Federal Aviation
Administration

2016
National Aviation Research Plan
(NARP)

Final

April 2016

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

2016 NARP-Final
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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)

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Executive Summary

Aviation is a vital resource for the United States (U.S.) because of its strategic, economic, and social importance. It provides opportunities for business, job creation, economic development, law enforcement, emergency response, personal travel, and leisure. It also attracts investment to local communities and opens up new domestic and international markets and supply chains. As a result, the U.S. needs a system that leads the global aviation community and responds quickly to changing and expanding transportation needs. The Federal Aviation Administration (FAA) supports this system through the introduction of new technologies and procedures, innovative policies, and advanced management practices that promote safety and environmental sustainability.

The NARP is the FAA's performance-based plan to ensure that Research and Development (R&D) investments are well managed, deliver results, and sufficiently address national aviation priorities. The NARP integrates the FAA R&D programs into a portfolio that addresses the near, mid, and far-term research needs of the aviation community. The NARP features R&D principles and goals that support the strategic visions laid out by the President, Secretary of Transportation, and FAA Administrator. This approach enables the FAA to address the current challenges of operating the safest, most efficient air transportation system in the world while building a foundation for the future system in an environmentally sound manner.

Section 44501(c) of Title 49 of the United States Code (49 U.S.C. § 44501(c)) requires the Administrator of the FAA to submit the NARP to Congress annually with the President's Budget. The NARP includes applied R&D as defined by the Office of Management and Budget (OMB) Circular A-11[1] and involves activities funded in three appropriation accounts: Research, Engineering and Development (R,E&D), Facilities and Equipment (F&E), and Grants-In-Aid for Airports (AIP).

In FY 2017, the FAA plans to invest a total of $403,335,000 in R&D. The R&D investment spans multiple appropriations for the FAA, including $167,500,000 in R,E&D; $189,460,000 in F&E; and $46,375,000 in AIP. The funding will be used to achieve the three central FAA R&D Principles of improve aviation safety, improve efficiency, and reduce environmental impacts. The NARP aligns with the White House National Science and Technology Council (NSTC)[2] *National Aeronautics Research and Development Plan*, the *U.S. Department of Transportation's Strategic Plan for Fiscal Years(FY) 2014–2018*, and the *Federal Aviation Administration Strategic Initiatives 2014-2018*[3].

[1] OMB Circular No. A-11, *Preparation, Submission and Execution of the Budget*, June 30, 2015, section 84, page 8 (http://www.whitehouse.gov/OMB/circulars).
[2] For more information on the National Science and Technology Council (NSTC), go to (http://www.whitehouse.gov/ostp/nstc).
[3] FAA Administrator Michael P. Huerta released his *Federal Aviation Administration Strategic Initiatives 2014-2018* on February 19, 2014. For more information, go to (http://www.faa.gov/about/plans_reports/media/FAA_Strategic_Initiatives_Summary.pdf).

Preface

The 2016 NARP includes the following major changes from the 2015 NARP:

- Inclusion of additional F&E-funded R&D work in the following portfolios:
  - 1A02 National Airspace System (NAS) Improvement of System Support Laboratory;
  - 1A03 William J. Hughes Technical Center Facilities;
  - 1A04 William J. Hughes Technical Center Infrastructure Sustainment;
  - 1A05 Next Generation Transportation System - Separation Management Portfolio;
  - 1A06 Next Generation Transportation System - Improved Surface/Terminal Flight Data Manager(TFDM) Portfolio;
  - 1A07 Next Generation Transportation System - On Demand NAS Portfolio;
  - 1A08 Next Generation Transportation System - Improved Multiple Runway Operations Portfolio;
  - 1A09 Next Generation Transportation System - NAS Infrastructure Portfolio, and
  - 1A10 Next Generation Support Portfolio.

  Representative programs from each of the above F&E portfolios have been highlighted in the narrative of this year's NARP (Chapters 1-3), with milestone and program information mirroring the FY 2017-2021 Capital Investment Plan (CIP). CIP content is current as of January 13, 2016.

- Addition of a new R,E&D-funded program named 'NextGen Information Security' (BLI A12.d).

- Addition of three new research goals, in conjunction with the inclusion of the above-referenced new areas (i.e., additional F&E sponsored programs and the A12.d NextGen Information Security program).

- Slight rewording of Safety goal 7, which now reads 'Safe and efficient integration of increased commercial space launch and re-entry activity into the NAS.'

- Elimination of the Systems Safety Management Transformation program (F&E - 3A10B) from the 2016 NARP (both from the financial tables as well as from the main body of the NARP), since no R&D activities are currently being conducted under that area.

- Slight rewording and updating of the three NARP principles for clarity and accuracy.

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Introduction

To maximize the opportunities that the aviation industry provides, the U.S. must not only maintain, but also continue to improve upon the NAS so that it remains responsive to rapidly changing and expanding transportation needs, while ensuring the highest level of safety. Increased mobility, higher productivity, reduced environmental impact, and greater efficiency, are possible by introducing new technologies, procedures; innovative policies and advanced management practices. Collaborative, needs-driven R&D is central to this process, as it enables the U.S. to be a world leader in its ability to move people and goods by air safely, securely, quickly, affordably, efficiently and in an environmentally sound manner.

Mission

The FAA's mission is to provide the safest and most efficient aerospace system in the world. To support this mission, the FAA's corresponding R&D mission is to conduct, coordinate, and support domestic and international R&D of aviation-related products and services that will ensure a safe, efficient, and environmentally sound global air transportation system. It supports a range of research activities from materials and aeromedical research to the development of new products, services, and procedures.

Vision

The overall vision of the FAA is to strive to reach the next level of safety, efficiency, environmental responsibility, and global leadership. The FAA is accountable to the American public and stakeholders. In 2003, the Secretary of Transportation set forth a specific vision to transform the Nation's air transportation system into one that is substantially more capable of ensuring America maintains its leadership in global aviation[4]. That proclamation led to the Vision 100 – Century of Aviation Reauthorization Act[5], which became the foundation of the Next Generation Air Transportation System (NextGen). To support these visions, the FAA strives to conduct world-class, cutting edge R&D.

The FAA has defined five R&D organizational values to enable it to better manage its programs and achieve its R&D vision. They are:

- Goal driven - Achieve the mission. The FAA uses R&D as a primary enabler to accomplish its goals and objectives.
- World class - Be the best. The FAA delivers R&D results that are high quality, relevant, and improve the performance of the aviation system.

[4] Letter to the President from Secretary of Transportation Norman Y. Mineta, *America at the Forefront of Aviation: Enhancing Economic Growth*, November 25, 2003.
[5] Vision 100 – Century of Aviation Reauthorization Act, Public Law 108-176, December 12, 2003 (http://www.gpo.gov/fdsys/pkg/PLAW-108publ176/pdf/PLAW-108publ176.pdf).

- Collaborative - Work together. The FAA partners with other government agencies, industry, and academia to capitalize on national R&D capabilities to transform the air transportation system.
- Innovative - Turn ideas into reality. The FAA empowers, inspires, and encourages our people to invent new aviation capabilities and create new ways of doing business to accelerate the introduction of R&D results into new and better aviation products and services.
- Customer focused - Deliver results. The FAA R&D program delivers quality products and services to the customer quickly and affordably.

By aggressively promoting these values, the FAA will generate the maximum benefit from its R&D resources to help achieve its vision and the national vision of a transformed aviation system.

National Goals and Strategic Plans

The establishment of national goals provides a framework for the FAA to identify and confront the most significant research challenges facing our Nation's aviation system. This section explains how the White House Office of Science and Technology Policy, Office of the Secretary of Transportation, and FAA framework of goals and strategic plans are connected, as well as how the FAA R&D portfolio supports the larger effort by providing research to pursue the near, mid, and far-term needs of the aviation community.

National Aeronautics Research and Development Plan

The National Aeronautics Research and Development Policy (December 2006) established a series of guiding principles to conduct Federal aeronautics R&D:

- Aviation safety is paramount.
- Mobility through the air is vital to economic stability, growth, and security as a Nation.
- Aviation is vital to national security and homeland defense.
- Security of and within the aeronautics enterprise must be maintained.
- The United States should continue to possess, rely on, and develop its world-class aeronautics workforce.
- Assuring energy availability and efficiency is central to the growth of the aeronautics enterprise.
- The environment must be protected while sustaining growth in air transportation.

To advance these principles, on February 2, 2010, the NSTC published the most recent National Aeronautics Research and Development Plan. The plan lays out high-priority national aeronautics R&D challenges, goals, and supporting objectives to guide the conduct of U.S. aeronautics R&D activities through 2020. As the first in a process of biennial updates, the plan

provides focused updates to a number of specific R&D goals and objectives in the National Plan for Aeronautics Research and Development and Related Infrastructure published in 2007. This R&D plan:

- Supports the coordinated efforts of the Federal departments and agencies in the pursuit of stable and long-term foundational research;
- Ensures U.S. technological leadership in aeronautics for national security and homeland defense capabilities;
- Advances aeronautics research to improve aviation safety, air transportation, and reduce the environmental impacts of aviation;
- Promotes the advancement of fuel efficiency and energy independence in the aviation sector, and
- Spurs the development of innovative technologies that enable new products and services.

For more information, go to (http://www.whitehouse.gov/sites/default/files/microsites/ostp/aero-rdplan-2010.pdf).

U.S. Department of Transportation Strategic Plan

The *U.S. Department of Transportation's Strategic Plan for Fiscal Years 2014–2018: Transportation for A New Generation,* was created with input from the U.S. Department of Transportation's (DOT) leadership, employees, and stakeholders. The plan re-imagines America's transportation system as the means by which we connect with one another, grow our economy, and protect the environment. The national objectives of general welfare, economic growth, stability, and the security of the U.S. require development of transportation policies and programs that contribute to providing fast, safe, efficient, and convenient transportation at the lowest cost. They must also be consistent with other national objectives, including the efficient use and conservation of the resources of the U.S.[6] The plan fulfills the DOT's mission and sets the direction for the DOT to provide safe, efficient, convenient, and sustainable transportation choices, through five strategic goals supported by a wide-ranging management goal of organizational excellence:

- Safety;
- State of good repair;
- Economic competitiveness;
- Quality of life in communities, and
- Environmental sustainability.

For more information, go to (http://www.dot.gov/dot-strategic-plan).

[6] DOT's mission as stated in Section 101 of Title 49, U.S.C.

FAA Strategic Initiatives

FAA Administrator Michael P. Huerta released his Federal Aviation Administration Strategic Initiatives 2014-2018 on February 19, 2014, to underscore what will be strategically necessary for the FAA to lay the foundation for the aerospace system of the future. The document stresses that rapidly changing industry, technological opportunities, uncertain fiscal environment, an evolving workforce, and the global backdrop, comprise a compelling case for transformational change. The Administrator's priority initiatives include:

- **Risk-Based Decision Making** – build on safety management principles to proactively address emerging safety risk by using consistent, data-informed approaches to make smarter, system-level, risk-based decisions.
- **National Airspace System –** lay the foundation for the NAS of the future by achieving prioritized NextGen benefits, integrating new user entrants, and delivering more, efficient, streamlined services.
- **Global Leadership** – improve safety, air traffic efficiency, and environmental sustainability across the globe through an integrated, data-driven approach that shapes global standards, enhances collaboration and harmonization, and better targets FAA resources and efforts.
- **Workforce of the Future** – prepare FAA's human capital for the future, by identifying, recruiting, and training a workforce with the leadership, technical, and functional skills to ensure the U.S. has the world's safest and most productive aviation sector.

FAA strategic priorities for the agency include:

- Making aviation safer and smarter;
- Delivering benefits through technology and infrastructure;
- Enhancing global leadership, and
- Empowering and innovating with the FAA's people.

For more information, go to (http://www.faa.gov/about/plans_reports/media/faa_strategic_initiatives_summary.pdf).

Next Generation Air Transportation System (NextGen)

Enacted in 2003 under the *Vision 100 – Century of Aviation Reauthorization Act*, NextGen is the ongoing transformation of the NAS to advance growth and increase safety while reducing aviation's environmental impact. It represents an evolution from a ground-based system of Air Traffic Control, (ATC) to a satellite-based system of Air Traffic Management (ATM). This transformation is being enabled by a shift to smarter satellite-based and digital technologies and new procedures that combine to make air travel more convenient, predictable and environmentally friendly. In conjunction with innovative technologies, are new airport infrastructure and new procedures, including the shift of certain decision-making responsibilities from the ground to the cockpit.

FAA's Research and Development Principles and Goals

The FAA uses R&D to support policy and planning, regulation, certification, standards development, and modernization of the NAS. The FAA R&D portfolio supports both the day-to-day operations of the NAS and the development of NextGen. To achieve balance between the near, mid, and far-term, the FAA has defined three R&D principles. The R&D principles help the FAA align, plan, and evaluate its R&D portfolio. The R&D principles are:

- **Improve Aviation Safety –** systematically expand and apply knowledge to produce useful materials, devices, systems, or methods that will improve aviation safety and achieve the lowest possible accident rate.

- **Improve Efficiency–** systematically expand and apply knowledge to produce useful materials, devices, systems, or methods that will improve access to and increase the capacity and efficiency of the Nation's aviation system.

- **Reduce Environmental Impacts** – systematically expand and apply knowledge to produce useful materials, devices, systems, or methods that will reduce aviation's environmental and energy impacts.

The following table, Strategic Alignment of FAA R&D Principles, shows the primary relationship among the FAA R&D principles and elements from other pertinent strategic documents. The following chapters will provide greater detail about the 25 underlying goals that support FAA's accomplishment of these three principles.

Strategic Alignment of FAA R&D Principles

FAA R&D Principles	***DOT Strategic Plan* Goals**	***National Aeronautics Research and Development Plan* Principles**	***FAA Strategic Initiatives 2014-2018* Priorities**
Improve Aviation Safety	Safety	Aviation Safety	Make Aviation Safer and Smarter
Improve Efficiency	Economic Competitiveness	Mobility	Deliver Benefits Through Technology and Infrastructure
Reduce Environmental Impacts	Environmental Sustainability	Energy and Environment	Deliver Benefits Through Technology and Infrastructure

1.0 R&D Principle 1 - Improve Aviation Safety

Systematically expand and apply knowledge to produce useful materials, devices, systems, or methods that will improve aviation safety and achieve the lowest possible accident rate.

Ten R&D goals support R&D Principle - Improve Aviation Safety. Work is spread across three budget appropriations (R,E&D, F&E, and AIP):

- Goal 1 - Improved understanding of aerospace vehicle design, structure, and subsystems to reduce the potential for accidents and incidents and support the development of standards and policy and methodologies and tools for certification.

- Goal 2 - Improved knowledge of the human-system interface and a reduction in accidents and incidents through enhanced aerospace vehicle, air traffic, and technical operations that adapt to, compensate for, and augment the performance of the human.

- Goal 3 - Improved understanding of factors that influence human physiology and performance in aerospace environments and guidance and tools that enhance human safety, protection, and survival during civil aerospace operations.

- Goal 4 - Improved system-wide access and sharing of aviation safety data and analysis tools within the aviation community, providing safety resources that are integrated with operations of aviation industry stakeholders.

- Goal 5 - Established requirements and standards for enabling the availability and improving the quality and quantity of meteorological information to safely implement NextGen operational improvements.

- Goal 6 - Improved accuracy and accessibility of observed and forecast weather to reduce the number of accidents and incidents attributed to hazardous weather.

- Goal 7 - Safe and efficient integration of increased commercial space launch and re-entry activity into the NAS.

- Goal 8 - Improved vehicle safety and risk management, including knowledge of all safety-critical components and systems of the space vehicles and their operations, to better identify potential hazards and apply and verify hazard controls.

- Goal 9 - Guidance and tools that enhance human safety, protection, and survival during space operations.

- Goal 10 - No fatal accidents on certificated airports as a result of airport design, runway incursions or excursions, or wildlife strikes.

Table 1.0.1, Alignment of FAA R&D Safety Principle and Programs with NSTC Aviation Safety Goals, shows how the FAA's Aviation Safety R&D goals and programs align with the NSTC Aviation Safety Goals. In many cases, FAA R&D programs support more than one NSTC goal.

Table 1.0.1: Alignment of FAA R&D Safety Principle and Programs with NSTC Aviation Safety Goals

FAA R&D Principle	FAA R&D Programs	NSTC Goals		NSTC Principle	FAA Strategic Priority
Improve Aviation Safety	Advanced Materials/Structural Safety	Goal 1 - Develop Technologies to Reduce Accidents and Incidents Through Enhanced Vehicle Design, Structure, and Subsystems		Aviation Safety is Paramount	Make Aviation Safer and Smarter
	Aircraft Catastrophic Failure Prevention Research				
	Propulsion and Fuel Systems				
	Continued Airworthiness		Goal 2 - Develop Technologies, for Manned and Unmanned Systems, to Reduce Accidents and Incidents through Enhanced Aerospace Vehicle Operations on the Ground and in the Air		
	Aircraft Icing/Digital Systems Safety				
	Unmanned Aircraft Systems Research Program				
	Air Traffic Control/Technical Operations Human Factors	Goal 2 - Develop Technologies, for Manned and Unmanned Systems, to Reduce Accidents and Incidents through Enhanced Aerospace Vehicle Operations on the Ground and in the Air			
	Flightdeck/Maintenance/System Integration Human Factors				
	NextGen - Air Ground Integration Human Factors				
	Aeromedical Research	Goal 3 - Demonstrate Enhanced Passenger and Crew Survivability in the Event of an Accident			
	Fire Research and Safety				
	System Safety Management	Goal 2 - Develop Technologies, for Manned and Unmanned Systems, to Reduce Accidents and Incidents through Enhanced Aerospace Vehicle Operations on the Ground and in the Air			
	NextGen - Weather Technology in the Cockpit	Goal 2 - Develop Technologies, for Manned and Unmanned Systems, to Reduce Accidents and Incidents through Enhanced Aerospace Vehicle Operations on the Ground and in the Air			
	Weather Program				
	Commercial Space Transportation Safety	Goal 2 - Develop Technologies, for Manned and Unmanned Systems, to Reduce Accidents and Incidents through Enhanced Aerospace Vehicle Operations on the Ground and in the Air			
	Runway Incursion Reduction Program				
	Airport Cooperative Research Program - Safety				
	Airport Technology Research Program - Safety				

In FY 2017, 31 percent of total FAA R&D funding is allocated to R&D Principle 1 - Improve Aviation Safety. Program funding levels for the 2016 Enacted and 2017 Congressional Request are shown in Table 1.0.2. Percent of Program reflects each program's contribution towards R&D Principle 1 in the 2017 Congressional Request. Table 1.0.2 also lists the section and page number reference for each budget narrative within the FY 2017 Congressional Justification (CJ) for the President's Budget Request. The FY 2017 CJ will be made available by the DOT at https://www.transportation.gov/budget.

Table 1.0.2: Program Funding for R&D Principle 1 - Improve Aviation Safety

2016 BLI	Program	CJ Reference (Section /Page)	Appropriation Account	2016 Enacted ($000)	2017 Congressional Request ($000)	2017 Percent of Program
A11.a	Fire Research and Safety	3C/11	RE&D	6,000	7,925	100%
A11.b	Propulsion and Fuel Systems	3C/15	RE&D	2,034	2,574	100%
A11.c	Advanced Materials/Structural Safety	3C/17	RE&D	7,409	4,113	100%
A11.d	Aircraft Icing/Digital System Safety	3C/21	RE&D	5,500	5,102	100%
A11.e	Continued Airworthiness	3C/26	RE&D	8,987	10,269	100%
A11.f	Aircraft Catastrophic Failure Prevention Research	3C/31	RE&D	1,433	1,528	100%
A11.g	Flightdeck/Maintenance/System Integration Human Factors	3C/34	RE&D	5,000	8,513	100%
A11.h	System Safety Management	3C/37	RE&D	6,063	7,000	100%
A11.i	Air Traffic Control/Technical Operations Human Factors	3C/41	RE&D	5,410	6,165	100%
A11.j	Aeromedical Research	3C/45	RE&D	8,467	9,538	100%
A11.k	Weather Program	3C/49	RE&D	7,516	8,988	50%
A11.l	Unmanned Aircraft Systems Research	3C/54	RE&D	17,635	8,422	100%
A11.n	Commercial Space Transportation	3C/61	RE&D	2,000	2,953	100%
A12.b	NextGen - Air Ground Integration Human Factors	3C/68	RE&D	2,400	2,573	30%
A12.c	NextGen - Weather Technology in the Cockpit	3C/71	RE&D	1,822	1,827	45%
A14.a	System Planning and Resource Management	3C/85	RE&D	1,282	1,702	61%
A14.b	William J. Hughes Technical Center Laboratory Facility	3C/87	RE&D	2,831	2,803	82%
4A08	Center for Advanced Aviation System Development (CAASD)	3B/306	F&E	16,800	15,600	26%
--	Airport Cooperative Research Program - Safety	3D/36	AIP	5,000	5,000	100%
--	Airport Technology Research Program - Safety	3D/26	AIP	16,176	16,371	100%
	Total ($000)			**129,764**	**128,966**	

**CAASD R&D budget totals for 1) FY 2016 assume 28% for Safety, 72% to Efficiency, and 0% for Environmental and 2) FY 2017 and outyears assume 26% for Safety, 69% for Efficiency, and 5% for Environmental (subject to FFRDC Executive Board FY 2017 workplan approval).*

1.1 Aviation Safety R&D Goal 1

Improved understanding of aerospace vehicle design, structure, and subsystems to reduce the potential for accidents and incidents and support the development of standards and policy and methodologies and tools for certification.

1.1.1 Advanced Materials/Structural Safety (R,E&D - A11.c)

The Advanced Materials/Structural Safety Program supports Aviation Safety R&D Goal 1 by investigating a broad spectrum of issues related to the use of composite and advanced materials in aircraft structures. These include fatigue and damage tolerance issues from in-flight hail and ground vehicle collisions, environmental and aging effects, and bonded joints and repairs. The program also develops safety awareness training for advanced composite materials and manufacturing processes. The Structural Safety Program conducts research to develop or validate dynamic test methods, procedures and means of analysis to meet crashworthiness regulations. The program helps ensure that new aircraft structures demonstrate levels of safety equivalent to existing aircraft structures when subjected to survivable crash conditions.

The research milestones and their statuses are shown in Table 1.1.1, Advanced Materials/Structural Safety Program Milestones below, followed by a summary of the significant progress made in FY 2015 towards achieving the R&D goal.

Table 1.1.1: Advanced Materials/Structural Safety Program Milestones

Year	Milestone	Status	Notes
2015	Characterize the effects of blunt impact on composite structures typically used in fuselage applications	Completed	2015 NARP Status: On schedule
2016	Develop standards and methods to characterize dynamic properties of composite material systems	On schedule	
2017	Evaluate new material forms (e.g., discontinuous fiber composites) that have found application in primary aircraft structures	On schedule	
2017	Address specific Aviation Rulemaking Advisory Committee inputs and certification needs for certification of composite aircraft	On schedule	
2018	Develop assessment of typical range of ditching and other water landing scenarios to provide recommendations on certification requirements	On schedule	

Year	Milestone	Status	Notes
2018	Evaluate composites quality control Advisory Circular 21-26 for necessary updates and provide background data	On schedule	
2019	Identify key characteristics of metallic aircraft response to crash conditions to establish a baseline for other structural concepts and materials	On schedule	
2019	Develop background information and data for creation of a Part 21 Advisory Circular on composite structures	On schedule	
2020	Develop technical forensic and predictive data to allow analysis of structural failures after being subjected to post event conditions including fire and heat	On schedule	
2020	Develop a methodology to verify and validate models used for crashworthiness certification	On schedule	
2021	Perform initial evaluation of developed methodology for verification and validation of crashworthiness certification models on existing examples of aircraft structures built from novel materials or novel designs	On schedule	New milestone

Advanced Materials/Structural Safety Program Progress in FY 2015:

- ✓ Conducted element-level experiments to support accurate analysis procedure development, due to simplified geometries, loading conditions and isolated failure modes. The interested location is frame-to-floor where the ground service equipment normally impacts the aircraft fuselage. Frame element-level bending and bending-torsion tests are required to support frame failure modeling and study of frame-to-floor interaction. Successfully completed two C-frame Bending tests, while preparing for Bending-Torsion test. Blunt/soft impact to sandwich structures can cause core fraction with almost no surface dent. Conducted quasi-static honeycomb core-crushing experiments to support analytical model. The indentation/core-crushing model accurately predicted crushing; however, the model still needs to be improved in unloading response prediction.

- ✓ Completed draft of American Society for Testing and Materials (ASTM) test method for Mode I single cantilever beam fracture mechanics test method for sandwich composites. Also coordinated with ASTM committee for any technical issues. Completed round robin testing protocol for Mode I single cantilever beam sandwich fracture mechanics testing. Evaluated candidate notch sensitivity test methodologies for sandwich composites.

- ✓ Current crashworthiness aircraft response and occupant safety are predicated on the use of metallic structures of traditional semi-monocoque design. A finite element model of a narrow-body aircraft was developed to study the fuselage response during an aircraft impact. The model was modified to add the necessary structural detail to better represent the aircraft configuration that will be used to validate the model. The model was also modified to reflect recent information regarding the modeling of joint and sub-assembly connections. Pertinent information regarding accident data from the Turkish Airlines flight that crashed near the Amsterdam Schiphol Airport was obtained and is being used to guide the changes and establish necessary boundary and impact conditions.

- ✓ Established improved laboratory-to-laboratory and instrument-to-instrument reproducibility methodologies for Dynamic Mechanical Analysis (DMA). DMA is a preferred technique for determining the glass Transition Temperature (Tg) of polymer matrix composites. The Tg is a critical parameter for the selection of an appropriate composite material used in aircraft structures. Tg is used as a means to establish the maximum service temperature of the material. Several potential influencers of Tg measurements, such as thermocouple (TC) positioning, dimensional variation of specimens, and temperature calibration configurations and methods were evaluated. A 50% improvement in the reproducibility of Tg measurements was achieved with the implementation of the developed TC guidelines and temperature calibration procedures.

- ✓ Evaluated numerous issues associated with the introduction of bonded joints in aircraft structures. Characterized the effect of visco-elastic ratcheting which affects the long-term durability of fatigued bond joints. Evaluated the cause and effects of amine leaching (blush) on bonded structure performance. Developed a framework for the inclusion of bonded structure guidance into Composite Materials Handbook 17. Held forum at Composite Materials Handbook 17 Coordination Meeting to review needs and established content requirements for the handbook. Evaluated testing methods for composite structures durability. Coordinated with ASTM committees on inclusion of updates to current metal bond durability test methods.

1.1.2 Aircraft Catastrophic Failure Prevention Research (R,E&D - A11.f)

The Aircraft Catastrophic Failure Prevention Research Program supports Aviation Safety R&D Goal 1 by developing technologies and methods to assess risk and prevent occurrence of potentially catastrophic defects, failures, and malfunctions in aircraft, aircraft components, and aircraft systems. The program uses historical accident data and National Transportation Safety Board (NTSB) recommendations to examine and investigate turbine-engine uncontainment events and other engine-related impact events. Together with industry, the program develops material models associated with engine debris impact. These material models may be used for aircraft impact or shielding evaluations, engine containment evaluations and to assist both aircraft and engine certification.

The research milestones and their statuses are shown in Table 1.1.2, Aircraft Catastrophic Failure Prevention Research Program Milestones below, followed by a summary of the significant progress made in FY 2015 towards achieving the R&D goal.

Table 1.1.2: Aircraft Catastrophic Failure Prevention Research Program Milestones

Year	Milestone	Status	Notes
2015	Complete Inconel testing for certification by analysis	Completed	2015 NARP Status: On schedule
2016	Develop an anistropic material model for composite impact problems in aviation	On schedule	
2016	Complete MAT224 anistropic metal to account for cold working and directional manufacture	On schedule	
2016	Complete homogenous composite failure model	Deleted	Milestone is deleted because it is the same as the 2016 milestone stating: 'Develop an anistropic material model for composite impact problems in aviation.' This milestone is the second stage, failure portion of the complete model. 2015 NARP Status: On schedule
2017	Complete standard composite testing for certification by analysis	On schedule	
2018	Develop new tests needed for composite impact and failure	On schedule	
2018	Complete verification study for uniaxial composite impact	On schedule	
2019	Update certification by analysis guidance for metals	On schedule	
2020	Complete updates to uncontained engine and open rotor engine vulnerability analysis toolkit with improved impact accuracy, and revised fragment model that includes new events	On schedule	
2021	Update certification by analysis for composite material impact	On schedule	New milestone

Aircraft Catastrophic Failure Prevention Research Program Progress in FY 2015:

- ✓ Completed version 4.3 of the Uncontained Engine-Debris Damage-Assessment Model (UEDDAM) code in FY 2015. This new version includes updated additions to the penetration equations. The first addition is the gamma factor; developed by the FAA Commercial Space Program to ensure a more accurate penetration at oblique angles. The second addition is the Cs for shielding, which was developed for the open rotor-shielding program. These changes allow for more accurate estimates of shielding capability and penetration of the structure.

- ✓ Developed the data set necessary to incorporate the A380 uncontained engine failure debris into the multiple fragment debris model. Additional events are being studied which may also be included in the future. Current progress was reported during an April

2015 meeting with Transport Airplane Directorate. Final results will be reported in a revision to DOT/FAA/AR-99/11 Large Engine Uncontained Debris Analysis.

- ✓ Completed phase three of the four planned phase development of a composite impact and failure model for LS-DYNA. In 2015, damage theory was developed and strain equivalence verified between damaged and undamaged stress space. In 2016, the failure portion of the model will be developed.

- ✓ Completed several test series at National Aeronautics and Space Administration's Glenn Research Center (NASA GRC), including :

    - Ballistic impact testing of Inconel 718 for validation of an improved impact failure model (MAT224) in the LS-DYNA explicit finite element code.

    - Ballistic impact testing of T700/MTM45-1 triaxially braided composite material for post-test analysis of an open rotor engine fuselage protection concept.

    - Ballistic impact testing of T800/F3900 unidirectional composite material for validation of an improved impact failure model (MAT213) in the LS-DYNA explicit finite element code.

    - Static mechanical testing of T700/MTM45-1 triaxially braided composite material for input to an improved impact failure model (MAT213) in the LS-DYNA explicit finite element code.

- ✓ The Ohio State University completed the test series on Inconel 718 necessary to populate MAT224 in LS-DYNA. The data sets from approximately 200 tests were used to populate the tabular material model. Tests included tension, compression and shear, with strain rate and temperature dependence, along with fracture test series.

- ✓ The Arizona State University, NASA, and the FAA are making good progress on the MAT213 for composite failure, in order to develop an anistropic material model for composite impact problems in aviation.

- ✓ In order to complete the MAT224 anistropic metal, to account for cold working and directional manufacture; MAT264 has been created and implemented in a development version of LS-DYNA. It is on track for a 2016 release.

- ✓ Work began in 2015 designing specimens and developing a manufacturing process for test specimens in order to complete standard composite testing for certification by analysis.

1.1.3 Aircraft Icing/Digital System Safety (R,E&D - A11.d)

The Aircraft Icing/Digital System Safety Program supports Aviation Safety R&D Goal 1 by developing and testing technologies that detect frozen contamination, predict anti-icing fluid

failure, and ensure safe operations in atmospheric icing conditions. The program also develops new guidelines for testing, evaluating, and approving digital flight controls, avionics, and other systems during the certification of aircraft and engines and studies the airworthiness requirements of airborne cyber security.

NextGen -Advanced Systems and Software Validation supports Aviation Safety R&D Goal 1 by developing policy, guidance, technology, and training needs for the highly integrated and complex systems expected to operate in a NextGen environment. Such systems will rely on digital systems and be tightly integrated across airborne and ground-based components. The program supports end-to-end safety analysis and performance allocation, identifies safety opportunities and develops the regulatory framework for integration of NextGen technologies within the aircraft. The program will also identify and mitigate possible issues and shortcomings with the current processes used by the commercial aviation industry for requirements definition, validation, and verification for airborne systems. This program's initial year was funded under A11.n and subsequent work will be completed under A11.d.

The research milestones and their statuses are shown in Table 1.1.3, Aircraft Icing/Digital System Safety Program Milestones below, followed by a summary of the significant progress made in FY 2015 towards achieving the R&D goal.

Table 1.1.3: Aircraft Icing/Digital System Safety Program Milestones

Year	Milestone	Status	Notes
2015	Provide recommendations to address security vulnerabilities for aircraft systems and networks connectivity to non-governmental service providers including security controls	Completed	2015 NARP Status: On schedule
2015	Identify the issues and cause of system complexity on validation, verification, and safety in the context of certification	Completed	Milestone is revised because the scope of the task was broadened and redefined to fit in to the overall goal of the task. Old wording 'Identify issues of certification, validation, and verification, as well as flight safety, as they relate to the problems caused by the system's complexity' 2015 NARP Status: On schedule
2016	Complete testing on sloped surface testing of fluid behavior on flaps, slats, and main elements of aircraft and on flat plates at angles simulating angles of aircraft surfaces	Delayed	Milestone is delayed from 2015 to 2016 due to lack of suitable natural ambient snow conditions at the test site throughout the winter of 2014-2015. 2015 NARP Status: On schedule

Year	Milestone	Status	Notes
2016	Identify effects of system complexity on aircraft safety margins and investigate highly integrated, complex airborne systems difficult to validate and verify, and the potential for a reduction in aircraft safety margins with highly integrated, complex airborne systems	On schedule	
2016	Identify possible issues with the current process used by the commercial aviation industry regarding requirements' definition, validation, and verification for aircraft digital system requirements to ensure their applicability to NextGen systems	On schedule	
2016	Define complexity in the context of assurance of avionics system, identify the metrics that contribute to complexity, and demonstrate the applicability of the proposed metrics to manage complexity	On schedule	
2016	Provide recommendations for new criteria and guidance on multi-core processors used in aircraft systems	On schedule	
2016	Develop data and methods for guidance material for the airworthiness acceptance criteria and test methods for engines in simulated high ice water content environments	On schedule	
2017	Conduct aerodynamic test of swept wing with ice shapes in ONERA F1 wind tunnel	On schedule	
2017	Identify the assurance issues related to the applications running on virtual machines in airborne systems	On schedule	New milestone
2018	Create a validation database of ice shapes and their aerodynamic effects on swept wings for computational fluid dynamics	On schedule	
2018	Identify airborne electronic hardware development error types that remain undetected by verification techniques	On schedule	
2018	Investigate different techniques to calculate worst case execution time and explore the feasibility of deterministic behavior for multi-core processors implementations with dynamic allocation of code blocks to individual cores during run time	On schedule	2015 NARP Status: Accelerated
2019	Examine the gaps in the assurance processes used to verify and validate complex digital systems in integrated modular avionics and identify any potential failures and failure effects resulting from such complex systems integration	On schedule	Milestone was revised to add specificity after having defined the scope with well-formulated tasks. Old wording 'Develop criteria to ensure integration of complex digital systems.' 2015 NARP Status: On schedule

Year	Milestone	Status	Notes
2019	Report on use of computational fluid dynamics analysis and of test methods and scaling for iced swept wings	On schedule	
2020	Perform experiments, tests, analysis, and validation for engineering tools under construction for certification for super cooled large droplets	On schedule	New milestone
2021	Develop data package of experimental test, and analytical results that can be used for the development of guidance materials for means of compliance for certification in super cooled large droplets conditions	Delayed	Milestone is delayed from 2020 to 2021 because the sponsor of this work expanded the scope and timeline in the FY 2018 requirement. 2015 NARP Status: On schedule

Aircraft Icing/Digital System Safety Program Progress in FY 2015:

- ✓ A very strong swept wing model is required for aerodynamic testing ice shapes in the ONERA F1 pressurized tunnel in France. Design requirements were developed in FY 2015, and fabrication of the model will be completed in FY 2016.

1.1.4 Continued Airworthiness (R,E&D - A11.e)

The Continued Airworthiness Program supports Aviation Safety R&D Goal 1 by promoting the development of technologies, procedures, technical data, and performance models to prevent accidents and mitigate accident severity, related to civil aircraft failures as a function of their continued operation and usage. The program focuses on longer-term maintenance of the structural integrity of fixed-wing aircraft and rotorcraft, continued safety of aircraft engines, development of inspection technologies and the safety of electrical wiring interconnect and mechanical systems. Research will focus on emerging technologies such as damage tolerance and durability issues of new aluminum-lithium alloys, metal additive manufacturing (AM), new and emerging alloys to be studied for inclusion in Metallic Materials Properties Development and Standardization (MMPDS), and risk management methods to support the Aircraft Certification Services Monitor Safety/Analyze Data (MSAD) initiative, which is a data-driven, risk-based continued operational safety decision-making process.

The research milestones and their statuses are shown in Table 1.1.4, Continued Airworthiness Program Milestones below, followed by a summary of the significant progress made in FY 2015 towards achieving the R&D goal.

Table 1.1.4: Continued Airworthiness Program Milestones

Year	Milestone	Status	Notes
2015	Develop technical data to assess the application of advanced aluminum-lithium metallic alloys for primary fuselage structure in transport category airplanes	Completed	2015 NARP Status: Delayed from 2014 to 2015

Year	Milestone	Status	Notes
2015	Determine the current state of active flutter suppression in the commercial airplane sector to assess adequacy of existing standards, guidance, and regulations	Completed	2015 NARP Status: On schedule
2015	Develop test methods and provide data to assess arcing damage for new high voltage aerospace electrical systems	Completed	2015 NARP Status: On schedule
2016	Develop technical data and demonstrate advanced sensor technology and prototypes capable of real-time monitoring and evaluation of aircraft flight critical systems and composite structure	Delayed	Milestone is delayed from 2015 to 2016 due to the contractor's ongoing merger with another company and aircraft availability. A no cost extension has been granted by the FAA. 2015 NARP Status: On schedule
2016	Develop technical data to assess the fatigue and environmental durability of bonded repairs to metallic structure	On schedule	
2016	Produce proof of concept proficiency specimens to aid airline inspectors in familiarizing themselves with inspecting representative composite structure	On schedule	New milestone
2016	Develop technical data to evaluate nondestructive inspection's ability to detect hidden structural damage in composite material aircraft structure	On schedule	New milestone
2016	Determine needs of level I and level II training for 14 Code of Federal Regulations part 147 composite technicians and document teaching points to be used as curriculum	On schedule	New milestone
2016	Procure specimens with bonded repairs that have been aged in-service and conduct initial inspections in order to evaluate the durability of adhesive bonds used in repairs	On schedule	New milestone
2017	Develop test methods and provide data to assess bird strike avoidance and damage to rotorcraft	On schedule	New milestone
2017	Provide technical data for use by the FAA for approving angle of attack systems installation on general aviation airplanes	On schedule	

Year	Milestone	Status	Notes
2018	Develop technical data to assess damage tolerance of aluminum-lithium primary structure and follow on effort to material characterization	Delayed	Milestone is delayed from 2017 to 2018 since completion of the first phase project (which precedes this follow-on second phase project) was extended due to additional test requirements and because materials supplied by industry will take longer than originally planned. 2015 NARP Status: On schedule
2018	Develop technical data to evaluate non-flammable electrolyte lithium batteries and battery systems for aerospace applications	On schedule	
2018	Develop property standards for emerging process intensive materials	On schedule	
2019	Develop technical data to evaluate the feasibility of using fuel cell systems for aerospace application while retaining or improving the current level of safety in commercial transport aircraft	On schedule	
2020	Develop technical data to assess bonded repairs of wing structure	Delayed	Milestone is delayed from 2018 to 2020 due to budget shortfalls in FY 2015 from industry partner Boeing, which will delay fixture design and fabrication. 2015 NARP Status: On schedule
2021	Conduct test on an advanced metallic fuselage structure to access durability and damage tolerance of emerging technologies including unitized welded structure, new metallic alloys, and hybrid bonded construction	Delayed	Milestone is delayed from 2020 to 2021 due to delays in establishing cooperative research and development agreements with industry partners including ALCOA. 2015 NARP Status: Delayed from 2019 to 2020

Continued Airworthiness Program Progress in FY 2015:

- ✓ With the introduction of the Boeing 787 and the Airbus A350, there are now transport category aircrafts flying that are made predominately out of composite materials. Composite materials pose unique challenges to Airlines Inspectors who are looking to detect damage in these aircrafts. The objective of this work is to enhance the Inspector's ability to inspect composite laminate structures by developing training curriculum and proficiency specimens. Working with a research provider, the FAA has developed both the training curriculum and proficiency specimens this fiscal year.

- ✓ Identified significant frequencies, which provide the best sensitivity to detecting frame cracks and establishing excitation sources, which will detect hidden damage. The

objective of the work was to evaluate current nondestructive inspection tools ability to detect and characterize hidden structural damage in composite aircraft.

- ✓ Test methods were developed and data was provided in assessing arcing damage, for new high-voltage aerospace electrical systems. The research was conducted in-house, in the Arc Fault Evaluation Laboratory. Industry participated via cooperative research and development agreements.

1.1.5 Propulsion and Fuel Systems (R,E&D - A11.b)

The Propulsion and Fuel Systems Program supports Aviation Safety R&D Goal 1 by developing technologies, procedures, test methods, and criteria to enhance the airworthiness, reliability, and performance of civil turbine and piston engines, propellers, fuels, and fuel management systems.

The research milestones and their statuses are shown in Table 1.1., Propulsion and Fuel Systems Program Milestones below, followed by a summary of the significant progress made in FY 2015 towards achieving the R&D goal.

Table 1.1.5: Propulsion and Fuel Systems Program Milestones

Year	Milestone	Status	Notes
2015	Complete a certification tool that will predict the risk of failure of turbine engine rotor disks that may contain undetected material and manufacturing anomalies	Completed	2015 NARP Status: On schedule
2016	Enhance DARWIN® code to enable optimal autozoning to handle larger three dimensional files now more commonly used by engine manufacturers during rotor design	On schedule	
2017	Develop and release new DARWIN® analysis mode to address new Advisory Circular for attachment slots	On schedule	
2017	Develop and implement improved fleet risk analysis methods to address corrective actions	On schedule	
2018	Develop advanced stress intensity factor solutions for new geometries, extending the applicability of DARWIN® to new classes of life-limited engine components	On schedule	
2019	Develop and implement practical methods and tools to incorporate new/advanced integrated computational materials engineering manufacturing and design practices into damage tolerance methodologies	On schedule	

Year	Milestone	Status	Notes
2020	Develop and implement advanced damage tolerance methods and DARWIN® capabilities to address damage formation and growth at elevated temperatures, including environmental effects such as corrosion	On schedule	
2021	Initiate application DARWIN® for non-rotating components	On schedule	New milestone

Propulsion and Fuel Systems Program Progress in FY 2015:

- ✓ Updated the Design Assessment of Reliability With INspection software code (DARWIN®9.0) developed by Southwest Research Institute with several new capabilities for rotor designers and analysts. An optimal pre-zoning capability to create DARWIN® zones automatically and efficiently was implemented. Pre-zones are elements grouped by stress range, distance-to-surface, and temperature that have similar risk values. This capability greatly improves the speed and efficiency of the DARWIN® code and paves the way for analysis of very large three dimensional (3D) finite element models. A new capability that enables users to import 3D sector models directly into DARWIN® was implemented. A new stress intensity factor solution for partial-elliptical cracks that originate at corners with a 135° angle was added to the code. This solution will enable analysis of chamfered edges, which are commonly used design feature of turbine engines. These enhancements map directly to support future Advisory Circulars (ACs) planned by the FAA's Engine and Propeller Directorate. Benefits will accrue in the form of reduced risk of engine failures and fewer accidents, which in turn will lead to fewer injuries and fatalities.

1.1.6 Unmanned Aircraft Systems Research (R,E&D - A11.l)

The Unmanned Aircraft Systems (UAS) Research Program supports Aviation Safety R&D Goal 1 by conducting research to ensure the safe, efficient, and timely integration of UAS in the NAS. Information is provided to support certification procedures, airworthiness standards, operational requirements, maintenance procedures, and safety oversight activities for UAS civil applications and operations. Research activities focus on new technology assessments, methodology development, data collection and generation, laboratory and field validation, and technology transfer. The UAS Comprehensive Plan was signed by the Secretary of Transportation and submitted to Congress in November 2013.

The research milestones and their statuses are shown in Table 1.1.6, Unmanned Aircraft Systems Research below, followed by a summary of the significant progress made in FY 2015 towards achieving the R&D goal.

Table 1.1.6: Unmanned Aircraft Systems Research Program Milestones

Year	Milestone	Status	Notes
2015	Develop a comprehensive list of operational and airworthiness approval issues based on 14CFR 91 compliance	Completed	2015 NARP Status: On schedule
2015	Provide the FAA Administrator with UAS Center of Excellence proposal evaluation package	Completed	2015 NARP Status: On schedule
2016	Evaluate the American Society for Testing and Materials (ASTM) F38 small UAS industry standards to validate their applicability for establishing airworthiness of small UAS	On schedule	Milestone was revised because the evaluation is limited to ASTM standards for small UAS. Old wording 'Conduct field evaluations of unmanned aircraft system technologies and procedures (including sense and avoid, control and communications, and contingency management) to develop certification and airworthiness standards' 2015 NARP Status: On schedule
2017	Develop prototype antenna and brass board electronics, lab-test and flight test antenna final designs for Airborne Collision Avoidance System antennas along with hardware/software for test data collection	On schedule	
2017	Document the most optimal sensor fusion strategy and the sensitivity of each data fusion performance parameter in transitioning from sense and avoid Function one (remain well clear) to Function two (avoid collisions)	On schedule	
2017	Collect and analyze UAS Safety Data from Congressionally mandated test sites	Accelerated	Milestone is accelerated from 2018 to 2017 since the results of these data analyses will be presented in a report to Congress on findings and conclusions concerning the projects as required by Section 332(c)(5) of the 2012 FAA Modernization and Reform Act. This report is required no later than 90 days after the termination of the program, with the current termination date set for February of 2017 (unless extended by subsequent legislation). 2015 NARP Status: On schedule
2018	Define ground control station human interface requirements, UAS pilot training requirements, and ground observer requirements	Delayed	Milestone is delayed from 2015 to 2018 because this task has been assigned to the UAS Center of Excellence (established in May 2015). The work will begin in FY 2016 and is expected to complete in FY 2018. 2015 NARP Status: On schedule

Year	Milestone	Status	Notes
2018	Complete manufacturer and operator maintenance data collection and analysis and develop maintenance technician Part 147 practical test standards and UAS repair station operational criteria	On schedule	
2019	Develop UAS maintenance programs content and related UAS accident/incident data reporting requirements	On schedule	
2020	Update the Technical Standards Order for airborne detect and avoid for UAS, phase II	On schedule	
2020	Complete UAS navigation accuracy criteria	On schedule	New milestone
2021	Develop standardized procedures for UAS navigation and operational requirements for UAS platforms	On schedule	New milestone

Unmanned Aircraft Systems Research Program Progress in FY 2015:

- ✓ The UAS requires Sense and Avoid (SAA) systems to comply with 14 Code of Federal Regulations (CFR) 91 without a pilot on board the aircraft. Multiple sensors are needed to assure all threats (cooperative and non-cooperative) can be detected and tracked to remain well clear and safely separated from other aircraft. However, the use of multiple sensors requires strategies to combine (fuse) the position information obtained over time from each sensor. Without these strategies, threats may not be accurately detected and/or tracked, and the SAA system may provide inaccurate information. The Multi-Sensor Data Fusion research implemented several different sensor fusion strategies into a high-speed simulation environment. These strategies include centralized, distributed and hybrid configurations, as well as several different tracker filters. The sensors implemented into architecture are radar and Automatic Dependent Surveillance Broadcast (ADS-B). Once all fusion strategies are developed, tests can be conducted in various configurations to compare performance and examine trade-offs between each of the options.

- ✓ In order to integrate UASs into the NAS, the FAA will establish 14 CFR Part 107, allowing small UAS (sUAS) to operate in the NAS. As part of this rulemaking effort, ASTM has been selected by the FAA to establish a set of consensus standards for airworthiness, maintenance and operation in support of Part 107. These standards need to be exercised using a test case to find weaknesses in order to make them more robust, thus increasing safety of sUAS operations in the NAS. Electromagnetic interference, temperature, and vibration tests were conducted to assess the viability of the standards developed by ASTM's F38 committee. The outcome of the research will enable the committee to further refine sUAS certification requirements.

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1.2 Aviation Safety R&D Goal 2

Improved knowledge of the human-system interface and a reduction in accidents and incidents through enhanced aerospace vehicle, air traffic, and technical operations that adapt to, compensate for, and augment the performance of the human.

1.2.1 Air Traffic Control/Technical Operations Human Factors (R,E&D - A11.i)

The Air Traffic Control/Technical Operations Human Factors Program supports Aviation Safety R&D Goal 2 by emphasizing the concept of Human-System Integration (HSI) and safety aspects of the functions performed by Air Traffic Controllers and Technical Operations Personnel. The HSI concept addresses the interactions between workstation design, training and facility assignment, and human error and human performance.

The research milestones and their statuses are shown in Table 1.2.1, Air Traffic Control/Technical Operations Human Factors Program Milestones below, followed by a summary of the significant progress made in FY 2015 towards achieving the R&D goal.

Table 1.2.1: Air Traffic Control/Technical Operations Human Factors Program Milestones

Year	Milestone	Status	Notes
2015	Provide a draft of a revised Human Factors Design Standard for human factors application to air traffic control system acquisition	Completed	2015 NARP Status: On schedule
2015	Conduct a human-in-the-loop experiment to assess the possible effects of integration of UAS into Class C airspace, including effects on terminal controller workload and communications	Completed	2015 NARP Status: On schedule
2016	Deliver a method for the development of Terminal Radar Approach Control Air Traffic Controller training standards	On schedule	
2017	Validate the Terminal Radar Approach Control training standards and determine the reliability of the evaluation criteria	On schedule	
2018	Deliver human factors training information to support the Air Traffic Organization’s top five NAS hazards	On schedule	

Year	Milestone	Status	Notes
2019	Develop and implement an air traffic control information display and control management design strategy that incorporates best practices and lessons learned from prior and current air traffic user team activities in support of acquisition programs' efforts to implement new and revised controller functions	On schedule	Milestone was revised due to a change in sponsor priorities. The FAA's human factors and air traffic requirements staff have identified the need for a managed design approach for better information display and control management in the air traffic control workstation. Old wording 'Deliver a human performance data base to support Safety Risk Management Documents as part of the FAA Acquisition Management System' 2015 NARP Status: On schedule
2020	Develop air traffic control system automation policy and guidance for the FAA Acquisition Management System that leverages lessons learned from flight deck automation	On schedule	Milestone was revised due to change in sponsor priorities. The FAA's human factors and air traffic requirements staff have identified the need for additional guidance for use of air traffic control system automation. Old wording 'Develop tools and methods for conducting predictive human performance safety analyses of automated air traffic control systems' 2015 NARP Status: On schedule
2021	Expand the work on the air traffic control information display and control management design strategy to achieve agile design characteristics, allowing reconfiguration and evolution of the planned design to accommodate operational changes and to achieve greater flexibility in adapting the design	On schedule	New milestone

Air Traffic Control/Technical Operations Human Factors Program Progress in FY 2015:

- ✓ Assessed human and safety factors at the Remote Tower Facility at Leesburg Executive Airport. This project is a joint effort of the Virginia Small Aircraft Transportation System (VSATS) and Saab-Sensis Corporation in partnership with the Town of Leesburg, Virginia. The FAA is evaluating the suitability and safety impacts of the Remote Tower equipment for ATC tower operations. The human factors assessment identified several human factors and safety considerations, including the initial controller display calibration, ongoing display contrast filter management over the range of sky conditions, maintainability and system health monitoring considerations, as well as controller light gun slew controls. The Remote Tower facility configuration is identical to existing operational sites in Sweden and Finland. The facility includes a suite of video cameras that are contained in a specially designed protective housing, and which provide airport air and surface visual images to a set of video displays that Air Traffic Controllers

can use. The upcoming initial evaluation will allow controllers to passively observe traffic in the Remote Tower facility. Plans are forming for a later operational evaluation in which the Remote Tower facility controllers will conduct live ATC operations, while a temporary tower facility sited on the field will provide backup.

- ✓ Provided human factors facilitation support for the FAA Administrator's Runway Safety Call to Action Conference; which involved more than 100 people from the entire aviation community, including air carriers, airports, General Aviation (GA), and labor groups such as the National Air Traffic Control Association (NATCA) and Professional Aviation Safety Specialists partners. The purpose of the conference was to establish an action plan and a collaborative roadmap with stakeholders to develop additional runway safety solutions. At the conference, three areas were focused on, which safety data reveal as root causes for runway incursions:
    - Visual recognition which covers issues involving airport signs, marking and lighting;
    - Communications which involves problems with using correct ATC phraseology or hear-back/read-back errors, and
    - Procedures and awareness that involves errors made due to distraction or inattention.

1.2.2 Flightdeck/Maintenance/System Integration Human Factors (R,E&D - A11.g)

The Flightdeck/Maintenance/System Integration Human Factors Program supports Aviation Safety R&D Goal 2 by providing the human factors research for guidelines, handbooks, ACs and rules, and regulations, which ensure safe and efficient aircraft operations. Research results enable the FAA and industry to:

- Improve task performance and training for aircrew, inspectors, and maintenance technicians;
- Improve training for UAS control station and crew;
- Develop and apply error management strategies to flight and maintenance operations, and
- Ensure certification of new aircraft and design or modification of equipment considers human factors.

The research milestones and their statuses are shown in Table 1.2.2, Flightdeck/Maintenance/System Integration Human Factors Program Milestones below, followed by a summary of the significant progress made in FY 2015 towards achieving the R&D goal.

Table 1.2.2: Flightdeck/Maintenance/System Integration Human Factors Program Milestones

Year	Milestone	Status	Notes
2015	Report best practices for maintenance and ramp line operations safety assessment	Completed	2015 NARP Status: On schedule
2016	Provide recommendations for operational credit related to equipage with synthetic vision systems	On schedule	
2017	Provide recommendations for Automatic Dependent Surveillance Broadcast/Cockpit Display of Traffic Information minimum operational performance standards and related FAA guidance	On schedule	
2018	Define methods for evaluating both Traditional and Advanced Qualification Program training programs to support updates to guidance for crew resource management	On schedule	
2019	Address minimum equipment requirements for new operational concepts using advanced vision systems and head-up/head-mounted displays	On schedule	
2020	Provide a report with recommendations for helicopter crew resource management best practices	On schedule	
2021	Based on pilot performance data collected on the operational impacts associated with using combined vision systems in low visibility operations and produce a report that addresses the relevant pilot performance and operational impact findings	On schedule	New milestone

Flightdeck/Maintenance/System Integration Human Factors Program Progress in FY 2015:

- ✓ Conducted field tests of training materials and techniques for maintenance and ramp Line Operations Safety Assessments (LOSA) involving two major carrier/maintenance organizations. A survey of best practices was administered to all organizations who had initiated LOSA efforts. A report was submitted which documents results and includes a description of challenges and best practices for LOSA implementation.

1.2.3 NextGen - Air Ground Integration Human Factors (R,E&D - A12.b)

The NextGen - Air Ground Integration Human Factors Program supports Aviation Safety R&D Goal 2 by addressing flight deck and ATC integration for NextGen operational capabilities. It focuses on human factors issues that primarily affect the pilot side of the air-ground integration challenge. It conducts research to ensure pilots receive the right information at the right time for decision-making and collaboration with ATC to operate in the NAS safely. The program also includes research that addresses human performance and coordination requirements for pilots and Air Traffic Controllers, through development of the initial standards and procedures that lead

to operational capabilities for separation assurance. It assessed human factors risks and requirements associated with self-separation policies, procedures, and maneuvers, including interim operational capabilities for reduced and delegated separation and high-density airport traffic operations in reduced visibility using advanced flight deck technologies.

Although it is managed as a single program, the NextGen-Air Ground Integration Human Factors Program (A12.b) continues to support two NARP principles by addressing flight deck and ATC integration for NextGen operational capabilities. The elements described in this section under Aviation Safety R&D Goal 2 and those described in section 2.2.1 under Efficiency R&D Goal 2 define the program, and together provide the NextGen-Air Ground Integration Human Factors Program's FY 2015 budget and planned milestones from FY 2016 through FY 2021.

The research milestones and their statuses are shown in Table 1.2.3, NextGen-Air Ground Integration Human Factors Program Milestones below, followed by a summary of the significant progress made in FY 2015 towards achieving the R&D goal.

Table 1.2.3: NextGen-Air Ground Integration Human Factors Program Milestones

Year	Milestone	Status	Notes
2015	Complete research and provide human factors guidance for Automatic Dependent Surveillance-Broadcast/ Cockpit Display of Traffic Information equipment used for in-trail procedures	Deleted	Milestone was deleted because it involved an operational demonstration with a commercial airline that ultimately merged with another airline. As a result, the activity was redirected to a new area (see new milestone below). 2015 NARP Status: On schedule
2015	Complete human factors research and identify information requirements for flight deck-based interval management in the terminal area and closely spaced parallel approaches	Completed	New milestone created due to the necessary re-scoping of research on an original milestone (see milestone notes above). Sponsors redirected the research originally planned for the milestone above to this new milestone and completed work in FY 2015. New milestone
2019	Create a report describing the research and experimental findings related to knowledge and skill loss on the flight deck in the NextGen operating environment, where there is anticipation to be greater reliance on automation. This report will include enhanced training considerations and mitigations for skill loss.	On schedule	Milestone was previously shown under Principle 2 in the Flightdeck/Maintenance/System Integration Human Factors (R,E&D - A11.g) program but has been moved here as it better aligns to this program and to Principle 1.

Year	Milestone	Status	Notes
2020	Create a report describing results of human-in-the-loop simulations conducted to validate previous research outputs that included proposed training, procedural and other considerations to mitigate pilot knowledge and skill loss in the highly-automated aircraft flight deck in the NextGen operating environment	On schedule	
2021	Create a report of the findings of field tests that evaluate the effectiveness of the mitigations validated by the human-in-the-loop simulations previously conducted, and evaluate the relative effectiveness of training, procedures and equipment re-design as mitigation strategies against identified skill decay issues resulting from interfacing with highly automated flight deck procedures	On schedule	New milestone

NextGen - Air Ground Integration Human Factors Program Progress in FY 2015:

- ✓ Implementing the NextGen Air Transportation System includes the application of ADS-B technologies and procedures, to improve air traffic safety and efficiency. The current project involved the analysis of flight deck technologies and procedures using ADS-B for Interval Management (IM) operations and Closely-Spaced Parallel Approach (CSPA) operations in the existing airspace and in NextGen airspace. The use of IM procedures may permit increased capacity in the terminal area, particularly surrounding busy airports. With the use of ADS-B, IM may allow flight crews and ATC to effectively achieve and maintain spacing between aircraft in en route and terminal airspace. This technique will require new ATC and flight deck procedures and tools to allow for safe and efficient flight following. Controllers determine and assign intervals between aircraft whose flight crews then are required to keep these intervals using IM procedures. The flight crews need to get the right information to conduct IM operations. This information should be in a location on the flight deck that permits easy identification and validation. Currently, tools and procedures are being developed for both ground IM and flight deck IM. The application of CSPAs are also considered as a part of future airspace operations. It can increase the efficiency of airports in Instrument Meteorological Conditions (IMC) by allowing independent, parallel approaches to runways with a lateral separation of at least 2500 ft. The use of IM and CSPA offers the potential for increased capacity in the terminal area; however, each will require new display features, alerting technologies, and flight deck procedures. The project addressed findings from a focus group interview with six commercial pilots who had simulation experience with the use of a candidate IM technology. In the interviews, the research team addressed information requirements for the various tasks and procedures associated with IM and CSPA, including alerting/notification, target acquisition, maintaining position, aircraft performance awareness and modification, and responses to off-nominal events.

1.2.4 Center for Advanced Aviation System Development (F&E - 4A08)

The Center for Advanced Aviation System Development (CAASD) Program supports Aviation Safety R&D Goal 2 by developing and demonstrating a concept for a reduced cost surface surveillance capability for small and medium airports in the NAS and through examining methods for using speech recognition to improve surface safety.

CAASD made the following Progress in FY 2015 towards Aviation Safety R&D Goal 2:

- ✓ Voice communications are central to controllers and pilots in conducting surface operations. However, the information conveyed via voice is not used by automation systems intended to improve controller situation awareness and runway safety. Leveraging existing archives of controller speech and surveillance data, CAASD developed algorithms to automatically recognize controller runway clearances, compare clearances to surface surveillance data, and determine when aircraft behavior does not align with controller instructions. The envisioned system resulting from this research is expected to enable Airport Surface Detection Equipment Model X (ASDE-X) conflict detection and alerting as soon as aircraft movement begins. The concept is expected to improve runway safety and further the state-of-the-art in the use of controller speech as an information-rich data source. Findings from this work are being used to support a potential program of work in speech recognition-based capabilities.

- ✓ The development of the Low Cost Surface Awareness (LCSA) surveillance concept was completed, with the demonstration of a prototype. The 2015 prototype was enabled with the use of infrared cameras to monitor the movement of aircraft and vehicles across the airport surface. Algorithms were used to detect the presence of targets and to estimate their position on the airport surface. This information was then presented on a map display for use by air traffic control or airport operations. A prototype end-to-end LCSA system was implemented at Teterboro Airport in Teterboro, New Jersey. The demonstration was conducted in coordination with the Port Authority of New York and New Jersey (PANYNJ). The conclusion of the demonstration represents the end of the research phase of this project. LCSA now moves into the investment decision phase.

1.3 Aviation Safety R&D Goal 3

Improved understanding of factors that influence human physiology and performance in aerospace environments and guidance and tools that enhance human safety, protection, and survival during civil aerospace operations.

1.3.1 Aeromedical Research (R,E&D - A11.j)

The Aeromedical Research Program supports Aviation Safety R&D Goal 3 by identifying human conditions that indicate an inability to meet flight demands, both in the absence and in the presence of emergency flight conditions.

The research milestones and their statuses are shown in Table 1.3.1, Aeromedical Research Program Milestones below, followed by a summary of the significant progress made in FY 2015 towards achieving the R&D goal.

Table 1.3.1: Aeromedical Research Program Milestones

Year	Milestone	Status	Notes
2015	Accomplish experimental projects in support of regulations, certification, and operations for existing Aviation Rulemaking Committees by providing data and guidance for new or revised regulation of airliner cabin environment standards	Completed	2015 NARP Status: Delayed from 2014 to 2015
2015	Establish validation parameters for mathematical models that can evaluate whether aircraft type designs meet requirements for evacuation and emergency response capability, in lieu of actual tests	Completed	2015 NARP Status: On schedule
2015	Develop bleed air contamination models of engine compressors and high temperature air system for effects on the health and safety of passengers and crew	Completed	2015 NARP Status: On schedule
2015	Incorporate aerospace medical issues in the development of safety strategies concerning pilot impairment, incapacitation, spatial disorientation, and other aeromedical-related factors that contribute to loss of aircraft control	Completed	2015 NARP Status: On schedule
2015	Develop advanced methods to extract aeromedical information for prognostic identification of human safety risks	Completed	2015 NARP Status: On schedule

Year	Milestone	Status	Notes
2015	Deploy a system titled Aerospace Accident Injury and Autopsy Data System, capable of compiling, classifying, assessing, and determining causal factors of aviation-related injuries. The system will link aviation-related injuries to autopsy findings, medical certification data, aircraft cabin configurations, and biodynamic test results	Completed	2015 NARP Status: On schedule
2016	Apply and develop advances in gene expression, toxicology, and bioinformatics technology and methods to define human response to aerospace stressors	On schedule	
2017	Analyze medical certification and accident data to derive methods or tools to enhance aircrew health, education programs, and medical certification decision-making processes	On schedule	
2018	Develop advanced methodologies to analyze human biological samples for emerging drugs, toxins or factors that may impact pilot performance or assist in determining accident causality	On schedule	
2019	Develop and assess safety and emergency equipment standards, procedures, and criteria to ensure the protection and survival of all aircraft occupants from all aircraft incidents and accidents	On schedule	
2020	Identify biomarkers for the detection of degraded human performance, incapacitation, or impairment resulting from environmental, behavioral, or operational factors (e.g., hypoxia, alcohol consumption, or fatigue or pathology)	On schedule	
2021	Conduct research to enhance protection and survival from aircraft accidents	On schedule	New milestone
2021	Conduct research to enhance aircraft accident prevention and investigation methodologies	On schedule	New milestone

Aeromedical Research Program Progress in FY 2015:

- ✓ In order to develop advanced methods of extracting aeromedical information for identifying human safety risks, the program evaluated the impact of the presence of tricyclics in pilots involved in fatal aviation accidents. Tricyclics are used primarily in the clinical treatment of mood disorders. They are named after their chemical structure, which contains three rings of atoms. Results of this research will assist in defining human response to aerospace stresses, as well as identify the impact of antidepressant

medications that may affect pilot performance and assist in determining accident causality in the aviation environment.

- ✓ Examined the prevalence of drugs and alcohol in pilots fatally injured in civil aviation accidents that occurred during 2009-2013. The results of the study will be helpful in establishing current trends in drug usage and associated medical conditions in the pilot population.

- ✓ Conducted analyses and assessed postmortem concentrations of paroxetine, an antidepressant of the selective serotonin reuptake inhibitor class, in human specimens obtained from aviation accidents. Results from this research will assist the FAA and the NTSB in accident investigations and refine the existing knowledge base for human performance under the influence of selective serotonin reuptake inhibitors.

- ✓ Virtual Reality, in the form of 3D interactive simulations of emergency scenarios, is increasingly used for education in emergency preparedness training for human safety risks. Research was conducted to advance knowledge about different aspects of virtual emergency experiences. Results provided the following information:

    - The designs proposed are effective in improving emergency equipment standards and preparedness of common citizens, considering aviation safety as a relevant case study.

    - Changing specific visual and auditory features is effective to create emotionally different versions of the same experience, increasing the level of fear aroused in users. The protection motivation role of fear highlighted by psychological studies of traditional media also applies to desktop virtual reality.

- ✓ In November 2015, a workshop was conducted on Injury Mechanism Analysis in Aerospace Accident Investigation. The workshop addressed the biomechanics and biodynamics associated with aircraft accident injuries in support of research, developing the best methods of forensic evidence collection, and the establishment of aeromedical hazard criteria. Participants included scientists, aviation medical examiners, residents, accident investigators, and other members of the aeromedical community (government, academia, industry). The research ultimately supported the development of policy issues relative to the expansion of flight privileges that do not require medical oversight.

- ✓ Developed advanced methodologies to observe and calculate probabilities that are suitable for risk managers who have responsibilities in high-risk arenas, such as aviation.

- ✓ Provided recommendations on hazards to flight safety relative to the assessment of autopsy and forensic toxicology records from aircraft accident victims.

- ✓ Developed and assessed improved evacuation equipment and evacuation aids for visual, aural and tactile aides (such as lighting, aural way-finding systems, and symbolic information media) to enhance rapid evacuation. Based on the results of the studies and

equipment technology identified, it provided additional guidance material and potential language for regulatory requirements.

- ✓ Determined human impact tolerance levels and methods for predicting occupant unconsciousness and leg injuries that can occur during a survivable crash. The current brace position - head against the seat back with hands on top of the seat back - was only successful in reducing head injury risk for locked-out seat backs. However, for full break-over and energy absorbing seat backs, this position increased the severity of the head impact. To reduce detrimental interaction between the occupant's arms and the seatback, the current position was modified by placing the hands down by the lower legs instead of on the seat back. This alternate position was successful in significantly reducing head and neck injury risk for all of the seat back types evaluated. This research has led to the determination that as seat technology has evolved, the most effective brace position has as well, and the current positions recommended in AC 121-24B may need some adjustment to provide an equivalent level of safety for all passenger seat back types.

- ✓ Assessed the relevance of genetic risk scores for cardiovascular disease. A review of the literature for single nucleotide polymorphisms associated with cardiovascular disease revealed about 30 high-confidence single nucleotide polymorphisms. Individually, none is predictive for cardiovascular disease. Several authors combined some number of these single nucleotide polymorphisms into a genetic risk score modeled on the Framingham Risk Score that is based on traditional risk factors, including lipid profile, hypertension, age, family history, diabetes, and smoking status. All genetic risk scores were associated with cardiovascular disease and had a similar predictive value as traditional risk factors; however, when genetic risk scores were combined with predictive scores based on traditional risk factors, there was only a minimal increase in predictive value.

1.3.2 Fire Research and Safety (R,E&D - All.a)

The Fire Research and Safety Program supports Aviation Safety R&D Goal 3 by developing technologies, procedures, test methods, and fire performance criteria that can prevent accidents caused by hidden cabin or cargo compartment in-flight fires and fuel tank explosions and improve survivability during a post-crash fire. Fire safety focuses on near-term improvements in fire test methods and materials performance criteria, fire detection and suppression systems, fuel tank explosion protection, and identification of hazardous materials. Fire research addresses fundamental issues of (a) combustion toxicity; the impact of flame retardant chemicals, (b) health hazards of cabin materials; the impact of materials flammability on the initiation of in-flight fires, and (c) post-crash survivability. Far-term research focuses on enabling technology for ultra-fire-resistant interior materials.

The research milestones and their statuses are shown in Table 1.3.2 Fire Research and Safety Program Milestones below, followed by a summary of the significant progress made in FY 2015 towards achieving the R&D goal.

Table 1.3.2: Fire Research and Safety Program Milestones

Year	Milestone	Status	Notes
2015	Evaluate the effectiveness of a water spray system in a freighter main deck cargo compartment	Completed	2015 NARP Status: Delayed from 2014 to 2015
2015	Develop a performance standard for small lithium batteries transported in passenger carrying aircraft	Completed	2015 NARP Status: On schedule
2015	Evaluate aircraft improvements to protect against lithium battery cargo fires	Completed	2015 NARP Status: On schedule
2015	Develop and finalize a small-scale flammability test method for the in-flight fire resistance of composite fuselage structure	Completed	2015 NARP Status: On schedule
2016	Analyze the large number of in-flight smoke, odor and detector activation incidents	Delayed	Milestone is delayed from 2015 to 2016 due to a change in scope. The time period for the collection and analysis of incidents was extended by three years, from the original period of 2002 through 2011 and 2002 through 2014, in order to make the study more useful. 2015 NARP Status: On schedule
2016	Develop a computational fluid dynamics model for hidden fire growth	Deleted	Milestone is deleted due to a change in focus (i.e., to characterize the heat release rate and burning mode of materials in inaccessible locations). This data can be used as inputs to commercially available computational fluid dynamics codes that can be used to model hidden fires in aircraft. 2015 NARP Status: On schedule
2016	Evaluate the effectiveness of existing cargo compartment fire suppression systems on fires involving lithium ion batteries	On schedule	New milestone
2016	Conduct full-scale fuel-fire tests under simulated post-crash accident conditions to determine the efficacy of using non-heat-release-compliant materials in the lower area of business-class aircraft seats	On schedule	New milestone
2016	Evaluate methodologies for bench-scale screening of cabin materials and flame retardants for combustion toxicity	On schedule	New milestone
2017	Develop a new test apparatus and methodology for accurately measuring the heat release rate of honeycomb, thermoplastic, and other large surface-area cabin interior materials	On schedule	New milestone
2017	Determine mode of flame spread of structural composites in hidden areas and enclosed spaces	On schedule	New milestone

Year	Milestone	Status	Notes
2017	Determine the efficacy of current emergency smoke ventilation procedures and certification criteria	On schedule	
2018	Evaluate detector technology that discriminates between aircraft fire and non-fire smoke/odor sources	Delayed	Milestone is delayed from 2017 to 2018 due to delays in the estimated completion time of preceding milestones. 2015 NARP Status: On schedule
2018	Make available a searchable database of fire test results and material flammability for public, government and industry use	On schedule	New milestone
2018	Examine state-of-the-art technology for protection of compressed hydrogen in aircraft fuel cell applications	On schedule	
2019	Develop hidden fire detection and extinguishment improvements	Delayed	Milestone is delayed from 2016 to 2019 due to a change in sequence of test plans involving fire detection issues and a change in the estimated completion time of this work due to the unknown outputs of preceding milestones. 2015 NARP Status: On schedule
2019	Determine mechanism of gas phase flame inhibition by halogen and halogen replacement flame retardant	On schedule	New milestone
2019	Develop fire protection measures for aircraft fuel cell applications	On schedule	
2020	Test and evaluate an integrated aircraft fire detection and extinguishment system	Delayed	Milestone is delayed from 2018 to 2020 due to the unknown outcomes of preceding milestones. 2015 NARP Status: On schedule
2020	Conduct state-of-the-art review of fire-safe technology to replace stored compressed oxygen and chemical oxygen generators	On schedule	
2021	Conduct a cost-benefit analysis of an integrated fire detection and extinguishment system	Delayed	Milestone is delayed from 2019 to 2021 due to delays in the estimated completion time of preceding milestones. 2015 NARP Status: On schedule

Fire Research and Safety Program Progress in FY 2015:

- ✓ Configured and instrumented a DC-10 below- floor cargo compartment for testing. Preliminary testing was conducted to document the concentration of suppression agent that penetrates into loaded cargo containers inside the compartment. The results from the testing can be used to determine if the concentration is sufficient to prevent the ignition of flammable gases produced by lithium battery fires inside cargo containers.

- ✓ Configured and instrumented a section of the above ceiling attic space of a 747SP test fuselage with thermocouples and video cameras. A propane test burner was also

constructed and installed. This section of the airplane is ready for testing to begin to collect temperature data for the spread of heat from the burner throughout the space. The geometry of the attic space and the properties of the materials in this area were input into a Computational Fluid Dynamic code. The temperature data will be compared to the output predicted by the code using the same heat source.

1.4 Aviation Safety R&D Goal 4

Improved system-wide access and sharing of aviation safety data and analysis tools within the aviation community, providing safety resources that are integrated with operations of aviation industry stakeholders.

1.4.1 System Safety Management (R,E&D - A11.h)

The System Safety Management Program supports Aviation Safety R&D Goal 4 by developing risk management methods, prototype tools, technical information, and Safety Management System Procedures and Practices. In addition, the program develops an infrastructure that enables the free sharing of de-identified, aggregate safety information derived from government and industry sources in a protected manner. It also conducts research to leverage new technologies and procedures that enhance pilot, aircraft and operational safety in terminal and enroute domains.

The research milestones and their statuses are shown in Table 1.4.2, System Safety Management Program Milestones below, followed by a summary of the significant progress made in FY 2015 towards achieving the R&D goal.

Table 1.4.1: System Safety Management Program Milestones

Year	Milestone	Status	Notes
2015	Develop an integrated domain assessment proof of concept to support the air traffic safety oversight service's approval process of controls for high risk hazards	Completed	2015 NARP Status: On schedule
2015	Complete the study on best practices for training and use of angle of attack equipment in general aviation operations	Completed	2015 NARP Status: On schedule
2015	Expand the Aviation Safety Information Analysis and Sharing System Safety analysis to other domains (e.g., general aviation, rotorcraft, corporate, military)	Completed	2015 NARP Status: On schedule
2016	Complete an evaluation of an identified airplane-based measuring method concerning real-time runway slipperiness, reporting all potential runway surface conditions and airplane configurations	On schedule	

Year	Milestone	Status	Notes
2016	Develop test criteria by varying motion characteristics to span the domain of the criteria and compare variations against subjective opinions of motion quality	On schedule	
2016	Develop analytical capabilities for air traffic safety oversight service to target its oversight resources toward facilities posing the highest risk to air traffic safety	On schedule	
2016	Develop a process to create representative stall models that could be applied for most transport category airplanes for upset recovery training, in- flight simulators	On schedule	
2017	Develop concept of operations and a model to establish safety oversight profiles for Air Traffic Organization facilities, systems, procedures, and safety standards	On schedule	
2017	Develop an integrated domain safety risk evaluation model of NAS critical systems to support the assessment and approval of NAS critical system changes and controls for high risk hazards	Accelerated	Milestone was delayed in the 2015 NARP due to anticipation of delays in funds; however, there was no funding issue and the milestone is back on the original schedule to be completed in 2017. Old wording 'Expand the Integrated Domain Assessment from eight selected NAS systems to all major NAS systems.' 2015 NARP Status**:** Delayed from 2017 to 2018
2017	Develop criteria for determining when a missed approach should be performed	On schedule	
2018	Develop methodology to identify and optimize Air Traffic Safety Oversight Service oversight activities, surveillance targets, and data collection parameters based on risk trends and air traffic safety oversight service resources	On schedule	
2018	Develop an integrated domain safety risk evaluation model of air traffic procedures to support the assessment and approval of air traffic procedure changes related to separation minima	On schedule	Milestone was revised to describe the milestone more accurately. Old wording 'Develop additional capability to the Integrated Domain Assessment tool functions to support the evaluation of NAS procedure changes related to separation minima' 2015 NARP Status: On schedule

Year	Milestone	Status	Notes
2018	Develop state-of-art analytical capabilities for Aviation Safety Information Analysis and Sharing System to analyze rotorcraft data	On schedule	
2018	Determine the criteria for adoption of Helicopter Advanced Vision Systems for Point-in-Space Instrument Approach procedures	On schedule	New milestone
2019	Develop and demonstrate Safety Oversight Management System prototype tool and case studies for Air Traffic Safety Oversight Service	On schedule	
2019	Develop integrated domain safety risk evaluation prototype and demonstrate its applications in support of oversight of Air Traffic Organization	On schedule	Milestone was revised for clarity. Old wording 'Demonstrate applications of the Integrated Domain Assessment tool functions' 2015 NARP Status: On schedule
2020	Develop advance risk assessment capabilities for safety oversight	On schedule	
2021	Research and develop a web-based tool to enable air traffic safety oversight service and flight standards service to rapidly view, graph, and analyze runway surface event safety data	On schedule	New milestone

System Safety Management Program Progress in FY 2015:

- ✓ Evaluated two proposed methods to estimate the real-time runway slipperiness level using recorded aircraft data during landing roll and frameworks for communicating runway slipperiness information in a timely manner. The research team will continue the evaluation of methods to summarize the strengths and shortcomings of different proposed systems regarding the technical accuracy and usefulness of information obtained for airplane-based runway condition reporting in real time in FY 2016.

- ✓ Completed the analysis of motion data and pilot subjective feedback and documented findings in a technical report titled Transfer of Training on the Vertical Motion Simulator. The research team also compared the simulator motion data against subjective assessments and existing literature to develop recommendations for motion criteria, and documented findings in a technical report titled Objective Motion Cueing Criteria Investigation Based on Three Flight Tasks.

- ✓ Updated a mathematical stall model for A330 based on findings from a Subject Matter Expert Pilot's evaluation. Modeling efforts for additional aircraft types are continuing, including a collection of powered data for the high-wing turbo-prop and a T-tail regional jet.

- ✓ Extended the Facility Risk Assessment Tool (FRAT) by identifying additional risk factors and supporting data sources to quantify each risk factor. Software was defined for

database architecture; and a pseudo code was needed to translate FRAT risk model and risk factor algorithms to the level of detail needed for further prototype development. User sessions were conducted to validate the utility and usability of FRAT framework and outputs, including risk factor scores, facility risk scores, risk-based performance trends, and comparison of risk across groups of ATC facilities with similar attributes.

- ✓ Utilized Helicopter Flight Data Monitoring (HFDM) data collected along with state-of-the-art methods and analysis techniques as part of a cloud-based repository to develop prototype safety tools and metrics for the rotorcraft community. In addition, in order to reach the various communities and mission segments within the rotorcraft industry, the research team established an HFDM working group and secured participation from several key helicopter air ambulance and Oil and Gas Provider Operators. Initial research findings were presented to the helicopter community at various outreach events including Heli-Expo. 2015, Helicopter Safety Summit 2015, and 2015 World Helicopter Day.

1.4.2 Center for Advanced Aviation System Development (F&E - 4A08)

The Center for Advanced Aviation System Development (CAASD) supports Aviation Safety R&D Goal 4 by providing an air traffic control manager dashboard to support the quick analysis of critical safety data.

CAASD made the following Progress in FY 2015 towards Aviation Safety R&D Goal 4:

- ✓ Air Traffic Control Managers have a need for simple, up-to-date visualizations that support the analysis of safety data, and allow for the fast interpretation of performance and safety issues. CAASD has developed the Manager’s Dashboard, which provides a collection of visualizations to enable local, district, regional, and national Air Traffic Managers to quickly monitor and review performance and related safety data. The Manager's Dashboard is available through the FAA's Facility Safety Portal and provides a detailed view of incidents by type, date, and location, as well as system-wide trends. As a result, the dashboard provides standardized data, which can be accessed regularly, and can support the quick analysis of critical safety data.

1.5 Aviation Safety R&D Goals 5 and 6

Established requirements and standards for enabling the availability and improving the quality and quantity of meteorological information to safely implement NextGen operational improvements.

Improved accuracy and accessibility of observed and forecast weather to reduce the number of accidents and incidents attributed to hazardous weather.

1.5.1 NextGen - Weather Technology in the Cockpit (R,E&D - A12.c)

The NextGen – Weather Technology in the Cockpit (WTIC) Program supports Aviation Safety R&D Goals 5 and 6 by doing research to develop, verify, and validate recommended requirements for incorporation into Minimum Weather Service (MinWxSvc) standards. The MinWxSvc is defined as the minimum cockpit meteorological (MET) information, minimum performance standards (e.g., accuracy) of the MET information, minimum information rendering standards, and enhanced training on cockpit MET information and technology. WTIC research identifies safety hazards/risks attributable to adverse weather conditions and associated gaps of MET information in the cockpit. The MinWxSvc standards will resolve the identified MET information gaps to mitigate the associated safety risks/hazards.

Although it is managed as a single program, the WTIC Program (A12.c) continues to support all three NARP principles. The elements described in this section, listed under Aviation Safety R&D Goals 5 and 6; as well as those described in section 2.4.1 under Efficiency R&D Goals 4 and 5; and those in section 3.1.4 under Environmental R&D Goals 1 through 3, define the program and provide the WTIC Program's FY 2016 budget and planned milestones from FY 2016 through FY 2021.

The research milestones and their statuses are shown in Table 1.5.1, NextGen-Weather Technology in the Cockpit Program Milestones below, followed by a summary of the significant progress made in FY 2015 towards achieving the R&D goals.

Table 1.5.1: NextGen - Weather Technology in the Cockpit Program Milestones

Year	Milestone	Status	Notes
2015	Quantify the impacts to the NAS of uplinking graphical turbulence guidance and eddy dissipation rate to the cockpit	Completed	2015 NARP Status: Delayed from 2014 to 2015

Year	Milestone	Status	Notes
2015	Develop NextGen Part 121/135 and Part 91 concepts of operations (ConOps) for the provision, integration, and use of weather information in the cockpit. Perform functional analyses of the concepts of operations including developing functional architecture, SV-1 (Systems Interface), SV-2 (Systems Communication), and SV-4 (Systems Functionality) drawings to enable the derivation of service level requirements that can be allocated to enabling systems	Descoped and Completed	Milestone is revised because the ConOps development and functional analyses were the intended scope of this milestone. The complexity and schedule for deriving service level requirements are based on the ConOps and functional analysis products so these tasks will be performed as separate follow-on tasks and milestones. Old wording 'Develop NextGen Part 121, 135, and Part 91 concepts of operation and user requirements for the provision, integration, and use of weather information in the cockpit' 2015 NARP Status: Delayed from 2014 to 2015
2016	Provide a set of validated weather test questions for FAA Flight Standards approval to be included in the pilot practical and written test standards for pilot certification	On schedule	New milestone
2016	Develop recommendations for standards on time stamping of cockpit composite weather presentations	On schedule	2015 NARP Status: Delayed from 2014 to 2016
2016	Assess the benefits and impacts on pilot confidence in weather forecasts by providing meteorological-uncertainty information to the cockpit	On schedule	Milestone is revised due to the need of clarification of the milestone. Additional factors, besides pilot confidence, need to be researched before minimum weather services standards recommendations can be made for providing uncertainty information to the cockpit. Old wording 'Develop recommendations for providing meteorological-uncertainty information to the cockpit to increase pilot confidence in weather forecasts.' 2015 NARP Status: On schedule
2017	Propose standards and develop recommendations to address meteorological information shortfalls that were identified as causal factors in selected weather-related safety incidents/accidents	Delayed	Milestone is delayed from 2015 to 2017, as resolutions to the selected shortfalls are more complex than originally planned, resulting in additional research phases. 2015 NARP Status: On schedule

Year	Milestone	Status	Notes
2017	Provide recommendations for rendering standards for inclusion in the Weather Technology in the Cockpit minimum weather service recommendations for general aviation	Delayed	Milestone is delayed from 2016 to 2017 because research results identified the need for additional trade studies to be performed before rendering recommendations can be developed. 2015 NARP Status: On schedule
2017	Demonstrate examples of the integration of weather information, along with selected navigation and other flight information into cockpit decision-making and shared situational awareness among pilots, dispatchers, and Air Traffic Controllers supported by NextGen air and ground capabilities	On schedule	
2019	Complete development of initial set of Minimum Weather Service recommendations for Part 91 related to information content, training enhancements, and presentation (human-machine interface) attributes that will resolve or reduce identified general aviation (GA) safety risks associated with gaps of meteorological information in the cockpit	On schedule	Milestone was revised since GA weather technology equipage and access to meteorological information continuously changes and progresses; a configuration baseline will be used to develop an initial set of recommendations. The impacts of changes in GA equipage and information access from the selected baseline will be assessed after the initial set of recommendations is developed. Old wording 'Complete development of recommendations for Part 91 Minimum Weather Service information content, training enhancements, and presentation (human-machine interface) attributes that will resolve or reduce identified general aviation safety risks associated with gaps of MET information in the cockpit.' 2015 NARP Status: On schedule

NextGen - Weather Technology in the Cockpit Program Progress in FY 2015:

- ✓ The Partnership to Enhance General Aviation Safety, Accessibility, and Sustainability (PEGASAS), which is the FAA Center of Excellence (COE) for GA, successfully developed a proof of concept flight training device with the capability to vary the latency of displayed weather information. This prototype training device will be used in a demonstration to assess the benefits of enhanced focused training on the latency of GA cockpit weather information. Safety risks associated with weather information latency were identified by earlier WTIC research and by NTSB. In addition, PEGASAS

completed the development of a focused training course on the latency of cockpit weather information. PEGASAS completed an assessment that identified a recommendation for rendering a GA cockpit adverse weather notification. The recommendation will be validated for inclusion in the WTIC GA MinWxSvc recommendations.

- ✓ The WTIC program drafted an initial set of 100 candidate weather related pilot exam questions that were delivered to FAA Flight Standards for review. Questions approved by Flight Standards will be validated before incorporating them into the pilot exam and practice exams. An instructor led training module on Next-Generation Weather Radar (NEXRAD) was completed and verified.

1.5.2 Weather Program (R,E&D - A11.k)

The Weather Program supports Aviation Safety R&D Goals 5 and 6 by conducting applied research focused on improving weather information required for integration into decision-support tools to reduce the impact of adverse weather on the NAS. The improved weather information increases safety by supporting better operational planning and decision-making by ATM, dispatchers, and pilots.

Although it is managed as a single program, the Weather Program (A12.c) continues to support two NARP principles. The elements described in this section under Aviation Safety R&D Goals 5 and 6 and those described in section 2.4.2 under Efficiency R&D Goals 4 and 5 define the program, and together provide the Weather Program's FY 2016 budget and planned milestones from FY 2016 through FY 2021.

The research milestones and their statuses are shown in Table 1.5.2, Weather Program Milestones below, followed by a summary of the significant progress made in FY 2015 towards achieving the R&D goals.

Table 1.5.2: Weather Program Milestones

Year	Milestone	Status	Notes
2016	Demonstrate integrated FAA/National Weather Service ceiling and visibility forecast capability	On schedule	
2016	Transition in-flight icing Alaska forecast and analysis capability for implementation (as part of the NAS Infrastructure Portfolio section of the *NextGen Implementation Plan*)	Delayed	Milestone is delayed from 2015 to 2016 because of a new research approach resulting from collaboration with the National Weather Service. A technical review of the analysis portion is not planned until fourth quarter of FY 2016. 2015 NARP Status: On schedule
2016	Transition ceiling and visibility Alaska analysis capability for implementation (as part of the NAS Infrastructure Portfolio section of the *NextGen Implementation Plan*)	On schedule	

Year	Milestone	Status	Notes
2016	Complete initial demonstration/ validation of zero-36 hour probabilistic forecast of oceanic convection	On schedule	
2016	Develop preliminary roadmap for weather product development to support safe and efficient UAS operations	On schedule	New milestone
2017	Transition Offshore Precipitation Capability (radar-like analysis) for operational implementation	On schedule	Milestone was revised because renewed interest from the FAA may result in the National Weather Service not being the only path for operational implementation. Old wording 'Transition Offshore Precipitation Capability (radar-like analysis) to the National Weather Service for operational implementation' 2015 NARP Status: On schedule
2018	Transition Continental United States in-flight icing forecast and analysis capability, that includes liquid water content, drop-size distribution, and temperature, for implementation (as part of the NAS Infrastructure Portfolio section of the *NextGen Implementation Plan*)	On schedule	

Weather Program Progress in FY 2015:

- ✓ Completed a technical review, which evaluated the scientific validity of the In-Flight Icing Product for Alaska (IPA) forecast capability, which meets NextGen requirements for high resolution forecasts of atmospheric conditions conducive to aircraft icing for geographical areas outside the Continental United States. The IPA forecast capability will transition to the National Weather Service (NWS) test bed for evaluation in the fourth quarter of FY 2015.

- ✓ Inclusion of liquid water content, drop size distribution, and temperature will enable the development of a higher resolution; more frequently updated icing hazard forecast and diagnosis product. In the long-term, it will provide the required data for development of aircraft/airframe specific icing forecasts and analyses. An initial analysis was performed on how to improve the microphysics schemes for prediction of liquid and ice and their direct application to icing prediction. Additionally, new methods were developed to fuse numerical weather prediction model predicted liquid water content and drop size with observations, as well as an initial research analysis on incorporating additional estimates of cloud drop size based on satellite data.

- ✓ To more effectively and efficiently plan, as well as control and execute transoceanic flights, there is a need for a more accurate zero-36 hour forecast of oceanic convection. The areal domain encompassing the western Atlantic and Caribbean was added to the existing Pacific Ocean domain. Forecast accuracy was increased as two additional global

weather forecast models were added to the ensemble forecasts and data from the new Global Precipitation Measurement Satellite Mission was also incorporated.

- ✓ In response to an air traffic safety action filed, the ability to detect and visualize precipitation beyond the range of NEXRAD weather radar offshore in near real-time is being researched. An initial Offshore Precipitation Capability Prototype was developed and demonstrated to show capabilities, and initial meetings with the NWS were conducted to discuss collaboration and eventual transition to operations.

1.6 Aviation Safety R&D Goals 7 - 9

Safe and efficient integration of increased commercial space launch and re-entry activity into the NAS.

Improved vehicle safety and risk management, including knowledge of all safety-critical components and systems of the space vehicles and their operations, to better identify potential hazards and apply and verify hazard controls.

Guidance and tools that enhance human safety, protection, and survival during space operations.

1.6.1 Commercial Space Transportation Safety (R,E&D - A11.n)

The Commercial Space Transportation (CST) Safety Program supports Aviation Safety R&D Goals 7, 8, and 9 by examining safety considerations for commercial space transportation operations and integration into the NAS. Fiscal year 2016 represents the first year of a comprehensive, dedicated commercial space transportation safety budget line. The R&D Program is intended to enable advances in critical areas spanning four thematic areas that address:

- Safe and efficient integration of increased commercial space launch and re-entry activity into the NAS;
- Advanced safety assessment methods;
- Advanced vehicle safety technologies and methodologies, and
- Human spaceflight and physiological safety factors.

The new program enables the maturation of research concepts for follow-on implementation and use in methods, systems, operations and regulations, policy and guidance. Previously, FAA's commercial space transportation research was limited to work conducted by its Center Of Excellence (COE) established in 2010. The COE currently consists of nine member universities and six affiliate members, 25 principal investigators, almost four dozen students, 27 research partners, and 55 industry partners.

The new Commercial Space Transportation Program allows the FAA to perform research in critical areas that are necessary to ensure that the FAA is adequately prepared to meet its public safety mission. Within the overall effort, AST must continue to find ways to improve the integration of commercial space operations into the NAS. These approaches 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. They are 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. It also improves methods for leveraging the results of collision avoidance analyses for more efficient launch and reentry planning and NAS integration. Further, the research in this program supports the FAA's regulatory response for NEPA compliance.

The research milestones and their statuses are shown in Table 1.6.1, Commercial Space Transportation Safety Program Milestones below, followed by a summary of the significant progress made in FY 2015 towards achieving the R&D goals.

Table 1.6.1: Commercial Space Transportation Safety Program Milestones

Year	Milestone	Status	Notes
2015	Identification and testing of nontoxic monopropellant safety hazards due to leaking seals and valves	Completed	Milestone was revised because work was descoped as this was identified as the most salient and highly prioritized hazard. Old wording 'Conduct a study to identify means of preventing hazards (such as fires and explosions) involving nontraditional monopropellants and oxidizers (specifically hydrogen peroxide and nitrous oxide) used in propulsion systems in commercial space applications' 2015 NARP Status: On schedule
2016	Compare debris predictions to empirical evidence from recent mishaps to identify potential areas for improvement in public safety assessments (Supports advanced safety assessment methods)	On schedule	New milestone
2017	Review available data and analyses to identify priority areas of concern for repetitive use considerations of high utilization reusable spaceflight vehicles (Supports advanced vehicle safety technologies and methodologies)	On schedule	New milestone
2017	Assessment of screening and training requirements for pilots with repeated exposures to sustained high acceleration, as well as conduct aerobatic flights and National Aerospace Training and Research Center testing (Supports human spaceflight and physiological safety factors)	On schedule	New milestone

Year	Milestone	Status	Notes
2018	Report results of thermal ablation testing and analysis of ultra-high temperature composites for thermal protection systems in liquid rocket engine plume	Delayed	Milestone is delayed from 2014 to 2018 due to reprioritization of available resources. Funding for this task is scheduled in FY 2015 that is intended to continue pursuit of this milestone. 2015 NARP Status: On hold pending further funding
2018	Gather high-fidelity measurements of rocket source noise and noise in communities near spaceports, and conduct initial validation of models for long range sound propagation through complex atmospheric conditions (Supports safe and efficient integration of increased commercial space launch and re-entry activity into the NAS)	On schedule	New milestone
2018	Identify and assess algorithm improvements for launch collision avoidance, with initial formulation of improved trajectory and uncertainty input data requirements (Supports safe and efficient integration of increased commercial space launch and re-entry activity into the NAS)	On schedule	New milestone
2018	Identify candidate approaches to characterize dynamic population clusters in public safety analysis methods and evaluate potential mitigation measures (Supports advanced safety assessment methods)	On schedule	New milestone
2018	Identify draft recommended practices for crew human factors for suborbital winged commercial spaceflight vehicles (Supports human spaceflight and physiological safety factors)	On schedule	New milestone
2019	Identify draft recommended practices for autonomous flight safety systems (Supports advanced vehicle safety technologies and methodologies)	On schedule	New milestone
2019	Identify improved methods for assessing a proposed launch or reentry site location for its impact on the public, to include airspace and airport operations, other transportation modes, population centers, and critical national assets (Supports safe and efficient integration of increased commercial space launch and re-entry activity into the NAS)	On schedule	New milestone

Year	Milestone	Status	Notes
2020	Complete Whole Atmosphere Model implementation coupling ionosphere and magnetospheric forcing and assimilate high-resolution data	Delayed	Milestone is delayed from 2015 to 2020 due to reprioritization of available resources. 2015 NARP Status: On hold pending further funding
2020	Develop and assess separation standards for improved airspace management of launch/reentry vehicles, such as hybrids and manned stratospheric balloons, during non-explosive phases of flight (Supports safe and efficient integration of increased commercial space launch and re-entry activity into the NAS)	On schedule	New milestone
2020	Develop refined approaches to estimate failure probabilities for reusable launch and reentry vehicles (Supports advanced safety assessment methods)	On schedule	New milestone
2021	Develop and demonstrate methods to automatically declare aircraft hazard areas in real-time during launch or re-entry (Supports safe and efficient integration of increased commercial space launch and re-entry activity into the NAS)	On schedule	New milestone
2021	Develop improved models to characterize aircraft vulnerability to impact with space-vehicle break-up debris, including model development and refinement to reduce over-conservatism applied to airspace keep-out areas used to protect against launch or re-entry failures (Supports advanced safety assessment methods)	On schedule	New milestone
2021	Assessment of methods, procedures, and technologies available for Protection of Spaceflight Participants in commercial spaceflight vehicles, as well as compare cabin designs with historical precedents for safety (Supports human spaceflight and physiological safety factors)	On schedule	New milestone

Commercial Space Transportation Safety Program Progress in FY 2015:

- ✓ Performed tank fragmentation testing which includes axisymmetric testing, to characterize propellant tank crack propagation with high input pressure loading. Tests at New Mexico Institute of Mining and Technology have been performed with 6061 aluminum tubes; all showing a clear tendency in crack opening (or propagation). Low and high input pressure loading cases correlated closely with the number of openings in the test sample, delivering a way to predict the fragmentation characteristics of small-scale and large-scale storage tanks of different materials. This understanding will be applied to the numerical simulation and prediction of fragmentation hazards in composite tanks.

- ✓ Nearly eliminated air traffic disruptions by launch operations, by creating dynamically allocated compact envelopes to identify hazard areas in the airspace for arbitrary space vehicles flying from any spaceport. Over a course of 90 days, simulated cases include seven vehicles, 10 locations, 14 mission profiles, and compared traditional hazard areas versus compact envelopes. Use of compact envelopes nearly eliminate (i.e., reduce by 97%) the disruption of air traffic due to launch operations as simulated using Future ATM Concepts Evaluation tool. Some cases resulted in the complete elimination of air traffic disruption. FAA Human-In-The Loop simulations have been conducted and support the baseline assumptions of the model.

- ✓ Completed suborbital spaceflight medical research by the University of Texas Medical Branch (UTMB) in support of the FAA COE for commercial space transportation. UTMB researchers examined and studied 85 test subjects with an assortment of pre-existing conditions including back and neck injuries, heart disease, hypertension, diabetes, and pulmonary problems while be subjected to the forces of multiple, simulated, suborbital flights. The research task was conducted in conjunction with a COE CST industry partner, the National Aerospace Training and Research (NASTAR) Center, and the National Space Biomedical Research Institute. This research is extremely valuable in helping better understand how space travel impacts and effects individuals (who have not undergone astronaut training) with pre-existing conditions. While it is acknowledged more research needs to be conducted, UTMB's work; along with its partners will eventually lead to the establishment of health standards for private space travel. UTMB researchers were recognized for their research excellence at the Aerospace Medical Association Annual Scientific Meeting in San Diego, California, on May 13-16, 2014.

1.7 Aviation Safety R&D Goal 10

No fatal accidents on certificated airports as a result of airport design, runway incursions or excursions, or wildlife strikes.

1.7.1 Airport Cooperative Research Program – Safety (AIP)

The Airport Cooperative Research Program (ACRP) – Safety supports Aviation Safety R&D Goal 10 by preventing or mitigating potential injuries and accidents within the airport operational environment. A fundamental element of the program is to produce results that provide protection of aircraft passengers and airport personnel through improved safety training, airport design, and advanced technology implementation.

The research milestones and their statuses are shown in Table 1.7.1, Airport Cooperative Research Program below, followed by a summary of the significant progress made in FY 2015 towards achieving the R&D goal.

Table 1.7.1: Airport Cooperative Research Program – Safety Milestones

Year	Milestone	Status	Notes
2016	Develop a guidebook for airports on conducting the safety risk management process	On schedule	
2016	Develop a toolkit to assist airports in effectively planning for, responding to and recovering from significant weather events	On schedule	
2017	Prepare for the connected airport and internet of things	On schedule	New milestone
2017	Develop an airport emergency operations center design guide	On schedule	New milestone

Airport Cooperative Research Program – Safety Progress in FY 2015:

- ✓ The FAA and airports across the country conduct Safety Risk Management (SRM) panels annually. There are 14 airports that have participated in the FAA Part 139 Safety Management System Implementation Study. Since the conclusion of the study, there are a handful of airports that continue to voluntarily convene SRM panels. The objective of the synthesis is to describe lessons learned, effective practices, and tools from airports and other industries that have led SRM. The intent of the report is to provide new material and complement existing documents. The Principal Investigator collected information from additional airports to gain lessons learned on non-airport-led SRM panels. Regarding SRM processes from other industries, the Principal Investigator compiled literature and tools useful to airport operators. The Principal Investigator will deliver a report in September 2015, that summarizes responses to interview questions, compiles effective practices and lessons learned, identifies gaps in practice, and provides

templates, checklists, worksheets, and other tools for easy reference by airports undertaking SRM panel processes. One or two case examples from other industries will be included in the report. The project is now active with an assigned project manager, project number (S04-14), and a contractor selected through the Request for Proposal (RFP) process.

- ✓ In recent years, significant weather events such as tornados, hurricanes, severe precipitation and extreme temperatures have caused a variety of impacts to airports. A string of hurricanes in 2004 and 2005 brought widespread damage and impacts to the East Coast and Gulf region that adversely affected multiple airports and their infrastructure and operations. With the increase in these significant weather events, it is important for airports to better plan for, respond to, and recover from such events. The objective of this research is to develop a toolkit that raises airport operator awareness about vulnerabilities caused by significant weather events; helps airports develop more robust contingency and recovery plans in addition to airport emergency plans as well as describe impact prevention and mitigation strategies. The toolkit will be based on a review of the historical weather data and impacts, as well as best practices and lessons learned from airports' responses to recent significant weather events. A kick-off teleconference meeting was held within one month of the Notice to Proceed, as well as a web-enabled teleconference tied to the panel review and ACRP approval of other interim deliverables deemed appropriate. The research will include appropriate interim deliverables, including:
    - A toolkit that meets the requirements as stated in the objective, and emphasizes impact prevention and mitigation strategies.
    - A PowerPoint presentation that summarizes the details of the toolkit useful for future webinars.
    - A contractor's final report that documents the entire research effort, including any assumptions used and the research team's recommendation of research needs and priorities for additional related research.

  The project is now active with an assigned project manager, project number (02-49), and a contractor selected through the RFP process, with an expected completion date of January 1, 2016.

1.7.2 Airport Technology Research Program – Safety (AIP)

The Airport Technology Research Program (ATRP) – Safety supports Aviation Safety R&D Goal 10 by increasing airport safety through research that improves (a) airport lighting and marking, (b) reduces wildlife hazards near airport runways, (c) improves airport fire and rescue capability, and (e) reduces surface accidents.

The research milestones and their statuses are shown in Table 1.7.2, Airport Technology Research Program – Safety Milestones below, followed by a summary of the significant progress made in FY 2015 towards achieving the R&D goal.

Table 1.7.2: Airport Technology Research Program – Safety Milestones

Year	Milestone	Status	Notes
2015	Complete human factor laboratory/ simulation tests on use of linear light sources on airports	Completed	2015 NARP Status: Delayed from 2014 to 2015
2015	Update the Airport Safety Database and publish updated analysis report	Completed	2015 NARP Status: Delayed from 2014 to 2015
2015	Complete evaluation of prototype construction signs to determine the effectiveness of the construction signs in increasing the awareness of pilots and vehicle operators to existing construction on the airfield and in mitigating adverse operational incidents at airports during construction	Completed	2015 NARP Status: Delayed from 2014 to 2015
2015	Publish report on characterization of foreign object debris collected at Chicago O'Hare International Airport	Completed	2015 NARP Status: Delayed from 2014 to 2015
2015	Complete construction of the National Airport Pavement and Materials Research Center	Completed	Milestone was revised due to facility name change. Old wording 'Complete construction of the High Temperature Pavement Test Facility.' 2015 NARP Status: Delayed from 2014 to 2015
2015	Complete upgrade of all FAA Pavement Software to Windows Presentation Foundation to create a common platform to integrate the programs	Completed	2015 NARP Status: On schedule
2015	Complete definition of airport pavement failure for 40 Year Pavement Life project	Completed	2015 NARP Status: Delayed from 2014 to 2015
2015	Install Taxiway Centerline Deviation systems at two airplane design group-1 airports	Completed	2015 NARP Status: On schedule
2015	Complete the Approach Hold/Runway Safety Area field evaluations at Chicago O'Hare and Cleveland International Airport	Completed	2015 NARP Status: On schedule
2015	Investigate the feasibility of conducting a runway centerline deviation study using a prototype sensing and data acquisition system	Completed	2015 NARP Status: On schedule
2015	Complete Draft Advisory Circular on Guidance for Selection, Procurement and Management of Safety Management System Software	Completed	2015 NARP Status: On schedule
2015	Evaluation of web-patterned structural methyl methacrylate paint markings	Completed	2015 NARP Status: On schedule

Year	Milestone	Status	Notes
2016	Complete in-service testing of new light emitting diode lighting circuits for use on airports	Delayed	Milestone is delayed from 2015 to 2016 due to a delay in acquiring prototype test equipment and lighting fixtures required to conduct field evaluation and was revised since infrastructures identified for final testing is designed to operate on any size airport. Old wording 'Complete in-service testing of new light emitting diode lighting circuits at a large and small airport.' 2015 NARP Status: Delayed from 2014 to 2015
2016	Complete rehabilitation of the Airport Technology Research Taxiway	Delayed	Milestone is delayed from 2015 to 2016 due to a construction contract award protest delaying the Notice to Proceed and commencement of the taxiway rehabilitation project pending the resolution of the protest. 2015 NARP Status: On schedule
2016	Complete Mu-Slip testing with nose gear brake testing and main gear brake testing, both on contaminated runway surfaces	Delayed	Milestone is delayed from 2015 to 2016 because Mu-Slip Testing with B727 is delayed due to mechanical and electrical problems encountered with the aircraft. Aircraft instrumentation has been upgraded which will allow for effective Mu-Slip Testing on contaminated runway surfaces during FY 2016. 2015 NARP Status: On schedule
2016	Publish guidebook on dynamic test performance requirements for frangible connections/structures utilized in runway and terminal safety areas	On schedule	
2016	Publish a report on the findings of the Approach Hold/Runway Safety Area Study	On schedule	
2016	Complete second phase testing of engineered material arresting system signs for airports	On schedule	New milestone
2016	Publish a report on the taxiway centerline deviation data collection effort at airplane design group -II airports	On schedule	New milestone
2016	Complete testing on the use of streaming, clean firefighting agents in aircraft rescue and firefighting responses to aircraft cargo compartment fires	On schedule	

Year	Milestone	Status	Notes
2017	Complete a one year cost-benefit study of utilizing foreign object debris detection systems on airports, which will be based on available foreign object debris systems currently in operation at civil airports as of October 2014	Delayed	Milestone is delayed from 2016 to 2017 because the decision has been made to incorporate at a minimum a second airport in addition to Boston. Delays in the installation of that second system have pushed back the target completion date. The completion of data collection will take place at the General Edward Lawrence Logan International Airport. 2015 NARP Status: On schedule
2020	Development of new firefighting performance requirements for the use of compressed air foam technologies in aircraft rescue and firefighting	On schedule	

Airport Technology Research Program – Safety Progress in FY 2015:

- ✓ The Airport Safety Database is a collection of public and non-public government data that has been categorized and compiled into a central location as a resource for the FAA Office of Airports. The database houses incident and accident reports dating from January 1, 2000 through March 31, 2015. Two internal FAA reports have been developed. Work is planned to integrate additional data sources and derive and apply analytic methods to define underlying causal factors.

- ✓ Completed upgrade of all FAA Pavement Software to Windows Presentation Foundation (WPF) to create a common platform to integrate the program. The review and acceptance of the work is pending. All FAA Pavement Software, i.e., FAARFIELD (FAA Rigid and Flexible Iterative Elastic Layered Design), COMFAA 3.0 etc., were updated from Visual Basic 6 (VB6) or VB.NET Winforms to WPF in preparation for the Pavement R&D software integration project.

- ✓ The introduction of new large aircraft, such as the Airbus A380 and Boeing 747-800, presented challenges to our Nation's airports that do not meet the minimum design requirements to accommodate aircraft categorized as Airplane Design Group (ADG)-VI. In 1999 the FAA initiated the Taxiway Centerline Deviation Study to determine if these aircraft can solely operate on airports designed for smaller aircraft. Through data collection and analysis it was found these aircraft could safely operate on straight sections of taxiways 75 in. wide. The data collection has continued through the smaller ADG's and two ADG-I systems have been installed. On December 16, 2014 a system was installed at Bay Bridge Airport in Stevensville, MD and on February 10, 2015 a system was installed at Valkaria Airport in Valkaria, FL. These systems measure the distance an aircraft's nose gear deviates from the taxiway centerline. The data collected may support additional changes in airport design standards.

- ✓ After completing in-service testing of new lighting emitting diode lighting circuits for use on airports, test infrastructure was installed at Purdue University Airport for in-service evaluation. Testing began in September 2015.

1.7.3 Runway Incursion Reduction Program (F&E - 1A01A - S09.02-00 - Advanced Technology Development and Prototyping)

The Runway Incursion Reduction Program supports Aviation Safety R&D Goal 10 by conducting research, development, and operational evaluation of technologies to increase runway safety. Consistent with standing National Transportation Safety Board recommendations, research emphasis will remain on technologies that provide direct safety indications and alerts to pilots at large airports, as well as, those that can be applied cost effectively at small to medium airports. The program will test alternative airport surface detection technology and the application of these technologies for pilot, controller, and vehicle operator situational awareness tools. Current initiatives include the development and operational testing of the Small Airport Surveillance Sensor (SASS), Runway Safety Assessment studies, Enhanced Final Approach Runway Occupancy Signal (eFAROS) evaluations, and the removal of the Low Cost Ground Surveillance (LCGS) pilot sites. When appropriate, investment analyses will be performed to support acquisition and implementation of selected solutions

Additional information on this F&E program can be found by referencing the FY 2017 – 2021 CIP.

The research milestones and their statuses are shown in Table 1.7.3, Runway Incursion Reduction Program Milestones below.

Table 1.7.3: Runway Incursion Reduction Program Milestones

Year	Milestone	Status	Notes
2016	Complete annual technical and operational evaluation report of existing Runway Incursion Reduction Program Prototype Systems	On schedule	
2016	Complete annual report documenting results of human-in-the-loop testing human factors, safety logic, aircraft performance, or any uncertainty or deficiency pertaining to surface based runway incursion indications	On schedule	
2016	Complete annual report on runway incursion prevention shortfall analysis	On schedule	
2016	Complete annual report on testing of safety logic enhancements to runway incursion detection and prevention products	On schedule	
2016	Publish the Project Plan and Resource Management Plan for the utilization of a small airport surveillance sensor as a sensor to drive the activation of direct to pilot alerting safety logic	On schedule	

Year	Milestone	Status	Notes
2017	Complete annual technical and operational evaluation report of existing Runway Incursion Reduction Program prototype systems	On schedule	New milestone
2017	Complete annual report documenting results of human-in-the-loop testing human factors, safety logic, aircraft performance, or any uncertainty or deficiency pertaining to surface based runway incursion indications	On schedule	New milestone
2017	Complete annual report on testing of safety logic enhancements to runway incursion detection and prevention products	On schedule	New milestone
2017	Complete report documenting candidate site selection for a system to test the utilization of a small airport surveillance sensor as a sensor to drive the activation of direct to pilot alerting safety logic	On schedule	New milestone
2017	Complete report on integration of a system to test the utilization of a small airport surveillance sensor as a sensor to drive the activation of direct to pilot alerting safety logic	On schedule	New milestone
2017	Publish the initial Project Plan and Resource Management Plan for the utilization of an advanced ground surveillance sensor to drive the activation of direct to pilot alerting safety logic	On schedule	New milestone

2.0 R&D Principle 2 - Improve Efficiency

Systematically expand and apply knowledge to produce useful materials, devices, systems, or methods that will improve access to and increase the capacity and efficiency of the Nation's aviation system.

Ten R&D goals support R&D Principle 2 - Improve Efficiency. Work is spread across three budget appropriations (R,E&D, F&E, and AIP):

- Goal 1 - Improved aircraft separation processes associated with current generalized and static air navigation service provider wake turbulence mitigation separation standards.

- Goal 2 - Improved human-system integration and an increase in ATC efficiency through enhanced controllers-pilots coordination in cooperatively managing traffic loads as cockpit technology and air traffic workstations are more closely connected.

- Goal 3 - Feasible procedures, operational methods, and technologically-advanced systems that can decrease workload and increase efficiency of the NAS.

- Goal 4 - Established requirements and standards for enabling availability and improving the quality and quantity of meteorological information to reduce impacts of adverse weather on rerouting, NAS capacity, and NextGen operational procedures.

- Goal 5 - Improved accuracy and accessibility of observed and forecast weather information to improve NAS efficiency (e.g., reduced delays and cancellations, increased capacity in high traffic areas).

- Goal 6 - Availability of existing airport facilities protected and used as efficiently as possible, while making strategic investments in new facilities consistent with evolving aviation needs.

- Goal 7 – Improved cyber resiliency for the NAS system of systems in the case of determined adversaries with persistent attacks that try to undermine the NAS.

- Goal 8 – Improved methods and/or capabilities that enable safe reduction in separations standards, increase in airspace capacity and/or efficient management of aircraft trajectories.

- Goal 9 – Safe reduction in separation standards for approaches to closely spaced parallel runways to enable increased airport capacity.

- Goal 10 – Improved methods, technologies and capabilities that enable increased surface traffic movement efficiency.

Table 2.0.1, Alignment of FAA R&D Efficiency Principle and Programs with NSTC Mobility Goals shows how the FAA's Efficiency R&D goals and programs align with the NSTC Mobility Goals. In many cases, FAA R&D programs support more than one NSTC goal.

Table 2.0.1: Alignment of FAA R&D Efficiency Principle and Programs with NSTC Mobility Goals

FAA R&D Principle	FAA R&D Programs	NSTC Goals		NSTC Principle	FAA Strategic Priority
Improve Efficiency	NextGen - Wake Turbulence	Goal 1 - Develop Reduced Aircraft Separation in Trajectory- and Performance-Based Operations	Goal 4 - Maximize Arrivals and Departures at Airports and in Metroplex Areas	Mobility Through the Air is Vital to Economic Stability, Growth, and Security as a Nation	Deliver Benefits Through Technology and Infrastructure
	Wake Turbulence - Re-categorization				
	NextGen - Air Ground Integration Human Factors				
	Oceanic Tactical Trajectory Management				
	Advanced Methods				
	Closely Spaced Parallel Runway Operations				
	Surface Tactical Flow				
	New Air Traffic Management Requirements	Goal 2 - Develop Increased NAS Capacity by Managing NAS Resources and Air Traffic Flow Contingencies	Goal 1 - Develop Reduced Aircraft Separation in Trajectory- and Performance-Based Operations		
	Major Airspace Redesign		Goal 4 - Maximize Arrivals and Departures at Airports and in Metroplex Areas		
	System Capacity, Planning and Improvements				
	Operations Concept Validation and Infrastructure Evolution				
	NextGen - Weather Technology in the Cockpit	Goal 3 - Reduce the Adverse Impacts of Weather on Air Traffic Management Decisions	Goal 2 - Develop Increased NAS Capacity by Managing NAS Resources and Air Traffic Flow Contingencies		
	Weather Program				
	Weather Observation Improvements				
	Airport Cooperative Research Program - Capacity	Goal 2 - Develop Increased NAS Capacity by Managing NAS Resources and Air Traffic Flow Contingencies			
	Airport Technology Research Program - Capacity				

In FY 2017, 55 percent of total FAA R&D funding is allocated to R&D Principle 2 - Improve Efficiency. Program funding levels for the 2016 Enacted and 2017 Congressional Request are shown in Table 2.0.2. Percent of Program reflects each program's contribution towards R&D Principle 2 in the 2017 Congressional Request. Table 2.0.2 also lists the section and page number reference for each budget narrative within the FY 2017 Congressional Justification (CJ) for the President's Budget Request. The FY 2017 CJ will be made available by the DOT at https://www.transportation.gov/budget.

Table 2.0.2: Program Funding for R&D Principle 2 - Improve Efficiency

2016 BLI	Program	CJ Reference (Section /Page)	Appropriation Account	2016 Enacted ($000)	2017 Congressional Request ($000)	2017 Percent of Program
A11.k	Weather Program	3C/49	RE&D	7,516	8,988	50%
A12.a	NextGen - Wake Turbulence	3C/65	RE&D	8,541	8,609	100%
A12.b	NextGen - Air Ground Integration Human Factors	3C/68	RE&D	5,600	6,003	70%
A12.c	NextGen - Weather Technology in the Cockpit	3C/71	RE&D	1,822	1,827	45%
A12.d	NextGen - Information Security	3C/75	RE&D	0	1,000	100%
A14.a	System Planning and Resource Management	3C/85	RE&D	278	369	13%
A14.b	William J. Hughes Technical Center Laboratory Facility	3C/87	RE&D	614	609	18%
1A01	Advanced Technology Development & Prototyping	3B/12	F&E	21,300	24,800	100%
1A02	NAS Improvement of System Support Laboratory	3B/19	F&E	1,000	1,000	100%
1A03	William J. Hughes Technical Center Facilities	3B/21	F&E	19,050	19,000	100%
1A04	William J. Hughes Technical Center Infrastructure Sustainment	3B/23	F&E	12,200	12,200	100%
1A05	Next Generation Transportation System - Separation Management Portfolio	3B/26	F&E	31,500	25,800	100%
1A06	Next Generation Transportation System - Improved Surface/TFDM Portfolio	3B/35	F&E	17,000	2,000	100%
1A07	Next Generation Transportation System - On Demand NAS Portfolio	3B/37	F&E	11,000	8,500	100%
1A08	Next Generation Transportation System - Imp Multiple Runway OPS Portfolio	3B/43	F&E	8,000	6,500	100%
1A09	Next Generation Transportation System - NAS Infrastructure Portfolio	3B/47	F&E	11,000	17,660	100%
1A10	Next Generation Support Portfolio	3B/56	F&E	10,000	12,000	100%
4A08	Center for Advanced Aviation System Development (CAASD)	3B/306	F&E	43,200	41,400	69%
--	Airport Cooperative Research Program - Capacity	3D/36	AIP	5,000	5,000	100%
--	Airport Technology Research Program - Capacity	3D/26	AIP	13,248	13,408	100%
	Total ($000)			**227,869**	**216,672**	

**CAASD R&D budget totals for 1) FY 2016 assume 28% for Safety, 72% to Efficiency, and 0% for Environmental and 2) FY 2017 and outyears assume 26% for Safety, 69% for Efficiency, and 5% for Environmental (subject to FFRDC Executive Board FY 2017 workplan approval).*

2.1 Efficiency R&D Goal 1

Improved aircraft separation processes associated with current generalized and static air navigation service provider wake turbulence mitigation separation standards.

2.1.1 NextGen - Wake Turbulence (R,E&D - A12.a)

The NextGen - Wake Turbulence Program supports Efficiency R&D Goal 1 by conducting research to increase airport runway capacity safely by reducing aircraft wake separation minima under certain conditions and addressing wake turbulence constraints in today's terminal and enroute airspace and in the future NextGen airspace designs.

The research milestones and their statuses are shown in Table 2.1.1, NextGen-Wake Turbulence Program Milestones below, followed by a summary of the significant progress made in FY 2015 towards achieving the R&D goal.

Table 2.1.1: NextGen - Wake Turbulence Program Milestones

Year	Milestone	Status	Notes
2015	Evaluate air traffic control procedures for providing wake mitigation separations between UAS and piloted aircraft	Completed	2015 NARP Status: On schedule
2015	Develop and assess readiness of statistics-based wake encounter risk evaluation tool for use by FAA Wake Turbulence Subject Matter Experts in evaluating NextGen Trajectory Based Operations flight routing procedures	Completed	2015 NARP Status: On schedule
2016	Develop the initial performance measures that will be used by the air traffic control terminal automation systems for dynamically setting wake separation minima in the terminal airspace for each pair of aircraft	On schedule	
2017	Develop prototype information display for the controller decision support tool used to allow reduced wake separations for instrument approaches to a single runway	On schedule	
2018	Perform analysis in support of Safety Risk Management Documentation for Wake Turbulence Mitigation for Single Runway procedure	On schedule	
2019	Complete development of detailed operational concepts for dynamically modifying required wake mitigation separations	On schedule	

Year	Milestone	Status	Notes
2020	Complete prototype enhancements to weather based forecast algorithms, used by wake mitigation air traffic control decision support tools to enable use of real time weather observations from aircraft	On schedule	
2021	Perform analysis in support of safety risk management documentation for dynamic pairwise wake separation standards	On schedule	New milestone

NextGen - Wake Turbulence Program Progress in FY 2015:

- ✓ Completed feasibility analysis of dynamic wake mitigating procedure for closely spaced parallel departures, called paired departures. The following aircraft must stay ahead of the wake of the leading aircraft (wake generator) by starting its roll within a certain time after the leading aircraft begins movement. Analysis was performed to determine the wind parameters and controller human factors requirements that would enable the procedure for use at San Francisco International Airport (SFO). The analysis was then used to develop a notional operational concept and a potential procedure availability estimate for SFO, which was provided to the ATC stakeholders to allow formal consideration for proceeding with an operational demonstration of paired departures at SFO.

- ✓ Utilized prior research into enroute wake encounter mitigation to propose wake mitigation procedure, for use during climb-through and descend-through operations. The procedure addresses situations described in recent enroute wake encounter reports by proposing the use of lateral offsets to avoid potential wake hazards. Additionally, analysis of enroute wake data was performed through the translation of Canadian National Research Center measurements of wakes generated by aircraft when they are in cruise into data sets that can be used in validating the outputs of wake models being applied in the enroute flight region. The analysis will aid in the refinement of current proposed enroute wake mitigating procedures and the development of future procedures.

- ✓ Conducted an initial high level assessment of the additional capacity benefit that could be achieved by changing ATC wake separation criteria dynamically based on flight conditions and sequencing. The assessment focuses on a number of operational concepts for both single runway and multiple runway wake mitigation. It considers the addition of weather effects and individual aircraft performance factors to achieve benefit above the static pairwise separation capability, achieved through the implementation of Phase II of re-categorization of Wake Turbulence standards in FY 2017. The assessment considers the trade-off between solution complexity and feasibility against the potential benefit of the operational concept. The final assessment will be complete in FY 2017.

2.1.2 Wake Turbulence - Re-Categorization (F&E - 1A05B – G06M.02-02 - NextGen – Separation Management Portfolio)

The Wake Turbulence - Re-Categorization Program supports Efficiency R&D Goal 1 by addressing one of the major constraints in implementing processes and procedures that will allow more aircraft flights into and out of airports and through congested air corridors. In the near term, RECAT Phase I has rebalanced the wake turbulence separation standards to address today's mix of aircraft utilizing the nation's core airports. RECAT Phase I has yielded significant additional arrival and departure runway throughput for those airports whose fleet mix closely matches the design of the RECAT Phase I standards. The first operational use of the RECAT Phase I standards occurred in November 2012 at the Memphis International Airport (MEM), and since been implemented at ATC facilities serving six additional metropolitan area (Louisville/Cincinnati, Atlanta, Houston, Charlotte, New York City/Newark, and Chicago) airports. FedEx, the major air carrier at MEM, has received a double digit MEM departure runway throughput capacity increase since the introduction of the RECAT Phase I standards as well as significant fuel savings in their MEM arrival operations. United Parcel Service is seeing similar benefits at its major hub airport Louisville International Airports. Delta Air Lines, the major air carrier at Hartsfield-Jackson Atlanta International Airport (ATL), is reporting significant decrease in operating cost at ATL. The increased runway throughput capacity is achieved by reduction in many of the previously required wake mitigation in-trail separation distances of aircraft. Implementation of the RECAT Phase II wake separation standards is projected to provide an additional 4-7% increase in a Core airport's runway throughput capacity.

Additional information on this F&E program can be found by referencing the FY 2017 – 2021 CIP.

The research milestones and their statuses are shown in Table 2.1.2, Wake Turbulence-Re – Categorization Program Milestones below, followed by a summary of the significant progress made in FY 2015 towards achieving the R&D goal.

Table 2.1.2: Wake Turbulence - Re-Categorization Program Milestones

Year	Milestone	Status	Notes
2015	Complete a Safety Risk Management Document for operational use of the leader/follower pairwise static wake separation standards	Completed	This milestone was scheduled to be completed in 2016 but was completed early since the Safety Risk Management Document was signed by the FAA's Air Traffic Organization Safety and Technical Training group in FY 2015. Old wording 'Complete a NAS change proposal and associated Safety Risk Management Document for operational use of the leader/follower pairwise static wake separation standards 2015 NARP Status: On schedule

Year	Milestone	Status	Notes
2016	Develop prototype software and adaptation changes for FAA automation platforms to evaluate requirements for use with the leader/follower pairwise static wake separation standards	On schedule	
2016	Complete changes to FAA Orders for implementing leader/follower pairwise static wake separation standards	On schedule	
2016	Complete application software adaptation and training for key-site implementation for leader/follower pairwise static wake separation standards	On schedule	
2017	Complete concept feasibility description of dynamic wake separation standards	On schedule	
2017	Complete initial deployment of the RECAT Phase II wake separation standards to three metropolitan area airports – for evaluation of the standards use and modification (if required) for ease of application by controllers	On schedule	New milestone
2017	Develop detail descriptions of ATC dynamic wake separation standards alternatives and how they would be applied in the NAS	On schedule	New milestone
2017	Deliver briefings to and conduct data gathering with the aviation community concerning alternative ATC dynamic wake separation processes and procedures	On schedule	New milestone
2018	Complete high level analyses on feasibility and benefit of using dynamic wake separation standards	On schedule	
2019	Develop detailed descriptions of Air Navigation Service Provider processes and procedures for use of dynamic wake separation standards	Not started	

2.2 Efficiency R&D Goal 2

Improved human-system integration and an increase in ATC efficiency through enhanced controllers-pilots coordination in cooperatively managing traffic loads as cockpit technology and air traffic workstations are more closely connected.

2.2.1 NextGen - Air Ground Integration Human Factors (R,E&D - A12.b)

The NextGen - Air Ground Integration Human Factors Program supports Efficiency R&D Goal 2 by addressing flight deck and ATC integration for NextGen operational capabilities. It focuses on human factors issues that primarily affect the pilot side of the air-ground integration challenge. It conducts research to ensure pilots receive the right information at the right time for decision-making and collaboration with ATC to operate in the NAS efficiently.

The research milestones and their statuses are shown in Table 2.2.1, NextGen-Air Ground Integration Human Factors Program Milestones below, followed by a summary of the significant progress made in FY 2015 towards achieving the R&D goal.

Table 2.2.1: NextGen - Air Ground Integration Human Factors Program Milestones

Year	Milestone	Status	Notes
2015	Develop a report that identifies information requirements for flight deck based interval management addressing the content, form, and location of information necessary for interval management applications	Completed	2015 NARP Status: On schedule
2016	Complete research and recommendations for developing, evaluating, and/or approving standard operating procedures in NextGen	On schedule	
2017	Create a report presenting human factors considerations for the evaluation and integration of electronic flight bag/portable electronic device/tablet technologies with NextGen applications/operations	On schedule	
2018	Create a report with human factors recommendations and considerations for the design and evaluation of Electronic Chart Software related to NextGen capabilities	On schedule	

NextGen - Air Ground Integration Human Factors Program Progress in FY 2015:

- ✓ Completed a draft deliverable for a major section of the milestone final report. In this section, the authors describe a framework that lays the foundations for the design of

procedures and checklists. The framework assumes that procedures are designed to govern the interactions between technology, humans, and the operational environment. These three components are defined individually and the importance of considering the interactions between them is explained.

- ✓ Completed a draft report describing pilot perspectives on Performance Based Navigation (PBN) terminal instrument flight procedures. Professional pilots reviewed, briefed, and discussed six PBN procedures, and researchers extracted a list of subjective complexity factors based on the interviews. Some complexity comes from the procedure design, such as transitions and waypoint names. In addition, some procedure designs induce more complex chart depictions, however, certain subjective complexity factors are outside the control of procedure designers, such as weather or fatigue. Automated systems available to the pilots (e.g., type of vertical navigation system) also affect pilots' opinions about procedure designs. This research guides the future development of NextGen PBN procedures.

2.3 Efficiency R&D Goal 3

Feasible procedures, operational methods, and technologically-advanced systems that can decrease workload and increase efficiency of the NAS.

2.3.1 Major Airspace Redesign (F&E - 1A01D - M08.28-04 - Advanced Technology Development and Prototyping)

The Major Airspace Redesign Program supports Efficiency R&D Goal 3 by by funding physical changes in facilities necessary to accommodate airspace redesign. Implementation of an airspace redesign frequently results in changes to the number and span of control of operational positions or sectors, including changes to sector, area or facility boundaries.

The FAA prioritizes candidate airspace redesign projects to determine which projects provide the most benefits and develops criteria for assessing a project's system-wide impact. Airspace redesign efforts seek to optimize Terminal, En Route and Oceanic airspace by redesigning airspace via projects in major metropolitan areas with critical system wide impacts. Modernization of airspace through the Major Airspace Redesign Program is characterized by the migration from constrained ground-based navigation to the freedom of an Area Navigation / Required Navigation Performance based system. Airspace redesign efforts will modernize airspace in support of the full utilization of NextGen capabilities. Airspace Redesign will increase system efficiency by reducing limitations that the airspace places on the system. Congestion, complexity and limited departure points in the current airspace can result in restrictions, limiting airport throughput. Airspace redesign addresses large, complex, multi-facility changes impacting NAS performance.

Additional information on this F&E program can be found by referencing the FY 2017 – 2021 CIP. Note that the two recurring milestones shown in the table below are required whenever an airspace redesign project is conducted.

The research milestones and their statuses are shown in Table 2.3.1 below.

Table 2.3.1: Major Airspace Redesign Program Milestones

Year	Milestone	Status	Notes
2016	Conduct engineering analysis as needed for Caribbean airspace redesign implementation	On schedule	Recurring annual milestone
2016	Implement infrastructure changes resulting from airspace redesign	On schedule	Recurring annual milestone
2017	Conduct engineering analysis as needed for Caribbean airspace redesign implementation	On schedule	Recurring annual milestone
2017	Implement infrastructure changes resulting from airspace redesign	On schedule	Recurring annual milestone

2.3.2 New Air Traffic Management Requirements (F&E - 1A09 – G01M.02-02 - NextGen – NAS Infrastructure Portfolio)

The New Air Traffic Management (ATM) Requirements Program supports Efficiency R&D Goal 3 by identifying new opportunities to improve the efficiency and effectiveness of ATM and expanding capacity by developing decision support tools that improve the strategic management of operations in the NAS. New ATM requirements activities include:

- New radar requirements (surveillance and weather);
- Enterprise information protocol & exchange standards;
- Future Collision Avoidance System (Future CAS);
- Weather transition;
- Synchronization of air/ground procedures, and
- Advanced air ground communications.

The service analysis and operational demonstration activities within this program support the development of operational improvements that will increase the number of arrivals and departures at major airports.

Additional information on this F&E program can be found by referencing the FY 2017 – 2021 CIP.

The research milestones and their statuses are shown in Table 2.3.2, New Air Traffic Management Requirements Program Milestones below.

Table 2.3.2: New Air Traffic Management Requirements Program Milestones

Year	Milestone	Status	Notes
2016	Develop cost estimates for airborne access to system wide information management (two-way)	On schedule	
2016	Define high level requirements document for Multifunction Phased Array Radar	On schedule	
2016	Deliver assessment report on Phased Array Radar interface to NAS Automation Systems	On schedule	
2016	Complete update to Multifunctional Phased Array Radar Cost model based on advanced technology demonstrator	On schedule	
2016	Establish, standardize, and document the baseline versions of exchange models	On schedule	
2016	Develop enterprise solution documentation to mediate across NAS system	On schedule	
2016	Complete common information protocols and exchange standards documentation	On schedule	
2016	Develop interoperability requirement of UAS collision avoidance systems	On schedule	

Year	Milestone	Status	Notes
2016	Develop Airborne Collision Avoidance System Xu System requirements specifications	On schedule	
2016	Complete Airborne Collision Avoidance System Xu operational capability flight demonstration flight test	On schedule	
2016	Conduct assessment of mature research for transition to the NWS for their implementation and product dissemination into the NAS	On schedule	
2016	Develop and validate weather requirements for NWS to improve forecasts in support of FAA operational decision making	On schedule	
2016	Develop initial document for two-way communications procedures between Flight Management Systems and Ground Systems	On schedule	
2016	Support and document the development of the L-Band communications standards and prototypes with international community	On schedule	
2016	Support and document the development of the Next Generation Aeronautical Mobile-Satellite Route Service satellite-based communications standards, along with the international community, which will support the NextGen and Single European Sky ATM requirements	On schedule	
2017	Finalize Multifunctional Phased Array Radar performance requirements	On schedule	New milestone
2017	Develop detailed Multifunctional Phased Array Radar advanced technology demonstrator test and evaluation plan	On schedule	New milestone
2017	Assess Flight Information Exchange Model compliance with the International Civil Aviation Organization Reference model	On schedule	New milestone
2017	Develop transition plan for Flight Information Exchange Model	On schedule	New milestone
2017	Conduct quality assurance /quality control validation for Weather Information Exchange Model	On schedule	New milestone
2017	Review the Airborne Collision Avoidance System Xu System Requirements and Specification V1.0 document to inform RTCA SC-147 and SC-228 with standards development activities	On schedule	New milestone
2017	Incorporate optimization and tuning updates with stakeholder feedback into the Airborne Collision Avoidance System Xu Run 3 logic	On schedule	New milestone

Year	Milestone	Status	Notes
2017	Complete the Airborne Collision Avoidance System Xu Run 3 Algorithm Design Description document	On schedule	New milestone
2017	Conduct engineering studies and analyses which evaluate the translation of weather information into operational impacts	On schedule	New milestone
2017	Develop and validate weather requirements for NWS to improve forecasts in support of FAA operational decision making	On schedule	New milestone
2017	Develop validation plan for air/ground procedure synchronization	On schedule	New milestone
2017	Develop documentation of air/ground procedures standards with user community	On schedule	New milestone
2017	Conduct trials and develop a validation report for air/ground procedure synchronization	On schedule	New milestone
2017	Conduct engineering assessment of L-band communication system performance from prototype testing conducted under Single European Sky ATM Research development activities	On schedule	New milestone
2017	Develop Minimum Operational Performance Standards for Iridium-Next which will enable the Satcom system to support data communications in domestic airspace	On schedule	New milestone
2017	Conduct prototype testing to support the development of Internet Protocol Standards to support the FAA's Data-Comm Segment 2 and Future Communication Systems including NextSat, L-band Digital Aeronautical Communications System and Aeronautical Mobile Airport Communications System	On schedule	New milestone

2.3.3 Operations Concept Validation and Infrastructure Evolution (F&E - 1A01C - M08.29-00 - Advanced Technology Development and Prototyping)

The Operations Concept Validation and Infrastructure Evolution Program supports Efficiency R&D Goal 3 by developing and validating NAS level operational concepts that are key to the FAA modernization programs and NextGen. Developing operational concepts is the first step in developing an Enterprise Architecture. The program conducts the overall analysis and planning for NAS evolution by determining the required annual updates to the NAS Enterprise Architecture products: Operational Improvements, Operational Sustainment, and Operational Requirements. It executes research, engineering analysis, and evaluation in support of mission and investment analysis. The program conducts shortfall analyses as part of service analysis and ensures the linkage of proposed solutions back to validated operational needs to support budget planning and investment decisions. This program develops and maintains detailed second-level

concepts that support validation and requirements development. The work ensures that the NAS level operational concept and sustainment activities are integrated and consistent with the overall NAS Enterprise Architecture. This program also supports the development and sustainment of analytical and computer models used to assess and validate operational changes to the NAS.

Additional information on this F&E program can be found by referencing the FY 2017 – 2021 CIP.

The research milestones and their statuses are shown in Table 2.3.3, Operations Concept Validation and Infrastructure Program Milestones below.

Table 2.3.3: Operations Concept Validation and Infrastructure Evolution Program Milestones

Year	Milestone	Status	Notes
2016	Develop and provide annual updates to the NAS Enterprise Level Operational Requirements to reflect the results of research and development conducted in 2015	On schedule	
2016	Develop and provide annual updates to the NAS Enterprise Architecture for NAS level operational improvements and operational sustainment activities based on completed research and acquisition decisions made in 2015	On schedule	
2017	Develop annual updates to the NAS Enterprise Level Operational Requirements based on prior year research and development	On schedule	New milestone
2017	Develop annual updates to the NAS Enterprise Architecture for NAS level operational improvements and operational sustainment activities based on prior year research and acquisition decisions	On schedule	New milestone
2017	Conduct concept engineering activities and develop concept engineering/requirements validation artifacts, such as shortfall analyses, concept of operations, requirements, technical assessments, and evaluation documents	On schedule	New milestone
2017	Develop technical papers and reports in support of RTCA, the premier public-private partnership forum to develop consensus among aviation stakeholders across the globe. These artifacts include safety and performance requirements, operational services and environment definitions, minimum aviation system performance standards, minimum operational performance standards, and other reports as necessary	On schedule	New milestone

2.3.4 System Capacity, Planning and Improvements (F&E - 1A01B - M08.28-00 - Advanced Technology Development and Prototyping)

The System Capacity, Planning and Improvements Program supports Efficiency R&D Goal 3 by providing data and analyses on the NAS operations to FAA executives and managers to help them identify deficiencies and develop proposals to improve NAS performance. This work includes:

- Airport modeling and analysis using actual data collected from ATC systems in the field to determine the value of potential improvements in airspace or airfield modifications;
- Enhancements of the Performance Data Analysis and Reporting System (PDARS) through the implementation of the Data Visualization and Reporting System (DVARS), a fully integrated performance measurement tool designed to help the FAA improve the NAS by tracking the daily operations of the ATC system and their environmental impacts;
- Using PDARS/DVARS operational data to baseline the measurement and analysis of Next Generation Air Transportation System (NextGen) capability improvements such as the efforts to support Optimization of Airspace and Procedures in the Metroplex (OAPM);
- Leveraging new technologies to enhance capabilities of PDARS/DVARS;
- Development of new agency level metrics to enhance management awareness of, and response to, system performance. Maintain and enhance the FAA Operational Metrics Web Page;
- Benchmarking ATO performance with other Air Navigation Service Providers to support joint projects with EUROCONTROL and as part of International Civil Aviation Organization (ICAO), Civil Air Navigation Services Organization and Aerospace Transportation Advisory Group work plans. These efforts are performed to respond to inquiries on global flight efficiency performance targets for Air Traffic Management (ATM) or more general inquiries on the overall flight inefficiency that may be attributed to ATM;
- Provide analytical and modeling support for Commercial Space initiatives;
- Airport capacity studies that provide assessment of procedural, technology, or infrastructure improvements; and,
- Provide performance modeling and economic analysis to develop a business case with ICAO member states for reduced oceanic separation using ADS-B.

Additional information on this F&E program can be found by referencing the FY 2017 – 2021 CIP.

The research milestones and their statuses are shown in Table 2.3.4, System Capacity, Planning and Improvements Program Milestones below.

Table 2.3.4: System Capacity, Planning and Improvements Program Milestones

Year	Milestone	Status	Notes
2016	Complete design of Performance Data Analysis of Reporting System into a net-centric system	On schedule	
2016	Provide airport capacity modeling and annual service volume analysis report to support the FACT report	On schedule	
2016	Produce Joint Performance Benchmark Report with EUROCONTROL/the European Commission	On schedule	
2016	Prepare white paper on methodologies to standardize international measurement of system capacity, throughput, predictability and efficiency	On schedule	
2016	Develop upgrade of Performance Data Analysis of Reporting System visualization products	On schedule	
2016	Develop upgrade of Performance Data Analysis of Reporting System Processing System	On schedule	
2016	Complete enhancement of FAA Metrics webpage	On schedule	
2016	Provide performance modeling and economic analysis information to support the development of a business case with International Civil Aviation Organization member states in the North Atlantic region for reduced oceanic separation using Automatic Dependent Surveillance Broadcast (Out)	On schedule	
2017	Implement Performance Data Analysis of Reporting System/ Data Visualization and Reporting System web-based access capabilities	On schedule	New milestone
2017	Integrate available system wide information management data products into the Performance Data Analysis of Reporting System/Data Visualization and Reporting System	On schedule	New milestone
2017	Implement upgraded Performance Data Analysis of Reporting System/Data Visualization and Reporting System processing system	On schedule	New milestone
2017	Produce Annual Joint Performance Benchmark Report with EUROCONTROL/European Commission	On schedule	New milestone

Year	Milestone	Status	Notes
2017	Deliver performance modeling and economic analysis information to support the development of a business case with International Civil Aviation Organization member states in the North Atlantic region for reduced oceanic separation using Automatic Dependent Surveillance Broadcast (Out)	On schedule	New milestone

2.3.5 Center for Advanced Aviation System Development (F&E - 4A08)

The Center for Advanced Aviation System Development (CAASD) Program supports Efficiency R&D Goal 3 by:

- Defining a concept to support traffic managers in monitoring current and predicted airspace constraints;

- Developing a fast-time simulation capability to examine the impact of launch and re-entry vehicle operations on ATM, and

- Conducting research to mature a concept to support future time-based metering.

CAASD made the following Progress in FY 2015 towards Efficiency R&D Goal 3:

- ✓ Traffic Flow Managers have a need for monitoring and alerting capabilities for current and predicted NAS constraints. To support research in this area, CAASD developed a proof-of-concept prototype, termed the NAS Operations Dashboard, which provides a single integrated display of real-time data obtained from multiple decision support tools. The NAS Operations Dashboard continuously monitors user-defined thresholds for NAS parameters (e.g., airborne holding, diversions, arrival performance, and taxi times) and alerts when thresholds have been reached or exceeded. Feedback from users indicates that the NAS Operations Dashboard can improve situational awareness, resulting in fast problem identification and resolution.

- ✓ The increasing pace of commercial space launches is driving a need for better ways to accommodate launch and recovery vehicles into air traffic operations in the NAS. To address this need, CAASD developed a modeling capability to explore alternative separation concepts and surveillance performance requirements associated with the integration of commercial space vehicle operations in the NAS. The model leverages existing modeling and simulation capabilities from researchers across the field and aligns with the FAA Commercial Space Vehicle Operations Concept of Operations. The developed model can be used to analytically evaluate the safety of separation concepts with an initial set of space vehicle models, thus providing objective data to inform the concept and associated requirements.

- ✓ Concepts were developed and requirements defined in 2015 to assist En Route Controllers with time-based metering of operations. To assist controllers in meeting assigned metering times, a path stretch capability is under development that provides a small path change that can absorb delays and improve timing. CAASD assisted the FAA in improving the operational suitability of the path stretch capability. Specifically, CAASD has identified design features that address initial operational concerns, context, and integrate path stretch advisories with advisories from other systems. The proposed design was prototyped in CAASD's laboratory and examined through operational subject matter assessments with controllers. Through this exercise, the subject matter experts concluded that the path stretch concept was sufficiently mature to move forward into the acquisition decision making process.

2.4 Efficiency R&D Goals 4 and 5

Established requirements and standards for enabling availability and improving the quality and quantity of meteorological information to reduce impacts of adverse weather on rerouting, NAS capacity, and NextGen operational procedures.

Improved accuracy and accessibility of observed and forecast weather information to improve NAS efficiency (e.g., reduced delays and cancellations, increased capacity in high traffic areas).

2.4.1 NextGen - Weather Technology in the Cockpit (R,E&D - A12.c)

The NextGen – Weather Technology in the Cockpit (WTIC) Program supports Efficiency R&D Goals 4 and 5 by doing research to develop, verify, and validate recommended requirements for incorporation into MinWxSvc standards. The MinWxSvc is defined as:

- Meteorological Information (MET);
- Minimum performance standards (e.g., accuracy) of the MET information;
- Minimum information rendering standards, and
- Enhanced training on cockpit MET information and technology.

To develop the MinWxSvc recommendations, WTIC research is performing gap analyses to identify operational shortfalls impacting efficiency attributable to adverse weather conditions and associated gaps of MET information in the cockpit. The MinWxSvc standards will resolve the identified MET information gaps to mitigate the efficiency-related operational shortfalls.

The research milestones and their statuses are shown in Table 2.4.1, NextGen-Weather Technology in the Cockpit Program Milestones below, followed by a summary of the significant progress made in FY 2015 towards achieving the R&D goals.

Table 2.4.1: NextGen - Weather Technology in the Cockpit Program Milestones

Year	Milestone	Status	Notes
2016	Initial verification demonstrations of recommended implementations of adverse weather alerting functions for the flight deck	On schedule	

Year	Milestone	Status	Notes
2017	Quantify NAS benefits from uplinking/crosslink of enhanced meteorological information to the cockpit	Delayed	Milestone was revised due to the use of other methods besides modeling and simulation to quantify NAS benefits. Milestone is delayed from 2016 to 2017 due to NextGen priorities and to align with ongoing RTCA standards development work. Old wording 'Develop models to run simulations to quantify NAS benefits from uplinking/crosslink of enhanced meteorological information to the cockpit' 2015 NARP Status: On schedule
2017	Perform simulations and/or demonstration of providing initial minimum weather service enhanced wind information (accuracy, timeliness, etc.) recommendations to the Flight Management System and Air Traffic Control Systems to verify realization of predicted benefits of associated NextGen application program(s)	On schedule	Milestone was revised to clarify the scope of the necessary research to verify Weather Technology in the Cockpit minimum weather service recommendations relative to wind accuracy. Old wording 'Provide accurate and timely wind information to the Flight Management System and Air Traffic Control Systems, and demonstrate realization of predicted benefits of associated NextGen application programs' 2015 NARP Status: Delayed from 2015 to 2017
2018	Propose standards for improving weather information to the flight deck in oceanic and non-controlled airspace	On schedule	
2020	Complete development of recommendations for Part 121/135 minimum weather service attributes that resolve meteorological information gaps associated with shortfalls in NAS efficiency	On schedule	
2021	Assess the impact of maturing NextGen operational capabilities and requirements on initial Weather Technology in the Cockpit minimum weather service recommendations	On schedule	New milestone

NextGen - Weather Technology in the Cockpit Program Progress in FY 2015:

- ✓ Completed functional analyses of the WTIC Part 121/135 ConOps and the Part 91 concept of operations. The functional analyses developed Functional Architecture Documents (FAD), SV-1 (Systems Interface Description) , SV-2 (Systems Communication Description), and SV-4 (Systems Functionality Description) views. The

FAD details the set of functions, requirements, and architecture of necessary Data Link Weather (DLW) capabilities to implement/enable NextGen weather benefits. The drawings resulting from the functional analyses will be used to identify minimum DLW services, internal and external service interfaces for DLW, and gaps in existing functions and data for DLW.

- ✓ Completed a proof of concept to predict aircraft behavior while operating in the vicinity of convection. Based on the positive results of the proof of concept phase, additional research will be performed to assess potential applications for the cockpit or to support automated rerouting tool.

2.4.2 Weather Program (R,E&D - A11.k)

The Weather Program supports Efficiency R&D Goals 4 and 5 by conducting applied research focused on improving weather information required for integration into decision-support tools to reduce the impact of adverse weather on the NAS. The improved weather information enhances NAS efficiency and capacity by supporting better operational planning and decision-making by ATM, dispatchers, and pilots.

The research milestones and their statuses are shown in Table 2.4.2, Weather Program Milestones below, followed by a summary of the significant progress made in FY 2015 towards achieving the R&D goals.

Table 2.4.2: Weather Program Milestones

Year	Milestone	Status	Notes
2015	Transition turbulence forecast capability for all flight levels for implementation (as detailed in the NAS Infrastructure Portfolio section of the *NextGen Implementation Plan*)	Completed	2015 NARP Status: On schedule
2016	Develop recommended guidelines for implementing airport ramp procedures during lightning events to maximize efficiency and increase safety of the NAS	On schedule	
2016	Transition global turbulence forecast capability for implementation	On schedule	
2018	Transition Alaska turbulence forecast capability for implementation (as detailed in the NAS Infrastructure Portfolio section of the *NextGen Implementation Plan*)	On schedule	
2018	Transition North American rapid refresh ensemble weather forecast model (13 km) to the NWS for operational implementation	On schedule	
2019	Transition global-scale probabilistic convection guidance capability for implementation	On schedule	

Year	Milestone	Status	Notes
2020	Transition high resolution rapid refresh ensemble weather forecast model (three kilometer with one kilometer nests) to the NWS for operational implementation	On schedule	
2021	Implement high-resolution ceiling and visibility analysis capability into helicopter emergency medical service tool	On schedule	New milestone

Weather Program Progress in FY 2015:

- ✓ Lightning events at airports not only result in safety concerns for airport personnel and passengers, but also impact flight schedules and efficiency of services. In FY 2015, a cross-section of airports was surveyed to determine localized impacts due to lightning events, whether there were procedures in place and the interest in obtaining and implementing lightning warning procedures. Additionally, data was gathered at a Core30 airport of lightning events, ramp closures, aircraft delays, and conformance to ramp procedures in order to verify procedural standards at major airports.

- ✓ The development of a prototype global turbulence forecast product was completed. In order to increase accuracy the product is being modified to allow use of higher resolution (13 km versus 25 km) data from the numerical weather prediction model that provides the primary input.

2.4.3 NextGen – Weather Observation Improvements (F&E 1A09 - G04W.02-01 - NAS Infrastructure)

The NextGen Weather Observation Improvements Program supports Efficiency R&D Goal 5 by managing the the evolution of the existing aviation weather observation sensor networks to one that provides the optimal quantity and quality of ground, air, and space-based sensors. A consistent and effective aviation weather sensor network is fundamental to NextGen. Of primary focus is the surface weather sensor network in the Terminal environment. A comprehensive list of weather observation shortfalls is continuously refined and prioritized based on feedback from key stakeholders and user groups. The program uses this information to explore potential NextGen-enabled concepts and to mitigate the high priority shortfalls. Technical studies are underway to identify methods to optimize existing ground-based legacy surface platforms. In the near term, this program is addressing current limitations of the sensor network for the Terminal environment; specifically, the ability to identify the type and intensity of frozen precipitation which impacts the efficiency of winter weather and deicing operations and conduct technical and operational risk assessments of alternative solutions. Improvements to the aviation weather-observation sensor network may require collaboration between the FAA and other NextGen partners including the National Oceanic and Atmospheric Administration (NOAA) and the Department of Defense (DoD).

Additional information on this F&E program can be found by referencing the FY 2017 – 2021 CIP.

The research milestones and their statuses are shown in Table 2.4.3, Weather Observation Improvements Program Milestones below.

Table 2.4.3: Weather Observation Improvements Program Milestones

Year	Milestone	Status	Notes
2017	Produce a concept maturity technology plan for terminal wind operational improvements that identifies improved spatial sampling in the terminal area, improved information availability, and sensor modernization and consolidation opportunities	On schedule	New milestone
2017	Complete update of weather observations shortfall analysis; ascertain stakeholder buy-in and prioritization, and document terminal winds operational improvement in NAS Infrastructure portfolio	On schedule	New milestone
2017	Deliver assessment of market technologies and maturing research and development programs for adverse wind mitigating applications	On schedule	New milestone
2017	Complete required AMS system engineering artifacts for terminal-area adverse winds useful segment	On schedule	New milestone

2.5 Efficiency R&D Goal 6

Availability of existing airport facilities protected and used as efficiently as possible, while making strategic investments in new facilities consistent with evolving aviation needs.

2.5.1 Airport Cooperative Research Program – Capacity (AIP)

The Airport Cooperative Research Program (ACRP) – Capacity supports Efficiency R&D Goal 6 by providing better airport planning and design. Future aviation demand will rely on the ability of airports to accommodate increased aircraft operations, larger aircraft, and more efficient passenger throughput. The program is preparing for future needs while simultaneously solving current and near-term airport capacity issues.

The research milestones and their statuses are shown in Table 2.5.1, Airport Cooperative Research Program – Capacity Milestones below, followed by a summary of the significant progress made in FY 2015 towards achieving the R&D goal.

Table 2.5.1: Airport Cooperative Research Program – Capacity Milestones

Year	Milestone	Status	Notes
2015	Develop a primer on the benefits of a whole-building systems lifecycle approach to airport operations and maintenance optimization and re-commissioning	Completed	2015 NARP Status: Delayed from 2014 to 2015
2015	Create guidance on successful Computer Maintenance Management Systems selection and practices	Completed	2015 NARP Status: Delayed from 2014 to 2015
2015	Quantify the national aggregate value of airports to communities and to aviation stakeholders	Completed	2015 NARP Status: Delayed from 2014 to 2015
2015	Estimate the economic impact of air cargo at airports	Completed	2015 NARP Status: Delayed from 2014 to 2015
2015	Prepare guidance to assist airports in using benefit-cost analysis and other analytical techniques to make airport capital investment decisions	Completed	2015 NARP Status: Delayed from 2014 to 2015
2015	Develop guidelines for air cargo facility planning and development at airports	Completed	2015 NARP Status: Delayed from 2014 to 2015
2016	Use disaggregated socioeconomic data in air passenger demand studies	On schedule	New milestone
2016	Realistic use of economically integrated business park development for airports	On schedule	New milestone
2017	Technology solutions to facilitate Americans with disabilities travelers	On schedule	New milestone

Airport Cooperative Research Program – Capacity Progress in FY 2015:

- ✓ Computer Maintenance Management Systems (CMMS) are an efficient and effective tool for airports to manage maintenance activities that can be defined in many ways with different components. Outputs from a CMMS can provide inputs to any number of different airport functions, such as budgeting, capital planning, and setting of rates and charges. With a number of different off-the-shelf CMMS software packages available with an assortment of features, functions, capabilities; and add-on components; advancing technology; and airports with different resources and needs, it can be overwhelming for airport staff to understand and evaluate the best solution for their airport when selecting a CMMS that will work now and in the future. Choosing the right software, however, is only the beginning, as there are many other factors that ensure a successful CMMS in terms of implementation, ongoing operations, and support and maintenance. The objective of this research is to provide guidance to airport staff in selecting a CMMS that will best meet their individual needs as well as successfully integrating the CMMS into airport processes, procedures, and other information technology systems. The guidebook is in the editing and publication process and is expected to be published in the last quarter of 2015.

2.5.2 Airport Technology Research Program – Capacity (AIP)

The Airport Technology Research Program (ATRP) – Capacity supports Efficiency R&D Goal 6 by providing better airport planning, designs, and improves runway pavement design, construction, and maintenance. It ensures that new pavement standards will be ready to support safe international operation of NextGen-heavy aircraft and makes pavement design standards available to users worldwide.

The research milestones and their statuses are shown in Table 2.5.2, Airport Technology Research Program – Capacity Milestones below, followed by a summary of the significant progress made in FY 2015 towards achieving the R&D goal.

Table 2.5.2: Airport Technology Research Program – Capacity Milestones

Year	Milestone	Status	Notes
2015	Complete development of Display Playback Animation Software for the Airport and Airspace Simulation Model	Completed	2015 NARP Status: Delayed from 2014 to 2015
2015	Perform economic analysis of heated pavements at selected airports	Completed	2015 NARP Status: On schedule
2016	Study the effect of high tire pressure on performance of hot mix asphalt pavement under heavy aircraft wheel load	Delayed	Milestone is delayed from 2015 to 2016 since the completion and opening of the National Airport Pavement Materials and Research Center was delayed due to poor weather during construction. 2015 NARP Status: On schedule

Year	Milestone	Status	Notes
2016	Characterize the performance of warm mix asphalt and compare it with the performance of standard P-401 hot mix asphalt	Delayed	Milestone is delayed from 2015 to 2016 because the completion and opening of the National Airport Pavement Materials and Research Center was delayed due to poor weather during construction. 2015 NARP Status: On schedule
2016	Study the effects of polymer modified binder on the performance/life of P-401 hot mix asphalt	Delayed	Milestone is delayed from 2015 to 2016 because the completion and opening of the National Airport Pavement Materials and Research Center was delayed due to poor weather during construction. 2015 NARP Status: On schedule
2016	Complete full-scale test on CC-7 perpetual pavements at the FAA National Airport Pavement Test Facility (NAPTF) database to validate/modify/refine hot mix asphalt Fatigue Failure Model in FAARFIELD System	On schedule	
2016	Complete in-service testing of new light emitting diode lighting circuits for use on airports	On schedule	New milestone
2017	Pavement roughness index for airports	On schedule	
2018	New method to calculate aircraft classification number and pavement classification number	On schedule	
2019	Standardization of the life-cycle cost analysis process	On schedule	
2020	Long term full scale testing of concrete pavement for 40 year life	On schedule	

Airport Technology Research Program – Capacity Progress in FY 2015:

- ✓ Software animations are being developed that will allow users to watch ‘what if’ scenarios of taxi routes, etc. for various applications like phases of airport construction, new procedures, alternate runway use. Updates to the first version of the animation software are ongoing with new functions/improvements.

- ✓ Completed Runway Safety Area (RSA) Lighting and Marking field evaluations of prototype approach hold signage and marking at Chicago O'Hare International Airport (ORD), Cleveland Hopkins International Airport (CLE) and Nashville International Airport (BNA). The evaluations included signs that displayed runway departure information in several configurations and were paired with the Pattern B (ladder) marking. The results of the study indicate the new sign and marking combination is beneficial for use on taxiways that intersect approach and departure surfaces.

2.6 Efficiency R&D Goal 7

Improved cyber resiliency for the NAS system of systems in the case of determined adversaries with persistent attacks that try to undermine the NAS.

2.6.1 NextGen – Information Security (R,E&D A12.d)

The NextGen Information Security Program supports Efficiency R&D Goal 7 by directly supporting the FAA Cyber-Security Strategic Plan goals and objectives to:

1. protect and defend the FAA networks and systems
2. deter and mitigate risks of cyber-attacks.

It will apply the Risk-Based Decision-Making strategic approach to enhance the FAA data-driven risk making capabilities. The program will conduct research to help prevent and deter disruptive cyber incidents that affect the ATC mission and improve resiliency in the event an incident does occur. Current information security measures in place for the NAS are robust. However, cyber capabilities are rapidly increasing at the same time that costs for adversaries to execute those attacks are decreasing. This reality necessitates some prudent exploration of advanced detection and defense capabilities for the NAS systems. The program will take proactive and collaborative approach to work with other Federal agencies, NAS stakeholders, and academic institutions to identify, develop, and implement methods, tools, and technologies to meet the research requirements of FAA Cyber-security Strategic Plan goals and objectives.

The program will meet the FAA priority needs as defined by the FAA Cyber-Security Steering Committees in all three FAA cyber domains: 1) Operational NAS, 2) Mission Support, and 3) NAS R&D. Specific focus will be placed on the unique technical challenges of NAS operations and service delivery with increasing demands of network connectivities.

Major activities planned in FY 2017 will include:

- Exploring applicability of self-adaptive systems and networks to improve resilience in the event of attempted cyber disruption;
- Researching advanced big-data analytics approaches to detect and respond to advanced persistent threats and insider threats;
- Exploring adoption of techniques to provide design assurance in mixed-trust environments, and
- Defining candidate list for cyber resilience metrics for use for the NAS.

The research milestones and their statuses are shown in Table 2.6.1, NextGen - Information Security Program Milestones below.

Table 2.6.1: NextGen – Information Security Program Milestones

Year	Milestone	Status	Notes
2017	Develop program plan and research initiatives to support the FAA Cybersecurity Strategic Plan	On schedule	New milestone
2017	Formulate research activities to support national aviation system priority needs set forth by the FAA Cybersecurity Steering Committee	On schedule	New milestone

2.7 Efficiency R&D Goal 8

Improved methods and/or capabilities that enable safe reduction in separation standards, increase in airspace capacity, and/or efficient management of aircraft trajectories.

2.7.1 Oceanic Tactical Trajectory Management (F&E 1A05 - G01A.02-02 NextGen Separation Management)

The Oceanic Tactical Trajectory Management (OTTM) Program supports Efficiency R&D Goal 8 by addressing Oceanic Trajectory Management in Four Dimensions (OTM-4D). The key objective of this concept is to use trajectory-based operations to improve fuel efficiency, system predictability, and performance by enabling airlines and other operators to flight plan and fly closer to their optimal, or preferred 4D trajectories while in oceanic airspace. This requires new decision support capabilities and integration with traffic flow management.

This program will develop the following capabilities: Traffic Congestion Depiction and Flight Specific Likelihood Feedback, Re-Profile Alert and Pre-Oceanic Planner. These capabilities are all dependent on the 4-D Stochastic Trajectory Model which provides a three-dimensional (longitude, latitude, altitude) density function of a flight position with respect to its planned flight time.

With increased system precision and enhanced automation, aircraft can more closely fly routes to realize the airlines' goals for fuel efficiency and schedule reliability. Reduced separation standards for aircraft that rely on shared state and intent data will lead to fewer predicted conflicts, and as a result, fewer diversions from the preferred routing. Reduced separation standards will also result in more efficient use of capacity within flow-constrained airspace, allowing more aircraft to fly through those areas, rather than being re-routed or delayed to avoid them.

Additional information on this F&E program can be found by referencing the FY 2017 – 2021 CIP.

The research milestones and their statuses are shown in Table 2.7.1, Oceanic Tactical Trajectory Management Program Milestones below.

Table 2.7.1: Oceanic Tactical Trajectory Management Program Milestones

Year	Milestone	Status	Notes
2017	Complete benefits analysis and validation and report results	On schedule	New milestone
2017	Develop Functional Analysis for Controller 4D Trajectory Insight	On schedule	New milestone

Year	Milestone	Status	Notes
2017	Conduct modeling and simulation and report results for: o Traffic Congestion Depiction and Flight Specific Likelihood Feedback o Pre-Oceanic Coordination Planner o Re-Profile Alert	On schedule	New milestone
2017	Complete tech transfer and associated documentation	On schedule	New milestone

2.7.2 Advanced Methods (F&E 1A07 – G05A.02-02 On Demand NAS Information)

The Advanced Methods for Traffic Flow Management (TFM) supports Efficiency R&D Goal 8 by exploring technologies, infrastructure enhancements and procedural changes to meet current and future traffic management needs. This program will support improvements to increase airport capacity and sector throughput, and reduce sector delays by providing the NAS users and Air Traffic Management with a common understanding of the NAS constraints. The program will develop and test prototype improvements and provide operational concepts and requirements for implementation by automation programs and operational organizations.

Advanced Methods for TFM will analyze different technologies, infrastructure enhancements, and procedural changes to support more efficient use of airport capacity, increases in sector throughput, and reductions in sector delays.

Additional information on this F&E program can be found by referencing the FY 2017 – 2021 CIP.

The research milestones and their statuses are shown in Table 2.7.2, Advanced Methods Program Milestones below.

Table 2.7.2: Advanced Methods Program Milestones

Year	Milestone	Status	Notes
2017	Conduct concept engineering activities to develop the following products for individual capabilities under Constraint Prediction, Monitoring and Alerting, Operational Response Development, and TFM System Performance Analysis Capability: o Updated Capability Functional Analysis; o Updated Capability Requirements; and o Rough order of magnitude cost estimates.	On schedule	New milestone

2.8 Efficiency R&D Goal 9

Safe reduction in separation standards for approaches to closely spaced parallel runways to enable increased airport capacity.

2.8.1 Closely Spaced Parallel Runway Operations (F&E 1A08 – G06N.01-02 NextGen Improved Multiple Runway Operations)

The Closely Spaced Parallel Runway Operations Program (CSPO) supports Efficiency R&D Goal 9 by accelerating activities to provide increased arrival and departure operations to airports with closely spaced parallel runways in limited visual conditions. CSPO will develop the performance requirements that enable the implementation of innovative procedures, tools and controller or pilot aids that increase capacity at airports utilizing multiple independent and dependent operations. This initiative will enhance procedures that allow dependent operations to closely spaced parallel runways or converging approaches to runways greater than 700 feet apart, as well as supporting independent operations to parallel runways between 2,500 feet and 4,300 feet. Furthermore, CSPO will identify potential alternatives for meeting functional requirements such as applying existing and new technologies to current standards, evaluating high update rate surveillance requirements and sensors such as Automatic Dependent Surveillance-Broadcast (ADS-B), navigation system performance and pilot and controller response times used for risk assessments, and the development of new standards to facilitate NextGen applications.

CSPO is focused on finding safe ways to recover capacity lost by the current aircraft-to-aircraft separation procedures required for simultaneous operations to closely spaced parallel runways during limited visual conditions. The goal of CSPO analysis is to maintain the same arrival and departure rates regardless of weather conditions. Using CSPO, some airports may increase arrival rates by as much as 6 to 12 operations per hour but will vary based on local operations and procedures.

Additional information on this F&E program can be found by referencing the FY 2017 – 2021 CIP.

The research milestones and their statuses are shown in Table 2.8.1, Closely Spaced Parallel Runway Operations Program Milestones below.

Table 2.8.1: Closely Spaced Parallel Runway Operations Program Milestones

Year	Milestone	Status	Notes
2017	Perform analysis of data collected in Paired Approach (PA) to CAT I minima human in the loop (HITL) simulations and provide technical report	On schedule	New milestone

Year	Milestone	Status	Notes
2017	Complete Simultaneous Approaches using High Update Rate surveillance technical report and supply a status memo	On schedule	New milestone
2017	Perform analysis of course divergence on departure to support future CSPO departures HITL simulations and provide technical report	On schedule	New milestone
2017	Complete Demonstration Execution Plan	On schedule	New milestone
2017	Perform safety assessment for flight demonstration	On schedule	New milestone
2017	Complete prototype demonstration cockpit avionics and ground ATC tools (as needed)	On schedule	New milestone

2.9 Efficiency R&D Goal 10

Improved methods, technologies and capabilities that enable increased surface traffic movement efficiency.

2.9.1 Surface Tactical Flow (F&E 1A06 - G02A.01-01 NextGen – Improved Surface/Terminal Flight Data Manager (TFDM) Portfolio)

The Surface Tactical Flow (STF) Program supports Efficiency R&D Goal 10 by developing trajectory-based surface operations in support of NextGen. It leverages the development efforts of the NASA Surface Management System (SMS) and provides guidelines for the development of a collaborative Surface Traffic Management (STM) system. The STM system will provide the tools necessary to achieve a fully collaborative surface environment where the input of airlines, airports and air traffic controllers are all used to provide a shared surface situational awareness. Shared awareness is required to safely expand the use of airport capacity by coordinating surface and airborne trajectory based operations. The STF program will support the Surface Collaborative Decision Making (CDM) sub team of the CDM Stakeholder's Group (CSG) to incorporate flight operator and airport authority stakeholder viewpoints for potential NAS-wide deployment of surface capabilities.

The STF program will conduct research activities to develop and mature Surface Trajectory-Based Operations (STBO) capabilities to leverage and extend mid-term STBO capabilities of information sharing, planning and scheduling, and taxi route management.

The STF program will move Aircraft to and from the runway in a more efficient, predictable, and coordinated manner complying with Traffic Management Initiatives and supporting user preferences. This will increase efficiency and capacity while reducing controller workload through the automated assignment of runways, taxi routes, and departure queues.

Additional information on this F&E program can be found by referencing the FY 2017 – 2021 CIP.The research milestones and their statuses are shown in Table 2.9.1, Surface Tactical Flow Program Milestones below.

Table 2.9.1: Surface Tactical Flow Program Milestones

Year	Milestone	Status	Notes
2017	Conduct initial integration testing of departure scheduling with coordination of traffic management initiatives to provide inputs to the Airspace Technology Demonstration – 2 (ATD-2)	On schedule	New milestone
2017	Analyze Flight Strip event data from lesser equipped airports for integrating departure traffic into metroplex departure schedules	On schedule	New milestone

3.0 R&D Principle 3 - Reduce Environmental Impacts

Systematically expand and apply knowledge to produce useful materials, devices, systems, or methods that will reduce aviation's environmental and energy impacts.

Five R&D goals support R&D Principle 3 Reduce Environmental Impacts. Work is spread across three budget appropriations (R,E&D, F&E, and AIP):

- Goal 1 - Reduced significant community noise impacts in absolute terms.
- Goal 2 - Reduced impact of aviation emissions on air quality and global climate.
- Goal 3 - Improved energy efficiency and assured availability of sustainable alternative jet fuels.
- Goal 4 - Established requirements, policies, procedures, and resources to allow airports in the United States to become environmentally friendly neighbors.
- Goal 5 - Established data and methodologies to support certification of alternative fuels for General Aviation aircraft.

Table 3.0.1, Alignment of FAA R&D Environmental Principle and Programs with NSTC Energy and Environment Goals shows how the FAA's Environment and Energy R&D goals and programs align with the NSTC Energy and Environment Goals. In many cases, FAA R&D programs support more than one NSTC goal.

Table 3.0.1: Alignment of FAA R&D Environmental Principle and Programs with NSTC Energy and Environment Goals

<table>
<tr><th>FAA R&D Principle</th><th>FAA R&D Programs</th><th colspan="3">NSTC Goals</th><th>NSTC Principle</th><th>FAA Strategic Priority</th></tr>
<tr><td rowspan="6">Reduce Environmental Impact</td><td>Environment and Energy</td><td rowspan="2">Goal 1 - Enable New Aviation Fuels Derived from Diverse and Domestic Resources to Improve Fuel Supply Security and Price Stability</td><td rowspan="3">Goal 2 - Advance Development of Technologies and Operations to Enable Significant Increases in the Energy Efficiency of the Aviation System</td><td>Goal 3 - Advance Development of Technologies and Operational Procedures to Decrease the Significant Environmental Impacts of the Aviation System</td><td rowspan="6">Assuring Energy Availability and Efficiency is Central to the Growth of the Aeronautics Enterprise, and the Environment Must be Protected while Sustaining Growth in Air Transportation</td><td rowspan="6">Deliver Benefits Through Technology and Infrastructure</td></tr>
<tr><td>NextGen - Environmental Research - Aircraft Technologies, Fuels, and Metrics</td></tr>
<tr><td>Environment and Energy – Environmental Management Systems and Advanced Noise and Emissions Reduction</td><td rowspan="2"></td><td rowspan="2"></td></tr>
<tr><td>NextGen - Weather Technology in the Cockpit</td></tr>
<tr><td>Airport Cooperative Research Program - Environment</td><td colspan="2">Goal 1 - Enable New Aviation Fuels Derived from Diverse and Domestic Resources to Improve Fuel Supply Security and Price Stability

Goal 2 - Advance Development of Technologies and Operations to Enable Significant Increases in the Energy Efficiency of the Aviation System</td><td rowspan="2">Goal 3 - Advance Development of Technologies and Operational Procedures to Decrease the Significant Environmental Impacts of the Aviation System</td></tr>
<tr><td>Airport Technology Research Program - Environment</td><td colspan="2"></td></tr>
<tr><td>NextGen - Alternative Fuels for General Aviation</td><td colspan="3">Goal 3 - Advance Development of Technologies and Operational Procedures to Decrease the Significant Environmental Impacts of the Aviation System</td></tr>
</table>

In FY 2017, 14 percent of total FAA R&D funding is allocated to R&D Principle 3 - Reduce Environmental Impacts. Program funding levels for the 2016 Enacted and 2017 Congressional Request are shown in Table 3.0.2. Percent of Program reflects each program's contribution towards R&D Principle 3 in the 2017 Congressional Request. Table 3.0.2 also lists the section and page number reference for each budget narrative within the FY 2017 Congressional Justification (CJ) for the President's Budget Request. The FY 2017 CJ will be made available by the DOT at https://www.transportation.gov/budget.

Table 3.0.2: Program Funding for R&D Principle 3 - Reduce Environmental Impacts

2016 BLI	Program	CJ Reference (Section /Page)	Appropriation Account	2016 Enacted ($000)	2017 Congressional Request ($000)	2017 Percent of Program
A11.m	NextGen - Alternative Fuels for General Aviation	3C/58	RE&D	7,000	5,792	100%
A12.c	NextGen - Weather Technology in the Cockpit	3C/71	RE&D	405	406	10%
A13.a	Environment and Energy	3C/78	RE&D	16,074	15,013	100%
A13.b	NextGen - Environmental Research - Aircraft Technologies, Fuels, and Metrics	3C/81	RE&D	25,823	26,174	100%
A14.a	System Planning and Resource Management	3C/85	RE&D	540	716	26%
4A08	Center for Advanced Aviation System Development (CAASD)	3B/306	F&E	0	3,000	5%
--	Next Generation Transportation System - Environment Portfolio		F&E	1,000	0	100%
--	Airport Cooperative Research Program - Environment	3D/36	AIP	5,000	5,000	100%
--	Airport Technology Research Program - Environment	3D/26	AIP	1,576	1,595	100%
	Total ($000)			**57,418**	**57,697**	

**CAASD R&D budget totals for 1) FY 2016 assume 28% for Safety, 72% to Efficiency, and 0% for Environmental and 2) FY 2017 and outyears assume 26% for Safety, 69% for Efficiency, and 5% for Environmental (subject to FFRDC Executive Board FY 2017 workplan approval).*

3.1 Environment and Energy R&D Goals 1 - 3

Reduced significant community noise impacts in absolute terms.

Reduced impact of aviation emissions on air quality and global climate.

Improved energy efficiency and assured availability of sustainable alternative jet fuels.

3.1.1 Environment and Energy (R,E&D - A13.a)

The Environment and Energy Program supports Environment and Energy Goals 1, 2, and 3 by characterizing aircraft noise and emissions as well as their consequential impacts on the environment. It then provides guidance on mitigating such impacts and provides fundamental knowledge, development, and validates methodologies, models, metrics, and tools. It analyzes and balances the inter-relationships between noise and emissions and considers local to global impacts as well as determine economic consequences. The program also reduces scientific uncertainties related to aviation environmental issues to support decision-making.

The research milestones and their statuses are shown in Table 3.1.1, Environment and Energy Program Milestones below, followed by a summary of the significant progress made in FY 2015 towards achieving the R&D goals.

Table 3.1.1: Environment and Energy Program Milestones

Year	Milestone	Status	Notes
2015	Advance the understanding of noise impacts on social welfare and health	Completed	2015 NARP Status: On schedule
2015	Develop approved method for measuring particulate matter from gas turbine engines	Completed	2015 NARP Status: On schedule
2015	Develop methods to account for regional climate impact of aviation emissions	Completed	2015 NARP Status: On schedule
2015	Improve understanding of the impacts of aircraft emissions in urban air shed area	Completed	2015 NARP Status: On schedule
2016	Advance the understanding of noise impacts on social welfare and health	On schedule	
2016	Develop new standard for aircraft carbon dioxide emissions	On schedule	New milestone

Year	Milestone	Status	Notes
2016	Develop methodologies to quantify and assess the impacts of aviation emissions	On schedule	Milestone was revised due to the development of new standards was broken out as a separate milestone. Old wording 'Develop new standards and methodologies to quantify and assess the impacts of aviation emissions' 2015 NARP Status: On schedule
2017	Refine methods for estimation of aircraft contribution to climate change and implement them in analytical tools	On schedule	
2017	Advance the understanding of noise impacts on social welfare and health	On schedule	
2018	Develop air quality model to capture global impacts of aviation emissions	On schedule	
2018	Advance noise propagation methodology for implementation in analytical tools	On schedule	
2018	Release improved version of Aviation Environmental Design tool	On schedule	New milestone
2019	Develop new standard for particulate matter emissions	On schedule	
2019	Explore appropriate metric for aircraft surface noise levels	On schedule	
2019	Develop improved tool and methodologies for cost-benefit analysis	On schedule	New milestone
2020	Enhance methodology for estimation of aviation contribution to climate change	On schedule	
2021	Improve analytical capabilities of aviation environmental analysis tools	On schedule	New milestone

Environment and Energy Program Progress in FY 2015:

- ✓ In order to minimize environmental consequences of aviation, the FAA continued research to advance the understanding of noise impacts on social welfare and health. Several research projects have been sponsored to analyze potential health effects on residents. The largest study is addressing annoyance due to aircraft noise and consists of a comprehensive survey of residents living around 20 airports in the U.S. Studies on annoyance expand beyond fixed wing aircraft to also explore impact from rotorcraft noise. These studies are still underway and their results are not final. The comprehensive survey should be complete in the first half of 2017.

- ✓ Social welfare and health effects of noise on residents are being addressed by additional projects focusing on potential impacts such as long-term cardiovascular health, sleep disturbance, and children's leaning. All of these projects are in various states of completion. The first phase of the sleep work was completed in 2014 and the second phase is ongoing with an expected completion date of 2016. The cardiovascular health work is an expansion of a 2014 study that is also ongoing and should be completed in 2017. Finally, the first student learning project was completed in 2013 and the second phase is on-going with a scheduled completion date in mid-2017.

- ✓ A new noise source that is recently gaining attention is that from commercial space vehicles. Studies were initiated to evaluate existing launch noise models and their potential integration with noise models that are used for commercial aviation. Such capabilities will be needed to support the assessment of environmental effects of commercial space flights and the studies are scheduled to be completed in late 2017.

- ✓ Research also continues to explore the human response to sonic booms that are produced by a potential new generation of supersonic vehicles. This research is assessing whether lower boom levels could be acceptable in terms of environmental and social welfare impacts.

- ✓ The standardized non-volatile Particulate Matter (nvPM) measurement system specifications are currently being implemented in the ICAO Annex 16, Volume II. The North American Reference System was used to acquire nvPM data from six different aircraft engines in the past year. These datasets not only demonstrate the robustness of the standardized measurement approach, but also characterize the nvPM emissions profile from the different engines. The tested engines range from smaller mixed turbofans for use in regional jets to larger engines rated for use in Boeing 737 and Airbus 320 aircraft. During FY 2016, the North American Reference System will continue to be inter-compared with engine manufacturers' nvPM systems. Measurement campaigns are planned at General Electric Aviation, Ohio; Pratt and Whitney, Connecticut; and Honeywell, Arizona to characterize engine nvPM emissions and to perform inter-comparison of measurement systems. Data acquired during these campaigns will facilitate the promulgation of an international engine nvPM emissions standard by ICAO by February 2016. This first-of- its-kind standard combines the health-based nvPM emissions with the visibility-based smoke number standard. In addition, data from six representative engines from U.S. manufacturers will be acquired to inform the development of a more stringent Landing and Take-Off (LTO) cycle based nvPM mass and number standard that is proposed to be promulgated by February 2019.

- ✓ The climate impacts of aviation have large spatial variability. The regional changes in temperature for simulated radiative forcing were quantified using the Regional Temperature Potential (RTP) concept. Initial results from other models suggested the need to develop aviation specific RTP matrices. Based on the results, two complex climate models are being utilized to inform the development of a tool which when completed can be used globally to capture the regional radiative forcing and temperature changes for various policy scenarios. Using results from the two models, metrics that capture regional impacts of aviation are being evaluated. Targeted model simulations are being conducted to develop and refine regional temperature correlations that are specific to aviation and are based on the evaluation of the regional climate metrics. Based on the results, a simple climate model that relates regional emissions to regional temperature change for short-lived climate forcers is being developed. Applicability of the simple model for contrail and contrail induced forcing will also be investigated in FY 2016.

- ✓ To better account for the impact of aviation emissions on surface air quality within the U.S., researchers have developed a tool based on the Community Multi-scale Air Quality

Direct Decoupled Method modeling framework, to quantify the contribution of aviation to primary and secondary particulate matter and ozone concentrations in varied air sheds around the U.S. The researchers will use the air quality and health impact models to develop metrics to characterize impacts and the contribution of airport emissions to surface air quality in these air shed regions. Such metrics will enable evaluation of the environmental costs and benefits analysis of changes to the national airspace through operations, aircraft technology and the use of alternative jet fuels.

Over the last decade, the FAA's Office of Environment and Energy (AEE) has developed the Aviation Environmental Design Tool (AEDT). AEDT 2b was publicly released in 2015 for airport to global level aviation environmental analysis. AEDT is a comprehensive environmental software tool that allows for thorough assessment of the environmental effects of aviation and it has the capability to assess the inter-dependencies between aviation-related noise, fuel burn and emission affects. This single tool facilitates comprehensive environmental review required for National Environmental Policy Act (NEPA) and general conformity analyses. AEDT 2b was released to the public on May 29, 2015. The tool and its associated documentation can be found at (http://www.aedt.faa.gov). AEDT 2b implements many functionalities including:

- Modeling of noise, emissions, and dispersion metrics;
- Emissions dispersion from curved tracks;
- Emissions from airplane startup and taxi phases of flight;
- Airplane taxi delay and sequence modeling;
- Emissions from Auxiliary Power Units, Ground Support Equipment and other non-aircraft emissions sources, and
- Modeling of multiple airports in a single study.

3.1.2 Environment and Energy – Environmental Management System and Noise/Emission Reduction (F&E - 1A08 – G06M.02-01 - NextGen – Environment Portfolio)

The Environment and Energy – Environmental Management System (EMS) and Noise/Emission Reduction Program supports Environment and Energy Goals 1, 2, and 3 by supporting development and implementation of the NextGen (EMS) as well as development and assessment of integrated environmental assessment capability. The EMS framework evaluates progress towards aviation environmental and energy goals within the NAS, and aids in the development of new options to further mitigate the impact of aviation on the environment. The NextGen EMS framework relies on environmental assessment capabilities and their use to examine the current and future state of the NAS. This effort has led to enhancements of local to NAS-wide environmental assessment capabilities within the AEDT. The assessment has also improved environmental impacts, economic capabilities in the Aviation Environment Portfolio Management Tool, along with NAS design tools, simulation models and performance monitoring systems. The environmental modeling capabilities are being used with a combination of the

FAA terminal area forecast and improvements in operational procedures from NextGen incorporation, fleet technology advancement, and estimates of future alternative jet fuel penetration in order to estimate current and future environmental performance of the NAS. With these efforts, the NextGen EMS framework is providing a systematic examination of options for noise, fuel burn, and emissions reduction to support sustainable mobility growth.

Note that this program is no longer funded and does not appear in the FY 2017 – 2021 CIP.

The research milestones and their statuses are shown in Table 3.1.2, Environment and Energy – Environmental Management System and Noise/Emission Reduction Program Milestones below.

Table 3.1.2: Environment and Energy – Environmental Management System and Noise/Emission Reduction Program Milestones

Year	Milestone	Status	Notes
2016	Submit a report on enhancements to Aviation Environmental Design tool terminal area capabilities to enable the evaluation of environmental impacts from NextGen	On schedule	
2016	Submit a final report on integration of NextGen simulation models and data with Aviation Environmental Design tool software version 2b	On schedule	

3.1.3 NextGen - Environmental Research - Aircraft Technologies, Fuels, and Metrics (R,E&D - A13.b)

The NextGen - Environmental Research - Aircraft Technologies, Fuels, and Metrics Program supports Environment and Energy Goals 1, 2, and 3 by developing solutions to mitigate aviation environmental impacts in absolute terms and increase fuel efficiency. It matures aircraft technologies through the Continuous Lower Energy, Emissions and Noise (CLEEN) Program to reduce noise and emissions at the source level. It assesses, demonstrates, and supports qualification of alternative aviation fuels that reduce emissions that impact air quality and climate change. Availability of alternative aviation fuels also increases energy security. The program also supports research to determine the appropriate goals and metrics to manage NextGen aviation environmental impacts needed to support EMS.

The research milestones and their statuses are shown in Table 3.1.3, NextGen – Environmental Research-Aircraft Technologies, Fuels, and Metrics Program Milestones below, followed by a summary of the significant progress made in FY 2015 towards achieving the R&D goals.

Table 3.1.3: NextGen - Environmental Research - Aircraft Technologies, Fuels, and Metrics Program Milestones

Year	Milestone	Status	Notes
2015	Demonstrate Continuous Lower Energy, Emissions and Noise Engine Weight Reduction and High Temperature Impeller technologies	Completed	2015 NARP Status: On schedule
2015	Evaluate novel future alternative jet fuels to ensure their compatibility with existing aircraft and fueling infrastructure	Completed	2015 NARP Status: On schedule
2015	Assess the environmental benefits of the first round of Continuous Lower Energy Emissions and Noise Airframe and Engine technologies	Completed	2015 NARP Status: On schedule
2015	Initiate Continuous Lower Energy, Emissions and Noise Phase II activities to demonstrate technologies that can reduce energy use, emissions, and noise	Completed	2015 NARP Status: On schedule
2016	Refine the estimates of aircraft contribution to climate change using the latest methods and knowledge	Deleted	Milestone is deleted because this research is now included in the A13.a 2016 milestone 'Develop new standards and methodologies to quantify and assess the impacts of aviation emissions' 2015 NARP Status: On schedule
2016	Refine the environmental and economic sustainability assessment of renewable alternative turbine engine fuels using the latest methods and knowledge	On schedule	
2016	Develop methodology to estimate global lifecycle emissions of alternative jet fuels	On schedule	New milestone
2016	Demonstrate technologies that can reduce energy use, emissions, and noise in year two of the second phase of the Continuous Lower Energy, Emissions and Noise Program	On schedule	New milestone
2017	Demonstrate Continuous Lower Energy, Emissions and Noise Advanced Turbine Components	On schedule	
2017	Demonstrate technologies that can reduce energy use, emissions, and noise in year three of the second phase of the Continuous Lower Energy, Emissions and Noise Program	On schedule	Milestone was revised to capture the year associated with the Continuous Lower Energy, Emissions and Noise program. Old wording ‘Demonstrate technologies that can reduce energy use, emissions, and noise via the second phase of the Continuous Lower Energy, Emissions and Noise program’ 2015 NARP Status: On schedule
2018	Advance approval methodology for alternative jet fuels	On schedule	

Year	Milestone	Status	Notes
2018	Demonstrate technologies that can reduce energy use, emissions, and noise in year four of the second phase of the Continuous Lower Energy, Emissions and Noise Program	On schedule	New milestone
2019	Advance the understanding of alternative jet fuel composition and environmental performance	On schedule	
2019	Utilize methodology to provide global lifecycle emissions of alternative jet fuels	On schedule	New milestone
2019	Demonstrate technologies that can reduce energy use, emissions, and noise in year five of the second phase of the Continuous Lower Energy, Emissions and Noise Program	On schedule	New milestone
2020	Assess the environmental benefits of the second round of Continuous Lower Energy Emissions and Noise airframe and engine technologies	On schedule	
2020	Initiate Continuous Lower Energy, Emissions and Noise Phase III activities to demonstrate technologies that can reduce energy use, emissions, and noise	On schedule	New milestone
2021	Demonstrate technologies that can reduce energy use emissions and noise via the third phase of the Continuous Lower Energy Emissions and Noise Program	On schedule	New milestone

NextGen - Environmental Research - Aircraft Technologies, Fuels, and Metrics Program Progress in FY 2015:

- ✓ Under the CLEEN Program, Honeywell has designed, built, and demonstrated engine weight reduction and high temperature impeller technologies. Honeywell's testing of the technologies has culminated in ground engine tests in 2014 and 2015, bringing all technologies to technology readiness level six, indicating a high level of maturity and readiness to enter product development outside of the CLEEN Program. The Honeywell CLEEN technologies provide 5% fuel burn reduction as part of a planned 15.7% fuel burn reduction engine package.

- ✓ Under the CLEEN Program, Rolls-Royce has completed a series of laboratory, rig, and auxiliary power unit tests on a range of candidate fuels and blends, representing a range of novel raw materials, processes, blend stocks, and final products. Many of the fuels examined show significant promise and potential benefits. Several projects were also initiated under the Aviation Sustainability Center of Excellence (ASCENT) that will provide test data to aid the existing alternative jet fuel certification and qualification process, as well as support a streamlined process in the future.

- ✓ The FAA has completed a project under the Partnership for Air Transportation Noise and Emissions Reduction (PARTNER) COE, which focused on modeling and assessment of the CLEEN airframe and engine technologies. The Georgia Institute of Technology

employed the Environmental Design Space Modeling Tool, in conjunction with proprietary data from the CLEEN companies' development work to model and assess the benefits of CLEEN airframe and engine technologies. In addition to CLEEN technologies, the PARTNER study also examined other near term aircraft and engine technologies that are being developed by industry. The results of this effort have been incorporated within the U.S. Government's Aviation Greenhouse Gas Emissions Reduction Plan. The work to assess aircraft and engine technologies, including those from the CLEEN Program, is continuing under ASCENT in a new aircraft technology modeling and assessment project.

- ✓ Following the success of the CLEEN Program initiated in 2010, the FAA has awarded eight agreements under CLEEN II for further development of new aircraft technologies and alternative jet fuels that will reduce aviation's environmental impact. The CLEEN II Program; planned to run during 2015-2020, will help industry accelerate technologies through a crucial phase in maturation, culminating in full scale ground and flight test demonstrations and showing readiness for product implementation. At the conclusion of the development effort for a CLEEN II technology, each company cost sharing with the FAA is invested in the success and is confident the product can enter into service. Once entered into service, the CLEEN II technologies will realize their fuel burn, emissions, and noise benefits throughout the fleet for years to come.

3.1.4 NextGen - Weather Technology in the Cockpit (R,E&D - A12.c)

The NextGen – Weather Technology in the Cockpit (WTIC) Program supports Environment and Energy Goals 1, 2, and 3 by doing research to develop, verify, and validate recommended requirements for incorporation into MinWxSvc standards. The MinWxSvc standards will resolve cockpit MET information gaps to mitigate current and NextGen operational shortfalls that negatively impact the environment (e.g., unnecessary fuel consumption).

The research milestones and their statuses are shown in Table 3.1.4, NextGen-Weather Technology in the Cockpit below, followed by a summary of the significant progress made in FY 2015 towards achieving the R&D goals.

Table 3.1.4: NextGen - Weather Technology in the Cockpit Program Milestones

Year	Milestone	Status	Notes
2016	Complete service analyses on incorporating enhanced weather information and new/evolving technologies into the cockpit to enhance NAS efficiency in adverse weather	On schedule	

NextGen - Weather Technology in the Cockpit Program Progress in FY 2015:

- ✓ A shortfall analysis was completed to identify weather-related operational shortfalls and safety risks for current and NextGen flight operations in oceanic and remote regions. The research identified cockpit MET information gaps that are causal factors of the associated

shortfall. The WTIC MinWxSvc recommendations will be developed to resolve the identified MET information gaps with the objective of mitigating the associated operational shortfalls.

3.2 Environment and Energy R&D Goal 4

Established requirements, policies, procedures, and resources to allow airports in the United States to become environmentally-friendly neighbors.

3.2.1 Airport Cooperative Research Program – Environment (AIP)

The Airport Cooperative Research Program (ACRP) – Environment Program supports Environment and Energy Goal 4 by examining the impact an airport has on the surrounding environment and advances the science and technology for creating an environmentally friendly airport system. Projects include (a) the study of airport specific aviation noise, emissions and their environmental impacts, (b) developing strategies and guidance for green airports via reduction in noise and emissions, (c) infrastructure and benefits of alternative aviation fuels at airport facilities, (d) deicing management, and (e) advanced noise and emissions databases. The research milestones and their statuses are shown in Table 3.2.1, Airport Cooperative Research Program – Environment Milestones below, followed by a summary of the significant progress made in FY 2015 towards achieving the R&D goal.

Table 3.2.1: Airport Cooperative Research Program – Environment Milestones

Year	Milestone	Status	Notes
2015	Improve, enhance, and update the Sustainable Aviation Guidance Alliance website with new and existing sustainable practices data	Completed	2015 NARP Status: On schedule
2015	Review, evaluate, and document current helicopter noise models and identify potential improvements to the Integrated Noise Model and the Aviation Environmental Design tool to better capture the unique complexity of helicopter operations	Completed	2015 NARP Status: Delayed from 2014 to 2015
2015	Assess the current body of knowledge regarding the impact of airport operations on air quality and public health	Completed	2015 NARP Status: Delayed from 2014 to 2015
2015	Produce guidance on the application of whole effluent toxicity testing to airport deicing runoff	Completed	2015 NARP Status: Delayed from 2014 to 2015
2015	Develop an inventory methodology to help airports quantify aircraft lead emissions at airports	Completed	2015 NARP Status: Delayed from 2014 to 2015
2016	Manage perfluorocarbon impacts at airports	On schedule	New milestone
2016	Track aviation alternative fuel	On schedule	New milestone
2017	Develop a renewable resource strategy at airports	On schedule	New milestone

Airport Cooperative Research Program – Environment Progress in FY 2015:

- ✓ With increased attention and interest toward sustainable practices and their incorporation into airport planning, construction, and everyday operations; many airport operators are committed to maintaining more sustainability through a variety of mechanisms, such as policy statements, adoption of goals, measuring and reporting, and the development of airport-specific sustainability guidelines. While airports have implemented sustainable practices focused on improving environmental, economic, and social viability; many do not have staff expertise or resources to learn about the sustainable practices applicable to that airport. In order to assist airport operators, the Sustainable Aviation Guidance Alliance (SAGA) was created in late 2008 by the FAA, Airports Council International-North America, the Airport Consultants Council, the American Association of Airport Executives and the Air Transport Association to collect information on hundreds of airport sustainability initiatives across the U.S., Canada, and internationally. Work continues to improve and enhance the SAGA website as well as provide recommendations for maintaining and updating the website and its sustainable practices over time. The scope of research has been expanded to include a full beta test of the website, which is currently underway, and to facilitate transitioning of the website to a permanent host. The SAGA Database was launched in October 2009 and is available online at (http://www.airportsustainability.org).

3.2.2 Airport Technology Research Program – Environment (AIP)

The Airport Technology Research Program (ATRP) – Environment Program supports Environment and Energy Goal 4 by establishing up-to-date exposure-response relationships for community annoyance and sleep disturbance in the U.S. by collecting extensive data, which covers a wide variety of airport types and geographic locations. The results will help guide National Aviation Noise Policy, determinations of community noise impacts, land use guidelines around airports, and mitigation funding.

The research milestones and their statuses are shown in Table 3.2.2, Airport Technology Research Program - Environment Milestones below, followed by a summary of the significant progress made in FY 2015 towards achieving the R&D goal.

Table 3.2.2: Airport Technology Research Program – Environment Milestones

Year	Milestone	Status	Notes
2015	Develop and gain approval for a survey instrument to collect data for the Aircraft Noise and Annoyance study	Completed	2015 NARP Status: Delayed from 2014 to 2015
2015	Complete the study on analyzing air quality samples from forcible entry testing on composite materials	Completed	2015 NARP Status: On schedule
2015	Evaluate the effectiveness of using artificial turf in runway safety areas to mitigate the burrowing of the protected gopher tortoise	Completed	2015 NARP Status: On schedule

Year	Milestone	Status	Notes
2017	Complete data collection for the Aircraft Noise and Annoyance study	Delayed	Milestone is delayed from 2016 to 2017 due to extensive review of the survey instrument. The data collection is now estimated to be completed in November 2016. 2015 NARP Status: On schedule
2017	Complete updates to the dose-response curves for U.S. airports using data collected from the Aircraft Noise and Annoyance study	Delayed	Milestone is delayed from 2016 to 2017 due to delay in related milestone above. Once the data collection is completed, the dose-response curves are estimated to be completed in March 2017. 2015 NARP Status: On schedule
2017	Publish a report on the findings of the artificial turf installation and its effectiveness in mitigating the burrowing of the protected gopher tortoise	On schedule	New milestone

Airport Technology Research Program – Environment Progress in FY 2015:

- ✓ The FAA has initiated a major effort to update the scientific evidence of the relationship between aircraft noise exposure and its effects on communities around U.S. airports. With over 12,000 individuals to be surveyed around 20 U.S. airports, an aircraft noise survey of this magnitude has never been conducted in the U.S. During FY 2013- 2014, aircraft noise and survey experts developed a robust survey instrument to collect human responses on aircraft noise and annoyance, with survey design and methodology continuing into FY 2015. The survey instrument (OMB Control Number 2120-0762) was approved for use on April 27, 2015.

- ✓ A number of airports in the FAA southern region continue to have difficulty meeting the regulations under Part 139 for holes in their RSA caused by the burrowing of gopher tortoises. Due to the tortoises being listed as a threatened species in the State of Florida, mitigating actions (i.e., tortoise removal or relocation and burrow eliminations) are heavily regulated, expensive and time-consuming. Yet having the burrows in such close proximity to runways is a safety hazard to aircraft that may leave the pavement surface. Artificial turf has been identified as a material that can be used to cover large portions of airport property with multiple benefits. Benefits include reduced maintenance costs, reduction of attractive vegetative food sources for hazardous wildlife species and consistent ground cover. Thus, a research study was initiated to assess artificial turf as a potential solution for mitigating the burrowing of gopher tortoises within the RSA environment Orlando-Sanford International Airport from May 1, 2014-April 30, 2015. The artificial turf was also evaluated for its durability and maneuverability and braking action. The findings will be documented in a final report in early FY 2016.

3.3 Environment and Energy R&D Goal 5

Established data and methodologies to support certification of alternative fuels for General Aviation aircraft.

3.3.1 NextGen - Alternative Fuels for General Aviation (R,E&D - A11.m)

The NextGen - Alternative Fuels for General Aviation Program supports Environment and Energy Goals 5 by addressing the use of alternative and renewable fuels for GA to lessen aviation environmental impacts on air and water quality. The program develops data and methodologies to support certification of alternative aviation fuels for GA aircraft.

The research milestones and their statuses are shown in Table 3.3.1, NextGen-Alternative Fuels for General Aviation Program Milestones below, followed by a summary of the significant progress made in FY 2015 towards achieving the R&D goal.

Table 3.3.1: NextGen - Alternative Fuels for General Aviation Program Milestones

Year	Milestone	Status	Notes
2015	Finalize laboratory and rig test methods	Completed	2015 NARP Status: On schedule
2016	Develop engine and fuel test methods to evaluate the performance, safety, durability, and operability of unleaded aviation gasoline	On schedule	
2016	Complete laboratory and rig testing	On schedule	
2017	Perform initial engine and aircraft testing	On schedule	
2018	Perform engine and aircraft testing to address remaining areas of concern	On schedule	
2019	Complete engine and aircraft testing	On schedule	
2020	Identify non-transparent fleet and identify a test program for approval of non-transparent engines and aircraft	On schedule	
2021	Complete testing on modification to the critical segment of the non-transparent fleet for approved use on piston aviation fuels initiative approved fuels	On schedule	New milestone

NextGen - Alternative Fuels for General Aviation Program Progress in FY 2015:

- ✓ Completed fit-for-purpose Phase I standardized tests on five fuels including the baseline 100LL reference fuel. Testing covered cold storage, hot surface ignition, storage stability, and oven storage. Specific rigs have been constructed to evaluate novel fuel

properties of the proposed Piston Aviation Fuels Initiative (PAFI) fuels on the entire GA fleet. Many of the fuel properties fall outside the experience of the general aviation fleet. For example, a new fuel may experience a phase separation at low temperatures and cause an engine shutdown in flight or a fuel may not be compatible with gaskets or seals.

- ✓ Acquired aircraft fabric, metallics, non-metallics, composites, fuel bladder, and distribution system materials for fuel soaking in proposed Phase I PAFI fuels.

- ✓ Prepared a preliminary plan for standardized engine testing for Phase II. This includes identification of Phase II aircraft and engine test article makes and models, and associated specific tests. Representative aircraft and engine test articles covering the entire fleet of 167000 aircraft makes, models and designs have been selected like a Piper Saratoga aircraft with a Lycoming 350 HP engine.

4.0 R&D Business Management

This chapter reviews the FAA R&D portfolio according to the FY 2017 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 FAA R&D principles and goals, the R&D addresses the specific needs of sponsoring organizations, including (a) Aviation Safety, (b) Air Traffic Organization, (c) Airports, (d) NextGen, and (e) Policy, International Affairs and Environment. 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[7] 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 NextGen 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, initial spares, initial maintenance contracts and training for equipment, facilities, and other construction projects. The F&E appropriation account funds R&D from two programs; 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. 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. This appropriation account funds the administrative expenses of the FAA Office of Airports, as well as airport-related R&D conducted in the ACRP and the ATRP.

The ACRP organization; its procedures and administration by the Transportation Research Board (TRB) were established in a 2005 Memorandum of Agreement (MOA) that was signed by the U.S. Secretary of Transportation, the President of the National Academy of Sciences, and the Administrator of the FAA. The purpose of the ACRP is to research problems shared by airports

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

that are not being addressed by other Federal research programs. Each year, the TRB solicits the public and the aviation industry for research topics on airport issues involving safety, operations, capacity, and environment. The ACRP Oversight Committee reviews the topics submitted and selects the most promising ones for funding.

The purpose of the ATRP is to develop new or improved airport standards or procedures. The FAA Office of Airports sponsors ATRP research projects and reviews project deliverables. Research results are used to update or produce new ACs used by airports and industry to design and construct airport infrastructure, procure airport capital equipment, and support FAA regulatory requirements for airport safety. ATRP research areas include:

- Airport lighting and marking;
- Airport pavement design and construction;
- Airport design;
- Heliport design;
- Aircraft rescue and firefighting;
- Surface surveillance;
- Airport capacity;
- Mitigation of wildlife hazards, and
- Airport environment.

4.2 R&D Summary Budget Tables

This section provides five tables presenting the (a) FAA R&D budget by appropriation, (b) program sponsor, (c) R&D category, (d) performance goal, and (e) NextGen R&D. It presents the FY 2016 Enacted and FY 2017 President's Request, and planned funding for FY 2018 through 2021; which are estimates and subject to change. The amounts shown for F&E programs in FY 2016 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 2016 Enacted and FY 2017 President's Request budgets and the estimated funding through FY 2021, 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 2016 Enacted and FY 2017 President's Request budgets and the estimated funding through FY 2021, grouped by requesting organization. Requesting (also known as sponsoring) organizations include Aviation Safety; Air Traffic Organization; Airports; NextGen; and Policy, International Affairs and Environment.

4.2.3 Research Category

The FAA R&D portfolio includes both applied R&D as defined by the OMB Circular A-11[8]. 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 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 2016 through 2021.

4.2.4 Performance Goal

Table 4.2.4, Planned R&D Budget by Performance Goal (Budget Exhibit II) shows the FAA R&D budget by the performance goals defined in Exhibit II of the FAA President's Request for FY 2017. The R&D programs apply to three of the goals in the *U.S. Department of*

[8] 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).

Transportation's Strategic Plan for Fiscal Years 2014–2018: Safety, Economic Competitiveness, and Environmental Sustainability. Many R&D programs apply to more than one goal. However, for budgeting purposes, most programs are included under only one goal. The table provides information on contract costs and personnel costs requested for FY 2017. For Table 4.2.4, Planned R&D Budget by Performance Goal (Budget Exhibit II); the System Planning and Resource Management (A14.a) is considered part of mission support for the R,E&D appropriation account and is pro-rated across the three DOT goals as follows: Safety at 61%; Economic Competitiveness at 13%; and Environmental Sustainability at 26%. William J. Hughes Technical Center Facility (A14.b) is also considered part of mission support and is pro-rated between Safety at 82% and Economic Competitiveness at 18%. The F&E-funded Next Generation Support Portfolio, NAS Improvement of System Support Laboratory, William J. Hughes Technical Center Facilities, and William J. Hughes Technical Center Infrastructure Sustainment programs provide cross-cutting mission support services, infrastructure, and capabilities that are leveraged across all the F&E-funded portfolios in totality and fall entirely under the Economic Competitiveness goal.

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 34% of the total requested R&D budget reported in the NARP for FY 2017, and it represents 14% 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 budget plan by line item and appropriation.

Table 4.2.1: Planned R&D Budget by Appropriation Account

2016 BLI	Program	Appropriation Account	2016 Enacted Budget ($000)	2017 Congressional Request ($000)	2018 Estimate ($000)	2019 Estimate ($000)	2020 Estimate ($000)	2021 Estimate /1 ($000)
Research, Engineering and Development (RE&D)								
A11.a	Fire Research and Safety	RE&D	6,000	7,925	8,113	8,312	8,476	8,679
A11.b	Propulsion and Fuel Systems	RE&D	2,034	2,574	2,625	2,685	2,729	2,789
A11.c	Advanced Materials/Structural Safety	RE&D	7,409	4,113	4,189	4,283	4,347	4,439
A11.d	Aircraft Icing/Digital System Safety	RE&D	5,500	5,102	5,211	5,333	5,427	5,550
A11.e	Continued Airworthiness	RE&D	8,987	10,269	10,469	10,708	10,877	11,114
A11.f	Aircraft Catastrophic Failure Prevention Research	RE&D	1,433	1,528	1,556	1,591	1,614	1,648
A11.g	Flightdeck/Maintenance/System Integration Human Factors	RE&D	5,000	8,513	8,714	8,929	9,104	9,322
A11.h	System Safety Management	RE&D	6,063	7,000	7,142	7,307	7,429	7,594
A11.i	Air Traffic Control/Technical Operations Human Factors	RE&D	5,410	6,165	6,369	6,550	6,733	6,924
A11.j	Aeromedical Research	RE&D	8,467	9,538	9,809	10,068	10,308	10,578
A11.k	Weather Program	RE&D	15,031	17,976	18,242	18,623	18,838	19,204
A11.l	Unmanned Aircraft Systems Research	RE&D	17,635	8,422	8,604	8,809	8,971	9,177
A11.m	NextGen - Alternative Fuels for General Aviation	RE&D	7,000	5,792	5,913	6,051	6,154	6,293
A11.n	Commercial Space Transportation	RE&D	2,000	2,953	2,994	3,056	3,089	3,147
A12.a	NextGen - Wake Turbulence	RE&D	8,541	8,609	8,787	8,991	9,142	9,345
A12.b	NextGen - Air Ground Integration Human Factors	RE&D	8,000	8,575	8,754	8,959	9,114	9,319
A12.c	NextGen - Weather Technology in the Cockpit	RE&D	4,048	4,059	4,149	4,250	4,330	4,432
A12.d	NextGen - Information Security	RE&D	0	1,000	1,020	1,044	1,061	1,084
A13.a	Environment and Energy	RE&D	16,074	15,013	15,267	15,599	15,809	16,133
A13.b	NextGen - Environmental Research - Aircraft Technologies, Fuels, and Metrics	RE&D	25,823	26,174	26,712	27,332	27,786	28,403
A14.a	System Planning and Resource Management	RE&D	2,100	2,788	2,860	2,929	2,992	3,064
A14.b	William J. Hughes Technical Center Laboratory Facility	RE&D	3,445	3,412	3,501	3,591	3,670	3,762
	RE&D TOTAL	**RE&D**	**166,000**	**167,500**	**171,000**	**175,000**	**178,000**	**182,000**

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

Facilities & Equipment (F&E)								/2
1A01	Advanced Technology Development & Prototyping	F&E	21,300	24,800	30,200	30,200	31,200	28,200
1A02	NAS Improvement of System Support Laboratory	F&E	1,000	1,000	1,000	1,000	1,000	1,000
1A03	William J. Hughes Technical Center Facilities	F&E	19,050	19,000	19,000	19,000	19,000	19,000
1A04	William J. Hughes Technical Center Infrastructure Sustainment	F&E	12,200	12,200	10,000	10,000	11,600	11,700
1A05	Next Generation Transportation System - Separation Management Portfolio	F&E	31,500	25,800	34,500	41,500	50,000	62,000
1A06	Next Generation Transportation System - Improved Surface/TFDM Portfolio	F&E	17,000	2,000	4,000	8,000	11,000	9,000
1A07	Next Generation Transportation System - On Demand NAS	F&E	11,000	8,500	17,000	21,500	34,500	43,500
1A08	Next Generation Transportation System - Imp Multiple Runway OPS Portfolio	F&E	8,000	6,500	2,000	1,000	0	0
1A09	Next Generation Transportation System - NAS Infrastructure	F&E	11,000	17,660	24,000	23,000	24,000	29,000
1A10	Next Generation Support Portfolio	F&E	10,000	12,000	12,800	12,800	12,800	12,800
--	Next Generation Transportation System - Environment Portfolio	F&E	1,000	0	0	0	0	0
4A08	Center for Advanced Aviation System Development (CAASD)	F&E	60,000	60,000	60,000	65,000	65,000	65,000
	F&E TOTAL	**F&E**	**203,050**	**189,460**	**214,500**	**233,000**	**260,100**	**281,200**
Grants-In-Aid for Airports (AIP)								
--	Airport Cooperative Research Program - Capacity	AIP	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
--	Airport Cooperative Research Program - Safety	AIP	5,000	5,000	5,000	5,000	5,000	5,000
--	Airport Technology Research Program - Capacity	AIP	13,248	13,408	13,405	13,405	13,405	13,405
--	Airport Technology Research Program - Environment	AIP	1,576	1,595	1,595	1,595	1,595	1,595
--	Airport Technology Research Program - Safety	AIP	16,176	16,371	16,367	16,367	16,367	16,367
	AIP TOTAL	**AIP**	**46,000**	**46,375**	**46,367**	**46,367**	**46,367**	**46,367**
	GRAND TOTAL		**$415,050**	**$403,335**	**$431,867**	**$454,367**	**$484,467**	**$509,567**

Notes:

/1 The funding levels listed for years 2018 to 2021 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

2016 BLI	Program	Appropriation Account	2016 Enacted Budget ($000)	2017 Congressional Request ($000)	2018 Estimate ($000)	2019 Estimate ($000)	2020 Estimate ($000)	2021 Estimate ($000) /1
Aviation Safety (AVS)								
A11.a	Fire Research and Safety	RE&D	6,000	7,925	8,113	8,312	8,476	8,679
A11.b	Propulsion and Fuel Systems	RE&D	2,034	2,574	2,625	2,685	2,729	2,789
A11.c	Advanced Materials/Structural Safety	RE&D	7,409	4,113	4,189	4,283	4,347	4,439
A11.d	Aircraft Icing/Digital System Safety	RE&D	5,500	5,102	5,211	5,333	5,427	5,550
A11.e	Continued Airworthiness	RE&D	8,987	10,269	10,469	10,708	10,877	11,114
A11.f	Aircraft Catastrophic Failure Prevention Research	RE&D	1,433	1,528	1,556	1,591	1,614	1,648
A11.g	Flightdeck/Maintenance/System Integration Human Factors	RE&D	5,000	8,513	8,714	8,929	9,104	9,322
A11.h	System Safety Management	RE&D	6,063	7,000	7,142	7,307	7,429	7,594
A11.j	Aeromedical Research	RE&D	8,467	9,538	9,809	10,068	10,308	10,578
A11.l	Unmanned Aircraft Systems Research	RE&D	17,635	8,422	8,604	8,809	8,971	9,177
	AVS TOTAL		**68,528**	**64,984**	**66,432**	**68,025**	**69,282**	**70,890**
NextGen (ANG)								
A11.m	NextGen - Alternative Fuels for General Aviation	RE&D	7,000	5,792	5,913	6,051	6,154	6,293
A12.a	NextGen - Wake Turbulence	RE&D	8,541	8,609	8,787	8,991	9,142	9,345
A12.b	NextGen - Air Ground Integration Human Factors	RE&D	8,000	8,575	8,754	8,959	9,114	9,319
A12.c	NextGen - Weather Technology in the Cockpit	RE&D	4,048	4,059	4,149	4,250	4,330	4,432
A12.d	NextGen - Information Security	RE&D	0	1,000	1,020	1,044	1,061	1,084
A14.a	System Planning and Resource Management	RE&D	2,100	2,788	2,860	2,929	2,992	3,064
A14.b	William J. Hughes Technical Center Laboratory Facility	RE&D	3,445	3,412	3,501	3,591	3,670	3,762
	Subtotal	**RE&D**	33,134	34,235	34,984	35,815	36,463	37,299
1A01	Advanced Technology Development & Prototyping	F&E	21,300	24,800	30,200	30,200	31,200	28,200
1A02	NAS Improvement of System Support Laboratory	F&E	1,000	1,000	1,000	1,000	1,000	1,000
1A03	William J. Hughes Technical Center Facilities	F&E	19,050	19,000	19,000	19,000	19,000	19,000
1A04	William J. Hughes Technical Center Infrastructure Sustainment	F&E	12,200	12,200	10,000	10,000	11,600	11,700
1A05	Next Generation Transportation System - Separation Management Portfolio	F&E	31,500	25,800	34,500	41,500	50,000	62,000
1A06	Next Generation Transportation System - Improved Surface/TFDM Portfolio	F&E	17,000	2,000	4,000	8,000	11,000	9,000
1A07	Next Generation Transportation System - On Demand NAS Portfolio	F&E	11,000	8,500	17,000	21,500	34,500	43,500
1A08	Next Generation Transportation System - Imp Multiple Runway OPS Portfolio	F&E	8,000	6,500	2,000	1,000	0	0
1A09	Next Generation Transportation System - NAS Infrastructure Portfolio	F&E	11,000	17,660	24,000	23,000	24,000	29,000
1A10	Next Generation Support Portfolio	F&E	10,000	12,000	12,800	12,800	12,800	12,800
--	Next Generation Transportation System - Environment Portfolio	F&E	1,000	0	0	0	0	0
	Subtotal	**F&E**	143,050	129,460	154,500	168,000	195,100	216,200 /2
	ANG TOTAL		**176,184**	**163,695**	**189,484**	**203,815**	**231,563**	**253,499**

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

2016 BLI	Program	Appropriation Account	2016 Enacted Budget ($000)	2017 Congressional Request ($000)	2018 Estimate ($000)	2019 Estimate ($000)	2020 Estimate ($000)	2021 Estimate ($000) /1
Air Traffic Organization (ATO)								
A11.i	Air Traffic Control/Technical Operations Human Factors	RE&D	5,410	6,165	6,369	6,550	6,733	6,924
A11.k	Weather Program	RE&D	15,031	17,976	18,242	18,623	18,838	19,204
	Subtotal	**RE&D**	20,441	24,141	24,611	25,173	25,571	26,128
4A08	Center for Advanced Aviation System Development (CAASD)	F&E	60,000	60,000	60,000	65,000	65,000	65,000
	Subtotal	**F&E**	60,000	60,000	60,000	65,000	65,000	65,000 /2
	ATO TOTAL		**80,441**	**84,141**	**84,611**	**90,173**	**90,571**	**91,128**
Commercial Space Transportation (AST)								
A11.n	Commercial Space Transportation	RE&D	2,000	2,953	2,994	3,056	3,089	3,147
	AST Total		**2,000**	**2,953**	**2,994**	**3,056**	**3,089**	**3,147**
Airports (ARP)								
--	Airport Cooperative Research Program - Capacity	AIP	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
--	Airport Cooperative Research Program - Safety	AIP	5,000	5,000	5,000	5,000	5,000	5,000
--	Airport Technology Research Program - Capacity	AIP	13,248	13,408	13,405	13,405	13,405	13,405
--	Airport Technology Research Program - Environment	AIP	1,576	1,595	1,595	1,595	1,595	1,595
--	Airport Technology Research Program - Safety	AIP	16,176	16,371	16,367	16,367	16,367	16,367
	ARP TOTAL		**46,000**	**46,375**	**46,367**	**46,367**	**46,367**	**46,367**
Policy, International Affairs, and Environment (APL)								
A13.a	Environment and Energy	RE&D	16,074	15,013	15,267	15,599	15,809	16,133
A13.b	NextGen - Environmental Research - Aircraft Technologies, Fuels, and Metrics	RE&D	25,823	26,174	26,712	27,332	27,786	28,403
	APL TOTAL		**41,897**	**41,187**	**41,979**	**42,931**	**43,595**	**44,536**
	GRAND TOTAL		**$415,050**	**$403,335**	**$431,867**	**$454,367**	**$484,467**	**$509,567**

Notes:

/1 The funding levels listed for years 2018 to 2021 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

2016 BLI	Program	Appropriation Account	2016 Enacted Budget ($000)	2017 Congressional Request ($000)	2018 Estimate ($000)	2019 Estimate ($000)	2020 Estimate ($000)	2021 Estimate ($000) /1
Applied Research								
A11.a	Fire Research and Safety	RE&D	6,000	7,925	8,113	8,312	8,476	8,679
A11.b	Propulsion and Fuel Systems	RE&D	2,034	2,574	2,625	2,685	2,729	2,789
A11.c	Advanced Materials/Structural Safety	RE&D	7,409	4,113	4,189	4,283	4,347	4,439
A11.d	Aircraft Icing/Digital System Safety	RE&D	5,500	5,102	5,211	5,333	5,427	5,550
A11.e	Continued Airworthiness	RE&D	8,987	10,269	10,469	10,708	10,877	11,114
A11.f	Aircraft Catastrophic Failure Prevention Research	RE&D	1,433	1,528	1,556	1,591	1,614	1,648
A11.g	Flightdeck/Maintenance/System Integration Human Factors	RE&D	5,000	8,513	8,714	8,929	9,104	9,322
A11.h	System Safety Management	RE&D	6,063	7,000	7,142	7,307	7,429	7,594
A11.i	Air Traffic Control/Technical Operations Human Factors	RE&D	5,410	6,165	6,369	6,550	6,733	6,924
A11.j	Aeromedical Research	RE&D	8,467	9,538	9,809	10,068	10,308	10,578
A11.k	Weather Program	RE&D	15,031	17,976	18,242	18,623	18,838	19,204
A11.l	Unmanned Aircraft Systems Research	RE&D	17,635	8,422	8,604	8,809	8,971	9,177
A11.m	NextGen - Alternative Fuels for General Aviation	RE&D	7,000	5,792	5,913	6,051	6,154	6,293
A11.n	Commercial Space Transportation	RE&D	2,000	2,953	2,994	3,056	3,089	3,147
A12.a	NextGen - Wake Turbulence	RE&D	8,541	8,609	8,787	8,991	9,142	9,345
A12.b	NextGen - Air Ground Integration Human Factors	RE&D	8,000	8,575	8,754	8,959	9,114	9,319
A12.c	NextGen - Weather Technology in the Cockpit	RE&D	4,048	4,059	4,149	4,250	4,330	4,432
A12.d	NextGen - Information Security	RE&D	0	1,000	1,020	1,044	1,061	1,084
A13.a	Environment and Energy	RE&D	16,074	15,013	15,267	15,599	15,809	16,133
A13.b	NextGen - Environmental Research - Aircraft Technologies, Fuels, and Metrics	RE&D	25,823	26,174	26,712	27,332	27,786	28,403
A14.a	System Planning and Resource Management	RE&D	2,100	2,788	2,860	2,929	2,992	3,064
A14.b	William J. Hughes Technical Center Laboratory Facility	RE&D	3,445	3,412	3,501	3,591	3,670	3,762
	Subtotal	**RE&D**	166,000	167,500	171,000	175,000	178,000	182,000
--	Airport Cooperative Research Program - Capacity	AIP	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
--	Airport Cooperative Research Program - Safety	AIP	5,000	5,000	5,000	5,000	5,000	5,000
--	Airport Technology Research Program - Capacity	AIP	13,248	13,408	13,405	13,405	13,405	13,405
--	Airport Technology Research Program - Environment	AIP	1,576	1,595	1,595	1,595	1,595	1,595
--	Airport Technology Research Program - Safety	AIP	16,176	16,371	16,367	16,367	16,367	16,367
	Subtotal	**AIP**	46,000	46,375	46,367	46,367	46,367	46,367
	Applied Research TOTAL		**212,000**	**213,875**	**217,367**	**221,367**	**224,367**	**228,367**
	Applied Research PERCENT		**51.1%**	**53.0%**	**50.3%**	**48.7%**	**46.3%**	**44.8%**

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

2016 BLI	Program	Appropriation Account	2016 Enacted Budget ($000)	2017 Congressional Request ($000)	2018 Estimate ($000)	2019 Estimate ($000)	2020 Estimate ($000)	2021 Estimate ($000) /1
Development								
1A01	Advanced Technology Development & Prototyping	F&E	21,300	24,800	30,200	30,200	31,200	28,200
1A02	NAS Improvement of System Support Laboratory	F&E	1,000	1,000	1,000	1,000	1,000	1,000
1A03	William J. Hughes Technical Center Facilities	F&E	19,050	19,000	19,000	19,000	19,000	19,000
1A04	William J. Hughes Technical Center Infrastructure Sustainment	F&E	12,200	12,200	10,000	10,000	11,600	11,700
1A05	Next Generation Transportation System - Separation Management	F&E	31,500	25,800	34,500	41,500	50,000	62,000
1A06	Next Generation Transportation System - Improved Surface/TFDM	F&E	17,000	2,000	4,000	8,000	11,000	9,000
1A07	Next Generation Transportation System - On Demand NAS Portfolio	F&E	11,000	8,500	17,000	21,500	34,500	43,500
1A08	Next Generation Transportation System - Imp Multiple Runway OPS	F&E	8,000	6,500	2,000	1,000	0	0
1A09	Next Generation Transportation System - NAS Infrastructure	F&E	11,000	17,660	24,000	23,000	24,000	29,000
1A10	Next Generation Support Portfolio	F&E	10,000	12,000	12,800	12,800	12,800	12,800
--	Next Generation Transportation System - Environment Portfolio	F&E	1,000	0	0	0	0	0
4A08	Center for Advanced Aviation System Development (CAASD)	F&E	60,000	60,000	60,000	65,000	65,000	65,000
	Development TOTAL		**203,050**	**189,460**	**214,500**	**233,000**	**260,100**	**281,200**
	Development PERCENT		**48.9%**	**47.0%**	**49.7%**	**51.3%**	**53.7%**	**55.2%**
	GRAND TOTAL		**$415,050**	**$403,335**	**$431,867**	**$454,367**	**$484,467**	**$509,567**

Notes:

/1 The funding levels listed for years 2018 to 2021 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 (Budget Exhibit II)

2016 BLI	Program	Appropriation Account	2017 Contract Costs ($000)	2017 Personnel Costs ($000)	2017 Other In-house Costs ($000)	2017 Congressional Request ($000)	/1
1. Safety							
A11.a	Fire Research and Safety	RE&D	4,001	3,814	110	7,925	
A11.b	Propulsion and Fuel Systems	RE&D	1,801	763	10	2,574	
A11.c	Advanced Materials/Structural Safety	RE&D	3,150	908	55	4,113	
A11.d	Aircraft Icing/Digital System Safety	RE&D	3,175	1,847	80	5,102	
A11.e	Continued Airworthiness	RE&D	7,376	2,783	110	10,269	
A11.f	Aircraft Catastrophic Failure Prevention Research	RE&D	1,200	318	10	1,528	
A11.g	Flightdeck/Maintenance/System Integration Human Factors	RE&D	4,352	4,081	80	8,513	
A11.h	System Safety Management	RE&D	4,738	2,182	80	7,000	
A11.i	Air Traffic Control/Technical Operations Human Factors	RE&D	237	5,808	120	6,165	
A11.j	Aeromedical Research	RE&D	2,601	6,767	170	9,538	
A11.k	Weather Program	RE&D	17,194	737	45	17,976	
A11.l	Unmanned Aircraft Systems Research	RE&D	6,850	1,372	200	8,422	
A11.m	NextGen - Alternative Fuels for General Aviation	RE&D	5,436	341	15	5,792	
A11.n	Commercial Space Transportation	RE&D	2,953	0	0	2,953	
A14.a	System Planning and Resource Management	RE&D	580	939	183	1,702	/2
A14.b	William J. Hughes Technical Center Laboratory Facility	RE&D	1,066	1,689	49	2,803	/2
	Subtotal	**RE&D**	66,710	34,349	1,317	102,376	
--	Airport Cooperative Research Program - Safety	AIP	4,903	97	0	5,000	
--	Airport Technology Research Program - Safety	AIP	14,297	2,074	0	16,371	
	Subtotal	**AIP**	19,200	2,171	0	21,371	
	1. Safety TOTAL		**85,910**	**36,520**	**1,317**	**123,747**	
2. Economic Competitiveness							
A12.a	NextGen - Wake Turbulence	RE&D	8,118	366	125	8,609	
A12.b	NextGen - Air Ground Integration Human Factors	RE&D	7,950	586	39	8,575	
A12.c	NextGen - Weather Technology in the Cockpit	RE&D	3,172	860	27	4,059	
A12.d	NextGen - Information Security	RE&D	1,000	0	0	1,000	
A14.a	System Planning and Resource Management	RE&D	126	204	40	369	/2
A14.b	William J. Hughes Technical Center Laboratory Facility	RE&D	231	366	11	609	/2
	Subtotal	**RE&D**	20,597	2,382	241	23,221	

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

2016 BLI	Program	Appropriation Account	2017 Contract Costs ($000)	2017 Personnel Costs ($000)	2017 Other In-house Costs ($000)	2017 Congressional Request ($000)	/1
1A01	Advanced Technology Development & Prototyping	F&E	24,800	0	0	24,800	
1A02	NAS Improvement of System Support Laboratory	F&E	1,000	0	0	1,000	
1A03	William J. Hughes Technical Center Facilities	F&E	19,000	0	0	19,000	
1A04	William J. Hughes Technical Center Infrastructure Sustainment	F&E	12,200	0	0	12,200	
1A05	Next Generation Transportation System - Separation Management Portfolio	F&E	25,800	0	0	25,800	
1A06	Next Generation Transportation System - Improved Surface/TFDM Portfolio	F&E	2,000	0	0	2,000	
1A07	Next Generation Transportation System - On Demand NAS Portfolio	F&E	8,500	0	0	8,500	
1A08	Next Generation Transportation System - Imp Multiple Runway OPS Portfolio	F&E	6,500	0	0	6,500	
1A09	Next Generation Transportation System - NAS Infrastructure Portfolio	F&E	17,660	0	0	17,660	
1A10	Next Generation Support Portfolio	F&E	12,000	0	0	12,000	
4A08	Center for Advanced Aviation System Development (CAASD)	F&E	60,000	0	0	60,000	
	Subtotal	**F&E**	189,460	0	0	189,460	/3
--	Airport Cooperative Research Program - Capacity	AIP	4,903	97	0	5,000	
--	Airport Technology Research Program - Capacity	AIP	11,710	1,699	0	13,409	
	Subtotal	**AIP**	16,613	1,796	0	18,409	
	2. Economic Competitiveness TOTAL		**226,670**	**4,178**	**241**	**231,089**	
4. Environmental Sustainability							
A13.a	Environment and Energy	RE&D	12,662	2,176	175	15,013	
A13.b	NextGen - Environmental Research - Aircraft Technologies, Fuels, and Metrics	RE&D	25,560	599	15	26,174	
A14.a	System Planning and Resource Management	RE&D	244	395	77	716	/2
	Subtotal	**RE&D**	38,466	3,170	267	41,903	
--	Airport Cooperative Research Program - Environment	AIP	4,903	97	0	5,000	
--	Airport Technology Research Program - Environment	AIP	1,393	202	0	1,595	
	Subtotal	**AIP**	6,296	299	0	6,595	
	4. Environmental Sustainability TOTAL		**44,762**	**3,469**	**267**	**48,498**	
	GRAND TOTAL		**$357,342**	**$44,167**	**$1,826**	**$403,335**	

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 System Planning and Resource Management is considered part of Mission Support for the RE&D program and is pro-rated across the three goal areas as follows: Safety at 61%; Economic Competitiveness at 13%; and Environmental Sustainability at 26%. William J. Hughes Technical Center is considered part of Mission Support; it is pro-rated between Safety at 82% and Mobility at 18%.

/3 The amounts shown for F&E programs in FY 2017 reflect the entire budget for those portfolios.

Table 4.2.5: NextGen R&D Funding

2016 BLI	Program	Appropriation Account	2016 Enacted Budget ($000)	2017 Congressional Request ($000)	2018 Estimate ($000)	2019 Estimate ($000)	2020 Estimate ($000)	2021 Estimate ($000) /1
NextGen - F&E								/2
1A05	Next Generation Transportation System - Separation Management Portfolio	F&E	31,500	25,800	34,500	41,500	50,000	62,000
1A06	Next Generation Transportation System - Improved Surface/TFDM Portfolio	F&E	17,000	2,000	4,000	8,000	11,000	9,000
1A07	Next Generation Transportation System - On Demand NAS Portfolio	F&E	11,000	8,500	17,000	21,500	34,500	43,500
1A08	Next Generation Transportation System - Imp Multiple Runway OPS Portfolio	F&E	8,000	6,500	2,000	1,000	0	0
1A09	Next Generation Transportation System - NAS Infrastructure Portfolio	F&E	11,000	17,660	24,000	23,000	24,000	29,000
1A10	Next Generation Support Portfolio	F&E	10,000	12,000	12,800	12,800	12,800	12,800
--	Next Generation Transportation System - Environment Portfolio	F&E	1,000	0	0	0	0	0
	F&E TOTAL	**F&E**	**89,500**	**72,460**	**94,300**	**107,800**	**132,300**	**156,300**
NextGen - RE&D								
A11.l	Unmanned Aircraft Systems Research	RE&D	17,635	8,422	8,604	8,809	8,971	9,177
A11.m	NextGen - Alternative Fuels for General Aviation	RE&D	7,000	5,792	5,913	6,051	6,154	6,293
A12.a	NextGen - Wake Turbulence	RE&D	8,541	8,609	8,787	8,991	9,142	9,345
A12.b	NextGen - Air Ground Integration Human Factors	RE&D	8,000	8,575	8,754	8,959	9,114	9,319
A12.c	NextGen - Weather Technology in the Cockpit	RE&D	4,048	4,059	4,149	4,250	4,330	4,432
A12.d	NextGen - Information Security	RE&D	0	1,000	1,020	1,044	1,061	1,084
A13.b	NextGen - Environmental Research - Aircraft Technologies, Fuels, and Metrics	RE&D	25,823	26,174	26,712	27,332	27,786	28,403
	RE&D TOTAL	**RE&D**	**71,047**	**62,631**	**63,939**	**65,436**	**66,558**	**68,053**
	NextGen R&D TOTAL		**$160,547**	**$135,091**	**$158,239**	**$173,236**	**$198,858**	**$224,353**

Notes:

/1 The funding levels listed for years 2018 to 2021 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.

4.3 R&D Evaluation

Since R&D tends to be far-term in nature, it does not lend itself to traditional return-on-investment analysis; such as net present value. The FAA conducts evaluation through formal and informal reviews by internal and external groups.

4.3.1 Internal Portfolio Reviews

The FAA R&D portfolio receives continuous internal review to ensure that it meets customer needs, high quality standards, and management excellence.

R&D Executive Board

The FAA's R&D Executive Board (REB) includes senior executives representing the major FAA R&D sponsors. 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 program planning teams 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/).

Joint Resources Council

The Joint Resources Council (JRC) is the FAA's corporate-level acquisition decision-making body that provides strategic guidance for the R&D portfolio process and ensures that the research requirements support the FAA NAS program. The JRC reviews and approves the proposed R&D portfolio.

4.3.2 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. 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.

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.[9] 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. For 2015, the REDAC held two full committee meetings and 10 subcommittee meetings and produced two reports documenting their recommendations. By clicking on the REDAC tab, the recommendations from these reports are provided at: (http://www.faa.gov/go/redac).

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. Currently, the Committee has 27 members. 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/).

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 2016 projects in August 2015. 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

[9] 49 U.S.C § 44508 - Research advisory committee

of the practice in critical areas within the industry. The selected research areas include (a) integrating climate resiliency into airport management systems, (b) cost benefit analysis of storm water infrastructure improvements, (c) airport emergency operations and (d) preparing for the connected airport and the Internet of Things. For more information go to (http://www.trb.org/ACRP/Public/).

5.0 Partnership Activities

The 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. The FAA uses a variety of partnership mechanisms described in this chapter.

5.1 Federal Government

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 Memoranda of Understanding (MOUs), MOAs, Interagency Agreements, and International Agreements (IA). The FAA also creates partnerships with other agencies through a variety of interagency committees.

5.1.1 Cooperative Agreements

Both MOUs and MOAs support joint research activities between departments or agencies. An 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. An MOU does not require either party to obligate funds and does not create a legally binding commitment. An 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. An MOA may include IAs; written agreements between the FAA and other agencies in which the FAA agrees to receive or exchange supplies or services with the other agency. International Agreements establish an R&D relationship between the FAA and foreign governments or quasi-governmental entities.

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). FAA provides $5 million per year to the TSA through an MOA that establishes procedures to conduct research in the areas of intruder detection, baggage screening, and equipment evaluation. The MOA also provides the ACRP the ability to submit security research topics to TSA for funding consideration under the TSA Airport Research Program.

5.1.2 Interagency Committees

The FAA creates partnerships with other agencies through a variety of interagency committees and groups. Some of the interagency committees and groups that the FAA is associated with are described below.

The Federal Interagency Committee on Aviation Noise

The Federal Interagency Committee on Aviation Noise 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/).

The U.S. Global Change Research Program

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/).

5.2 Industry

The FAA complies with all applicable Federal guidelines and legislation concerning the transfer of technology. The FAA's goal is to transfer knowledge, facilities, equipment, or capabilities developed by its laboratories and R&D programs to the private sector. This helps expand the U.S. technology base and leverage Federal R&D investments. The FAA does this through the following groups and mechanisms:

Commercial Aviation Safety Team

Founded in 1998, the Commercial Aviation Safety Team (CAST) has developed an integrated, data-driven strategy to reduce the commercial aviation fatality risk in the U.S. and promote new government and industry safety initiatives throughout the world. The CAST charters working group stakeholders to conduct in-depth analysis of the top accident categories in commercial aviation, where safety enhancements are identified. Successes of CAST prove that the concept of industry and government working together on common commercial air travel accident prevention strategies is highly effective. Members of CAST (not all-inclusive) include:

- Airbus;
- Boeing;
- GE Aviation;
- Air Line Pilots Association;
- Allied Pilots Association;
- ICAO;
- Flight Safety Foundation;
- International Air Transport Association;
- European Aviation Safety Authority;
- FAA;
- NASA;
- National Air Traffic Controllers Association;
- Regional Airline Association;
- Transport Canada Civil Aviation, and
- DoD.

General Aviation Joint Steering Committee

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.

Cooperative Research and Development Agreements

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 way to meet Congressionally mandated technology transfer requirements. For more information, go to (http://www.faa.gov/go/techtran). For detailed information on active CRDAs in FY 2015, see (http://www.faa.gov/about/office_org/headquarters_offices/ang/offices/tc/about/campus/faa_host/RDM/media/pdf/FAA_Active_FY2015_Agreements.pdf).

Patents Issued through the U.S. Patent and Trademark Office

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. For more information, go to (http://www.faa.gov/go/techtran).

Small Business Innovation Research

Small Business Innovation Research (SBIR) contracts encourage the private sector to invest in long-term research that helps the Federal Government meet its R&D objectives. Eligible small businesses compete for Phase I contracts to conduct feasibility-related experimental or theoretical research. The government awards a Phase II contract based on the results of Phase I. The government encourages contractors to pursue other funding sources for Phase III and to attract venture capitalists to commercialize the innovation. For more information, go to

(http://www.faa.gov/go/techtran) and (http://www.volpe.dot.gov/work-with-us/small-business-innovation-research).

Aerospace Vehicle Systems Institute

The Aerospace Vehicle Systems Institute (AVSI) is a cooperative industry, government, and academic venture for investigation and standardization of aerospace vehicle systems to reduce life-cycle cost and accelerate development of systems, architectures, tools, and processes. For more information, go to (http://www.avsi.aero/).

Commercial Aviation Alternative Fuels Initiative

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).

5.3 Academia

The FAA has an extensive program to foster research and innovative aviation solutions through the Nation's colleges and universities. By doing so, it leverages the Nation's significant investment in basic and applied research and helps to build the next generation of aerospace engineers, managers, and operators. The FAA works with academia in three ways; the Joint University Program (JUP), aviation research grants, and Air Transportation COEs.

5.3.1 Joint University Program

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/).

5.3.2 Aviation Research Grants

Public Law 101-508 Section 9205 authorizes the FAA to establish research grant programs that encompass a broad spectrum of aviation research activities. These programs encourage and support innovative and advanced research with potential benefit to the FAA mission. All colleges, universities, and other non-profit research institutions qualify for research grants. This FAA program also supports the long-term growth of the aviation industry by encouraging academic institutions to establish and nurture aviation research programs that increase the talent base in aviation. For detailed information on active aviation research grants in FY 2015, go to (http://www.faa.gov/about/office_org/headquarters_offices/ang/offices/tc/about/campus/faa_host/RDM/media/pdf/FAA_Active_FY2015_Agreements.pdf).

5.3.3 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 open dialogue and competitive process, the FAA Administrator selects a university team 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, who conduct focused research and development and related activities over a period of 10 years. 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 match FAA grant awards, dollar-for-dollar, with contributions from nonfederal 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 $250 million in matching contributions to augment FAA research efforts. Through long-term cost-sharing activities, the government and university-industry teams leverage resources to advance the technological future of the Nation's aviation industry while educating and training the next generation of aviation scientists and professionals.

During FY 2015, the FAA COE Program Management Office (PMO) awarded $19.8 million in support of 191 FAA projects. The FAA negotiated and executed 24 COE cooperative agreements, issued 236 grant awards, executed 48 other COE actions, and generated more than $25 million in matching contributions from industry and other nonfederal sources. Post-award activities included the conduct of a successful 10-year evaluation for the Joint COE for Advanced Materials, and a five-year evaluation of the COE for CST. The successful five-year COE CST evaluation resulted in the FAA Administrator's concurrence with the request to continue the COE for CST into Phase II. Thereafter, the FAA COE PMO negotiated and executed nine COE CST Phase II cooperative agreements with the core members, and the COE added seven new affiliate members.

Additionally, the FAA COE PMO completed a competition to establish the COE for UAS and finalized significant pre-award activities in preparation for the establishment of a new COE in September, 2015. The pre-award competitive process culminated in the submission of proposals representing more than 75 universities throughout the U.S. and their industry and other affiliates, which was followed by the conduct of a technical evaluation of the submissions, as well as a management and fiscal review of the best qualified proposals. The process enabled the FAA Administrator to select the new COE UAS team in FY 2015, as planned. The COE PMO negotiated and entered into 15 new cooperative agreements with the COE UAS core universities.

In March 2015, the FAA Administrator concurred with a request submitted by the ATO to begin a competition for a new COE for Technical Training and Human Performance (TT/HP). The FAA COE PMO initiated plans to begin the competitive process to establish the COE with the ATO, and developed and published a Draft Solicitation prior to the public meeting, conducted on October 21-22, 2015 in Arlington, VA. The COE PMO is currently planning to accept proposals, conduct a technical evaluation, management, and fiscal review, with the expectation that the new COE for TT/HP will be selected, established and funded in FY 2016.

The FAA COE cooperative agreements commit to annual base funding in support of research and related COE activities over a period of 10 years and allow for an additional two year period to assure orderly close out of all activities. The FAA intends for each public-private partnership to successfully meet COE requirements, and to become a self-sufficient national aviation resource thereafter. Recognized for its developed expertise, COE members are expected to generate funding and be able to compete for and conduct research activities for the aviation community as needed. By becoming self-sufficient, the COE university members may continue to support the FAA. However, the Agency no longer commits to annual base funding levels and the COE universities may conduct research that is fully funded by the agency as well as other entities.

COE members assist in conducting mission-critical research in areas that focus on topics that have included:

- UAS;
- Alternative jet fuels and environment;
- CST;
- GA safety;
- Accessibility and sustainability;
- Advanced materials;
- Airliner cabin environment and intermodal transportation research;
- Aircraft noise and aviation emissions mitigation;
- GA research;
- Airworthiness assurance;
- Aviation operations research;
- Airport Technology, and
- Computational modeling of aircraft structures.

Four of these centers, Computational Modeling of Aircraft Structures (CMAS), Aviation Operations Research (NEXTOR), Airworthiness Assurance (AACE), and Airport Technology Research (CEAT), have fully satisfied their requirements. Currently, NEXTOR serves as a self-sufficient resource for the aviation community, and CEAT continues to conduct major research initiatives to support modernization efforts with ORD. In addition to completing the competition to establish a COE for UAS and initiating the competitive process to establish a new COE for TT/HP, the FAA supported six active public-private partnerships throughout the U.S. with academic institutions, their industry and other affiliates. They are the:

- COE for Alternative Jet Fuels and Environment;
- COE for General Aviation Safety, Accessibility and Sustainability;
- COE for Commercial Space Transportation;
- COE for Research in the Cabin and Intermodal Transport Environment;
- Joint COE for Advanced Materials, and
- COE Partnership for PARTNER.

For more information about each FAA Center of Excellence, see the following COE descriptions and go to (http://www.faa.gov/go/coe).

COE for Unmanned Aircraft Systems

On May 8, 2015 FAA Administrator Michael Huerta announced the selection of the COE for UAS (ASSURE). The research efforts of this COE will focus on the following topic areas:

- ATC interoperability;
- Airport ground operations;
- Control and communication;
- Detect and avoid;

- Human factors;
- Low altitude operations safety;
- Noise reduction;
- Spectrum management;
- UAS crew training and certification, including pilots;
- UAS traffic management, and
- UAS wake separation standards for UAS integration into the NAS.

Under the leadership of Mississippi State University, the following universities serve on this COE team:

- Drexel University;
- Embry-Riddle Aeronautical University;
- Kansas State University;
- Montana State University;
- New Mexico State University;
- North Carolina State University;
- The Ohio State University;
- Oregon State University;
- University of Alabama-Huntsville;
- University of Alaska-Fairbanks;
- University of California-Davis;
- University of Kansas;
- University of North Dakota; and
- Wichita State University.

Associate members include Auburn University, Concordia, Indiana State University, Louisiana Tech University, Southampton and Tuskegee University.

The FAA is also planning to fund this COE through a cost-share contract for tasks to be completed for the sole benefit of the Agency. The FAA funded 24 grant projects, and the FAA COE PMO awarded $4.7 million to 12 of the 15 COE members in September of FY 2015 to begin Phase I of the research partnership. The COE currently reflects a $9.4 million level-of-effort as members are matching grant awards dollar-for-dollar from non-federal sources in keeping with congressional requirements. For additional information, go to (http://www.assureuas.org).

COE for Alternative Jet Fuels and Environment

On September 13, 2013, U.S. Secretary of Transportation Anthony Foxx announced the selection of the COE for ASCENT. The R&D efforts of this COE address the following major topic areas related to alternative jet fuels:

- Feedstock development;
- Processing and conversion research;
- Regional supply and refining infrastructure;

- Environmental benefits analysis;
- Aircraft component deterioration and wear assessment, and
- Fuel performance testing.

Areas relating to environmental issues are:

- Aircraft noise and impacts;
- Aviation emissions and impacts;
- Aircraft technology assessment;
- Environmentally and energy efficient gate-to-gate aircraft operations, and
- Aviation modeling and analysis.

Under the leadership of Washington State University and the Massachusetts Institute of Technology serving as Co-Lead, the following universities also serve on this team:

- Boston University;
- Georgia Tech Research Corporation;
- Missouri University of Science and Technology;
- Oregon State University;
- Pennsylvania State University;
- Purdue University;
- Stanford University;
- University of Dayton;
- University of Hawaii;
- University of Illinois;
- University of North Carolina;
- University of Pennsylvania;
- University of Tennessee; and
- University of Washington.

The FAA has supported 55 projects and awarded $10.6 million to the 16 member universities in FY 2015, and COE members generated $11 million in matching contributions from non-federal sources. Since inception, this COE has supported 83 projects at a $39 million level of effort. For additional information, go to (http://www.ascent.aero/).

COE for Commercial Space Transportation

On August 18, 2010, U.S. Secretary of Transportation Ray LaHood announced the selection of the COE for Commercial Space Transportation. The R&D efforts of the COE address four major areas: (a) space launch traffic management and launch operations; (b) launch vehicles, operations, technologies and payloads; (c) human spaceflight and (d) industry viability, including commercial, policy, international, legal, and regulatory viability. The FAA COE PMO closed out the COE CST Phase I cooperative agreement and conducted a successful evaluation. With the transition to Phase II, the University of Texas – Galveston serves as the Administrative Lead for this COE with new affiliates and eight core university members, which include:

- New Mexico State University;
- New Mexico Institute of Mining and Technology;
- Florida Institute of Technology;
- Florida State University;
- Stanford University;
- University of Central Florida;
- University of Colorado, and
- University of Florida.

The COE added seven additional non-funded affiliate members who work collaboratively to augment FAA research and provide matching contributions; the affiliates currently include:

- McGill University;
- Baylor College of Medicine;
- MITRE Corporation;
- Embry-Riddle Aeronautical University;
- National Aerospace Training and Research Center (NASTAR);
- Satwest-Satellite Communications and Aerospace**,** and
- University of Nebraska-Lincoln.

The FAA supported 58 COE tasks awarding $1.3 million grants through cooperative agreements with the nine member universities. Since its inception, the FAA has awarded $7.5 million in grants, and the COE core universities with their affiliates have provided matching contributions in excess of $13 million. The COE currently reflects a $21 million level-of-effort. Nine new COE cooperative agreements were negotiated and executed in 2015 and the FAA Administrator concurred with the request to enable the COE members to begin a Phase II five-year period through 2020. For additional information, go to (http://www.coe-cst.org/).

COE for General Aviation Safety, Accessibility and Sustainability

On September 27, 2012, U.S. Secretary of Transportation Ray LaHood announced the selection of the new COE for General Aviation - PEGASAS. Fully operational in 2013, this COE has focused on the following GA topic areas:

- Flight safety,
- Communication;

- Navigation and surveillance;
- Human factors;
- Weather;
- Airport technology;
- Propulsion and structures;
- Continued airworthiness, and
- System safety management.

Under the leadership of Purdue University, the following universities serve as core members of the team:

- Florida Institute of Technology;
- Georgia Institute of Technology;
- Iowa State University;
- The Ohio State University, and
- Texas A&M University.

The FAA supported 35 projects, awarded $3.1 million to the six member universities in FY 2015 while the COE generated more than $3 million in matching contributions from non-federal sources. Since its inception, the FAA has awarded $8.7 million grants. The core universities with their affiliates have provided matching contributions in excess of $8.8 million. As a result of the rigorous COE competitive process, this COE is also funded through an Indefinite Delivery Indefinite Quantity (IDIQ) contract, and currently reflects a $21 million level of effort through both funding vehicles and matching contributions. For additional information, go to (http://www.pegasas.aero/).

COE for Airliner Cabin Environment and Intermodal Research (ACERite)

In 2004, FAA Administrator Marion Blakey selected the COE for Airliner Cabin Environment (ACER) with Harvard University and Purdue University as the Technical Leads and Auburn University serving as the Administrative Lead. Following the Phase I evaluation and a recommendation from Secretary of Transportation Mary Peters, the COE expanded scope from airliner cabin research activities to include the intermodal transport environment. In 2008, the COE was renamed the COE for Research in the Intermodal Transport Environment. This COE has conducted R&D on cabin air quality, chemical and biological threats, and other related topics.

In FY 2015, the COE PMO extended cooperative agreements to prepare the COE for self-sufficiency. Under the on-going administrative leadership of Auburn University and current technical leadership of Kansas State University, core members currently include:

- Boise State University;
- Harvard School of Public Health;
- Purdue University, and
- Rutgers University School of Biomedical and Health Services.

Since its inception, the FAA has awarded more than $22.6 million in grants, and the COE core universities with their affiliates have provided matching contributions in excess of $28 million. The COE currently reflects a $45.3 million level of effort, and is preparing for close-out activities. For additional information, go to (http://www.acer-coe.org/).

Joint COE for Advanced Materials

In 2003, FAA Administrator Marion Blakey selected the Joint COE for Advanced Materials (JAMS) under the leadership of the University of Washington and Wichita State University. This COE conducts R&D on:

- Material standardization and shared databases;
- Bonded joints;
- Structural substantiation;
- Damage tolerance and durability;
- Maintenance practices;
- Advanced material forms and processes;
- Unique advanced materials cabin safety;
- Life management of materials, and
- Nanotechnology for composite structures.

Member universities include:

- Edmonds Community College;
- Florida International University;
- Northwestern University;
- Oregon State University;
- Purdue University;
- University of California at Los Angeles;
- University of Delaware;
- University of Utah;
- Tuskegee University, and
- Washington State University.

In FY 2015, the FAA awarded $2.1 million to support related research and the COE members and affiliates generated matching contributions of more than $2.4 million. Since its inception, the FAA has awarded $28 million in grants and the COE core universities with their affiliates have provided matching contributions in excess of $30 million. The COE currently reflects a $58 million level-of-effort. For additional information, go to (http://www.jams-coe.org/).

COE Partnership for Air Transportation Noise and Emissions Reduction

In 2003, the FAA Administrator Marion Blakey selected the COE PARTNER with Massachusetts Institute of Technology serving as the Lead. This FAA COE has been co-sponsored by NASA and Transport Canada and has conducted R&D to identify, understand,

measure, and mitigate the impacts of aircraft noise and aviation emissions. The COE focused on reducing uncertainty in issues dealing with climate impact and the health and welfare effects of emissions to actionable levels. Core member universities have included:

- Boston University;
- Georgia Institute of Technology;
- Harvard University;
- Missouri University of Science and Technology (formerly University of Missouri - Rolla);
- Pennsylvania State University;
- Purdue University;
- Stanford University;
- University of Illinois at Urbana-Champaign;
- University of North Carolina - Chapel Hill;
- University of Pennsylvania, and
- York University in Canada.

The COE continued to prepare for close-out activities during FY 2015. Since its inception, the FAA has awarded $50 million in grants, and the COE core universities with their affiliates have provided matching contributions in excess of $50 million. The COE currently reflects a $110 million level-of-effort. For additional information, go to (http://partner.mit.edu/).

COE for Airport Technology

In 1995, the Administrator selected the COE for Airport Pavement Research under the leadership of the University of Illinois at Urbana-Champaign and North Carolina A&T University as a participating member. This COE was initially established to focus on pavement issues. In 2005, Rensselaer Polytechnic Institute joined the COE and the FAA expanded the scope to include R&D on wildlife hazard mitigation, lighting, and other airport safety topics, and changed its name to the COE for Airport Technology. Since its inception, the FAA has awarded more than $20 million in grants. The COE core universities with their affiliates have provided matching contributions in excess of $20 million, and reflect a $41.5 million level-of-effort. This COE successfully completed FAA and congressional requirements, and is self-sufficient. This COE continues to work closely with ORD on modernization efforts. For further information, go to (http://www.ceat.uiuc.edu/).

COE for Operations Research

The NEXTOR was established in 1996. This COE initially consisted of five core universities:

- University of California at Berkeley serving as the lead;
- Massachusetts Institute of Technology;
- Virginia Polytechnic Institute;
- University of Maryland, and
- George Mason University.

The COE successfully completed its 10-year obligations serving as an Air Transportation COE and transitioned to self-sufficiency. NEXTOR now includes the following universities: George Mason University, Georgia Institute of Technology Purdue University, Massachusetts Institute of Technology University of California at Berkeley, The Ohio State University, University of Maryland at College Park, Virginia Polytechnic Institute and State University. NEXTOR continues to perform R&D in the areas of air traffic management and control, system performance studies and metrics, and aviation economics and policy. Since inception, FAA grants, contracts and matching contributions have totaled more than $71 million. The Center has been serving other government agencies and the aviation community and is a fully successful national resource, as originally planned. For further information go to (http://www.nextor.org).

5.4 International

The FAA uses cooperative agreements with European and North American aviation organizations to participate in aviation safety and ATM modernization programs and to leverage research activities that harmonize operations and promote a seamless and safe air transportation system worldwide.

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/).

Atlantic Interoperability Initiative to Reduce Emissions

Established in 2007, the Atlantic Interoperability Initiative to Reduce Emissions (AIRE) provides a foundation for cooperation between the FAA and the European Commission to promote and harmonize environmental initiatives and procedures in European and North American airspace. In addition to facilitating transatlantic interoperability between aviation authorities and industry partners, such as aircraft manufacturers, air operators, and providers of aviation navigation services, AIRE promotes information sharing and demonstration of procedures and practices that reduce noise and environmental emissions. Demonstrations have occurred annually since 2008 and include optimizations in all phases of flight; airport surface, terminal area, and enroute oceanic. Demonstrations have resulted in savings in fuel and emissions across all three of these domains. For more information, go to (http://ec.europa.eu/transport/modes/air/environment/aire_en.htm).

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).

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/).

International Helicopter Safety Team

Attendees at the 2005 International Helicopter Safety Symposium agreed upon the need to reduce the helicopter accident rate by 80%, by 2016. To achieve this goal, the attendees formed an independent group known as the International Helicopter Safety Team (IHST). The IHST is co-chaired by the FAA and industry. Major industry participants include:

- Helicopter Association International;
- American Helicopter Society International;
- Helicopter Association of Canada;
- Bell Helicopter;
- Sikorsky Helicopter;
- Eurocopter;
- Shell Aircraft;
- CHC helicopter; and
- AgustaWestland.

IHST members also established international partnerships in countries with significant helicopter operations and worked to encourage the overseas industries to carry out accident analysis and develop safety interventions. Worldwide partners now supporting the work of the IHST include government and industry participants from the U.S., Canada, Brazil, Japan, Australia, India, Russia, and multiple countries in Europe and in the Middle East/North Africa region. To facilitate a data-driven approach to safety, the IHST initiates joint government and industry teams to analyze accidents, conduct causal analyses, and recommend intervention implementation strategies. While completing these analyses of helicopter accidents and their causes, the IHST and its worldwide partners develop safety toolkits, instructional and educational safety videos, and specific safety recommendations aimed at helping members of the helicopter industry enhance their safety practices and reduce the accident rate. By the end of 2012, the accident rate had been reduced 30% since 2001-2005. For more information, go to (http://www.ihst.org/Default.aspx?tabid=1507&language=en-US).

References

Chaturvedi, A.K., Cliburn, K.D., Craft, K.J., Dulkadir, Z. & Hickerson, J.S. (2014). Tricyclic antidepressants found in pilots fatally injured in civil aviation accidents. *Office of Aerospace Medicine*. *Report No. DOT/FAA/AM-14/11*.

Canfield, D.V., Chaturvedi, A.K., Craft, K.J., Hickerson, J.S. & Rogers, P.B. (2015). Prevalence of ethanol and drugs in civil aviation accident pilot fatalities 2009–2013. *Office of Aerospace Medicine*. Report No. DOT/FAA/AM-15/13.

Johnson, R.D., Kemp, P.M. & Lewis, R.J., Distribution of paroxetine in postmortem fluids and tissues. (2015). *Office of Aerospace Medicine*. Report # DOT/FAA/AM-15/11.

Johnson, R.D., Kemp, P.M. & Lewis, R.J. (2015). Paroxetine in postmortem fluids and tissues from nine aviation accident victims. *Journal of Analytical Toxicology* (in press).

Buttussi, F., & Zangrando, N. (2014). *Proceedings of the 20th ACM Symposium on Virtual Reality Software and Technology.* Desktop virtual reality for emergency preparedness: user evaluation of an aircraft ditching experience under different fear arousal conditions. New York, New York, USA, ACM Press, New York, November 2014, 141-150

DeJohn, C. & Mills, B. (2015). A comparison of personal flying accident rates between selected light sport aircraft and general aviation aircraft. *Journal of Aerospace Medicine and Human Performance* (submitted).

DeJohn, C., Mills, B., Porras, D. & Ricaurte, E.M.(2015). *Proceedings of the Aerospace Medical Association Annual Conference*. Comparison of hazards to flight safety identified by

autopsy in U.S. pilots with and without FAA medical certificates. Lake Buena Vista, FL. Journal of Aerospace Medicine and Human Performance 2015;86(3):180[75]

DeJohn, C., Laverde, C., Mills, B., Porras, D. & Ricaurte, E.M. (2015) *Proceedings of the Aerospace Medical Association Annual Conference*. Comparison of post-mortem toxicological hazards findings of federal aviation administration medically certified third-class and self-certified pilots. San Diego, CA. *Journal of Aerospace Medicine and Human Performance* 2015;86(3):180[74]

Rogers, P.B. and Stoner J.A. (2015). Modification of the sandwich estimator in generalized estimating equations with correlated binary outcomes in rare event and small sample size settings. J Computational Statistics & Data Analysis - Elsevier (submitted).

Rogers PB. *A Note on Interpreting Probabilities Concerning Rare Events with Application to Aviation*. DOT/FAA/AM-15/XX (undergoing FAA clearance review).

Colubi, A.M., Kontoghiorghes, E.J. & Lee, J.C. (2015). Computational statistics & data analysis. The *Official Journal of the International for Statistical Computing. ISSN: 0167-9473.*

Chittaro, L. (2015). Designing serious games for safety education: “learn to brace” vs traditional pictorials for aircraft passengers. *IEEE Explore Digital Library*. Visualization and Computer Graphics , *Issue 99.*

Chittaro L, Buttussi F, Zangrando N. (2014) *Desktop virtual reality for emergency preparedness: User evaluation of an aircraft ditching experience under different arousal conditions*. Virtual Reality Software and Technology. Association for Computing Machinery: New York

Life Vest App for Facebook, Android, and iPhone now available online.

Oculus Rift (Virtual Reality) version of Virtual Ditching (Surviving a Plane Crash) now available at (http://www.share.oculus.com).

Burian, D. (2015). Aviation Relevance of Genetic Risk Scores for Cardiovascular Disease. *Office of Aerospace Medicine*. *Report # DOT/FAA/AM-15/10.*

DeWeese R.L., Moorcroft D.M., Taylor A.M. *Effect of passenger position on crash injury risk in transport-category aircraft*. Office of Aerospace Medicine Report No. DOT/FAA/AM-15/17.

Acronyms and Abbreviations

Acronym	Definition
A	
AC	Advisory Circular
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
AIP	Grants-In-Aid for Airports Appropriation
AIRE	Atlantic Interoperability Initiative to Reduce Emissions
AOPA	Aircraft Owners and Pilots Association
ASCENT	Aviation Sustainability Center of Excellence
ASPIRE	Asia and Pacific Initiative to Reduce Emissions
ASTM	American Society for Testing and Materials
AST	Office of Commercial Space Transportation
ATC	Air Traffic Control
ATM	Air Traffic Management
ATO	Air Traffic Organization
ATRP	Airport Technology Research Program
C	
CAAFI	Commercial Aviation Alternative Fuels Initiative
CAASD	Center for Advanced Aviation System Development
CAST	Commercial Aviation Safety Team
CDM	Collaborative Decision Making
CEAT	Center of Airport Technology Research
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
CRDA	Cooperative Research and Development Agreement
CSPA	Closely Spaced Parallel Approach
CST	Commercial Space Transportation

Acronym	Definition
D	
DARWIN®	Design Assessment Of Reliability With Inspection
DLW	Datalink Weather
DMA	Dynamic Mechanical Analysis
DNL	Day-Night Noise Level
DoD	U.S. Department of Defense
DOT	U.S. Department of Transportation
E	
EDS	Environmental Design Space
Efaros	Enhanced Final Approach Runway Occupancy Signal
EMS	Environmental Management System
EUROCONTROL	European Organisation for the Safety of Air Navigation
F	
F&E	Facilities and Equipment Appropriation
FAD	Functional Architecture Documents
FAA	Federal Aviation Administration
FAARFIELD	FAA Rigid and Flexible Iterative Elastic Layered Design
FDM	Flight Data Monitoring
FMS	Flight Management System
FRAT	Facility Risk Assessment Tool
FY	Fiscal Year
G	
GA	General Aviation
GAJSC	General Aviation Joint Steering Committee
GEOSS	Global Earth Observation System of Systems
H	
HFDM	Helicopter Flight Data Monitoring
HSI	Human-System Integration
I	
IA	International Agreements
ICAO	International Civil Aviation Organization
IHST	International Helicopter Safety Team
IMC	Instrument Meteorological Conditions
J	
JAMS	Joint COE for Advanced Materials
JRC	Joint Resources Council
JUP	Joint University Program

Acronym	Definition
L	
LCSA	Low Cost Surface Awareness
LOSA	Line Operations Safety Assessment
LTO	Landing and Take-Off
M	
MET	Meteorological
MinWxSvc	Minimum Weather Service
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
NEXRAD	Next Generation Weather Radar
NextGen	Next Generation Air Transportation System
NEXTOR	National Center of Excellence for Aviation Operations Research
NRC	Canadian National Research Council
NSTC	National Science and Technology Council
NTSB	National Transportation Safety Board
nvPM	Non-volatile Particulate Matter
NWS	National Weather Service
O	
OMB	Office of Management and Budget
ORD	Chicago O'Hare International Airport
P	
PAFI	Piston Aviation Fuels Initiative
PARTNER	Partnership for Air Transportation Noise and Emissions Reduction
PDARS	Performance Data Analysis and Reporting System
PEGASAS	Partnership to Enhance General Aviation Safety, Accountability and Sustainability
PMO	Program Management Organization
R	
R&D	Research and Development
R,E&D	Research, Engineering and Development Appropriation
REB	Research and Development Executive Board
REDAC	Research, Engineering, and Development Advisory Committee

Acronym	Definition
RFP	Request for Proposal
RSA	Runway Safety Area
RTP	Regional Temperature Potential
S	
SAA	Sense and Avoid
SAGA	Sustainable Aviation Guidance Alliance
SBIR	Small Business Innovation Research
SRM	Safety Risk Management
STBO	Surface Trajectory-Based Operations
STF	Surface Tactical Flow
STM	Surface Traffic Management
sUAS	Small Unmanned Aircraft System
T	
3D	Three Dimensional
TC	Thermocouple
TFDM	Terminal Flight Data Manager
TFM	Traffic Flow Management
Tg	Transition Temperature
TRB	Transportation Research Board
TSA	Transportation Security Administration
U	
UAS	Unmanned Aircraft System
U.S.	United States
USGCRP	U.S. Global Change Research Program
UTMB	University of Texas Medical Branch
W	
WTIC	Weather Technology in the Cockpit