

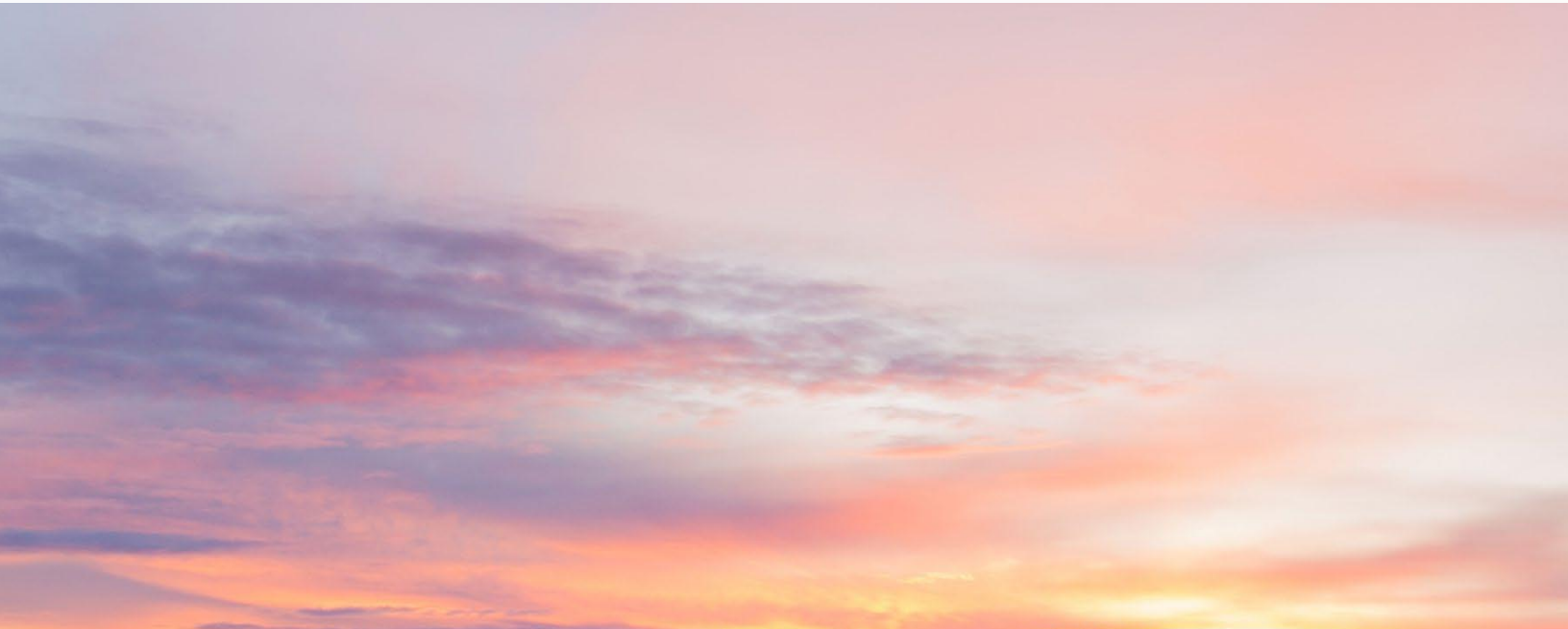




**Federal Aviation
Administration**



2020 Research and Development Annual Review



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2020 Annual Review

January 2022

The Research and Development (R&D) Annual Review (AR) 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. The R&D AR is available on the internet at <http://www.faa.gov/go/narp>.





Foreword

The Federal Aviation Administration's (FAA) Research and Development (R&D) Management Division is charged with supporting the development of the agency's R&D portfolio, and tracking R&D program goals and activities to ensure their alignment with Department of Transportation and FAA strategic goals for the National Airspace System.

The R&D Management Division is responsible for producing the congressionally-mandated National Aviation Research Plan (NARP) and this R&D Annual Review (AR) on behalf of the FAA Administrator.

This is a companion document to the NARP. While the NARP is forward looking and describes planned research activities over the next five years, the R&D AR provides a snapshot of R&D work from the previous fiscal year, highlighting major accomplishments, R&D Goals, and current fiscal year performance information.

The past year has been a time of unprecedented uncertainty and public health challenges for the nation as we confronted a global pandemic. While FAA R&D has experienced these impacts, the agency continues its commitment to safety, innovation, and global aviation leadership through a creative, thoughtful, and flexible approach to executing research priorities.

With restrictions on in-person interactions, the FAA has used alternative means to effectively collaborate with partners in industry, academia, and around the world through important exercises, information sessions, and virtual conferences. From conducting fully virtual Research, Engineering, and Development Advisory Committee meetings to improving laboratory test apparatus for increased data quality during times of decreased manpower, the FAA has adapted to face these new challenges.

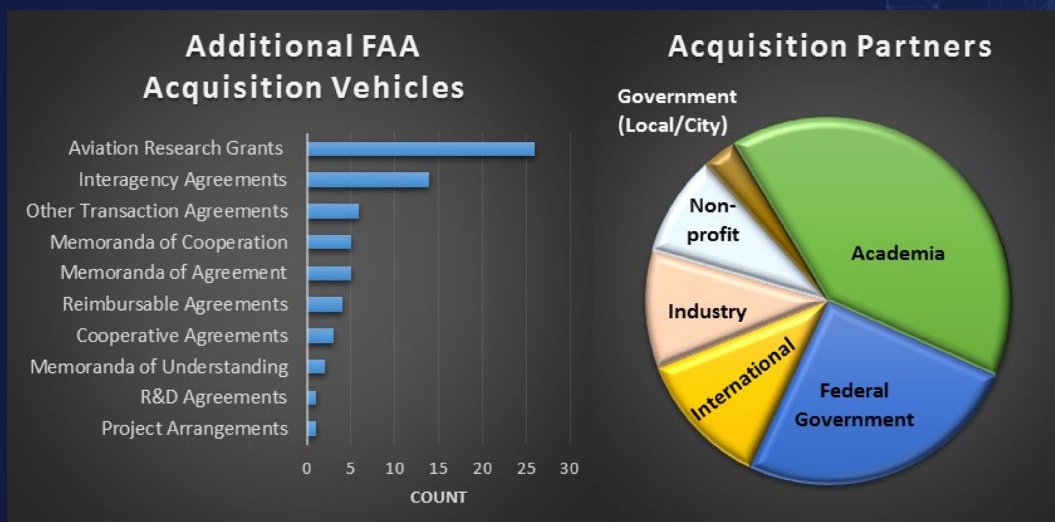
The agency has continued with a forward-thinking mindset, ensuring that FAA R&D continues to enable industry innovation.

Partnerships

In pursuit of the agency's mission, the FAA maintains partnerships with over 350 stakeholders representing federal agencies, academia, industry, international entities, and technical societies.

The FAA's partners include aircraft and parts manufacturers, design and engineering companies, nonprofits, external testing facilities, domestic and international organizations, and representatives of large and small businesses.

Due to wide-ranging research needs and partnering opportunities, the FAA uses a variety of available vehicles. These include grants, interagency agreements, memoranda of cooperation, memoranda of agreement, reimbursable agreements, and other vehicles. The agency also leverages unique opportunities offered by Cooperative Research and Development Agreements (CRADA) to enable many of these partnerships.





350 + Agreements

130 + Separate Stakeholders

200 + COE Grants

40 + CRADAS

60 + Other Contracts

Federal Interagency and Nonprofit

The FAA leverages the research capabilities of federal partners and nonprofit organizations to advance national and international aviation objectives through the use of interagency and reimbursable agreements.

17 Federal Agreements 6 Nonprofit Agreements

Federal Partners

In FY 2020, the majority of the FAA's active federal interagency agreements were with NASA, totaling eight. Collaboration through interagency agreements includes:

- Research into complex digital airborne systems reliability, safety, risk assessment, and verification
- Research and testing of aircraft structures and materials
- Development of performance-based standards for new cockpit pilot interfaces
- Stabilized approach criteria
- Improved methodologies for certifying General Aviation aircraft

Other federal partners include the Volpe National Transportation System Center, Defense Logistics Agency, U.S. Air Force Lifecycle Management Center, U.S. Air Force Research Laboratory, Naval Air Warfare Center Weapons Division, and Department of Agriculture. These agreements support many important activities and products such as the development of the Metallic Materials Properties Development and Standardization (MMPDS) Handbook, data collection and analysis of high intensity runway edge lights, and continued research and exploratory development efforts in aircraft rescue and firefighting.



Nonprofit Partners

In 2020, the FAA maintained partnerships with three nonprofit institutions: Battelle Memorial Institute, National Institute of Aerospace (NIA), and Southwest Research Institute (SRI).

- Battelle is supporting the FAA in developing the MMPDS handbook which outlines materials the aerospace industry can use when designing aircraft parts to ensure they comply with material strength requirements.
- Ongoing FAA-NIA agreements support the study of damage modes in lightweight sandwich structures for the Composite Materials Handbook-17. These agreements also support developing an FAA framework for partnering with academic institutions for science, technology, engineering, and mathematics (STEM), internships, and STEM learning initiatives for kindergarten through 12th grade.
- SRI is supporting the FAA in investigating a probabilistic damage tolerance approach for designing metal additive manufactured parts of higher criticality, and developing damage tolerance and risk assessment methods for turbine engine life-limited parts that need to be replaced on a regular basis due to wear and tear during the life of an aircraft.

Academic

The FAA collaborates with academic institutions through a variety of mechanisms including centers of excellence (COE) grants, aviation research (AR) grants, and participation in the Joint University Program (JUP) for Air Transportation Research.

These partnerships benefit FAA research initiatives by providing access to key academic scholars and practitioners, while promoting invaluable work experience for students. In addition, students may elect to continue to pursue a career in aviation-related research.

Centers of Excellence

COEs are a unique mechanism enabling the FAA to recruit leading academic institutions to advance aviation research objectives. The FAA has partnerships with more than 40 universities, colleges, and institutes through the program. Participants are required to obtain additional funding to match the amount provided by the FAA. This effectively doubles the value and ensures the research aligns with industry priorities.

In FY 2020, the FAA substantially increased investment in the program. COEs support technology transfer and research in the following core areas:

- Unmanned aircraft systems
- Alternative jet fuels and environment
- Advanced materials
- General Aviation safety
- Technology training and human performance
- Commercial space transportation

COEs focus on a broad range of current and emerging critical research needs. For example, Wichita State University received grants to develop aircraft design and certification guidance for polymer-based additive manufacturing technologies. The University of Dayton Research Institute is investigating alternative jet fuels.

Other areas of research focus on validating low-altitude detect-and-avoid standards for unmanned aircraft systems, community measurement of aviation emissions on ambient air quality, assessment of supersonic aircraft noise in high-altitude airspace, disaster preparedness and response, and cybersecurity.

COE Grants - An Extraordinary Year

	FY 2019	FY 2020
Grants	97	217
Awards	\$20.6M	\$78.6M

217 COE Grants

24 AR Grants

7 CRADAs

3 JUP Partners



Aviation Research Grants

Established by Congress in 1990, aviation research grants are an essential mechanism for the FAA to advance critical research for the long-term growth of civil aviation. In FY 2020, the agency awarded 24 grants representing 20 different academic institutions. The awards fund crucial research on a number of current and emerging topics including:

- Safe integration of active flutter suppression into new aircraft
- 3D iced-wing aerodynamics
- Flight load data for heavy air tankers to develop methodologies for correlating atmospheric turbulence to structural loads
- Frost evolution on aviation wing-skin surfaces and in cold-soaked fuel frost conditions
- Photometry and radiometry studies focused on airport lighting and visual guidance systems
- Emerging aviation fire risks such as lithium battery fires
- Creating a numerical framework of essential fire properties to better understand and predict flammability of materials
- Metal and composite material testing and modeling for engine fragment impacts
- Investigating alternative acceptance methods for unbound pavement materials (e.g., subgrade, subbase, and base)

FY 2020 Cooperative R&D Agreements

26

INDUSTRY

UPS • FedEx • Afton Chemical •
GE • Rockwell Collins •
Boeing • Kerr Avionics
DFW • Astronics •
Protean

ACADEMIA

Dayton Research Institute
Clarkson • George Mason
Rutgers • Fairfield •
Rowan

7

FY 2020 CRADAs

45 Ongoing
4 Closed
7 Amended

Diakon Solutions
ATECH • GSSL •
Metis Design • Acellent •
Aviation Safety Advancements •
Lectromechanical Design

Adacel Systems •
CMC Electronics •
BlindSquare • Team Eagle •
Thales Avionics

SMALL BUSINESS

INTERNATIONAL

7

5

CRADAs

The FAA implements CRADAs with industry, academic, small business, and international partners. Although the government does not provide funding, non-government partners gain access to unsurpassed facilities, equipment, services, intellectual property, personnel, and other resources. CRADAs can be implemented much more rapidly than traditional contract vehicles because they are exempt from various procurement requirements.

Academic

In FY 2020, academic CRADA partners included Clarkson University, Fairfield University, George Mason University School of Business, Rowan University, Rutgers University, and University of Dayton Research Institute.

These agreements promoted research into testing and model validation of structural health monitoring systems, enhancing aircraft conflict-probe tools and algorithms, creating state-of-the-art airport pavement design methods and materials, and studying the airworthiness of next generation solid state battery technology.

FAA UAS Research Funding Awarded

In August 2020, the transportation secretary announced a university research investment into the safe integration of drones into the National Airspace System.

The FAA center of excellence for unmanned aircraft systems (UAS) research, known as the Alliance for System Safety of UAS through Research Excellence, provided:

- \$1.5 million to validate low-altitude detection and avoidance standards
- \$1.4 million to study safety risks and mitigations for UAS operations at and around airports
- Nearly \$1.2 million to research urban air mobility safety standards, aircraft certification, and market feasibility

UAS remain a critical focus for the agency due to today's estimated fleet of 1.65 million recreational and commercial drones, and predictions that this number may climb to **2.3 million by 2024***

*FAA Aerospace Forecast Fiscal Years 2020–2040.



Joint University Program for Air Transportation Research

The Joint University Program funds graduate-level research into technologies and methods that have the potential to improve the safety and efficiency of the National Airspace System.

An FAA partnership with Massachusetts Institute of Technology and Ohio University focuses on emerging capabilities. A key benefit of the research is the opportunity for students to gain valuable firsthand experience managing research for real-world applications.

FY 2020 research topics included:

- Aircraft delayed deceleration approaches
- Flight testing of subscale SuperSTOL (short takeoff and landing) aircraft
- Civil aviation automation trends
- Automated assessment and tactical planning for thunderstorm avoidance
- Optimal location of high-speed taxiways to reduce runway occupancy time
- Use of data mining to identify degraded braking conditions on airport surfaces
- Analysis of safety and certification criteria for electric propulsion systems in aircraft
- Runway surface inspection technology using integrated sensor systems such as surveillance and customized radars, cameras, and infrared monitors
- Computational modeling of fire spread in aircraft cargo holds

The FAA maintains a detailed list of the past year's [FAA-funded research](#).

Under the Joint University Program, Massachusetts Institute of Technology graduate student Jacqueline Thomas, Ph.D., observed as the Boeing 777 ecoDemonstrator innovation accelerator landed at Atlantic City International Airport flying a procedure she designed.

The November 2019 flight was a first step in developing a standard flight procedure to mitigate aviation carbon emissions and noise pollution. The delayed deceleration approach keeps an aircraft in this “clean” configuration for as long as possible. Remaining more aerodynamic means less drag, lower engine power settings, reduced fuel burn and carbon emissions, as well as less noise. This work was funded under ASCENT, the FAA Center of Excellence for Alternative Jet Fuels and Environment.



Industry

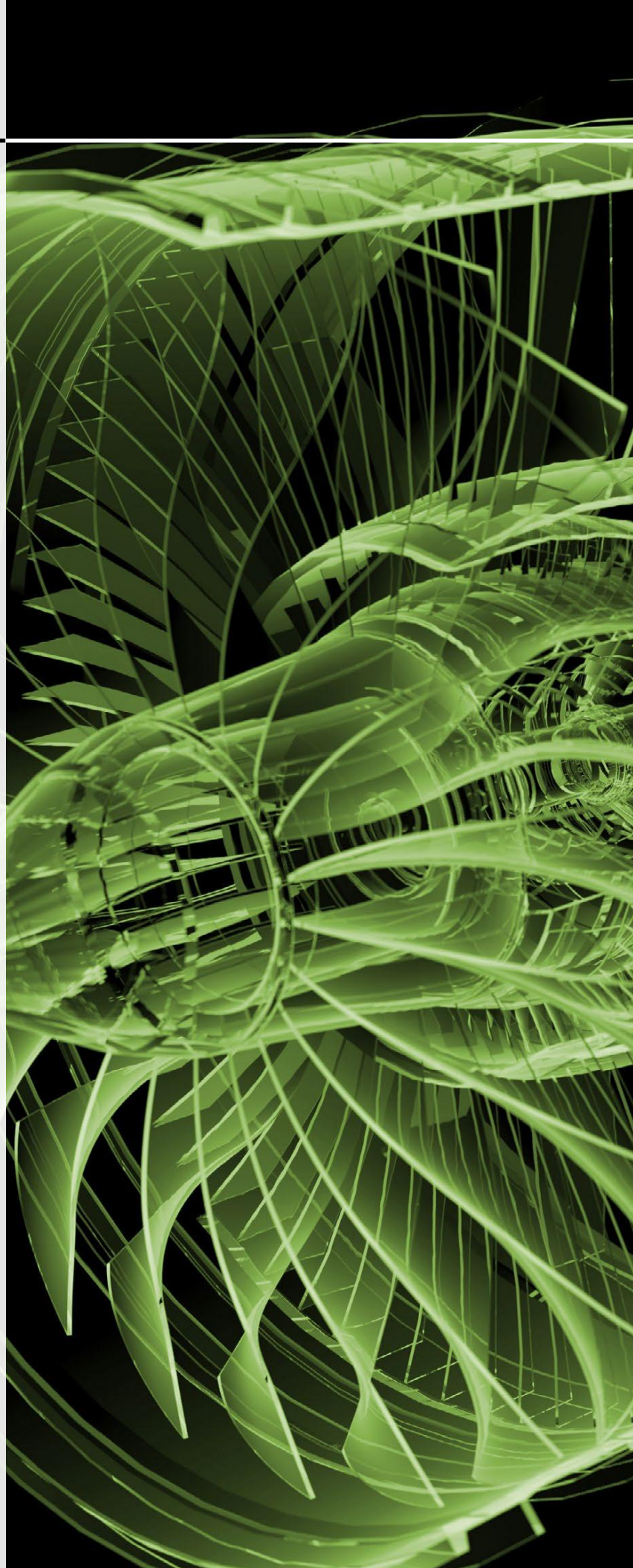
The FAA engages with industry partners using a variety of vehicles. CRADAs enable industry to access federally-developed and funded state-of-the-art laboratories, facilities, services, and associated intellectual property. The agency benefits from the innovations, knowledge, and drive of these capable partners.

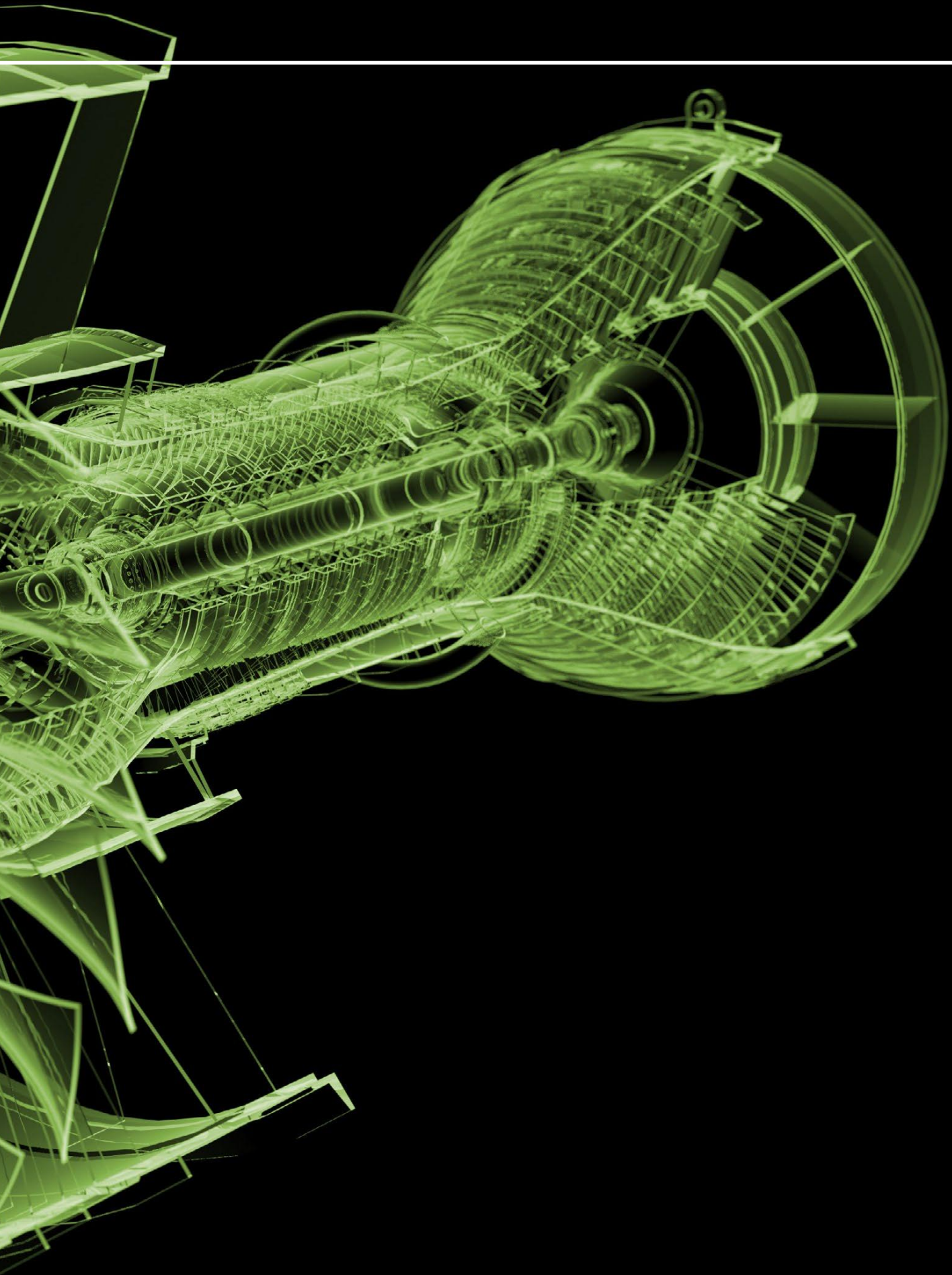
26 CRADAs

7 Other Vehicles

Memoranda of agreement (MOA) are used to leverage federal laboratory resources in collaboration with industry. MOA partners include the Delaware River and Bay Authority, Metropolitan Airports Commission, National Institute of Aerospace, Port of Seattle, and the University of Pennsylvania. These partnerships allow the FAA to develop research infrastructure at local airports. Work includes quantifying the safety benefits of foreign object debris detection systems and indoor navigation aids to help blind and visually impaired passengers traverse airports.

Additional FAA-funded opportunities are pursued through other vehicles such as procurement contracts and other transaction agreements.





International

The FAA engages with partners outside of the United States through international and cooperative agreements to share resources and harmonize operations. The knowledge capital obtained through the FAA's research and development investments is necessary for the safe and efficient evolution of domestic and international air travel.

7 CRADAs

Other

8 International Vehicles

FAA representatives and researchers hold positions on 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.

Among the FAA's international partners are Transport Canada, National Resource Council of Canada, European Union Aviation Safety Agency, Eurocontrol, Civil Aviation Authority (CAA)-United Kingdom, CAA-Singapore, Brazil's National Civil Aviation Agency, and the Technical University of Denmark. Areas of research include aircraft icing, advanced materials, wake turbulence, and air traffic management collaboration.

The FAA also leverages cooperative agreements with other aviation organizations in Europe, North America, and Asia to participate in aviation safety and air traffic modernization programs, leverage research activities that harmonize operations, and promote a seamless and safe air transportation system worldwide. Examples of these partnerships include agreements with the European Organization for the Safety of Air Navigation, International Civil Aviation Organization, Single European Sky Air Traffic Management Research Joint Undertaking, Japan's Civil Aviation Bureau, and Warsaw Institute of Aviation.

When international agencies are involved in FAA research, it is often because the results have a global reach, and benefit domestic and international partners.





Collaborative Fire Research

Due to the unavailability of original aircraft equipment and environmental regulation requirements, aircraft manufacturers and suppliers are often forced to replace materials, which results in a costly recertification process. This can be of particular concern when trying to recertify materials relating to fire safety. The FAA is currently collaborating with industry to address this. By testing samples of various cabin interior materials, researchers hope to develop new procedures, and create pass or fail criteria for individual components.

As part of this research, the FAA's Fire Research and Safety Team initiated a Material Similarity Task Group within the International Aircraft Materials Fire Test Forum to develop methods and criteria for comparing the flammability of aircraft cabin materials.

This research leverages the FAA's patented microscale combustion calorimeter to test the flammability of materials. When testing is complete, the FAA will issue an advisory circular or policy letter to codify this cost effective FAA safety technology.



The 9th International Conference for Research in Air Transportation (ICRAT) successfully conducted a first ever virtual conference using a combination of synchronous and asynchronous modes.

(September 2020) The FAA's Eric Neiderman, Ph.D., and Eurocontrol's Marc Bourgois jointly chaired the event that supports and encourages innovative research from graduate students and new practitioners in the field.

The virtual conference included approximately 150 participants from 20 countries across 17 time zones. The ICRAT is held in even-numbered years and alternates between U.S. and European host universities. The University of South Florida hosted this year's event, and will host the next in-person meeting in 2022.



Participation in Technical Societies

Professional societies are vital to FAA research. These organizations provide a mechanism to bring together experts, knowledge, and technology for the purpose of sharing information; creating industry standards of conduct; and developing industry design standards for technology, processes, and systems.

The agency's workforce participates as technical society chairpersons, committee and subcommittee members, technical experts, and members of a wide variety of professional organizations.

FAA participation in technical societies includes:



- **Aerospace Medical Association**
- **American Meteorological Society**
- **American Society for Testing and Materials (ASTM)**
- **ASTM International Committee E08 on Fatigue and Fracture**
- **American Society of Mechanical Engineers**
- **DOT Artificial Intelligence Research and Development Task Force**
- **General Aviation Manufacturers Association Simplified Vehicle Operations Subcommittee**
- **Human Factors and Ergonomics Society**
- **International Academy of Aviation and Space Medicine**
- **National Weather Association**
- **SAE Commercial Aircraft Composite Repair Committee**
- **SAE A-21 Aircraft Noise Measurement Aviation Emission Modeling Committee**
- **SAE A-22 Fire Protection and Flammability Committee**
- **SAE G-12 Aircraft Ground De-icing Steering Group**
- **SAE G-34 Committee for Applied Artificial Intelligence in Aviation Systems**
- **Underwriters Laboratories 5800 Battery Fire Containment Products Committee**
- **Vertical Flight Society**



Performance Results

Overview

In support of the FAA's mission, the agency uses research and development (R&D) to support policymaking and planning, regulation, certification, standards development, and modernizing the National Airspace System (NAS). The FAA R&D portfolio supports day-to-day operations in the NAS and balances near-term, mid-term, and long-term aviation needs.

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

1. Improving NAS operations and management capabilities
2. Accelerating the use of new technologies in the NAS
3. Capitalizing on infrastructure use
4. Improving human performance within the system
5. Improving NAS integrated modeling and system-wide analysis

The following sections contain a detailed description of the five FAA goals, followed by a status of the outputs that were planned in FY 2020, and success stories organized by goal. The output charts and success stories provide samples of the research being performed, as well as snapshots of National Aviation Research Plan output performance results and key 2020 R&D results.

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

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

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



Goal 1 Output Status

Output Description	Planned Completion Date	Status	FY 2020 NARP Location
Recommendations for integrated demand management and preconditioning based on lab and/or field trials assessing the feasibility of using strategic traffic flow management tools	9/30/2020	Completed	Page 14
Air traffic operational concepts to optimize airspace and airport capacity in the highly congested Northeast Corridor of the United States	9/30/2020	Completed	Page 15
Recommendations for preliminary air/ground trajectory synchronization implementation and integration of air traffic management functions to enable Trajectory Based Operations	9/30/2020	Completed	Page 15
Air/ground trajectory synchronization prototype version 1.0, which leverages scheduled time of arrival from Time Based Flow Management and En Route Automation Modernization field 10b to improve accuracy of sector loading and arrival demand prediction in the Traffic Flow Management System	9/30/2020	Completed	Page 15
Technical feasibility assessment for air/ground trajectory synchronization prototype version 1.0 to conclude prototype development and validation activities, and also to provide recommendations for future implementation	9/30/2020	Completed	Page 15
Benefits analysis for air/ground trajectory synchronization prototype version 1.0	9/30/2020	Completed	Page 15
Documentation of safety measures justifying procedural changes to reduce the Minimum Radar Separation within 10 nautical miles (nm) of the runway threshold from 2.5 to 2.0 nm	9/30/2020	Delayed	Page 15
Development of methods and procedures for aircraft operating in No Transgression Zones (NTZ) to increase the efficiency of future controller tools and inform procedure and tool development for monitoring departure NTZs	9/30/2020	Completed	Page 15
Technical report on safety assessment of the dynamic wake risk mitigation solution	9/30/2020	Completed	Page 16
Validation plan for Established on Required Navigation Performance pure duals independent operations concept	9/30/2020	Completed	Page 17
Gap analysis between 1) applicable commercial space regulations, vehicle profiles and performance characteristics and 2) current airport design guidance, standards, and regulations	9/30/2020	Delayed	Page 18
Technical transfer to industry (through report documentation) of Small Airport Surveillance Sensor cooperative surveillance capability for Mode S and Air Traffic Control Radio Beacon System targets	9/30/2020	Delayed	Page 18
Needs analysis document that reflects the current state of demand for unmanned aircraft systems (UAS) users to prioritize NAS system requirements development areas	9/30/2020	Completed	Page 19
Concept of Operations (ConOps) for Class E Upper Airspace Traffic Management to develop a vision for upper airspace operations, encompassing the range of operational mission characteristics in this airspace; including geostationary, extreme velocity, and long-duration operations	4/30/2020	Completed	Page 20
ConOps for urban air mobility to develop an airspace management concept that describes a vision for emerging flight operations and their interaction with UAS traffic management (UTM) and air traffic management	8/1/2020	Completed	Page 20
ConOps document for integrated UTM operations	9/30/2020	Completed	Page 20
UTM flight information management for integrated operations use cases, operational views, information flows and exchanges, and roles and responsibilities allocation tables	9/30/2020	Completed	Page 20
Technical deep dive analysis report on UAS automation systems	9/30/2020	Completed	Page 20
ConOps document for UAS lost-link procedures	9/30/2020	Completed	Page 20
Development of scenarios to dynamically use operator-submitted trajectory preferences	9/30/2020	Completed	Page 25

Performance Results

Goal 1 Success Stories

Localized Aviation Model Output Statistics Program (LAMP)

– The LAMP system provides aviation forecast guidance for over 2,000 locations in the contiguous United States, Alaska, Hawaii, and Puerto Rico. The hourly weather updates are valid over a 25-hour period. During FY 2020, the FAA Weather Program funded and added several forecast improvements to the LAMP system as part of a National Weather Service (NWS) software update. These improvements include enhancing ceiling, visibility, and obstruction-to-vision guidance, as well as expanding information over offshore regions.

The release also included a forecast extension from 25 to 38 hours for ceiling, visibility, obstruction to vision, and probability of precipitation. These improvements provide NAS safety benefits by incrementally improving weather information so that pilots can avoid flying into adverse conditions. Improved ceiling and visibility forecasts support improved efficiency if used to proactively manage air traffic. The LAMP model also supports Terminal Aerodrome Forecast, a format for reporting weather forecast information.

Visibility Estimation through Image Analytics (VEIA) Algorithm

– In March 2020, the Weather Program, in collaboration with the agency's Aviation Weather Cameras program (AvCams), began an experimental demonstration of the VEIA capability. The VEIA algorithm estimates visibility using the AvCams camera imagery by identifying edges in the image and comparing the strength of those edges with a synthesized clear day image. The algorithm utilizes the strong correlation between the edge strength ratio of the two images and the meteorological visibility to provide visibility estimates where traditional meteorological observations are not available. [FAA Weather Cameras](#) are available online.

The addition of the VEIA algorithm to AvCams is a major advancement in support of aviation safety in Alaska, where it can be difficult to obtain accurate reports of visibility conditions. Traditional weather observations are widely dispersed and inadequately forewarn of hazardous weather that could be encountered at remote airstrips, along heavily traveled routes, or through mountain passes. The VEIA algorithm transforms FAA weather cameras located throughout Alaska into automated visibility sensors. VEIA's output can be utilized directly by pilots or integrated into automated weather products and may serve as a cross-check capability for traditional visibility sensors.

Helicopter Emergency Medical Services (HEMS) Tool

– The HEMS Tool is a web-based interactive display of multiple weather products specifically designed to support short-distance and low-altitude helicopter flights common among emergency responders. After receiving FAA approval, five upgrades to the HEMS Tool were put into operation

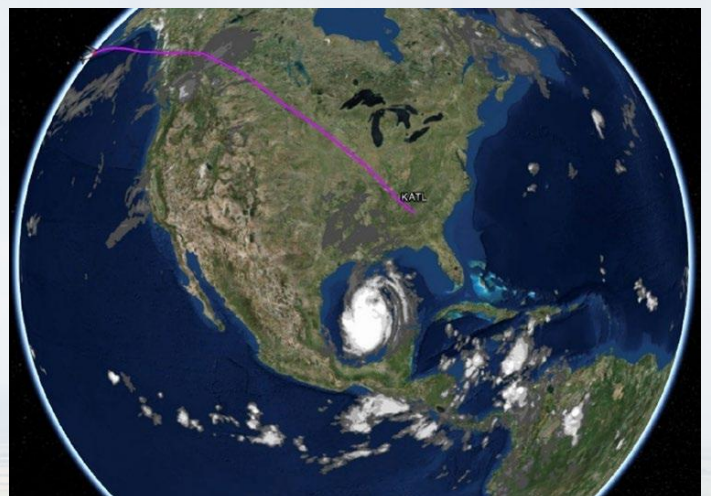
by NWS in March 2020. The changes include usability upgrades and a new hourly ceiling and visibility forecast out to six hours. The improved [HEMS Tool](#) is available online.

Icing Product (IPA) – Utilizing output from a numerical weather prediction model, the IPA creates a gridded display showing the probability of icing, the severity of that icing, and the potential for hazardous freezing rain or drizzle to occur. In 2020, the FAA developed and delivered the IPA to the National Oceanic and Atmospheric Administration-NWS Aviation Weather Center. While final implementation of IPA on a NWS platform is currently delayed, the NWS Alaska Aviation Weather Unit will continue to use an experimental IPA feed to provide the location with supplemental information to enhance official icing forecasts. This product will greatly benefit aviation safety in Alaska, especially for General Aviation.

Remote Oceanic Meteorology Information Operational (ROMIO)

– The Weather Technology in the Cockpit (WTIC) program's ROMIO demonstration evaluated the feasibility and benefits of uplinking two weather products used to show thunderstorm activity directly into the flight deck of commercial aircraft on transoceanic routes, and demonstrated ways to use these products. The FAA accepted a final benefits analysis report for the ROMIO demonstration in 2020.

The report identified and quantified numerous benefits including an estimated reduction of 48.3 million kilograms of carbon dioxide for the participating airlines, reductions in the average number of weather- and traffic-related deviations per flight, and a 20 percent reduction in the probability of encountering high-exposure thunderstorms that could cause injuries and damage to aircraft.



Cloud Top Height view of Hurricane Delta produced by ROMIO from an airline cockpit viewer.

The ROMIO project also completed another benefits analysis which included more preliminary results. This interim report presented analyses of 18,326 flights from March 2018 to August 2019 that crossed the Inter-Tropical Convergence Zone, an area of low pressure which circles the Earth near the equator.

Crowdsourcing Information to Improve Pilot Perception – In 2020, the WTIC program finished collecting data to evaluate pilot perception of information presented in FAA aviation weather camera images. The purpose of this study was to identify specific aspects of the photographs — such as obstructions to visibility, flight obstacles, and areas of low ceiling and visibility — that can be derived using crowdsourcing techniques. By converting camera images into digital and textual information, data can be uplinked in a low-bandwidth format and made available to flight service stations for easy dissemination by voice.

Automatic Dependent Surveillance–Broadcast (ADS-B) Vertical Rate for Turbulence Information – While turbulence is normal and happens often, it can be dangerous and cause injuries to passengers and crew of an aircraft. In 2020, the FAA's WTIC program presented a final briefing on the feasibility of using ADS-B information to calculate turbulence. ADS-B replaces radar technology with satellites to track aircraft movements and broadcasts information about an aircraft's GPS location, altitude, ground speed, and other data to ground stations and other aircraft, once per second.

Aircraft are sometimes diverted away from turbulence to prevent encountering the unstable air. There are times, however, when turbulence is not actually present and a reroute is not needed. ADS-B turbulence research studied sample aircraft data and successfully demonstrated that a method called "zero crossings" is an effective way to identify particular aircraft maneuvers and prevent them from triggering false alarms of turbulence encounters. The estimated output rate of turbulence information is approximately once per minute on any ADS-B-equipped aircraft.

The study showed clear potential to provide meaningful turbulence information to the cockpit using vertical rate information provided by ADS-B downlinked reports. This information can also be used to enhance the accuracy of turbulence products such as the Graphical Turbulence Guidance Nowcast.

Researchers found that the methodology and algorithms have the potential to increase the number of turbulence observations by multiple orders of magnitude, as well as provide more accurate information than pilot reports, or PIREPs. This could help forecasters spot turbulence and allow them to share the information sooner with pilots.

Performance Results

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

The advancement and introduction of non-traditional aviation industries are pushing the boundaries of technology into all corners of the National Airspace System (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 providing decision makers essential data, and analysis of that data, 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.

Goal 2 Output Status

Output Description	Planned Completion Date	Status	FY 2020 NARP Location
Training videos, guidance material, and advisory circular support for research that leads to proposed new aircraft material flammability standards	9/30/2020	Completed	Page 31
Documentation of unmanned aircraft systems (UAS) automation/autonomy experimentation to support regulatory guidance	9/30/2020	Delayed	Page 33
Safety/cost-benefit analysis detailing the environmental impacts, health effects, and capital costs regarding a change in the composition of conventional jet fuels	9/30/2020	Delayed	Page 34
Summary of experimental data that was acquired, and analyses that were performed, to inform the development of an engine particulate matter emissions standard in the International Civil Aviation Organization (ICAO) Committee on Aviation Environmental Protection	9/30/2020	Completed	Page 35
Evaluation of current state of research supporting UAS Human-Automation Interaction requirements in support of regulatory guidance	9/30/2020	Delayed	Page 35
Technical analyses to support the inclusion of sustainable aviation fuels created from waste and biomass feedstocks and lower carbon aviation fuels created from fossil feedstocks, within the ICAO Carbon Offsetting and Reduction Scheme for International Aviation	9/30/2020	Completed	Page 35
Continuous Lower Energy, Emissions, and Noise Phase II activities to demonstrate certifiable aircraft and engine technologies and to enable industry to expedite introduction of these technologies into current and future aircraft	9/30/2020	Delayed	Page 37

Goal 2 Success Stories

Engine Testing for Alternative Fuel Formulations – General Aviation supports 1.2 million jobs directly or indirectly, and contributes over \$247 billion to the U.S. economy, including a \$75 billion positive effect on the balance of trade (2018 figures). This economic benefit is at risk unless the existing fleet of 170,000 aircraft can safely transition to unleaded fuels. Aviation gasoline (avgas) is the only remaining transportation fuel in the United States that contains lead.

In 2020, the FAA completed additional combustion research testing with one of the prospective fuel companies on their unleaded avgas candidate fuel under a pre-established Cooperative Research and Development Agreement. Testing consisted of engine flight cycle testing on a high fuel flow, turbo-charged aircraft engine. The data from this research builds upon prior testing and will be used to develop additional research plans, support refinement of the company's fuel formulation, and create an ASTM fuel specification.

The FAA completed detonation testing on alternative fuel formulations through a memorandum of understanding with a second of the prospective fuel companies. The company used the data from this second phase of testing to refine their fuel formulation and support efforts to develop an ASTM fuel specification.

The FAA is using data from both of these tests as part of the Piston Aviation Fuel Initiative to meet the objectives of section 565 of the FAA Reauthorization

Act of 2018, which requires the FAA Administrator to authorize an unleaded replacement fuel for General Aviation upon determining there is a qualified, safe alternative.

Aircraft Cabin Fire Smoke Toxicity – The FAA filed a patent application for a new and useful method to measure the toxins generated by cabin materials over a full range of conditions in aircraft cabin fires, from early stage (oxygen rich) to late stage (oxygen starved), where toxic gases are produced. Researchers developed the method by modifying the FAA's patented microscale combustion calorimeter — a research tool used to improve fire safety of aircraft materials — to allow high-temperature combustion (greater than 1300°C) of fire gases at controlled fuel/oxygen ratios.

Aerosol Can Explosion Simulator – Researchers developed designs and procedures to update a simulator used to test aerosol can explosions.

A team of experienced fire safety technicians met through weekly teleconferences to discuss overhauling the prototype apparatus designed by the FAA in the 1990s. The simulator mimics the result of an aerosol can packed in a passenger's bag upon exposure to a cargo compartment fire. The simulation has become a required component of the FAA's minimum performance standard for cargo-compartment halon-replacement agents.

During the meetings, the team proposed improvements that will resolve existing shortcomings, as well as, several new functional improvements. These include updating the constituent fill procedure and design, installing a more robust pressure gauge and pneumatic valve, using an enhanced heat tape, and creating a lighter support structure.

The redesigned simulator will need 50 percent less time for refilling, and a single technician to perform refills and test location placement. Upgraded safety features will prevent

continued on p.22



Researchers test an aerosol can simulator explosion in a DC-10 cargo compartment.



Performance Results

Goal 2 Success Stories (continued)

accidental discharges and make removal of aerosol contents easier. Once a prototype of the new simulator is ready, the team intends to review the testing procedures and identify ways to add remote engineering controls to the device so testing capacity can increase from two to four tests per day.

Freight and Fuel Transportation Optimization Tool (FTOT) – The FTOT tool analyzes transportation needs and limitations associated with fuel and raw material collection, processing, and distribution in the continental United States. As of 2020, the public version of the FTOT is available and can be downloaded from GitHub.

The FTOT suggests optimal routes for transporting freight and fuel across the country. The FAA uses the tool to identify barriers in the alternative jet fuel supply chain that must be overcome to effectively produce and market fuels. The FTOT is distributed freely to support the development and expansion of this emerging industry. The tool was developed at the Volpe National Transportation Systems Center on behalf of the FAA, Department of Energy, and the U.S. Navy's Office of Naval Research.

Structurally Efficient Wing Technology – Boeing has completed development and testing of a structurally-efficient wing technology under the FAA's Continuous Lower Energy, Emissions, and Noise program. The company developed a combination of materials and manufacturing technologies over a 5-year period to reach this stage. The technology is expected to yield up to 3.5 percent in fuel burn reduction when applied to future aircraft designs.

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

The FAA and industry use a probabilistic damage tolerance based design code called the Design Assessment of Reliability with Inspection, or DARWIN®, to help predict and prevent these types of failures. Manufacturers use the software code to design and certify life-limited engine parts that need to be replaced on a regular basis due to wear and tear during the life of an aircraft.

To expand DARWIN®'s capabilities to address other classes of life-limited engine parts, a new capability was recently added which now allows it to analyze cracks in hollow cyl-

inders. The new capability will be directly applicable to engine shafts and engine cases and will significantly expand DARWIN®'s capabilities beyond rotors. This new solution has already been implemented into DARWIN® 9.4. More information regarding DARWIN® is available online.

Integration of Expanded and Non-Segregated UAS Operations – The FAA hosted a peer review panel to evaluate a research task plan submitted by Ohio State University, the FAA Center of Excellence (COE) for Unmanned Aircraft Systems (UAS) research, on the safe integration of small Unmanned Aircraft Systems (sUAS) into the NAS. The plan, called "Integration of Expanded and Non-Segregated UAS Operations into the NAS: Impact on Traffic Trends and Safety," aims to provide insight through the forecasting of drone operations using operational trend analysis and a risk framework development.

The panel consisted of members from NASA, Department of Homeland Security, Boeing, and various FAA safety offices, who collectively assessed the project's research questions, objectives, scope, expected outcomes, and planning documents. After the COE presented a project overview, including its planned experimental approach, the panel responded with positive feedback on the project direction and approach with minor suggestions for refinement and improvement. The COE incorporated the panel's feedback and is now proceeding with the first phase of research.

Small Unmanned Aircraft Systems – Operators of small drones are currently required to fly the devices within view, or visual line of site. There is a desire, however, to eventually allow sUAS operations beyond visual line of site so businesses can take advantage of the technology, such as cargo delivery, infrastructure inspection, and passenger transport.

The FAA is working on standards to ensure sUAS flown beyond visual line of sight are safe. The sUAS detect-and-avoid requirements for a beyond-visual-line-of-sight operations project began flight testing in 2020 to address this issue. The activity was hosted by the University of North Dakota in conjunction with the Northern Plains UAS test site.

The purpose of the testing was to examine a methodology for evaluating the ability of a detect-and-avoid system to conform to a proposed standard. Having a robust, safe detect-and-avoid system is one of the requirements needed to safely complete beyond-visual-line-of-sight operations. Enabling these operations is one of the key capabilities needed to safely integrate UAS into the NAS.



Performance Results

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 National Airspace System (NAS). Research under this goal includes airport runways, taxiways, air traffic management, and aircraft systems and networks, as well as electrical airport sub-infrastructure 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.

Goal 3 Output Status

Output Description	Planned Completion Date	Status	FY 2020 NARP Location
Pavement prediction modeling tools based on pavement, traffic, and/or environmental inputs that yield extended pavement life performance indexes	9/30/2020	Completed	Page 42
Establishment of a Cyber Integrated Mitigation Identification and Evaluation Process (MIDEP) for application to selected safety risk assessment (SRA) risks	9/30/2020	Completed	Page 44
Periodic cyber SRA reports identifying apertures, vulnerabilities, and risks associated with individual avionics SRA subjects, along with assessment conclusions and recommendations	9/30/2020	Completed	Page 44
Cyber technical findings from applying the MIDEP to identified aircraft cyber safety risks	9/30/2020	Completed	Page 44
Cybersecurity risk assessment report on flight deck electronic flight bag and aircraft interface device technologies and architecture	9/30/2020	Completed	Page 44
Cybersecurity risk assessment report on flight deck internet protocol data-link technologies and architecture	9/30/2020	Completed	Page 44

Goal 3 Success Stories

Flight Deck Collaborative Decision Making (FD CDM) – Collaborative Decision Making is a joint FAA and aviation industry initiative to improve the flow of air traffic through the increased exchange of information. The FAA's FD CDM program develops tools to support streamlined communications between flight crews and air traffic managers using connected aircraft technologies and the System Wide Information Management system.

In FY 2020, the FAA completed a functional analysis and initial architecture design for a tool that would allow pilots to receive digital taxi instructions to guide the flight crew along the airport surface. Digital taxi instructions would improve situational awareness of surrounding ground traffic, improve surface navigation for all aircraft on the airport surface, and reduce verbal communication between flight crews and air traffic controllers, reducing the risk of miscommunication.

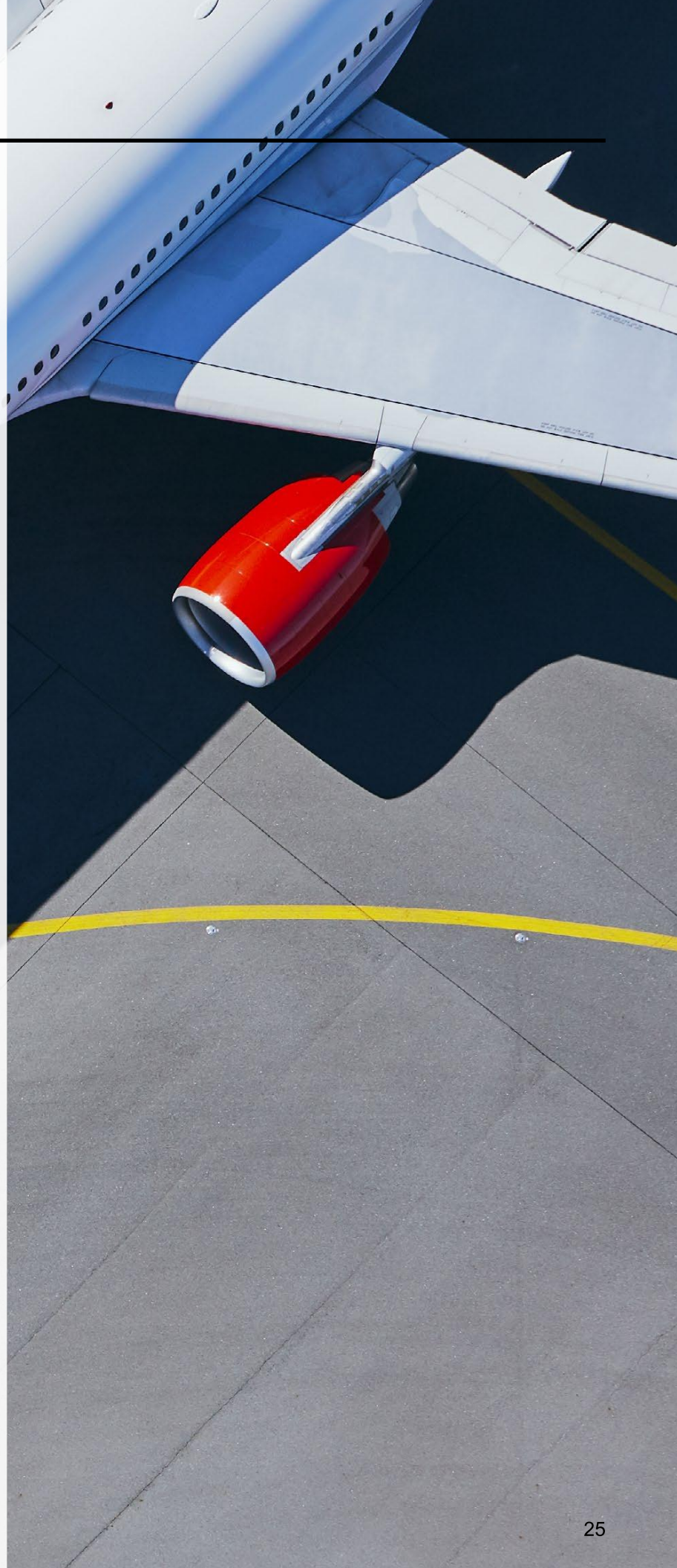
Electronic Flight Bags and Air-ground Data Links – Recent advancements on the aircraft flight deck include rapidly expanding applications for electronic flight bags (EFB), high-bandwidth air to ground data links using internet protocols, and leveraging aircraft interface devices to perform real-time analysis. These advances and additional information enable system-wide information sharing and allow the flight crew to more fully and collaboratively participate in air traffic management decisions. Connected systems, however, are not without risk.

Through the Flight Deck Data Exchange Requirements project, researchers identified initial cybersecurity concerns and recommended security controls for these tools. By implementing these controls, data exchange can be permitted over commercial IP datalinks, which will improve airspace safety and efficiency while reducing industry investment.

Aircraft Systems Information Security/Protection (ASISP)

– The ASISP program focuses on protecting aircraft networks and systems from cyber attacks. Researchers concluded the third phase of the program in the third quarter of FY 2020, which focused on executing cyber Safety Risk Assessments (SRA). The team developed a methodology to conduct multiple “prototype” SRAs, including a joint assessment with industry on flight management systems, which are the computers used by flight crews aboard aircraft.

Some of the prototype assessments helped address concerns regarding EFBs and field-loadable software, as well as recommendations from the Aviation Rulemaking Advisory Committee. Researchers used information from the EFB assessment to provide guidance to modify the cybersecurity section of Advisory Circular 120-76, “Authorization for Use of Electronic Flight Bags.” The methodology has also been adopted for trial use by the Cyber Safety Commercial Aviation Team.



Performance Results

Goal 4: Improve human performance within the system

Advanced technologies and capabilities challenge human operators and maintainers, including aircraft and unmanned aircraft systems (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 aeromedical factors related to an individual's ability to meet flight demands. Optimized human performance is fundamental to the safe operation of the NAS and inherent to the safety of the airspace community, especially the flying customer, who relies on the FAA to provide the safest air transportation system in the world. Research includes passenger safety in flight and during emergencies.

Goal 4 Output Status

Output Description	Planned Completion Date	Status	FY 2020 NARP Location
Development of an empirically-validated color palette useful to color vision deficient controllers, to be referenced in the air traffic control (ATC) display color standard, for use in future ATC display acquisitions	6/30/2020	Completed	Page 51
Initial report on operational analysis of speech recognition technology application for traffic flow management	9/30/2020	Completed	Page 51
Study of transportation accident rates involving operators at various concentrations of cannabinoids (DELTA-9-THC and/or 11-NOR-9-CARBOXY-THC)	9/30/2020	Completed	Page 54
Study outlining guidance, training, and research strategies to improve human physiologic response in three different hypoxic environments	9/30/2020	Completed	Page 54

Goal 4 Success Stories

Airliner Cabin Safety – Improving crash safety and survival is of paramount concern to the FAA and its counterparts around the world. In the first quarter of 2020, the FAA's Cabin Safety, Crash Biodynamics, and Engineering Sciences teams, jointly offered 11 presentations on aeromedical research at the Triennial Fire and Cabin Safety Conference.



CAMI's BioMark instrument is capable of large-scale testing of biological specimen for the presence of COVID-19 through gene expression analysis.

These presentations distribute research accomplishments in these areas to the international community, which will use the research results to improve the global safety of the aerospace system.

COVID-19 Testing Assistance – Coronavirus is an illness caused by a virus that can spread from person to person. The SARS-CoV-2 (COVID-19) strain of the virus was designated as a worldwide pandemic in 2020. Testing for COVID-19 helps identify those who are infected, allowing earlier treatment and self-quarantine to prevent the spread of the virus.

The FAA's Bioaeronautical Sciences Research Laboratory at the Civil Aerospace Medical Institute (CAMI) loaned a testing instrument, called the BioMark HD,

to the Oklahoma Medical Research Foundation and Oklahoma University Medical Center. The instrument dramatically increased Oklahoma's COVID-19 testing throughput — enabling many hundreds of thousands of samples to be analyzed each day while using only about 10 percent of the reagent used in standard tests.

Seat Pitch and Width – The ability of passengers to move from their seats to available exits in an emergency is a key element of occupant safety. Seating arrangement has a direct impact on evacuation time. Airlines and airframe manufacturers are proposing new ways to improve customer comfort while maximizing the use of space by varying seat pitch and width.

CAMI presented a live feed of seat pitch and width experimental test scenarios to the Evacuation Aviation Rulemaking Committee. Researchers demonstrated test methods, procedures, and equipment. This event effectively addressed prior industry concerns about the realism of the tests and the ability to draw conclusions from the simulation results.



Passengers exit an aircraft during an experimental test scenario.

Flight Deck Interval Management – Interval Management consists of a set of ground and flight deck capabilities and procedures used in combination by air traffic controllers and flight crews to more efficiently and precisely manage spacing between aircraft in a stream of traffic. During an Interval Management operation, the controller instructs the flight crew to achieve and maintain a particular amount of space from another aircraft. The flight crew will use the aircraft's computer system, or flight deck, to follow the instruction. Human factors researchers from the FAA, in coordination with RTCA and the European Organization for Civil Aviation Equipment, have recommended the removal of a requirement in the minimum operational performance standards for Flight Deck Interval Management. Researchers came to this conclusion using simulation results to clarify pilot roles and responsibilities, and develop general guidance on how to better display interval management notification on auxiliary displays in a way that will better capture the flight crew's attention.



Human factors researchers measure a participant's cognitive activity in an air traffic control simulation.

Optimization of Air Traffic Control Information Presentation (OAIP) – The OAIP project created a new human-in-the-loop simulation in 2020 that integrates seven new technologies for high-altitude air traffic control. Prototypes of the new technologies already exist separately, but until now, no other platform existed for human factors researchers to examine these technologies simultaneously. Using the latest tools for measuring human perception, attention, and cognition, researchers conducted a high-fidelity simulation examining the effects of the new technologies on controller performance in high-altitude airspace, including visual scanning, mental workload, and decision making.

Human factors studies are used to create future system improvements and training programs that will make the NAS safer, more efficient, and more flexible by addressing issues such as increased human error, increased distraction or information overload, increased workload, and reduced situational awareness.

Stress Management Training for Future Air Traffic Controllers – CAMI's Aerospace Human Factors Research Division developed a stress management course to help air traffic control trainees during FAA academy training. The course covered stress and stressors, consequences of stress, and strategies for effectively managing stress. Results from the training evaluation found positive gains in trainees' stress management knowledge, confidence, and use of stress management techniques during training. Trainees reported the course was informative, engaging, and important to their success. The stress management course was formally incorporated into the air traffic controller training curriculum.

Stress Management Quick Tips



Progressive Muscle Relaxation

Actively tense a muscle group, hold for 5 seconds; release and repeat; focus on the release feeling



Diaphragmatic Breathing

Breathe in through your nose filling your lower lungs and expanding the diaphragm; hold; breathe out through your mouth; decreases heart rate and reducing physiological reaction to acute stressors



Journaling

A form of communication to release stress through writing; Logging stress is a more targeted way to manage events contributing to stress experiences; Also log things that reduce your stress



Rational Self Talk

Evaluate initial responses to stressful events and reframe into a positive, rational thought; helps to restructure reactions to stress and remain mindful



Compartmentalization

A technique that involves temporarily ignoring distractions and stressors to focus on the task at hand; good for short, acute stressors



Meditation

Focus on an object or activity until the body reaches a calm, physical and mental state; practicing for as little as three minutes can improve stress



Sleep

Stick to a schedule; spend at least 30 minutes outside daily; avoid bright lights at bedtime; avoid caffeine, alcohol, and nicotine before bed



Mindfulness

Focus on the "now"; Self-awareness of your current thoughts and surroundings; helps with relaxation



Exercise

Improves your mood, increases endorphin production; the "feel-good" neurotransmitter

Performance Results

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

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

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

Goal 5 Output Status

Output Description	Planned Completion Date	Status	FY 2020 NARP Location
Development of recommendations for accelerating access in higher airspace for integration of commercial space operations in the near term by leveraging current National Airspace System (NAS) capabilities	9/30/2020	Completed	Page 61
Probabilistic modeling toolset for estimating the decreased/increased wake encounter risk resulting from proposed changes in NAS airspace design or air traffic control procedures	9/30/2020	Completed	Page 61
Integrated Domain-Safety Risk Evaluation Tool that will include a model of NAS systems and procedures, as well as their interfaces linked to NAS safety data	6/30/2020	Completed	Page 62
Semantic data mining tool development for the enhancement of the FAA's ability to detect risk, and provide insight into the trends and locations of unsafe events	9/30/2020	Delayed	Page 62
Development of predictive methodologies, and a survey of artificial intelligence applications and hardware across industry and academia to evaluate existing approaches that can be adapted to safety analytics	9/30/2020	Completed	Page 62
Enhanced simulation modeling framework deployable across the NAS enterprise cloud infrastructure	9/30/2020	Delayed	Page 62

Goal 5 Success Stories

Emerging Metallic Structures Technology – Aircraft manufacturers are increasingly using emerging metallic structures, including advanced alloys and hybrids, which are stronger and lighter than metals commonly used to build older aircraft. These new technologies and the risks they pose as they age are not as well understood as the traditional systems they replace. The FAA is examining structural integrity issues associated with emerging metallic structures used in fuselage designs and creating testing tools to ensure these new materials are safe.

Through a Cooperative Research and Development Agreement (CRADA) with Arconic, the FAA completed testing on a baseline fuselage panel made with conventional materials and processes at the agency's Full-Scale Aircraft Structural Test Evaluation and Research facility. The resulting data provides researchers with the information needed to evaluate damage tolerance performance of new panel designs made with emerging metal technologies. Researchers conducted fatigue testing on a second panel constructed with an advanced aluminum-lithium alloy. Results revealed slower crack growth behavior in the second panel compared to the first.

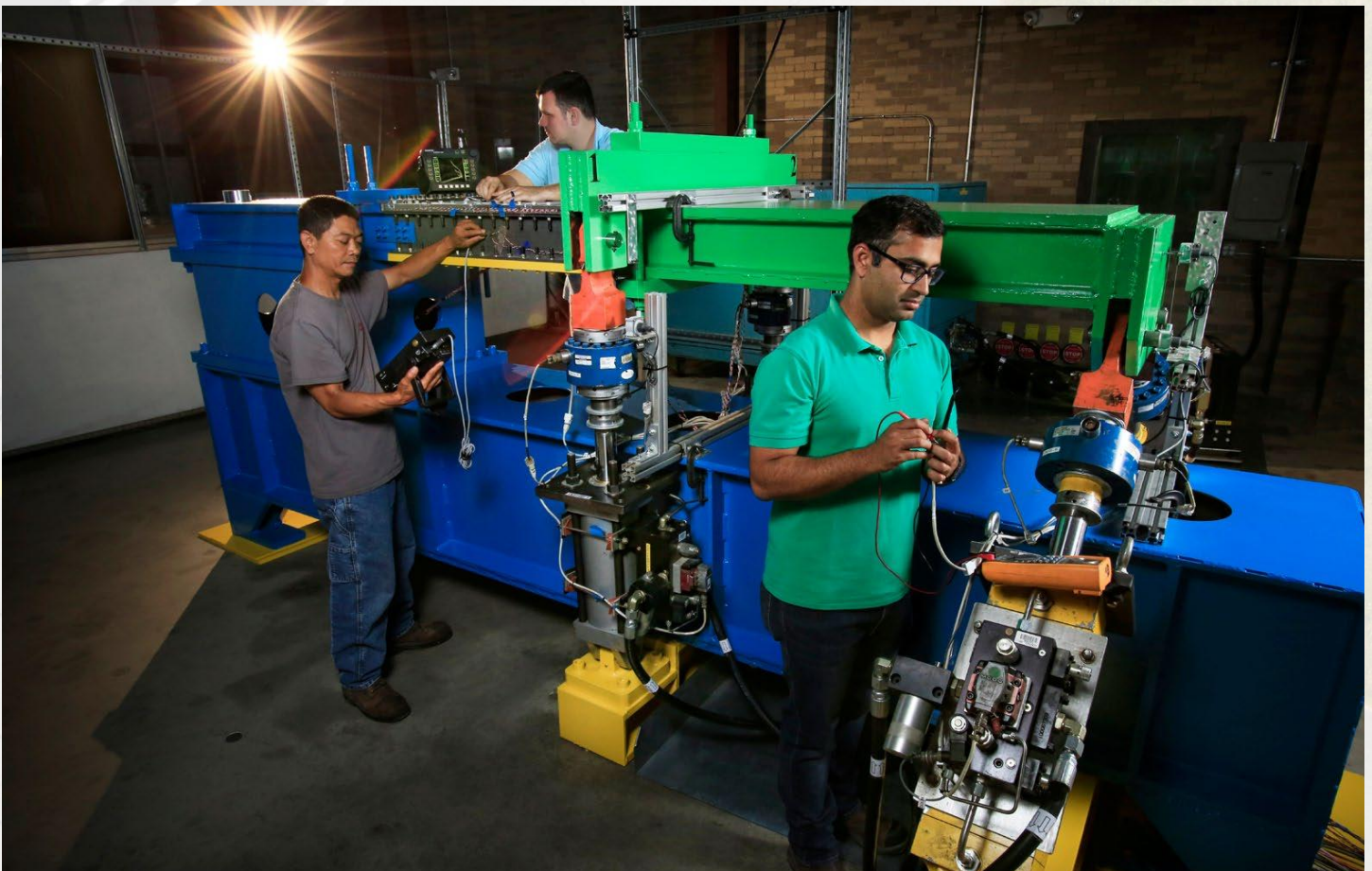
Metallic Material Properties Development and Standardization (MMPDS) – The FAA participated in the 35th MMPDS Coordination Committee Meeting from March 24 to April 6, 2020. Sessions were held by teleconference in response to the COVID-19 pandemic. The meeting was spread over three weeks in two-hour, daily intervals for the four major task groups: emerging technology, guidelines, fasteners, and materials. Over 70 representatives from material suppliers and users around the world attended the meeting. Participants finalized eight agenda items and identified projects scheduled for final approval. Approved items will be included in the next version of the MMPDS handbook.

Aircraft Beam Structural Testing – Bonded repairs are those that blend complex-shaped patches into aerodynamic surfaces. Under a CRADA, the FAA and Boeing investigated safety and structural integrity issues with bonded repair technology applied to composite wing panels.

Tests were conducted using the Aircraft Beam Structural Test fixture housed at the FAA's Structures and Materials Laboratory. Researchers assessed size limits for several types of wing repairs using solid composite laminates.

Results determined that a single-sided repair in a double-sided through-the-thickness repair configuration did not properly restore the strength of the composite wing panel.

Pilot Safety Training Video – When a flight crew decides not to continue on an approach to land, the procedures that follow are called a go-around. During a go-around, the pilot attempts to make another landing or diverts to another location. The FAA created a training video to help pilots improve safety during go-arounds using the FAA's A330 full flight simulator. The video was developed and recorded through a collaboration between the FAA's William J. Hughes Technical Center, Mike Monroney Aeronautical Center, and Embry-Riddle Aeronautical University, as part of the FAA's System Safety Management program. The video will be used to develop a multimedia training program for pilots.



The Airframe Structural Beam Test apparatus evaluates wing and stabilizer panels under realistic flight load conditions.

Research Deployed

The FAA Research and Development portfolio is a robust, productive collection of 25 research programs spanning multiple research domains — a grouping of programs with a common focus area or body of knowledge. These domains are airport technology, aircraft safety assurance, digital systems and technologies, environment and weather impact mitigation, human and aeromedical factors, and aviation performance and planning.

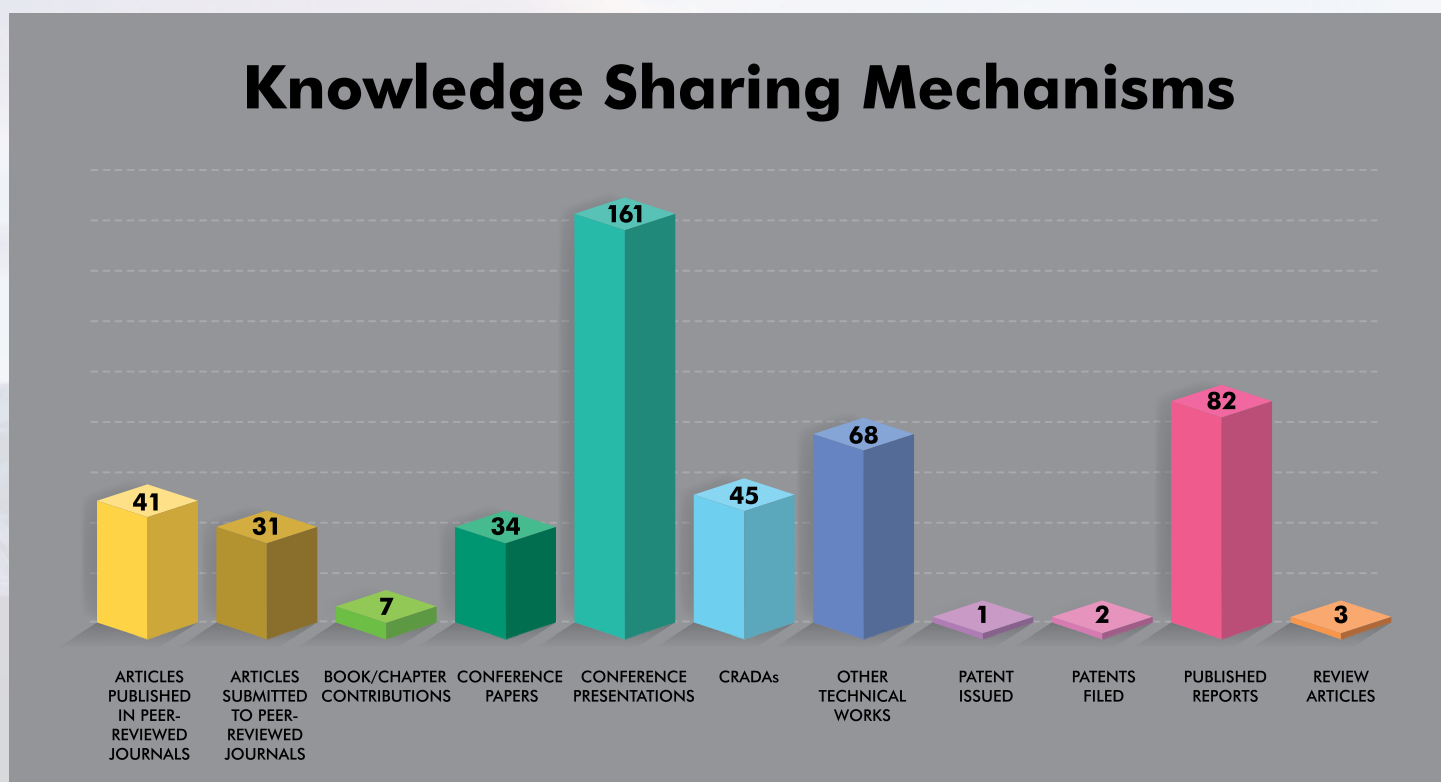
The objective of FAA research is to enhance aviation safety, promote National Airspace System (NAS) efficiency, and foster global harmonization. The agency benefits the American public and the nation's economy by leveraging agency knowledge, facilities, and capabilities to fulfill public and private sector needs. The FAA broadly disseminates findings to other agencies, industry, and professional organizations through a variety of mechanisms.

Technology Transfer

The FAA's knowledge sharing mechanisms include physical results, as well as other equally important collaborations and partnerships. Through the Technology Transfer program, the agency shares a range of information from formal reports, standards, software, and patents to technical knowledge, innovative ideas, and new processes or practices.

In FY 2020, the FAA produced advisory circulars, engineering briefs, orders, statutes and regulations, and over 500 other research products including more than 200 conference presentations. In addition to these formal products, the FAA collaborated with other federal agencies, universities, industry, and standards-setting organizations to share expertise and resources to promote national, Department of Transportation, and agency goals.

The FAA Technical Transfer program is in the process of framing an overarching plan to effectively capture the broad range and number of products produced across the agency.



The figure illustrates knowledge transfer captured through data calls conducted by the Research, Engineering, and Development portfolio group.

Successful FY 2020 FAA Technology Transfer Collaborations

UAS Disaster Preparedness and Response – In FY 2020, the FAA conducted numerous interviews, outreach projects, and workshops in support of the FAA Reauthorization Act of 2018, section 359, requiring the FAA to study Unmanned Aircraft Systems use by fire departments and emergency services agencies.

The team interviewed disaster relief workers and emergency responders, including government agencies such as FEMA and Department of the Interior, as well as local and state emergency response teams. This research included a historical literature review. The findings and resources used during this effort were successfully transitioned over to the Alliance for System Safety of UAS through Research Excellence for further research.

Stationary Doppler Target Suppressor (SDTS) Radar Detector – The FAA received a patent for the tool in FY 2020. The SDTS improves detection of targets in the vicinity of cluttered environments such as wind farms, and reduces false alarms resulting from wind turbines and other complex structures in such busy settings.

This invention is a critical improvement in the detection of airborne targets over and around the vicinity of wind farms and utility grade wind turbines, which severely impact radar systems used by the DoD, Department of Homeland Security, and FAA.

The tool roughly doubles radar system performance in wind farm areas and reduces false target detections of turbines by half, resulting in a significantly improved view of the skies for all operators. The software-based invention functions so well that it has been deemed by the North American Aerospace Defense Command and U.S. Northern Command as a mitigation approach for deployment of new wind farms.

The FAA was awarded United States Patent No. 10,514,454 on December 24, 2019 for this invention. The tool is available for license from the FAA Technology Transfer Office.

Integrated Domain Safety Risk Evaluation Tool (ID-SRET) – The FAA completed development of the ID-SRET, a prototype tool that provides the agency's Air Traffic Oversight Service (AOV) a comprehensive platform to analyze and evaluate the safety impact of NAS-wide and air traffic control procedure changes. The new tool will support AOV's risk-based decision making.



FAA Weather Courses – The FAA completed 10 mini-weather courses to assist flight instructors in teaching weather. The courses, which qualify for [FAA WINGS](#) pilot proficiency credit, address gaps in pilot weather knowledge.

The FAA's Weather Technology in the Cockpit program transitioned the courses to the National Association of Flight Instructors (NAFI) during a Mentor Live presentation focused on teaching summer weather.

Metro Aviation, an air medical helicopter and maintenance service, reported that portions of the Mentor Live content will be incorporated into the company's pilot weather training. Beyond use by flight instructors, the training aids transitioned to NAFI can also be used by student pilots for self-paced learning. Based on feedback from NAFI, the products transferred are anticipated to reach thousands of flight instructors through the recorded session, in addition to 450 attendees of the live session. NAFI has since posted links to the courses online so their instructors can use them to teach student pilots about weather.

Ballistic Impact Simulations of an Aluminum 2024 Panel – The FAA's Aircraft Catastrophic Failure Prevention program develops data and methods to study uncontained engine fragment impacts. This occurs when engine parts break due to abnormalities in the metal and fragments escape the engine case, striking other parts of the aircraft. The program provides analytical tools to evaluate engine containment mechanisms and protect critical systems that may need shielding from uncontained engine debris.

Through the LS-DYNA® Aerospace Working Group — a partnership of government, industry, and academia — the FAA works with industry to improve modeling and dynamic analysis methods used for engine certification and compliance. The program published a [technical report](#) validating a new material and failure model for an aluminum alloy recently developed (*MAT_224 for Aluminum 2024) for use with LS-DYNA® software.

Research Deployed

Technology Transfer Collaborations (continued)



The update improves the numerical modeling of turbine engine blade-out containment tests and assesses uncontained threats to aircraft structures. The model inputs were derived from laboratory specimens designed to characterize the temperature, strain rate, and complex fracture effects on the alloy. The simulations accurately predicted a series of 34 ballistic impact tests conducted at NASA's Glenn Research Center without making any modifications to the material input, representing a major milestone in the project. The study validates the recent model under challenging realistic conditions, featuring heavy blade root shaped block projectiles impacting aluminum target panels.

International LS-DYNA® Conference – Representing the Aircraft Catastrophic Failure Prevention program, Daniel Cordasco delivered a keynote speech at the 16th International LS-DYNA® Conference. The event was held virtually as part of the Ansys Simulation World event in June 2020. Over 2,700 participants from industry, government, and academic institutions from around the world attended the conference.

Cordasco's presentation titled, "The Long and Winding Road towards a Predictive Material and Failure Model for Aluminum 2024-T351 Undergoing Impact," received over 800 unique views.

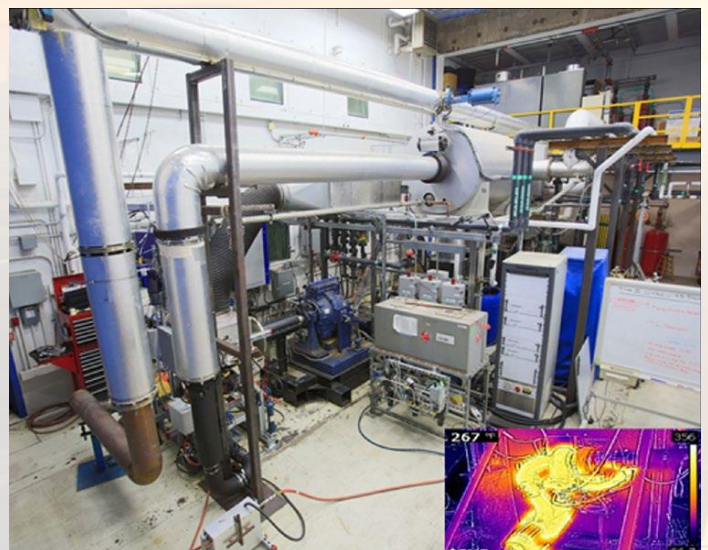
The presentation gave a historical overview of the development, verification, and validation of a material and failure model with sufficient predictive capability for the assessment of engine debris impacts on aircraft structures. The research culminated in the creation of a methodology that could reliably predict results for wide classes of impacts, with varying projectile shapes, velocities, impact angles, as well as varying target geometries and thicknesses.

Experimental testing advances and increasing computational power were critical in the creation of the new simulation tools to provide better analysis for jet engine certification. FAA researchers presented six additional presentations on modeling of aerospace metal and composite materials for dynamic applications.

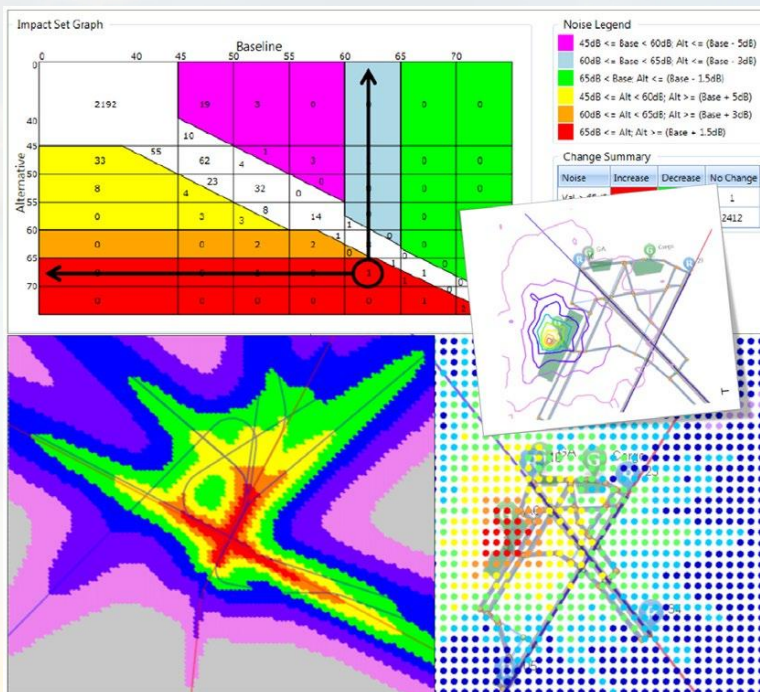
Simulating Engine Parameters by Altitude – Members of the FAA's Fuels and Energy program completed mini-detonation testing on a high-fuel flow, turbo-charged aircraft engine using the current base fuel formula from Shell Global Solutions.

The long-term research collaboration between the FAA and Shell provides the FAA's Piston Aviation Fuels Initiative insight into the performance characteristics of alternative fuel formulations under development by industry.

Shell is leveraging the FAA's unique engine test equipment, which measures over 36 million data points per minute from 50 different engine parameters across a range of simulated altitudes. This program is addressing the number one issue facing General Aviation today; identifying a safe and suitable unleaded fuel to eliminate lead emissions from the 165 million gallons of leaded aviation gasoline used annually.



Researchers test unleaded aviation gasolines under the Piston Aviation Fuels Initiative program.



The Aviation Environmental Design Tool is used internationally to model the environmental impacts of aviation noise, fuel burn, and emissions.

Improved Environmental Impact Modeling – In FY 2020, the Aviation Environmental Design Tool (AEDT) team released AEDT version 3c of the internationally used software.

The updated version was developed in collaboration with NASA, Volpe National Transportation Systems Center, ATAC Corporation, Senzig Engineering, RoVolus, Massachusetts Institute of Technology, Pennsylvania State University, and Georgia Institute of Technology. This comprehensive software system is used globally to model aircraft performance in space and time to estimate fuel consumption, emissions, noise, and air quality consequences.

AEDT provides policy makers and the aviation community an integrated tool to assess the environmental impact of air traffic operations. Due to the significant environmental challenges posed by aviation, all FAA actions requiring noise, fuel burn, or emissions modeling are required to use this updated version.

Version 3c provides more accurate aircraft performance modeling, including high-altitude airports and fuel burn calculations, for aircraft operations in the terminal area. The software also provides emissions dispersion modeling updates and tools to help U.S. airports meet their National Environmental Policy Act and Clean Air Act obligations.

Conclusion

FAA research and development fosters the creativity needed to provide safe, efficient, and environmentally-sound solutions beyond today's boundaries and prioritizes the integration of advanced technologies into the National Airspace System. To learn more about the FAA's planned research activities, view the Annual Review's companion document, the National Aviation Research Plan.





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