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

Office of the Administrator

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

October 9, 2024

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 (FAA) National Aviation Research Plan (NARP) for Fiscal Years (FY) 2025–2029, as required by Title 49 United States Code § 44501(c). The plan conforms to the Government Performance and Results Act.

The NARP highlights and reports annually on the FAA's 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's Strategic Goals and supports guidance issued by OMB and the Office of Science and Technology Policy.

The NARP describes research deemed necessary to ensure the continued capacity, safety, and efficiency of aviation in the United States. As required by statute, 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 2023 R&D Annual Review, a congressionally required companion document to the NARP.

A similar letter has been sent to the Ranking Member of the Senate Committee on Commerce, Science, and Transportation and the Chairman and Ranking Member of the House Committee on Science, Space, and Technology.

Sincerely,

Michael G. Whitaker
Administrator

Enclosures

ANG-231101-001

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

October 9, 2024

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

Dear Ranking Member Cruz:

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

October 9, 2024

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

Dear Chairman Lucas:

I am pleased to transmit the Federal Aviation Administration (FAA) National Aviation Research Plan (NARP) for Fiscal Years (FY) 2025–2029, as required by Title 49 United States Code § 445011(c). The plan conforms to the Government Performance and Results Act.

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Administrator

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ANG-231101-001

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

Office of the Administrator

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

October 9, 2024

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

Dear Ranking Member Lofgren:

I am pleased to transmit the Federal Aviation Administration (FAA) National Aviation Research Plan (NARP) for Fiscal Years (FY) 2025–2029, as required by Title 49 United States Code § 44501(c). The plan conforms to the Government Performance and Results Act.

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Sincerely,

Michael Whitaker
Administrator

Enclosures

ANG-231101-001

National Aviation Research Plan (NARP)

FY 2025–2029

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*

U.S. Department of Transportation
Federal Aviation Administration

"In a rapidly evolving aviation landscape, our flexibility and creativity will be critical to the successful integration of drones, commercial space launches, and air taxis into the National Airspace System. These exciting challenges are poised for our innovative solutions."

Michael Whitaker
FAA Administrator

Message from FAA Administrator
Michael Whitaker

The FAA is essential to our nation's traveling public and economy. We manage over 54 million flights and nearly a billion passengers each year. Our mission is to provide the safest aerospace system in the world.

We continue to challenge yesterday's assumptions with how we see the future of aviation and aerospace unfolding. How do we make it safer, accessible, eco-friendly, and sustainable?

What we do know is the future will be exciting. It will be evolutionary and revolutionary, where science fiction becomes a reality as new aerospace opportunities emerge.

There have been significant advancements in the research and development of autonomous vehicles, environmentally friendly electric aircraft, and new types of space vehicles. These new technologies bring new challenges and opportunities to the National Airspace System (NAS).

I am pleased to present the National Aviation Research Plan for Fiscal Years 2025–2029. This five-year plan outlines how the FAA's work encourages innovation while keeping America's air traffic operations safe and efficient.

This plan demonstrates the FAA's commitment to integrating new aerospace technologies and vehicles into our air traffic management system through NAS evolution.

The document shows how we work with our partners to deliver research solutions that maximize benefits to American taxpayers and the global flying public.

I invite you to read on to learn more about the critical role that FAA research and development plays in the continuation and evolution of American and global aviation.

At the FAA, the sky is not the limit — it is just the beginning.

The NARP outlines the FAA's strategic vision for advancing aviation safety, efficiency, and sustainability through targeted research and development.

Executive Summary

The National Aviation Research Plan (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 careful management and delivery of results. Section 44501(c) of title 49 of the U.S. Code requires the FAA Administrator to submit the NARP to Congress annually with the President's Budget.

The NARP outlines the FAA's strategic vision for advancing aviation safety, efficiency, and sustainability through targeted research and development.

The document features a framework of R&D goals that supports the strategic visions laid out by the President, Secretary of Transportation, and FAA Administrator regarding safety, organizational excellence, fostering economic strength and global competitiveness, and transforming the nation's infrastructure while focusing on equity, sustainability, and climate protection.

This approach allows the FAA to address the current challenges of operating the world's safest, most efficient aerospace transportation system while modernizing the National Airspace System (NAS) to support increased diversity and volume of users.

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 a global impact.

The success of the FAA's R&D relies on strong collaboration among federal agencies, industry stakeholders, research institutions, and international partners. The NARP details the FAA's R&D partnerships and collaborations with other agencies, academia, and the aerospace industry.

The document focuses on the ways technology transfers out of the agency, how the FAA partners with outside groups to maximize every R&D dollar invested, and the role of an external advisory committee. The NARP details projected funding over a five-year timeframe for each R&D program.

By pushing the boundaries of aerospace technologies, the FAA ensures continuous NAS improvement and contributes to global progress, reinforcing its role as a leader in aviation and space innovation.

Table of Contents

1.0 Introduction

The FAA's commitment to research and development (R&D) is a cornerstone of its mission to provide the world's safest, most efficient aerospace system. Through rigorous R&D efforts, the FAA strives to advance aviation safety, efficiency, and environmental sustainability.

The National Aviation Research Plan (NARP) outlines the FAA's strategic vision for aerospace research and development.

The agency invests in cutting-edge technologies, data analysis, and innovative solutions to address emerging challenges, such as integrating new aerospace vehicles and technologies into the National Airspace System (NAS) and reducing aviation's environmental impact.

This congressionally required document describes the importance of federally funded R&D. The NARP explains the FAA's research goals and how the agency structures R&D to ensure alignment of all research activities with agency goals and priorities, highlighting expected results for select activities.

The highlighted research areas support the agency by:

- **Considering noise, emissions, and other environmental issues to advance aviation in an environmentally responsible and energy-efficient manner**
- **Using informed decision-making and data-driven approaches to prioritize safety and public health**
- **Supporting performance-based standards as a basis for regulatory compliance by providing the framework for required levels of system and operator performance**
- **Preparing transportation systems for the next generation by making them more adaptable, sustainable, resilient, available, and equitable — to deliver new capabilities faster**

The NARP outlines the FAA's R&D partnerships and collaborations with other agencies, academia, and the aerospace industry. These include technology transfer initiatives, R&D partnerships, and interactions with an external advisory committee.

The FAA funds R&D in three budgetary accounts: Research, Engineering, and Development (RE&D), Facilities and Equipment, and the Airport Improvement Program. FAA R&D activities in these accounts encourage great innovation while ensuring aerospace safety needs are met.

The FAA R&D *Funding Profile* describes the RE&D investment plan details for the five-year period 2025–2029.

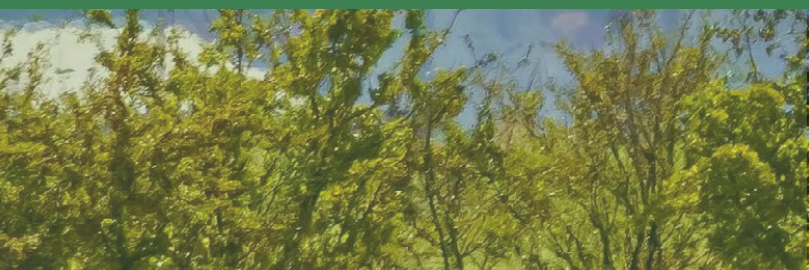
FAA Research Facilities

The FAA operates state-of-the-art research and development facilities in two locations. The William J. Hughes Technical Center for Advanced Aerospace is in Atlantic City, NJ. The Civil Aerospace Medical Institute and the Flight Research and Analysis Group are located at the Mike Monroney Aeronautical Center in Oklahoma City, OK.

Each location provides unique research, development, test, and evaluation platforms to facilitate upgrades, improvements, and operational sustainment for the National Airspace System. The laboratories serve as a resource for government-industry partnerships.

Collaboration internally and across federal agencies, academia, the U.S. military, and the aviation industry is vital for sharing research and information, developing policy, and promoting best practices globally.

Researchers at the FAA's William J. Hughes Technical Center for Advanced Aerospace and the Mike Monroney Aeronautical Center keep the FAA on the cutting edge of innovation while supporting the agency's mission to provide a safe and efficient National Airspace System.



1.1 Why FAA Research and Development Matters

FAA research is primarily applied R&D designed to help the agency 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 to modernize NAS operations**
- **Evaluation and validation of requirements, procedures, and methods**
- **Production of useful materials, devices, systems, tools, and technologies**

FAA research, analyses, and development enable new technologies, procedures, and training methods that advance aviation technology. FAA R&D helps the aerospace community adapt to new safety issues and service demands resulting from increased unmanned aircraft systems, commercial spaceflight activities, and the birth of new industries such as advanced air mobility.

The research will influence the future of FAA oversight, considering the expansion of aviation industries, the sustained growth in aviation, the incorporation of more sophisticated analytical safety tools, and the adoption of mature safety management systems.

Agency research aims to counter growing cybersecurity threats posed by increasingly interconnected systems and minimize the impact of aerospace activities on the environment. R&D helps the aerospace industry modernize the nation's infrastructure, creating new technologies and business opportunities.

The FAA substantially impacts aviation, space, and the U.S. economy. This increases American economic competitiveness, fuels economic growth, and creates jobs. 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.

1.2 How the FAA's Research Shapes the Future

FAA research focuses on a core safety mission and prioritizes integrating emerging technologies into the NAS while minimizing environmental impacts.

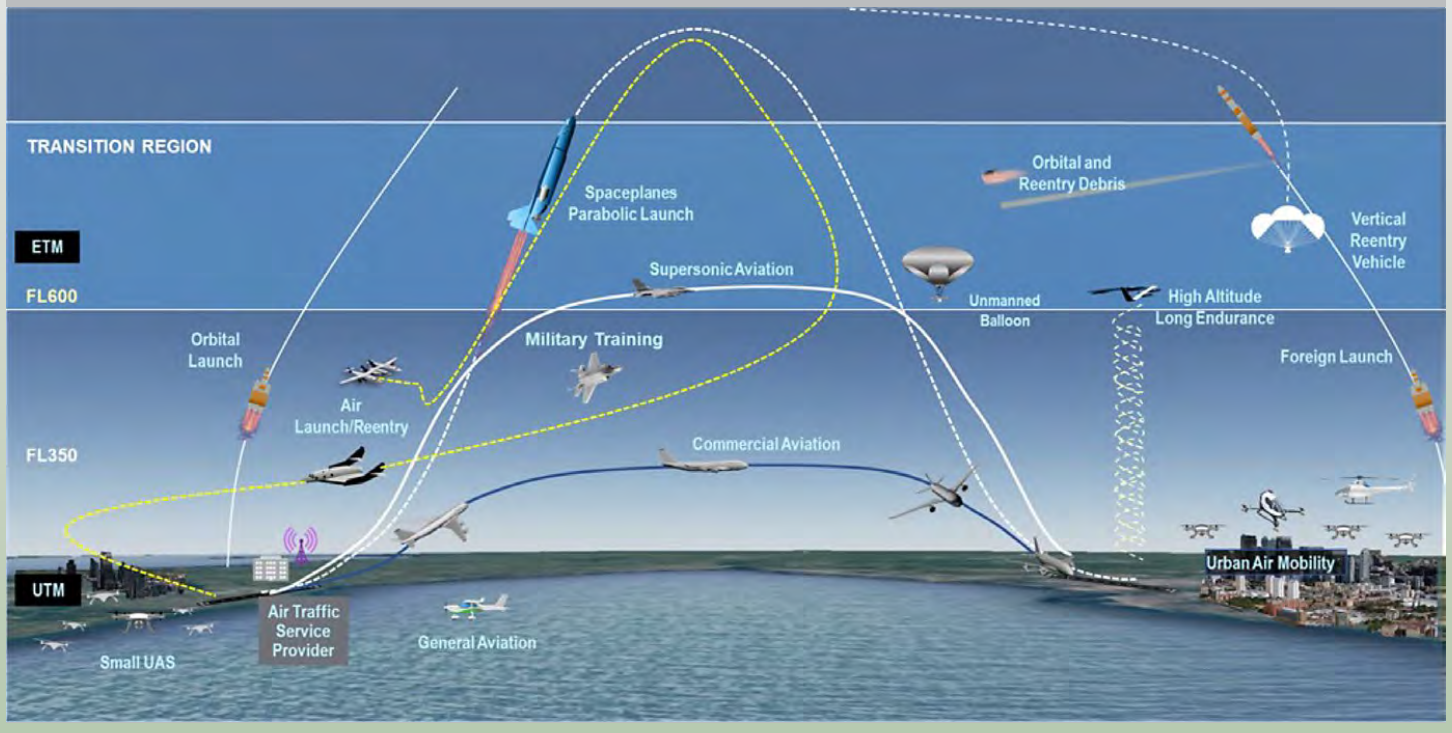
The NAS is evolving to support diverse aerospace operations brought about by new technologies and vehicle types. As the world becomes more digitally interconnected, there is exponential growth in data availability, computing power, and storage capacity.

Improvements made through the FAA's deployment of NextGen provide the foundation for the future. By adding new planned capabilities and services and capitalizing on modern information-based technology, the FAA will continue transforming the aviation system and accommodating all users in a changing environment.

NAS evolution will address the expected changes and take advantage of data, innovative technologies, and new capabilities in three areas:

- **Operations:** NAS evolution will accommodate the increased diversity and number of aerospace operations while improving traditional air traffic services.
- **Infrastructure:** Public and private infrastructure will provide agile and resilient air traffic management services that can evolve as new needs emerge.
- **Integrated Safety Management:** Increased information sharing will allow new levels of collaboration and provide data to detect and correct safety risks in real time.

Diversity of Future NAS Operations



Supporting National Airspace System Evolution through Laboratory Innovation

National Airspace System (NAS) evolution requires advanced research and development (R&D) laboratories where new aircraft concepts can be safely developed and evaluated. The R&D laboratories at the William J. Hughes Technical Center provide the critical infrastructure to support the agency's evolution to a safer, more efficient, and more resilient NAS.

A key objective of NAS evolution is to accommodate new vehicle types and services, such as advanced air mobility (AAM) and remote tower operations that integrate modern software applications and infrastructure.

Advanced Air Mobility

AAM is a rapidly emerging new aerospace industry sector that aims to integrate highly automated aircraft safely and efficiently into the NAS. In partnership with NASA, the FAA developed the NASA/FAA Laboratory Integrated Test Environment, which is made up of multiple labs to support AAM research.

Cockpit Simulation Facility

The Cockpit Simulation Facility (CSF) provides medium and high-fidelity flight deck simulation capabilities to help researchers develop new flight deck technologies and procedures. The CSF has numerous aircraft simulators, including a Sikorsky S76-D helicopter, Airbus A320, Boeing 737 MAX, BD-5 MicroJet, and two new virtual reality motion-based helicopter flight simulators (R22 and H125). The CSF uses the S76-D helicopter simulator to support AAM research.

Target Generator Facility

The Target Generator Facility (TGF) provides the infrastructure to connect and drive multiple laboratory environments and automation systems, providing simulated targets that are indistinguishable from live radar targets. The TGF supports AAM research by providing scenario development, aircraft modeling, and integration support activities.

NextGen Prototyping Network

The NextGen Prototyping Network (NPN) provides a highly performing, scalable, and secure network environment for FAA and non-agency partners to collaborate while protecting critical FAA resources. The network serves as the FAA Research and Development Network Domain and supports AAM research by providing the underlying network infrastructure integrating NASA and FAA systems. The agency is expanding NPN to become the R&D operational environment.

Remote Tower Systems

Remote Tower Systems allow air traffic controllers to monitor an airport through airfield camera arrays connected to remote displays and control equipment.

National Aerospace Research and Technology Park

The National Aerospace Research and Technology Park (NARTP), located just outside the Technical Center, provides a location for aviation industry, academic, and government partners to work with the FAA to foster innovation and collaboration and promote sustained economic growth for the region near the center.

FAA researchers are installing remote tower control systems at the NARTP to support remote tower research. The systems will connect researchers to nearby Atlantic City International Airport camera masts.

A key objective of NAS evolution is to accommodate new vehicle types and services.

Commercial Space Transportation

A growing interest in commercial space brings new possibilities for the industry, including providing transportation to the international space station laboratories for research and space tourism.

The FAA manages licensing and regulatory work for this rapidly growing industry and is responsible for ensuring the protection of the public, property, national security, and foreign policy interests of the United States during commercial space launch and reentry activities. The agency also oversees a variety of other space-related programs and research initiatives, including:

- **Improving the integration of commercial space operations into the National Airspace System (NAS) to minimize impact on air travel and maximize safety**
- **Researching and demonstrating emerging safety-enabling technologies for commercial space vehicles, assisting with technology transition to the aerospace industry as appropriate**
- **Evaluating, maturing, and demonstrating opportunities to use current and emerging NAS capabilities, such as radar and Automatic Dependent Surveillance–Broadcast, to support commercial space transportation**
- **Conducting research that supports crew members and spaceflight participants**
- **Improving debris models for nominal and off-nominal launch and reentry operations**

The FAA is working with those involved in every aspect of the commercial space industry to meet needs now and into the future.

A growing interest in commercial space transportation brings new possibilities for the industry.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2.0 FAA Research and Development

The FAA balances research and development (R&D) investments between those that are strategic and those that are mission oriented. Strategic investments include understanding and supporting emerging technologies, capabilities, and services, as well as addressing the changing needs of system users. Mission-oriented investments include agency research priorities and continued FAA safety and efficiency enhancements.

The agency consistently strives to:

- **Improve the planning, programming, and budgeting of the agency's R&D portfolio**
- **Increase the return on taxpayer investment; enhance productivity; and ensure the relevance, quality, and performance of the R&D portfolio**
- **Develop a comprehensive view of the R&D required to support a vibrant aerospace sector**

The FAA accomplishes this by leveraging internal senior management guidance and external advice and recommendations.

R&D Executive Board

The agency's R&D Executive Board (REB) provides an oversight approach to managing the R&D portfolio development process. The REB frequently meets throughout the year to discuss and coordinate a well-balanced portfolio, set priorities, and make funding recommendations.

Research, Engineering, and Development Advisory Committee

The congressionally mandated Research, Engineering, and Development Advisory Committee (REDAC) provides external stakeholder input to the FAA's R&D portfolio development. The committee provides advice and recommendations to the FAA Administrator on the aerospace research program's needs, objectives, plans, approaches, content, and accomplishments.

The REDAC also helps ensure the FAA coordinates present and future aerospace research with similar activities conducted outside the agency.

REDAC members include professionals from the aviation and space industries, 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 willing to make. Additional information is available in *Section 3.3 – Advisory Committee.*

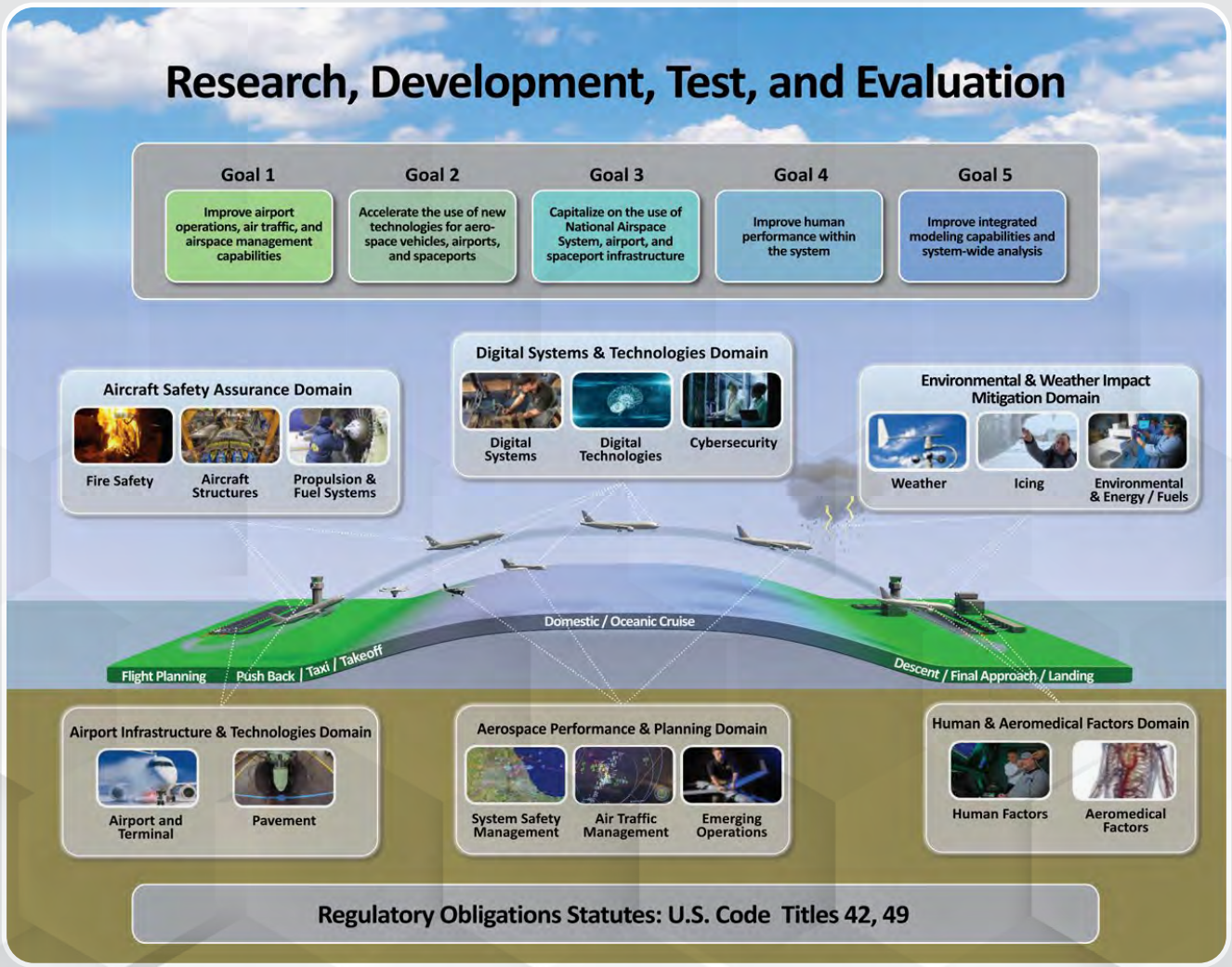
2.1 FAA R&D Framework

The FAA has developed research goals that support its multiple regulatory and operational mission areas, including the modernization of the National Airspace System (NAS), policymaking, regulation, certification, and standards development.

- **Goal 1 – Improve airport operations, air traffic, and airspace management capabilities**
- **Goal 2 – Accelerate the use of new technologies for aerospace vehicles, airports, and spaceports**
- **Goal 3 – Capitalize on the use of NAS, airport, and spaceport infrastructure**
- **Goal 4 – Improve human performance within the system**
- **Goal 5 – Improve integrated modeling capabilities and system-wide analysis**

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:

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



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

The FAA's Strategic Outlook for Aviation Research

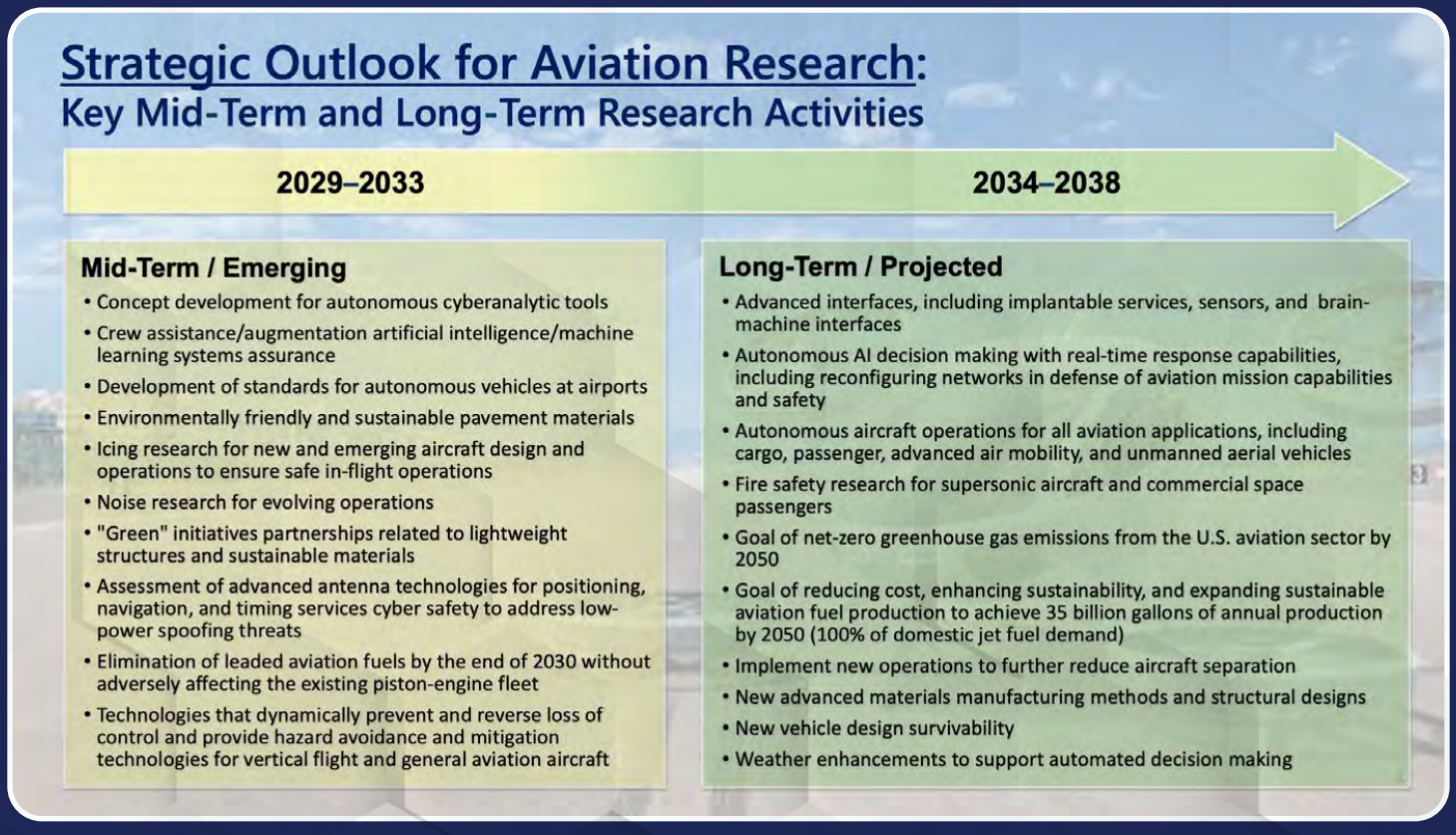
Sharing a story that is relatable and easy to comprehend can help aviation stakeholders better understand the FAA's research initiatives. This helps connect the dots between research and the flying experience.

The FAA is evolving how it communicates about the agency's research and development portfolio. The Strategic Outlook for Aviation Research (SOAR) highlights and encourages discussion on the research and development (R&D) portfolio strategy, including expected outcomes, research drivers, and long-term projections.

The agency identifies emerging trends and research areas where it needs to lead and strategically partner with academia, the aerospace industry, and other governmental agencies. The SOAR charts will display the R&D portfolio over a 15-year timeframe, focused on mid-term activities (emerging areas the FAA is monitoring or partnering to address five to 10 years out) and long-term activities (forecasted trends that the agency is observing and gaining knowledge about that may occur 10 to 15 years from now).

The Research, Engineering, and Development Advisory Committee will review the SOAR charts to help anticipate future needs, understand where the aerospace industry is going, identify opportunities to partner, and better support change.

The example SOAR chart below shows the FAA's strategic outlook in key research areas from 2029 to 2033 (mid-term activities) and 2034 to 2038 (long-term activities). Near-term research efforts that support the chart are described in ***Section 2.3 – Research Priorities by R&D Goal.***



2.2 Department of Transportation Strategic Goals, Research Priorities, and Grand Challenges

The FAA invests in high-priority research and development activities that are critical to the NAS and align with the strategic goals of the agency's parent organization, the Department of Transportation (DOT), as described in the *Research, Development, and Technology Strategic Plan.* DOT's strategic goals are:

- **Safety:** Make our transportation system safer for all people. Advance a future where transportation-related serious injuries and fatalities are eliminated.
- **Economic Strength and Global Competitiveness:** Grow an inclusive and sustainable economy. Invest in our transportation system to provide American workers and businesses with reliable and efficient access to resources, markets, and good-paying jobs.
- **Equity:** Reduce inequities across our transportation systems and the communities they affect. Support and engage people and communities to promote safe, affordable, convenient, and multi-modal access to opportunities and services while reducing transportation-related disparities, adverse community impacts, and health effects.
- **Climate and Sustainability:** Tackle the climate crisis by ensuring that transportation plays a central role in the solution. Substantially reduce greenhouse gas emissions and transportation-related pollution and build more resilient and sustainable transportation systems to benefit and protect communities.
- **Transformation:** Design for the future. Invest in purpose-driven research and innovation to meet the challenges of the present and modernize a transportation system of the future that serves everyone today and in decades to come.
- **Organizational Excellence:** Strengthen our world-class organization. Advance the DOT mission by establishing policies, processes, and an inclusive and innovative culture to effectively serve communities and responsibly steward the public's resources.

Addressing significant challenges such as climate change, equitable access to transportation, creating good jobs, and the efficiency and resilience of global supply chains will require a whole-of-government approach.

To meet these challenges, DOT seeks to guide and inspire research across the federal government and the nation through a series of "grand challenges."

The grand challenges describe desired outcomes. While they do not denote a specific grant or research program, the grand challenges serve as a call to innovation for transportation researchers, entrepreneurs, and public policymakers.

Department of Transportation Strategic Goals, Research Priorities, and Grand Challenges

Safety

Grand Challenge

Zero fatalities: Advance a future without transportation-related serious injuries and fatalities

Priorities

- Human factors
- Data-Driven System Safety
- Cybersecurity

Transformation

Grand Challenge

The future transportation system-of-systems: Develop connected, intelligent infrastructure that provides people-centered mobility

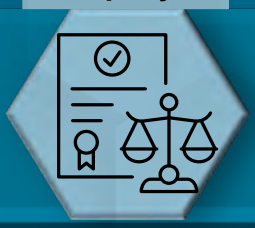
Priorities

- Integrated system-of-systems
- Data-driven insight
- New and novel technologies

Equity

Grand Challenge

Equitable mobility for all: Create an equitable transportation system that provides safe, affordable, accessible, and convenient mobility options for all users



Priorities

- Equity and accessibility assessment
- Mobility innovation
- Wealth creation

Climate and Sustainability

Grand Challenge

Net-zero emissions: Create a transportation system that supports an economy with net-zero greenhouse gas emissions

Priorities

- Decarbonization
- Sustainable and resilient infrastructure

Economic Strength and Global Competitiveness

Grand Challenge

Resilient supply chains: Create a multi-modal freight system that can withstand and rapidly recover from severe disruptions

Priorities

- Resilient supply chains
- Create pathways to good quality jobs
- Advanced asset management
- System performance

FAA Research and Development Domain Alignment to Department of Transportation Grand Challenges

	Domain	Grand Challenges
1	Aerospace Performance and Planning	**The future transportation system-of-systems** Develop connected, intelligent infrastructure that provides people-centered mobility
2	Aircraft Safety Assurance	**Zero fatalities** Advance a future without transportation-related serious injuries and fatalities
3	Airport Infrastructure and Technologies	**Equitable mobility for all** Create an equitable transportation system that provides safe, affordable, accessible, and convenient mobility options for all users
4	Digital Systems and Technologies	**The future transportation system-of-systems** Develop connected, intelligent infrastructure that provides people-centered mobility
5	Environmental and Weather Impact Mitigation	**Net-zero emissions** Create a transportation system that supports an economy with net-zero greenhouse gas emissions
6	Human and Aeromedical Factors	**Zero fatalities** Advance a future without transportation-related serious injuries and fatalities

Advanced Air Mobility Implementation Plan: Innovate28

The FAA developed a program to support initial operations of electric vertical takeoff and landing aircraft, also known as air taxis, in several U.S. early adopter communities by 2028.

Developed with NASA, other government agencies, and aerospace industry partners, the ***FAA's Innovate28 AAM Implementation Plan***, released in July 2023, aims to broaden the adoption of advanced air mobility (AAM) in the coming years and shows how all of the pieces of AAM work will come together.

The "28" in Innovate28 refers to the FAA's aims to scale operations at one or more key sites in the National Airspace System by 2028. The date also coincides with the 2028 Olympics, where air taxis are expected to be in demand.

Innovate28 has four near-term goals:

- **To define the safest and most efficient routes while minimizing the impact on air traffic facilities and area residents**
- **To be responsive to aerospace industry plans for initial commercial operations**
- **To develop a repeatable process to allow ease of implementation at other locations**
- **To plan for permanent and scalable processes, procedures, infrastructure, and mechanisms to support continued AAM operations**

The agency's efforts are part of a larger Department of Transportation-led interagency working group. Composed of members from more than 15 federal agencies, the team is developing a national AAM strategy and identifying key national issues for the rollout.

AAM is expected to become a $30 billion market by 2030. For AAM to succeed, the FAA must address how to certify aircraft and pilots, manage airspace access, ensure pilot training, develop infrastructure, maintain security, determine power and energy sources, and engage communities.

Completing all these steps will allow AAM vehicles to fully and safely integrate into the NAS with maximum flexibility as the industry evolves.

Advanced air mobility is expected to become a $30 billion market by 2030.

2.3 Research Priorities 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 long term, extending beyond 2029, the current NARP focuses on a five-year window beginning in 2025.

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. The area around the timeline shows research drivers, outcomes, and partners.

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 airspace management capabilities

Key Programs and Initiatives

Efficient airport operations and enhanced air traffic and airspace management capabilities are vital to maintaining the world's most complex airspace system. Research under this goal supports airport and spaceport systems and 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 (UAS) and space vehicles into the NAS, ensuring safe airport and spaceport access.

To achieve this goal, the FAA will:

- **Use artificial intelligence (AI) for more accurate and tailored weather forecasting**
- **Implement new capabilities to improve operations on the airport surface**
- **Evaluate the use of AI and machine learning (ML) to improve traffic flow management operations by addressing system-wide demand and capacity imbalances**
- **Use wake turbulence recategorization to increase capacity during poor weather conditions**
- **Explore concepts to increase airport capacity through reduced separation standards, expand applications of dependent and independent operations, and allow operations in lower-visibility conditions**
- **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 Program

Using Artificial Intelligence and Virtual Reality to Incorporate Relevant Weather Information into Preflight and In-Flight Planning Tools for Hazard Mitigation

The FAA's weather program is researching AI to proactively support the growing number and types of users in the NAS.

Researchers anticipate that future weather information will need to be tailored and information-focused to effectively and efficiently support data-driven decisions.

The weather program uses various software applications to provide AI assistance with weather model biases and to feed decision-support tools that analyze the anticipated actions of users, including pilots, air traffic controllers, and dispatchers, to support a more efficient and safer NAS.

Using Artificial Intelligence and Virtual Reality to Incorporate Relevant Weather Information into Preflight and In-Flight Planning Tools for Hazard Mitigation

Driver
Research how to best use artificial intelligence (AI) with an emphasis on providing a more accurate weather forecast and/or making the forecast tailorable to specific users based on the weather hazard

Outcome
Improve the accuracy of weather hazard information by incorporating AI into model development research and decision-support tools

2024	2025	2026	2027	2028	2029

Activity: Use AI to improve weather hazard forecasts and diagnoses outputs that feed decision-support tools
Result: Enhanced decision-support tools that predict future hazards and/or how the hazard will impact users

Activity: Research and incorporate enhanced methods of machine learning and AI into decision-support tools
Result: Tools that better predict the weather hazard or the behavior of the operator mitigating that hazard

Activity: Targeted convective weather research related to near-term Traffic Flow Management (TFM) requirements
Result: Improve thunderstorm forecasts to better meet stringent TFM weather needs

Activity: Transition the initial version of the Offshore Precipitation Capability (OPC) into operations
Result: Transfer OPC capability to the FAA's NextGen Weather Processor

Partners: Airline operations centers, National Laboratories, National Oceanic and Atmospheric Administration, National Weather Service, Academia, Commercial weather providers and research companies

Traffic Flow Management Portfolio

Surface Tactical Flow

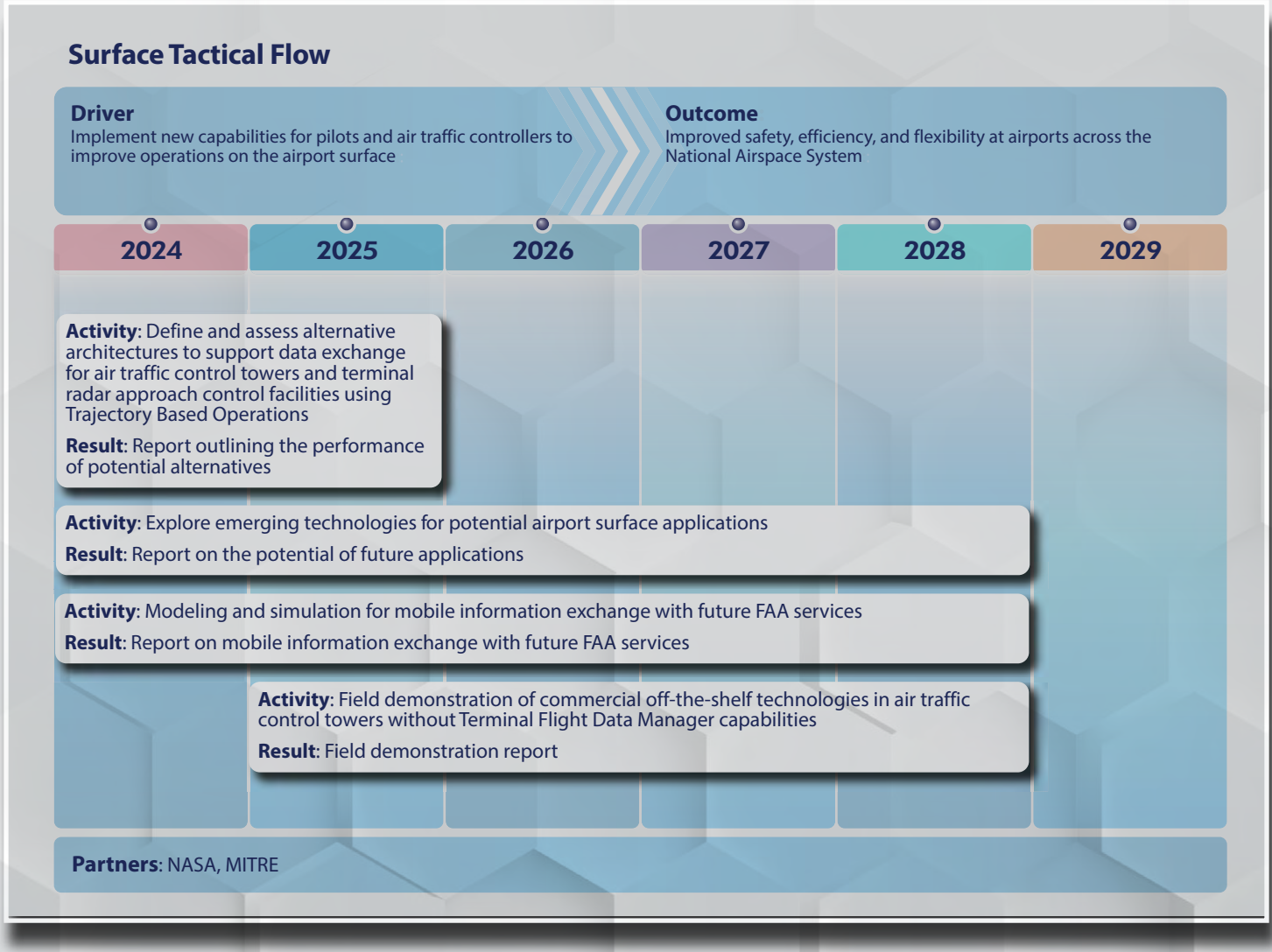
At most airports, aircraft departures are managed in the order they push back from the gate. This can overload runways and cause long taxi and hold times on the airport surface (runways, taxiways, and aircraft parking areas).

Holding aircraft longer at the gate allows air traffic controllers to shift some of the departure wait time away from the taxiway and prevent long departure queues. This saves fuel, reduces emissions, and gives air carriers and passengers more flexibility before 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 with tools to make better decisions about reducing congestion.

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

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



Traffic Flow Management Portfolio

Strategic Flow Management Application

Air traffic managers often strategically reroute large numbers of aircraft to reduce congestion in a particular region of airspace due to constraints that diminish capacity.

Reducing bottlenecks in one area of the country often increases 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) uses AI and ML to help balance NAS-wide demand and capacity.

SFMA provides automated, flight-specific route options that consider operator preferences, resources, potential weather impacts, and metering times — the timeframe 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 destinations.

Strategic Flow Management Application

Driver
Develop new traffic flow management techniques and applications to reduce reroutes, delays, and environmental impacts by increasing flight efficiency

Outcome
Results will be used for further research and the development of investment analysis documentation for proposed Traffic Flow Management System enhancements

2024	2025	2026	2027	2028	2029

Activity: Perform Traffic Flow Management (TFM) capability modeling

Result: Analysis of potential capabilities for further development to decrease the use of reroutes, increase flight efficiency, and reduce delays

Activity: Human-in-the-loop simulation planning, development, and evaluation for selected capabilities

Result: Identification of TFM-related shortfalls and further development of selected TFM capabilities

Activity: Release a new version of the Flow Information Exchange Model (FLXM) to stakeholders for further analysis that includes additional traffic flow concepts

Result: Lessons learned through this activity will be used in the future development of FLXM

Activity: Concept maturation of performance-based TFM

Result: Identification, analysis, and demonstration of potential capabilities for further development

Partners: NASA

Separation Management Portfolio

Wake Turbulence Recategorization

Wake turbulence, rotating vortices that form behind an airplane's wings as it flies through the air, can be hazardous to nearby aircraft. The bigger the aircraft, the stronger the wake turbulence produced.

Air traffic controllers must space out aircraft so the wake from one plane does not impact others behind it. By refining aircraft wake turbulence categories, 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.

The FAA will use research results 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 cancellations, reduce inflight operating costs, and ensure the safety of the aircraft, crew, passengers, and cargo.

Wake Turbulence Recategorization

Driver
Improve airport capacity by safely reducing required wake turbulence separation during instrument meteorological conditions

Outcome
Controller automation tools that increase throughput at busy airports while minimizing wake safety risk

2024	2025	2026	2027	2028	2029
Activity: Demonstrate proof of concept for a dynamic wake turbulence solution at the William J. Hughes Technical Center **Result**: Demonstration results will allow for the technology transfer of a dynamic wake solution work product to the FAA's Air Traffic Organization for further maturation					
Activity: Develop a shortfall analysis report of weather data in the design of wake hazard mitigating decision-support tools **Result**: Documentation of shortfalls to support the future development of a terminal concept					
Activity: Develop design requirements for incorporating Airport Surface Observation System data into the dynamic wake solution **Result**: Document the projected performance of the dynamic wake solution at airports that would achieve the most capacity benefit for its use					
Activity: Develop a safety assessment report for the dynamic wake solution in the terminal domain **Result**: Assessments of controller usability of the dynamic wake solution and its safety and benefit to commercial aviation					

Partners: Air carriers, Air Line Pilots Association, International Civil Aviation Organization, Eurocontrol

Separation Management Portfolio

Closely Spaced Parallel Runway Operations

Airports are typically most efficient when the weather is clear and calm. In these conditions, aircraft can take off and land at a steady pace using visual flight rules (VFR) separation standards. 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 allowed the FAA to develop procedures and tools to increase airport arrivals and departures in all weather conditions.

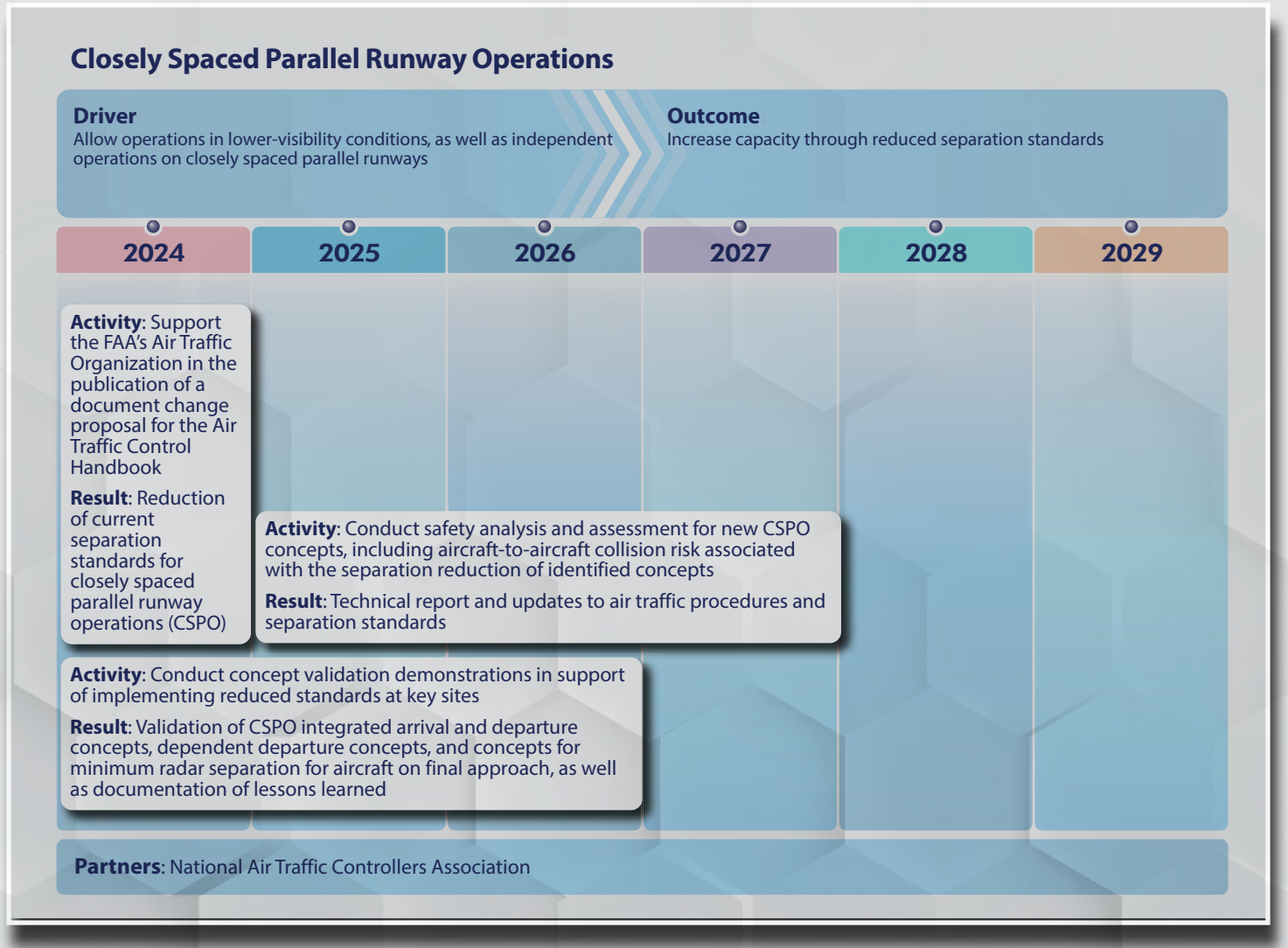
When VFR approaches are not possible due to low visibility, arrivals and departures at busy airports can still be significantly increased using simultaneous independent and dependent CSPO.

The program uses modern flight tracking technology that more accurately displays an aircraft's position to reduce the separation standards required for these operations.

Research in this area will result in updates to advisory circulars by the FAA's Office of Airports and changes to the Air Traffic Control (ATC) Handbook through a document change proposal.

Current research continues to explore ways to increase takeoffs and landings by:

- **Safely reducing aircraft separation standards**
- **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**



Separation Management Portfolio

Integrated National Airspace System Design and Procedure Planning

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.

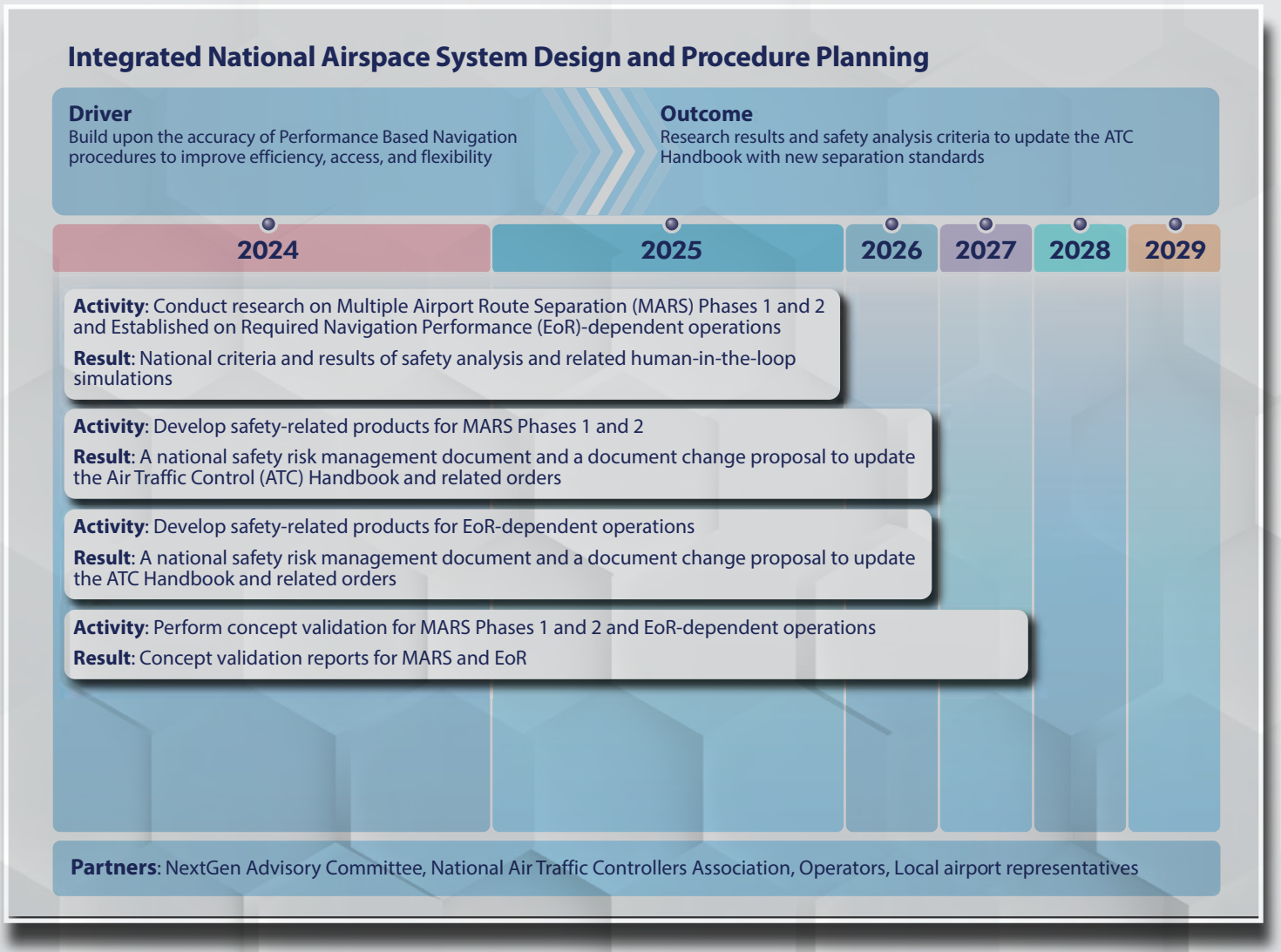
Current research builds upon the success of PBN procedures at select airports, specifically Established on Required Navigation Performance (EoR) and Multiple Airport Route Separation (MARS).

The EoR concept increases the use of instrument approach procedures that allow planes to turn to align with the runway sooner, reducing passenger time, track miles flown, fuel burn, aircraft emissions, and overall noise footprint while maintaining safety and capacity.

While EoR is used at one airport, MARS extends the EoR concept to multiple airports in close proximity, increasing throughput for both approaches and departures and reducing congestion in the surrounding airspace. Both concepts improve the repeatability and predictability of operations.

Initially driven by aviation industry priorities through the FAA's NextGen Advisory Committee to enhance air travel through the 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 will drive changes to the ATC Handbook and other criteria, which will be updated with new separation standards as positive results are known.



NAS Infrastructure Portfolio

New Air Traffic Management Requirements

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

One area of focus is creating and validating standards for using internet protocol (IP) networks to transmit air-to-ground and ground-based ATM data using the Internet Protocol Suite. These improvements will allow the following:

- **Future operations, including Trajectory Based Operations**
- **Increased security measures to protect the safety of critical applications**
- **Improved interoperability with other systems**
- **Additional support for current systems, such as Data Communications, System Wide Information Management, and weather and aeronautical data transmission**

New Air Traffic Management Requirements

Driver
Identify opportunities to improve strategic air traffic management through the development of new decision-support tools

Outcome
Increase airspace capacity through future standards tools, guidance, and applications

2024

Activity: Complete the development of Internet Protocol Suite (IPS) standards, including performance standards validation

Result: Finalized versions of IPS RTCA Minimum Aviation System Performance Standards; IPS standards and recommended practices for the International Civil Aviation Organization with an accompanying technical manual, and Airlines Electronic Engineering Committee IPS form, fit, and function standards

2025

Activity: Develop enhanced services applications, requirements documentation, and a security and safety assessment for the IPS Gateway

Result: Program documentation, including analysis reports and specifications to support the successful transmission of air-to-ground enhanced services using IPS

Activity: Conduct safety risk management analysis for using artificial intelligence (AI) to support air traffic controller functions

Result: Requirements for the potential use of AI to support controller functions

2026

Activity: Conduct large-scale demonstrations using the Boeing Eco-Demonstrator with IPS avionics and corresponding IPS ground gateway

Result: Verification that IPS data transmission meets performance requirements in an operational air traffic control environment and documentation to support a successful investment analysis readiness decision

2027 | **2028** | **2029**

Partners: Airframe manufacturers, Avionics vendors, Air traffic service providers, Eurocontrol, Single European Sky Air Traffic Management Research Joint Undertaking

NAS Infrastructure Portfolio

Weather for Forecast Improvements

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 flight deck, 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.

Weather for Forecast Improvements

Driver
Improve forecast predictions and how weather information is disseminated in the National Airspace System

Outcome
Development of weather prediction services and recommendations on how to improve the use of weather information

2024	2025	2026	2027	2028	2029
Activity: Complete final investment decision (FID) documentation for the Terminal Precipitation on the Glass (TPoG) project **Result**: Achieve an FID for TPoG					
Activity: Develop concept and requirements definition (CRD) documentation for the Cloud Services for Aviation Weather (CSAW) capability **Result**: Achieve an investment analysis readiness decision for initial CSAW capability					
	Activity: Conduct shortfall analysis for the Weather Services for Extensible Traffic Management (xTM) tool **Result**: The identification of traffic management shortfalls in relation to Weather Services for xTM				
			Activity: Develop a concept of operations and an operational capability business case for Weather Services for xTM in accordance with CRD **Result**: CRD documentation for Weather Services for xTM		

Partners: National Weather Service

2.3.2 Goal 2: Accelerate the 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 into all corners of 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 and civil aviation; and provides decision makers essential data and analysis to shape the future of the NAS.

This research yields a safer, more efficient NAS with reduced environmental impacts. It keeps pace with continuously changing technology to properly certify operators and operations of new industries, improve aircraft performance, and drive policy.

To achieve this goal, the FAA will:

- **Develop vertiport standards to support advanced air mobility (AAM) operations**
- **Study potential unleaded and renewable replacement fuels for the existing general aviation fleet of 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 the environmental impacts of supersonic aircraft and encourage technological solutions that support their reintroduction into the nation's aircraft fleet**
- **Analyze airworthiness and safety certification of highly integrated, complex digital aircraft systems**
- **Research ways to make it easier for emergency responders to incorporate the use of drones during emergencies and to enhance disaster preparedness and response efforts**
- **Develop performance-based standards and test methodologies to ensure the durability, endurance, and reliability of electric engines**
- **Develop modeling tools and means of compliance methods to ensure the safety of current and newly designed engine propulsion systems**
- **Evaluate halon-replacement firefighting agents and update minimum performance standards for their use**

Airport Technology Research Program

Vertiport Infrastructure and Design Standards to Support Advanced Air Mobility Systems

Advanced air mobility (AAM) describes a new transportation system that uses emerging technologies, such as vertical takeoff and landing and short takeoff and landing aircraft, to transport people or cargo at lower altitudes and within a shorter range than traditional aircraft. AAM can help increase access to areas underserved by the current aviation industry.

AAM will bring operational challenges to the NAS. New aircraft types will require new landing infrastructure, charging stations (if powered by electricity), and terminals that can accommodate many aircraft flying frequent, short flights while being mindful of existing ground transportation routes.

Therefore, the AAM transportation systems must include well-designed and conveniently located vertiports — specialized vertical aircraft takeoff and landing areas. FAA research provides a framework and data for developing sound vertiport guidance.

Vertiport Infrastructure and Design Standards to Support Advanced Air Mobility Systems

Driver
Identify advanced air mobility (AAM)-related safety risks and develop new vertiport infrastructure that will meet AAM needs in rural, suburban, and urban environments

Outcome
Vertiport standards that support the design and operation of facilities used by VTOL aircraft with various power sources, considering electric, hydrogen, hybrid, and alternative fuels

2024

Activity: Conduct an assessment of future vertiport electrical and hydrogen infrastructure

Result: Improved understanding of required AAM infrastructure needs

Activity: Complete ongoing testing to study downwash and outwash from vertical takeoff and landing (VTOL) aircraft

Result: Improved understanding of outwash and downwash considerations in vertiport design

Activity: Test operational performance of VTOL aircraft, including taxi and turn radius, landing precision, and approach and departure slopes

Result: Data-derived and performance-based vertiport sizing standards for touchdown and liftoff, final approach and takeoff, and vertiport safety areas

2025 | 2026 | 2027 | 2028 | 2029

Activity: Develop a test methodology to study integrating automation into vertiports

Result: Improved understanding of automation integration for vertiports

Partners: National Renewable Energy Laboratory, NASA, Center of Excellence for Alternative Jet Fuels and Environment, European Union Aviation Safety Agency, International regulators, U.S. Air Force

Alternative Fuels for General Aviation Program

Alternative Fuels for General Aviation

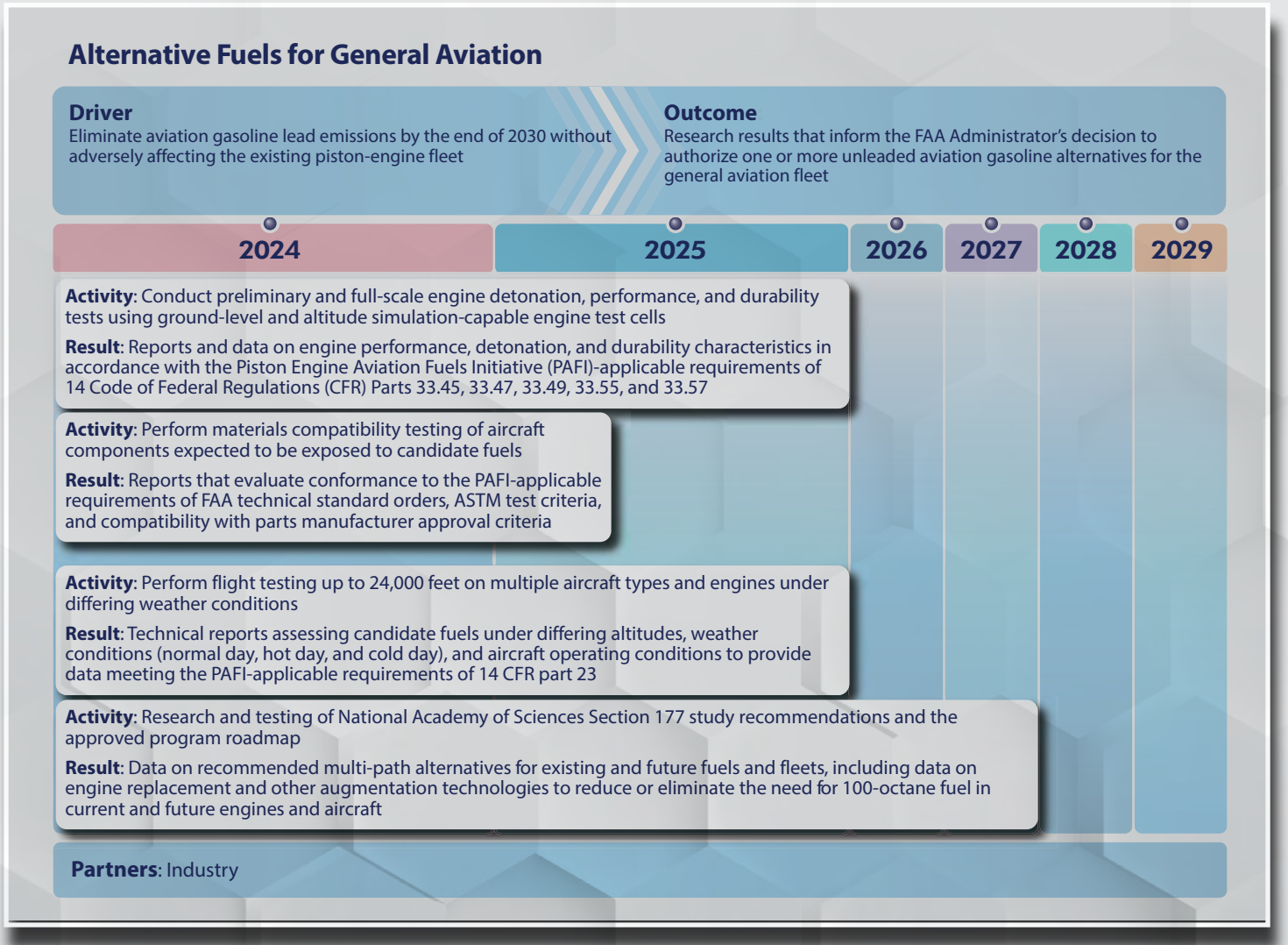
Hi-octane leaded aviation gasoline (avgas) is the only remaining transportation fuel in the United States that contains lead. The FAA is working closely with aviation industry stakeholders on research that will provide the critical data necessary for the FAA Administrator to authorize one or more unleaded replacement fuels for piston-engine aircraft as required by Congress.

In the fall of 2023, the Environmental Protection Agency (EPA) announced a final endangerment finding that airborne emissions from leaded avgas pose a public health hazard. The EPA and FAA must undertake rulemaking within their respective authorities to enact standards addressing the finding.

The FAA previously commenced an action under the Eliminate Aviation Gasoline Lead Emissions (EAGLE) initiative to safely eliminate leaded aviation fuel by the end of 2030 without adversely affecting the existing piston-engine fleet. In coordination with EAGLE, the FAA collaborates with the EPA to develop companion regulations to address the endangerment finding. These will include a final timeline for the regulation of avgas fuel composition.

Making continued progress towards these goals, in November 2023, the FAA completed pre-screening testing and approved a candidate unleaded fuel to advance to full-scale testing, the defined pathway leading to a fleet authorization of unleaded avgas fuels.

The fuel, named UL100E by the team that produced it, successfully passed detonation testing and a 150-hour engine durability test at the FAA's William J. Hughes Technical Center under the Piston Aviation Fuels Initiative (PAFI), a collaborative industry/government testing program. This is the first unleaded fuel to pass the PAFI 150-hour durability pre-screening test.




Sustainable
Aviation
Fuel
JET A-1

Fueling Aviation's Sustainable Transition

The FAA is launching a new competitive grant program called Fueling Aviation's Sustainable Transition (FAST). Investments made through the program will accelerate the production and use of sustainable aviation fuels (SAF) and the development of low-emission aviation technologies.

Established by the Inflation Reduction Act of 2022, the FAST program will carry out projects in the United States that produce, transport, blend, or store sustainable aviation fuels and develop, demonstrate, and apply low-emission aviation technologies.

This work supports the U.S. aviation climate goal to achieve net zero greenhouse gas emissions by 2050.

The sustainable aviation fuels elements of the program, termed FAST-SAF, will provide more than $244 million to help deploy jet fuels made from renewable sources.

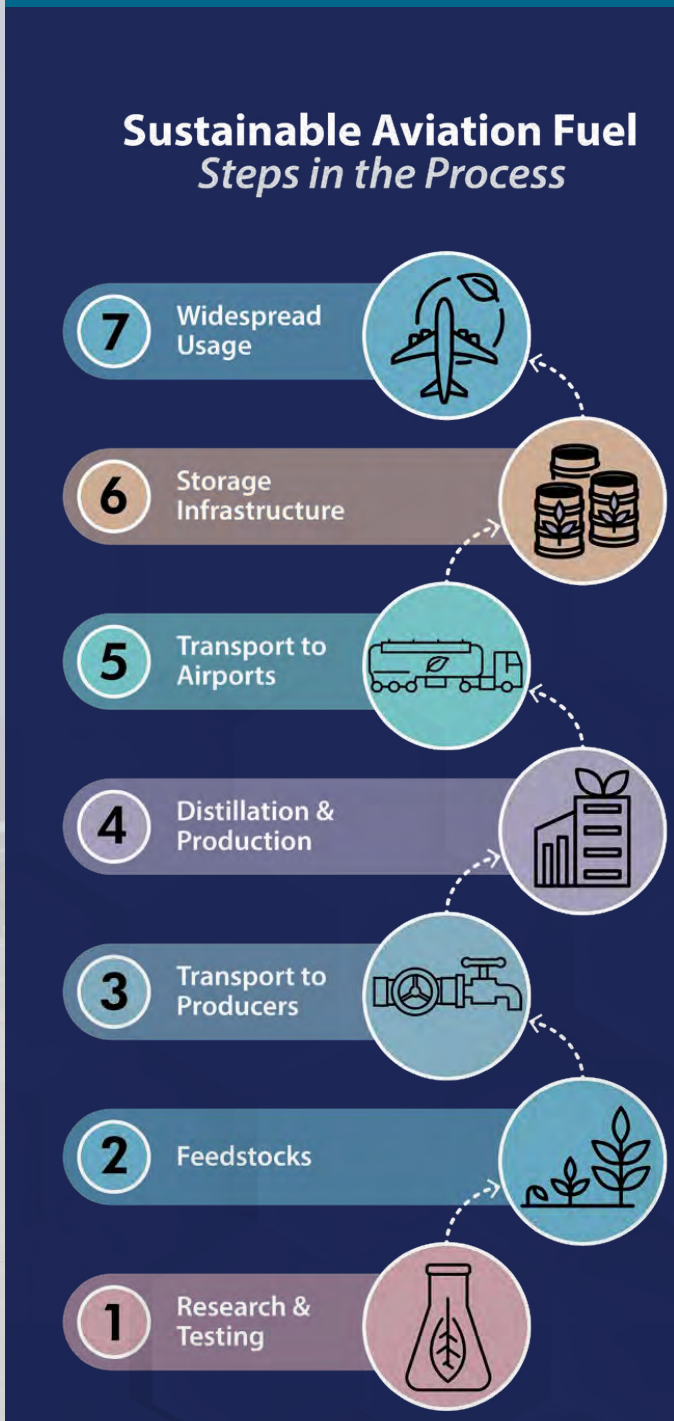
These fuels will offer more than a 50% reduction in lifecycle carbon dioxide emissions and can be used safely in today's aircraft and engines.

Complementing the FAA's existing SAF research efforts, FAST-SAF will support the buildout of infrastructure related to SAF production, transportation, blending, and storage while supporting scoping studies related to infrastructure needs for SAF.

This approach allows the FAA to hit the ground running where infrastructure needs are already well defined while supporting areas of the country and supply chains just starting their SAF journey.

The low-emissions aviation technologies elements of the program, termed FAST-Tech, will provide more than $46 million to develop and demonstrate new technologies that will improve fuel efficiency, reduce emissions, and make every drop of SAF go further toward supplying aviation's demand for jet fuel.

FAST-Tech will support the research and development of individual low-emissions technologies while enhancing test capabilities to accelerate multiple low-emissions technologies toward maturity and future use.



Environmental Research - Aircraft Technologies and Fuels Program

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

Through the Continuous Lower Energy, Emissions, and Noise (CLEEN) program, the FAA is working with the aviation industry to develop certifiable aircraft and engine technologies that increase fuel efficiency while reducing noise and emissions.

CLEEN is a cost-share partnership with aviation manufacturers that helps accelerate the research and development of environmentally beneficial technologies. These efforts culminate in full-scale ground and flight test demonstrations, ultimately supporting the deployment of these technologies into the flying aircraft fleet.

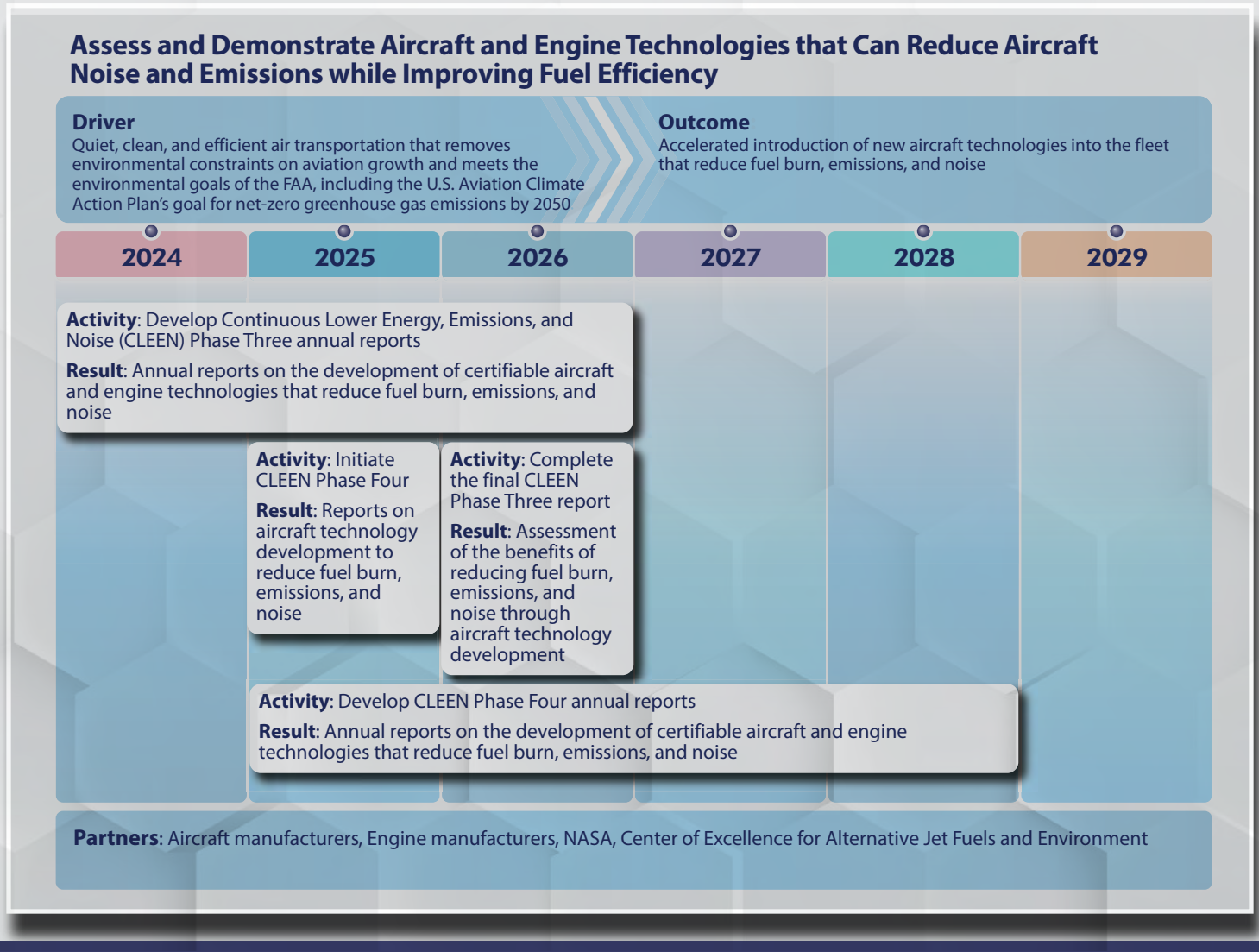
The program is implemented in five-year phases, each with specific improvement goals. In Phase Three of the program, which began in 2021, research focuses on reducing certification noise levels, community noise, nitrous oxide emissions, particulate matter emissions, and fuel burn from aircraft.

Efforts under CLEEN Phase Three will continue through 2026, at which point industry partners will have mature, environmentally beneficial technologies that they can use in their next generation of aircraft and engines.

In 2023, the FAA conducted a market survey of the aviation industry to guide the development of future research. The agency is currently developing plans for Phase Four of CLEEN. The FAA plans to launch the program in 2025, pending budgetary considerations.

Researchers in the CLEEN program also work with the Commercial Aviation Alternative Fuels Initiative and the Aviation Sustainability Center (ASCENT), the FAA's Center of Excellence for Alternative Jet Fuels and Environment, to obtain critical information on sustainable aviation fuels. The goal is to ensure the fuels are safe for use up to 100% blend levels.

This is above the currently approved 50% blend with conventional petroleum-based jet fuel. ASCENT researchers also work closely with the FAA to ensure these fuels are adequately credited under international emissions standards.



Noise Standards for New Aircraft

Aerospace companies are developing new types of aircraft, such as drones, advanced air mobility (AAM) vehicles, and a new generation of supersonic aircraft. These vehicles use advanced technologies and innovative operating methods.

While some are expected to create less noise than existing aircraft, the new vehicles may have different operational characteristics and operate closer to people. This means existing noise certification methods may not apply.

The FAA is currently analyzing concepts of operation, collecting data, and funding research to measure the noise generated by these new aircraft — work that will help protect the public's health and welfare from aviation noise.

New noise standards are needed for regulators to quantify the noise levels of these aircraft and to provide data the FAA needs to determine the impact of new aircraft operations on nearby residents. Specifically, researchers need to assess noise exposure near takeoff and landing sites and communities where the vehicles will operate.

For future supersonic aircraft, the FAA expects government and aerospace industry investments in noise mitigation research for engines and advanced technologies to allow these aircraft to operate alongside the fleet of planes we see at airports today while complying with the existing noise limits.

The agency supports noise research for new aircraft through the Aviation Sustainability Center (ASCENT), the FAA's Center of Excellence for Alternative Jet Fuels and Environment. In addition, the FAA is working to collect data from AAM manufacturers.

Through its ASCENT research and work with the aerospace industry, the FAA continues to create new noise certification standards that are economically reasonable, technologically sound, and appropriate for these new aircraft types.

Internationally, the agency is working with the European Union Aviation Safety Agency and the International Civil Aviation Organization to coordinate the certification of these vehicles. The FAA works with NASA to research human response to drone and AAM noise.

Collectively, this work will ensure that new aircraft contribute to an environmentally responsible and sustainable National Airspace System.

The FAA is currently analyzing concepts of operation, collecting data, and funding research to measure the noise generated by these new aircraft.

Environmental Research - Aircraft Technologies and Fuels Program

Supersonic Aircraft

Supersonic aircraft fly faster than the speed of sound, which could dramatically reduce passenger travel time. The DOT and the FAA are taking steps to encourage the development of civil supersonic aircraft to accelerate the reintroduction of these high-speed airliners into the nation's fleet.

Work examines the environmental impacts of supersonic aircraft, such as landing and takeoff noise, emissions, fuel burn, and sonic booms. The FAA will use the research results to formulate policies and international standards and support the development of analytical methods for noise mitigation technologies as directed by Congress.

There are potentially two generations of supersonic airplanes. Generation 1 aircraft would fly supersonically over the oceans but subsonic over land. These aircraft would use technological advances to reduce their environmental impact relative to the Concorde (a supersonic aircraft introduced in 1976 that was ultimately retired almost three decades later).

Generation 1 aircraft would still produce a strong sonic boom when flying beyond Mach 1 (faster than the speed of sound). Generation 2 supersonic airplanes would use advanced airframe technology to mitigate the severity of sonic booms and potentially allow supersonic flight over land.

Supersonic Aircraft

Driver
Examine the impacts of reintroducing supersonic flight, including understanding aircraft engine parameters and improving the prediction of supersonic aircraft noise

Outcome
Support domestic rulemaking and international standards setting

2024	2025	2026	2027	2028	2029

Activity: Model and measure the basics of jet noise and complex mixed engine exhaust flows of a supersonic airplane

Result: Multi-fidelity methods that will enable reliable noise reduction estimates for takeoff and landing jet noise

Activity: Conduct clean sheet supersonic engine design and performance analyses

Result: Data to aid decision making on fuel burn, emissions, and noise impacts of clean sheet and derivative propulsion systems, providing a roadmap for technology development

Activity: Develop landing and takeoff noise standards and recommended practices at ICAO for Generation 1 supersonic airplanes

Result: Globally accepted landing and takeoff noise standards and recommended practices for new Generation 1 supersonic airplanes, which will provide manufacturers with the regulatory certainty needed to complete their designs

Activity: Develop low sonic boom standards and recommended practices at ICAO for Generation 2 supersonic airplanes flying in en route airspace

Result: Globally accepted low sonic boom standards and recommended practices for new Generation 2 supersonic airplanes, which will allow potential supersonic flight over land

Partners: International Civil Aviation Organization (ICAO), Airframe and engine manufacturers, Center of Excellence for Alternative Jet Fuels and Environment, NASA

Digital Systems Safety Program

Complex Digital Systems

The increasing complexity of aircraft avionics and flight control systems has created new challenges for the assurance of digital systems safety.

The aviation industry is introducing newer systems due to technological innovations and a desire to reduce costs and shorten the time it takes to bring new products to market. These systems increasingly rely on software and digital technologies, which are difficult to test and validate under all foreseeable operating conditions.

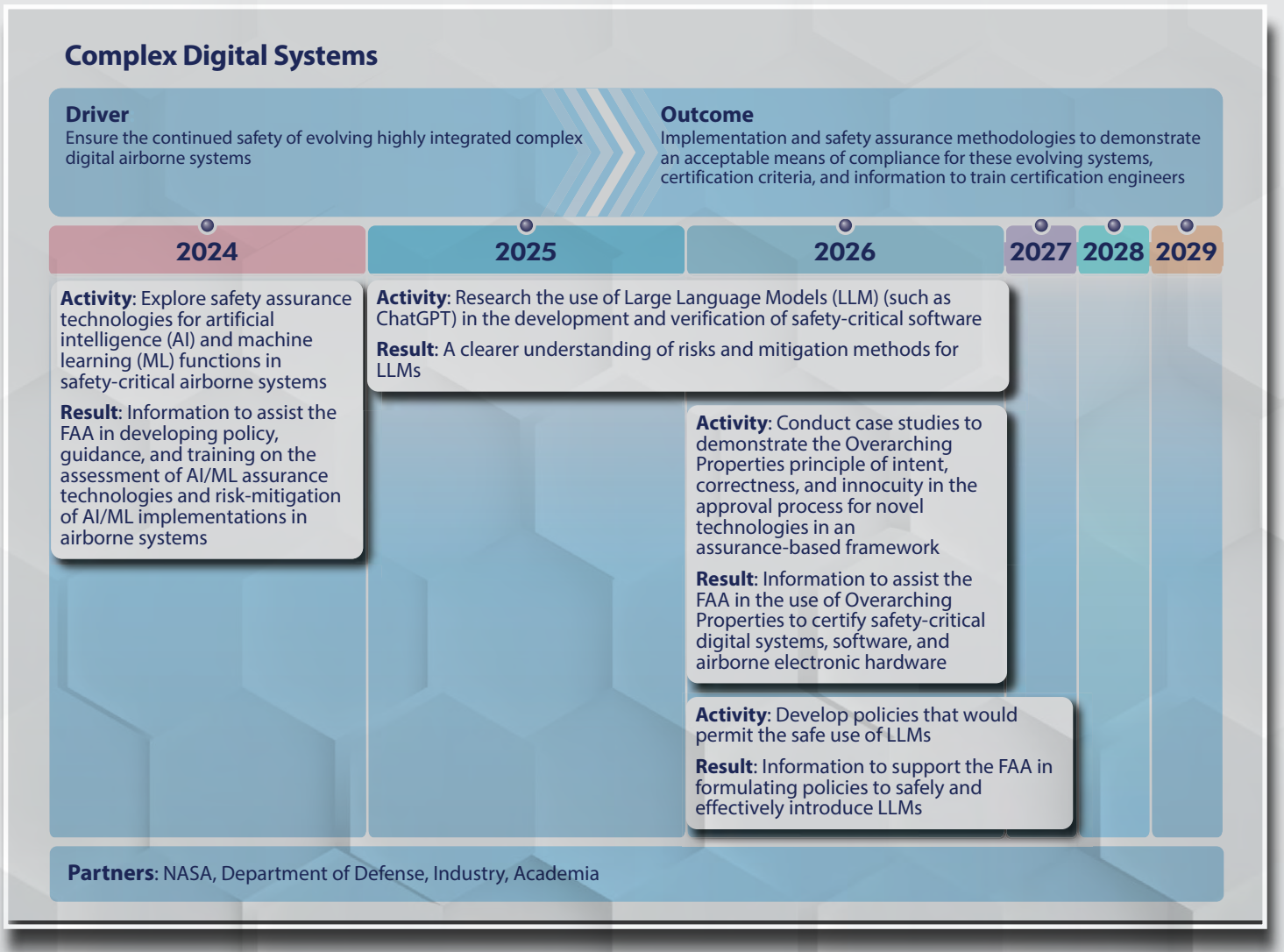
Adding to concerns, the aviation industry is proposing the increased use of AI and ML in critical aviation systems and using autonomous (non-piloted) aircraft under conditions where regulations and guidance do not exist.

Introducing AI and ML into these systems adds additional layers of complexity. These technologies are not yet well understood in a safety-critical environment, and there is a risk that they could introduce new hazards.

This makes it difficult for researchers and standards-setting bodies to develop recommendations for verifying these new technologies under various normal and abnormal operating conditions. If one of these critical systems were to fail, it could result in the loss of the aircraft and life.

Research will focus on analyzing airworthiness and safety certification of highly integrated complex digital aircraft systems, including software and airborne electronic hardware, such as autopilots, flight controls, and engine controls, as well as the use of AI and ML in these products.

The FAA will use the data and results of the research to create policy and guidance for the certification and means of compliance for new aircraft and systems using these technologies. The FAA is committed to working with the aviation industry and other stakeholders to develop consensus recommendations to ensure the safe and ethical use of these technologies.



Unmanned Aircraft Systems Program

Unmanned Aircraft Systems Disaster Preparedness and Emergency Response

The real-time capabilities and versatile functions of UAS, also known as drones, and their ability to deploy rapidly make them powerful tools during emergencies and for disaster preparedness and response.

Drones can improve these operations and help save lives. Improving our nation's ability to use UAS by researching and developing best practices and tools to prepare for, respond to, and recover from disasters will help state and local first responders and emergency management organizations adopt and implement drone technologies.

Research will focus on creating procedures that help improve collaboration between local, state, and federal government agencies to ensure proper coordination during disaster and emergency response situations.

Specific emphasis will be given to expanding the role of the FAA's UAS center of excellence in transportation disaster preparedness and emergency response as directed by Congress in the 2018–2022 omnibus budget appropriations.

Unmanned Aircraft Systems Disaster Preparedness and Emergency Response

Driver
Increase the use of unmanned aircraft systems (UAS) during emergencies and for disaster preparedness and response by removing barriers to adoption and enhancing interagency communication

Outcome
Develop requirements, technical standards, policies, procedures, guidelines, regulations, best practices, and tools to allow emergency and disaster preparedness and response operations for UAS

2024

Activity: Complete UAS flight testing to demonstrate various use cases for emergencies and disaster preparedness and response activities

Result: Document lessons learned

Activity: Study interagency coordination procedures and coordination between human-crewed and unmanned aircraft

Result: Recommendations for the safe operation of UAS and coordination among agencies during disaster and emergency response efforts

2025

Activity: Research best practices and tools to improve safety, enhance effectiveness, and remove barriers for UAS disaster preparedness, response, and recovery

Result: Multimedia content and tools showing best practices

2026 | 2027 | 2028 | 2029

Activity: Conduct drills and exercises to test the previously-developed best practices and tools

Result: Updates to best practices and tools, as needed

Partners: Alliance for System Safety of Unmanned Aircraft Systems through Research Excellence, Department of Homeland Security, Federal Emergency Management Agency, NASA, Department of Commerce, National Oceanic and Atmospheric Administration, National Institute of Standards and Technology, Department of Agriculture, U.S. Forest Service; State and local governments

Propulsion and Fuel Systems Program

Electric Propulsion Certification Standards

The aviation industry is researching electric propulsion systems to potentially decrease aircraft emissions and reduce dependence on fossil fuels. Companies are pursuing electrically propelled designs in various aircraft types, including fixed-wing airplanes, large air carriers, and rotorcraft.

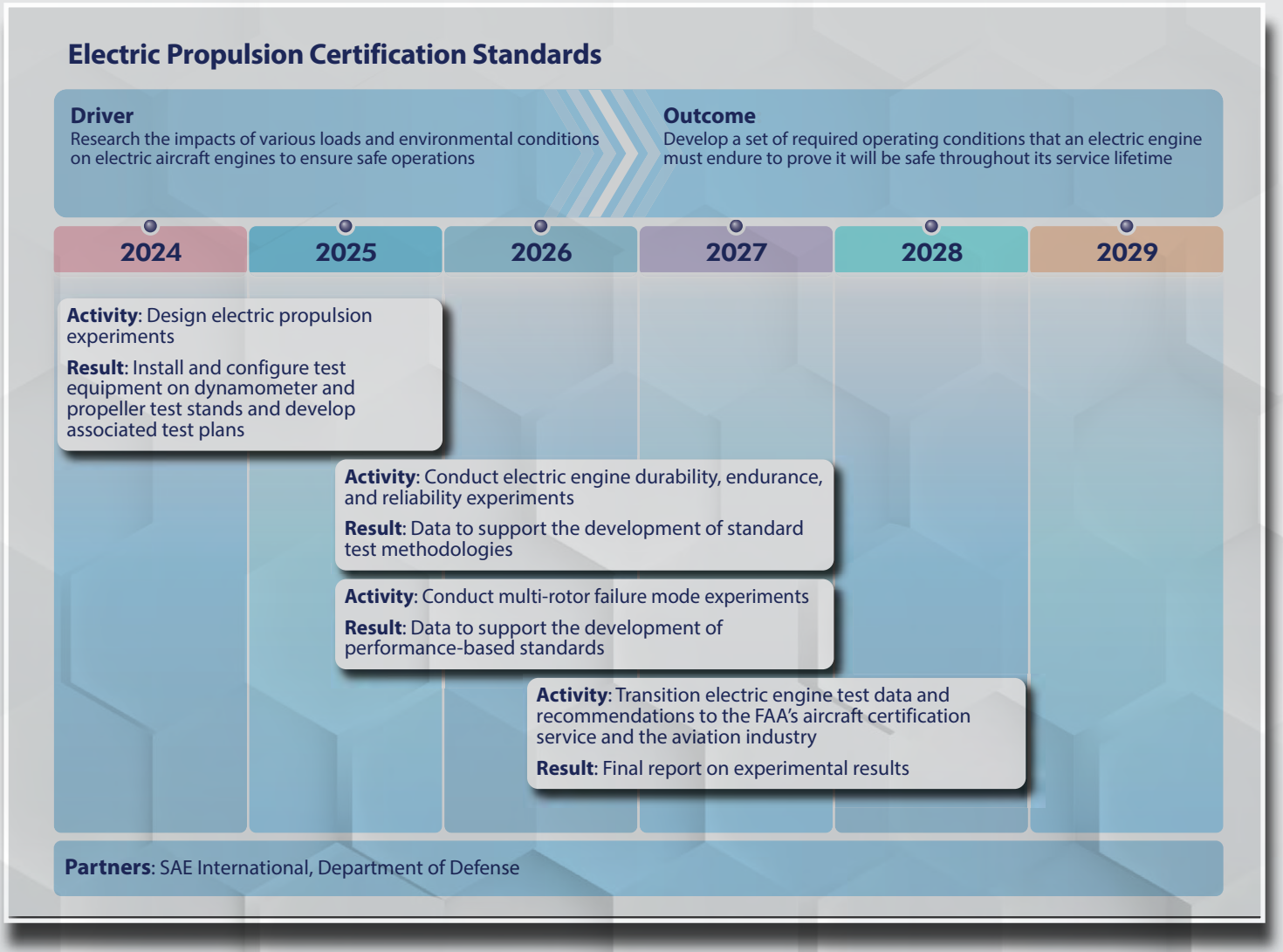
New propulsion system designs differ significantly from traditional fossil fuel-powered systems and necessitate new certification rules.

Although such guidance exists for electric cars, the standards are not directly applicable due to the difference in system architecture, operating voltage, and environmental conditions experienced during flight.

The FAA is developing performance-based standards and test methodologies to ensure the durability, endurance, and reliability of electric aircraft engines.

The research will address environmental and electromagnetic (lightning) impacts on electric engines, such as altitude, humidity, and temperature.

Researchers will also analyze the hazards associated with the failure of one or more electric engines in a multi-engine electric propulsion system.



Propulsion and Fuel Systems Program

Advanced Analysis Methods for Rotor Burst and Blade Release Impacts

Fragments released when fan blades and other high-speed rotating engine components break apart can seriously threaten aircraft safety. Several in-service fan blade fractures in recent years resulted in engine parts striking other areas of the aircraft. One of these accidents led to a passenger fatality.

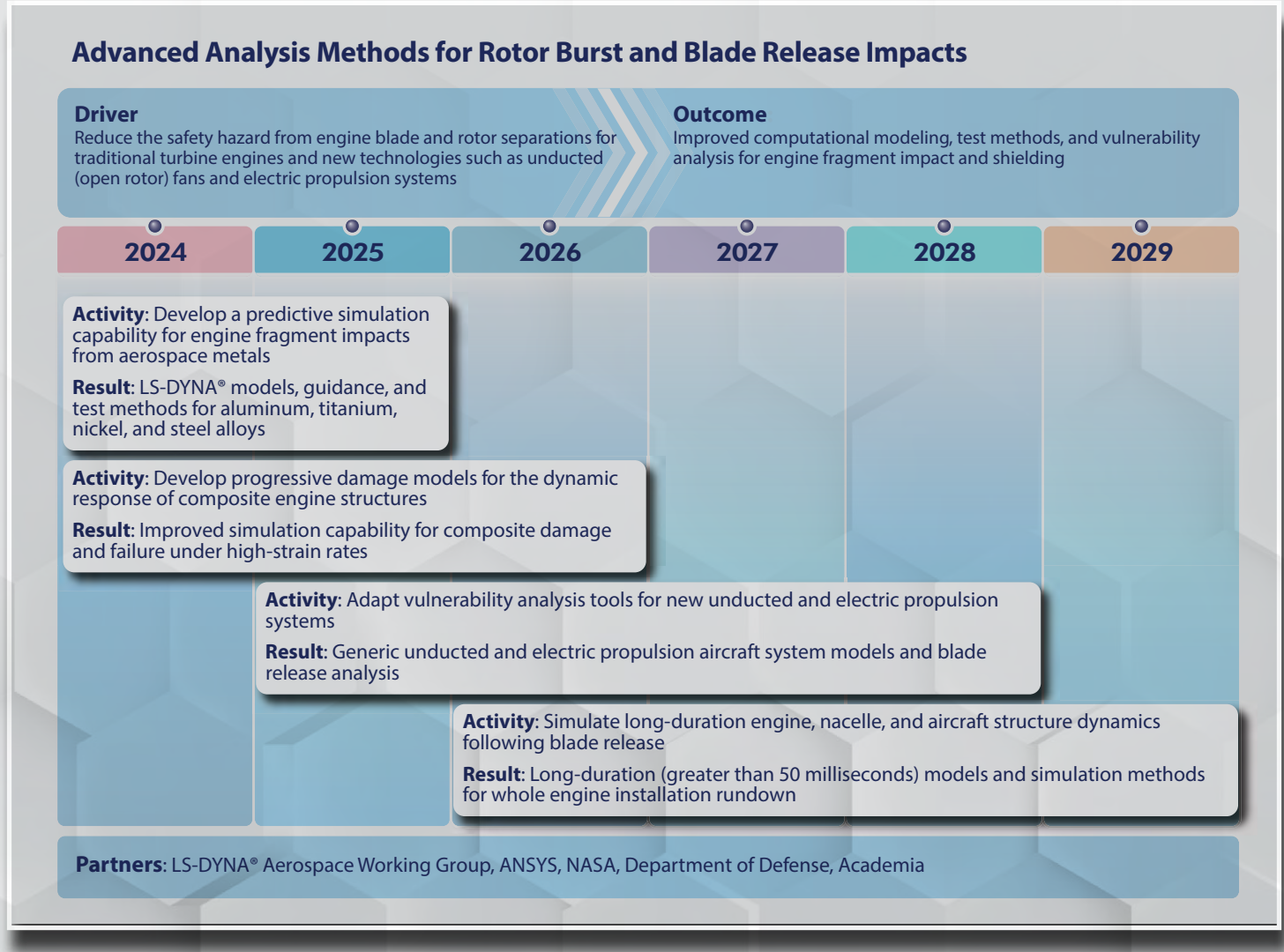
Manufacturers rely upon computer simulations produced by LS-DYNA® and other dynamic analysis software to ensure that traditional turbine designs are robust enough to meet FAA certification test requirements for blade containment and debris hazard minimization.

The aviation industry is rapidly pursuing new propulsion concepts such as unducted (open rotor) composite fans and electric propulsion systems. These designs lack containment structures around the largest blades, necessitating shielding to prevent engine fragments from impacting the aircraft.

In collaboration with NASA, the Department of Defense, the aviation industry, and academia, FAA researchers are developing modeling tools and means of compliance methods to ensure the safety of these new propulsion systems.

The LS-DYNA® Aerospace Working Group — a partnership of government, the aviation industry, and academia — published modeling guidelines and several material models for widely used aerospace metals and composites.

The improved methodology more accurately predicts damage and penetration, leading to safer shielding designs and vulnerability analysis tools for current and future propulsion systems.



Fire Research and Safety Program

Aircraft Halon Replacement

Aircraft halon replacement research assists the international aviation community with testing environmentally safe halon-alternative fire suppression agents for use in cargo compartments, engines, auxiliary power units, lavatory trash receptacles, and hand-held fire extinguishers.

The FAA collaborates with aviation industry partners to test firefighting agents with unique characteristics not envisioned when the agency developed minimum performance standard (MPS) test methods for non-halon agents.

Qualification testing of new firefighting agents provides mutual benefits to the participating parties. The aviation industry gains halon-alternative agents that meet EPA and FAA requirements. The FAA acquires valuable knowledge and direct experience with these new substances to help update MPS test methods.

The FAA will publish a report called "Handbook for Halon Replacement Minimum Performance Standards," featuring the improved MPS test methods derived from this research. The agency will regularly update the document with evolving fire suppression technologies.

Aircraft Halon Replacement

Driver
Conduct qualification testing for firefighting agents with unique characteristics not envisioned at the time the agency developed minimum performance standard (MPS) test methods for non-halon agents

Outcome
Publish the "Handbook for Halon Replacement Minimum Performance Standards," highlighting improved MPS test methods derived from this research

2024	2025	2026	2027	2028	2029

Activity: Evaluate halon replacement extinguishing agents for propulsion systems at the William J. Hughes Technical Center's (WJHTC) propulsion test facilities, including the Generic Nacelle Fire Simulator (gNFS) and a Boeing 747SP Pratt & Whitney JT9D test engine

Result: Determine an acceptable concentration of a solid-aerosol halon replacement agent in the gNFS and test engine operated as needed to achieve intended test conditions

Activity: Evaluate the current cargo compartment MPS through the Cargo Halon Replacement Task Group

Result: Develop a more robust standardized test method for the aviation industry to qualify halon replacement firefighting agents in the cargo compartment

Activity: Construct suitable test fixtures and evaluate the effectiveness and potential toxicity of non-halon fire suppression agents, including water, in hand-held and lavatory extinguishers

Result: Updates to the current MPS, as necessary

Activity: Evaluate the effectiveness of MPS testing of halon replacement suppression agents for cargo compartments

Result: Publish reports assessing MPS testing procedures and results from fire test scenarios

Partners: Industry

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 area includes airport runways, taxiways, air traffic management, aircraft systems and networks, and 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 internal and external threats due to rapid advances and sophistication of cyber-attacks. The resulting analysis will lead to a longer-lasting, lower-cost, dependable infrastructure defended against cyber events.

To achieve this goal, the FAA will:

- **Ensure the continued resilience of positioning, navigation, and timing (PNT) systems through the use of advanced antenna technologies, GPS authentication, and complementary avionics for cyber safety**
- **Develop new tools to protect the NAS from cyber-attacks using AI and ML**
- **Study the feasibility of using geosynthetic materials in airport pavement**

Digital Systems Safety Program

Aircraft Positioning, Navigation, and Timing Cyber Safety Resilience

PNT services have expanded dramatically over the past few decades, becoming essential for current and future aviation operations.

Numerous Global Navigation Satellite Systems, or satellite constellations, provide global and regional PNT services, including the U.S. Space Force's global positioning system (GPS). Flight crews also use the FAA's Wide Area Augmentation System — a navigation tool that dramatically increases GPS accuracy, integrity, and availability at all locations for all phases of flight.

The ability to accurately receive PNT information during flight is critical to the safe operation of an aircraft. Intentional or unintentional disruptions to these services present a significant safety hazard.

Research conducted by the FAA and its partners will identify regulatory guidance and validate a concept of operations seeking to ensure the continued resilience of these systems through the use of advanced antenna technologies, GPS authentication, and complementary PNT avionics for cyber safety. The FAA will use the results to develop related technical standard orders and advisory circulars.

Aircraft Positioning, Navigation, and Timing Cyber Safety Resilience

Driver
Increase aircraft positioning, navigation, and timing (PNT) resiliency through advanced antenna technologies, validated authentication requirements, and complementary PNT capabilities

Outcome
Mitigate safety and efficiency threats to aircraft operations that rely on GPS/GNSS services

2024	2025	2026	2027	2028	2029

Activity: Develop and validate GPS/Global Navigation Satellite Systems (GNSS) multi-element controlled reception antenna and antenna electronics that prevent interference and manipulation

Result: Technical standards orders and installation guidance for civil and commercial aviation

Activity: Assess the use of authenticated (in-kind and cryptographic) and unauthenticated data within the avionics and aircraft

Result: Concept of operations and validated method for initial avionics in-kind authentication of GPS/GNSS PNT data

Activity: Assess the use of commercially available terrestrial and non-terrestrial complementary PNT capabilities within aircraft avionics

Result: Recommendations for complementary PNT capabilities that modernize aircraft PNT access and increase PNT resiliency

Partners: Department of Transportation, U.S. Air Force Research Laboratory, U.S. Space Command, Naval Air Warfare Center Aircraft Division, Academic institutions, Manufacturers

Information Technology/Cybersecurity Program

Cybersecurity Data Science with Artificial Intelligence and Machine Learning

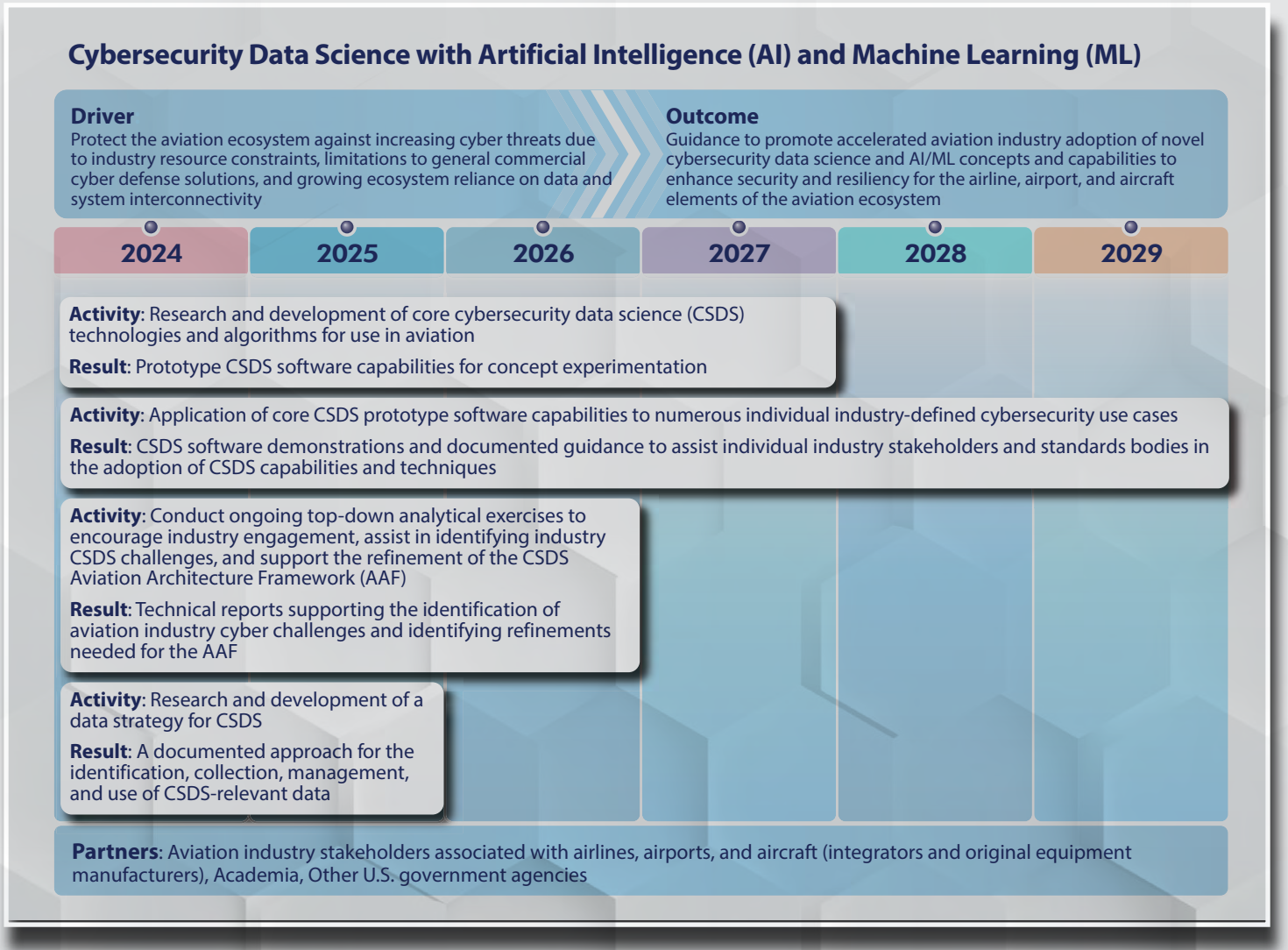
The *U.S. National Strategy for Aviation Security* identifies and describes the aviation ecosystem, which includes all aspects of airports, airlines, aircraft, airlift, operators, and aviation management, as well as the interconnection of the world's airspace.

The FAA's information cybersecurity research and development program conducts research, analysis, demonstrations, evaluations, and prototype development of cybersecurity data science (CSDS) tools, technologies, and methods to detect, prevent, and mitigate the effects of cyber-attacks on elements of the aviation ecosystem.

The program explores CSDS concepts focusing on AI and ML. The research is conducted collaboratively with the aviation industry to address specific stakeholder cybersecurity concerns. Applying CSDS with AI and ML concepts to individual aviation industry challenges — through prototyping, experimentation, and demonstration — will allow greater collaboration and assist the aviation industry with CSDS implementation decisions.

The primary research aims to accelerate the aviation industry's timely adoption of novel CSDS and AI/ML technologies to enhance cybersecurity for the airline, airport, and aircraft elements of the national aviation ecosystem, increasing safety and resiliency (availability and reliability). Critical research results will include documented guidance for aviation industry stakeholders and standards-setting bodies.

This multi-year collaborative effort will allow the aviation industry to use lessons learned from this research to strengthen their cybersecurity, individually and collectively, making the broader aviation ecosystem more resilient and safer for the flying public.



Airport Technology Research Program

Use of Geosynthetics in Airport Pavement Structures

Geosynthetics are materials used to reinforce soil and stone layers of foundations and pavement structures. While geosynthetics show a benefit in highway pavements, they have not been tested under aircraft loads, which are many times greater.

In cooperation with the geosynthetics industry, the FAA is working to determine the benefits of using geosynthetic materials to reinforce airport pavement layers. The goal is to extend pavement longevity or reduce airport pavement thickness, potentially reducing construction and maintenance costs.

As required by Congress, the FAA is encouraging the use of durable, resilient, and sustainable materials and practices, including geosynthetic materials and other innovative technologies where research shows they are applicable.

To meet industry demand, the FAA is conducting full-scale accelerated pavement testing of geosynthetic reinforced pavement structures at the William J. Hughes Technical Center's National Airport Pavement Testing Facility in Atlantic City, NJ.

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 through updates to FAA advisory circulars.

Use of Geosynthetics in Airport Pavement Structures

Driver
Determine if using geosynthetic materials can extend pavement longevity and decrease material construction costs through thinner pavement structure

Outcome
Quantify the benefits of using geosynthetic materials in airport pavements through improved modeling and update the FAA's advisory circular related to pavement design and evaluation

2024	2025	2026	2027	2028	2029
Activity: Collect data during testing and after pavement failure **Result**: Provide interim recommendations on the use of geosynthetic materials for selected airport pavements		**Activity**: Perform further test pavement construction and testing of geosynthetic-reinforced pavements based on results from the first round of testing **Result**: Updated FAA advisory circular on airport pavement design and evaluation			
		Activity: Collect data during testing and after pavement failure **Result**: Provide updated interim recommendations on the use of geosynthetic materials for selected airport pavements			
				Activity: Model the use of geosynthetic materials within the pavement structure **Result**: Update airport pavement design software and reporting methods	

Partners: Geosynthetic Materials Association, Federal Highway Administration, U.S. Army Corps of Engineers, Academia, Industry

Solar-Powered Airfield Lighting

The growth of the solar energy market in recent years has allowed airports to generate electricity using photovoltaic (PV) panels to convert sunlight into energy. Solar-powered airfield lighting provides a cost-effective solution for small, remote, or off-grid airports challenged by the higher costs associated with conventional lighting systems.

The FAA is evaluating the effectiveness of such lighting in geographically diverse regions. Research will include:

- **Investigating the suitability and reliability of the technology**
- **Determining battery and PV requirements**
- **Assessing the functionality and durability of the fixtures**
- **Comparing installation and maintenance costs of solar lighting to conventional lighting systems**

Researchers have agreements with four general aviation airports to install and assess the performance of different light fixtures in the field. The FAA chose the sites to expose the systems to environmental extremes in various locations across the country.

Cape May County Airport in New Jersey, where researchers finalized the experimental test array design, is the prototype site. The team chose Penn Yan Airport in upstate New York because of heavy annual snowfall. Researchers selected Casa Grande Municipal Airport in Arizona for extreme heat and abundant solar energy.

Finally, the team chose Olympia Regional Airport in western Washington due to prolonged periods of overcast conditions and persistent rainfall.

This research supports the FAA's initiative to build a net-zero sustainable aviation system by 2050, utilizing renewable energy sources like the sun to fight climate change. Data gathered from each site will support future guidance and standards for airports interested in installing solar airfield lighting.

Research findings will also lead to best practices for installing and maintaining these systems. Ultimately, this research will raise the overall safety of the flying public by providing more sustainable, cost-effective lighting systems for all airports.

Locations Selected for Solar-Powered Lighting Research

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, and air traffic controllers. The impact of design, technology, new concepts of operation, and physiological and psychological stressors can profoundly affect human performance, resulting in less-than-optimal responses during routine and emergency events.

Research in this goal area seeks to optimize human performance through capability assessments, training, and operational evaluations. Activities address human and medical 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 aerospace 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:

- **Lead a safety risk assessment of infectious disease transmission risk onboard passenger aircraft to create a cabin health safety response plan with an associated analytic tool kit**
- **Develop objective metrics assessing cognitive performance risks due to operator fatigue**
- **Establish operational standards for the use of advanced vision systems by pilots**
- **Study capabilities and crew complements to allow new automatic takeoff and landing operations not covered by existing FAA guidance**
- **Research the causes of helicopter accidents and tools that might help prevent crashes**
- **Evaluate prototypes to develop a path to 14 Code of Federal Regulations (CFR) 60 certification for technologies that simulate interactions between pilots and ATC during pilot training**

Aeromedical Program

Communicable Disease in Air Travel Research

The FAA's Office of Aerospace Medicine is leading a safety risk assessment on communicable disease transmission onboard passenger aircraft to support agency preparedness planning. Researchers at the FAA's Civil Aerospace Medical Institute in Oklahoma City, OK, will develop a modeling, simulation, and analysis framework.

The output of this research will allow the risk assessment team to estimate the transmission risk quantitatively for diseases requiring contact tracing, such as COVID-19, within transport aircraft cabins.

Researchers will identify risk mitigation strategies, evaluate the associated supporting scientific data, and implement solutions in the modeling and simulation environment to evaluate the effect on disease transmission risk. The FAA will use the knowledge gained from these research activities to create a cabin health safety response plan with an associated analytic tool kit.

Communicable Disease in Air Travel Research

Driver
Manage the transmission risk for diseases of potential public health significance within transport aircraft cabins

Outcome
Management of disease transmission risk through a Safety Management System with an associated risk assessment toolset

2024	2025	2026	2027	2028	2029

Activity: Conduct field and laboratory studies to evaluate environmental and human behavioral factors associated with disease transmission from the boarding gate through a flight on a single-aisle, narrow-body aircraft (such as Boeing 737 and Airbus A321) to deplanement

Result: Develop a framework for modeling, simulation, analysis, and other associated tools

Activity: Research cabin health safety mitigations

Result: Produce risk mitigation solution sets, an associated mitigation evidence base, and mitigation modeling and simulation representations

Activity: Develop and deploy a cabin health safety risk assessment toolkit

Result: Transition the risk analysis toolkit to preparedness planners in multiple government agencies, as well as aircraft operators for use in their safety management systems to allow data-driven, risk-based decision making

Activity: Conduct field and laboratory studies to evaluate factors associated with disease transmission in regional jets

Result: Enhanced scope of risk assessment tools for use by more airline operators

Partners: Department of Homeland Security, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, National Research Council of Canada, Industry

Aeromedical Program

Diagnosing Operator Performance Impairment from Fatigue

Fatigue from sleep loss or schedule disruption, such as jet lag, negatively impacts human performance and is a known risk factor for aviation and transportation accidents.

Fatigue prevention measures, such as duty-hour limitations, cannot account for fatiguing conditions such as commute time, lifestyle factors, and rest opportunities outside the workplace. Further, FAA research demonstrates that individuals may underestimate their level of fatigue impairment, leading to inaccurate self-assessments.

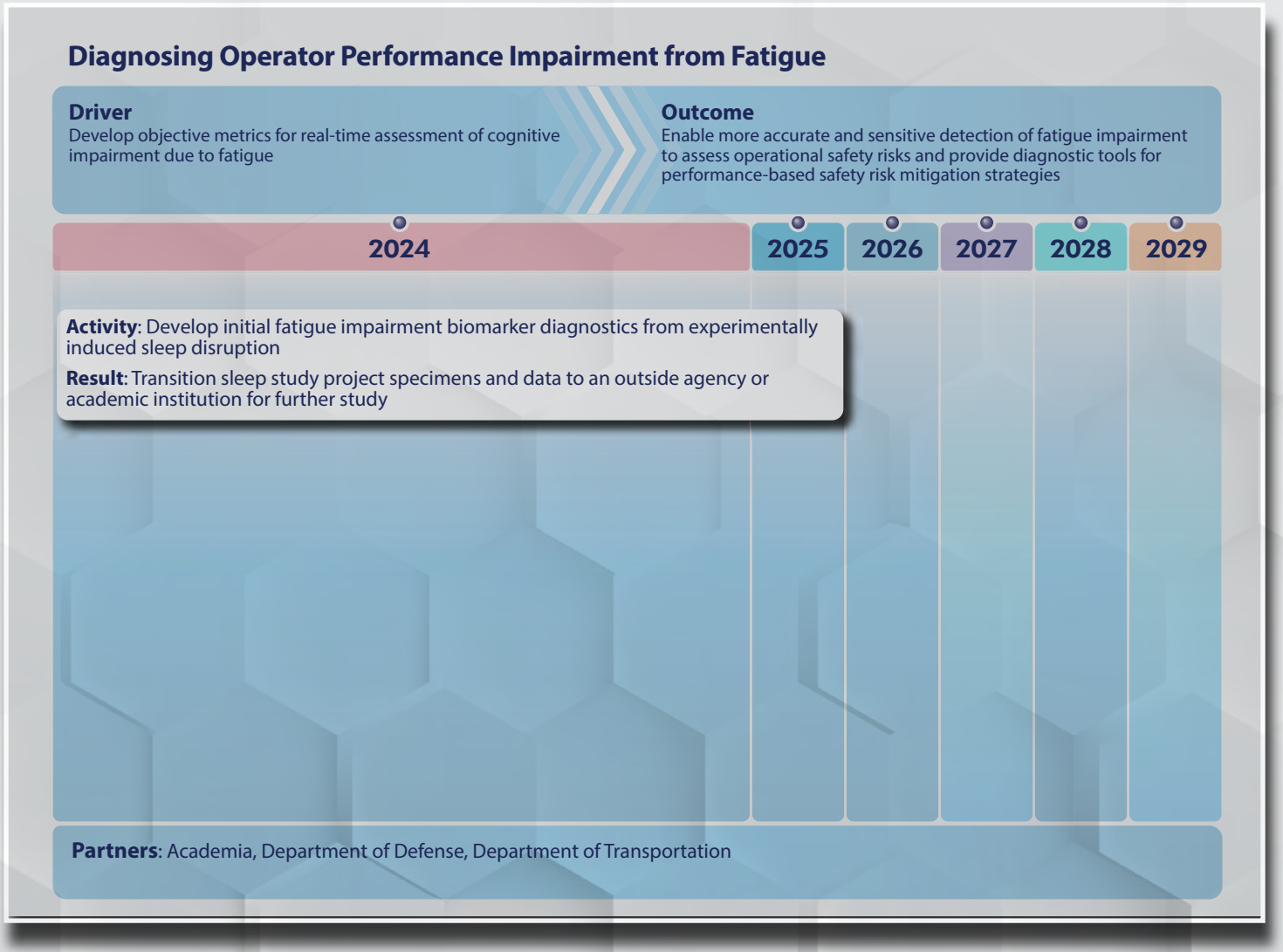
The development of an objective metric to accurately determine fatigue levels is needed, particularly as new types of operations, including unmanned aircraft systems, may introduce new fatigue risks.

This program seeks to develop biologically based diagnostic tools using biomarkers to objectively identify fatigue levels in individuals. Researchers will apply these tools to provide a reliable means of identifying fatigue in aviation accident investigations.

Accurate fatigue assessment is crucial to understanding the extent of the safety risk and creating the knowledge base for ensuring that regulations can appropriately address fatigue risks. Tools developed under this program may also provide improved diagnostics to allow objective real-time measurement of operator fatigue for accident prevention and data-driven safety risk management.

Following stakeholder coordination and adoption by the aviation industry, these tools could be helpful for fatigue risk management strategies and improving current regulations, such as 14 CFR 117 and 14 CFR 121.467 — the federal guidelines governing flight, duty, and rest requirements for flight crews.

The tools could allow new ways to safely expand operations when current duty-hour limitations are too restrictive to meet public demand for services. The research may also be useful in measuring and managing fatigue risk in novel operations such as commercial space flights.



Commercial Human Spaceflight Research

The goal is to provide the correct level of oversight while continuing to encourage innovation in the aerospace industry.

After decades of government-only launches, commercial space transportation companies are increasingly sending communications equipment and humans into space. These companies provide crucial services for carrying people and supplies to the International Space Station.

Space tourism also accounts for a boost in suborbital flights and future planned orbital launches. As more people participate in commercial space activities, the risks increase. Space tourists do not go through the same selection process as NASA astronauts. They are regular people from the general population of varying ages and with potential medical conditions that many people face.

Regulating Spaceflight

When the FAA finalized launch and reentry regulations in 2020, it signaled a new era of regulating commercial spaceflight, with the agency moving from restrictive guidance to performance-based regulations that allow the FAA to approve a means of compliance with the requirements. This allows innovative companies to continue to push the boundaries of technology while allowing the FAA to keep pace with evolving needs and protect public safety.

Congress placed a moratorium on human spaceflight regulations in 2012. Lawmakers extended it to January 1, 2025, through the FAA Reauthorization Act of 2024. The FAA will continue conducting human spaceflight research to fill in the remaining gaps in knowledge and assist in creating appropriate regulations. The goal is to provide the correct level of oversight while continuing to encourage innovation in the aerospace industry.

Human Factors Research

Research will focus on creating standards, potential regulations, and additional means of compliance. This includes standards for health and determining what medical conditions to evaluate before allowing crew or spaceflight participants on board.

Another area of focus is the amount of training required for certain crew and safety-related positions aboard a space vehicle. Research will also include personal safety equipment and systems for survivability.

Flight Deck, Maintenance, Systems Integration Human Factors Program

Operational Criteria for Advanced Vision Systems

Advanced vision systems can provide additional visual information to pilots. These technologies may enhance safety, provide an alternative to natural vision, and increase access to airports and runways during low-visibility operations.

Research will assess the contribution of sensor-based technologies and displays to pilot performance, including cognitive and physiological impacts. The results could indicate if a technology or display type supports equivalent performance to natural vision.

The FAA will use the results for safety decisions and to develop operational requirements, standards, conditions, limitations, mitigations, and authorizations for the expanded use of these technologies.

Operational Criteria for Advanced Vision Systems

Driver
Examine new ways of using approved and emerging flight deck equipment to enhance safety and access during low-visibility operations

Outcome
Evidenced-based policy changes to increase throughput and accessibility to airports and runways during low-visibility approach, landing, and takeoff operations

2024	2025	2026	2027	2028	2029

Activity: Research the expanded use of Synthetic Vision Guidance Systems (SVGS)

Result: Report on SVGS contributions to pilot performance during low-visibility takeoff operations

Activity: Research the expanded use of single/dual head-up display (HUD) technologies

Result: Report on the contributions of single/dual HUD technologies and symbology on head-down displays to pilot/crew performance in low-visibility conditions

Activity: Research human factors methods and tools to evaluate new advanced vision systems

Result: Report on operational evaluation considerations for Enhanced Flight Vision Systems and SVGS

Activity: Research the use of advanced vision systems and new display technologies as alternatives for natural vision

Result: Report on the contributions of advanced vision systems to pilot performance during low-visibility operations

Partners: Original equipment manufacturers, Avionics manufacturers and suppliers, Commercial and business aviation community

Flight Deck, Maintenance, Systems Integration Human Factors Program

Single/Dual Pilot Workload during New Automatic Takeoff and Landing Operations

Advances in sensor-based technologies and combinations of automated systems are expected to enable new automatic takeoff and landing (autoland) operations. End users of these technologies could range from a single pilot onboard an aircraft to multi-person crews not always collocated on a flight deck.

Researchers will study these emerging technologies, systems, and crew compositions to support the safe integration of these technologies into NAS operations. Results will increase understanding of operational pilot workload, pilot visual scan patterns, pilot responses and interventions, and relevant coordination tasks.

The FAA will use the results to develop new guidance for automatic takeoff operations and the expansion of autoland operations.

Single/Dual Pilot Workload during New Automatic Takeoff and Landing Operations

Driver
Safe integration of flight deck technologies and procedures not yet authorized in National Airspace System operations

Outcome
Research basis for new operations specifications, guidance, and criteria related to new automatic takeoff operations, the expanded use of autoland operations, and additional crew complements

2024	2025	2026	2027	2028	2029

Activity: Human factors assessment of automatic takeoff operations conducted by a single pilot using natural vision in a small airplane

Result: Report on single pilot workload and performance

Activity: Human factors assessment of autoland operations conducted by a single pilot using natural vision in a small airplane

Result: Report on single pilot workload and performance

Activity: Human factors assessment of automatic takeoff operations conducted by a multi-person crew not always collocated on a flight deck using natural vision in a transport airplane

Result: Report on flight crew workload and performance

Activity: Human factors assessment of autoland operations conducted by a multi-person crew not always collocated on a flight deck using natural vision in a transport airplane

Result: Report on flight crew workload and performance

Partners: Original equipment manufacturers, Avionics manufacturers and suppliers, Commercial and general aviation communities

System Safety Management/Terminal Area Safety Program

Vertical Flight Safety Research

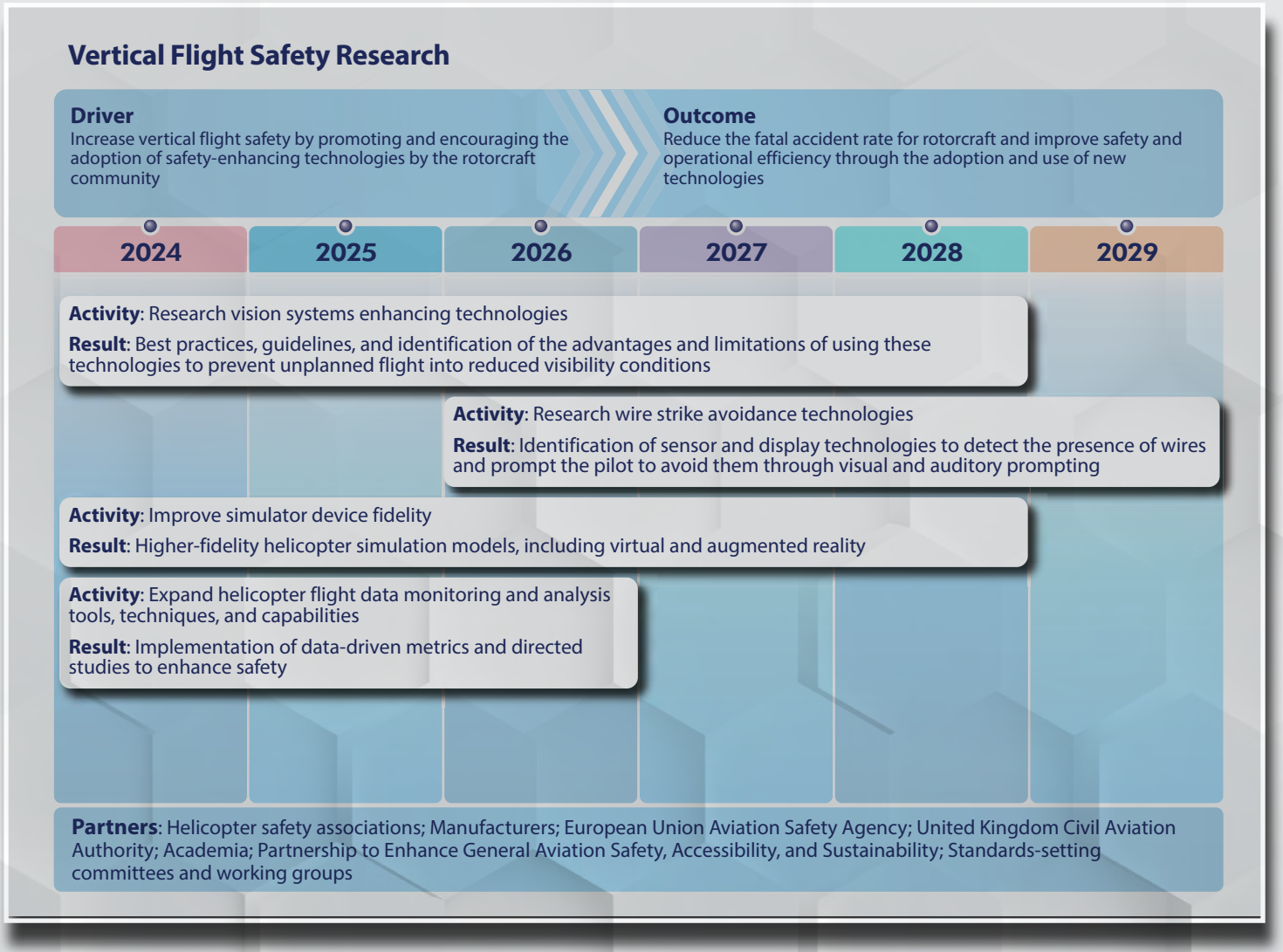
Helicopter accidents are typically associated with poor weather, spatial disorientation, sustained low-altitude flight in environments full of obstacles, and a decline of basic skills resulting in a loss of control of the aircraft.

Rotorcraft safety research addresses the top causes of these accidents and incidents. Research topics include flight data monitoring, aerodynamic and noise models, and virtual and augmented reality.

Work also involves vision systems and related technologies, such as enhanced, synthetic, and combined vision systems, as well as head-worn and helmet-mounted displays. These tools can provide increased visual information and cues to help pilots reorient themselves at the onset of potential problems.

Related rotorcraft safety research work includes:

- **Rotorcraft wire strike detection and mitigation**
- **Higher-fidelity simulation devices and models**
- **Electric vertical takeoff and landing noise modeling**
- **Low-level vertical flight infrastructure, including routes, procedures, vertiport and heliport lighting, markings, sensors, and ground infrastructure**



System Safety Management/Terminal Area Safety Program

Evaluation of Simulated Air Traffic Control Environments that Utilize Artificial Intelligence

Airline pilots are trained using high-fidelity, Level D full-flight simulators. Although these devices offer a realistic flight experience, they typically do not provide true-to-life air traffic control (ATC) interactions.

Simulator instructors or others often act as air traffic controllers during training exercises. These conversations do not accurately reflect real-life exchanges between controllers and pilots, creating gaps in training that can result in miscommunication during actual flight operations.

Simulated ATC technologies that use voice recognition, voice synthesis, and AI to create realistic communications during simulator training are under development. However, the FAA does not currently have a method to certify these new tools for pilot training.

Researchers will evaluate these prototype systems to determine their effectiveness, strengths, and limitations.

Using the findings of this research, the FAA can develop a path for certification for simulated ATC environments.

The goal is to improve the pilot training experience and reduce the rate of accidents and incidents related to pilot-controller miscommunication.

Evaluation of Simulated Air Traffic Control Environments that Utilize Artificial Intelligence

Driver
Evaluate simulated air traffic control environments (SATCE) that use artificial intelligence to determine how to certify their use for pilot training

Outcome
Guidance and recommendations regarding the use of SATCE products for pilot training to reduce operational errors related to pilot-controller communications

2024	2025	2026	2027	2028	2029

Activity: Conduct market research on the current capabilities and availability of SATCE systems

Result: A literature survey report on SATCE system capabilities and recommendations for systems to evaluate

Activity: Evaluate SATCE system prototypes through experimentation

Result: Report documenting test design, experiment implementation, data collection, and analysis of results

Activity: Develop guidance on the effective use of virtual reality and SATCE systems

Result: Final report with guidance and recommendations for the use of SATCE products for pilot training

Partners: To be determined

Aircraft Certification, Safety, and Accountability Act

FAA human factors research supports and addresses the content and intent of the Aircraft Certification, Safety, and Accountability Act (ACSAA) passed by Congress in 2020.

ACSAA provides requirements for the FAA to better integrate human factors throughout the aircraft design and certification process.

These requirements were influenced by recent aviation accidents and technological advances proposed for flight deck equipment design, pilot and maintenance technician training, and flight operations. FAA human factors research will focus on the following:

- **Human-system safety**
- **Human-machine interface and interaction**
- **Personnel qualification and training**

The agency will use data from multiple human factors research, engineering, and development projects to clarify and expand human factors in regulatory policy and processes for the FAA's Flight Standards and Aircraft Certification services.

ACSAA provides requirements for the FAA to better integrate human factors throughout the aircraft design and certification process.

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

Key Programs and Initiatives

Using data sharing, artificial intelligence, and machine learning technologies, the FAA has created tools to analyze and model safety, environmental impact, and other data supporting the NAS.

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

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 given the introduction of new and emerging technologies.

This work will allow the NAS to deliver the highest quality service to the greatest number of people in a timely, safe, and practical manner.

To achieve this goal, the FAA will:

- **Update existing environmental modeling tools to improve noise measurement and exposure maps, including sound produced by supersonic aircraft**
- **Continue to validate emerging explosive yield models for liquid oxygen-liquid methane rocket propellant to more accurately predict the impacts of explosions**

Environment and Energy Program

Environmental Tools/Aviation Environmental Design Tool

Aircraft noise is the primary environmental obstacle to aviation growth. Researchers use the Aviation Environmental Design Tool (AEDT) to model aircraft performance in space and time to estimate fuel use, emissions, noise, and air quality consequences. AEDT is at the core of a comprehensive suite of software tools the agency uses to assess the environmental effects of aviation.

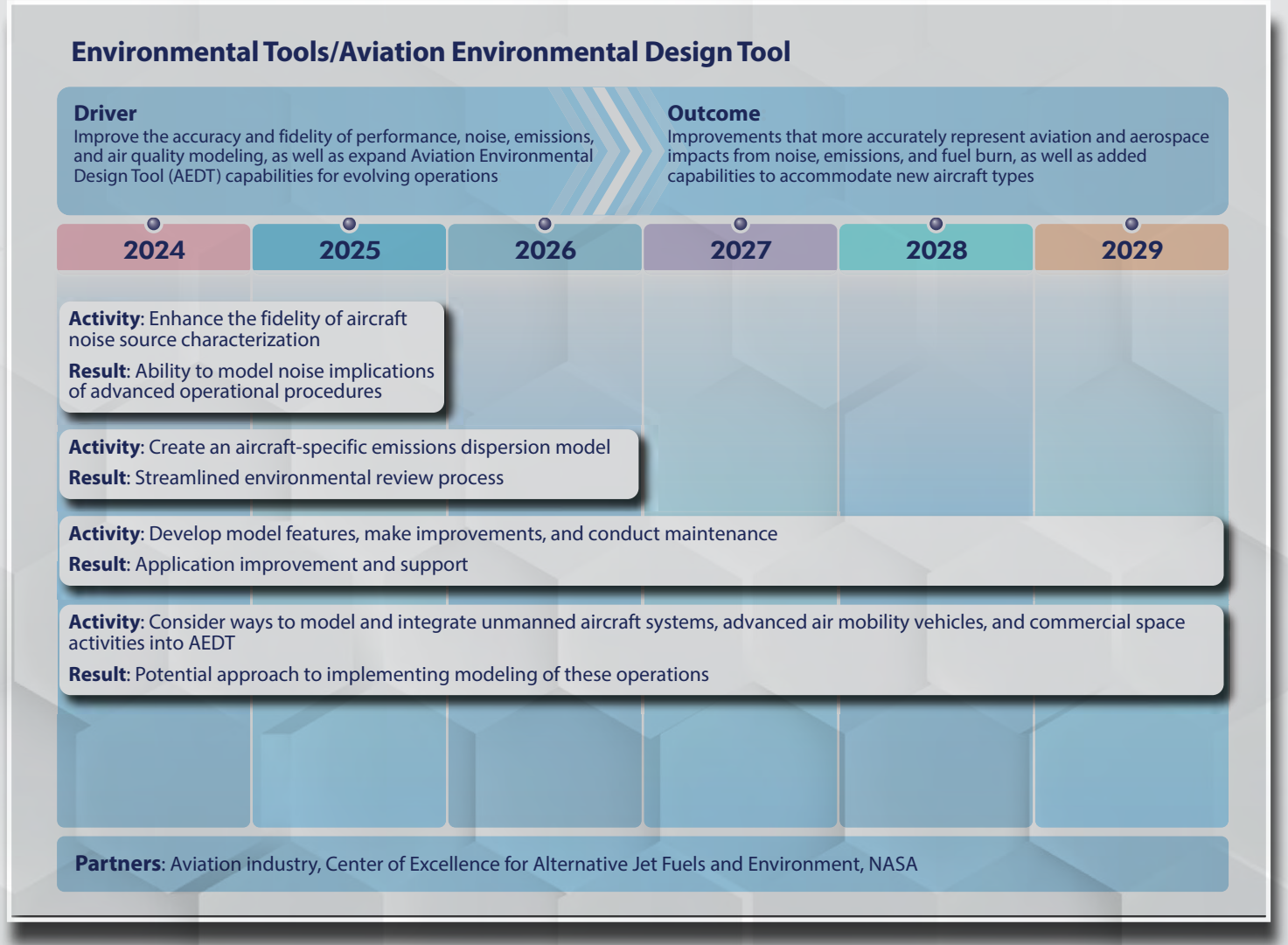
The FAA uses AEDT during environmental reviews of federal actions associated with changes to airports, airspace, and other applicable aviation activities. AEDT is also valuable for domestic and international aviation environmental policy analysis.

The agency sponsors research to improve the accuracy of AEDT and expand its modeling capabilities. Work in the next five years will result in improvements in noise characterization, including farther from the airport for existing aircraft and the ability to model new aerospace vehicles entering the NAS.

Researchers will update AEDT's current emissions dispersion model to better represent and model aircraft-specific emissions.

These capabilities will help airports demonstrate compliance with the National Environmental Policy Act and the EPA's Clean Air Act requirements, streamlining the environmental review process and avoiding delays in airport construction and needed upgrades.

The resulting enhanced modeling capabilities will simplify decision making by the FAA and others in the aviation and space industries.



Commercial Space Transportation Safety Program

Explosive Yield Research

The FAA is licensing new commercial space launch vehicles powered by a combination of liquid-oxygen and liquid-methane rocket propellant. An accident involving a large launch vehicle full of such fuel at or near a launch site could create a powerful explosion that could break windows a significant distance away during certain weather conditions.

The strength of the explosion, or explosive yield, is driven by several factors, such as total propellant mass in a given propellant combination of liquid oxygen-liquid methane.

Very little relevant test data exists to support modeling the strength of liquid oxygen-liquid methane explosions. Researchers intend to validate theory-based explosive yield models developed for liquid oxygen-liquid methane.

The only significant test database exists for Rocket Propellant-1 (a form of kerosene) and liquid hydrogen, both of which have been used for decades. These traditional propellant combinations have significantly different properties than liquid oxygen-liquid methane.

Explosive Yield Research

Driver
Advance the state-of-the-art modeling of liquid oxygen-liquid methane rocket propellant explosions

Outcome
Improve the understanding of hazard limits associated with launch site accidents for vehicles containing a combination of liquid oxygen and liquid methane propellants

2024 | 2025 | 2026 | 2027 | 2028 | 2029

Activity: Low-velocity dynamic testing of liquid oxygen-liquid methane (LOX/LCH4) with varying propellant mass and pressurization

Result: Initial explosive yield curve

Activity: Medium- to high-velocity dynamic testing of LOX/LCH4 propellant with varying impact velocity and pressurization

Result: Improved explosive yield curve

Activity: Determine methods for dynamic testing of LOX/LCH4 in partnership with NASA, the Department of Defense, and industry

Result: Maturation of explosive yield curve and models to the level of traditional propellants

Partners: Commercial space transportation industry, NASA, Department of Defense, The Aerospace Corporation


AI

Improving Safety Analytics to Build a Shared Picture of Risk

The FAA's success in ensuring the safety of the aviation system is historically based on studying the causes of accidents. This is changing with the emergence of previously unknown risk factors from new aerospace vehicles, new technologies, and increasing system complexity. The agency is researching ways to predict and prevent future accidents by improving safety analytics and using the resulting safety data to evaluate system risk using advances in data technologies.

Obtaining Safety Data through Advanced Technologies

Advances in data analytics, machine learning (ML), and enterprise-level data management show great promise for improving the information available to FAA inspectors, engineers, and analysts. These technologies make safety analysis much faster and increase the overall safety data available.

ML methods such as natural language processing help analysts extract valuable, actionable information from written reports on safety events. Temporal fusion transformers — another machine learning tool — can quickly scan multiple information sources and draw connections between concurrent, seemingly unrelated events that, in reality, have contributed to accidents in the past or may elevate the risk of accidents in the future.

The FAA is building its capacity to process the enormous amounts of data produced by these technologies through the Enterprise Information Management cloud services, which allows researchers to combine data from many sources using advancements in cloud architecture, ontology (study of properties and relationships), data virtualization, information visualization, and business intelligence.

Producing both more *and* better safety data through these advanced technologies helps the FAA improve safety oversight. Embedded within the data is valuable system-wide information that can further enhance safety.

System Risk Models

System risk models show how various safety controls interact, revealing potential points of weakness or failure, and they give safety experts a framework for organizing safety data. FAA decision makers use this information to decide when controls need redundancy or should be strengthened.

Inspectors use the models to understand a safety finding's likelihood of occurrence and how other findings might be linked. This provides guidance about where to inspect next. As real-world data fills in the framework, the risk calculations throughout these models grow more accurate, improving the overall picture of aviation risk.

The models may also greatly enhance the qualitative safety management systems (SMS) that product and service providers use to manage and monitor system risk by enabling a standard calculation of risk that can be shared across the aviation industry. Product and service providers can use this tool to place a numeric value on the various risk factors within their operations, resulting in an overall risk score that can be compared to similar risk scores for other organizations.

These scores can be shared with the FAA without jeopardizing proprietary data or business processes. This will allow the agency to measure the performance of an SMS and identify emerging risks across all of aviation through advanced safety analytics and risk assessment.

The agency is researching ways to predict and prevent future accidents by improving safety analytics and using the resulting safety data to evaluate system risk using advances in data technologies.

3.0 Partnerships and Collaboration

The FAA collaborates with nearly 400 stakeholders from academia, the aviation industry, other federal agencies, international entities, and technical societies to drive continuous improvement in the National Airspace System (NAS) and maintain leadership in global aviation.

The agency has instituted and participates in various programs and initiatives to maximize the benefits of these relationships, including technology transfer, centers of excellence, aviation research grants, national consortiums, interagency partnerships, and other agreements.

3.1 Technology Transfer

The FAA's Technology Transfer program allows the transfer of research and development technologies among government, industry, and academia.

It promotes the dissemination of federally funded research and innovations to private and public entities as required by the Stevenson-Wydler Technology Innovation Act of 1980.

The program operates under three pillars of success, bringing the latest technology into FAA labs and advancing innovation out of the agency to the private sector.

Stimulating Collaboration

The FAA's Technology Transfer program promotes synergy and growth between internal agency research and the aviation community.

In coordination with the FAA's legal counsel, the agency allows the sharing of advanced expertise, facilities, and capabilities with the aviation industry, academia, and federal partners.

The program uses the full range of available options to bring new technologies to the marketplace and promote economic development.

Encouraging and Protecting Innovation

With the assistance of the FAA's legal counsel, the Technology Transfer program office manages the agency's patent licensing program.

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

Promoting Public Benefit

A significant focus of the Technology Transfer program is to communicate the innovations and outcomes of FAA research to industry, other federal agencies, and the general public.

FAA researchers contribute to technical advancement through various means, including traditional technology transfer mechanisms such as Cooperative Research and Development Agreements (CRADA) and patent licenses.

The agency also disseminates its research through technical notes and reports, advisory circulars, regulatory guidance, technical findings, participation in technical society panels, and membership in international advisory organizations and other forums.

Innovation and Technology Advisory Council

The ITAC supports the maturation of innovative aviation ideas from members of the Technical Center's federal workforce.

The William J. Hughes Technical Center's Innovation and Technology Advisory Council (ITAC) demonstrates the agency's commitment to technology transfer and innovation.

The ITAC provides a workforce perspective on the center's technical strategy and encourages and supports the maturation of innovative aviation ideas from any member of the Technical Center's federal workforce. A full-time chairperson leads the council in strategy recommendations and idea evaluation.

Through its limited term of service and a steady rotation of new members, the council remains fresh, and the overall innovation community continues to grow. The ITAC has received approximately 30 FAA employee innovations and matured several promising ideas, including:

- **Aircraft icing protection**
- **A simulated pilot voice recognition/response system**
- **A flexible data compiler**
- **Aircraft modeling based on real-time traffic data**

Council members represent broad technical knowledge, business acumen, project management, safety risk management, acquisitions, and local partnerships. After their one-year term, alum council members remain in the community of expertise as ITAC associates.

Cooperative Research and Development Agreements

The FAA's Technology Transfer program uses Cooperative Research and Development Agreements (CRADA) as a primary mechanism for collaborative research. Established by the Federal Technology Transfer Act of 1986 (P.L. 99-502), CRADAs allow federal labs to negotiate licensing arrangements for patented inventions. These agreements offer unique opportunities and benefits for the FAA to work with domestic and international partners from academia and the aviation industry to address complex challenges.

The FAA conducts research through CRADA partnerships in a variety of areas, including:

- **Advanced air mobility**
- **Advanced materials**
- **Aircraft braking**
- **Airport firefighting**
- **Airport pavement**
- **Airport surface surveillance**
- **Artificial intelligence**
- **Computer modeling and simulation**
- **Cybersecurity**
- **Electric vertical takeoff and landing**
- **Enhanced vision systems**
- **Human performance**
- **National Airspace System Evolution**
- **Structures/structural health monitoring**
- **Trajectory Based Operations**
- **Unleaded fuels**
- **Unmanned aircraft systems operations**

Industry and academic entities with innovative solutions to aviation challenges are encouraged to contact the FAA *Technology Transfer office* to pursue mutually beneficial research. By sharing their resources, both parties benefit from accelerated technological maturation and reduced technical risk.

If the research is appropriate for a CRADA and meets the agency's needs, the office initiates the development process and manages the agreement through completion. In cases where the research is better suited to a grant, interagency agreement, or another type of vehicle, the Technology Transfer office provides a conduit to the appropriate FAA organization to establish that agreement.

By sharing their resources, both parties benefit from accelerated technological maturation and reduced technical risk.

3.2 Partnerships

The FAA works to expand and strengthen cooperation with other federal laboratories and agencies, the aviation industry, and academia to promote technology transfer and joint research.

Industry Partnerships

The FAA recognizes the aviation industry's vital role in driving innovation and assisting the FAA in meeting the demands of these new technologies. The agency develops and maintains strong industry relationships through multiple arrangements, including committees, programs, boards, and campaigns.

An important example of this collaboration is the industry-led research conducted by the FAA's Airport Cooperative Research Program (ACRP). This research responds to aviation needs not addressed by other federal programs and those that individual airports cannot cost-effectively undertake.

ACRP is managed by the Transportation Research Board of the National Academies of Sciences, Engineering, and Medicine and funded by the FAA through the Airport Improvement Program.

This congressionally mandated program is a national resource for the airport industry, providing valuable information, guidance, and practical tools to airport owners and operators.

Projects align with FAA research goals and focus on topics identified as critical by airport operators, the aviation industry, and users. The research, overseen by industry experts and a designated FAA subject matter expert, provides guidance in the form of handbooks and best practices.

Planned Research with the Aviation Industry over the Next Five Years

- **Accommodation of cognitive and sensory diversity for airport travelers**
- **Augmented and virtual reality in the airport environment**
- **Guidance for automation to optimize airport efficiency**
- **Preparation for hydrogen-powered aircraft and other vehicles at airports**
- **Seismic resiliency for horizontal infrastructure at airports**
- **Techniques for modifying flight track design to reduce noise exposure and annoyance**

Centers of Excellence

The FAA's Centers of Excellence (COE) program aims to advance aviation technologies and expand FAA research capabilities. The program promotes critical collaboration and coordination between government, academia, and industry.

Congress established the COE program through the Omnibus Budget Reconciliation Act of 1990 – Public Law (P.L.) 101-508, Title IX – Aviation Safety and Capacity Expansion Act, now codified, in relevant part, at section 44513 of title 49 of the U.S. Code.

Using selection criteria provided under P.L. 101-508, the FAA Administrator and the Secretary of Transportation conducted an open and rigorous competitive process to select COE members throughout the United States.

The selected core and affiliate university members provide congressionally required matching funding, expertise, and resources to supplement FAA research capabilities for 10 years.

Five COEs are active today:

- **Center of Excellence for Alternative Jet Fuels and Environment**
- **Center of Excellence for General Aviation Safety**
- **Center of Excellence for Technical Training and Human Performance**
- **Center of Excellence for Unmanned Aircraft Systems**
- **The Joint Center of Excellence for Advanced Materials**

The program has designated 13 COEs — including 92 core universities — since the inception of the program and the first grant award in 1993. Several universities served on multiple COE teams. With their non-federal affiliates, COE partners provided nearly $400 million in matching contributions.

Centers of Excellence Research Planned over the Next Five Years

- **Advanced air mobility noise reduction modeling**
- **Advanced air mobility safety standards, aircraft certification, and impact on market feasibility and growth potentials**
- **Clean sheet supersonic engine design and performance**
- **Fatigue behavior of advanced and ceramic matrix composite materials for aircraft design and certification**
- **Improvements to flight inspection antenna modeling and simulations**
- **Transportation disaster preparedness and response**

Aviation Research Grants and Cooperative Agreements

The FAA addresses specific research needs through the aviation research grant program. The program funds academic and nonprofit institutions to conduct innovative applied research.

Congress established the program under the FAA Research, Engineering, and Development Authorization Act of 1990 (P.L. 101-508) and the Aviation Security Improvement Act of 1990 (P.L. 101-604). The agency issues notices of funding opportunities to secure proposals.

The program oversees aviation research grants and cooperative agreements, encompassing two general categories: research deemed by the FAA Administrator as key to the long-term growth of civil aviation and research focused on preventing catastrophic failures. Grants may range from 12 months to a maximum of 60 months.

Research is conducted under an aviation research grant unless significant FAA engagement will benefit the project. In those cases, the agency uses cooperative agreements.

The FAA's involvement ranges from providing research guidance to requiring FAA review and approval of each research phase before the start of subsequent steps.

Research Planned through Aviation Research Grants and Cooperative Agreements over the Next Five Years

- **Aircraft safety technology**
- **Airports**
- **Aviation weather**
- **Capacity and air traffic control technology**
- **Communications, navigation, and surveillance**
- **Human factors and aviation medicine**
- **Systems science and operations research**

Federal Interagency Partners

The FAA maintains ongoing agreements with agencies across the federal government to advance the safety and efficiency of the NAS, including:

- **Centers for Disease Control and Prevention**
- **Department of Agriculture**
- **Department of Defense**
- **Department of Energy**
- **NASA**
- **National Institute for Occupational Safety and Health**
- **National Oceanic and Atmospheric Administration**
- **National Transportation Safety Board**
- **Naval Medical Research Unit Dayton**
- **Smithsonian Institution**
- **Volpe National Transportation Systems Center**

The FAA and government partners benefit from access to state-of-the-art facilities and technical expertise by combining resources to focus on a shared objective. This approach significantly advances the rate of scientific discovery and saves taxpayer dollars.

Interagency Research Planned over the Next Five Years

- **Creating prioritized, risk-based recommendations for how FAA and airport operators can address climate change and severe weather impacts at vulnerable airports**
- **Determining efficient transportation systems for future smart airport technologies**
- **Developing and validating experimental and computational icing simulation tools for advanced air mobility vehicles, unmanned aerial vehicles, subsonic transport airframes, and rotorcraft and aircraft engines in all icing environments**
- **Studying infectious disease transmission risk in air travel through modeling, simulation, and analysis**

International Partnerships

Agreements between the FAA and international partners are critical to 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.

Key International Research Partners

- **Airservices Australia**
- **Brazil Air Navigation Service Provider**
- **Civil Aviation Authority of Singapore**
- **International Civil Aviation Organization**
- **Japan Civil Aviation Bureau**
- **National Research Council of Canada**
- **Single European Sky Air Traffic Management Research Joint Undertaking**
- **Transport Canada**
- **United Kingdom Civil Aviation Authority**

International Research Planned over the Next Five Years

- **Assessing the ability of the latest generation of enhanced vision systems, synthetic vision systems, combined vision systems, and head-worn/head-down display systems to enhance safety for helicopter operations**
- **Evaluating a cutting-edge energy storage system designed for the electric vertical takeoff and landing aircraft market**
- **Quantifying the impact of contaminated runway conditions on aircraft wheel braking performance**
- **Researching structural health monitoring for aviation applications**

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). The Aviation Safety Research Act of 1988 (P.L. 100-591) established the REDAC.

The FAA Research, Engineering, and Development Authorization Act of 1990 (P.L. 101-508) expanded the committee's responsibilities.

Composed of aerospace experts and related emerging technology-focused corporations, universities, associations, consumers, and government agencies, this group provides advice and recommendations to the FAA Administrator on the aviation research portfolio's needs, objectives, plans, approaches, content, and accomplishments.

By providing valuable feedback from customers and stakeholder groups, the REDAC ensures the coordination of research activities with other government agencies and the aerospace industry.

3.3.1 REDAC Recommendations with the FAA's Responses

The REDAC met in the fall of 2022 and spring of 2023 to advise the FAA on the RE&D and Airport Improvement Program-funded R&D portfolios. REDAC's fall 2022 and spring 2023 recommendations for FAA's R&D activities and the agency's responses are detailed and explained in the below reports:

- *FAA Response to REDAC Guidance for the FY 2025 Research and Development Portfolio*
- *FAA Response to REDAC Recommendations for the FY 2025 Research and Development Portfolio*

The REDAC provided 41 recommendations for the FAA's R&D portfolio. The FAA responded with the following:

- **35 – Fully concur**
- **4 – Partially concur**
- **2 – Non concur**

Summary of FAA Non-Concurrence with REDAC Recommendations

REDAC Recommendations to the FAA	FAA's Responses
The National Airspace System Operations subcommittee recommends the FAA develop alternate funding mechanisms for unmanned aircraft systems (UAS)-related academic research and development that would facilitate forming research partnerships with academic and other institutions that cannot currently be funded through the center of excellence (COE) for UAS. These partnerships would strengthen the research products generated for UAS integration and enhance the ability of those products to influence technical requirements and policy decisions. The committee recommends the FAA develop an expanded process for identifying and selecting the most effective research organizations to conduct a given study, along with associated efficient funding vehicles enabling those organizations to perform research with minimal delay, overhead, or other fees.	The COE is required to address all FAA research needs. If the capability does not exist, the COE team is obligated to contact other institutions to establish that capability. At this time, this arrangement will continue through May 7, 2025. Additionally, the FAA can use non-COE funding to seek other opportunities with many highly qualified research performers outside of the academic community.
The subcommittee on aircraft safety recommends that the FAA expand research on budget line item A11DS, Digital Safety Systems. The subcommittee suggests the agency include data link communications cyber resiliency research to establish the relevant regulatory cyber-attack reporting requirements for the aviation industry when implementing data link communications technologies, such as the internet protocol suite (IPS). The subcommittee suggests the relevant regulatory cyber resiliency requirements are published concurrently with the release of IPS technology performance regulations to help the aviation industry best meet cyber-attack reporting requirements and prevent costly upgrades after IPS systems are initially deployed.	Controller Pilot Data Link Communications and Automatic Dependent Surveillance–Contract (ADS-C) and their air and ground applications are operational programs for the FAA. Development activities, including cyber events, are under the purview of the FAA's Program Management Office (PMO). The PMO will use Facilities and Equipment budget lines to address the recommendation.


34,086.04
213.00
4,076.60
144.29

4.0 FAA Research and Development Funding Profile

The FAA Research and Development (R&D) portfolio supports regulation, certification, and standards development along with National Airspace System (NAS) modernization, policymaking, and planning.

The R&D portfolio addresses the specific needs of FAA sponsoring organizations, including Aviation Safety; Air Traffic Organization; Airports; NextGen; Policy, International Affairs, and Environment; and 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

Three budgetary accounts[1] fund FAA R&D.

1. 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 to meet future air traffic demands.

2. 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), and initial maintenance contracts and training for equipment, facilities, and other construction projects. The F&E account funds R&D in two areas[2]:

- **Advanced Technology Development and Prototyping —** These programs develop and validate technology and systems that support air traffic services, including requirements for evolving air traffic systems architecture and airport safety and capacity improvements.
- **Various Portfolios — These programs have broad applicability.**

3. 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 various research activities to assist with 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 FY 2024 Enacted funding, the FY 2025 President's Budget Request, and planned funding for FY 2026 through 2029. It also highlights the R&D contract and personnel costs for FY 2025.

[1] FAA Order 2400.12, FAA Financial Manual, issued July 3, 2019.

[2] Programs in these areas are typically in concept development/demonstration phases before FAA investment decisions.

Table 1: Planned R&D Budget by Account

Program	Account	2024 Enacted ($000)
Fire Research and Safety	RE&D	7,136
Propulsion and Fuel Systems	RE&D	4,000
Advanced Materials/Structural Safety	RE&D	14,720
Aircraft Icing	RE&D	2,472
Digital System Safety	RE&D	3,689
Continued Airworthiness	RE&D	8,425
Flight Deck/Maintenance/System Integration Human Factors	RE&D	14,301
System Safety Management/Terminal Area Safety	RE&D	9,252
Air Traffic Control/Technical Operations Human Factors	RE&D	5,911
Aeromedical Research	RE&D	10,000
Weather Program	RE&D	14,786
Unmanned Aircraft Systems Research	RE&D	31,128
Alternative Fuels for General Aviation	RE&D	11,201
Commercial Space Transportation Safety	RE&D	2,000
Wake Turbulence	RE&D	3,728
Information/Cyber Security	RE&D	5,707
Environment and Energy	RE&D	21,000
Environmental Research - Aircraft Technologies and Fuels	RE&D	68,000
System Planning and Resource Management	RE&D	5,097
Aviation Grant Management	RE&D	20,000
Women in Aviation and Pilot Shortage Study	RE&D	5,000
William J. Hughes Technical Center Laboratory Facilities	RE&D	5,447
Aviation Accessibility Research	RE&D	2,000
Aircraft Radio Altimeter Development, Testing, and Certification	RE&D	5,000
RE&D TOTAL	**RE&D**	**280,000**

/1 The funding levels listed for years 2026 to 2029 are estimates and subject to change.

2025 President's Budget ($000)	*2025 Contract Costs ($000)*	*2025 Personnel Costs ($000)*	*2025 Other In-house Costs ($000)*	2026 Estimate ($000)	2027 Estimate ($000)	2028 Estimate ($000)	2029 Estimate ($000)
8,750	*3,578*	*5,087*	*85*	7,051	7,214	7,722	8,200
5,174	*2,625*	*2,504*	*45*	5,000	4,000	6,880	7,000
2,548	*1,285*	*1,213*	*50*	14,720	15,088	3,526	4,100
3,064	*1,739*	*1,300*	*25*	3,000	2,534	4,000	4,000
6,312	*4,294*	*1,993*	*25*	5,375	3,781	7,110	6,000
10,339	*6,234*	*4,030*	*75*	8,400	8,636	8,925	10,000
16,382	*9,746*	*6,531*	*105*	15,000	14,659	15,150	15,300
15,000	*11,898*	*3,037*	*65*	9,500	9,483	9,650	10,300
5,993	*1,875*	*4,033*	*85*	5,911	6,059	6,391	6,500
12,186	*6,690*	*5,376*	*120*	11,000	10,250	12,205	12,100
19,843	*17,215*	*2,573*	*55*	15,436	15,156	19,220	19,400
15,567	*13,551*	*1,901*	*115*	23,986	31,906	21,130	20,500
8,411	*8,361*	-	*50*	10,000	11,481	11,700	12,500
5,350	*5,350*	-	-	5,000	2,050	5,657	6,000
4,243	*3,127*	*1,031*	*85*	4,728	3,821	4,180	4,300
5,943	*5,059*	*804*	*80*	5,000	5,850	7,515	8,000
21,194	*17,856*	*3,228*	*110*	20,800	21,525	21,305	22,000
70,994	*67,882*	*3,102*	*10*	67,800	69,700	71,034	73,000
5,088	*3,146*	*1,897*	*45*	5,097	5,224	6,200	5,700
2,125	*1,378*	*747*	-	4,650	8,000	13,000	13,000
-	-	-	-	-	-	-	-
5,494	*2,481*	*2,973*	*40*	6,597	5,583	5,500	6,100
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-
250,000	***195,370***	***53,360***	***1,270***	**254,051**	**262,000**	**268,000**	**274,000**

/1

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

Program	Account	2024 Enacted ($000)
Advanced Technology Development and Prototyping	F&E	32,718
William J. Hughes Technical Center Laboratory Sustainment	F&E	16,055
William J. Hughes Technical Center Infrastructure Sustainment	F&E	9,500
Separation Management Portfolio	F&E	13,680
Traffic Flow Management Portfolio	F&E	9,500
On Demand NAS Portfolio	F&E	8,075
NAS Infrastructure Portfolio	F&E	11,400
Support Portfolio	F&E	4,750
Unmanned Aircraft Systems (UAS)	F&E	13,300
Enterprise, Concept Development, Human Factors, & Demonstrations Portfolio	F&E	10,450
NAS Automation Evolution	F&E	-
Center for Advanced Aviation System Development (CAASD)	F&E	55,000
F&E TOTAL	**F&E**	**184,428**
Airport Cooperative Research		15,000
Airport Technology Research		41,801
AIP TOTAL	**AIP**	**56,801**
GRAND TOTAL		**$521,229**

/1 The funding levels listed for years 2026 to 2029 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 we

2025 President's Budget ($000)	*2025 Contract Costs ($000)*	*2025 Personnel Costs ($000)*	*2025 Other In-house Costs ($000)*	2026 Estimate ($000)	2027 Estimate ($000)	2028 Estimate ($000)	2029 Estimate ($000)	/1
			-					/2
31,900	*31,900*	-	-	34,500	36,420	36,390	36,160	
23,400	*23,400*	-	-	19,900	16,900	17,000	17,000	
39,000	*39,000*	-	-	23,000	15,000	15,000	15,000	
11,000	*11,000*	-	-	15,800	14,000	13,000	13,000	
9,000	*9,000*	-	-	9,000	9,000	12,000	12,000	
9,000	*9,000*	-	-	10,000	9,000	10,000	12,000	
12,500	*12,500*	-	-	17,100	15,000	16,000	20,000	
8,000	*8,000*	-	-	7,000	8,000	7,000	8,000	
20,000	*20,000*	-	-	16,000	16,000	16,000	16,000	
10,000	*10,000*	-	-	10,500	10,500	11,500	11,500	
-	-	-	-	40,000	-	-	-	
57,000	*57,000*	-	-	57,000	47,000	47,000	47,000	
230,800	***230,800***	**-**	**-**	**259,800**	**196,820**	**200,890**	**207,660**	
15,000	*15,000*	-	-	15,000	15,000	15,000	15,000	
43,360	*43,360*	-	-	44,929	42,500	42,500	42,500	
58,360	***58,360***	**-**	**-**	**59,929**	**57,500**	**57,500**	**57,500**	
$539,160	***$484,530***	***$53,360***	***$1,270***	**$573,780**	**$516,320**	**$526,390**	**$539,160**	

ell as acquisition, operational testing, and other non-R&D activities.