2023 Research and Development Annual Review

U.S. Department of Transportation
Federal Aviation Administration

Contents

2023 Annual Review

June 2024

The Research and Development Annual Review is a companion document to the National Aviation Research Plan, a report of the Federal Aviation Administration to the United States Congress pursuant to section 44501(c)(3) of title 49 of the U.S. Code. This document is available online at *faa.gov/go/narp*.

Foreword

The FAA continues to provide the safest and most efficient aerospace system in the world, while building a foundation for the future with an approach that focuses on safety, accessibility, and sustainability. However, significant challenges persist during these times of innovation; as new forms of air transportation are continually developed, aviation impacts the global environment. These opportunities and challenges require continued progress on important issues, including combating climate change, protecting the environment, and advancing the agency's safety mission.

The FAA's research and development supports National Airspace System (NAS) evolution by enabling technological, policy, and procedural advancements with a focus on safety and environmental responsibility.

The Annual Review highlights the accomplishments of the research completed during the prior fiscal year, including a description of research results disseminated to the private sector and a description of new technologies developed by the agency. The Annual Review is the companion document to the FAA's National Aviation Research Plan, which describes planned research activities over the next five years.

In FY 2023, the FAA conducted research on a variety of areas which collectively support and drive innovation, including reducing noise, emissions, and other environmental topics which advance aviation in a responsible and energy-efficient manner; using informed decision-making and data-driven approaches to prioritize safety and public health; and preparing transportation systems for the next generation by making them more adaptable, sustainable, resilient, and equitable.

Performance Results

Overview

The FAA uses research and development (R&D) to support its multiple regulatory and operational mission areas, including National Airspace System (NAS) modernization, policymaking, regulation, certification, and standards development. The FAA R&D portfolio supports day-to-day operations in the NAS and balances near-, mid-, and long-term aviation needs.

The FAA's R&D goals focus on researching and identifying solutions for:

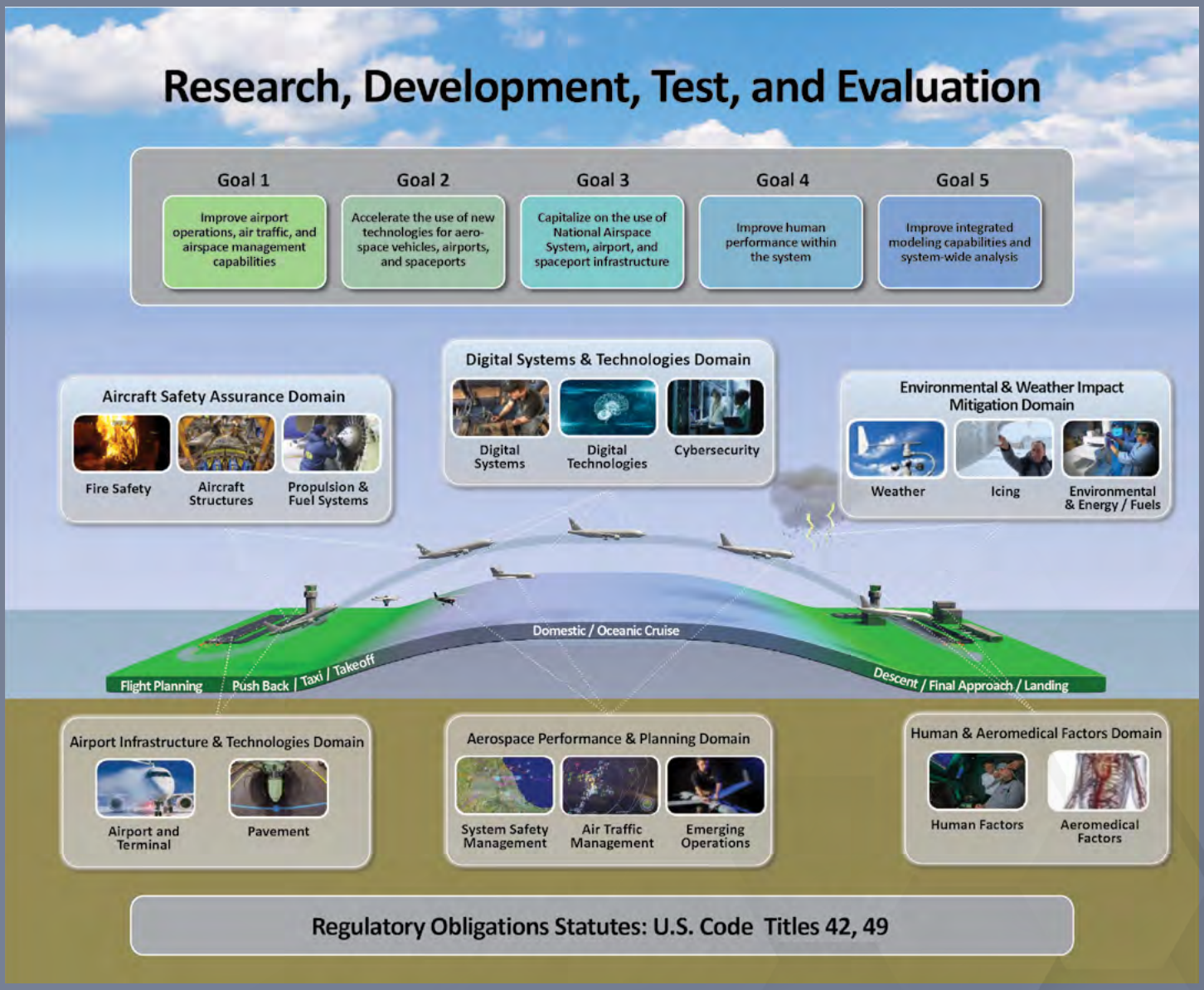
- **Improving operations and management capabilities**
- **Accelerating the use of new technologies**
- **Capitalizing on infrastructure use**
- **Improving human performance**
- **Improving integrated modeling and system-wide analysis**

FAA R&D goals address aviation 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 FAA's R&D activities span multiple research domains which are a grouping of programs with a common focus area or body of knowledge.

The FAA's R&D research domains are:

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

The following sections provide in-depth descriptions of the R&D goals, highlight FY 2023 research accomplishments, feature research results disseminated to the private sector, and offer an overview of new technologies developed by the FAA.



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

Goal 1:

Improve airport operations, air traffic, and air space management capabilities

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

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

Goal 1 Research Activities Completed

Weather for Forecast Improvements Research Activity

Domain	Activity Name	Results	FY 2024–2028 NARP Location
NextGen - NAS Infrastructure Portfolio	Achieve investment analysis readiness decision	Formalized investment analysis readiness decision for the Terminal Precipitation on the Glass project	Page 19

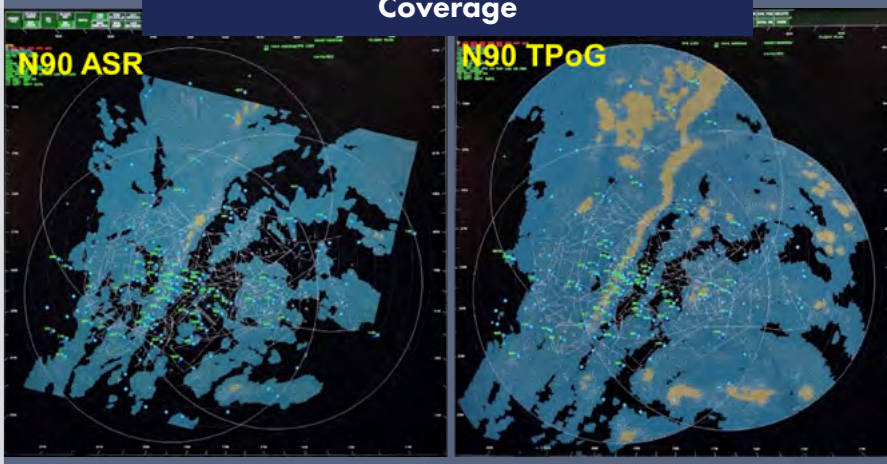
Goal 1 Success Stories

Improved Precipitation Information for Air Traffic Control

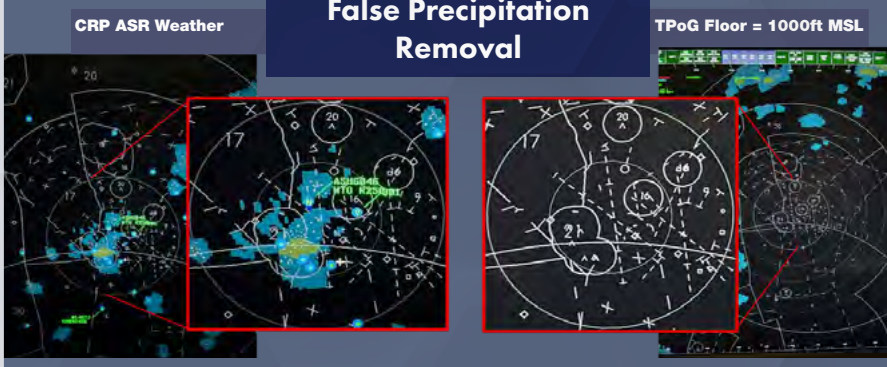
Air traffic controllers at Terminal Radar Approach Control Facilities (TRACON) do not have consistent access to accurate, reliable, and timely weather information. Poor precipitation depiction from airport surveillance radars hinders the controller from issuing accurate weather advisories in the terminal environment, efficiently maneuvering traffic around weather, and effectively anticipating changes to traffic patterns and separation strategies.

The FAA's Terminal Precipitation on the Glass (TPOG) software application will deliver improved weather radar coverage to potentially all 137 FAA Standard Terminal Area Replacement System (STARS) precipitation displays at TRACONs across the country. STARS is a digital automation system controllers use to track aircraft and view weather. The TPOG program achieved a final investment decision in October of 2023.

Improved Accuracy & Coverage



False Precipitation Removal



FAA Partners on UAS Field Testing

In collaboration with NASA and the aviation industry, the FAA established the UAS Traffic Management (UTM) Field Test project to validate standards and evaluate interoperability among UTM participants. The FAA conducted small UAS flight testing in collaboration with Virginia Tech's Mid-Atlantic Aviation Partnership, the Lone Star UAS Center of Excellence and Innovation at Texas A&M in Corpus Christi, and Griffiss International Airport in Rome, NY. Researchers tested several use cases in April 2023, including drone delivery of emergency medical supplies to a hospital while other drones yielded to the simulated life-saving flight, investigating an errant drone near a parade, and responding to other UAS incidents.

UTM allows drones to fly without air traffic control and is separate from but complementary to the current FAA air traffic management system, which enables drones to safely fly up to 400 feet above ground level. Operators must exchange information with each other on flight intent and airspace constraints to stay deconflicted. The goal of the UTM Field Test is to help increase airspace access as business cases require drones to fly within and outside of the operator's line of sight. The project demonstrated how new technologies can support drone operations in a realistic environment.

Map interfaces allowed attendees to observe each operator's perspective of where nearby drones intended to fly, including how operators were alerted when a drone strayed from its intended flight path. Industry plans to supply information services or third-party services for deconfliction with what are known as UAS service suppliers. These suppliers would fall under FAA regulatory authority.

Flights during the UTM Field Test project presented diverse missions in complex environments, including operations over people and at night. With flight testing completed, the FAA plans to publish findings that will help the agency with policy development and provide the UAS industry with updated standards to support routine beyond visual line-of-sight operations.

A map interface offers the operator's perspective of a drone flight during a showcase event of the UTM Field Test project.

During a flight for the UTM Field Test project in March 2023, a UAS service supplier sends flight data to the operator to warn when other drones fly outside of their designated space, or if a priority flight requires them to land or alter their flight path to make way.

Modifying Lighting Systems to Enhance Safe Landings

The FAA has extensive expertise in modifying lighting systems to help pilots land their planes safely. These systems are called Visual Glide Slope Indicators, including precision approach path indicator (PAPI) systems and visual approach slope indicator (VASI) systems. These lighting systems are located near runways and help pilots see if their plane is landing at the right angle, which is critical to ensure a safe landing.

If the plane lands too high or too low, it can result in a hard landing, damaging the aircraft and causing injuries to passengers and crew. Pilots use these lighting systems to adjust their altitude and ensure a smooth landing.

The FAA modified a VASI and a newer FAA-designed LED PAPI system at DeKalb Peachtree Airport in Georgia and Huntingburg Regional Airport in Indiana.

Custom internal metal shields called “baffles” reduce the angular coverage of the system’s lights to satisfy the FAA’s required landing approach criteria. These systems could not be commissioned for operation in the NAS without baffles installed.

Airport Pavement Expertise Highlighted

In June 2023, FAA airport pavement design and evaluation experts attended the International Airfield and Highway Pavement Conference in Austin, TX. Hosted by The American Society of Civil Engineers' Transportation & Development Institute, the conference gathered stakeholders from the Federal Highway Administration, the Texas Department of Transportation, academia, and others.

The FAA highlighted its Rigid and Flexible Iterative Elastic Layered Design (FAARFIELD 2.0), the agency's software used for airport pavement thickness design, evaluation, and pavement strength reporting. The tool uses the Aircraft Classification Rating - Pavement Classification Rating (ACR-PCR) method of measurement.

ACR-PCR is used to report airport runway, taxiway, and apron pavement strength. The International Civil Aviation Organization (ICAO) method has been adopted as the global standard for reporting pavement strength. Pavement strength is key to keeping the over 64,000 airports worldwide open and operational.

The workshop highlighted the FAA's role as a global leader in aviation safety and efficiency. Thirty-eight individuals from six countries attended the event, including consulting engineers, representatives of government and military organizations, and academia.

Microscale Weather Modeling for UAS/AAM Operations

The FAA issued a final report on microscale urban/suburban weather modeling for unmanned aircraft systems (UAS) and advanced air mobility (AAM) operations in fiscal year 2023. The work further illustrates the value of fast-time, microscale weather modeling as UAS/AAM operations expand. Applied to the city of Winston-Salem, NC, the model was executed for several targeted experiments to demonstrate value in identifying urban/suburban microscale weather risks for potential UAS/AAM operational services and applications.

Insights were gathered from identifying weather risks for varied time of day and wind direction, but also through new advanced modeling applications and development /refinement of risk identification. This work improved the understanding of the complexities and challenges of urban/suburban microscale weather for UAS/AAM operations and offered solutions for managing and mitigating associated aviation weather risks.

FAA's Weather Training Assists the U.S. Coast Guard

The U.S. Coast Guard (USCG) in Mobile, AL used multiple FAA weather program safety forum presentations, white papers, and training research products to develop a severe weather training program for the USCG aviation community. The training materials provided by the FAA addressed numerous topics and issues that the USCG needed to enhance weather safety.

The Chief of the Fixed Wing Fleet Training, USCG Aviation Training Center, sent a letter thanking the agency for assistance in developing the weather training and stated that the training will be cleared for use in the near future. One beneficial example cited by the USCG was a list of products to use five to six days in advance to be better prepared for spontaneous flights where time to study the current weather is limited.

Goal 2:

Accelerate the use of new technologies for aerospace vehicles, airports, and spaceports

The advancement and introduction of technologies from non-traditional aviation industries are reaching all corners of the NAS. Research under this goal supports applied innovation that identifies and demonstrates new aerospace vehicle, airport, and spaceport technologies; the certifying and licensing of aerospace operators and vehicles; and the study of alternative fuels for general and civil aviation, providing decision makers with essential data and analysis to shape the future of the NAS.

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

Goal 2 Research Activities Completed

Complex Digital Systems Research Activity

Domain	Activity Name	Results	FY 2024–2028 NARP Location
Digital System Safety	Develop a safety verification framework to evaluate learning-based aviation systems	Information and recommendations on using a safety verification framework to ensure airborne learning systems are safe	Page 31

Effects of Different Platform Materials on Rotorcraft Testing Research Activity

Domain	Activity Name	Results	FY 2024–2028 NARP Location
Continued Airworthiness	Analyze National Transportation Safety Board data to determine common fuel system characteristics present in accidents with post-crash fires	Data to design a test fuel system that is representative of those typically involved in aircraft experiencing post-crash fires	Page 20

Unmanned Aircraft Systems Detection and Mitigations at Airports

Domain	Activity Name	Results	FY 2024–2028 NARP Location
Aerospace Performance and Planning	Complete test and evaluation of UAS detection and mitigation technologies	Develop a plan to certify and authorize the deployment of counter-UAS technologies in the airport environment	Page 35

Goal 2 Success Stories

UAS Detection and Mitigation Testing 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 to 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, was directed by Congress in the FAA Reauthorization Act of 2018, section 383.

During the five-year program, which sunset on September 30, 2023, the FAA successfully evaluated 18 vendors/systems that featured 30 different drone detection and mitigation technologies at the Atlantic City International Airport in New Jersey. Of those 18 vendors/systems, 10 vendors successfully graduated from Atlantic City and were then installed at one of four other host airports for continued validation testing. The four host airports included Syracuse Hancock International Airport in New York, Rickenbacker International Airport in Ohio, Huntsville International Airport in Alabama, and Seattle-Tacoma International Airport in Washington.

Researchers conducted a total of 14,772 UAS flights at the five airports against a variety of technologies to determine true operational capabilities in detecting and/or mitigating UAS. A fleet of 42 different UAS, featuring models of different size, color, material, and transmission frequency, were flown in different flight patterns at various distances from the airport to document the technologies' ability to detect and/or mitigate the UAS. Data captured from the UAS will be compared to data from the detection/mitigation technology and used to determine key operational parameters for the research effort.

Research results will lead to the implementation of new technologies to make airports safer for passengers and traditional, crewed aircraft. Results from this testing and evaluation will also be used to support other section 383 requirements, including the aviation rulemaking committee and the plan for certifying, permitting, or authorizing UAS detection and mitigation technologies at airports around the country.

Aviation Fire Survivability Testing

Over the last 50 years, the likelihood of death by fire in a survivable aviation accident has dropped by more than 50 percent. The FAA is working to eliminate all aircraft fire hazards, whether from cabin components (seat cushions, wiring, and storage bins) or post-crash impacts.

Research is being conducted across five program areas: cargo fire safety, hazardous materials fire safety, propulsion power and fuels fire safety, materials flammability and cabin safety, and advanced fire research. The research aims to improve passenger safety by making the aircraft more resistant to fire and developing detection systems to suppress or extinguish a cabin fire, allowing for an aircraft's safe landing.

Since aviation fire safety is a global issue, the FAA and several international airworthiness authorities, including Transport Canada Civil Aviation, the United Kingdom Civil Aviation Authority, European Union Aviation Safety Agency, Brazil's National Civil Aviation Agency, Australia's Civil Aviation Safety Authority, and the Civil Aviation Authority of Singapore, have partnered on research to advance safety through the Fire and Cabin Safety Research Group. The agency has also developed a *Fire Safety website* as a hub for aircraft fire safety knowledge, containing decades of laboratory research and updated with the most recent findings.

Thermal runaway consumes an entire cargo pallet of lithium batteries in minutes.

The FAA uses actual aircraft fuselages and cargo compartments to test and evaluate causes of aviation fires and the latest means of suppression and prevention.

An FAA fire safety technician exposes aircraft materials to an open flame.

A compliant drone is flown toward an FAA-owned Boeing 727 airframe located on the FAA ramp at Atlantic City International Airport to simulate an inspection during a demonstration of Remote ID.

A compliant drone inspects the FAA's Boeing 727 while broadcasting remote ID messages during a demonstration of Remote ID at the William J. Hughes Technical Center.

UAS Detection Proof-of-Concept

Remote ID, the formal name for a UAS or drone's digital "license plate," is part of the FAA's effort to integrate drones into the National Airspace System (NAS) safely and securely.

The FAA demonstrated Remote ID and UAS Detection Link (RIDDL), a proof-of-concept project, at Atlantic City International Airport in October 2022. Current UAS detection systems detect and track unmanned aircraft using radio frequency, radar, and electro-optical/infrared sensors. RIDDL is a new technology to identify UAS and supplement UAS detection data using prototype data correlation services.

The Remote ID digital license plate transmits information such as aircraft type and owner, location, and performance, to people on the ground and other airspace users. The FAA, law enforcement, and other federal agencies can use Remote ID to help find the ground control station when a drone is flying unsafely or in restricted airspace. Public safety agencies may also request the identity of the drone's owner from the FAA. Data correlation services help authorized entities submit queries to the FAA using a drone's serial ID or location and receive a response with registration and airspace authorizations in near-real-time. By March 2024, most drones will need Remote ID to legally fly in the NAS. As UAS operations grow across the United States, RIDDL technology can enable routine operations in complex locations and environments.

A National Air Traffic Controllers Association (NATCA) representative observes an unmanned aircraft flight track from the remote ID broadcast during a technology demonstration at the William J. Hughes Technical Center.

Reducing the Risk of Bird Strikes

Bird and other wildlife strikes to aircraft cause an estimated $900+ million in damage to U.S. civil and military aircraft annually. A new technology that uses ultraviolet LED landing lights to reduce the risk of bird strikes on rotorcraft and general aviation aircraft has been gaining traction in aviation and business communities. An FAA presentation on the technology at the Southern New Jersey Professional Societies in April 2023 and an article published in the FAA Focus in July 2023 led to even more interest in the technology.

FAA researchers met with Lite Enterprise, the company that developed the ultraviolet LED light, and Air Tractor, an aircraft manufacturing company in Texas. Air Tractor is interested in installing the UV LED light on their AT-802A aircraft and is willing to support research and data collection on the UV LED. Given its product line of agricultural, firefighting, and utility general aviation aircraft, Air Tractor has an interest in improving bird mitigation safety for pilots.

While more research needs to be done, this new collaboration could help the attainment of a certificate to allow this UV light to be installed in general aviation aircraft and helicopters. Ultimately, this program is an example of research-to-reality where FAA safety research led to the development of a relatively low-cost UV LED that can mitigate the risk of bird strikes, improving pilot safety.

Unleaded Aviation Fuel Testing

Aviation gasoline (avgas) is the only remaining transportation fuel in the United States that contains lead. 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 FY 2023, an FAA program tested five different unleaded fuel candidates for their detonation characteristics. The fuels were formulated to different specifications targeting the fuel specification ASTM D-910 and the fuel provider team's draft ASTM specification. ASTM is a standards organization that sets fuel specification standards to define the performance property requirements for aviation fuels. The testing compared limited detonation characteristics of the fuels, and based on the data, the fuel provider decided to update their current ASTM fuel specification and create a second specification for a fuel with different anti-detonation additive boundaries.

The FAA will use this test data along with other test results to verify if the fuel meets the requirements for entry into the full-scale Piston Engine Aviation Fuels Initiative (PAFI) test program, which supports the evaluation of candidate unleaded fuels to replace approved leaded gasoline, with the objective to qualify a fleet-wide solution.

LOX/Methane Rocket Testing

The FAA's LOX/methane test series is a program that evaluates the safety of rockets that use liquid oxygen (LOX) and methane as propellants. The program involves testing the rockets and gathering information to support public safety decisions about the launch of these rockets. In May, August, and September 2023, the agency conducted three successful tests to measure the explosive yield of LOX/methane using a ground sensor network.

LOX and methane are used as rocket propellants for several reasons. Methane is a simpler and cheaper fuel to produce than other rocket fuels, such as kerosene and hydrogen. Methane is also environmentally friendly and produces less residue buildup than other fuels. Additionally, it can be produced on other celestial bodies, which makes it a good option for future space exploration missions. Finally, methane also allows rocket engines to run at higher pressures, which can lead to more efficient performance.

The tests included a 150-foot drop tower to drop test articles filled with LOX and liquid methane to impact and explode (as a rocket filled with these propellants would). It also included a network of dozens of embedded sensors (such as pressure probes, calorimeters, and microphones) to measure the explosive yield and other parameters of the resulting LOX/methane explosion. All support equipment to enable the operation of the test site, such as power supplies, fiber optic cables, and large storage tanks of liquid oxygen and methane, were integrated with the drop tower and sensor network and tested.

These explosive tests were the first large scale system-level tests of LOX/methane propellant in a scenario when a launch vehicle loses thrust early in flight and impacts the ground — mirroring an aircraft or spacecraft explosion.

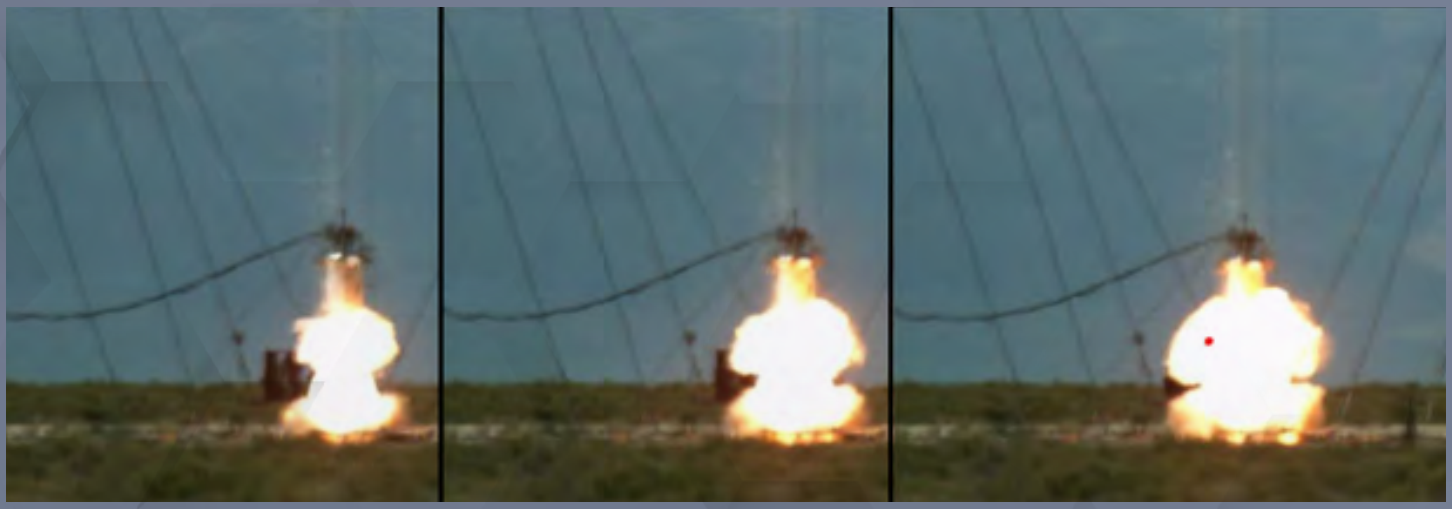
Data collected from the testing will be used to support public safety decisions about launches of LOX/methane rockets. It will also be used in planning and executing upcoming FAA LOX/methane explosive tests. Finally, NASA and the Department of Defense will use important lessons learned from these tests for their own future LOX/methane testing plans.

A LOX/methane test article (sized for a 2000 lb. load of propellants) undergoes tests at contractor facility. It was successfully used in the inert drop test for risk reduction after being filled with cryogenic liquid nitrogen.

The 150-foot drop tower at US Army Dugway Proving Ground, Utah was designed and deployed in support of FAA LOX/methane explosive testing. Test articles containing varying amounts of LOX and liquid methane propellants are raised and then dropped to an impact zone from the center of the tower.

A test article is prepared with instrumentation prior to being remotely loaded with LOX and liquid methane propellants for the first explosive drop test on August 18, 2023.

A drop tower camera image of the LOX/methane explosion during testing on September 15, 2023.



A high-speed camera captures the LOX/methane explosion in the test article after impact and ignition during the August 18, 2023 drop test.

Investigating sUAS Mid-Air Collisions

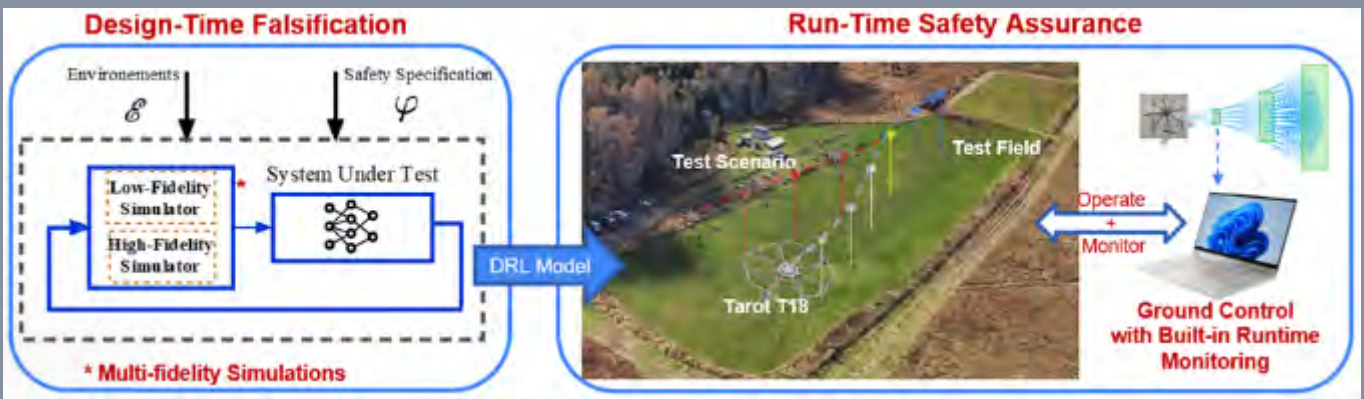
In June 2023, the FAA conducted the final phase of research intended to provide high-fidelity data from the actual ingestion of a DJI Phantom 3 small unmanned aircraft systems (sUAS) into a CFM International CFM56-7B turbofan engine. As sUAS become more common in the NAS, research to understand the potential severity of sUAS mid-air collisions with aircraft must be conducted so that conclusions and recommendations can be made. Results of FAA sUAS research are being adopted, utilized, and referenced in several standards and policy documents.

The Joint Authorities for Rule Making on Unmanned Systems (JARUS) quantitative methods group is integrating the research task's findings into a draft appendix to the JARUS Specific Operations Risk Assessment.

The FAA team managed a successful UAS - High-Bypass Turbofan Engine Ingestion Test. Despite the resulting condition of the equipment from this testing, the results are highly informative to the Safety strategic goal and additional research efforts that aim to support safety standards rule makers.

Safety Verification Framework to Evaluate Learning-Based Aviation Systems

The FAA developed a testing procedure for certifying learning-based functions in safety-critical aviation systems. The procedure is built upon a unique framework that incorporates simulators of varying fidelity levels to expedite the optimization of the target certification objective and to maximize the extraction of safety-critical information per simulation.



The test flights demonstrate the safe operation of the drone, deployed with the DRL Model verified in design time (left of the figure), under the scenario of a multi-drone intersection operation. The runtime safety of the operation is assured and displayed through the trajectory prediction capable runtime monitoring system that is built into the ground control station.

Agency Hosts International Aircraft Fire and Cabin Safety Research Conference

The FAA hosted the International Aircraft Fire and Cabin Safety Research Conference in Atlantic City, New Jersey, collaborating with nine international aviation authorities to coordinate the conference. Held in October 2022, the conference shares knowledge with the international aviation community about research activities in the transport category of airplane fire and cabin safety.

The conference theme "Going Green – The Effect on Aircraft Cabin and Fire Safety," included presentations by the United States Environmental Protection Agency, NASA, Boeing, and Universal Hydrogen. Other topics were cabin safety, crash dynamics (including occupant injury and large-scale crash data), cabin and flight deck fire prevention, cargo hazards/risks/mitigations, cargo compartment fire protection, power plant and propulsion fire protection, and fire research (including modeling and advanced materials).

More than 600 participants attended, including international aviation authorities, government agencies, airlines, airframe manufacturers, universities, aircraft engine and interior manufacturers, fire extinguishing agent manufacturers, and fire research and test laboratories. Conference proceedings are available on the Fire Safety website at ***https://www.fire.tc.faa.gov/2022Conference/conference.asp.***

UEDDAM Training

The FAA oversaw the creation of a training package for the Uncontained Engine Debris Damage Assessment Model (UEDDAM), delivered under an Interagency Agreement with the Naval Air Warfare Center.

UEDDAM is a software analysis package used to evaluate and minimize commercial aircraft vulnerability from uncontained fragments in the event of a turbine engine failure. Fragments released when fan blades and other high-speed rotating engine components break apart can seriously threaten aircraft safety, one such accident resulting in a passenger fatality.

The training is a collection of videos, exercises, and reference material delivered to users with UEDDAM version 6. It demonstrates how to apply a UEDDAM analysis to mitigate hazards from an uncontained engine failure following a methodology aligned with FAA certification requirements.

Previous UEDDAM training sessions have been in-person or virtual, necessitating a scheduled class with an instructor and enough attendees. The new training package provides a stand-alone approach, allowing users to access the material on demand at their convenience.

Electric Propulsion Certification Standards

FAA researchers collaborated with multiple manufacturers to determine the key characteristics of a propeller test stand to evaluate electric engines for electric vertical takeoff and landing (eVTOL) aircraft.

Based on the collaborations, the key requirement was that the stand be capable of rotating the test article between vertical lift and cruise orientations to replicate how the eVTOLs will perform in the real world.

After multiple rounds of design, the team constructed the propeller test stand with the assistance of the FAA's William J. Hughes Technical Center's machine shop. In February 2023, the test stand was commissioned utilizing an electric engine provided by an industry partner.

Starting in FY 2024, the new test capability will address the durability, endurance, and reliability of eVTOL electric engines, improving the FAA's certification readiness as eVTOLs become common in the coming years.

Goal 3:

Capitalize on the use of NAS, airport, and spaceport infrastructure

A durable, long-life, and resilient infrastructure forms the backbone of an efficient, safe, and secure NAS. Research under 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 internal and external threats due to rapid advances and sophistication of cyber attacks.

The resulting analysis will lead to a longer-lasting, lower-cost, dependable infrastructure defended against cyber events.

Goal 3 Research Activities Completed

Domain	Activity Name	Results	FY 2024–2028 NARP Location
No activities highlighted in the FY 2024-2028 NARP were completed in FY 2023			

Goal 3 Success Stories

Airports Combat Human Trafficking

Human trafficking is a critical public concern, with tens of millions of global victims who are moved across international borders and between states using various forms of transportation, including buses, trains, and airplanes. Traffickers may be transporting victims through airports, or victims may be traveling of their own accord, unaware that the job opportunity at the end of their journey is not legitimate.

The Transportation Research Board (TRB) Airport Cooperative Research Program's ***ACRP Research Report 249: Developing an Airport Program to Address Human Trafficking: A Guide*** provides a comprehensive yet scalable process to help airports identify and respond to possible human trafficking activity at their facilities.

This product was cited at the conference of the DOJ's Office of Justice Programs as a quality guide for airports to use in creating and standardizing anti-trafficking programs in airports as part of the Whole-of-Government approach to combating human trafficking.

Supplemental to the report are ***Appendices*** and a ***Toolkit*** that offer a series of resources and references that airports can use to develop a tailored program.

Supply Chain AI/ML Proof-of-Concept

The FAA Cybersecurity Data Science (CSDS) research program conducted a remote proof-of-concept demonstration for industry stakeholders on supply chain cybersecurity concerns in July 2023. Research partner Lincoln Laboratory, located in Lexington, MA, hosted the demo for several Cybersecurity Commercial Aviation Team (CS CAT) members, including Boeing, NetJets, and Astronautics.

The demonstration focused on reducing the typical human level of effort required to analyze thousands of commercial software parts identified in Software Bills of Material (SBOMs) to determine potential impacts from known cybersecurity vulnerabilities. The demonstration showed that CSDS concepts utilizing artificial intelligence and machine learning (AI/ML) dramatically reduced analysis time through automation and enabled an enhanced risk assessment through the addition of exploitability analysis.

Industry communicated strong interest in the concepts and requested a direct evaluation of the CSDS program prototype software. Additional stakeholder feedback will be gathered before the FAA provides final written findings or guidance for potential industry implementation of the CSDS and AI/ML concepts. Results may also be used by industry to revise relevant industry standards.

FAA Addresses Cybersecurity Concerns

The FAA is collaborating with multiple industry stakeholders on a range of cybersecurity concerns to identify major challenges. Cybersecurity Data Science (CSDS) research experiments provide useful guidance to enhance industry cybersecurity through evolving CSDS and artificial intelligence/machine learning (AI/ML) technologies.

One significant stakeholder, the Port Authority of New York/New Jersey (PANY/NJ), has identified initial operational challenges that could impact the aviation ecosystem if cyberattacks occurred and has partnered with the FAA to perform research into new AI/ML methodologies to resolve these issues.

Program success during this fiscal year included the successful completion of the use case and prototype capability concept phase. With the strong support of the stakeholder, the research is now moving into the experimentation phase to evaluate potential capabilities that might address use case challenges.

Goal 4:

Improve human performance within the system

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 routine and emergency events.

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

Goal 4 Research Activities Completed

Domain	Activity Name	Results	FY 2024–2028 NARP Location
No activities highlighted in the FY 2024-2028 NARP were completed in FY 2023			

Goal 4 Success Stories

EPS Testing in an Upgraded Lab

In FY 2022, the FAA completed a laboratory upgrade at the William J. Hughes Technical Center in Atlantic City, N.J. The laboratory will research electric propulsion systems (EPS) for airplanes — an emerging technology that will revolutionize flight in the coming decades and reduce both aviation's carbon footprint and operating costs. The safety research completed at the upgraded laboratory will be shared with the aviation industry —while at the same time helping the FAA to build EPS policy. Research includes altitude, temperature, and humidity testing — environmental factors that must be examined to ensure EPS work safely.

Analysts predict that the transition to electric engines will begin with smaller planes in this decade and next, with wide-body commercial jets flying electric by the mid-2040s. Today, companies are exploring and developing new concepts that will enable planes to fly without combustion engines. The issue is that current FAA rules, guidance, and policies for aircraft propulsion systems are focused on combustion engines. EPS react very differently than combustion engines in the way they work and in the way they might fail.

Electric engines help reduce aviation's carbon footprint, estimated to account for 2 to 3 percent of the world's annual carbon emissions. The upgraded laboratory is an important part of the FAA's effort to address sustainability and environmental issues. In addition to eliminating fuel costs for operators, electric engines could also lead to lower maintenance costs.

New Vertical Flight Simulation Laboratory

In FY 2023, the FAA opened the new Vertical Flight Aviation Simulation Technologies (VFAST) Laboratory. The laboratory began operations during the Air Traffic Control Association (ATCA) Tech Center Tuesday event in April 2023.

This was the first of many milestones for the laboratory, which played host to over 25 tours, qualification assessments from FAA's Flight Standards service, and a study on rotorcraft Loss of Control (LOC).

The LOC study addressed the top cause of rotorcraft fatal accidents and the key conditions that kick off loss-of-control events. This study featured three rotorcraft simulators (Airbus H125, Robinson R22, and Sikorsky S76-D) flown by 18 pilots over a three-week period.

The FAA, the Vertical Aviation Safety Team (VAST), the U.S. Helicopter Safety Team (USHST), and other industry, academia, and government partners will use the results from the study to raise awareness of the dangers of loss of control and how to mitigate its onset through various recovery techniques. In addition to the LOC study, the VFAST laboratory qualified the H125 and R22 simulators as flight simulation training devices (FSTDs). This effort is the first of its kind in the U.S. to evaluate virtual reality training devices proposed as FSTDs.

The FAA's vertical flight safety research team led the qualification efforts, bringing virtual reality knowledge to usher in the next generation of flight training devices for use by the U.S. helicopter community.

Communicable Disease in Air Travel

To assist its research on air travel disease transmission, the FAA collaborated with international partners on a 24-month research program. The program will develop an open source, validated disease transmission risk estimation tool with associated data for a narrow body, single aisle passenger transport aircraft use case. To collect data for the program, the FAA established an agreement with the National Research Council Canada (NRC) to leverage the Centre for Air Travel Research (CATR) and their relationships with Canadian airports and airlines to conduct laboratory and field data collection on the human behavioral and environmental factors contributing to disease transmission risk.

Program results will be transferred to government preparedness planners and those in the aviation industry conducting safety risk assessments as part of airline safety management systems. The working group also established an interagency agreement with Centers for Disease Control and Prevention (CDC) National Institute for Occupational Safety and Health (NIOSH) to identify an inventory of risk controls and effectiveness estimates. Additionally, the CDC Division of Global Migration and Quarantine assigned two physicians to provide pathogen and infectious dose data. Lastly, a cooperative agreement with Boeing will build off their Confident Traveler Initiative and collaboratively develop risk estimation models using the data generated by NRC, NIOSH, and the CDC.

The program's first phase will deliver a comprehensive data acquisition plan and methodology based on the risk estimation model architecture proposed by the FAA and Boeing. The second phase will execute the data acquisition plan in airports, on operational aircraft, and in CATR and provide the data to the FAA and Boeing for model development and validation.

Goal 5:

Improve integrated modeling capabilities and system-wide analysis

Using technologies such as data sharing, AI, and ML, 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 allow the NAS to deliver the highest quality service to the greatest number of stakeholders in a timely, safe, and practical manner.

Goal 5 Research Activities Completed

Domain	Activity Name	Results	FY 2024–2028 NARP Location
No activities highlighted in the FY 2024-2028 NARP were completed in FY 2023			

Goal 5 Success Stories

Better Weather Predictions Enhance Safety

The Weather Program developed a tool called Ensemble Prediction of Oceanic Convective Hazards (EPOCH) to meet an International Civil Aviation Organization (ICAO) requirement. Convective storms pose a safety threat for aviation, and this threat increases for transoceanic flights due to the much longer flight times (up to 18 hours) and lack of weather radar coverage.

The ICAO is requiring World Area Forecast Centers (WAFCs) to produce finer resolution information to enhance safety and efficiency. EPOCH takes multiple runs of multiple national and international numerical weather models and produces a 6 to 48-hour forecast of convective activity worldwide for flight planning purposes. The FAA transferred this capability to the National Weather Service in June 2023, where it was put into operation. NAS operators will benefit from EPOCH in various ways. The finer resolution output of the hazard is anticipated to enhance safety, improve route planning, and minimize deviations. Another benefit is that because the capability spans WAFCs, providers are collaborating on its implementation, which should provide a more globally consistent forecast.

Improved AEDT Models Aircraft Exhaust Gasses

The AERMOD, the American Meteorological Society/ Environmental Protection Agency (EPA) regulatory model, is the required emissions dispersion model for airport air quality analysis, and it is integrated as part of the Aviation Environmental Design Tool (AEDT). AEDT is a software system that models aircraft performance in space and time to estimate fuel consumption, emissions, noise, and air quality consequences.

Currently, AERMOD does not have the ability to account for the plume rise associated with aircraft exhaust gases. The FAA's Center of Excellence for Alternative Jet Fuels and Environment (ASCENT) developed an approach that computes the plume rise of aircraft exhaust, which is implemented in a new version of AERMOD scheduled for release in December 2023. This will improve airport air quality analyses of FAA actions.

AEDT's current greenhouse gas emissions computing and reporting capabilities need enhancements to address gaps in greenhouse gas emissions source coverage, especially for ground support equipment (GSE). The FAA initiated research using EPA's latest tools to develop the best possible data. The enhancements will not only improve AEDT's greenhouse gas emissions reporting capabilities but will also improve airport air quality analyses of FAA actions.

FY 2023 Research Agreements

The FAA research and development (R&D) portfolio is a collection of programs spanning multiple aviation-related domains. The agency's unsurpassed laboratories and expertise enable cutting-edge research, resulting in technical knowledge and products that enhance the safety, capabilities, and efficiency of the National Airspace System and benefit the American people.

In pursuit of the agency's mission, the FAA maintains partnerships with almost 400 stakeholders including other federal agencies, as well as domestic and international partners from academia and the aviation industry. This year, the agency executed 110 new agreements.

NEW AGREEMENTS – FY 2023

	New	Ongoing
Center Of Excellence Grant	95	177
Aviation Research Grant	2	50
Cooperative R&D Agreement	3	42
Inter Agency Agreement	3	25
International Agreement	0	36
Other	7	3
	110	333

Research Grants

The FAA engages with academic institutions to support its mission through two primary mechanisms: Centers of Excellence (COE) grants and aviation research grants/cooperative agreements.

Centers of Excellence

COEs enable collaboration and coordination between government, academia, and the aerospace industry to advance aviation technologies and expand FAA research capabilities. Among the unique benefits of this program are the congressionally required matching contributions, effectively doubling resources, and the opportunity for the next generation of aviation professionals to actively pursue solutions to aviation's biggest challenges. The 95 FY 2023 COE awards represented an obligation of $43.5M in matching funds to 27 different academic institutions.

2023 CENTERS OF EXCELLENCE GRANTS

CENTER OF EXCELLENCE	ACTIVE GRANTS	FY23 AWARDS (#)	FY23 AWARDS ($M)
Unmanned Aircraft Systems (UAS)	92	12	$4.25
Alternative Jet Fuels & Environment (AJFE)	110	51	$23.64
Advanced Materials (JAMS)	48	27	$14.46
Technical Training & Human Performance (TTHP)	13	1	$0.50
General Aviation (PEGASUS)	9	4	$0.55
	272	95	$43.41

Aviation Research Grants and Cooperative Agreements

Aviation research grants and cooperative agreements focus on innovative research the FAA Administrator considers key to the long-term growth of civil aviation and research focused on preventing catastrophic failures. This year the agency awarded 2 new aviation research grants to 2 academic institutions for a total of 53 ongoing projects.

2023 AVIATION RESEARCH GRANTS

ACADEMIC INSTITUTION	RESEARCH AREA	FY23 GRANT ($)
Arizona State University	Composite Material Modeling	$100,000
The Ohio State University	Human Factors Guidance for the Design, Implementation and Evaluation of AI/ML in the Human-Automation ATC Systems	$913,450
		$1,013,450

ONGOING RESEARCH TOPICS

- Effect of Supercooled Large Droplets Ice Accretion on the Aerodynamic Performance of Swept Wings
- Active Flutter Suppression
- Durability of Bonded Repairs and Damage Tolerance of Advanced Metallic Materials
- Cabin Interior and Engine Related Impact and Failure Analysis Guidelines
- Fire Protection and Mitigation in Hidden Areas of Commercial Airplane Cabins
- Strategies for Risk Reduction using Virtual Reality Simulation of Real Airports
- Evaluating Preflight Weather Briefing Strategies
- Flight Crew Visual Scanning Techniques on Transport Category Aircraft
- Integrated Avionics Technology Development
- Occupant Safety in Obliquely Mounted Aircraft Seats
- Probabilistic Integrity and Risk Assessment of Turbine Engines

eVTOL Battery Safety Testing

Sponsored by the FAA's Joint Centers of Excellence for Advanced Materials, in collaboration with industry partners, the National Institute for Aviation Research at Wichita State University conducted a full-scale 50-foot drop test of an electric vertical take-off and landing (eVTOL) battery. The project aimed to provide information to support the certification of battery system crash resistance using existing fuel system crashworthiness regulations.

Occupant safety is a key part of the overall technical and management processes associated with the design, development, and operation of eVTOL transport systems. To improve occupant safety, the performance and behavior of the complete vehicle (seats, batteries, and the surrounding airframe structure) during an emergency landing event must be evaluated and analyzed.

Battery test data will help the agency determine what testing methodology to use to evaluate the crashworthiness of battery systems as more eVTOL vehicles move toward certification.

Accurately calculating fuel flow rates for commercial jet taxi operations is important because it helps reduce fuel consumption and emissions.

Accurate Fuel Flow Rates Help Reduce Fuel Consumption

The Aviation Sustainability Center (ASCENT) developed a new methodology to accurately calculate fuel flow rates for commercial jet taxi operations at airports.

This new methodology has been published by SAE International, an international aerospace standards-setting organization, and is now incorporated into FAA's Aviation Environmental Design Tool (AEDT).

Accurately calculating fuel flow rates for commercial jet taxi airport operations – which are movements of aircraft while on the ground under its own power – is important because it helps reduce fuel consumption and emissions. Fuel burn during taxi operations is a significant contributor to total fuel burn for commercial aircraft.

The ASCENT Center of Excellence is a cooperative aviation research organization co-led by Washington State University and the Massachusetts Institute of Technology. The center is funded by the FAA, NASA, the Department of Defense, Transport Canada, and the Environmental Protection Agency. The center works to create science-based solutions for the aviation industry's biggest challenges.

FAST Grant Program

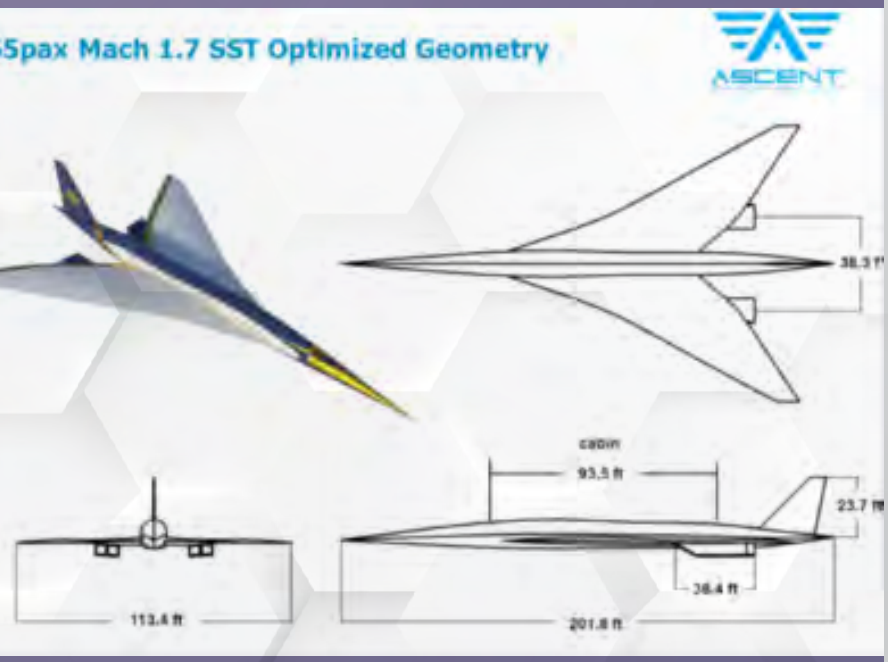
In September 2023, the FAA launched the new Fueling Aviation's Sustainable Transition (FAST) grant program. The program will make investments to accelerate production and use of sustainable aviation fuels and to develop low-emission aviation technologies. FAST supports the U.S. aviation climate goal to achieve net zero greenhouse gas emissions by 2050.

Projects under the program will produce, transport, blend, or store sustainable aviation fuel and develop, demonstrate, and apply low-emission aviation technologies. The sustainable aviation fuels elements of the program will provide more than $244 million to advance the deployment of jet fuels made from renewable sources, and that provide greater than 50% reduction in lifecycle carbon dioxide emissions. They also need to be used safely in today's aircraft engines.

The low-emission aviation technologies element of the program will provide more than $46 million to develop and demonstrate new technologies that improve fuel efficiency, reduce emissions, and supply aviation's demand for jet fuel. Applications for grants are due in November 2023, with awards targeted for mid-2024.

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

Georgia Tech graduate student Jackson Larisch and recent graduate Reagan Mayo install a test nozzle in GTRI's Anechoic Static Jet facility, where banks of microphones record sound from the nozzle as air passes through, while other instruments measure air flow velocity and pressure. (Credit: Sean McNeil, GTRI)



Conceptual design of a 65 passenger supersonic airplane traveling at a speed of Mach 1.7 designed by Georgia Institute of Technology under an FAA ASCENT research grant in support of standards development analyses.

Noise Reduction for Supersonic Aircraft

The Georgia Tech Research Institute (GTRI) conducted baseline noise reduction testing of jet engine exhaust designs for anticipated future supersonic airplanes. GTRI used test measurements to study and correlate design mechanisms with flow response for noise reduction.

Research was sponsored by the FAA through the ASCENT Center of Excellence for Alternative Jet Fuels and Environment and Gulfstream Aerospace.

The goal was to address engine sound generated by supersonic aircraft operating at subsonic speeds for takeoff and landing at airports. The Concorde, one of the greatest supersonic aircraft ever designed and built, was retired in 2003 partially due to noise pollution from its sonic booms.

Research was sponsored by the FAA through the ASCENT Center of Excellence for Alternative Jet Fuels and Environment and Gulfstream Aerospace. Key to controlling the dominant jet noise for supersonic design aircraft will be the configuration of engine structures that mix heated air exiting the engines with cool air flowing around them. Designing the mixer is a multidisciplinary task that must carefully balance engine performance against noise to meet aircraft-level requirements.

Under ASCENT's supersonic-focused collaborative grant effort, gathered experimental data is shared for computational modeling through grants to Stanford University, Penn State University, and the University of Illinois. The universities will use the data for "fine tuning" and validation of their multi-fidelity noise prediction models. Conclusions will be made available to the FAA and to companies interested in developing civilian supersonic aircraft. Boom Supersonic and Gulfstream Aerospace provided cost matching support for modeling.

Signaling Electrical Emergencies with Smart Sensors

In July and August 2023, a University of Maryland graduate student, working under an aviation research grant, conducted tests to detect internal contaminant sources in the flight deck of an aircraft.

The tests were part of a larger project that aims to find technology capable of identifying airborne contaminants resulting from overheated or malfunctioning electrical equipment, like fans or wiring. Two different sensors were evaluated, both of which use machine learning to discern between different types of airborne contaminants. Samples evaluated included gases and particulates derived from overheating various materials, including printed circuit boards, aircraft wire, and environmental control system recirculation fans.

The testing evaluated the accuracy and repeatability of these smart sensors. If these technologies are proven reliable, they could one day be integrated into aircraft systems, giving flight crews an accurate assessment of the origin of odors that could be present in the flight deck (such as electrical failure, varnish, plastic, etc.). Most importantly, this information could contribute to decision-making procedures in cases of emergency. Results will be published in a report to be presented at the Society of Fire Protection Engineers annual conference in October 2023.

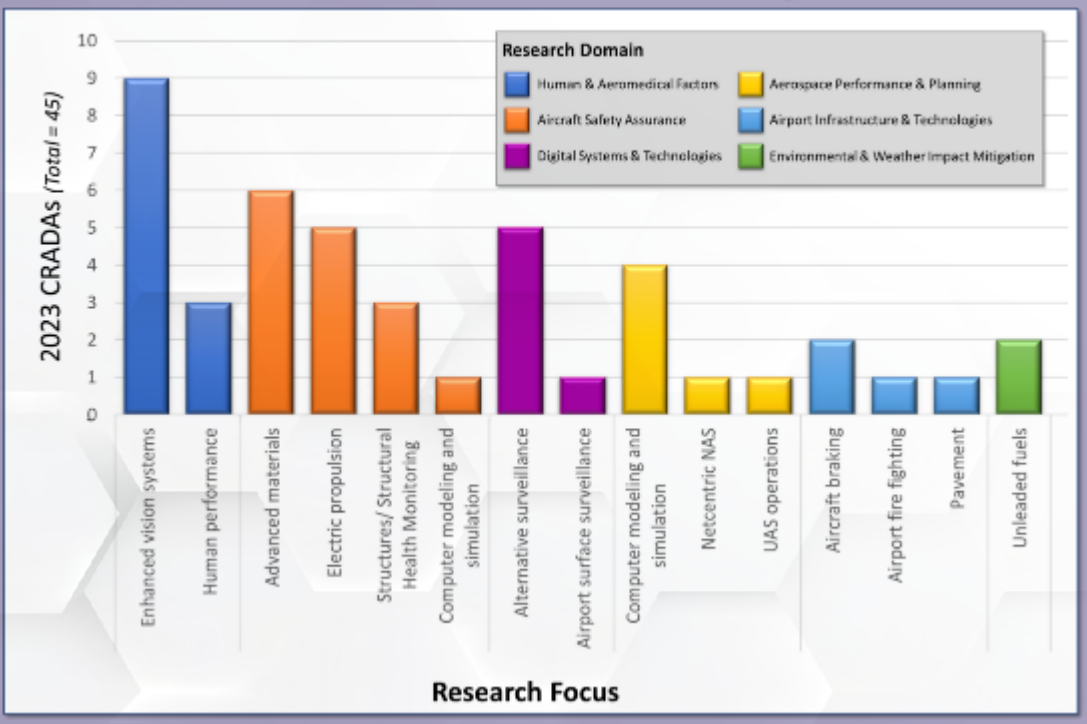
Overheating of printed circuit board substrate material.

Cooperative Research and Development Agreements

The FAA's Technology Transfer program promotes innovative R&D with other government agencies, industry, and academia and disseminates federally funded research innovations for the benefit of the American public.

The program executes Cooperative Research and Development Agreements (CRADA). Congress enacted these uniquely beneficial agreements to stimulate collaboration from the nation's cutting-edge federal laboratories and external partners. Benefits include favorable patent opportunities and access to federal laboratories and experts.

FAA CRADA Research Focus by Domain



Stimulating Collaboration through Cooperative Research and Development Agreements

The FAA encourages important cutting-edge research with the aviation industry, academia, and international partners through Cooperative Research and Development Agreements (CRADA). These unique vehicles can be implemented rapidly, similar to other contracts and agreements awarded under the FAA's Acquisition Management System.

Although FAA partners do not receive government funds, they benefit substantially from access to unsurpassed facilities and expertise. In return, the agency can evaluate upcoming advanced technologies and processes to facilitate their certification and safe integration into the National Airspace System.

Interagency Agreements

The FAA benefited from agreements with 19 federal partners in 2023. The collaborations supported multiple agency initiatives, including those presented below.

Interagency Agreements - 2023

NAVAL AIR STATION

National Institute for Occupational Safety and Health
NIOSH

NAVAL MEDICAL RESEARCH UNIT
NAMRU DAYTON

CDC

NASA

NASA Langley Research Center

Research Focus

- Bleed Air Study/Cabin Air Quality
- Crashworthiness of Rotorcraft Aircraft Seats in Vertical Takeoff and Landing Research
- Centers for Disease Control and Prevention - Off- Flight Pilot Incapacitation – Pilot Mortality Data Match
- Disease Transmission in Air Travel Modeling, Simulation and Analysis

The FAA will provide guidance to airport operators on issues with the new foam falling within its regulatory authority.

FAA Plans Transition to Fluorine-Free Firefighting Foam

In December 2022, Congress directed the FAA to develop a plan to ensure the orderly transition from current aircraft fire fighting foam containing per- and polyfluoroalkyl substances (PFAS) to a replacement firefighting foam. The agency created the *Aircraft Firefighting Foam Transition Plan* in May 2023 in response to the Congressional directive.

Earlier this year, the Department of Defense (DoD) published a *new fluorine-free foam (F3) military specification (MILSPEC)* to comply with the requirements set by the National Defense Authorization Act. The next step is for foam manufacturers to submit their F3 products for qualification by DoD. Once DoD certifies that a foam meets the new MILSPEC, it will be added to the qualified product list. The FAA considers these new, firefighting foams on the qualified product list acceptable for use.

As described in the transition plan, the FAA will provide guidance to airport operators on issues with the new foam falling within its regulatory authority. For issues outside of its authority, the FAA will identify industry best practices as they become available.

PFAS, a group of manufactured chemicals contained in current aircraft firefighting foams, have been found to cause serious health problems, including cancer, if people are exposed to them over a long period of time. Therefore, the FAA accelerated research for an alternative firefighting foam that did not contain PFAS and issued guidance intended to help reduce the existing foam's environmental impact.

Measuring High Energy Impact Events

A generic engine fan blade model developed by the FAA's ASSURE Center of Excellence will be utilized as a test case by the LS-DYNA® Aerospace Working Group (AWG). LS-DYNA® is a tool used to analyze high-energy impact events.

The tool modeled Inconel 718, a material widely used for turbine engine components such as blades, disks, casing, and other structures, which can be subject to impact in the event of a rotating part failure.

The model is accessible for AWG industry members to use and provide feedback on before being posted to the external publicly available website.

LS-DYNA® AWG is a partnership of federal agencies, corporations, and universities working together to support the use, development, and reliability of LS-DYNA® for aerospace numerical analysis. The ASSURE COE blade model will be instrumental in improving the consistency and reliability of aerospace impact simulations.

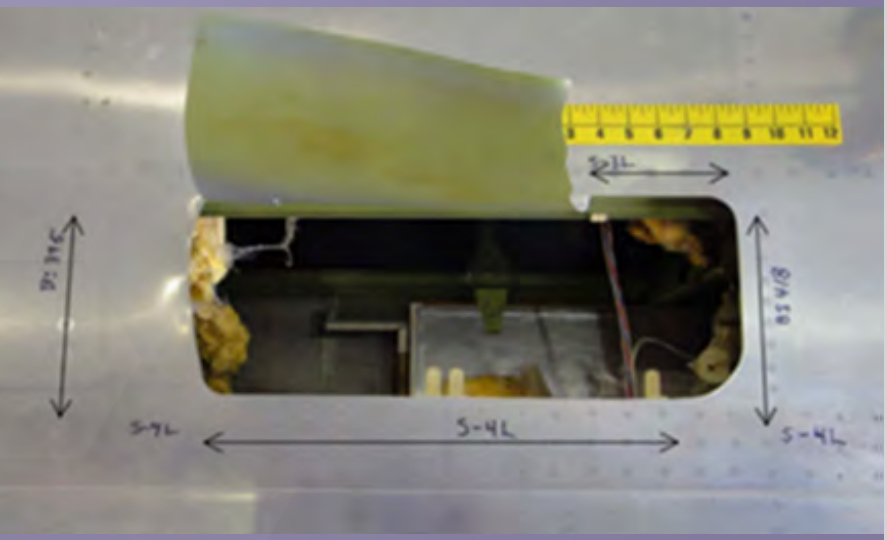
International Agreements

As a key performer in the global aviation community, the FAA maintains collaborative relationships with multiple international partners to make the global aviation system safer, more efficient, and more sustainable.

FAA researchers hold positions across multiple global harmonization and standards-setting bodies and serve as world-renowned subject matter experts on many topics.

Their contributions enable the United States to drive international standards and increase America's economic advantage in aviation.

By working together with international partners, the agency leverages collective resources, expertise, and experience to address common challenges and opportunities in the aviation sector. This fosters mutual trust and understanding among different countries and regions, promotes coordination of regulations and practices, and facilitates the safe and efficient movement of people and goods across borders.



Boeing B-757-200 fuselage skin rupture at chemical mill line resulting in rapid depressurization, NTSB Report #11-001, 2010.

Structural Health Monitoring for Aircraft Structures

At the 2023 Aerospace Industry Steering Committee for Structural Health Monitoring Spring Meeting in Tokyo, the FAA presented research on structural health monitoring (SHM). SHM uses installed sensors to inspect aircraft structures for damage (cracks, corrosion, delaminations), which take the place of traditional inspection technologies. The meeting brought together international industrial, government, and academic participants to discuss using structural health monitoring for a wide variety of commercial and military purposes. Topics included standards development, procedures, processes, and technology implementation and certification guidelines.

One focus area included a recently completed in-house test on the FAA's Full-Scale Aircraft Structural Test Evaluation and Research (FASTER) fixture. The test, conducted at the William J. Hughes Technical Center, looked at the SHM sensor's ability to detect damage in aircraft skin panels manufactured using chemical milling. While chemical milling of aircraft skin can provide benefits such as weight reduction, it has been associated with several incidents of cracking at the edges of the milled areas, which could lead to aircraft depressurization. The FAA has issued airworthiness directives requiring accomplishment of service bulletin inspections of the mill line to help prevent potentially serious issues.

Program data will be used as an initial proof of concept of the capability and reliability of SHM systems in mill line crack scenarios to avoid difficult and/or time-consuming inspections on chemical mill lines. Sensor installations for in-service data collection are planned for Korean Air, Japan Airlines, and Delta Airlines. Collected data will be used for future SHM certification.

Best Practices for RVSM Fight Plan Audits

In June 2023, the FAA discussed air traffic modeling separation standards related to flight plan audits with members of the European Regional Monitoring Agency (EUR RMA). Topics included the process, procedures, and management of flight plan audits and EUR bulletin reports implemented by EUR RMA.

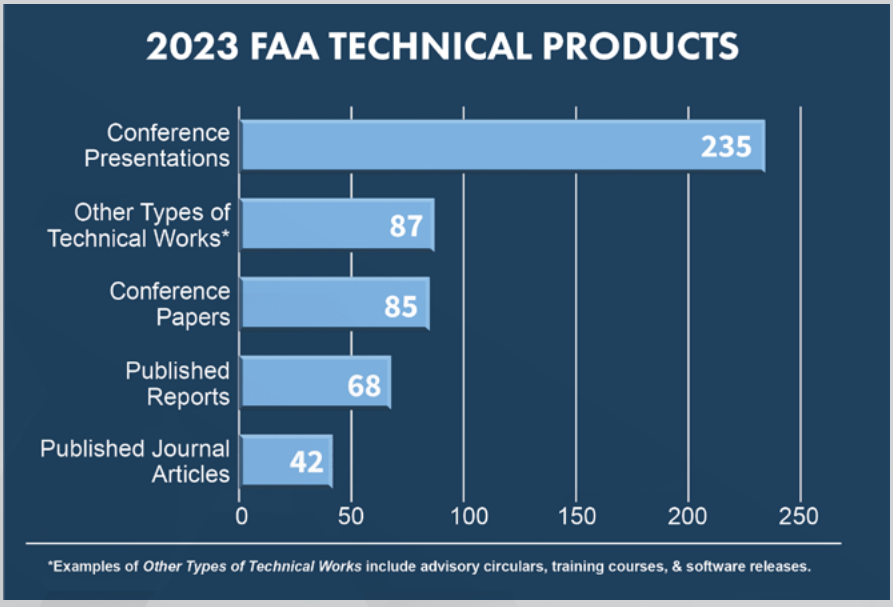
RMAs conduct flight plan audits for their region or jurisdiction. Flight plan audits ensure airspace safety by identifying non-approved operators and aircraft using Reduced Vertical Separation Minimum (RVSM) airspace without approval. Separation standards are vertical and horizontal distances that facilitate the safe navigation of aircraft. The standards ensure safe separation from the ground, from other aircraft, and from protected airspace.

RVSM helps increase airspace capacity, promote greater efficiency, and possibly increase aircraft fuel savings. Knowledge gained from the discussions will help with the creation of a monthly flight plan audit for U.S. RVSM airspace. The meeting provided an increased understanding of procedures required for more frequent traffic audits, which will increase safety in U.S. regional airspace.

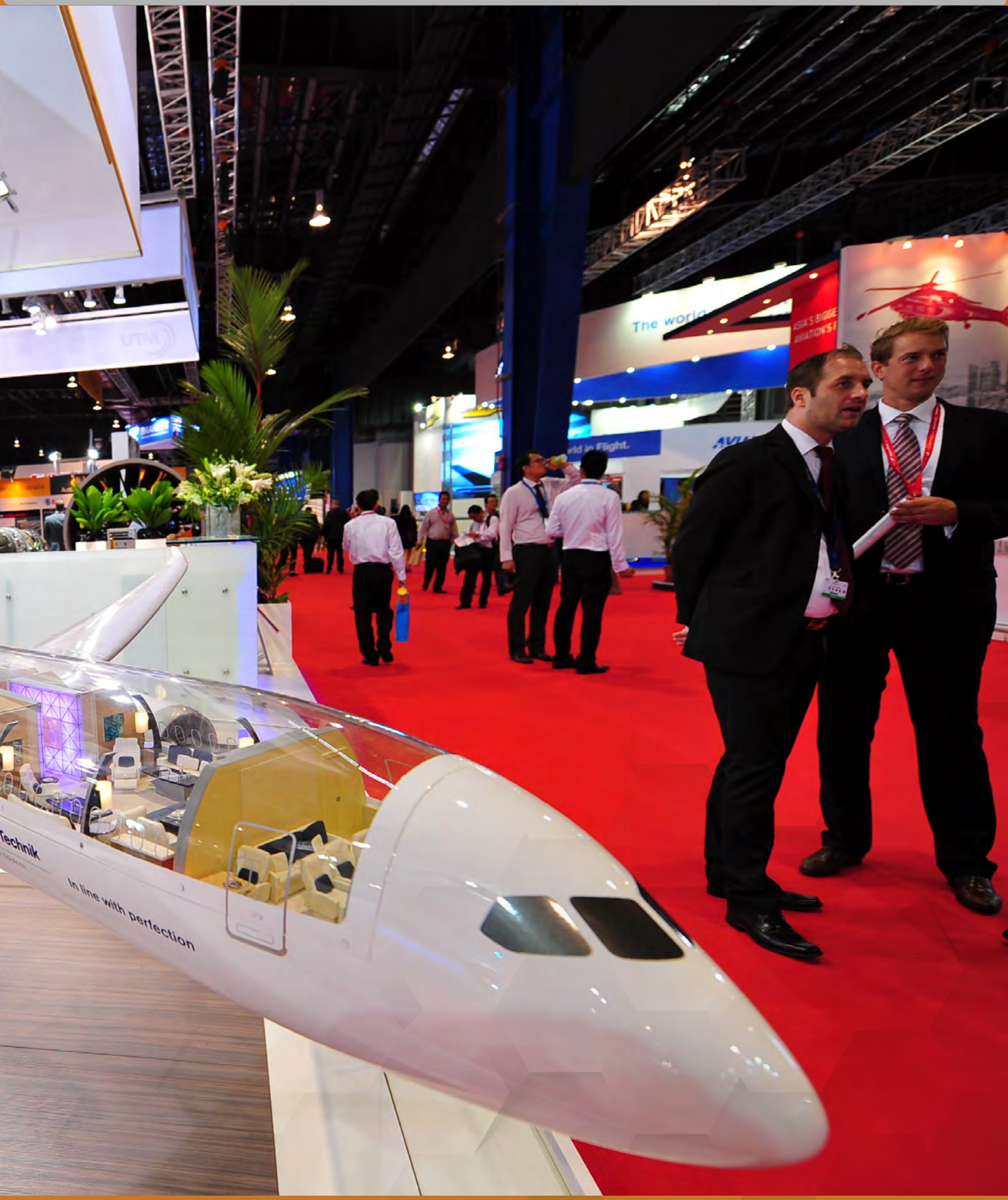
Reduced Vertical Separation Minimum (RVSM) helps increase airspace capacity, promote greater efficiency, and possibly increase aircraft fuel savings.

Disseminating Research to the Private Sector

The FAA disseminates a broad range of information and products, including formal reports, standards, software, patents, technical knowledge, innovative ideas, and new processes and practices. In 2023, the FAA participated in multiple conferences, distributed technical reports and other products, and published peer-reviewed journal articles. The sustained quality and technical merit of agency products continue to resonate within the research community.



In addition to these formal products, the FAA collaborated with other federal agencies, universities, the aerospace industry, and standards-setting organizations to share expertise and resources to promote national, Department of Transportation, and agency objectives.

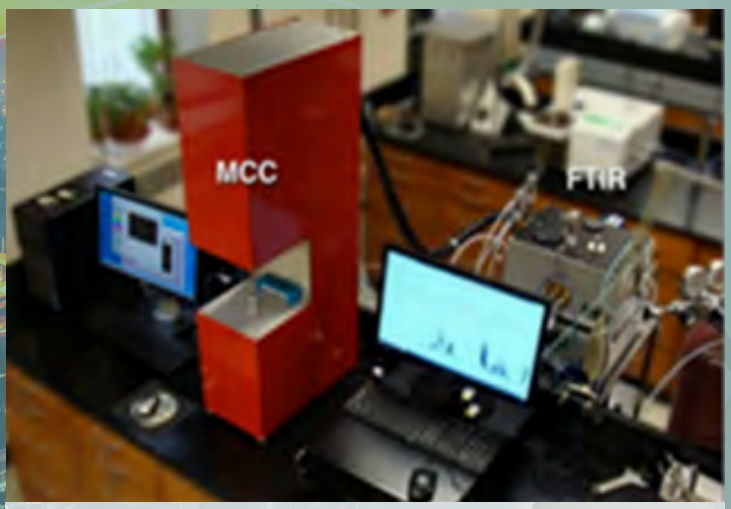

Technik
In line with perfection

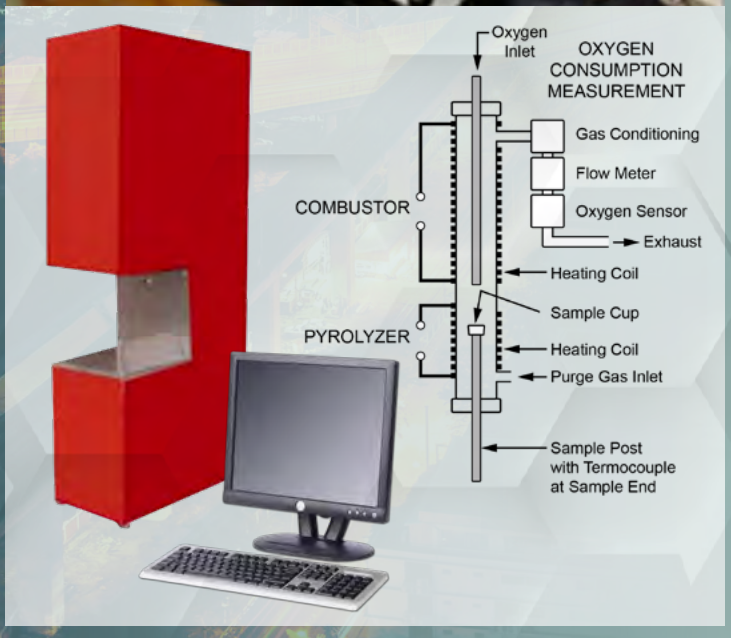
FY 2023 FAA Technology Transfers

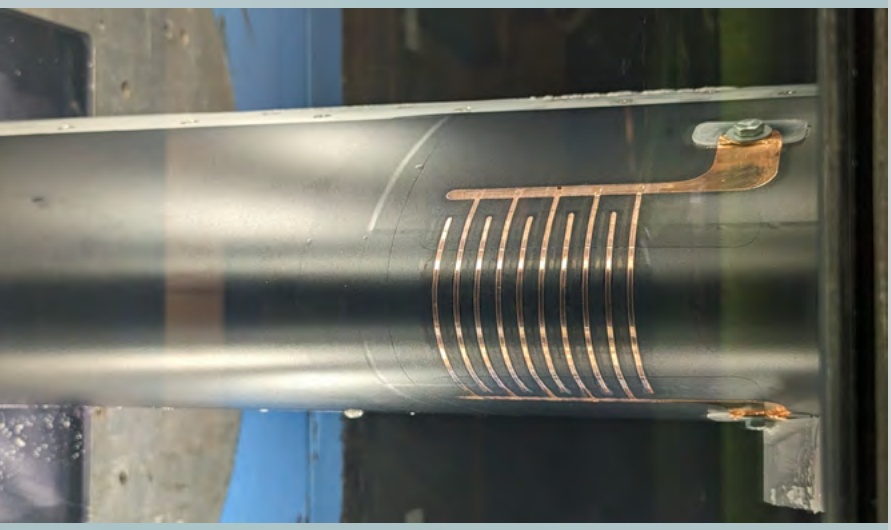
FAA Awarded a U.S. Patent

FAA fire safety researchers were awarded a patent on a system and method for flameless, premixed combustion of solids in a microscale fire calorimeter (MFC) at high temperatures of combustion and under precisely controlled fuel-to-oxygen ratios. These techniques can be used to test plastic samples to assess and evaluate the impact of aircraft cabin materials on occupant survivability in post-crash fires.

Measurements made at different fuel/oxygen ratios help to better understand the flame chemistry and the mix of combustion products for various materials throughout the different stages of a full-scale fire in an aircraft cabin.







FAA Plasma Deicer Employee Invention 'Spin-Out'

In the final stage of preliminary work, the FAA executed a memorandum of agreement (MOA) with Collins Aerospace for the use of its Goodrich Tunnel to test and validate an innovative, FAA employee-invented, prototype aircraft ice accretion prevention system. The goal of this project is the development and possible commercialization of the Plasma Deicer as an alternative to existing aircraft anti-icing technology for the benefit of both the aviation industry and the flying public. The execution of this MOA concludes a five to six-year collaborative process between the FAA, Collins Aerospace, and Princeton University.

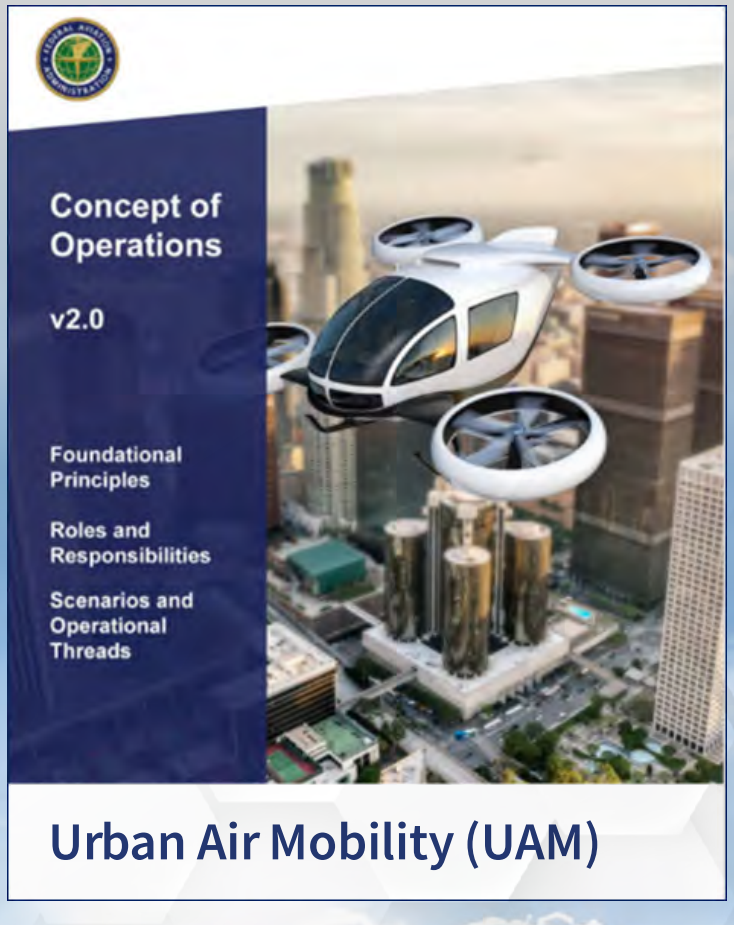
Phase I of the project began in September 2023, and will focus on preparing this technology as an economical ice protection system for general aviation aircraft. Certification tests will establish, through icing wind tunnel experiments, the Plasma Deicer anti-icing and de-icing performance data that complies with 14 CFR Part 91.527 atmospheric conditions, and experimentally validate its electromagnetic interference (EMI) mitigation techniques. Phase I will also design, build, and qualify the Plasma Deicer prototype for certification tests and possible commercialization.

Urban Air Mobility ConOps 2.0

The FAA released the second version of the Urban Air Mobility (UAM) Concept of Operations (ConOps). Building on the initial version released in 2020, the new version incorporates feedback from NASA and industry partners.

The document is key to maturing the agency's overall Advanced Air Mobility (AAM) concept. It is aimed at developing an air transportation system that moves people and cargo between local, regional, intraregional, and urban locations not previously served or underserved by aviation using these new aircraft, technologies, infrastructure, and operations. AAM will support a wide range of passenger, cargo, and other operations within and between urban and rural environments.

The new ConOps represents progress in the work to mature the UAM concept through ongoing government and industry stakeholder collaboration.



Billy Nolen, acting FAA Administrator, congratulates the sUAS Applications at Airports team at FAA headquarters immediately preceding the 55th Annual Awards Ceremony on January 26, 2023. The team consists of (back row, left to right) Matthew Brynick, Nick Subbotin, James Patterson, Keith Bagot, and Garrison Canter, and (front row) Wesley Major and Michael DiPilato.

The winning team's research in sUAS applications on airport grounds includes: obstruction surveys, aircraft rescue and firefighting (live monitoring and accident documentation), wildlife hazard management (dispersing and monitoring wildlife), foreign object debris detection, airfield lighting inspections, airfield pavement inspections, airport perimeter inspections, and construction monitoring.

DOT Recognizes sUAS Safety Efforts

FAA researchers were recognized for improving safety through the integration of small, unmanned aircraft systems (sUAS) at airports during The Department of Transportation (DOT) Secretary's 55th Annual Awards Ceremony in January 2023. The Secretary's Team Award highlights groups whose efforts contribute significantly to the accomplishment of the DOT mission and goals, which include safety, climate and sustainability, innovation, and equity.

The FAA team partnered with federal agencies, airports, industry groups, and academia to develop and test concepts to expand airport safety across the country using sUAS aircraft. FAA research demonstrated the potential for how sUAS technology can streamline procedures, enhance response times, and ultimately improve safety.

Through testing, the FAA helped expand the boundaries for using small drones operationally, determine the minimum requirements for each type of use, and provide technical guidance for safely using sUAS on airport grounds. Research evaluated how sUAS could enhance airfield management functions that, in the past, were performed by people on the ground. New technologies allow airport stakeholders to receive data with heights, distances, and angles they did not previously have.

Research required collaboration between the FAA and other groups. For example, the agency worked with the National Oceanic and Atmospheric Administration's National Geodetic Survey to demonstrate the use of small drones for obstruction analysis. Together, they collected information on various constructed and natural obstructions at five airports and compared the accuracy of collected data from sUAS with established datasets to assess the benefits and limitations of using drones for obstacle collection surveys.

Enhancing Cybersecurity in the NAS

Cybersecurity attacks are on the rise and pose more risk as modern society becomes increasingly reliant on digital data. In 2020, a group of hackers conducted a $10 million ransomware attack on Garmin's aviation flight planning and navigation services. By 2022, the FBI received reports of $10.3 billion in monetary damages due to cyber-criminal activity.

Seeing the threat, the FAA established a program to enhance its cybersecurity nearly a decade ago. The cybersecurity strategy continues *to protect the FAA's information systems, data, and networks and to ensure the safety and security of the National Airspace System (NAS)*. In 2023, the program continued its participation on the AIA Civil Aviation Cybersecurity Subcommittee and U.S. Aviation Coordination of Cybersecurity & E-enabled Standards Strategy (US ACCESS) working group.

The FAA's Cybersecurity Data Science (CSDS) program is aimed at enhancing cybersecurity for the airline, airport, and aircraft elements of the NAS. It seeks to accelerate the aviation industry's safe and timely adoption of emerging artificial intelligence/machine learning (AI/ML) technologies to increase safety and resilience. In 2023, the program collaborated with the Aerospace Industries Association to issue a white paper titled "*The Role of Cybersecurity Data Science in Aviation Cybersecurity*." This publication includes guidelines for aviation industry adoption and adaptation of CSDS and AI/ML technologies to increase safety and resilience. The agency has also continued to work with its international partners, such as the RTCA Special Committee, EUROCAE, and other certification authorities, to establish cybersecurity standards.

FAA Works to Certify eVTOLs

Rapid technological advances supporting the development of new aircraft, such as electric vertical takeoff and landing (eVTOL) vehicles, pose unique challenges to the FAA. These vehicles are evolving rapidly toward commercialization in the coming years. However, these unconventional vehicles do not fit into the FAA's current regulatory framework and will require new approaches.

Fortunately, the agency is already working to reform its certification processes to include these new vehicles. It has increased oversight of aircraft manufacturers, updated the criteria for conducting safety assessments, and initiated technical advisory boards of independent experts to ensure a consistent and thorough approach for all aircraft certification projects.

To test the new framework, Joby became the first vendor to complete the third stage of "type certification" for its aircraft, which is FAA approval of an aircraft design and all component parts (including propellers, engines, control stations, etc.). The unique five-seat aircraft can take off and land like a helicopter and tilt its six rotors to fly like an airplane at up to 200 mph. The FAA accepted the manufacturer's certification plans to address a comprehensive set of factors including its unique flight controls, energy storage, and propulsion. In June 2023, the aircraft secured a Special Airworthiness Certificate from the FAA, clearing it to begin flight testing.

Over the next year, the agency will continue to observe the aircraft during testing to ensure that all design and performance issues are addressed. Once Joby successfully completes all requirements, the FAA will pave the way for commercial operations, issuing an Air Carrier or Operating Certificate and Operations Specifications.

Participation in Professional and Technical Societies

Professional and technical societies bring together experts, knowledge, and technology to share information, create aerospace industry standards, and develop design standards for technology, processes, and systems.

FAA experts provide substantial contributions and guidance in these areas by serving on boards of directors and as chairs, committee and subcommittee members, technical experts, and general members for over 40 separate organizations across nearly 100 focus areas.

Conclusion

FAA research and development continues to find new ways to make flying safer, cleaner, more efficient, and environmentally sound. It is pushing beyond today's boundaries to prioritize integrating advanced technologies into the National Airspace System. To learn more about FAA's planned research activities, view the Annual Review's companion document, the ***National Aviation Research Plan***.