2017/2018
National Aviation Research Plan
(NARP)

June 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

2017/2018 NARP
June 2019

The *National Aviation Research Plan* (NARP) is a report of the Federal Aviation Administration to the United States Congress pursuant to Section 44501(c) of Title 49 of the United States Code. The NARP is available on the Internet at http://www.faa.gov/go/narp

Letter from the Acting Administrator Dan Elwell

The FAA is pleased to provide a combined 2017/2018 National Aviation Research Plan in accordance with Section 44501(c) of Title 49 of the United States Code (49 U.S.C. § 44501(c)). The NARP details how the FAA structures and executes its Research and Development (R&D) to ensure the Nation's investments are well placed and deliver results addressing national aviation priorities.

In prior submissions, we structured the NARP to address how we were executing our R&D portfolio in relation to appropriation accounts (Research, Engineering and Development, Facilities and Equipment, and Airport Improvement Program). Elements of our portfolio were directly linked to Budget Line Items (BLIs). While this approach spoke directly to how well Congress' appropriations were being executed, it did not necessarily address how the FAA's R&D portfolio was evolving and responding to the nation's fast-paced, ever changing aviation technology needs.

This year's combined 2017/2018 NARP submission is unique in two respects; it includes both FY 18 and FY 19 research plans and, it is redesigned to better illustrate the FAA's Research and Development through an objective-based approach versus a budget-focused format. This redesigned NARP will improve the FAA's conveyance of their Research and Development Plans by focusing on three DOT strategic goals:

1. SAFETY: Reduce Transportation-Related Fatalities and Serious Injuries Across the Transportation System,
2. INFRASTRUCTURE: Invest in Infrastructure to Ensure Safety, Mobility and Accessibility and to Stimulate Economic Growth, Productivity and Competitiveness for American Workers and Businesses and
3. INNOVATION: Lead in the Development and Deployment of Innovative Practices and Technologies that Improve the Safety and Performance of the Nation's Transportation System

Table of Contents

List of Tables

List of Figures

1.0 Introduction

1.1 Approach

Section 44501(c) of Title 49 of the United States Code (49 U.S.C. § 44501(c)) requires that the FAA Administrator submit its National Aviation Research Plan (NARP) to Congress annually with the President's Budget. The NARP details how the FAA structures and executes its Research and Development (R&D) to ensure the Nation's investments are well placed and deliver results addressing national aviation priorities.

In prior submissions, we structured the NARP to address how we were executing our R&D portfolio in relation to appropriation accounts (Research, Engineering and Development, Facilities and Equipment, and Airport Improvement Program). Elements of our portfolio were directly linked to Budget Line Items (BLIs). While this approach spoke directly to how well Congress' appropriations were being executed, it did not necessarily address how the FAA's R&D portfolio was evolving and responding to the nation's fast-paced, ever changing aviation technology needs.

This year's NARP submission is unique in two respects; it includes both FY 18 and FY 19 research plans and, it is redesigned to better illustrate the FAA's Research and Development through an objective-based approach versus a budget-focused format. This redesigned NARP will improve the FAA's conveyance of their Research and Development Plans by focusing on three DOT strategic goals:

1. SAFETY: Reduce Transportation-Related Fatalities and Serious Injuries Across the Transportation System,
2. INFRASTRUCTURE: Invest in Infrastructure to Ensure Safety, Mobility and Accessibility and to Stimulate Economic Growth, Productivity and Competitiveness for American Workers and Businesses and
3. INNOVATION: Lead in the Development and Deployment of Innovative Practices and Technologies that Improve the Safety and Performance of the Nation's Transportation System

To guide us in achieving these DOT strategic goals, we have set out a series of R&D Goals (such as "Accelerate the use of new technologies for aerospace vehicles, airports, and spaceports", and "Improve modeling capabilities and system-wide analysis"). To round out this new approach, we developed associated Objectives and outputs to focus our efforts and allow us to measure how well we are doing. With this structure, we can continually align outputs with Objectives, identify gaps between them, and institute new or adjust existing programs to address those gaps. We further understand that successful research will only provide benefits when the technology is transferred to our aviation industry partners. So, a measure of output success will be the transfer of the developed technology to an industry partner, and their successive implementation into programs and/or products.

This paradigm shift and redesign requires phasing in, so this year's NARP is a hybrid document. It reports on our R&D portfolio in terms of the newly established Objectives, while maintaining a link with the existing BLIs. As we move into the future, you will see the NARP reflecting a more dynamic R&D portfolio that will contribute to our nation's continued security and economic well-being.

1.2 A Research Portfolio Adapting to Changing Needs

1.2.1 The National Aviation Research Plan (NARP)

In October 1985, the FAA published the agency's first research and development plan entitled "The Federal Aviation Administration Plan for Research, Engineering and Development." In the cover letter, then Administrator Donald D. Engen wrote "*This research, engineering, and development (RE&D) plan has been developed by the FAA to meet the challenges that face the National Airspace System (NAS) through the year 2010*."

As the aviation industry evolves the FAA has responded by annually revisiting its research and development (R&D) portfolio, reaffirming or making adjustments to ensure emerging challenges are identified and addressed and effectively communicated through the FAA's National Aviation Research Plan.

The NARP highlights and reports on the FAA's applied R&D as defined by the Office of Management and Budget (OMB) Circular A-11 and involves activities funded in three appropriation accounts:

1. Research, Engineering and Development (RE&D):
   - Safety, Efficiency, Environmental and Mission Support (21 Business Line Items (BLIs))
2. Facilities & Equipment (F&E)
   - Advanced Technology Development & Prototyping (ATD&P)
   - NextGen Portfolios
   - Center for Advanced Aviation Systems Development (CAASD)
3. Airport Improvement Program (AIP)
   - Airport Technology & Airport Cooperative Research (2 BLIs)

1.2.2 Aviation – A Changing World with Changing Needs

Over the past decade, aviation has undergone an accelerated evolution. There are roughly a million people airborne at any one time, with about 100,000 flights crisscrossing the globe. Of these flights, over 10,500 global destinations are connected to airports within the United States. For example, with 200 gates, Hartsfield-Jackson Atlanta International Airport is the busiest airport in the world with 104 million passengers and nearly 900,000 operations a year. While these numbers by themselves are staggering, the latest prediction models estimate that there will be a doubling of passengers by 2035. At the same time, the use of drones or unmanned aircraft systems (UAS) has increased dramatically, with over 530,000 new UAS user registrations in 2016 alone (Source: the FAA's 2016 Performance and Accountability Report (PAR)).

The last decade has also shown an exponential growth of new and emergent technologies with massive changes in aircraft design now mostly comprised of advanced composite materials, new manufacturing collaboration and techniques, and the addition of additive manufacturing (3D printing). Designer drugs have been introduced into the market, there are more advanced biomedical methods available and novel bioengineering technology that will influence human performance in flight and survival from emergency events.

Not only are major changes occurring within the traditional airspace, but advances in commercial space are making significant impacts. The FAA's Performance and Accountability Report (PAR) states "an increase of 200 percent the number of launch and reentry operations it oversees" and the complexity of these operations are increasing dramatically. With commercial space companies currently placing unmanned robots on the moon, the projections for the future are endless. Ideas of space tourism, interplanetary travel and commercial space stations are all steps that show how the landscape of aviation is evolving and the FAA is working hard to address these new challenges head on.

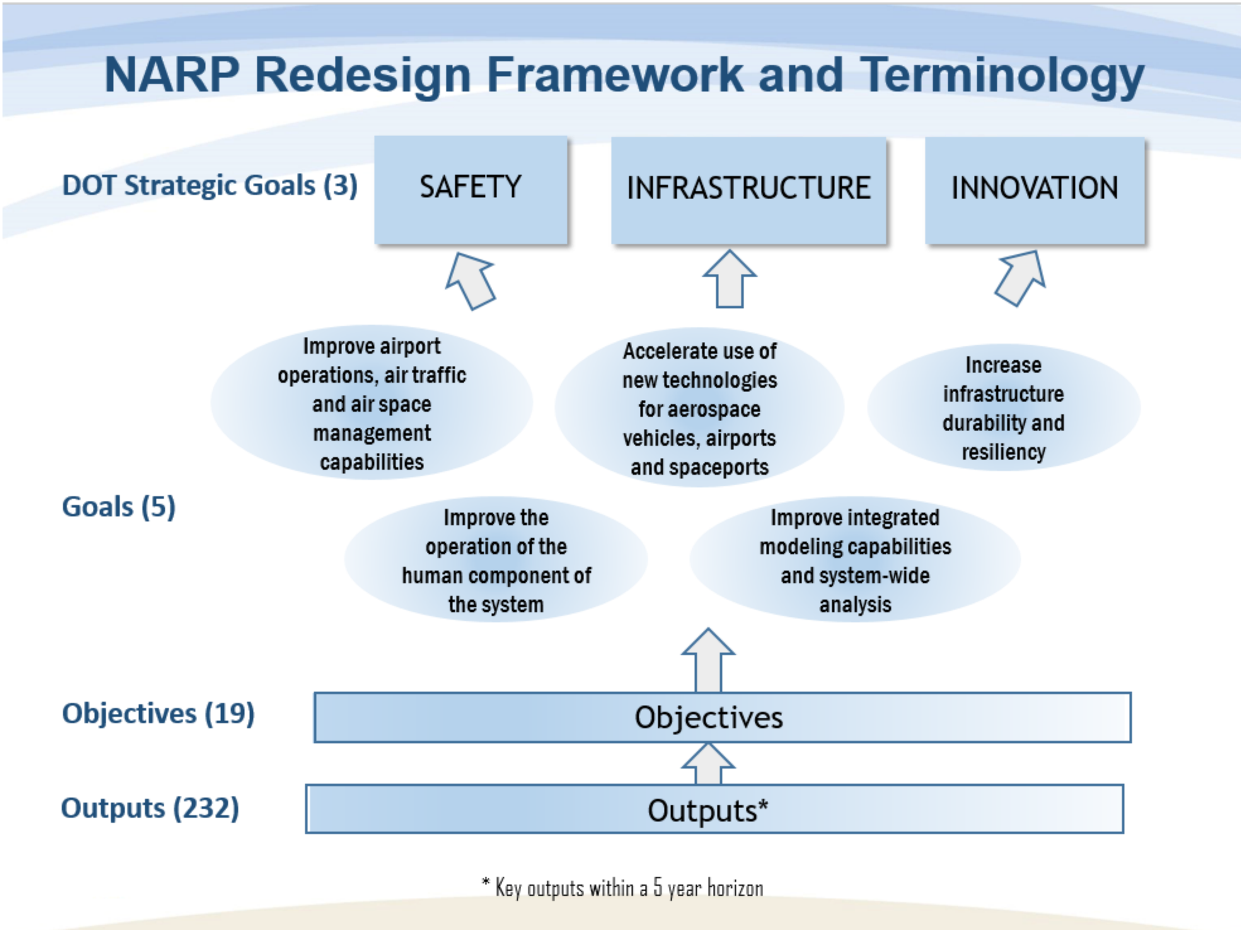
Increased air traffic, and the concentration of flight paths that have resulted from precision navigation, has also led to increased public concern about aviation noise. The FAA is taking a comprehensive approach to address aviation noise by supporting research to understand the impact of aviation noise, promote community outreach, and enhance mitigation through aircraft technologies and advanced operation procedure development.

NAS Horizons is an FAA-wide project that is tasked with providing the FAA, interagency, and aviation community a range of options in strategies, technologies, and concepts for the NAS, to be prepared for the challenges of 2045 and beyond. Specifically, the NAS Horizons project will be evaluating current and projected global and aviation trends and identifying the operational concepts and enabling technologies that the FAA might lead, fast follow or closely monitor to ensure that the NAS remains dynamic and resilient over the coming decades. This process will aid FAA leadership in strategic planning for 2045 and beyond, and implement its strategic Goals through investment, policy, organizational design, and partnership development.

1.2.3 NARP – A Reflective Redesign

The globally changing aviation industry requires a holistic FAA research and development 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. We also received feedback from the Research, Engineering and Development Advisory Committee (REDAC), its subcommittees and others regarding the need for the FAA to have a higher level strategy and improved plan. To better respond to the needs of stakeholders, the NARP was redesigned to effectively communicate our strategy, Goals, and plan in the context of technology-driven change and within a framework of DOT strategic goals, R&D goals, Objectives and outputs. To strengthen the understanding of the relevance and effectiveness of the FAA's R&D, the NARP's framework was changed from 2017's 25 Goals and 419 Milestones to 5 strategic Goals, 19 focused Objectives and 232 representative research outputs as illustrated in **Figure 1.2.3, NARP Redesign Framework and Terminology**.

Figure 1.2.3 NARP Redesign Framework and Terminology



These changes enable tighter integration across FAA organizations and provide direct line-of-sight and alignment to operational results and the FAA/Department of Transportation (DOT) Strategic Priorities and DOT's Critical Transportation Topic Areas.

2.0 FAA Research & Development Introduction

2.1 Why FAA Research & Development Matters

To ensure that the FAA remains the safest and most efficient aerospace system in the world, it is imperative that, through world-leading R&D, the FAA continues to strive to improve the safety and efficiency of flight on a global scale.

This is why the FAA's R&D is so critical …

On the windy and wet evening of October 27, 2016, a chartered Boeing 737 overran a rain-soaked Runway at New York's LaGuardia airport, careening off into the grass when the pilot was unable to stop on the remaining runway. Miraculously, none of the 48 people onboard were injured. Including the future Vice President of the United States, Mike Pence.
But, was this really a miracle? Or, as experts recognized, the proper functioning of a safety design improvement installed at LaGuardia – an Engineered Material Arresting System (EMAS), originally designed and developed at the FAA.

Since the 1990s, the FAA has done extensive research to improve runway safety areas (RSAs). The RSA is typically 500 feet wide and extends 1,000 feet beyond each end of the runway, and provides a graded area in the event an aircraft overruns, undershoots, or veers off the side of the runway. In some cases, the standard RSA is not practical due to lack of available and feasible land. This extensive research lead to the development of the Engineered Material Arresting System (EMAS). The 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 causing the aircraft to decelerate as it rolls through the material. The EMAS technology can be installed to help slow or stop an aircraft that overruns the runway, even if the RSA is less than the standard 1,000-foot runway overrun.

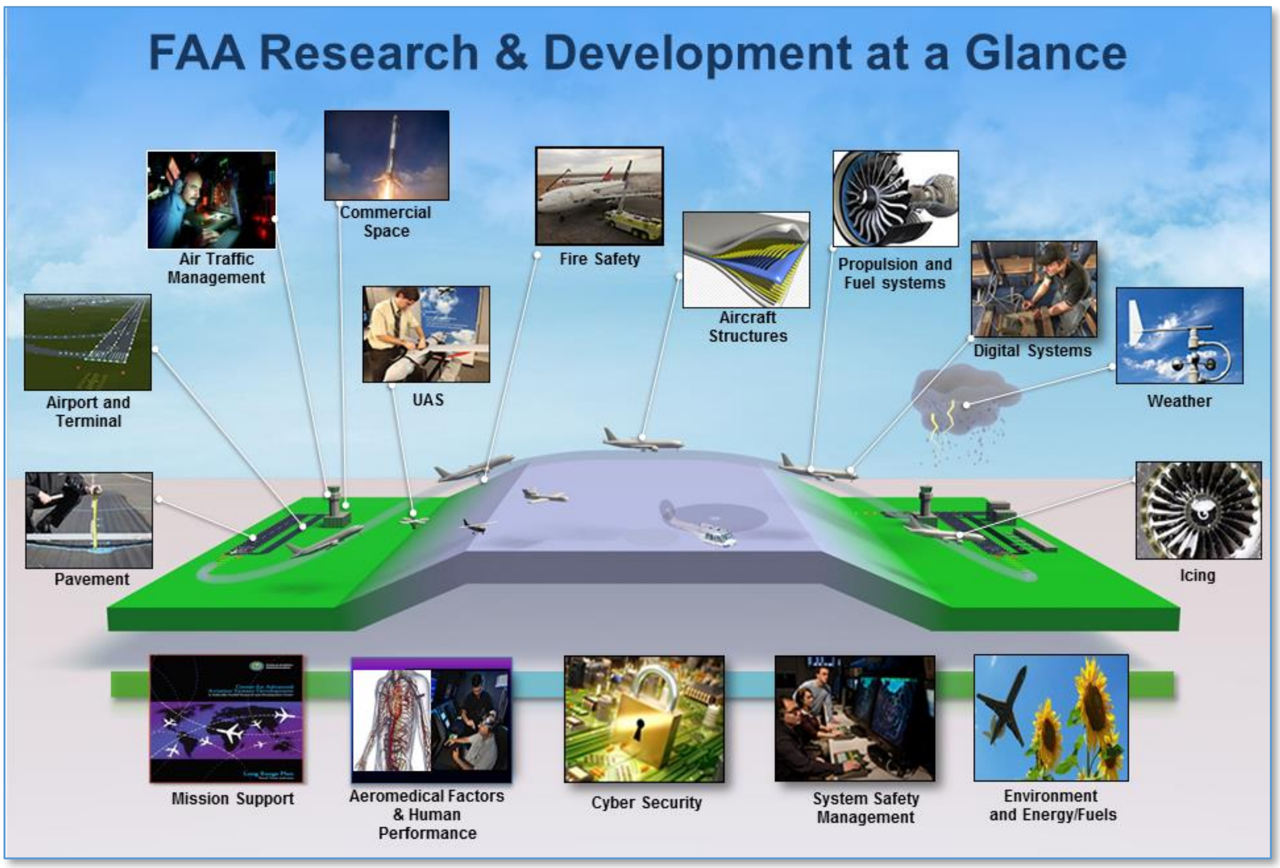
As a result of the extensive research and development performed by the FAA, the EMAS technology has safely stopped 12 overrunning aircrafts, and possibly saved many more lives.

The FAA is best positioned to do the R&D that is critical to providing the safest air transportation system in the world. As we know, this complex and dynamic world of aviation includes risks. The FAA's research mitigates those risks and ensures that the aviation community - the flying public, airlines, aircraft manufacturers and other stakeholders - is being heard and protected from all types of hazards such as lithium batteries, bird strikes, extreme weather, and other threats to aircraft and aviation. Safety is the paramount priority, but risk mitigation also ensures worldwide economic health and value since the aviation industry supports $2.7 trillion (3.5%) of the world's gross domestic product (GDP).

2.2 FAA Research & Development Portfolio Introduction

Consistent with the three DOT strategic goals of Safety, Infrastructure and Innovation, the FAA has a robust profile of aviation R&D projects. The varied projects, when evaluated for their intended focus, fall in one of the categories depicted in **Figure 2.2, FAA Research and Development at a Glance.** This figure highlights all the aviation elements of the NAS in which research is planned, that when taken all together, comprise the whole of the FAA's aviation R&D portfolio. Our discussion of these elements starts at the left of the graphic and continues clockwise until we have completed the Story of the FAA's research efforts.

Figure 2.2 FAA Research and Development at a Glance



Starting at an airport's ground level, two essential categories of research are conducted – runway **Pavement** and **Airport and Terminal** projects. Pavement research focuses on improvements to the FAARFIELD computerized runway pavement design program; improved and alternative pavement asphalt and concrete construction materials; and developing predictive maintenance models; all meant to extend pavement life, reduce cost, and improve service. Airport and Terminal projects focus on both operational and infrastructure elements not associated with pavement. Operational projects such as assessing state-of-the-art capabilities in Surface Taxi Conformance Monitoring (STCM) technology to reduce runway incursions, and diverse studies of wake turbulence – mitigation, modulation, and weather impacts; will certainly improve aircraft safety on the ground. Sample infrastructure projects, are the improvement of airport lighting and airport paint markings which also have significant safety implications.

Critical to aviation is how we manage the vehicles that fly. **Air Traffic Management**, as its name suggests, manages air traffic both on the ground and in the air. In this category, projects center on separating aircraft on departures and approaches, improving multiple runway operations, and delivering air traffic control decision support tools like air-to-ground trajectory synchronization to support Trajectory Based Operations (TBO). The recent rapid introduction of **Commercial Space** vehicles and Unmanned Aircraft Systems (**UAS**) has made airspace management more complex. Representative Commercial Space research projects look to improve vehicle safety and risk management by predicting environmental conditions for launch; developing launch citing tools; and developing rocket trajectory envelopes so as to minimize impact on air traffic management operations during vehicle launch and reentry. The present and forecasted continued proliferation of UAS in the NAS is met with such research as UAS detection and avoidance, UAS visibility enhancement, and the development of operational performance standards.

Turning now to the aircraft that fly in the NAS and how we ensure their safe operation, **Fire Safety** projects address in-flight fires such as studying the behavior of materials in actual accident conditions and on improving post-crash survivability. Notable research in this category is the continued efforts in testing the effects of lithium batteries when transported as cargo. Projects in the **Aircraft Structures** category address the material make up and construction of various aircraft. Projects here include the evaluation of varied composites, alloys, and their fabrication techniques; analysis of environmental and aging effects on aircraft structures, and modeling bird strike impacts to aircraft structures and engines, all helpful in promulgating continued airworthiness. Moving into the aircraft and in particular the engine, or **Propulsion and Fuel Systems**, planned studies here include use of the DARWIN engine design code to address engine damage formulation and growth at elevated temperatures; the impact of uncontained engine fragments and its counterpart – the development of improved engine containment systems; and effects of volcanic ash on propulsion systems. Last in this grouping is the onboard aircraft **Digital Systems** category. As modern avionics and control systems become increasingly network accessible, they can also lead to vulnerabilities. Digital systems research looks to mitigate those vulnerabilities by developing a cyber-integrated Safety Risk Assessment (SRA) Methodology for analysis of cyber threats to aircraft safety in an airborne network environment. The Digital System Safety program is also developing electronic hardware guidance material required for such devices as Portable Electronic Devices (PEDs).

Because weather can negatively affect aircraft, airport operations, and/or air traffic management, various research projects are included in both the **Weather** and **Icing** categories. Research is planned by both the Weather and NextGen Weather programs to include a Continental United States (CONUS) in-flight icing analysis and forecast capability, an automated Offshore Precipitation Capability, and developed standards for real-time broadcasting of aircraft-observed weather data, amongst others.

The categories appearing on the bottom of the FAA Research & Development at a Glance graphic represent the cross-cutting research in the FAA R&D portfolio that affects all the previously described categories. In **Environment & Energy/Fuels** – aircraft noise, aircraft emissions, and their environmental impacts are characterized such that the appropriate mitigation strategies can be developed. Along with industry cost-share partners in the Continuous Lower Energy Emissions and Noise (CLEEN) program, the FAA is accelerating the maturation of aircraft and engine technologies that could reduce noise, emissions and fuel burn from the aircraft fleet. The FAA is also working with a myriad of partners across government, industry and academia to advance the development of alternative jet fuels and an unleaded replacement for general aviation gasoline. **System Safety Management** advances safety data collection and risk analysis and prototype risk-based decision making capabilities.

Cyber Security entails research meant to prevent disruptive cyber incidents and improve resiliency to cyber-attacks. Significant work in this area includes developing a FAA Cyber Security Research and Development Plan that includes research on identifying aircraft cyber safety risks and identifying advanced analytical and visualization methods for predicting and responding to cyber events. An evolving NAS requires research on various aspects of Human interaction with the system. The **Aeromedical Factors & Human Performance** projects are performed from a human engineering perspective to look at a breadth of issues including performance assessment, training, certification, health, equipment interaction, and more. Examples of key Aeromedical and Human Factors projects include minimizing inherent human weakness to prevent accidents through evidence-based medicine, identifying hazards and investigating injury/death patterns in civilian flight accidents, operational use of advanced vision systems and head-up/head-mounted displays, developing Graphic User Interface (GUI) style guides, and for the growing UAS industry – UAS air carrier remote pilot and crew training and testing requirements.

The last cross-cutting research category is that of **Mission Support**. This is a unique research category in that the work performed in this area sustains the specialized FAA research facilities at the William J Hughes Technical Center (WJHTC); manages the entire R&D portfolio; and creates and delivers the NARP and Annual Report; and oversees the research work performed by MITRE-CAASD (Center for Advanced Aviation System Development) for the FAA.

2.3 Strategic Discussion of Resources

The Office of Management and Budget FY 2019 Administration Research and Development Budget Priorities memo encourages, among other things, the R&D priority practice of maximizing interagency coordination and the modernization and management of the FAA research infrastructure, necessary for spurring future advances.

2.3.1 FAA Partnerships

In keeping with the priority practice of maximizing interagency coordination, the FAA portfolio of research projects includes successfully established partnerships with other U.S. government agencies, NASA, state and local governments, the private sector, academia, and international partners. Such partnerships help the FAA leverage critical resources and capabilities to ensure that the Agency can achieve its Goals and Objectives. By partnering with other organizations, the FAA gains access to both internal and external innovators, promotes the transfer of FAA technologies to the private sector for other civil and commercial applications, and expands the U.S. technology base. Of particular note, the FAA has partnered with NASA on various levels to include structured Research Transition Teams (RTTs), of which there are five, which focus on transitioning NASA technologies to the FAA. NASA and the FAA currently support the following RTTs:

- Efficient Flow into Congested Airspace (EFICA) RTT
- Integrated Arrival/Departure/Surface (IADS) RTT
- Applied Traffic Flow Management (ATFM) RTT
- System-wide Safety (SWS) RTT
- Unmanned Aircraft Systems Traffic Management (UTM) RTT

Additionally, enormous benefits are gained by fostering partnerships and affiliations with institutions of higher education - coordinating and unleashing the best minds on the toughest problems in mission critical areas. This is achieved through the FAA's Air Transportation Centers of Excellence (COEs) and its network of schools and cost-sharing industry partners. Collaboration with these partners enables the FAA to maximize its resources while also leveraging the knowledge, experience, skill and resources of others. During FY 2017, the FAA COE Program Management Office (PMO) awarded $24.6 million in support of 119 projects at 62 COE universities throughout the U.S. The FAA executed 224 grant awards and other actions, and generated more than $30 million in matching contributions from industry and other Non-Federal sources.

See **Appendix 2** for more information on Interagency, International, and Academia **Partnerships** and **Appendix 6** for more information on **Partner Activities.**

2.3.2 Laboratory Resources

State-of-the-art research laboratories physically provide the FAA R&D portfolio with unique one-of-a-kind capability to conduct world-leading research. These laboratories are where applied research is conducted to improve aircraft and airport safety including full-scale test facilities for aircraft fire, pavement, aircraft structures, propulsion systems and flight simulators. Research conducted includes recreation of events in a controlled test environment, simulations, identifying causal factors associated with aviation accidents, optimizing both the people operating within the NAS and the machines/systems comprising the NAS and developing biochemical methods to detect the presence of medications, toxins, and other substances that may impact an airman’s performance in-flight. The FAA’s research laboratory facilities exist in two geographic locations, each offering separate and distinct capabilities; the William J. Hughes Technical Center (WJHTC) located in Atlantic City, NJ and the Mike Monroney Aeronautical Center (MMAC) located in Oklahoma City, OK. For a more detailed description of the FAA laboratories **see Appendix 3 Research Laboratories.**

3.0 FAA Research & Development Profile

3.1 Introduction of Research & Development Goals

The FAA's Mission is to provide the safest and most efficient aerospace system in the world including:

- Regulating civil aviation and U.S. commercial space transportation to promote safety
- Encouraging and developing civil aeronautics, including new aviation technology and researching and developing the National Airspace System
- Developing and operating a system of air traffic control and navigation for civil aircraft
- Developing and carrying out programs to control aircraft noise and other environmental effects of civil aviation

The FAA's Applied Research & Development (R&D) is used to benefit the aerospace community by keeping pace with advanced aerospace technologies while systematically expanding and applying aerospace system knowledge in the:

- Provision of research data and analyses for aerospace policy, guidance, and standards development
- Evaluation and/or validation of requirements, procedures, and methods
- Production of useful materials, devices, systems, tools, and technologies

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 National Airspace System (NAS). The FAA R&D portfolio supports both the day-to-day operations of the NAS and balances between near-, mid-, 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 DOT strategic goals:

- **SAFETY: Reduce Transportation-Related Fatalities and Serious Injuries Across the Transportation System**. Safety has consistently been DOT's top strategic and organizational goal. To improve transportation safety, DOT seeks to work effectively with State, local, Tribal, and private partners; address human behaviors to reduce safety risks; improve safety data analysis to guide decisions; continue to employ safety countermeasures; ensure that automation brings significant safety benefits; and pursue performance-based rather than prescriptive regulations.
- **INFRASTRUCTURE: Invest in Infrastructure to Ensure Safety, Mobility and Accessibility and to Stimulate Economic Growth, Productivity and Competitiveness for American Workers and Businesses**. DOT seeks to work effectively with State, local, Tribal, and private partners to guide investments that stimulate economic growth, improve the condition of transportation infrastructure, and enable the efficient and safe movement of people and goods. To achieve this goal, DOT will provide guidance, technical assistance, and research that leverages Federal funding, accelerates project delivery, reduces project lifecycle costs, and optimizes the operation and performance of existing facilities. By using innovative forms of financing and project delivery, encouraging partnerships between the public and private sectors, and strategically balancing

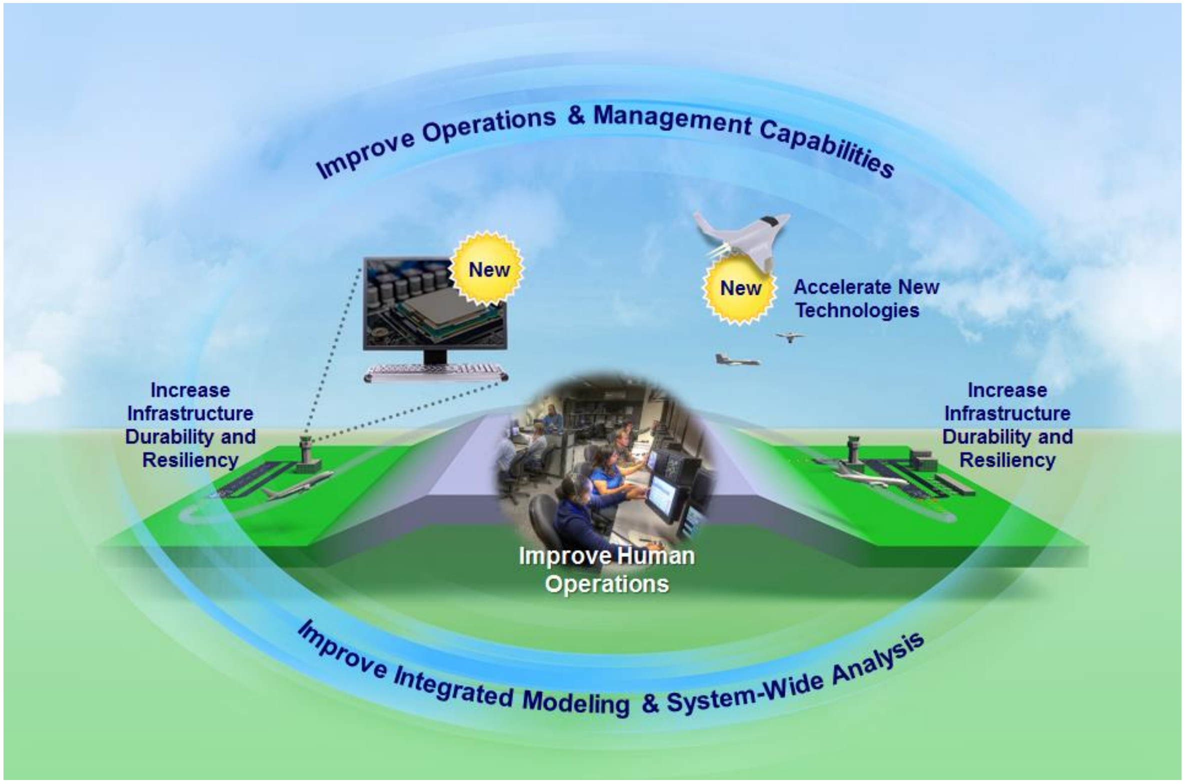
investments across various modes of transportation to promote greater efficiencies, DOT can maximize the returns to the Nation's economy and people.

- **INNOVATION: Lead in the Development and Deployment of Innovative Practices and Technologies that Improve the Safety and Performance of the Nation's Transportation System.** Emerging technologies are transforming our transportation system. DOT seeks to continue its leadership role guiding research investments and facilitating the deployment of beneficial transportation technologies. By engaging with the private and public sectors, DOT can leverage Federal resources to support technology transfer and ensure the safety and security of new technologies.

The FAA R&D Goals necessary to achieve DOT's strategic goals 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. As depicted in **Figure 3.1 Holistic View of the Aviation System**, the FAA's 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. Increasing NAS Infrastructure Durability and Resiliency
4. Improving Human Operations in the NAS
5. Improving NAS Integrated Modeling and System-Wide Analysis

Figure 3.1 Holistic View of the Aviation System



3.2 Research & Development Goals/Objectives/Outputs

The following sections identify the representative R&D work for each goal and objective (depicted below) that make up the FAA's R&D framework.

Goal 1

Improve Airport Operations, Air Traffic, and Air Space Management Capabilities

Objective 1a: Separation Management

Identify and develop new separation management tools, procedures, and/or requirements for the aerospace community to safely evolve separation management, improve access and flexibility in the NAS, enable the most efficient aircraft routes, and increase airspace capacity.

Objective 1b: Air/Surface Traffic Management

Identify and develop new traffic management tools, operating procedures and/or requirements for the aerospace community's use of airborne and surface movement data to enable en route efficiency more flexible arrival and departure operations and to efficiently use runway capacity.

Objective 1c: Integrated Weather Information

Identify and develop high quality weather analysis and forecast capabilities for the aerospace community to support efficient airport operations and air traffic management decision-making to safely mitigate the impacts of adverse weather.

Objective 1d: Collaborative Decision Making

Identify and develop methods for better access to and exchange of aerospace information for the aerospace community to make the best use of available airspace and airport/spaceport capacity and improve NAS efficiency through greater flexibility, predictability, user preference accommodation, and timely coordination/collaboration.

Objective 1e: Airport/Spaceport Systems

Identify and develop guidelines for the design and implementation of airport/spaceport systems, infrastructure and procedures and their use to increase efficiency, optimize capacity, and enhance safety.

Objective 1f: Aerospace Vehicle Operation

Identify, develop, and validate new and enhanced tools, procedures, and/or requirements for the aerospace community to effectively and safely manage the expanded operation of existing and future aerospace vehicles in the evolving NAS.

Objective 1g: Noise and Emission

Identify and develop tools, methods, and procedures and/or requirements for the aerospace community to reduce the noise and emissions from aerospace vehicle operations.

Goal 2

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

Objective 2a: Applied Innovation

Identify and demonstrate new aerospace vehicle and airport/spaceport technologies that could be adopted by the aerospace community to improve safety, increase efficiency, and reduce environmental impacts.

Objective 2b: Certification/Licensing

Identify, develop, and validate technologies, procedures, and methods for the aerospace community to effectively and efficiently certificate and license aerospace operators and vehicles in different environmental conditions and envelopes.

Objective 2c: Alternative Fuels

Identify and evaluate alternative fuels that provide equivalent safety and improved performance relative to conventional fuels.

Objective 2d: Data Analysis

Provide data and analyses to decision-makers to inform development of guidance, standards, and policy measures.

Goal 3

Increase Infrastructure durability and resiliency

Objective 3a: Durability – NAS, Airport & Spaceport Infrastructure

Identify and develop methods for the aerospace community to increase useful life of airport/spaceport infrastructure, NAS materials, and equipment to reduce maintenance, repairs, and replacement costs.

Objective 3b: Resiliency – NAS, Airport & Spaceport Infrastructure

Identify, develop, and validate procedures for the aerospace community that enable recovery of NAS operations following a disruptive event and ensure continued safe operations.

Objective 3c: Cybersecurity – Aviation Ecosystem*

Identify, develop, and validate new and enhanced tools, procedures, and strategies to enhance the aerospace community's ability to prevent, deter, detect, and respond to cyber-attacks to ensure continued safe operations.

* Aircraft, Airlines, Airports, Aviation Operators, & Actors

Goal 4

Improve the operation of the human component of the system

Objective 4a: Human Performance

Identify, develop and validate new technologies, policies, training methodologies, personnel selection tools and procedures to improve the performance of humans in the operation of the aerospace systems.

Objective 4b: Aeromedical Factors

Identify, develop and validate medical, computational biology, forensic sciences, and biomedical engineering tools and procedures to optimize human protection and survival in aerospace operations.

Goal 5

Improve integrated modeling capabilities and system-wide analysis

Objective 5a: Aerospace System

Identify and develop a sufficient scientific understanding of aerospace systems to enable aerospace community's development of solutions to enhance safety, improve efficiency, and reduce environmental impacts.

Objective 5b: Data Engineering

Identify, develop, and validate new methods and analytical and predictive capabilities for the aerospace community to collect, aggregate, analyze, and share NAS data to effectively monitor and improve system-wide performance.

Objective 5c: System Performance

Identify and develop tools, methods, studies, reports, and assessments for use by the aerospace community that evaluate, in an integrated manner, the system-wide performance, and impacts of new and existing aerospace vehicles, air traffic concepts, and airport/spaceport operations.

In the following sections, each objective includes a table (see **Figure 3.2 Outputs Table**) detailing the principal planned work products or output that will result from R&D conducted at the FAA and/or with collaborators. The 'Collaborators' column identifies partners performing the research. A 'YES' in the 'Long-Term Research?' column represents foundational research that will be applied beyond the five year horizon. An 'X' in a 'Fiscal Year' column indicates the approximate fiscal year timeframe the research output will be delivered. Note that the outputs shown are not comprehensive; rather, they are representative significant outputs of the R&D work that is being conducted.

Figure 3.2 Outputs Table

Output	Collaborators	Long Term Research?	Fiscal Year					
			18	19	20	21	22	23

3.2.1 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 keys to maintaining the most complex National Airspace System (NAS) in the world. 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. In addition, this work will result in the incorporation of new entrants in the NAS including Unmanned Aerial Systems (UASs) and Space Vehicles.

3.2.1.1 Goal 1 – Alignment with Long-Term Vision for Aviation

Recognizing that mobility through the air is vital to economic stability, growth and security, research performed in support of this goal seeks to address mobility challenges expressed by the Office of Science and Technology Policy in its National Aeronautics Research and Development Plan. Among these challenges, our future aviation system must be capable of[1]:

- Reducing separation distances between aircraft to increase traffic density without compromising safety.
- Developing the capability to perform four-dimensional (space plus time) trajectory based planning
- Dynamically balancing airspace capacity to meet demand by allocating airspace resources and reducing adverse impacts associated with weather.
- Increasing airport approach, surface, and departure capacity.

To address these challenges, the FAA has articulated through its Enterprise Architecture Long Range Service Roadmap several future operational improvements (OIs) which necessitate continued research aimed at the Objectives embodied in this goal. For example, continuing research is needed to enable:

---

[1] *Ref: OSTP National Aeronautics R&D Plan*

- Advanced Automation Support for Separation Management2 whereby automation provides the controller with tools to manage aircraft separation with more advanced wake separation standards and performance based navigation capabilities.
- Automated Negotiation/Separation Management3 whereby separation management automation negotiates with properly equipped aircraft and adjusts individual Four-Dimensional Trajectories (4DTs) to provide efficient trajectories, manage complexity, and provide separation assurance.
- Flexible Airspace Management4 in which automation supports reallocation of trajectory, surveillance, communications, and display information to different positions or different facilities and the ability to change sector boundaries, airspace volume definitions and move controller capacity to meet demand.
- Integrated Arrival and Departure Airspace Management5 in which new airspace design takes advantage of expanded use of terminal procedures and separation standards to increase aircraft flow and introduce additional routes and flexibility to reduce delays in major metropolitan areas supporting multiple high-volume airports.

3.2.1.2 Goal 1 Objectives

1a Separation Management – ***Identify and develop new separation management tools, procedures, and/or requirements for the aerospace community to safely evolve separation management, improve access and flexibility in the NAS, enable the most efficient aircraft routes, and increase airspace capacity.***

As the demand for more and more daily flights increase across the National Airspace System (NAS), the FAA is improving its ability through research and technology to increase the number of arrivals and departures from airports by understanding how decreasing the amount of space required between the aircraft may be accomplished.

One of the key factors in developing new separation management technology is wake turbulence. Turbulence that is created by an aircraft's wake has a significant impact on how closely aircraft can safely be spaced in the NAS whether on arrival or departure. Research is currently underway to develop a decision support tool that will examine the potential amount of aircraft that can land at an airport when air traffic controllers (ATC) cannot process visual arrivals, and taking into account the wake risk associated with closer aircraft spacing. This decision support tool will yield an increase in the number of daily arrivals and departures in low to no-visibility conditions.

While decision support tools are essential to increase airport throughput, weather also plays a major role in determining separation management. Understanding how the weather is affecting the aircraft at any given moment is a crucial component not only for the ATCs but also the pilots in the cockpits. The FAA is striving to find ways to provide relevant real time weather data to the

---

[2] *Ref: NASEA OI 102160*
[3] *Ref: NASEA OI 104121*
[4] *Ref: NASEA OI 108206*
[5] *Ref: NASEA OI 104122*

pilots and assuring that the sufficient amount of data is being sent. This will advise the cockpit of any impacts the weather events might have on the flight plan.

1b Air/Surface Traffic Management - *Identify and develop new traffic management tools, operating procedures and/or requirements for the aerospace community's use of airborne and surface movement data to enable en route efficiency, more flexible arrival and departure operations, and to efficiently use runway capacity.*

With all the research, development and innovation taking place to ensure safe effective separation between aircraft, the FAA understands that managing all of that traffic whether in the air or on the ground is critical. To this end, research specifically geared toward air/surface traffic management is underway to create and enable more efficiency and flexibility in the NAS.

One of the first steps in managing the traffic is to find ways to handle the ever increasing air traffic work load. Using Strategic Flow Management Application (SFMA), the FAA is researching how to identify operational shortfalls and gaps for rerouting airborne flights. The SFMA capability will be designed to provide traffic managers and air traffic controllers with more automated flight-specific trajectory advisory functions that will consider a wide range of input factors (i.e., operator preferences, resource capacity, weather impact, and meter time assignments). With an average of 5,000 flights in the air at any one time in the U.S., SFMA will help resolve flow problems earlier, reduce unnecessary flying time, and improve metering operations resulting in an increase in efficiency.

To address the need for managing surface traffic the FAA has begun to direct its attention to capabilities surrounding departure and arrival scheduling and how much space between aircraft is required when they are still on the ground. Concurrently, working in collaboration with NASA, the FAA is making strides towards better coordination between airport operators, Air Traffic Controllers and flight operators in order to optimize the true capabilities of the data that each of these groups possesses.

Of course, none of this can be accomplished without effective communication processes. As advances in air and surface traffic management progress so must the communication systems that are vital to their coordination. To this end, the FAA is researching and developing standards for new air/ground communication protocols that not only align with U.S. flight standards but also International Civil Aviation Organization (ICAO) standards. Without communication standardization and an eye for better communication systems, efforts to achieve the goal of effective traffic management will be greatly hindered.

1c Integrated Weather Information - *Identify and develop high quality weather analysis and forecast capabilities for the aerospace community to support efficient airport operations and air traffic management decision-making to safely mitigate the impacts of adverse weather.*

One of the greatest factors impacting the aerospace community on a daily basis is the weather. Through the years, mankind's ability to accurately forecast the weather has always been a challenge but it has been improving, and that ability is key to DOT's Safety and Innovation strategic goals. The FAA is doing research to leverage and apply higher quality weather forecasting and analysis products.

While knowing whether it will rain or snow that day is important and understanding the severity and location of storms is paramount, research that is being done by the FAA goes much deeper. Making predictions regarding the amount of turbulence that aircraft might encounter that day, analyzing and understanding visibility ranges, as well as knowing where small "pop up" storms are developing are major factors in the efficiency and safety of daily National Airspace System (NAS) operations. To this end, the FAA is developing weather prediction capabilities that will have longer forecasts and improved accuracy that will ultimately improve operational planning and decision making.

However, predicting the weather is not enough. Communication of the weather real-time is a key contributing factor in safely mitigating adverse weather. So not only is the FAA relying on prediction models, but it is also researching standards to allow aircraft to broadcast weather real-time using on-board sensors. This will allow management of air traffic decisions to be based on data much more current than what is provided now, which can be up to an hour old.

Understanding how much weather information is required for pilots to safely navigate in this modern age is paramount. With aircraft flying over many different types of terrain and environments, having reliable weather hazard information (such as convection and turbulence) fed to the cockpit allows the pilots to make sound safety and efficiency requests/decisions in regards to their aircraft.

Integrating weather information into both the airport via modeling, and aircraft via various standards, is an area of research that becomes increasingly important as air traffic volume increases. Having the ability to safely mitigate the impacts of adverse weather by increasing the capabilities within airports and air traffic management is a fundamental element in the FAA reaching its goal of improving airport operations across the NAS.

1d Collaborative Decision Making - *Identify and develop methods for better access to, and exchange of, aerospace information for the aerospace community to make the best use of available airspace and airport/spaceport capacity and improve NAS efficiency through greater flexibility, predictability, user preference accommodation, and timely coordination/collaboration.*

As the demand for more and readily available information increases, the FAA is improving its ability through research and technology to ensure that aeronautical information is consistent across applications and locations, and are available to authorized subscribers and equipped aircraft. For example, the FAA is researching available Flight Deck Data Exchange technology alternatives to augment capabilities and accelerate benefits for non DataComm and Aeronautical Telecommunications Network Baseline 2 equipped operators. Access to information will increase the ability to adapt to changing conditions, for example, by making better use of flight paths through inactive Special-Use Airspace (SUA) and adjusting routes per event notification information.

Continued growth of Commercial Space transportation requires research in critical areas that are necessary to ensure that the FAA is adequately prepared to meet its public safety and airspace efficiency missions. The Commercial Space Transportation research program continues to do work on improving the integration of commercial space operations into the NAS. Generally speaking, the program looks to 1) safely reduce the amount of airspace closed to other stakeholders, 2) develop timely response to emergency scenarios, and 3) improve methods for leveraging the results of collision avoidance analyses for more efficient launch and reentry planning and NAS integration. Research is planned to better compute the collision avoidance limits and improved trajectories that will define commercial space launch window opportunities; those times when a vehicle can be safely launched into orbit to avoid hitting, or being hit by, objects already in space.

1e Airport/Spaceport Systems - *Identify and develop guidelines for the design and implementation of airport/spaceport systems, infrastructure and procedures and their use to increase efficiency, optimize capacity, and enhance safety.*

An increase of traffic in the air means that there is a corresponding increase of traffic on the ground. With this increase, safety and efficiency on the ground is an ever evolving concern. The FAA is researching new and innovative processes and guidelines to proactively reduce the probability of any incidents. All the while still optimizing the flow of aircraft, operators and passengers through airport/spaceport facilities.

Incidents occurring on the runway and taxiways are commonly the first things that come to mind when discussing safety on the ground. The FAA refers to these as runway incursions. With constant arrivals and departures, there is an ever increasing chance that an incursion might occur. However, the work that is being done on runway incursions is creating new technology and recommendations that will send direct safety indications and alerts to pilots and aircrews to allow them to take immediate corrective action – proactively eliminating any incident that was anticipated to occur. Whether through the use of such technologies as Airport Surface Detection Equipment (ASDE-X) or Runway Status Lights (RWSL), safety measures are being used and updated on a continual basis.

However, runway incursions are not the only area in which the FAA is devoting its attention. The FAA is looking at the design of airport emergency operations and procedures to ensure that any airport-wide disruptions, whether physical, technological, functional or operational can be handled effectively and efficiently. As airports embark on projects to update facilities and infrastructure, environmental factors must be considered. Identifying and developing a streamlined methodology by which environmental protection specialists and planners can adhere to National Environmental Policy Act (NEPA) guidelines is imperative in assuring projects can be completed in a timely manner. While there is a significant focus on a lot of these large scale efforts, research such as technological advances to assist blind and visually impaired passengers, display the broad spectrum of areas of concern and innovation being addressed by the agency.

In the area of spaceports, research will focus on assessing the impact of spaceports on the public in order to support the increasing demand and cadence of commercial space operations. Research activities will also include the impact of spaceport operations on airspace and aircraft operations, as well as the safety of population centers and critical national assets. The research approach is designed to facilitate safe integration of spaceports within the NAS while enabling industry growth to ensure global competitiveness of the U.S. space industry.

The importance of reducing runway incursions all the way to supporting passengers with disabilities as they traverse our nation's airports cannot be understated. As the FAA strives to develop guidelines and technological advances for this broad range of airport systems, the research and development efforts of these FAA programs are a fundamental element in the FAA reaching its goal of improving airport/spaceport operations across the NAS.

1f Aerospace Vehicle Operation - *Identify, develop, and validate new and enhanced tools, procedures, and/or requirements for the aerospace community to effectively and safely manage the expanded operation of existing and future aerospace vehicles in the evolving NAS.*

A growing challenge to the efficient and safe management of the NAS is the integration of newer aerospace vehicles into an already crowded airspace system. Added to the volume of general aviation private aircraft, commercial aircraft, and manned stratospheric balloons are hybrid vehicles, Unmanned Aircraft Systems (UAS), and commercial space vehicles. The research and development work planned to integrate aerospace vehicles into the NAS to ensure NAS operation efficiency and safety are varied. For example, UAS research areas include standards for detect and avoid (DAA) systems, collision avoidance functionality, geofencing, and containment capabilities for large and small UAS. These emerging capabilities will require technical specifications, operational standards, manufacturing, and design standards based on the risk of collision with airborne and ground- based hazards.

Commercial Space transportation research projects examine operational requirements and development of Concepts of Operations especially addressing launch, reentry and recovery activities. These developments will safely reduce the amount of airspace that must be closed to other stakeholders, develop timely response capabilities to off-nominal scenarios; and quickly release airspace that is no longer affected. This research will be critical to the FAA's ability to facilitate the integration of spaceports located in the vicinity of major airports or complex airspace, as well as improve management of space vehicle trajectories and hazard areas for return from orbit to land-based sites.

Research aligning with this objective also supports the development and sustainment of analytical and computer models used to assess and validate operational changes to the NAS; changes precipitated by weather, infrastructure, or traffic flow. One example is the evaluation of the ability to use existing Traffic Flow Management System traffic management initiative programs to strategically precondition the flow of traffic for use in emerging Time Based Flow Management technology.

1g Noise and Emission - *Identify and develop tools, methods, and procedures and/or requirements for the aerospace community to reduce the noise and emissions from aerospace vehicle operations.*

Over the last two decades, we've made significant progress in reducing aircraft noise for people living around airports. Advances in aircraft technology, operational procedures, and noise abatement programs at airports all work together to mitigate noise. We are continuing these efforts with aircraft and engine manufacturers and the airports to further reduce aircraft noise.

But as individual aircraft noise levels have decreased, we've seen increases in the number of operations at many airports, particularly at night and in the early morning hours and the number of people living around airports also has increased. As a result, over the past few years, the FAA has received a much higher level of scrutiny over noise and emissions from the general public and those communities surrounding airports in particular. With increased community concern, the FAA has realized a stronger need to dive deeper into finding ways that noise and emissions can be reduced from the existing aircraft fleet. In addition to conducting research to examine the potential for improved aircraft operational concepts that could reduce noise, the FAA is also developing improved methods to evaluate the need for noise abatement materials in buildings.

Table 3.2.1.3 Goal 1 Outputs

Output	Collaborators	Long Term R&D	Fiscal Year					
			18	19	20	21	22	23
Objective (1a): Identify and develop new separation management tools, procedures, and/or requirements for the aerospace community to safely evolve separation management, improve access and flexibility in the NAS, enable the most efficient aircraft routes, and increase airspace capacity.								
High level analysis in support of Safety Risk Management Documentation for Wake Turbulence Mitigation for Single Runway procedure and associated decision support tool to insure the flight safety of the developed capability.	EUROCONTROL		X					
Technical report detailing initial operational concepts for dynamically modifying required wake mitigation separations for Terminal and EnRoute.	EUROCONTROL			X				
Feasible concepts using analyses of potential procedures, processes and applications of NextGen era capabilities that allow the safe relaxation of the ATC wake encounter hazard mitigation constraint on NAS throughput capacity.							X	X
Wake risk mitigation separation recommendations provided to ATC for new aircraft types beginning operations in the NAS.	Aircraft manufacturers		X	X	X	X	X	X
Dynamic wake risk mitigation separation algorithms, incorporating the use of NextGen era real time aircraft observed weather data, for use in the development of advanced ATC terminal and enroute decision support tools.								X
Established on Required Navigation Performance (EoR) Human-In-The-Loop (HITL) Data Collection Effort (DCE) Summary Status Report.	NATCA, Pilots		X					
Conduct EoR Radius-to-Fix (RF) concept validation studies for Independent Duals and Triples at Launch Site(s).	NATCA, MITRE				X	X		
FAA input to the Internet Protocol (IP) standards to support Data Comm Segment 2 and Future Communications systems.				X				
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.	MITRE/CAASD		X					

Output	Collaborators	Long Term R&D	Fiscal Year 18	19	20	21	22	23
Objective (1b): Identify and develop new traffic management tools, operating procedures and/or requirements for the aerospace community's use of airborne and surface movement data to enable en route efficiency more flexible arrival and departure operations and to efficiently use runway capacity.								
Evaluation report on Air Traffic Management functional interactions to develop Air/Ground Trajectory Synchronization use cases and concepts.				X				
Concept validation report for Strategic Flow Management Application (SFMA).			X					
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.	NASA		X					
Report on the preliminary findings of leveraging Electronic Flight Bag technologies to expand participation of airspace users, particularly the General Aviation and Business Jet communities, in integrated departure scheduling capabilities data sharing.				X				
Report on the application of the NASA's ATD-2 collaborative arrival/departure/surface metering capability metroplex operations research to the FAA's Integrated Departure Scheduling concept.					X			
Preliminary Concept of Operations for use of Traffic Flow Management Toolset for Time Based Flow Management pre-conditioning.			X					
Objective (1c): Identify and develop high quality weather analysis and forecast capabilities for the aerospace community to support efficient airport operations and air traffic management decision-making to safely mitigate the impacts of adverse weather.								
A Continental United States in-flight icing analysis and forecast capability enhancement via assimilation of sensor and satellite data.	NWS		X					
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.	NWS		X					

Output	Collaborators	Long Term R&D	Fiscal Year					
			18	19	20	21	22	23
A 6 to 36 hours probabilistic forecast of oceanic convection that incorporates data from international weather forecast models.	NWS				X			
A high resolution turbulence forecast capability that integrates new diagnostics for clear-air, mountain-wave and low-level turbulence as well as the high resolution rapid refresh (3 kilometer) numerical weather prediction model.	NWS				X			
Continental U.S. probabilistic ceiling and visibility gridded forecast capability that incorporates data from numerical weather prediction (NWP) model.	NWS			X				
An automated Offshore Precipitation Capability (OPC) that blends weather satellite imagery, lightning data, and numerical weather prediction model data, coupled with a "machine learning technique", to produce a near real-time estimate of precipitation including thunderstorms.	AJM							X
A high-resolution ceiling and visibility analysis capability that incorporates data from the high resolution rapid refresh numerical weather prediction model.	NWS						X	
Terrestrial and space weather model that will permit improved prediction of environmental conditions for safe and efficient launch and re-entry operations tailored to commercial space transportation industry needs.	NOAA				X			
Standards for real time broadcast of aircraft observed weather data (ADS-Wx) for use by ground based automation applications such as dynamically determining wake risk mitigation separations and traffic management Decision Support Tools (DSTs).	NIA, CAASD, MIT/LL, RTCA			X				
Identification, demonstration, and validation of Minimum Weather Service recommendations for producing visibility and surface winds weather information via crowd source processing and sensing, and the downlinking of Insitu weather information from the aircraft via ADS-B link.	Alaska Weather Cam office, RTCA		X	X	X			
Minimum Weather Service content definitions for weather information sent to the cockpit via Aircraft Access to SWIM (AATS) to support Data Comm clearance requests sent to the cockpit.	RTCA	YES	X	X	X	X	X	

Output	Collaborators	Long Term R&D	Fiscal Year					
			18	19	20	21	22	23
Minimum Weather Service recommendations report on minimum convective weather information, and associated parameters of this information, needed in the cockpit to resolve gaps attributable to safety hazards and operational inefficiencies.	Airlines	YES	X	X	X	X	X	X
Minimum Weather Service recommendations report to determine minimum turbulence and icing information needed in the cockpit, and associated parameters of this information to resolve gaps attributable to safety hazards and operational inefficiencies.	Boeing, Airlines	YES	X	X	X	X	X	X
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.			X					
Report on the analysis, and recommendations of wind measuring technologies and siting/installation alternatives.				X				
Objective (1d): Identify and develop methods for better access to and exchange of aerospace information for the aerospace community to make the best use of available airspace and airport/spaceport capacity and improve NAS efficiency through greater flexibility, predictability, user preference accommodation, and timely coordination/collaboration.								
Improved algorithms for launch collision avoidance to facilitate safe and efficient commercial space transportation, including improved trajectory and uncertainty input data guidelines.					X			
Flight deck data exchange concept and operational use cases to identify data exchange requirements utilizing certified and non-certified flight deck automation systems.					X			
A spaceport site location prototyping tool for assessing the site integration and safety challenges using data on air-traffic and airport operations, space vehicle trajectories and hazard areas, data on other transportation modes, population centers, and critical national assets.	MITRE/CAASD			X				
Develop and demonstrate a process for space launch and reentry collaborative decision making (CDM.)	MITRE/CAASD		X					

Output	Collaborators	Long Term R&D	Fiscal Year					
			18	19	20	21	22	23
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.			X					
Objective (1e): Identify and develop guidelines for the design and implementation of airport/spaceport systems, infrastructure and procedures and their use to increase efficiency, optimize capacity, and enhance safety.								
Detailed design information to support the design of airport emergency operations centers to respond to any airport-wide disruptions.			X					
Roadmap to identify a scalable, easily accessible and centralized geospatial environmental mapping tool for the FAA's environmental protection specialists and planners.				X				
Specifications for technologies that will assist blind and visually impaired passengers in safely and confidently navigating the airport terminal to update airport standards.					X			
Gap analysis between applicable commercial space regulations, vehicle profiles and performance characteristics and current airport design guidance, standards, regulations.				X				
Data analysis and cost benefit of the performance of alternative Foreign Object Debris (FOD) detection systems to evaluate the improvement over standard visual FOD inspections at our Nation's airports.				X				
Classification system for airport paint markings that reflects how various paint materials perform under exposure to environment and aircraft traffic for support to paint marking specifications and guidance to airport authorities.		YES	X	X	X	X	X	X
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.			X					
Conduct engineering analysis as needed for Caribbean airspace redesign implementation			X					

Output	Collaborators	Long Term R&D	Fiscal Year					
			18	19	20	21	22	23
Report documenting Technical Transfer to Industry of Small Airport Surveillance Sensor (SASS) cooperative surveillance capability for Mode S & ATCRBS targets.	MIT Lincoln Lab, Air Force	YES	X	X	X			
Report on global state-of-the-art capabilities in Surface Taxi Conformance Monitoring (STCM) technology to reduce Runway Incursions.		YES	X					
Prototype algorithms and human interfaces for taxi conformance monitoring used in prototype cockpit-based and tower-based taxi conformance monitoring system to reduce Runway Incursions at controlled airports.		YES		X	X	X	X	
Reports on acquisition, installation and operational testing and evaluation of Runway Incursion Prevention Shortfall Assessment (RIPSA) test system(s) at key candidate test sites.		YES	X	X	X	X	X	X
Guidance on how to safely, efficiently, and seamlessly integrate UAS autonomous cargo delivery operations into the National Airspace System (NAS).	MITRE/CAASD		X					
Technical and tradeoff analysis results for UAS operational issues such as: (1) Night Operations; (2) Expanded Visual Line-of-Sight (EVLOS); (3) UAS operations under the Mode C Veil (furthering urban package delivery, operations over people, Beyond Visual Line of Sight (BVLOS)); and (4) Small UAS (sUAS) operations on airfields, to inform the Airspace Aviation Rulemaking Committee on UAS operations in Controlled Airspace.	MITRE/CAASD		X					
Objective (1f): Identify, develop, and validate new and enhanced tools, procedures, and/or requirements for the aerospace community to effectively and safely manage the expanded operation of existing and future aerospace vehicles in the evolving NAS.								
Draft separation standards for improved airspace management of launch/reentry vehicles, such as hybrids and manned stratospheric balloons, during non-explosive phases of flight	Lincoln Labs, MIT				X			
Develop draft commercial space Concept of Operations.			X					

Output	Collaborators	Long Term R&D	Fiscal Year					
			18	19	20	21	22	23
Develop draft preliminary commercial space program requirements derived from past prototyping efforts and conceptual solutions.			X					
Demonstration of an advanced flight control scheme based on an active stick feel system that evaluates various flight characteristics when used by inexperienced and/or experienced pilots.				X				
Technical report documenting new and innovative technology for automated autopilot systems, envelope protection, and/or flight path control leveraged for General Aviation to enhance aircraft safety.						X		
Report documenting research conducted on the effectiveness of two possible technologies capable of mitigating bird strikes on rotorcraft.	Lite Enterprises, Origo Corp.		X	X	X			
Research to develop candidate mission profiles and a risk model that will support streamlined airworthiness approval processes for small UAS.	MITRE/CAASD Industry		X					
Objective (1g): Identify and develop tools, methods, and procedures and/or requirements for the aerospace community to reduce the noise and emissions from aerospace vehicle operations.								
Report describing advanced operational procedural concepts that could reduce community noise exposure while maintaining safe flight operations and guidance for air space planners on how these concepts could be incorporated.	Industry, NASA, MITRE, ASCENT COE, Massport		X	X	X	X	X	X
Report on the operational feasibility of conducting steeper approaches in the NAS in order to reduce noise.	MITRE		X					
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.			X					

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

The advancement and introduction of non-traditional aviation industries are pushing the boundaries of technology into all corners of the National Airspace System. 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.

3.2.2.1 Goal 2 – Alignment with Long-Term Vision for Aviation

Future aviation operations must accommodate the increasing demand for airspace access by traditional civil aviation users as well as new entrants. In addition to the growth in commercial space and unmanned aircraft system operations, the NAS will need to accommodate future generations of advanced aircraft with revolutionary configurations such as hybrid wing-body, small supersonic jets, cruise-efficient short take-off and landing, or advanced rotorcraft while also achieving significantly reduced environmental impact and sustained safety assurance[6]. In support of this vision, research initiatives under the NextGen Environmental Engine and Aircraft Technologies – Phase III[7] will continue to support the acceleration of certification and maturation of aircraft technologies for noise, emissions and energy efficiency improvements.

3.2.2.2 Goal 2 Objectives

2a Applied Innovation ***- Identify and demonstrate new aerospace vehicle and airport/spaceport technologies that could be adopted by the aerospace community to improve safety, increase efficiency, and reduce environmental impacts.***

As the world's aviation sector has grown, the FAA has moved forward with better management of growing environmental concerns. These efforts involve advancements toward a more environmentally sustainable aviation system, and we are making tremendous strides.
Research efforts include accelerating the development and integration of new aircraft and engine technologies to reduce fuel burn, emissions and noise; developing sustainable alternative aviation fuels to reduce environmental impacts, enhance energy security and provide economic benefits; ensuring we have appropriate policies, environmental standards and market-based measures to

---

[6] *Ref: OSTP National Aeronautics R&D Plan*
[7] *Ref: NASEA OI 702104*

support advantageous technologies and operational innovations and accelerate their integration into the commercial fleet, the airport environment and entire national aviation system; and putting in place operational improvements that enable reductions in fuel burn (emissions) and noise.

Because the environment presents a constraint on the growth of aviation, the FAA is working in partnership with industry to develop aircraft technologies that reduce noise, emissions and fuel burn. The Continuous Lower Energy, Emissions and Noise (CLEEN) Program is the FAA's principal effort to accelerate the maturation of new aircraft and engine technologies. The CLEEN Program is a key element of the NextGen strategy to achieve environmental protection that allows for sustained aviation growth. The CLEEN Program is a public/private partnership wherein the FAA is working with industry partners through a cost-sharing program where the companies match or exceed the funding provided by the FAA. Through the CLEEN Program, the aviation industry is able to expedite the integration of these technologies into current and future aircraft thus delivering benefits for decades to come.

While not often considered an environmental issue or even an issue of innovation, research into wildlife in the NAS, their effect on aircraft, and ways to mitigate those effects is a major point of emphasis. We all remember the 'miracle on the Hudson.' This is just one dramatic example of the risk to safety that bird strikes can cause. Clearly, bird strikes in particular can be detrimental to safety. As such, the FAA is researching and reporting on various techniques and technologies that help with habitat and wildlife control, analyzing the behavioral reactions of wildlife to aerospace vehicles and creating bird concentration advisories that can be sent to pilots. By doing this, a reduction in the number of damaging and potential fatal bird strikes in the NAS is anticipated.

2b Certification/Licensing *- Identify, develop, and validate technologies, procedures, and methods for the aerospace community to effectively and efficiently certificate and license aerospace operators and vehicles in different environmental conditions and envelopes.*

The FAA is committed to making aviation safer and more efficient and has made a lot of progress. Collaboration between the FAA and industry is allowing the aviation community to benefit from upgraded technology and higher levels of safety. There are many critical safety risk factors within the aircraft themselves and the FAA has devoted resources to identifying those hazards and providing certification and licensing guidelines based on the research that is being performed. For example, the Part 23 proposed rule and Non-Required Safety Enhancing Equipment (NORSEE) policy are aimed at streamlining aircraft certification and will speed up the time it takes to move safety-enhancing technologies for small airplanes into the marketplace. It will reduce costs and streamline the installation of equipment, such as traffic advisory systems, terrain awareness and warning systems; attitude indicators; fire extinguishing systems; and autopilot or stability augmentation systems.

Among the many safety hazards onboard aircraft, fire is a primary focus, and because of the FAA's research in this area we have seen the following aircraft fire safety improvements in commercial airliners worldwide: seat fire-blocking layers, low heat and smoke release cabin panels, floor proximity lighting, heat resistant evacuation slides, burn-through resistant cargo liners, Halon 1211 extinguishers, cargo compartment fire detection and suppression systems, in-flight fire resistant and post-crash fire burn-through resistant thermal acoustic insulation, and fuel tank inerting systems. Over the past several years our work on lithium battery cargo shipment fire safety has received considerable interest and action by the aviation community. The research test results were a major factor in the decision by airlines worldwide to cease shipment of lithium batteries. Today our work on lithium batteries is focused on mitigation and safe shipment, including the development of packaging standards, evaluation of improved cargo containers and pallet covers, and the development of an on-board fire suppression system for freighters.

In the event of an actual fire the FAA has ongoing research wherein the FAA Aircraft Rescue and Fire Fighting (ARFF) Research Program evaluates new technologies for increasing post-crash fire survivability on aircraft and determines methods to increase the performance capabilities of ARFF vehicles. In the last five to ten years there have been new firefighting systems, technologies, and concepts entering the general firefighting industry and changing how firefighters strategize, tactically extinguish fire, and effectively perform their jobs and the FAA is continuing to help advance these efforts.

Certifying, licensing and providing the proper methods and procedures to be followed are all ways that the FAA is enhancing and strengthening the aerospace community.

2c Alternative Fuels - *Identify and evaluate alternative fuels that provide equivalent safety and improved performance relative to conventional fuels.*

Today’s new aircraft are more than 70 percent more fuel efficient than 40 years ago. The current U.S. fleet of aircraft fuel efficiency averages 64 miles per gallon on a per passenger basis. Aircraft most recently put into commercial service can now get over 100 passenger miles per gallon. However, in order to keep up with the current demands for air transportation, we are burning approximately 23 billion gallons of jet fuel a year. The aviation industry has stated that they want to use alternative fuels as a part of a basket of measures to address the increased emissions that will accompany the projected demands for air transportation growth which are forecasted to double in the next 15 to 20 years. The FAA is supporting the efforts of industry by evaluating alternative fuels that will have improved performance and equivalent safety to what is currently being used.

To accomplish this the FAA is coming at the problem from many different angles. Research is underway to replace leaded fuel with unleaded fuel by running nearly 50 tests in multiple aircraft and a few model engine types. Concurrently, the FAA is doing a technical analysis of alternative fuels from things such as feedstock production.

While searching for suitable alternative fuels, there are regulations and standardization that must be taken into account. The FAA is proactively working with industry to ensure that new fuels are tested extensively to ensure they are safe for use. The FAA is also partnering with other governmental agencies and industry to evaluate the environmental benefits of alternative fuels, and ensuring that this information is used to inform the development of international standards. The FAA has been working toward a goal of achieving the approval of at least one alternative jet fuel type per year and to ensure that domestically-produced alternative jet fuels receive credit under international emissions crediting schemes. Much of the work on alternative jet fuels is being done through the Commercial Aviation Alternative Fuels Initiative (CAAFI), the Aviation Sustainability Center of Excellence (ASCENT), and the CLEEN Program.

2d Data Analysis *- Provide data and analyses to decision-makers to inform development of guidance, standards, and policy measures.*

Open and transparent exchange of information and data between the FAA and industry is necessary to find problems in the national airspace system before they result in an incident or accident. If there is a failing, whether human or mechanical, we want to know about it, learn from it and make the changes necessary to prevent it from happening again. The FAA's role of ensuring that the NAS runs safely and efficiently can only be completed by providing guidance, standards and policy measures for all stakeholders and users of the NAS. Research plays a vital role in providing the necessary data for FAA leadership to make informed decisions as to what guidance, standards and measures should be issued.

The wide array of research data and analysis that are currently being conducted and planned for in the future stretches across many different areas of research. Research into engine designs that test every aspect and stress limitations; quantifying aircraft structural strength during crash testing; and aircraft designs that will operate in frigid atmospheric conditions, are just a couple of the technologies being researched. Knowledge derived from studies such as these will be used to develop several advisory circulars over the next few years. Research results will also assist in creating guidance that, when employed, will: reduce or eliminate fire hazards associated with hydrogen based fuel cells; reduce aircraft noise and emissions; and detail ways to make unmanned aircraft highly visible to manned pilots. These are but a few examples of the breadth of research the FAA is performing.

Policy, standards and other guidance provided by the FAA cannot be done without having the correct information to make a well-informed determination of the requirements necessary to be implemented. With all of the stakeholders in the aerospace community relying on the guidance provided by the FAA, the data and analyses provided through the vast array of research projects is the principal key to accelerating the assimilation of new technologies into the NAS.

Table 3.2.2.3 Goal 2 Outputs

Output	Collaborators	Long Term R&D	Fiscal Year					
			18	19	20	21	22	23
Objective (2a): Identify and demonstrate new aerospace vehicle and airport/spaceport technologies that could be adopted by the aerospace community to improve safety, increase efficiency, and reduce environmental impacts.								
Report of recommended performance parameters of autonomous flight safety systems to improve the safety and efficiency of testing commercial space transportation operations.					X			
Recommended practices for industry to improve the safety of commercial space transportation operations by employing measures for protection of occupants across three perspectives (mission design, vehicle design, and human physiology) for commercial spaceflight in order to influence the technical standards.						X		
Report on Continuous Lower Energy, Emissions and Noise Phase II (CLEEN II) activities to demonstrate certifiable aircraft and engine technologies and to enable industry to expedite introduction of these technologies into current and future aircraft.	Industry, NASA, DOD		X	X	X			
Report on Continuous Lower Energy, Emissions and Noise Phase III (CLEEN III) activities to demonstrate certifiable aircraft and engine technologies to expedite introduction of these technologies into current and future aircraft.	Industry, NASA, DOD	YES			X	X	X	X
Assessment report on the environmental benefits of the Continuous Lower Energy Emissions and Noise Phase II airframe and engine technologies (CLEEN II).	Industry, NASA, DOD, ASCENT COE				X			
Assessment report of the performance of an Aeronautical Mobile Airport Communication Systems (AeroMACS) installed at Boston-Logan International Airport for Non-Federal operations in the field.			X	X				
Reports on the applied research effectiveness of implementing and providing bird concentration advisories to air traffic controllers, so that they can provide bird advisories to pilots.	CEAT		X	X	X	X		
Reports on the effectiveness of various new techniques and technologies for habitat management and wildlife control techniques for minimizing wildlife strikes with aircraft at and away from all airports nationwide.	USDA		X	X	X	X	X	
Updated FAA National Wildlife Strike Database to provide the aerospace community the ability to collect, aggregate, analyze and share bird strike data in the NAS and to improve system-wide safety.	USDA Smithsonian	YES	X	X	X	X	X	X

Output	Collaborators	Long Term R&D	Fiscal Year 18	19	20	21	22	23
Data and analyses to support the integration of sensory ecology, physiology, and behavior information to understand animal reactions to vehicles, with the goal of developing onboard systems that elicit earlier alert and escape behaviors in response to high-speed aircraft.	USDA		X	X	X	X	X	
Technical report on the investigation and capabilities of innovative ice protection technologies, such as ice phobics and nanotechnology.		YES					X	
Technical report that summarizes the research and contains the information and data that supported each phase of the research activity for Fuel Cell (hydrogen based) system installations on civil aircraft.	Boeing, Honeywell, Teledyne, Infinity					X		
Technical report that summarizes the research and contains the information and data for Rechargeable Lithium batteries and battery system installations on Transport category aircraft.	Teledyne, ADA Technologies, UDRI, Eagle Richer, DNV-GL				X			
Technical report on use of computational fluid dynamics analysis and of test methods and scaling for iced swept wings.	NASA			X				
Research to ensure the safe introduction and proliferation of adhesively bonded structure into modern aircraft and report results of the various methods for inspection of aged in-service repairs.	Wichita State Univ, NIAR							
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.	NASA		X					
A validated computational fluid dynamics (CFD) model for heat and gas transport inside an aircraft fuselage.	NIST						X	
Objective (2b): Identify, develop, and validate technologies, procedures, and methods for the aerospace community to effectively and efficiently certificate and license aerospace operators and vehicles in different environmental conditions and envelopes.								
Technical report on the performance of fire detection technologies capable of discriminating between actual aircraft fire and non-fire events.	Manufacturing Industry, University of Maryland		X					

Output	Collaborators	Long Term R&D	Fiscal Year					
			18	19	20	21	22	23
A Vertical Flame Propagation (VFP) test method apparatus prototype for material in inaccessible areas of aircraft such as ducts and wiring.	Boeing, Airbus, Bombardier, Embraer		X					
Training videos, guidance material and advisory circular support for research that leads to proposed new aircraft material flammability standards.	Airframe manufacturers			X				
Test results from an evaluation of more realistic methods of generating smoke to be used for certification testing.	Manufacturing Industry				X			
Technical report compiling simulation results as well as training and technology recommendations to update go-around regulations and guidance.							X	
Development of new firefighting performance requirements for the use of compressed air foam system (CAFS) technologies in aircraft rescue and firefighting.	DOD - USAF				X			
Data analysis of events that have occurred on or in the vicinity of an airport to identify top airport safety risk areas.		YES	X	X	X	X	X	X
Annual updates to Design Assessment of Reliability with Inspection (DARWIN®) engine design code that incorporates advanced stress intensity factor solutions, integrated computational materials engineering (ICME), damage tolerance methods to address engine damage at elevated temperatures, application for non-rotating components and risk analysis of additively manufactured components.	DOD, NASA, Engine Manuf.	YES	X	X	X	X	X	X
Annual updates to the Composite Manual Handbook-17 contents on Sandwich Disbond testing and modeling methodologies.	Univ of Utah, Wichita State Univ, Univ of Washington, National Institute of Aerospace		X	X	X	X		
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.	Wichita State Univ	YES	X					

Output	Collaborators	Long Term R&D	Fiscal Year					
			18	19	20	21	22	23
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.	AVSI		X					
Technical report containing criteria for safe certification regarding the use of Distributed Integrated Modular Avionics (DIMA) in modern aircraft systems.						X		
Annual update to the Metallic Materials Properties Development Standardization (MMPDS) Handbook and derivative products.	MMPDS Government Steering Group, industry consortium	YES	X	X	X	X	X	X
Develop preliminary procedures and guidelines for establishing design values for highly process-dependent emerging metallic-based materials including metal additive manufacturing.	Alcoa, Constellium, Boeing, Bombardiar,Embraer, NIAR	YES	X	X	X	X	X	
Technical Data to assess the applicability of existing regulations and develop the framework needed to safely certify Additive Manufacturing (AM) parts.	Kansas Aviation Research & Technology Consortium	YES	X	X	X	X	X	X
Validation of the new rotorburst and fan bladeout predictive capability which will advance certification.	NASA		X					
Technical report describing 1) recommended minimum standards and design guidelines for UAS control stations; 2) UAS crewmember training and certification requirements; 3) UAS crewmember procedures and operational requirements during normal and non-normal events.				X				
Report on review of current regulations and standards, and recommend changes for the UA visibility enhancement.					X			
Final report documenting results of UAS automation/autonomy experimentation to support regulatory guidance.				X				

Output	Collaborators	Long Term R&D	Fiscal Year					
			18	19	20	21	22	23
Objective (2c): Identify and evaluate alternative fuels that provide equivalent safety and improved performance relative to conventional fuels.								
Research report with potential means to streamline the American Society for Testing and Materials (ASTM) international approval process for alternative jet fuels.	Industry, USG, int'l stakeholders, ASCENT COE		X					
Data and research reports on alternate fuel performance to replace leaded with unleaded fuels for a Transparent Fleet Authorization for General Aviation (GA) aircraft.	AOPA, API, EAA, GAMA, NBAA, NATA, Industry		X					
Research report that examines whether changing the composition of conventional jet fuels is cost beneficial in regards to environmental impacts, health effects, capital costs, and operator costs.	Industry, NASA, DOD, int'l stakeholders, ASCENT COE		X					
Research report with lifecycle greenhouse gas emissions values for alternative jet fuels for use by the International Civil Aviation Organization (ICAO) Committee on Aviation Environmental Protection (CAEP).Technical analyses will be conducted on the use of alternative jet fuels from feedstock production, transportation, fuel production, and combustion in the engine.	Industry, USG, int'l stakeholders, ASCENT COE		X					
Data collection and research reports for the approval of at least one alternative jet fuel type per year by ASTM International.	Industry, USG, int'l stakeholders, ASCENT COE	YES	X					
Objective (2d): Provide data and analyses to decision-makers to inform development of guidance, standards, and policy measures.								
Technical reports documenting data to evaluate current industry repair design characteristics, and quality control procedures of aircraft composite structures, resulting in advanced training guidance and improved composite maintenance practices used by industry.	Wichita State University	YES	X		X	X		

Output	Collaborators	Long Term R&D	Fiscal Year					
			18	19	20	21	22	23
Technical reports documenting structural integrity data for composite and metal bonded structures, evaluations of industry process quality control procedures and the tests & analysis methods used for structural integrity, and provide training and detailed background on best industry practices.	Washington State Univ, Florida International Univ, Univ of Washington, Univ of Utah	YES	X	X	X	X		
Develop a database to contain the validated aerodynamic effects of ice shapes on swept-wings for computational fluid dynamics.	NASA		X					
Report on results of experiments, tests, analysis, and validation for engineering tools under development; tools to be used for confirming the presence of super-cooled large droplets (SLD).	NASA				X			
Data package of experimental test, and analytical results regarding super cooled large droplets conditions.	NASA					X		
A software tool, with supporting documentation, by gathering the required data, to improve methodologies, and develop tools to be used to successfully implement probabilistic methods for risk assessment and risk management of general aviation's fatigue-failure safety concerns.	Univ of Texas, Textron Aviation		X		X	X		
Technical report documenting 1) UAS experiment(s) for investigating ways to make unmanned aircraft highly visible to manned pilots; 2) analysis of the experimental data addressed by research questions of this study; and 3) implications of the research results for supporting regulatory guidance for UAS integration into the NAS.					X			
Report documenting the review of prior FAA and NASA research on Minimum Detect and Avoid (DAA) Display and Flight Path Information.			X					
Literature review to outline current state of research supporting UAS Human-Automation Interaction requirements in support of regulatory guidance.			X					
Reports that summarize experimental data that was acquired, and analyses that were performed, to inform the development of an engine particulate matter (PM) emissions standard in the International Civil Aviation Organization (ICAO) Committee on Aviation Environmental Protection (CAEP).	Industry, USG, int'l stakeholders, ASCENT COE		X	X				

Output	Collaborators	Long Term R&D	Fiscal Year					
			18	19	20	21	22	23
Reports that summarize analyses that were performed to inform the development of the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) within ICAO CAEP.	Industry, USG, int'l stakeholders		X	X				
Reports that summarize data and analyses that are used to inform the development of new noise and emissions standards in ICAO CAEP.	Industry, USG, int'l stakeholders				X	X	X	

3.2.3 Goal 3 - Increase 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 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.

3.2.3.1 Goal 3 – Alignment with Long-Term Vision for Aviation

It is envisioned that new NAS technologies will make it possible for an FAA facility to access another facility's flight plans, surveillance, and communications enabling the swift resumption of operations at a different location[8]. A more agile and flexible communications architecture will contribute to a more resilient NAS by enabling the rapid transfer of existing ground-to-ground and air-to-ground voice communications to other facilities during off-nominal events. These capabilities will enable the restoration of critical services to achieve 90 percent of normal operations within 24 hours of a major outage, and 100 percent of critical services in as little as one week[9].

Research performed pursuant to this goal will support development and sustainment of the 11 Information Systems Security (ISS) and business services specified in the Information Systems Security Roadmap of the NAS Enterprise Architecture to enhance NAS resiliency to cyber threats.

3.2.3.2 Goal 3 Objectives

3a Durability – NAS, Airport & Spaceport Infrastructure ***- Identify and develop methods for the aerospace community to increase useful life of airport/spaceport infrastructure, NAS materials, and equipment to reduce maintenance, repairs, and replacement costs.***

The FAA ensures that U.S. airports are safe and efficient and assists airports in optimizing the safety, security, capacity, efficiency, economic and environmental sustainability of their airports. Additionally, the FAA is responsible for ensuring the nation's system of airports have the right technology and infrastructure to support evolving needs. The Airport Technology Research Program is comprised of numerous research projects centered on the increased durability of

[8] *Ref: NASEA OI 106208*
[9] *Ref: Future of the NAS, p.34*

airport runway pavement infrastructure. The projects address diverse aspects of pavement infrastructure including new and improved pavement design modeling tools, pavement construction material studies, pavement performance database, and pavement construction and maintenance governance.

The FAARFIELD airfield pavement program is planned for new modeling capabilities for varied pavement construction elements (e.g. joint types, strengths, materials); new abilities to input varied environmental climatic factors; new crack damage predictive capabilities; and major improvements to the program's functionality enhancing the user experience. A searchable database constitutes another project that will contain long-term comprehensive construction, performance, maintenance, traffic usage, and weather data necessary to develop new design models for extended airport pavement life. While these planned tool enhancements address pavement design, other planned tool-related projects are maintenance and repair assistive tools based on the characterization of runway roughness and that perform predictive life analysis of reconstructed airport runways.

Airport pavement construction material studies will be performed toward achieving extended product life. Hot-mix and warm-mix asphalt performance comparison testing, evaluations on the use of polymer modified binders in these comparative asphalt mixes, and the use of synthetic materials are examples of such testing. As the FAA currently does not have standards and specifications for use of some of these materials, projects are planned to develop these standards.

Collectively these projects will enable airports to build more durable longer-lasting runways, reduce cost of pavement construction (and reconstruction), improve maintenance response, and reduce runway closures.

3b Resiliency – NAS, Airport & Spaceport Infrastructure *- Identify, develop, and validate procedures for the aerospace community that enable recovery of NAS operations following a disruptive event and ensure continued safe operations.*

The FAA is responsible for providing safe and efficient air navigation services to airspace users and that includes developing and implementing contingency plans for restoring air traffic service in response to emergencies. Even a relatively minor interruption could result in significant adverse nationwide impact on air traffic. Comprehensive and coordinated planning, between air traffic control facilities, airports, stakeholders and organizations that support them, can avert disruptions or mitigate their impact to safe and reliable service to the flying public. One example is the FAA's investment in mobile asset management technologies and a new NAS Recovery Communications System to increase system resiliency in the event of a catastrophic incident.

Airports prone to harsh winter weather benefit from new technologies designed to mitigate operationally disruptive events or to enable continued safe operations recovery following such events. The Airport Technology Research Program will facilitate research into alternative heated pavement technologies (e.g. geothermal pavements, electrically conductive materials, et al) that when deployed can help reduce the cost of snow removal and reduce winter condition weather delays.

New NextGen technologies will make it possible for an FAA facility to access another facility's flight plans, surveillance, and communications enabling the swift resumption of operations at a different location. However, some commercial technologies are becoming obsolete and will no longer be available for use within the NAS. Therefore, the FAA will continue to monitor and research these technological changes so that services that rely on commercial infrastructures can still be provided as antiquated technology is no longer supported. New technology must ready the NAS through system modernization and technology refresh. Additionally, the shift to satellite-based navigation and surveillance results in the need to find a cost-effective solution to ensure resiliency in the event of a loss or interruption of these satellite-based services.

3c Cybersecurity – Aviation Ecosystem (Aircraft, Airlines, Airports, Aviation Operators, & Actors) *- Identify, develop, and validate new and enhanced tools, procedures, and strategies to enhance the aerospace community's ability to prevent, deter, detect, and respond to cyber-attacks to ensure continued safe operations.*

While current information security measures in place for the NAS are robust, increased resiliency of our aerospace systems in detecting and deterring cyber-attacks requires prudent exploration of advanced detection and defense capabilities for the NAS systems. In recent years, the FAA has been shifting air traffic control from ground-based technology to satellites. While modernization has resulted in greater efficiency for the aviation industry, it has also made the FAA and the industry vulnerable to cyber-attacks because of the increasingly connected aviation ecosystem. Cybersecurity has become an elevated risk that is among the most pressing issues impacting the aviation industry today and it is imperative for the FAA to have programs and policies in place that can constantly monitor and keep pace with advancing and evolving threat vectors.

Cybersecurity represents one of the biggest challenges facing the FAA. In response, the FAA developed a Cybersecurity Research and Development (R&D) plan that identifies research required to prevent, detect, and react to cyber-attacks, and to safely secure the FAA's NAS and mission support infrastructure. Example areas include communication systems; network-based information systems; satellite-based navigation, positioning, and timing systems, including Global Positioning System (GPS)-based timing; information technology; mission system automation; surveillance; and weather systems.

Airplane systems are also becoming increasingly automated and more connected to computer systems. The Aircraft Digital Safety Program plans research focusing on the airworthiness requirements of airborne cyber security. This program will develop an approved Safety Risk Assessment Methodology that will culminate with the development of a Mitigation Identification and Evaluation Process useful in proposing cyber risk mitigations. The process will be applied to specific aerospace system elements with reported actionable vulnerabilities and risks.

With a focus on protecting and defending FAA networks and systems and then deterring and mitigating Cyber-attack risks, the NextGen Information Security program plans research that leverages on advanced big-data analytics approaches applied to FAA network analysis. After attaining proof of concept, the project will move to demonstrate Big-Data analytics in a Mission Support environment attempting to predictively determine the potential of unauthorized access, destruction, disclosure, or modification of information or the denial of service. Combined Big-

Data analytics based predictive tools and mitigation identification and evaluation processes will better position the FAA to ensure safe and continuous operations in a more durable and resilient aerospace system.

Table 3.2.3.3 Goal 3 Outputs

Output	Collaborators	Long Term R&D	Fiscal Year					
			18	19	20	21	22	23
Objective (3a): Identify and develop methods for the aerospace community to increase useful life of airport/spaceport infrastructure, NAS materials, and equipment to reduce maintenance, repairs, and replacement costs.								
Modeling inputs including concrete overlay, concrete joint type, and concrete strength for the FAARFIELD pavement design program.			X	X				
Asphalt overlay modeling inputs with new design methodology for the FAARFIELD design program.			X	X	X			
Report on performance comparison results of P-401 Hot Mix Asphalt (HMA) and Warm Mix Asphalt (WMA) when subjected to aircraft loading.			X	X				
Polymer Modified Binders in HMA and WMA research quantifying advantages of use based on full-scale accelerated pavement tests.			X	X				
New FAA Standards and Specifications for WMA and Recycled Asphalt Pavement for use on airport pavements.			X	X	X			
FAARFIELD airfield pavement design program improvement, based on airport pavement performance data.		YES	X	X	X	X	X	X
Specification guidance on the use of geosynthetics, geogrids, and geotextiles as reinforcing base/subbase layers, separation layers, and/or drainage layers in the airport pavement structure.		YES	X	X	X	X	X	X
FAARFIELD airport pavement design program user interface and functionality improvements			X					
A new design model that will be incorporated into the FAARFIELD airfield pavement design program, for use in predicting reflection crack damage when designing airport pavement HMA thickness concrete overlays.			X	X	X	X		
New airport pavement roughness index based on accelerometer values acquired from inertial profiling systems to help airports schedule pavement repairs and minimize downtime at the airport.				X	X			
Updated versions of the FAA programs ProFAA and ProGroove to help airports better characterize runway pavement roughness and groove conditions.				X	X			
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.			X					

Output	Collaborators	Long Term R&D	Fiscal Year					
			18	19	20	21	22	23
A French and Spanish Interface to the FAA program PAVEAIR 3.0.			X	X				
A searchable database (PA-40) uniting comprehensive construction, performance, maintenance, traffic usage and weather data on a representative set of runways at large- and medium-hub airports in the US.			X	X				
Pavement prediction modeling tools based on pavement, traffic, and/or environmental inputs, that will yield extended pavement life performance indexes.				X				
Objective (3b): Identify, develop, and validate procedures for the aerospace community that enable recovery of NAS operations following a disruptive event and ensure continued safe operations.								
Update guidance to advisory circular AC 150/5370-17 to provide alternative heated pavement technologies (e.g., geothermal, electrically conductive materials, and nanotechnology) and design guidance to reduce negative impact to airport operations while increasing safety and efficiency during adverse winter weather conditions.		YES	X	X	X	X	X	X
Technical analysis report and assessments of PS network performance.	MITRE/CAASD		X					
Analysis reports and assessments on relevant national and international data communications	MITRE/CAASD		X					
Assess the mobility and security of new Radio Technical Commission for Aeronautics (RTCA) SC-223, International Civil Aviation Organization (ICAO) Communications Panel, Working Group I and Airlines Electronic Engineering Committee (AEEC) IPS standards	MITRE/CAASD		X					
Identify research requirements including IP network protocol and subnetwork protocol multi-link and mobility management options to improve data communications system performance.	MITRE/CAASD		X					
Technical report evaluating the effectiveness of modern aircraft's architectures such as integrated modular avionics (IMA) that are claimed to have minimized development and design errors relative to legacy systems, where systems on-board the aircraft ran independently.	NASA Langley				X			
Objective (3c): Identify, develop, and validate new and enhanced tools, procedures, and strategies to enhance the aerospace community's ability to prevent, deter, detect, and respond to cyber-attacks to ensure continued safe operations.								
Cyber Integrated Safety Risk Assessment (SRA) Methodology for analysis of cyber threats to aircraft safety in an airborne network environment.	MIT/LL, ACA, John Hopkins Univ		X					

Output	Collaborators	Long Term R&D	Fiscal Year					
			18	19	20	21	22	23
Periodic cyber SRA reports identifying apertures, vulnerabilities and risks associated with individual avionics SRA subjects, with assessment conclusions and recommendations.	MIT/LL, ACA, John Hopkins Univ, DHS		X	X	X	X	X	X
Establish Cyber Integrated Mitigation Identification & Evaluation Process (MIDEP) for application to selected SRA risks.	MIT/LL, ACA			X				
Cyber Technical findings from applying the MIDEP to identified aircraft cyber safety risks.	MIT/LL, ACA, John Hopkins Univ, DHS, Intelligence Agencies, DoD	YES		X	X	X	X	
Analysis report on initial demonstration of Big Data Cyber Analytics and data collection proof of concept.	DHS, DOD			X				
Report on mission support demonstration of advanced analytical methods and visualization methods for predicting and responding to cyber event.	DHS, DOD			X				
Report on NAS demonstration of advanced analytical methods and visualization methods for predicting and responding to cyber events.	DHS, DOD				X			

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

The human is principally the most vulnerable component of the National Airspace System. Humans, serving in the capacity of aircrew (including UAS remote pilots), cabin crew, maintenance, air traffic control, and other NAS roles, are invariably subject to psychophysiological breakdown, and therefore less than optimal performance during both normal and emergency events. 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.

3.2.4.1 Goal 4 – Alignment with Long-Term Vision for Aviation

New generations of advanced air vehicle designs as well as the increased reliance on automation to support future aviation operational concepts necessitate increased research emphasis to determine and address related human performance implications. Safe aviation operations in the future NAS will be sustained by:

(1) Improved understanding of the key parameters of human performance in aviation to support the human contribution to safety during air and ground operations for appropriate situational awareness and effective human-automation interaction, including during off-nominal and degraded situations.
(2) Assured safe operations for the complex mix of vehicles (including UAS) anticipated within the airspace system enabled by NextGen.
(3) Enhanced probability that passengers and crew will survive and escape safely when accidents do occur.

The NAS Enterprise Architecture specifies in its Human Systems Integration (HSI) Roadmap a wide range of focus area activities to be integrated with, and addressed as part of, the NAS infrastructure evolution to ensure human centered design and human performance/safety are an integral part of the development of future operational systems. The research performed pursuant to this goal supports the focus areas outlined in the HSI Roadmap.

3.2.4.2 Goal 4 Objectives

4a Human Performance – ***Identify, develop and validate new technologies, policies, training methodologies, personnel selection tools and procedures to improve the performance of humans in the operation of the aerospace systems.***

Improved human performance in the operation of increasingly diverse and complicated aerospace systems is required to ensure safe and efficient use of those varied systems. The research projects associated with this Human Performance objective broadly covers Human Factors and systems integration; On-Demand NAS information and Weather information in the cockpit; the growing areas of Unmanned Aircraft Systems and Commercial Space Transportation; and Airport Operations.

Human Factors research looks to improve crew resource management, task performance and training for those individuals critically important to efficient and safe aerospace systems operations. They are aircrew, aircraft inspectors, maintenance technicians, Air Traffic Controllers, and Technical Operations personnel; each needing to be properly vetted, properly trained, and properly equipped. Human Factors research is planned to improve crew resource recruitment and aptitude evaluation methods, which will need to evolve as the jobs change with increased introduction of automation. Training improvements will be investigated in such specialized areas as helicopter operations, virtual reality training aid technologies, and air traffic control. Human Factors research seeks to improve operations by enhancing the equipment and systems with which these individuals interact. Aircrew will benefit from advanced vision and head mounted displays as well as new insight into the risks of combined vision systems use in low visibility operations. Air Traffic Controllers will utilize improved information placement on their traffic displays, and color vision deficient controllers will be aided by color palettes designed for the optimal use of colors used for alerts. In the cockpit, aircrew will be assisted by improved auto flight system mode indicators.

Improved human performance is realized with improved information content, access, and recording. Several projects aim to do just that as found in the On-Demand NAS Information and Weather Technology in the Cockpit (WTIC) programs. Through an iterative process, the On-Demand NAS Information portfolio looks to aid in the concept development, modeling, and test support of a speech recognition capability to facilitate traffic flow management information recording and logging. The WTIC program will focus on essential meteorological information rendering to ensure that pilots interpret weather information effectively. Pilot weather-related training and testing is also to be evaluated.

As the definition of aerospace systems grows to include unmanned aircraft systems (UAS) and commercial space transportation, so too must the research into human engagement and operation of these systems. As with conventional aircraft, these new technologies require properly vetted and trained operators and operations guidance/regulation.

4b Aeromedical Factors – *Identify, develop and validate medical, computational biology, forensic sciences, and biomedical engineering tools and procedures, to optimize human protection and survival in aerospace operations.*

The principal contributions of FAA’s Aerospace Medical Research to the public are:

- Continued Operational Safety – by maximizing the strengths of the human link in the NAS and minimizing inherent human weakness to prevent accidents and improve safety through evidence-based medicine,
- Risk Management – by identifying hazards and investigating injury/death patterns in civilian flight accidents towards an aeromedical safety management system, and

- Certification Standards & Policy – by formulating criteria that will lead to improved knowledge management and decision-making processes in aerospace medicine, aircraft certification, flight standards, and accident investigation/ prevention programs.

In other words, the FAA's Aeromedical Research Program supports improvement of the operation of the human component of aviation by identifying human conditions that indicate an inability to meet flight demands, both in the absence and in the presence of emergency flight conditions. Various aeromedical research projects are planned to aid in medical certification, aircraft certification, and expedited aeromedical review of aviation accidents. The FAA's aerospace medical research program is conducted at the Civil Aerospace Medical Institute (CAMI) in Oklahoma City. Aeromedical expertise is fundamental to the continued technical and scientific discovery that would assure the future of the FAA as a world leader in aviation safety and include research plans for:

- Advances in medicine, engineering, and computer sciences (e.g., robotics, nanotechnology, gene therapy, and bioinformatics);
- Discovery of biomarkers that signal fatigue, hypoxia, impairment, and disease in civil aviation operations
- Introduction of designer drugs and other illegal substances into the market and their assessment in accident investigation; Incapacitation in-flight; aging U.S. airmen; medications used by the same
- Improved aircraft materials, equipment, cabin configurations, life support systems, and evacuation assistive devices – all of which may affect survival from an aircraft accident; and
- Expansion of the transportation envelope, and thus, the environmental stressors passengers and crew may experience (e.g., hypoxia, acceleration).

Table 3.2.4.3 Goal 4 Outputs

Output	Collaborators	Long Term R&D	Fiscal Year					
			18	19	20	21	22	23
Objective (4a): Identify, develop and validate new technologies, policies, training methodologies, personnel selection tools and procedures to improve the performance of humans in the operation of the aerospace systems.								
Review of current Crew Resource Management (CRM) training and evaluation practices and recommend will updates to AC 120-51, CRM Training.	Airlines		X					
Minimum equipment operational requirements for the operational use of advanced vision systems and head-up (HUD)/head-mounted displays (HMD) in low visibility conditions.		YES	X	X	X	X	X	X
Recommendations on training and operational effectiveness of contemporary training methods and devices, including guidance on emerging technologies (e.g., virtual reality or augmented reality and mobile devices) and risk management strategies for risks associated with the changing pilot workforce.		YES			X	X		
Recommendations report addressing helicopter training devices, scenario based training, and helicopter crew resource management best practices.			X					
Design an experiment to address the human performance impacts of features and functions of CVS systems.		YES	X	X	X	X	X	X
New approaches to air traffic controller aptitude testing for use in the hiring process to improve efficiency.	MITRE, APTMetrics	YES		X		X		X
Recommendations on alternative, more efficient, training technologies and practices to improve training of newly hired air traffic control personnel over the next decade.	MITRE, Universities			X	X	X		
Recommendations to improve controller visual scanning techniques for improved controller initial and recurrent training.	Universities		X					
Guidance on information presentation, coding, placement, accessibility, and usability based on a systematic evaluation of current user interface elements in air traffic control displays.			X	X	X			
Complete an empirically validated color palette useful to color vision deficient controllers, to be referenced in the ATC Display Color Standard, for use in future ATC display acquisitions.			X					
Complete Technical Operations Graphical User Interface (GUI) Style Guide for new ATO equipment, to standardize the design of maintainer-system interfaces, for use in future ATC acquisitions.			X	X	X			
A Technical Operations Talent Acquisition Process, including new selection tools, to aid in the selection of ATO technician position applicants to evolve the maintenance culture.					X	X		X
Report documenting the gap analysis review of regulations, standards and guidance applicable to the required knowledge, skill, and tests for operating UAS in various kinds of operations that would be outside the 107 framework.				X				

Output	Collaborators	Long Term R&D	Fiscal Year					
			18	19	20	21	22	23
Experiment design plan to expand, refine and/or validate the prior related research results on UAS air carrier remote pilot duty and rest requirements to include fatigue issues to standardize crew duty and rest requirements.					X			
Report documenting the experimental results and analysis for air carrier UAS remote pilot crew staffing, based on prior research work to standardize UAS air carrier remote pilot and crew requirements.						X		
Knowledge and skills testing report containing experimental results and analysis for air carrier UAS remote pilots based on prior research work to standardize UAS air carrier remote pilot and crew training and testing requirements.						X		
Report documenting the duties and rest requirements specific to air carrier operations containing experimental results and analysis for air carrier UAS remote pilots based on prior research work.						X		
Report of recommended criteria by which operators can assess their compliance with specific FAA regulations related to human factors of suborbital winged commercial spaceflight vehicle design, mission design, restraint and stowage, and vehicle operations.				X				
Update regulatory and guidance material on the presentation of electronic charting information.			X					
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.				X				
Boeing and Airbus flight simulator evaluations of prototype awareness displays and alerting systems.					X			
Minimum Weather Service recommendations report specifying minimum rendering requirements to enable and ensure effective pilot interpretation of weather information in the cockpit.	Industry, AOPA	YES	X	X	X	X	X	X
Identification, demonstration, and validation of weather-related training and testing required for pilots, and for recommendations for pilot trainers/demonstrators (standalone and online) capabilities.	AOPA, industry	YES	X	X	X	X	X	X
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.			X					
Operational concept and requirements development, and model enhancement recommendation report for Advanced Coordination prototyping traffic flow management (TFM) recording and logging capability.			X					
Concept of Operations (ConOps), Proof of concept emulation/prototype and Speech Validation Test Report for speech recognition for traffic flow management (TFM) recording and logging.				X	X	X		
Final research report documenting the results of experiments and resulting analysis of the design of Detect and Avoid (DAA) display and/or flight path guidance information required for an UAS pilot.				X				
Expanded Radar Vectoring Aptitude Test capability to include aptitude for additional controller skills including scanning and planning.	MITRE/CAASD		X					

Output	Collaborators	Long Term R&D	Fiscal Year					
			18	19	20	21	22	23
Objective (4b): Identify, develop and validate medical, computational biology, forensic sciences, and biomedical engineering tools and procedures, to optimize human protection and survival in aerospace operations.								
Technical report on comparison across multiple types of sleep deprivation.								X
Technical report on photoluminescent floor proximity escape path marking systems.					X			
Two technical reports on ATD construction harmonization.						X	X	
Two technical reports on occupant protection for legacy rotorcraft.					X			

3.2.5 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.

3.2.5.1 Goal 5 – Alignment with Long-Term Vision for Aviation

Safety assurance and environmental impact mitigation added in the increasingly complex NAS of the future will be informed by an improved suite of data sources and analytical tools and capabilities. Aircraft safety assurance processes and practices will evolve toward a system enabled with capabilities to predict, monitor and assess the health of aircraft, at the material, subsystem and component level more efficiently and effectively[10]. Aviation environmental analyses, impact determinations and mitigation decisions will continue to be based on a solid scientific foundation[11]. Risk-based Decision Making services will provide data to inform system-level risk based decisions[12].

Continued research under the Integrated Environmental Modeling - Phase III initiative[13] will support continuing update of the integrated aviation environmental analysis tool suite for the latest scientific knowledge and use this capability to further evaluate both the environmental consequences and impacts of aviation as well as the performance of potential mitigation options.

Planned operational improvement of the Automated Safety Information Sharing and Analysis[14] will enhance aviation operational safety and contribute to reduced risk by automating risk identification and notification processes. Improvements will be made to the ASIAS analytical capabilities to extend their coverage, improve the speed of risk identification and notification and enhance safety mitigation evaluation.

10 Ref: OSTP National Aeronautics R&D Plan
11 Ref: NASEA Env. & Energy Service Roadmap
12 Ref: NASEA Risk-based Decision Making Service roadmap
13 Ref: NASEA OI 701104
14 Ref: NASEA OI 601104

3.2.5.2 Goal 5 Objectives

5a Aerospace System – *Identify and develop a sufficient scientific understanding of aerospace systems to enable the aerospace community's development of solutions to enhance safety, improve efficiency, and reduce environmental impacts.*

From the beginning, aviation has been about evolution and open-mindedness. At each milepost, progress depended on an individual – or a group of individuals – unafraid to challenge conventional wisdom. To accomplish this, we must maintain an open and transparent exchange of information and data between the FAA and industry. Aerospace systems are also becoming increasingly complex as technology advances and these systems must go through stringent testing during development to ensure adherence to strict safety standards. Through varied partnerships, the FAA is continually looking for new ways to enable aerospace system innovation and development efforts.

The FAA has a robust noise research roadmap on quantifying impacts of noise, exploring and deploying noise mitigation measures, and understanding the noise from new entrants such as drones and supersonic aircraft. For example, the FAA is currently conducting research projects to quantify the impact of aircraft noise on sleep disturbance and cardiovascular health with the Aviation Sustainability Center (ASCENT), at the FAA Center of Excellence for Alternative Jet Fuels and Environment. The FAA also has an emissions research roadmap includes research in emissions source characterization, aviation emissions modeling and health impacts. By addressing these issues, the agency believes that better methods and procedures will be developed so that the aerospace community will have less of a perceived negative impact by those communities surrounding airports and the general public.

The FAA is also partnering with industry to establish standards that support UAS operations in an expanding set of missions, platforms, and capabilities. Research in support of this partnership includes UAS design and airworthiness, software assurance, operations and mission requirements, pilot training, and maintenance. This includes standards for Command & Control systems (C2), Detect-And-Avoid (DAA) technology, and identification & tracking capabilities. It's hard to think of any part of the Aerospace industry that isn't changing and evolving in some way. In some cases, the need to change is imposed externally, as with unmanned aircraft and cyber security threats. In others, we are initiating change from within, as with compliance philosophy and our nationwide deployment of NextGen.

5b Data Engineering – *Identify, develop, and validate new methods and analytical and predictive capabilities for the aerospace community to collect, aggregate, analyze, and share NAS data to effectively monitor and improve system-wide performance.*

Data Engineering research will be conducted for the purposes of monitoring and improving the performance of diverse integrated elements of the System-wide NAS, from wake turbulence detection at local airport runways to determining spatial satellite collision fragment sizes, and, from predicting NAS safety trends to predicting performance of the NAS.

The NextGen Wake Turbulence Program will continue work on developing an aircraft flight data recording tool to gather statistics on the frequency aircraft are encountering low-impact (and this more frequent) wake turbulence during flight. This will prove helpful in predicting the probability of an aircraft encountering wake turbulence-induced damage precipitated by a change in air traffic operation performance. As with Wake Turbulence in providing predictive performance capabilities, the UAS research program will develop an analytical tool based on researched UAS Flight Data monitoring parameters (UFDMs). This phased research will culminate with a comprehensive set of UFDMs to aid in predicting risk occurrences of unmanned aircraft in the NAS. Another analytic and predictive tool is planned by the Commercial Transportation Safety Program, with the goal of improving the safety and efficiency of commercial space transportation operations. In this case the subject of probabilistic analysis, is the determination of fragment size and mass associated with satellite collisions.

While these projects are unique to particular aerospace system elements interacting in the NAS– UAS, aircraft on a runway, incursions in space – other data-based studies focus on the safety and capacity performance of the fully integrated NAS. The System Safety program for example looks to develop a software tool for early identification of emerging safety trends in the NAS and for timely and effective safety oversight of the Air Traffic Organization. A second software tool, designed to model the NAS and dependent operational procedures, will predictively identify and assess safety issues related to changes to NAS legacy systems and the introduction of new systems or operational procedures to the NAS. With a focus on monitoring and improving NAS capacity, the System Capacity, Planning and Improvements program sponsors operational NAS performance capability studies that identify constraints in the NAS and assess capacity, the predictability of capacity and flight trajectory efficiency for operators.

5c System Performance – *Identify and develop tools, methods, studies, reports, and assessments for use by the aerospace community that evaluate, in an integrated manner, the system-wide performance, and impacts of new and existing aerospace vehicles, air traffic concepts, and airport/spaceport operations.*

As utilization of the NAS continues to grow due to increased air traffic demand and the introduction of new aerospace vehicle types, NAS System Performance based research is required, to meet that increased demand. Four programs will develop System performance tools and assessments relevant to system impacts, air traffic concepts and airport operations.

Increased airport runway capacity resultant wake turbulence and increased aircraft noise and emissions are direct effects of increased demand. The NextGen Wake Turbulence Program and the Environment and Energy Program, respectively, are developing performance modeling tools with capabilities unique to each of those areas. As airport runway capacity is dependent partly on wake turbulence separation minima, a modeling tool is planned to estimate wake encounter probabilities when NAS airspace design or ATC procedures are changed.

The Environment and Energy Program is continuously developing and improving a suite of modeling and analytical tools that is able to model changes in aviation demand, fleet composition, aircraft technology development, operational procedures, and the use of alternative fuels. These tools enable the FAA to understand the consequences of changes in various aspects of the aviation system on noise and emissions as well as the impacts on the health and welfare of the public. This tool suite is used both for domestic purposes to meet regulatory requirements as well as for international decision making. On the domestic front, it is helping to streamline the process for environmental compliance thus helping to facilitate the development of new infrastructure. The tool suite has also been used extensively to evaluate the costs and benefits of emissions and noise standards at ICAO CAEP (Civil Aviation Organization Committee on Aviation Environmental Protection.) This tool suite has been central to the United States technical leadership at ICAO CAEP for over a decade.

Efforts directed at increasing arrival and departure operations at airports with closely spaced parallel runways in limited visual conditions, has airport operations system performance implications. Research work in this area, conducted by the Closely Spaced Runway/Parallel Runway Operations Program, will evaluate new reduced separation air traffic approach concepts such as the closest point a trailing aircraft can be to the lead aircraft. This study is to include a safety analysis of the 'Gate Violations and Breakout' Procedures meant to govern reduced aircraft separation. Also associated with separation, studies are planned to analyze mixed arrivals and departures to determine if collision separations can be reduced through the use of more efficient runway utilization.

Table 3.2.5.3 Goal 5 Outputs

Output	Collaborators	Long Term R&D	Fiscal Year 18	19	20	21	22	23
Objective (5a): Identify and develop a sufficient scientific understanding of aerospace systems to enable aerospace community's development of solutions to enhance safety, improve efficiency, and reduce environmental impacts.								
Finite Element Analysis model to evaluate aircraft response to selected impact scenarios, supporting crashworthiness impact requirements and guidance material development.	Wichita State Univ		X					
Data package and methods for guidance material for the airworthiness acceptance criteria and test methods for engines in simulated high ice water content environments.	NRCC		X					
Technical report with information and data that ensures more complex, increased voltage, and highly integrated electrical system technology is safely introduced onto traditional, current and future aircraft electrical architecture.							X	
Technical report on methodologies with data which will enable the FAA to evaluate Active Flutter Suppression (AFS) control synthesis with special attention on uncertainty in modeling and interaction with other active control systems in operation.	Univ of Washington, Milan Polytechnic Institute		X					
Studies to establish guidance for Certification by Analysis of Turbine Engine Fan Blade Off requirements and evaluation of new material models in LSDYNA to predict multiple failure modes from a single input deck.	LSTC				X			
Vulnerability analysis to update uncontained engine and open rotor engine vulnerability analysis toolkit with improved impact accuracy, and revised fragment model that includes new events.	NAWC					X		
Validation of the MAT_213 computation model of impact response of various composite architectures, to establish guidance by certification analysis.	NASA						X	
Methods and sample problems for modeling bird strike impact to aircraft structure and engine are being developed.	Simulants for Impact and Ingestion Committee							X
Report compiling research results of the state of wet runway performance in a wide variety of rain rate and runway construction/maintenance situations to update current wet runway regulations and guidance.	Air Operators						X	
Conduct a national sleep study to collect nationally representative data on the relationship between aircraft noise exposure and residential sleep disturbance	Univ. of Pennsylvania, HMMH	YES	X				X	

Output	Collaborators	Long Term R&D	Fiscal Year					
			18	19	20	21	22	23
Report on the reassessment of current metrics relative to community exposure to aircraft noise using the most recent annoyance information collected at U.S. airports.	USG		X	X				
Reports summarizing research on technologies to reduce supersonic aircraft noise, the public reaction to advanced supersonic aircraft noise, and procedures needed to certify aircraft noise to create the body of knowledge to support the development of en-route noise standards for airplanes that exceed Mach 1.	Industry, USG, int'l stakeholders, ASCENT COE		X	X	X	X	X	X
Report on the analysis findings from the National Civil Airport Aircraft Noise Annoyance Survey telephone data.				X				
Objective (5b): Identify, develop, and validate new methods and analytical and predictive capabilities for the aerospace community to collect, aggregate, analyze, and share NAS data to effectively monitor and improve system-wide performance.								
Safety Oversight Management System tool that will include a data-driven closed-loop system outlining Air Traffic Safety Oversight Service (AOV) oversight activities, targets, and data collection parameters based on emerging safety trends associated with ATC systems at the facility and NAS levels.					X	X		
Integrated Domain – Safety Risk Evaluation Tool that will include a model of NAS systems and procedures as well as their interfaces linked to the NAS safety data.					X			
Report documenting the minimum standard list of flight data monitoring (FDM) parameters that serves as a baseline for collecting and analyzing UAS FDM (UFDM).				X				
UAS analysis tools and techniques required to integrate UAS Flight Data Monitoring (UFDM) into Aviation Safety Information Analysis and Sharing (ASIAS).					X			
Report documenting a comprehensive set of UFDM parameters for risk occurrence/flight operation/mission profiles.						X		
An Aviation Safety Information Analysis (ASIAS) capability that monitors UAS operations that intersect with civilian NAS operations.							X	
Report on recommended methods to determine the probabilistic fragment size and mass distributions due to satellite collisions.	Air Force Research Lab						X	
Enhancement to aircraft flight data recorder (FDR) screening utility to enable it to gather additional statistics on aircraft encounters with low strength wake turbulence.	Air carriers, NIA, pilot unions, NASA			X				

Output	Collaborators	Long Term R&D	Fiscal Year					
			18	19	20	21	22	23
Develop data mining and analysis tools, produce capacity studies, and utilize performance metrics and modeling/analysis to identify constraints in the NAS and assess capacity the predictability of capacity and flight trajectory efficiency for operators.	GRA, VA Tech, MIT	YES	X	X	X	X	X	X
Approach procedure assessment using automated speech recognition technology for communication between air traffic controllers and pilots at expanded airport sites across the NAS.	MITRE/CAASD		X					
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.	MITRE/CAASD	X						
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.	MITRE/CAASD	X						
Identify safety topic trends, monitor frequency of safety events, and detect the emergence of safety topics using topic modeling processes.	MITRE/CAASD	X						
Objective (5c): Identify and develop tools, methods, studies, reports, and assessments for use by the aerospace community that evaluate, in an integrated manner, the system-wide performance, and impacts of new and existing aerospace vehicles, air traffic concepts, and airport/spaceport operations.								
Probabilistic modeling tool set for estimating the decreased/increased wake encounter risk resulting from proposed changes in NAS airspace design or ATC procedures	NASA, NRC Canada, NEXTOR II, CSSI			X				
Aviation Environmental Design Tool (AEDT) Version 3 with improved aircraft performance modeling capabilities including noise, emissions, and fuel burn estimation methodologies.	Industry, USG, int'l stakeholders, ASCENT COE		X					
Advanced emissions modeling capabilities that leverage the latest national and international research.	ASCENT COE		X					
Improved analytical capabilities of aviation environmental analysis tools by expanding the computational models for aircraft performance, noise and emissions source generation processes, and noise and emissions propagation processes.	Industry, USG, int'l stakeholders, ASCENT COE				X	X	X	X
Quantitative analyses through modeling of the change in fuel use and emissions that could result from changes in aircraft technology, operational procedures and alternative fuel use.	Industry, USG, ASCENT COE		X			X		
UAS Requirements for NAS Voice System (NVS) Program.	NATCA		X					
UAS Contingency Procedures Human-in-the-Loop (HITL) Simulations Technical Report.	NATCA			X				
UAS Automation System Requirements Technical Assessment on UAS flight planning and trajectory modeling.				X				

Output	Collaborators	Long Term R&D	Fiscal Year					
			18	19	20	21	22	23
Validated Unmanned Traffic Management (UTM) Use Cases for Beyond Visual Line of Sight UAS Operations.	NASA Ames NATCA		X					
Concept of Operations Version 1.0: "Beyond Visual Line of Sight UAS Operations below 400 Ft AGL under UTM Construct."	NASA Ames NATCA			X				
Front Gate analyses and technical report for Paired Approach to CAT I minima.			X					
Operational gate violations and breakout procedures safety analysis and technical report for Paired Approach to CAT I approach minima.				X				
Initial analysis of the Integrated Closely Spaced Arrival Departure Operations capability.					X			
Analysis of the Integrated Closely Spaced Arrival Departure Operations capability.						X		
Technical report of Integrated Closely Spaced Arrival Departure Operations.							X	
Initial set of common utilities for processing and formatting SWIM data as well as a proposed process for releasing these utilities to the user community through open source, thereby lowering the entrance bar to SWIM.	MITRE/CAASD		X					
Forensic Toolset that, at a minimum, includes an updated Composite Failure Analysis Handbook and a Handbook for Composite Aircraft Accident Investigation.	Airforce Research Lab, Airbus, Exponent	YES					X	X

4.0 Research & Development Budget and Management

This chapter reviews the FAA R&D portfolio according to the FY 2019 President's Budget submission. It summarizes the three budget appropriation accounts under which R&D is currently being conducted, shows how much the FAA is spending on R&D and describes the R&D program execution.

The FAA R&D portfolio supports regulation, certification, and standards development; modernization of the NAS, and policy and planning. In order to support DOT strategic goals, FAA R&D Goals, and Objectives, the R&D addresses the specific needs of sponsoring organizations, including (a) Aviation Safety, (b) Air Traffic Organization, (c) Airports, (d) NextGen, (e) Policy, International Affairs and Environment and (f) Commercial Space. The R&D Management Division under the Assistant Administrator for NextGen manages the FAA R&D portfolio for the Agency.

4.1 Appropriation Accounts

Three of four of the FAA's appropriation accounts fund the R&D portfolio: R,E&D, F&E; and AIP. The following sections provide a summary of these three FAA appropriation accounts[15] and how the R&D portfolio is derived from each.

4.1.1 Research, Engineering and Development (R,E&D)

The R,E&D appropriation account funds R&D programs that improve the NAS, by increasing its safety, security, productivity, capacity, and environmental compatibility; in order to meet the expected air traffic demands of the future. The R,E&D appropriation account funds roughly 46% of the programs included in the FAA R&D portfolio.

4.1.2 Facilities and Equipment (F&E)

The F&E appropriation account funds capital investments relating to air navigation facilities and equipment, aviation safety systems including acquisition costs, installation, testing and laboratories, initial spares, initial maintenance contracts and training for equipment, facilities, and other construction projects. The F&E appropriation account funds R&D from two areas: Advanced Technology Development and Prototyping and within the NextGen Portfolios. In general, programs from these groups are in the concept development and demonstration phase prior to an FAA investment decision.

Advanced Technology Development and Prototyping R&D Programs develop and validate technology and systems that support air traffic services, to include the requirements associated with the evolving air traffic system architecture and improvements in airport safety and capacity.

[15] FAA Order 2500.8B, Funding Criteria for Operations, F&E, and R,E&D Accounts, dated October 1, 2006.

NextGen Portfolio R&D programs comprise the other half of the F&E Activity R&D Program and have broad applicability across NextGen.

4.1.3 Grants-In-Aid for Airports (AIP)

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

4.2 R&D Summary Budget Tables

This section provides five tables presenting the (a) FAA R&D budget by appropriation, (b) program sponsor/requesting organization, (c) research category, (d) performance goal, and (e) NextGen R&D. It presents the FY 2017 Enacted and FY 2018 and 2019 President's Request, and planned funding for FY 2020 through 2023; which are estimates and subject to change. The amounts shown for F&E programs in FY 2017 and beyond reflect the entire budget for those portfolios; a change made from prior years due to the reclassification of existing work to better align with OMB Circular A-11 Research Definitions.

4.2.1 Appropriation Account

Table 4.2.1, Planned R&D Budget by Appropriation Account, shows the FAA R&D FY 2017 Enacted and FY 2018 and 2019 President's Request budgets and the estimated funding through FY 2023, grouped by appropriation account. The F&E appropriation has programs that are not part of the R&D portfolio, as the NARP only presents R&D.

4.2.2 Requesting Organization

Table 4.2.2, Planned R&D Budget by Requesting Organization, shows the FAA R&D FY 2017 Enacted and FY 2018 and 2019 President's Request budgets and the estimated funding through FY 2023, grouped by requesting organization. Requesting (also known as sponsoring) organizations include Aviation Safety; Air Traffic Organization; Airports; NextGen; Policy, International Affairs and Environment and Commercial Space.

4.2.3 Research Category

The FAA R&D portfolio includes both applied R&D as defined by the OMB Circular A-11[16]. Applied research is the systematic study to gain knowledge or understanding necessary to determine the means by which a recognized and specific need may be met. Development is the systematic application of knowledge or understanding directed toward production of useful materials, devices, and systems or methods; including design, development, and improvement of

[16] OMB Circular A-11, Preparation, Submission and Execution of the Budget, July 25, 2014 (Revised November 2014), section 84, page 8 (http://www.whitehouse.gov/OMB/circulars).

prototypes and new processes to meet specific requirements. **Table 4.2.3, Planned R&D Budget by Research Category**, shows the FAA R&D portfolio according to these categories with the percent of applied R&D for FY 2017 through 2023.

4.2.4 Performance Goal

Table 4.2.4, Planned R&D Budget by Performance Goal shows the FAA R&D budget by the performance Goals defined in Exhibit II of the FAA President's Request for FY 2019.

The R&D programs apply to all four of the Goals in the *U.S. Department of Transportation Strategic Plan for FY 2018 -2022*: Safety, Infrastructure, Innovation and Accountability. Many R&D programs apply to more than one DOT goal however, for budgeting purposes, most programs are included under only one DOT goal. The table provides information on contract costs and personnel costs requested for FY 2019.

4.2.5 NextGen R&D

Funded by both R,E&D and F&E appropriations, the FAA NextGen R&D portfolio is a subset of the FAA R&D portfolio, reported in the NARP. The FAA NextGen R&D portfolio represents 35% of the total requested R&D budget reported in the NARP for FY 2019, and it represents 13% of the FAA NextGen portfolio. The FAA R&D portfolio includes the entire R,E&D contribution to NextGen, but only part of the F&E contribution to NextGen. **Table 4.2.5, NextGen R&D Funding**, provides the FAA NextGen R&D portfolio five-year/outyear budget plan by line item and appropriation.

Table 4.2.1: Planned R&D Budget by Appropriation Account

2018 BLI	Program	Appropriation Account	2017 Enacted ($000)	2018 President's Request ($000)	2019 President's Request ($000)	2020 Estimate ($000)	2021 Estimate ($000)	2022 Estimate ($000)	2023 Estimate ($000) /1
Research, Engineering and Development (RE&D)									
A11.a	Fire Research and Safety	RE&D	7,425	7,044	4,867	4,927	4,993	5,060	5,129
A11.b	Propulsion and Fuel Systems	RE&D	2,074	2,269	555	573	590	607	625
A11.c	Advanced Materials/Structural Safety	RE&D	6,500	4,338	2,300	2,286	2,285	2,284	2,283
A11.d	Aircraft Icing/Digital System Safety	RE&D	5,102	9,253	7,684	7,606	7,578	7,550	7,521
A11.e	Continued Airworthiness	RE&D	9,269	10,437	4,969	4,931	4,923	4,914	4,906
A11.f	Aircraft Catastrophic Failure Prevention Research	RE&D	1,528	1,570	0	0	0	0	0
A11.g	Flightdeck/Maintenance/System Integration Human Factors	RE&D	7,305	6,825	5,052	5,054	5,077	5,101	5,125
A11.h	System Safety Management	RE&D	6,500	4,149	799	826	849	873	897
A11.i	Air Traffic Control/Technical Operations Human Factors	RE&D	6,165	5,196	1,436	1,475	1,510	1,546	1,583
A11.j	Aeromedical Research	RE&D	8,538	9,765	3,875	3,966	4,051	4,138	4,228
A11.k	Weather Program	RE&D	15,476	13,399	6,580	6,429	6,342	6,253	6,161
A11.l	Unmanned Aircraft Systems Research	RE&D	20,035	6,787	3,318	3,316	3,328	3,340	3,353
A11.m	NextGen - Alternative Fuels for General Aviation	RE&D	7,000	5,924	0	0	0	0	0
A11.n	Commercial Space Transportation	RE&D	2,453	1,796	2,500	2,433	2,393	2,352	2,309
A12.a	NextGen - Wake Turbulence	RE&D	8,609	6,831	3,519	3,499	3,499	3,498	3,498
A12.b	NextGen - Air Ground Integration Human Factors	RE&D	8,575	6,757	1,336	1,335	1,340	1,345	1,350
A12.c	NextGen - Weather Technology in the Cockpit	RE&D	4,059	3,644	1,525	1,531	1,541	1,552	1,563
A12.d	NextGen - Information Security	RE&D	1,000	1,000	1,232	1,219	1,214	1,208	1,203
A12.e	NextGen - Flightdeck Data Exchange	RE&D	0	0	1,035	1,024	1,020	1,016	1,011
A13.a	Environment and Energy	RE&D	16,013	14,497	11,588	11,357	11,230	11,099	10,965
A13.b	NextGen - Environmental Research - Aircraft Technologies, Fuels, and Metrics	RE&D	27,174	23,151	7,578	7,513	7,495	7,477	7,458
A14.a	System Planning and Resource Management	RE&D	2,288	2,135	1,480	1,492	1,507	1,523	1,539
A14.b	William J. Hughes Technical Center Laboratory Facility	RE&D	3,412	3,233	1,178	1,208	1,235	1,264	1,293
	RE&D TOTAL	**RE&D**	**176,500**	**150,000**	**74,406**	**74,000**	**74,000**	**74,000**	**74,000**

Table 4.2.1: Planned R&D Budget by Appropriation Account (cont'd)

2018 BLI	Program	Appropriation Account	2017 Enacted ($000)	2018 President's Request ($000)	2019 President's Request ($000)	2020 Estimate ($000)	2021 Estimate ($000)	2022 Estimate ($000)	2023 Estimate ($000) /1
Facilities & Equipment (F&E) /2									
1A01	Advanced Technology Development & Prototyping	F&E	24,800	26,800	33,000	35,000	34,100	34,200	30,000
1A02	William J. Hughes Technical Center Facilities	F&E	19,000	18,000	21,000	20,000	20,000	20,000	20,000
1A03	William J. Hughes Technical Center Infrastructure	F&E	12,200	10,000	12,000	10,000	10,000	10,000	10,000
1A04	Next Generation Transportation System - Separation Management Portfolio	F&E	32,800	13,500	16,589	21,500	26,600	41,200	43,500
1A06	Next Generation Transportation System - On Demand NAS	F&E	11,500	12,000	20,500	29,500	35,500	29,600	26,300
1A07D	Next Generation Transportation System - NAS Infrastructure	F&E	17,660	17,500	13,500	15,500	25,000	26,000	26,000
1A08	Next Generation Support Portfolio	F&E	12,000	12,000	12,800	10,000	11,000	11,000	9,000
4A08	Center for Advanced Aviation System Development (CAASD)	F&E	60,000	57,000	57,000	57,000	60,000	60,000	60,000
1A05	Next Generation Transportation System - Traffic Flow Management Portfolio	F&E	0	10,800	14,000	11,000	13,000	18,000	11,000
1A09	Next Generation Transportation System - Unmanned Aircraft Systems (UAS)	F&E	0	15,000	14,000	17,000	20,000	20,000	20,000
1A10	Next Generation Transportation System - Enterprise, Concept Development, Human Factors, & Demonstrations Portfolio	F&E	0	9,000	9,500	10,000	9,000	9,000	9,000
-	William J Hughes Technical Center Laboratory Improvement	F&E	1,000	1,000	0	0	0	0	0
	F&E TOTAL	**F&E**	**199,460**	**202,600**	**223,889**	**236,500**	**264,200**	**279,000**	**264,800**
Grants-In-Aid for Airports (AIP)									
--	Airport Cooperative Research Program - Capacity	AIP	5,000	5,000	5,000	5,000	5,000	5,000	5,000
--	Airport Cooperative Research Program - Environment	AIP	5,000	5,000	5,000	5,000	5,000	5,000	5,000
--	Airport Cooperative Research Program - Safety	AIP	5,000	5,000	5,000	5,000	5,000	5,000	5,000
--	Airport Technology Research Program - Capacity	AIP	13,408	15,560	14,679	14,679	14,679	14,679	14,679
--	Airport Technology Research Program - Environment	AIP	1,595	400	0	0	0	0	0
--	Airport Technology Research Program - Safety	AIP	16,371	17,250	18,515	18,515	18,515	18,515	18,515
	AIP TOTAL	**AIP**	**46,375**	**48,210**	**48,194**	**48,194**	**48,194**	**48,194**	**48,194**
	GRAND TOTAL		**$422,335**	**$400,810**	**$346,489**	**$358,694**	**$386,394**	**$401,194**	**$386,994**

Notes:

/1 The funding levels listed for years 2020 to 2023 are estimates and subject to change.

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

Table 4.2.2: Planned R&D Budget by Requesting Organization

2018 BLI	Program	Appropriation Account	2017 Enacted ($000)	2018 President's Request ($000)	2019 President's Request ($000)	2020 Estimate ($000)	2021 Estimate ($000)	2022 Estimate ($000)	2023 Estimate ($000) /1
Aviation Safety (AVS)									
A11.a	Fire Research and Safety	RE&D	7,425	7,044	4,867	4,927	4,993	5,060	5,129
A11.b	Propulsion and Fuel Systems	RE&D	2,074	2,269	555	573	590	607	625
A11.c	Advanced Materials/Structural Safety	RE&D	6,500	4,338	2,300	2,286	2,285	2,284	2,283
A11.d	Aircraft Icing/Digital System Safety	RE&D	5,102	9,253	7,684	7,606	7,578	7,550	7,521
A11.e	Continued Airworthiness	RE&D	9,269	10,437	4,969	4,931	4,923	4,914	4,906
A11.f	Aircraft Catastrophic Failure Prevention Research	RE&D	1,528	1,570	0	0	0	0	0
A11.g	Flightdeck/Maintenance/System Integration Human Factors	RE&D	7,305	6,825	5,052	5,054	5,077	5,101	5,125
A11.h	System Safety Management	RE&D	6,500	4,149	799	826	849	873	897
A11.j	Aeromedical Research	RE&D	8,538	9,765	3,875	3,966	4,051	4,138	4,228
A11.l	Unmanned Aircraft Systems Research	RE&D	20,035	6,787	3,318	3,316	3,328	3,340	3,353
	AVS TOTAL		**74,276**	**62,437**	**33,419**	**33,485**	**33,674**	**33,867**	**34,067**
NextGen (ANG)									
A11.m	NextGen - Alternative Fuels for General Aviation	RE&D	7,000	5,924	0	0	0	0	0
A12.a	NextGen - Wake Turbulence	RE&D	8,609	6,831	3,519	3,499	3,499	3,498	3,498
A12.b	NextGen - Air Ground Integration Human Factors	RE&D	8,575	6,757	1,336	1,335	1,340	1,345	1,350
A12.c	NextGen - Weather Technology in the Cockpit	RE&D	4,059	3,644	1,525	1,531	1,541	1,552	1,563
A12.d	NextGen - Information Security	RE&D	1,000	1,000	1,232	1,219	1,214	1,208	1,203
A12.e	NextGen - Flightdeck Data Exchange	RE&D	0	0	1,035	1,024	1,020	1,016	1,011
A14.a	System Planning and Resource Management	RE&D	2,288	2,135	1,480	1,492	1,507	1,523	1,539
A14.b	William J. Hughes Technical Center Laboratory Facility	RE&D	3,412	3,233	1,178	1,208	1,235	1,264	1,293
	Subtotal	**RE&D**	34,943	29,524	11,305	11,308	11,356	11,406	11,457
1A01	Advanced Technology Development & Prototyping	F&E	24,800	26,800	33,000	35,000	34,100	34,200	30,000
1A02	William J. Hughes Technical Center Facilities	F&E	19,000	18,000	21,000	20,000	20,000	20,000	20,000
1A03	William J. Hughes Technical Center Infrastructure Sustainment	F&E	12,200	10,000	12,000	10,000	10,000	10,000	10,000
1A04	Next Generation Transportation System - Separation Management Portfolio	F&E	32,800	13,500	16,589	21,500	26,600	41,200	43,500
1A06	Next Generation Transportation System - On Demand NAS Portfolio	F&E	11,500	12,000	20,500	29,500	35,500	29,600	26,300
1A07D	Next Generation Transportation System - NAS Infrastructure Portfolio	F&E	17,660	17,500	13,500	15,500	25,000	26,000	26,000
1A08	Next Generation Support Portfolio	F&E	12,000	12,000	12,800	10,000	11,000	11,000	9,000
1A05	Next Generation Transportation System - Traffic Flow Management Portfolio	F&E	0	10,800	14,000	11,000	13,000	18,000	11,000
1A09	Next Generation Transportation System - Unmanned Aircraft Systems (UAS)	F&E	0	15,000	14,000	17,000	20,000	20,000	20,000
1A10	Next Generation Transportation System - Enterprise, Concept Development, Human Factors, & Demonstrations Portfolio	F&E	0	9,000	9,500	10,000	9,000	9,000	9,000
-	William J Hughes Technical Center Laboratory Improvement	F&E	1,000	1,000	0	0	0	0	0
	Subtotal	**F&E**	139,460	145,600	166,889	179,500	204,200	219,000	204,800 /2
	ANG TOTAL		**174,403**	**175,124**	**178,194**	**190,808**	**215,556**	**230,406**	**216,257**

Table 4.2.2: Planned R&D Budget by Requesting Organization (cont'd)

2018 BLI	Program	Appropriation Account	2017 Enacted ($000)	2018 President's Request ($000)	2019 President's Request ($000)	2020 Estimate ($000)	2021 Estimate ($000)	2022 Estimate ($000)	2023 Estimate ($000) /1
Air Traffic Organization (ATO)									
A11.i	Air Traffic Control/Technical Operations Human Factors	RE&D	6,165	5,196	1,436	1,475	1,510	1,546	1,583
A11.k	Weather Program	RE&D	15,476	13,399	6,580	6,429	6,342	6,253	6,161
	Subtotal	**RE&D**	21,641	18,595	8,016	7,904	7,852	7,799	7,744
4A08	Center for Advanced Aviation System Development (CAASD)	F&E	60,000	57,000	57,000	57,000	60,000	60,000	60,000
	Subtotal	**F&E**	60,000	57,000	57,000	57,000	60,000	60,000	60,000 /2
	ATO TOTAL		**81,641**	**75,595**	**65,016**	**64,904**	**67,852**	**67,799**	**67,744**
Commercial Space Transportation (AST)									
A11.n	Commercial Space Transportation	RE&D	2,453	1,796	2,500	2,433	2,393	2,352	2,309
	AST Total		**2,453**	**1,796**	**2,500**	**2,433**	**2,393**	**2,352**	**2,309**
Airports (ARP)									
--	Airport Cooperative Research Program - Capacity	AIP	5,000	5,000	5,000	5,000	5,000	5,000	5,000
--	Airport Cooperative Research Program - Environment	AIP	5,000	5,000	5,000	5,000	5,000	5,000	5,000
--	Airport Cooperative Research Program - Safety	AIP	5,000	5,000	5,000	5,000	5,000	5,000	5,000
--	Airport Technology Research Program - Capacity	AIP	13,408	15,560	14,679	14,679	14,679	14,679	14,679
--	Airport Technology Research Program - Environment	AIP	1,595	400	0	0	0	0	0
--	Airport Technology Research Program - Safety	AIP	16,371	17,250	18,515	18,515	18,515	18,515	18,515
	ARP TOTAL		**46,375**	**48,210**	**48,194**	**48,194**	**48,194**	**48,194**	**48,194**
Policy, International Affairs, and Environment (APL)									
A13.a	Environment and Energy	RE&D	16,013	14,497	11,588	11,357	11,230	11,099	10,965
A13.b	NextGen - Environmental Research - Aircraft Technologies, Fuels, and Metrics	RE&D	27,174	23,151	7,578	7,513	7,495	7,477	7,458
	APL TOTAL		**43,187**	**37,648**	**19,166**	**18,870**	**18,725**	**18,576**	**18,423**
	GRAND TOTAL		**$422,335**	**$400,810**	**$346,489**	**$358,694**	**$386,394**	**$401,194**	**$386,994**

Notes:

/1 The funding levels listed for years 2020 to 2023 are estimates and subject to change.

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

Table 4.2.3: Planned R&D Budget by Research Category

2018 BLI	Program	Appropriation Account	2017 Enacted ($000)	2018 President's Request ($000)	2019 President's Request ($000)	2020 Estimate ($000)	2021 Estimate ($000)	2022 Estimate ($000)	2023 Estimate /1 ($000)
Applied Research									
A11.a	Fire Research and Safety	RE&D	7,425	7,044	4,867	4,927	4,993	5,060	5,129
A11.b	Propulsion and Fuel Systems	RE&D	2,074	2,269	555	573	590	607	625
A11.c	Advanced Materials/Structural Safety	RE&D	6,500	4,338	2,300	2,286	2,285	2,284	2,283
A11.d	Aircraft Icing/Digital System Safety	RE&D	5,102	9,253	7,684	7,606	7,578	7,550	7,521
A11.e	Continued Airworthiness	RE&D	9,269	10,437	4,969	4,931	4,923	4,914	4,906
A11.f	Aircraft Catastrophic Failure Prevention Research	RE&D	1,528	1,570	0	0	0	0	0
A11.g	Flightdeck/Maintenance/System Integration Human Factors	RE&D	7,305	6,825	5,052	5,054	5,077	5,101	5,125
A11.h	System Safety Management	RE&D	6,500	4,149	799	826	849	873	897
A11.i	Air Traffic Control/Technical Operations Human Factors	RE&D	6,165	5,196	1,436	1,475	1,510	1,546	1,583
A11.j	Aeromedical Research	RE&D	8,538	9,765	3,875	3,966	4,051	4,138	4,228
A11.k	Weather Program	RE&D	15,476	13,399	6,580	6,429	6,342	6,253	6,161
A11.l	Unmanned Aircraft Systems Research	RE&D	20,035	6,787	3,318	3,316	3,328	3,340	3,353
A11.m	NextGen - Alternative Fuels for General Aviation	RE&D	7,000	5,924	0	0	0	0	0
A11.n	Commercial Space Transportation	RE&D	2,453	1,796	2,500	2,433	2,393	2,352	2,309
A12.a	NextGen - Wake Turbulence	RE&D	8,609	6,831	3,519	3,499	3,499	3,498	3,498
A12.b	NextGen - Air Ground Integration Human Factors	RE&D	8,575	6,757	1,336	1,335	1,340	1,345	1,350
A12.c	NextGen - Weather Technology in the Cockpit	RE&D	4,059	3,644	1,525	1,531	1,541	1,552	1,563
A12.d	NextGen - Information Security	RE&D	1,000	1,000	1,232	1,219	1,214	1,208	1,203
A12.e	NextGen - Flightdeck Data Exchange	RE&D	0	0	1,035	1,024	1,020	1,016	1,011
A13.a	Environment and Energy	RE&D	16,013	14,497	11,588	11,357	11,230	11,099	10,965
A13.b	NextGen - Environmental Research - Aircraft Technologies, Fuels, and Metrics	RE&D	27,174	23,151	7,578	7,513	7,495	7,477	7,458
A14.a	System Planning and Resource Management	RE&D	2,288	2,135	1,480	1,492	1,507	1,523	1,539
A14.b	William J. Hughes Technical Center Laboratory Facility	RE&D	3,412	3,233	1,178	1,208	1,235	1,264	1,293
	Subtotal	**RE&D**	176,500	150,000	74,406	74,000	74,000	74,000	74,000
--	Airport Cooperative Research Program - Capacity	AIP	5,000	5,000	5,000	5,000	5,000	5,000	5,000
--	Airport Cooperative Research Program - Environment	AIP	5,000	5,000	5,000	5,000	5,000	5,000	5,000
--	Airport Cooperative Research Program - Safety	AIP	5,000	5,000	5,000	5,000	5,000	5,000	5,000
--	Airport Technology Research Program - Capacity	AIP	13,408	15,560	14,679	14,679	14,679	14,679	14,679
--	Airport Technology Research Program - Environment	AIP	1,595	400	0	0	0	0	0
--	Airport Technology Research Program - Safety	AIP	16,371	17,250	18,515	18,515	18,515	18,515	18,515
	Subtotal	**AIP**	46,375	48,210	48,194	48,194	48,194	48,194	48,194
	Applied Research TOTAL		**222,875**	**198,210**	**122,600**	**122,194**	**122,194**	**122,194**	**122,194**
	Applied Research PERCENT		**52.8%**	**49.5%**	**35.4%**	**34.1%**	**31.6%**	**30.5%**	**31.6%**

Table 4.2.3: Planned R&D Budget by Research Category (cont'd)

2018 BLI	Program	Appropriation Account	2017 Enacted ($000)	2018 President's Request ($000)	2019 President's Request ($000)	2020 Estimate ($000)	2021 Estimate ($000)	2022 Estimate ($000)	2023 Estimate ($000) /1
Development									
1A01	Advanced Technology Development & Prototyping	F&E	24,800	26,800	33,000	35,000	34,100	34,200	30,000
1A02	William J. Hughes Technical Center Facilities	F&E	19,000	18,000	21,000	20,000	20,000	20,000	20,000
1A03	William J. Hughes Technical Center Infrastructure Sustainment	F&E	12,200	10,000	12,000	10,000	10,000	10,000	10,000
1A04	Next Generation Transportation System - Separation Management Portfolio	F&E	32,800	13,500	16,589	21,500	26,600	41,200	43,500
1A05	Next Generation Transportation System - Traffic Flow Management Portfolio	F&E	0	10,800	14,000	11,000	13,000	18,000	11,000
1A06	Next Generation Transportation System - On Demand NAS Portfolio	F&E	11,500	12,000	20,500	29,500	35,500	29,600	26,300
1A07D	Next Generation Transportation System - NAS Infrastructure Portfolio	F&E	17,660	17,500	13,500	15,500	25,000	26,000	26,000
1A08	Next Generation Support Portfolio	F&E	12,000	12,000	12,800	10,000	11,000	11,000	9,000
1A09	Next Generation Transportation System - Unmanned Aircraft Systems (UAS)	F&E	0	15,000	14,000	17,000	20,000	20,000	20,000
1A10	Next Generation Transportation System - Enterprise, Concept Development, Human Factors, & Demonstrations Portfolio	F&E	0	9,000	9,500	10,000	9,000	9,000	9,000
4A08	Center for Advanced Aviation System Development (CAASD)	F&E	60,000	57,000	57,000	57,000	60,000	60,000	60,000
-	William J Hughes Technical Center Laboratory Improvement	F&E	1,000	1,000	0	0	0	0	0
	Development TOTAL		**199,460**	**202,600**	**223,889**	**236,500**	**264,200**	**279,000**	**264,800** /2
	Development PERCENT		**47.2%**	**50.5%**	**64.6%**	**65.9%**	**68.4%**	**69.5%**	**68.4%**
	GRAND TOTAL		**$422,335**	**$400,810**	**$346,489**	**$358,694**	**$386,394**	**$401,194**	**$386,994**

Notes:

/1 The funding levels listed for years 2020 to 2023 are estimates and subject to change.

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

Table 4.2.4: Planned R&D Budget by Performance Goal

2018 BLI	Program	Appropriation Account	2019 Contract Costs ($000)	2019 Personnel Costs ($000)	2019 Other In-house Costs ($000)	2019 President's Request ($000)	/1
DOT Goal: Safety							
A11.a	Fire Research and Safety	RE&D	1,725	3,080	62	4,867	
A11.b	Propulsion and Fuel Systems	RE&D	0	544	11	555	
A11.c	Advanced Materials/Structural Safety	RE&D	1,509	760	31	2,300	
A11.d	Aircraft Icing/Digital System Safety	RE&D	5,583	2,056	45	7,684	
A11.e	Continued Airworthiness	RE&D	3,394	1,513	62	4,969	
A11.g	Flightdeck/Maintenance/System Integration Human Factors	RE&D	2,779	2,222	51	5,052	
A11.h	System Safety Management	RE&D	0	754	45	799	
A11.i	Air Traffic Control/Technical Operations Human Factors	RE&D	157	1,230	49	1,436	
A11.j	Aeromedical Research	RE&D	649	3,130	96	3,875	
A11.k	Weather Program	RE&D	6,163	392	25	6,580	
A11.l	Unmanned Aircraft Systems Research	RE&D	2,521	684	113	3,318	
A11.n	Commercial Space Transportation	RE&D	2,500	0	0	2,500	
	Subtotal	**RE&D**	26,980	16,365	590	43,935	
--	Airport Cooperative Research Program - Safety	AIP	5,000	0	0	5,000	
--	Airport Technology Research Program - Safety	AIP	16,449	2,066	0	18,515	
	Subtotal	**AIP**	21,449	2,066	0	23,515	
	Safety TOTAL		**48,429**	**18,431**	**590**	**67,450**	
DOT Goal: Infrastructure							
A13.a	Environment and Energy	RE&D	10,271	1,218	99	11,588	
A13.b	NextGen - Environmental Research - Aircraft Technologies, Fuels, and Metrics	RE&D	7,190	379	9	7,578	
	Subtotal	**RE&D**	17,461	1,597	108	19,166	
1A03	William J. Hughes Technical Center Infrastructure Sustainment	F&E	12,000	0	0	12,000	
4A08	Center for Advanced Aviation System Development (CAASD)	F&E	57,000	0	0	57,000	
	Subtotal	**F&E**	69,000	0	0	69,000	/2
--	Airport Cooperative Research Program - Capacity	AIP	5,000	0	0	5,000	
--	Airport Technology Research Program - Capacity	AIP	13,041	1,638	0	14,679	
--	Airport Cooperative Research Program - Environment	AIP	5,000	0	0	5,000	
	Subtotal	**AIP**	23,041	1,638	0	24,679	
	Infrastructure TOTAL		**109,502**	**3,235**	**108**	**112,845**	

Table 4.2.4: Planned R&D Budget by Performance Goal (cont'd)

2018 BLI	Program	Appropriation Account	2019 Contract Costs ($000)	2019 Personnel Costs ($000)	2019 Other In-house Costs ($000)	2019 President's Request ($000) /1
DOT Goal: Innovation						
A12.a	NextGen - Wake Turbulence	RE&D	3,081	367	71	3,519
A12.b	NextGen - Air Ground Integration Human Factors	RE&D	1,027	287	22	1,336
A12.c	NextGen - Weather Technology in the Cockpit	RE&D	1,027	483	15	1,525
A12.d	NextGen - Information Security	RE&D	1,232	0	0	1,232
A12.e	NextGen - Flightdeck Data Exchange	RE&D	1,027	0	8	1,035
	Subtotal	**RE&D**	7,394	1,137	116	8,647
1A01	Advanced Technology Development & Prototyping	F&E	33,000	0	0	33,000
1A02	William J. Hughes Technical Center Facilities	F&E	21,000	0	0	21,000
1A04	Next Generation Transportation System - Separation Management Portfolio	F&E	16,589	0	0	16,589
1A05	Next Generation Transportation System - Traffic Flow Management Portfolio	F&E	14,000	0	0	14,000
1A06	Next Generation Transportation System - On Demand NAS	F&E	20,500	0	0	20,500
1A07D	Next Generation Transportation System - NAS Infrastructure Portfolio	F&E	13,500	0	0	13,500
1A08	Next Generation Support Portfolio	F&E	12,800	0	0	12,800
1A09	Next Generation Transportation System - Unmanned Aircraft Systems (UAS)	F&E	14,000	0	0	14,000
1A10	Next Generation Transportation System - Enterprise, Concept Development, Human Factors, & Demonstrations Portfolio	F&E	9,500	0	0	9,500
	Subtotal	**F&E**	154,889	0	0	154,889 /2
	Innovation TOTAL		**162,283**	**1,137**	**116**	**163,536**
DOT Goal: Accountability						
A14.a	System Planning and Resource Management	RE&D	622	824	34	1,480
A14.b	William J. Hughes Technical Center Laboratory Facility	RE&D	159	985	34	1,178
	Accountability TOTAL		**781**	**1,809**	**68**	**2,658**
	GRAND TOTAL		**$320,995**	**$24,612**	**$882**	**$346,489**

Notes:

/1 Many R&D programs apply to more than one goal area; however, for budgeting purposes most programs are included in only one goal area.

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

Table 4.2.5: NextGen R&D Funding

2018 BLI	Program	Appropriation Account	2017 Enacted ($000)	2018 President's Request ($000)	2019 President's Request ($000)	2020 Estimate ($000)	2021 Estimate ($000)	2022 Estimate ($000)	2023 Estimate ($000) /1
NextGen - F&E									/2
1A04	Next Generation Transportation System - Separation Management Portfolio	F&E	32,800	13,500	16,589	21,500	26,600	41,200	43,500
1A05	Next Generation Transportation System - Traffic Flow Management Portfolio	F&E	0	10,800	14,000	11,000	13,000	18,000	11,000
1A06	Next Generation Transportation System - On Demand	F&E	11,500	12,000	20,500	29,500	35,500	29,600	26,300
1A07D	Next Generation Transportation System - NAS Infrastructure Portfolio	F&E	17,660	17,500	13,500	15,500	25,000	26,000	26,000
1A08	Next Generation Support Portfolio	F&E	12,000	12,000	12,800	10,000	11,000	11,000	9,000
1A09	Next Generation Transportation System - Unmanned Aircraft Systems (UAS)	F&E	0	15,000	14,000	17,000	20,000	20,000	20,000
1A10	Next Generation Transportation System - Enterprise, Concept Development, Human Factors, & Demonstrations Portfolio	F&E	0	9,000	9,500	10,000	9,000	9,000	9,000
	F&E TOTAL	**F&E**	**82,460**	**89,800**	**100,889**	**114,500**	**140,100**	**154,800**	**144,800**
NextGen - RE&D									
A11.l	Unmanned Aircraft Systems Research	RE&D	20,035	6,787	3,318	3,316	3,328	3,340	3,353
A11.m	NextGen - Alternative Fuels for General Aviation	RE&D	7,000	5,924	0	0	0	0	0
A12.a	NextGen - Wake Turbulence	RE&D	8,609	6,831	3,519	3,499	3,499	3,498	3,498
A12.b	NextGen - Air Ground Integration Human Factors	RE&D	8,575	6,757	1,336	1,335	1,340	1,345	1,350
A12.c	NextGen - Weather Technology in the Cockpit	RE&D	4,059	3,644	1,525	1,531	1,541	1,552	1,563
A12.d	NextGen - Information Security	RE&D	1,000	1,000	1,232	1,219	1,214	1,208	1,203
A12.e	NextGen - Flightdeck Data Exchange	RE&D	0	0	1,035	1,024	1,020	1,016	1,011
A13.b	NextGen - Environmental Research - Aircraft Technologies, Fuels, and Metrics	RE&D	27,174	23,151	7,578	7,513	7,495	7,477	7,458
	RE&D TOTAL	**RE&D**	**76,452**	**54,094**	**19,543**	**19,437**	**19,437**	**19,436**	**19,436**
	NextGen R&D TOTAL		**$158,912**	**$143,894**	**$120,432**	**$133,937**	**$159,537**	**$174,236**	**$164,236**

Notes:

/1 The funding levels listed for years 2020 to 2023 are estimates and subject to change.

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

5.0 Performance Management

The FAA has re-designed the NARP to meet the aviation community's evolving needs emerging from technological and budgetary changes. The journey through the re-design process made it apparent that the FAA should not only re-energize our efforts to communicate how we are performing, but to emphasize how that performance will enable the transformative effects we are seeking to support the future of aviation. The new framework of 'DOT strategic goals', 'FAA Goals,' 'Objectives,' and 'Outputs,' clarified the work being performed in each functional area, which allows for a broader, more integrated view of the NAS components that the FAA seeks to influence with its research and development investments. Specifically, the new NARP outputs have been designed to provide a window into some of the key deliverables that stem from the R&D work itself, setting the stage for a better basis from which to judge impact.

As stated previously, Section 44501(c) of Title 49 of the United States Code (49 U.S.C. § 44501(c)) requires that the FAA Administrator submit its National Aviation Research Plan (NARP) to Congress annually with the President's Budget. The NARP details how the FAA structures and executes its Research and Development (R&D) to ensure the Nation's investments are well placed and deliver results addressing national aviation priorities. See **Figure 5.0 NARP Content** for NARP content alignment to legislative requirements.

Figure 5.0 NARP Content

Statutory reporting requirement	NARP Section
The Administrator of the FAA shall prepare and publish annually a national aviation research plan and submit to Congress no later than the submission of the President's budget to Congress.	***NARP***
Describe the research, engineering, and development that the agency considers necessary for a 5-year period.	**Section 3.3**
Identify allocation of resources for long-term research, near-term research, and development activities.	**Section 3.3**
Identify individual R&D projects in each funding category described in the annual budget request.	**Section 4.0**
Provide estimates by year on the schedule, cost, and workforce levels for R&D, including research activities carried out under cooperative agreements with other Federal departments and agencies.	**Section 4.0** **Appendix 6**
Specify the Goals and priorities for allocation of resources for major categories of R&D, including the rationale for the priorities identified as necessary for the FAA to perform.	**Section 3.0** **Section 5.1**
Coordinate with all internal stakeholders to ensure that duplication or gaps in research do not occur.	**Section 3.0** **Section 5.1**
Highlight R&D Technology Transfer among government, industry, and academia.	**Section 6.0**
Highlight R&D activities that address the recommendations of the research advisory committee (REDAC), and document the recommendations not accepted, specifying the reasons for non-acceptance.	**Appendix 1**

The NARP's outputs paint a picture of the key research being pursued by the Agency over the next five years. This redesign strategy allows the FAA to determine gaps in the research and adjust as needed to meet the changing environment inherent to the aviation community. The FAA plans to publish annually the R&D Annual Review to demonstrate how much R&D is being achieved toward each objective and if the FAA's overall plan is being met. However, the FAA also expects that with better visibility, adjustments to the plan will result as we endeavor to better respond to the ever changing landscape of aviation.

5.1 R&D Evaluation

The FAA conducts evaluation through formal and informal reviews by internal and external groups.

5.1.1 Internal Portfolio Reviews

The FAA R&D portfolio receives continuous internal review throughout the entire iterative R&D Portfolio Development Process to ensure that it meets customer needs, high quality standards, and management excellence. The portfolio development process comprises numerous steps in seven major phases including: Guidance; Program Area Portfolio Preparation; FAA Portfolio Review; Budget Submission; Budget Adjustment; Program Planning and Execution; and Program Evaluation. The R&D Executive Board is responsible for Guidance, Portfolio Review, Budget Preparation, Program Planning & Execution and Program Evaluation. The Joint Resource Council has final approval authority on Budget Submission.

5.1.1.1 R&D Executive Board

The FAA REB, with assistance from Program Planning Teams (PPT), coordinates the development of the Agency's annual R&D investment portfolio. The primary responsibility of the REB is to coordinate the annual R&D investment portfolio. In particular, the REB plans, presents, and defends the R,E&D portion of the R&D program, and determines program impacts from changes that occur during budget formulation activities and Congressional submission phase of the budget process. The REB includes representatives from the FAA lines of business (associate administrators) and assistant administrators who sponsor or manage funds for R&D programs. When R&D portfolio formulation is complete, the REB provides portfolio approval. The process helps the FAA establish research priorities to meet its strategic Goals and Objectives, as well as ensure effective engagement with research stakeholders. The REB uses PPTs comprised of internal sponsors and researchers to review program outcomes and outputs, prioritize and plan research efforts, recommend research priorities and programs, and prepare research portfolios. For more information, click on the R&D Executive Board tab at (http://www.faa.gov/about/office_org/headquarters_offices/ang/offices/tc/about/campus/faa_host/RDM/).

5.1.1.2 Joint Resources Council

The Joint Resources Council (JRC) is chaired by the FAA Acquisition Executive (FAE) and assures compliance with Acquisition Management System (AMS) policy. The purpose of the JRC is to act as the FAA's investment decision-making body charged with the responsibility of approving and overseeing the management of investments regardless of the type of funding appropriation, allocating resources and establishing program offices chartered with the responsibility of managing approved investments."

5.1.2 External Portfolio Reviews

The FAA R&D portfolio receives periodic external review from advisory committees to ensure that it meets customer needs and is technically sound and the FAA seeks feedback from the National Academies and through user surveys and discussion groups. Researchers present their progress reports at public forums and science reviews, publish and present technical papers, obtain formal peer validation of science, and maintain and share lessons learned. See **Appendix 4: FAA Governance Bodies & External Advisory Committees** for more background information on the FAA's External Advisory Committees, and for the most recent REDAC review of FAA's portfolio, refer to **Appendix 1: REDAC Findings/Recommendations with FAA's Response.**

5.2 Introduction of Planned Annual Review Format/Content Changes

The R&D Annual Review has long been a venue to express the results of the FAA's research efforts by providing highlights of the research conducted during the previous fiscal year. The FAA has been working hard to determine the best way to update the annual review to better measure our results. The research community has been developing techniques not only to show on-time and on-cost performance of research efforts, but also to show the quality of the work being conducted. In conjunction with the NARP redesign effort, the FAA envisions redesigning the Annual Review (starting with the FY 2018 R&D Annual Review, which will accompany the 2019 NARP) to include qualitative highlights of the Agency's R&D work during the year along with a more quantitative or substantive view of the research.

A literature search has revealed that the research community in general has unique challenges in showing the value and quality of R&D, simply because there is often no direct path from the research to a tangible product resulting from that research. Sometimes, the answer resulting from research is purely that the approach or technology will not work to solve the original problem being researched. While this type of result may look to the untrained eye as a failure, it will in fact ultimately save vast amounts of resources that might otherwise have been wasted on a doomed approach.

The FAA expects that the new approach to the Annual Review planned for next year will help more effectively communicate the Agency's performance progress and its effect on the aviation community.

6.0 Technology Transfer

It is not an exaggeration to state that federally funded research and development is foundational to the United States economy. It has been estimated that two-thirds of the most influential technologies of the past 50 years were supported by Federal R&D at national laboratories and universities. Federal R&D dollars germinate in communities, bringing dollars and jobs into local regions. These Federal investment dollars greatly impact local technological capacities, drive high-skilled employment, and fund local academic institutions, small businesses, and high-tech entrepreneurs. Cumulatively, the impact on the United States economy and competitiveness is significant.

6.1 Technology Transfer

Federal agency Technology Transfer programs such as the FAA's Technology Transfer Program play a crucial role in this economic success. The FAA through its Federal laboratories and Technology Transfer program has successfully collaborated and continues to collaborate with Non-Federal entities in numerous areas and via a broad variety of vehicles and arrangements to include Cooperative Research and Development Agreements, Memoranda of Understanding (MOU), Memoranda of Agreement (MOA), Interagency Agreements, and International Agreements (IA). For more information on Technology Transfer and associated tools/mechanisms see **Appendix 5: Technology Transfer.**

The FAA Technology Transfer Program and the FAA at large will continue to successfully collaborate with private business, academia, and state and local governments to provide partnership opportunities on innovative research of mutual interest, to increase the return on investment (ROI) of every taxpayer dollar spent on Federal R&D, and to accelerate the successful adoption of technologies and innovations from the government to the marketplace. The resulting synergies will continue to drive the FAA's mission of providing the safest, most efficient aerospace system in the world, and to enhance the growth and competitiveness of the United States – maintaining its standing as a world leader.

6.2 Patents/Licenses

The FAA's Technology Transfer Program Office promotes and coordinates the agency's patents for commercialization. The agency encourages its inventors, engineers, scientists, and researchers to patent their novel innovations or developed technologies through the U.S. Patent and Trademark Office. A patent is a grant of a property right and gives the owner the right to exclude anyone else from making, using, or selling the invention. Inventions patented by FAA inventors are available for commercial licensing, and can result in royalty payments that are shared with the inventor and the agency. Legislation allows inventors to receive up to $150,000 per year over their salary from royalty payments, continuing even after they separate from Federal service. Additionally, the FAA strives to identify active patents resulting from FAA funded agreements. These patented technologies are available for use by the government and its contractors on a cost-free basis when used for government purposes.

6.3 Documents and Reports

In addition to the NARP and annual report, another way the FAA communicates with all the stakeholders is by publishing research and development technical reports, scientific articles, newsletters and other documents describing in detail the extraordinary work that is being performed by the FAA. These documents describe the research, process, progress, results, and if available, the reports list any conclusions and recommendations as a result of the research. These Technical reports can be found on the FAA's WJHTC and CAMI Technical Libraries' websites: https://www.faa.gov/about/office_org/headquarters_offices/ang/offices/tc/library/ and https://www.faa.gov/about/office_org/headquarters_offices/avs/offices/aam/cami/library/online_libraries/aerospace_medicine/

Appendix 1: REDAC Findings/Recommendations with FAA's Response

U.S. Department
of Transportation

Federal Aviation Administration

Office of the Administrator

800 Independence Ave., S.W.
Washington, D.C. 20591

January 25, 2017

Dr. R. John Hansman, Ph.D. Chair,
Research, Engineering and
Development Advisory Committee
Massachusetts Institute of Technology
77 Massachusetts Avenue
Cambridge, MA 02139

Dear Dr. Hansman:

Thank you and the Federal Aviation Administration's Research, Engineering and Development Advisory Committee (REDAC) for your October 20, 2016, letter providing strategic guidance recommendations for the Fiscal Year 2019 Research and Development (R&D) Portfolio. The RED AC acknowledgement of the Agency's efforts pertaining to key topics of significant interest that include initiatives of the small Unmanned Air Systems Integration in the National Airspace System; the industry engagement supporting Performance Based Navigation Time, Speed and Spacing Strategy; and the National Aviation Research Plan enhancements is highly appreciated. These vital focus areas remain paramount for successful improvements within the R&D portfolio and we will continue to address these key Objectives.

I have reviewed your recommendations and enclosed are the responses to the Subcommittee recommendations.

We will continue to incorporate the Committee's recommendations and foster increased communications as we build an R&D portfolio that addresses safety, efficiency, and capacity of the air transportation system in an environmentally sound manner.

Sincerely,

Michael P. Huerta Administrator

Enclosure

FAA Response to REDAC Guidance for the Fiscal Year (FY) 2019 Research and Development (R&D) Portfolio

Subcommittee on Aircraft Safety

Finding: Real Time System-Wide Safety Assurance - In the fall of 2014, the REDAC Aircraft Safety (SAS) Subcommittee identified, and defined, Real Time System-Wide Safety Assurance as a significant emerging issue worthy of future FAA research resource expenditure. NASA has also identified this subject, although possibly defined slightly differently, as one of its top strategic thrusts. The topic has risen to the level of a NASA/FAA Joint Research Transition Team item. SAS received a briefing on this subject and was pleased to enhance its knowledge of government efforts and strategic direction on this important topic. In particular, the definition of "real-time" as meaning in time to mitigate the hazard is very appropriate. The Committee also supports the vision for a capability that is distributed among users who can employ system-wide knowledge and information to mitigate local and regional safety issues. SAS will use this new knowledge to refine its emerging issue going forward in hopes of adding value to the Research Transition Team (RTT) efforts.

Recommendation (1): The System-Wide Safety Research Transition Team should provide the SAS and other appropriate industry sectors with updates on progress toward real-time system-wide safety and solicit regular input from those stakeholders. We also recommend that focus be put on short term research deliverables (less than 5 years) as the need for the ability to make an impact for in-time mitigations is immediate and necessary.

FAA Response: The NASA/FAA System-Wide Safety Assurance Research Transition Team (RTT) leadership concurs with the Committee's recommendation and is undertaking actions to address the recommendation. In FY 2017, the R TT will host three system safety themed workshops including Human Performance, Data Tools & Prognostics, and Verification & Validation. Workshop invitations will be extended to members of the REDAC Subcommittee on Aircraft Safety, the FAA, and NASA as well as government/industry safety teams including Commercial Aviation Safety Team (CAST) and General Aviation Joint Steering Committee (GA JSC). The RTT will use information collected during the workshops to identify common critical safety assurance Goals and coordinate relevant system safety research efforts. In addition, the RTT will prioritize work by focusing on near-term technology infusion (5 years or fewer). Further, NASA will use information from the workshops to inform their multi-year Thrust 5: Real-Time System-Wide Safety Assurance plans.

Finding: Additive Manufacturing - The Subcommittee finds that progress has been made in accelerating research activities around the topic of additive manufacturing. The Additive Manufacturing National Team (AMNT) is in place with an approved charter and initial documents have been released to the Aircraft Certification Office (ACO) and Manufacturing Inspection District Office (MIDO) to aid in the certification of parts produced by additive manufacturing methods. Collaborations are also ongoing with industry organizations including Aerospace Industries Association (AIA) and Society of Automotive Engineers (SAE) to establish working groups and committees. An FAA Additive Manufacturing roadmap is under development which includes training and education, development of regulatory documents, Research and Development (R&D) plan and interagency communication. The roadmap and R&D plan were not shared with the Subcommittee.

Recommendation (2): The FAA should share the draft roadmap and accompanying R&D plan with the Subcommittee for review and comment.

FAA Response: The FAA concurs with the Committee's recommendation on Additive Manufacturing (AM) with the noted exceptions and clarifications and intends to undertake the following actions to address the recommendation. The strategic FAA AM roadmap is due to the FAA Aircraft Certification Service management by September 2017, in accordance with the official Additive Manufacturing National Team charter. The roadmap is being developed and matured; however, it will only be available in a draft form by the time of the next SAS meeting (early March 2017) and will not be reviewed by the FAA management at that time. Therefore, the roadmap will not be presented to SAS in its entirety. Instead, the information to be presented at the next SAS meeting will include the outline of the roadmap and its key elements necessary to provide sufficient context for the multi-year AM R&D plan that will be presented as well.

Finding: Fatigue Knowledge Affecting Aviation Safety - FAA implemented science based flight and duty time regulations for commercial passenger carriers in February 2014. These rules were the first significant revisions made in over 60 years and greatly changed how the agency regulates airline operations. Evaluations are ongoing with the regulatory situation for large cargo carriers and smaller commercial operations. This is an acknowledgment from FAA that pilot fatigue remains a significant safety concern and must be addressed. The Subcommittee is concerned because there is no evidence that significant FAA research into human fatigue incidence, effects, mechanisms, or countermeasures in US civil aviation is taking place. Without objective data or evidence gathered by research, it is very difficult to validate existing regulations or develop new ones.

Experience and recent data suggests that even though the new regulations seem to be an effective mitigation to pilot fatigue in many cases, the fatigue problem has not been solved, and continues to create risk in various aspects of flight operations ranging from commercial to general aviation in both fixed-wing and rotary-wing aircrew. Experience from the Department of Defense (DOD) suggests that operator fatigue will be a problem in UAS operators as well.

The Subcommittee acknowledges comments from the FAA that fatigue research occurs in various programs across the research portfolio, but is unable to evaluate the efficiency, applicability and adequacy of the current and future programs since they have not been presented to the Subcommittee in any organized form.

Recommendation (3): The SAS requests that, in the upcoming SAS 201 7 spring meeting, the FAA presents a coherent and holistic view of the fatigue problem in U.S. aviation. The presentation should include the knowledge gaps in fatigue potentially affecting aviation safety and the relevant research programs at FAA and other government agencies concerned with aviation and non-aviation fatigue, which can be both, funded and unfunded, and/or current and planned research activities. If the conclusion is that further research is not needed, the rationale for that conclusion should be provided.

FAA Response: The FAA concurs with the Committee's recommendation and is undertaking the following action to address its recommendation. We will give the SAS a presentation covering the FAA view· of fatigue in flight operations and maintenance at the spring 2017 meeting.

Subcommittee on Environment and Energy

Finding: Strategic Aspects of the Environment and Energy R&D Plan - The Subcommittee reaffirms its previous finding that there is a strong strategic context to the Environment & Energy RE&D plan. The program identifies specific Goals for noise, air quality, energy /efficiency, and climate. These Goals are set to achieve environmental protection for sustainable aviation system growth. The plan is developed after consideration of the need to balance / prioritize projects related to the five pillars, i.e., improving scientific understanding and tools, developing technology for mitigating environmental impact, operational efficiency improvement, developing / qualifying sustainable alternative aviation fuel, and maintaining US leadership in global aviation environmental policy and market based measure development. The FAA, in consultation with the Subcommittee, has also rebalanced the portfolio when needed to fit the funding profile or to achieve time critical capabilities.

Recommendation (1): Given the current environmental landscape and the impact of the various environmental issues on the aviation system, the Subcommittee recommends the Environment & Energy portfolio focus on noise and operations, environmental impact reduction technology maturation (CLEEN), alternative fuels, and tools to support policy development. The Subcommittee also recommends that the FAA continue to consider the interdependencies between noise, air quality, and CO2 in these plans.

Operationally noise has become a constraint to the implementation of flight procedures that can deliver improved efficiency, and airport capacity and access. In addition to the development of efficient procedures, a better understanding of annoyance, acceptability, and effective community engagement are needed to make more progress on this NextGen goal. Thus, the subcommittee feels that successful and rapid execution of the Noise roadmap is necessary.

While operational procedures will provide emissions reductions in the near term, in order to achieve the aggressive longer term Goals, low emissions airplane/ engine technologies need to be matured and validated for implementation in future designs. To achieve this, the Subcommittee recommends the continuation and acceleration of CLEEN and alternative aviation fuel development and qualification.

FAA Response: The FAA concurs with the Committee's recommendation and is undertaking the following actions to address its recommendation. The FAA appreciates both the Subcommittee's positive evaluation of the Environment and Energy R&D Portfolio and your input on priorities.

Noise is the FAA' s number one environmental issue. Noise is a challenge to the implementation of Performance-Based Navigation operational procedures and the capacity and efficiency benefits of NextGen. We have a number of efforts ongoing to address this challenge within our noise roadmap. Next year will see the completion of the airport community noise survey. This is a key component of our aviation noise roadmap that is eagerly anticipated by our stakeholders. We are also excited about our recently announced collaboration with Massport as this research effort could lead to ideas on how noise can be reduced from changes in aircraft operations. We are also seeking additional opportunities to mitigate noise at its source through the use of new technologies and changes in aircraft operations.

We appreciate the Subcommittee's support for technology maturation through the CLEEN Program and our efforts to advance alternative aviation fuels. We also appreciate the support of the Subcommittee for the development of analytical tools to support policy development. These analytical tools have been critical to our activities in the International Civil Aviation Organization/Committee on Aviation Environmental Protection (ICAO CAEP) and the continued U.S. leadership therein. Continued funding is critical to the development of our modeling capabilities. Funding is needed to ensure we have robust participation in the ICAO CAEP process and the generation of data to support the decision-making process within ICAO CAEP.

Finding: Aviation Environmental Design Tool (AEDT) - The Subcommittee recognizes that this program has delivered an environmental assessment tool, the AEDT suite, which has and is enabling informed policy decisions and US leadership in International Civil Aviation Organization/Committee on Aviation Environmental Protection (ICAO/CAEP). The AEDT tool has also been released to stakeholders outside of FAA to perform environmental assessments. The development of these tools required significant resources from 2010 to 2015 funded by the NextGen F&E. Starting in 2017, the F&E funding has been zeroed out. But several functionality and usability related improvement needs have been identified for the AEDT tool.

Recommendation (2): Given the resource constraints, the Subcommittee recommends that the AEDT development needs list be reviewed and prioritized based on considerations of value and urgency. Improving usability that delivers additional value to a broader stakeholder group may be preferred over adding a capability that may help a limited stakeholder group except in situations of strategic importance in FAA's support of national and international initiatives. Improved usability may also bring additional users. Making the right priority choices is important since this development will now have to be covered in the RE&D funds that support the hi.gh-priority research identified earlier.

FAA Response: The FAA concurs with the Committee's recommendation and is undertaking the following actions to address its recommendation. We appreciate the recognition that our Aviation Environment Design Tool (AEDT) is enabling informed policy decisions and providing U.S. leadership in ICAO/CAEP. AEDT has been at the core of our efforts to support the ICAO/CAEP standard setting process and it is the required tool for environmental analyses under the National Environmental Policy Act. We agree that AEDT development needs to be prioritized, and the Office of Environment and Energy (AEE) are currently developing a long-term plan. This plan will be shared with the REDAC next year.

Finding: Inter-Agency Collaborations and Partnerships - The Subcommittee is pleased to see the continuing collaboration between the FAA and NASA and other government agencies.

Recommendation (3): As NASA executes on its revamped aeronautics program, the Subcommittee encourages FAA to look for more collaboration opportunities, including gathering noise and emissions data, that may help projects in the FAA portfolio, i.e., go beyond sharing plans and results.

FAA Response: The FAA concurs with the Committee's recommendation and is undertaking the following actions to address its recommendation. We agree on the need for continued collaboration with NASA as well as the entire Federal Government. This is especially important given reduced Federal funding for R&D.

NASA and AEE are working closely together in several areas. Individuals from NASA and AEE co-led the development of the Federal Alternative Jet Fuel Strategy that was recently released. We are working closely together on research that will streamline the approval process for new alternative jet fuels. We have a number of efforts that are ongoing with NASA wherein we are looking at the noise from supersonic aircraft, helicopters, and unmanned aircraft. We also are working closely with NASA to conduct particulate matter emission measurements from commercial aircraft engines. AEE will continue to engage NASA to find efforts that deliver benefits to both agencies.

Finding: Environmental Human Resources and Subject Matter Experts -Several Subcommittee members are concerned about staff availability at F AA-AEE to continue to execute this program efficiently with an ever-growing set of responsibilities.

Recommendation (4): The Subcommittee encourages the FAA to continue to feed their pipeline of environmental professionals.

FAA Response: The FAA concurs with the Committee's recommendation and is undertaking the following actions to address its recommendation. We appreciate the Subcommittee's concerns about staff availability within AEE. Their work load has indeed increased due to increasing concerns regarding aviation noise and our international efforts to mitigate aircraft carbon dioxide emissions. AEE has had good success in filling positions with highly qualified environmental professionals. This is due in part to the students and staff that have been trained as a part of PARTNER and ASCENT, the FAA Centers of Excellence for environment and alternative jet fuels. AEE has also seen a number of their environmental professionals go to other parts of the FAA, which is helping the Agency as a whole to be better equipped to handle environmental issues.

Subcommittee on NAS Operations

General Observations: UAS Integration in the NAS -The Subcommittee commends the continuing progress that the FAA is making in responding to the challenge of integrating UAS in the NAS. 1n its previous meeting, the Subcommittee recommended that the FAA actively engage with the UAS stakeholder community and share the work it has done to date, including the FAA UAS Concept Maturation Plan. The Subcommittee further recommended that the FAA establish high level system engineering leadership that can prioritize UAS research and development across all the FAA organizations. The Subcommittee has the following findings and recommendations:

Finding: UAS Stakeholder Community Engagement - The FAA has begun to engage the UAS stakeholder community as part of the NASA UAS Traffic Management (UTM) workshops. The

FAA has established a framework for future engagement through the Drone Advisory Committee and has developed a UAS External Stakeholder Plan. The Subcommittee finds that these are significant steps in the right direction.

Recommendation (1): The Subcommittee recommends that the FAA continue this momentum, placing considerable emphasis on communication of its technical and operational challenges to the user community, through sharing of documents such as the UAS Concept Maturation Plan, and in turn merging input received from a broad range of UAS stakeholders into future planning activities. While the FAA ultimately has the responsibility for the safety and efficiency of the NAS, it is the Subcommittee's strong opinion that an open dialogue of these issues with the user community will foster a more collaborative environment in which to solve them.

FAA Response: The FAA concurs with the Committee's findings and recommendation and is undertaking the following actions to address the recommendation. We have met with the Drone Advisory Committee (DAC) and a DAC Subcommittee has been formed to engage with the community on priority topics. We are also maintaining our close cooperation with the community through our standards groups such as RTCA SC228, NASA on UTM, and UAS in the NAS, which includes their industry partners, the UAS COE (ASSURE), the UAS EXCOM, ICAO, and efforts through the National Academies.

Finding: UAS Leadership Structure - FAA has recently established an agency-wide UAS leadership structure consisting of a senior UAS Board, a UAS Executive Committee, and a UAS Implementation Plan Working Group. These steps are valuable in accelerating the pace off AA engagement with the burgeoning industry. However, the Subcommittee remains concerned about the adequacy of these actions alone to sustain the pace of engagement necessary to avoid having the industry and government lose ground in economic opportunities for the nation. In its briefing to the Subcommittee, the FAA stated that this structure was intended to organize and prioritize the UAS research, development, and implementation across the FAA. During its briefing on the FY2017 budget, the FAA provided the Subcommittee with the language that accompanied the House and Senate marks on the FY2017 RE&D budget request. In previous years, the Unmanned Aircraft Systems Budget Line Item (BLI) has been used to perform safety-related research (e.g., airframe safety and certification) overseen by A VS. The Subcommittee notes that the FY2017 language pertaining to Unmanned Aircraft Systems Research includes language that would allow the FAA to use a portion of that BLI to develop and validate operational concepts and procedures supporting the integration of UAS into the National Airspace System that are necessary to close the operational and technical shortfalls identified in the UAS Concept Maturation Plan. This would require participation of multiple FAA organizations to accomplish work within this single BLI. There is a clear need to prioritize and coordinate UAS research and development across the RE&D and F&E budgets and across FAA organizations.

Recommendation (2): The FAA should leverage the new UAS leadership structure to prioritize and plan UAS research and development across budget elements and across organizations. The UAS Concept Maturation Plan provides one potential framework for this plan.

FAA Response: The FAA concurs with the Committee's findings and recommendation and is undertaking the following actions to address its recommendation. The FAA is using the UAS Implementation Plan, and its ongoing efforts with its partners, to develop a UAS R&D

roadmap during FY 2017. The roadmap will include the combined efforts across FAA U AS budgets, partner activities such as NASA UAS efforts and will be mapped to key decision points and rulemaking, policy, and operational targets.

Subcommittee on Airports

The following Findings and Recommendations were developed during the Airport Subcommittee deliberations.

Finding: National Airport Pavement Materials Research Center (RPA P2) - The Subcommittee is pleased with the work on reflective cracking under Research Project Area (RPA) P2, but believes the research needs to consider the effects vertical loads--both vehicular and environmental-have on such cracking.

Recommendation (1): The Subcommittee recommends that the FAA include vertical loads in its reflexive cracking test plan.

FAA Response: The FAA concurs with the Committee's finding and is undertaking the following actions to address its recommendation(s). An asphalt overlay of a concrete test lane will be constructed at National Airport Pavement and Materials Research Center (NAPMRC) in one of the future Test Cycles to study reflective cracking under both environmental and vehicular loads. Aircraft vertical loads will be applied using the Heavy Vehicle Simulator.

Finding: Asphalt Concrete Pavement Heat Exposure - The effects of environmental conditions-particularly sustained exposure to high temperatures-on asphalt concrete pavements are not being fully considered in current FAA pavement design guidance.

Recommendation (2): The Subcommittee recommends that pavement testing being undertaken Under RP A P2 provide necessary data to incorporate a wider range of environmental factors into FAA pavement design software, which is developed and refined under Software Program Development and Support (RPA P7).

FAA Response: The FAA concurs with the Committee's finding and is undertaking the following actions to address its recommendation(s): Asphalt pavement performance data under high pavement temperatures is being collected from full-scale tests at NAPMRC (RPA P2). Laboratory tests are planned on asphalt materials (both binders and mixes) to characterize the material properties (master stiffness curves) under different environmental (temperatures) and loading (rate of loading/frequency) conditions. A database of material properties will be developed for different asphalt binder grades and mixes (allowed under FAA AC 150/5370-lOG) which will be incorporated into FAARFIELD.

Finding: Runway Surface Safety Technology (RPA ·S6) - Both Subcommittee and FAA staffs believe that additional subject matter expertise is needed to ensure that aircraft braking friction research being conducted under RP A S6 is producing valid data and is appropriately synchronized with other FAA and industry research regarding aircraft braking.

Recommendation (3): The Subcommittee strongly supports the creation of an expert working group that can advise and review FAA Airport Technology and Flight Standards Aircraft Braking research programs. This expert working group should involve representatives from the FAA, academia, aircraft/braking system manufacturers, and others that are developing runway braking friction assessment technologies.

FAA Response: The FAA concurs with the Committee's finding and is undertaking the following actions to address its recommendation(s): The FAA will sponsor the formation of an expert working group in the first quarter of FY 2017. The group will have Subject Matter Experts from FAA, industry, and academia. The working group will meet at least twice a year to review, discuss and provide technical guidance on the FAA 's Aircraft Braking Friction research programs. Note: it is intended to have the first meeting of this working group in early winter 2017.

Subcommittee on Human Factors

Finding: Mixed Equipage - The Human Factors (HF) Subcommittee asked if any HF research was going on in mixed equipage. Two years ago, the REDAC Committee identified mixed equipage as one of the top issues the FAA will face in the next ten years. While an effort to address this began in FY 2015 with a literature review, there is currently no HF research addressing the mixed equipage issue.

Recommendation (1): HF researchers conduct a deep dive on mixed equipage and report out at a future HF Subcommittee meeting on their plan to conduct research in this area.

FAA Response: The FAA appreciates the Committee's recommendation regarding a deep dive on human factors research related to mixed equipage. However, the FAA does not concur with the deep dive as an approach to addressing mixed equipage human factors research. In place of a deep dive, the FAA will facilitate a discussion on mixed equipage at the next Human Factors Subcommittee meeting.

Finding: Human Factors UAV Guidance - The HF Subcommittee recommended that the FAA HF community provide HF guidance to UAV industry to influence UAV design and operation in the short term in a previous finding and recommendation. The Subcommittee was not fully satisfied with the HF community response as the response was to generate new specific guidance documents. The HF Subcommittee believes while this is useful for the long-term, it will take too long to impact current designers and that already existing guidance is sufficient to give initial guidance to UAS designers.

Recommendation (2): The FAA HF Community engages UAV industry quickly to share UAV HF guidance principles and report out on their progress at the next Subcommittee meeting.

FAA Response: The FAA concurs with the Committee's recommendation and is undertaking the following actions to address the recommendation. Because the UAS industry needs to be better informed regarding human factors guidance that is available, we are preparing information that can be presented at UAS industry meetings and will report on the progress at the next Subcommittee meeting.

Finding: Human Factors Portfolio Prioritization - The Subcommittee continues to observe that HF research funding is now focused more on Next Gen and UAVs and there is a significant reduction in HF Core research dollars. The Subcommittee is concerned about critical areas such as fatigue and other key HF research areas that may suffer as a result of this shift in emphasis. This is a previous action item.

Recommendation (3): The Subcommittee recommends the HF research community evaluate its overall portfolio and discuss with your key FAA stakeholders to ensure the HF research portfolio is focused on the top priorities including core research areas, and report out to the HF □DAC Subcommittee at its next meeting.

FAA Response: The FAA concurs with the Committee's recommendation and has undertaken the following actions to address the recommendation. The FAA has already coordinated with the technical sponsors of the research projects to ensure that the top priorities are addressed.

Finding: Human Factors Consultation - The HF Subcommittee continues to be concerned about the FAA not meeting their Next Gen efficiency Goals due to lack of Human Factors consideration. Recent results with Performance Based Navigation (PBN) is one area that this Subcommittee has previously identified as an issue and continues to be a problem as Next Gen implements new increments in the FAA system.

Recommendation (4): The HF Subcommittee recommends the FAA HF research community assess Next Gen implementation and identify areas where efficiencies could be increased with HF consultation or HF research and report out to the HF Subcommittee on their results.

FAA Response: The FAA concurs with the Committee's recommendation with the noted exceptions and clarifications and intends to undertake the following actions to address the recommendation. The NextGen Human Factors budget lines must be used for pre-implementation activities that support NextGen concept development and validation at the enterprise level; therefore, post-implementation assessments of NextGen tools are outside of the approved purview of the office. However, Office of NextGen, Human Factors Division, recognizes the opportunity to positively influence potential efficiency gains by proactively identifying enterprise-level Human Factors considerations and developing mitigation strategies and best practices to address these considerations during the development and validation of NextGen concepts. Specific activities to influence post-implementation efficiency gains of NextGen concepts include the development of a PBN Procedures Development Guidebook (in progress), developing an approach for collecting and utilizing PBN workload metrics (planned), exploring ways to optimize contingency operations in a degraded NextGen environment (planned), and researching how to support the implementation of time, speed, and spacing tools through effective change management practices (planned).

U.S. Department of Transportation
Federal Aviation Administration

Office of the Administrator

800 Independence Ave., S.W.
Washington, D.C. 20591

November 1, 2017

Dr. R. John Hansman, Ph.D. Chair, Research, Engineering and
Development Advisory Committee Massachusetts Institute of Technology
77 Massachusetts Avenue
Cambridge, MA 02139

Dear Dr. Hansman:

Thank you and the Federal Aviation Administration's Research, Engineering and Development Advisory Committee for your June 14, 2017, letter providing recommendations on the Fiscal Year 2019 Research and Development (R&D) Portfolio. The important guidance generated during the REDAC Winter- Spring 2017 meeting is sincerely appreciated.
Various important topics discussed during this meeting included the future investigation of Cyber-Security issues, continued enhanced development of the National Aviation Research Plan, and engaged knowledge sharing and technical collaborations to promote successful outcomes of Unmanned Air Systems (UAS) Integration in the NAS. We will also continue, as suggested, to investigate and implement sound practices to conduct early benefits analyses necessary to prioritize R&D efforts throughout the FAA.

I have reviewed your recommendations and enclosed are the Agency responses to the various Subcommittee recommendations.

We will continue to incorporate the Committee's recommendations as we maintain an R&D portfolio that addresses safety, efficiency, and capacity of the air transportation system in an environmentally sound manner.

Sincerely,

Michael P. Huerta
Administrator
Enclosure

FAA Response to REDAC Guidance for the Fiscal Year (FY) 2019 Research and Development (R&D) Portfolio

Subcommittee on Aircraft Safety

Finding: Propulsion Research Resource Targets - As modern aircraft have evolved to employ new and novel materials to improve efficiency and reduce life cycle costs the FAA has appropriately applied increased funding levels to conduct research in the area of advanced materials. The majority of this funding is being directed at aircraft composite structures. Engine manufacturers also continue to push for improvements in fuel economy and provide some of the enabling technologies to the advancements and benefits observed at the aircraft level. The funding levels associated with propulsion research continue to decline and are proposed at $I.IM for FY19. This is nearly a 50% reduction from 2015 levels and compares unfavorably to the nearly $7.2M planned for aircraft composites research.

The Subcommittee made a prior recommendation that the FAA consider funding of advanced inspection techniques, hot corrosion in nickel alloys, cold dwell fatigue in titanium and advanced computational methods for microstructure changes. These could be target areas for propulsion research in future years.

Recommendation 1: The FAA should evaluate the target funding levels for propulsion research with a goal of achieving a proper balance between aircraft advanced material and propulsion research budgets.

FAA Response: The FAA appreciates the Committee's assessment of propulsion research. In fact, some of the areas previously recommended have been supported; such as advanced inspection and cold dwell fatigue. However, propulsion sponsorship is based on potential certification and guidance needed for such areas. Since the limited research budget cannot support all areas of interest, only those requiring certification products are considered for sponsorship.

Finding: Unmanned Aircraft Systems (UAS) Implementation Plan - The Aircraft Safety (SAS) REDAC reviewed the 2019 proposed research portfolio and specifically research related to UAS. Several of the smaller items in the presented plan were questioned (e.g. hi-visual contrast, air carrier operational considerations) for their necessity and safety value in relationship to our understanding of other possibly conflicting research being conducted in the same general areas. As we have noted in the past it is still hard to get a complete picture of the total research scope related to UAS. It is especially difficult to understand the context of this proposed research without appreciating the full picture of FAA-funded DAS-related research given that overwhelming majority of the UAS research resources are grants to the UAS COE (i.e., ASSURE). Visibility to safety research requirements in other areas of the UAS implementation plan need to be reviewed as well.

Recommendation 2: Complete, update and make routinely available to SAS REDAC the UAS implementation plan so that we may get a clearer picture of the complete UAS research plan. The REDAC SAS would also like to routinely receive information about the UAS research being conducted by ASSURE. To better understand how the significant research investment has benefited the FAA, we would like a briefing on the highlights of UAS research portfolio including ASSURE over the last two years and how this research has impacted FAA decisions with regard to UAS related regulations and other decisions.

FAA Response: The FAA appreciates the Committee's recommendation on the (Unmanned Aircraft Systems (UAS) Implementation Plan. The FAA continues to update the UAS Implementation Plan to document and coordinate internal FAA activities to enable the integration of UAS in the National Airspace System (NAS). This document is not intended for external release and will not be provided to the SAS RED AC. However, the FAA will continue to keep the SAS REDAC informed on its UAS research program and how research informs FAA UAS integration activities. This includes:

- The UAS Integration R&D Plan as outlined in Section 2211 of the FAA Extension, Safety, and Security Act of 2016 which describes the application of research internal and external to the FAA.
- The FAA' s U AS R&D Portfolio, including research conducted in partnership with ASSURE, and with other research performers.

The FAA provided briefings on the ASSURE COE and the UAS R&D Plan to the Subcommittee at the fall 2017 meeting.

Finding: Fatigue Research Program - The REDAC Subcommittee on Aircraft Safety (SAS) received a deep dive briefing on the FAA' s overall fatigue research program. The Subcommittee was impressed with the progress that parts of the program are making, particularly the research on fatigue genomics and biomarkers. However, the Subcommittee remains concerned that the FAA program is not taking a holistic approach to fatigue, which remains a widely acknowledged and pervasive risk to aviation safety. There is a concern that this may be a consequence of the reductions to the A11G BLI, which averaged 80% over the past three years.

Currently, there are no funded programs to detect and mitigate fatigue problems across the breadth of civil aviation -- other areas of aviation operations that have widely acknowledged fatigue concerns seem to have been overlooked. While aviation maintainers and air traffic controllers have been recently studied, other broad areas of aviation, including aeromedical ambulances, other commercial aviation, and general aviation operations are not being sponsored by any of the FAA policy holders and potential fatigue problems are not being addressed.

Finally, there is no convincing plan to analyze data from the Fatigue Risk Management Plan (FRMP) or Fatigue Risk Management System (FRMS), to determine the utility and cost-effectiveness of these important FAA fatigue initiatives.

Recommendation 3: The Subcommittee recommends an expanded fatigue research program that integrates the different policyholders, funding programs, and research organizations within the FAA. This program should provide surveillance for early indicators of fatigue hazards across aviation operations in the US. The integrated research program should facilitate identification and advocacy for needed research and ensure sharing of results across aviation domains within the FAA.

FAA Response: The FAA concurs with the Committee's finding, with the noted clarifications below, and intends to undertake the following actions to address the recommendations:

- The briefing provided to the Subcommittee on Aircraft Safety (SAS) focused on programs within the purview of the Aviation Safety portfolio that covered the flight deck operations, maintenance, and even aeromedical factors.
- Other fatigue efforts and activities relating to air traffic operations and technical operations, are not included under this aviation safety portfolio and were not briefed.

To address the SAS findings, we will conduct an internal technical exchange meeting with representatives from the other agency policy organizations and the results of this meeting will be presented at the spring 2018 SAS meeting.

Recommendation 4: The Subcommittee also recommends that a structured research program to assess the effectiveness of Fatigue Risk Management Plan (FRMP)/Fatigue Risk Management System (FRMS) in Part 121 passenger carrying operations be planned, given high priority for funding, and commenced immediately.

FAA Response: The FAA concurs with the Committee's recommendation to address the effectiveness of the FRMP/FRMS, and is planning to proceed once the FRMP/FRMS database has been established and populated with the appropriate data. The FAA provided a briefing on the FRMP/FRMS database at the fall 2017 meeting.

Subcommittee on Human Factors

Finding: Human Factors Portfolio Prioritization and Competencies - The Human Factors (HF) Subcommittee had a previous finding concerned about how HF research funding for NextGen and Unmanned Aerial Vehicles (UAVs) have significantly increased at the expense of core HF research areas like fatigue and training. The Subcommittee received a briefing on the prioritization process but it did not answer the question. Further Subcommittee discussion addressed how the HF research community manages its competencies whether organic, contract, or Centers of Excellence. The HF Community could not tell the HF Subcommittee how it assesses its technical competencies.

Recommendation 1: The Subcommittee recommends that the FAA HF research community establishes a process to define and assess its technical competencies in a Lead, Leverage, Watch, or similar construct to be able to determine the status of their ability to respond to changing FAA priority needs.

FAA Response: The FAA concurs with the Committee's recommendation regarding a process to define and assess its Human Factors technical competencies and has taken the following action. A process has been established to define and assess the Human Factors competencies. This assessment will be conducted periodically to determine the status of organic, contract, and academic expertise.

Recommendation 2: The Subcommittee recommends the FAA Human Factors (HF) community report out to the HF REDAC Subcommittee at its next meeting.

FAA Response: The FAA concurs with the Committee's recommendation on Human Factors portfolio prioritization and competencies. A briefing was made to the HF REDAC Subcommittee at the August 2017 meeting.

Finding: NextGen HF Research Support - The Subcommittee has made previous recommendations on the need for HF research in NextGen. The Subcommittee received a briefing and was very pleased with the HF communities' response and proposed research plan for FYI 9. However, due to current budget deliberations, this research was reflected as unfunded. The Subcommittee supports this proposed research.

Recommendation 3: The Subcommittee recommends the FAA assess the priority and funding of this HF NextGen research and report out the results at the next HF Subcommittee meeting.

FAA Response: The FAA concurs with the Committee's recommendation. A briefing was presented to the HF RED AC Subcommittee on the NextGen research prioritization and funding process at the August 2017 meeting.

Finding: Mixed-Capability NextGen Environment - For two years a recurring topic of discussion at the REDAC Human Factors Subcommittee meetings raised questions around Human System Integration (HSI) across multiple capabilities and operational changes converging at the human operator and users over the coming years. For NextGen to realize its planned operational benefits and capabilities, the human operators and users of the NAS, both on the flight deck and on the ground, must be willing and able to effectively utilize the combined suites of capabilities and operational changes they will be given by the system.

It is not clear to the Subcommittee whether, or to what extent, integrated assessments across the users and stakeholders of those combined suites of capabilities have adequately been done in order to reduce risk and ensure the delivery of benefits. Discussion around these questions inspired the Subcommittee to request that the FAA summarize what efforts have been made on this issue, so that the Subcommittee can provide appropriate and useful advice.

Recommendation 4: The Human Factors Subcommittee requests the FAA define the plan, including any research, for assessing the risks and alternative designs and procedural solutions related to the multiple capabilities across the NAS and increased complexity on the human role in Next Gen. This complexity includes the interaction of the various humans and systems as well as integrated human performance considerations on pilots, dispatchers, and controllers and traffic managers and report back to the HF committee on this research plan at the next meeting. This will enable the Subcommittee to assess the extent to which human-system collaboration concerns have been accounted for in the complex multi-capability of NextGen and to determine where more specific HF research may be warranted.

FAA Response: The FAA concurs with the Committee's recommendation and has undertaken the following actions to address the recommendation. The FAA has initiated research to assess the impact of multiple capabilities across the NAS and the increased complexity of the human role in NextGen. A briefing on this research program was provided at the HF REDAC Subcommittee's August 2017 meeting.

Subcommittee on Environment and Energy

Finding: Noise Research - Noise research is making substantial progress in studies related to the understanding of impact of aviation noise on annoyance, sleep, health, and children's learning and in the planning of studies related to noise from supersonic aircraft, Unmanned Aerial Systems (UAS), and commercial space. Some of the impacts of noise have become barriers to the implementation of NextGen.

Recommendation 1: Since the results of some of these studies will generate significant public interest, the Subcommittee recommends the FAA prepare a public outreach plan to proactively manage this public interest.

FAA Response: The FAA concurs with the Committee's finding and recommendation and is undertaking the following actions concerning ongoing studies related to understanding aviation noise annoyance and impacts of aviation noise on sleep, health, and children's learning. We are developing a public outreach plan to communicate noise issues more effectively using new and innovative ways to engage the public.

Finding: Aviation Environmental Design Tool (AEDT) - In response to the action from the last Subcommittee meeting, FAA provided clarity on improvements and further development needs for the Aviation Environmental Design Tool (AEDT). This will enable enhanced usability, improved airspace and airport design, continued support for analyses that support domestic and international decision-making. The FAA also identified key risks to AEDT development (e.g. availability of Base of Aircraft Data (BADA) 4 on airplane performance and noise) and has developed appropriate contingency plans.

Recommendation 2: The Subcommittee recommends the FAA continue the simultaneous (and balanced) development of usability improvements and enhanced features in the near term.

FAA Response: The FAA concurs with the Committee's finding and recommendation and is undertaking the following actions to address its recommendation. We appreciate the Subcommittee's support for the continued development of the Aviation Environment Design Tool. AEDT is the required tool for domestic environmental analyses and has been at the core of our efforts to support the ICAO CAEP standard setting process. The new developments will allow AEDT to more accurately capture fuel burn in the terminal area, which is important for the benefits assessment of NextGen, and to improve AEDT's ability to calculate noise at levels below day-night average sound level (DNL) 65. Based on the Subcommittee's support, we will move forward with these efforts.

Finding: Continuous Lower Energy, Emissions, and Noise (CLEEN) Program - In partnership with industry, the Continuous Lower Energy, Emissions, and Noise (CLEEN) Program is maturing new technologies that will continue to show significant engine and aircraft performance benefits (fuel burn and operations improvement, noise and emissions reduction). The Commercial Aviation Alternative Fuels Initiative (CAAFI) also continues to make significant progress in advancing alternative jet fuels as a private public partnership between the FAA and industry.

CLEEN and CAAFI are both very successful industry/FAA cost-share programs as is the Aviation Sustainability Center (ASCENT), the FAA Center of Excellence for Alternative Jet Fuels and Environment. Three quarters of Environment and Energy research funds are generating 100% plus cost matching from Non-Federal partners (CLEEN, CAAFI, and ASCENT). This leverages scarce FAA R&D funds to accomplish significant advances and improvements.

Recommendation 3: The Subcommittee encourages Public Private Partnerships like CLEEN, CAAFI and ASCENT programs to leverage resources and recommends that FAA should continue to prioritize robust funding for these programs.

FAA Response: The FAA concurs with the Committee's finding and recommendation and is undertaking the following actions to address its recommendation. We appreciate the Subcommittee's recognition that the vast majority of the Environment and Energy R&D program has been leveraging resources from the private sector via public-private partnerships. CLEEN and ASCENT account for roughly three quarters of the RE&D Environment and Energy funding. As such, three quarters of the RE&D budget is generating 100% cost share. CAAFI does not have a cost-share requirement so the non-government funds going toward it have not been tracked over time. However, the effort has considerable industry support - especially from the airlines - and has been successful in directing efforts across the Federal Government. CLEEN, CAAFI, and ASCENT have all been successful because of their strong engagement with industry. We were excited to see that the work of the FAA and industry in CAAFI to advance alternative jet fuels was highlighted as a model for public-private partnerships in the UN Secretary General's 2016 report on Sustainable Transport.

Finding: Operational Research Program - The operational research program is an important and impactful program in the Environment and Energy portfolio. These projects are being worked (or planned to be worked) in collaboration with the FAA Air Traffic Organization (ATO), FAA NextGen Office (ANG), FAA Office of Airports (ARP), NASA, and MassPort.

Recommendation 4: The Subcommittee is pleased to see this research included in the portfolio after having been impacted due to the reduction and eventual elimination of F &E funds for this category. We encourage FAA to pursue this research while recognizing the potential for environmental benefits thru operational changes in all phases of flight.

FAA Response: The FAA concurs with the Committee's finding and recommendation and is undertaking the following actions to address its recommendation. We are pleased with the collaboration that has developed around the F AA-MassPort-MIT effort to examine how noise could be changed and potentially reduced via changes in aircraft operational procedure concepts.

The collaboration with MassPort is part of our overall effort to accelerate the maturation of low noise aircraft technologies and noise mitigation techniques for arrivals and departures that could reduce community noise exposure. While the CLEEN program will help to reduce noise from new aircraft, we know that we also need to find ways to reduce the noise from the current fleet of aircraft while maintaining safety. The FAA-MassPort-MIT effort is using tools that were developed by MIT (as a part of the ASCENT Center of Excellence) with funding from FAA to evaluate procedures and procedure modifications with noise reduction potential. We have also begun efforts with UPS to identify and evaluate operational procedure concepts that could reduce noise, including those being developed in the FAA-MassPort-MIT effort. Based on the Subcommittee's support, we will continue to conduct research to identify procedures and procedural changes that could mitigate noise from the current fleet.

Finding: Staff Vacancy Expansion -The workload of FAA AEE staff has been increasingly driven by CO2 standard setting, global market based measure (CORSIA) development, non-volatile particulate matter standard settings, supersonic aircraft, and a broad range of noise work. Staff vacancies within the organization are a big concern. These vacancies need to be filled. A lack of skilled personnel could delay completion of critical projects, and in the long term, prevent achievement of the core FAA mission, including improving efficiency of aviation system.

Recommendation 5: The Subcommittee recommends that the FAA place a high priority on filling staff vacancies to manage the AEE portfolio and support the expanding workload.

FAA Response: The FAA concurs with the Committee's finding and recommendation and is undertaking the following actions to address its recommendation. We understand the Subcommittee's concern about staff availability within the Office of Environment and Energy. The work load in AEE has indeed increased due to increasing concerns regarding aviation noise and the continuing international efforts. AEE have had good success over the years in filling positions with highly qualified environmental professionals. This is due in part to the students and staff that have been trained as a part of PARTNER and ASCENT, the FAA Centers of Excellence for environment and alternative jet fuels. We are currently in the process of developing hiring plans in accordance with administration guidance.

Finding: Collaborative Research Topic Priorities -The REDAC Environment and Energy Subcommittee had believed that water issues were proactively being addressed by the Airports and Safety RED AC Subcommittees, but learned that water research was not a priority on the 10- year research plan for the Airport Technology Research (ATR) Program.

Recommendation 6: REDAC Subcommittees Designate Federal Officials (DFOs) should communicate amongst each other and develop a list of research topics that they believe are priorities but feel is within the domain of a different subcommittee.

FAA Response: The FAA concurs with the Committee's finding and recommendation and is undertaking the following actions to address its recommendation. Representatives from Environment and Energy, Airports and Safety portfolios have met to discuss water research items that are being addressed via the Airports and Safety Portfolios. These discussions have led to a better collective understanding of the water research that is being conducted by the FAA. In addition to airports and safety, much research on water issues is also being undertaken by the Airports Cooperative Research Program (ACRP). At present, it appears that water issues are being handled appropriately.

Subcommittee on NAS Operations

Finding: Operations Concept Validation - The Subcommittee received briefings on Operations Concept Validation Modeling (BLI lAl1) and Operations Concept Development & Infrastructure (BLI: IAOIC). The Subcommittee found the briefings to reflect the high quality of the briefers and the excellent research and development work carried out in both areas. The Subcommittee notes that operations concept validation activity represents one of the most valuable programmatic risk mitigation investment tools available to the FAA for advancing the state of the art in airspace operations. Early identification and resolution of operational and integration issues yields tremendous cost avoidance during implementation.

The strategic context motivating FAA and NAS users' investment in ops concept validation includes both near and far term considerations. These considerations include the accelerating pace of change affecting all aspects of the Agency's NextGen portfolio. Examples include the pace of advancement in connected aircraft capabilities, increased confidence in investment decisions on the part of NAS users to complement FAA investments, community sensitivity to terminal airspace noise resulting from improved arrival and departure management schemes, as well as advancements.in aircraft and airspace automation systems and concepts, among others.

The Committee observes that the priority given to Ops Concept Validation projects has been in decline over recent years. In particular, the work that was performed under BLI 1A11 was moved from a cross-cutting, enterprise-level F&E activity to within the NextGen portfolios. There, this activity competes directly for funding with the day-to-day pressures of NextGen implementation. Portfolio managers are very much focused on program implementation and thus it is very difficult for them to properly prioritize this work, particularly since the work should be done well in advance of implementation. The Subcommittee notes that the result has been a significant decline 1n the level of effort devoted to operational concept validation across the FAA.

Recommendation 1: The Subcommittee recommends that the FAA increase the priority given to Ops Concept Validation investments, particularly those that are closer to implementation, as the most effective and affordable means of strategic risk mitigation in a time of rapid technological and business concept advancements affecting the NAS. The savings in time and implementation cost more than offset the relatively low cost of increased concept validation.

FAA Response: The FAA concurs that operations concept validation activities constitute one of the most effective programmatic risk mitigation investment tools available to the Agency for advancing cutting-edge airspace operations. The FAA agrees with the Subcommittee's recommendation that priority be given to those operations concept validation investments which are closer to implementation, as the most effective and affordable means of strategic risk mitigation in a time of rapid technological and business concept advancements affecting the NAS. Therefore, the FAA will be consolidating concept validation work from individual portfolios into a cross-cutting, enterprise-level F&E funding line. This approach will be reflected in the Agency's FY 2018 budget formulation process. The FAA has in place internal mechanisms by which it identifies and prioritizes those key areas that will receive prioritization over others. This is a key strategic decision-making process that also takes into consideration the fluid nature of the budget formulation process and out-year planning activities captured in the FAA's capital investment planning documents and enterprise architecture.

General Observation:

The Runway Incursion Reduction Program (RIRP) has been developed to address the NTSB recommendation A-00-66 (July 6, 2000), which states:

"[The FAA should] require, at all airports with scheduled passenger service, a ground movement safety system that will prevent runway incursions; the system should provide a direct warning capability to flight crews. In addition, demonstrate through computer simulations or other means that the system will, in fact, prevent incursions."

In 2015, the Subcommittee found that this NTSB recommendation failed to address the cost/benefit assessment that is required as part of an investment decision and recommended that the FAA should estimate the potential benefits of the Runway Safety Assessment (RSA) and Small Airport Surveillance Sensor (SASS) projects under RIRP.

In response to this recommendation, the FAA conducted a causal factor analysis and technology evaluation study under the Runway Incursion Prevention Shortfall Analysis (RIPSA).

Finding: The Runway Incursion Prevention Shortfall Analysis (RIPSA) - The RIPSA project was intended to (1) identify the causal factors associated with runway incursions at small and medium airports and (2) identify feasible runway incursion prevention technologies to address those factors. The Subcommittee has previously noted that feasibility includes technical performance and cost/benefit. While the RIPSA analysis has examined the estimated cost and general technical performance of candidate technologies, the project did not estimate the benefits pool available to runway incursion prevention technologies as recommended by the REDAC in the fall of 2015. The Subcommittee finds that the FAA cannot perform cost-effective research and development of runway incursion prevention technologies in the absence of any knowledge of the potential benefits pool that such technologies target.

Recommendation 2: The FAA should not invest any more funds in Runway Incursion Prevention technologies until they have estimated the benefits pool as previously recommended by the REDAC. Further technology development in these projects should be contingent upon an initial positive cost/ benefit estimate. REDAC looks forward to reviewing this benefits estimate in its fall 2017 meeting.

FAA Response: The FAA appreciates the Committee’s view on stopping the funding of runway incursion prevention technologies until benefits have been estimated. However, we are not able to pursue this recommendation at this time for the following reasons: The Objectives of the assess their technical capability and operational feasibility. If the systems meet the technical requirements and prove to be feasible, only then, in accordance with the FAA’s AMS process, does the RIRP proceed with activities pertaining to cost and benefits estimation. The lessons learned during the test and evaluation of the technologies determine what section of the benefits pool the system can claim, and are used to build a potential business case for an acquisition decision by the FAA.

The Runway Safety Metric, currently under development, will serve as the cornerstone to quantify the benefits of all future runway safety systems, included those being investigated by the RIRP. As this metric is still being developed, the estimation of the benefits pool is a future activity in the roadmap for the Runway Safety Group; one that will be applied to all applicable runway safety systems and technologies.

The RIRP and the Runway Safety Group continued discussing this approach with the REDAC NAS Ops Subcommittee at the fall 2017 meeting to keep them apprised on the development of the FAA Runway Safety Metric and RIRP' s progress towards a potential business case/benefits estimate.

Subcommittee on Airports

Finding: Cross-cutting Strategic Research - The Subcommittee supports the FAA' s efforts to update its research strategy, Goals, Objectives via the NARP, particularly with respect examining how the FAA's various research programs can more effectively address research that cuts across multiple research areas (e.g., air traffic system operations, airports, safety, and environment). Such a cross-cutting approach to research has proven to be successful in the area of airport noise research involving both the Airport Technology Research Program and Environmental Research Program.

Recommendation 1: The Subcommittee recommends that the FAA seek additional opportunities to utilize cross-cutting approaches to research and development that draw on the skills and expertise from multiple research programs. In addition to aircraft noise, research areas that are ripe for this approach are (1) Cyber-Security, (2) Unmanned Aircraft Systems (UAS), (3) Time-Based Flow Management (especially the surface elements of TBFM), (4) management of operations during irregular operations such as airport construction and adverse weather conditions, and (5) aviation safety management.

FAA Response: The FAA concurs with the Committee's finding and is undertaking the following actions to address its recommendation(s): The FAA's Airport Technology Research Branch (ATR) will continue to seek opportunities to leverage other research programs, and when needed, will partner up with others (government agencies, trade associations, private industry, etc.) to enhance the ATR research portfolio. For instance, unmanned aircraft systems (UAS) research needs are constantly evolving, and the ATR branch is currently fully engaged with others at FAA, airports, and industry to define airports-related UAS research and is planning to execute its research as part of a larger government-wide UAS research portfolio.

Finding: Airports Research Prioritizations - The Subcommittee placed a high priority on research into new categories of aeronautical vehicles--UAS and commercial space vehicles specifically--and their potential impacts on airport safety, operations, and infrastructure. Other high priority research areas are (1) pilot perception of light emitting diode (LED)-based airfield lighting systems (RPA S5), (2) aircraft rescue and firefighting agents (RP A S3), (3) runway incursion prevention technologies (RP A S 1), and (4) noise standard development/refinement based on the findings of ongoing noise annoyance data collection (RPAs N2-N5).

Recommendation 2: The Subcommittee recommends that the FAA Office of Airports place a high priority on research associated with the research areas that include (1) pilot perception of light emitting diode (LED)-based airfield lighting systems (RPA S5), (2) aircraft rescue and firefighting agents (RPA S3), (3) runway incursion prevention technologies (RPA Sl), and (4) noise standard development/refinement based on the findings of ongoing noise annoyance data collection (RPAs N2-N5), as well as, UAS and Commercial Space.

FAA Response: The FAA concurs with the Committee's finding and is undertaking the following actions to address its recommendation(s): The FAA's Airport Technology Research

Branch (ATR) with concurrence from the FAA's Office of Airports is placing high priority on research areas identified in Recommendation #2.

Finding: Research Programs Completion Projections - Although it understands that the timelines for research projects are inherently uncertain, the Subcommittee would like to have a better understanding of when research projects are expected to conclude and get periodic updates regarding their schedule for completion as the projects progress.

Recommendation 3: The Subcommittee recommends that the FAA provide information regarding the estimated schedules for completing new research projects and provide schedule updates regarding ongoing research projects in its briefings to the Subcommittee.

FAA Response: The FAA concurs with the Committee's finding and is undertaking the following actions to address its recommendation(s): The FAA's Airport Technology Research Branch Research Program Area (RP A) managers will provide estimated schedules with planned starts and projected durations of major projects in their Research Program Areas.

Finding: Research Completion Priorities - The Subcommittee finds that priority should be given to research projects that are close to completion (i.e., issuance of final research findings and/or conclusions), particularly those that have promising practical applications.

Recommendation 4: The Subcommittee recommends that the FAA prioritize research projects that are close to completion such as the regarding trapezoidal grooving project (RPD S.1.4).

FAA Response: The FAA concurs with the Committee's finding and is undertaking the following actions to address its recommendation(s): The FAA's Airport Technology Research Branch (ATR) with concurrence from the FAA's Office of Airports is constantly reviewing the list of research projects that are ready to be undertaken and for which results can be obtained in a timely manner, and plans to fund these as soon as budgets allow to proceed. For example, the final FY 2017 ATR budget was recently received and ATR proceeded with funding of the trapezoidal grooving project in the summer of 2017.

Appendix 2: Partnerships

A2.0 Introduction to Partnerships

FAA enhances and expands its R&D capabilities through partnerships with other government, industry, academic, and international organizations. Such partnerships help the FAA leverage critical resources and capabilities to ensure that the Agency can achieve its Goals and Objectives. By partnering with other organizations, the FAA gains access to both internal and external innovators, promotes the transfer of FAA technologies to the private sector for other civil and commercial applications, and expands the U.S. technology base.

A2.1 Interagency Partnerships

Other Federal departments and agencies conduct aviation-related R&D that directly or indirectly supports the FAA Goals and Objectives. To leverage R&D, researchers at the FAA collaborate with their colleagues in government; both foreign and domestic, through cooperative agreements, such as MOUs, MOAs, and Interagency Agreements (IA). Following below are brief descriptions of the NASA partnered RTTs, and the numerous interagency committees and groups with which the FAA is associated.

A2.1.1 NASA

As previously stated, the FAA has partnered with NASA at various levels including research work performed through structured RTTs that focus on transitioning NASA technologies to the FAA. This focus on transitioning NASA aviation research to the FAA, facilitated by the RTTs, is one way the FAA is leveraging NASA's critical component of aviation research funding. Some of the research projects performed by the RTTs are documented in the output tables for each goal. The five RTTs are briefly described below.

A2.1.1.1 Efficient Flow into Congested Airspace (EFICA) RTT

EFICA focuses on a few key technologies in the dense arrival/departure airspace. These focus on areas such as Terminal Sequencing and Spacing (TSAS) and Flight-deck Interval Management (FIM), including work with FAA's Air Traffic Organization (ATO). NASA's Airspace Technology Demonstration One (ATD-1) project directly addresses terminal area congestion, and evaluates the benefits of advanced arrival management technologies across a range of aircraft equipage levels during moderate to high levels of traffic demand.

A2.1.1.2 Integrated Arrival/Departure/Surface (IADS) RTT

The IADS RTT includes the Airspace Technology Demonstration Two (ATD-2) IADS efforts meant to significantly improve IADS efficiency and reduce delays. ATD-2 will develop and deliver an integrated metroplex traffic manager to the FAA NextGen and Air Traffic Organizations, flight operators, and airport operators, that leverages NASA, FAA and industry technologies to enable simultaneous improvement of the predictability and efficiency of arrival, departure and surface operations.

A2.1.13 Applied Traffic Flow Management (ATFM) RTT

ATFM encompasses operational concepts, procedures and technologies supporting air traffic management, air traffic control and user operations mostly in en route airspace. It includes the NASA Airspace Technology Demonstration Three (ATD-3) subproject efforts, focusing on technologies for traffic re-routing around flow constraints, such as convective weather or special use airspace. The goal is to enable, by 2020, increased Traffic Flow Management (TFM) efficiency and reduced delays, in domestic airspace, by delivering advanced integrated air/ground technologies and procedures that use automation to continuously search for more efficient routes for individual flights and groups of flights.

A2.1.1.4 System-wide Safety (SWS) RTT

The SWS RTT was formed between NASA and the FAA in 2015 to jointly identify common critical safety assurance Goals, coordinate research efforts and facilitate transition of technologies, tools and knowledge to the FAA. The National Transportation and Safety Board (NTSB) has since joined RTT discussions as a potential additional recipient of SWS RTT products. The SWS RTT has as its goal: (1) develop and mature techniques for identifying NAS-level anomalies, hazards and precursors to safety incidents; (2) research technologies and techniques to support human operator performance and monitoring; and (3) provide support for alternative paths to certification to benefit the FAA and industry by developing and transitioning qualified tools that reduce cost and increase confidence in complex systems.

A2.1.1.5 Unmanned Aircraft Systems Traffic Management (UTM) RTT

UTM is a separate, but complementary set of services to the ATM system for beyond visual line of sight (BVLOS) UAS operations in uncontrolled/Class G airspace and in designated areas in controlled airspace – initially under 400 ft above ground level (AGL). With UTM, Operators are responsible for the coordination, execution, and management of operations, with rules of the road established by FAA. The FAA interacts with UTM only for information/data exchange purposes, as required. The UTM RTT was formed between NASA and the FAA in 2015 to jointly identify, quantify, conduct, and effectively transfer UTM capabilities and technologies to the FAA as the implementing agency, and to provide guidance and information to UTM stakeholders to facilitate an efficient implementation of UTM operations. The UTM RTT goal is to: (1) research and mature increasingly complex UTM operational scenarios and technologies; (2) demonstrate those capabilities on the NASA UTM research platform; and (3) deliver to the FAA Technology Transfer packages that enable NAS service expectations for low-altitude airspace operations by providing insight and capability requirements for critical services.

A2.1.2 The U.S. Global Change Research Program (USGCRP)

The U.S. Global Change Research Program (USGCRP) began as a presidential initiative in 1989. It was mandated by Congress in the Global Change Research Act of 1990 (P.L. 101-606), which called for a comprehensive and integrated U.S. research program which will assist the Nation and the world to understand, assess, predict, and respond to human-induced and natural processes of global change. Thirteen Federal departments and agencies participate in the USGCRP including the DOT. The FAA contributes by assessing and identifying potential measures to reduce fuel consumption and greenhouse gas emissions; by conducting research to support USGCRP, and by leveraging research with other U.S. Government agencies to reduce uncertainties surrounding aviation emissions and their effect on climate change. For more information go to (http://www.globalchange.gov/).

A2.1.3 The Federal Interagency Committee on Aviation Noise (FICAN)

The Federal Interagency Committee on Aviation Noise (FICAN) was formed by the FAA in 1993 to provide forums for debate over future research needs to better understand, predict, and control the effects of aviation noise, as well as encourage new technical development efforts in these areas. For more information go to (http://www.fican.org/).

A2.1.4 Interagency Planning Office (IPO) for NextGen

The Interagency Planning Office (IPO) for NextGen leads interagency and international coordination and collaboration to resolve complex challenges critical to NextGen. Additionally, the IPO leverages stakeholder expertise to identify research, coordinate, prioritize shared issues, and bring the appropriate resources/partners together to advance NextGen. The IPO leads the congressionally mandated interagency collaboration on NextGen issues. To address these national challenges, the IPO works with partner agencies on (R&D) initiatives and other complex issues critical to the NextGen aviation enterprise. Partner agencies include the Departments of Commerce (DOC), Defense (DoD), Homeland Security (DHS), and the National Aeronautics and Space Administration (NASA). The FAA also collaborates with the Office of the Director of National Intelligence (ODNI), White House Office of Science and Technology Policy (OSTP), and other critical stakeholders as needed. During fiscal year 2017, the IPO expanded collaboration to include the National Geospatial-Intelligence Agency (NGA), National Science Foundation (NSF), and National Transportation Safety Board (NTSB) as partner agencies.

A2.1.5 NextGen Executive Board (NEB)

The NextGen Executive Board (NEB) is an executive-level forum for partner agencies to coordinate and collaborate on aviation challenges or areas of mutual interest to member agencies. This key executive-level interagency body provides strategic guidance on initiatives and solutions to assure that the interagency voice is elevated and integrated into the greater NextGen enterprise. The NEB also provides guidance/direction to the IPO’s interagency work. Current membership includes executive-level representatives from the following agencies:

- FAA
- National Aeronautics and Space Administration
- Department of Defense
- Department of Transportation
- Department of Commerce

- Department of Homeland Security
- Office of Science and Technology Policy, and
- Office of the Director of National Intelligence (Ex Officio)

A2.1.6 The Interagency Arctic Research Policy Committee

The FAA assists DOT in its participation in the Interagency Arctic Research Policy Committee (IARPC) deliberations. The FAA has two core functions: (i) it informs IARPC of its efforts in studying the effects of aviation on the arctic environment and (ii) it informs the effect of climate change in the arctic on FAA operations in Alaska. The FAA reports its findings and participates in developing policy papers to the DOT representative. IARPC comprises agencies, departments, and offices across the Federal Government and is chaired by the National Science Foundation. IARPC also cooperates with the State of Alaska, indigenous organizations, academic institutions, non-governmental organizations, the Arctic Council, and international partners. (http://www.iarpccollaborations.org/index.html)

A2.1.7 General Aviation Joint Steering Committee (GAJSC)

As part of the Safer Skies Focused Safety Agenda launched in 1998, the FAA and the GA community agreed to a goal of reducing the overall GA fatal accident rate. The General Aviation Joint Steering Committee (GAJSC), co-chaired by the FAA and the Aircraft Owners and Pilots Association (AOPA) Air Safety Institute, is the primary conduit for government and aviation industry cooperation, communication, and coordination for aircraft accident mitigation. The GAJSC conducts its activities through three working groups; Personal/Sport Aviation, Technically Advanced Aircraft/Automation, and Turbine Aircraft Operations. Members of GAJSC include:

- FAA;
- AOPA;
- AOPA Air Safety Institute;
- Experimental Aircraft Association;
- General Aviation Manufacturers Association;
- Helicopter Association International;
- National Air Transportation Association;
- National Business Aviation Association;
- NTSB, and
- NWS.

For more information, see (http://www.gajsc.org/).

A2.1.8 Aviation Vehicle Systems Institute (AVSI)

AVSI is a cooperative research environment comprised of major aerospace companies and government organizations working along with academia to solve problems common to its members. AVSI provides a predefined framework for cooperative research allowing members to save money through cost sharing and to solve problems outside the scope of a single organization. AVSI Provides these Advantages to Members:

- A framework for cooperative research with protected intellectual property and in-place contracting and non-disclosure agreements.
- A structure to solve pre-competitive problems economically through cost sharing.
- The ability to address problems that cannot be solved by a single organization.
- An organization through which members can speak to regulatory agencies and suppliers with a unified industry voice.

For more information, see (https://www.avsi.org/en/).

A2.1.9 Commercial Aviation Alternative Fuels Initiative (CAAFI)

The Commercial Aviation Alternative Fuels Initiative (CAAFI) seeks to enhance energy security and environmental sustainability for aviation through alternative jet fuels. Jointly founded by the FAA, Airlines for America, Airport Council International-North America and Aerospace Industries Association in 2006; CAAFI is a coalition that focuses the efforts of commercial aviation to engage the emerging alternative fuels industry. It enables its diverse participants – whom represent all the leading stakeholders in the field of aviation - to build relationships, share and collect data, identify resources and direct research, development and deployment of alternative jet fuels. For more information, go to (http://www.caafi.org).

A2.1.10 Commercial Aviation Safety Team (CAST)

The Nation's impressive commercial aviation safety record is due in part to the aviation industry and government voluntarily investing in the right safety enhancements to reduce the fatality risk in commercial air travel in the United States. The work of the Commercial Aviation Safety Team (CAST), along with new aircraft, regulations, and other activities, reduced the fatality risk for commercial aviation in the United States by 83 percent from 1998 to 2008.

CAST has evolved beyond the "historic" approach of examining past accident data to a proactive approach that focuses on detecting risk and implementing mitigation strategies before accidents or serious incidents occur. The goal over the next eight years is to transition to prognostic safety analysis. In 2010, CAST set a new goal to reduce the U.S. commercial fatality risk by another 50 percent from 2010 to 2025.

For additional information, see (http://www.cast-safety.org).

A2.2 International Partnerships

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. The following are some of the international committees and groups that the FAA is associated with:

A2.2.1 The European Organisation for the Safety of Air Navigation

The EUROCONTROL is a civil and military organization with the goal of developing a seamless, pan-European ATM system. In 1986, EUROCONTROL and the FAA established the first Memorandum of Cooperation (MOC), which was updated in 1992 and again in 2004. The aim of the MOC and its governance structure is to broaden the scope of the cooperation between the two organizations and their respective partners in the areas of ATM research, strategic ATM analysis, technical harmonization, operational harmonization, and safety and environmental factor harmonization. For more information, go to (http://www.eurocontrol.int/).

A2.2.2 Single European Sky Air Traffic Management Research (SESAR) Joint Undertaking

The SESAR Joint Undertaking is a public-private partnership under the European Commission and is responsible for the modernization of air traffic management systems and operations for European Union states. SESAR is very similar to the FAA NextGen program and the U.S. signed an MOC with the European Commission in 2011 to harmonize NextGen and SESAR development. For more information, see, (http://www.sesarju.eu/).

A2.2.3 Japan Civil Aviation Bureau (JCAB)

The FAA signed an agreement with Japan in 2006 to share information and lessons learned with the JCAB on research, development, and operations of ATM systems. The collaborative work is conducted by the Future Air Transport System (FATS) Work Group; which is chaired by the NextGen Organization and includes participation from the ATO. Japan is in the process of a large ATM modernization effort called, "Collaborative Actions for Renovation of Air Traffic Systems (CARATS)". The FATS work group shares information to help harmonize NextGen and CARATS. For more information, see (http://www.mlit.go.jp).

A2.2.4 Singapore Air Traffic Management Centre of Excellence

The FAA joined the Singapore ATM Centre of Excellence in 2013 and signed an MOC to collaborate on ATM operations, research, and development. Both the NextGen Organization and ATO are undertaking new collaboration efforts with Singapore under this MOC. NextGen harmonization will focus on remote towers, UAS, and aviation information sharing standards as part of the core work program in 2017.

A2.2.5 Transport Canada

After successfully completing 10 years of partnership with the FAA to support the PARTNER COE, Transport Canada continues to sponsor the ASCENT COE. Transport Canada has studied and will continue to study air quality at Canadian airports, to develop and implement practices that reduce air pollution from airports. Canada, as a member state of the ICAO, works to reduce smog-forming pollutants from the aviation sector and participates in the COE partnership to advance the state of knowledge in many key areas. For more information, go to (http://www.tc.gc.ca/eng/menu.htm).

A2.2.6 The Asia and Pacific Initiative to Reduce Emissions

The Asia and Pacific Initiative to Reduce Emissions (ASPIRE), established in 2008, is a partnership of Asian and Pacific Air Navigation Service Provider (ANSP) focused on environmental stewardship in the Pacific Ocean region. Under ASPIRE, current and future partners pledge to adopt and promote best practices to reduce fuel consumption and engine emissions. ASPIRE demonstrations have consisted of green flights that use existing efficiency procedures in an ideal, unconstrained air traffic environment. As a result of these successful demonstration flights, ASPIRE-Daily was launched in 2011 to promote the use of best practices such as user-preferred routing, Dynamic Airborne Reroute Procedures, and optimizations during arrival and departure between selected city pairs to promote daily fuel-savings. For more information, go to (http://www.aspire-green.com/).

A2.3 Academia

A2.3.1 FAA Air Transportation Centers of Excellence

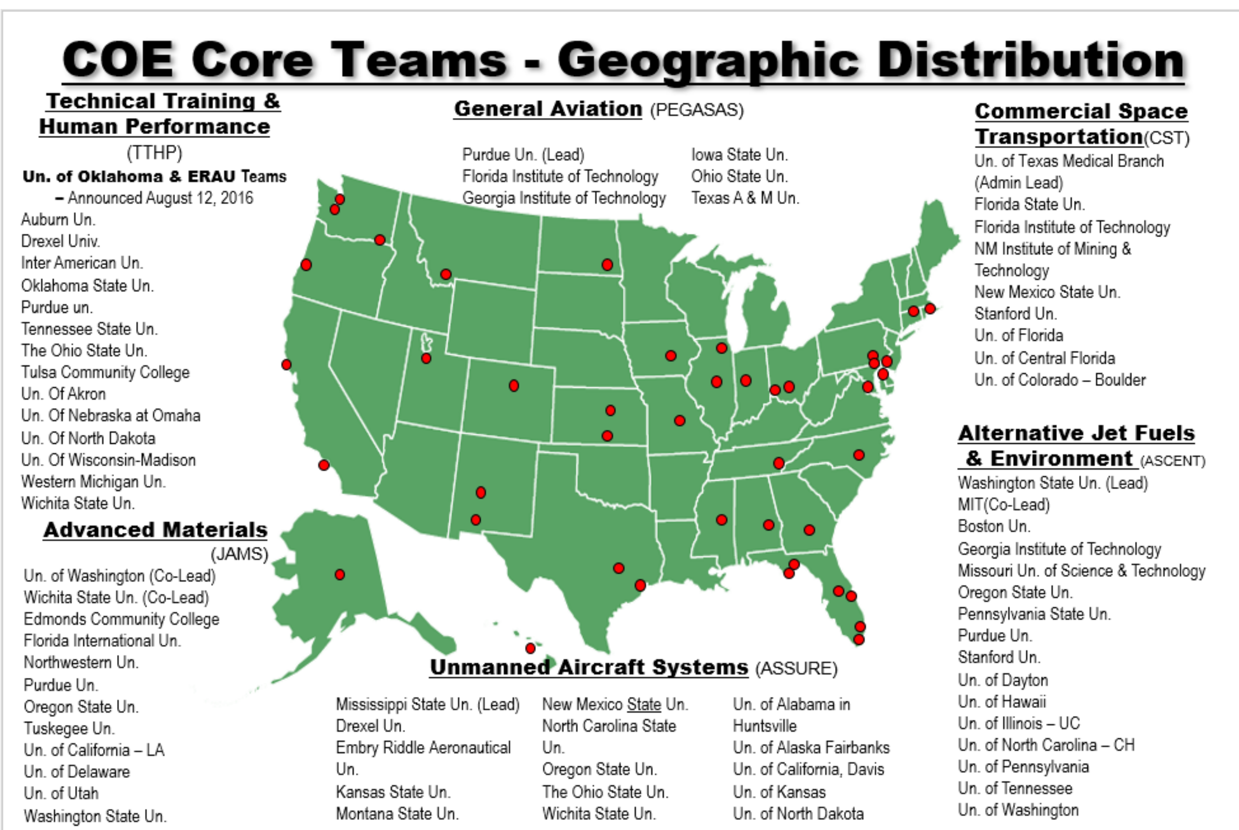
The FAA recognizes the need to develop the Nation’s technology base while educating the next generation of aviation professionals. Following a rigorous public dialogue and a competitive process based on criteria set forth in the enabling legislation, FAA RE&D Authorization Act of 1990, Public Law 101-508, the FAA Administrator selects a team comprised of multiple universities to serve as a COE in specific mission-critical topics. The COEs are established through cooperative agreements with the Nation’s premier universities, members and affiliates to conduct focused R&D and related activities over a period of five to ten years. Once the COE fully satisfies its requirements, it will be considered self-sufficient.

The COE program facilitates collaboration and coordination between government, academia, and industry to advance aviation technologies and expand FAA research capabilities through Congressionally required matching contributions. COE members and affiliates match FAA grant awards, dollar-for-dollar, with contributions from Non-Federal sources, and may also provide additional contributions through cost-share contracts. Over the life of the program, the COE universities with their Non-Federal affiliates have provided more than $300 million in matching contributions to augment FAA research efforts. Through long-term cost-sharing activities, the government joins with our university-industry teams to leverage resources and advance the technological future of the Nation’s aviation industry while educating and training the next generation of aviation scientists and professionals.

Since 1990, the FAA has entered into cooperative agreements with thirteen competitively selected COEs that were established with academic institutions and their industry affiliates throughout the United States. The COE members have assisted in conducting mission-critical research in areas that focus on the following topics:

- Technical Training and Human Performance;
- Unmanned Aircraft Systems;
- Alternative Jet Fuels and Environment;
- General Aviation Safety, Accessibility and Sustainability;
- Commercial Space Transportation;
- Advanced Materials;
- Airliner Cabin Environment and Intermodal Transportation Research;
- Aircraft Noise and Aviation Emissions Mitigation;
- General Aviation Research;
- Airworthiness Assurance;
- Operations Research;
- Airport Technology Research, and
- Computational Modeling of Aircraft Structures.

Four of these centers, Computational Modeling of Aircraft Structures Aviation Operations Research (NEXTOR), Airworthiness Assurance (AACE), Airport Technology Research (CEAT), and Airliner Cabin Environment and Intermodal Transportation Research (ACERite) have fully satisfied their requirements. Currently, NEXTOR and ACERite serve as self-sufficient resources for the aviation community, and CEAT continues to conduct major research initiatives to support modernization efforts with Chicago O'Hare International airport. As illustrated below, there are currently six active COEs performing R&D activities all across the country.



A2.3.2 Joint University Program (JUP)

The JUP is a research partnership between the FAA and Ohio University, Massachusetts Institute of Technology, and Princeton University. The program aids in the development of a safer and more efficient air transportation system by identifying promising targets for development, conducting long-term research, and educating technological leaders. The FAA and NASA benefit directly from the results of the research and gain valuable feedback from university researchers regarding the Goals and effectiveness of government programs. An additional benefit of JUP is the creation of a talented cadre of engineers and scientists who will form a core of advanced aeronautical expertise in industry, academia, and government. For more information, see (http://u2.princeton.edu/~jup/).

Appendix 3: Research Laboratories

A3.1 WJHTC Laboratories

A3.1.1 Florida NextGen Test Bed (FTB)

FTB provides a forum to help foster NextGen partnerships with industry, academia, and government by providing a facility for the integration and demonstration of new functions. It is governed by the FAA and used by NextGen stakeholders with industry, academia, and government. The FTB provides an integrated NAS based platform for NextGen by leveraging NAS systems augmented by prototype functionality.

A3.1.2 Research & Development Human Factors Laboratory (RDHFL)

The Research Development and Human Factors Laboratory is used to conduct human factors research in a congressionally mandated effort (the Aviation Safety Research Act of 1988 [Public Law 100-591]) to ensure a safe and effective implementation of National Airspace Systems concepts, equipment and procedures.

A3.1.3 NextGen Integration and Evaluation Capability Laboratory (NIEC)

The NIEC leverages existing NAS operational systems and high fidelity, real-time simulation capabilities to create an integrated, flexible and reconfigurable environment that can be tailored for NextGen research as well as test and evaluation.

A3.1.4 Full Scale Fire Test Facility (FSFTF)

The FSFTF is a purpose-built facility that includes a single-floor office space, a small 1200-square-feet shop area, and a large 13,000-square- feet hangar-like test cell for conducting a multitude of fire tests. In addition, there is a large 5000- square-feet warehouse attached to the main test cell for storage of supplies, components, vehicles and other equipment necessary to carry out the range of tests conducted in the facility.

A3.1.5 National Airport Pavement Test Facility

The National Airport Pavement Test Facility, built in partnership with the Boeing Company, is dedicated to airport pavement research. Rigid and flexible pavements embedded with more than 1000 sensors are subjected to simulated aircraft traffic enabling researchers to collect high quality, accelerated test data.

A3.1.6 National Airport Pavement and Materials Research Center

The National Airport Pavement and Materials Research Center provides the ability to test the effects of high tire pressures on pavement surface layers, pavement materials, and alternative pavement materials with the Heavy Vehicle Simulator for Airports.

A3.1.7 Full-Scale Aircraft Structural Test Evaluation and Research (FASTER) Facility

The FASTER facility is used for testing full-scale curved-panel aircraft fuselage sections under conditions much like those experienced by an aircraft in actual operation. Data objected from these tests support and validate analytical models developed by FAA researchers to predict the strength of fuselage structures.

A3.1.8 Structures and Materials Lab (SML)

The SML provides to ability to conduct research into emerging aviation structural design, fabrication techniques, and materials. The lab includes a suite of material test machines, an electron microscope, and an Aircraft Beam Structural Test (ABST) capability.

A3.1.9 Propulsion and airpOWer Engineering Research (POWER) laboratory

The POWER laboratory has three test cells dedicated to full-scale engine research, more than 20 engines in-house ranging from a small experimental Rotax engine to a Pratt & Whitney PT6 turboprop engine. Types of engine testing historically performed at the POWER laboratory include detonation, endurance, power performance, emissions, operability, and starting.

A3.1.10 Aviation Fuels Chemistry Laboratory

The Aviation Fuels Chemistry Laboratory is a state-of-the-art facility supporting aviation fuels research and development. The core function of the lab is to evaluate a fuel's engine performance relative to its chemical compositions and physical properties.

A3.2 MMAC Laboratories

A3.2.1 Flight Deck Human Factors Laboratory

Conducts a broad-based program of applied human factors research on causal factors associated with aviation accidents and issues involving the design, operation, and maintenance of flight deck equipment in the NAS.

A3.2.2 NAS Human Factors Safety Research Laboratory

Conducts an integrated program of research on the relationship of factors concerning individuals, work groups, and organizations as employees perform their jobs.

A3.2.3 The Flight Operations Simulation Laboratory

Consists of Level D Boeing 737 and Airbus 330/320 full flight simulators as well as high-fidelity air traffic control simulator stations, designs studies and provides test options to fit research needs from modeling airspace environments to evaluating aircraft, pilot, and air traffic controller performance.

A3.2.4 Flight Systems Laboratory

Assesses the safety of new, emerging, proposed and modified flight operational concepts, navigation, and surveillance systems to improve flight operations, standards, criteria, capacity, and aviation safety in both the National Airspace System, and internationally.

A3.2.5 Bioaeronautical Sciences and Protection & Survival Research Labs

Used to develop biochemical laboratory methods, conduct research on accident fatalities, and serve as the primary national site for toxicology-testing for Federal agencies, including the FAA and the National Transportation Safety Board (NTSB). The labs are also used for the development of national and international aviation safety equipment standards and survival procedures, as well as for research on cosmic radiation events of aerospace medical concern.

A3.2.6 Forensic Toxicology Laboratories

Measures drug, alcohol, toxic gases, and toxic industrial chemicals detected in biological specimens collected from victims of fatal aircraft accidents in support of accident investigation and development of strategic measures to reduce safety risks.

A3.2.7 Biochemistry Laboratories

Identifies biochemical factors that affect humans and the development of new and sensitive analytical procedures to detect the presence of medications and other emerging substances, including designer drugs.

A3.2.8 Functional Genomics Laboratories

Determines molecular expression changes in response to factors that affect aviation safety (fatigue, hypoxia, alcohol, pathology).

A3.2.9 Autopsy Program Facility

Coordinates and acquires autopsy data and other information required for the aeromedical evaluation of aircraft accidents and its integration in various research databases.

A3.2.10 Knowledge Management Laboratory

Provides robust information technology tools and processes to manage and understand aerospace medical data of importance to aviation and space medicine.

A3.2.11 Medical Research Laboratory

Provides aerospace medical expertise and maintains state-of-the-art aerospace research medical data resources needed to provide information for data-driven decision making by FAA policy makers and aerospace medicine managers.

A3.2.12 Aerospace & Environmental Physiology Laboratories

Identifies environmental factors that may influence human physiology in aerospace environments, in response to stressors such as hypoxia, acceleration, and biological-chemical threats, and also develop test procedures to assess adequacy of life support systems, medical devices, and other equipment at altitude.

A3.2.13 Numerical Sciences Laboratory

Exploits modern computational, analytical skills, and high performance computing capability to discover and implement ways for quantifying and visualizing risk within the aerospace medicine environment and support bioinformatics efforts.

A3.2.14 Cabin Safety Laboratories

Monitors and resolves aircraft cabin safety problems and conduct studies and tests pertaining to emergency aircraft evacuation and post-crash survival. Research topics include seating density, exit size and location, passenger flow rates through exits, and flight attendant behavior.

A3.2.15 Biodynamics Research Laboratories

Develops new methods, techniques, and equipment for evaluating injury potential and methods to reduce injury and enhance survival

Appendix 4: FAA Governance Bodies & External Advisory Committees

A4.1 Research, Engineering, and Development Advisory Committee

Established in 1989, the Research, Engineering, and Development Advisory Committee (REDAC) provides advice and recommendations to the FAA Administrator on the needs, Objectives, plans, approaches, content, and accomplishments of the aviation research portfolio. The Committee also assists in ensuring FAA research activities are coordinated with other government agencies and industry.[17] The REDAC considers aviation research needs in five areas; (a) NAS operations, (b) airport technology, (c) aviation safety, (d) human factors, and (e) environment and energy. Each fiscal year, the REDAC conducts two full committee meetings and 10 subcommittee meetings and produces two reports documenting its recommendations. The recommendations from these reports are available at: http://www.faa.gov/go/redac (select the REDAC tab).

A4.2 Commercial Space Transportation Advisory Committee

Established in 1984, the Commercial Space Transportation Advisory Committee (COMSTAC) provides information, advice, and recommendations to the FAA Administrator on matters concerning the U.S. commercial space transportation industry. COMSTAC members' professional affiliations constitute a broad cross-section of the commercial space transportation field, including domains such as:

- Commercial expendable and reusable launch vehicle activities
- Commercial launch site operations
- Satellite manufacturing and operations
- Space policy and education
- Space law
- Insurance and finance;
- State government and economic development programs
- Space advocacy, and
- Trade, as well as technical associations.

The COMSTAC provides recommendations, findings, and observations concerning commercial space transportation initiatives and may comment as appropriate on R&D reports and activities. For more information go to (http://www.faa.gov/about/office_org/headquarters_offices/ast/advisory_committee/).

---

[17] 49 U.S.C § 44508 - Research advisory committee

A4.3 Transportation Research Board

The National Research Council established the TRB in 1920 as the National Advisory Board on Highway Research. In 1974, the Board was renamed TRB to reflect its expanded services to all modes of transportation. The TRB mission is to promote innovation and progress in transportation through research. The mission is fulfilled through the work of its standing committees and task forces. The TRB manages the ACRP for the FAA with program oversight and governance provided by representatives of airport operating agencies.

The ACRP Oversight Committee announced their FY 2017 projects in July 2016. The selected research projects will examine different research areas that target near-term solutions to problems facing airport operators and industry stakeholders. The projects will report on the state of the practice in critical areas within the industry. The selected research areas include (a) integrating UAS (Unmanned Aircraft Systems) into airports, (b) evaluating climate resilience through cost benefit analysis, and (c) collecting and sharing airport safety and operational data. For more information go to (http://www.trb.org/ACRP/Public/).

Appendix 5: Technology Transfer

A5.1 Technology Transfer

The FAA's Technology Transfer Program was principally established with the enactment of the Stevenson-Wydler Technology Innovation Act of 1980 (P.L. 96-480), the Federal Technology Transfer Act of 1986 (P.L. 99-502) and successive related legislation, and serves to ensure the practical application of FAA Federal research by moving knowledge, facilities, equipment, and capabilities developed by its Federal laboratories and R&D programs out to Non-Federal entities such as private business, academia, and state and local governments. As further mandated by the Stevenson-Wydler Act and set forth in the FAA Order 9550.6B (May 2014), the FAA assigned the responsibility to manage and direct the FAA Technology Transfer Program to the Office of Research and Technology Applications (ORTA) located at the William J. Hughes Technical Center (WJHTC).

Primary R&D, technology, and innovation generators for the FAA Technology Transfer Program are the FAA's two government owned, government operated (GOGO) research organizations. The first laboratory is located at the William J. Hughes Technical Center (WJHTC) in the Atlantic City, New Jersey area and is the primary facility supporting the Next Generation Air Transportation System, or NextGen along with safety and research Objectives. The WJHTC also serves as the national scientific test base for research and development, test and evaluation, and verification and validation in air traffic control, communications, navigation, airports, aircraft safety, and security. The second lab is the Civil Aerospace Medical Institute (CAMI), located in Oklahoma City, Oklahoma. CAMI provides research into factors that influence human performance in the aerospace environment and focuses on finding ways to understand them and then communicate that understanding to the aviation community. Each of these organizations serves an essential function in ensuring the FAA's mission of providing the safest, most efficient aerospace system in the world.

A5.2 Tools & Mechanisms

A5.2.1 Cooperative Research and Development Agreement

A Cooperative Research and Development Agreement (CRDA) is collaborative in nature and allows the FAA to share facilities, equipment, services, intellectual property, personnel, and other resources with Non-Federal entities, such as private industry, academia, and state and local government agencies. The CRDAs are a highly effective in meeting the Congressionally mandated Technology Transfer requirements. These agreements provide agencies with a means to offer intellectual property rights and other Federal resources that would otherwise not be available to a collaborating partner. Funds may come into the Federal agency but no funds may be obligated by the Federal agency under a CRDA. CRDAs must be collaborative and must be within the mission of the Federal agency. An additional benefit of CRDAs is their ability to be developed and implemented much more rapidly than traditional contracts and procurements.

Because CRDAs are sensitive to the needs of business organizations, trade secrets or confidential information supplied by a partner shall not be disclosed in order to protect commercially valuable information. Trade secrets or privileged information that develops during the course of a CRDA can be protected from disclosure for up to five years.

A5.2.2 Other Cooperative Agreements

The FAA collaborates closely with other Federal departments and agencies as well as international agencies in conducting aviation-related R&D that directly or indirectly supports the FAA’s Goals and Objectives. Leveraging R&D efforts, researchers at the FAA collaborate with these colleagues through various collaborative arrangements, including cooperative agreements, such as Memoranda of Understanding (MOU), Memoranda of Agreement (MOA), Interagency Agreements, and International Agreements (IA).

A5.2.2.1 MOU/MOA

MOUs and MOAs support joint research activities between Federal departments or agencies. More specifically, a MOU is a high-level agreement describing a broad area of research that fosters cooperation between departments or agencies and develops a basis for establishing joint research activities. A MOU does not require either party to obligate funds and does not create a legally binding commitment. A MOA is an agreement describing a specific area of research under a broader MOU, which creates a legally binding commitment and may require the obligation of funds.

A5.2.2.2 Interagency Agreements

An MOA may include Interagency Agreements (IA); written agreements between the FAA and other agencies in which the FAA agrees to receive or exchange supplies or services with the other agency. NASA and the DoD are the FAA’s closest R&D partners in the Federal Government. Both agencies cooperate on research with the FAA through an MOU. The FAA also works closely with the Transportation Security Administration (TSA).

Appendix 6: Partner Activities

The tables that follow detail the FAA's partner activities including active 1) Cooperative Research and Development Agreements (CRDAs), 2) Center of Excellence (COE) grants, and 3) Interagency Agreements (IAs).

Active Cooperative Research and Development Agreements (CRDAs) in FY 2017						
Executed Date	FAA R&D Program	CRDA Number	Industry Partner	Period of Performance		Subject
				Start Date	Stop Date	
7/25/2006	Technology Development & Prototyping Division	06-CRDA-0216	Rowan University	7/24/2014	1/20/2017	Improve the analysis and display of air traffic data.
10/30/2007	Aviation Research Division	07-CRDA-0236	The Boeing Company	10/21/2014	10/31/2019	Long-term partnership to conduct research into areas of safety and airframe integrity of high importance and mutual interest to the industry and FAA. The verification and certification of the design, analysis, and applications of bonded repairs are of high importance to The Boeing Company, airplane operators and the FAA Technical Center.
2/19/2008	Engineering Development Services Division	08-CRDA-0245	New Mexico State University	2/19/2015	2/19/2017	Research to integrate unmanned aircraft system (UAS) into the National Airspace System (NAS) and to validate procedures and proposed regulations.
12/10/2008	Laboratory Services Division	08-CRDA-0251	Daikon Solutions LLC	11/4/2014	12/10/2019	Develops, produces, commercializes, supports and advances the Sun Keyboard System Translator (SunKeyST) capability.
1/27/2009	Laboratory Services Division	09-CRDA-0257	Daikon Solutions LLC	1/27/2014	1/27/2019	Facilitates the development, test, installation and implementation of a production-model Aircraft Geometric Height Measurement Element (AGHME) capability.
6/15/2009	Engineering Development Services Division	09-CRDA-0258	General Atomics Aeronautical Systems Inc	6/15/2015	6/15/2017	This CRDA is a mechanism to perform a series of collaborative unmanned aerial vehicle/system (UAV/UAS) modeling, simulation, demonstration and analysis activities.
6/26/2009	Engineering Development Services Division	09-CRDA-0259	AAI Corporation	12/26/2014	12/26/2016	Perform variety of operational and technical assessments to meet specific Objectives to support integration of UAS into the NAS.
6/19/2009	Engineering Development Services Division	09-CRDA-0260	GE Aviation Systems LLC	6/19/2014	6/19/2018	Perform a variety of operational and technical assessments to meet specific Objectives to support integration of UAS into the NAS.
5/13/2010	Laboratory Services Division	10-CRDA-0266	Insitu, Inc.	1/29/2014	1/31/2019	UAS industry is actively seeking opportunities to optimize the capabilities of UAS technology and expand their horizons by non- military applications that will support the establishment of civil aviation standards.
12/23/2010	Engineering Development Services Division	10-CRDA-0268	United Parcel Service Co.	12/23/2010	12/23/2020	Collaborating Partner (CP) will be able to provide the FAA additional information and data regarding the usefulness of the Surface Decision Support System (SDSS) in daily operations that would facilitate surface traffic requirement development and enhance surface traffic management operations with the NAS.
1/20/2012	Aviation Research Division	12-CRDA-0281	United Parcel Service Co.	9/15/2014	9/20/2018	Collaboration to observe anti-icing fluid failure characteristics on aircraft flaps and slats under conditions of winter precipitation and simultaneously observe fluid failure behaviors on aircraft wings.

Active Cooperative Research and Development Agreements (CRDAs) in FY 2017						
Executed Date	FAA R&D Program	CRDA Number	Industry Partner	Period of Performance		Subject
				Start Date	Stop Date	
7/2/2012	Aviation Research Division	12-CRDA-0285	Team Eagle Ltd	7/2/2012	7/2/2018	Team Eagle, Ltd., in conjunction with the University of Waterloo, Ontario Centers of Excellence and industry experts, and the FAA are each working on independent research projects with the common objective of developing the technology for effectively evaluating and measuring the effect of contaminant on aircraft wheel braking performance. Both projects are focusing on a better understanding of the performance of the Aircraft Anti-Skid Brake System (ASBS) on contaminated runway surfaces.
7/18/2012	Test & Evaluation Services Division	12-CRDA-0286	Selex Systems Integration, Inc.	7/14/2015	5/22/2017	Testing and research will be conducted to study the overall impact to the spectrum congestion and the feasibility of utilizing data received by the Automatic Dependent Surveillance Broadcast (ADS-B) Radio Stations to reduce that congestion.
1/30/2014	Center Operations Division	13-CRDA-0288	The Richard Stockton College of New Jersey	1/30/2014	1/30/2017	Facilitate cooperative field and laboratory research projects that address wildlife, natural resource, and ecological management needs through the use of geospatial technologies and high-definition surveying scanning tools.
11/29/2012	Laboratory Services Division	13-CRDA-0289	The Boeing Company	6/23/2014	11/29/2017	Technical evaluation of FAA Next Generation (NextGen) Air Transportation System concepts and other mutually beneficial aviation research.
6/24/2013	Aviation Research Division	13-CRDA-0292	ESCO-Zodiac	11/4/2013	6/24/2017	The FAA and Zodiac Aerospace are conducting joint research under a CRDA to evaluate performance of Aircraft Anti-Skid Brake Systems (ASBS) when stopping on contaminated (low friction) runway surfaces.
9/29/2014	Engineering Development Services Division	14-CRDA-0295	FedEx	9/29/2014	9/30/2024	Addresses NextGen surface initiatives to evaluate the viability and benefits of new concepts and applications in an operational environment. Evaluates Surface Decision Support System (SDSS) and Non-Movement Area (NMA) surveillance.
11/4/2013	Aviation Research Division	13-CRDA-0296	Ametek Aerospace and Defense	11/4/2013	11/4/2019	Provide access to testing equipment, technical expertise and setups for prototype testing of Electronic Power Distribution Systems (EPDS). This technology is currently displacing standard electromechanical devices that have been used for years. The unique testing facilities here at William J Hughes Technical Center (WJHTC) will provide insight into how this technology will perform under abnormal conditions in an aircraft.
7/25/2014	Aviation Research Division	14-CRDA-0297	DFW	7/25/2014	7/25/2019	The objective of this partnership is to provide a mechanism for the conduct of research and exploratory development efforts in aircraft rescue and firefighting. The collaboration will increase opportunities for outcomes that will be beneficial to the FAA and Dallas Fort Worth (DFW) as resources are maximized through the joint use of essential one-of-a kind environmentally acceptable live fire research facilities.
4/29/2014	Aviation Research Division	14-CRDA-0298	Astronics AES	4/29/2014	4/29/2020	The Objectives of this Agreement are to provide access to testing equipment, technical expertise and setups for prototype testing of solid state power control devices. This technology is currently displacing standard electromechanical devices that have been used for years.

Active Cooperative Research and Development Agreements (CRDAs) in FY 2017						
Executed Date	**FAA R&D Program**	**CRDA Number**	**Industry Partner**	**Period of Performance**		**Subject**
				Start Date	**Stop Date**	
6/6/2014	Aviation Research Division	14-CRDA-0299	Northrop Grumman Systems Corporation	6/6/2014	6/5/2020	Northrop Grumman and the FAA intend to perform mutually beneficial extensive research to produce the data, information, and characteristics required for the development of UAS standards, certification criteria and procedures for routine flight operations. These activities will provide the WJHTC with platforms for testing UAS capabilities and airspace integration strategies in controlled environments.
10/9/2015	NAS Information Systems Security	15-CRDA-0303	Raytheon	10/9/2015	10/9/2017	The FAA NISSE team and RTCS will work in cooperation supplying their own unique portion of talent, resources, and hardware to develop a version of the commercial of the shelf product (COTS) Security Blanket for the IBM AIX platform.
12/15/2014	Aviation Research Division	14-CRDA-0304	Shell Global Solutions (US), Inc.	12/15/2014	5/15/2020	This agreement supports testing unleaded fuels admitted into the FAA testing program under the FAA Solicitation DTFACT-13-R-00015.
11/4/2014	Aviation Research Division	14-CRDA-0305	Swift Fuels, LLC	11/4/2014	4/4/2020	This agreement supports testing unleaded fuels admitted into the FAA testing program under the FAA Solicitation DTFACT-13-R-00015.
10/1/2014	Aviation Research Division	15-CRDA-0306	Total Marketing Services	10/1/2014	3/1/2020	This agreement supports testing unleaded fuels admitted into the FAA testing program under the FAA Solicitation DTFACT-13-R-00015.
5/28/2015	NextGen R&D Integration Division	15-CRDA-0307	Rockwell Collins	5/28/2015	5/28/2017	The fundamental test objective is proving the basic feasibility to use a small form factor radio in a composite Small Unmanned Aircraft System (sUAS) airframe at point-to- point (P2P) ranges that allow flexible employment of sUAS.
5/15/2015	Aviation Research Division	15-CRDA-0308	Rowan University	5/15/2015	5/15/2018	Mutual exchange of general information and relevant research results on state-of-the-art airport pavement and safety topics which is further described in the attached Obligation of the Parties.
10/21/2015	Aviation Safety-Flight Standards Service	15-CRDA-0309	Burlington Northern Santa Fe Railway	10/21/2015	10/19/2018	The safety of airspace and railway operations is critical to government and industry. The FAA and BNSF agree to collaborate to develop technologies that will enhance the safe integration of UAS into the NAS, including small UAS operations beyond visual line of sight, detect and avoid technologies, and unique inspection methods.
8/12/2015	Aviation Research Division	15-CRDA-0310	ALCOA/Arconic	8/12/2015	8/12/2019	In partnership with Alcoa, conduct a full-scale test using the FAA's Full- Scale Aircraft Structural Test Evaluation and Research (FASTER) lab on the next generation advanced metallic fuselage structure to access durability and damage tolerance of emerging technologies including unitized welded structure, new metallic alloys (aluminum -lithium), and hybrid construction.

Active Cooperative Research and Development Agreements (CRDAs) in FY 2017						
Executed Date	FAA R&D Program	CRDA Number	Industry Partner	Period of Performance		Subject
				Start Date	Stop Date	
10/1/2015	Aviation Research Division	15-CRDA-0312	Kongsberg Aeronautical Information Services	10/1/2015	9/29/2017	The Kongsberg Safety Systems AS and the FAA's Terminal Area Safety Research Program will collaboratively evaluate the application of Kongsberg's patent technology to report real-time runway friction conditions. The technical validity and process complexity of the developed method/technique will be demonstrated with flight data provided by Kongsberg and its partner United Airline for all potential runway surface conditions and B737 configurations.
6/12/2015	Airspace Policy & Regulation Group	15-CRDA-0313	Precision Hawk USA, Inc.	6/12/2015	6/12/2018	The FAA and PrecisionHawk USA Inc. agree to collaborate to develop technologies that will enhance the safe integration of UAS into the NAS, including sUAS operations beyond visual line of sight/extended visual line of sight, detect and avoid technologies, UAS tracking technologies, UAS airspace management technologies, and unique certification methods.
10/6/2015	Flight Standards Service - Unmanned Aircraft systems (UAS) Integration	16-CRDA-0316	CACI	10/6/2015	10/6/2017	UAS NAS integration. The purpose of this CRDA is to serve as a mechanism to safely explore procedures and processes in and around the FAA's airport environment to identify rogue Unmanned Aircraft (UA)/UAS and Pilot in Command (PIC).
6/16/2016	Aviation Research Division	16-CRDA-0317	ATECH Inc.	6/16/2016	6/15/2018	This agreement establishes an official agreement between the FAA and engineered material arresting system (EMAS) manufacturer that is needed in the modeling, testing, evaluation, data analysis, and technical monitoring to develop an EMAS system that meets FAA Advisory Circular 150-5220-22b. The EMAS manufacturer will provide reports to the FAA to review and comment during their research and development.
11/20/2015	Technology Development & Prototyping Division	16-CRDA-0318	Rowan University	11/20/2015	11/20/2017	The FAA's Modeling and Simulation (M&S) Branch (ANG-C55) will technical transfer to Rowan Engineering Department several algorithms and associated software tools for their incorporation into classroom and/or engineering clinic student projects.
5/5/2016	Technology Development & Prototyping Division	16-CRDA-0319	Stockton University	2/5/2016	2/2/2018	The FAA's Modeling and Simulation Branch and Stockton University will collaborate to enhance the simulation and analysis process used to perform NextGen research.
6/30/2016	Engineering Development Services Division	16-CRDA-0321	Honeywell International	6/30/2016	6/28/2019	This CRDA will allow for the exchange of equipment and data between Honeywell Int'l (HI) and the FAA with the goal of supporting final validation work for the draft International Civil Aviation Organization (ICAO) GAST-D (GBAS Approach Service Type D) Standards and Recommended Practices (SARPS) and any additional data
6/16/2016	Engineering Development Services Division	16-CRDA-0322	R Cubed Engineering	6/16/2016	6/15/2018	The ANG-C33 branch will utilize its resources to evaluate, understand and document the performance of the R Cubed's Severe Weather Avoidance Procedure (SWap) units. R Cubed will research performance capabilities of small commercially available UAS and develop realistic flight scenarios.

Active Cooperative Research and Development Agreements (CRDAs) in FY 2017						
Executed Date	FAA R&D Program	CRDA Number	Industry Partner	Period of Performance		Subject
				Start Date	Stop Date	
3/15/2016	Aviation Research Division	16-CRDA-0323	Genesys Aerosystems	3/15/2016	3/16/2018	To develop regulatory guidance or the certification of fly by wire advanced flight control systems (AdFC). The FAA needs to understand the changes, from a practical application, of in-flight performance related to these new AdFC. As such, the FAA will conduct AdFC tests to determine pilot response to various AdFC configurations.
3/15/2016	Laboratory Services Division	16-CRDA-0324	ASB Avionics LLC	3/16/2016	3/16/2018	The FAA Technical Center Flight Test Program will provide the aircraft platform and support for ASB Avionics LLC to achieve Supplement Type Certification of AMLCD EFIS displays as direct replacements for existing Cathode Ray Tube (CRT) displays.
9/6/2016	Aviation Safety-Flight Standards Service	16-CRDA-0325	CNN, Inc.	9/6/2016	9/6/2018	This CRDA will support one of three Focus Areas within the UAS Pathfinder Program announced publicly by the Federal Aviation Administration (FAA) Administrator on May 6, 2015. UAS Pathfinder Focus Area One (FA1) is a
4/20/2016	Engineering Development Services Division	16-CRDA-0326	GSSL, Inc. dba Near Space Corporation	4/20/2016	4/20/2018	NSC to provide a Garmin GDL-88 receiver to be mated with a ANG- C33 NRSR (NextGen Remote Surveillance Receiver) single board computer system for the purpose of providing ADS-B data to the ground in the Tillamook Valley. The data feed will be incorporated into the Real Time Tracking System (RTTS) feed for NSC to monitor their own flight activities. The resulting data will be able to provide continuous ADS-B data sets for platform flight paths from the surface through altitudes up to 120kft.
8/1/2016	Technology Development & Prototyping Division	16-CRDA-0327	AgentFly Technologies s.r.o.	8/1/2016	8/1/2019	The AgentFly system development was supported by several FAA contracts. The AgentFly system is currently used by the FAA Tech Center and is planned to be further enhanced and used widely for different projects and studies. This CRDA is to support teams in using AgentFly and to exchange data to improve AgentFly functions and performance for specific use in the FAA Tech Center.
5/9/2016	Flight Standards Service - Unmanned Aircraft systems (UAS) Integration	16-CRDA-0329	Gryphon Sensors, LLC	5/9/2016	5/9/2018	The purpose of this CRDA is to serve as a mechanism to safely explore procedures and processes in and around the FAA's airport environment(s) to identify errant or hostile Unmanned Aircraft Systems (UAS) consisting of the Unmanned Aircraft (UA) and Pilot-in-Command (PIC).
6/16/2016	Engineering Development Services Division	16-CRDA-0330	uAvionix	6/16/2016	6/15/2018	uAvioniX and ANG-C33 will collaborate to test the performance of the low SWap transceivers. The ANG-C33 branch will utilize the GPS simulator and Virtual Target Generator in the ESTL to evaluate and understand the true performance of the low SWaP units.
5/9/2016	Flight Standards Service - Unmanned Aircraft systems (UAS) Integration	16-CRDA-0332	Liteye Systems, Inc.	5/9/2016	5/9/2018	The purpose of this CRDA is to serve as a mechanism to safely explore procedures and processes in and around the FAA's airport environment(s) to identify errant or hostile Unmanned Aircraft Systems (UAS) consisting of the Unmanned Aircraft (UA) and Pilot-in-Command (PIC).
5/9/2016	Flight Standards Service - Unmanned Aircraft systems (UAS) Integration	16-CRDA-0333	Sensofusion	5/9/2016	5/9/2018	The purpose of this CRDA is to serve as a mechanism to safely explore procedures and processes in and around the FAA's airport environment(s) to identify errant or hostile Unmanned Aircraft Systems (UAS) consisting of the Unmanned Aircraft (UA) and Pilot-in-Command (PIC).

Active Cooperative Research and Development Agreements (CRDAs) in FY 2017						
Executed Date	FAA R&D Program	CRDA Number	Industry Partner	Period of Performance		Subject
				Start Date	Stop Date	
6/3/2016	Laboratory Services Division	16-CRDA-0334	Pentagon Performance, Inc.	6/30/2016	6/29/2018	To cooperatively develop a proof-of- concept that measures the suitability, effectiveness, efficiency, and safety of the Smart Airport Landing System (SALS) and coordinate the completion of a Safety Management Systems (SMS) Study if applicable and/or feasible.
8/1/2016	Technology Development & Prototyping Division	16-CRDA-0335	Fairfield University	8/1/2016	8/1/2018	The FAA's Modeling and Simulation (M&S) Branch (ANG-C55) will technical transfer to Fairfield University School of Engineering several algorithms and associated software tools for their incorporation into classroom and/or engineering student projects. The collaboration is envisioned to generate new and creative solutions to determine how new features and capabilities could be developed and enhance these FAA M&S tools.
9/6/2016	Aviation Research Division	16-CRDA-0336	Astronics Corporation, MaxViz	9/6/2016	9/6/2018	To reduce the fatal accident rate associated with helicopter operations, the FAA is undertaking a campaign to encourage increased use of Instrument Flight Rules, primarily in adverse weather conditions and for specific helicopter mission segments.
8/16/2016	Aviation Research Division	16-CRDA-0338	Afton Chemical Corp. Mix-Viz	8/16/2016	8/13/2021	The FAA WJHTC is undergoing extensive R, D, T&E testing on alternative unleaded aviation gasolines. This parallels that work and is for the testing of a potential unleaded replacement fuel.
10/28/2016	Aviation Research Division	16-CRDA-0339	Livermore Software Tech.	10/28/2016	10/28/2020	This CRDA will help transition research products into public use as part of the commercial LS-DYNA product that industry is using for the analysis.
11/16/2016	Technology Development & Prototyping Division	16-CRDA-0340	Rutgers	11/16/2016	11/15/2019	The FAA's Modeling and Simulation (M&S) Branch (ANG-C55) and Separation Standards and Analysis Branch (ANG-E61) will conduct a technical transfer to Rutgers School of Engineering (SoE) of several algorithms and associated software tools for their incorporation into classroom and/or senior design projects.
1/13/2017	Laboratory Services Division	17-CRDA-0343	Rockwell Collins	1/13/2017	1/13/2022	This CRDA will provide the FAA with an advanced research capability to study helicopter operations including reduced visibility all weather operations, flight maneuvers near the edge of the operating envelope, and fly-by-wire concepts
1/20/2017	Technology Development & Prototyping Division	17-CRDA-0344	Rowan University	1/20/2017	1/18/2019	The FAA's Modeling and Simulation (M&S) Branch (ANG-C55) will technical transfer to Rowan University College of Science & Mathematics several algorithms and associated software tools for their incorporation into classroom and/or engineering student projects.
5/9/2017	Aviation Research Division	17-CRDA-0345	Thales	5/29/2017	5/8/2020	This project examines how the FAA can allow helicopter operators to utilize new technologies present in the latest generation of Enhanced Vision Systems (EVS)/Synthetic Vision System (SVS)/Combined Vision Systems (CVS)/Head Worn Display (HWD)/Head Down Display (HDD) systems available on the market today to enhance safety for VFR and IFR helicopter operations.
6/9/2017	Flight Standards Service - Leadership Development Branch	17-CRDA-0348	George Mason University	6/9/2017	6/7/2019	To conduct research to study the effects of how government organizations and people progress through change.

Active Cooperative Research and Development Agreements (CRDAs) in FY 2017						
Executed Date	FAA R&D Program	CRDA Number	Industry Partner	Period of Performance		Subject
				Start Date	Stop Date	
9/7/1994	Aviation Research Division	94-CRDA-0065	Engineered Arresting Systems Corporation	9/7/2014	9/7/2018	The FAA and ZASA (formerly ESCO) continue to learn, refine, and improve upon the safety, development, and procedures of soft ground arresting systems call EMAS for civil airports.
7/29/1996	Aviation Research Division	96-CRDA-0097	The Boeing Company	7/29/2011	7/29/2021	Research on real-time real-weight pavement testing at the National Aviation Pavement Test Facility to determine wheel interaction effects followed by trafficking test to develop pavement failure criteria.

The table below details the FAA's Centers of Excellence (COE) grants.

COE Grants in FY 2017					
Period of Performance		Grant Number	Grant Title	Recipient Institution	Award Amount
Award Date	End Date				
10/14/2016	1/10/1900	15-C-CST-UTMB-11	Admin. Support Services	The Univ of Texas Medical Branch at Galveston	$ 7,665.00
10/18/2016	10/18/2017	15-C-CST-UTMB-008	Task 308: Suborbital SFP Anxiety Assessment	University of Texas Medical Branch at Galveston	$ 49,170.00
10/18/2016	10/17/2017	15-C-CST-UTMB-009	Task 309: Suborbital Pilot Assessment	University of Texas Medical Branch at Galveston	$ 71,500.00
10/18/2016	10/18/2017	15-C-CST-UTMB-010	Task 310: Increasing Cabin Survivability in Commercial Spacecraft	University of Texas Medical Branch at Galveston	$ 24,334.00
10/20/2016	10/19/2017	15-C-CST-UC-007	TASK 186: MITIGATE THREATS THROUGH SPACE ENVIROMENT MODELING AND PREDICTIONS	Regents of the University of Colorado	$ 63,500.00
10/24/2016	10/23/2017	13-C-AJFE-GIT-028	TRAVEL SUPPORT FOR the FAA NJFCP PROGRAM	Georgia Tech Research Corporation	$ 55,000.00
10/25/2016	8/31/2017	12-C-GA-FIT-16	Project 20: General Aviation Runway Incursions	Florida Institute of Technology	$ 8,700.00
11/1/2016	6/30/2017	12-C-GA-OSU-33	Project 17 - LED Lighting: Hot/Cold Performance Testing	The Ohio State University	$ 115,298.00
11/15/2016	11/30/2016	15-C-UAS-OSU-08	Surveillance Criticality for SAA	The Ohio State University	$ 24,962.00
11/28/2016	3/31/2018	13-C-AJFE-GIT-29	Paramedic Uncertainty Assessment for AEDT 2b	Georgia Tech Research Corporation	$ 80,000.00
11/29/2016	7/31/2017	12-C-GA-GIT-14	Rotorcraft ASIAS	Georgia Tech Research Corporation	$ 89,255.50
12/6/2016	5/31/2017	15-C-CST-NMT-10	Nitrous Oxide Composite Tank Testing	New Mexico Institute of Mining and Technology	$ 100,000.00
12/8/2016	8/31/2017	12-C-AM-UW-32	Improving Adhesive Bonding Through Surface Characterization	University of Washington	$ 75,000.00
12/8/2016	6/30/2017	12-C-GA-ISU-13	LED Lighting- Hot/Cold Performance Testing	Iowa State University of Science and Tech	$ 119,370.00
12/8/2016	8/31/2017	12-C-GA-TEES-15	LED Lighting: Hot/Cold Performance Testing	Texas A&M Engineering Experiment Station	$ 115,298.00
12/28/2016	9/30/2017	12-C-GA-FIT-17	Airport Safety Database and Analyses	Florida Institute of Technology	$ 50,000.00
12/28/2016	12/31/2017	12-C-GA-GIT-15	General Aviation 2030- GA Exploratory Analyses	Georgia Tech Research Corporation	$ 99,999.00
12/28/2016	12/31/2017	12-C-GA-ISU-14	FAA Pavement Marking Presence Tool	Iowa State University of Science and Tech	$ 65,000.00
12/28/2016	12/31/2017	12-C-GA-PU-49	General Aviation 2030- GA Exploratory Analyses	Purdue University	$ 49,994.00
12/28/2016	8/31/2017	13-C-AJFE-UNC-06	Development of Aviation Air Quality Tools for Airport-Specific Impact Assessment: Air Quality Modeling	The Univ of North Carolina at Chapel Hill	$ 212,494.00

COE Grants in FY 2017					
Period of Performance		Grant Number	Grant Title	Recipient Institution	Award Amount
Award Date	End Date				
3/6/2017	12/31/2017	12-C-GA-PU-50	Drop-In Aviation Fuel Fire Safety	Purdue University	$ 117,985.00
3/7/2017	12/31/2017	12-C-AM-WISU-069	Dynamic Response of Composite Structures Subjected to Blast Loading-Phase III	Wichita State University	$ 270,000.00
3/8/2017	3/9/2018	12-C-AM-UW-033	Certification of Discontinuous Fiber Composite Material Forms for Aircraft Structures	University of Washington	$ 224,000.00
3/17/2017	2/28/2017	15-C-UAS-MTSU-05	UAS Human Factors Considerations	Montana State University	$ 10,650.00
3/21/2017	8/31/2018	13-C-AJFE-GIT-30	Parametric Uncertainty Assessment for AEDT 2b	Georgia Tech Research Corporation	$ 300,000.00
3/28/2017	8/31/2017	15-C-UAS-MTSU-06	Human Factors Considerations	Montana State University	$ 36,407.00
3/29/2017	8/31/2017	15-C-UAS-ERAU-8	Human Factors Considerations	Embry-Riddle Aeronautical University	$ 19,869.00
3/29/2017	8/31/2017	15-C-UAS-KSU-06	Human Factors Considerations of UAS Procedures & Controls Stations	Kansas State University	$ 4,590.00
3/29/2017	8/31/2017	15-C-UAS-NMSU-08	Human Factors Considerations	The Regents of New Mexico State Univ-MSC PSL	$ 6,000.00
3/29/2017	8/31/2017	15-C-UAS-UND-07	Human Factors Considerations of UAS Procedures & Control Stations	University of North Dakota	$ 5,282.00
3/30/2017	3/31/2018	12-C-GA-GIT-018	National General Aviation Flight Information Database (SAGA)	Georgia Tech Research Corporation	$ 70,000.00
4/3/2017	4/2/2017	15-C-UAS-MSU-021	Performance Analysis of UAS Detection Technologies Operating in Airport Environments	Mississippi State University	$ 50,000.00
4/3/2017	4/2/2018	15-C-UAS-NMSU-09	Performance Analysis of UAS Detection Technologies Operating in Airport Environments	The Regents New Mexico State University	$ 50,000.00
4/5/2017	4/4/2018	15-C-UAS-UND-05	Performance Analysis of UAS Detection Technologies Operating in Airport Environments	University of North Dakota	$ 50,000.00
4/6/2017	2/8/2017	15-C-CST-UTMB-12	Admin Support Services	University of Texas Medical Branch At Galveston	$ 12,190.00
4/11/2017	8/31/2017	15-C-UAS-MSU-22	Human Factors Considerations	Mississippi State University	$ 8,700.00
4/12/2017	8/31/2017	15-C-UAS-UAF-01	Human Factors Considerations	University of Alaska-Fairbanks	$ 6,000.00
4/13/2017	12/31/2017	12-C-AM-UCSD-10	Impact Damage Formation on Composite Aircraft Structures	The Regents of the Univ of Calif,UC San Diego	$ 65,000.00
4/14/2017	5/31/2018	15-C-CST-UFL-02	DebriSat Panel Preparation and Fragment Characterization	University of Florida	$ 75,000.00
5/3/2017	8/31/2017	12-C-AM-WISU-070	Composite Awareness for Aviation Safety Inspectors	Wichita State University	$ 40,000.00
5/7/2017	5/7/2020	15-C-UAS-MSU-025	Performance Analysis of UAS Detection Technologies Operating in Airport Environments	Mississippi State University	$ 50,000.00
5/7/2017	5/7/2020	15-C-UAS-NMSU-10	Performance Analysis of UAS Detection Technologies Operating in Airport Environments	The Regents of New Mexico State University	$ 50,000.00
5/7/2017	5/7/2020	15-C-UAS-UND-09	Performance Analysis of UAS Detection Technologies Operating in Airport Environments	University of North Dakota	$ 50,000.00
5/17/2017	5/17/2018	15-C-UAS-WISU-04	UAS Airborne Collision Severity Peer Review	Wichita State University	$ 4,647.00
5/19/2017	5/19/2018	15-C-UAS-MTSU-07	UAS Airborne Collision Severity Peer Review	Montana State University	$ 2,379.00
5/31/2017	5/31/2018	15-C-CST-NMT-011	OMIS License	New Mexico Institute of Mining and Technology	$ 50,000.00
6/29/2017	6/30/2018	12-C-GA-PU-055	Safety Analysis for General Aviation	Purdue University	$ 121,575.00
6/30/2017	6/30/2018	15-C-CST-SU-08	Advanced 4D Special Use Airspace Research	Brd of Trustees of Leland Stanford Jr Univ	$ 5,000.00

COE Grants in FY 2017					
Period of Performance		Grant Number	Grant Title	Recipient Institution	Award Amount
Award Date	End Date				
7/7/2017	7/6/2019	12-C-GA-PU-057	Heated Pavements - Phase Change Materials	Purdue University	$ 210,000.00
7/7/2017	9/30/2018	13-C-AJFE-BU-011	Community Measurement of Aviation Emission Contribution of Ambient Air Quality	Trustees of Boston University, BUMC	$ 270,000.00
7/7/2017	5/31/2018	15-C-CST-UTMB-13	COE CST Administrative Support	University of Texas Medical Branch At Galveston	$ 161,758.00
7/11/2017	6/30/2018	12-C-GA-ISU-019	Heated Pavements	Iowa State University of Science and Technology	$ 272,247.00
7/14/2017	8/31/2018	13-C-AJFE-BU-012	Cardiovascular Disease and Aircraft Noise Exposure	Trustees of Boston University, BUMC	$ 340,000.00
7/14/2017	9/30/2018	13-C-AJFE-WASU-12	Administer Program Office for Center of Excellence for Alternative Jet Fuels and Environment – 01	Washington State University	$ 400,002.00
7/17/2017	5/31/2018	12-AM-WISU-075	FAA Research Requirement on Lightning Strike of Composites	Wichita State University	$ 124,287.00
7/17/2017	9/30/2018	12-C-AM-UU-017	Development of a Building Block Approach for Crashworthiness Testing of Composites	The University of Utah	$ 75,000.00
7/17/2017	8/31/2018	12-C-AM-WISU-073	Environmental Factor Influence on Composite Design and Certification	Wichita State University	$ 150,000.00
7/17/2017	8/31/2018	12-C-AM-WISU-074	Damage Tolerance Testing and Analysis Protocols for Full-Scale Composite Airframe Structures under Repeated Loading	Wichita State University	$ 225,000.00
7/17/2017	3/13/2018	16-C-TTHP-WISU-008	Annual Report Preparation and Information Dissemination Yr 1	Wichita State University	$ 94,400.00
7/17/2017	8/11/2018	16-C-TTHP-WISU-009	Exec Business Management, Annual Report Preparation and Information Dissemination, Sponsor Relations, and Coordination Activities Year 2	Wichita State University	$ 76,000.00
7/19/2017	7/31/2018	12-C-GA-GIT-019	Rotorcraft ASIAS	Georgia Tech Research Corporation	$ 149,526.00
7/19/2017	8/31/2018	13-C-AJFE-UNC-007	Development of Aviation Air Quality Tools for Airport Specific Impact Assessment Air Quality Modeling	University of North Carolina at Chapel Hill	$ 200,390.00
7/19/2017	9/30/2018	13-C-AJFE-UPENN-6	Pilot Study on Aircraft Noise and Sleep Disturbance	The Trustees of the Univ of Pennsylvania	$ 135,306.00
7/24/2017	8/30/2018	13-C-AJFE-GIT-031	Aircraft Technology Modeling and Assessment	Georgia Tech Research Corporation	$ 562,500.00
7/25/2017	8/31/2018	13-C-AJFE-PU-018	Aircraft Technology Modeling and Assessment	Purdue University	$ 107,067.00
7/26/2017	8/31/2018	13-C-AJFE-MIT-031	Analytical Approach for Quantifying Noise from Advanced Operational Procedures	Massachusetts Institute of Technology	$ 250,000.00
7/26/2017	8/31/2018	13-C-AJFE-MIT-032	Development of NAS Wide and Global Rapid Aviation Air Quality	Massachusetts Institute of Technology	$ 250,000.00
7/31/2017	5/31/2018	15-C-CST-UC-08	Human Factors - Vehicle Design Focus	University of Colorado Boulder	$ 81,581.00
7/31/2017	12/31/2017	15-C-CST-UC-09	RA3 Workshop Event	University of Colorado Boulder	$ 12,486.00
7/31/2017	7/31/2018	15-C-CST-UCF-006	Robust and Low-Cost LED Absorption Sensor	University of Central Florida	$ 50,000.00
8/1/2017	9/30/2018	12-C-AM-UU-015	Development and Evaluation of Fracture Mechanics Test Methods for Sandwich Composites: Notch Sensitivity & Damages Assessment	The University of Utah	$ 75,000.00
8/1/2017	8/31/2018	12-C-AM-UW-034	Improving Adhesive Bonding of Composites Through Surface Characterization	University of Washington	$ 75,000.00
8/1/2017	8/31/2018	12-C-AM-WiSU-071	Wind Tunnel Testing Services - Swept Wing	Wichita State University	$ 35,840.00

COE Grants in FY 2017					
Period of Performance		Grant Number	Grant Title	Recipient Institution	Award Amount
Award Date	End Date				
8/1/2017	8/31/2018	13-C-AJFE-PU-019	Techno-Economic and Lifecycle Analysis of Alternative Aviation Biofuels Supply Chains	Purdue University	$ 400,000.00
8/1/2017	7/31/2018	13-C-AJFE-PU-020	Quantifying Uncertainties in Predicting Aircraft Noise in Real-World	Purdue University	$ 90,000.00
8/1/2017	9/30/2018	13-C-AJFE-UH-008	Alternative Jet Fuel Supply Chain Analysis	University of Hawaii	$ 125,000.00
8/1/2017	7/31/2018	13-C-AJFE-UTENN-6	Techno-Market Analysis of US Biorefinery Supply Chains from Feedstock to Alternative Jet Fuels	University of Tennessee	$ 225,000.00
8/1/2017	7/31/2018	13-C-AJFE-WaSU-013	Alternative Jet Fuel Supply Chain Analysis	Washington State University	$ 396,037.00
8/1/2017	9/30/2018	15-C-UAS-MTSU-08	STEM II	Montana State University	$ 45,000.00
8/1/2017	1/31/2020	15-C-UAS-NMSU-12	STEM II	The Regents of New Mexico State University	$ 15,000.00
8/1/2017	6/9/2019	15-C-UAS-NMSU-13	Minority Outreach - UAS as a STEM Minority Outreach	The Regents of New Mexico State Univ-MSC PSL	$ 33,000.00
8/1/2017	1/31/2020	15-C-UAS-UAF-02	STEM II	University of Alaska-Fairbanks	$ 44,982.00
8/2/2017	5/31/2018	15-C-CST-NMSU-02	Space Object Database	The Regents of New Mexico State University	$ 99,039.00
8/7/2017	9/30/2018	12-C-AM-UU-016	Durability of Adhesively Bonded Joints for Aircraft Structures	The University of Utah	$ 75,000.00
8/8/2017	9/30/2018	12-C-AM-OSU-008	Failure of Notched Laminates Under Out-of-Plane Bending	Oregon State University	$ 80,000.00
8/8/2017	8/14/2018	13-C-AJFE-GIT-032	Noise Power Distance Re-evaluation	Georgia Tech Research Corporation	$ 75,000.00
8/10/2017	12/31/2019	13-C-AJFE-MST-010	ReExamination of Engine to Engine PM Emissions variability using an ARP Reference Sampling and Measurement System	The Curators of the Univ of Missouri - Rolla	$ 725,500.00
8/10/2017	9/30/2018	15-C-UAS-MSU-026	ASSURE Program Management	Mississippi State University	$ 1,148,662.00
8/14/2017	8/14/2018	12-C-AM-FIU-008	Effect of Surface Contamination on Composite Bond Integrity and Durability	Florida International University	$ 75,000.00
8/14/2017	12/31/2018	12-C-AM-WiSU-072	Development and Safety Management of Composite Certification Guidance	Wichita State University	$ 176,000.00
8/14/2017	8/15/2018	12-C-AM-WSU-007	Durability of Bonded Aerospace Structures	Washington State University	$ 72,994.00
8/14/2017	8/31/2018	13-C-AJFE-GIT-033	CLEEN II System Level Assessment	Georgia Tech Research Corporation	$ 170,000.00
8/14/2017	11/30/2018	13-C-AJFE-GIT-034	National Jet Fuels Combustion Program _Advanced Combustion Area # 3	Georgia Tech Research Corporation	$ 206,000.00
8/14/2017	8/14/2018	13-C-AJFE-GIT-035	Takeoff /Climb Analysis to Support AEDT APM Development	Georgia Tech Research Corporation	$ 75,000.00
8/14/2017	8/31/2018	13-C-AJFE-MIT-033	Alternative Jet Fuel Supply Chain Analysis	Massachusetts Institute of Technology	$ 475,000.00
8/14/2017	8/31/2018	13-C-AJFE-MIT-034	Naphthalene Removal Assessment	Massachusetts Institute of Technology	$ 290,000.00
8/14/2017	8/31/2018	13-C-AJFE-MIT-035	Surface Analysis to Support AEDT APM Development	Massachusetts Institute of Technology	$ 75,000.00
8/14/2017	8/31/2018	13-C-AJFE-MIT-036	Analysis to Support the Development of an Engine nvPM Emissions Standard	Massachusetts Institute of Technology	$ 200,000.00
8/14/2017	8/31/2018	13-C-AJFE-MIT-037	Improving Climate Policy Analysis Tools	Massachusetts Institute of Technology	$ 150,000.00
8/14/2017	12/31/2018	13-C-AJFE-OSU-005	Turbulent Flame Speed of Conventional and Alternative Jet Fuels Project	Oregon State University	$ 59,000.00
8/14/2017	9/30/2018	13-C-AJFE-PSU-031	Alternative Jet Fuel Supply Chain Analysis	Pennsylvania State University	$ 234,424.00

COE Grants in FY 2017					
Period of Performance		Grant Number	Grant Title	Recipient Institution	Award Amount
Award Date	End Date				
8/14/2017	12/31/2018	13-C-AJFE-PSU-033	Acoustical Model of Mach Cut-off	Pennsylvania State University	$ 150,000.00
8/14/2017	7/31/2018	13-C-AJFE-PSU-035	FAA Aviation Sustainability center (ASCENT) Supersonics community Impact	Pennsylvania State University	$ 71,000.00
8/14/2017	7/31/2018	13-C-AJFE-PSU-036	Outreach Project	Pennsylvania State University	$ 25,000.00
8/14/2017	8/31/2018	13-C-AJFE-PSU-037	Rotorcraft Noise Abatement Procedures Development	Pennsylvania State University	$ 150,000.00
8/14/2017	8/31/2019	13-C-AJFE-UD-016	Alternative Jet Fuels test and Evaluation	University of Dayton Research Institute	$ 999,512.00
8/14/2017	9/30/2018	13-C-AJFE-UD-017	National Jet Fuels Combustion Program - Area 7	University of Dayton Research Institute	$ 192,997.00
8/14/2017	9/30/2018	13-C-AJFE-UI-018	Evaluation of FAA Climate Tools	Board of Trustees of the Univ of Illinois	$ 100,000.00
8/14/2017	8/14/2018	13-C-AJFE-UI-019	Alternative Fuels Test Database Library	Board of Trustees of the Univ of Illinois	$ 165,000.00
8/14/2017	8/31/2018	15-C-CST-UC-010	CubeSat Cluster Deployment Tracking	University of Colorado Boulder	$ 75,000.00
8/14/2017	1/31/2020	15-C-UAS-UCD-001	STEM II	University of California-Davis	$ 45,000.00
8/14/2017	3/1/2019	16-C-TTHP-ERAU-17	ATC Scenario Training Technology (ASTT)	Embry-Riddle Aeronautical University	$ 350,000.00
8/14/2017	8/11/2018	16-C-TTHP-OK-017	COE TTHP Technical Support	The University of Oklahoma	$ 120,000.00
8/15/2017	8/27/2018	15-C-CST-FSU-05	High Temperature, Optical Sapphire Pressure Sensors	Florida State University	$ 49,200.00
8/15/2017	8/31/2018	15-C-CST-SU-010	Probabilistic Debris Model Development	LELAND STANFORD JUNIOR UNIVERSITY, THE	$ 54,400.00
8/15/2017	7/31/2018	15-C-CST-UCF-007	RA2 Workshop Event	University of Central Florida	$ 13,000.00
8/17/2017	9/30/2018	12-C-GA-FIT-021	Scenario Based Training for Rotorcraft	Florida Institute of Technology	$ 50,000.00
8/17/2017	9/30/2018	12-C-GA-GIT-020	Scenario Based Training for Rotorcraft	Georgia Tech Research Corporation	$ 248,000.00
8/17/2017	7/31/2018	12-C-GA-TEES-019	Human Performance Impacts of Head-Worn Displays for General Aviation, Phase I	Texas A&M Engineering Experiment Station	$ 227,025.00
8/21/2017	9/28/2018	12-C-GA-PU-060	Management and Administration	Purdue University	$ 175,000.00
8/21/2017	3/31/2019	12-C-GA-PU-061	Technology Assessment to Improve Operations Counts at Non-Towered Airports	Purdue University	$ 215,154.00
8/23/2017	11/1/2018	12-C-AM-WISU-076	Certification by Analysis - Structural Crashworthiness	Wichita State University	$ 426,100.00
8/25/2017	12/31/2018	13-C-AJFE-PSU-034	Identification of Noise Acceptance Onset for Noise Certification Standards of Supersonic Airplane	Pennsylvania State University	$ 150,000.00
8/25/2017	7/17/2018	15-C-CST-UTMB-014	Suborbital SFP Anxiety Assessment	University of Texas Medical Branch At Galveston	$ 15,000.00
8/30/2017	9/30/2019	12-C-AM-WISU-077	Composites Materials Handbook	Wichita State University	$ 125,000.00
8/30/2017	7/30/2017	15-C-CST-FSU-06	Optical Measurements of Rocket Nozzle Thrust and Noise	Florida State University	$ 70,500.00
8/30/2017	8/11/2018	16-C-TTHP-ERAU-018	COE TTHP Travel Support - Program Management	Embry-Riddle Aeronautical University	$ 28,000.00
8/30/2017	8/11/2018	16-C-TTHP-ERAU-019	COE TTHP Program Support	Embry-Riddle Aeronautical University	$ 96,000.00
8/30/2017	8/31/2018	16-C-TTHP-ERAU-020	AJW-3 Project #1 Fleet Assessment/Modernization Study	Embry-Riddle Aeronautical University	$ 99,500.00
8/30/2017	4/30/2018	16-C-TTHP-PU-003	Technical Operations: Airway Transportation Systems Specialist Training Analysis	Purdue University	$ 7,967.00
8/30/2017	6/18/2018	16-C-TTHP-WISU-010	Survey and Site Visit Process	Wichita State University	$ 20,000.00
8/31/2017	5/31/2018	15-C-CST-FIT-005	Design and Ops Considerations for Human Space Flight Occupant Safety	Florida Institute of Technology	$ 80,000.00
8/31/2017	7/31/2018	15-C-CST-UCF-008	Composite TPS Material	University of Central Florida	$ 43,970.00
8/31/2017	12/31/2017	15-C-UAS-OSU-09	Secure Command and Control Link with Interference Mitigation	The Ohio State University	$ 80,000.00

COE Grants in FY 2017					
Period of Performance		Grant Number	Grant Title	Recipient Institution	Award Amount
Award Date	End Date				
8/31/2017	6/30/2018	16-C-TTHP-DU-04	Air Traffic and Tech Ops JTA workbooks database	Drexel University	$ 50,000.00
8/31/2017	1/31/2018	16-C-TTHP-ERAU-21	Part 141 Pilot School Model Feasibility Study	Embry-Riddle Aeronautical University	$ 47,500.00
8/31/2017	9/30/2018	16-C-TTHP-ERAU-022	Managing Training Content Including Adaptive Learning Capabilities Using 21st Century Technology	Embry-Riddle Aeronautical University	$ 80,127.00
9/14/2017	8/31/2018	12-C-AM-UW-035	Administration of JAMS-AMTAS Center of Excellence	University of Washington	$ 80,273.00
9/14/2017	12/31/2018	12-C-AM-WISU-078	Administration of JAMS-CECAM Center of Excellence	Wichita State University	$ 75,000.00
9/14/2017	8/31/2018	12-C-GA-PU-062	Weather Technology in the Cockpit Program	Purdue University	$ 352,433.00
9/14/2017	12/31/2018	13-C-AJFE-PU-021	National Jet Fuels Combustion Program: Area #5 Atomization Tests and Models	Purdue University	$ 150,000.00
9/14/2017	12/31/2018	13-C-AJFE-SU-017	Shock Tube and Flow Reactor Studies of the Kinetics of Jet Fuels	Brd of Trustees of Leland Stanford Jr Univ CS	$ 200,000.00
9/14/2017	9/30/2018	16-C-TTHP-IAU-003	Managing Training Content Including Adaptive Learning Capabilities Using 21st Century Technology	InterAmerican University	$ 19,810.00
9/14/2017	6/30/2018	16-C-TTHP-IAU-004	Employee Footprint: 21st Century Approach towards Employee Development	InterAmerican University	$ 15,405.00
9/14/2017	9/30/2018	16-C-TTHP-OK-018	Feasibility Study of Flight Inspection Aided by UAS-Based Sensing and Calibration	The University of Oklahoma	$ 99,998.00
9/14/2017	7/31/2018	16-C-TTHP-OK-019	Creating an Adaptive and Distributed Competency-Based Learning Environment to Develop the Next Generation of Aviation Safety Inspectors	The University of Oklahoma	$ 86,806.00
9/14/2017	7/31/2018	16-C-TTHP-UA-006	Comprehensive Aircraft Fleet Study and System Optimization using Analytical Hierarchy Process and Discrete Event Simulation Modeling	University of Akron	$ 73,197.00
9/14/2017	4/30/2018	16-C-TTHP-WMU-3	Technical Operations: Airway Transportation Systems Specialist Training Analysis	Western Michigan University	$ 27,572.00
9/17/2017	9/30/2018	12-C-AM-WISU-079	Inspection and Teardown of Aged In-Service Bonded Repairs	Wichita State University	$ 774,975.00
9/17/2017	8/30/2019	12-C-AM-WISU-080	Polymer-Based Additive Manufacturing (PBAM) Guidance for Aircraft Design and Certification	Wichita State University	$ 575,000.00
9/17/2017	2/28/2019	12-C-AM-WISU-081	Guidelines for Formulating and Writing Process Control Documents and Process Specifications for Advanced Materials	Wichita State University	$ 250,000.00
9/17/2017	9/30/2018	12-C-AM-WISU-082	Adhesive Bond Qualification Guidance for Aircraft Design and Certification	Wichita State University	$ 675,000.00
9/19/2017	6/30/2018	16-C-TTHP-ERAU-023	Benchmark Premier Technical Training Providers	Embry-Riddle Aeronautical University	$ 99,500.00
9/20/2017	1/31/2019	15-C-UAS-MSU-028	Ground Collision Severity Studies	Mississippi State University	$ 268,243.00
9/20/2017	1/31/2019	15-C-UAS-OSU-010	Ground Collision Severity Studies	The Ohio State University	$ 255,351.00
9/20/2017	1/31/2019	15-C-UAS-UAH-04	Ground Collision Severity Studies	University of Alabama in Huntsville	$ 759,375.00
9/20/2017	1/31/2019	15-C-UAS-WISU-05	Ground Collision Severity Studies	Wichita State University	$ 759,612.00

COE Grants in FY 2017					
Period of Performance		Grant Number	Grant Title	Recipient Institution	Award Amount
Award Date	End Date				
9/20/2017	6/30/2018	16-C-TTHP-OSU-004	Employee Footprint: 21st Century Approach towards Employee Development	The Ohio State University	$ 20,023.00
9/25/2017	6/30/2018	16-C-TTHP-AU-003	Employee Footprint: 21st Century Approach Towards Employee Development	Auburn University	$ 26,952.00
9/30/2017	9/30/2018	12-C-GA-GIT-017	Center of Excellence Student Outreach	Georgia Tech Research Corporation	$ 49,040.00
9/30/2017	9/30/2018	12-C-GA-ISU-016	Center of Excellence Student Outreach	Iowa State University of Science and Technology	$ 6,390.00
9/30/2017	9/30/2018	12-C-GA-PU-054	Center of Excellence Student Outreach	Purdue University	$ 42,396.85
12/31/2017	12/31/2018	13-C-AJFE-PSU-032	Quantifying Uncertainties in Predicting Aircraft Noise in Real-World Situations	Pennsylvania State University	$ 110,000.00

The table below details the FAA's active Interagency Agreements (IAs).

Interagency Agreements (IAs) in FY 2017							
FAA Org	Agreement Type	Agreement Number	Agency (if applicable)	Organization	Period of Performance		Purpose
					Start Date	End Date	
ANG-E2	IA	DTFACT-12-X-00003	DOD	US Air Force Research Laboratory - Tyndall Air Force Base	3/29/2012	2/28/2018	Provide a mechanism for the conduct of research and exploratory development efforts in aircraft rescue and fire fighting.
ANG-E2	IA	DTFACT-12-X-00009	DOE	Department of Energy (DOE)/National Nuclear Security Administration (NNSA)/Sandia Site Office (SSO)	9/30/2012	9/30/2019	Sandia National Labs agreement for research in the areas of maintenance and inspection, structural and health monitoring, and nondestructive evaluation.
ANG-E2	IA	DTFACT-13-X-00003	NASA	Ames Research Center	1/31/2013	1/31/2018	Conduct flight simulator testing of objective motion cueing criteria.
ANG-E2	IA	DTFACT-13-X-00010	DOD	US Naval Air Warfare Center Weapons Division (NAWCWD)	9/24/2013	9/23/2018	Support uncontained engine debris damage assessment modeling.
ANG-E2	IA	DTFACT-14-A-00010	DOD	US Air Force Lifecycle Management Center	8/26/2014	8/25/2019	Conduct research for tasks in the area of airborne systems at Software Engineering Institute (SEI) (Carnegie- Mellon), a Federally Funded Research Development Center.
ANG-E2	IA	DTFACT-14-X-00001	N/A	Smithsonian Institution	4/19/2014	4/18/2019	Identification of bird strike remains through feather and DNA analysis.
ANG-E2	IA	DTFACT-14-X-00003	DOD	US Naval Air Warfare Center	6/13/2014	6/12/2019	Support Metallic Materials Properties Development and Standardization (MMPDS) work.
ANG-E2	IA	DTFACT-14-X-00006	NASA	Johnson Space Center	9/25/2014	9/25/2019	Continue a collaborative procedure to standardize the methods and data used in damage tolerance assessments used in the aerospace industry.
ANG-E2	IA	DTFACT-14-X-00007	USDA	Wildlife Services	6/20/2014	6/20/2018	Conduct research on methods and tools for mitigating wildlife hazards through habitat management.

Interagency Agreements (IAs) in FY 2017							
FAA Org	**Agreement Type**	**Agreement Number**	**Agency (if applicable)**	**Organization**	**Period of Performance**		**Purpose**
					Start Date	**End Date**	
ANG-E2	IA	DTFACT-14-X-00009	DOD	US Army Corps of Engineers (USACE), Engineer Research and Development Center (ERDC)	8/28/2014	9/30/2019	The purpose of this Agreement is to have the FAA and ERDC GSL/CERL work jointly in support of FAA Goals relative to airport pavement research and development, and to share such information in areas of mutual interest.
ANG-E2	IA	DTFACT-15-X-00002	NASA	Glenn Research Center	12/11/2014	12/10/2019	Aircraft icing tasks and super cooled large droplets.
ANG-E2	IA	DTFACT-15-X-00006	NASA	Ames Research Center	7/10/2015	7/9/2019	Conduct rotorcraft advanced flight control research using rotorcraft simulator at NASA Ames to collect rotorcraft data.
ANG-E2	IA	DTFACT-15-X-00007	DOD	US Naval Air Warfare Center	7/16/2015	7/15/2020	Agreement with FAA and DOD Naval Surface Warfare Center Carderrock-Dahlgren Division at the William J. Hughes Technical Center to provide support for the integration of UAS into the NAS.
ANG-E2	IA	DTFACT-16-X-00005	DOD	Naval Air Warfare Center Weapons Division (NAWCWD)	9/24/2016	9/23/2021	Support uncontained engine debris damage assessment modeling. (Note: This new IA was initiated due to difficulty at NAWC accepting another increment under DTFACT-13-X-0010.)
ANG-E2	IA	DTFACT-17-X-80000	NASA	Ames Research Center	2/21/2017	2/20/2021	Conduct joint R&D, testing, and activities related to the development of stable approach criteria
ANG-E2	IA	DTFAWA-14-C-00019 - Annex 15	NASA	Langley Research Center	5/18/2017	5/18/2018	Conduct joint R&D, testing, and activities related to the angle-of-attack devices and indicators.
ANG-E2	IA	Headquarters DTFAWA-10-C-00080 TO #0216TA03	N/A	MITRE CAASD	9/20/2016	10/31/2017	Application of Equivalent Lateral Spacing Operations (ELSO) for Departure Noise Abatement PBN.
ANG-E2	IA	Headquarters DTFAWA-10-C-00080 TO #0216TF01	N/A	MITRE CAASD	9/20/2016	11/30/2017	Runway length evaluations.
ANG-E2	IA	Headquarters DTFAWA-10-C-00080 TO #0216TG01	N/A	MITRE CAASD	9/20/2016	9/30/2018	Hub airport analysis.
ANG-E2	IA	Headquarters DTFAWA-11-X-80007 TO #48	N/A	MIT-LL	5/26/2011	3/21/2020	Conduct Aircraft Systems Information Security Protection effort developed a Safety Risk assessment (SRA) study.
ANG-E3	IA	II-CERCLA—FAA-90101	EPA	Environmental Protection Agency	1992-NPL delisting	N/A	Identify FAA, EPA, and tenant responsibilities per CERCLA (regulatory requirement)
ANG-E5 ANG-E6	IA	TBD	DOD	United States Air Force, Air Force Life Cycle Management Center, Aerospace Management Systems Division, Landing Systems Branch (AFLCMC/HBAB)	TBD	TBD	To attain FAA certification for operation of the D-RAPCON system within the NAS.
ANG-E2	IA	DTFACT-14-X-00004	NASA	Armstrong Flight Research Center	3/25/2014	3/24/2019	Develop safety systems and improve methodologies for certifying general aviation aircraft.

Interagency Agreements (IAs) in FY 2017							
FAA Org	Agreement Type	Agreement Number	Agency (if applicable)	Organization	Period of Performance		Purpose
					Start Date	End Date	
ANG-E2	IA	Headquarters DTFAWA-10-C-00080 TO # 0217CB04	N/A	MITRE CAASD	6/12/2017	12/31/2017	ASIAS NAS Enterprise Repository (NER) NEXTGEN prototyping Network (NPN)
AAM-600	IAA	DTFAAC-17-X-00001	DOD	Naval Medical Research Unit-D	8/24/2016	9/30/2018 to be extended	Modafinil as a countermeasure to fatigue/sleep deprivation research - biomarker discovery
ANG-C6	IA	DTFACT-17-X-80002	NOAA	National Centers for Environmental Prediction (NCEP)	7/1/2017	6/30/2022	Conduct aviation hazard diagnosis and forecast research and development, and Technology Transfer to NCEP.
ANG-C6	IA	DTFACT-15-X-80005	NOAA	National Severe Storms Laboratory (NSSL)	7/9/2015	7/8/2020	Conduct research and development of weather sensing and processing networks.
ANG-C6	IA	DTFAWA-16-X-80009	NOAA	Earth System Research Laboratory (ESRL)	6/1/2016	5/31/2021	Conduct meteorological research and development, related to modeling and data assimilation techniques, measurement of forecast quality and Technology Transfer to NCEP"
AAM-600	OTA	DTFACT-13-A-00003		Università degli Studi di Udine, Italy	4/12/2013	10/31/2017 potential extension, pending budget	Cabin Safety - development of strategies to augment evacuation survival (aircraft accidents)
AAM-600	MOA	AVS-RM-AAC-15-A735	DOT	NTSB	12/3/2015	12/2/2020 to be extended	Surface Accidents - forensic toxicology analyses of biological specimens
AAM-600	MOA	14-273-SM-01	DOD	USAFSAM	9/30/2014	9/30/2016	Altitude - research on Human Physiologic Response Comparison in Three Hypoxic Environments
AAM-600	MOA	12-C-AM-WISU Amend 056		Wichita State University	8/11/2016	1/31/2018	Crash Survival- Development of System Level Crashworthiness Injury Criteria and Certification Methodology
AAM-600	MOU	None	DOD	US Air Force	12/4/2013	12/3/2018 to be extended	Military Egress (MET) - Cabin Safety Procedures
AAM-600	MOU	None	DOD	US Navy	10/31/2013	10/30/2018 to be extended	MET
AAM-600	MOU	TBD	DOD	Walter Reed Army Inst. of Research	TBD	TBD	Rotations/Laboratory Training - Functional Genomics Research Laboratorie
ANG-1	MOU	None	DOD, DHS, DOC, DOT, NASA		3/10/2017	TBD	Constitutes a formal agreement among the agencies to continue collaboration to define the longer term, interagency NextGen
ANG-E2	Reimbursable	ANG-RM-ACT-13-T028	DHS	Science and Technology	5/6/2013	9/30/2018	The purpose of this Agreement between the FAA and the Sponsor is to characterize and assess the vulnerability of wide-body composite aircraft to internal explosions such as are produced by terrorist emplaced improvised explosive devices.
ANG-E2	Reimbursable	ANG-RM-ACT-13-T028-A1	DHS	Science and Technology	5/20/2013	9/30/2019	Characterization and assessment of explosive vulnerability of new commercial composite aircraft.

Interagency Agreements (IAs) in FY 2017							
FAA Org	Agreement Type	Agreement Number	Agency (if applicable)	Organization	Period of Performance		Purpose
					Start Date	End Date	
ANG-E2	Reimbursable	ANG-RM-ACT-14-T055 DTFACT-15-Z-00003	DOD	US Air Force Research Laboratory	7/23/2015	7/22/2020	Strategic partnership between the AFRL and the WJHTC for cooperative efforts of the Metallic Materials Properties Development and Standardization (MMPDS) handbook activities.
ANG-E2	Reimbursable	ANG-RM-ACT-15-T056	DOD	US Army Tank Automotive Research, Development and Engineering Center (TARDEC)	3/10/2016	3/9/2021	WJHTC to provide subject matter expertise, consult, test and evaluate relevant to flammability, smoke, and toxicity for interior materials of military ground vehicle platforms.
ANG-E2	Reimbursable	ANG-RM-ACT-17-CT-001598	DOD	Defense Logistics Agency (DLA)	10/1/2018	9/30/2024	Strategic partnership between the DLA and the WJHTC for cooperative efforts of the Metallic Materials Properties Development and Standardization (MMPDS) handbook activities.
ANG-E2	Reimbursable	ANG-RN-ACT-16-CT-000670	USDA	Forest Service	9/15/2016	9/14/2021	Perform research on and process the operational flight load data to obtain statistical data to support he fatigue management program of firefighting airplanes.
AAM-500	IAA	DTFAVP-17-X-00140 FAN2C8		VOLPE	10/15/2017	1/15/2018	Electronic Flight Bag Technologies and Interfaces: The flight deck is an information-intensive environment, and with a rise in the use of Electronic Flight Bag (EFB) functions on the flight deck, it is important to understand the implications of this use on pilot monitoring, pilot workload, and head-down time.
AAM-500	IAA	DTFAVP-17-X-00079 FB58C1		VOLPE	5/10/2017	3/31/2018	Determine the limitations of use of EFVS to support landing and taxi/surface operations to determine if low-visibility operations can be extended to airports that do not have specific infrastructure designed to support these operations.
AAM-500	IAA	DTFAVP-17-X-00068/ 0001 FAN2C7		VOLPE	4/3/2017	12/31/2017	Low Visibility Operations/Surface Movement Guidance and Control System: Identify human factors considerations in the design and use of LVO/SMGCS charts including their symbology.
AAM-500	IAA	DTFAVP-17-X-00014 FB52C1		VOLPE	12/7/2016	8/15/2018	Identifying features that contribute to display compellingness and potential mitigations. Data from safety reports show that the presentation of information on electronic displays and Electronic Flight Bags/ Personal Electronic Devices (EFBs/PEDs) are compelling, that is, information presented on those devices draw attention and convey validity.
AAM-500	IAA	DTFAVP-17-X-00033 FB52C2		VOLPE	1/30/2017	8/15/2018	Human Factor Considerations for electronic displays and information display elements. Understand the human factors considerations related to the use of data-driven charts.

Appendix 7: Acronyms and Abbreviations

Acronym	Definition
A	
ABST	Aircraft Beam Structural Test
AACE	Airworthiness Assurance Center of Excellence
ACERite	Airliner Cabin Environment and Intermodal Transportation Research
AAM	Office of Aerospace Medicine
AATS	Aircraft Access to SWIM
AC	Advisory Circular
ACA	Astronautics Corporation of America
ACER	Airliner Cabin Environment
ACRP	Airport Cooperative Research Program
ADG	Airplane Design Group
ADS-B	Automatic Dependent Surveillance-Broadcast
AEDT	Aviation Environmental Design Tool
AEE	Office of Environment and Energy
AEEC	Airlines Electronic Engineering Committee
AeroMACS	Aeronautical Mobile Airport Communication Systems
AGL	Above Ground Level
AIP	Grants-In-Aid for Airports Appropriation
AM	Additive Manufacturing
AMS	Acquisition Management System
ANSP	Air Navigation Service Provider
AOPA	Aircraft Owners and Pilots Association
AOV	Air Traffic Safety Oversight Service
API	American Petroleum Institute
ARFF	Aircraft Rescue and Fire Fighting
ASCENT	Aviation Sustainability Center of Excellence
ASDE-X	Airport Surface Detection Equipment
ASIAS	Aviation Safety Information Analysis and Sharing
ASPIRE	Asia and Pacific Initiative to Reduce Emissions
AST	Office of Commercial Space Transportation
ASTM	American Society for Testing and Materials
ATC	Air Traffic Control
ATCRBS	Air Traffic Control Radar Beacon System
ATD&P	Advanced Technology Development & Prototyping
ATD-1	Airspace Technology Demonstration Phase 1
ATD-2	Airspace Technology Demonstration Phase 2

Acronym	Definition
ATD-3	Airspace Technology Demonstration Phase 3
ATM	Air Traffic Management
ATO	Air Traffic Organization
ATRP	Airport Technology Research Program
AVS	Office of Aviation Safety
AVSI	Aerospace Vehicles Systems Institute
B	
BLI	Budget Line Item
BVLOS	Beyond Visual Line of Sight
C	
CAAFI	Commercial Aviation Alternative Fuels Initiative
CAASD	Center for Advanced Aviation System Development
CAEP	Committee on Aviation Environmental Protection
CAFS	Compressed Air Foam System
CAMI	Civil Aerospace Medical Institute
CARATS	Collaborative Actions for Renovation of Air Traffic Systems
CAST	Commercial Aviation Safety Team
CAT	Category
CDM	Collaborative Decision Making
CEAT	Center of Airport Technology Research
CFD	Computational Fluid Dynamics
CFR	Code of Federal Regulations
CIP	Capital Investment Plan
CLEEN	Continuous Lower Energy, Emissions and Noise
CMAS	Computational Modeling of Aircraft Structures
CMMS	Computer Maintenance Management Systems
COE	Center of Excellence
COMSTAC	Commercial Space Transportation Advisory Committee
ConOps	Concept of Operations
CONUS	Continental United States
CORSIA	Carbon Offsetting and Reduction Scheme for International Aviation
CRDA	Cooperative Research and Development Agreement
CRM	Crew Resource Management
CSPA	Closely Spaced Parallel Approach
CSET	Composite Structural Engineering Technology
CSSI	CSSI, Inc. – Engineering Company
CST	Commercial Space Transportation
CVS	Combined Vision Systems

Acronym	Definition
D	
DAA	Detect and Avoid
DARWIN®	Design Assessment Of Reliability With Inspection
DCE	Data Collection Effort
DHS	Department of Homeland Security
DIC	Digital Image Correlation
DIMA	Distributed Integrated Modular Avionics
DLW	Datalink Weather
DMA	Dynamic Mechanical Analysis
DNL	Day-Night Noise Level
DNV-GL	Quality Assurance and Risk Management Company
DoD	U.S. Department of Defense
DOT	U.S. Department of Transportation
DST	Decision Support Tool
E	
EAA	Experimental Aircraft Association
EDS	Environmental Design Space
Efaros	Enhanced Final Approach Runway Occupancy Signal
EFICA	Efficient Flow into Congested Airspace
EMAS	Engineered Material Arresting System
EMS	Environmental Management System
EoR	Established on Required
EUROCONTROL	European Organisation for the Safety of Air Navigation
EVLOS	Expanded Visual Line-of-Sight
F	
4DTs	Four-Dimensional Trajectories
F&E	Facilities and Equipment Appropriation
FAA	Federal Aviation Administration
FAARFIELD	FAA Rigid and Flexible Iterative Elastic Layered Design
FAD	Functional Architecture Documents
FAE	FAA Acquisition Executive
FASTER	Full-Scale Aircraft Structural Test Evaluation and Research facility
FDR	Flight Data Recorder
FDM	Flight Data Monitoring
FIM	Flight-deck Interval Management
FMS	Flight Management System
FRAT	Facility Risk Assessment Tool
FY	Fiscal Year

Acronym	Definition
G	
GA	General Aviation
GAJSC	General Aviation Joint Steering Committee
GAMA	General Aviation Manufacturers Association
GDP	Gross Domestic Product
GEOSS	Global Earth Observation System of Systems
GPS	Global Positioning System
GRA	GRA, Inc – Air Traffic Management Corporation
GUI	Graphical User Interface
H	
HFDM	Helicopter Flight Data Monitoring
HITL	Human In The Loop
HMA	Hot Mix Asphalt
HMD	Head Mounted Display
HMMH	Harris Miller Miller & Hanson Inc.
HSI	Human-System Integration
HUD	Head Up Display
I	
IA	Interagency Agreements
IA	International Agreements
IADS	Integrated Arrival/Departure/Surface
IARPC	Interagency Arctic Research Policy Committee
ICAO	International Civil Aviation Organization
ICME	Integrated Computational Materials Engineering
IHST	International Helicopter Safety Team
IMA	Integrated Modular Avionics
IMC	Instrument Meteorological Conditions
IoT	Internet of Things
IP	Internet Protocol
IPO	Interagency Planning Office
IPS	Intrusion Prevention System
IR	Infrared
ISS	Information Systems Security
J	
JAMS	Joint COE for Advanced Materials
JCAB	Japan Civil Aviation Bureau
JRC	Joint Resources Council
JUP	Joint University Program

Acronym	Definition
K	
KPI	Key Performance indicators
L	
LCSA	Low Cost Surface Awareness
LL	Lincoln Labs
LOSA	Line Operations Safety Assessment
LSDYNA	Multi-physics Simulation Software by Livermore Software Technology Corp.
LSTC	Livermore Software Technology Corporation
LTO	Landing and Take-Off
M	
MCP	Multi-Core Processor
MET	Meteorological
MinWxSvc	Minimum Weather Service
MIT	Massachusetts Institute of Technology
MMAC	Mike Monroney Aeronautical Center
MMPDS	Metallic Materials Properties Development Standardization
MOA	Memorandum/a of Agreement
MOC	Memorandum/a of Cooperation
MOU	Memorandum/a of Understanding
N	
NARP	National Aviation Research Plan
NAS	National Airspace System
NASA	National Aeronautics and Space Administration
NASA GRC	NASA's Glenn Research Center
NASTAR	National Space Transportation Research
NAWC	Naval Air Warfare Center, China Lake
NATA	National Air Transportation Association
NBAA	National Business Aviation Association
NEB	NextGen Executive Board
NEPA	National Environmental Policy Act
NEXRAD	Next Generation Weather Radar
NextGen	Next Generation Air Transportation System
NEXTOR	National Center of Excellence for Aviation Operations Research
NIA	National Institute for Aviation Research
NIAR	National Institute for Aviation
NIST	
NOAA	National Oceanographic and Atmospheric Administration
NORSEE	Non-Required Safety Enhancing Equipment

Acronym	Definition
NRC	National Research Council
NRCC	National Research Council of Canada
NSTC	National Science and Technology Council
NTSB	National Transportation Safety Board
NVPM	Non-volatile Particulate Matter
NVS	NAS Voice System
NWP	National Weather Prediction
NWS	National Weather Service
O	
OI	Operational Improvement
OMB	Office of Management and Budget
OPC	Offshore Precipitation Capability
ORD	Chicago O'Hare International Airport
OST	Office of the Secretary
OSTP	Office of Science and Technology Policy
P	
PAFI	Piston Aviation Fuels Initiative
PAR	Performance and Accountability Report
PARTNER	Partnership for Air Transportation Noise and Emissions Reduction
PCI	Pavement Condition Index
PDARS	Performance Data Analysis and Reporting System
PED	Portable Electronic Device
PEGASAS	Partnership to Enhance General Aviation Safety, Accountability and Sustainability
PM	Particulate Matter
PMO	Program Management Organization
POWER	Propulsion and airpOWer Engineering Research Lab
PPT	Program Planning Team
R	
R&D	Research and Development
RD&T	Research, Development, and Technology
R,E&D	Research, Engineering and Development Appropriation
REB	Research and Development Executive Board
REDAC	Research, Engineering, and Development Advisory Committee
RFP	Request for Proposal
RIPSA	Runway Incursion Prevention Shortfall Assessment
RNAV	Required Navigation
RNP	Required Navigation Performance
ROI	Return On Investment

Acronym	Definition
RSA	Runway Safety Area
RTCA	Radio Technical Commission for Aeronautics
RTP	Regional Temperature Potential
RWSL	Runway Status Lights
S	
SAA	Sense and Avoid
SASS	Small Airport Surveillance Sensor
SAGA	Sustainable Aviation Guidance Alliance
SBIR	Small Business Innovation Research
S-CDM	Surface Collaborative Decision Making
SESAR	Single European Sky Air Traffic Management Research
SFMA	Strategic Flow Management Application
SLD	Super Cooled Large Droplets
SML	Structures and Materials Lab
SRA	Safety Risk Assessment
SRM	Safety Risk Management
STBO	Surface Trajectory-Based Operations
STCM	Surface Taxi Conformance Monitoring
STF	Surface Tactical Flow
STM	Surface Traffic Management
SUA	Special Use Airspace
sUAS	Small Unmanned Aircraft System
SWIM	System Wide Information Management
SWS	System-wide Safety
T	
3D	Three Dimensional
TBO	Trajectory Based Operations
TC	Thermocouple
TFDM	Terminal Flight Data Manager
TFM	Traffic Flow Management
THC	Tetrahydrocannabinol
TRB	Transportation Research Board
TSA	Transportation Security Administration
TSAS	Terminal Sequencing and Spacing
U	
UAS	Unmanned Aircraft System
UDRI	University of Dayton Research Institute
UFDM	UAS Flight Data Monitoring

Acronym	Definition
U.S.	United States
USAF	United States Air force
USDA	United States Department of Agriculture
USG	U.S. Global
USGCRP	U.S. Global Change Research Program
UTM	Unmanned Aircraft Systems Traffic Management
UTMB	University of Texas Medical Branch
V	
VFP	Vertical Flame Propogation
W	
WJHTC	William J. Hughes Technical Center
WMA	Warm Mix Asphalt
WTIC	Weather Technology in the Cockpit
Wx	Weather