2018
Research and Development
Annual Review

August 2019

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

2018 Annual Review
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The R&D AR is a companion document to the National Aviation Research Plan (NARP), a report of the Federal Aviation Administration (FAA) to the United States (U.S.) 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).

Executive Summary

With the latest report from the International Air Transport Association showing a 33 percent decline in the all-accident rate in 2018, as compared to the previous 5 year period (2013-2017), aviation is safer than it has ever been. This record is the result of a collaborative, data-driven research culture that allows government and industry to work together and make proactive safety improvements throughout the National Airspace System (NAS).

Effective research enables the Federal Aviation Administration's (FAA) mission to provide the safest, most efficient aerospace system in the world. In addition, research enables the FAA to continue to build on this unparalleled safety record, increase system efficiency and integrate new airspace users. As new technologies change the aviation industry, the FAA's research approach must evolve by refocusing on the strategic identification of emerging issues, opportunities, and knowledge gaps. This process includes identifying and leveraging complementary research performed throughout the department and by industry, academic, and government partners.

The United States' global aviation leadership and unparalleled aviation safety record is informed by the continued efforts of FAA research and development described in this Annual Review for Fiscal Year 2018. This year's research success was made possible through a robust network of academic and industry partners that complemented and augmented the Agency's research staff and state-of-the-art research laboratories and resources.

Section 44501(c) of Title 49 of the United States Code (49 U.S.C. § 44501(c)) requires the Administrator of the FAA to submit the National Aviation Research Plan (NARP) and the Annual Review (AR) to Congress annually with the President's Budget. In accordance with the statute, this AR provides a summary of research accomplishments made via the three appropriation accounts: Research, Engineering and Development (RE&D), Facilities and Equipment (F&E), and Airport Improvement Program (AIP). The AR also enables comparison and traceability to research objectives outlined in the 2018 NARP.

The 2018 NARP featured our new research portfolio framework of Research and Development (R&D) goals, objectives, and outputs. Together they supported the strategic visions laid out by the President, Secretary of Transportation, and the FAA Administrator concerning governance, safety, innovation, infrastructure, and accountability. The 2018 AR has been redesigned to focus not only on our success stories but provide snapshots of our work. The approach and structure of this AR is consistent with the NARP and contains core research goals and objectives.

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Introduction

The FAA R&D program provides expert research-based innovative solutions to address challenges and shortfalls of legacy operational systems and innovative development within the aviation industry. Through its investments in aviation research, the FAA R&D program also promotes the advancement and integration of new technologies, aids in economic development, and ensures the safest skies, operational efficiency, and an environmentally acceptable aerospace system. This Annual Review (AR) summarizes the FAA's significant research accomplishments and advancement in the aviation research mission for fiscal year (FY) 2018.

The 2018 AR is responsive to Government Accountability Office recommendations from a 2017 audit, and consistent with the newly restructured 2018 NARP. This new structure presents research performance aligned to five core research goals. The five core goals address improving airport operations and traffic management; accelerating use of new technologies; improving infrastructure resiliency and durability; improving operations of the human component; and modeling capabilities and system-wide analysis. Mapping research performance to these five goals enables focused research planning, enables performance monitoring within those core areas, and aids in identifying gaps in aviation research.

Major Accomplishments

FAA research results support policymaking and planning, regulation, certification, standards development, and modernization of the NAS. The 2018 research program achievements considered transformational to the aviation industry are summarized below:

Airport operations and traffic management

Efficient airport operations together with enhanced air traffic and airspace management capabilities are keys to maintaining the most complex NAS in the world. There are several NextGen programs making essential research-based contributions to the NAS. For example, the Wake Turbulence Re-categorization Program (RECAT) aids in addressing separation management, while the Unmanned Aircraft Systems Flight Information Management Program (UAS Flight Information Management) addresses integration of new entrants into the NAS by managing the impact of wake on following aircraft.

Airports to safely accommodate 10% more flights during their busiest parts of the day

The RECAT project provides the transition of wake research knowledge into designs of Air Traffic Control (ATC) wake encounter mitigation procedures and decision support tools. This research will enable future NextGen operational improvements for both the terminal and En route domains. During FY18, the RECAT project initiated the development of an ATC decision support tool requirements design that will allow controllers to apply aircraft-to-aircraft wake separation specific to aircraft type and current weather conditions. Wake research is supplying the vital information concerning wake strength, wake transport, and wake decay and its interaction with weather. This information will be incorporated into the algorithms of the RECAT decision support tool design requirements. Implementation of the RECAT decision support tool design requirements will enable airports to safely accommodate 10% more flights during their busiest parts of the day.

The UAS Flight Information Management program developed an overarching concept of operations (ConOps) for UAS operations conducted Beyond Visual Line of Sight (BVLOS) Operations, and under 400 feet above ground level. The ConOps and associated products are the first step in developing a UAS traffic management ecosystem that provides management services to enable UAS operations in low altitude airspace where air traffic services are not provided.

Accelerating use of new technologies

The advancement and introduction of non-traditional aviation industries are pushing the boundaries of technology into all corners of the NAS. Advancing technologies in the NAS focuses on applied innovation that identifies and demonstrates, amongst others, new aerospace vehicles technologies (e.g. adhesive bonded repairs), certificating and licensing of aerospace operators (pilot duty times), and the study of alternative fuels. As the introduction of new technologies continues, this research will yield a safer, more efficient NAS with reduced environmental impact, certified operators and operations of the new industries, improved aircraft performance, and driving policy in keeping with the pace of newly introduced technology.

The Continued Airworthiness research program has found, in addressing aircraft structural repairs, that adhesive bonded repairs offer advantages compared to industry-accepted mechanically fastened repairs. Benefits include being more aerodynamically efficient, display better load transfer, and in many cases, is less intrusive and easier to install. Data provided by this program is used to assess, calibrate and verify tools and methods for evaluating and monitoring the bonded repair integrity over the life of the part. For example, the results were used to implement the bonded repair solution to in-service cracking issues on the MD80 aircraft family of horizontal stabilizers. This bonded repair solution reduced aircraft downtime by 60% compared to conventional repair solutions while maintaining mandated levels of safety.

Aircraft downtime reduced by 60% compared to the conventional repair solution

The Alternative Fuels program cooperated with industry and academia to accomplish the goal of fleet-wide authorization for a novel, unleaded fuel composition. The research provided a model for industry to prepare certificate applications with the goal of extending the approved aircraft model lists.

Research and Development of critical life-support systems for Commercial Spacecraft such as Carbon Dioxide detectors that operate in microgravity conditions will provide the industry with methodologies and capabilities designed to improve safety in off nominal flight and emergency conditions. Development of new sensors that utilize light emitting diodes (LEDs), collimating and condenser lenses, a diffraction grating, and other innovations will improve the fidelity of detection systems and enable regulatory approaches that are less conservative and burdensome on industry.

Increasing NAS Infrastructure Durability and Resiliency

A durable, long-life and resilient infrastructure forms the backbone of an efficient, safe, and secure NAS. Research in this Goal includes airport runways, taxiways, air traffic management and aircraft systems and networks, as well as electrical airport sub-infrastructures and lighting. This research focuses on increasing the useful life of this infrastructure, decreasing maintenance and repair costs, NAS operations recovery from disruptive events, and cybersecurity that protects and defends FAA systems from both internal and external threats due to rapid advances and sophistication of cyber-attacks. Cyber work will include NextGen research that will leverage advanced big-data analytical approaches to our complex interdependent networks. Resulting research will lead to a longer lasting, lower cost, dependable infrastructure, defended against cyber events.

The office of Aviation Safety conducted research on checksums and Cyclic Redundancy Codes (CRCs), which included a review of existing error detection performance metrics utilized by the aviation industry, a comparison of various checksum and CRC approaches, and a proposed methodology for mapping CRC and checksum design parameters to aviation integrity requirements. This work resulted in Advisory Circular 00-66 that provides the aviation industry guidance on the selection of CRCs and checksum algorithms that ensure critical data integrity of software loaded onto aircraft systems to avoid corruption and avert potential accidents and incidents.

In fiscal year (FY) 2018, researchers from the FAA's Airport Technology Research and Development Branch (ATR) conducted research to determine performance specifications (output wavelength, minimum vertical beam spread, and minimum radiant intensity) for infrared (IR) emitters to be incorporated into L-810 (steady burning light) and L-864 (flashing light) LED obstruction light fixtures to ensure compatibility with Night Vision Goggles (NVGs) currently in use. The results from this research effort will increase the ability for pilots using NVGs to see red LED obstruction lights which is otherwise problematic due to the fact that the light generated falls outside the visible spectrum of some NVG lens filters.

Pilots using NVGs can better view LED light spectrums

The FAA customized a traditional Asphalt Pavement Analyzer (APA) that is used to test the rutting resistance of asphalt mixtures used in highway pavements. The new customized APA can simulate aircraft tire pressures up to 260 psi with variable rate of loading to simulate different aircraft speeds. This research has led to the development of APA rut resistance acceptance criterion for P-401 Hot Mix Asphalt for use on airport pavements and has been included in the draft FAA Advisory Circular 150/5370-10H Standards Specifications for Construction of Airports.

Improving operations of the human component

Humans are the most vulnerable component of the NAS. The FAA recognizes this fact and strives to understand the human operator and their interactions with complex aviation systems. This includes a portfolio of research that includes everything from the certificating and licensing of operators to mitigating the impacts that newly emerging technology might have on the operator.

Regarding certificating and licensing operators, the System Integration Human Factors research program participated in the Flightcrew Member Fatigue Focus Team (FMFFT) meetings with several Air Carrier groups to discuss the best approach for introducing pilot flight and duty limitations and rest exemptions into their respective airlines. Core funded research provided scientific human performance data used in the implementation of a Fatigue Risk Management System (FRMS) for exceeding prescriptive duty time limits. The FAA's FMFFT received 19 FRMS applications from a few of the 86 eligible air carriers; many are still works in progress, but several have demonstrated an equivalent level of safety. The change to this rule made it possible for operators to offer new long-haul flights to global city-pairs that were not possible before.

This rule change made it possible for operators to offer new long-haul flights that were not possible before

Research is required to validate new technologies and innovations introduced into the NAS to improve the human performance of NAS operators. Optimized human performance in the NAS is fundamental to the safe operation of the NAS and inherently to the safety of the airspace community, especially the flying customer, who relies on the FAA to provide the safest transportation system in the world. The NextGen Integration Human Factors research program provided scientific human performance data that informs the ground-breaking Enhanced Flight Vision System (EFVS) rule; 14 CFR 91.176. The EFVS rule opens the door for operators to use EFVS in lieu of natural vision to descend below the published Decision Height for the first time. This technology enables low visibility approach operations on more than 11,592 instrument approach procedures.

New technology to enable low visibility approach operations on more than 11,592 instrument approach procedures

Modeling capabilities and system-wide analysis

Modeling capabilities and system-wide analysis includes understanding the aerospace modeling systems used to analyze the NAS, developing analytical and predictive capabilities used in the capture, parsing, analysis, and sharing of data, and developing a toolset to evaluate NAS system-wide performance. This is particularly important given the introduction of new and emerging technologies. 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 of systems. This work also improves the robustness, adaptability, flexibility, and accuracy of these integrated analytical and computational modeling tools and enables NAS effectiveness in the delivery of the highest quality service to the greatest number of stakeholders in a timely, safe, and practical manner.

The Closely Spaced Parallel Operations group conducted front gate analyses and a produced a feasibility report for Paired Approach to CAT I minima. The report addressed the feasibility of decreasing the current Minimum Radar Separation (MRS) standard from 2.5NM to a lower standard of 2.0 NM on final approach, which will allow controllers to have additional flexibility in terminal operations leading to a possible capacity increase.

Decreasing the MRS standard from 2.5NM to 2.0NM will increase ATC capacity

A terminal Human-In-The-Loop (HITL) simulation was conducted to validate Unmanned Aircraft System (UAS) Contingency Procedures and Requirements. This research focused on determining the operational impact of UAS lost-link events in the terminal environment using standardized lost-link procedures, and examining the impacts of the contingency procedures on air traffic controllers in the terminal environment.

Commercial space research supported the development of a new space situational awareness tool that is able to integrate different databases of space object and debris information. This tool would enable increased insights for commercial space operations and provide a level of detail currently not available. As more commercial space companies plan to launch through the NAS into orbit, this awareness will improve the results of collision avoidance analyses, thereby allowing better definition of launch windows, and minimizing the possible impact of delays on commercial aviation.

Performance Highlights

American aviation represents 5.1% of the United States' (U.S.) Gross Domestic Product, yields 10.6M U.S. jobs, stimulates $1.6T in US economic activity, and constitutes $59.9B of US trade (or 8% of US exports). With the latest report from the International Air Transport Association showing a 33% decline in the all-accident rate in 2018 as compared to the previous 5-year period (2013-2017), and as demonstrated in the prior research outcome examples, aviation is more efficient and safer than it has ever been. While this is an achievement to recognize, the April 17, 2018 Southwest Airlines flight 1380 accident is a reminder that proves, the FAA must be vigilant and continue its focus on safety and risk management.

The FAA's R&D program enables the US to provide the safest, most efficient aerospace system in the world while also increasing system efficiency and integrating new airspace users. Historically, FAA's applied research is born from the demands of the flying public and aviation industry, demands that usually result from either aviation accidents and/or the industry's need for increased capacity or throughput. Additionally, as enhanced knowledge and new technologies change the aviation industry, FAA must identify emerging technologies, opportunities and knowledge gaps requiring research and deliberately leverage complementary research performed by partners in industry, academia, and across federal government. Examples of some of FAA's 2018 research outcomes include:

- Minimum performance requirements of mist/nitrogen cargo compartment fire suppression systems;
- Demonstrations of severe and hidden structural damage of aircraft due to ramp impacts;
- Safety risk assessment on Electronic Flight Bags;
- Recommended methods for providing of weather and radar information in remote areas,
- Assessment of the severity of midair collisions between small UAS and manned aircraft,
- Development and validation of a comprehensive method for the analysis of 22 benzodiazepines in postmortem fluids,
- Validation standards for new Terminal Radar Approach Control training.

Applied FAA-based aviation research over the years has been invaluable in establishing policy and transferring technology within these core goal areas. Research conducted and applied in FY 2018 and recent years, adds to prior research successes, the following are two examples.

> The FAA Weather Technology in the Cockpit (WTIC) program sponsored an operational demonstration to evaluate the feasibility to uplink convective storm data products to commercial aircraft flying routes over remote, oceanic regions for display on an electronic flight bag (EFB). The effort was called the Remote Oceanic Meteorology Information Operational (ROMIO) demonstration and was a collaborative effort between the FAA, the weather research community, airlines, and ground-to-air communications providers. The ROMIO was developed to demonstrate operational strategies for the use of rapidly updated Cloud Top Height (CTH) and Convective Diagnosis Oceanic (CDO) products on the flight deck, in Air Route Traffic Control Centers (ARTCC) and as part of Airline Operations Center (AOC) flight dispatch operations. Participating airlines included Delta Air Lines, United Airlines and American Airlines.
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> In July 2018, a Delta Airlines pilot involved in the demonstration flew two transcontinental flights midweek with a fair amount of convective activity. The pilot used the CTH and CDO products evaluated by the WTIC Program and reported that the CTH product was "spot on" and the CDO product was "accurate as well." The pilot found that the playback feature was a "great tool showing whether the convective activity is maturing or declining," thus enabling responsive decision making, while also addressing improvements of airspace capacity. Overall, the pilot's assessment was that the tools provided by the WTIC Program for the demonstration gave him "a real time, accurate planning tool for deviation."

The demonstration successfully helped to identify and validate the ability and usefulness in providing convective meteorological information services to aircraft for safe and efficient flight in oceanic and remote airspace

Our second example is the Engineered Material Arresting System (EMAS).

For several years, the FAA has actively worked to improve Runway Safety Areas (RSAs) at commercial service airports. The RSA is typically 500 feet wide and extends 1,000 feet beyond each end of the runway. It provides a graded area in the event that an aircraft overruns, undershoots, or veers off the side of the runway. Many airports were built before the current 1,000-foot RSA standard was adopted approximately 20 years ago. In some cases, it is not practicable to achieve the full standard RSA because there may be a lack of available land. There also may be obstacles such as bodies of water, highways, railroads, and populated areas or severe drop-off of terrain.

The FAA conducted research to determine how to improve safety at airports where the full RSA cannot be obtained. Working in concert with the University of Dayton, the Port Authority of New York and New Jersey, and the Engineered Arresting Systems Corporation (ESCO) of Logan Township, NJ, a new technology emerged to safely arrest overrunning aircraft – EMAS. EMAS uses crushable material placed at the end of a runway to stop an aircraft that overruns the runway. The tires of the aircraft sink into the lightweight material and the aircraft decelerates as it rolls through the material.

The EMAS technology provides safety benefits in cases where land is not available, where it would be very expensive for the airport sponsor to buy the land off the end of the runway, or where it is otherwise not possible to have the standard 1,000-foot overrun. A standard EMAS installation extends 600 feet from the end of the runway. An EMAS arrestor bed can still be installed to help slow or stop an aircraft that overruns the runway, even if less than 600 feet of land is available.

Because of FAA's research and development, EMAS technology has safely stopped 13 overrunning aircraft and saved 288 lives

The most recent event took place on February 4, 2018, when a Beech Jet 400A landing at Burke Lakefront Airport, Cleveland, went off the end of the runway into the departure end EMAS. The aircraft came to rest approximately two-thirds the way into the EMAS along the extended centerline of the runway. There were no injuries to any of the four occupants on board the aircraft. This recent save shows the efficacy of the long-standing FAA's research program on stopping overruns at airports.

Year Summary

The FAA is charged with promoting the safety and efficiency of the nation's aviation system. We maintain the system's integrity and reliability through our broad authority to enforce safety regulations and conduct oversight of the civil aviation industry. We do a constant reevaluation of our efforts and create a recurring cycle of planning, program execution, measurement, verification, and reporting. This is done through our strategic plans, annual business plans, human capital plans, program evaluations, Annual Performance and Accountability Reports. Creating a strong link between resources and performance helps FAA focus on accomplishing its priorities while taking into account their costs and benefits. Please note that FY18 is the baseline year for the redesigned Annual Review on research. Subsequent publications will show year over year comparisons with FY18 as the baseline.

R&D Portfolio

The globally changing aviation industry requires a holistic FAA R&D strategy that illustrates how it fits together across all the functions of the NAS and pursues an agile approach in addressing aviation's changing environment over the next five years. The FAA's National Aviation Research Plan (NARP) highlights and reports annually on the FAA's applied R&D as defined by the Office of Management and Budget (OMB) Circular A-11. The FAA R&D strategy includes funding programs in either of three appropriation accounts: RE&D; F&E; and AIP.

Research results funded through the RE&D appropriation inform policies, standards and regulatory guidance to assure safety as well as human performance, wake turbulence, weather, and environmental impact considerations in the design and operation of aircraft and ground based systems. The Safety, Efficiency, Environmental and Mission Support programs are RE&D funded.

Research programs funded through the F&E appropriation are pre-implementation developmental programs intended to mature new air traffic management operational concepts, technologies, and demonstrations for eventual system acquisition and deployment. The following research programs are F&E funded Advanced Technology Development & Prototyping (ATD&P); NextGen Portfolios; and the Center for Advanced Aviation Systems Development (CAASD).

Research programs funded through the AIP appropriation discover and evaluate new technologies and methods to enhance safety and efficiency of airport operations and the durability of its infrastructure. Both the Airport Technology Research Program (ATRP) and the Airport Cooperative Research Program (ACRP) are AIP funded.

Though representing only a small fraction of the total FAA appropriation, R&D funding makes it possible for the FAA to maintain our U.S. position as a global leader in aviation as we:

- Provide the foundation for the safety innovations that are being implemented throughout the NAS every day;

- Increase system efficiency and integrate new airspace users, benefitting the aviation industry as well as the American flying public;
- Support a wide range of research activities from materials and aeromedical research to the development of new products, services, and procedures;
- Manage and modernize its research infrastructure in order to identify emerging technologies, opportunities and knowledge gaps requiring research;
- Increase the knowledge base and expertise of FAA representatives and researchers who - as world-renowned subject matter experts - sit on global harmonization and standards setting bodies, thereby enabling the US to be a global leader in influencing and driving international standards that affect our aviation economic advantage;
- Lower the regulatory burden on industry, allowing for maximum economic benefit to America
- Rapidly respond to the realities and challenges of integrating new entrants into the NAS. Commercial space regulatory reform is underway, in direct response to National Space Council directives.

Partnerships

The FAA maintains extensive partnerships with stakeholders representing aircraft and aircraft part manufacturers, design and engineering companies, external testing facilities, both domestic and international organizations, and representatives of large and small business. The FAA collaborates with federal agency partners, industry and academia in promoting the transfer of FAA technologies to the private sector for other civil and commercial applications, and expands the U.S. technology base.

To establish Academia partners, maximize impact and support Science Technology Engineering and Math (STEM) priorities, the FAA uses the Grants-based Centers of Excellence (COE) program and formal agreements such as Cooperative Research and Development Agreements (CRADA), Interagency Agreements (IA) or Memorandum of Agreement (MOA).

Federal

The FAA engages with Federal Partners through IAs and/or MOAs to leverage their research capacity to advance national and aviation objectives.

2018: (59) Federal Agreements

Examples of current interagency partnerships include the National Aeronautics and Space Administration (NASA) and the National Oceanic and Atmospheric Administration (NOAA); the U.S. Global Change Research Program; the Federal Interagency Committee on Aviation Noise; the Interagency Planning Office for NextGen; the General Aviation Joint Steering Committee; and the Aviation Vehicle Systems Institute.

There are many successful partnerships with other federal agencies, including other DOT organizations. Within the DOT, subject matter expertise and laboratory facilities are shared through technical interchanges, joint research projects, and committee participation. These include material sciences joint research with the Federal Highway Administration (FHWA) for asphalt component studies and concrete beam analysis. The results of the research are used to provide modified standards for testing concrete beams.

Another example is the FAA's human factors research in the area of fatigue and drowsiness, the development of a test to detect fatigue through gene expression biomarkers. This will aid the research by the National Highway Traffic Safety Administration (NHTSA) for drowsy driving prevention.

Academia

Centers of Excellence are a unique partnership mechanism, which allow the FAA to enlist the best and brightest in our colleges and universities, and leverage matching contributions to advance aviation research objectives. The FAA's COE Program also supports technology transfer and conducts partnered research in the following core areas: Technology Training and Human Performance; Unmanned Aircraft Systems (UAS); Alternative Jet Fuels and Environment; General Aviation Safety; Commercial Space Transportation; and Joint COE Advanced Materials.

Additionally, COE performers are required to obtain other funding to match the amount the FAA provides for the programs. This effectively doubles the value, and ensures the research aligns with industry priorities.

2018: (58) Grants Awarded
$11,869,000 in Industry Matching Funds

A recent accomplishment of the UAS COE includes the evaluation of airborne collision hazard severity of an unmanned aircraft with a manned aircraft. The research team evaluated the potential impacts of a 2.7-pound and 4-pound quadcopter, and a 4-pound, and 8-pound fixed wing drone on a single-aisle commercial transport jet and a business jet. They examined impacts to the wing leading edge, the windshield, and the vertical and horizontal stabilizers. The windshields generally sustained the least damage and the horizontal stabilizers suffered the most serious damage.

The conclusion was that a drone collision with large manned aircraft can cause more structural damage than birds of the same weight for a given impact speed. This research concluded that unmanned aircraft system manufacturers should adopt "detect and avoid" or "geo-fencing" capabilities to reduce the probability of collisions with other aircraft. This research will also be used to develop operational and collision risk mitigation requirements for drones.

Industry

The FAA engages with Industry partners through Cooperative Research and Development Agreements (CRADA) to leverage their research capacity to advance National and Aviation objectives.

2018: (38) Industry Agreements

Examples of current CRADAs with industry include airlines, a primary user of the NAS, who are actively engaged in applying FAA research to increase safety. For example, Eddy Dissipation Rate (EDR) algorithms are utilized to predict the location of turbulence along an aircraft's route and altitude of flight, and measure the impact of turbulence on the aircraft if it is inadvertently encountered. From a passenger's perspective, turbulence can be not only an uncomfortable and often terrifying experience, but can also cause in-flight injuries. If severe enough, turbulence can also cause structural damage to an aircraft.

The FAA's WTIC program developed an EDR algorithm, EDR cockpit viewer, and EDR Technical Transfer package in collaboration with Delta Airlines. Over the last year, Delta Airlines has been utilizing this technology with great success, including actively engaging airlines to partner in the use of this open source algorithm. Delta's ultimate goal is to enhance the algorithm through use of a greater set of EDR data generated by Delta and the partnering airlines. This will increase safety and passenger comfort, and reduce risk of aircraft damage through more efficient flight operations resulting from turbulence avoidance.

International

The knowledge capital obtained through FAA's R&D investments is necessary to inform safe and efficient evolution of aviation on both domestic and international fronts. Influencing global aviation standards is highly dependent on the knowledge base of FAA representatives/researchers who are on global harmonization and standards setting bodies and serve as world renown subject matter experts. This knowledge base enables the US to be a global leader in influencing and driving international standards that affect our aviation economic advantage. The FAA engages with International partners through Cooperative Agreements to leverage their research capacity to harmonize operations

2018: (4) International Agreements

The FAA uses cooperative agreements with European, North American, and Asian aviation organizations to participate in aviation safety and air traffic modernization (ATM) programs and to leverage research activities that harmonize operations and promote a seamless and safe air transportation system worldwide. Examples of international partnerships include the European Organization for the Safety of Air Navigation; International Civil Aviation Organization, the Single European Sky Air Traffic Management Research Joint Undertaking; the Japan Civil Aviation Bureau; and Transport Canada.

When international agencies are involved the FAA's research, it is often because the results have a global reach, and benefit domestic and international partners. One such example is the use of the FAA's Design Assessment of Reliability With INspection (DARWIN) software tool, an innovative technology designed to address early detection of uncontained rotor failures. DARWIN performs probabilistic damage tolerance analysis to determine the risk of fracture of safety-critical components such as aircraft engine rotors.

In March of 2018, the FAA hosted a DARWIN training workshop that consisted of representatives of more than forty different organizations from twelve different countries. The list of participants included twelve aircraft/rotorcraft engine manufacturers; many US government agencies including the FAA, United States Air Force/AFRL, NAVAIR, US Army, NIST, and five NASA Centers;

other airworthiness agencies including European Aviation Safety Agency and Transport Canada; nine other manufacturers of aircraft, rotorcraft, space propulsion systems, or power generation turbines; the European Space Agency; and others.

The DARWIN tool has become robust enough to provide an FAA-acceptable means for applicants to show compliance to certification requirements of turbine engine life limited parts. Providing this ability allow for the streamlining of the certification process, thus reducing the burden on industry, while simultaneously increasing the overall safety of the aircraft.

Society Participation

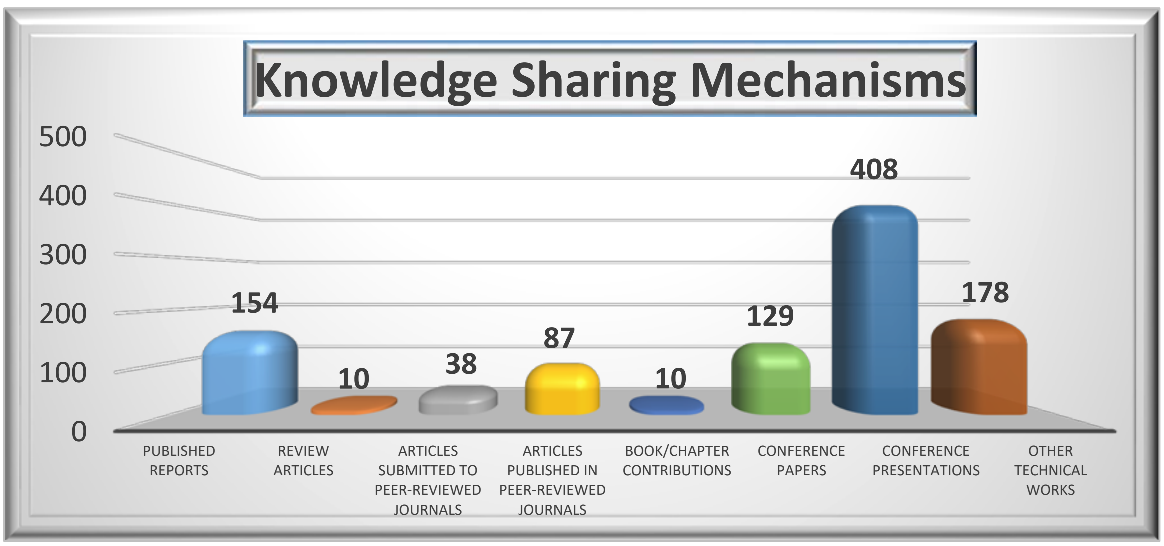
Professional societies play an important role in the world. They provide the mechanism to bring together people, knowledge, and technology for the purpose of sharing information, creating industry standards of conduct, and developing industry design standards for technology, processes and systems.

As the world leader in aviation safety and air traffic control, the FAA is committed to active participation in pertinent professional societies. Our participation provides a forum for technology transfer of FAA research results, and collateral transfer of knowledge from other leading organizations back to the FAA. This strategic collaboration leads to new global industry standards and information exchange. This is accomplished by participating in organizations such as RTCA, SAE, ASTM, European Organisation for Civil Aviation Equipment (EUROCAE), IEEE, American Institute of Aeronautics and Astronautics (AIAA), Aerospace Human Factors Association (ASHFA), Royal Aeronautical Society and Aviation, International Civil Aviation Organization (ICAO), and more.

In several of these societies, FAA personnel, because of their core subject knowledge, hold key leadership and other supporting positions to help guide the transfer of research knowledge. In 2018, FAA Research personnel served as Executive Officers, Steering Committee Leads, and Journal Reviewers. Examples of these roles include Aerospace Human Factors Association (ASHFA) Executive Committee officer, Chair of the government steering committee for Metallic Materials Properties Development and Standardization (MMPDS), Heavy Vehicle Simulator International Alliance (HVS-IA) Executive Committee Member, and Aerospace Medicine and Human Performance Journal Reviewer. FAA experts also participated in outreach, and presented research papers at conferences, forums, and committees.

Knowledge Transfer

The FAA R&D portfolio is a robust, productive portfolio of 34 research programs spanning core R&D areas of airport technology, aircraft safety assurance, digital systems and technologies, environment and weather impact mitigation, human & aeromedical factors, and aviation performance and planning. Daily, the broad network of FAA researchers perform their work to the end that their work would save lives and provide greater levels of safety and efficiencies within the NAS and abroad. However simply doing the research is not enough. The information resulting from this research needs to be transferred and shared with other groups, organizations and collaborators so that the results can be accessed, evaluated, integrated, and built upon. The FAA, recognizing its obligation to help advance aviation research, utilizes several means to transfer its body of research. The Knowledge Sharing Mechanisms chart below depicts the various methods used to transfer and share research results: Published Reports; Review Articles; Articles Submitted to and Published in Peer-Reviewed Journals; Book Contributions; Conference Papers and Presentations; and many other documented Technical Works.



In FY18 alone, the FAA and its staff of diverse subject matter experts has produced over 1,000 knowledge sharing items, consisting of over 400 conference presentations. The presentations occurred at various conferences and society meetings such as the Society for Experimental Mechanics (SEM) Annual Conference, Euromech Conference, 6th Aviation Range and Aerospace Meteorology (ARAM) Special Symposium, and the 2018 Asia Oceania Geosciences Society (AOGS) assembly. In addition to these published works, the FAA R&D also had 9 invention leads approved.

A few detailed examples of the body of work that was shared follows:

2018: 9 Invention Leads Approved

From March 20-22, 2018, an FAA research team attended the March 2018 Aviation Safety InfoShare meeting in Baltimore, MD. The semi-annual meeting allows aviation safety professionals from industry, government, and academia to share their safety concerns and best practices in a protected environment. At the meeting, FAA personnel presented *Stabilized approach criteria: bridging the gap between theory and practice* during the Flight Operations session. The briefing provided more than 300 InfoShare attendees with an overview of ongoing research regarding stabilized approach criteria and the results of the first experiment that was completed in February. The experiment was based on the use of level-D flight simulators to aid in developing stabilized approach and go-around rates.

In spring of 2018, a journal article titled "Analysis and Characterization of Damage Using a Generalized Composite Material Model Suitable for Impact Problems" was published in the *Journal of Aerospace Engineering*. The article details the development of a damage model for a generalized composite material suitable for more accurate impact simulations. This research was supported by the FAA Aircraft Catastrophic Failure Prevention Program in conjunction with the NASA Advanced Composites Program and performed in collaboration with Arizona State University. This work serves to meet the need for a robust generalized composite material model capable of producing predictive and accurate impact simulations. Predictive impact models will improve aviation safety by advancing modeling capability for turbine engine containment and will help to ensure that the threat of uncontained engine debris fragments to the aircraft is minimized as more composite materials are used for engine and aircraft structures.

FAA Researchers attended and delivered multiple presentations at the 2018 North American Thermal Analysis Society conference, held in Philadelphia, PA on August 6-9, 2018. The first was a talk entitled "Isokinetics" on a unified approach to the measurement of chemical reaction rates, such as the burning rate of cabin materials. This capability improves on other methods of isothermal and nonisothermal kinetic analysis by eliminating the need to know (or guess) the reaction mechanism in order to obtain the kinetic parameters. The second was a presentation entitled, "Heat of Combustion of Polymer Decomposition Products." The data resulting from our oxidation experiments when used in fire models, shows how the heat of combustion of evolved gases can change throughout polymer decomposition for some materials and remain constant for others. This should help to understand why materials with low heat release rates fail certain regulatory tests.

The FAA presented two papers at the 2018 AIAA Aviation Forum in Atlanta, GA during the week of June 25, 2018. The AIAA Aviation Forum is an annual event that serves as an opportunity to present recent progress on aircraft design, air traffic management and operations, and aviation technologies, as well as policy, planning, and market issues affecting the future direction of the global aviation industry. This year's forum had nearly 3,000 aerospace professionals from government, industry, and academia in attendance. The first paper presented titled, "Human-in-the-loop Study on Angle-of-attack Indicator Effectiveness for Transport Category Airplanes," provides a detailed description of the development and execution of a human-in-the-loop simulator study to evaluate the effectiveness of various angle-of-attack (AOA) displays. The second paper presented was "Development of Possible Go-Around Criteria for Transport Aircraft." This paper provided an overview of the first phase of a human-in-the-loop study that was designed to collect data for the development of go-around criteria.

Research & Development – FY18 Performance

In support of the FAA's mission, the FAA uses R&D to support policymaking and planning, regulation, certification, standards development, and modernization of the NAS. The FAA R&D portfolio supports both the day-to-day operations of the NAS and balances between near-term, mid-term, and far-term aviation needs, acknowledging that NASA is critical to the mid-, and far-term research work. To help the FAA align and plan its R&D portfolio, the FAA has defined a research planning framework consisting of three overarching R&D Outcomes that systematically expand and apply knowledge to produce useful materials, devices, systems, or methods that:

- Improve Aerospace Safety – improve aerospace safety and achieve the lowest possible accident rate
- Improve Operational Effectiveness – improve access to and increase the capacity and operational efficiency of the Nation's aerospace system.
- Reduce Environmental Impact – reduce aerospace environmental impacts.

The Goals necessary to achieve these Outcomes depend upon critical components within the National Airspace System such as air vehicles, airports and airport systems, human operators, air traffic systems, and air traffic information. The FAA's Goals focus on researching and identifying solutions for:

1. Improve airport operations, air traffic, and air space management capabilities
2. Accelerate use of new technologies for aerospace vehicles and airport/spaceports
3. Increase infrastructure durability and resiliency
4. Improve the operation of the human component of the system
5. Improve integrated modeling capabilities and system-wide analysis

The 2018 NARP documents the agency's 5 Goals (above) and 19 supporting Objectives with over 220 planned outputs spanning 5 years. The following sections highlight examples of completed 2018 outputs and their associated location in the 2017/2018 NARP.

Goal 1 - Improve Airport Operations, Air Traffic, and Air Space Management Capabilities

Research under this goal supports airport operations, air traffic and traffic management research related to separation management, time-based management with respect to air and surface traffic management, integrated weather information, collaborative decision making, airport and spaceport systems, aerospace vehicle operations, and noise and emission management. As NextGen continues to evolve, additional research, concept development and validation is needed to reduce risk and identify technical and operational requirements that will deliver improved services in the effort to increase capacity, efficiency, system flexibility and safety.

Examples of research outputs supporting this goal are as follows:

- High level analysis in support of Safety Risk Management Documentation for Wake Turbulence Mitigation for Single Runway procedure and associated decision support tool to ensure the flight safety of the developed capability. *(2017/2018 NARP pg.24)*

- Research the expansion of a previously demonstrated performance based regulatory framework to a broader set of airspace below Flight Level 600, as well as, creating a risk evaluation method for new entrant trends. *(2017/2018 NARP pg.24)*

- FAA operational assessment report of NASA's Airspace Technology Demonstration Phase 2 (ATD-2) collaborative departure metering capability, including Surface Collaborative Decision Making (S-CDM) and collaboration with flight operators, airport operators, and ATC. *(2017/2018 NARP pg.25)*

- A Continental United States in-flight icing analysis and forecast capability enhancement via assimilation of sensor and satellite data. *(2017/2018 NARP pg.25)*

- A Rapid Refresh atmospheric numerical weather prediction model with expanded domain, longer forecasts, and improved accuracy via better assimilation of satellite and sensor data, and internal representation of winds, temperatures, and clouds. *(2017/2018 NARP pg.25)*

- Concept validation report for Strategic Flow Management Application (SFMA). *(2017/2018 NARP pg.25)*

- Report documenting the physical and environmental conditions including sensor siting, spatial and temporal filtering, and fusion/selection for reporting wind conditions that are negatively impacting effective wind observations at the subject airports. *(2017/2018 NARP pg.27)*

- Develop and demonstrate a process for space launch and reentry collaborative decision making (CDM.) *(2017/2018 NARP pg.27)*

- Conduct engineering analysis as needed for Caribbean airspace redesign implementation. *(2017/2018 NARP pg.28)*

- Detailed design information to support the design of airport emergency operations centers to respond to any airport-wide disruptions. *(2017/2018 NARP pg.28)*

- Report on testing of L-810 (steady burning) and L-864 (flashing) red obstruction lights equipped with infrared (IR) that will provide technical information to support the development of standards for obstruction lights with IR. *(2017/2018 NARP pg.28)*

- Report on global state-of-the-art capabilities in Surface Taxi Conformance Monitoring (STCM) technology to reduce Runway Incursions. *(2017/2018 NARP pg.29)*

- Develop draft commercial space Concept of Operations. *(2017/2018 NARP pg.29)*

- Guidance on how to safely, efficiently, and seamlessly integrate UAS autonomous cargo delivery operations into the National Airspace System (NAS). *(2017/2018 NARP pg.29)*

- An Internet of Things (IoT) manual that will provide information to airport operators and stakeholders regarding how to plan for and implement IoT technology and networks in an airport environment. *(2017/2018 NARP pg.30)*

- Develop updated correction factors for ASTM E966 (Standard Guide for Field Measurements of Airborne Sound Insulation of Building Facades and Facade Elements) that are more suitable for aircraft noise applications. *(2017/2018 NARP pg.30)*

- Develop draft preliminary commercial space program requirements derived from past prototyping efforts and conceptual solutions. *(2017/2018 NARP pg.30)*

- Research to develop candidate mission profiles and a risk model that will support streamlined airworthiness approval processes for small UAS. *(2017/2018 NARP pg.30)*

Other significant accomplishments in relation to this Goal include:

In November 2017, the first of three phases for the ATD-2 were completed, which will decrease the wait for departures and eliminate the need for voice coordination to negotiate release times by using electronic negotiation activities. Over the course of the year, data of these new capabilities were captured and analyzed to evaluate their effectiveness. In September of 2018, NASA and the FAA completed technical transfer activities containing over 3000 pages of data and analysis.

In July of 2018, new variations of numerical weather prediction models were transitioned to the National Weather Service (NWS) and implemented into operations. Implementation of the Rapid Refresh (RAP) and High Resolution Rapid Refresh (HRRR) models has increased the ability to forecast weather over North America, Central America, parts of

South America, Europe and Asia, as well as major portions of both the Atlantic and Pacific oceans by 18 hours. Providing industry, pilots and air traffic controllers nearly an additional day of weather forecasting provides an immense improvement in safety and much greater flexibility when planning airport operations and improving their ability to manage the NAS.

Researchers performed collaborative tests with Airbus Operations GmbH (Germany) at the FAA William J. Hughes Technical Center on September 10-14, 2018. The researchers evaluated artificial smoke generators used for certification of aircraft cargo compartment smoke detectors under varying ambient conditions. Ambient conditions were varied to simulate flight conditions ranging from sea-level to 8,000-foot cabin altitude and reduced air temperature. The measurements acquired included light obscuration, temperature, and air velocity, as well as particle size distribution with a Scanning Mobility Particle Sizer (SMPS). Five different aircraft smoke detectors were included in the test campaign to evaluate the response time and determine if detector response can be correlated to any of the measured parameters. Data gathered from the test series will be used to develop performance standards for artificial smoke and a standardized method for characterization of the output from artificial smoke generators.

Fire extinguishment testing was performed in a nacelle fire simulator in conjunction with a team from the U.S. Army. The purpose of the testing was to assist the U.S. Army with its preliminary investigations of a potential halon-replacing fire extinguishing agent. The combined team performed 18 tests to observe the behavior and performance of the potential candidate agent while attempting to simulate a pressurization gas generation technology. This research leverages previous work by industry and the US Department of Defense. The US Army will use the acquired information and apply it to future considerations when funding becomes available for follow-on research.

Goal 2 - Accelerate use of new technologies for aerospace vehicles and airport/spaceports

Research under this goal supports applied innovation that identifies and demonstrates new aerospace vehicles and airport/spaceport technologies, certificating and licensing of aerospace operators and vehicles, the study of alternative fuels, and providing decision-makers essential data and analysis of that data used in policy formation that shapes the future of the NAS. As the introduction of new technologies continues, this research will yield a safer, more efficient NAS with reduced environmental impact, certified operators and operations of the new industries, improved aircraft performance, and driving policy in keeping with the pace of newly introduced technology.

Examples of research outputs supporting this goal are as follows:

- Technical report on the performance of fire detection technologies capable of discriminating between actual aircraft fire and non-fire events. *(2017/2018 NARP pg.36)*

- New test protocols with newly developed high speed Digital Image Correlation (DIC) and thermal imaging (IR) technology needed to populate new predictive analytical models for engine fragment impact into composite structure used for engine containment and fuselage structure. *(2017/2018 NARP pg.36)*

- Technical report on the investigation and capabilities of innovative ice protection technologies, such as ice phobics and nanotechnology. *(2017/2018 NARP pg.36)*

- Technical report on use of computational fluid dynamics analysis and of test methods and scaling for iced swept wings. *(2017/2018 NARP pg.36)*

- A Vertical Flame Propagation (VFP) test method apparatus prototype for material in inaccessible areas of aircraft such as ducts and wiring. *(2017/2018 NARP pg.37)*

- Modeling and simulation capability to support crashworthiness design and certification guidance of composite aircraft structures for improvements to the Composite Structural Engineering Technology (CSET) course. *(2017/2018 NARP pg.37)*

- Technical report to make recommendations and technical data for guidance development on Multi-Core Processor (MCP) safety assurance criteria and supporting guidance data for safe implementation of MCPs for use onboard an aircraft. *(2017/2018 NARP pg.38)*

- Develop a database to contain the validated aerodynamic effects of ice shapes on swept-wings for computational fluid dynamics. *(2017/2018 NARP pg.40)*

Other significant accomplishments in relation to this Goal include:

In FY 2018, the FAA paved the way for comparing test outputs with simulation outputs to refine the analysis and improve the results of new predictive analytical models for engine fragment impact into composite structures used for engine containment and fuselage structure design. Advances in computing capability, digital photography, and infrared thermography have seen exponential growth in capability in recent years. Using new Digital Image Correlation technology, researchers are provided full field strain and displacement data rather than data for a single gage location. Researchers can now compare full field test data against full field simulations from finite element analysis to compare and refine the simulations. This work allows researchers to measure the Taylor-Quinney thermal coefficient, which relates to the heat generated during plastic deformation.

In the area of Advanced Materials, the FAA has completed the final configuration of critical parameters in the VFP apparatus, which has resulted in 3 VFP prototype units being produced by Marlin Engineering and delivered to the FAA's William J. Hughes Technical Center, as well as Boeing and Airbus for use in further testing. As testing moves forward it will provide more realistic methods of evaluating the flammability contribution of new materials used in the construction of commercial aircraft to reduce weight and improve efficiency.

In November 2017, the Fire Safety Branch, along with researchers from the University of Cincinnati, co-authored a compelling article published in the refereed journal *Fire and Materials International*. In the article, <u>Experimental study of the burner for FAA fire test: NextGen burner</u>; the authors describe experiments that measured factors such as fuel/air equivalence ratios and thermocouple properties that affected the results of material flammability tests using the new burner. The University of Cincinnati conducted the testing under a grant from the FAA Fire Safety Branch. The results of this research provide a new burner that will be used to improve performance and reliability of required fire certification tests on power plant-related materials.

Advances in aerospace material technologies require evaluation to ensure they perform safely. As a result, the FAA is performing research to assess the use of Aluminum-Lithium Alloys for Primary Structures. This study will assess the material properties and mechanical behavior of the next generation of aluminum lithium (Al-Li) alloys being used in aerospace structures – such as the Bombardier C-Series – through comparisons made to conventional aerospace aluminum alloys. Industry partners include Bombardier and Constellium. The first phase of this project was completed and focused on material characterization. The test results revealed that the mechanical properties of typical third-generation Al-Li alloys were comparable to those of baseline aluminum alloys. However, there were fatigue damage modes unique to the Al-Li materials tested, which included interlaminar and eyebrow cracking in lap joint specimens that were designed to induce unrealistic bending (four times that in a typical fuselage lap-joint). These results will be used in follow on studies to determine if there are unique characteristics to realistic built-up structures including lap-joints with Al-Li alloys, compared with traditional metallic alloys. Results will be used for certification and maintenance standards as applicable.

Another achievement in aerospace vehicles was realized by improving the Uncontained Engine Debris Damage Assessment Model (UEDDAM). UEDDAM is a software tool intended to provide a standardized methodology for uncontained aircraft turbine engine failure analysis. UEDDAM is intended to aid in the design and certification of aircraft by allowing the analyst to model an uncontained engine failure by using aircraft geometry, engine debris characteristics, and fault tree analysis to perform Monte Carlo simulations on fragment trajectories to assess the hazard. The model provides an accurate vulnerability assessment of the aircraft allowing the user to show advisory circular compliance and mitigate the potential threat from an uncontained failure through system positioning, isolation, and shielding. Improvements to the code were made with the release of UEDDAM v5.0 which allows for high performance computing implementation scaling over a large number of processors resulting in drastically reduced runtimes.

Goal 3 - Increase infrastructure durability and resiliency

Research in this goal applies to an infrastructure comprising airport runways, taxiways, air traffic management and aircraft systems and networks, as well as electrical airport sub-infrastructures, and lighting. Goal 3 research focuses on increasing the useful life of this infrastructure and decreasing maintenance and repair costs, NAS operations recovery from disruptive events, and cybersecurity that protects and defends FAA systems from both internal and external threats due to rapid advances and sophistication of cyber-attacks. Cyber work will include NextGen research that will leverage advanced big-data analytical approaches to our complex interdependent networks. Resulting research will lead to a longer lasting, lower cost, dependable infrastructure, defended against cyber events.

Examples of research outputs supporting this goal are as follows:

- FAARFIELD airport pavement design program user interface and functionality improvements. *(2017/2018 NARP pg.46)*

- New and improved FAA PAVEAIR 3.0. This version will improve Pavement Condition Index (PCI) calculation, Prediction Modeling, and contains an FAA prediction curve library, helpful in determining when to perform meaningful maintenance and repairs to pavement systems. *(2017/2018 NARP pg.46)*

- Cyber Integrated Safety Risk Assessment (SRA) Methodology for analysis of cyber threats to aircraft safety in an airborne network environment. *(2017/2018 NARP pg.47)*

- Analysis reports and assessments on relevant national and international data communications *(2017/2018 NARP pg.47)*

Other significant accomplishments in relation to this Goal include:

Researchers completed initial testing for an assessment of emerging metallic structures technology (EMST) using the FAA's Full-Scale Aircraft Structural Test Evaluation and Research (FASTER) facility during the week of May 21, 2018. Data from this study will be used to determine the structural integrity and safety performance of EMST, to assess the relevance of existing regulations, and to inform whether additional safety standards and regulatory guidance should be developed to provide improved safety beyond that afforded by the existing airworthiness standards.

The FAA met with researchers from George Mason University (GMU) from September 4-7, 2018 to conduct an annual review of the impact model development for metallic and composite materials supporting the FAA Aircraft Catastrophic Failure Prevention Program (ACFPP) task for Advanced Analysis Methods for Impact and Blade Release. Uncontained turbine engine failures pose a threat to commercial aircraft safety and have the potential to produce catastrophic outcomes if the aircraft is not adequately protected from the released fragments. The ACFPP has developed several new material models for impact applications to suit the need for predictive models, which are being incorporated into finite element analysis software. A major focus has been on creating a standardized approach to developing material models for metals and composites. To prove out this methodology, material models for several common aerospace metals including Aluminum 2024, Titanium-64, Inconel 718, and the carbon fiber reinforced polymer T800/F3900 are being created. GMU researchers have been largely responsible for development of the computational models that follow a tabulated approach making use of experimental data supplied by The Ohio State University (OSU) and validated against ballistic impact data from NASA Glenn Research Center.

Goal 4 - Improve the operation of the human component of the system

Research in this goal looks first to optimize human performance in these various roles through capability assessments, training, and operation evaluations. Secondly, research will address aeromedical factors related to an individual's inability to meet flight demands. Optimized human performance in the NAS is fundamental to the safe operation of the NAS and inherently to the safety of the airspace community especially the flying customer who relies on the FAA to provide the safest transportation system in the world.

Example research outputs supporting this goal are as follows:

- Recommendations report addressing helicopter training devices, scenario based training, and helicopter crew resource management best practices. *(2017/2018 NARP pg.52)*

- Recommendations to improve controller visual scanning techniques for improved controller initial and recurrent training. *(2017/2018 NARP pg.52)*

- Update regulatory and guidance material on the presentation of electronic charting information. *(2017/2018 NARP pg.53)*

- A 31C compliant Airport Emergency Plan preparation tool that includes an interactive electronic template, supporting training curriculum and use tools, and electronic interactive instructions and guidance. *(2017/2018 NARP pg.53)*

- Identify the specific needs that pilots have for Area Navigation (RNAV) and Required Navigation Performance (RNP) procedures in the NextGen environment and a final report with pilot reviews and recommendations. *(2017/2018 NARP pg.53)*

- Expanded Radar Vectoring Aptitude Test capability to include aptitude for additional controller skills including scanning and planning. *(2017/2018 NARP pg.53)*

Other significant accomplishments in relation to this Goal include:

A key research area the FAA has targeted to improve the human performance during flight is the decision making process to perform go-arounds during unstable approaches. Most accidents occur during the approach and landing phases of flight, and operations in this area account annually for approximately 65% of all accidents. A Flight Safety Foundation (FSF) study of 16 years of runway excursions determined that 83% could have been avoided with a decision to go around. Approximately 4% of approaches are unstable and only 3% of unstable approaches result in a go-around. In an effort to reduce accidents during approach and landing, researchers from FAA, in collaboration with NASA Ames, conducted human-in-the-loop simulation experiments to develop universal and simplified missed approach criteria. The goal was to improve go-around compliance and reduce the risk of approach and landing accidents. The experiment was conducted using the B747-400 Level D simulator at NASA Ames and the A330-200 and B737-800 Level D Simulators at the Mike Monroney Aeronautical Center (MMAC). A total of 36 commercial type-rated pilots are participated in the experiment with six crews per simulator. Each pilot was presented a set of 92 randomized scenarios with various starting conditions and was asked to land all the approaches (no go-arounds were allowed). The objective simulator data and subjective pilot questionnaire data collected helped the research team determine which approach conditions will likely result in a risky and/or abnormal landing. The aggregate data from all three simulators, 3,312 landings in total, will be used to develop missed approach criteria recommendations, and reduce accidents in the critical phase of flight.

The Flight Deck Human Factors Research program on advanced vision systems, head-up displays (HUD), and head mounted displays informs data-driven policy and operational criteria for low visibility flight operations to make it possible for flights in and out of airports when weather might otherwise prevent those operations. The advanced vision system research program has already enabled policy changes that permit a Synthetic Vision Guidance System on a head-down display (SVGS/HDD) to be used to conduct low visibility approaches on Special Authorization Category I (SA CAT I) Instrument Landing System (ILS) instrument approach procedures. SA CAT I ILS approaches can be flown in visibilities as low as RVR 1400 feet and to a lower decision height of 150 feet. Prior to this policy change, SA CAT I ILS approaches could only be conducted using a HUD. Permitting these low visibility approaches to be flown using an SVGS/HDD enables more operators who don’t have a HUD, or who don’t have adequate space in the cockpit for a HUD, to fly more instrument approaches in low visibility conditions. Today, there are 150 SA CAT I ILS approach procedures and more are added to the inventory weekly. This means increased landings and decreased delays – all while maintaining our global leadership in aviation safety. The FAA is the first civil aviation authority in the world to authorize SVGS/HDD for SA CAT I ILS approaches.

In the area of low visibility takeoff, research is being conducted that could expand HUD-guided takeoffs which are currently only conducted from twelve runways at four airports. Expanding HUD-guided takeoffs could enable lower takeoff visibilities on 221 runways at 203 airports in the NAS. These initiatives aim to determine the effect of these operations on pilot performance and operational safety at greater numbers of airports and runways throughout the NAS. The success of this research is due to the partnership with manufacturers (e.g., Elbit, Gulfstream, Honeywell) and operators (e.g., FEDEX) with an approximate 60/40 cost share. The safety and economic benefits to the public are many. For example, airlines and other aircraft operators who use these technologies will be able to more safely fly into and out of more airports under low visibility conditions, making more vital services available to the public – all while maintaining our global leadership in safety. This helps increase the resiliency, durability, and reliability of our transportation infrastructure as a whole. Safely introducing new technologies into low visibility flight operations is not possible without research to understand the effect on pilot performance and operational safety.

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

Research associated with this goal includes developed scientific understanding of aerospace systems used to develop NAS improvements, developed analytical and predictive capabilities used in the capture, parsing, analysis, and sharing of data, and a developed toolset to evaluate NAS system wide performance especially given the introduction of new and emerging technologies. 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 of systems. This work will also improve the robustness, adaptability, flexibility, and accuracy of these integrated analytical and computational modeling tools enables NAS effectiveness in the delivery of the highest quality service to the greatest number of stakeholders in a timely, safe, and practical manner.

Examples of research outputs supporting this goal are as follows:

- Data package and methods for guidance material for the airworthiness acceptance criteria and test methods for engines in simulated high ice water content environments. *(2017/2018 NARP pg. 59)*

- UAS Requirements for NAS Voice System (NVS) Program. *(2017/2018 NARP pg. 61)*

- Determination as to whether Machine Learning can be used to augment predictive risk detection based on the use of deep learning, neural networks, and other machine learning techniques. *(2017/2018 NARP pg. 61)*

- Identify safety topic trends, monitor frequency of safety events, and detect the emergence of safety topics using topic modeling processes. *(2017/2018 NARP pg. 61)*

- Finite Element Analysis model to evaluate aircraft response to selected impact scenarios, supporting crashworthiness impact requirements and guidance material development. *(2017/2018 NARP pg. 64)*

- Feasibility study on using voice data, in conjunction with known events to provide new knowledge into the contextual environment of the event. Research will be based on developed Key Performance indicators (KPIs) of risk that provide insight into the trends and locations of unsafe events. *(2017/2018 NARP pg. 66)*

- Front Gate analyses and technical report for Paired Approach to Category (CAT) I minima. *(2017/2018 NARP pg. 67)*

- Concept of Operations Version 1.0: "Beyond Visual Line of Sight UAS Operations below 400 Ft Above Ground Level under UAS Traffic Management Construct." *(2017/2018 NARP pg. 67)*

Other significant accomplishments in relation to this Goal include:

The Office of NextGen (ANG) officially transitioned NextGen Enterprise Repository (NER) R&D capabilities to support an FAA-wide, enterprise approach to data access and Big Data analytics on the Cloud in April 2018. Engineers from the Aviation Research Division and the Technology Development and Prototyping Division briefed leaders within ANG and the FAA chief data officer on specific capabilities, tools, data, and knowledge fostered over the three-year NER effort. System Safety Section personnel supported the transition of software and technologies that provide near real-time streaming of System Wide information Management (SWIM) data directly to Big Data technologies on Enterprise Information Management's (EIM) Enterprise Capability (EC) within the FAA's Cloud Service (FCS). The NER work will help the FAA in moving forward by creating a single, authoritative data source and robust analytical capability that allows all FAA lines of business to share, collaborate, and enhance their productivity and effectiveness in developing machine learning and decision support systems. Branch personnel and the Aviation Safety Information Analysis and Sharing (ASIAS) program will continue to support the assimilation of FAA Big Data technologies with their work on the Technical Center's Computer Analytics and Shared Services Integration Environment (CASSIE) and through collaboration with the EIM EC team.

We Welcome Your Comments

Thank you for your interest in the FAA's FY 2018 Research and Development Annual Review.
We welcome your comments on how we can make this report more informative for our readers.

Please send your comments to:
Office of Research Management
Federal Aviation Administration
William J. Hughes Technical Center
Atlantic City Airport, AC NJ

Acronyms

Acronym	Definition
A	
ACFPP	Aircraft Catastrophic Failure Prevention Program
ACRP	Airport Cooperative Research Program
AIP	Grants-In-Aid for Airports Appropriation
Al-Li	Aluminum Lithium
ANG	Office of NextGen
AOC	Airline Operations Center
AOGS	Asia Oceania Geosciences Society
AR	Annual Review
ARAM	Aviation Range and Aerospace Meteorology
ARTCC	Air Route Traffic Control Centers
ASIAS	Aviation Safety Information Analysis and Sharing
ATC	Air Traffic Control
ATD&P	Advanced Technology Development & Prototyping
ATD-2	Airspace Technology Demonstration Phase 2
ATRP	Airport Technology Research Program
B	
BVLOS	Beyond Visual Line of Sight
C	
CAASD	Center for Advanced Aviation System Development
CASSIE	Computer Analytics and Shared Services Integration Environment
CDO	Convective Diagnosis Oceanic
COE	Center of Excellence
ConOps	Concept of Operations
CRDA	Cooperative Research and Development Agreement
CSET	Composite Structural Engineering Technology
CTH	Cloud Top Height
D	
DARWIN®	Design Assessment Of Reliability With Inspection
DIC	Digital Image Correlation
E	
EC	Enterprise Capability
EDR	Eddy Dissipation Rate
EFB	Electronic Flight Bag
EFVS	Enhanced Flight Vision System

Acronym	Definition
EIM	Enterprise Information System
EMAS	Engineered Material Arresting System
EMST	Emerging Metallic Structures Technology
EUROCAE	European Organization for Civil Aviation Equipment
ESCO	Engineered Arresting Systems Corporation
F	
F&E	Facilities and Equipment Appropriation
FAA	Federal Aviation Administration
FASTER	Full-Scale Aircraft Structural Test Evaluation and Research facility
FCS	FAA's Cloud Service
FHWA	Federal Highway Administration
FMFFT	Flightcrew Member fatigue Focus Team
FRMS	Fatigue Risk Management System
FY	Fiscal Year
G	
GMU	George Mason University
H	
HDD	Head Down Display
HRRR	High Resolution Rapid Refresh
HUD	Head Up Display
HVS-IA	Heavy Vehicle Simulator International Alliance
I	
IA	Interagency Agreements
ILS	Instrument Landing System
IR	Infrared
M	
MCP	Multi-Core Processor
MMAC	Mike Monroney Aeronautical Center
MMPDS	Metallic Materials Properties Development Standardization
MOA	Memorandum/a of Agreement
N	
NARP	National Aviation Research Plan
NAS	National Airspace System
NASA	National Aeronautics and Space Administration
NER	NextGen Enterprise Repository
NHTSA	National Highway Traffic Safety Administration
NOAA	National Oceanographic and Atmospheric Administration
NVG	Night Vision Goggles

Acronym	Definition
NWS	National Weather Service
O	
OMB	Office of Management and Budget
OSU	Ohio State University
R	
RAP	Rapid Refresh
R&D	Research and Development
R,E&D	Research, Engineering and Development Appropriation
RECAT	Re-categorization Program
RNAV	Required Navigation
RNP	Required Navigation Performance
ROMIO	Remote Oceanic Meteorology Information Operational
RSA	Runway Safety Area
S	
SA CAT I	Special Authorization Category I
SEM	Society for Experimental Mechanics
STEM	Science Technology Engineering and Math
SVGS	Synthetic Vision Guidance System
SWIM	System Wide Information Management
U	
UAS	Unmanned Aircraft System
UEDDAM	Uncontained Engine Debris Damage Assessment Model
U.S.	United States
V	
VFP	Vertical Flame Propagation
W	
WTIC	Weather Technology in the Cockpit