U.S. Department
of Transportation
**Federal Aviation
Administration**

Office of the Administrator

800 Independence Ave., S.W.
Washington, DC 20591

August 15, 2022

The Honorable Maria Cantwell
Chair
Committee on Commerce, Science, and Transportation
United States Senate
Washington, DC 20510

Dear Chair Cantwell:

I am pleased to transmit the Federal Aviation Administration's (FAA) National Aviation Research Plan (NARP) Fiscal Years (FY) 2022–2026, as required by 49 U.S.C. § 44501(c). The plan conforms to the Government Performance and Results Act.

The FAA's NARP highlights and reports annually on the agencies applied Research and Development (R&D) as defined by the Office of Management and Budget (OMB) Circular A-11. The plan aligns with the U.S. Department of Transportation Strategic Goals and supports guidance issued by OMB and the Office of Science and Technology.

The NARP describes research deemed necessary to ensure the continued capacity, safety, and efficiency of aviation in the United States. As required by code, the NARP identifies goals, objective priorities, funding estimates, research governance practices, and technology transfer activities. The FAA R&D strategy includes funding programs in either of three budgetary accounts: Research, Engineering, and Development; Facilities and Equipment; and the Airport Improvement Program.

I am also pleased to transmit the FAA's FY 2020 R&D Annual Review, a congressionally required companion document to the NARP.

Identical letters have been sent to Chair Johnson, Ranking Members Wicker and Lucas.

Sincerely,

Billy Nolen
Acting Administrator

Enclosure

U.S. Department
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800 Independence Ave., S.W.
Washington, DC 20591

August 15, 2022

The Honorable Roger Wicker
Ranking Member
Committee on Commerce, Science, and Transportation
United States Senate
Washington, DC 20510

Dear Ranking Member Wicker:

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800 Independence Ave., S.W.
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August 15, 2022

The Honorable Eddie Bernice Johnson
Chair
Committee on Science, Space, and Technology
U.S. House of Representatives
Washington, DC 20515

Dear Chair Johnson:

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800 Independence Ave., S.W.
Washington, DC 20591

August 15, 2022

The Honorable Frank Lucas
Ranking Member
Committee on Science, Space, and Technology
U.S. House of Representatives
Washington, DC 20515

Dear Ranking Member Lucas:

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Federal Aviation Administration

National Aviation Research Plan (NARP) FY 2022–2026

January 2022

Report of the Federal Aviation Administration (FAA) to the United States Congress pursuant to section 44501(c) of Title 49, United States Code

The NARP is available online at http://www.faa.gov/go/narp

"At the FAA, we make sure safety propels innovation, so that innovation can propel progress."

Steve Dickson
FAA Administrator

Message from the Administrator

Steve Dickson

The FAA is pleased to present the National Aviation Research Plan (NARP) for Fiscal Years 2022–2026.

Rapid innovation in aerospace is fundamentally transforming aviation. Aircraft manufacturers are contemplating a rebirth of supersonic civil aircraft, and aerospace companies are exploring ways to connect New York and Shanghai in under 40 minutes. Commercial space launch activity has increased tenfold in just a few years. In the unmanned sector, it's a pretty safe bet there are "first flights" of new applications every day.

More than ever, we need our researchers to continue finding creative solutions to complex aviation problems. To succeed, we must balance bold new ideas with tried and true safety considerations.

This has never been more true than over the past year, as we all faced uncertainty during the global pandemic. While the FAA experienced numerous challenges from COVID-19, our resilient and innovative workforce found new ways to continue research and development efforts and collaborate with our aviation stakeholders to carry the FAA mission forward.

Targeted research and development is critical to continuing modernization of the air traffic system, ensuring the safe integration of drones into the National Airspace System, facilitating the safe and efficient movement of an accelerating volume of passengers and cargo across this country and internationally, and much more.

When we take the energy and creativity of new-found industries, unconstrained by conventional aviation wisdom, and apply them to problems and opportunities in the public realm, the sky is the limit for what we can accomplish, that is, in a typical year at the FAA.

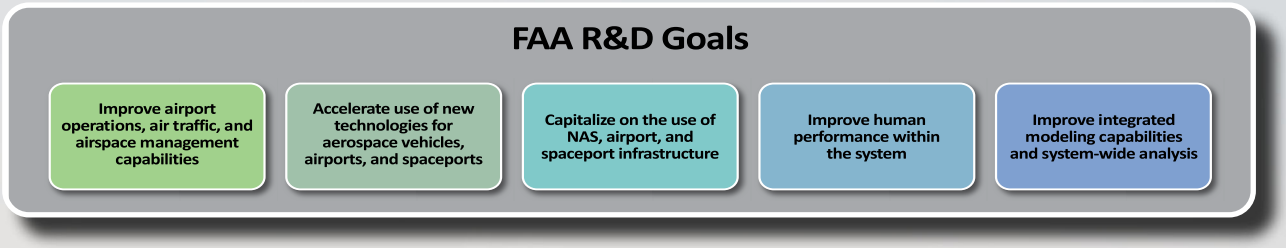
This research plan will outline how the work we're doing encourages innovation while keeping America's air traffic operations safe and efficient. It will show how we work with our partners to deliver research solutions that provide value to the American people. Our success depends on how well we collaborate with all of our stakeholders to address pressing issues like the safety and efficiency of airport surface operations and aircraft noise.

Day after day, our world-class scientists and engineers conduct cutting-edge research in FAA facilities. I invite you to read on to learn more about the part that FAA research plays in the support, maintenance, and evolution of American and global aviation.

Executive Summary

National Aviation Research Plan (NARP) Objective

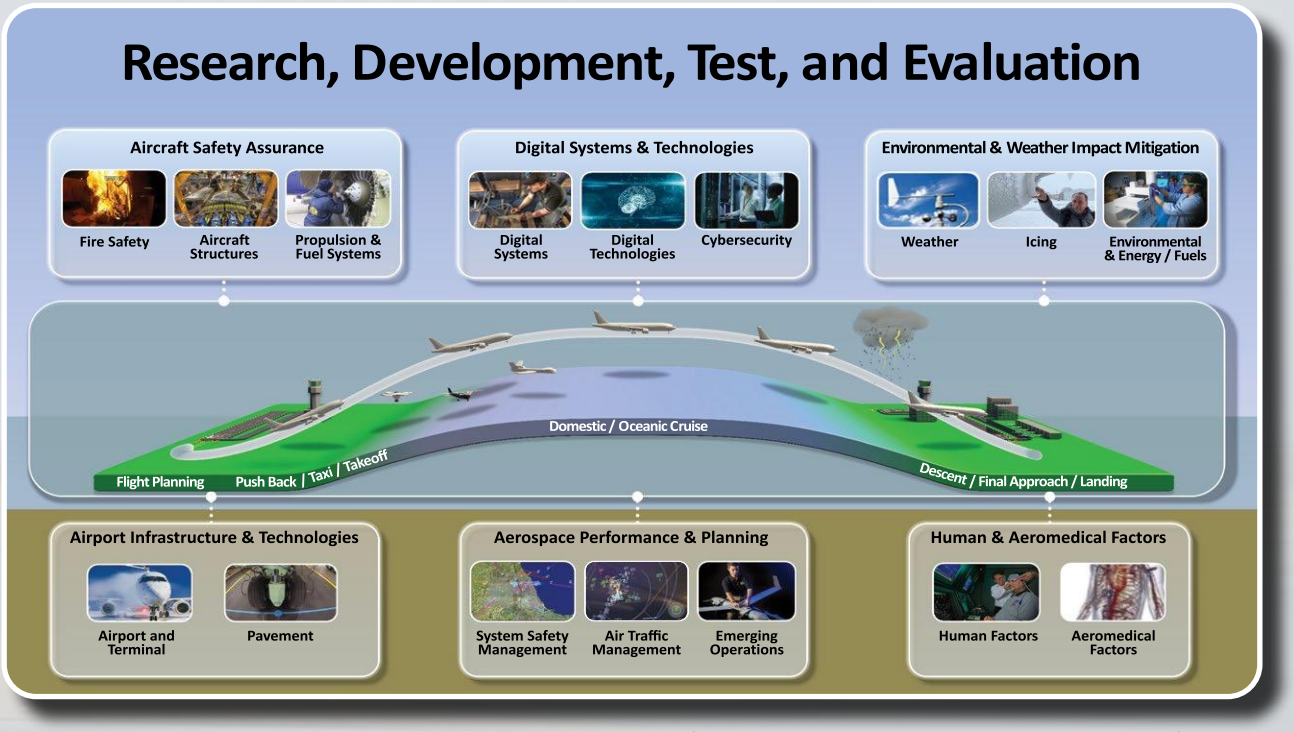
The NARP — a congressionally-required document — presents the FAA's research and development (R&D) goals, highlights planned research in support of each goal, and details how the FAA collaborates with other agencies, academia, and industry to best leverage each dollar of R&D funding.



Document Highlights

The NARP is divided into four sections. The first describes the importance of federally-funded R&D, and how research innovations benefit the national economy, the aerospace industry, the flying public, and the American tax payer. The second identifies the influences on FAA research goals and describes how the FAA structures its R&D to meet aerospace needs, giving highlights of past and expected results for select activities.

The next section outlines the FAA's R&D partnerships and collaborations with other agencies, academia, and industry. These include technology transfer initiatives, R&D partnerships, and external advisory committee interactions. The final section details projected funding over a five-year timeframe for each R&D program area.



This abstract graphic represents FAA research and development focus areas. White dotted lines indicate areas of impact before, during, and after flight. These connections are notional and not intended to be comprehensive.

Key Takeaways

FAA R&D fosters the creativity needed to provide safe, efficient, and environmentally-sound solutions beyond today's boundaries. FAA R&D also prioritizes the integration of advanced technologies, such as supersonic aircraft and unmanned aircraft systems, into the National Airspace System.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Contents

Participants wear headphones to listen for, and respond to, radio communication from air traffic controllers in the test environment at the FAA's terminal sequencing and spacing laboratory in Atlantic City, NJ.

1.0 Introduction

1.1 Introduction to the NARP

Section 44501(c) of title 49 of the U.S. Code requires annual submission of the National Aviation Research Plan (NARP) to Congress by the FAA Administrator with the President's Budget. The NARP describes how the FAA's investments in research and development (R&D), as defined by the Office of Management and Budget Circular A-11, address national aerospace priorities through rigorous management and delivery of results.

The document features an R&D framework that enables the FAA to address the current challenges of operating the safest, most efficient aerospace transportation system in the world while building a foundation for a future system with an environmentally sound approach.

The NARP provides a close-up view of a selection of the FAA's R&D priorities, which collectively support and drive innovation, represent areas of congressional or public interest, support near-term regulatory actions, and have global impact. The highlighted research areas are designed to produce results in support of the agency in:

- Developing a better understanding of technologies, so policy offices can craft minimum safety regulations and standards
- Standardizing approaches that industry can use to show compliance with safety regulations
- Developing strategies to evolve the National Airspace System (NAS) to accommodate increasing air traffic, expanding markets, and changing technologies.

The document details the FAA's R&D partnerships and collaborations with other agencies, academia, and industry. It focuses on how technology transfers out of the agency, the many ways the FAA partners with outside groups to maximize every R&D dollar invested, and the role of an external advisory committee.

The FAA funds R&D in three budgetary accounts: Research, Engineering, and Development (RE&D), Facilities and Equipment (F&E), and the Airport Improvement Program (AIP). FAA RE&D activities in these accounts ensure the continued capacity, safety, and efficiency of aerospace in the United States. The FAA R&D Funding Profile in Section 4.0 of the NARP describes the RE&D investment plan details for the five-year period from 2022 to 2026.

R&D Investments

In FY 2021, the FAA's R&D portfolio distributes $469 million across three budgetary accounts:

- ***$198 million for RE&D***
- ***$215 million for F&E***
- ***$56 million for AIP.***

1.2 Why FAA R&D Matters

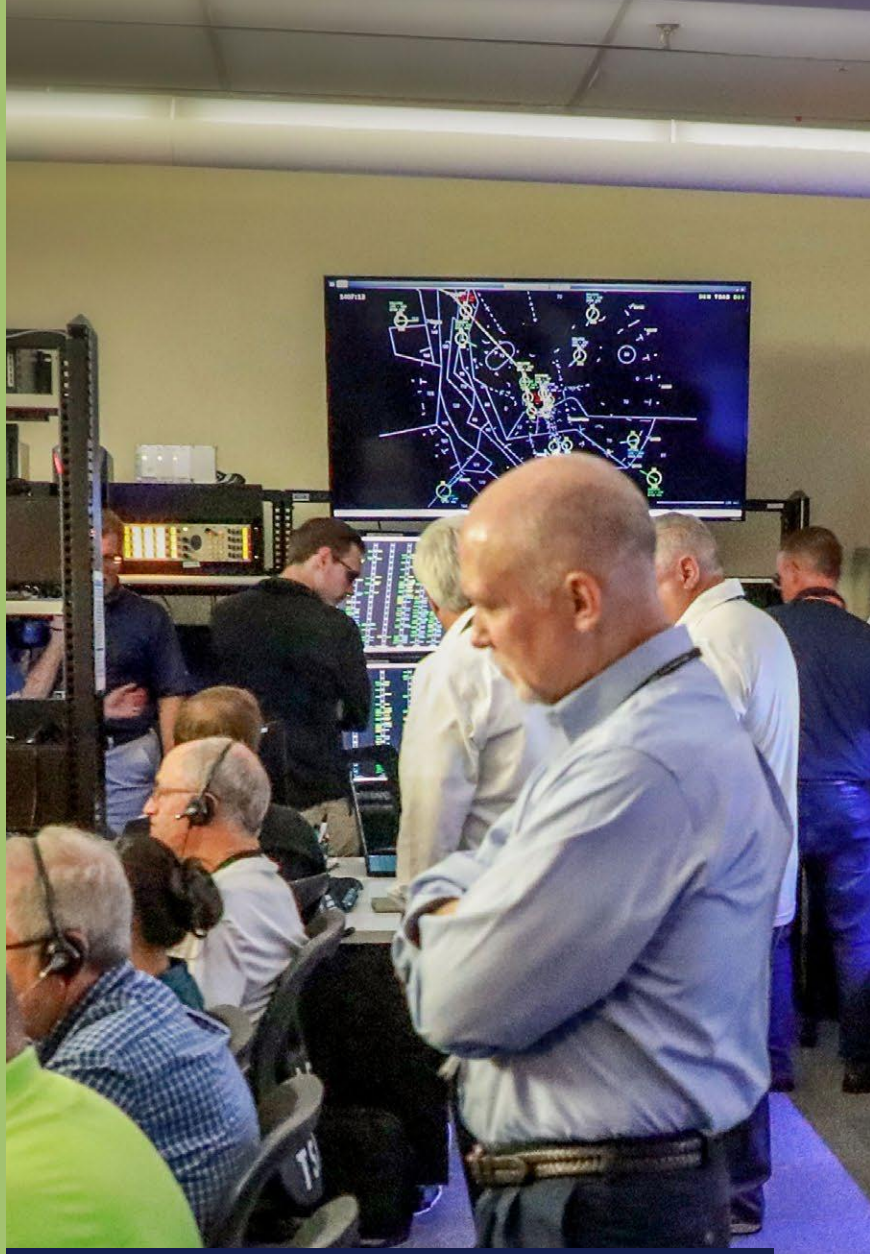
Research and development is the creative work undertaken on a systematic basis to increase the knowledge of man, culture, and society, and the use of this knowledge to devise new applications. FAA research is primarily applied R&D designed to help the FAA develop policies, regulations, certifications, guidance, and standards that increase safety and modernize the NAS.

Outputs of this R&D include:

- Provision of research data and analyses
- Evaluation and/or validation of requirements, procedures, and methods
- Production of useful materials, devices, systems, tools, and technologies.

R&D is critical to reinforcing the FAA's role as the world's premier aerospace body and is essential for the continued evolution of the NAS. It facilitates adapting to new safety issues and service demands resulting from increased activities of unmanned aircraft systems and commercial space flight, countering the growing cybersecurity threats from increasingly interconnected systems, and minimizing the impact of aerospace activities on the environment.

The FAA has a substantial positive impact on aviation and aerospace, and by extension, the United States. R&D enables industry to build upon this country's infrastructure and increase economic growth. It further contributes to American prosperity by enabling new technologies and industries, and creating American jobs.



The FAA's state-of-the-art research laboratories provide the unique research, development, and test and evaluation platforms necessary to conduct leading-edge research and meet mission critical program objectives.

Laboratory facilities exist in two locations, each offering separate and distinct capabilities that are the gateway for National Airspace System upgrades, improvements, and operational sustainment. The William J. Hughes Technical Center is located in Atlantic City, NJ. The Civil Aerospace Medical Institute and the Flight Research and Analysis Group are both located at the Mike Monroney Aeronautical Center in Oklahoma City, OK.

These laboratories were developed to provide the most value in meeting research and development program objectives and serve as a resource for government-industry partnerships. Collaboration internally and across federal agencies, academia, the U.S. military, and the aviation industry is important for sharing research and information, developing policy, and promoting best practices globally.

1.3 How FAA Research Enables Industry and Innovation

FAA research is focused on a core safety mission and prioritizes the integration of advanced technologies into the NAS. The agency fosters creativity and innovation by leveraging extensive in-house research expertise and agreements with federal, academic, industry, and international partners to promote technical innovation, technology transfer, as well as science, technology, engineering, and mathematics learning initiatives for students.

Among the primary agreements the FAA employs are interagency agreements, memoranda of agreement, centers of excellence (COE) and aviation research grants, Cooperative Research and Development Agreements, as well as international and other transaction agreements.

COEs in particular are well suited to stimulate economic innovation and growth by:

- Developing a highly trained workforce in very specific and advanced areas of research
- Maximizing innovation and information sharing through a stronger research community
- Increasing alignment with industry needs to stimulate and accelerate new product development and dissemination.

The agency also enables innovation by encouraging the transfer of federally-funded innovations for public and private use through its Technology Transfer program.

2.0 FAA Research & Development

2.1 Structuring FAA Research around Aerospace Needs

The FAA consistently strives to improve the planning, programming, and budgeting of the R&D portfolio; increase the return on taxpayer investment; enhance productivity; ensure the relevance, quality, and performance of the R&D portfolio; and develop a comprehensive view of the R&D required to support a vibrant aviation sector.

The FAA balances R&D investments between those that are strategic and those that are mission-oriented. Strategic investments include understanding and enabling emerging technologies and new business models, and addressing the changing needs of system users. Mission-oriented investments include agency priorities and continued FAA enhancements.

The FAA accomplishes this by leveraging internal senior management guidance and external advice and recommendations. The agency's R&D Executive Board (REB) provides an oversight approach to managing the R&D portfolio development process. The REB meets many times throughout the year to discuss and coordinate a well-balanced portfolio and make funding recommendations.

External stakeholder input to the FAA's R&D portfolio development is primarily received through the congressionally-mandated Research, Engineering, and Development Advisory Committee (REDAC). The committee 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. Section 3.3 provides additional information about the REDAC.

Enabling Commercial Space Exploration

Cutting-edge R&D supports the advancement of commercial space transportation operations. The FAA regulates all commercial space operations pertaining to launches, reentries, and their associated sites in the United States. During these operations, the FAA Office of Commercial Space Transportation simultaneously ensures the safety of the uninvolved public and their property, protects the many interests of the U.S. government, and encourages, facilitates, and promotes the commercial space transportation industry. To be successful, FAA R&D activities must keep pace with industry's rapid adoption of technological and operational innovations.

Through research, the FAA maintains its expertise and understanding of a complex commercial space sector and its role in advancing the U.S. economy amid increasing global competitiveness. Research supporting, or involved with, commercial space transportation enables the development of new, highly experimental, and innovative technologies.

Planned research activities align with recent regulatory changes, improving the FAA's understanding of policy, law, regulation, and market issues and trends, and using research outputs to augment the government's oversight responsibilities. Industry infrastructure research impacts the calculation of important parameters of regulator decision making, for example maximum probable loss for safe integration of spaceports, airports, and sea ports within different population centers. Human spaceflight operations research, such as the collection and analysis of human physiological response to hypersonic spaceflight, contributes to a risk-based approach to systemic safety knowledge.

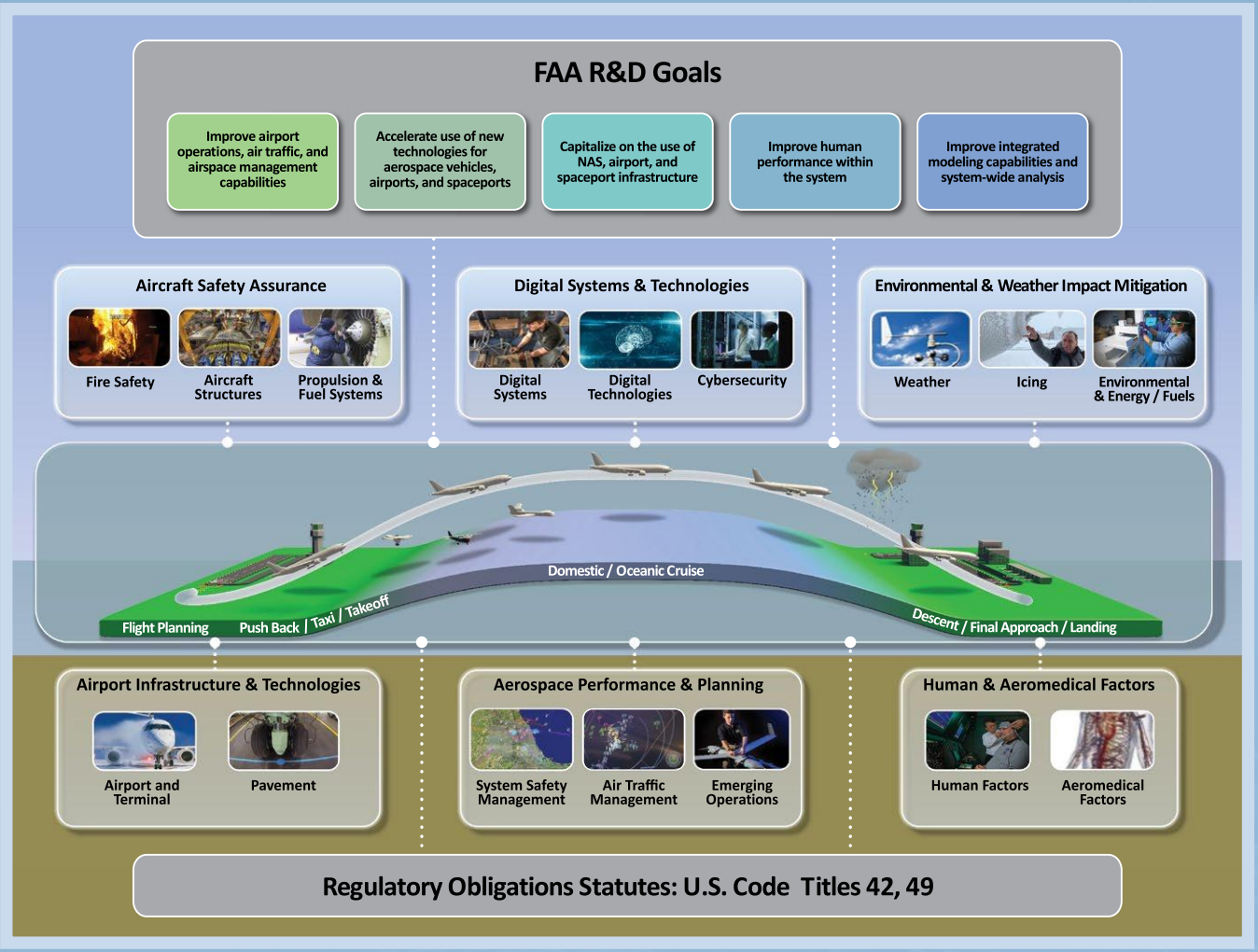
2.2 FAA R&D Framework

The FAA has developed research goals that support its multiple regulatory and operational mission areas, including NAS modernization, policymaking, regulation, certification, and standards development. FAA research focuses on identifying solutions for:

- Accelerating the use of new technologies
- Capitalizing on infrastructure use
- Improving human performance
- Improving integrated modeling and system-wide analysis
- Improving operations and management capabilities

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:

- Aerospace performance and planning
- Aircraft safety assurance
- Airport infrastructure and technologies
- Digital systems and technologies
- Environmental and weather impact mitigation
- Human and aeromedical factors



2.3 Research Highlights by R&D Goal

Information highlighted in the following sections represents significant FAA R&D work in each goal area. Although some of the featured research is considered long term, extending beyond 2026, the NARP focuses on a five-year timeframe.

Timelines below the research descriptions feature select tasks from that research, the timeframe in which the tasks are scheduled to occur, and the expected results of that work. Research drivers, outcomes, and partners are represented in the area around the timeline.

The highlighted research includes only a sample of specific activities and is not intended to represent or characterize the full breadth of the FAA's research portfolio. The timelines represent work currently planned but are subject to change as the agency's needs, resources, and research priorities evolve.

2.3.1 Goal 1: Improve airport operations, air traffic, and air space management capabilities

Key programs and initiatives:

Efficient airport operations, together with enhanced air traffic and airspace management capabilities, are key to maintaining the world's most complex airspace system. Research under this goal supports airport and spaceport systems/operations, air traffic management (ATM) in the air and on airport surfaces, integrated weather information, aerospace vehicle operations, and noise and emissions management.

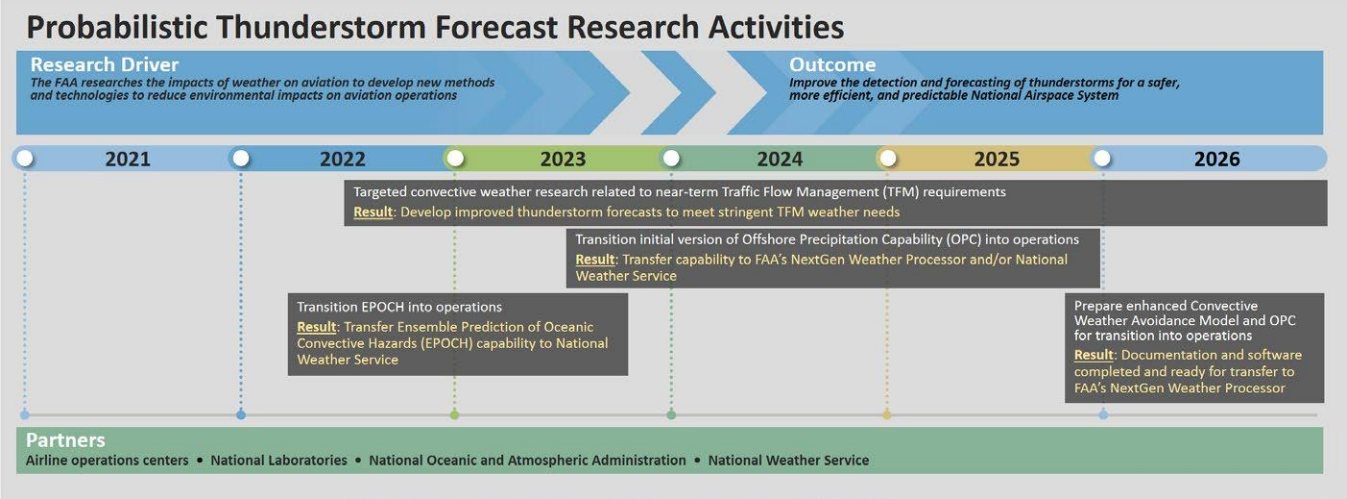
As the NAS continues to evolve, additional research, concept development, and validation are needed to reduce risk, and identify technical and operational requirements that will provide improved services to increase capacity, efficiency, system flexibility, and safety. In addition, this work will continue to integrate unmanned aircraft systems and space vehicles into the NAS.

To achieve this goal, the FAA will:

- Develop high-resolution and frequently-updated probabilistic thunderstorm forecasts
- Implement new capabilities to improve operations on the airport surface
- Evaluate the use of artificial intelligence and machine learning to improve traffic flow management operations by addressing system-wide demand and capacity imbalances
- Continue using wake turbulence recategorization to increase capacity during poor weather conditions
- Continue to explore concepts to increase airport capacity through reduced separation standards, expand applications of dependent and independent operations, and enable operations in lower-visibility conditions
- Continue to improve air traffic flow efficiency to and from airports by expanding the use of certain satellite-enabled navigation routes and procedures
- Develop and implement new support tools, technologies, standards, and guidance to improve ATM efficiency and effectiveness
- Conduct tests, evaluations, and demonstrations to advance and refine new weather information capabilities.

Weather Research Program

Develop High Resolution and Frequently Updated Probabilistic Thunderstorm Forecasts



Weather Program Highlight

Weather is the primary cause of flight delays in the NAS. Thunderstorms are a major contributor, especially in the summer months. Research will focus on developing an ability to offer a probability, in terms of a percentage, of whether a thunderstorm could occur in a specific location at a specific time.

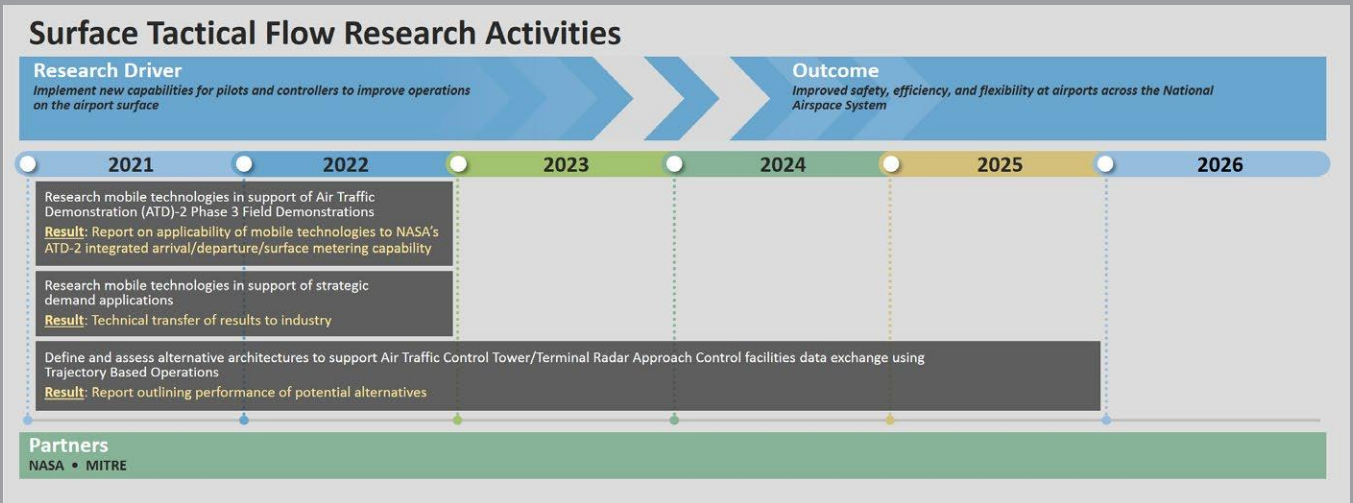
Better forecasts can help reduce delays, increase passenger safety and comfort, and keep the NAS running efficiently. Forecast modeling will be used nationwide but will be particularly helpful around the major hubs in New York City, Atlanta, and Chicago, where most delays originate. The program will also research ways to better translate forecast information so air traffic controllers, air carriers, pilots, and others can better integrate the information into their decision-making process.

FAA weather research is leading to better forecasts that can help reduce delays, increase passenger safety and comfort, and keep the National Airspace System running efficiently.

Traffic Flow Management Portfolio

Air traffic managers use Traffic Flow Management procedures and capabilities to control overall traffic flow across the country and alleviate disruptions to ensure safety, efficiency, and equity in air traffic services.

Surface Tactical Flow



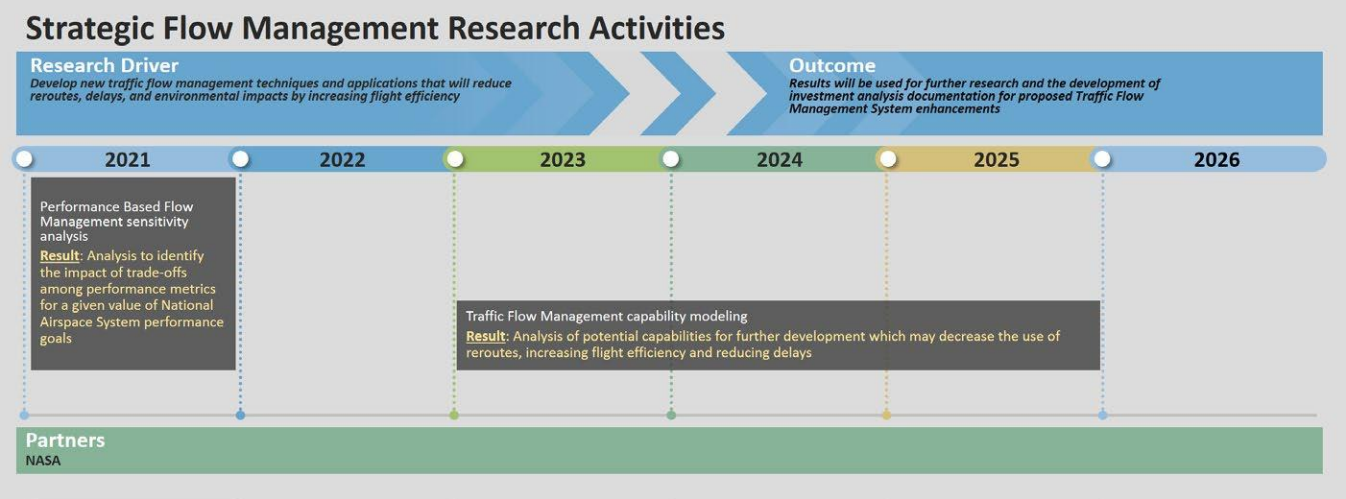
Traffic Flow Management Highlight

At most airports, aircraft departures are managed in the order in which they push back from the gate. This can overload runways and cause long taxi and hold times on the airport surface. Shifting some of the departure wait time from the taxiway — by holding aircraft longer at the gate — prevents long departure queues. This saves fuel, reduces emissions, and gives air carriers and passengers more flexibility prior to pushback. Precisely scheduling takeoffs to help aircraft better integrate into the overhead stream of air traffic increases NAS efficiency. Coordinating schedules between airport operators, air traffic controllers, and flight operators provides air traffic managers tools to make better decisions about how to reduce congestion.

Current research will focus on implementing new capabilities for pilots and controllers to improve surface operations. Benefits will include:

- Increased situational awareness
- Increased arrivals and departures
- Improved use of airspace and ground assets by integrating surface and airspace operations
- Decreased environmental impact through reduced taxi time and fuel usage.

Strategic Flow Management Application



Traffic Flow Management Highlight

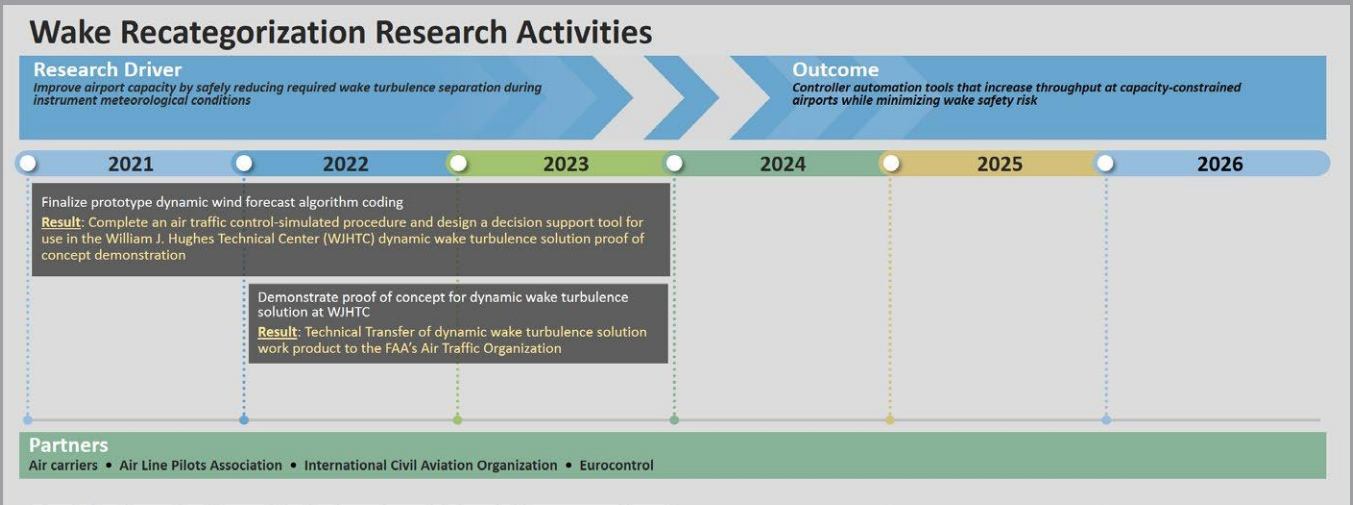
Air traffic managers often strategically reroute large numbers of aircraft to reduce congestion in a particular region of airspace. Reducing a bottleneck in one area of the country can reduce flight efficiency and increase delays in other parts of the NAS. Current research will identify ways to decrease the use of these large strategic reroutes.

The Strategic Flow Management Application (SFMA) program uses artificial intelligence and machine learning to help balance NAS-wide demand and capacity. SFMA provides automated, flight specific route options that take into consideration operator preferences, resources, potential weather impacts, and metering times — the timeframe in which an aircraft is instructed to arrive at a particular location. This helps air traffic managers prevent congestion, reduce unnecessary flying time, and improve the sequencing of aircraft to their destination.

Separation Management Portfolio

Separation Management improvements provide air traffic controllers with tools and procedures to safely reduce the required separation between aircraft with various types of navigation equipment and wake performance capabilities. Allowing aircraft to safely take off and land closer to each other can translate into improved NAS reliability and predictability, fewer delays, and less fuel burn.

Wake Turbulence Recategorization

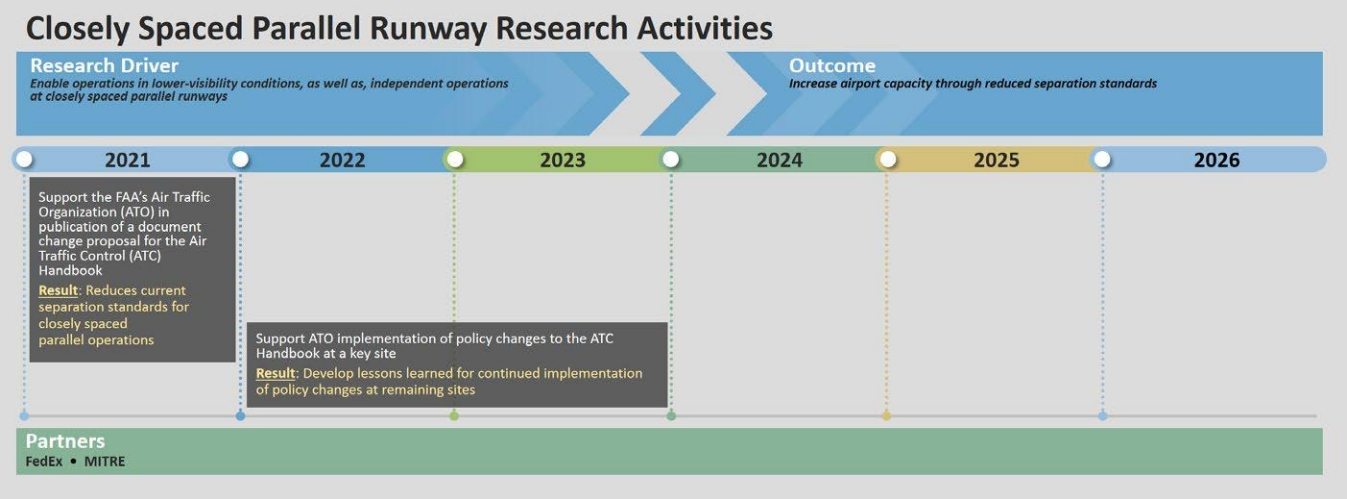


Separation Management Highlight

Wake turbulence, which forms vortices behind the wings of an aircraft as it passes through the air, can be hazardous to nearby aircraft. The bigger the aircraft, the bigger the wake. Air traffic controllers must space out aircraft so the wake from one plane does not impact others behind it. By recategorizing wake standards, the FAA has safely decreased the required separation between certain aircraft.

Current research will focus on using Wake Recategorization to increase capacity when poor weather or other conditions require instrument flight rules (IFR) procedures. This work will be used to develop standards, processes, and decision support tools for air traffic controllers, allowing them to increase takeoffs and landings at crowded airports. This would result in fewer flight delays and cancelations — and reduced inflight operating costs — while ensuring the safety of the aircraft, crew, passengers, and cargo.

Closely Spaced Parallel Runway Operations



Separation Management Highlight

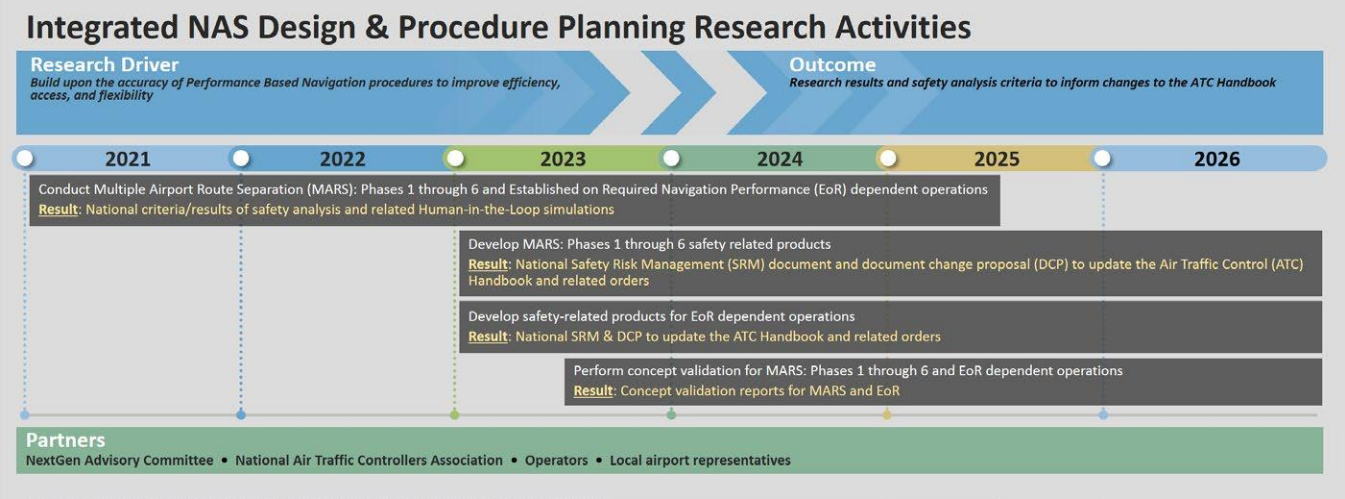
Airports are typically most efficient when the weather is clear and calm. Aircraft can take off and land at a steady pace using visual flight rules (VFR). This is not true when visibility deteriorates due to poor weather, which requires more restrictive IFR procedures. Improving closely spaced parallel runway operations (CSPO) — side-by-side runways spaced less than 4,300 feet apart laterally — has enabled the FAA to develop procedures and tools to increase airport arrivals and departures in all weather conditions. Current research continues to explore ways to increase takeoffs and landings by:

- Safely reducing aircraft separation
- Expanding applications for dependent operations, which are staggered aircraft arrivals and departures on parallel runways
- Increasing the use of independent operations, which occur when two aircraft arrive or depart side by side
- Enabling operations in lower-visibility conditions.

When VFR approaches are not possible due to low visibility, arrivals and departures at busy airports can still be significantly increased by using simultaneous independent CSPO. High-update rate surveillance, which uses Automatic Dependent Surveillance–Broadcast to more accurately display an aircraft's position, can reduce the separation standards required for these operations. Research in this area will result in updates to FAA Order JO 7110.65Y, known as the ATC Handbook, through a document change proposal.

Separation Management Portfolio (continued)

Integrated NAS Design and Procedure Planning



Separation Management Highlight

The FAA has established a network of thousands of precisely defined, satellite-enabled Performance Based Navigation (PBN) routes and procedures throughout the country to improve air traffic flow to and from airports through all phases of flight. Current research will build upon the success of PBN procedures at select airports, specifically Established on Required Navigation Performance (EoR) and Multiple Airport Route Separation (MARS).

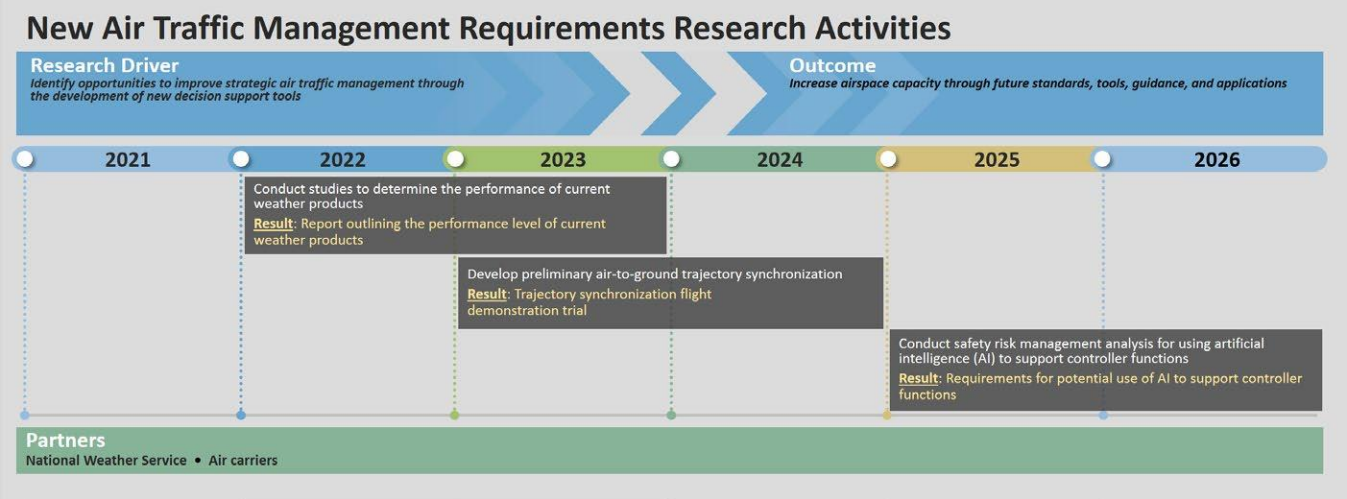
The EoR concept increases the use of procedures that allow planes to turn to align with the runway sooner, reducing passenger time, track miles, fuel burn, aircraft exhaust emissions, and noise while maintaining safety and capacity. While EoR is used at one airport, MARS extends the EoR concept to multiple airports in close proximity, increasing takeoffs and landings, and reducing congestion in the surrounding airspace.

Initially driven by industry priorities through the FAA's NextGen Advisory Committee to enhance air travel through Northeast Corridor, the new goal of the MARS research is to create national standards. This would allow more airports across the country to benefit from the concept. Safety analysis results and criteria will drive changes to the ATC Handbook, which will be updated with new separation standards as positive results are known.

NAS Infrastructure Portfolio

As technology evolves over time, the FAA researches, develops, and implements new support tools, technologies, standards, and guidance to improve ATM efficiency and effectiveness.

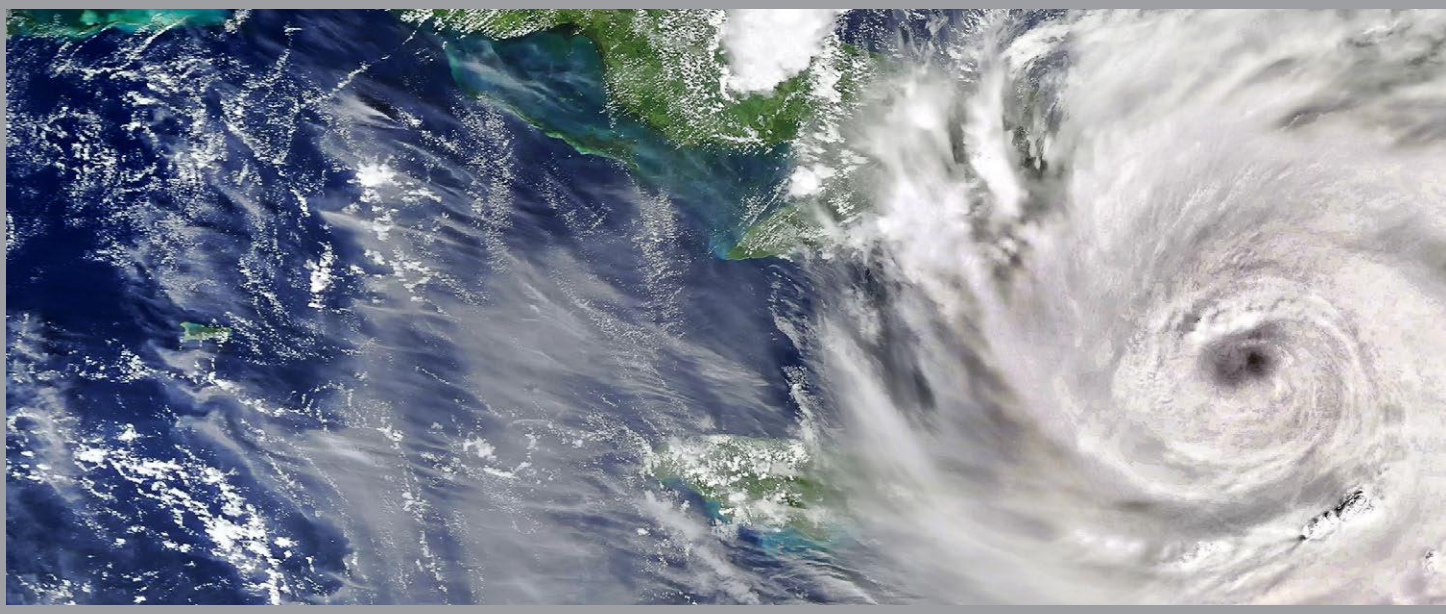
New Air Traffic Management Requirements



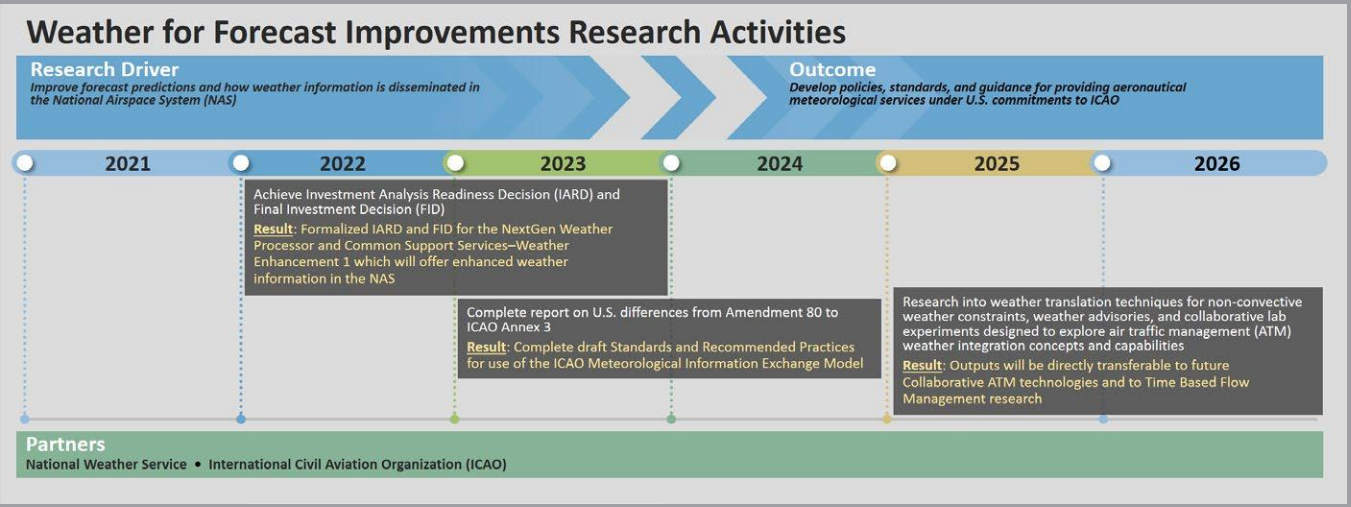
NAS Infrastructure Highlight

While air traffic control involves safely guiding aircraft to and from specific airports, ATM looks at air traffic from a nationwide perspective to balance air traffic demand with system capacity. The New ATM Requirements project is studying ways to integrate new and emerging technologies to enhance tools for strategically managing aircraft.

Research will evaluate the performance of current weather products used by air traffic managers, develop ways to better synchronize air-to-ground trajectory information, and study the use of artificial intelligence and machine learning to support air traffic control functions. Resulting operational improvements will increase the number of arrivals and departures at major airports.



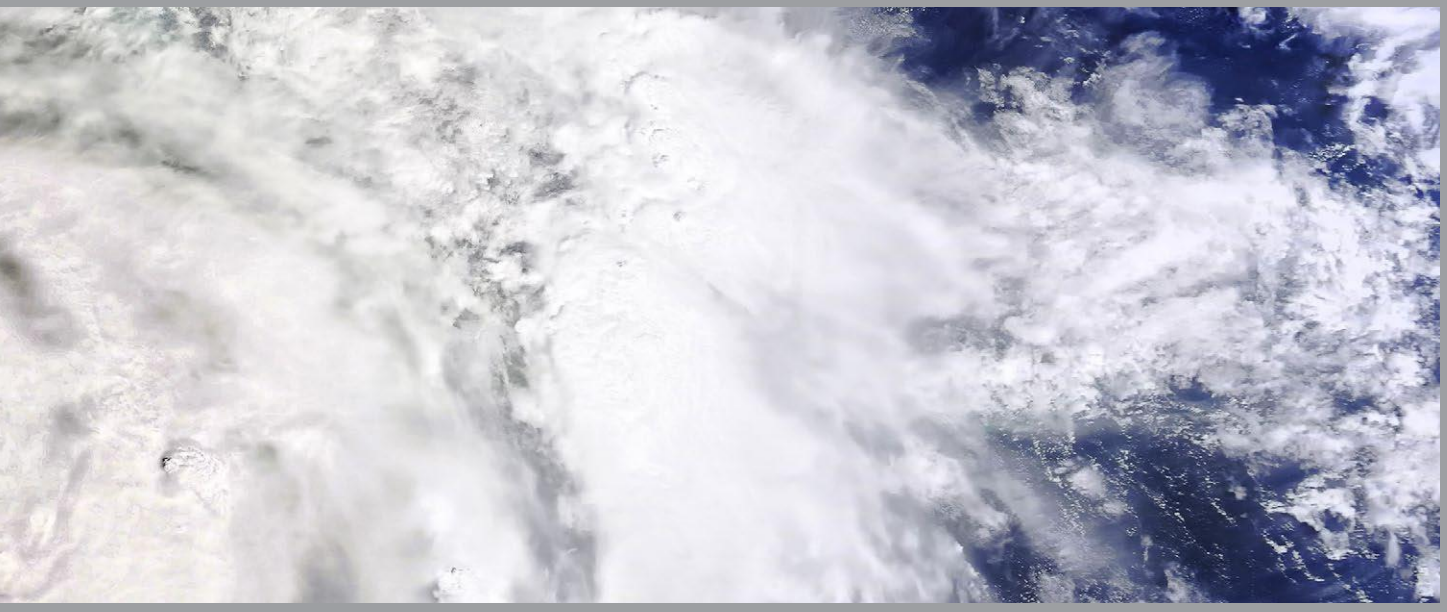
Weather for Forecast Improvements



NAS Infrastructure Highlight

Inclement weather, including thunderstorms, snowstorms, wind shear, icing, and fog can create potentially hazardous conditions and often results in reroutes, flight delays, and cancellations. Accurate weather forecasts help air traffic managers, operators, and pilots better plan for poor weather, increasing safety and reducing delays.

The Weather for Forecast Improvements project will study current tools available for obtaining aviation-related weather information and identify future needs for weather forecast information. The goal is to provide more accurate information to the cockpit, enabling flight crews to make more informed decisions. The program will conduct tests, evaluations, and demonstrations to develop new weather products and ensure they are ready for safe implementation in the NAS.



2.3.2 Goal 2: Accelerate use of new technologies for aerospace vehicles, airports, and spaceports

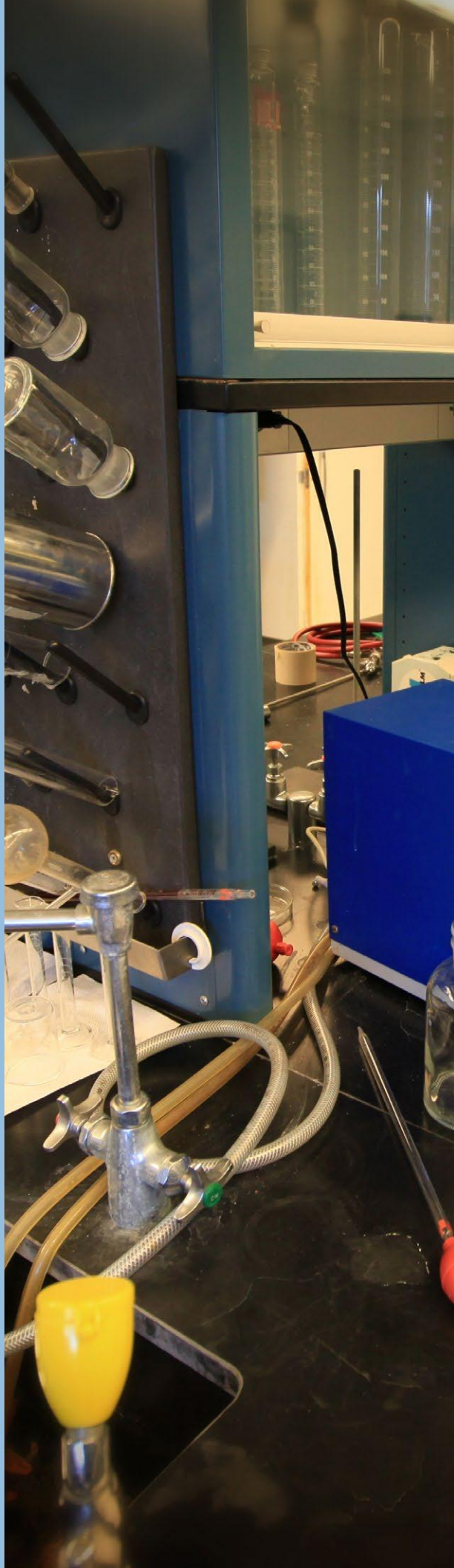
Key programs and initiatives:

The advancement and introduction of non-traditional aviation industries are pushing the boundaries of technology throughout the NAS. Research under this goal supports applied innovation that identifies and demonstrates new aerospace vehicle, airport, and spaceport technologies; certificating and licensing of aerospace operators and vehicles; the study of alternative fuels for General Aviation and civil aviation; and provides decision makers essential data and analysis to shape the future of the NAS.

As the introduction of new and emerging technologies continues, this research will yield a safer, more efficient NAS, with reduced environmental impacts. Long-term research will keep pace with continuously changing technology in order to properly certify operators and operations of the new industries, improve aircraft performance, and drive policy.

To achieve this goal, the FAA will:

- Study potential replacement fuels for the existing fleet of General Aviation aircraft
- Evaluate and demonstrate aircraft and engine technologies that can reduce aircraft noise and emissions while improving fuel efficiency; and conduct testing, analysis, and coordination activities to support the development and deployment of sustainable aviation fuels for gas turbine engines
- Examine environmental impacts of supersonic aircraft and advance technological solutions to support their reintroduction into the nation's aircraft fleet
- Identify ways to detect and stop unauthorized drone activity without interfering with flight operations
- Research ways to make it easier for emergency responders to incorporate the use of drones to enhance disaster preparedness and emergency response efforts.

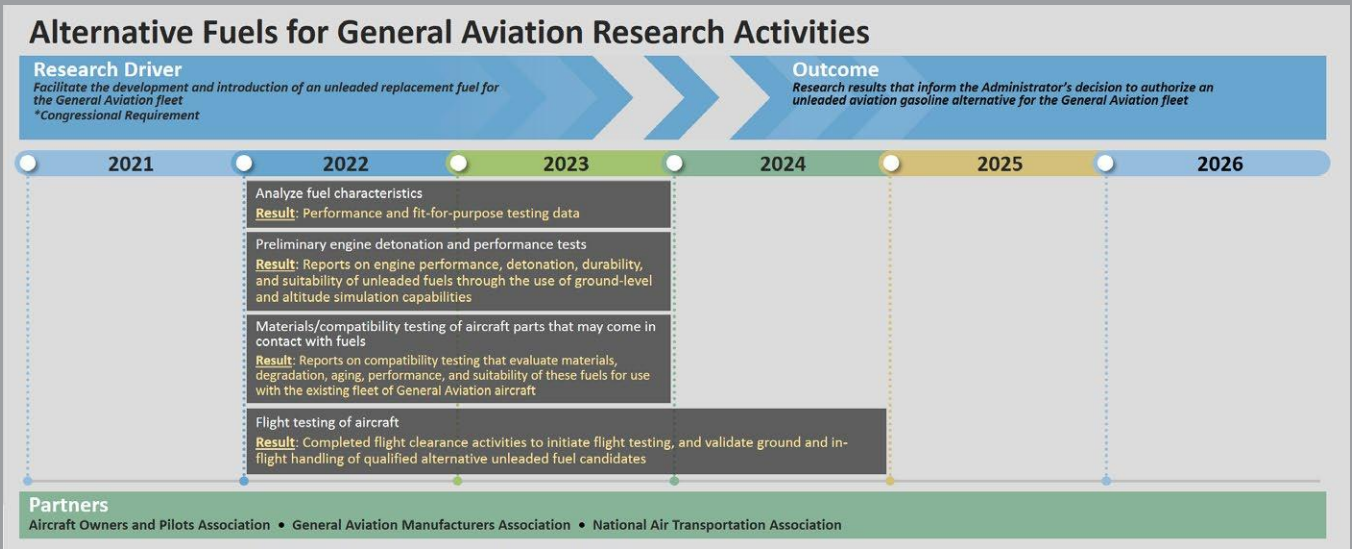


The FAA is researching potential replacement fuels for the leaded aviation gasoline currently used by the general aviation community. This work will provide critical data for the FAA Administrator to authorize an unleaded fuel replacement.

An FAA scientist at the William J. Hughes Technical Center in Atlantic City, NJ, performs testing as a part of the alternative fuels program.

Alternative Fuels for General Aviation

Alternative Fuels for General Aviation



Alternative Fuels for General Aviation Highlight

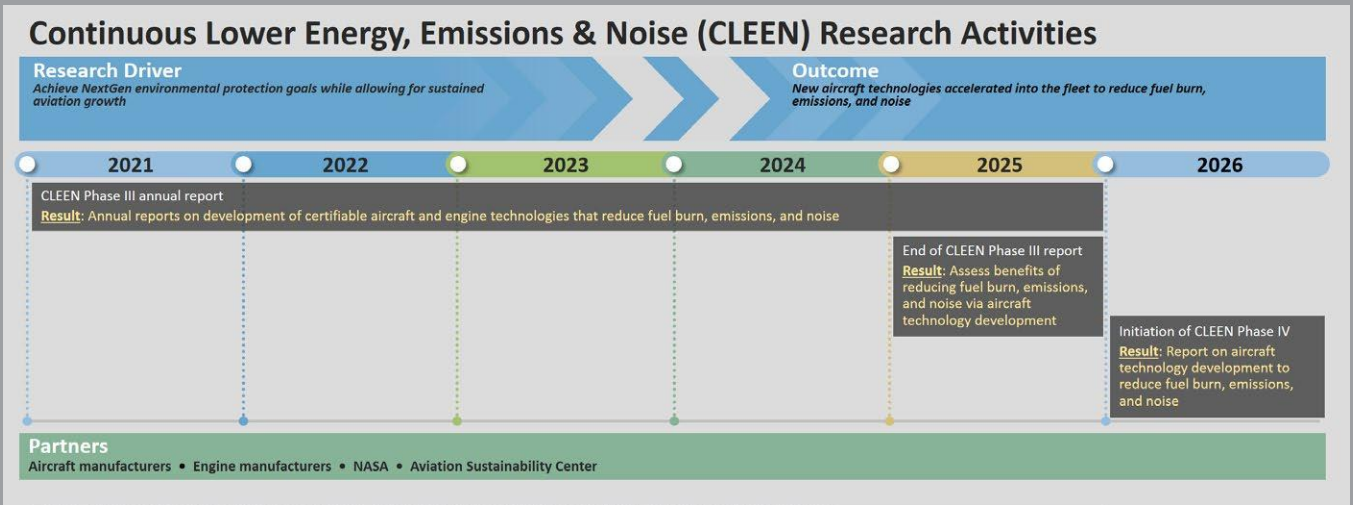
General Aviation supports 1.2 million jobs directly or indirectly, and contributes over $247 billion to the U.S. economy, including a $75 billion positive effect on the balance of trade (2018 figures). This economic benefit is at risk unless the fleet can safely transition to unleaded fuels. Aviation gasoline (avgas) is the only remaining transportation fuel in the United States that contains lead.

Over 170,000 piston-engine General Aviation aircraft currently in use rely on this fuel for safe operation. The lead additive in avgas creates the very high octane levels required to prevent detonation (engine knock) in high power aircraft engines. Operation of an aircraft with inadequate fuel octane can result in engine failure and aircraft accidents. The FAA is working closely with industry on research that will provide the critical data necessary for the FAA Administrator to authorize an unleaded replacement fuel in accordance with section 565 of the 2018 Reauthorization Act.

NextGen Environmental Research: Aircraft Technologies and Fuels

(In partnership with the broader Environment and Energy Portfolio)

Assess and Demonstrate Aircraft and Engine Technologies that Can Reduce Aircraft Noise and Emissions while Improving Fuel Efficiency



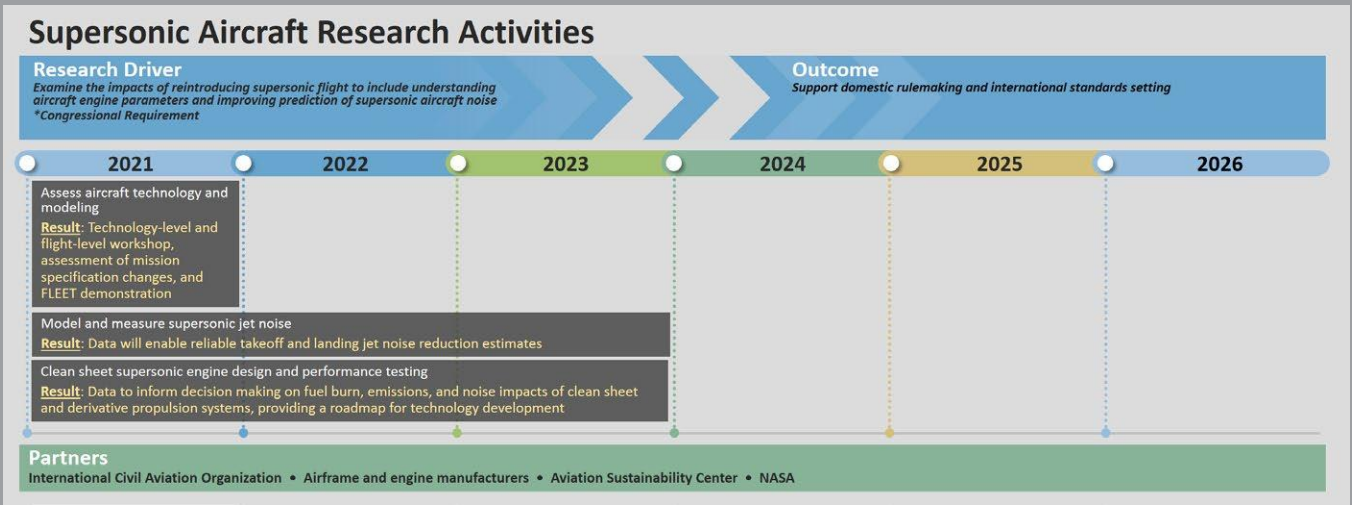
NextGen Environmental Highlight

Through the Continuous Lower Energy, Emissions, and Noise (CLEEN) program, the FAA is working with industry to develop certifiable aircraft and engine technologies that increase fuel efficiency, while reducing noise, emissions, and aircraft operating costs. CLEEN is a cost-share partnership with aviation manufacturers that helps accelerate environmentally beneficial technologies. These technology development efforts culminate in full-scale ground and flight test demonstrations, which ultimately support deployment of these technologies into the NAS.

The goal of CLEEN is to achieve environmental protection while allowing for sustained aviation growth. The program is implemented in five-year phases, each with specific improvement goals. In Phase III of the program, research is focusing on reducing certification noise levels, community noise, nitrous oxide and particulate matter emissions, and fuel burn for both subsonic and supersonic aircraft. Goals for Phase IV will be determined in the coming years.

Researchers in the CLEEN program are also working with the Commercial Aviation Alternative Fuels Initiative and the Alternative Jet Fuels and Environment (ASCENT) Center of Excellence to obtain critical information on sustainable aviation fuels to ensure they are safe for use. ASCENT researchers are also working closely with the FAA to ensure these fuels are being adequately credited under international emissions standards.

Supersonic Aircraft

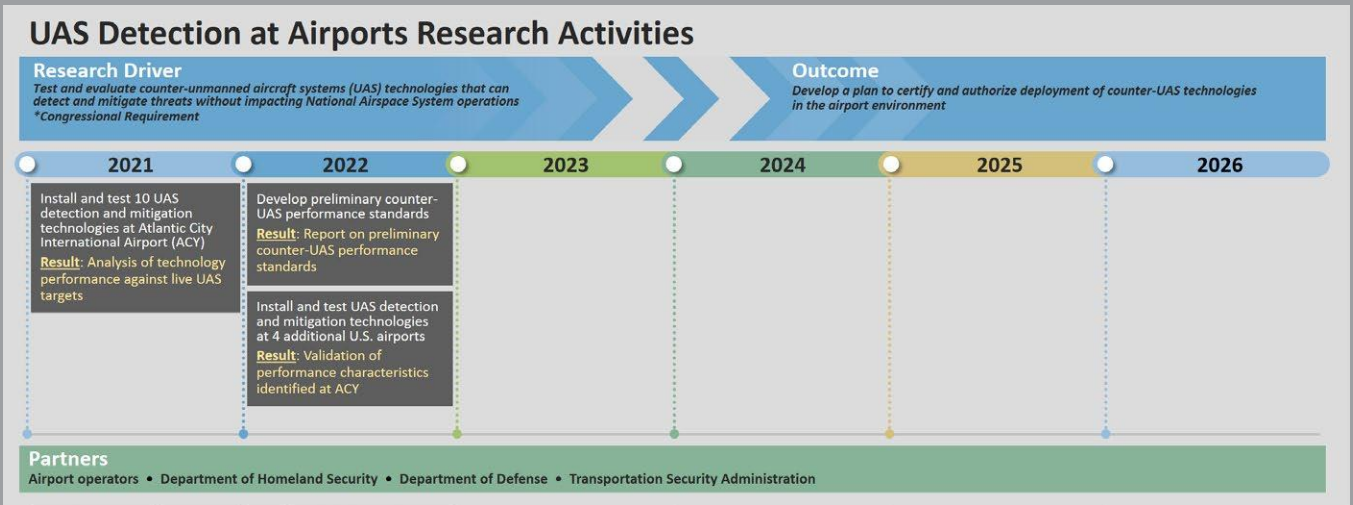


NextGen Environmental Highlight

Supersonic aircraft, which fly faster than the speed of sound, may one day allow passengers to spend more time at their destination and less time traveling there. The Department of Transportation and the FAA are taking steps to advance the development of civil supersonic aircraft. This research is critical to accelerating the reintroduction of these high-speed aircraft into the nation's fleet. Work examines the impacts of supersonic aircraft on environmental factors such as landing and takeoff noise, emmissions, fuel burn, and sonic booms. The FAA will use the research results to develop policies and international standards, and support the development of new technologies as directed by Congress in the FAA Reauthorization Act of 2018, section 181.

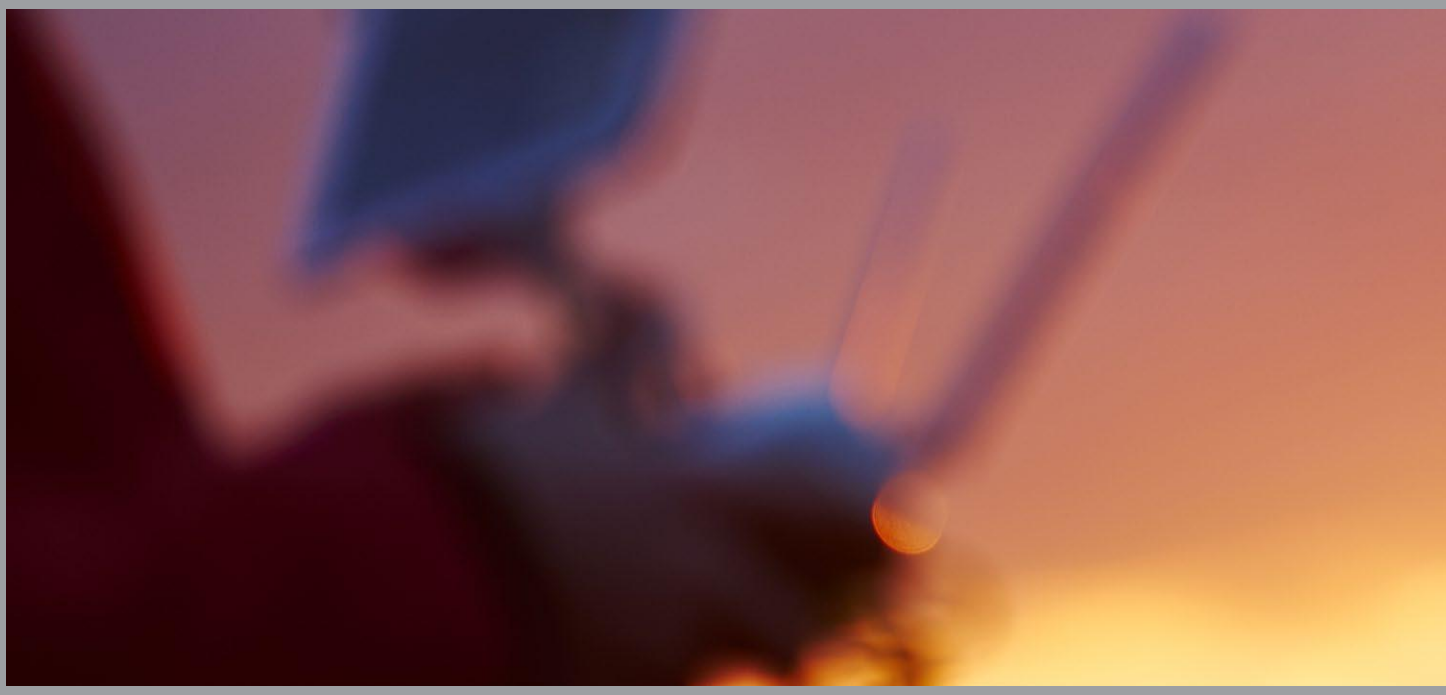
Unmanned Aircraft Systems (UAS)

UAS Detection at Airports

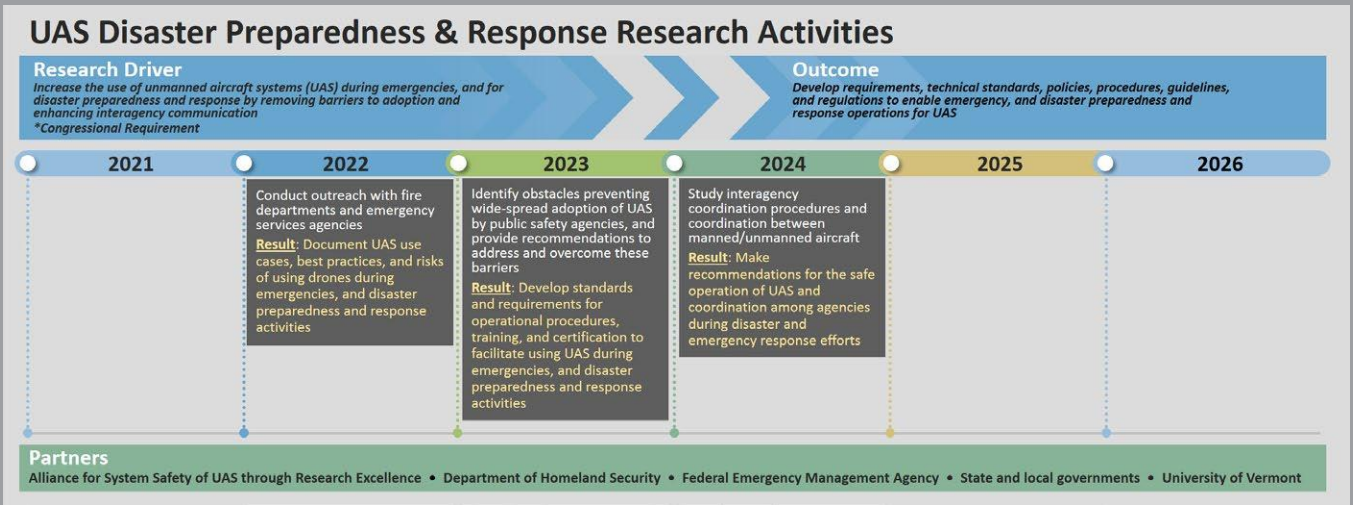


Unmanned Aircraft Systems Highlight

Detecting unauthorized UAS, or drone, activity at the nation's airports and removing that threat ensures the safety and security of the flying public. Research will identify regulations and standards — necessary for the safe use of counter-UAS technologies — that do not adversely impact or interfere with safe airport operations, air navigation, air traffic services, or the safe and efficient operation of the NAS, as directed by Congress in the FAA Reauthorization Act of 2018, section 383. The FAA will test drone detection and mitigation systems at five airports as part of this research.



UAS Disaster Preparedness and Response



Unmanned Aircraft Systems Highlight

The real-time capabilities and versatile functions of drones and their ability to deploy rapidly in emergencies make them a powerful tool for disaster preparedness and emergency response. Drones can improve these operations and help save lives.

Research will focus on creating procedures that help facilitate coordination between local, state, and federal government agencies, as well as airports, to ensure proper coordination during emergency situations. Specific emphasis will be given to studying UAS use by fire departments and emergency management agencies as directed by Congress in the Reauthorization Act of 2018, section 359, and the Omnibus Budgets of 2018 and 2019.

2.3.3 Goal 3: Capitalize on the use of NAS, airport, and spaceport infrastructure

Key programs and initiatives:

A durable, long-life, and resilient infrastructure forms the backbone of an efficient, safe, and secure NAS. Research in this goal includes airport runways, taxiways, air traffic management, and aircraft systems and networks, as well as electrical airport sub-infrastructures and lighting.

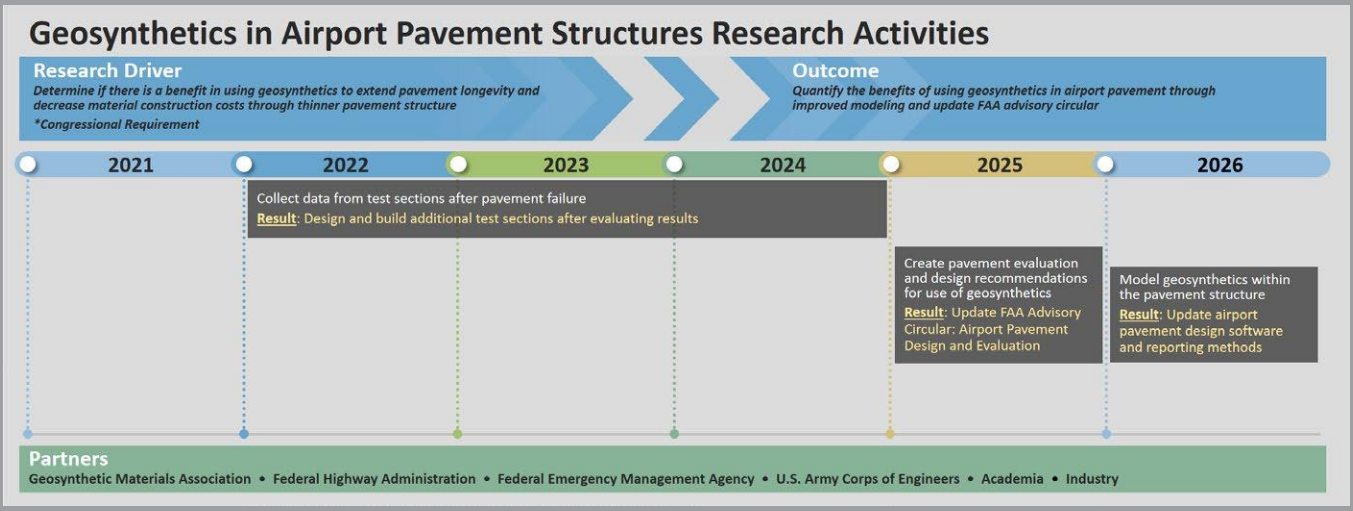
Research focuses on increasing the useful life of this infrastructure and decreasing maintenance and repair costs, NAS operations recovery from disruptive events, and cybersecurity research that protects and defends FAA systems from both internal and external threats due to rapid advances and sophistication of cyber attacks. Resulting research will lead to a longer lasting, lower cost, dependable infrastructure, defended against cyber events.

To achieve this goal, the FAA will:

- Study the feasibility of using geosynthetic materials in airport pavement
- Identify and test alternatives to fluorine-based foam firefighting chemicals
- Develop new tools to protect the NAS from cyber attacks using artificial intelligence and machine learning.

Airport Technology Research Program

Use of Geosynthetics in Airport Pavement Structures



Airport Technology Highlight

Geosynthetics are materials used to reinforce foundations and pavement. The geosynthetics industry is trying to determine if there is a benefit to using geosynthetic material to extend pavement longevity or reduce airport pavement thickness, a factor in construction and maintenance costs. While geosynthetics show a benefit in highway pavements, they have not been tested under aircraft loads, which are many times greater.

This research supports the FAA Reauthorization Act of 2018, section 525, which states that the FAA should encourage the use of durable, resilient, and sustainable materials and practices — including the use of geosynthetic materials and other innovative technologies. To meet industry demand, the FAA will conduct full-scale accelerated pavement testing. The research will determine whether pavement life is improved and provide guidance to ensure proper design, construction, and installation of geosynthetic materials within airport pavements.

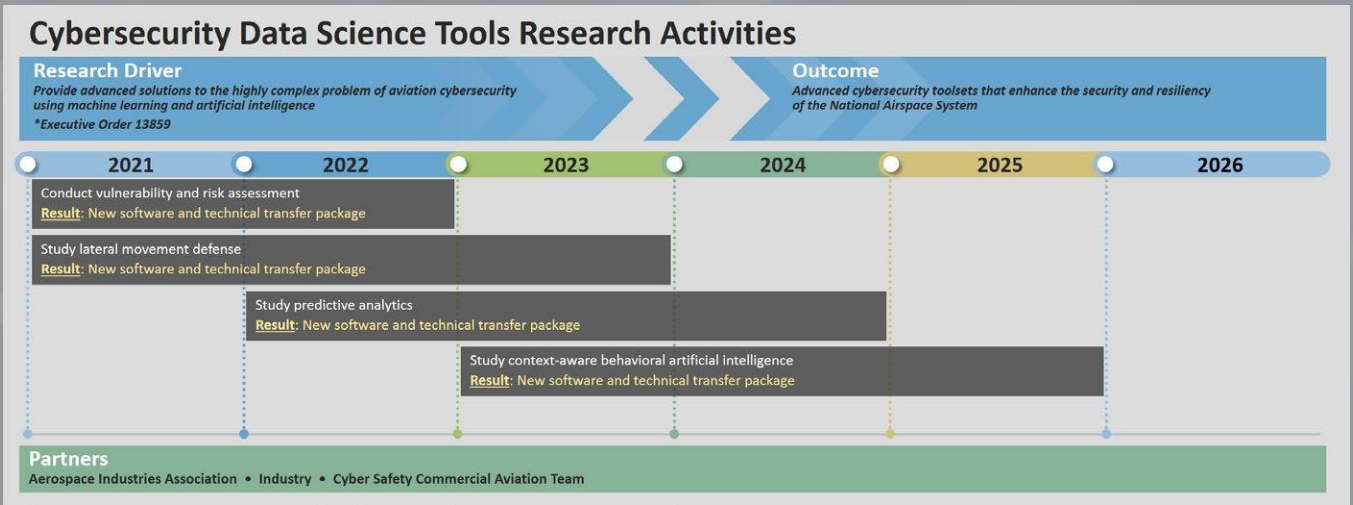
Alternatives to Aqueous Film Forming Foams (AFFF) in Firefighting Agents

Airport Technology Highlight

Aircraft fires often occur in tough-to-access areas such as aircraft engines and cargo holds. They typically involve spilled jet fuel and a variety of other hazardous materials. Airports are required to have a minimum supply of fire extinguishing agents — known as Aqueous Film Forming Foams — available at all times for use in emergency situations. Some of the chemicals used in AFFF, such as fluorine, may be of concern for the environment and human health. This research supports the FAA Reauthorization Act of 2018, section 332, by seeking to identify fluorine-free alternatives that meet the same safety standards as AFFF. Related research will look at ways to improve firefighting techniques following a crash.

Information Technology/Cybersecurity

Cybersecurity Data Science (CSDS) Tools



Information Technology/Cybersecurity Highlight

The FAA manages air traffic control operations through a complex network of computer and information systems. A cyber attack could have devastating consequences on aviation operations and safety. Research activities include developing critical research to create enhanced capabilities for a more resilient, safe, and secure aviation system. Using artificial intelligence and machine learning, researchers will establish a suite of CSDS tools that enable proactive monitoring of NAS systems to detect, prevent, and mitigate the effects of cyber attacks.

2.3.4 Goal 4: Improve human performance within the system

Key programs and initiatives:

Advanced technologies and capabilities challenge human operators and maintainers, including aircraft and UAS remote pilots, cabin crew, maintenance personnel, air traffic controllers, and others. The impact of design, technology, new concepts of operation, and physiological and psychological stressors can have a profound effect on human performance, which can result in less than optimal performance during normal and emergency events.

Research in this goal area seeks to optimize human performance through capability assessments, training, and operational evaluations. Activities address aeromedical factors related to an individual's ability to meet flight demands. Optimized human performance is fundamental to the safe operation of the NAS and inherent to the safety of the airspace community, especially the flying customer, who relies on the FAA to provide the safest air transportation system in the world. Research includes passenger safety in flight and during emergencies.

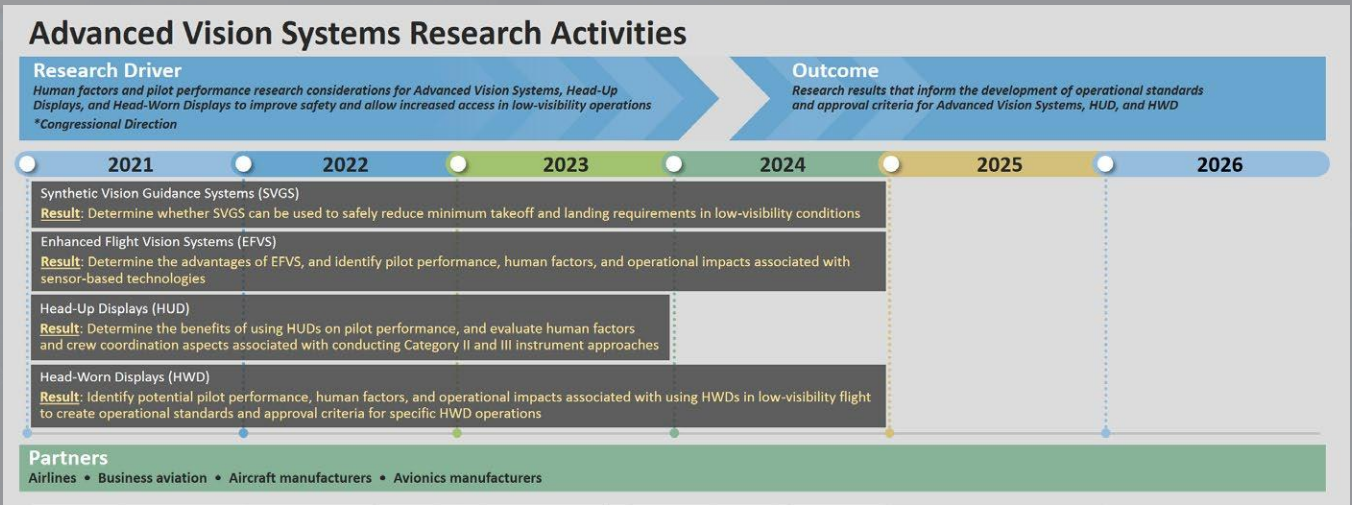
To achieve this goal, the FAA will:

- Research the causes of helicopter accidents and tools that might help prevent crashes
- Establish operational standards for the use of advanced vision systems
- Evaluate the impact of aircraft seat pitch and width on passenger safety
- Study sources of reported contaminates aboard passenger aircraft and establish methods to more accurately and effectively detect such occurrences.

A participant wears a special cap that measures electrical activity in various parts of his brain as he manages simulated air traffic at the Research, Development, and Human Factors Laboratory at the FAA's William J. Hughes Technical Center in Atlantic City, NJ.

Flight Deck, Maintenance, Systems Integration Human Factors

Operational Standards for Advanced Vision Systems

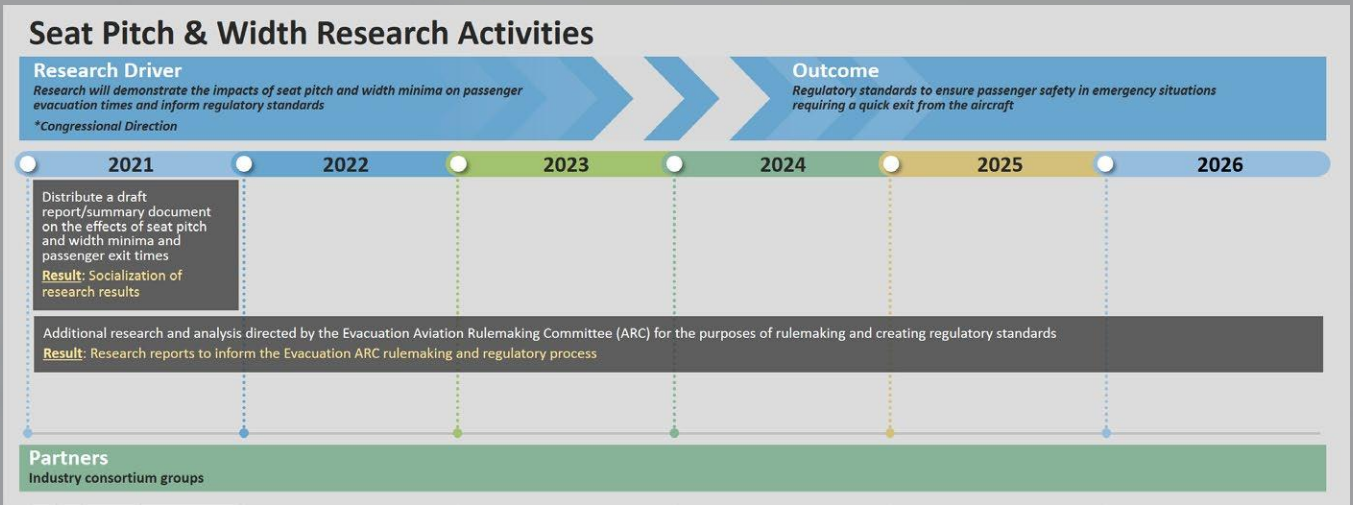


Flight Deck, Maintenance, Systems Integration Human Factors Highlight

Advanced vision systems provide additional visual information to pilots through a fixed head-up display or head-worn device. These tools can enhance safety and allow greater access to airports in low-visibility situations. Research will study the cognitive and physiological effects pilots experience while using advanced vision systems, sensor-based technologies, and emerging display technologies, as well as whether these tools improve pilot performance. The FAA will use the results to develop operational requirements, standards, conditions, limitations, mitigations, and authorizations for the expanded use of these systems.

Aeromedical Program

Human Protection and Survival Research to Evaluate Seat Pitch and Width



Aeromedical Highlight

The ability of passengers to move from their seats to available exits in an emergency is a key element of occupant safety. Seating arrangement has a direct impact on evacuation time. Airlines and airframe manufacturers are proposing new ways to improve customer comfort while maximizing the use of space by varying seat pitch and width. Research in this area will evaluate the effects of these changes on the time it takes passengers to exit the aircraft. In accordance with the FAA Reauthorization Act of 2018, section 577, data derived from this work will help the agency create regulatory standards and requirements for minimum aircraft seat pitch and width.

The FAA performs research on aircraft cabin safety at the Civil Aerospace Medical Institute in Oklahoma City, OK. Research includes studies on cabin air quality and the impact of seat pitch and width configurations during emergency evacuations.

Managing In-flight Infectious Disease Risks during Air Travel

Researchers at the FAA's Civil Aerospace Medical Institute (CAMI) in Oklahoma City, OK are examining the safety risk associated with inflight transmission of diseases of public health significance, such as the SARS-CoV-2 (COVID-19) strain of the Coronavirus, which was designated as a world-wide pandemic in 2020.

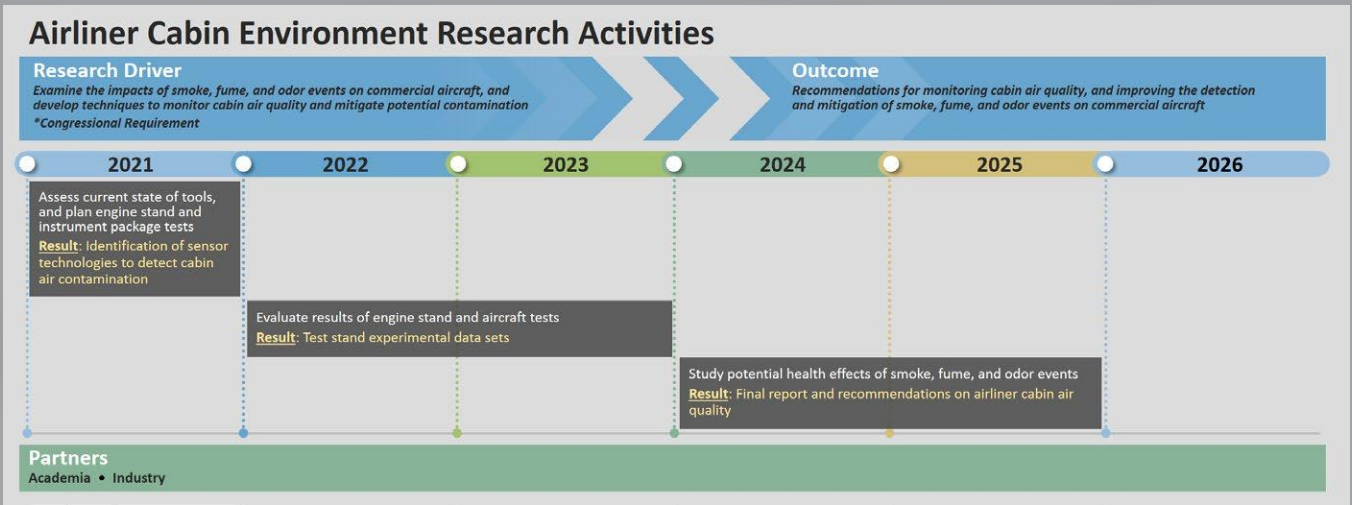
Over the past year, the aviation industry, academia, and the DoD have collected data and conducted studies on the aircraft cabin environment, providing a framework to help manufacturers improve cabin air quality on board. CAMI researchers are currently examining the commercial airliner cabin environment to determine how to estimate the risk of infectious disease spread during flight.

Using modeling and simulation, scientists are developing tools to estimate the risk during boarding, inflight, and exiting the aircraft, and how factors such as passenger spacing, physical barriers, use of personal protective equipment (e.g., masks), and changes to airflow impact the risk for disease transmission.

Researchers will conduct tests to generate data, and use publicly accessible datasets from other researchers, to validate their modeling tools. The goal is to create a data driven, risk-based "cabin safety playbook" or guidance for the aviation community on how to effectively respond to future pandemic events.

Aeromedical Program

Airliner Cabin Environment (Air Quality)

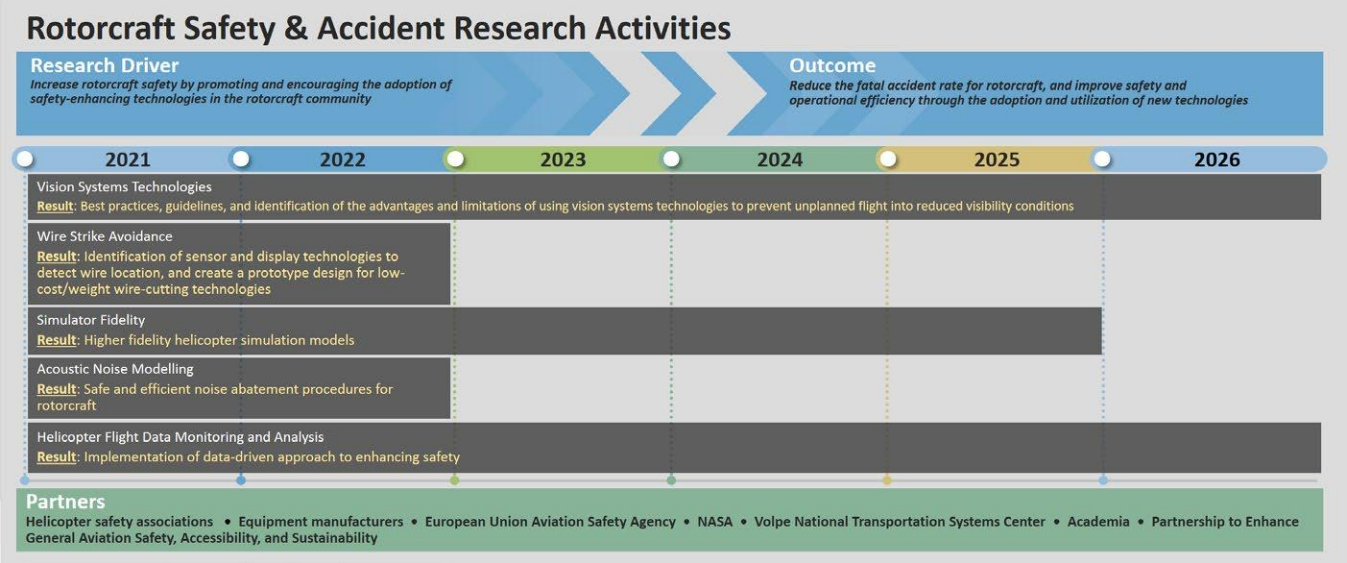


Aeromedical Highlight

Reports of cabin air contaminants can often be linked to engine oil leaks or other fluids being ingested into the engine, drawn into the air supply, and distributed throughout the cabin and flight deck. Smoke, odor, or fumes can enter the environmental control system used for ventilation, pressurization, and temperature control of the airplane. Research will identify and measure contaminant levels in U.S. commercial aircraft cabins, assess potential health effects on passengers and flight crew, and create a more objective means for detecting contaminants, as required by the FAA Reauthorization Act of 2018, section 326.

System Safety Management/Terminal Area Safety

Rotorcraft Safety and Accident Research



System Safety Management/Terminal Area Safety Highlight

There have been a number of high-profile accidents involving rotorcraft in recent times, none more visible than the helicopter crash that claimed the lives of superstar basketball player Kobe Bryant, his daughter, and seven others in January 2020. A common theme in a majority of these accidents is flying in low-visibility conditions. The incidents were typically associated with bad weather, fog, clouds, pilot spatial disorientation, and loss of control of the rotorcraft.

Rotorcraft safety research aims to address the top causes of accidents and incidents. Research includes enhanced vision systems and related technologies — such as synthetic vision systems, combined vision systems, and head-worn and helmet-mounted displays — which can provide increased visual information and cues to help pilots reorient themselves at the onset of potential problems. Related work includes rotorcraft wire strike detection and mitigation, higher-fidelity simulation devices, and aircraft and rotorcraft noise modeling.

FAA rotorcraft safety research conducted at the FAA's William J. Hughes Technical Center in Atlantic City, NJ, aims to address the top causes of accidents and incidents to increase helicopter safety.

2.3.5 Goal 5: Improve integrated modeling capabilities and system-wide analysis

Key programs and initiatives:

Using technologies such as data sharing, artificial intelligence, and machine learning, the FAA has created a number of tools to analyze and model safety, environmental impact, and other data in support of the NAS. As an example of the agency's commitment in this area, the FAA is bringing together experts from across the agency through the Big Data Analytics Working Group. The team explores opportunities to use these capabilities to resolve pressing challenges across the NAS.

These types of integrated modeling capabilities and system-wide analyses will facilitate the FAA's ability to produce state-of-the-art quantitative and qualitative analyses of complex systems. Work in this goal area will improve the robustness, adaptability, flexibility, and accuracy of these integrated analytical and computational modeling tools.

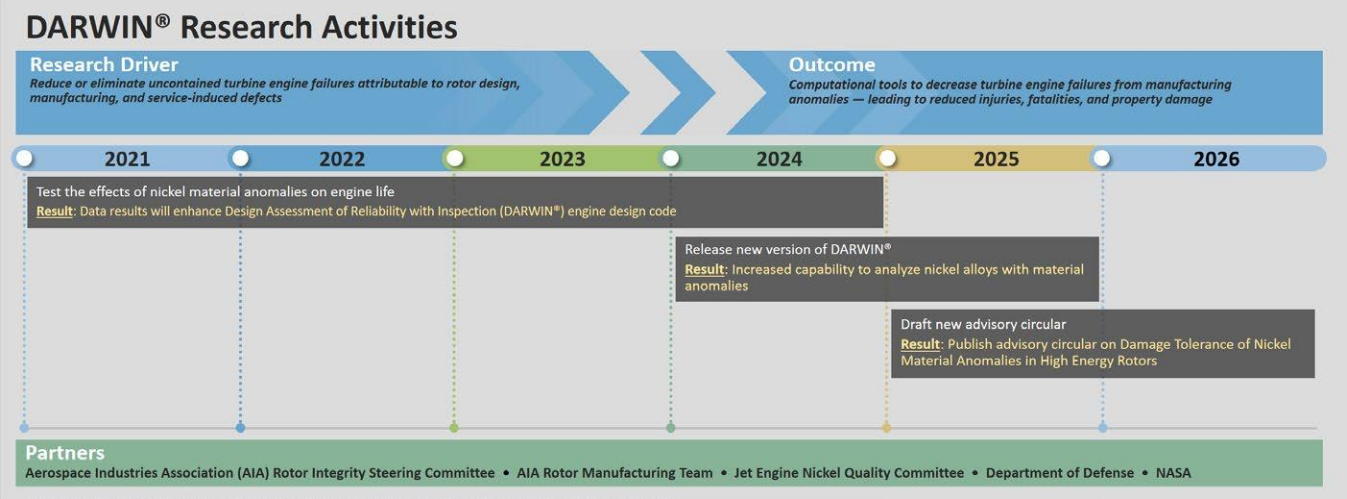
Research associated with this goal includes developing a scientific understanding of aerospace systems used to develop NAS improvements; analytical and predictive capabilities used in the capture, parsing, analysis, and sharing of data; and a toolset to evaluate NAS system-wide performance, especially in view of the introduction of new and emerging technologies. This will enable NAS effectiveness in the delivery of the highest quality service to the greatest number of stakeholders in a timely, safe, and practical manner.

To achieve this goal, the FAA will:

- Provide regulatory guidance and create a new version of the probabilistic damage tolerance based design code known as DARWIN® to account for anomalies and defects in engine materials made with nickel alloys
- Study the possibility of adding UAS data to the Aviation Safety Information and Analysis Sharing (ASIAS) tool
- Update existing environmental modeling tools to improve noise measurement and exposure maps, including sound produced by supersonic aircraft.

Propulsion and Fuel Systems

Design Assessment of Reliability with Inspection (DARWIN®)



Propulsion and Fuel Systems Highlight

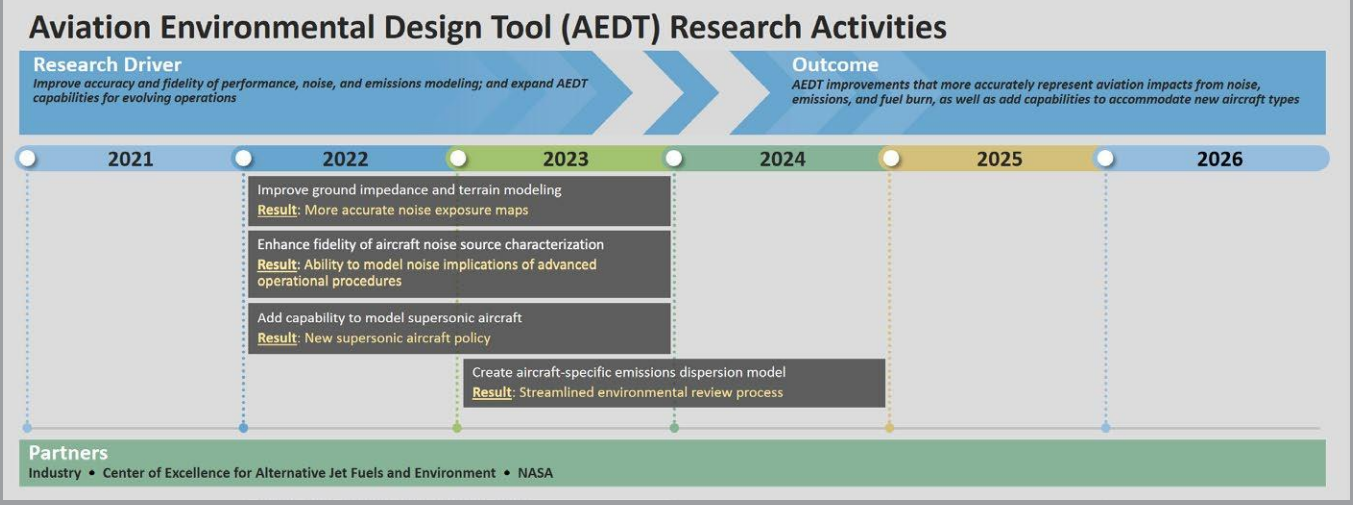
Jet engines contain high-energy rotating parts, such as fan, compressor, and turbine rotors. When engine parts break due to abnormalities in the metal, fragments can escape the engine case and impact other parts of the aircraft. These uncontained engine failures can pose a serious threat to passengers and the continued safe operation of the aircraft.

The FAA and Southwest Research Institute, in collaboration with industry, developed DARWIN® to determine the probability of failure of critical engine parts. Engine manufacturers use the software code to design and verify the compliance of life-limited engine parts that need to be replaced on a regular basis due to wear and tear during the life of an aircraft.

Current propulsion and fuel systems research will focus on the effects of anomalies in engine components made of nickel, a super alloy used in commercial aviation that can withstand extreme operational stresses and temperatures. Research is motivated, in part, by a 2016 uncontained turbine engine failure in Chicago caused by a nickel anomaly. The goal will be to create an updated version of DARWIN® that can help prevent failures in nickel parts, as well as a new advisory circular providing regulatory guidance on nickel damage tolerance in high-energy rotors.

Environment and Energy

Environmental Tools/AEDT



Environmental Highlight

Aviation noise is the primary environmental obstacle to aviation growth. The FAA maintains a comprehensive suite of software tools that support thorough assessment of the environmental effect of aviation. At the core of the tools suite is the Aviation Environmental Design Tool (AEDT), which models aircraft performance in space and time to estimate fuel use, emissions, noise, and air quality consequences. AEDT's primary objective is to facilitate the environmental review of federal actions associated with changes to airports, airspace, and other applicable aviation activities. AEDT is also used by the FAA for domestic and international aviation environmental policy analysis. The FAA sponsors research to improve the accuracy of AEDT and expand its modeling capabilities. Improvements to AEDT over the next five years will result in:

- More accurate noise exposure maps to support airport noise compatibility programs
- Higher fidelity noise characterization that will enable modeling of aircraft noise at further distances from airports, where some communities are expressing concerns; and better understanding of the benefits of advanced operational procedures
- The ability to model the full flight fuel consumption and noise of supersonic aircraft operations to help the agency create new polices and regulations.

In addition, the current emissions dispersion model in AEDT will be updated to better represent aircraft-specific emissions to help airports demonstrate compliance with the National Environmental Policy Act and the Environmental Protection Agency's Clean Air Act requirements, thereby streamlining the environmental review process and avoiding delays in airport construction and needed upgrades.

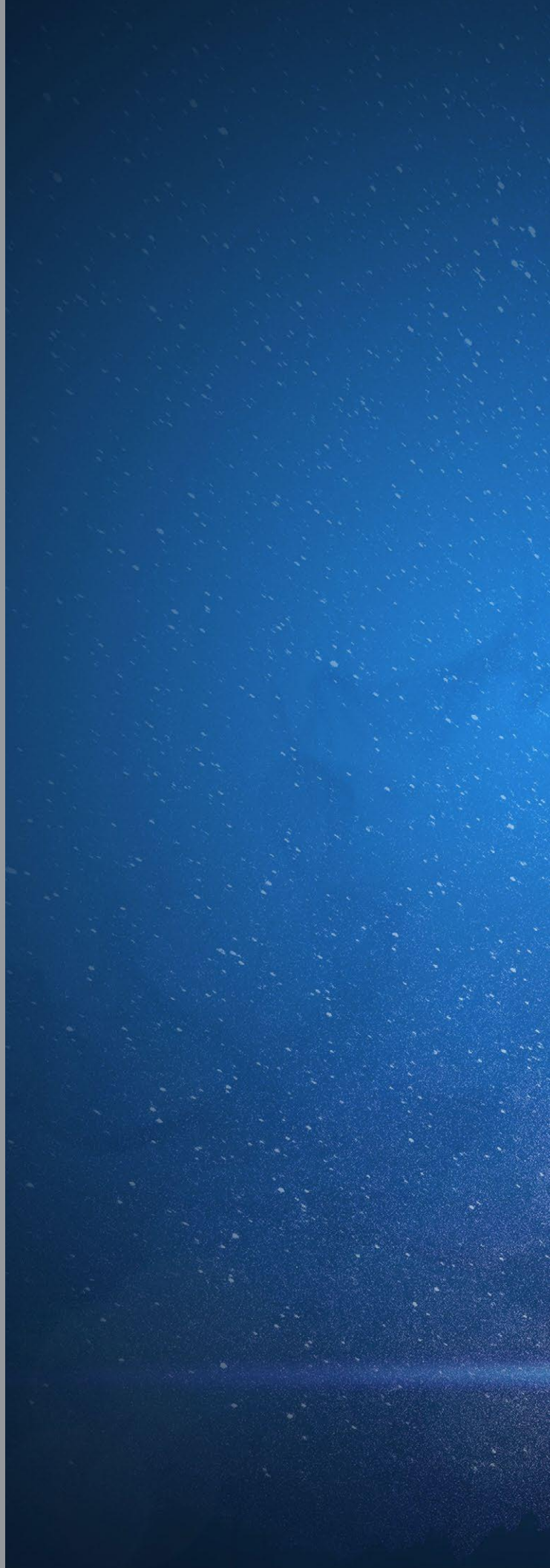
AEDT development is supported by a robust research program through the ASCENT Center of Excellence. The ASCENT program also includes several projects to evaluate the potential impacts of noise on sleep and health, as well as the effects of emissions on air quality and climate change. The resulting knowledge and enhanced modeling capabilities will be available to inform decision making by FAA and others in the aviation industry.

System Safety Management

Aviation Safety Information and Analysis Sharing

The ASIAS program is a collaborative government-industry initiative to analyze data and share aviation safety analysis, in order to discover safety concerns before accidents or incidents occur. More than 150 organizations across the aviation community — including commercial and corporate aviation operators, General Aviation and rotorcraft participants, trade associations, government agencies, universities, and others — contribute various data for safety analysis.

The ASIAS team collaborates closely with the Commercial Aviation Safety Team and the General Aviation Joint Steering Committee, and is conducting research on new data sources to incorporate into program analysis, including UAS data.



3.0 Partnerships and Collaboration

The FAA partners with industry, academia, and outside agencies through various mechanisms including Cooperative Research and Development Agreements (CRADA), centers of excellence (COE), interagency agreements, patent license agreements, and other avenues. These methods provide collaborating parties access to FAA facilities and subject matter experts who will conduct advanced research.

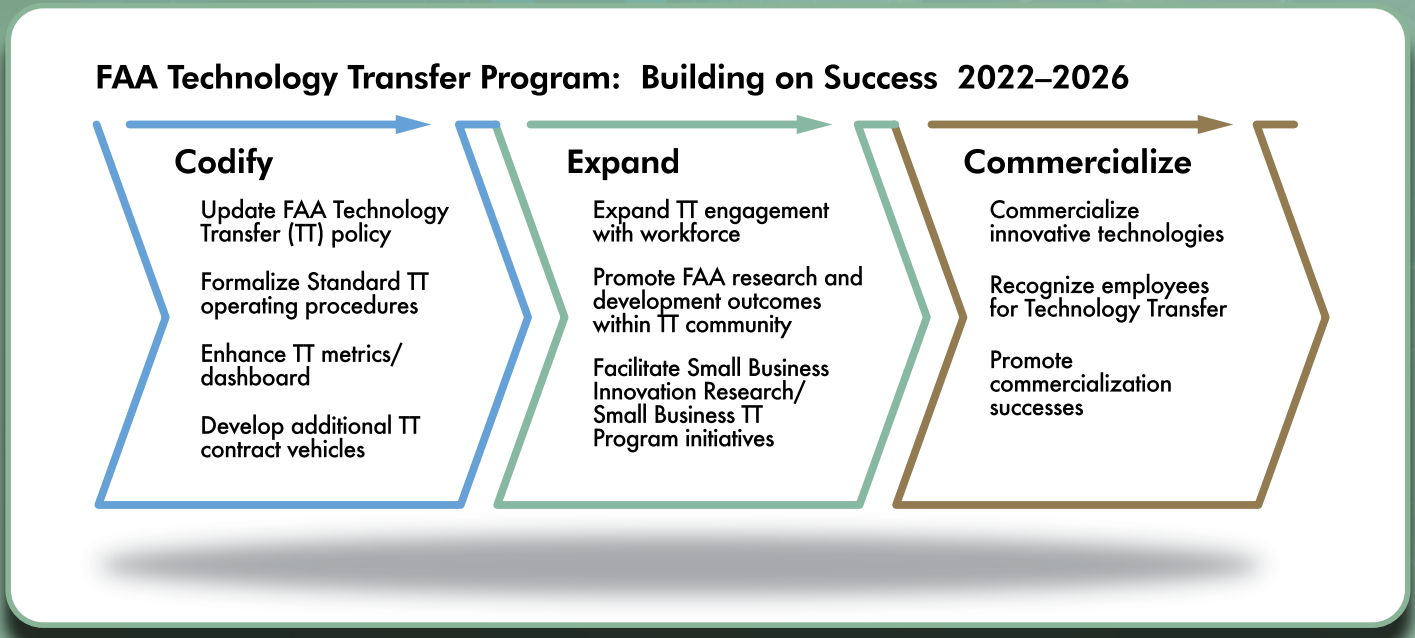
3.1 Technology Transfer

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.



Enabling Collaboration

The Technology Transfer program is committed to facilitating research with all partners. The FAA accomplishes this by serving as a conduit for the exchange of innovative solutions and technical advances between federal and non-federal researchers.

The program's primary technology transfer mechanism is the CRADA. These congressionally-authorized agreements are uniquely effective in providing collaborating partners access to federal intellectual property rights, as well as critical expertise and lab resources. CRADAs have significantly advanced aviation safety through research in material fatigue, nondestructive inspection, flammability standards, airframe integrity, and aircraft rescue and firefighting technologies.

When an FAA researcher identifies a potential opportunity and consults the Technology Transfer program office, the office assesses whether or not the research meets specific criteria that would justify a CRADA as an appropriate vehicle. In instances when a CRADA is not the appropriate research vehicle, the program office will assist the FAA researcher in locating the proper point of contact for their research need, whether a grant, interagency agreement, or contract.

The FAA is reinvigorating its efforts to engage in research with small businesses through the Small Business Innovation Research program. This highly successful federal program implements a three-phased approach focused on the validation and commercialization of innovative solutions.

Managing Intellectual Property

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.

Dissemination of FAA Knowledge

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.

3.2 Partnerships

Centers of Excellence

Congress established COEs through section 44513 of Title 49 of the U.S. Code. The FAA works with more than 80 academic institutions through this program, including universities, colleges, and institutes, resulting in a network of cost-sharing industry partners. COE universities enter into agreements with the FAA that generate one-to-one matching contributions from non-federal sources to augment FAA funds. By matching funds, collaboration with these partners enables the FAA to maximize its resources while leveraging the knowledge, experience, skill, and resources of the FAA and academic institutions.

Since 1992, the COE universities with their non-federal affiliates have provided more than $300 million in matching contributions to supplement FAA research funding. Through long-term cost-sharing activities, the government joins with university-industry teams to share resources and advance the technological future of the aviation industry along with educating and training the next generation of aviation scientists and professionals. There are currently six COEs that focus on different aspects of aviation and space activities.

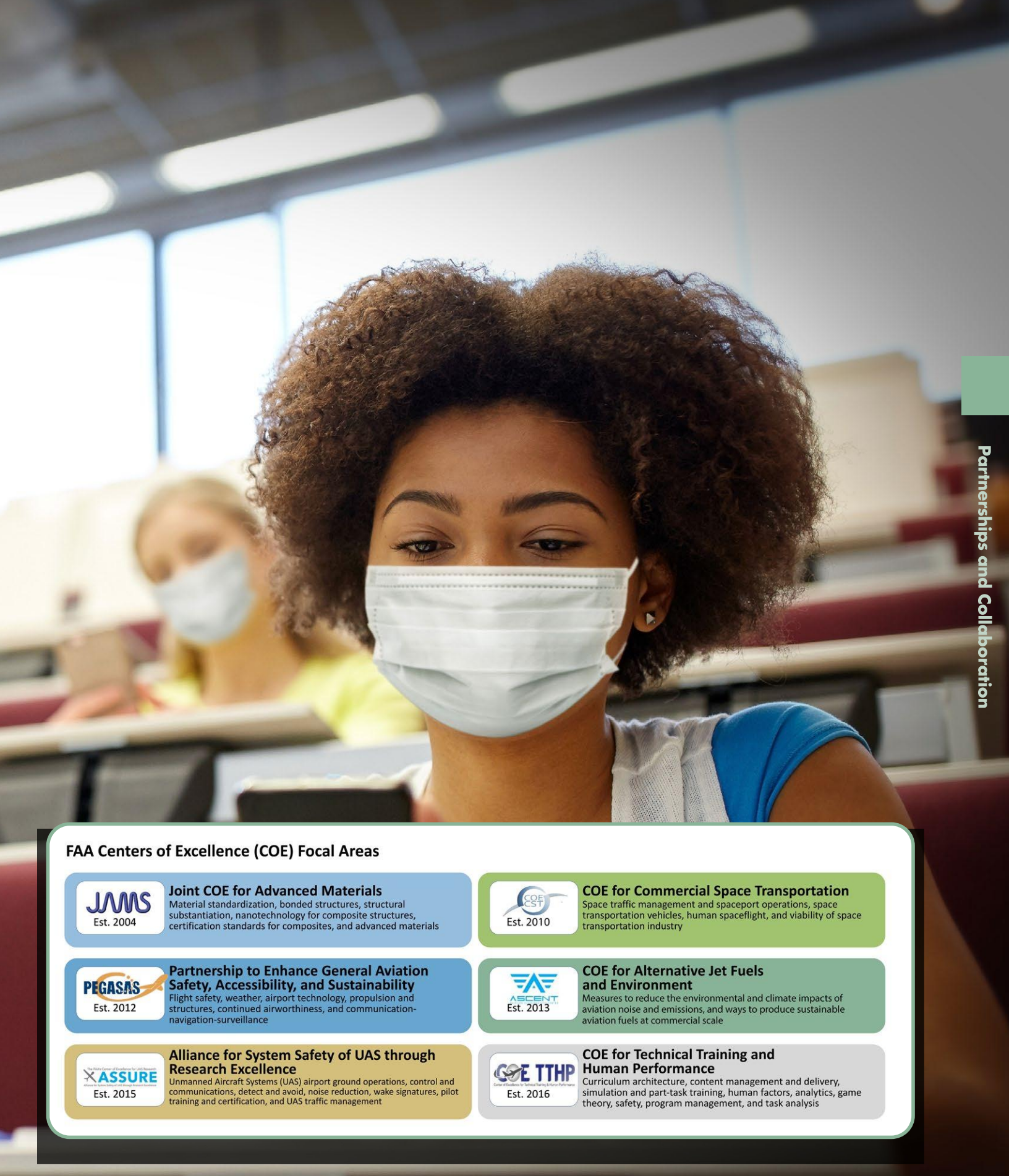
Other Agreements and Grants

In accordance with the Stevenson-Wydler Technology Innovation Act of 1980, federal laboratories are required to expand and strengthen cooperation with government, industry, and academia to promote technology transfer and joint research. The FAA does this in the following ways:

- Leveraging resources from a broad range of government laboratories to support research efforts
- Transferring technology to non-federal entities and providing outside organizations with a means for accessing federal laboratory technologies
- Encouraging the exchange of scientific and technical personnel among academia, industry, and federal laboratories.

FAA agreements with international partners are critical to global harmonization efforts and ensuring the United States remains a global leader in influencing and driving international standards. The FAA engages with multiple partners through international agreements and CRADAs. These unique arrangements, which enable federal labs to negotiate licensing arrangements for patented inventions, were established by the Federal Technology Transfer Act of 1986.

Aviation research grants support aviation-related research across the entire spectrum of physical, chemical, biological, medical, psychological, mathematical, and engineering sciences with the potential to gain further knowledge in emerging aviation technologies.



FAA Centers of Excellence (COE) Focal Areas

Joint COE for Advanced Materials
Est. 2004
Material standardization, bonded structures, structural substantiation, nanotechnology for composite structures, certification standards for composites, and advanced materials

COE for Commercial Space Transportation
Est. 2010
Space traffic management and spaceport operations, space transportation vehicles, human spaceflight, and viability of space transportation industry

Partnership to Enhance General Aviation Safety, Accessibility, and Sustainability
Est. 2012
Flight safety, weather, airport technology, propulsion and structures, continued airworthiness, and communication-navigation-surveillance

COE for Alternative Jet Fuels and Environment
Est. 2013
Measures to reduce the environmental and climate impacts of aviation noise and emissions, and ways to produce sustainable aviation fuels at commercial scale

Alliance for System Safety of UAS through Research Excellence
Est. 2015
Unmanned Aircraft Systems (UAS) airport ground operations, control and communications, detect and avoid, noise reduction, wake signatures, pilot training and certification, and UAS traffic management

COE for Technical Training and Human Performance
Est. 2016
Curriculum architecture, content management and delivery, simulation and part-task training, human factors, analytics, game theory, safety, program management, and task analysis

Industry Partnerships

The FAA partners with aviation stakeholders to conduct industry-led research. The Airport Cooperative Research Program (ACRP), for example, is designed to respond to aviation needs not addressed by other federal research programs and those that cannot be undertaken cost effectively by individual airports.

With an annual investment of $15 million, this congressionally-mandated program is a national resource for the airport industry, providing valuable information, guidance, and practical tools to airport owners and operators.

ACRP projects align with FAA research goals and focus on topics identified as critical by airport operators, industry, and users. Current work includes:

- Providing guidelines to help airports incorporate large-scale, unpredictable events into air traffic forecasting
- Investigating potential alternative materials, configurations, and technologies for the Engineered Material Arresting System, a material that helps stop airplanes if they overrun the end of the runway
- Developing a forensic method to differentiate among potential sources of perfluoroalkyl and polyfluoroalkyl contamination at airports and surrounding areas, a potentially hazardous group of chemicals found in current firefighting foams.

The research should help practitioners identify which applications may be most appropriate for their unique needs, including those of General Aviation airports. ACRP is managed by the Transportation Research Board of the National Academies of Sciences, Engineering, and Medicine and funded by the FAA with Airport Improvement Program funds. ACRP's mission is to develop near-term, practical solutions to problems faced by airport operators.

ACRP uses contractors, selected in a competitive process, to conduct the research, which is overseen by industry experts and a designated FAA subject matter expert. The results of the research are published in the form of handbooks and best practices.

The Engineered Material Arresting System (EMAS) captures a US Airways Express flight in January 2010, following an aborted takeoff at Yeager Airport in Charleston, WV. There were no injuries reported.

EMAS, a tool further enhanced through the Airport Cooperative Research Program, uses crushable material to stop aircraft that accidentally travel beyond the end of the runway, protecting them from further danger. The airplane's tires sink into the lightweight material, slowing it down.

3.3 Advisory Committee

The FAA's research and development (R&D) portfolio is reviewed externally by the Research, Engineering, and Development (RE&D) Advisory Committee (REDAC). This group of aviation and aerospace industry experts channels valuable feedback from customer and stakeholder groups, and ensures FAA research activities are coordinated with other government agencies and industry. The REDAC considers aerospace research needs in five areas: National Airspace System operations, airport technology, aviation safety, human factors, and environment and energy. Committee members represent corporations, universities, associations, consumers, and government agencies.

3.3.1 REDAC Recommendations with the FAA's Response

The REDAC met in the fall of 2019 and the spring of 2020 to provide advice to the FAA on the RE&D and Airport Improvement Program funded R&D portfolio. The REDAC's programmatic recommendations relate to the overall research program such as roadmaps, program plans, funding and staffing; whereas, research-specific recommendations are intended to influence actual research activities within the overall FAA R&D portfolio.

FAA responses to the fall 2019 meeting are outlined in a report titled, "FAA Response to REDAC Guidance for the FY 2022 Research and Development Portfolio."

The agency's responses to the spring 2020 meeting are explained in a report titled, "FAA Response to REDAC Recommendations for the FY 2022 Research and Development Portfolio."

The REDAC provided 43 recommendations for the FAA's R&D portfolio. The FAA responded with the following:

- 32 – Fully concur
- 8 – Partially concur
- 3 – Non concur.

Of these, 32 were categorized as programmatic and 11 as research specific. The first two tables that follow provide a summary of the 11 research-specific REDAC recommendations and highlight FAA research activities that support the recommendations. The third table provides a summary of the recommendations with which the FAA did not concur.

3.3.2 Summary REDAC Recommendations and Implementation Status by the FAA

Summary of Research-Specific REDAC Recommendations - Fall 2019	
REDAC Recommendations to the FAA	**FAA's Supportive Research Activities**
Airports Subcommittee	
Aqueous Film Forming Foams (AFFF)/Perfluoroalkyl and Polyfluoroalkyl Substances Alternatives Research: The subcommittee reiterates its recommendation that the FAA proceed with all due speed with defensible research into the performance and use of alternatives to AFFF in the civil aviation sector, including completing and commissioning its new fire research facility at the William J. Hughes Technical Center. We also request that the FAA provide updates prior to subcommittee meetings if unexpected events or circumstances delay this research.	The FAA commissioned a newly built fire safety research facility in the fall of 2019, and began testing candidate firefighting agents in 2020. The agency is seeking to identify fluorine-free alternatives that meet the same safety standards as AFFF. The agency will inform the subcommittee, prior to scheduled committee meetings, if unexpected events or circumstances arise with the potential to significantly delay research.
Environment and Energy Subcommittee	
Emissions: The subcommittee recommends the FAA continue the simultaneous balanced development of usability improvements, enhanced features, and increased accuracy of the Aviation Environmental Design Tool (AEDT) in the near term. The FAA should make a point of emphasis to improve the dispersion modeling that is used by AEDT to evaluate air quality impacts. We also recommend that the FAA reach out to airports that use air quality and noise monitors, and partner with them in order to get their emissions and noise data to support modeling efforts.	As required by the Environmental Protection Agency (EPA), AEDT uses the American Meteorological Society/EPA Dispersion Model (AERMOD) to model the dispersion of criteria pollutants. However, AERMOD was not designed for aircraft emissions. For example, it cannot accurately capture the three-dimensional effects of a rising aircraft plume. The FAA awarded a grant to the University of North Carolina under the Alternative Jet Fuels and Environment (ASCENT) Center of Excellence (COE) to help determine an appropriate and efficient approach to address AERMOD's dispersion modeling deficiencies. The FAA subsequently developed an expedited work program to accelerate the overall timeline for model development. To support this effort, the agency is looking to identify means to obtain high-quality air quality data to validate the results from the new dispersion model for AEDT.
Staffing: The subcommittee recommends the FAA place a high priority on filling staff vacancies to manage the FAA Office of Environment and Energy portfolio, and support the expanding workload.	The FAA is in the process of executing a hiring plan developed in accordance with administration guidance. To accommodate the evolving nature of industry and FAA needs, the agency is seeking individuals to fill these openings. The FAA's Office of Environment and Energy has experienced success over the years by filling positions with highly-qualified environmental professionals including students and staff trained as a part of the Partnership for Air Transportation Noise and Emissions Reduction and ASCENT, the FAA COEs for environment and alternative jet fuels.

Summary of Research-Specific REDAC Recommendations - Fall 2019

REDAC Recommendations to the FAA	FAA's Supportive Research Activities
Human Factors Subcommittee	
Urban Air Mobility (UAM) Research Gap: The subcommittee recommends the FAA invest in human factors (HF) research associated with increasingly automated operations, such as UAM, as soon as possible. The FY 2022 research plan provided by the FAA offices of NextGen and Aviation Safety should specifically identify the need to address UAM HF issues. This research should include human-machine systems integration, pilot/operator training and certification, and airspace interoperability between traditional and UAM operations, as appropriate to the organization. Report out about the UAM HF research plan at the next Human Factors subcommittee meeting.	The FAA is engaged with NASA and industry partners to consider a myriad of proposals for methods of operating UAM vehicles, levels of autonomy, and operations within the airspace. The FAA conducted human factors research in FY 2020 looking at human impacts from new operations and new uses of autonomy.
NAS Operations Subcommittee	
Unmanned Aircraft Systems (UAS) Detection System Research: UAS issues — especially those associated with unauthorized UAS activity on or near airports — cut across multiple FAA research programs, as well as those of other federal agencies. The subcommittee recognizes that the Airport Technology Research and Development branch has a leading role in developing performance standards and use guidance for airport-deployable UAS detection systems, if these systems will be eligible for FAA grant funding. We strongly recommend that the FAA expedite this UAS detection system research. The subcommittee also strongly supports ongoing research into airport UAS use cases, and research and development activities by other FAA lines of business regarding UAS detection, tracking, interdiction, and traffic management.	The agency formed an internal UAS research program focused on expediting drone detection research at and near airports. Research will identify regulations and standards necessary for the safe use of counter-UAS technologies that do not adversely impact safe airport operations, air navigation, air traffic services, or the safe and efficient operation of the National Airspace System (NAS). Additional research will focus on creating procedures that help facilitate coordination between local, state, and federal government agencies, as well as airports, to ensure proper coordination during emergency situations. Specific emphasis will be given to studying UAS use by fire departments and emergency management agencies.

Summary of Research-Specific REDAC Recommendations - Spring 2020

REDAC Recommendations to the FAA	FAA's Supportive Research Activities
Aircraft Safety Subcommittee	
Genetic Biomarkers and Aircrew Performance: The subcommittee requests that the FAA consider the potential short- and long-term benefits of objective genetic-based biomarkers for aircrew stress and impaired performance, and evaluate possible funding strategies to support this important and unique forward-looking research program.	The FAA is evaluating the potential short- and long-term benefits of objective genetic-based biomarkers for aircrew stress and impaired performance, as well as exploring potential funding avenues to support the research program. Through the Civil Aerospace Medical Institute, the FAA currently conducts biomedical engineering research across multiple types of sleep deprivation. This research will identify biological markers for time awake and cognitive impairment to aid in safety, and help prevent fatigue-related accidents and injuries.
Environment and Energy Subcommittee	
Public-Private Partnerships: The subcommittee continues to endorse public-private partnerships like the Continuous Lower Energy, Emissions, and Noise (CLEEN), Commercial Aviation Alternative Fuels Initiative (CAAFI), and ASCENT programs to leverage resources, and recommends that FAA should continue to allocate robust funding for these programs.	The FAA works to maximize the impact of taxpayer dollars by improving the efficiency of federal programs through partnerships with industry and creating benefits for the American public. The vast majority of the Environment and Energy research and development program has been leveraging resources from the private sector via public-private partnerships. CLEEN, CAAFI, and ASCENT have all been successful because of their strong engagement with industry. The agency is also working in close collaboration with a number of federal agencies in topics related to jet fuel. The FAA provided over $34 million in funding to the ASCENT COE over the last year. These funds will ensure ASCENT maintains a robust research program that helps industry develop innovative solutions to reduce the impacts of aviation on the environment. The FAA is also working very diligently to stand up the third five-year phase of the CLEEN Program, planned to run from 2020 through 2025. CLEEN Phase III will continue the model of partnership with industry to mature technologies that will reduce noise, emissions, and fuel burn for decades to come.

Summary of Research-Specific REDAC Recommendations - Spring 2020

REDAC Recommendations to the FAA	FAA's Supportive Research Activities
Environment and Energy Subcommittee	
Noise Research: The subcommittee strongly supports the prioritization of noise research that will support informed decision making, the introduction of new entrants into the NAS, and enable NextGen deployment.	The FAA has been working for many years to better understand the issues associated with noise from subsonic airplanes and helicopters, and to identify solutions that could help address noise concerns. For example, the agency is continuing to explore operational procedure concepts and engagement approaches that could help identify ways to mitigate noise issues while also improving AEDT to ensure it can quantify aircraft noise at further distances from airports, where some communities are expressing concerns. Noise reduction from gas turbine powered, fixed wing aircraft is an area of emphasis for the third phase of the CLEEN program, which began in 2020. The FAA is also working in close collaboration with NASA to address noise from subsonic and supersonic aircraft, helicopters, UAS, and UAM. Finally, the agency stood up several new ASCENT COE projects in the last year to address noise. These will help us better understand noise generation from a wide range of vehicle types and should help the FAA and aviation industry develop cost-effective solutions to reduce the impacts of noise on communities.
Sustainable Aviation Fuels (SAF): It is the position of this subcommittee that the FAA should maintain a leadership role in the development of SAFs to ensure that the rules to be considered will be beneficial to U.S. industry. Since the maturation of the Alternative Jet Fuel program will be a major environmental benefit for the public and create a new industry within the United States that benefits rural America and the U.S. aviation industry, we strongly recommend that the FAA Office of Environment and Energy continues to allocate funds for the continuation of research on SAFs.	Our efforts ensure these fuels are safe for use and the results of our efforts are reducing the time and costs to get new fuels approved. Continued approvals for new fuels ensure the aviation industry has access to a broad range of fuel options. More fuel options should reduce the cost of fuel production, enable greater environmental benefits, and allow for greater blend levels. Eight different fuel types have been approved for use in civil aviation by ASTM International. Our research efforts also ensure a wide range of aviation fuels can receive credit under the International Civil Aviation Organization (ICAO) Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA). This is critical not only to allowing airlines additional means to meet their international commitments under CORSIA, but also to gain international agreement on what is meant by sustainability. The research program is also providing substantial support to CAAFI, which is essential for coordinating efforts across the aviation industry. The FAA's Office of Environment and Energy continues to coordinate with other federal agencies to make sustainable aviation fuels a focus area of the overall federal effort to stimulate the development of the Bioeconomy and support rural development. This has resulted in the formation of a new interagency working group focused on SAF under the auspices of the multi-agency Biomass Research and Development Board.

Summary of Research-Specific REDAC Recommendations - Spring 2020

REDAC Recommendations to the FAA	FAA's Supportive Research Activities
Environment and Energy Subcommittee	
Global Leadership: The subcommittee recommends the continuing strong support of all research efforts and programs that will allow the FAA and the United States to maintain their current global leadership position on ICAO's Committee on Aviation Environmental Protection (CAEP). It is the belief of the subcommittee that if the FAA/United States does not maintain its leadership position at ICAO CAEP, it will not be able to influence policy and rulemaking. This could have a significant negative impact on the U.S. aviation industry.	It is critical for the FAA to have robust participation in the ICAO CAEP process. The agency has allocated resources to provide leadership in many of the CAEP working groups, as FAA leadership is critical to securing overall U.S. objectives at ICAO. FAA prioritized research efforts include developing the modeling capabilities and generating the data needed to support the decision-making process within ICAO CAEP. Much of this work is being done by ASCENT COE universities and the Volpe National Transportation Systems Center, in close collaboration with NASA and industry. The FAA is currently working with U.S. stakeholders and the international community to develop noise standards for supersonic aircraft with a focus on landing and takeoff noise. These aircraft will need the operational flexibility to take off and land in other countries, which will require international agreement at ICAO on noise standards. As AEDT is the primary tool for supporting decision making related to noise at ICAO CAEP, the FAA is working with the Volpe Center to enhance its capabilities to include supersonic aircraft. The FAA is also standing up a new project in ASCENT in close collaboration with NASA, DoD, and industry to improve models to develop supersonic aircraft with reduced jet noise on takeoff. In addition to this broad effort related to supersonic aircraft, the FAA is also working to ensure the evaluation of any long-term aspirational goal is based on robust scientific analyses that quantify the economic costs and potential benefits of any specific goal.
NAS Operations Subcommittee	
UAS Data Access: The FAA should expand the Alliance for System Safety of UAS through Research Excellence (ASSURE) effort to provide a means for storing and accessing the growing sets of UAS-related data and make those data, whenever possible openly available to the outside research community (i.e., not restricted due to proprietary or other concerns). As part of this effort, a data access clearinghouse capability (including associated schemas, data storage, and data exchange interfaces) should be developed that would enable researchers to identify and access data, and then share results. The NAS Operations subcommittee believes that providing these data in this way would enable the FAA to leverage the significantly larger external UAS community beyond ASSURE, resulting in more rapid innovation and resolution of research issues than would otherwise be possible.	The ASSURE COE is currently working on UAS analysis tools and techniques required to integrate UAS flight monitoring data into the ASIAS tool. Researchers are also working on data and forecasts of expanded and non-segregated operations facilitating UAS integration.

Summary of FAA Non-Concurrence with REDAC Recommendations - Fall 2019

REDAC Recommendations to the FAA	FAA's Response
NAS Operations Subcommittee	
Continuing Capability Utilization Evaluation Program: The FAA should establish a crosscutting airspace services capability utilization-monitoring program that collects data on existing and newly deployed automation systems and procedures. This program would include collecting data on overall system performance and benefits (e.g., are assumptions on delay reduction being realized and are optimal procedures being used during convective weather impacts?), as well as more detailed human-use considerations (e.g., are training enhancements needed and are workload limits managed within appropriate boundaries?). Data could be provided to the Aviation Safety Analysis and Sharing (ASIAS) tool and other repositories for broader analysis and identification of airspace services safety risk trends. To ensure long-term continuity, a reliable funding stream and staffing levels need to be identified to maintain the effectiveness of this program.	The FAA appreciates the committee's general finding and recommendation to establish a continuing capability utilization-evaluation program. However, the FAA is unable to pursue this recommendation within the scope of the research and development portfolio. From a lifecycle perspective, this falls under the scope of implementation and post-implementation activities.
Runway Incursion Reduction Program (RIRP): The program office should develop a more detailed acquisition concept including a list of candidate airports, quantitative assessment of the safety or operational impact that deployment of the targeted technologies would achieve at these airports, and a notional process by which the program office would support these airports in the system development and acquisition process. This acquisition concept should be presented to the subcommittee at the spring 2020 meeting.	The FAA appreciates the committee's view on the RIRP. However, the agency is not in agreement with this finding and cannot pursue this recommendation for the following reasons. The finding appears to have misidentified the role of RIRP and the airport operating authorities in the development and acquisition of the runway incursion prevention systems. None of these tasks falls under the purview of airport operators as described in the finding.
Wake Turbulence: We encourage the evaluation of the potential benefits of the wake hazard research program being applied to General Aviation that could be extended to the flight decks for business, as well as commercial aviation through the study of flight deck graphical wake avoidance advisories on mobile devices. In addition, the program office should develop a plan and strategy on how the en route wake encounter data being gathered through the Aviation Safety Reporting System (ASRS) and ASIAS are being leveraged and applied to inform the needed research, as well as mitigation technologies and procedures.	The FAA appreciates the committee's finding and recommendation on a study of flight deck graphical wake avoidance advisories. However, the FAA is not able to pursue the recommendation at this time due to current fiscal year funding levels, identified program goals, and the current state of real-time weather information to provide data for wake hazard identification. The FAA concurs with the committee's finding and recommendation on en route wake encounter data. The FAA is currently using en route ASRS data to inform concept development activities that address en route wake hazards. Research results will inform future mitigation technologies and procedures.

4.0 FAA R&D Funding Profile

The FAA Research and Development (R&D) portfolio supports regulation, certification, and standards development along with modernization of the National Airspace System (NAS), policy, and planning. The R&D portfolio addresses the specific needs of FAA sponsoring organizations, including (a) Aviation Safety, (b) Air Traffic Organization, (c) Airports, (d) NextGen, (e) Policy, International Affairs, and Environment, and (f) Commercial Space. The R&D Management Division, under the Assistant Administrator for NextGen, manages the FAA R&D portfolio for the agency.

4.1 Budgetary Accounts

FAA R&D is funded through three budgetary accounts[1] — RE&D; F&E, and AIP

Research, Engineering, and Development (RE&D)

The RE&D account funds programs that improve the NAS by increasing safety, security, productivity, capacity, and environmental compatibility in order to meet future air traffic demands.

Facilities and Equipment (F&E)

The F&E account funds capital investments relating to air navigation facilities and equipment, aviation safety systems (including acquisition costs, installation, testing, and laboratories), initial maintenance contracts and training for equipment, facilities, and other construction projects. The F&E account funds R&D in two areas[2]:

1. Advanced Technology Development and Prototyping — Programs develop and validate technology and systems that support air traffic services, including requirements for evolving air traffic system architecture, and improvements in airport safety and capacity
2. Various NextGen Portfolios — Programs have broad applicability across NextGen.

Airport Improvement Program (AIP)

The AIP account provides grants to local and state airport authorities to help ensure the safety, capacity, and efficiency of U.S. airports. Through the AIP, the FAA funds a range of research activities to assist in airport development, preservation of critical facilities, economic competitiveness, and environmental sustainability.

4.2 R&D Summary Budget Table

Budgetary Accounts

Table 1, "Planned R&D Budget by Account," shows the FY 2020 and 2021 Enacted and FY 2022 President's Requests, and planned funding[3] for FY 2023 through 2026. It also highlights the R&D contract and personnel costs for FY 2022.

1 FAA Order 2400.12, FAA Financial Manual, issued on July 3, 2019.
2 Programs in these areas are typically in concept development/demonstration phases prior to FAA investment decisions.
3 These are estimates and subject to change.
4 Due to the reclassification of existing work to better align with OMB Circular A-11 Research Definitions, the amounts shown for F&E programs reflect the entire budget for those portfolios, not just funding for R&D.

Table 1: Planned R&D Budget by Account

Program	Account	2020 Enacted ($000)	2021 Enacted ($000)	2022 President's Budget ($000)	*2022 Contract Costs ($000)*	*2022 Personnel Costs ($000)*	*2022 Other In-house Costs ($000)*	2023 Estimate ($000)	2024 Estimate ($000)	2025 Estimate ($000)	2026 Estimate ($000)
Fire Research and Safety	RE&D	7,200	7,136	7,576	*3,005*	*4,466*	*104*	7,367	7,607	7,847	8,087
Propulsion and Fuel Systems	RE&D	2,100	4,215	3,121	*1,033*	*2,034*	*54*	5,471	5,711	5,951	6,191
Advanced Materials/Structural Safety	RE&D	14,720	14,720	1,678	*602*	*1,019*	*57*	2,886	3,366	3,846	4,326
Aircraft Icing	RE&D	9,000	6,426	2,472	*1,309*	*1,120*	*43*	3,353	3,593	3,833	4,074
Digital System Safety	RE&D	-	-	3,689	*1,903*	*1,742*	*45*	5,287	5,527	5,767	6,007
Continued Airworthiness	RE&D	10,269	11,269	8,829	*5,202*	*3,524*	*104*	12,430	12,670	12,910	13,150
Aircraft Catastrophic Failure Prevention Research	RE&D	1,565	1,565	-	-	-	-	-	-	-	-
Flightdeck/Maintenance/System Integration Human Factors	RE&D	7,300	7,469	14,301	*9,552*	*4,654*	*94*	15,292	15,532	15,772	16,012
System Safety Management/Terminal Area Safety	RE&D	4,500	5,485	7,898	*5,174*	*2,641*	*83*	10,111	10,351	10,591	10,831
Air Traffic Control/Technical Operations Human Factors	RE&D	5,800	5,685	5,911	*2,282*	*3,515*	*114*	5,911	6,151	6,391	6,631
Aeromedical Research	RE&D	7,919	10,235	13,257	*8,385*	*4,694*	*178*	8,975	9,215	9,455	9,695
Weather Program	RE&D	12,911	6,236	13,786	*12,672*	*1,067*	*47*	16,178	16,418	16,658	16,898
Unmanned Aircraft Systems Research	RE&D	24,035	24,035	22,077	*20,340*	*1,579*	*158*	14,935	15,175	15,415	15,655
Innovation and Emerging Technologies	RE&D	-	-	8,500	*8,500*	-	-	10,000	10,240	10,480	10,720
Alternative Fuels for General Aviation	RE&D	1,900	2,524	4,986	*4,986*	-	-	2,385	2,625	2,865	3,105
Commercial Space Transportation	RE&D	2,500	5,840	5,708	*5,708*	-	-	5,708	5,948	6,188	6,427
NextGen - Wake Turbulence	RE&D	5,000	3,698	3,728	*2,809*	*820*	*99*	3,728	3,968	4,208	4,448
NextGen - Air Ground Integration Human Factors	RE&D	5,300	6,000	3,000	*2,402*	*555*	*43*	-	-	-	-
NextGen - Weather Technology in the Cockpit	RE&D	3,144	1,982	3,028	*1,821*	*1,186*	*21*	3,028	3,268	3,508	3,748
NextGen - Flightdeck Data Exchange Requirements	RE&D	1,005	1,000	1,000	*1,000*	-	-	-	-	-	-
NextGen - Information Security	RE&D	2,675	4,769	4,769	*4,769*	-	-	4,769	5,249	5,729	6,209
Environment and Energy	RE&D	18,013	20,304	20,336	*17,450*	*2,773*	*113*	21,163	21,403	21,643	21,883
NextGen - Environmental Research - Aircraft Technologies, Fuels, and Metrics	RE&D	29,174	31,465	33,476	*32,545*	*919*	*12*	33,976	34,216	34,456	34,696
Aircraft Cabin Environment Research	RE&D	1,000	-	-	-	-	-	-	-	-	-
System Planning and Resource Management	RE&D	12,135	13,022	4,141	*2,457*	*1,637*	*48*	4,141	4,381	4,621	4,861
Aviation Workforce Development	RE&D	-	-	5,752	*5,752*	-	-	5,925	6,165	6,405	6,645
William J. Hughes Technical Center Laboratory Facility	RE&D	3,500	2,921	5,481	*2,838*	*2,596*	*46*	10,981	11,221	11,461	11,701
ARPA-C Aviation Climate Research	RE&D	-	-	50,000	*50,000*	-	-	50,000	50,000	50,000	50,000
RE&D TOTAL	**RE&D**	**192,665**	**198,000**	**258,500**	***214,496***	***42,541***	***1,463***	**264,000**	**270,000**	**276,000**	**282,000**

FAA R&D Funding Profile

Table 1: Planned R&D Budget by Account (Continued)

Program	Account	2020 Enacted ($000)	2021 Enacted ($000)	2022 President's Budget ($000)	*2022 Contract Costs ($000)*	*2022 Personnel Costs ($000)*	*2022 Other In-house Costs ($000)*	2023 Estimate ($000)	2024 Estimate ($000)	2025 Estimate ($000)	2026 Estimate ($000)
Advanced Technology Development & Prototyping	F&E	40,900	26,600	29,000	*29,000*	-	-	39,800	36,560	41,230	36,520
William J. Hughes Technical Center Facilities	F&E	20,000	16,900	16,900	*16,900*	-	-	16,900	16,900	16,900	16,900
William J. Hughes Technical Center Infrastructure Sustainment	F&E	15,000	10,000	16,000	*16,000*	-	-	10,000	10,000	10,000	10,000
Next Generation Transportation System - Separation Management Portfolio	F&E	20,500	21,200	23,500	*23,500*	-	-	26,500	21,700	21,000	24,000
Next Generation Transportation System - Traffic Flow Management Portfolio	F&E	19,800	8,000	13,000	*13,000*	-	-	10,000	10,000	11,000	14,000
Next Generation Transportation System - On Demand NAS	F&E	8,500	10,500	9,000	*9,000*	-	-	8,500	9,500	10,500	15,000
Next Generation Transportation System - NAS Infrastructure	F&E	11,500	15,000	10,500	*10,500*	-	-	14,500	14,400	14,500	17,000
Next Generation Support Portfolio	F&E	11,000	8,400	7,000	*7,000*	-	-	8,000	8,000	8,000	8,000
Next Generation Transportation System - Unmanned Aircraft Systems (UAS)	F&E	51,900	22,000	24,000	*24,000*	-	-	26,000	27,000	24,000	31,000
Next Generation Transportation System - Enterprise, Concept Development, Human Factors, & Demonstrations Portfolio	F&E	19,000	19,000	10,600	*10,600*	-	-	11,000	11,000	11,500	12,000
Center for Advanced Aviation System Development (CAASD)	F&E	57,000	57,000	57,000	*57,000*	-	-	57,000	57,000	57,000	57,000
F&E TOTAL	**F&E**	**275,100**	**214,600**	**216,500**	***216,500***	**-**	**-**	**228,200**	**222,060**	**225,630**	**241,420**
Airport Cooperative Research Program - Capacity	AIP	5,000	5,000	5,000	*5,000*	-	-	5,000	5,000	5,000	5,000
Airport Cooperative Research Program - Environment	AIP	5,000	5,000	5,000	*5,000*	-	-	5,000	5,000	5,000	5,000
Airport Cooperative Research Program - Safety	AIP	5,000	5,000	5,000	*5,000*	-	-	5,000	5,000	5,000	5,000
Airport Technology Research Program - Capacity	AIP	15,567	19,500	28,652	*28,652*	-	-	19,950	19,950	19,950	19,950
Airport Technology Research Program - Environment	AIP	332	500	500	*500*	-	-	2,500	2,500	2,500	2,500
Airport Technology Research Program - Safety	AIP	17,257	20,718	11,809	*11,809*	-	-	18,511	18,511	18,511	18,511
AIP TOTAL	**AIP**	**48,156**	**55,717**	**55,961**	***55,961***	**-**	**-**	**55,961**	**55,961**	**55,961**	**55,961**
GRAND TOTAL		**$515,921**	**$468,317**	**$530,961**	***$486,957***	***$42,541***	***$1,463***	**$548,161**	**$548,021**	**$557,591**	**$579,381**

Notes:

/1 The funding levels listed for years 2023 to 2026 are estimates and subject to change.

/2 The budget amounts shown for F&E programs reflect the entire budget for those portfolios, including R&D activities as well as acquisition, operational testing, and other non-R&D activities.

FAA R&D Funding Profile

U.S. Department of Transportation
Federal Aviation Administration
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