National Aviation Research Plan (NARP)

FY 2023–2027

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

Message from Acting Administrator Billy Nolen

This is an exciting time in the aerospace industry. Along with entirely new forms of transportation, such as drones and urban air mobility vehicles, we've seen a rebirth in space with a national enthusiasm not witnessed since the Apollo days.

This period also has ushered in significant challenges, notably those arising from COVID-19, and responsibilities such as reducing the environmental impact of aviation and aerospace noise and emissions. We cannot let the pandemic or any other obstacle keep us from making progress on important issues, like combating climate change and protecting the environment.

We're looking at a future with drones, rockets, air taxis, and supersonic transport. Add onto that: artificial intelligence, big data analytics, smart devices, and increasingly complex cybersecurity needs for aviation and aerospace. We want to safely enable these innovations while proactively addressing the challenges they present.

There's hard work ahead, but I know that we are the most innovative when we are challenged. History is our proof. Through our diverse range of research and development activities, the FAA is always preparing for the future and cementing its vital role in ensuring the safety of air travel.

I am pleased to present the National Aviation Research Plan for Fiscal Years 2023–2027. 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 advancing aviation in an environmentally-responsible and energy-efficient manner by considering noise, emissions, and other environmental issues.

Finally, the plan shows how we work with our partners to deliver research solutions that will maximize benefits to American taxpayers and the global flying public. Collaboration not only makes us smarter and stronger. It also makes aviation even safer.

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.

"The FAA plays a vital role in ensuring the safety of the traveling public."

Billy Nolen, FAA Acting Administrator

Executive Summary

National Aviation Research Plan Objective

The National Aviation Research Plan (NARP) presents the FAA's research and development (R&D) goals, highlights planned research in support of each goal, and details how the FAA works with other agencies, academia, and industry to best leverage each dollar of R&D funding.

Document Highlights

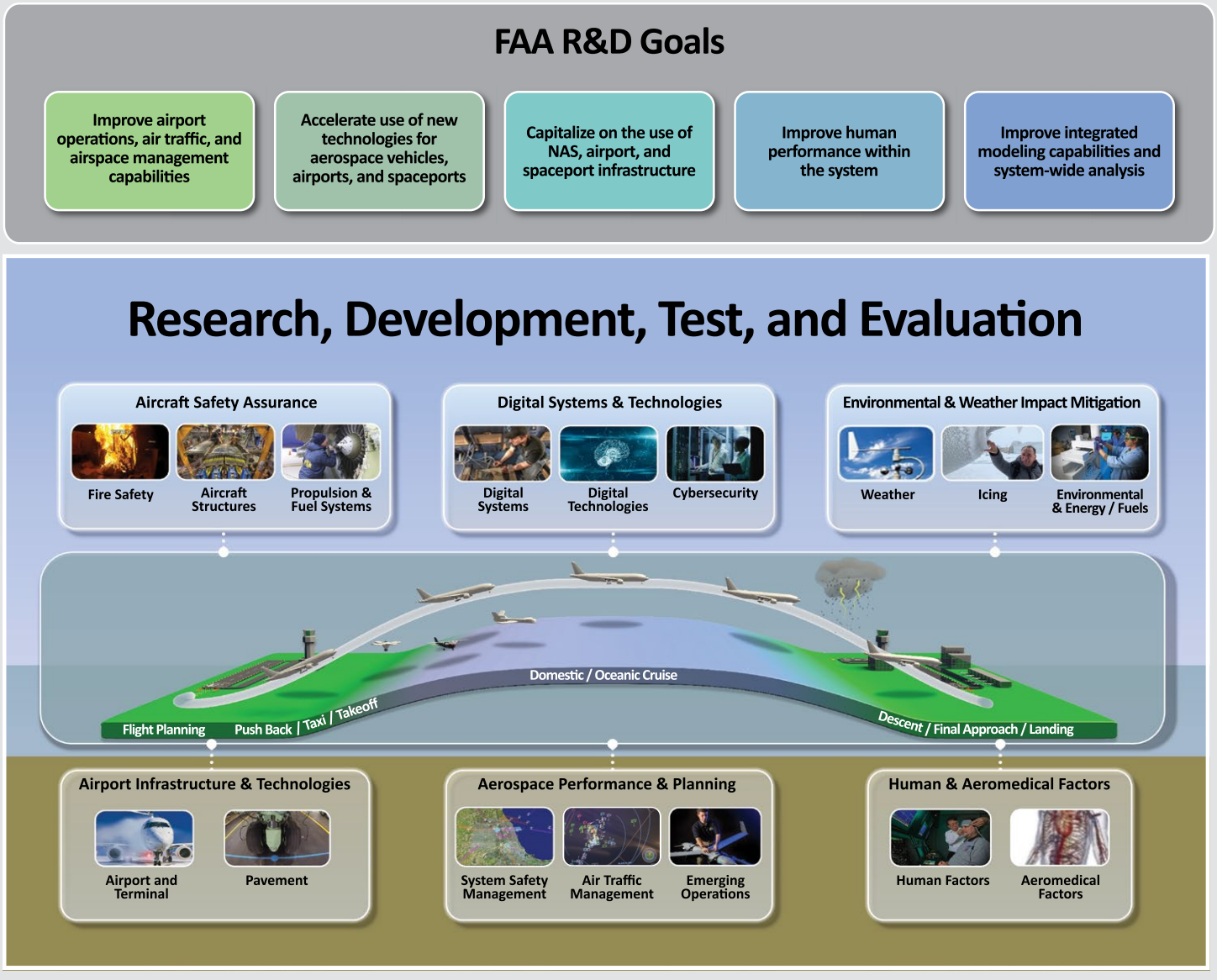
This congressionally-required document is divided into four sections. The first section describes the importance of federally-funded R&D, and the second identifies the FAA's research goals. This second section also describes how the FAA structures R&D to ensure alignment of all research activities with these goals and priorities, giving highlights of past and expected results for select activities.

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

Key Takeaways

FAA R&D cultivates the innovation needed to:

- **Provide safe and efficient solutions to an evolving National Airspace System**
- **Prepare the aviation system for the next generation, making it more adaptable, sustainable, resilient, equitable, and safer for all**
- **Advance aviation in an environmentally responsible and energy-efficient manner.**



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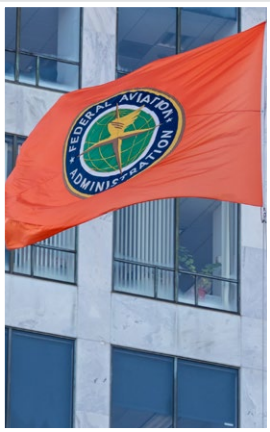
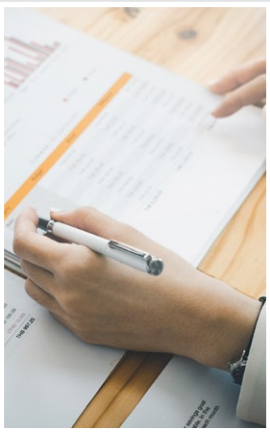




1.0 Introduction

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

This approach enables the FAA to address the current challenges of operating the safest, most efficient aerospace transportation system in the world while building a foundation for a future system with an environmentally conscious approach.

The NARP provides a close-up view of a selection of the FAA's R&D priorities, which collectively support and drive innovation, represent areas of congressional or public interest, support near-term regulatory actions, and have global impact. The highlighted research areas are designed to produce results in support of the agency 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**
- **Preparing transportation systems for the next generation by making them more adaptable, sustainable, resilient, equitable, and safer for all.**

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

The FAA funds R&D in three budgetary accounts: Research, Engineering, and Development (RE&D); Facilities and Equipment; and the Airport Improvement Program. FAA R&D activities in these accounts enable great innovation while ensuring that all aerospace safety needs are met. The FAA *R&D Funding Profile* in Section 4.0 of the NARP describes the RE&D investment plan details for the five-year period, 2023–2027.

FAA Research and Development Investments

In FY 2023, the FAA plans to invest a total of $534.5 million in the R&D portfolio, distributed across three budgetary accounts:

- **$260.5 million for Research, Engineering, and Development**
- **$218.2 million for Facilities and Equipment**
- **$55.8 million for the Airport Improvement Program.**

1.1 Why FAA R&D 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 National Airspace System (NAS).

Outputs of this R&D include:

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

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

The FAA has a substantial positive impact on aviation and aerospace, and by extension, the U.S. economy. R&D enables the aviation industry to modernize this country's infrastructure and fuel economic growth. It further contributes to American economic competitiveness by enabling new technologies and industries, and creating American jobs.

FAA Research Facilities

The FAA operates state-of-the-art research facilities in two locations. The William J. Hughes Technical Center is located in Atlantic City, NJ. The Civil Aerospace Medical Institute and the Flight Research and Analysis Group are located at the Mike Monroney Aeronautical Center in Oklahoma City, OK. Each location provides unique research, development, and test and evaluation platforms necessary to facilitate upgrades, improvements, and operational sustainment.

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 important for sharing research and information, developing policy, and promoting best practices globally.

Positioning, Navigation, and Timing Resilience

In transportation, positioning, navigation, and timing (PNT) refer to capabilities that provide the following services with a high level of precision:

- Location (positioning)
- Ability to move to a new location along a path (navigation)
- Knowledge of the current time (timing).

GPS is the most recognizable global provider of PNT service, but any system, network, or capability that can calculate one or more of these components is considered a PNT service. PNT use within aviation has expanded dramatically over the past few decades, becoming a largely invisible utility supporting numerous technologies, systems, and services. These technologies include:

- Global Navigation Satellite Systems – satellite constellations that provide PNT services on a global or regional basis
- Wide Area Augmentation System – a navigation system that dramatically increases GPS accuracy, integrity, and availability, increasing safe access to airports in lower-visibility conditions.

The aviation industry relies heavily on PNT technologies to support the transition of the National Airspace System to Performance Based Navigation — an advanced satellite-enabled form of air navigation that improves air traffic flow efficiency to and from airports through precise and repeatable flight paths.

The ability to accurately receive PNT information during flight is critical to the safe operation of the aircraft. Intentional or unintentional disruptions to these services present a significant safety hazard. Ongoing research conducted by the FAA and its partners seeks to ensure the continued resilience of these systems through the use of advanced antenna technologies, GPS authentication, and complementary avionics for cyber-safety.

1.2 How the FAA's Research Shapes the Future

FAA research is focused on a core safety mission and prioritizes the integration of advanced technologies into the NAS while minimizing their environmental impacts. Sustainability and addressing climate concerns are major priorities in aviation, given that the transportation sector is *one of the largest contributors*[1] to greenhouse gas emissions, according to the U.S. Environmental Protection Agency. The FAA is pursuing a number of efforts to reduce the impact aviation has on the environment. The agency continues to research:

- **Technology improvements to increase fuel efficiency**
- **Feedstocks and other processes that can be used to develop sustainable aviation fuels**
- **More fuel-efficient air traffic procedures, which continue to reduce aircraft fuel burn.**

The agency continually collaborates with international aviation counterparts to reduce global transportation-related emissions. Through the Continuous Lower Energy, Emissions, and Noise program, the FAA is reducing community noise exposure and particulate matter emissions at their source — the aircraft engine.

Planned FAA research will analyze, model, and measure technologies capable of reducing noise, improving air quality, increasing energy efficiency, and producing sustainable aviation fuels at commercial scale.

FAA researchers will study the impacts of aviation noise on community annoyance, sleep, health, and children's learning. The agency will strive to advance, among other things, the screening and testing of alternative and sustainable aviation fuels, the development of electric and hybrid-electric propulsion technology, and engine design and airframe efficiency to reduce the environmental impacts of aviation noise and emissions.

Mission

The FAA's continuing mission is to provide the safest and most efficient aerospace system in the world.

Vision

The agency's vision is to reach the next level of safety, efficiency, environmental responsibility, and global leadership, and be accountable to the American public and FAA stakeholders. The FAA's major responsibilities include:

- **Regulating civil aviation and U.S. commercial space transportation to promote safety**
- **Encouraging and developing civil aviation, aeronautics, air traffic control, and commercial space through technological innovation and effective research and development**
- **Developing and operating a system of air traffic control and navigation for civil aircraft**
- **Developing and carrying out programs to understand and reduce the environmental impacts of aviation and commercial space transportation on the American public**

[1] *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2019 (published 2021)*

Sustainability at the FAA

The Aviation Sustainability Center, or *ASCENT*, is the FAA's Center of Excellence for Alternative Jet Fuels and Environment. Washington State University and the Massachusetts Institute of Technology co-lead the center.

ASCENT

ASCENT comprises a coalition of 16 leading U.S. research universities and over 60 private sector stakeholders working in partnership with international research programs, federal agencies, and national laboratories. Research focuses on:

- **Meeting FAA environmental and energy goals, including reducing noise, improving air quality, reducing climate impacts, and increasing energy efficiency**
- **Exploring ways to produce sustainable aviation fuels at commercial scale, creating an industry with the potential for large-scale economic development and job creation**
- **Studying science-based solutions that will benefit the aerospace industry, and improve the health and quality of life for those living and working around airports.**

The center of excellence is funded by the FAA, NASA, Department of Defense, Transport Canada, and the Environmental Protection Agency.

2.0 FAA Research and Development

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

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

R&D Executive Board

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

Research, Engineering, and Development Advisory Committee

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

REDAC members include aerospace professionals from industry, Federally Funded Research and Development Centers, and academia who are best positioned to identify aviation drivers, issues, requirements, and influencing technologies; and understand the level of research investment the aerospace industry is making or willing to make. Section 3.3 provides additional information about the *REDAC*.

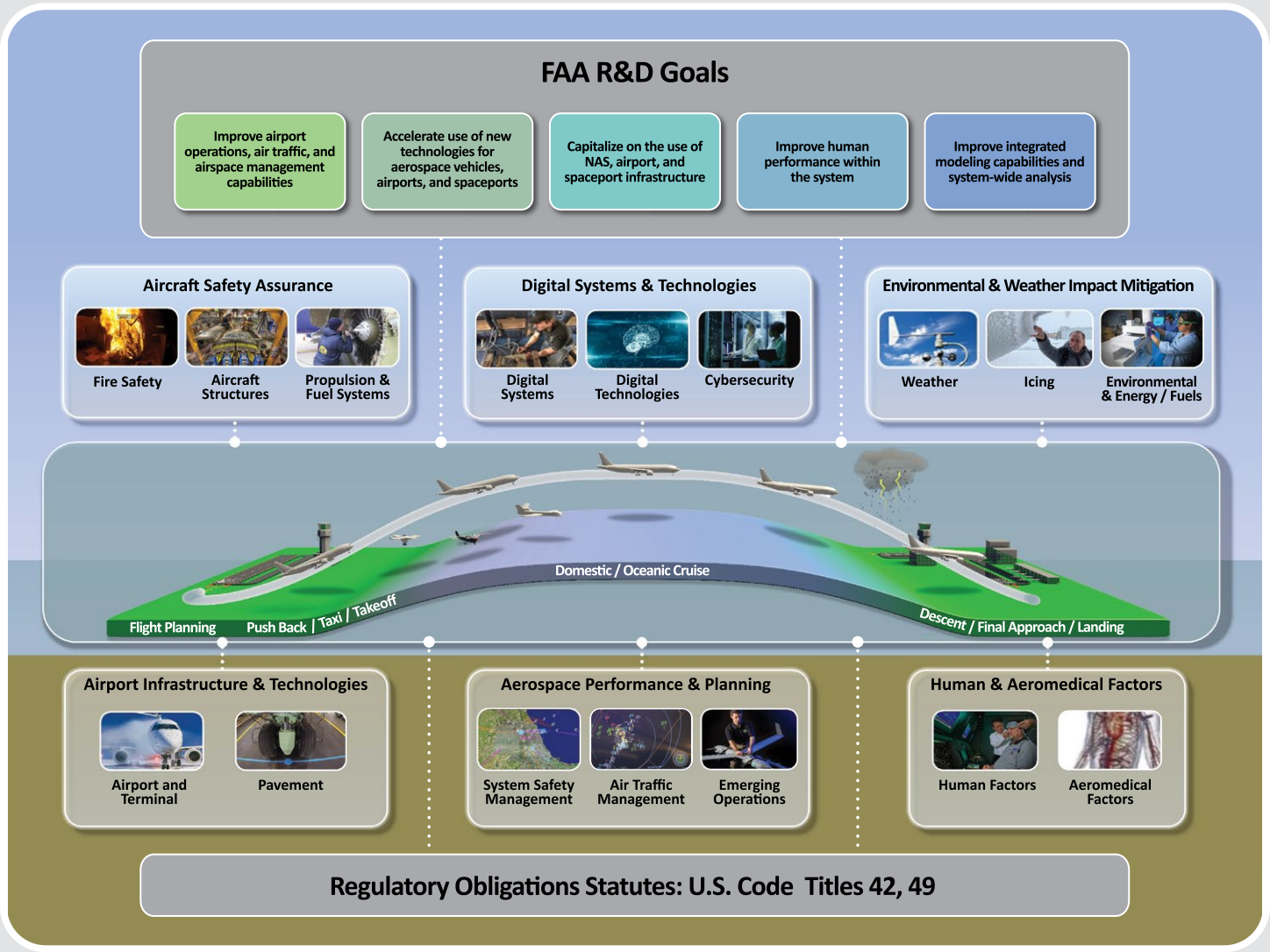
2.1 FAA R&D Framework

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

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

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

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



2.2 Department of Transportation Innovation Principles

The FAA invests in high-priority research and development activities that are critical to the National Airspace System (NAS) and align with the overarching innovation principles of the agency's parent organization, the Department of Transportation (DOT).

Serve Our Policy Priorities

Creating high quality jobs, achieving racial equity, and increasing opportunity for all Americans, as well as tackling the climate crisis should drive innovation. Innovations should reduce deaths and serious injuries on our nation's transportation network, while committing to the highest standards of safety across technologies.

Help America Win the 21st Century

The DOT must play a meaningful role in future proofing infrastructure, enabling adaptability and resilience, and helping communities and public sector partners to bring legacy systems into the digital age.

Support Workers

The DOT will empower workers and expand access to skills, training, and the choice of a union. They will have a seat at the table in shaping innovation.

Allow for Experimentation and Learn from Failure

The DOT is committed to supporting public sector experimentation, sharing insights, embracing open data and transparency, while protecting privacy. That means elevating lessons learned from both successful deployments and those that fall short.

Provide Opportunities to Collaborate

The DOT will embrace public private partnerships that share risk, foster purpose-driven innovation and protect the interests of the public, workers, and communities. The DOT must encourage an outcomes-based approach that is technology neutral.

Be Flexible and Adapt as Technology Changes

The DOT should identify opportunities for interoperability among innovations and foster cross-modal integration. In addition, DOT's posture must remain nimble, with a commitment to support technologies that further our policy goals.

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 considered long term, extending beyond 2027, the current NARP focuses on a five-year window beginning in 2023.

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

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

Goal 1

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

Key programs and initiatives:

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

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

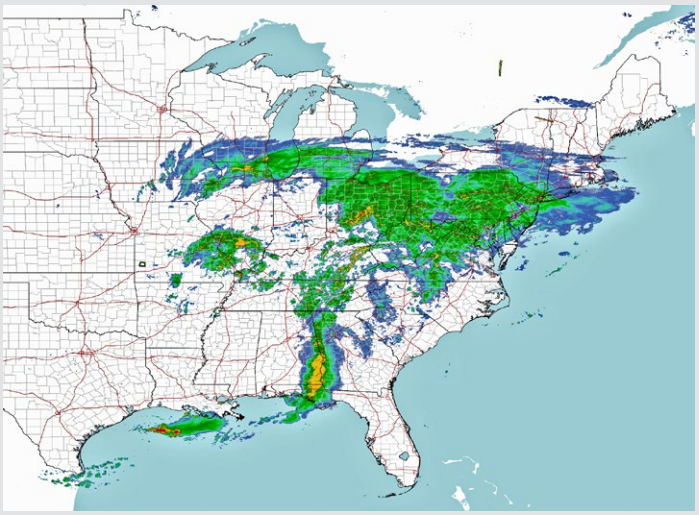
To achieve this goal, the FAA will:

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

Develop High Resolution and Frequently Updated Probabilistic Thunderstorm Forecasts

Nearly 70 percent of all air traffic delays can be attributed to weather, costing airlines and passengers billions of dollars each year in fuel and lost time. Thunderstorms are a major contributor to delays, especially in the summer months. Better weather forecasts can help reduce delays, increase passenger safety and comfort, and keep the NAS running efficiently.

Researchers are studying new types of forecast models that can be focused with higher resolution around major hubs such as airports in the Northeast Corridor, Atlanta, and Chicago, where most delays originate due to weather conditions. The program is also researching ways to improve translation of forecast information, so air traffic controllers, air carriers, pilots, and others can better integrate the information into their decision-making processes.



Develop High Resolution and Frequently Updated Probabilistic Thunderstorm Forecasts

Driver
Research the impacts of weather on aviation to develop new methods and technologies to reduce environmental impacts on aviation operations

Outcome
Improve the detection and forecasting of thunderstorms for a safer, more efficient, and predictable National Airspace System

2022

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

2023

Activity: Transition Ensemble Prediction of Oceanic Convective Hazards (EPOCH) into operations

Result: Transfer EPOCH capability to the National Weather Service

2025

Activity: Transition the initial version of the Offshore Precipitation Capability (OPC) into operations

Result: Transfer OPC capability to the FAA's NextGen Weather Processor

2026

Activity: Prepare the Enhanced Convective Weather Avoidance Model (CWAM) for transition into operations

Result: Finalize documentation and software to transfer CWAM to the FAA's Next Generation Weather Processor

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

Traffic Flow Management Portfolio

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

Surface Tactical Flow

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

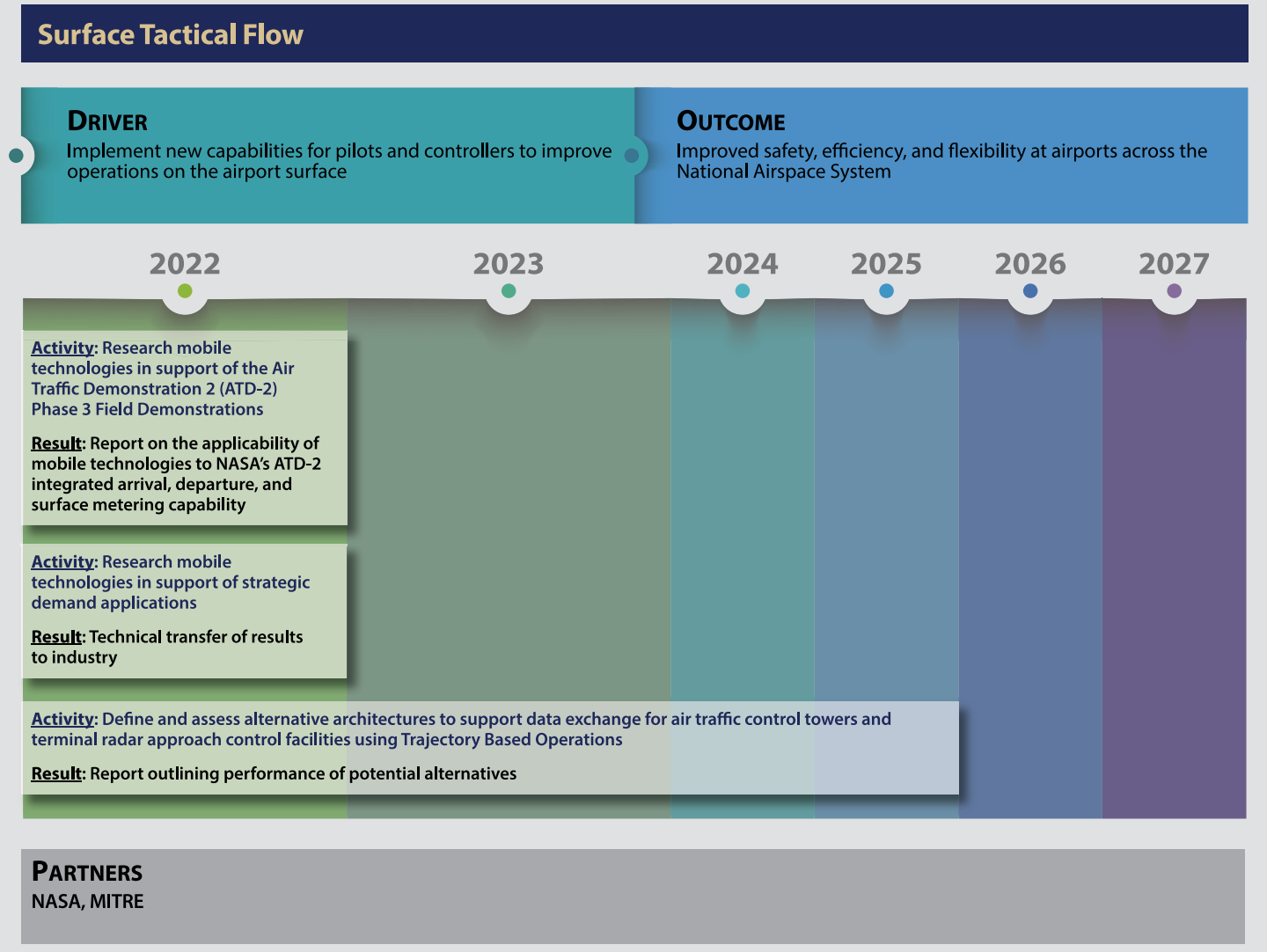
This saves fuel, reduces emissions, and gives air carriers and passengers more flexibility prior to pushback.

Precisely scheduling takeoffs to help aircraft better integrate into the overhead stream of air traffic increases NAS efficiency. Coordinating schedules between airport operators, air traffic controllers, and flight operators provides air traffic managers tools to make better decisions about how to reduce congestion.

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

Benefits will include:

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



Strategic Flow Management Application

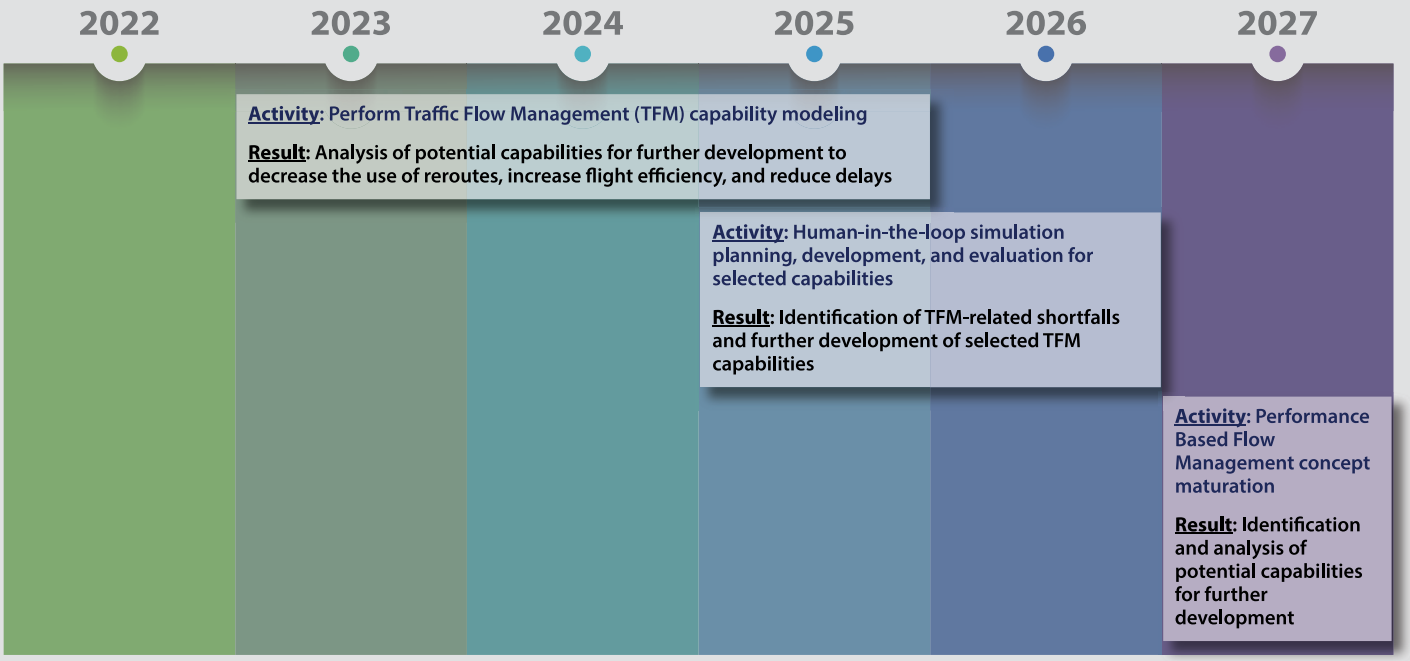
Air traffic managers often strategically reroute large numbers of aircraft to reduce congestion in a particular region of airspace. Reducing a bottleneck in one area of the country can reduce flight efficiency and increase delays in other parts of the NAS. Current research will identify ways to decrease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

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

Strategic Flow Management Application

Driver
Develop new traffic flow management techniques and applications that will 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



Partners
NASA

Separation Management Portfolio

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

Wake Turbulence Recategorization

Wake turbulence, rotating vortices which form behind the wings of an airplane as it flies through the air, can be hazardous to nearby aircraft.

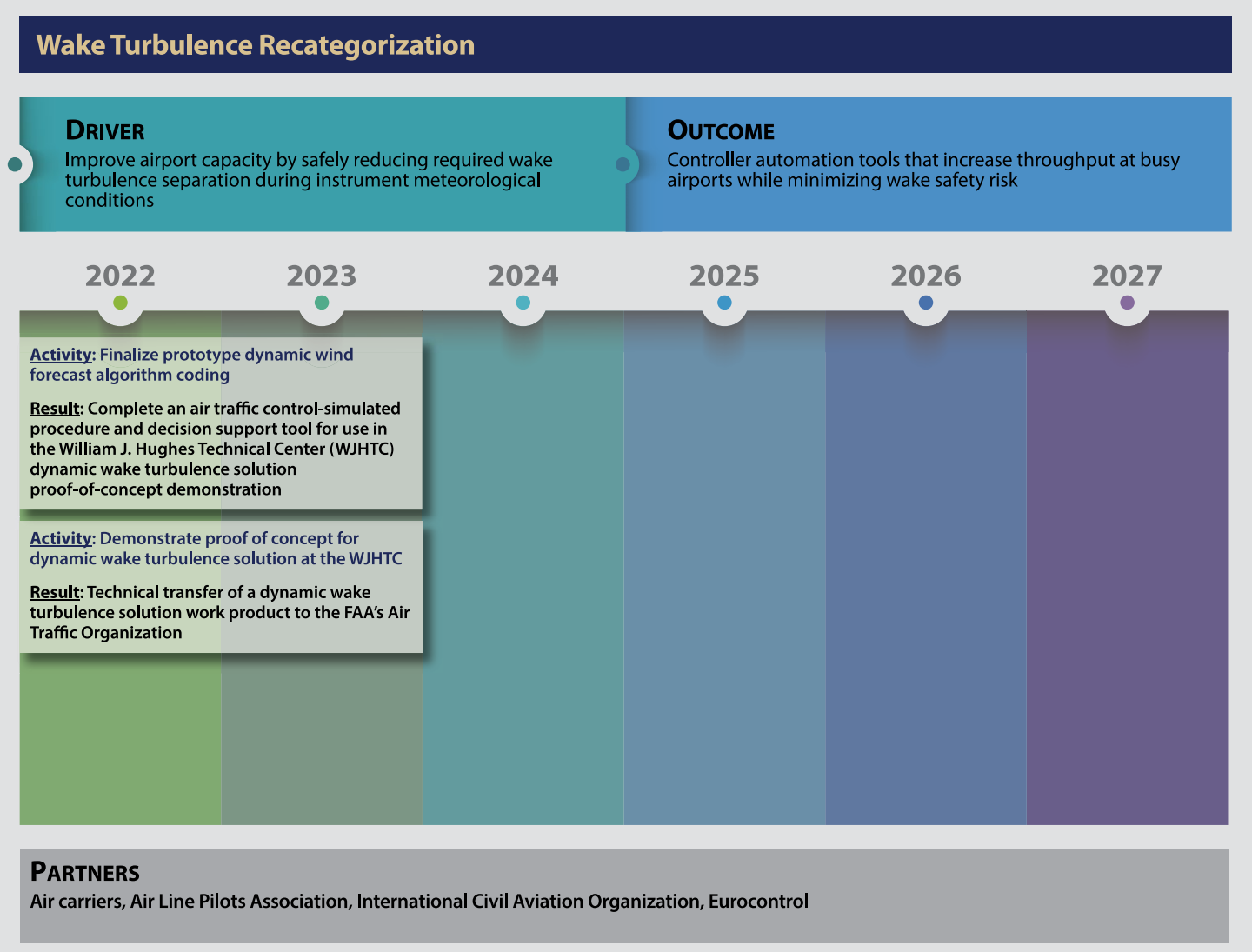
The bigger the aircraft, the bigger the wake. Air traffic controllers must space out aircraft, so the wake from one plane does not impact others behind it.

By recategorizing wake standards, the FAA has safely decreased the required separation between certain aircraft.

Current research will focus on using Wake Recategorization to increase capacity when poor weather or other conditions require instrument flight rules (IFR) procedures.

This work will be used to develop standards, processes, and decision support tools for air traffic controllers, allowing them to increase takeoffs and landings at crowded airports.

This would result in fewer flight delays and cancelations — and reduced inflight operating costs — while ensuring the safety of the aircraft, crew, passengers, and cargo.



Closely Spaced Parallel Runway Operations

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.

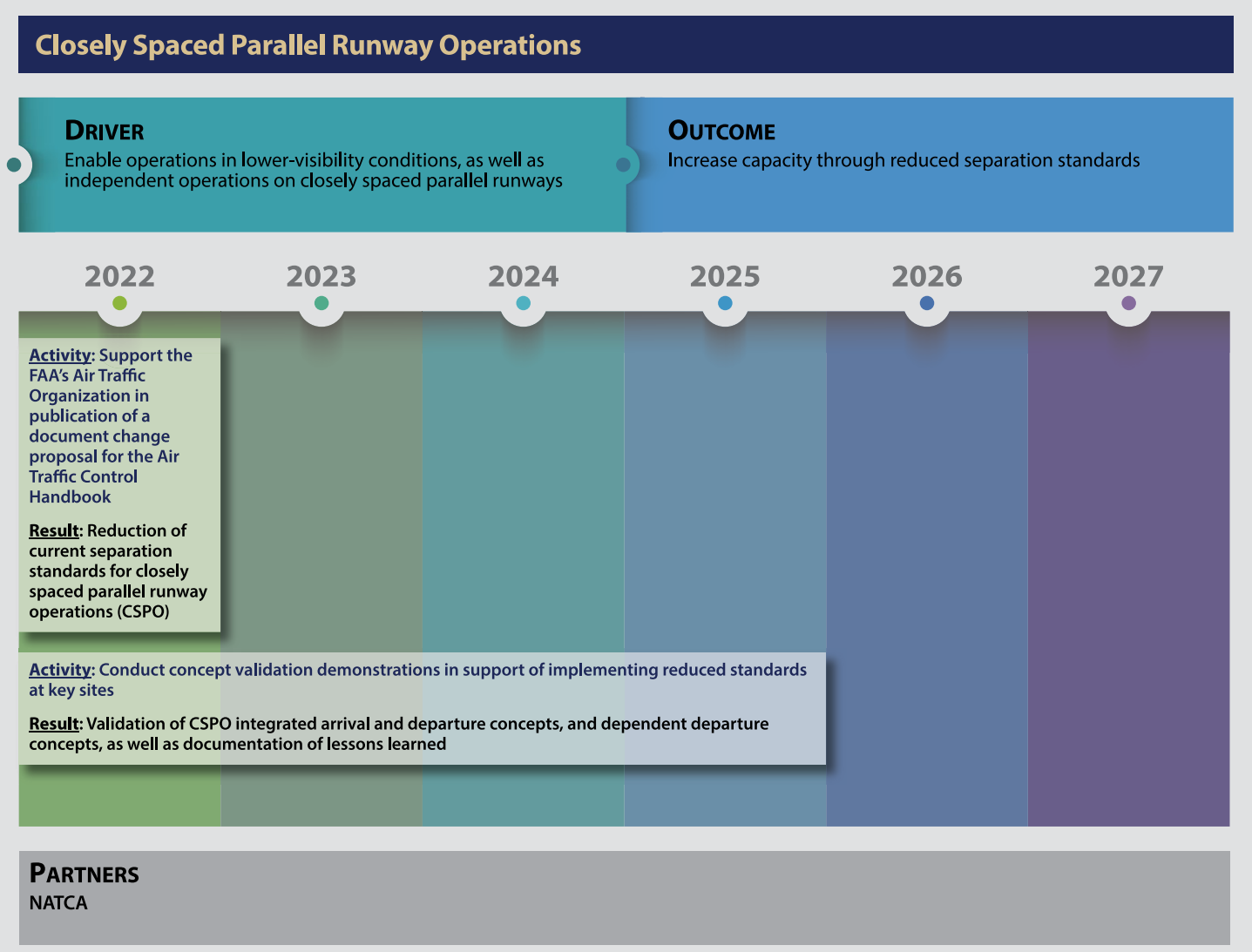
Improving closely spaced parallel runway operations (CSPO) — side-by-side runways spaced less than 4,300 feet apart laterally — has enabled the FAA to develop procedures and tools to increase airport arrivals and departures in all weather conditions.

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

The program seeks to leverage modern surveillance 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 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.**



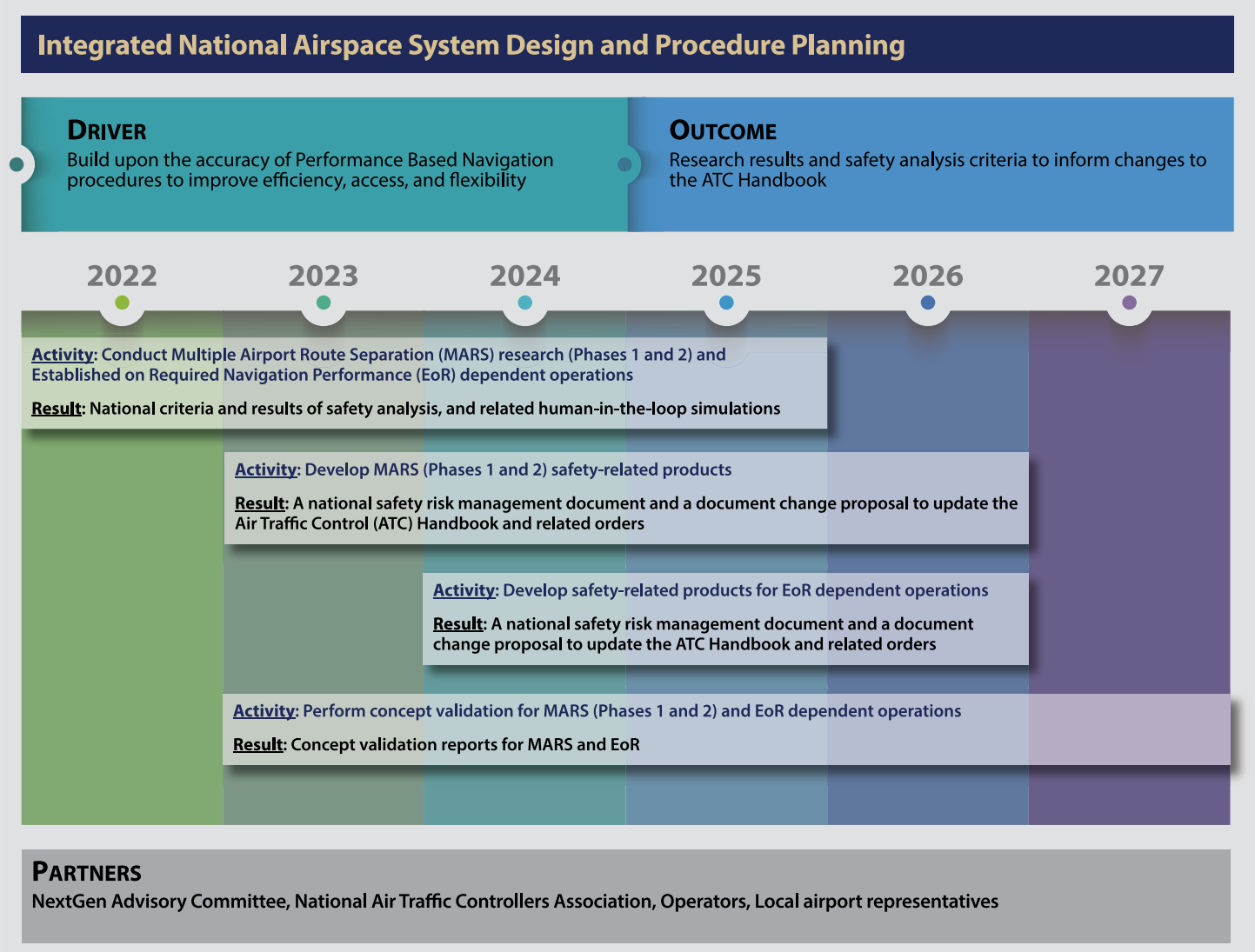
Separation Management Portfolio (continued)

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

The EoR concept increases the use of instrument approach procedures that allow planes to turn to align with the runway sooner, reducing passenger time, track miles flown, fuel burn, aircraft exhaust 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 repeatability and predictability of operations.

Initially driven by 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.



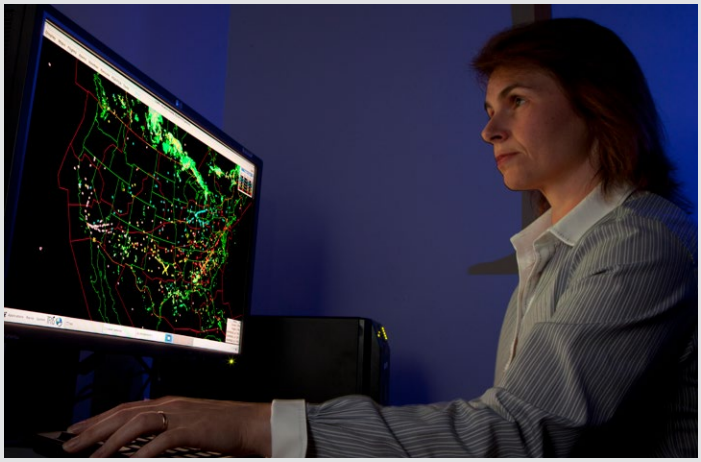
NAS Infrastructure Portfolio

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

New Air Traffic Management Requirements

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

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



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

2022

Activity: Conduct studies to determine the performance of current weather products

Result: Report outlining the performance level of current weather products

2023

Activity: Identify and address multiple challenges to advancing the overall enterprise surveillance architecture to meet the future needs of the National Airspace System (NAS)

Result: Enhanced resiliency of surveillance services across the NAS and implementation of advanced surveillance data processing applications

2024

2025

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

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

2026

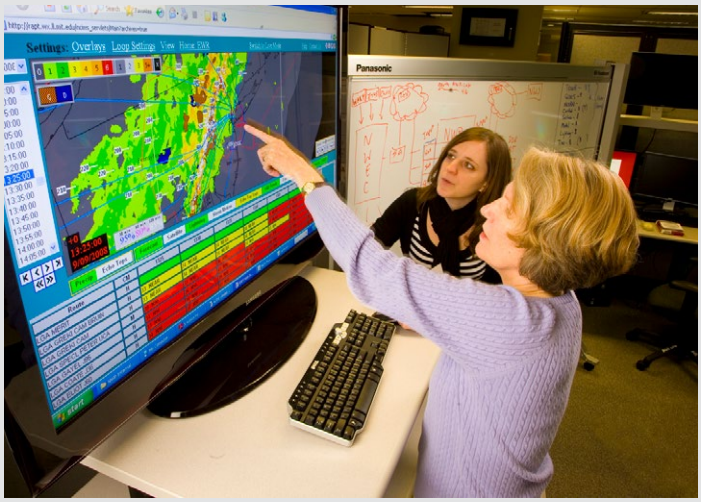
2027

PARTNERS
National Weather Service, Air carriers

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

2022

Activity: Achieve investment analysis readiness decision and final investment decision

Result: Formalized investment analysis readiness decision for the Next Generation Weather Processor and Common Support Services–Weather Enhancement 1

2023

Activity: Complete initial cloud services for aviation weather studies

Result: Development of preliminary requirements and architecture for a service-based approach to support dynamic weather application

2024

2025

Activity: Research into weather translation techniques for non-convective weather constraints, weather advisories, and collaborative lab experiments

Result: Outputs that will be directly transferable to future collaborative air traffic management technologies and to Time Based Flow Management research

2026

2027

Partners
National Weather Service

Continued Airworthiness

Effects of Different Platform Materials on Rotorcraft Testing

Preventing or delaying fuel-induced fires can provide the critical time needed for passengers to exit a helicopter following a crash. Current FAA rotorcraft design requirements increase the level of safety in the event of a survivable crash by decreasing the likelihood or delaying the onset of a post-crash fire.

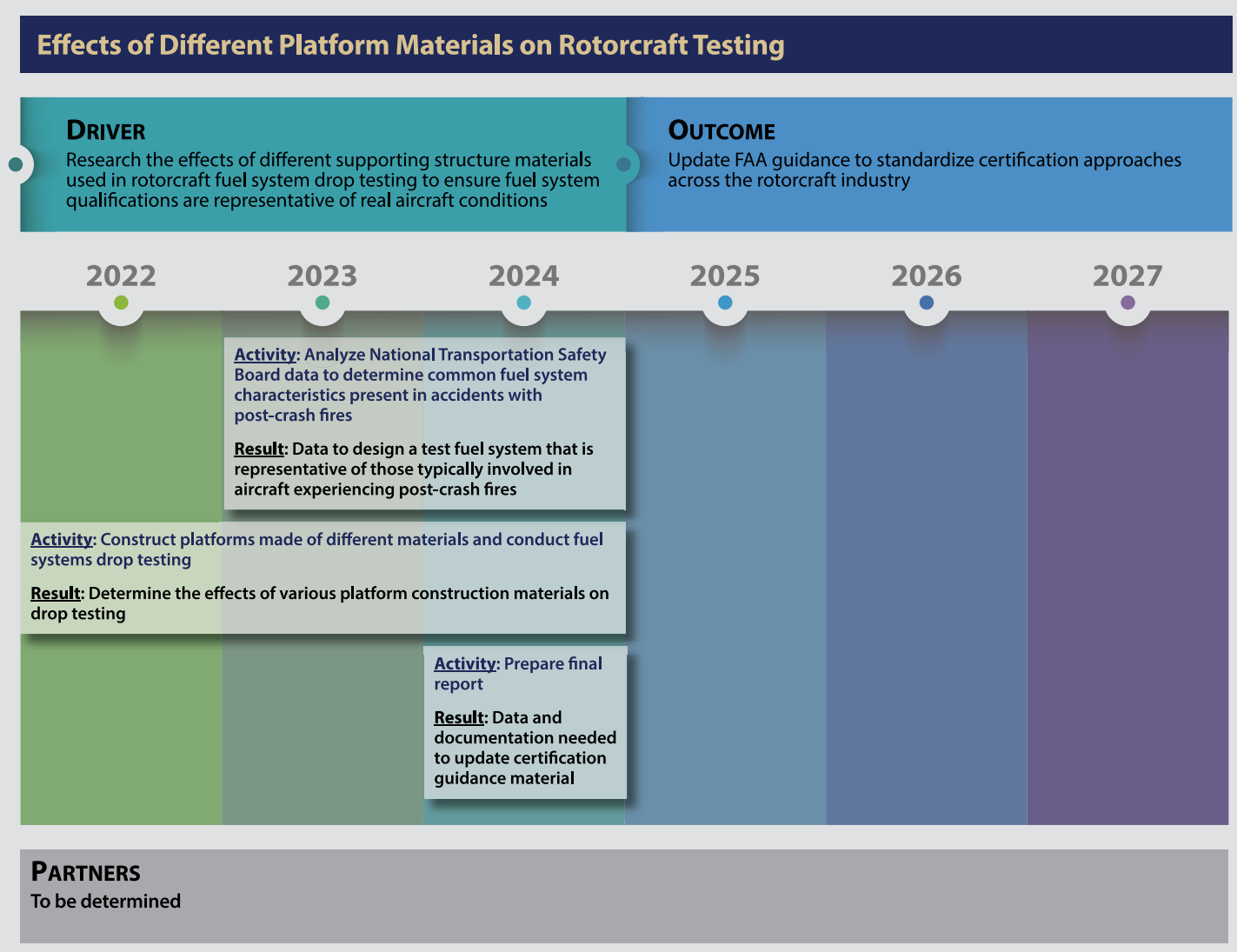
These requirements minimize crash-induced fuel leaks and contact with potential fuel ignition sources during and after a crash. This increases the time occupants have available to exit the aircraft before a post-crash fire becomes critical.

For a manufacturer to demonstrate full compliance with FAA requirements, a complete fuel tank structure filled with water to 80 percent capacity is dropped 50 feet in a controlled experiment. There must be no leakage after the drop.

Breakaway fittings or flexible lines are required to prevent spillage from interconnecting tanks where motion created upon impact may create a hazard.

Researchers will study the effects of using different supporting structure materials used for rotorcraft fuel system drop testing as directed by Congress in the FAA Reauthorization Act of 2018, section 317.

The FAA will use the results to update guidance and standardize certification approaches across the rotorcraft industry to ensure the fuel system qualification process is representative of real aircraft conditions.



Goal 2

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

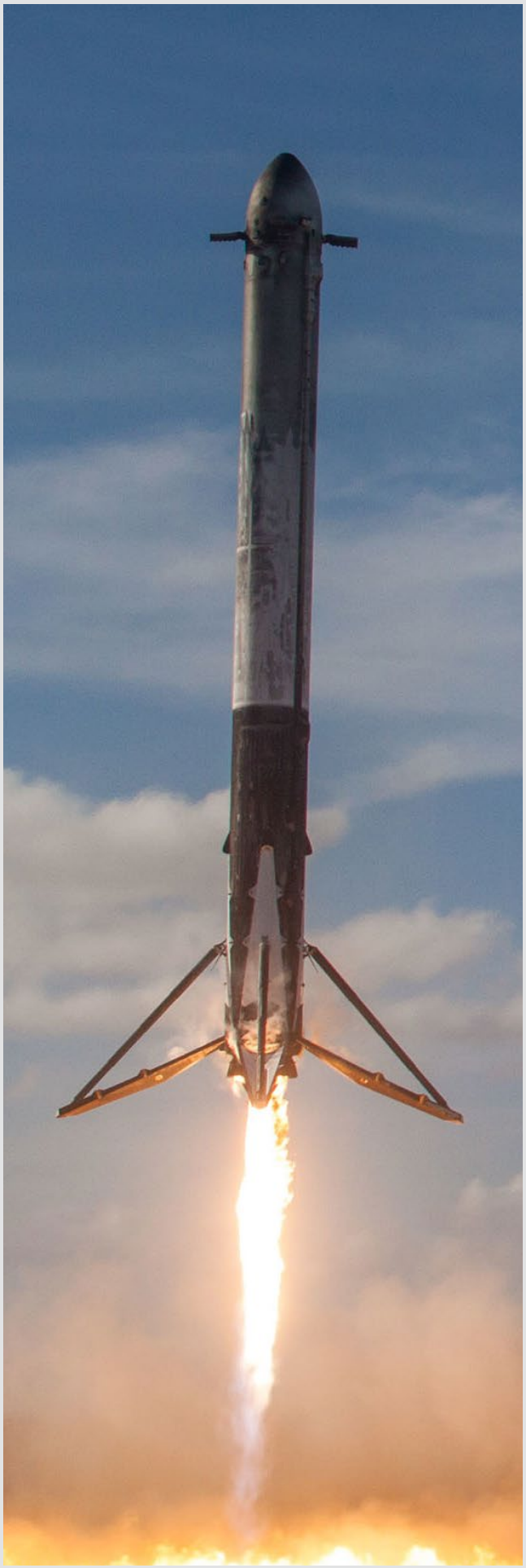
Key programs and initiatives:

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.

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

To achieve this goal, the FAA will:

- **Study potential replacement fuels for the existing fleet of general aviation aircraft**
- **Evaluate and demonstrate aircraft and engine technologies that can reduce aircraft noise and emissions while improving fuel efficiency; and conduct testing, analysis, and coordination activities to support the development and deployment of sustainable aviation fuels for gas turbine engines**
- **Examine environmental impacts of supersonic aircraft and advance technological solutions to support their reintroduction into the nation's aircraft fleet**
- **Identify ways to detect and stop unauthorized drone activity without interfering with flight operations**
- **Research ways to make it easier for emergency responders to incorporate the use of drones during emergencies, and to enhance disaster preparedness and response efforts**
- **Validate explosive yield models for liquid oxygen-liquid methane rocket propellant to more accurately predict the impacts of explosions**
- **Test and evaluate the flammability of newly-developed aircraft components to enhance safety during inflight and post-crash fires.**



Alternative Fuels for General Aviation

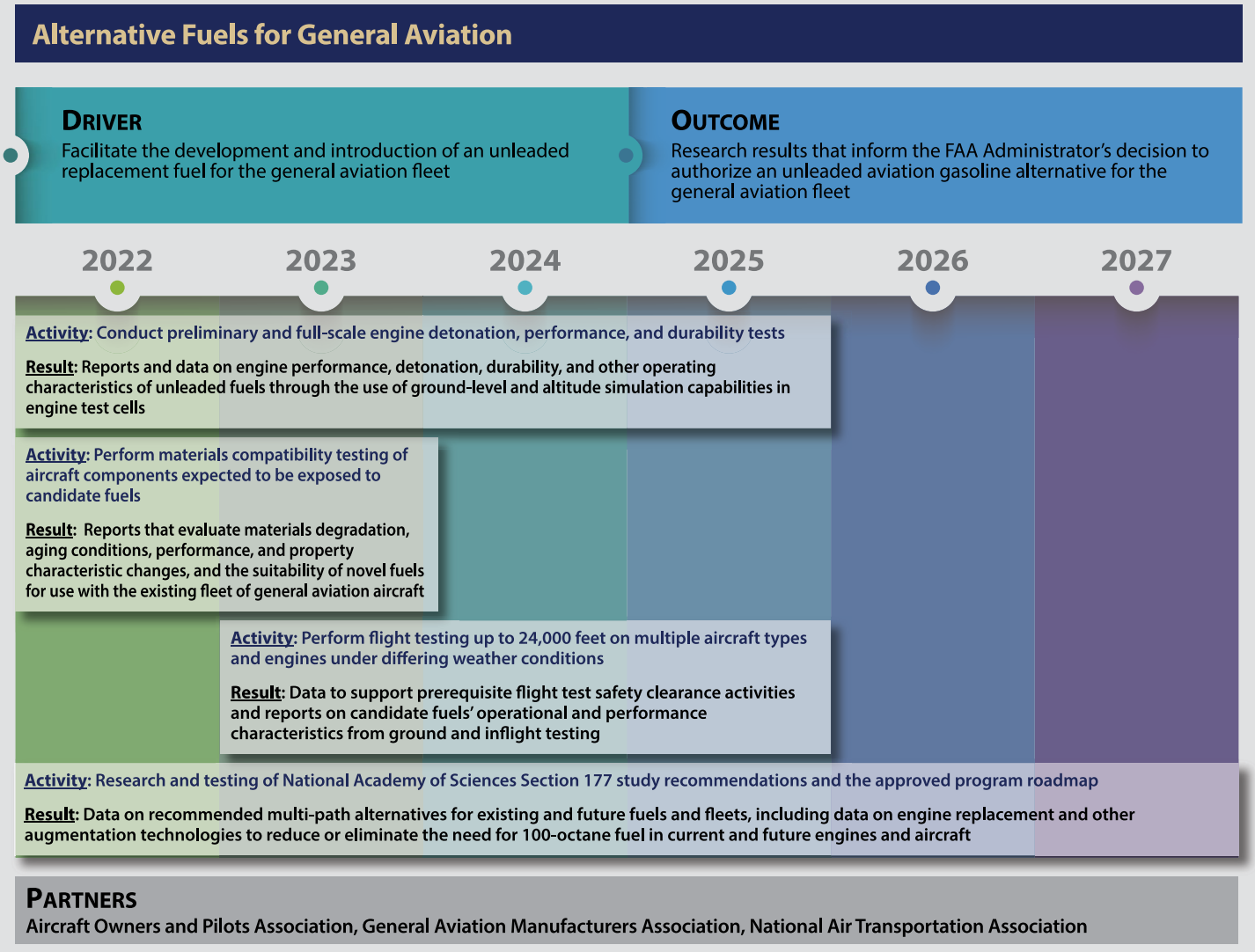
Alternative Fuels for General Aviation

General aviation supports 1.2 million jobs directly or indirectly and contributes over $247 billion to the U.S. economy, including a $75 billion positive effect on the balance of trade (2020, General Aviation Manufacturers Association).

However, this economic benefit is at risk unless the fleet can safely transition to unleaded fuels. Aviation gasoline (avgas) is the only remaining transportation fuel in the United States that contains lead. Over 170,000 piston-engine general aviation aircraft currently in use rely on this fuel for safe operation.

The lead additive in avgas creates the very high-octane levels required to prevent detonation (engine knock) in high-power aircraft engines. Operating an aircraft with inadequate fuel octane can result in engine failure and aircraft accidents.

The FAA is working closely with the aviation industry on research that will provide the critical data necessary for the FAA Administrator to authorize an unleaded replacement fuel in accordance with section 565 of the FAA Reauthorization Act of 2018.



Modernizing General Aviation Fuel Systems to Reduce Climate Impact

The administration has prioritized addressing the climate crisis by improving fuel efficiency and reducing emissions to lessen the impact of aircraft operations on air quality. One area of focus is piston-engine general aviation aircraft. These airplanes and helicopters play an important role in the nation's economy, providing support for business and personal needs, medical flights, emergency services, charter services, and flight training, to name a few examples.

In some cases, these aircraft are the only available method of travel and are crucial to transporting life sustaining food and supplies for people living in the most remote areas of the United States, such as parts of Alaska. Averaging more than 50 years in age, these essential aircraft use antiquated and inefficient fuel systems, relying on leaded aviation gasoline for safe operation.

The FAA is taking a multi-pronged approach to reducing the climate impact of these aircraft while helping to sustain their important role through the following advancements in aircraft technologies, as well as research into partially renewable and sustainable aviation fuels.

- The most promising near-term research supports improvements in air quality by replacing current leaded aviation gasoline with an unleaded alternative, eliminating airborne lead emissions. This includes research into partially renewable aviation gasoline.
- The FAA is accelerating the maturation of certifiable, environmentally beneficial aircraft and engine technologies such as electronic ignitions. Once available, these technologies can be adopted by a large portion of the existing fleet to improve fuel efficiency. This will be critical to reducing harmful engine emissions from general aviation.
- Longer-term research will evaluate emerging technologies — such as fully electric, electric-hybrid, and fuel cell electric propulsion technologies — that reduce the demand for fossil fuels and lower aviation emissions.


DO NOT PUSH
DO NOT PUSH

NextGen Environmental Research: Aircraft Technologies and Fuels

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

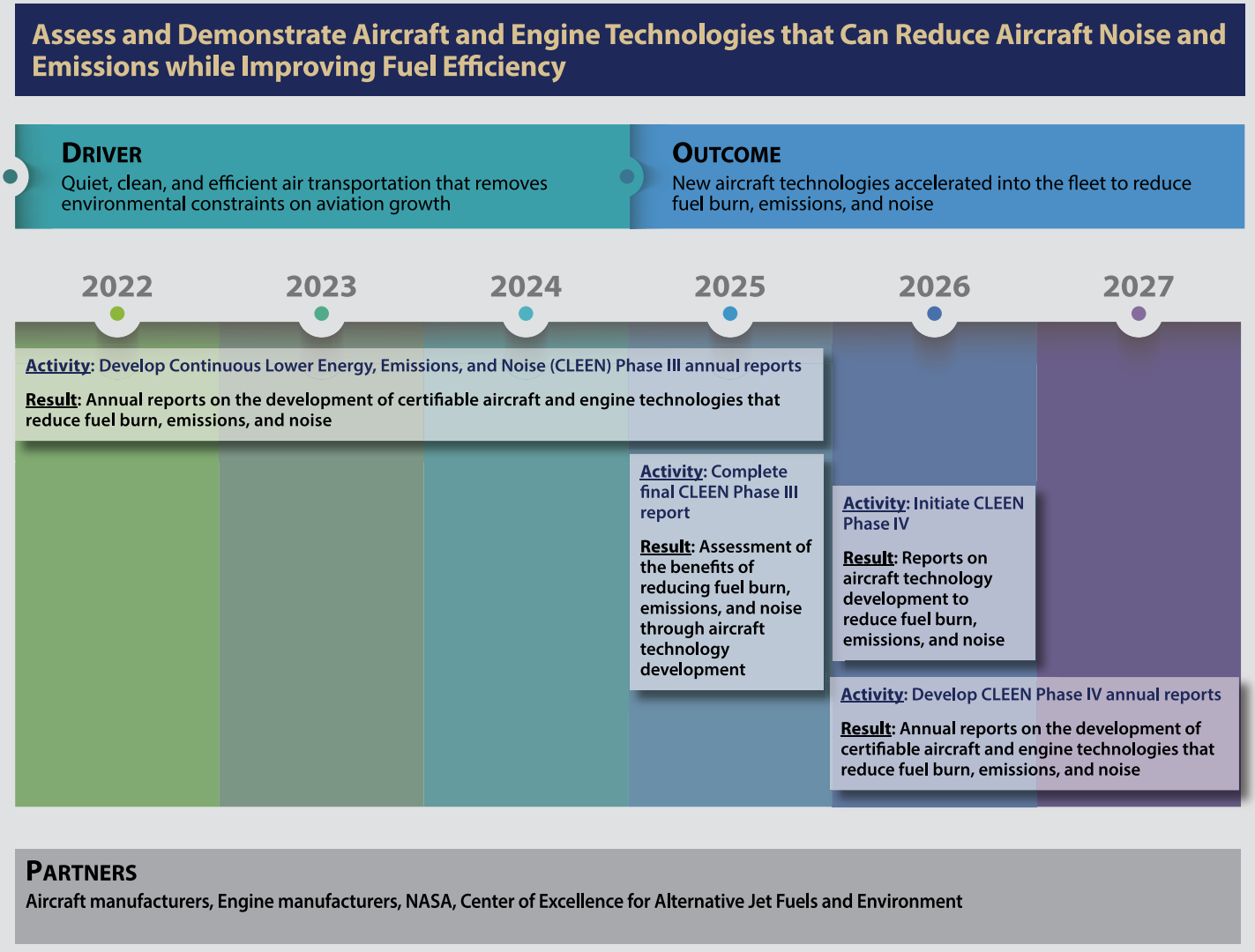
Through the Continuous Lower Energy, Emissions, and Noise (CLEEN) program, the FAA is working with industry to develop certifiable aircraft and engine technologies that increase fuel efficiency while reducing noise, emissions, and aircraft operating costs.

CLEEN is a cost-share partnership with aviation manufacturers that helps accelerate environmentally beneficial technologies. These development efforts culminate in full-scale ground and flight test demonstrations, which ultimately support deployment of these technologies into the NAS. The goal of CLEEN is to achieve environmental protection that enables sustained aviation growth. The program is implemented in five-year phases, each with specific improvement goals.

In Phase III of the program, which began in 2021, research is focusing on reducing certification noise levels, community noise, nitrous oxide, and particulate matter emissions, as well as fuel burn for subsonic and supersonic aircraft. Goals for Phase IV will be determined in the coming years.

Researchers in the CLEEN program are also working with the Commercial Aviation Alternative Fuels Initiative and the Center of Excellence for Alternative Jet Fuels and Environment (ASCENT) to obtain critical information on sustainable aviation fuels to ensure they are safe for use.

ASCENT researchers are working closely with the FAA to ensure these fuels are being adequately credited under international emissions standards.



Supersonic Aircraft

Flying faster than the speed of sound, supersonic aircraft may one day allow passengers to spend more time at their destination and less time traveling there. The DOT and the FAA are taking steps to advance the development of civil supersonic aircraft. This research is critical to accelerating the reintroduction of these high-speed aircraft into the nation's fleet. Work examines the 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 develop policies and international standards and support analytical methods development for noise mitigation technologies as directed by Congress in the FAA Reauthorization Act of 2018, section 181.

Supersonic Aircraft

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

OUTCOME
Support domestic rulemaking and international standards setting

2022 | 2023 | 2024 | 2025 | 2026 | 2027

Activity: Assess global environmental effects from aircraft technologies for modeled scenarios to 2050

Result: Technology-level and flight-level analyses, assessment of original equipment manufacturer mission specifications, and projection of local environmental effects at national and international airports

Activity: Model and measure basics of supersonic jet noise

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

Activity: Conduct clean sheet supersonic engine design and performance analyses

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

PARTNERS
International Civil Aviation Organization, Airframe and engine manufacturers, Center of Excellence for Alternative Jet Fuels and Environment, NASA

United States Aviation Climate Action Plan

The FAA led the development of the United States Aviation Climate Action Plan, a reflection of America's vision for the aviation sector consistent with the broader economy-wide objective to achieve net-zero emissions no later than 2050.

The United States submitted the *updated action plan to the International Civil Aviation Organization (ICAO) in November 2021*[1] to compile and quantify progress towards international aviation climate goals.

The FAA developed the plan with input from partner agencies, including the Department of Transportation (DOT), Department of Energy (DOE), Department of State, Environmental Protection Agency, NASA, and the Department of Agriculture (USDA).

The Critical Role of Research

Aviation climate research is critical to achieving the ambitious targets set out in the climate action plan. New aircraft technology has historically been the main factor in reducing aviation's environmental impacts, a *70 percent improvement in fuel efficiency over the last 50 years*.[2]

Research that continues to advance new aircraft technology will reinforce the U.S. aviation emissions trajectory laid out in the climate action plan. Initiatives like the FAA's Continuous Lower Energy, Emissions, and Noise public-private partnership and alternative fuels for general aviation will help expedite development of certifiable aircraft and engine technologies that reduce fuel burn and engine emissions, as well as noise.

Additionally, the FAA is directing aircraft technology innovation research at universities across the country through the Center of Excellence for Alternative Jet Fuels and Environment to advance and expand industry's technical knowledge base.

Air Traffic Management Improvements

Research on air traffic management operational improvements will provide additional emissions reductions on top of technological advances. For example, evaluating enhancements to surveillance technology to safely allow reduced separation between aircraft and improve accommodation of altitude, speed, and route-change requests in areas like oceanic airspace is critical, as transoceanic flights to and from the United States emit comparable carbon dioxide emissions (CO_2) as domestic flights.

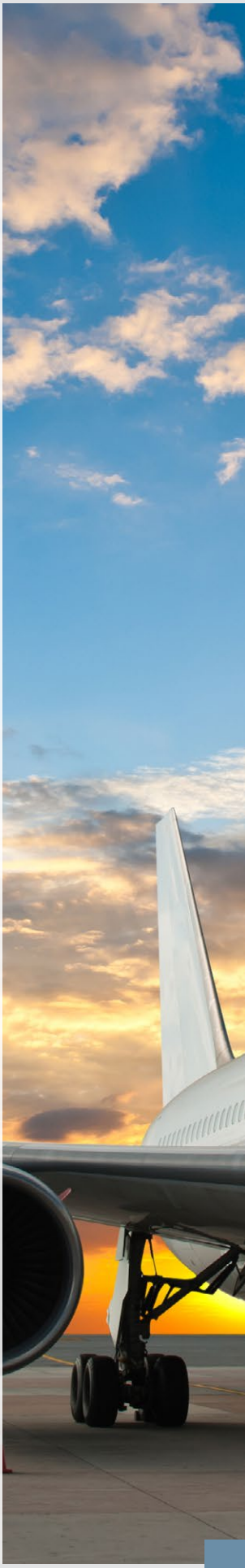
Sustainable Aviation Fuels

Aircraft technology and operational improvements alone cannot achieve the amount of emissions reductions needed to meet the goals of the action plan. Research to develop and deploy drop-in sustainable aviation fuels (SAF) that can be used in the same infrastructure, engines, and aircraft is critical to achieving these objectives.

The United States has prioritized the development and deployment of SAF as a key aviation climate priority through a coordinated government-wide effort to reduce the cost, enhance the sustainability, and expand the production and use of SAF. The DOT, FAA, DOE, NASA, and USDA are collaboratively working to accelerate the research, development, demonstration, and deployment needed to greatly expand SAF usage.

International Standards

This research also enables the United States to develop international standards at ICAO. Development of the first CO_2 standard for civil aircraft, as well as the standard for the Carbon Offsetting and Reduction Scheme for International Aviation, heavily relied on aviation climate research. Future international standards-setting efforts contemplated in the action plan that maximize environmental benefits, and are technically feasible and economically reasonable, will equally rely on sound aviation climate research.



[1] *https://www.faa.gov/sustainability/aviation-climate-action-plan*

[2] *https://www.faa.gov/newsroom/continuous-lower-energy-emissions-and-noise-cleen-program?newsId=22534*

Unmanned Aircraft Systems

Unmanned Aircraft Systems Detection at Airports

Detecting unauthorized UAS, or drone, activity at the nation's airports and removing that threat ensures the safety and security of the flying public.

Research will identify regulations and standards necessary for the safe use of counter-UAS technologies that do not adversely impact or interfere with safe airport operations, air navigation, air traffic services, or the safe and efficient operation of the NAS — as directed by Congress in the FAA Reauthorization Act of 2018, section 383.

The FAA will test drone detection and mitigation systems at five airports as part of this research.

Unmanned Aircraft Systems Detection at Airports

Driver
Test and evaluate counter-unmanned aircraft systems (UAS) technologies that can detect and mitigate threats without impacting National Airspace System operations

Outcome
Develop a plan to certify and authorize deployment of counter-UAS technologies in the airport environment

2022

Activity: Develop preliminary counter-UAS performance standards

Result: Report on preliminary counter-UAS performance standards

Activity: Install and test UAS detection and mitigation technologies at four additional U.S. airports

Result: Validation of performance characteristics identified during initial testing at Atlantic City International Airport

2023

Activity: Complete test and evaluation of UAS detection and mitigation technologies

Result: Develop a plan to certify and authorize deployment of counter-UAS technologies in the airport environment

2024 2025 2026 2027

Partners
Airport operators, Department of Homeland Security, Department of Defense, Department of Justice, Transportation Security Administration

Unmanned Aircraft Systems (continued)

Unmanned Aircraft Systems Disaster Preparedness and Response

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

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

Unmanned Aircraft Systems Disaster Preparedness and 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, and regulations to enable emergency, and disaster preparedness and response operations for UAS

2022	2023	2024	2025	2026	2027
Activity: Conduct outreach with fire departments and emergency service agencies **Result**: Document UAS use cases, best practices, and risks of using drones during emergencies, and disaster preparedness and response activities	**Activity**: Identify obstacles preventing wide-spread adoption of UAS by public safety agencies, and provide recommendations to overcome these barriers **Result**: Development of standards and requirements for operational procedures, training, and certification to facilitate using UAS during emergencies, and disaster preparedness and response activities	**Activity**: Study interagency coordination procedures and coordination between manned and unmanned aircraft **Result**: Recommendations for the safe operation of UAS and coordination among agencies during disaster and emergency response efforts	**Activity**: Complete UAS flight testing to demonstrate various use cases for emergencies, and disaster preparedness and response activities **Result**: Document lessons learned		

Partners

Alliance for System Safety of Unmanned Aircraft Systems through Research Excellence, Department of Homeland Security, Federal Emergency Management Agency, NASA, National Oceanic and Atmospheric Administration, United States Forest Service, State and local governments, University of Vermont

Promoting Emerging Technologies and Innovation

In 2023, the FAA is launching a new Emerging Technology Accelerator program that will engage innovators across the country in developing creative solutions for current and future aviation challenges.

Through these partnerships, the FAA will provide a path for entrepreneurs to rapidly mature promising technologies and transfer them to the aviation industry while allowing the agency to leverage these emerging technologies and more rapidly respond to operational challenges.

The FAA anticipates the air transportation system will evolve in the years ahead into an integrated information environment that includes diverse air vehicle types and airspace operations. Advancing towards this future vision requires an innovative environment that attracts talent from all sectors of society, lowers the barriers for presenting promising technology to aviation stakeholders, and creates a space for meaningful solution demonstration and validation.

The program will leverage the agency's science and technology infrastructure, including laboratories and staff at the FAA's William J. Hughes Technical Center in Atlantic City, NJ, and Civil Aerospace Medical Institute in Oklahoma City, OK, to provide relevant settings for technology demonstrations and readiness evaluations.

This program enables the FAA to:

- **Increase its agility for rapidly addressing emerging air transportation needs**
- **Align its research and development activities with known and forecast challenges and opportunities in the aviation industry**
- **Address statutory requirements by investing in longer-term research**
- **Influence and shape the air transportation system of the future.**

Distinctive program objectives include advancing selected innovation proposals from initial consideration to technology transfer. Inclusion and equitable access to growth opportunities are key objectives of this program. Through outreach and partnership efforts, the FAA will emphasize extending the program's reach to traditionally underserved communities.

Commercial Space Transportation Safety

Explosive Yield Research

The FAA is licensing new commercial space launch vehicles using a combination of liquid-oxygen and liquid-methane rocket propellant. An accident involving a large launch vehicle full of such propellant at or near a launch site could create a powerful explosion resulting in a public safety hazard.

Explosions like this can break windows a significant distance away from a launch site 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. Currently, almost no relevant test data exists to support modeling the strength of liquid oxygen-liquid methane explosions.

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.

Traditional propellant combinations have significantly different properties than liquid oxygen-liquid methane. Research will validate theory-based explosive yield models developed for 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

2022	2023	2024	2025	2026	2027
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: Dynamic testing of LOX/LCH4 in partnership with NASA, 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

Transforming the Office of Commercial Space

The FAA's Office of Commercial Space Transportation (AST) is planning the Innovation Foresight project to transition AST from a traditional, siloed structure to an adaptive and collaborative organization that responds quickly to industry, ecosystem, and environmental trends, and incorporates an operational architecture that enables agile responses to unanticipated threats.

Early detection of such trends begins with intensive data collection, analysis, and integration. In order to accomplish this, AST will need to ensure data across different industry segments is cross-compatible, standardized, robust, citable, accurate, validated, and auditable.

Researchers will then be able to use decision-making approaches that are based on the best data available given situational factors, such as uncertainty and innovation, and create data dictionaries for analysis based on machine learning.

These capabilities will fulfill AST's dual mission goals of safety and facilitation through more efficient tactical actions and new foundations of data that enable operational decision making.

Fire Research and Safety

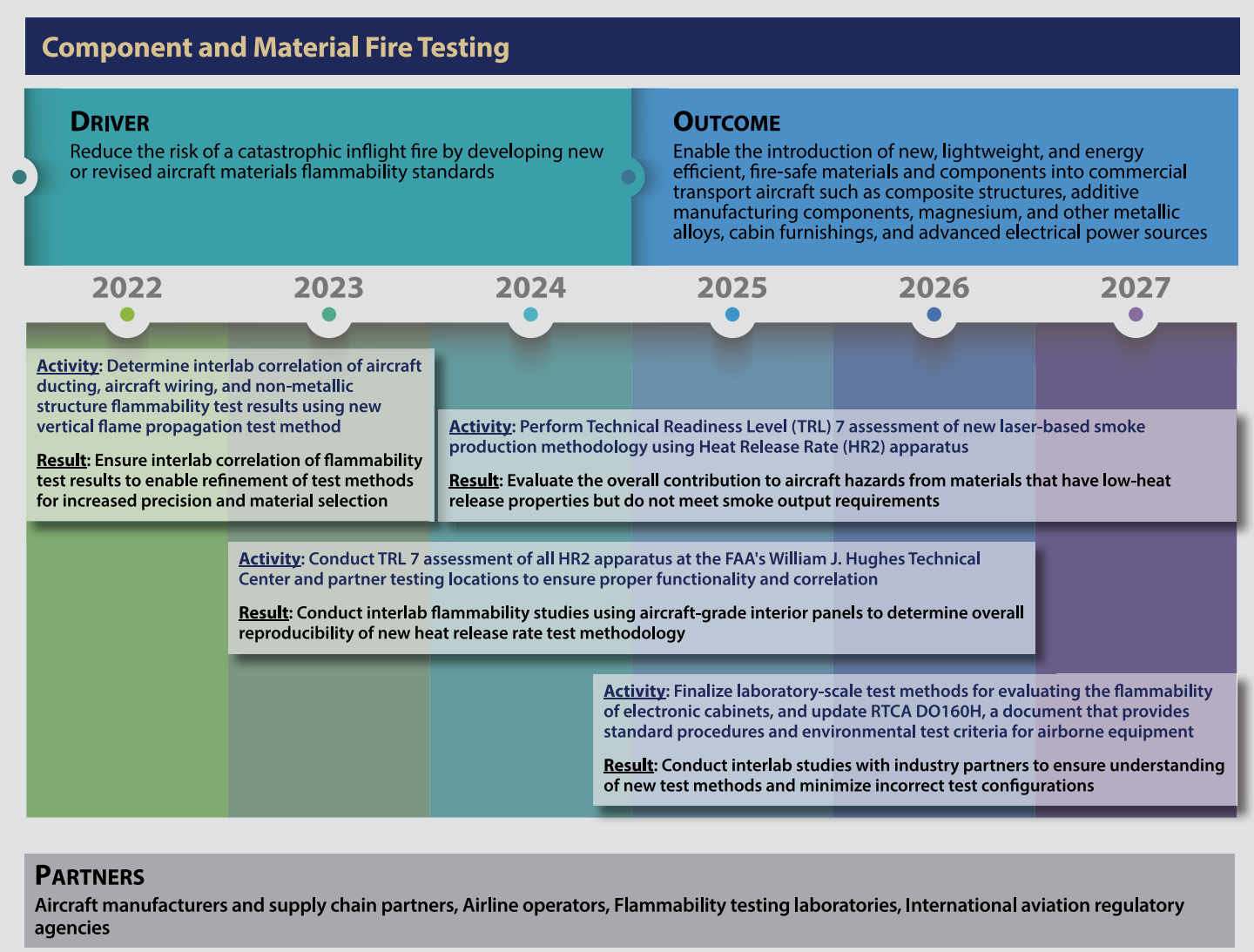
Component and Material Fire Testing

The catastrophic consequences of an uncontrollable fire during flight are a large loss of life and the destruction of the aircraft. The FAA's Fire Research and Safety program focuses on preventing accidents caused by inflight fires and improving the survivability of post-crash fires.

The aviation industry continues to introduce new technologies and materials into aircraft designs to decrease weight and increase operating efficiency. Component and Material Fire Testing research aims to ensure these new components are safely integrated into new aircraft designs. To do this, researchers must better understand the safety implications of the new materials.

This is critical when considering the possibility of a fire breaking out in hidden areas of the aircraft that are not accessible during flight. These include wiring insulation, air ducting, and the aircraft fuselage, which in newer designs is often constructed with non-metallic composites.

Prior to the introduction of composite structures, there was no need for flammability standards for the aluminum fuselage, as it is inherently non-flammable. A primary focus of this research is to ensure composite fuselage structures meet a minimum flammability standard based on realistic full-scale testing.



Goal 3

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

Key programs and initiatives:

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

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

To achieve this goal, the FAA will:

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

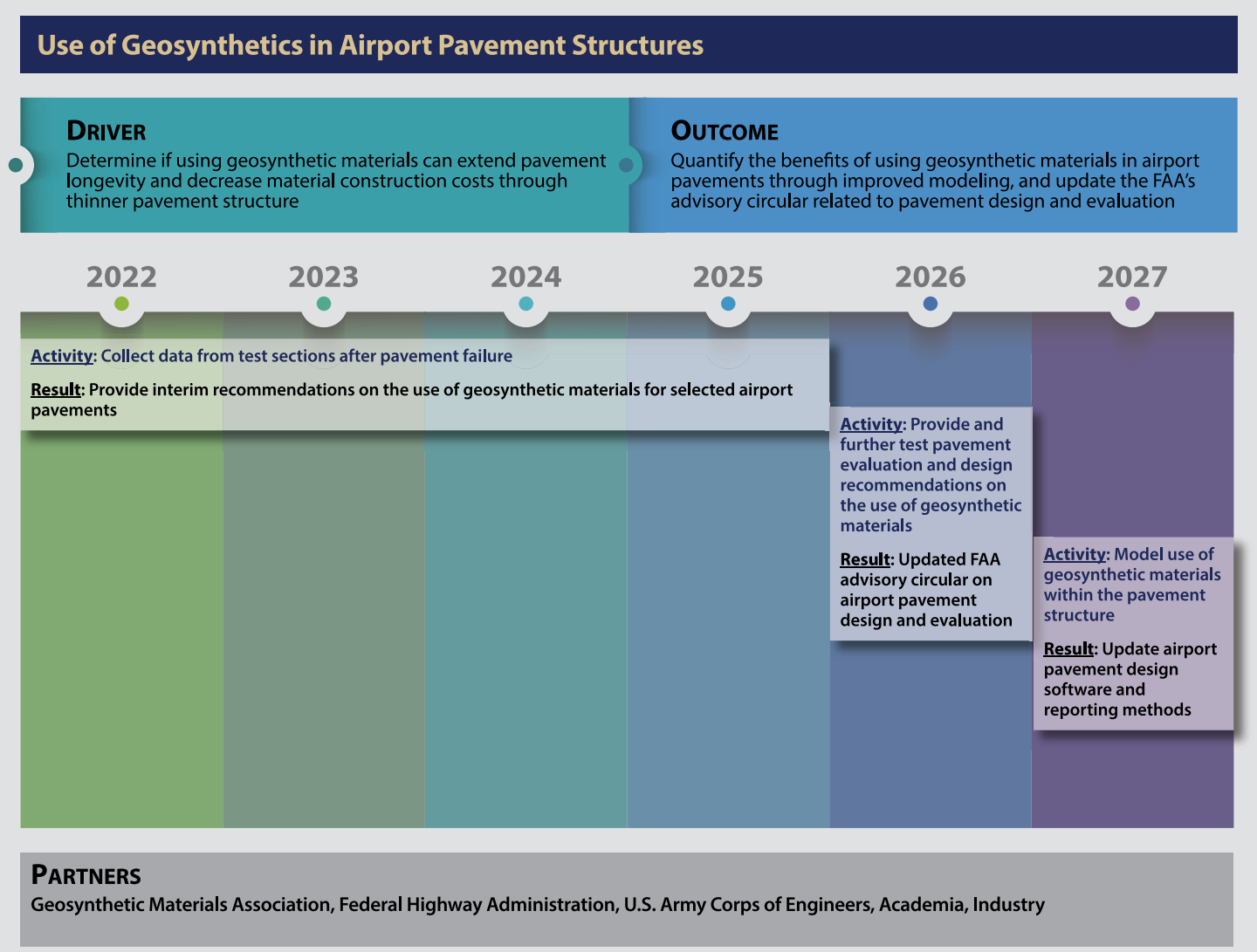
Airport Technology Research Program

Use of Geosynthetics in Airport Pavement Structures

Geosynthetics are materials used to reinforce foundations and pavement structures. In cooperation with the geosynthetics industry, the FAA is trying to determine the benefits of using geosynthetic materials to extend pavement longevity or reduce airport pavement thickness, a factor in construction and maintenance costs. While geosynthetics show a benefit in highway pavements, they have not been tested under aircraft loads, which are many times greater.

This research supports the FAA Reauthorization Act of 2018, section 525, which states that the FAA should encourage the use of durable, resilient, and sustainable materials and practices, including geosynthetic materials and other innovative technologies. To meet industry demand, the FAA is conducting pavement depth evaluation through full-scale accelerated pavement testing 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.



Alternatives to Aqueous Film Forming Foams in Firefighting Agents

Aircraft fires often occur in tough-to-access areas, such as engines and cargo holds. They typically involve spilled jet fuel and a variety of other hazardous materials. Airports are required to have a minimum supply of fire extinguishing agents — known as aqueous film forming foams (AFFF) — available at all times for use in emergency situations.

Some of the chemicals used in AFFF, such as fluorinated surfactants, are among a class of manufactured chemicals known as perfluoroalkyl and polyfluoroalkyl substances (PFAS), which are of concern for the environment and human health. This research supports the FAA Reauthorization Act of 2018, section 332, by seeking to identify PFAS-free alternatives that meet the same safety standards as AFFF. Related research will look at ways to improve firefighting techniques following a crash.

Alternatives to Aqueous Film Forming Foams in Firefighting Agents

Driver
Identify safer alternatives to fluorine-based firefighting agents, improve firefighting effectiveness, and reduce post-crash fire fatalities

Outcome
Identification and creation of standards for the use of PFAS-free replacement foams, compressed air foam systems, and ultra-high-pressure firefighting technology; as well as strategies for the use of high-reach extendable turrets to minimize disruption of thermal balance in post-crash fires

2022 | 2023 | 2024 | 2025 | 2026 | 2027

Activity: Work with foam manufacturers and the Department of Defense to identify alternatives to currently used firefighting foams that are free of perfluoroalkyl and polyfluoroalkyl substances (PFAS)

Result: Identification of a PFAS-free replacement foam

Activity: Develop strategies and tactics for using PFAS-free foams to extinguish fuel fires

Result: Creation of standards for the use of PFAS-free foams

Activity: Evaluate compressed air foam systems as primary discharge devices for fighting liquid fuel fires

Result: Creation of standards for compressed air foam systems and ultra-high-pressure firefighting technology

Activity: Follow-on research for the use of PFAS-free foams

Result: Develop guidance for the changeover and implementation from aqueous film forming foams to PFAS-free foams

Partners
Department of Defense, Dallas/Fort Worth International Airport Fire Training Research Center, National Fire Protection Association, International Civil Aviation Organization Rescue and Fire Fighting Working Group

Information Technology/Cybersecurity

Cybersecurity Data Science Tools

The FAA manages air traffic control operations through a complex network of computer and information systems. A cyber-attack could have devastating consequences on aviation operations and safety. The primary purpose of the Cybersecurity Data Science program is to identify effective and innovative ways to apply artificial intelligence, machine learning, and data science technologies to enhance cybersecurity for aircraft, airlines, and airports.

Researchers will work directly with the aviation industry to explore common cybersecurity concerns. This multi-year collaborative effort will better enable industry to utilize lessons learned from this research to strengthen their own cybersecurity, both individually and collectively, making the broader aviation ecosystem more resilient and safer for the flying public.

Cybersecurity Data Science Tools

Driver
Provide advanced solutions to the highly complex problem of aviation cybersecurity using machine learning and artificial intelligence (AI)

Outcome
Advanced cybersecurity toolsets that enhance the security and resiliency of the aviation ecosystem

2022	2023	2024	2025	2026	2027
Activity: Vulnerability and risk assessment technology research **Result**: New software and technical documentation					
Activity: Lateral Movement Defense (LMD) technology research **Result**: Development and advanced technology demonstration of new LMD software prototype					
Activity: Predictive Analytics (PA) technology research **Result**: PA software prototype and technical documentation					
	Activity: Context-Aware Behavioral (CAB) AI technology research **Result**: Report outlining state-of-the-art CAB AI techniques and potential application to the aviation ecosystem				

Partners
Aerospace Industries Association, Industry, Cyber Safety Commercial Aviation Team, Other U.S. government agencies

Goal 4

2.3.4 Goal 4: Improve human performance within the system

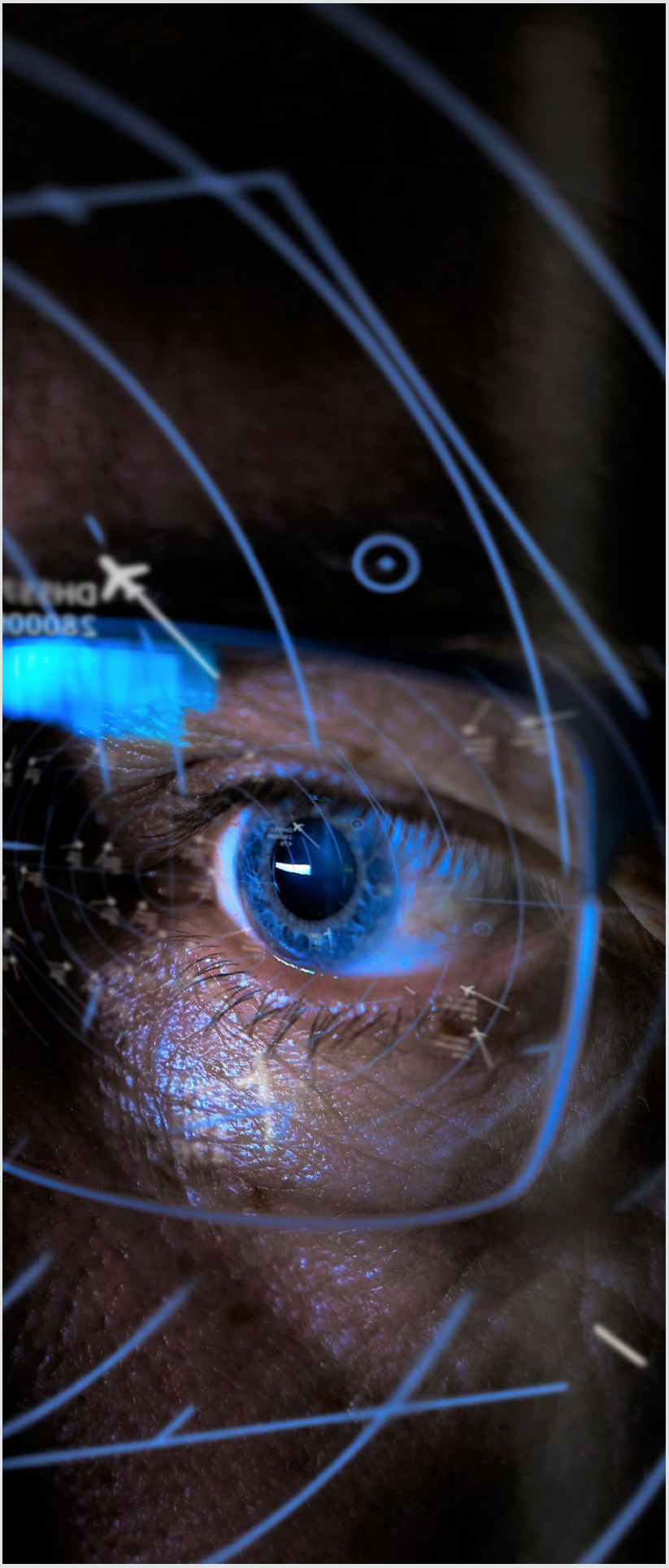
Key programs and initiatives:

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

- **Establish operational standards for the use of advanced vision systems**
- **Study sources of reported contaminates onboard passenger aircraft and establish methods to more accurately and effectively detect such occurrences**
- **Lead a safety risk assessment of communicable disease transmission risk onboard passenger aircraft to create a cabin health safety response plan and analytic tool kit**
- **Research the causes of helicopter accidents and tools that might help prevent crashes**
- **Evaluate prototypes to develop a path to certification for technologies that simulate interactions between pilots and ATC during pilot training**
- **Address recommendations specified in the Consolidated Appropriations Act of 2021, division V, title I – Aircraft Certification, Safety, and Accountability Act.**



Flight Deck, Maintenance, Systems Integration Human Factors

Operational Standards for Advanced Vision Systems

Advanced vision systems provide additional visual information to pilots through a fixed head-up display or head-worn device. These tools can enhance safety and allow greater access to airports in low-visibility conditions.

Research will study the cognitive and physiological effects pilots experience while using advanced vision systems, sensor-based technologies, and emerging display technologies, as well as whether these tools improve pilot performance.

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

Operational Standards for Advanced Vision Systems

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

Outcome
Evidence-based policy changes to increase throughput and accessibility to airports/runways for low-visibility approach, landing, and takeoff operations

2022	2023	2024	2025	2026	2027
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 human factors methods and tools to evaluate new Enhanced Flight Vision Systems (EFVS) implementations and operations **Result**: Report on operational evaluation considerations for EFVS					
Activity: Research the expanded use of single/dual head-up display (HUD) technology **Result**: Report on contributions of single/dual HUD to pilot/crew performance during Category II and III approaches and landings in low-visibility conditions					
Activity: Research impacts of advanced vision systems on new display technologies **Result**: Report on contributions to pilot performance from advanced vision systems on head-worn displays during low-visibility flight operations					

Partners
Aircraft manufacturers, Avionics manufacturers, Airlines, Business aviation

Aircraft Certification, Safety, and Accountability

FAA human factors research supports and addresses the content and spirit of the Aircraft Certification, Safety, and Accountability Act passed by Congress in 2020. The law provides recommendations for the agency to better integrate human factors throughout the aircraft design and certification process. Current human factors research will focus on:

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

Recent aviation accidents, combined with advanced technologies proposed for flight deck equipment design, training for pilots and maintenance staff, and flight operations, are key drivers of this work. The FAA will use research results to clarify and expand human factors in aviation safety, regulatory policy, and processes used by the FAA's Flight Standards and Aircraft Certification services.

Aeromedical Program

Airliner Cabin Environment (Air Quality)

Reports of cabin air contaminants can often be linked to engine oil leaks or other fluids being ingested into the engine, drawn into the air supply, and distributed throughout the cabin and flight deck.

Smoke, odors, and fumes can enter the environmental control system used for ventilation, pressurization, and temperature control of the airplane.

This research will identify and measure contaminant levels in U.S. commercial aircraft cabins, assess potential health effects on passengers and flight crew, and create a more objective means for detecting contaminants, as required by the FAA Reauthorization Act of 2018, section 326.

Airliner Cabin Environment (Air Quality)

DRIVER
Examine the impacts of smoke, odor, and fume events onboard commercial aircraft, and identify sensor technologies to monitor cabin air quality and mitigate potential contamination

OUTCOME
Recommendations for how to monitor cabin air quality and sensor technologies to improve the detection of potential contaminants

2022	2023	2024	2025	2026	2027
Activity: Conduct engine test stand and ground-based aircraft tests, and evaluate the results **Result**: Engine test stand and ground-based aircraft experimental data sets		**Activity**: Examine the potential health effects of smoke, odor, and fume events **Result**: Final report and recommendations on airliner cabin air quality			

PARTNERS
Academia, Industry

Aeromedical Program (continued)

Infectious Disease Research

The FAA's Office of Aerospace Medicine is leading a safety risk assessment on communicable disease transmission onboard passenger aircraft. Researchers at the FAA's Civil Aerospace Medical Institute in Oklahoma City, OK, will develop a modeling, simulation, and analysis framework. This will allow researchers to estimate the transmission risk for respiratory diseases of potential public health significance, such as COVID-19, within transport aircraft cabins.

Researchers will identify risk mitigation solutions, 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 knowledge gained from these research activities to create a cabin health safety response plan with an associated analytic tool kit.

Infectious Disease Research

Driver
Understand and minimize the transmission risk for respiratory diseases of potential public health significance within transport aircraft cabins

Outcome
Improved understanding of the communicability of infectious diseases and improved mitigation solutions

2022	2023	2024	2025	2026	2027
Activity: Conduct a cabin health safety risk assessment **Result**: Develop a framework for modeling, simulation, and analysis, and other associated tools					
Activity: Research cabin health safety mitigation **Result**: Produce risk mitigation solution sets, an associated mitigation evidence base, and mitigation modeling and simulation representations					
		Activity: Develop a cabin safety risk management plan **Result**: Transition the cabin health safety response plan and analysis toolkit to the Centers for Disease Control and Prevention			

Partners
To be determined

System Safety Management/Terminal Area Safety

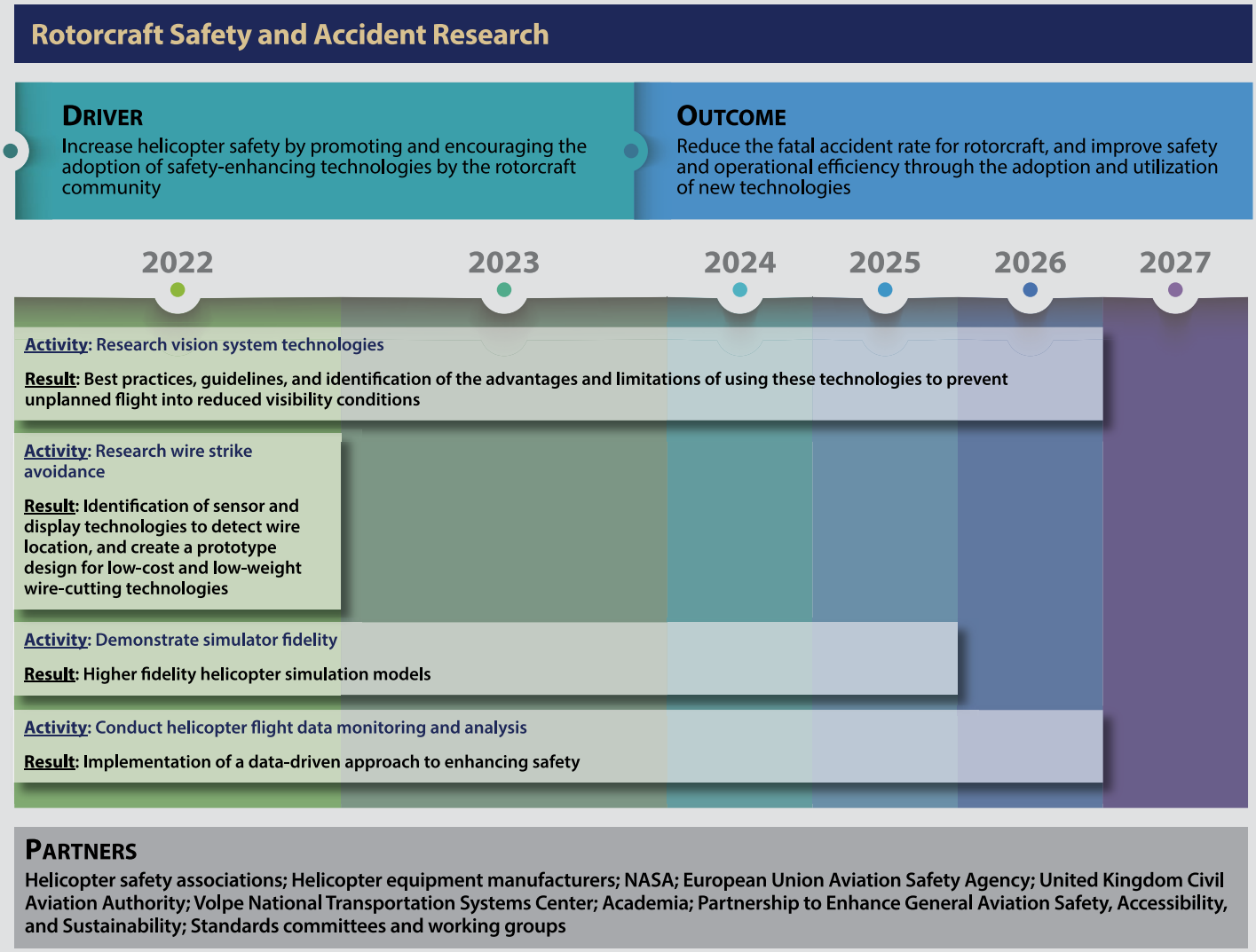
Rotorcraft Safety and Accident Research

A number of high-profile helicopter accidents in recent times involve a common theme, flying in low-visibility conditions. The incidents were typically associated with bad weather, fog, clouds, pilot spatial disorientation, and loss of control of the rotorcraft.

Rotorcraft safety research aims to address the top causes of accidents and incidents. Research includes enhanced vision systems and related technologies — such as synthetic vision systems, combined vision systems, and head-worn and helmet-mounted displays — which can provide increased visual information and cues to help pilots reorient themselves at the onset of potential problems.

Related work includes:

- **Rotorcraft wire strike detection and mitigation research**
- **Higher-fidelity simulation devices and models**
- **Helicopter flight data monitoring**
- **Rotorcraft electric vertical takeoff and landing noise modeling**
- **Vertical flight low-level infrastructure, including routes, procedures, vertiport and heliport lighting, markings, sensors, and ground infrastructure.**



Evaluation of Air Traffic Control Simulators that Utilize Artificial Intelligence

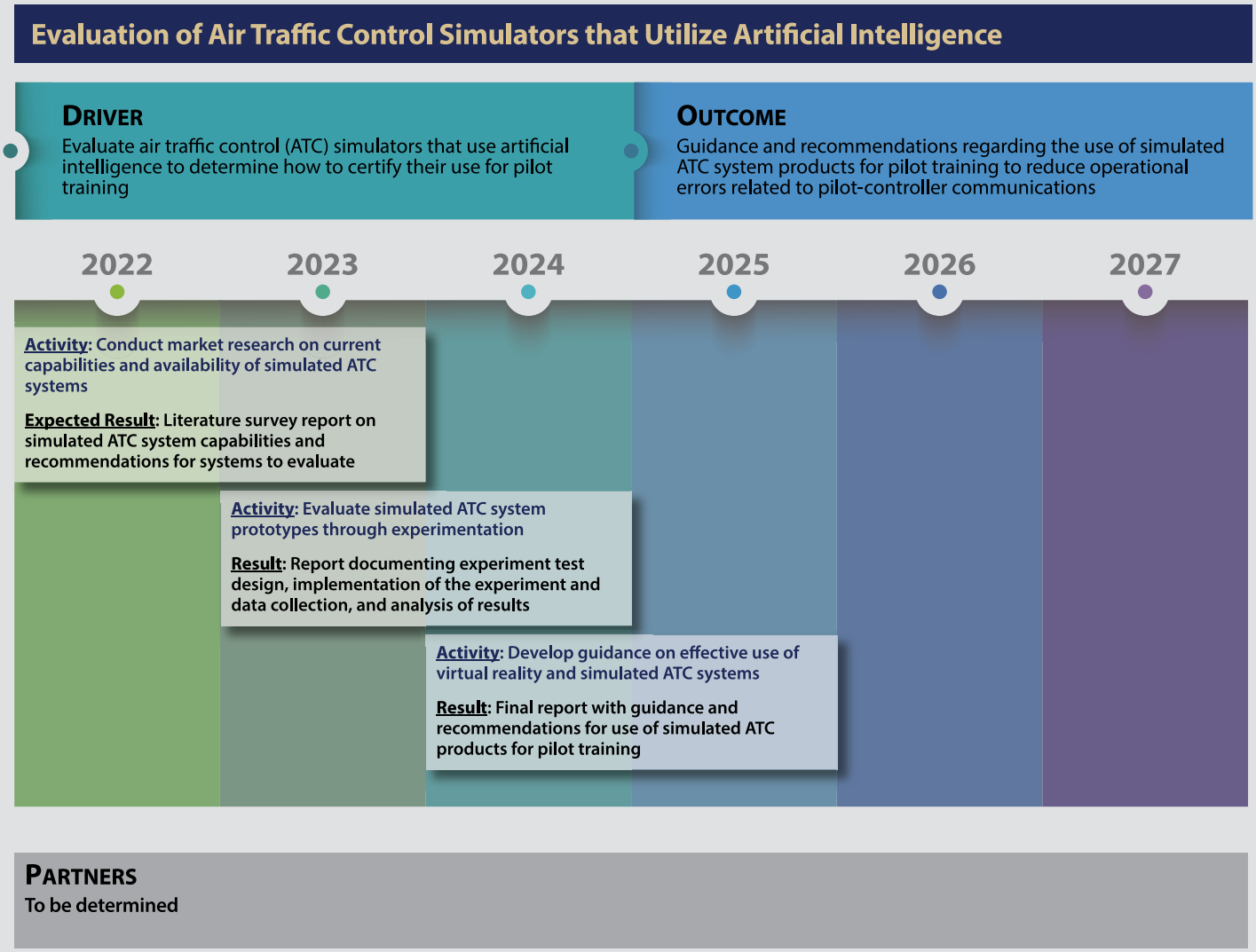
Airline pilots are trained using high fidelity, Level D full-flight simulators. Although these devices offer a realistic flight experience, they typically do not provide true-to-life air traffic control (ATC) interactions.

During training exercises, simulator instructors or other individuals often act as air traffic controllers. These conversations do not accurately reflect real-life exchanges between controllers and pilots. This creates gaps in training that can result in miscommunication during actual flight operations.

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

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

Using the findings of this research, the FAA can develop a path for certification for simulated ATC systems, improving the pilot training experience and possibly reducing the rate of accidents and incidents related to pilot-controller miscommunication.



Goal 5

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

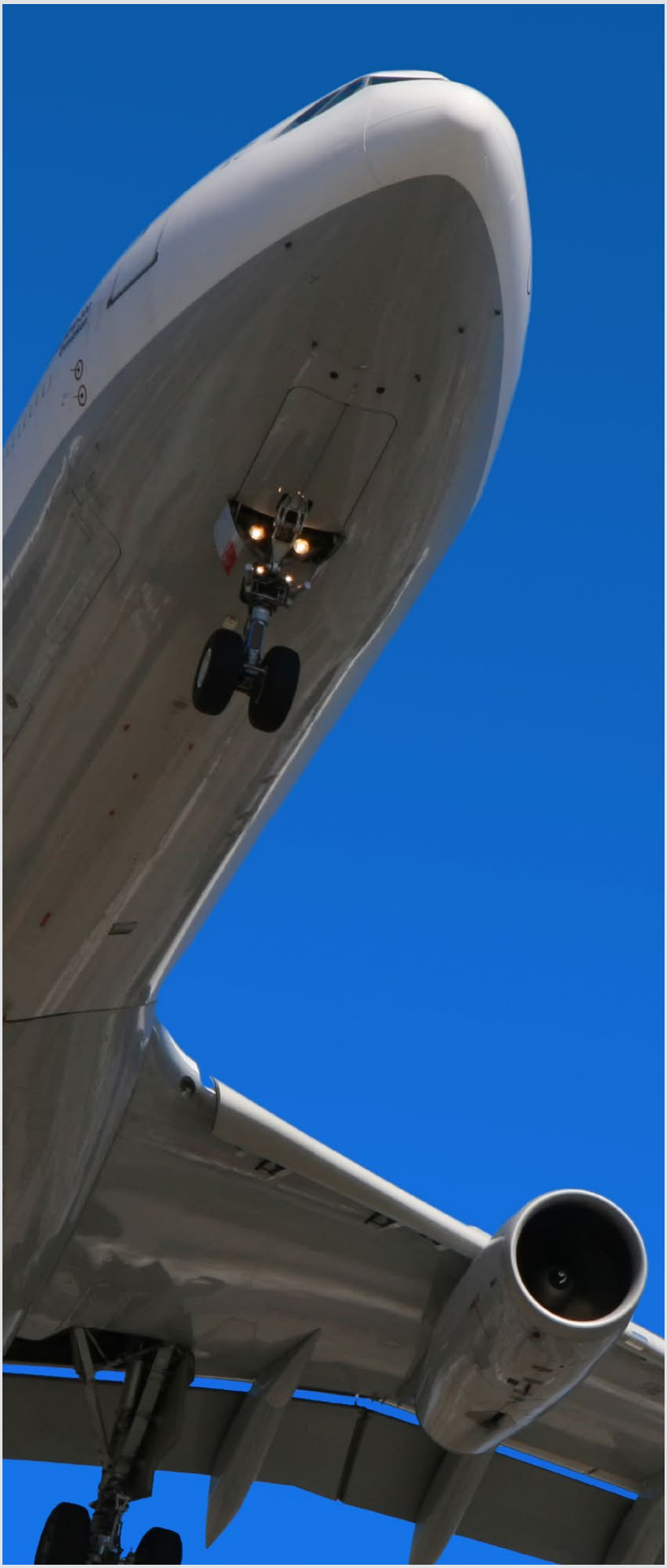
Key programs and initiatives:

Using technologies such as data sharing, artificial intelligence, and machine learning, the FAA has created a number of tools to analyze and model safety, environmental impact, and other data in support of the NAS. Integrated modeling capabilities and system-wide analyses will facilitate the FAA's ability to produce state-of-the-art quantitative and qualitative analyses of complex systems. Work in this goal area will improve the robustness, adaptability, flexibility, and accuracy of these integrated analytical and computational modeling tools.

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

To achieve this goal, the FAA will:

- **Provide regulatory guidance and create a new version of the probabilistic damage tolerance based design code known as DARWIN® to account for anomalies and defects in engine materials made with nickel alloys**
- **Update existing environmental modeling tools to improve noise measurement and exposure maps, including sound produced by supersonic aircraft.**



Propulsion and Fuel Systems

Advanced Damage Tolerance and Risk Assessment Methods for Engine Life Limited Parts

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

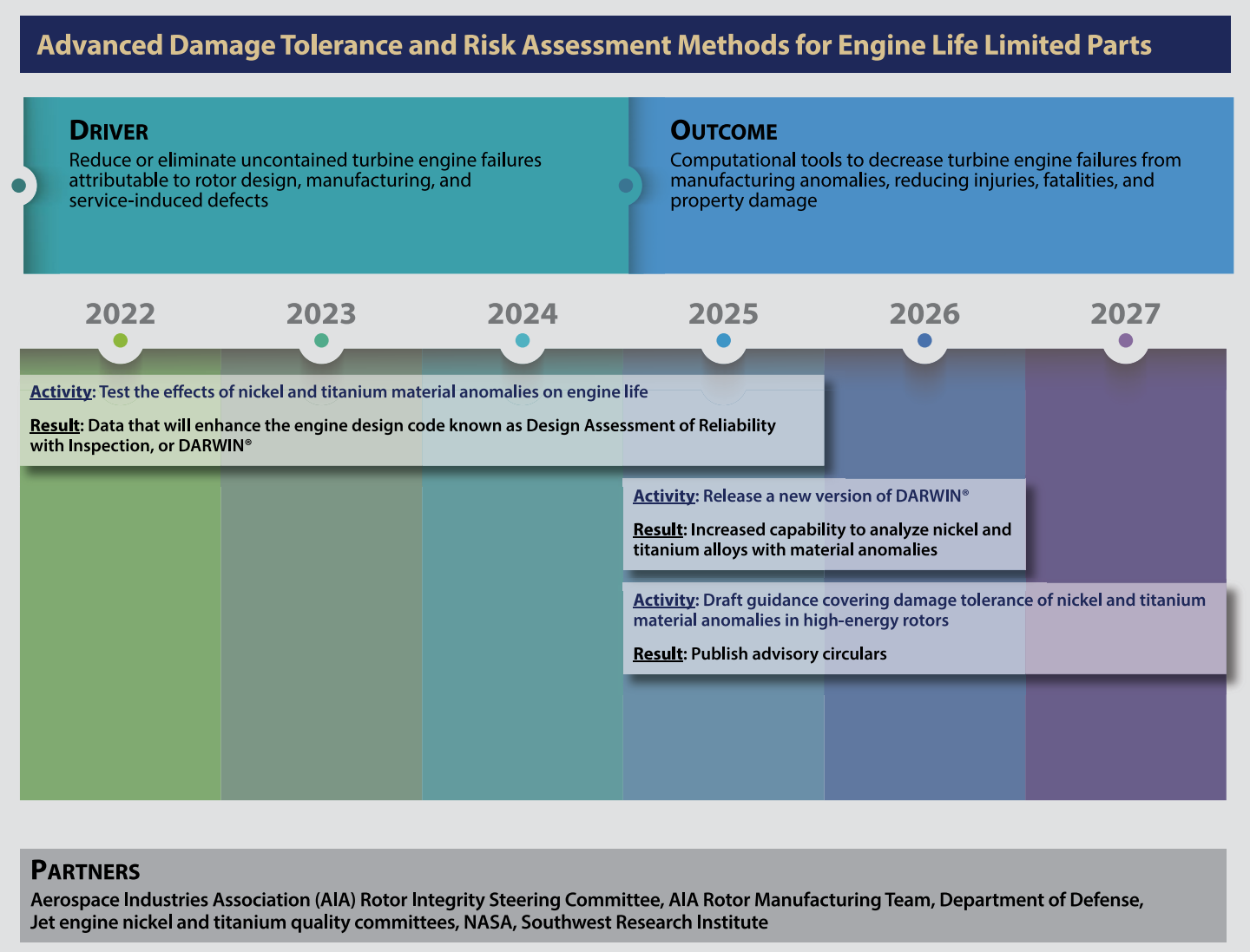
The FAA and Southwest Research Institute, in collaboration with the aviation industry, developed a tool called Design Assessment of Reliability with Inspection, or DARWIN®, to determine the probability of failure of critical engine parts.

Engine manufacturers use the software code to design and verify the compliance of life-limited engine parts that need to be replaced on a regular basis due to wear and tear during the life of an aircraft.

Current propulsion and fuel systems research will focus on the effects of anomalies in engine components made of nickel and titanium, both of which are used to make critical rotating components.

Research is motivated in part by a 2016 uncontained turbine engine failure in Chicago caused by a nickel anomaly and another uncontained failure in 2017 from a metallurgical condition known as cold dwell fatigue that can shorten the expected life of titanium engine components.

The goal is to create updated versions of DARWIN® that can help prevent failures in nickel and titanium parts, as well as new regulatory guidance on nickel and titanium damage tolerance in high-energy rotors.



Environment and Energy

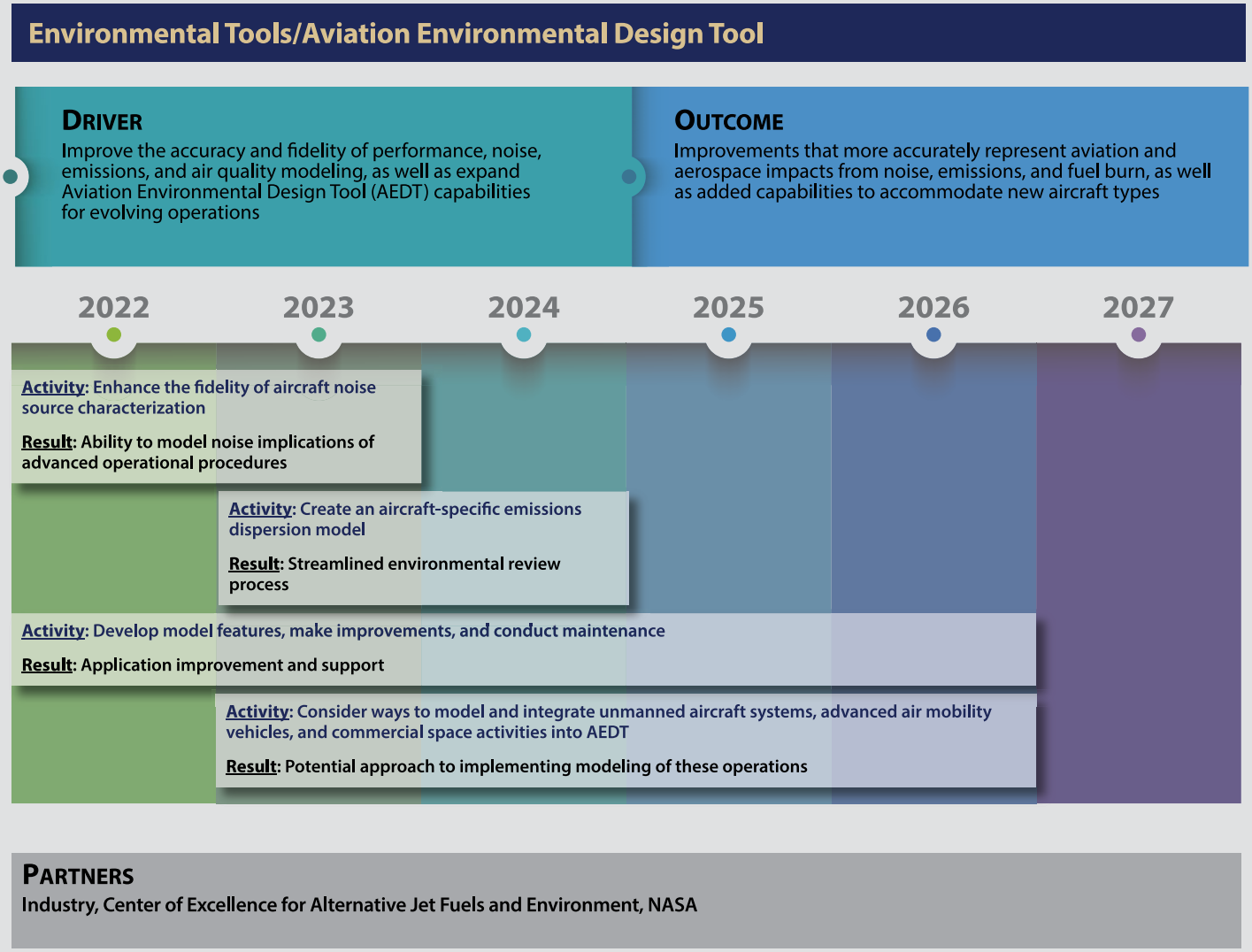
Environmental Tools/Aviation Environmental Design Tool

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 to facilitate the environmental review of federal actions associated with changes to airports, airspace, and other applicable aviation activities. AEDT is also a valuable tool 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 entrants such as supersonic aircraft.

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

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



Big Data Analytics Working Group

The Big Data Analytics Working Group demonstrates the agency's commitment to empower the FAA workforce to proactively use, disseminate, and advance big data analytics methods and best practices.

Collaboration

The working group facilitates collaboration and knowledge sharing between the laboratories at the FAA's William J. Hughes Technical Center and Mike Monroney Aeronautical Center. The team engages employees to learn and disseminate big data analytics technology to address complex challenges facing aviation and space, and improve the safety and efficiency of the National Airspace System.

Mentorship

Through data sharing, mentorship, and empowerment, the working group facilitated a former FAA intern's completion of a doctorate in aerospace engineering. The student's thesis documented a prototype algorithm that assessed the efficacy and impact of traffic management initiatives on the daily operations of eight Northeast Corridor airports. Using machine learning, the algorithm more consistently and accurately predicted patterns than the labor-intensive methods used by subject matter experts to gather and evaluate the data.

The intern's classification methodology amassed metrics such as number of diversions, ground stops, departure delays, and airborne holdings from each of the airports. Using this analysis, the intern was able to identify key trends and patterns among a respective airport's traffic management initiatives that either accelerated or impeded operations. Such information helps air traffic managers make more informed decisions, resulting in less flight delays.

Addressing Complex Challenges

Members of the working group facilitated the development of a machine learning/artificial intelligence application to process text-based, non-structured safety reporting data for rotorcraft and fixed-wing aircraft. The prototype automates a *currently labor-intensive process* to classify incidents, accidents, and events as "fire-related" or "non-fire-related" using data from several publicly available safety databases. This critical safety research helps prevent these types of events in the future.

3.0 Partnerships and Collaboration

The FAA maintains partnerships with over 300 stakeholders representing academia, industry, international entities, technical societies, and other federal agencies.

The FAA accomplishes this through various mechanisms, including Cooperative Research and Development Agreements (CRADA), centers of excellence (COE), national consortiums, interagency agreements, patent license agreements, and other avenues. These methods provide partners access to the agency's facilities and subject matter experts to conduct advanced research.

3.1 Technology Transfer

The FAA's Technology Transfer program promotes the dissemination of federally-funded research and innovations to the commercial marketplace and American public. The agency achieves this by facilitating the exchange of the FAA's knowledge, facilities, and capabilities with industry, academia, and other federal partners. The program fulfills three primary roles:

- **Promoting and enabling government-industry collaboration**
- **Sharing technical advances resulting from FAA research and development efforts**
- **Managing patent licenses and royalties.**

The program's primary technology transfer mechanism is the *CRADA*. These agreements offer unique collaborative opportunities for the FAA to work with domestic and international partners from academia and industry to address complex aviation challenges.

Through CRADAs, the FAA will continue to research how to effectively integrate new aerospace vehicles into the National Airspace System (NAS) and tackle the challenges of certification for unmanned aircraft systems (UAS) airframes and system components, as well as UAS beyond-visual-line-of-sight for inspection operations.

Cooperative Research and Development Agreements (CRADA) in Action

Together with CRADA partners, the FAA conducts research in a variety of areas, including:

- **Advanced materials**
- **Airport pavements**
- **Enhanced/synthetic vision systems**
- **Electrical propulsion systems**
- **Fire resistance of polymeric materials**
- **Flight deck simulations**
- **Predictive impact modeling (uncontained engine failures)**
- **Solid-state power control and protective devices**
- **Structural health monitoring**
- **Surface surveillance systems**
- **Unleaded fuel for general aviation aircraft.**

3.2 Partnerships

Centers of Excellence

Congress established the COE program through passage of the Omnibus Budget Reconciliation Act of 1990 (Public Law 101-508), title IX – Aviation Safety and Capacity Expansion Act, which is now codified in relevant part at section 44513 of title 49 of the U.S. Code. The mission of the FAA's COE program is to advance aviation technologies and expand the agency's research capabilities while educating the next generation of aviation professionals.

The program enables critical collaboration and coordination between government, academia, and industry. More specifically, using selection criteria provided under the law, 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 funds and resources to supplement FAA research capabilities and serve as a primary source of subject-matter-expertise to the agency for a 10-year period. There are currently six active COEs that focus on various aspects of aviation and space activities:

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

Centers of Excellence Initiatives (2023 to 2027)

- **Research advanced composite materials and repairs**
- **Investigate ceramic matrix composite and polymer-based additive manufacturing**
- **Develop a method to assess the severity of airborne collisions involving unmanned aircraft systems (UAS)**
- **Mitigate rotorcraft wire strikes**
- **Enhance weather interfaces for air traffic controllers**
- **Test prospective UAS integration safety and security technologies**
- **Reduce engine emissions**
- **Identify flight recorder requirements for UAS integration into the National Airspace System**

Aviation Research Grants

Over the next five years, research is planned in subject areas, including: improved pilot training, improved pilot procedures during unexpected events, airport lighting and visual guidance, and air traffic alarm management.

Established by Congress under the FAA Research, Engineering, and Development Authorization Act of 1990 (Public Law 101-508) and the Aviation Security Improvement Act of 1990 (Public Law 101-604), aviation research grants are an essential mechanism for the agency to advance critical research for the long-term growth of civil aviation and aerospace.

The program funds academic and nonprofit research institutions to conduct innovative advanced research in scientific and engineering disciplines relevant to, and in furtherance of, the FAA mission. This research allows the agency to gain knowledge and understanding of current and emerging topics, including:

- **Ice accretion on swept-wing aircraft, and electric vertical takeoff and landing vehicles**
- **Advanced materials research, including structural integrity assessment of metal additive manufacturing parts, and evaluating bonded repairs and damage tolerance**
- **Damage modes in lightweight sandwich structures**
- **Fire protection of commercial aircraft systems and mitigation of fire propagation in hidden areas of commercial airplane cabins**
- **Probabilistic integrity and risk assessment of turbine engines**
- **Flight loads and airframe usage analysis of next-generation air tankers**
- **Flight deck vision systems**
- **Occupant safety in aircraft seats mounted obliquely (at an angle).**

Federal Interagency Partners

The FAA leverages the capabilities of federal agency counterparts to increase the safety and efficiency of the NAS through resource pooling and research collaboration in areas such as evolving operations, fire safety, propulsion and fuel, advanced materials, digital systems, weather, human factors, and aeromedical research.

The FAA's Interagency Agreements

- **Department of Agriculture**
- **Department of Defense**
- **National Transportation Safety Board**
- **National Oceanic and Atmospheric Administration**
- **Department of Energy**
- **Smithsonian Institute**
- **NASA**
- **Volpe National Transportation System Center**

Partnering with NASA on Modernization

Over the past decade, the FAA and NASA have been working together with aviation industry and academic partners on many aspects of the FAA's NextGen modernization program, which transitioned radar-based air traffic control to a satellite-based system.

Through this partnership, NASA's Airspace Operations and Safety Program (AOSP) developed new technologies to provide advanced automated support to air navigation service providers and aircraft operators to reduce flight times and delays, and ensure greater safety in all weather conditions.

Going forward, the FAA will support NASA's AOSP and Advanced Air Vehicles Program with the Hi-Rate Composite Aircraft Manufacturing project. The work aims to develop mature, affordable, thermoset and thermoplastic manufacturing and assembly technologies with reduced equipment and tooling costs. This would create a faster, more cost-effective production cycle for lightweight airframe structures. Researchers will also develop model-based engineering tools needed to rapidly mature and enhance component design and manufacturing processes.

The agencies will also collaborate on electric propulsion research, expand NASA's role in FAA aviation research and test cases for advanced air mobility, and develop a digital twin of the National Airspace System that models the real-life system.

International Partnerships

The FAA collaborates with international partners to support global harmonization efforts and ensure the United States remains a world leader in influencing and driving international aviation standards. The FAA engages with multiple partners through international agreements and CRADAs.

Over the next five years, the United States will continue to collaborate with other nations and international partners on several initiatives, including reducing aviation greenhouse gas emissions through voluntary, regulatory, and market-based options for aircraft, fuels, and the aviation system. In addition, the United States will begin to implement the International Civil Aviation Organization's carbon dioxide emission standards for new aircraft, which were developed collaboratively with the Environmental Protection Agency and the FAA.

Key International Research Partners

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

Industry Partnerships

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

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 REDAC was established under the Aviation Safety Research Act of 1988 (Public Law 100-591), and its responsibilities were later expanded under the FAA Research, Engineering, and Development Authorization Act of 1990 (Public Law 101-508).

Composed of experts from aviation, aerospace, and related emerging technology-focused corporations, universities, associations, consumers, and government agencies, this group provides advice and recommendations to the FAA Administrator on the needs, objectives, plans, approaches, content, and accomplishments of the aviation research portfolio. By providing valuable feedback from customer and stakeholder groups, the REDAC ensures that FAA research activities are coordinated with other government agencies and the aviation industry.

3.3.1 REDAC Recommendations with the FAA's Response

The REDAC met in the fall of 2020 and spring of 2021 to provide advice to the FAA on the RE&D and Airport Improvement Program funded R&D portfolio. The REDAC's recommendations relate to the overall research program such as roadmaps, program plans, funding and staffing; and are intended to influence actual research activities within the overall FAA R&D portfolio.

REDAC's fall 2020/spring 2021 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 2023 Research and Development Portfolio*
- *FAA Response to REDAC Recommendations for the FY 2023 Research and Development Portfolio.*

In Summary

The REDAC provided 32 recommendations for the FAA's R&D portfolio. The FAA responded with the following:

25 – Fully concur

7 – Partially concur

0 – Non concur.

4.0 FAA R&D Funding Profile

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

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

Research, Engineering, and Development

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

Facilities and Equipment

The Facilities and Equipment (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 system architecture, and airport safety and capacity improvements.
- Various NextGen Portfolios — These programs have broad applicability across NextGen.

Airport Improvement Program

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

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

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

4.2 R&D Summary Budget Table

Budgetary Accounts

Table 1, “Planned R&D Budget by Account,” shows FY 2022 Enacted, FY 2023 President’s Budget Request, and planned funding for FY 2024 through 2027. It also highlights the R&D contract and personnel costs for FY 2023.

Table 1: Planned R&D Budget by Account

Program	Account	2022 Enacted	2023 President's Budget	*2023 Contract Costs ($000)*	*2023 Personnel Costs ($000)*	*2023 Other In-house Costs ($000)*	2024 Estimate ($000)	2025 Estimate ($000)	2026 Estimate ($000)	2027 Estimate ($000) /1
Fire Research and Safety	RE&D	7,136	7,367	*2,627*	*4,634*	*106*	7,525	7,867	8,024	8,417
Propulsion and Fuel Systems	RE&D	3,000	5,471	*3,150*	*2,266*	*55*	6,147	6,371	6,647	6,921
Advanced Materials/Structural Safety	RE&D	14,720	2,886	*1,767*	*1,057*	*62*	2,449	3,886	3,449	4,966
Aircraft Icing	RE&D	2,472	3,353	*2,147*	*1,162*	*44*	3,808	3,853	4,308	4,352
Digital System Safety	RE&D	3,689	5,287	*3,439*	*1,807*	*41*	6,811	5,787	7,311	6,327
Continued Airworthiness	RE&D	8,829	12,430	*8,668*	*3,656*	*106*	8,140	12,930	8,640	13,470
Flight Deck/Maintenance/System Integration Human Factors	RE&D	14,301	15,292	*9,792*	*5,405*	*95*	14,944	15,792	15,444	16,332
System Safety Management/Terminal Area Safety	RE&D	7,000	10,111	*7,286*	*2,740*	*85*	8,975	10,611	9,476	11,151
Air Traffic Control/Technical Operations Human Factors	RE&D	5,911	5,911	*2,148*	*3,647*	*116*	6,361	6,411	6,861	6,951
Aeromedical Research	RE&D	11,000	10,000	*4,950*	*4,870*	*180*	12,121	10,500	12,622	11,040
Weather Program	RE&D	13,786	16,178	*15,023*	*1,107*	*48*	15,237	16,678	15,736	17,219
Unmanned Aircraft Systems Research	RE&D	22,077	14,935	*13,137*	*1,638*	*160*	19,854	15,435	20,354	15,976
Emerging Technology Accelerator (ETA)	RE&D	-	10,000	*9,735*	*265*	-	10,500	11,200	11,000	11,740
Alternative Fuels for General Aviation	RE&D	5,434	12,385	*12,385*	-	-	14,670	12,885	15,170	13,426
Commercial Space Transportation Safety	RE&D	5,708	5,708	*5,708*	-	-	6,157	6,208	6,657	6,748
Wake Turbulence	RE&D	3,728	3,728	*2,777*	*851*	*100*	4,678	4,228	5,178	4,769
NextGen - Air Ground Integration Human Factors	RE&D	3,000	-	-	-	-	-	-	-	-
NextGen - Weather Technology in the Cockpit	RE&D	2,659	3,028	*1,776*	*1,231*	*21*	3,978	3,528	4,478	4,068
NextGen - Flight Data Exchange	RE&D	1,000	-	-	-	-	-	-	-	-
Information/Cyber Security	RE&D	4,769	5,500	*5,425*	-	*75*	6,413	7,500	6,913	8,050
Environment and Energy	RE&D	22,000	21,163	*18,171*	*2,877*	*115*	21,285	22,163	21,785	22,703
NextGen - Environmental Research - Aircraft Technologies and Fuels	RE&D	67,500	73,976	*71,863*	*2,101*	*12*	74,425	74,976	74,925	75,516
System Planning and Resource Management	RE&D	3,300	4,141	*2,394*	*1,699*	*48*	5,091	5,141	5,591	5,685
Aviation Workforce Development - Section 625	RE&D	10,000	6,169	*5,494*	*675*	-	2,000	2,569	2,500	3,109
William J. Hughes Technical Center Laboratory Facilities	RE&D	5,481	5,481	*2,741*	*2,694*	*46*	5,431	6,481	5,931	7,064
RE&D TOTAL	**RE&D**	**248,500**	**260,500**	***212,603***	***46,382***	***1,515***	**267,000**	**273,000**	**279,000**	**286,000**

Notes:

/1 The funding levels listed for years 2024 to 2027 are estimates and subject to change.

4.0 FAA R&D Funding Profile

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

Program	Account	2022 Enacted	2023 President's Budget	*2023 Contract Costs ($000)*	*2023 Personnel Costs ($000)*	*2023 Other In-house Costs ($000)*	2024 Estimate ($000)	2025 Estimate ($000)	2026 Estimate ($000)	2027 Estimate ($000) /1
										/2
Advanced Technology Development and Prototyping	F&E	24,000	25,300	*25,300*	-	-	32,000	34,090	33,510	43,610
William J. Hughes Technical Center Laboratory Sustainment	F&E	16,900	16,900	*16,900*	-	-	16,900	16,900	16,900	16,900
William J. Hughes Technical Center Infrastructure Sustainment	F&E	10,701	15,000	*15,000*	-	-	10,000	10,000	10,000	10,000
NextGen - Separation Management Portfolio	F&E	20,500	18,000	*18,000*	-	-	17,000	17,000	20,000	20,000
NextGen - Traffic Flow Management Portfolio	F&E	13,000	21,000	*21,000*	-	-	10,000	11,000	14,000	14,000
NextGen - On Demand NAS Portfolio	F&E	9,000	8,500	*8,500*	-	-	9,500	10,500	15,000	16,000
NextGen - NAS Infrastructure Portfolio	F&E	10,500	25,500	*25,500*	-	-	16,400	18,500	21,000	22,000
NextGen Support Portfolio	F&E	5,000	5,000	*5,000*	-	-	8,000	8,000	8,000	8,000
NextGen - Unmanned Aircraft Systems (UAS)	F&E	15,500	15,000	*15,000*	-	-	27,000	24,000	31,000	18,000
NextGen - Enterprise, Concept Development, Human Factors, & Demonstrations Portfolio	F&E	10,600	11,000	*11,000*	-	-	11,000	11,500	12,000	12,000
Center for Advanced Aviation System Development (CAASD)	F&E	57,000	57,000	*57,000*	-	-	57,000	57,000	57,000	57,000
F&E TOTAL	**F&E**	**192,701**	**218,200**	***218,200***	**-**	**-**	**214,800**	**218,490**	**238,410**	**237,510**
Airport Cooperative Research		15,000	15,000	*15,000*	-	-	15,000	15,000	15,000	15,000
Airport Technology Research		40,961	40,828	*40,828*	-	-	40,960	40,960	40,960	40,960
AIP TOTAL	**AIP**	**55,961**	**55,828**	***55,828***	**-**	**-**	**55,960**	**55,960**	**55,960**	**55,960**
GRAND TOTAL		**$497,162**	**$534,528**	***$486,631***	***$46,382***	***$1,515***	**$537,760**	**$547,450**	**$573,370**	**$579,470**

Notes:

/1 The funding levels listed for years 2024 to 2027 are estimates and subject to change.

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