOT Strategic Goal
Department of Transportation – FY 2023 Budget Federal Aviation Administration RD&T Program Budget

RD&T Program Name	FY 2023 Pres. Budget ($000)	SAFETY ($000)	ECONOMIC GROWTH ($000)	EQUITY ($000)	CLIMATE SOLUTIONS ($000)	TRANSFORMATION ($000)	ORGANIZATIONAL EXCELLENCE ($000)
Fire Research and Safety	8,150	8,150					
Propulsion and Fuel Systems	7,042				7,042		
Advanced Materials /Structural Safety	3,000	3,000					
Aircraft Icing	3,353	3,353					
Digital System Safety	5,287					5,287	
Continued Air Worthiness	12,430	12,430					
Aircraft Catastrophic Failure Prevention Research	-						
Flight deck/Maintenance/System Integration Human Factors	15,292	15,292					
System Safety Management/Terminal Area Safety	10,111	10,111					
Air Traffic Control/Technical Operations Human Factors	6,100	6,100					
Aeromedical Research	14,000	14,000					
Weather Program	18,200	18,200					
Unmanned Aircraft Systems Research	15,000	15,000					
Alternative Fuels for General Aviation	6,000				6,000		
Emerging Technology Accelerator (ETA)	10,000		10,000				
Commercial Space Transportation Safety	6,279		6,279				
Wake Turbulence	3,728	3,728					
NextGen - Weather Technology in the Cockpit	3,028	3,028					
Information/Cyber Security	5,500					5,500	
Environment & Energy	23,500				23,500		
NextGen – Environmental Research – Aircraft Technologies and Fuels	45,500				45,500		
System Planning and Resource Management	4,500						4,500
Aviation Workforce Development - Section 625	6,000			6,000			
William J. Hughes Technical Center Laboratory Facilities	10,500						10,500

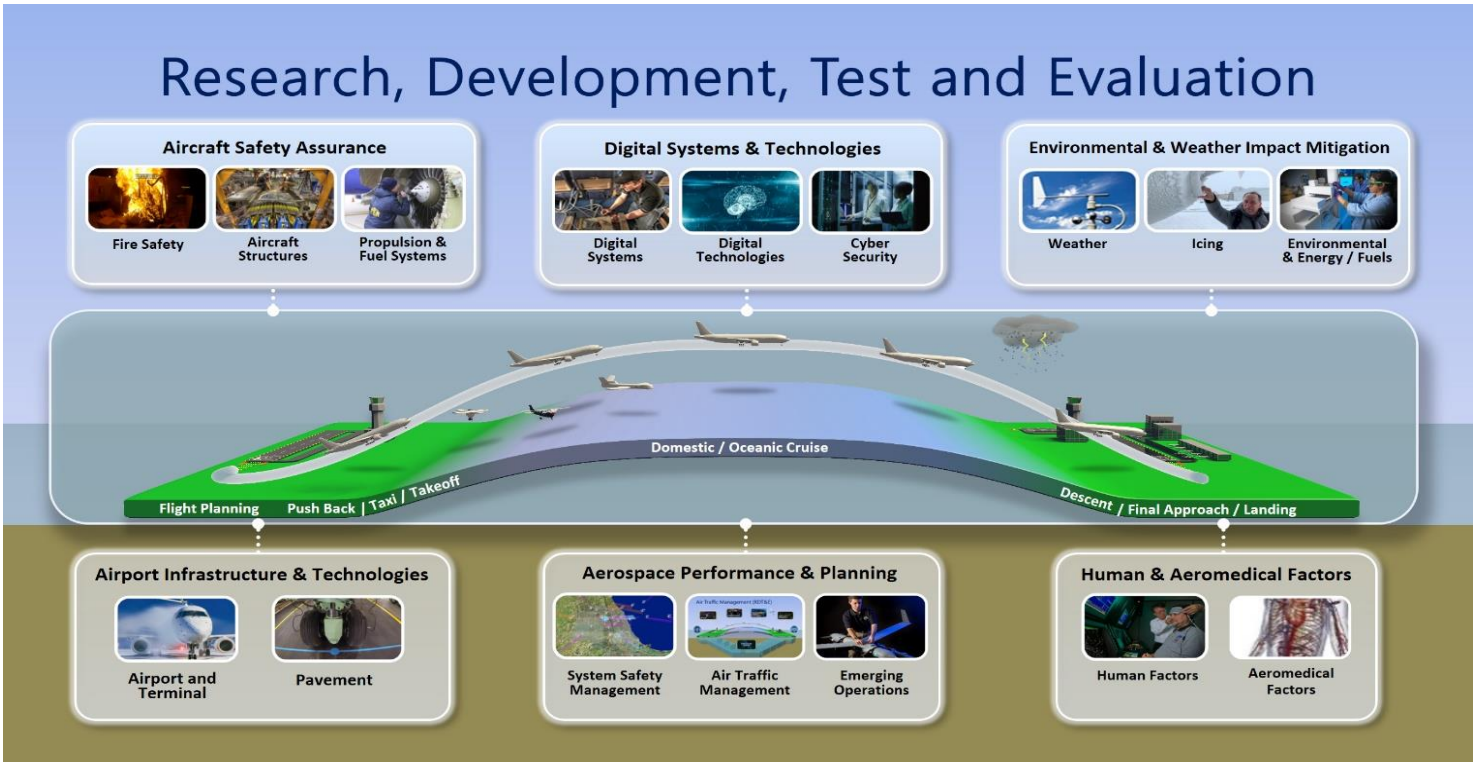
RD&T Program Name	FY 2023 Pres. Budget ($000)	SAFETY ($000)	ECONOMIC GROWTH ($000)	EQUITY ($000)	CLIMATE SOLUTIONS ($000)	TRANSFORMATION ($000)	ORGANIZATIONAL EXCELLENCE ($000)
ARPA-C Aviation Climate Research	50,000				50,000		
Advanced Technology Development & Prototyping	35,300					35,300	
William J. Hughes Technical Center Laboratory Sustainment	16,900					16,900	
William J. Hughes Technical Center Infrastructure Sustainment	15,000					15,000	
NextGen - Separation Management Portfolio	18,000					18,000	
NextGen Traffic Flow Management Portfolio	22,000					22,000	
NextGen - On Demand NAS Portfolio	8,500					8,500	
NextGen - NAS Support Portfolio	25,500					25,500	
NextGen - NAS Infrastructure Portfolio	5,000					5,000	
NextGen Unmanned Aircraft Systems	15,000					15,000	
NextGen Enterprise, Concept Development, Human Factors, & Demonstrations	11,000					11,000	
Center for Advanced Aviation System Development (CAASD)	57,000		57,000				
Airport Technology Research Program	41,071	12,525	8,825	3,600	7,250	8,871	
Airport Cooperative Research Program	15,000	6,000	1,500	750	750	6,000	
Administrative	19,492					19,492	
Totals	**597,263**	**130,917**	**83,604**	**10,350**	**140,042**	**217,350**	**15,000**

Chapter 2 – FY 2022 RD&T Programs

FAA RD&T Domains

FAA R&D goals address aviation and space research needs including air and space vehicles, airports and airport systems, spaceports, human operators, air traffic systems, air traffic information, and the customers they serve — the flying public. The goals span multiple research domains, a grouping of programs with a common focus area or body of knowledge. The research domains are:

- Airport Infrastructure and Technologies
- Aircraft Safety Assurance
- Digital Systems and Technologies
- Environmental and Weather Impact Mitigation
- Human and Aeromedical Factors
- Aerospace Performance and Planning



Airport Infrastructure and Technologies

United States Department of Transportation
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Airports Cooperative Research Program
($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 Transportation Research Board 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 includes 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 AOC will be selecting research projects for FY 2021 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 Secretary of Transportation 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 Environmental Protection Agency 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 13 voting members and shall include seven members who are chief executive officers, managers, or members of the governing boards of airports (three from large hubs, two from medium-size hubs, and two from small hubs, non-hubs, or general aviation airports); five 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.

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Airports Technology Research Program
($40,961,000)

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 applications of solar technologies at airports, UAS operations, using innovative and smart sensors to enhance safety, airfield pavement testing, 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-22, the ATR program will remain engaged in a multitude of airport safety areas. Some examples are; research the future needs of Advanced Air Mobility (AAM)vehicles on airport ground infrastructures, development of new specifications for the use of solar lighting fixtures 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:

- Research performance studies to determine pavement surface treatment application and locations on the airfield.
- Research pavement design and construction and evaluation design of pavements for seasonal frost and permafrost.
- Investigate alternative ways other than nuclear density machines for acceptance of unbound pavement materials.
- Research the field performance of solar powered lighting systems in various regions of the United States.
- Research the impact and needs of AAM, including electric Vertical Take-Off (eVTOL) vehicles on existing and future airport infrastructures.
- Perform full scale testing of various Aircraft Firefighting agents to investigate the reduction or elimination of Per- and polyfluoroalkyl substances (PFAS) at airports.
- Assess and perform field testing for the use of UAS applications at airports, for pavement inspection, aircraft firefighting situational awareness, obstruction surveys and other uses.
- At several airports, perform field testing of several technologies for the detection and mitigation of UAS.
- Develop machine learning and artificial intelligence schemes to integrate runway and weather conditions, to predict reduced aircraft braking capabilities on icy and wet runways.

Expected Program Outcomes:

- Guidance for airport pavement, for seasonal frost and permafrost design, including recommendations for capturing the effect of accelerating warming trends
- Standards for the operational and routine use of UAS at airports for infrastructure assessment and safety enhancements, as well as the detection and mitigation of unauthorized UAS
- Guidance for the application of solar technologies at airports
- Guidance and requirements for infrastructure design for AAM vehicles
- Standards for Fluorine Free Foam (FFF) aircraft firefighting agents
- Predictive Machine Learning Based Scheme to predict reduced aircraft braking when landing on runways with reduced friction capabilities

Collaboration Partners:

In addition to the REDAC, the ATR program has direct interactions with airport consultants, airport authorities, academia, airport contractors, and the paving industry (Airport Concrete Paving Association, Asphalt Institute & National Asphalt Paving Association). These stakeholders provide direct inputs into current needs, future trends, and FAA Advisory Circular deficiencies while helping to shape the ATR program's research needs today and into the future.

Interagency Agreements:

U.S. Army Engineer Research and Development Center (ERDC): This agreement enables 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: This agreement enables 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): This agreement enables 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: This agreement enables collaboration between FAA and Smithsonian Institute 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.

National Renewable Energy Laboratory (NREL): This agreement enables collaboration between FAA and NREL to research and determine the infrastructure needs for AAM vehicles.

Cooperative Research and Development Agreements (CRADAs):

ATECH Inc.: The FAA and ATECH Inc. have entered into a Cooperative Research and Development Agreement (CRADA) to share intellectual knowledge and perform research and development activities on engineered material arresting system (EMAS) that safely arrest aircraft that overrun runways.

Council for Scientific and Industrial Research (CSIR) – South Africa: This CRADA supports technical information exchanges in materials research, pavement design and full-scale pavement testing. This collaboration benefits both organizations in the sharing of critical technical information.

Memoranda of Understanding (MOU):

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

Federal Highway Administration (FHWA): This MOU supports technical information exchanges in full scale pavement testing, pavement instrumentation, pavement materials and pavement design. This collaboration benefits both organizations in the sharing of critical technical information.

Other Transaction Authority (OTA):

Boeing Company: The ATRP has an 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, and separation standards, to re-align the aircraft wingspan ranges so that newer aircraft do not hit the upper limits of the allowed wingspan range.

Aircraft Safety Assurance

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Fire Research and Safety
($7,576,000)

Program Description:

The Fire Research and Safety program seeks to protect aircraft occupants through the prevention or mitigation of in-flight fires and the improvement of survivability in the event of a post-crash fire. Researchers in this program conduct tests to evaluate potential fire threats from the integration of new aerospace technologies and develop procedures, standardized test methods, and data to support the certification of aircraft systems and materials.

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 and the American public through the mitigation of the catastrophic consequences of an uncontrollable aircraft fire, including loss of life and the destruction of the aircraft. This program is necessary to continue and improve the current levels of safety of aircraft as technology, materials, and construction methods evolve. The testing supports the need to upgrade aircraft certification standards to keep pace with the emerging technologies used by the aerospace industry, while also working towards the development, validation, and transfer of cost-effective aircraft fire safety technology to industry.

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 William J. Hughes Technical Center (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:

- Evaluating fire hazards associated with electrical power sources, including lithium and other types of batteries in support of international research

- Developing new and/or revised aircraft materials flammability standards to include new requirements for materials used in inaccessible areas of an aircraft, newly introduced structural and component materials, and new manufacturing processes such as additive manufacturing
- Performing tests to support the development of new standards for fire detection and containment in cargo containers, and tests to evaluate new fire suppression agents and systems for aircraft cargo compartments
- Performing tests to evaluate novel designs for freighter aircraft fire suppression systems
- Performing tests to evaluate new chemical agents and systems for suppressing fires in aircraft engines and auxiliary power units
- Developing a capability to verify and validate computational models proposed to the FAA for certification-by-analysis in lieu of performing fire tests including the creation of standardized fire test fixtures that simulate aircraft engines, cargo compartments, and hidden spaces to generate experimental data for model validation

Expected Program Outcomes:

- By 2026, develop the enabling technology to prevent accidents caused by in-flight fires in large cargo and passenger transport aircraft by improving fire detection and suppression capabilities, and upgrading the flammability requirements for materials in inaccessible areas.
- By 2026, enable the introduction of new, lightweight/energy efficient, fire-safe materials and components into commercial transport aircraft — such as composite structures, additive manufacturing components, magnesium, and other metallic alloys, cabin furnishings, and advanced electrical power sources.
- By 2026, support and facilitate the evaluation and replacement of Halon fire extinguishing agents and halogenated cabin material flame-retardants with effective and practical alternatives.
- By 2026, develop validation methodologies for certification-by-analysis, including standard practices for experimental validation of computational models.

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.

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Advanced Materials/Structural Safety
($1,678,000)

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 that 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:

- Partner with industry to generate data, perform analysis, and provide recommendations that will support the FAA's ongoing efforts to develop industry guidance for design, certification, and process control for emerging advanced materials.
- Document best industry practices for certifying adhesively bonded joints and composite repairs, which are traditionally developed in a case-by-case, company-specific, proprietary manner, promoting standardization and increasing safety.
- Partner with academia and industry to investigate high-cycle fatigue behaviors of bonded rotorcraft blades, which have experienced higher than expected accident rates. There may be aging effects of the adhesive that we do not fully understand, and existing certification protocols may not adequately represent the operating environment required to capture time-sensitive behaviors and ensure safety.
- Develop a comprehensive guideline that identifies key characteristics, key process parameters, and recommended tests to promote standardization in bonded joint design for new construction, and repairs for transport category aircraft and rotorcraft applications.

Expected Program Outcomes:

- Partner with industry and academia to develop data for use in promoting performance-based safety standards for:
    - All aspects of composite maintenance such as repair design, maintenance processes, and inspection methods which are mostly non-standardized
    - Implementation of new seating systems made of composite materials, providing an update to current industry standards created for metallic seat structures
    - Certifying adhesively bonded joints and composite repairs
    - Implementation of innovative polymer-based additive manufacturing technologies in aviation products
- Partner with industry and academia to evaluate innovative materials and/or processing techniques, as well as new applications such as urban air mobility and commercial space with an emphasis on applications involving critical structures.
- Partner with industry and academia to develop new industry standards for implementing composite and other innovative advanced material forms into aviation products.

Collaboration Partners:

In addition to the REDAC, public and stakeholder input is received through close research collaboration with the industry members that comprise 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), 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, this program includes a broad range of main aircraft and composite material OEMs including Boeing, Lockheed, 3M, Airbus, Bombardier, and Embraer, among others, who 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
($8,829,000)

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:

- Determine the relevance and standardize the use of different materials in helicopter fuel cell drop tests as prescribed in Fuel Cell Crash Resistance § 27/29.952
- Partner with industry and government to generate data to identify and demonstrate damage tolerance performance of new technologies that could be adapted by the aerospace community to improve safety, increase efficiency, and validate procedures
- Collaborate with NASA, DoD, and industry to develop tools, methodologies, and data to mitigate the risks associated with structural failures, and distribute updated standardized handbooks supporting aircraft certification and continued airworthiness
- Obtain data, develop methodologies, and create nonlinear models required to establish safe and realistic freeplay limits for control surfaces of transport category aircraft to prevent freeplay-induced vibrations
- Address the number one safety goal of the FAA's Small Airplane Standards staff, to reduce general aviation fatal accidents due to loss of control
- Develop changes to Part 23 and Part 27 of the Title 14 Code of Federal Regulations to address urban air mobility movement

Expected Program Outcomes:

- Develop standardized acceptable design and certification compliance data to enable the FAA and industry to operate in a cost effective and efficient manner, while providing a level-playing field and uniform standards for all certification agents
- Generate technical information to support the development of industry standards, FAA policy documents, regulations, methods of compliance, advisory circulars, and performance-based rule making activities
- Generate data to develop mission-specific guidance, and performance-based rules and updates for airworthiness directives and guidance materials
- Partner with industry and government to conduct research on advanced technologies to promote transportation safety, efficiency, and technology innovation
- Use scientific methods and data-driven processes to guide safety programs, reduce prescriptive regulations, and enable innovative approaches to improving safety
- Develop data to support industry standards and means of compliance to provide urban air mobility vehicles a clear path to certification
- Provide data on new technologies to develop policy and regulatory guidance that will support applications for new products and their potential use on legacy aircraft, and promote performance-based safety standards and measures
- Develop software to provide a data-driven risk-level distribution for a fleet of aircraft, which will enable the FAA to proactively provide safety guidance, and develop performance-based safety rules and consensus-based standards
- Develop a standardized tool for damage tolerance assessments used by the FAA and industry to meet performance-based safety standards and promote certification efficiency
- Investigate the flight characteristics of multiple rotor vehicles
- Create prototype wire cutting/detecting technologies for light weight rotorcraft and a wire sensor detection system to reduce rotorcraft wire strikes
- Generate data to quantify the effects of turbulence on structural integrity and maintenance of aircraft for use in performance-based rule making and to update airworthiness directives and guidance materials

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 of this program is leveraging and collaborating 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 (CRADAs) 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 CRADAs. 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 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.

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Propulsion and Fuel Systems
($3,121,000)

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:

- Conduct testing of turbine engine nickel alloys to determine the detrimental effects of nickel material anomalies on fatigue life. This data will be used to enhance the DARWIN engine design code.
- Support the LS-DYNA® Aerospace Working Group in developing predictive analytical models in the LS-DYNA® software to simulate the impact of metal and composite materials, along with associated test data, quality assurance problems and methods, sample problems, and guidance to advance analysis in certification.

Expected Program Outcomes:

- Develop an updated version of DARWIN able to analyze nickel alloys containing material anomalies.
- Develop innovative methods to inspect critical rotating components to prevent uncontained turbine engine failures and accidents
- Develop data and analysis methods for uncontained engine fragment impacts, and provide analytical tools for evaluating engine containment systems and protection from uncontained engine debris

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:

- AIA RISC
- AIA 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)

Digital Systems and Technologies

Digital System Safety
($3,689,000)

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 the FAA and industry in certifying aircraft employing advanced digital airborne systems.

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.

Anticipated Program Activities:

- *Activity 1* – Implementation Methodologies for Automation Using Artificial Intelligence: Introduction of AI technologies into safety-critical airborne systems pose risks if not thoroughly studied and assessed. The goal of this activity is to assess that risk and develop assurance criteria for different levels of criticality. Research outputs will include interim reports identifying safety issues related to system certification — delineating mitigation techniques and validating their efficacy.
- *Activity 2* – Pilot Studies to Evaluate the Concept of Abstraction Layer (AL) for Alternate Assurance Digital Systems/Report: Study the new assurance approaches to certify AI implementations and assess the feasibility of these approaches in a certification environment by identifying potential improvements, clarifications, gaps, and issues with their use. 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* – Integrated Service Reliability: Currently there is a large gap in knowledge regarding the reliability of lead-free solder, semiconductor device wear-out models, alternative wire bonds, and thermal energy atmospheric neutron environments. The goal of this task is to use flight tests to study the risks associated with each of these areas. Research outputs will include plans, designs, reports, qualification, certification test results, and operation manuals.

Expected Program Outcomes:

- Enable the introduction of new technologies into airborne systems without risking safety
- Develop secure communication between aircraft and satellites used for navigation

Collaboration Partners:

The main source of public and stakeholder input is from FAA Subject Matter Experts (SME) on the BLI Planning Teams. These SMEs 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.

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.

Information/Cyber Security
($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. The 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:

- Develop Cyber Security Data Science (CSDS) algorithms and tools to detect emerging threats and APTs
- Identify and evaluate the initial set of requirements for cyber data analytics across select components of the aviation ecosystem
- Investigate the various data suites for cybersecurity threats across select components of the aviation ecosystem
- Establish proof of concept cyber data distribution models and analytical cells for select components of the aviation ecosystem
- Establish an event/data logging baseline for aviation ecosystem information/cybersecurity

Expected Program Outcomes:

- Conduct research to understand and address cybersecurity vulnerabilities related to the deployment of connected and automated air transportation technologies and systems. This includes the development and integration of innovative algorithms, execution of advanced technology concept exploration studies, and demonstrations and evaluations of promising data science tools.

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; and
- Carnegie Mellon University/SEI – Self-adaptive Network, Strong Authentication and integrity in mixed trust environments.

NextGen - Flight Deck Data Exchange
($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 factors 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 Internet of Things (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:

- Develop a prototype environment to enable secured information exchange for avionics equipment defined in the scope of the project, including but not limited to electronic flight bags, aircraft interface devices, and flight management systems
- Research existing security controls, rules, guidance, and policies to manage cybersecurity risks for exchanging safety-critical information and data
- Develop architecture and scenarios describing end-to-end data connections for securely exchanging safety-critical information such as flight clearance, and command and control instructions
- Identify and evaluate threats and vulnerabilities associated with current avionics, on board aircraft systems, and associated safety-critical data elements, and provide mitigation strategies to address cybersecurity risks

Expected Program Outcomes:

- Explore ways to protect safety-critical data and identify security defense mechanisms and approaches to prevent accidental or unauthorized modification, destruction, or disclosure of information
- Develop security mitigation strategies to enable the exchange of safety-critical data to aircraft avionics using Internet Protocol data links
- By 2025, expand research to include additional on-board aircraft systems, such as flight management systems and other certified avionics, to fully address the cybersecurity needs of connected aircraft

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.

Environmental and Weather Impact Mitigation

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Aircraft Icing
($2,472,000)

Program Description:

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 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, 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 industry working groups and committees, and participation in national and international conferences.

Anticipated Program Activities:

- Provide annual guidance to the airline industry for updating ground deicing programs
- Test and evaluate a new design for an artificial snow machine that will be used to determine how long anti-icing fluid provides protection from frozen contamination

Expected Program Outcomes:

- Provide information for the annual ground icing notice issued by the FAA's Flight Standards organization

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 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 recent testing.

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Weather Program
($13,786,000)

Program Description:

The Weather Program performs applied research to minimize the impact of weather on the National Airspace System (NAS). 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 program leverages advances in meteorological science to enhance observation methods, improve weather prediction models, and produce increasingly accurate forecasts of convective weather, turbulence, icing, and low ceiling and visibility conditions. 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. The timely dissemination and presentation of such information provide decision support input to enable traffic flow managers, controllers, pilots, and airline operations personnel to implement tactical and strategic traffic management initiatives to avoid encounters with severe weather, reduce delays and mitigate safety risks.

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; improve the accuracy and relevancy of legacy weather products and services mandated by FAA regulatory guidance and/or international agreements; and support the achievement of the NextGen weather vision and ultimately the FAA's 2035 NAS Vision.

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 return on investment 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 the transition of the Ensemble Prediction of Oceanic Convective Hazards tool to NWS in order to improve forecasts of convective storms
- Continue development of enhancements to incorporate artificial intelligence into the Convective Weather Avoidance Model, to improve forecast accuracy in preparation for operational transition
- Demonstrate a Terminal Area Icing Weather Information for NextGen prototype to improve the detection and discrimination of freezing drizzle and freezing rain diagnoses and forecasts

- Complete development of a convectively-induced turbulence forecast capability to include improved diagnoses of turbulence categories in order to improve forecasts and diagnoses of atmospheric turbulence
- Complete transition of Visibility Estimation through Image Analytics (VEIA) to the FAA weather camera website to improve GA safety by providing an additional source of visibility observations in data sparse regions for direct use by pilots, dispatchers, meteorologists, and flight service
- Mature new high-resolution icing detection, analysis and forecast capabilities using advanced weather satellite and radar data to better alert pilots and controllers of hazardous aircraft icing conditions and reduce General Aviation (GA) accidents
- Create weather standards and minimum operational thresholds required for Unmanned Aircraft System integration into the NAS

Expected Program Outcomes:

- By FY 2022, complete development of a prototype ceiling and visibility onset and cessation capability for the Core 30 Airports, available, via the NWS, for user assessment and meteorological evaluation that will improve safety of operations
- By 2023, complete development of the Offshore Precipitation Capability (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, GA, NWS, 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, and 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
- USAF
- Australia Bureau of Meteorology
- Environmental and Climate Change Canada
- National Research Council of Canada

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NextGen - Weather Technology in the Cockpit
($3,028,000)

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, reduce pilot workload, and increase fuel efficiency to lower gas emissions for 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 Instrument Flight Rules (IFR) and Visual Flight Rules (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 on all part-type aircraft 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 identifies and develops resolutions to gaps in pilot weather training materials and courseware.

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 safety and efficiency benefits in adverse weather conditions for all part-type aircraft.

Anticipated Program Activities:

- Develop objective criteria and associated minimum weather service recommendations for issuing fully automated VNR statements
- Investigate cockpit weather-related gaps for helicopter operations
- Conduct research in support of minimum weather service recommendations for calculating turbulence information using downlinked Automatic Dependent Surveillance–Broadcast (ADS-B) reports and presenting the resulting turbulence forecast/nowcast information in cockpits to improve turbulence avoidance decision making
- Conduct research to produce meaningful visibility, ceiling, weather radar, and wind information for use in remote regions that lack infrastructure, the Automated Surface Observing System, and weather radar

Expected Program Outcomes:

- Enhance helicopter safety by developing minimum weather service standards to resolve safety-related concerns identified in the current gap analysis project and provided by National Transportation Safety Board accident analyses
- Enhance general aviation safety by identifying decision thresholds to enable automating the issuance of VNR statements, which are currently only available through a voice service
- Increase turbulence observations by orders of magnitude to enable enhanced turbulence forecasts and nowcasts, which will enhance safety and fuel efficiency relative to turbulence encounters
- Expand weather training and pilot weather testing to resolve known and new knowledge gaps for GA and evolving operations pilots to ensure safe operations during adverse weather
- Develop methods to use ADS-B to downlink pilot weather reports (PIREPs) to increase the number of PIREPs and improve their accuracy, enhancing safety during adverse weather
- Use innovative crowd sourcing techniques to produce visibility, ceiling, wind and weather radar information to enhance access and freight delivery in remote areas
- Support evolving technological air traffic flow management solutions by identifying minimum performance standards for use in the development of new Technical Standard Orders for cockpit weather technology
- Create minimum weather service standards for remote weather sensors and non-traditional weather sensors, such as cameras, to provide information to evolving operations and GA pilots for adverse weather avoidance decisions
- Develop methods to notify pilots when weather information from certified observations at a distant location may not be reflective of the corresponding area of their flight operations to enhance the safety and fuel efficiency of weather avoidance decisions

Collaboration Partners:

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: The WTIC program partners with Rockwell Collins through an agreement where research is jointly performed by the WTIC program. Rockwell Collins, contractor support is provided at a reduced rate resulting in increased resources. This partnership has been performing 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 a georeferenced image. 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: 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 the process while still meeting pilot needs. The VNR project is an example of a WTIC project that provides outputs to support Future Flight Services' need to automate VNR and WTIC's development of MinWxSvc recommendations.

Aircraft Owners and Pilots Association (AOPA): The partnership with AOPA has two benefits. First, AOPA provides 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 positioned to encourage 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 for their pilots to make them educated consumers. This ultimately drives the market to incorporate WTIC recommended enhancements.

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 the 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 (PEGASAS): 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): 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 cost savings when executing the research.

NTSB: The 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.

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Alternative Fuels for General Aviation
Enacted ($4,986,000)

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 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, the private sector does that.

Anticipated Program Activities:

- Generate engine performance, detonation, durability and other operating data required to assess the suitability of candidate unleaded fuels through the use of ground level and altitude simulation capabilities in engine test cells
- Develop data and requirements necessary to support aircraft flight test clearance activities
- Generate materials degradation, aging, performance characteristic, and other property data changes to verify the suitability of these fuels for use with the existing fleet of general aviation aircraft through laboratory rig and materials compatibility testing
- Generate chemical and physical fuel property data for the candidate unleaded fuels and lube oils necessary to assess their suitability for use with the existing general aviation fleet

Expected Program Outcomes:

- By 2023, provide data to support identification of unleaded fuel candidates that successfully meet the safety criteria for engine detonation thresholds with the existing general aviation aircraft fleet
- By 2023, provide data to support identification of unleaded fuel candidates that meet the safety criteria for rig and materials compatibility with the existing general aviation aircraft flee

- Complete the necessary flight clearance activities to initiate and continue flight testing activities through 2023 to validate the ground and in-flight handling and performance characteristics of qualified alternative unleaded fuel candidates

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

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Environment and Energy
($20,336,000)

Program Description:

The FAA's long-term vision is to remove environmental constraints on aviation growth by achieving quiet, clean, and efficient air transportation. This program supports this vision by advancing our 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 aviation. 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 $11 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). Concerns about the impacts of aircraft emissions on climate change could limit the growth of international aviation. 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. This research supports the Administration's vision as outlined in Executive Order 14008 to put the United States on a path to achieve net-zero carbon dioxide emissions, economy-wide, by no later than 2050. The research in this budget line item also addresses local environmental concerns that are a result of aviation noise and emissions that impact local air quality. This includes the need for environmental justice in line with Executive Order 12898. This program's research efforts support the development of technological innovations for the current fleet of aircraft that will mitigate climate change and address local environmental concerns. Furthermore, the program will coordinate efforts with federal partners to ensure that knowledge is shared broadly thus increasing the benefits provided by the supported efforts.

Anticipated Program Activities:

- Provide the data and analysis necessary to support the development of international standards for subsonic and supersonic aircraft
- Provide data and analysis necessary to support the development of noise certification standards and processes for UAS and AAM vehicles
- Develop more efficient noise and emissions certification processes for subsonic aircraft and engines
- Continue the development of analytical tools for noise and emissions modeling, noise screening for environmental compliance, and fleet and operations scenarios forecasting
- Develop advanced operational procedural concepts that could reduce community noise exposure while maintaining safe flight operations and providing guidance for air space planners on how these concepts could be incorporated
- Develop a decision support tool to enable industry to mitigate the climate impacts of contrails and aviation induced cloudiness
- Develop the methodologies and data necessary to enable industry to design aircraft technologies with reduced noise and emissions
- Expand the scientific understanding of the impacts of aircraft noise on communities and aviation emissions on air quality and climate change

Expected Program Outcomes:

- Conduct analyses to support the development of new international standards for subsonic and supersonic transport aircraft and engines in ICAO CAEP
- Conduct measurements and complete analyses to inform the development of noise standards for UAS and AAM vehicles
- Release AEDT Version 3e and the noise screening method
- Support the development of a more efficient and accurate environmental review process
- Support the development of more efficient certification processes
- Conduct analyses to support the development of operational procedure concepts to mitigate the environmental impacts of the current fleet of airplanes and helicopters

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 other FAA-hosted environmental 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 funded 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 funded 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 57 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 FY2020 ASCENT had 60 active research projects involving 186 students and has produced 125 publications, reports and presentations.

NextGen Environmental Research – Aircraft Technologies and Fuels
($33,476,000)

Program Description:

The NextGen Environmental Research – Aircraft Technologies and Fuels Program supports efforts to develop new aircraft and engine technologies, and advance sustainable aviation fuels in line with the Administration's commitments on climate change and the environment. Technologies developed by this program will result in a fleet of aircraft that have lower noise, use less fuel, and produce fewer emissions. This program also provides test data, analyses, and methodologies to support the development and deployment of sustainable aviation fuels. Funds from this program ensure novel jet fuels are drop-in compatible with today's fleet of aircraft and are certified as being safe for use. They also ensure that sustainable aviation fuels, produced from renewable and waste feedstocks, and lower carbon aviation fuels, produced from fossil feedstocks, are appropriately credited under the International Civil Aviation Organization (ICAO) Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA).

Through the Continuous Lower Energy Emissions and Noise (CLEEN) program,[1] which is supported by this project, 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. Technologies accelerated by the CLEEN program have relatively large technological risk. Government resources help mitigate this risk and incentivize aviation manufacturers to invest in developing these technologies. By cost sharing the development with the FAA, industry is willing to accept the greater risk. Once entered into service, the CLEEN technologies will produce noise, fuel burn, and emissions benefits throughout the fleet for years to come. The FAA is currently standing up the third five-year phase of the CLEEN Program and expects to make a press release in early summer 2021.

Funding from this program also supports efforts by ASCENT — the FAA's Center of Excellence (COE) for Alternative Jet Fuels and Environment — to develop innovative technological solutions to reduce noise, emissions, and fuel burn from subsonic and supersonic aircraft. Aircraft technology development projects under ASCENT complement the CLEEN Program's industry partnership approach by providing a venue for university-led research to expand knowledge broadly across the industry and develop technologies at all levels of maturity that will reduce noise, emissions, and fuel burn. The program also provides funding for alternative jet fuel testing and analysis efforts by ASCENT. This cooperative aviation research organization is co-led by Washington State University and Massachusetts Institute of Technology.[2]

This program also supports the Commercial Aviation Alternative Fuels Initiative (CAAFI) in its effort to engage with commercial aviation and emerging alternative fuels industries.[3]

This research project is required under Title 49 Sections 40101, 44714, 44715, and 47511 as well as Title 42 Section 7571 and 7572.

Program Objectives:

[1] For more information on the CLEEN Program, please see http://faa.gov/go/cleen
[2] For more on the ASCENT COE, please see http://ascent.aero
[3] For more on the Commercial Aviation Alternative Fuels Initiative (CAAFI), please see http://caafi.org

The main goal of the NextGen Environmental Research – Aircraft Technologies and Fuels program is the development of aircraft and engine technologies and sustainable aviation fuels that collectively will 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 and sustainable aviation fuels this program helps to remove environmental constraints on aviation growth by achieving quiet, clean, and efficient air transportation.

Anticipated Program Activities:

- Develop aircraft and engine technologies, as well as sustainable aviation fuels for subsonic and supersonic aircraft through the CLEEN program that reduce noise and emissions while increasing fuel efficiency
- Evaluate innovative technological solutions to reduce noise, emissions, and fuel burn from subsonic and supersonic aircraft through ASCENT
- Support the approval of novel jet fuel pathways within the ASTM International certification process through testing and coordination to ensure these fuels are safe for use
- Support efforts to evaluate sustainable aviation fuels that can be used safely at greater than a 50% blend level, the current maximum allowable volume, with the goal of developing sustainable aviation fuels that can be used without any blending with conventional jet fuel
- Support the inclusion of sustainable aviation fuels created from waste and renewable feedstocks, and lower carbon aviation fuels created from fossil feedstocks, within the ICAO CORSIA framework
- Through ASCENT and CAAFI, identify barriers to the use of sustainable aviation fuels by the aviation industry and work across the U.S. government and with industry to overcome these barriers

Expected Program Outcomes:

- Continue activities within the third phase of the CLEEN program to demonstrate technologies that can reduce energy use, emissions, and noise for subsonic and supersonic aircraft
- Conduct testing to support the approval of at least one alternative jet fuel type per year and streamline the ASTM certification process to reduce the time and cost of certification
- Identify sustainable aviation fuels that could be used at greater than a 50% blending level and develop ASTM certification processes to enable their use at these higher blending percentages
- Identify innovative solutions to reduce noise, emissions, and fuel burn through ASCENT
- Develop lifecycle greenhouse gas emissions values for alternative fuel pathways and sustainability criteria for use in CORSIA

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 sustainable aviation 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.

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Aviation Climate Research
($50,000,000)

Program Description:

The Aviation Climate Research (ACR) Program invests in high-risk, accelerated research that has transformative impact potential to reduce greenhouse gas emissions from aviation in support of the 2030 and 2050 U.S. climate change goals. This program will be executed in coordination with the new Advanced Research Projects Agency for Climate (ARPA-C) that will be located within the Department of Energy.

Program Objectives:

The program will enhance and accelerate research in the areas of sustainable aviation fuels for jet engines, unleaded fuel alternatives for piston-engine aircraft, and alternate aircraft technologies including electric propulsion. More specifically, the program will support the development of sustainable aviation fuels that could be used in jet engines without blending with conventional petroleum-based jet fuel, evaluate aviation fuel supply chains to reduce the cost to produce sustainable aviation fuels and maximize their environmental benefits, and accelerate the identification of safe alternatives to leaded aviation fuel. Additionally, the program will support the accelerated development of fuel efficient, low-emissions aircraft technologies, including electric propulsion, and support collaborative research in the areas of climate adaptation and resilience.

To ensure the work can be done in an expedited manner, the work will enhance essential laboratory capabilities and build on existing research partnerships that the FAA has established with academia and industry such as the Aviation Sustainability Center of Excellence (ASCENT), the Commercial Aviation Alternative Fuels Initiative (CAAFI), the Piston Aviation Fuels Initiative (PAFI), and the Continuous Lower Energy Emissions and Noise (CLEEN) Program. The extended research enabled by this program will be coordinated with air transportation stakeholders in industry and academia and with partner federal agencies including the Department of Energy and U.S. Department of Agriculture.

The FAA intends for the ACR Program Management Plan to focus on the following:

- Conducting a new five-year phase of the CLEEN Program that would focus on accelerating the development of technologies that could have a transformative impact in reducing climate impacts from the commercial fleet of aircraft. These technologies could also have benefits in terms of reducing noise and emissions that impact air quality.
- Start a coordinated multi-year effort across ASCENT, CLEEN and CAAFI to develop and test sustainable aviation fuels that could be used in jet engines without blending with conventional petroleum-based jet fuel.
- Evaluate aviation fuel supply chains within ASCENT to reduce the cost to produce sustainable aviation fuels and maximize their environmental benefits.
- Examine potential replacements for leaded aviation gasoline through PAFI and the development of low-emissions aircraft technologies, including electric propulsion, which could be used in the general aviation fleet.
- The program will also support development of capabilities that exploit and leverage weather information to improve aviation efficiencies, reduce fuel use, and reduce greenhouse gas emissions.

Anticipated Program Activities:

- Develop ACR Program Management Plan to include how the program will build on other FAA environment and energy programs and federal interagency partner efforts
- Initiate program coordination outreach and review/select research initiatives for ACR funding
- Execute ACR-funded research initiatives.

Expected Program Outcomes:

- Establish a programmatic framework for increased investment in targeted high-risk, accelerated research to reduce greenhouse gas emissions from aviation.
- Establish interagency coordination and alignment
- Execute ACR-funded research initiatives

Collaboration Partners:

This program will be coordinated with air transportation stakeholders in industry and academia and with partner federal agencies including the Department of Energy, NASA, NOAA, and U.S. Department of Agriculture.

The program will leverage longstanding efforts in ASCENT, CAAFI, PAFI, and the CLEEN Program and their extensive networks, which have been discussed previously in this AMRP alongside the BLIs for NextGen – Environmental Research (ASCENT, CAAFI, and CLEEN), Environment and Energy (ASCENT), and Alternative fuels for General Aviation (PAFI).

Human and Aeromedical Factors

United States Department of Transportation
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Flight Deck/Maintenance/Systems Integration Human Factors
($14,301,000)

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 Flight deck/Maintenance/System Integration Human Factors program responds to research, engineering, and development (RE&D) requirements defined by technical sponsors in Office of Aviation Safety (AVS). Outputs from this program inform AVS personnel who incorporate evaluation criteria into human factors – related regulations, guidance material, standards, job aids, and other documentation to support safety. In FY2022, the Flight deck/Maintenance/System Integration Human Factors program will respond to three RE&D requirements:

Improved Transport Operational Safety through Pilot Training, Qualification, Procedures and Flight Operations. The objective of this requirement is to evaluate human factors and pilot/crew performance considerations associated with pilot training, procedures, and operations in transport category aircraft in 14 CFR Part 121 and Part 135 operations. This research will provide input to the FAA on how to improve pilot training, qualification, and procedures. It will inform relevant policy, operational requirements, standards, procedures, limitations, mitigations, guidance material, and updates to industry recommended practices. In addition, research results will provide data to support the FAA in responding to the NTSB recommendations, and other safety data analyses and recommendations such as the PARC/CAST Flight Deck Automation Working Group report, recent accidents, the Air Carrier Training Aviation Rulemaking Committee, and the upcoming International Civil Aviation Organization (ICAO) Personnel Training and Licensing Panel.

Enhanced Flight Vision System (EFVS), Enhanced Vision Systems (EVS), Synthetic Vision Systems (SVS), Heads Up Displays, Helmet Mounted Displays – Certification and Ops Approval Criteria. The objective of this requirement is to evaluate human factors and pilot performance considerations when using head-up display (HUD), head-down displays, and various advanced vision implementations during new low visibility concepts of operation. This research will inform the development of operational requirements, standards, conditions, limitations, mitigations, and authorizations to use these technologies. In addition, research results will contribute to increasing safety, access, and throughput to airports and runways when visibility is a limiting factor.

Human Factors Considerations and Emerging Trends Associated with Helicopter Air Ambulance Operations. The objective of this requirement is to evaluate human factors and pilot/crew performance considerations associated with Helicopter Air Ambulance operations (HAA). This research will provide information to improve the FAA's understanding of current HAA industry risks, emerging issues, and trends. This research will inform policy, operational requirements, standards, procedures, limitations, mitigations, and guidance material pertaining to helicopter air ambulance operations. In addition, research results will contribute to reducing the number of accidents and incidents attributable to human factors considerations in HAA operations.

Anticipated Program Activities:

- Obtain research data on incorrect air carrier pilot response and management of system malfunctions and partial system failures in transport category aircraft operations. RE&D results will be documented in a technical report.
- Identify, document, and synthesize human factors requirements, guidelines, and data to support the operational evaluation of aircraft systems, operations, and procedures. RE&D results will be documented in a reference document for Flight Standards Human Factors (RDFSHF).
- Obtain research data on the training and behavioral marker construct and identify potential cognitive indicators of pilot performance in crew resource management (CRM). RE&D results will be documented in a research plan report.

- Obtain initial research data that could indicate whether a synthetic vision guidance system (SVGS) is a viable alternative to traditional Category III rollout system requirements by providing more visual and position information to pilots throughout the entire operation, including rollout. RE&D results will be documented in a Phase 1 of 2 research report.
- Develop and apply a rotorcraft human factors analysis framework to identify causal and contributing human factors HAA safety events that occurred 2014 – present. RE&D results will be documented in a technical report.

Expected Program Outcomes:

- Research will provide input to the FAA on how to improve pilot training, qualification, and procedures. It will inform relevant policy, operational requirements, standards, procedures, limitations, mitigations, guidance material, and updates to industry recommended practices. In addition, research results will provide data to support the FAA in responding to the NTSB recommendations, and other safety data analyses and recommendations.
- Research will inform the development of operational requirements, standards, conditions, limitations, mitigations, and authorizations to use of advanced vision system technologies. In addition, research results will contribute to increasing safety, access, and throughput to airports and runways when visibility is a limiting factor.
- Research will inform policy, operational requirements, standards, procedures, limitations, mitigations, and guidance material pertaining to helicopter air ambulance operations. In addition,

research results will contribute to reducing the number of accidents and incidents attributable to human factors considerations in HAA 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 bio-physiological 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, CAE Simulation, Rockwell Collins, Elbit
- Labor: Transport Workers Union (TWU), IAM, Teamsters, Aircraft Operators and Pilots Association (AOPA), Air Line Pilots Association (ALPA), Association of Flight Attendants (AFA), Professional Aviation Maintenance Association (PAMA)
- Academia: PEGASAS Center of Excellence, University of Oklahoma, Oklahoma State University, Texas A&M, Georgia Institute of Technology, Purdue, Florida Institute of Technology, Embry Riddle Aeronautical University, Ohio State, Iowa State, Wichita State University, Massachusetts Institute of Technology
- Government: US Navy, US Air Force, NTSB, NASA, NOAA, NHTSA, Department of Homeland Security, Transportation Safety Institute, Aerospace Medicine Research Alignment and Collaboration (AMRAC) working group, Army, Volpe
- International: ICAO, EASA, CAA, SAE, and International Air Transport Association (IATA), 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 and NASA – fatigue research). This strategy has proven to be successful with the wide utilization and adoption of research findings.

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Air Traffic Control/Technical Operations Human Factors
($ 5,911,000)

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 technical sponsors. The program addressed human factors and training challenges through targeted research that yields an understanding of human performance, and those factors that contribute to facility-specific impacts, especially for high-impact facilities. In the training domain, the program conducts research to evaluate the effectiveness of realistic simulation capabilities that provide a medium for training complex task performance where Air Traffic Control (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. 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 (NAS). 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 are managed within the ATO Program Management Office (PMO), this program will focus on integration of human factors considerations to enhance user-system design. Human performance research will contribute to enhancing the overall system's performance, reducing errors, and helping reduce life cycle ownership costs. The program, through the FAA's PMO coordination, provides human factors R&D results that support the development and implementation of new technologies and procedures in the NAS. 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:

- Develop a validated ATC and technical operations alerting guidance document, as well as a training outline for a controller and technical operations training course on managing alerts and tuning alarms and alerts
- Develop a report, including a literature review and industry survey on human supervisory control interactions in aviation and relevant industries, with recommendations for performance measures for ATC methods using advanced artificial intelligence (AI) decision-aiding approaches
- Create a report to document prospective workload, performance, and fatigue measures that could be used to establish criteria to support recommendations for controller-workload-based fatigue-mitigation guidance and training
- Research and analyses to incorporate the latest scientific and technical information into the Human Factors Design Standard (HF-STD-001) in the areas of design of automated ATC systems, information display and management, and design requirements for workstation arrangement and display characteristics
- Develop a report identifying air traffic controller performance measures that are sensitive to the use of ATC automation capabilities, and initial candidate recommendations for controller training
- Create a research plan and execution roadmap to address key human factors competencies and knowledge bases to aid in ATC task automation — reducing errors, improving system design, and enhancing the effectiveness of training

Expected Program Outcomes:

- By 2023, develop recommendations for new ATC technology integration and controller training with advanced measures of controller performance and capability utilization that the ATO's Program Management Organization can apply in the acquisition of new ATC technologies and capabilities

- By 2024, develop facility operational guidance and training for recognition and mitigation of workload effects on controller fatigue and performance, and recommendations for updates in the training course based on controller training program reaction measures
- By 2025, recommend potential predictors of ATC developmental success in training and differentiate aptitudes and skills needed for success in ATC towers, Terminal Radar Approach Control Facilities, and Air Route Traffic Control Centers to inform ATC option placement guidance and training approaches

Collaboration Partners:

Public input about research requirements is provided by the Research Engineering and Development Advisory Committee (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/ATO 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)
- REDAC – HF Subcommittee- 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 Federally Funded Research and Development Center (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 in some cases – analyzing their data.

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NextGen – Air Ground Integration Human Factors
($3,000,000)

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.

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Program Objectives:

The primary goal of the NextGen/Air Ground Integration Human Factors program is enhanced safety and operational efficiency. In FY 2022 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 Flight crew 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:

- Evaluate the effect of advanced vision systems, emerging sensor-based technologies (i.e., multiple sensor systems), and new display types — such as head-worn displays (HWD) and helmet-mounted displays (HMD) — on pilot performance, human factors, and flight deck operations in transport category aircraft during low visibility operations
- Identify and understand the effects of new operator control mode inputs (i.e., voice, multi-touch, gaze), coupled with unique helicopter factors (vibration, space limitations, etc.), on human-system performance during single and multi-crew helicopter operations
- Evaluate the effects of planned air/ground system enhancements, flight deck system dependencies, and their respective NextGen concept of operation on the role of pilots, the expectations placed on flight crews, and human performance
- Evaluate a range of methods to factor in human behavior in human-system safety and risk-assessments.

Expected Program Outcomes:

- Provide human factors data to support the expanded use of HWDs and HMDs, with and without advanced vision capabilities, to conduct flight operations in lower than standard approach and landing minima
- Provide human factors data to support the evaluation of new operator control mode inputs — individual controls (voice, gaze, multi-touch) and combined controls — for use during single and multi-crew helicopter operations, including potential human factors design assumptions, limitations, and mitigations
- Provide foundational human factors data to address the impact of interdependent flight deck systems on failure detection, diagnosis, and mitigation in highly automated aircraft
- Provide human factors data to support the expanded use of planned air/ground communication, navigation, and surveillance capabilities needed for end-to-end time-based flight operations.

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 (e.g., 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.

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Aeromedical Research
($13,257,000)

Program Description:

The Aeromedical Research Program focuses on safety sensitive personnel and airline passenger health, safety, and performance in current and forecasted future civilian aerospace operations. The program performs aerospace-relevant applied research in the biomedical, biodynamics and survivability/cabin safety sciences. This research culminates in the transition of knowledge and technology to enable innovation in aerospace operations and mitigation and prevention of aeromedical hazards associated with aerospace mishaps.

Program Objectives:

This program will support improvements in the safety of passenger cabin environments during routine flight operations by focusing on detection of cabin events from bleed air contamination, transmission of infectious respiratory diseases of potential public health concern, and radiation exposure from extreme space weather events. Additionally, the program will support improvements in the safety of pilots by focusing on development of new approaches to aeromedical risk computation for certification decision-making and biomarker-based methods for detection of fatigue and drug use. Lastly, the program will support improvements in aircraft survivability and innovation in aircraft design by enhancing passenger safety during adverse events and streamlining the certification process for safety equipment and cabin designs.

Anticipated Program Activities:

- Quantify how often smoke, odor, and fume events occur on U.S. commercial airlines, determine the types of reported symptoms, and identify associated health effects
- Identify and measure chemicals resulting from bleed air contamination, assess the potential health effects, and identify detection technologies and preventative techniques
- Conduct a safety risk analysis of inflight respiratory diseases of potential public health concern.
- Improve space weather nowcasting by incorporating an enhanced model for calculating radiation dose rates during storms
- Identify post-COVID-19 infection health effects of potential concern for continued pilot medical certification
- Identify alternative tests for use in aeromedical certification to measure an airman's neurocognitive function relative to pilot norms
- Develop methods for forecasting the stability of an airman's state of health using machine learning algorithms trained on large, commercially available healthcare claims datasets
- Identify associations between changes in genetic biomarkers and performance under varying fatigue states (acute sleep loss, chronic sleep restriction, and shift work)
- Identify genetic biomarkers associated with cognitive deficits induced by sleep loss for one night, and determine how those biomarkers are affected by a pharmaceutical fatigue countermeasure
- Develop a methodology for using finger stick blood samples to detect genetic biomarkers
- Determine an optimized methodology for processing and analyzing samples to detect genetic biomarkers

- Establish a biological sample repository of airmen fatalities from aviation accidents that is suitable to support future research of associations between genetic biomarkers and safety risks
- Detect changes in genetic biomarkers associated with use of specific drugs to provide a confirmatory assay for postmortem drug screening and expand the range of tissues available for forensic analysis of drug use
- Quantify the effectiveness of passenger education methods on retention of cabin safety information related to luggage retrieval in emergency situations
- Develop injury criteria and test methods to evaluate the crash safety for obliquely oriented seats
- Determine the level of protection provided by the most common legacy rotorcraft, and identify potential injury mitigation strategies for each model
- Quantify the impact of proposed transport aircraft cabin and door configuration changes on the speed of passenger egress
- Develop methods using virtual reality to evaluate the safety effects of aircraft cabin configuration changes
- Explore potential applications for numerical modeling in various cabin safety areas and establish criteria for validation of models for use in certification
- Review exit rating criteria for ditching exits as directed in section 337 of the FAA Reauthorization Act of 2018
- Develop vertical calibration procedures for the anthropomorphic test device pelvis
- Determine if performance-based metrics are as accurate as current prescriptive-based metrics for the certification of new oxygen systems

Expected Program Outcomes:

- Use the results of the smoke, odor, and fume research activities to recommend potential safety improvements and inform regulations
- Use the results of the safety risk analysis of inflight respiratory diseases to scope follow on research activities leading to the development of a cabin safety pandemic playbook in preparation for future pandemics
- Upgrade the CARI-7 computer program to provide more accurate Solar Radiation Alert System and International Civil Aviation Organization radiation advisories
- Use the results of the COVID-19 health effects and neurocognitive testing research activities to inform updates to aeromedical certification guidance
- Use the results of the exploration of computational approaches in aeromedical certification to inform requirements for the post-Aerospace Medicine Safety Information System aeromedical certification system
- Use the results of genetic biomarker research activities to mature fatigue and drug assessment methodologies for future transition into the Civil Aerospace Medical Institute's forensic sciences laboratory for use in accident investigations
- Use passenger training effectiveness data to recommend potential improvements to passenger education processes and materials
- Certify obliquely oriented seats through new injury criteria and test methods
- Use the results of injury mechanism analysis to identify and recommend potential safety improvements to rotorcraft manufacturers, and to inform regulations
- Use performance data to assist in determining the safety of evacuating from new and differing aircraft cabin designs
- Certify additional cabin safety applications through more efficient means, where and when possible, and safe to do so
- Certify new oxygen systems through performance-based metrics, if possible, to safely do so

Collaboration Partners:

Aeromedical Research maintains a diverse program that capitalizes on robust partnerships with multiple partners:

- Government: FAA - Office of Aerospace Medicine; FAA - Accident Investigation and Prevention (AVP); Aviation Flight Standards (AFS); FAA - Aircraft Certification (AIR): National Transportation Safety Board; National Aeronautics and Space Administration; National Oceanic and Atmospheric Administration; Department of Defense; National Highway Traffic Safety Administration; and the Ditching Advisory and Rulemaking Committee
- Academia: Kansas State University, Auburn University, Boise State University, Baylor College of Medicine, and Medical College of Wisconsin
- Industry: MedAir, Inc.; SAE International; and SAFE Association
- International: South African National Space Agency; International Cabin Safety Research Technical Group; and the International Civil Aviation Organization

Aerospace Performance and Planning

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System Safety Management/Terminal Area Safety
($7,898,000)

Program Description:

The main goals of this program are 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.

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).

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.

Through these programs, 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 operational go-around problems; 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 the NTSB's Safety Recommendations such as A-07-003, A-04-62, A-07-64, and A-01-069.

Anticipated Program Activities:

- Develop descriptive analytics and proof of concept tools to create safety performance indicators for surface operations
- Develop concepts and models for a sector risk profile tool for aeronautical information services
- Develop tools, techniques, and metrics, and provide analytical expertise to the Helicopter Issue Analysis Team and examine safety data and methodologies to reduce the fatal accident rate within the vertical flight community

- Create safety metrics and software prototypes for general aviation using surveillance broadcast services data, (e.g., Automatic Dependent Surveillance–Broadcast {ADS-B}), to better analyze risk within the general aviation community
- Conduct a literature review and market survey for virtual reality and simulated air traffic control devices to improve commercial pilot training
- Create improved mathematical/physics-based flight dynamics for helicopter simulator/flight training device models for semi-rigid and rigid rotor systems for aerodynamic conditions of interest to improve rotorcraft pilot training
- Perform a comprehensive literature survey in the area of reducing human error through cognitive bias awareness, which can be used to improve pilot training
- Document experimental data comprising mission-specific recommendations for proposed operational constraints/limitations/capabilities and technology concepts for vision systems

Expected Program Outcomes:

- Identify and visualize risks using flight data monitoring data from helicopter operations
- Develop runway operations safety analytics model, performance indicators, artificial intelligence, and machine learning algorithms for detecting and classifying safety event factors and anomalies on the airport surface
- Develop data model and define concepts for safety performance and safety risk indicators of Aeronautical Information Services (AIS) to provide a sound foundation for the development of an AIS risk profile tool
- Examine technologies to reduce safety risks via loss-of-control in flight
- Develop better mathematical models of helicopter flight simulator conditions including outside the envelope flight in all levels of simulators and aviation training devices to lower the fatal accident rate
- Evaluate applied research of transferring virtual reality technologies in piloted flight simulations
- Evaluate the safety enhancement from utilizing innovative augmented reality concepts for displaying flight information for helicopter flights during normal and low-visibility operations

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.

Commercial Space Transportation Safety
($5,708,000)

Program Description:

Commercial space transportation (CST) research focuses on four priorities that 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:

Statute directs the FAA AST to regulate commercial space launch and reentry operations only to the extent necessary to ensure compliance with international obligations of the U.S. and to protect the public health and safety, safety of property, and national security and foreign policy interests of the United States. Statute further directs AST 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's FY 2022 research activities will find innovative solutions through public-private collaborations and prototype development, to increase safety, efficiency, and U.S. global leadership in CST. AST's FY 2022 RD&T portfolio optimizes AST's mission execution through the development of improved regulations, safety assessment tools, and public safety technologies. FY22 funding supports regulatory research, addresses lessons learned, and enables the FAA to keep pace with the dynamic CST industry. Industry development research benefits all actors within different CST industry segments.

Anticipated Program Activities:

- Develop improved flight safety and hazard area models and methods, to improve analysis of possible cases of launch or re-entry failures and reduce overly conservative airspace closures
- In collaboration with industry, execute multiple large-scale activities to research topics of interest to industry and the FAA, including human (crew and spaceflight participant) research
- Execute industry emergence and innovation foresight research for multiple CST industry segments

Expected Program Outcomes:

- Improved estimation of flight safety phenomena impacting regulatory decisions (e.g., distant field over-pressure, impact of window breakage, hazard area prediction)
- Develop new sensors, materials, and technologies to improve safe operations of aerospace vehicles
- Collect and analyze data on human physiological responses to hypersonic spaceflight
- Improve understanding of policy, law, regulation, and market issues and trends

Collaboration Partners:

The AST Safety Research Program has multiple stakeholders informing the research program content. These include the Commercial Space Transportation Advisory Committee (COMSTAC), the Commercial Spaceflight Federation (CSF), and individual industry members, and universities.

Specific program partners include:

- Contractors (ARCTOS)
- FFRDCs (Aerospace Corp., MITRE/CAASD)
- Trade Organizations (ASTM, COMSTAC, CSF)
- Universities (Florida Tech, New Mexico State University, etc.)

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NextGen – Wake Turbulence
($3,728,000)

Program Description:

This program provides aircraft generated wake turbulence research that matures wake mitigation operational concepts to the point that they can be directly implemented by FAA orders and enter the FAA Facilities and Equipment (F&E) development and implementation process to meet National Airspace System (NAS) infrastructure enhancement requirements. This program supports the NextGen objective to accommodate increased demand (flights) during peak demand periods. The program provides increased access to airport runways and airspace through modifications to Air Traffic Control (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 prior to these aircraft entering service into the NAS. This project continues to determine wake separations to be applied to manufacturers' newly developed aircraft that will be entering the NAS and continues to address new entrants such as large Unmanned Aircraft Systems (UAS). Without this work, the 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 that wake separation standards will play in NextGen 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 and departing 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 to establish wake risk mitigation separation standards:
  The team will complete wake track statistical database assessments, if the aircraft type is similar to another already operating in the NAS. If not similar, aircraft performance and design data will be modeled to determine safe wake separation standards for air traffic controllers to use until wake track data for specific aircraft types can be collected and analyzed

- Collect and analyze wake track data to build a statistical basis for determining safe throughput-efficient wake separations between aircraft. Data analyses will be accomplished using collected wake track data.
- Assess proposed changes to air traffic control (ATC) procedures for wake encounter risk to include the finalized Wake Re-categorization (Wake Recat) total wind terminal area dynamic wake separation solution. A safety assessment will be provided as a part of the solution's documentation and technical transfer package.
- Develop a subset of absolute wake hazard metrics to use where relative metrics are not feasible.

Expected Program Outcomes:

- Determine wake mitigation separation standards for new aircraft types entering the NAS
- Collect data from ground-based and instrumented aircraft at flight level to set throughput capacity for efficient and safe aircraft wake separations
- Evaluate all changes to ATC safety procedures, including wake risk, before and after implementation
- Create an absolute wake hazard metric that will allow new aircraft types entering service in the NAS to be accurately assessed for data-driven wake separation recommendations
- Safely reduce required wake separations through the use of real-time weather sources such as ADS-B weather, which could result in more throughput

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.

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.

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Unmanned Aircraft Systems
($22,077,000)

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:

- Develop and validate detect-and-avoid performance for both small (below 55 pounds) and large UAS, to enable beyond visual line of sight operations
- Develop and validate command and control link performance

- Analyze UAS standards to track and map existing standards, and identify gaps in standards
- Develop and validate UAS pilot and visual observer training and qualifications
- Collect and analyze UAS data to identify safety risks for industry and government partners within the UAS safety team
- Identify and evaluate potential risks of UAS operations on and around the airport surface
- Evaluate UAS operations for wake turbulence considerations with emphasis on Urban Air Mobility
- Evaluate demand and safety impacts, focusing on increased UAS autonomy for large cargo and passenger transport operations
- Explore UAS air carrier operations to inform future requirements and regulations
- Investigate the use of UAS in response to natural disasters and emergencies, focusing on coordination between federal agencies and state/local governments
- Identify risks and proposed mitigations related to UAS security, including cybersecurity
- Explore counter-UAS detection technologies and their potential impacts on airport operations

Expected Program Outcomes:

- Define new standards and enforce all relevant UAS standards
- Protect critical infrastructure, data, and aviation systems
- Define and mitigate the integration challenges posed by the expanding set of UAS use cases in order to ensure the safety of the NAS
- Assure that NAS systems, equipment, and procedures are robust and resilient in order to safely support the new technologies and practices being introduced into transportation systems from new UAS use cases
- Improve data collection methods and analyses

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

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Advanced Technology Development & Prototyping
($29,000,000)

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:

- Complete annual report documenting results of Human in the Loop testing human factors, safety logic, aircraft performance, or any uncertainty or deficiency pertaining to surface-based runway incursion indications
- Complete annual technical and operational test and evaluation report of an advanced ground surveillance sensor to drive the activation of direct to pilot alerting safety logic
- Develop and demonstrate a prototype ATC tower-based taxi conformance monitoring system to reduce runway incursions at controlled airports
- Performance metric and analysis support for FAA Memorandums of Cooperation, International Civil Aviation Organization (ICAO) and Civil Air Navigation Services Organization
- Supporting key FAA International objectives to respond to inquiries on global flight efficiency performance targets for Air Traffic Management (ATM)
- Assess value of potential improvements through Airport modeling and analysis
- Historical data mining tools used to support ATO advanced planning
- Performance reporting tools for FAA offices
- Performance reporting tools used for FAA external stakeholders including airlines

- Developing methodology for emerging trends affecting NAS operations to include Commercial Space and Unmanned Aircraft Systems
- Developing reports, tools, and methodologies to assess NAS performance, identify constraints/restrictions, and quantify capacity utilization
- Conducting airport capacity studies that provide assessment of procedural, technology, or infrastructure improvements
- Conduct analyses to support assessments of new air traffic control operational concepts
- Develop common concept development, validation, and measurement methodologies to support the Single European Sky ATM Research Joint Undertaking
- Develop concepts of use to describe the operational use of new communication, navigation, automation, surveillance, and flight deck capabilities
- Produce reports on concept development and validation findings including second-level concepts, fast-time analyses, and human-in-the-loop real time studies
- Develop operational, information, and performance requirements
- Implement airspace redesign changes in the Northeast Corridor and support the required changes in the supporting infrastructure

Expected Program Outcomes:

- Runway safety assessment studies such as Runway Incursion Prevention Shortfall Analysis (RIPSA) to identify candidate small-to-medium sized airports with historically high rates of runway incursion (RI), where new RI prevention technologies can be prototyped and evaluated. These prototype systems will address the specific types of RI causal factors encountered at that site (e.g., converging runways, ground vehicle operations, taxiway/runway hotspots, etc.).
- Prototyping and evaluating the Small Airport Surveillance Sensor (SASS) at Hanscom Field, Massachusetts. SASS provides lower-cost secondary surveillance capability to either augment or provide standalone cooperative airport surface and terminal area airborne surveillance at small to medium sized airports that do not meet the cost/benefit criteria for the current generation of surface surveillance capabilities.
- Investigate the use of Surface Taxi Conformance Monitoring (STCM) to assist in Runway Incursion reduction. STCM research will focus on the development and demonstration of prototype ATC tower-based and/or cockpit-based taxi conformance monitoring systems to reduce RIs at controlled airports.
- Continue to provide a collaborative means for experts from the FAA, academia, and industry to develop recommendations for improving capacity, system efficiency, and ways to reduce delays at specific airports. Using performance-based measurement systems and operations research capability, this group is able to quantify the efficiency of the NAS to form the basis of recommendations for system improvements.
- Support the development and sustainment of analytical and computer models that are used to assess and validate operational changes to the NAS.
- The conceptual development of many Northeast Corridor initiatives is ongoing.

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
($23,500,000)

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 (NAS).

Anticipated Program Activities:

- Develop preliminary requirements and supporting safety assessments for adding the Dynamic wake risk mitigation solution enhancements to ATC decision support tools.
- Conduct EoR Pure Duals concept validation at Los Angeles International Airport (LAX).
- Provide data to support the development of SRMD and procedure authorization standards for integrated arrivals/departures operations.

Expected Program Outcomes:

- Design advanced algorithms that use weather/wind observed (including aircraft-based observations) and National Weather Service forecast model data to support ATC's use of Dynamic Wake separations in the terminal area and in the en-route airspace.

- Provide next MARS or EoR Concept Validation Report(s).
- Provide concept validation of implementing reductions for integrated arrivals/departures operations.

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.

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NextGen Transportation System - Traffic Flow Management Portfolio
($13,000,000)

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 (NAS). 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.

Statutory Requirements:

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

This program is driven by the FAA Modernization and Reform Act 2012 and FAA Reauthorization Act of 2018 under FAA Title II NextGen Air Transportation System and Air Traffic Control Modernization Section 202 NextGen Demonstrations and Concepts “In allocating amounts appropriated pursuant to section 48101(a) of title 49, United States Code, the Secretary of Transportation shall give priority to the following NextGen activities...”

The TFM Portfolio will evaluate trajectory negotiation and collaborative decision making between NAS operators and FAA traffic managers, along with advanced automation, in managing daily flight and flow decision-making, airspace and airport capability issues, such as special activity airspace and weather, to improve overall efficiency of the National Airspace System that are critical to NextGen.

Program Objectives:

The main goal of this NextGen – Traffic Flow Management (TFM) Portfolio is to improve 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:

- Evaluate mobile/Electronic Flight Bag (EFB)-based technologies that enable participation in integrated departure scheduling and enhanced data exchange with other types of flight operators (regional, cargo, international, etc.)
- Evaluate terminal data exchange capabilities and develop a prototype to quickly and accurately exchange information digitally within and across facilities, flight operators, and other NAS users
- Develop a modeling platform to conduct proof of concept activities for future TFM capabilities
- Develop models to evaluate the role of machine learning in the evolution of PBFM
- Develop information requirements for traffic flow management planning and execution functions
- Identify areas where machine learning/deep learning/artificial intelligence algorithms are critical to user performance
- Identify specific methods that will improve the acceptance and certification (as appropriate) of the methods that will be used for operational and safety improvements

Expected Program Outcomes:

- Develop a report on cloud-based technologies and services required to exchange data from EFB applications in a timely and secure manner
- Conduct lab demonstration and evaluation of terminal data exchange capabilities
- Conduct platform analysis and proof of concept activities
- Develop a machine learning/data mining capability that utilizes historical and real-time data
- Develop analysis report on existing FAA automation systems and stored data for suitability with artificial intelligence technology

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	The 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 of NAC commitments on the NAS through the work of a Joint Analysis Team 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 (SMS) support
MITRE	Leverage research integration and data exchange and assist with technology transfer
Airlines	Cooperative evaluations and development of airline tools
Airport Authorities	Support of research activities and access to operational subject matter experts

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NextGen Transportation System - On Demand NAS Portfolio
($9,000,000)

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 flight activities 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 the automation systems and communication systems functional requirements for the Dynamic Airspace Program
- Conduct functional analysis for Flight Deck Collaborative Decision-Making (FD CDM) applications for new Flight Deck capabilities
- Develop FD CDM negotiation concept, systems engineering artifacts and conduct proof of concept demonstrations for enhanced surface applications

Expected Program Outcomes:

- Evaluate existing methodologies, develop concept of operations, and design infrastructure prototypes to demonstrate operational capabilities of the FD CDM applications such as taxi instruction delivery, clearance delivery, Trajectory negotiations, and aircraft parameters exchange
- Technology transfer of dynamic airspace functional requirements to applicable programs

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, and aviation safety offices for policy development, concept maturation, and technical acceptance of investment capabilities.
International Civil Aviation Organization (ICAO) (external)	Partnership with ICAO ensures that the FAA is 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 technology transfer

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NextGen Transportation System - NAS Infrastructure Portfolio
($7,000,000)

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 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:

- Develop weather translation techniques for non-convective weather constraints, and weather advisory and collaborative lab experiments designed to explore ATM Weather Integration (AWI) concepts and capabilities
- Coordinate aviation weather issues with subject matter experts through Community of Interest (COI).
- Conduct concept development activities to identify requirements for an enterprise solution of input devices for NAS automation systems.
- Develop framework to advance the innovative concepts that leverage the connected aircraft for various application and establish an integrated roadmap for the development of future air traffic management services and policies that take advantage of the emerging air/ground connectivity.
- Analyses of command and control performance and security requirements to support the potential use of internet-based data exchange for command and control applications and document results.
- Conduct initial assessment of NAS-wide operations using ubiquitous communications
- Develop feasibility assessment of the potential use of Artificial Intelligence (AI)/Machine Learning (ML) to support controller operations and decision making

Expected Program Outcomes:

- Concept-level requirements and investment analysis products for NextGen Weather Processor (NWP) and Common Support Services – Weather (CSS-Wx) Future Enhancements
- Identify weather requirements to support of ceiling and visibility weather information
- Initial Ubiquitous Communications Framework
- Down-selected set of candidate input device technologies for NAS automation systems.

- Initial analysis of requirements for potential use of AI in support of controller functions

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.

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NextGen Support Portfolio
($10,500,000)

Program Description:

The NextGen Support Portfolio provides the NAS laboratory environments required to evaluate, mature, and validate the broad framework of NextGen concepts, technologies, operational functions, and systems before they are introduced into the NAS. This program provides the evaluation platforms at the NextGen Integration and Evaluation Capability (NIEC) and Florida NextGen Test Bed (FTB). These labs facilitate the conduct of NextGen concept demonstrations using research NAS environments without affecting actual National Airspace System (NAS) operations.

The NextGen Support Portfolio funding is used to continue laboratory operations in support of on-going NextGen Programs and to enhance existing NIEC and FTB lab capabilities as required to support the development and evaluation of advanced capabilities associated with evolving NextGen operational improvements and implementation plans.

Program Objectives:

This program supports the DOT's Strategic Goal of Innovation by providing targeted research and development within the FAA that will lead to new technology development and deployment in the NAS. Data generated by this program will allow for the assessment of regulatory approaches, foster information sharing and facilitate coordination and collaboration with industry and other stakeholders. Most importantly this program facilitates the testing and adoption of new technologies throughout the NAS.

Anticipated Program Activities:

- Provide infrastructure enhancements for NAS modernization research, engineering, development and validation exercises (e.g., Trajectory Based Operations, UAS Traffic Management and Advanced Air Mobility (AAM) Beyond Visual Line of Sight National Airspace System Evaluation (BNE)
- Provide engineering development and updates to lab systems to meet international data standards (i.e., Flight Information eXchange Model (FIXM))
- Evaluate the operational performance impacts of NAS modernization technologies and procedures, and publish associated annual report

Expected Program Outcomes:

- Laboratory infrastructure enhancements (i.e., FTB and NIEC) to support various demonstrations including Multi-Regional Trajectory Based Operations (MR TBO) and AAM BNE demonstrations
- Updated laboratory infrastructure and tools to meet new international data standards
- Enterprise Information Management (EIM) Platform simulation/study data source.

Collaboration Partners:

This program is a pathway to obtaining stakeholder input. Specifically, the NIEC laboratory is used to expose stakeholders in the ATM operational user community to emerging NextGen concepts and capabilities in

order to gain their assessment of the potential operational effectiveness and/or suitability of the concept for use in further maturation and development exercises or adoption/implementation.

The Florida NextGen Test Bed is a facility located at the Embry Riddle Aeronautical University in Daytona Beach, Florida. It supports the integration of new and emerging technologies into the NAS through demonstrations and evaluations. One of the main purposes of the Florida NextGen Test Bed is to provide an open-access location for industry, users, and vendors to demonstrate new capabilities and harness NAS architecture solutions. These demonstrations cultivate government, academia, and industry partnerships and facilitate decision making involving key stakeholders.

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NextGen Transportation System – Enterprise, Concept Development, Human Factors & Demonstrations Portfolio
($10,600,000)

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 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 provide 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:

- Develop human factors guidance for UAS operational interactions between UAS and UAS Traffic Management (UAM) operations and air traffic managed airspace
- Identify any gaps in the innovative airports demonstration requirements and update accordingly
- Develop an initial Innovative Airports system prototype
- Identify and explore artificial intelligence for NAS scenarios and use cases
- Conduct and support multiple demonstrations of matured NextGen concepts including Trajectory Based Operations

Expected Program Outcomes:

- Develop a report on analysis of information systems to support TBO integrated concept
- Complete Innovative Airports gap analysis
- Develop initial Innovative Airports Concept of Operations
- Develop an AI for the NAS Concept of Operations

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)	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.
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 of 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.

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NextGen Transportation System - Unmanned Aircraft Systems
($24,000,000)

Program Description:

Unmanned Aircraft Systems (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 delay, 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:

- Updated Integrated UTM Data Exchange Requirements Version 2.0 (e.g., applications for Identification and Tracking).
- Developing Advanced Air Mobility (AAM) Beyond Visual Line of Sight (BVLOS) NAS Evaluation (BNE) Use Case Development Shortfall Analysis

Expected Program Outcomes:

- Development of a separate but complementary traffic system to the FAA's air traffic management system
- Identify requirements for enabling and managing UAS operations in airspace that are conducted below 400 feet above ground, predominantly smaller UAS, where no air traffic control services exist today

- Leverage new vehicle designs and system technologies to evaluate the integration of Beyond Visual Line of Sight (BVLOS) operations in the NAS using large (>55 lbs.) UAS as a platform above 400 feet above ground level
- Live data collection from flight trials allowing for further development or enhancement of airspace management constructs and operational procedures into the NAS

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 the FAA's 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)	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) • 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

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Emerging Technologies Accelerator
($8,500,000)

Program Description:

The Innovation and Emerging Technologies Program was established to foster emerging science, engineering, and technology advancements and align innovation with known and forecasted challenges and opportunities in the aviation industry.

Program Objectives:

The program aims to address air transportation safety and efficiency needs in the near and far term. It also addresses statutory requirements to invest in long-term research that better positions the agency to shape the air transportation system of the future.

Anticipated Program Activities:

- Establish a program implementation framework
- Develop terms of reference and assemble a program oversight committee
- Develop an initial emerging technology review
- Develop and coordinate aviation challenge statements
- Release solicitation for innovation proposals

Expected Program Outcomes:

- By 2023, issue up to five awards for innovation proposals responsive to high-priority aviation challenges
- By 2025, transfer initial research results and innovation outputs to early adopters and/or producers

Collaboration Partners:

Not Applicable

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Aviation Workforce Development – Section 625
($5,752,000)

Program Description:

The Aviation Workforce Development grant program will provide support to administer grants for eligible projects that educate, develop, and recruit aircraft pilots and an aviation maintenance technical workforce, as directed by Congress in Section 625 of the FAA Reauthorization Act of 2018.

Program Objectives:

Consistent with section 625, program eligibility and outreach will be aimed at communities underrepresented in the industry as well as economically disadvantaged geographic areas and thus support equity in transportation federal policy objectives.

Anticipated Program Activities:

- Create and deliver curriculum designed to provide a meaningful aviation education to accredited institutions of higher education, high school or secondary schools, local government entities, flight schools, or aviation organizations to prepare students to become aircraft pilots, aerospace engineers, or unmanned aircraft systems operators
- Support the professional development of instructors or teachers using the above curriculum to teach students
- Establish or improve educational programs that teach technical skills used in aviation maintenance, including how to purchase equipment
- Establish scholarships or apprenticeships for individuals pursuing employment in the aviation maintenance industry
- Support outreach about careers in the aviation maintenance industry to primary, secondary, and post-secondary schools; and communities underrepresented in the aviation industry
- Support educational opportunities related to aviation maintenance technicians in economically disadvantaged geographic areas
- Support transition to careers in aviation maintenance, including members of the U.S. Armed Forces
- Enhance aviation maintenance technical education and the aviation maintenance industry workforce

Expected Program Outcomes:

- Provide grants to support education, recruitment, and development of aircraft pilots and aviation maintenance technicians

Collaboration Partners:

Not Applicable

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System Planning and Resource Management
($4,141,000)

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's REDAC, this program facilitates an independent, expert review of the FAA's R&D portfolio that provides meaningful recommendations for the FAA to refine and improve its portfolio. This results in a more effective research program that will benefit the public by making aviation safer and smarter and enhancing U.S. global leadership in aviation.

Anticipated Program Activities:

- Completion of annual congressional deliverables (NARP and 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 R&D management deliverables, including the Annual Modal Research Plan
- Enable the use of federal government labs, facilities, equipment, and personnel with public and private partners
- Facilitate government and private sector partnerships to help develop and commercialize aviation ideas, concepts, and products

Expected Program Outcomes:

- Ensure departmental R&D program planning and performance reporting requirements are satisfied, as specified in the Fixing America's Surface Transportation Act (Pub. L. No. 114-94).

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, 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 Executive Board (REB);
- 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; Serves as a 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.

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William J. Hughes Technical Center Laboratory Facility
($5,481,000)

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:

- Enhance the simulation infrastructure to evaluate human factors issues associated with introducing new consoles and advanced information displays to air traffic controllers
- Support cybersecurity exercises including DoD's "Whole of Nation" simulation
- Integrate FAA and partner networks and facilities into the NextGen Prototyping Network baseline. This will expand collaborative capabilities and position the FAA to best support NextGen research across the agency, and with other government agencies, industry, and academia
- Support Cybersecurity Test Facility partner activities investigating National Airspace System (NAS) cyber threats, which are expected to include joint FAA/DOD/DHS activities

- Target Generation Facility & Cockpit Simulation Facility (CSF) – Enhance FAA simulators for support of NAS R&D requirements, specifically to address the need to simulate and conduct high fidelity tests for programs such as four-dimensional trajectory

Expected Program Outcomes:

- The overall goal for the WJHTC Laboratory Facilities is to have the infrastructure in place and ready to support R&D program requirements when needed.
- The Concepts and Systems Integration – Research Development and Human Factors Laboratory will conduct proactive high-fidelity research on proposed changes to the air traffic controller displays to identify human performance issues by the end of FY 2022.
- The program will ensure all required partners supporting FAA research are integrated into the NextGen Prototyping Network baseline by the end of FY 2022 to maximize collaboration and best position the FAA to meet research goals.
- The CSF will merge two existing simulators together for a high-fidelity general aviation simulator. The avionics and visual systems will be upgraded to the current CSF standardized in-house platforms. Initial operating capability will be achieved by the end of FY 2022.

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, Liberty IT Solutions, Saab Sensis, SAIC, 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 2022 Annual Modal Research Plans

William J. Hughes Technical Center Laboratory Sustainment
($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 2023 Program Descriptions

Airport Infrastructure and Technologies

FY 2023 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 Transportation Research Board 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

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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.

Anticipated Program Activities:

- AOC will be selecting research projects for FY 2023 during summer meeting this year. These projects will be focused on the research need of the airports and aviation communities that are not addressed by the Federal research efforts.

FY 2023 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 applications of solar technologies at airports, UAS operations, using innovative and smart sensors to enhance safety, airfield pavement testing, 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-22, the ATR program will remain engaged in a multitude of airport safety areas. Some examples are; research the future needs of Advanced Air Mobility (AAM)vehicles on airport ground infrastructures, development of new specifications for the use of solar lighting fixtures 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:

- Research performance studies to determine pavement surface treatment application and locations at the airfield
- Research and develop asphalt surface and base courses (FAA Specifications P401, P403 and P404) minimum material, and construction and acceptance recommendations
- Evaluate different optimization techniques including, but not limited to, reinforcement learning (one of three basic machine learning paradigms) for use in the FAA software BAKFAA, along with a finite element forward calculation model
- Research the field performance of solar powered lighting systems in various regions of the United States
- Research the impact and needs of AAM, including electric Vertical Take-Off (eVTOL) vehicles on existing and future airport infrastructures
- Perform full scale testing of various Aircraft Firefighting agents to investigate the reduction or elimination of Per- and polyfluoroalkyl substances (PFAS) at airports
- Assess and perform field testing for the use of UAS applications at airports
- At several airports, perform field testing of several technologies for the detection of UAS
- Develop machine learning and artificial intelligence schemes, to integrate runway and weather conditions, to predict reduced aircraft braking capabilities on icy and wet runways

Aircraft Safety Assurance

FY 2023 Program Descriptions
Fire Research and Safety

Program Description:

The Fire Research and Safety program seeks to protect aircraft occupants through the prevention or mitigation of in-flight fires and the improvement of survivability in the event of a post-crash fire. Researchers in this program conduct tests to evaluate potential fire threats from the integration of new aerospace technologies and develop procedures, standardized test methods, and data to support the certification of aircraft systems and materials.

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 and the American public through the mitigation of the catastrophic consequences of an uncontrollable aircraft fire, including loss of life and the destruction of the aircraft. This program is necessary to continue and improve the current levels of safety of aircraft as technology, materials, and construction methods evolve. The testing supports the need to upgrade aircraft certification standards to keep pace with the emerging technologies used by the aerospace industry, while also working towards the development, validation, and transfer of cost-effective aircraft fire safety technology to industry.

Program Objectives:

The primary goals of this research are 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 William J. Hughes Technical Center (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:

- Component/Material Fire Testing
- Cargo Fire Protection
- Engine Fire Protection

FY 2023 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 that 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:

- Evaluation of long-term material and structural behavior
- Fatigue and damage tolerance behavior of bonded joints
- Crashworthiness performance of composite aircraft seats.
- Develop guidelines for characterizing new material forms and assessing manufacturing maturity.

FY 2023 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:

- Develop a method of compliance to support certification of advanced flight controls in General Aviation and hybrid vehicles
- Metallic Materials Development and Standardization (MMPDS)
- Examine the effects that different platform materials have on the results of rotorcraft fuel system drop testing
- Large electric energy storage systems research

FY 2023 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 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:

- Advanced Damage Tolerance and Risk Assessment Methods for Engine Life Limited Parts
- Improved Nondestructive Evaluation to Prevent Uncontained Engine Failures
- Advanced Analysis Methods for Impact of Aircraft Materials from Rotor Burst and Blade Release
- Engine Safety Event Prevention thru Engine Health Monitoring (EHM)
- Electric Motor Research for the Safe Implementation of Electric Propulsion

Digital Systems and Technologies

FY 2023 Program Descriptions
Digital System Safety

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 the FAA and industry in certifying aircraft employing advanced digital airborne systems.

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.

Anticipated Program Activities:

- Study of Assurance based approaches, and their adoption into the aviation certification
- Explore the use of alternative approaches to deployment of AI/ML based systems, and establish criteria that will make this acceptable

FY 2023 Program Descriptions
Information/Cyber 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; and
- 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. The 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

- Predictive analytics prototype development and demonstration
- Context Aware Behavioral AI Algorithm Adaptation and Initial Software Prototype Development
- Explainable AI- Stakeholder requirements and Use case development

Environmental and Weather Impact Mitigation

FY 2023 Program Descriptions
Aircraft Icing

Program Description:

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 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, 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 industry working groups and committees, and participation in national and international conferences.

Anticipated Program Activities:

- Ice protection of vertical stabilizer prior to takeoff
- Fluid protection time for mixed phase ground icing conditions

FY 2023 Program Descriptions
Weather Program

Program Description:

The Weather Program performs applied research to minimize the impact of weather on the National Airspace System (NAS). 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 program leverages advances in meteorological science to enhance observation methods, improve weather prediction models, and produce increasingly accurate forecasts of convective weather, turbulence, icing, and low ceiling and visibility conditions. 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. The timely dissemination and presentation of such information provide decision support input to enable traffic flow managers, controllers, pilots, and airline operations personnel to implement tactical and strategic traffic management initiatives to avoid encounters with severe weather, reduce delays and mitigate safety risks.

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; improve the accuracy and relevancy of legacy weather products and services mandated by FAA regulatory guidance and/or international agreements; and support the achievement of the NextGen weather vision and ultimately the FAA's 2035 NAS Vision.

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 return on investment 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:

- Improve Convective Weather Global Forecasts
- Develop Ceiling and Visibility (C&V) Decision Support Guidance
- Turbulence Forecast Enhancements
- Obtain Solar Radiation Measurements at En route Altitudes

FY 2023 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, reduce pilot workload, and increase fuel efficiency to lower gas emissions for 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 Instrument Flight Rules (IFR) and Visual Flight Rules (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 on all part-type aircraft 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 identifies and develops resolutions to gaps in pilot weather training materials and courseware.

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 safety and efficiency benefits in adverse weather conditions for all part-type aircraft.

Anticipated Program Activities:

- Investigate cockpit weather-related gaps for helicopter operations to develop resolutions
- Perform research to complete and verify initial minimum weather service recommendations for calculating turbulence information from data in downlinked Automatic Dependent Surveillance–Broadcast (ADS-B) reports to enhance the safety and efficiency of pilot turbulence avoidance decisions
- Conduct research to use crowd sourcing techniques to produce operationally useful visibility, ceiling, weather radar, and wind information to provide to cockpits for use in remote regions that lack infrastructure to enhance access to underserved communities
- Perform service analysis research to assess the potential to use a cloud environment to store a database of encountered weather (wind, turbulence, convection, etc.) for consumption, analysis, and use by any part-type proximate aircraft to make near real-time route/reroute decisions to optimize fuel efficiency, reduce emissions, and enhance safety
- Perform research to support an RTCA SC-206 proposed Airborne Reroute Information (ARI) Service that will enable flight crews to make intelligent route or reroute requests when a Traffic Management Initiative (TMI) is no longer representative of the current weather picture. The ARI Service will provide flight crews with relevant, timely, observed, and forecast weather information to safely participate in a Collaborative Decision Making (CDM) environment. The Air Navigation Service Provider CDM process uses TMIs and Air Traffic Flow Management regulations to ensure orderly flow of traffic around constrained airspace (e.g., constrained due to convective weather)
- Perform literature reviews, service analyses, and trade studies to identify automation and machine learning capabilities to identify potential methods for development of a cockpit decision support tool that outputs optimized fuel efficient routes/reroutes to safely avoid adverse weather.
- Research and verify gaps in pilot understanding of decorrelation impacts on weather information quality provided to cockpits and perform initial trade studies to identify potential cockpit-based “tools” to reduce or resolve selected gaps. This research activity includes identification and quantification of impactful causes of decorrelation.
- Develop minimum weather service recommendations and associated frameworks to enable flight instructors and schools to effectively incorporate augmented and virtual reality into their pilot weather training curriculum

FY 2023 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 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, the private sector does that.

Anticipated Program Activities:

- Engine testing of prospective fuels in fleet representative models
- Flight-testing on final candidate fuel formulations in fleet representative aircraft models
- Conduct laboratory analysis on candidate fuels and lubricating oils

FY 2023 Program Descriptions
Environment and Energy

Program Description:

The FAA's long-term vision is to remove environmental constraints on aviation growth by achieving quiet, clean, and efficient air transportation. This program supports this vision by advancing our 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 aviation. 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 $11 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). Concerns about the impacts of aircraft emissions on climate change could limit the growth of international aviation. 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. This research supports the Administration's vision as outlined in Executive Order 14008 to put the United States on a path to achieve net-zero carbon dioxide emissions, economy-wide, by no later than 2050. The research in this budget line item also addresses local environmental concerns that are a result of aviation noise and emissions that impact local air quality. This includes the need for environmental justice in line with Executive Order 12898. This program's research efforts support the development of technological innovations for the current fleet of aircraft that will mitigate climate change and address local environmental concerns. Furthermore, the program will coordinate efforts with federal partners to ensure that knowledge is shared broadly thus increasing the benefits provided by the supported efforts.

Anticipated Program Activities:

- Expand the scientific understanding of the impacts of aircraft noise on communities and aviation emissions on air quality and climate change

- Develop the methodologies and data necessary to enable industry to design aircraft technologies with reduced noise and emissions
- Continue the development of analytical tools for noise and emissions modeling, noise screening for environmental compliance, and fleet and operations scenarios forecasting
- Provide the data and analysis necessary to support the development of international environmental standards
- Develop advanced operational procedural concepts that could reduce community noise exposure while maintaining safe flight operations and providing guidance for air space planners on how these concepts could be incorporated
- Develop a decision support tool to enable industry to mitigate the climate impacts of contrails and aviation-induced cloudiness

FY 2023 Program Descriptions
NextGen – Environmental Research: Aircraft Technologies and Fuels

Program Description:

The NextGen Environmental Research – Aircraft Technologies and Fuels Project supports efforts to develop new aircraft and engine technologies, and advance sustainable aviation fuels in line with the Administration's commitments on climate change and the environment. Technologies developed by this program will result in a fleet of aircraft that have lower noise, use less fuel, and produce fewer emissions. This program also provides test data, analyses, and methodologies to support the development and deployment of sustainable aviation fuels. Funds from this program ensure novel jet fuels are drop-in compatible with today's fleet of aircraft and are certified as being safe for use. They also ensure that sustainable aviation fuels, produced from renewable and waste feedstocks, and lower carbon aviation fuels, produced from fossil feedstocks, are appropriately credited under the International Civil Aviation Organization (ICAO) Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA).

Through the Continuous Lower Energy Emissions and Noise (CLEEN) program,[4] which is supported by this project, 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. Technologies accelerated by the CLEEN program have relatively large technological risk. Government resources help mitigate this risk and incentivize aviation manufacturers to invest in developing these technologies. By cost sharing the development with the FAA, industry is willing to accept the greater risk. Once entered into service, the CLEEN technologies will produce noise, fuel burn, and emissions benefits throughout the fleet for years to come. The FAA is currently standing up the third five-year phase of the CLEEN Program and expects to make a press release in 2021.

Funding from this program also supports efforts by ASCENT — the FAA's Center of Excellence (COE) for Alternative Jet Fuels and Environment — to develop innovative technological solutions to reduce noise, emissions, and fuel burn from subsonic and supersonic aircraft. Aircraft technology development projects under ASCENT complement the CLEEN Program's industry partnership approach by providing a venue for university-led research to expand knowledge broadly across the industry and develop technologies at all levels of maturity that will reduce noise, emissions, and fuel burn. The program also provides funding for alternative jet fuel testing and analysis efforts by ASCENT. This cooperative aviation research organization is co-led by Washington State University and Massachusetts Institute of Technology.[5]

This program also supports the Commercial Aviation Alternative Fuels Initiative (CAAFI) in its effort to engage with commercial aviation and emerging alternative fuels industries
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 and sustainable aviation fuels that collectively will 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.

[4] For more information on the CLEEN Program, please see http://faa.gov/go/cleen
[5] For more on the ASCENT COE, please see http://ascent.aero

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 and sustainable aviation fuels this program helps to remove environmental constraints on aviation growth by achieving quiet, clean, and efficient air transportation.

Anticipated Program Activities:

- Develop aircraft and engine technologies, as well as sustainable aviation fuels for subsonic and supersonic aircraft through the CLEEN program that reduce noise and emissions while increasing fuel efficiency
- Evaluate innovative technological solutions to reduce noise, emissions, and fuel burn from subsonic and supersonic aircraft through ASCENT
- Through ASCENT and CAAFI, identify barriers to the use of sustainable aviation fuels by the aviation industry and work across the U.S. government and with industry to overcome these barriers
- Support the inclusion of sustainable aviation fuels created from waste and renewable feedstocks, and lower carbon aviation fuels created from fossil feedstocks, within the ICAO CORSIA framework
- Support the approval of novel jet fuel pathways within the ASTM International certification process through testing and coordination to ensure these fuels are safe for use

FY 2023 Program Descriptions
Aviation Climate Research

Program Description:

The Aviation Climate Research (ACR) Program invests in high-risk, accelerated research that has transformative impact potential to reduce greenhouse gas emissions from aviation in support of the 2030 and 2050 U.S. climate change goals. This program will be executed in coordination with the new Advanced Research Projects Agency for Climate (ARPA-C) that will be located within the Department of Energy.

Program Objectives:

The program will enhance and accelerate research in the areas of sustainable aviation fuels for jet engines, unleaded fuel alternatives for piston-engine aircraft, and alternate aircraft technologies including electric propulsion. More specifically, the program will support the development of sustainable aviation fuels that could be used in jet engines without blending with conventional petroleum-based jet fuel, evaluate aviation fuel supply chains to reduce the cost to produce sustainable aviation fuels and maximize their environmental benefits, and accelerate the identification of safe alternatives to leaded aviation fuel. Additionally, the program will support the accelerated development of fuel efficient, low-emissions aircraft technologies, including electric propulsion, and support collaborative research in the areas of climate adaptation and resilience.

To ensure the work can be done in an expedited manner, the work will enhance essential laboratory capabilities and build on existing research partnerships that the FAA has established with academia and industry such as the Aviation Sustainability Center of Excellence (ASCENT), the Commercial Aviation Alternative Fuels Initiative (CAAFI), the Piston Aviation Fuels Initiative (PAFI), and the Continuous Lower Energy Emissions and Noise (CLEEN) Program. The extended research enabled by this program will be coordinated with air transportation stakeholders in industry and academia and with partner federal agencies including the Department of Energy and U.S. Department of Agriculture.

The FAA intends for the ACR Program Management Plan to focus on the following:

- Conducting a new five-year phase of the CLEEN Program that would focus on accelerating the development of technologies that could have a transformative impact in reducing climate impacts from the commercial fleet of aircraft. These technologies could also have benefits in terms of reducing noise and emissions that impact air quality.
- Start a coordinated multi-year effort across ASCENT, CLEEN and CAAFI to develop and test sustainable aviation fuels that could be used in jet engines without blending with conventional petroleum-based jet fuel
- Evaluate aviation fuel supply chains within ASCENT to reduce the cost to produce sustainable aviation fuels and maximize their environmental benefits
- Examine potential replacements for leaded aviation gasoline through PAFI and the development of low-emissions aircraft technologies, including electric propulsion, which could be used in the general aviation fleet.
- The program will also support development of capabilities that exploit and leverage weather information to improve aviation efficiencies, reduce fuel use, and reduce greenhouse gas emissions.

Anticipated Program Activities:

- Execute research initiatives contained in the Program Management Plan in coordination with ARPA-C other agency partners

Human and Aeromedical Factors

FY 2023 Program Descriptions
Flight Deck/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 2023, five 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.

The fourth area is *Human Factors Considerations and Emerging Trends Associated with Helicopter Air Ambulance Operations*. This research will provide information that can be used to enhance the FAA's understanding of current industry risks and emerging issues and trends, reduce the number of accidents and incidents attributable to human factors considerations, improve strategies and procedures for controlling risks, and enable the development of fatigue risk measures that will inform improvements in the strategic use of rest facilities, fitness for duty requirements, and scheduling practices.

The fifth is to address proposed research directed by Congress in H.R. 133, Consolidated Appropriations Act, 2021, Division V. Aircraft Certification, Safety, and Accountability.

Anticipated Program Activities:

- Advances and Innovation in Equipment, Technology, Systems, and Operations
- Advanced Vision Systems
- Long Haul (LH)/Ultra-long-range (ULR) Flight Operations Study
- Helicopter Air Ambulance Operations

FY 2023 Program Descriptions
Air Traffic Control/Technical Operations Human Factors

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 technical sponsors. The program addressed human factors and training challenges through targeted research that yields an understanding of human performance, and those factors that contribute to facility-specific impacts, especially for high-impact facilities. In the training domain, the program conducts research to evaluate the effectiveness of realistic simulation capabilities that provide a medium for training complex task performance where Air Traffic Control (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. 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 (NAS). 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 are managed within the ATO Program Management Office (PMO), this program will focus on integration of human factors considerations to enhance user-system design. Human performance research will contribute to enhancing the overall system's performance, reducing errors, and helping reduce life cycle ownership costs. The program, through the FAA's PMO coordination, provides human factors R&D results that support the development and implementation of new technologies and procedures in the NAS. 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 Activities:

- Mitigate Controller Fatigue Effects from Workload
- Improve Human-Automation Teaming
- Compare Training Effectiveness of Various ATC Training Technologies and Methods

FY 2023 Program Descriptions
Aeromedical Research

Program Description:

The Aeromedical Research Program focuses on safety sensitive personnel and airline passenger health, safety, and performance in current and forecasted future civilian aerospace operations. The program performs aerospace-relevant applied research in the biomedical, biodynamics and survivability/cabin safety sciences. This research culminates in the transition of knowledge and technology to enable innovation in aerospace operations and mitigation and prevention of aeromedical hazards associated with aerospace mishaps.

Program Objectives:

This program will support improvements in the safety of passenger cabin environments during routine flight operations by focusing on detection of cabin events from bleed air contamination, transmission of infectious respiratory diseases of potential public health concern, and radiation exposure from extreme space weather events. Additionally, the program will support improvements in the safety of pilots by focusing on development of new approaches to aeromedical risk computation for certification decision-making and biomarker-based methods for detection of fatigue and drug use. Lastly, the program will support improvements in aircraft survivability and innovation in aircraft design by enhancing passenger safety during adverse events and streamlining the certification process for safety equipment and cabin designs.

Anticipated Program Activities:

- Fatigue Biomarker Panel: Identifying a Metric for Performance Impairment from Sleep Loss
- Precision-based, Data-driven Aeromedical Standards: Next Generation Aeromedical Certification Safety Management System (SMS)
- Develop Safety Standards for Omnidirectional Seats to Support Urban Air Mobility/eVTOL
- Determine the Influence of Delta-wing Design on Egress Paths and Evacuation Efficiency for Supersonic Transports

Aerospace Performance and Planning

FY 2023 Program Descriptions
System Safety Management/Terminal Area Safety

Program Description:

The main goals of this program are 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.

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).

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.

Through these programs, 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 operational go-around problems; 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 the NTSB's Safety Recommendations such as A-07-003, A-04-62, A-07-64, and A-01-069.

Anticipated Program Activities:

- Evaluation of simulated air traffic control (ATC) using artificial intelligence (AI)
- Evaluation of virtual reality goggles for immersive flight simulation
- Develop Helicopter Enhanced Flight Vision Systems (H-EFVS)
- Develop predictive analytics to recognize safety patterns and characterize risk exposure of changing Aeronautical Information Services systems and processes
- Develop data mining techniques to fulfil the analytical needs of Integrated Safety Assessment Model (ISAM)

FY 2023 Program Descriptions
Commercial Space Transportation

Program Description

Commercial space transportation (CST) research focuses on four priorities that 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 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 2023 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:

- Explosive Yield Research Project
- Orbital Spaceflight Participant Research
- Innovation Foresight Research Project

FY 2023 Program Descriptions
NextGen – Wake Turbulence

Program Description

This program provides aircraft generated wake turbulence research that matures wake mitigation operational concepts to the point that they can be directly implemented by FAA orders and enter the FAA Facilities and Equipment (F&E) development and implementation process to meet National Airspace System (NAS) infrastructure enhancement requirements. This program supports the NextGen objective to accommodate increased demand (flights) during peak demand periods. The program provides increased access to airport runways and airspace through modifications to Air Traffic Control (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 prior to these aircraft entering service into the NAS. This project continues to determine wake separations to be applied to manufacturers' newly developed aircraft that will be entering the NAS and continues to address new entrants such as large Unmanned Aircraft Systems (UAS). Without this work, the 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 that wake separation standards will play in NextGen 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 and departing 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 wake separations needed for new aircraft types entering the NAS
- Wake Mitigation Solutions and Associated Infrastructure Modification Recommendations
- Collect and analyze ground-based wake track data
- Assess proposed changes to ATC procedures for wake encounter risk to include the finalized RECAT terminal area dynamic wake separation solution: Among others, RECAT Dynamic Wake 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 2023 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:

- Conduct Science Technology Engineering and Math (STEM) Outreach to Minority K-12 Students Using Unmanned Aircraft Systems (UAS) as a Learning Platform
- Evaluate UAS Disaster Preparedness and Emergency Response Operations
- Explore the Impact of Lost Link (when the pilot in command loses the communications link with the UAS aircraft)
- Assess the Challenges of Retrofitting Technologies for Urban Air Mobility (UAM)

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:

- Complete technical transfer to industry for a prototype cockpit-based taxi conformance monitoring system to reduce Runway Incursions at controlled airports
- Develop proof-of-concept that integrates cooperative surveillance and speech recognition technologies with advanced ground surveillance sensor technology
- Bi-annual assessment of aviation operational performance with Europe as well as the Asia-Pacific region
- Populate the Common Metrics dashboard which is a reporting tool that allows for joint review of FAA traffic management initiatives and airline performance outcomes and is a key component of FAA/airline engagement
- Develop and validate NAS level operational concepts that are key to the FAA NAS modernization efforts and understand the opportunities and challenges presented to the ATO as new concepts evolve
- Develop concepts of use to describe the operational use of proposed communication, navigation, automation, surveillance, and flight deck capabilities
- Infrastructure changes and analyses to determine airspace structure requirements in the Northeast Corridor
- Major airspace redesign work to support Louisville Standiford Field (SDF) and UPS operations to include infrastructure changes associated with communications outlets and additional positions at SDF TRACON
- Development of major airspace design changes in Caribbean Airspace on track for implementation in FY23. These changes are to align with FAA investment in spaced based ADS-B services in the region.

FY 2023 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 (NAS).

Anticipated Program Activities:

- Develop finalized requirements for adding the RECAT Dynamic Wake risk mitigation solution enhancements to ATC decision support tools
- Develop safety assessments of the finalized requirements for RECAT Dynamic Wake
- Provide EoR Pure Duals Concept Validation Report(s)
- Provide concept validation of implementing reductions for integrated arrivals/departures operations

FY 2023 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 (NAS). 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 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:

- Mobile Technologies - Demonstration wrap-up, industry engagements, and technology interchange package
- Improvement of departure demand predictions through collection of strategic departure intent information and machine learning methods
- Conduct validation activities for future TFM concepts, including the integration of new and emerging entrants in flow management activities
- Develop recommendations report on lessons learned from the advanced automation learning/data mining capability prototyping activities
- Develop concept document for Artificial Intelligence in Traffic Flow Management

FY 2023 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 flight activities 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 flight deck negotiation concept and engineering activities, and conduct proof of concept exercise for FD CDM negotiation applications
- Develop flight deck clearance delivery application concept of use and engineering artifacts
- Develop concept for a resilient network beyond legacy systems and complete functional requirements for necessary automation and communication systems

FY 2023 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 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:

- Develop weather translation techniques for non-convective weather constraints, and weather advisory and collaborative lab experiments designed to explore ATM Weather Integration (AWI) concepts and capabilities
- Coordinate aviation weather issues with subject matter experts through Community of Interest (COI)
- Identify and conduct high-level assessment for candidate technologies suitable for an enterprise solution for automation systems in the NAS and produce a report
- Develop requirements for hardware application and link performance requirements to support the potential use of internet-based data exchange for command and control applications
- Develop initial safety risk management model to assess the use of AI in controller decision support tools
- Develop initial performance requirements for a ubiquitous communications framework

FY 2023 Program Descriptions
NextGen Support Portfolio

Program Description:

The NextGen Support Portfolio provides the NAS laboratory environments required to evaluate, mature, and validate the broad framework of NextGen concepts, technologies, operational functions, and systems before they are introduced into the NAS. This program provides the evaluation platforms at the NextGen Integration and Evaluation Capability (NIEC) and Florida NextGen Test Bed (FTB). These labs facilitate the conduct of NextGen concept demonstrations using research NAS environments without affecting actual National Airspace System (NAS) operations.

The NextGen Support Portfolio funding is used to continue laboratory operations in support of on-going NextGen Programs and to enhance existing NIEC and FTB lab capabilities as required to support the development and evaluation of advanced capabilities associated with evolving NextGen operational improvements and implementation plans.

Program Objectives:

This program supports the DOT's Strategic Goal of Innovation by providing targeted research and development within the FAA that will lead to new technology development and deployment in the NAS. Data generated by this program will allow for the assessment of regulatory approaches, foster information sharing and facilitate coordination and collaboration with industry and other stakeholders. Most importantly this program facilitates the testing and adoption of new technologies throughout the NAS.

Anticipated Program Activities:

- Provide infrastructure enhancements for NAS modernization research, engineering, development and validation exercises (e.g., Trajectory Based Operations, UAS Traffic Management and Advanced Air Mobility Beyond Visual Line of Site (AAM BNE)
- Provide necessary licenses, maintenance agreements, and equipment of the laboratory
- Complete annual update of the NSIP including analysis of future NAS requirements for integrated enterprise-level planning

FY 2023 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 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 provide 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:

- Complete human factors assessment of automation enhancement concepts across domains
- Update TBO operational scenarios, incorporating knowledge obtained from related concept development efforts
- Develop operational scenarios for the seamless integration of xTM in the 2030-2035 timeframe
- Develop initial use cases for the evolution of current safety critical systems to a distributed architecture

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

Program Description:

Unmanned Aircraft Systems (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:

- Updating of Integrated UTM Data Exchange Requirements Version 3.0 (e.g., applications for identification and tracking).
- Developing Advanced Air Mobility (AAM) Beyond Visual Line of Sight (BVLOS) NAS Evaluation (BNE) Concept of Use Development (ConUse) Version 2.0

FY 2023 Program Descriptions
Emerging Technologies Accelerator

Program Description:

The Innovation and Emerging Technologies Program was established to foster emerging science, engineering, and technology advancements and align innovation with known and forecasted challenges and opportunities in the aviation industry.

Program Objectives:

The program aims to address air transportation safety and efficiency needs in the near and far term. It also addresses statutory requirements to invest in long-term research that better positions the agency to shape the air transportation system of the future.

Anticipated Program Activities:

- By 2023, issue up to five awards for innovation proposals responsive to high-priority aviation challenges
- By 2025, transfer initial research results and innovation outputs to early adopters and/or producers

FY 2023 Program Descriptions
Aviation Workforce Development – Section 625

Program Description:

The Aviation Workforce Development grant program will provide support to administer grants for eligible projects that educate, develop, and recruit aircraft pilots and an aviation maintenance technical workforce, as directed by Congress in Section 625 of the FAA Reauthorization Act of 2018.

Program Objectives:

Consistent with section 625, program eligibility and outreach will be aimed at communities underrepresented in the industry as well as economically disadvantaged geographic areas and thus support equity in transportation federal policy objectives.

Anticipated Program Activities:

- Provide grants to support education, recruitment, and development of aircraft pilots and aviation maintenance technicians

FY 2023 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's REDAC, this program facilitates an independent, expert review of the FAA's R&D portfolio that provides meaningful recommendations for the FAA to refine and improve its portfolio. This results in a more effective research program that will benefit the public by making aviation safer and smarter and enhancing U.S. global leadership in aviation.

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 2023 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 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:

- 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.
- 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 2023 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 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

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