2015
National Aviation Research Plan
(NARP)

Final

August 2015

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

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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 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 *National Aviation Research Plan* (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 (RE&D), Facilities and Equipment (F&E), and Grants-In-Aid for Airports (AIP).

In FY 2016, the FAA plans to invest a total of $410,050,000 in R&D. The R&D investment spans multiple appropriations for the FAA, including $166,000,000 in RE&D; $198,050,000 in F&E; and $46,000,000 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 2014–2018*, and the *Federal Aviation Administration Strategic Initiatives 2014-2018*[3].

[1] OMB Circular A-11, *Preparation, Submission and Execution of the Budget*, July 26, 2013, section 84, page 8 (http://www.whitehouse.gov/OMB/circulars).
[2] For more information on the National Science and Technology Council (NSTC), see 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. This report is available at http://www.faa.gov/about/plans_reports/media/FAA_Strategic_Initiatives_Summary.pdf.

Preface

In the 2015 NARP, the research being conducted under the Facilities and Equipment (F&E) appropriation will be represented a bit differently than in previous years.

- Various F&E programs that have newly been identified as conducting research but that have not historically been represented in the NARP now will be included in the budget tables found in Chapter 4. These entries will appear at the rolled up portfolio level.
- The amounts shown in budget tables 4.2.1 through 4.2.5 for F&E programs in FY 2015 reflect only R&D activities: they do not include acquisition, operational testing, or other non-R&D activities. The amounts shown for F&E programs in FY 2016 and beyond are increased to reflect the entire budget for those portfolios. This increase is due to the reclassification of existing work to better align with OMB Circular A-11 Research Definitions.
- The amount shown in budget tables 4.2.1 through 4.2.4 for CAASD in FY 2015 includes only the R&D portion of the total CAASD line item amount. R&D represents 27.6% in FY 2015. The amount shown for CAASD in FY 2016 and beyond is increased to reflect the entire budget for the program. This increase is due to the reclassification of existing work to better align with OMB Circular A-11 Research Definitions.
- Two F&E programs (Air Traffic Control/Technical Operations Human Factors - F&E - 1A12A and Operations Concept Validation Modeling - F&E – 1A12B) that appeared in the *2014 NARP* have not been funded in FY 2015 and beyond and, therefore, have been removed from the *2015 NARP*.
- Two F&E programs (Systems Safety Management Transformation - F&E - 3A10B and Wake Turbulence - Re-Categorization - F&E - 1A06B) that have historically been presented as independent budget line items (BLIs) in the various financial tables of the NARP have now been subsumed into the new rolled up F&E portfolio lines. These programs will no longer appear at all in the goal funding tables in Chapters 1 -3 in the *2015 NARP*. While the programs' research efforts are detailed individually in the narrative of the *2015 NARP*, they will no longer be presented in future iterations of the *NARP*.

The 2015 NARP includes the removal of what used to be Efficiency goal 1 - "*Necessary NextGen related research priorities are identified, defined, and coordinated with partner agencies for improvements in efficiency and capacity*" - due to the dissolution of the Joint Planning and Development Office (JPDO). The NARP now showcases 21 underlying goals across the three main principles (Safety, Efficiency, and Environmental).

The FAA's strategic priorities (which accompany and complement Administrator Huerta's *Federal Aviation Administration Strategic Initiatives 2014-2018)* have newly been added this year.

Historically, research conducted under the Commercial Space Program was funded out of the Operations (Ops) appropriation. Last year (i.e., in the *2014 NARP*), Commercial Space research

was funded by Research, Engineering, & Development (RE&D) appropriation dollars allocated from the A12.b NextGen – Air Ground Integration Human Factors budget line item. In this year's *NARP*, Commercial Space research is being captured in a brand new, dedicated RE&D BLI (A12.d).

Finally, work conducted by the NextGen - Advanced Systems and Software Validation program, whose initial year was funded under A11.n as shown in the *2014 NARP*, will now be funded and completed under the A11.d BLI (Aircraft Icing/Digital System Safety).

Introduction

To maximize the opportunities that the aviation industry provides, the U.S. must not only maintain, but also continue to improve upon, the National Airspace System (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 through the introduction of new technologies and procedures, innovative policies, and advanced management practices. Collaborative, needs-driven research and development (R&D) is central to this process, because 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. These 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, available athttp://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 and 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:

- Mobility through the air is vital to economic stability, growth, and security as a Nation.
- Aviation is vital to national security and homeland defense.
- Aviation safety is paramount.
- 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
- Spurs the development of innovative technologies that enable new products and services

For more information, see the *National Aeronautics Research and Development Plan* (February 2010) available at 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 (DOT) Strategic Plan for Fiscal Years 2014–2018, *Transportation for A New Generation*, was created with input from 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 and stability, and the security of the U.S., require the development of transportation policies and programs that contribute to providing fast, safe, efficient, and convenient transportation at the lowest cost, consistent with those and other national objectives, including the efficient use and conservation of the resources of the U.S.[6] The Plan fulfills DOT's mission and sets the direction for DOT to provide safe, efficient, convenient, and sustainable transportation choices through five strategic goals that are supported by a wide-ranging management goal (Organizational Excellence):

- Safety
- State of Good Repair
- Economic Competitiveness
- Quality of Life in Communities
- Environmental Sustainability

The Plan may be found on DOT's website, at 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 *FAA Strategic Initiatives* on February 19, 2014 to underscore what will be necessary strategically for the FAA to lay the foundation for the aerospace system of the future. This 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 (NAS) -** 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:

- Make aviation safer and smarter
- Deliver benefits through technology and infrastructure
- Enhance global leadership
- Empower and innovate with the FAA's people

For more information, the *FAA Strategic Initiatives* is available athttp://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 and space 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 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 to a level that does not constrain growth.

The following table 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 21 underlying goals that support FAA's accomplishment of these 3 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 and space safety and achieve the lowest possible accident rate.

Ten R&D goals support R&D Principle 1 - Improve Aviation Safety with work spread across three budget appropriations (RE&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 - Optimized technical and regulatory provisions and processes used to oversee, coordinate, regulate, and promote safe and responsible activities for reliable aerospace operations between space and Earth.

- 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 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			
	Systems Safety Management Transformation				
	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 2016, 50 percent of total FAA R&D funding is allocated to R&D Principle 1 - Improve Aviation Safety. Program funding levels for the 2015 Enacted and 2016 President's Budget are shown in Table 1.0.2. Percent of Program reflects each program's contribution towards R&D Principle 1 in the 2016 President's Budget. Table 1.0.2 also lists the section and page number reference for each budget narrative within the FY 2016 Congressional Justification (CJ) for the President's Budget Request. The FY 2016 CJ is available at http://www.dot.gov/sites/dot.gov/files/docs/FY2016-BudgetEstimate-FAA.pdf.

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

2016 BLI	Program	CJ Reference (Section /Page)	Appropriation Account	2015 Enacted ($000)	2016 President's Budget ($000)	2016 Percent of Program
A11.a	Fire Research and Safety	3C/9	RE&D	6,000	6,643	100%
A11.b	Propulsion and Fuel Systems	3C/13	RE&D	2,000	3,034	100%
A11.c	Advanced Materials/Structural Safety	3C/15	RE&D	2,909	3,625	100%
A11.d	Aircraft Icing/Digital System Safety	3C/19	RE&D	5,500	6,920	100%
A11.e	Continued Airworthiness	3C/23	RE&D	9,619	8,987	100%
A11.f	Aircraft Catastrophic Failure Prevention Research	3C/28	RE&D	1,500	1,433	100%
A11.g	Flightdeck/Maintenance/System Integration Human Factors	3C/31	RE&D	6,000	9,947	100%
A11.h	System Safety Management	3C/34	RE&D	7,970	6,063	100%
A11.i	Air Traffic Control/Technical Operations Human Factors	3C/37	RE&D	5,400	5,995	100%
A11.j	Aeromedical Research	3C/41	RE&D	8,300	10,255	100%
A11.k	Weather Program	3C/45	RE&D	7,424	9,127	50%
A11.l	Unmanned Aircraft Systems Research	3C/50	RE&D	14,974	9,635	100%
A12.b	NextGen - Air Ground Integration Human Factors	3C/59	RE&D	6,788	6,213	70%
A12.c	NextGen - Weather Technology in the Cockpit	3C/62	RE&D	1,822	1,852	45%
A12.d	Commercial Space Transportation	3C/66	RE&D	0	3,000	100%
A14.a	System Planning and Resource Management	3C/75	RE&D	1,365	1,545	65%
A14.b	William J. Hughes Technical Center Laboratory Facility	3C/77	RE&D	2,455	2,480	72%
1A01A	Runway Incursion Reduction Program	3B/12	F&E	3,500	0	100%
4A08	Center for Advanced Aviation System Development (CAASD)	3B/316	F&E	5,465	18,600	31%
--	Airport Cooperative Research Program - Safety	3D/37	AIP	5,000	5,000	100%
--	Airport Technology Research Program - Safety	3D/26	AIP	15,523	16,176	100%
	Total ($000)			**119,513**	**136,529**	

**CAASD R&D budget totals for 1) FY 2015 assume 33% for Safety, 67% to Efficiency, and 0% for Environmental and 2) FY 2016 and outyears assume 31% for Safety, 64% for Efficiency, and 5% for Environmental (subject to FFRDC Executive Board FY 2016 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 (RE&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 below, followed by a summary of the significant progress made in FY 2014 towards achieving the R&D goal.

Table 1.1.1: Advanced Materials/Structural Safety Program Milestones

Year	Milestone	Status	Notes
2014	Establish design criteria for restraint systems that protect occupants at the highest impact levels that the aircraft structure can sustain	Completed	2014 NARP Status: On schedule
2014	Evaluate field bonded repair practices to update related guidance and training for composite aircraft structures	Completed	2014 NARP Status: On schedule
2014	Evaluate the ability of models to predict off-axis and multiple terrain impacts	Completed	2014 NARP Status: On schedule
2015	Characterize the effects of blunt impact on composite structures typically used in fuselage applications	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	

Year	Milestone	Status	Notes
2017	Address specific ARAC 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	
2018	Evaluate composites quality control AC 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 AC 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	New milestone
2020	Develop a methodology to verify and validate models used for crashworthiness certification	On schedule	New milestone

Advanced Materials/Structural Safety Program Progress in FY 2014:

- ✓ Accurately simulated results for full scale experiments completed in previous work. Research engineers correlated a series of shear tie compression tests to validate the finite element method (FEM) model and to improve FEM model simulation to correctly capture the sequence of shear tie fracture. Finite element parameters were finalized for the shear tie compression and derived analytical solution for stringer-element compression tests. The design process for modeling blunt impact of fuselage with floor structures to investigate the effects of impact glancing angle was started. Fuselage design will be similar to Boeing 787/Airbus 350 with composite skin, stringers, and floor beams and joints.

- ✓ Completed the Commercial Aircraft Composite Repair Committee round robin bonded repair tests performed at OEM (original equipment manufacturer) and five repair depots with a total of 117 panels. Repair materials and procedures were provided to each repair depot. The result showed that 1) workmanship, mechanic skill, knowledge and experience levels of the depot personnel do affect the residual strength of a repair, and 2) experience alone does not guarantee a fully capable repair (i.e., a repair with safety margins as predicted by the design).

- ✓ Developed a benchmark for the current use and future needs of bonded composite structure by conducting a workshop with experienced practitioners of composite bonding

design and manufacture from industry, academia and regulators. The workshop identified known issues and development needed to provide adequate safety in aircraft structures of bonded joints. The information gathered will be used to guide policy for certification of composite structural bonding.

- ✓ Evaluated Abaqus finite element software package built-in features for the ability to accurately simulate the mode III fracture of notched carbon-fiber panels. A design-of-experiments sensitivity study was conducted to determine 1) which material properties significantly influenced the results and 2) if changes in their values would give better agreement for all finite element analysis (FEA) results and experimental results. Work was done in developing procedures for an American Society for Testing and Materials (ASTM) standard to determine material properties for the Hashin Progressive Damage model. This analysis indicates that better agreement is not possible and thus errors in material properties are not a significant source of the discrepancy between the FEA results and the experimental results.

1.1.2 Aircraft Catastrophic Failure Prevention Research (RE&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 below, followed by a summary of the significant progress made in FY 2014 towards achieving the R&D goal.

Table 1.1.2: Aircraft Catastrophic Failure Prevention Research Program Milestones

Year	Milestone	Status	Notes
2014	Develop and verify an improved predictive capability for aircraft damage associated with engine failure and debris impact	Completed	2014 NARP Status: On schedule
2015	Complete Inconel testing for certification by analysis	On schedule	
2016	Develop an anisotropic material model for composite impact problems in aviation	On schedule	
2016	Complete MAT224 anisotropic metal to account for cold working and directional manufacture	On schedule	

Year	Milestone	Status	Notes
2016	Complete homogeneous composite failure model	On schedule	
2017	Complete standard composite tests 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	New milestone

Aircraft Catastrophic Failure Prevention Research Program Progress in FY 2014:

- ✓ Completed the generic yield surface enhancement to the tabulated Johnson-Cook material model known as MAT224 in LS-DYNA. The enhancement (MAT224-GYS) allows the design engineer to more accurately model materials that do not conform to the Von Mises theory. MAT224-GYS provides an improvement over both the Drucker and Cazacu-Barlat linear relationships in the Compressive Stress/Tensile Stress verses Shear Stress/Tensile Stress space and has been incorporated into LS-DYNA and has passed the quality assurance checks.

- ✓ Completed development of the constitutive relationship, damage and failure for Titanium - 6 Aluminum - 4 Vanadium and compared the results to ballistic tests performed at the National Aeronautic and Space Administration's (NASA) Glenn Research Center (NASA GRC). The simulation plot agrees well with the test data, showing good agreement for both the ballistic limit and the residual velocities of the projectile for impact velocities above the ballistic limit speed.

- ✓ Completed the ballistic impact test series at NASA GRC in various thickness plates of inconel 718. Planned testing for material property characterization was also completed at The Ohio State University. The Ohio State effort is a multiple year effort scheduled to be completed in 2015.

- ✓ Completed a full scale demonstration of a shield intended for a generic aircraft design as part of the open rotor shielding study. The design report was published as DOT/FAA/TC-13/34 in December 2013. In February, a full scale test was run at Naval Air Warfare Center China Lake with significant FAA and NASA GRC participation. The team successfully severed a composite blade from a running rig and impacted the shield at the desired simulation velocity. The shield performed as designed.

- ✓ Completed the development of the hardening curve for the new LS-DYNA material model MAT213. At this stage of the development the model is capable of simulating

elastic and plastic response of the material. In FY 2015, the damage model will be developed and in 2016, the failure will be developed to complete the model.

1.1.3 Aircraft Icing/Digital System Safety (RE&D - A11.d)

The Aircraft Icing/Digital System Safety Program supports Aviation Safety R&D Goal 1 by developing and testing technologies that 1) detect frozen contamination; 2) predict anti-icing fluid failure; and 3) 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 below, followed by a summary of the significant progress made in FY 2014 towards achieving the R&D goal.

Table 1.1.3: Aircraft Icing/Digital System Safety Program Milestones

Year	Milestone	Status	Notes
2014	Develop a cyber-security research plan to identify components in airborne networks that pose cyber security threats to aircraft safety	Completed	2014 NARP Status: On schedule
2014	Conduct field campaign on high ice water content atmospheric environments out of Darwin, Australia	Completed	2014 NARP Status: On schedule
2015	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 was delayed from 2014 to 2015 due to lack of the needed inclement weather conditions. 2014 NARP Status: On schedule

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	On schedule	Milestone was revised due to changing sponsor priorities. Old wording: "Provide a recommendation for design of a generic system architecture for an airborne network that identifies cyber security vulnerabilities" 2014 NARP Status: On schedule
2015	Test simulated ice shapes with and without roughness on swept wing model at low to moderate Reynolds number	Completed	2014 NARP Status: On schedule
2015	Identify issues of certification, validation and verification, and flight safety as relates to the problems that are caused by system's complexity	On schedule	New milestone
2016	Identify effects of system complexity on aircraft safety margins and investigate highly integrated, complex airborne systems being 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	Identify what specific tasks are necessary to ensure complex digital systems have been fully integrated	Deleted	Milestone is deleted due to changing sponsor priorities. 2014 NARP Status: Delayed from 2015 to 2016
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	New milestone
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	

Year	Milestone	Status	Notes
2018	Create a validation database of ice shapes and their aerodynamic effects on swept wings for computational fluid dynamics	On schedule	
2018	Determine feasibility of dynamic allocation of code blocks in multi-core processors	Deleted	Milestone is deleted as it has been combined with another milestone ('Develop methodology to accurately calculate WCET (worst case execution time) for multi-core processors') 2014 NARP Status: On schedule
2018	Identify airborne electronic hardware development error types that remain undetected by verification techniques	On schedule	
2018	Investigate different techniques to calculate WCET and explore the feasibility of deterministic behavior for MCP implementations with dynamic allocation of code blocks to individual cores during run time	Accelerated	Milestone was revised to combine it with another milestone and was accelerated from 2019 to 2018. Old wording: 'Develop methodology to accurately calculate WCET (worst case execution time) for multi-core processors' 2014 NARP Status: On schedule
2019	Develop criteria to ensure integration of complex digital systems	On schedule	
2019	Report on use of computational fluid dynamics analysis and of test methods and scaling for iced swept wings	On schedule	
2020	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 SLD conditions	On schedule	New milestone

Aircraft Icing/Digital System Safety Program Progress in FY 2014:

- ✓ Performed experimental studies in the Canadian National Research Council's (NRC) Research Altitude Test Facility over a period of several years under the FAA-NRC Memorandum of Cooperation NAT-I-8417. The research used various test articles to explore the effect of pressure and other parameters on the formation, adherence, and shedding of ice due to the ingestion of ice crystals in a test environment simulating a low pressure engine compressor. The research provided data and analysis for the improvement of modeling of the ice crystal ice accretion process and for sea level testing in non-pressurized facilities of ice crystal accretion within full scale engines. An important focus of the experimental work in 2014 was the production of data to develop and evaluate analytical scaling methods for sea level engine icing facilities that do not have altitude-pressure capability (which includes most engine icing facilities). Data was obtained and analyzed, but it is not yet clear how well such tests can adequately reproduce ice crystal events experienced at altitude. Further testing will be done, exploring whether accretion onset can be matched at low, high, and dynamic pressures by matching the ratio of liquid water content/total water content and varying inlet concentration ratio. In particular, the testing will focus on the effect of dynamic pressure,

which is of particular concern of engine manufacturers for sea level testing attempting to adequately simulate conditions at altitude. Progress was made toward developing a parametric scaling framework for testing of engines in static sea level facilities to evaluate their operation in ice crystal clouds at high altitude.

- ✓ Identified adverse events where the definition of requirements and validation and verification (V&V) processes may have been a contributing factor to the adverse event. Research identified possible issues and shortcomings with requirement definitions and V&V processes in eight potential error-generating scenarios that could cause a catastrophic condition. Phase 1 Final Draft Report, due in FY 2015, will describe the results.

1.1.4 Continued Airworthiness (RE&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 systems and mechanical systems.

The research milestones and their statuses are shown in Table 1.1.4 below, followed by a summary of the significant progress made in FY 2014 towards achieving the R&D goal.

Table 1.1.4: Continued Airworthiness Program Milestones

Year	Milestone	Status	Notes
2014	Perform the final phase of flight testing with the U.S. Army on the UH-60M which will be used to validate existing Gross Weight/Center of Gravity algorithms related to usage loads monitoring.	Completed	2014 NARP Status: On schedule
2015	Develop technical data to assess the application of advanced aluminum-lithium metallic alloys for primary fuselage structure in transport category airplanes	Delayed	Milestone is delayed from 2014 to 2015 due to a change in scope. 2014 NARP Status: On schedule
2015	Determine the current state of active flutter suppression in the commercial airplane sector to assess adequacy of existing standards, guidance, and regulations	On schedule	
2015	Develop test methods and provide data to assess arcing damage for new high voltage aerospace electrical systems	On schedule	

Year	Milestone	Status	Notes
2015	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	On schedule	
2016	Develop technical data to assess the fatigue and environmental durability of bonded repairs to metallic structure	On schedule	
2017	Develop technical data to assess damage tolerance of aluminum-lithium primary structure - follow on effort to material characterization	On schedule	
2017	Develop technical data to validate and enhance the Health Usage Monitoring System AC29-2C, MG-15 for a usage credit	Deleted	Milestone is deleted due to suspension of research by the sponsor. 2014 NARP Status: On schedule
2017	Provide technical data for use by the FAA for approving angle of attack systems installation on General aviation airplanes	On schedule	
2018	Develop technical data to evaluate non-flammable electrolyte lithium batteries and battery systems for aerospace applications	On schedule	
2018	Develop technical data to assess bonded repairs of wing structure	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	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 2019 to 2020 due to delays in infrastructure and equipment upgrades. 2014 NARP Status: On schedule

Continued Airworthiness Program Progress in FY 2014:

- ✓ Completed a major phase of testing in a joint effort between the FAA and the Boeing Company investigating the effects of environment on the structural robustness and fatigue performance of adhesively bonded repair technology using the FAA Full-Scale Aircraft Structural Test Evaluation and Research (FASTER) lab. B727 fuselage panels containing boron/epoxy (B/Ep) composite and aluminum bonded patches were fatigue tested under environmental conditions (165 degrees Fahrenheit and 85 percent humidity) up to a typical design service goal of 60,000 cycles. Results for the B/Ep composite

repairs reveal slower crack growth under hot-wet conditions compared to that under ambient lab conditions due to relaxation of thermal residual stresses. Data from this program will be used to improve predictive tools to design and analyze bonded repairs and to assess methods to quantify bonded repair integrity.

- ✓ Developed, maintained, and distributed an update to the Metallic Materials Properties Development and Standardization (MMPDS) Handbook and derivative products. The MMPDS is an accepted source for metallic material and fastener system allowables recognized by the FAA, all Departments and Agencies of the U.S. Department of Defense (DoD), and NASA. The commercial version of the MMPDS-09 was released April 2014. Significant changes to the Handbook include a new aluminum-lithium alloy, aluminum sand cast alloy, and a magnesium alloy. There are also additional thickness ranges and upgrades from S-basis to A- and B-basis design allowable properties for a steel alloy, several aluminum alloys, and a copper-nickel alloy. Many other material sections were revised, including updates for stabilized AMS specifications.

- ✓ Completed a major phase of material testing to better understand the material properties, mechanical behavior, and unique characteristics of typical next generation aluminum-lithium (Al-Li) being used in airframe structures. As a case study, two Al-Li alloys were considered; 2198-T8 and 2196-T8511 alloys used for skin and extrusion applications, respectively. Several properties were assessed and compared with baseline 2024-T3 and 7075-T6 alloys, including static properties; fatigue life and fatigue crack growth behavior; and supplemental properties. Although static test results indicated anisotropic behavior in the Al-Li alloys, particularly at the off-axis 45 degree grain orientation, measured static properties exceeded published A and B basis allowables in the MMPDS. In addition, fatigue test results reveal better fatigue crack growth resistance and longer fatigue lives for the Al-Li alloy compared to the baseline material. However, unique cracking behavior and delamination was observed in the 2198-T8 material when tested in a lap joint configuration warranting additional research and future tests of more complex built-up structures.

1.1.5 Propulsion and Fuel Systems (RE&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 1.1.5 below, followed by a summary of the significant progress made in FY 2014 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	On schedule	
2016	Enhance DARWIN® code to enable optimal autozoning to handle larger 3-D 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	
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	New milestone

Propulsion and Fuel Systems Program Progress in FY 2014:

- ✓ Updated the Design Assessment of Reliability with Inspection (DARWIN® 8.2) software code developed by Southwest Research Institute with several new capabilities and enhancements for rotor designers and analysts. These enhancements map directly to 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 (RE&D - A11.l)

The Unmanned Aircraft Systems Research Program supports Aviation Safety R&D Goal 1 by conducting research to ensure the safe, efficient, and timely integration of unmanned aircraft systems (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 below, followed by a summary of the significant progress made in FY 2014 towards achieving the R&D goal.

Table 1.1.6: Unmanned Aircraft Systems Research Program Milestones

Year	Milestone	Status	Notes
2014	Develop the capability to evaluate potential sense and avoid logic and algorithms and review several available algorithms for methodology development	Completed	2014 NARP Status: Delayed from 2013 to 2014
2014	Investigate control latencies during takeoff and landing scenarios in UAS with low levels of automation and determine information requirements for executing sense and avoid maneuvers in UAS	Completed	2014 NARP Status: On schedule
2014	Recommend data fusion strategies based on review (and validation where necessary) of existing sense and avoid research and documentation	Completed	2014 NARP Status: On schedule
2014	Conduct a human-in-the-loop experiment to assess lost link procedures and impacts of UAS lost link events on the NAS	Completed	2014 NARP Status: On schedule
2014	Conducted Public Meeting to discuss the effort to establish the new Center of Excellence for Unmanned Aircraft Systems (UAS COE)	Completed	As part of the Consolidated Appropriations Act of 2014, Congress mandated the FAA to complete the establishment of a UAS COE
2014	Published the final UAS COE solicitation	Completed	As part of the Consolidated Appropriations Act of 2014, Congress mandated the FAA to complete the establishment of a COE
2015	Develop a comprehensive list of operational and airworthiness approval issues based on 14CFR 91 compliance	On schedule	
2015	Define ground control station human interface requirements, UAS pilot training requirements, and ground observer requirements	On schedule	
2015	Provide the FAA Administrator with UAS COE proposal evaluation package	On schedule	As part of the Consolidated Appropriations Act of 2014, Congress mandated the FAA to complete the establishment of a UAS COE
2016	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	On schedule	

Year	Milestone	Status	Notes
2017	Develop prototype antenna and brassboard electronics, lab-test and flight test antenna final designs for Airborne Collision Avoidance System (ACAS-X) 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 1 (remain well clear) to function 2 (avoid collisions)	On schedule	
2018	Collect and analyze UAS Safety Data from Congressionally mandated test sites	On schedule	
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 2	On schedule	New milestone

Unmanned Aircraft Systems Research Program Progress in FY 2014:

- ✓ Acquired two prototype versions of sense and avoid (SAA) algorithms for integration into the FAA tool suite: 1) Airborne Collision Avoidance System (ACAS) unmanned airborne (UA) (developed by the Traffic Alert and Collision Avoidance System Program Office) and 2) Jointly Optimal Collision Avoidance (JOCA) (developed by Bihrle Applied Research for the U.S. Air Force). These prototype versions will be used to evaluate metrics for testing of future fully-developed SAA algorithms and collision avoidance logic. Researchers developed data formatting software for alternative surveillance sources and candidate methodologies for SAA logic and algorithm validation that assess feasibility and interoperability.

- ✓ Conducted two real-time, human-in-the-loop (HITL) simulations to examine the effects of control latency, which is the time between pilot input and feedback on control station displays -during critical phases -such as takeoffs and landings- and non-critical phases of flight. Scenarios tested included latencies ranging from 180-1026 milliseconds. More control difficulties were found for control latencies over 494 milliseconds, as noted by increased aircraft deviations from pattern during takeoff, increased pilot rudder inputs force at touchdown, increased pilots requested go-arounds, and poor aircraft handling ratings. The results provide information to support the development of UAS control latency standards.

- ✓ Conducted research on candidate surveillance sensors, sensor fusion, and tracking strategies. Recommendations were made on a representative mix of surveillance sensors and the potential multi-sensor data fusion strategies. Two of the selected sensors - radar and Automatic Dependent Surveillance-Broadcast (ADS-B) - had models developed and delivered in Java to researchers at the FAA William J. Hughes Technical Center. These were incorporated into the UAS Fast Time Simulation Environment Laboratory. The radar was selected as the sensor for non-cooperative intruders and ADS-B was selected for cooperative intruders. Five scenarios were simulated and the tracking errors identified were compared. Three candidate Kalman filter-based tracker algorithms were evaluated by examining the horizontal and vertical tracking performance, as well as differences in heading, speed, and altitude rates. All three will be additionally evaluated in Phase 2, which will combine the surveillance sensors and tracking algorithms to provide an optimized fused surveillance solution.

- ✓ Completed a HITL in May 2014, which included 10 weeks of simulation. A follow-on high-fidelity HITL simulation was used to evaluate the impact of specific UAS contingency operations and associated impacts to safety and efficiency in the NAS and their impact upon the controller. Specific contingency events that were examined included loss of control and/or communication link, flyaway, and flight termination with data analysis. Initial results indicate that participant controllers reduced capacity to maintain perceived safety and equalize workload. The associated loss of efficiency introduced will be one of the study outcomes that will be provided to assist with the development of procedures for handling UAS contingencies.

- ✓ Conducted the Center of Excellence for Unmanned Aircraft Systems (UAS COE) Public Meeting on May 28-29, 2014 at the National Convention Center in Leesburg, Virginia. During this meeting, the FAA and its partners provided information about the UAS research program and the COE process. In addition, the FAA released a draft version of the solicitation.

- ✓ Released the UAS COE final solicitation on August 12, 2014. The UAS Research Program Office and the COE Program Office worked together, and in coordination with the UAS Integration Office, ATC System Command Center, Department of the Interior, NASA, and others, to create this document. The participating universities used this final solicitation to submit their bids to become the highly desirable UAS Center of Excellence.

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 (RE&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 below, followed by a summary of the significant progress made in FY 2014 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	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	On schedule	New milestone
2016	Deliver a method for the development of Terminal Radar Approach Control (TRACON) air traffic controller training standards	On schedule	
2017	Validate the TRACON 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 5 NAS hazards	On schedule	
2019	Deliver a human performance data base to support Safety Risk Management Documents as part of the FAA Acquisition Management System	On schedule	
2020	Develop tools and methods for conducting predictive human performance safety analyses of automated air traffic control systems	On schedule	New milestone

Air Traffic Control/Technical Operations Human Factors Program Progress in FY 2014:

- ✓ Completed 10 draft chapters of the Human Factors Design Standard. The project team deleted outdated material, added new material, and revised existing material to be consistent with latest information. Revised chapters included Documentation, Visual Displays, Automation, and Designing Equipment for Maintenance. New chapters included Workspace Design, Audio and Voice Communications, Visual Indicators, Controls, Labeling and Marking, and Data Communications. Publication of the Human Factors Design Standard is on track for 2015.

1.2.2 Flightdeck/Maintenance/System Integration Human Factors (RE&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, rules, and regulations that 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 below, followed by a summary of the significant progress made in FY 2014 towards achieving the R&D goal.

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

Year	Milestone	Status	Notes
2014	Document the results of preliminary research on the role of startle, surprise, and distraction in jet upset/loss of control and identify potential mitigations.	Completed	2014 NARP Status: On schedule
2014	Analyze and provide recommendations on evolving methods of alternative fatigue risk assessment (e.g., voice analysis) that considers time on task fatigue and method validation	Completed	2014 NARP Status: On schedule
2015	Report best practices for Maintenance and Ramp Line Operations Safety Assessment (LOSA)	On schedule	
2016	Provide recommendations for operational credit related to equipage with synthetic vision systems	On schedule	
2017	Provide recommendations for ADS-B/Cockpit Display of Traffic Information minimum operational performance standards and related FAA guidance	On schedule	

Year	Milestone	Status	Notes
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 CRM best practices.	On schedule	New milestone

Flightdeck/Maintenance/System Integration Human Factors Program Progress in FY 2014:

- ✓ Conducted field study with industry and FAA field office participation to assess selected fatigue risk management techniques/practices. Successful fatigue risk management techniques and practices were identified to enable improvement in FAA policy and guidance for 14 Code of Federal Regulations (CFR) Part 145 Repair Stations and aviation maintenance personnel.

- ✓ Completed flight simulator study examining synthetic vision systems for credit on instrument approaches. Study data were collected to inform regulatory policy and potential 14 CFR Part 91 rulemaking for the use of synthetic vision systems for operational credit on instrument approaches.

- ✓ Completed report on "Use of Color on Airport Moving Maps and Cockpit Displays of Traffic Information (CDTIs)." This report identifies known issues related to color which have been identified on current airport moving maps and CDTIs. It provides human factors research recommendations which address the use of color and potential evaluation criteria for how an evaluator may assess the use of color on airport moving maps or other avionics displays.

- ✓ 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 is being drafted that documents results and includes a description of challenges and best practices for LOSA implementation.

1.2.3 NextGen - Air Ground Integration Human Factors (RE&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 done in the former NextGen - Self-Separation Human Factors (A12.d)

program, which addressed 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 the 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 2015 through FY 2020.

The research milestones and their statuses are shown in Table 1.2.3 below, followed by a summary of the significant progress made in FY 2014 towards achieving the R&D goal.

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

Year	Milestone	Status	Notes
2014	Complete research to identify likely human errors with NextGen flight deck avionics and potential means of compliance to new human error regulation 14 CFR 25.1302	Completed	2014 NARP Status: On schedule
2014	Evaluate and recommend minimum display standards and operational procedures for use of Cockpit Display of Traffic Information to support pilot awareness of potential ground conflicts and to support transition between taxi, takeoff, departure and arrival phases of flight	Deleted	Milestone is deleted due to changing sponsor priorities 2014 NARP Status: On schedule
2014	Complete research to enable enhanced aircraft spacing for surface movements in Low Visibility Operations/Surface Movement Guidance and Control System (LVO/SMGCS) Chart Usability	Completed	2014 NARP Status: Accelerated from 2015 to 2014
2015	Complete research and provide human factors guidance for Automatic Dependent Surveillance-Broadcast/ Cockpit Display of Traffic Information equipment used for In-Trail Procedures	On schedule	

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	New milestone

NextGen - Air Ground Integration Human Factors Program Progress in FY 2014:

- ✓ Completed human-in the-loop simulator study data collection evaluating CDTI Assisted Pilot Procedure concept. The project demonstrated the potential use of ADS-B In enabled flight deck display of traffic information to support coordinated interval management operations in the terminal environment. The procedure is expected to increase arrival efficiency and may result in less controller workload.

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 providing a concept for a reduced cost surface surveillance capability for small and medium airports in the NAS.

CAASD made the following progress in FY 2014 towards Aviation Safety R&D Goal 2:

- ✓ Developed Low Cost Surface Awareness, a block occupancy-based surface surveillance concept and prototype display using inexpensive sensors for course surveillance input. Advanced surface surveillance capabilities are cost-prohibitive to towered small and medium airports in the NAS. Under this research effort, CAASD developed a concept of operations, validated the concept with air traffic controllers in a simulation environment, and developed a small sensor network used to collect data at airports. Initial market analysis and a cost-benefit assessment has indicated that this concept could provide operational benefits to over 40 airports in the National Airspace System at a fraction of the cost of existing advanced surface surveillance systems. Low Cost Surface Awareness is expected to improve controller situation awareness of aircraft and vehicles on the surface, particularly in low visibility conditions.

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 (RE&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 below, followed by a summary of the significant progress made in FY 2014 towards achieving the R&D goal.

Table 1.3.1: Aeromedical Research Program Milestones

Year	Milestone	Status	Notes
2014	Develop and validate chemical kinetic models for bleed air systems for health and safety effects on passengers and crew	Completed	
2014	Develop and analyze methods to detect and analyze aircraft cabin contamination including chemical-biological hazards and other airborne irritants	Completed	
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	Delayed	Milestone is delayed from 2014 to 2015 due to extension of performance period by the Sponsor. 2014 NARP Status: On schedule
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	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	On schedule	

Year	Milestone	Status	Notes
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	On schedule	
2015	Develop advanced methods to extract aeromedical information for prognostic identification of human safety risks	On schedule	
2015	Deploy a system (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	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	New milestone

Aeromedical Research Program Progress in FY 2014:

- ✓ On May 14, 2013 the NTSB recommended lowering the alcohol driving limit to 0.05 grams per deciliter in blood in an effort to reduce the risk of injuries and deaths caused by

alcohol impairment (NTSB/SR-13/01). The Aerospace Medical Research Division of the Civil Aerospace Medical Institute (CAMI) conducted a study that examined 554 alcohol related publications to determine the feasibility and advisability of lowering the USA driving limit to 0.05 grams per deciliter blood alcohol content. Alcohol pharmacokinetics, instrument reliability, risk factors, law enforcement, and adjudication were considered in this overview of the literature for lowering alcohol limits.

- ✓ An academic research colloquium on Postmortem Forensic Toxicology in Aviation was conducted to address important issues in the subject area. The meeting was a scientific platform for medical examiners, coroners, forensic toxicologists, regional flight surgeons, NTSB personnel, and other accident investigation authorities, including FAA's Flight Standards District Offices and FAA's Office of Accident Investigation and Prevention employees. The overall outcome of the colloquium identified new avenues for future research activities in the field of aerospace medicine and toxicology.

- ✓ Evaluated biomarkers for the prediction and/or identification of various disqualifying pathologies that may cause incapacitation or impairment in-flight and result in aviation accidents (heart attacks, strokes, and others). Molecular biomarkers that signal disease are continuously being discovered. The identification of these biomarkers could aid the development of methods to facilitate disease diagnosis and development of decision support tools for medical certification and accident investigation processes.

- ✓ Assessed the clinical effects of cabin altitude during air travel on patients with pulmonary disease. Evaluated potential for increased risks to compromised individuals, such as Chronic Obstructive Pulmonary Disease (COPD) patients, and determined if there is an inflammatory response to hypoxia. This is a collaborative effort with the University of Oklahoma Health Sciences Center with a portion of the research sponsored by the Flight Attendants Medical Research Institute. Data sampling and collection phases have been completed.

- ✓ Developed a model regarding the kinetics of metabolic rundown in loss of consciousness resulting from hypobaric anoxia and +Gz acceleration.

- ✓ Conducted a research protocol developed to investigate the feasibility of novel hypoxia biomarkers (e.g. HPH1, S100B) in rapid decompression studies. A recent computational model that predicts physiological responses of passengers to rapid decompressions was validated. Physiologic monitoring included electroencephalography, transcranial Doppler blood flow, cardiovascular, and respiratory responses.

- ✓ Assessed the prevalence of diabetes in civil aviation pilots and developed a risk assessment model.

- ✓ Conducted a study to assess the prevalence of wheel well passengers and the characteristics of the 25 percent who survive. Stowaways in aircraft wheel wells face numerous health risks, many of which are fatal, such as: being mangled when undercarriage retracts, tinnitus, deafness, hypothermia, hypoxia, frostbite, acidosis and

falling when the doors of the compartment reopen. The landing gear compartment is not equipped with heating, pressure or oxygen, which are vital for survival at a high altitude.

- ✓ Developed a version of CARI (CARI-NAIRAS) that uses NASA's near real time Nowcast of Atmospheric Ionizing Radiation System (NAIRAS). The NAIRAS model predicts atmospheric radiation exposure from galactic cosmic rays and solar energetic particle events. The development of this CARI model requires the use of Monte Carlo simulations and calculations and thus relies on high performance computing capability.

- ✓ Conducted a study of the identification and comprehension of symbolic emergency exit signs for small transport airplanes. The signs use variations of approved symbols and are smaller than the sign approved for placement on a single, large transport category airplane. The main recommendations from this study are that future symbolic exit signs on transport-category airplanes be standardized and spaced within the cabin to provide the visual size needed for proper identification and comprehension.

- ✓ A project was conducted to identify, assess, and develop improved evacuation equipment and evacuation aids (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, additional guidance material and potential new regulatory requirements will be published. Initial implementation in the form of operational advice, e.g., Safety Alert for Operators, can also be used to encourage early adoption of enhanced evacuation systems.

- ✓ Developed effective media for enhanced aircraft passenger safety. Phase I assessed the comprehensiveness of placards, pictorials, pictograms, and other safety briefing of materials on board. Phase II applied findings from studies of emergency information resources to define enhanced safety information formats and media, including persuasive technology. The project was performed in collaboration with Rutgers University. It assessed the effects of reduced passenger mobility on evacuation performance.

- ✓ Conducted a study in response to the FAA Safety Team National Operations office's request for assistance with the collection, analysis, and reporting on fatal accident data in which a stall, a stall/spin, or a spin was determined to be a causal factor in the accident. The study provided operational data that will be collated with underlying human factors, medical, medical certification, and training issues.

- ✓ Evaluated the performance of inflatable emergency equipment for ditching scenarios. Part 1 evaluated the state-of-the-art in inflatable flotation device performance and alternative water landing survival strategies. (e.g., markings, handles, functional testing, floatation characteristics, assembly parts, etc.). The study supports revision of SAE International Aerospace Standard (AS) 1354, Individual Inflatable Life Preservers, by the Cabin Safety Provisions Technical Committee S-9. Part 2 incorporated findings of a research study concerning Technical Standard Order life preserver donning procedures to support FAA response to NTSB recommendation A-10-85: "Revise the life vest

performance standards contained in Technical Standard Order-C13 to ensure that they result in a life vest that passengers can quickly and correctly don."

- ✓ Developed more comprehensive and sensitive screening methodology for the identification of drugs. New medications are more potent and efficient and therapeutic levels of 1 or 2 nanogram/200 picograms in blood are hard to detect, yet may cause significant performance decrements. The result is a new biochemistry methodology using ultra-performance liquid chromatography – time of flight (mass spectrometry) (UPLC-TOF). For example, using TOF resolves compounds that are structurally different but have the same chemical formula (isobaric compounds). Use of UPLC augments specificity and accuracy (for identification of drugs).

1.3.2 Fire Research and Safety (RE&D - A11.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 combustion toxicity, the impact of flame retardant chemicals, health hazards of cabin materials, the impact of materials flammability on the initiation of in-flight fires, and post-crash survivability. Far-term research focuses on the enabling technology for ultra-fire-resistant interior materials.

The research milestones and their statuses are shown in Table 1.3.2 below, followed by a summary of the significant progress made in FY 2014 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	Delayed	Milestone is delayed from 2014 to 2015 due to a change in scope and focus. 2014 NARP Status: On schedule
2015	Develop a performance standard for small lithium batteries transported in passenger carrying aircraft	On schedule	
2015	Evaluate aircraft improvements to protect against lithium battery cargo fires	On schedule	
2015	Analyze the large number of in-flight smoke, odor and detector activation incidents	On schedule	
2015	Develop and finalize a small-scale flammability test method for the in-flight fire resistance of composite fuselage structure	On schedule	

Year	Milestone	Status	Notes
2016	Develop hidden fire detection and extinguishment improvements	On schedule	
2016	Develop a computational fluid dynamics model for hidden fire growth	On schedule	
2017	Evaluate detector technology that discriminates between aircraft fire and non-fire smoke/odor sources	On schedule	
2017	Determine the efficacy of current emergency smoke ventilation procedures and certification criteria	On schedule	
2018	Test and evaluate an integrated aircraft fire detection and extinguishment system	On schedule	
2018	Examine state-of-the-art technology for protection of compressed hydrogen in aircraft fuel cell applications	On schedule	
2019	Conduct a cost-benefit analysis of an integrated fire detection and extinguishment system	On schedule	
2019	Develop fire protection measures for aircraft fuel cell applications	On schedule	
2020	Conduct state-of-the-art review of fire-safe technology to replace stored compressed oxygen and chemical oxygen generators	On schedule	New milestone

Fire Research and Safety Program Progress in FY 2014:

- ✓ Undertook testing to evaluate the effectiveness of proposed fire containment covers and fire resistant containers with a built-in suppression system. Early test results showed promising effectiveness on fires involving ordinary combustible materials. Testing progressed to fires involving lithium metal and lithium-ion batteries. These fire mitigation proposals proved to not be effective against fires involving lithium metal batteries. The result of two tests involving bulk quantities of lithium-ion batteries was violent fuel/air explosions that destroyed the container. The cause of the explosions was the ignition of flammable hydrogen and hydrocarbon gases that had vented from the lithium-ion batteries during thermal runaway. These results have serious implications for the carriage of these types of batteries in the cargo compartments of passenger carrying aircraft due to the potential for causing a catastrophic accident. After these results, the focus of testing shifted to attempt to characterize the composition of the vented gases from a variety of battery chemistries and to determine the conditions required for fuel/air explosions to occur. This change in focus caused the delay in beginning work on evaluating the effectiveness of water spray systems in freighter main deck cargo compartments.

- ✓ The need for a performance packaging standard for the shipment of small lithium batteries on passenger aircraft was identified at the February meeting of the International Civil Aviation Organization (ICAO) Dangerous Goods Panel. A breakout group was formed, led by the FAA, to identify the requirements for a packaging standard that would allow shipment of otherwise prohibited cells in small quantities on passenger aircraft. A

draft standard was presented to the group by the FAA and used as a starting point. The draft has been through seven versions to date and is ready for field testing. Tests will be performed at the Tech Center and by the battery manufacturers to evaluate the standard and recommend changes or enhancements. Batteries in the size and type referred to in the standard have been procured. The standard, once accepted, will become part of the ICAO Dangerous Goods Technical Instructions and used as a basis for exemptions or approvals to allow shipment of lithium batteries on passenger aircraft in a restricted manner.

- ✓ Testing is underway to evaluate the potential of a Class E cargo compartment water mist systems to suppress cargo fires. If this type of systems proves to be potentially effective, testing will continue with fires involving lithium batteries. The fire hazards from lithium batteries vary widely depending on the type, size and chemistry. Representative types of batteries will be tested to evaluate if a water mist system might be effective on some common battery types.

- ✓ A study was undertaken to analyze in service occurrences of fire, smoke or fume (FSF) events on U.S. passenger and freighter airplanes in revenue service over a ten year period. In addition, false indications of fire and smoke in engines, cargo compartments, lavatories, etc., will be analyzed. The data sources are the FAA Accident and Incident Data System, NTSB Aviation Accident Database and FAA Service Difficulty Reports. It is estimated that over 16,000 occurrences from these data sources will be FSF and false warning evidence. As well as the textural information, date of occurrence, aircraft type, and other flight information, 24 data fields will be entered into the database. Examples of the data are location of FSF; type of detection; component, object or system producing fire/smoke; flight interruption; emergency evacuation; ground/airplane damage; and number of injuries. The study includes analysis of the data for important safety trends. For example, genuine and false alarms by source – engines, cargo compartments, lavatories, etc. – will be compared; and the frequency of the impacts of FSF events (diversions, overweight landings, etc.) will be assessed. Although data validation and analysis has not yet been carried out, certain parameters are being monitored throughout the study. The data suggests that over the period 2002 to 2005 inclusive, for example, approximately 66 percent of lavatory smoke detector warnings were false, approximately 94 percent of inaccessible cargo compartment smoke warnings were false, and unscheduled landings (diversions or returns to the departure airport) due to FSF or false warning events appear to be in the area of one per day. The final products of this study will be a final report analyzing the data and an accessible data base residing at the Fire Safety Branch web site at www.fire.tc.faa.gov.

- ✓ Three test apparatuses for evaluating the flame propagation potential of structural composites were constructed and validated with machine-to-machine comparative test series. Reproducibility was confirmed by testing all apparatuses in different laboratories, as well as shipping one device each to Boeing and Airbus, and performing the same test series. Currently, the apparatus is being used to evaluate the flammability of other inaccessible area materials, including environmental conditioning system ducting and wire insulation, though these applications require unique specimen mounting methods.

Guidance material is also being developed to adequately address the various configurations of materials to be tested with this apparatus, and is to be reviewed through the International Aircraft Materials Fire Test Working Group.

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 Systems Safety Management Transformation (F&E - 3A10B - G07M.02-01 - NextGen – System Safety Management Portfolio)

The Systems Safety Management Transformation Program supports Aviation Safety R&D Goal 4 by developing a comprehensive and proactive approach to aviation safety especially as it relates to the implementation of NextGen. The research enables safety assessments of proposed NextGen concepts, algorithms, and technologies and provides system knowledge to understand economic, implementation, operational and performance impacts (with respect to safety) of NextGen system alternatives. The program supports the development and implementation of integrated safety management systems across the air transportation system to ensure that the safety risk throughout the system is managed to an acceptable level.

Additional information on this F&E program can be found by referencing the NAS Enterprise Architecture.

Note that starting in FY 2015, this program's funding and activities have been subsumed into NextGen F&E portfolios and, as such, will no longer be presented individually in the narrative of future *NARP* publications.

The research milestones and their statuses are shown in Table 1.4.1 below.

Table 1.4.1: Systems Safety Management Transformation Program Milestones

Year	Milestone	Status	Notes
2015	Develop prototype system baseline risk software for airports and terminal areas without sophisticated surveillance Airport Surface Detection Equipment, Model X (ASDE-X sites)	On schedule	
2015	Develop prototype system risk forecast software for airports and terminal areas without sophisticated surveillance (ASDE-X sites)	On schedule	
2015	Test the prototype baseline and forecast software at the top 100 U.S. airports with and without sophisticated surveillance	On schedule	
2015	Test the prototype forecast software at the top 100 U.S. airports with and without sophisticated surveillance	On schedule	

Year	Milestone	Status	Notes
2015	Deliver trend analysis software for risk estimates for top 100 U.S. airports with data requirements for trend validation	On schedule	
2015	Develop baseline event sequence diagrams and probabilistic risk-based calculations for 30 accident scenarios relevant to aviation safety calibrated to U.S. historical data as well as additional accident scenarios relevant to Unmanned Aerial Vehicle (UAV) activity	On schedule	
2015	Implement fault-trees associated with primary failure modes relevant to the 30 accident scenarios in a web-based environment	On schedule	
2015	Customize risk-based reports for scenarios relevant to the FAA Lines of Business	On schedule	
2015	Develop Aviation Safety Information Analysis and Sharing (ASIAS) data interchange protocol and report that provides a model-based risk assessment of an airport surface safety risk	On schedule	
2015	Integrate international risk baselines (and a comparison report) through a cooperative research activity with Single European Sky ATM Research (SESAR)	On schedule	
2015	Deliver a preliminary peer-review report on FAA/ EUROCONTROL data exchange on ISAM and SESAR Accident Incident Model for system risk baselines	On schedule	
2015	Deliver model-based risk calculation software deployed in web-based environment extended to include new vehicles (UAV)	On schedule	
2015	Produce precursor data tracking requirements document including data requirements for UAV modeling	On schedule	
2015	Conduct annual NAS-wide risk impact assessment for implementation of NextGen using ISAM model and expert assessments	On schedule	
2015	Provide results of expert-judgment assessment of NextGen safety impacts on operational scenarios	On schedule	
2015	Deliver a peer review coordination report: ISAM results of NextGen and SESAR impacts (FAA/ EUROCONTROL cooperative effort)	On schedule	
2015	Conduct test of Standardized hazard taxonomy and associated Event Sequence Diagram and Fault Tree associations	On schedule	

Year	Milestone	Status	Notes
2016	Produce a detailed functional Concept of Operations (ConOps) for Integrated Assessment Safety Model (ISAM), including a data-interchange protocol and a precursor data tracking requirements document to link FAA data sources to ISAM feeds	On schedule	New milestone
2016	Incorporate a specific risk/barrier model assessment capability into the ISAM software to support ATO risk analysis	On schedule	New milestone
2016	Directly integrate the outputs of the airport and terminal risk baseline forecasting model into the ISAM risk model	On schedule	New milestone
2016	Increase the scope of the ISAM model to include domestic operations of international carriers, international operations of domestic carriers, and the impact of planned Single European Sky Air Traffic Management Research (SESAR) segments as relevant to each	On schedule	New milestone
2016	Update the ISAM model to cover planned NAS-wide changes due to NextGen, Rulemaking, and new vehicle implementations, and deliver annual NAS-wide risk impact assessment for NextGen implementation segments with a risk report and metric assessment using ISAM model and expert assessments	On schedule	New milestone

1.4.2 System Safety Management (RE&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 en route domains.

The research milestones and their statuses are shown in Table 1.4.2 below, followed by a summary of the significant progress made in FY 2014 towards achieving the R&D goal.

Table 1.4.2: System Safety Management Program Milestones

Year	Milestone	Status	Notes
2014	Complete the compilation of risk analysis data and/or statistical data into a format best suited for efficient use in transport airplane risk analysis	Completed	2014 NARP Status: On schedule

Year	Milestone	Status	Notes
2015	Develop an integrated domain assessment proof of concept to support of the Air Traffic Safety Oversight Service's approval process of controls for high risk hazards	On schedule	New milestone
2015	Complete the study on best practices for training and using Angle of Attack Equipment in general aviation operations.	On schedule	
2015	Expand the Aviation Safety Information Analysis and Sharing system safety analysis to other domains (e.g., general aviation, rotorcraft, corporate, military)	On schedule	
2016	Complete an evaluation of an identified airplane-based measuring method concerning real-time runway slipperiness reporting of all potential runway surface conditions and airplane configurations	On schedule	
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 (ATO) facilities, systems, procedures, and safety standards	On schedule	
2018	Expand the Integrated Domain Assessment from eight selected NAS systems to all major NAS systems	Delayed	Milestone is delayed from 2017 to 2018 due to anticipated delays in funding. 2014 NARP Status**:** On schedule

Year	Milestone	Status	Notes
2017	Develop criteria for determining when a missed approach should be performed	On schedule	Milestone was revised due to a shift in focus resulting from too few cases of go-around data. Old wording: "Complete an initial feasibility assessment of air traffic controllers calling for go-arounds according to the to-be-defined stabilized approach criteria" 2014 NARP Status: On schedule
2018	Conduct exploratory simulation study of appropriate angle-of-attack sensor and display combinations for mitigating low airspeed and upset events for GA aircraft	Deleted	Milestone is deleted due to changing sponsor priorities. 2014 NARP Status: On schedule
2018	Develop methodology to identify and optimize Air Traffic Safety Oversight Service (AOV) oversight activities, surveillance targets, and data collection parameters based on risk trends and AOV resources	On schedule	
2018	Develop additional capability to the Integrated Domain Assessment tool functions to support the evaluation of NAS procedure changes related to separation minima	On schedule	
2018	Develop the state-of-art analytical capabilities for rotorcraft Aviation Safety Information Analysis and Sharing (ASIAS) System to analyze rotorcraft data	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	Demonstrate applications of the Integrated Domain Assessment tool functions	On schedule	
2020	Develop advance risk assessment capabilities for safety oversight	On schedule	New milestone

System Safety Management Program Progress in FY 2014:

- ✓ Completed a study to determine underreporting frequencies for a wide category of transport airplane occurrences and malfunctions. The number of reports submitted by operators and manufacturers was compared with alternative sources of information for various categories of occurrences and malfunctions to determine if the type of occurrence affects the degree of underreporting. Representatives from various types of organizations in the aviation industry were consulted to gather their view on the characteristics that influence the amount of underreporting. The study reveals that while incidents are uniformly reported, there are varying degrees of underreporting for occurrences and

malfunctions. The reporting percentages range from 1 percent to 85 percent depending on the type of the occurrence. The underreporting frequencies are useful information for the Transport Airplane Directorate in conducting continued operational safety assessment.

- ✓ Conducted a study to determine the best practices of using an angle of attack (AOA) indicator to enhance the situational awareness of general aviation (GA) pilots. One hundred twenty pilots, divided into four groups, were recruited to participate in flight experiment using three different GA aircraft types flown. One group received training on the use of AOA indicator and was allowed use of AOA indicator during experimental flights, one group was trained but not allowed to use AOA indicator, one group was not trained but allowed to use AOA indicator, and one group neither received training nor allowed to use the AOA indicator. Data were collected during the experimental flights for analysis to determine if the stability of the aircraft approach was impacted with varying levels of exposure to an AOA indicator and training. A video was produced to train GA pilots on how to properly use the AOA indicator installed in a GA aircraft cockpit for different phases of flight. The ultimate research results will be used by the FAA Office of Accident Investigation and Prevention to educate the GA community on the benefit of using AOA indicators in GA operations.

- ✓ Expanded ASIAS into GA and rotorcraft. In the GA domain, the FAA conducted several research tasks to improve the capability of the National General Aviation Information Database, such as, developing and implementing the registration and account-creating functionality, and supporting the FAA GA ASIAS Demonstration Project. In rotorcraft, the FAA completed preliminary investigation of current technologies, techniques, and challenges surrounding widespread adoption of Helicopter Flight Data Monitoring (FDM). An initial set of FDM parameters, rates, and exceedances were analyzed along with causal factors signifying various events for rotorcraft accidents/incidents. Initial research findings and outreach efforts were presented to the helicopter community.

- ✓ The Terminal Area Safety (TAS) team identified models to characterize aircraft deceleration for determining runway slipperiness condition through airplane performance data during landing roll. The team applied the developed algorithm to process flight recordings obtained from previous winter operations and completed preliminary analyses of the runway condition to compare with weather data. The analyses are continued to evaluate the technical validity of the models and algorithms. Follow-up full scale operations will also be conducted to demonstrate the feasibility of the reporting for various combinations of surface conditions and the use of airplane deceleration devices.

- ✓ The TAS team conducted the first evaluation of the newly proposed objective motion cueing criteria in assessing simulator motion fidelity. The experiment used the NASA Ames Vertical Motion Simulator with different motion conditions to evaluate whether or not training with motion is valuable for initial training of commercial transport pilots. Sixty-one GA pilots flew four challenging tasks. Both subjective and objective measures were collected and analyzed. The TAS team presented the analysis results at June AIAA

Aviation Conference. Work continues on development of a plan for the follow-up evaluations.

- ✓ A Facility Risk Assessment Tool (FRAT) proof of concept was completed to assess air traffic facility risk within the NAS. The FRAT will be used by AOV to target its oversight resources toward ATC facilities posing the highest risk. An initial set of FRAT risk factors and supporting data sources were developed to quantify each risk factor. Techniques were identified and applied to integrate data sources to populate ATC facility attributes, quantify risk factors, and calculate overall facility risk. The initial development and test of FRAT risk model algorithms was completed, along with a prototype demonstration. User sessions were conducted with AOV 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 facilities with similar attributes. The initial FRAT Framework Analysis Report captured the outcomes of the algorithm development and test effort, including updated risk factors, data sources, quantitative risk models, and algorithms for calculating ATC facility safety risk factors and overall facility risk scores.

- ✓ The TAS team identified a list of configurations that are relevant to the critical characteristics in the development of a stall model for recovery training. The team also completed the extraction of geometric feature information from the previous wind tunnel test data. Work continued on correlation between the stall characteristics and geometric features, as well as preparation for the follow-up data collection and analyses.

- ✓ Completed the development of datasets, taxonomies, a model, methodologies, and prototype specifications for an Integrated Domain Assessment (IDA) of NAS changes to support AOV's approval process for mitigating high risk hazards due to changes in NAS. The structure information of eight NAS systems and their associated safety data (such as hazards, causes, and controls, as identified in Safety Risk Management Documents) were captured into datasets. A set of taxonomies were developed to classify the safety information. The IDA model that integrates system structure into safety information was developed to enable the identification of interactions and interdependencies among these eight systems. Two analytical methodologies to assess safety impact of changes in NAS as well as the effectiveness of controls were developed to support AOV's Approval, Acceptance, and Concurrence and Safety Management Action Review Team processes. The initial functional specifications of the IDA prototype were developed to guide the IDA tool development in FY 2015.

1.4.3 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 enabling a General Aviation FDM capability to inform the mitigation of safety issues.

CAASD made the following progress in FY 2014 towards Aviation Safety R&D Goal 4:

- ✓ Deployed the General Aviation Airborne Recording Device (GAARD), a prototype low-cost FDM capability for GA operators. The capability, an application for a smart phone or tablet, provides the GA community with a means to record and voluntarily submit basic flight data to a national archive, similar to that done for the commercial airline community via the FAA's ASIAS program. This FDM capability is a key enabler for the FAA's GA Demonstration Project, a program designed to identify, track, and mitigate safety issues experienced by GA operators.

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 (RE&D - A12.c)

The NextGen - Weather Technology in the Cockpit (WTIC) Program supports Aviation Safety R&D Goals 5 and 6 by developing, verifying, and validating requirements to support airworthiness standards for enabling availability and improving the quality and quantity of meteorological (MET) information to the aircraft to support safe current and NextGen operations. The program will result in the development of standards and requirements that define the weather information in the cockpit needed to support operations, the presentations and interfaces to enable proper information consumption and safe operations by pilots, and capabilities that enable efficient dissemination of the weather information to and from the cockpit at the right place and right time.

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 under Aviation Safety R&D Goals 5 and 6, those described in section 2.4.1 under Efficiency R&D Goals 4 and 5, and those described in section 3.1.4 under Environmental R&D Goals 1 through 3 define the program, and together provide the WTIC Program's FY 2015 budget and planned milestones from FY 2015 through FY 2020.

The research milestones and their statuses are shown in Table 1.5.1 below, followed by a summary of the significant progress made in FY 2014 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	Delayed	Milestone is delayed from 2014 to 2015 due to longer data collection period. 2014 NARP Status: On schedule
2015	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	Delayed	Milestone is delayed from 2014 to 2015 due to task complexity. 2014 NARP Status: On schedule

Year	Milestone	Status	Notes
2015	Propose standards and develop recommendations to address meteorological information shortfalls that were identified as causal factors in selected weather-related safety incidents/accidents	On schedule	2014 NARP Status: Delayed from 2014 to 2015
2016	Develop recommendations for standards on time stamping of cockpit composite weather presentations	Delayed	Milestone is delayed from 2014 to 2016 due to increased scope. 2014 NARP Status: On schedule
2016	Develop recommendations for providing meteorological-uncertainty information to the cockpit to increase pilot confidence in weather forecasts.	On schedule	2014 NARP Status: Delayed from 2015 to 2016
2016	Provide recommendations for rendering standards for inclusion in the WTIC minimum weather service recommendations for general aviation	On schedule	Milestone was revised for clarity. Old wording: "Provide recommendations on optimal presentation of general aviation weather information" 2014 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	Milestone was revised for clarity. Old wording: "Demonstrate the integration of navigation information and flight information, including weather information, into cockpit decision-making and shared situational awareness among pilots, dispatchers, and air traffic controllers supported by NextGen air and ground capabilities" 2014 NARP Status: Delayed from 2016 to 2017
2019	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 (GA) safety risks associated with gaps of MET information in the cockpit	On schedule	

NextGen - Weather Technology in the Cockpit Program Progress in FY 2014:

- ✓ Completed development of a Part 121/135 WTIC Concept of Operations (ConOps) and a Part 91 WTIC ConOps. These ConOps enable the WTIC program to begin functional analyses to produce user needs requirements and to identify operational shortfalls

(inefficiencies and safety risks) that are attributable to gaps of MET information in the cockpit. The WTIC minimum weather service will resolve the identified gaps.

- ✓ The Partnership to Enhance General Aviation Safety, Accessibility and Sustainability (PEGASAS), the FAA's COE for General Aviation, conducted initial gap and shortfall analyses of MET products, MET information, pilot training, and causal factors that contributed to unintended transition from visual flight rules into instrument MET conditions. Products developed by PEGASAS include an inventory of current weather products and technologies, a weather condition index tool, weather risk matrix, weather scenarios, and Pugh matrix. Recommendations for the WTIC GA minimum weather service will be developed to address the gaps and shortfalls identified in these analyses.

1.5.2 Weather Program (RE&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 2015 budget and planned milestones from FY 2015 through FY 2020.

The research milestones and their statuses are shown in Table 1.5.2 below, followed by a summary of the significant progress made in FY 2014 towards achieving the R&D goals.

Table 1.5.2: Weather Program Milestones

Year	Milestone	Status	Notes
2014	Complete initial evaluation of high-resolution in-flight icing analysis and forecast capability	Completed	2014 NARP Status: On schedule
2015	Transition in-flight icing Alaska forecast and analysis capability for implementation (as detailed in the NAS infrastructure portfolio section of the NextGen Implementation Plan (NGIP))	On schedule	2014 NARP Status: Delayed from 2014 to 2015
2016	Demonstrate integrated FAA/National Weather Service (NWS) ceiling and visibility forecast capability	On schedule	2014 NARP Status: Delayed from 2015 to 2016
2016	Transition ceiling and visibility Alaska analysis capability for implementation (as detailed in the NAS infrastructure portfolio section of the NextGen Implementation Plan (NGIP))	On schedule	

Year	Milestone	Status	Notes
2016	Complete initial demonstration/ validation of 0-36 hour probabilistic forecast of oceanic convection	On schedule	
2017	Transition Offshore Precipitation Capability (radar-like analysis) to the National Weather Service for operational implementation	On schedule	New milestone
2018	Transition CONUS in-flight icing forecast and analysis capability, that includes liquid water content, drop-size distribution, and temperature, for implementation (as detailed in the NAS infrastructure portfolio section of the NextGen Implementation Plan (NGIP))	On schedule	

Weather Program Progress in FY 2014:

- ✓ Completed a technical review, safety risk management, and operational evaluation of the Current Icing Product (CIP) and Forecast Icing Product (FIP) algorithms to meet NextGen Plan requirements of high resolution diagnoses and forecasts of atmospheric conditions conducive to aircraft icing. These upgraded algorithms, also known as CIP/FIP High Resolution (HiRes), improve the horizontal (13 kilometers) and vertical (500 feet) resolution and extend the forecast from 12 out to 18 hours. CIP/FIP HiRes were implemented operationally on the Aviation Digital Data Service in fourth quarter FY 2014.

1.6 Aviation Safety R&D Goals 7 - 9

Optimized technical and regulatory provisions and processes used to oversee, coordinate, regulate, and promote safe and responsible activities for reliable aerospace operations between space and Earth.

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 (RE&D – A12.d)

The Commercial Space Transportation Safety Program supports Aviation Safety R&D Goals 7, 8, and 9 by examining safety considerations for commercial space transportation, including those that involve crew and spaceflight participants' health and safety, spacecraft vehicle safety, launch, and re-entry risks, public safety, and personal property risk. In previous NARP versions, milestones for this research were funded through the FAA's Operations budget appropriation. In 2014, R&D for the Commercial Space Transportation Program was conducted through its COE and was funded through the NextGen – Air Ground Integration Human Factors (A12.b) budget line item (BLI). In FY 2016, a new, separate RE&D BLI – A12.d - has been created to capture the research being conducted for Commercial Space.

The Commercial Space Transportation Safety Program's R&D activities encompass a broad range of topics, divided into four major themes encompassing space operations (Space Traffic Management and Operations), space physical sciences (Space Transportation Operations, Technologies, and Payloads), space biological sciences (Human Spaceflight), and space social sciences (Space Transportation Industry Viability).

Since August 2010, a major contributor to the program's activities has been the universities that competed for, and were selected to become, the FAA Center of Excellence for Commercial Space Transportation (COE CST). The COE CST 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 research milestones and their statuses are shown in Table 1.6.1 below, followed by a summary of the significant progress made in FY 2014 towards achieving the R&D goals.

Table 1.6.1: Commercial Space Transportation Safety Program Milestones

Year	Milestone	Status	Notes
2014	Develop FACET (Future ATM Concepts Evaluation Tool) model to calculate probabilistic four-dimensional rocket trajectory envelopes to minimize impact on NAS	On schedule	
2014	Develop and deliver "anytime" version of Space Based Model Predictive Optimization to optimize power consumption and minimum energy trajectory calculations	On hold pending further funding	
2014	Report results of thermal ablation testing and analysis of ultra-high temperature composites for thermal protection systems in liquid rocket engine plume	On hold pending further funding	
2015	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	On schedule	2014 NARP Status: Delayed from 2014 to 2015
2015	Complete Whole Atmosphere Model implementation coupling ionosphere and magnetospheric forcing and assimilate high-resolution data	On hold pending further funding	
2015	Report centrifuge test results evaluating biomedical monitoring equipment	Completed	2014 NARP Status: On schedule

Commercial Space Transportation Safety Program Progress in FY 2014:

- ✓ Completed centrifuge testing that evaluated biomedical monitoring equipment and presented the results at the 2014 Aerospace Medical Association (AsMA) conference in May 2014. The research team for this effort won multiple awards, which were presented at the AsMa conference. A journal article outlining the results was published in July, 2014 (Blue, Rebecca S., et al. "Tolerance of centrifuge-simulated suborbital spaceflight by medical condition." Aviation, space, and environmental medicine 5.7 (2014): 721-729) and further articles are to planned to be published.

- ✓ Fabricated polymer derived ceramics (PDC)/carbon fiber laminated composites and tested them with the E-285 ablation test rig. Introduced the concept of three-dimensional composites into the Thermal Protection System (TPS) composites to improve the delamination resistance. Built an experimental setup for the vertically aligned carbon nanotube array as a new reinforcement of the PDC composites and tested it under different carbon nanotube growth conditions. The vertically aligned carbon nanotube array is expected to contribute highly anisotropic thermal conductivity to the final TPS composite.

- ✓ Created robust internal collaboration within the FAA to help accelerate 1) scenario development and 2) the actual running of many cases for the FACET (Future ATM Concepts Evaluation Tool) model.

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 – 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 below, followed by a summary of the significant progress made in FY 2014 towards achieving the R&D goal.

Table 1.7.1: Airport Cooperative Research Program – Safety Milestones

Year	Milestone	Status	Notes
2014	Develop a runway veer-off location distribution risk assessment model with guidelines for reporting and collecting runway veer-off incident/accident data	Completed	ACRP project 04-14 is completed and the tool is available at http://www.trb.org/ACRP/Blurbs/170535.aspx. 2014 NARP Status: On schedule
2014	Develop a scalable tool to create and maintain integrated incident response plans for hazards in and around airport terminals	Completed	ACRP project 04-15 is completed and the final report is available at: http://www.trb.org/main/blurbs/171121.aspx 2014 NARP Status: On schedule
2016	Develop a guidebook for airports on conducting the safety risk management process	On schedule	New milestone
2016	Develop a toolkit to assist airports in effectively planning for, responding to, and recovering from significant weather events	On schedule	New milestone

Airport Cooperative Research Program – Safety Progress in FY 2014:

- ✓ Explored a method to assess the risk of lateral runway excursions, also known as veer-offs, and suggested ways to improve veer-off incident and accident reporting.

- ✓ Created a tool that 1) maintains integrated incident response plans that address hazards in and around airport terminals, and 2) assists in the development of a response plan to help mitigate the impact of events on terminal users.

1.7.2 Airport Technology Research Program – Safety (AIP)

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

The research milestones and their statuses are shown in Table 1.7.2 below, followed by a summary of the significant progress made in FY 2014 towards achieving the R&D goal.

Table 1.7.2: Airport Technology Research Program – Safety Milestones

Year	Milestone	Status	Notes
2014	Complete evaluation to determine feasibility of implementing bird radar displays in air traffic control towers	Completed	2014 NARP Status: On schedule
2014	Complete the first phase of a study to establish a test protocol and collect baseline data for large aviation fuel fires at the New Large Aircraft Full-Scale Mockup	Completed	2014 NARP Status: On schedule
2014	Complete Taxiway Centerline Deviation data collection for Airplane Design Group - III.	Completed	2014 NARP Status: On schedule
2014	Conduct an evaluation of Approach Hold/Runway Safety Area signage and markings.	Completed	2014 NARP Status: On schedule
2014	Complete a review of problematic taxiway locations leading to runway incursions.	Completed	2014 NARP Status: On schedule
2015	Complete human factor laboratory/ simulation tests on use of linear light sources on airports	Delayed	Milestone is delayed from 2014 to 2015 due to the addition of simulation activities. 2014 NARP Status: On schedule
2015	Complete in-service testing of new light emitting diode lighting circuits at a large and small airport	Delayed	Milestone is delayed from 2014 to 2015 due to changes in specifications. 2014 NARP Status: On schedule
2015	Update the Airport Safety Database and publish updated analysis report	Delayed	Milestone is delayed from 2014 to 2015 and the report will be available early FY 2015 for internal use only. 2014 NARP Status: On schedule
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.	Delayed	Milestone is delayed from 2014 to 2015 due to a change in scope. 2014 NARP Status: On schedule

Year	Milestone	Status	Notes
2015	Publish report on characterization of foreign object debris collected at Chicago O'Hare International Airport (ORD)	Delayed	Milestone is delayed from 2014 to 2015 due to significant editing. 2014 NARP Status: On schedule
2015	Complete construction of the High Temperature Pavement Test Facility	Delayed	Milestone is delayed from 2014 to 2015 due to poor weather conditions. 2014 NARP Status: On schedule
2015	Complete upgrade of all FAA Pavement Software to Windows Presentation Foundation to create a common platform to integrate the programs	Delayed	Milestone is delayed from 2014 to 2015 due to task complexity. 2014 NARP Status: On schedule
2015	Complete definition of airport pavement failure for 40 Year Pavement Life project	Delayed	Milestone is delayed from 2014 to 2015 due to task complexity. 2014 NARP Status: On schedule
2015	Complete rehabilitation of the Airport Technology Research Taxiway	On schedule	2014 NARP Status: Delayed from 2014 to 2015
2015	Complete Mu-Slip testing with nose gear brake testing and main gear brake testing, both on contaminated runway surfaces	On schedule	2014 NARP Status: Delayed from 2014 to 2015
2015	Complete draft concept of operations for bird radar in air traffic control	Completed	2014 NARP Status: On schedule
2015	Complete first round of small scale fire testing of aviation biofuels	Completed	2014 NARP Status: On schedule
2015	Install Taxiway Centerline Deviation systems at two (2) ADG-1 airports	On schedule	New milestone
2015	Complete the Approach Hold/Runway Safety Area (RSA) field evaluations at ORD and Cleveland International Airport (CLE)	On schedule	New milestone
2015	Investigate the feasibility of conducting a runway centerline deviation study using a prototype sensing and data acquisition system	On schedule	New milestone
2015	Complete Draft Advisory Circular on Guidance for Selection, Procurement and Management of Safety Management System (SMS) Software	On schedule	New milestone
2015	Evaluation of Web-patterned Structural methyl methacrylate (SMMA) Paint Markings	On schedule	New milestone
2016	Survey airport communities to update dose-response curves for aircraft noise annoyance and sleep disturbance	Deleted	Milestone is deleted as it encompasses a multi-year effort already being captured in other milestones. 2014 NARP Status: Delayed from 2013 to 2016
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/RSA Study	On schedule	New milestone

Year	Milestone	Status	Notes
2016	Complete a 1 year cost-benefit study of utilizing foreign object debris (FOD) detection systems on airports. Study to be based on available FOD systems currently in operation at civil airports as of October 2014	On schedule	New milestone
2016	Complete testing on the use of streaming, clean firefighting agents in Aircraft Rescue and Firefighting (ARFF) responses to aircraft cargo compartment fires	On schedule	New milestone
2020	Development of new firefighting performance requirements for the use of Compressed Air Foam (CAF) technologies in ARFF	On schedule	New milestone

Airport Technology Research Program – Safety Progress in FY 2014:

- ✓ Conducted the first of two Knowledge Elicitation Activities (KEA) for the development of the Wildlife Surveillance Concept (WiSC). WiSC refers to the subsequent research effort following the preliminary assessment of the feasibility of integrating bird radar displays into ATC environments such as the Tower and Terminal Radar Approach Controls (TRACONs). The KEA was used to collect information from stakeholders including Certified Professional Controllers, Front Line Managers and commercial airline pilots to learn how the currently handle bird threat information and their perspectives on the potential introduction of supplemental bird threat information into the ATC environment.

- ✓ Completed an installation of artificial turf at Orlando Sanford International Airport to mitigate burrowing of Gopher Tortoises. The test section is 3.5 acres surrounding the blast pad of runway 18 with 4 wildlife cameras installed to monitor wildlife activity on and around the turf installation. Vehicle passage tests were also conducted to evaluate the durability of artificial turf in the airport environment.

- ✓ Completed field evaluation of prototype safety orange construction signs at Chicago O'Hare International Airport (ORD), Illinois; Portland International Airport (PDX), Oregon; Theodore Francis Green State Airport (PVD), Rhode Island; Long Island MacArthur Airport (ISP), New York; and Orlando Sanford International Airport (SFB), Florida. The signs evaluated included "Construction Ahead", "Construction On Ramp" and "TORA" (or "Take-off Run Available") signs. The results of the evaluation indicate that the orange signs offer a significant improvement in situational awareness for pilots and ground vehicle drivers operating within the vicinity of construction areas on an airfield.

- ✓ Evaluated Mu-Slip Characteristics of B727 Aircraft nose gear tires while braking on manufactured snow. Seventeen aircraft runs were conducted on a combination of new and tracked manufactured snow conditions to measure and record the Mu-Slip characteristics generated during braking. Testing was conducted on manufactured snow

test beds which were 300- 360 feet in length, 7 feet in width, and 2 inches in depth. The aircraft nose gear wheels traveled through the snow test beds at speeds ranging from 30 to 45 miles per hour with application of nose gear brake pressure/torque controlled by a programmable braking system. Mu-Slip curves were generated for representative aircraft braking runs on the manufactured snow. The Mu values increased rapidly to an approximate level of 0.14 at less than 5 percent wheel slip and reached an upper limit of 0.16 as the wheel slip exceeded 40 percent. These Mu values are representative of values identified from previous aircraft brake testing conducted on snow covered surfaces.

- ✓ Testing was completed on the study of forcible entry on composite materials used in aircraft fuselage construction. A fully automated test rig was developed. This test rig automated the operation of a rescue saw plunging into and cutting through various composite materials to determine both the forces required to cut through the materials as well as which types of saw blades had the best performance. The airborne particulate resulting from the cutting operation was also analyzed to help support future requirements in firefighter personal protective equipment.

- ✓ A literature review of the current and future uses of alternative fuels in the airport environment was completed. This literature review identified where the industry trends were heading in alternative fuels. While all types of alternative fuel sources were analyzed, the primary focus was on the biofuels. The inclusions of alcohols and other changes to the fuel chemistry may have an impact of the effectiveness of current firefighting foams. This review has led to an initial listing of biofuel products which have been subjected to fire testing to determine how current foams perform.

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. Emphasis is on technologies that provide for 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 tests alternative airport surface detection technologies and the application of these technologies for pilot, controller, and vehicle operator situational awareness tools. Program initiatives include removal of Low Cost Ground Surveillance (LCGS) pilot sites, Runway Safety Assessment studies, and Enhanced Final Approach Runway Occupancy Signal (eFAROS) evaluations.

Additional information on this F&E program can be found by referencing the NAS Enterprise Architecture.

The research milestones and their statuses are shown in Table 1.7.3 below.

Table 1.7.3: Runway Incursion Reduction Program Milestones

Year	Milestone	Status	Notes
2015	Develop readiness report based on coordination of preliminary requirements document and cost benefit analysis documents required for Enhanced Final Approach Runway Occupancy Signal Investment Analysis Readiness Decision	On schedule	
2015	Develop documentation such as the Business Case Analysis Report required for an Enhanced Final Approach Runway Occupancy Signal Investment Analysis Readiness Decision in support of terminal Program Management Organization (PMO)	On schedule	
2015	Develop annual technical and operational evaluation report of Enhanced Final Approach Runway Occupancy Signal units at all prototype locations	On schedule	
2015	Complete report on testing of safety logic enhancements to runway incursion detection and prevention products	On schedule	
2015	Publish initial Project Plan for evaluation of new initiative identified for runway incursion detection and prevention	On schedule	
2016	Complete annual technical and operational evaluation report of existing RIRP prototype systems	On schedule	New milestone
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 RI indications	On schedule	New milestone
2016	Complete annual report on Runway Incursion (RI) prevention shortfall analysis	On schedule	New milestone
2016	Complete annual report on testing of safety logic enhancements to Runway Incursion (RI) detection and prevention products	On schedule	New milestone
2016	Publish the Project Plan and Resource Management Plan (RMP) for the utilization of a Small Airport Surveillance Sensor (SASS) as a 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 capacity and efficiency of the nation's aviation system.

Six R&D goals support R&D Principle 2 - Improve Efficiency with work spread across three budget appropriations (RE&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.

Table 2.0.1 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	Goal 1 - Develop Reduced Aircraft Separation in Trajectory- and Performance-Based Operations Goal 4 - Maximize Arrivals and Departures at Airports and in Metroplex Areas			
	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 Goal 4 - Maximize Arrivals and Departures at Airports and in Metroplex Areas		
	Major Airspace Redesign				
	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				
	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 2016, 30 percent of total FAA R&D funding is allocated to R&D Principle 2 - Improve Efficiency. Program funding levels for the 2015 Enacted and 2016 President's Budget are shown in Table 2.0.2. Percent of Program reflects each program's contribution to R&D Principle 2 in the 2016 President's Budget. Table 2.0.2 also lists the section and page number reference for each budget narrative within the FY 2016 CJ for the President's Budget Request. The FY 2016 CJ is available at http://www.dot.gov/sites/dot.gov/files/docs/FY2016-BudgetEstimate-FAA.pdf.

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

2016 BLI	Program	CJ Reference (Section /Page)	Appropriation Account	2015 Enacted ($000)	2016 President's Budget ($000)	2016 Percent of Program
A11.k	Weather Program	3C/45	RE&D	7,424	9,127	50%
A12.a	NextGen - Wake Turbulence	3C/56	RE&D	8,541	8,680	100%
A12.b	NextGen - Air Ground Integration Human Factors	3C/59	RE&D	2,909	2,663	30%
A12.c	NextGen - Weather Technology in the Cockpit	3C/62	RE&D	1,822	1,852	45%
A14.a	System Planning and Resource Management	3C/75	RE&D	525	594	25%
A14.b	William J. Hughes Technical Center Laboratory Facility	3C/77	RE&D	955	965	28%
1A01B	System Capacity, Planning and Improvements	3B/13	F&E	6,000	0	100%
1A01C	Operations Concept Validation and Infrastructure Evolution	3B/14	F&E	4,000	0	100%
1A01D	Major Airspace Redesign	3B/14	F&E	5,000	0	100%
1A10E	New Air Traffic Management Requirements	3B/61	F&E	4,980	0	100%
4A08	Center for Advanced Aviation System Development (CAASD)	3B/316	F&E	11,095	38,400	64%
--	Airport Cooperative Research Program - Capacity	3D/37	AIP	5,000	5,000	100%
--	Airport Technology Research Program - Capacity	3D/26	AIP	12,714	13,248	100%
	Total ($000)			**70,964**	**80,528**	

**CAASD R&D budget totals for 1) FY 2015 assume 33% for Safety, 67% to Efficiency, and 0% for Environmental and 2) FY 2016 and outyears assume 31% for Safety, 64% for Efficiency, and 5% for Environmental (subject to FFRDC Executive Board FY 2016 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 (RE&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 en route airspace and in the future NextGen airspace designs.

The research milestones and their statuses are shown in Table 2.1.1 below, followed by a summary of the significant progress made in FY 2014 towards achieving the R&D goal.

Table 2.1.1: NextGen - Wake Turbulence Program Milestones

Year	Milestone	Status	Notes
2014	Provide wake separation recommendations for Airbus 350 series aircraft	Completed	2014 NARP Status: On schedule
2014	Add Phoenix and Las Vegas airports to those approved to use 7110.308 procedures for their closely spaced parallel runways	Deleted	Milestone was deleted/not achieved due to insufficient operational need for 7110.308 operations at PHX and LAS, according to the operational staff at these airports. The research team did 1) complete the safety analysis research for PHX and LAS and 2) develop safe and viable instrument procedures for both sites to support dependent staggered operations under 7110.308, in accordance with recommendations from RTCA Task Force 5. 2014 NARP Status: On schedule
2015	Evaluate air traffic control procedures for providing wake mitigation separations between unmanned aeronautical systems and piloted aircraft	On schedule	

Year	Milestone	Status	Notes
2015	Develop and assess readiness of statistics based wake encounter risk evaluation tool for use by FAA wake turbulence subject matter experts (SMEs) in evaluating NextGen Trajectory Based Operations flight routing procedures	On schedule	Milestone was revised for clarity. Old wording: "Deliver statistics based wake encounter risk evaluation tool for use by FAA wake turbulence subject matter experts (SMEs) in evaluating NextGen Trajectory Based Operations flight routing procedures" 2014 NARP Status: On schedule
2016	Develop the algorithms that will be used in the Air Navigation Service Provider (and flight deck as needed) automation systems for setting dynamic wake separation minimum for each pair of aircraft	Deleted	Milestone was deleted in order to focus on research yielding the highest benefit in the terminal airspace. Rather than developing algorithms in 2016, the research team is choosing to do a more thorough analysis of these multiple concepts and develop the performance measures used by ATC for dynamic separation procedures so that concept feasibility and potential benefits can be assessed against research complexity. 2014 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 minimum in the terminal airspace for each pair of aircraft	On schedule	The research performed in support of this milestone can affect future algorithm development as appropriate when concepts are down selected. New milestone
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	Produce the initial draft of a safety risk management document for the Wake Turbulence Mitigation for Arrivals – system	Deleted	Milestone was deleted since the Wake Turbulence Mitigation for Arrivals - system SRMD work will be funded out of F&E funding in FY 2016-17 instead of being funded by this R,E,&D BLI. Going forward, this RE&D program's focus will be on Single Runway procedures. 2014 NARP Status: On schedule

Year	Milestone	Status	Notes
2018	Perform analysis in support of safety risk management documentation for Wake Turbulence Mitigation for Single Runway procedure	On schedule	New milestone
2019	Submit a draft of the safety risk management document for Wake Turbulence Mitigation for Arrivals – system (WTMA-S)	Deleted	Milestone is deleted since WTMA-S work will no longer be conducted under this BLI' 2014 NARP Status: On schedule
2019	Complete development of detailed operational concepts for dynamically modifying required wake mitigation separations	On schedule	New milestone
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	New milestone

NextGen - Wake Turbulence Program Progress in FY 2014:

- ✓ The existing FAA ATC Orders 7110.308, 1.5-Nautical Mile Dependent Approaches to Parallel Runways Spaced Less Than 2,500 Feet Apart, and Order 7110.316, Reduced Wake Turbulence Separation on Departure from Heavy/B757 Aircraft Departing Parallel Runways, Spaced Less Than 2,500 Feet, Using Wake Turbulence Mitigation for Departures (WTMD) were written in the context of weight classes of aircraft. These Orders were revised to reflect the wake turbulence categories associated with the Re-Categorization of Wake Turbulence Categories (RECAT) (Order 7110.659A).

- ✓ Delivered to the FAA the initial version of a data screening utility to identify potential wake turbulence encounters in A330 and B737 data sets for further collection of wake encounter statistics. The data screening tool was developed to screen flight data recorder data sets for potential wake encounters during post-flight analyses. It utilizes multiple algorithms to distinguish potential wake turbulence encounters from atmospheric turbulence and other types of upsets. The tool was extensively exercised using research aircraft data sets containing known wake encounters and end-to-end full flight recorder data sets to verify its capabilities to identify potential wake encounters. Future versions of the screening utility will process extraction modules for more specific aircraft types as well as provide a generic extraction module for processing data from any aircraft. The data screening utility provides the FAA with an automated capability to identify potential wake turbulence encounters ranging from reported major impact occurrences to minor non-reported occurrences. The FAA can leverage these data to conduct detailed analyses that may identify "hot spots" for wake turbulence encounters, as well as to support efforts for determining absolute wake encounter metrics for future safety cases. Potentially, the

data screening utility can also contribute to post-implementation assessments of NextGen ATC procedures where wake turbulence may be a factor.

- ✓ Completion of the fast time wind forecast algorithm research platform. As research progressed on the utility of wind based wake mitigation decision support tools, there developed a common requirement to forecast the winds that will be along the aircraft flight paths for both tactical and strategic reasons. The existing wind forecast algorithm developed for the WTMD application was expanded and recoded in the JAVA language to be more adaptable to varying data input structures. The new research platform can be easily modified with new forecast logic and then used to determine the relative impact of these modifications running in fast-time on stored weather data files. The wind forecast algorithm research platform is currently being used to refine wind forecast algorithm parameters to increase the availability of the WTMD system deployed at the San Francisco International Airport.

2.1.2 Wake Turbulence - Re-Categorization (F&E - 1A06B – G06M.02-02 - NextGen – Separation Management Portfolio)

The Wake Turbulence - Re-Categorization Program supports Efficiency R&D Goal 1 by developing enhanced ATC procedures and separation standards that will safely allow reduced wake separations between aircraft, resulting in safe increased capacity for the nation's airports and airspace. The program is 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, it is rebalancing the wake turbulence separation standards to address today's mix of aircraft utilizing the nation's core airports.

Additional information on this F&E program can be found by referencing the NAS Enterprise Architecture.

Note that starting in FY 2015, this program's funding and activities have been subsumed into NextGen F&E portfolios and, as such, will no longer be presented individually in the narrative of future *NARP* publications.

The research milestones and their statuses are shown in Table 2.1.2 below, followed by a summary of the significant progress made in FY 2014 towards achieving the R&D goal.

Table 2.1.2: Wake Turbulence - Re-Categorization Program Milestones

Year	Milestone	Status	Notes
2016	Complete a NAS Change Proposal and associated Safety Risk Management Document for operational use of the Leader/Follower Pair-Wise Static wake separations	On schedule	New milestone

Year	Milestone	Status	Notes
2016	Develop prototype software and adaptation changes for FAA automation platforms to evaluate requirements are met for use with the Leader/Follower Pair-Wise Static wake separation standards	On schedule	New milestone
2016	Complete changes to FAA Orders for implementing Leader/Follower Pair-Wise Static wake separation standards	Not started	New milestone
2017	Complete application software adaptation and training for key-site implementation for Leader/Follower Pair-Wise Static wake separation standards	Not started	New milestone
2017	Complete concept feasibility description of dynamic wake separation standards	Not started	New milestone
2018	Complete high level analyses on feasibility and benefit of using dynamic wake separation standards	Not started	New milestone
2019	Develop detail descriptions of ANSP processes and procedures for use of dynamic wake separation standards	Not started	New milestone

Wake Turbulence - Re-Categorization Program Progress in FY 2014:

- ✓ Analysis of additional wake data (since the writing of the RECAT Phase I Safety Risk Management Document) was completed and resulted in additional separation reduction for single runway arrivals and departures, closely spaced parallel runway departures and vertical separation. The 7110.659A Order was revised to reflect these changes and a supporting safety risk management document was created using these data analyses to support the separation changes. It is expected that the revised orders will be approved by the FAA in the second quarter of FY 2015.

- ✓ RECAT Phase I began use in the Cincinnati/Northern Kentucky (CVG) tower and TRACON ATC operations March 11, 2014. It began use at the Hartsfield – Jackson Atlanta International Airport (ATL) tower and TRACON on June 1, 2014.

- ✓ A RECAT Phase II draft pair-wise static wake separation matrix was developed for 107 aircraft types, which covers approximately 99 percent of the aircraft flown in the NAS. Additionally, an optimization tool was developed to allow each TRACON to create the wake separation aircraft categories from the wake separation matrix that will provide the greatest increase in runway throughput for the airports it services.

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 (RE&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 below, followed by a summary of the significant progress made in FY 2014 towards achieving the R&D goal.

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

Year	Milestone	Status	Notes
2014	Develop initial guidance (evaluation methods and techniques) for Aircraft Certification personnel responsible for evaluating NextGen Avionics for potential human errors and error mitigation	Completed	2014 NARP Status: On schedule
2015	Develop a report that identifies information requirements for flight deck based Interval Management (FIM) addressing the content, form, and location of information necessary for IM applications.	On schedule	New milestone
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	

Year	Milestone	Status	Notes
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 anticipated to be greater reliance on automation. This report will include enhanced training considerations and mitigations for skill loss	On schedule	

NextGen - Air Ground Integration Human Factors Program Progress in FY 2014:

- ✓ Completed annotated bibliography that summarized findings in the literature and relevant regulatory and guidance material. It addressed considerations in the design of procedures with respect to technology, humans, and the operational environment. The research is expected to lead to revised guidance material for air carrier flight deck procedures to enhance flight crew performance in normal NextGen operations.

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 funding 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. Transition to a new configuration resulting from airspace redesign requires changes in the supporting infrastructure. These infrastructure changes can include: radio frequencies, connecting a radio site to a control facility, position to position connectivity, surveillance infrastructure modifications to ensure proper radar coverage; automation modifications to facility data and flight data processing; interfacility communication modifications; additional consoles and communication backup needs; and modifications to facility power and cabling. The program also supports the use of risk management and collaborative evaluation capabilities to identify requirements, opportunities and threats in the early stages of the design process.

Additional information on this F&E program can be found by referencing the NAS Enterprise Architecture. Please note that Major Airspace Redesign is intended to be a rapid response program to fill gaps when resources for major airspace redesign must be identified quickly to meet emerging requirements or to expedite completion of ongoing projects. There are no ongoing major airspace redesign projects at this time; however the program is currently evaluating candidate projects. In the future, airspace redesign projects are expected to be planned and executed by this program but have not yet been selected. 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
2015	Conduct engineering analysis for airspace redesign implementation	On schedule	Recurring annual milestone
2015	Implement infrastructure changes resulting from airspace redesign	On schedule	Recurring annual milestone
2016	Conduct engineering analysis for airspace redesign implementation	On schedule	Recurring annual milestone
2016	Implement infrastructure changes resulting from airspace redesign	On schedule	Recurring annual milestone

2.3.2 New Air Traffic Management Requirements (F&E - 1A10E – G01M.02-02 - NextGen – NAS Infrastructure Portfolio)

The New Air Traffic Management 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. The service analysis and operational demonstration activities within the program support the development of operational improvements that will increase the number of arrivals and departures at major airports. The New Air Traffic Management Requirements Program explores opportunities in the following areas: Traffic Alert and Collision Avoidance System, new radar requirements (surveillance and weather), trajectory modeling, airborne System Wide Information Management (SWIM), weather transition, cloud computing, automation convergence, synchronization of air/ground procedures, and advanced air ground communications.

Additional information on this F&E program can be found by referencing the NAS Enterprise Architecture.

The research milestones and their statuses are shown in Table 2.3.2 below.

Table 2.3.2: New Air Traffic Management Requirements Program Milestones

Year	Milestone	Status	Notes
2015	Develop operational requirements for Airborne Access to System Wide Information Management (2-way)	On schedule	
2015	Conduct functional analysis and allocation for Airborne Access to System Wide Information Management (2-way)	On schedule	
2015	Complete update to Multifunction Phased Array Radar (MPAR) Cost Model	On schedule	
2015	Develop and implement required capabilities and governance	On schedule	
2015	Develop strategy to ensure NAS systems maintain compliance with developed standards and protocols	On schedule	
2016	Develop cost estimates for Airborne Access to System Wide Information Management (2-way)	On schedule	
2016	Define high level requirements document for Multifunction Phased Array Radar (MPAR)	Delayed	Milestone is delayed from 2015 to 2016. 2014 NARP Status: On schedule
2016	Deliver assessment report on phased array radar interface to NAS automation systems	On schedule	New milestone
2016	Complete update to MPAR cost model based on advanced technology demonstrator	On schedule	New milestone

Year	Milestone	Status	Notes
2016	Establish, standardize, and document the baseline versions of exchange models	On schedule	New milestone
2016	Develop enterprise solution documentation to mediate across NAS system	On schedule	New milestone
2016	Complete common information protocols and exchange standards documentation	On schedule	New milestone
2016	Develop interoperability requirement of UAS collision avoidance systems	On schedule	New milestone
2016	Develop Airborne Collision Avoidance System (ACAS-X) Xu system requirements specifications	On schedule	New milestone
2016	Complete ACAS Xu operational capability flight demonstration flight test	On schedule	New milestone
2016	Conduct assessment of mature research for transition to the National Weather Service (NWS) for their implementation and product dissemination into the NAS	On schedule	New milestone
2016	Develop and validate weather requirements for NWS to improve forecasts in support of FAA operational decision making	On schedule	New milestone
2016	Develop initial document for two-way communications procedures between flight management systems and ground systems	On schedule	New milestone
2016	Support and document the development of the L-Band communications standards and prototypes with international community	On schedule	New milestone
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 SESAR requirements	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's modernization programs and NextGen. The program conducts the overall analysis and planning for NAS evolution by determining the required annual updates to the following NAS Enterprise Architecture products: Operational Improvements, Operational Sustainment, and Operational Requirements. It executes research, engineering analysis, and evaluation in support of mission analysis 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. The program develops and

maintains detailed second level concepts that support validation and requirements development. This work ensures that the NAS level operational concept and sustainment activities are integrated and consistent with the overall NAS Enterprise Architecture. In addition, the program supports the development and sustainment of analytical and computer models used to assess and validate operational changes to the NAS. The program contributes to the FAA's support for the RTCA, a non-profit association that develops standards based on manufacturers, government, and aviation operator inputs. RTCA also recommends operational improvements to increase the efficiency of air transportation.

Additional information on this F&E program can be found by referencing the NAS Enterprise Architecture.

The research milestones and their statuses are shown in Table 2.3.3 below.

Table 2.3.3: Operations Concept Validation and Infrastructure Evolution Program Milestones

Year	Milestone	Status	Notes
2015	Develop and provide annual updates to the NAS Enterprise Level Operational Requirements to reflect the results of research and development conducted in 2014	On schedule	
2015	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 2014	On schedule	
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	New milestone
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	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 NAS operations to identify deficiencies and develop proposals to improve NAS performance. The program provides a collaborative means for experts from the FAA, academia, and industry to develop recommendations for improving capacity and system efficiency, and to reduce delays at specific airports. Using performance measurement systems and operations research capability, this group is able to quantify the efficiency of the NAS to

form the basis of recommendations for system improvements. The program facilitates the modeling, measurement and analysis of the impact of new runways, airfield improvements, air traffic procedures, and other technological implementations to improve airport capacity and system efficiency.

Additional information on this F&E program can be found by referencing the NAS Enterprise Architecture.

The research milestones and their statuses are shown in Table 2.3.4 below.

Table 2.3.4: System Capacity, Planning and Improvements Program Milestones

Year	Milestone	Status	Notes
2015	Develop concept of operations to convert Performance Data Analysis and Reporting System (PDARS) into a net centric system	On schedule	
2015	Support PDARS enhancement as needed to support NextGen Programs and Technologies	On schedule	
2015	Support NextGen reporting capabilities to improve NextGen Program and Technology analysis	On schedule	
2015	Complete connectivity to En Route Automation Modernization to include remaining available sites	On schedule	
2015	Provide PDARS baseline data for before/after analysis of NextGen programs	On schedule	
2015	Incorporate noise profiling technology via the Aviation Environmental Design Tool module	On schedule	
2015	Complete PDARS analysis to evaluate and improve the weather metric	On schedule	
2015	Produce Joint Performance Benchmark Report with EUROCONTROL	On schedule	
2015	Complete PDARS modernization plan	On schedule	
2015	Provide performance modeling and economic analysis information to support the development of a business case with International Civil Aviation Organization member states for space base Automatic Dependent Surveillance Broadcast (ADS-B) Out over the North Atlantic	On schedule	
2016	Complete design of PDARS into a net centric system	On schedule	New milestone
2016	Provide airport capacity modeling and annual service volume analysis report to support the FACT report	On schedule	New milestone
2016	Produce Joint Performance Benchmark Report with EUROCONTROL/the European Commission	On schedule	New milestone

Year	Milestone	Status	Notes
2016	Prepare white paper on methodologies to standardize international measurement of system capacity, throughput, predictability and efficiency	On schedule	New milestone
2016	Develop upgrade of PDARS visualization products	On schedule	New milestone
2016	Develop upgrade of PDARS processing system	On schedule	New milestone
2016	Complete enhancement of FAA Metrics webpage	On schedule	New milestone
2016	Provide performance modeling and economic analysis information to support the development of a business case with ICAO member states for space base ADS-B (Out) over the North Atlantic	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 examining controllers' time on task in managing sector traffic and developing predictive tools to support strategic traffic flow management.

CAASD made the following progress in FY 2014 towards Efficiency R&D Goal 3:

- ✓ Developed a time-on-task controller workload model, which defines the amount of time that controllers spend performing ATC tasks, based on traffic volume and complexity, and can be used to estimate the number of controllers needed to manage sector traffic. CAASD is working with the FAA to develop a formal technology transfer plan for core components of the model. Flow Contingency Management (FCM), a decision support capability and airport capacity prediction model designed to improve capacity predictions for the two to 24 hour planning horizon, was also developed. FCM combines convective weather forecasts and provides improved "day-of" predictions of traffic, to better assess the impact of weather on traffic and to support decision making by personnel at the ATC System Command Center. Leveraging the integrated Traffic Management Initiative (TMI) modeling capability in FCM, MITRE CAASD developed automation-assisted design methods that are able to efficiently explore TMI problem sizes that were previously computationally-prohibitive for real-time assessment and decision making. Aiding this capability is the development of a historic TMI database that leverages a new method for capturing similarities in spatial and temporal data in order to identify previous TMIs that may aid in the mitigation of the current congestion prediction. By providing an integrated view of the likely problems, quantifying the potential impact, and assisting in the development of mitigation approaches, FCM will provide a significant step towards meeting the requirements of NextGen in the strategic traffic flow management environment.

- ✓ Investigated methods for providing common performance-based situation awareness of traffic flow management information to decision makers to provide objective analysis of

alternative courses of action and execution mechanisms. Air Traffic Flow Managers need to have common situational awareness of rapidly evolving issues. The concept includes a traffic management portal and app framework delivering a comprehensive, shareable, integrated system view to improve traffic management collaboration between non-collocated users. Additionally, the framework supports emerging FAA initiatives for data sharing and enterprise information technology strategies. The application of this research would improve efficiency of traffic management operations and advance FAA acquisition and contracting processes towards the philosophy of "acquiring an app at a time" leading to a leaner, more cost effective and collaborative NAS.

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 (RE&D - A12.c)

The NextGen - Weather Technology in the Cockpit Program supports Efficiency R&D Goals 4 and 5 by developing, verifying, and validating requirements to support airworthiness standards for enabling availability and improving the quality and quantity of MET information to the aircraft to support efficient current and NextGen operations. The program will result in the development of standards and requirements that define the weather information in the cockpit needed to support operations, the presentations and interfaces to enable proper information consumption and safe operations by pilots, and capabilities that enable efficient dissemination of the weather information to and from the cockpit at the right place and right time.

The research milestones and their statuses are shown in Table 2.4.1 below, followed by a summary of the significant progress made in FY 2014 towards achieving the R&D goals.

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

Year	Milestone	Status	Notes
2014	Produce plots of wind forecast and diagnosis errors versus performance of selected NextGen operations using realistic scenarios and sufficient fidelity to enable standards development	Completed	2014 NARP Status: Delayed from 2013 to 2014
2015	Complete demonstrations and provide data to support the development of human factors standards, guidance, and procedures for the presentation and use of meteorological information in the cockpit. Specific measurable performance objectives verified for human factors design elements	Deleted	Milestone is deleted due to redundancy with Minimum Weather Service milestone. 2014 NARP Status: On schedule
2016	Initial verification demonstrations of recommended implementations of adverse weather alerting functions for the flight deck	On schedule	

Year	Milestone	Status	Notes
2016	Develop models to run simulations to quantify NAS benefits from uplinking/crosslink of enhanced meteorological information to the cockpit	On schedule	
2017	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	Delayed	Milestone is delayed from 2015 to 2017 due to delays in prerequisite research efforts. 2014 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	Delayed	Milestone is delayed from 2019 to 2020 and was revised to changing program priorities and increase in scope. Old wording: "Complete development of recommendations for Part 121/135 Minimum Weather Service attributes that resolve gaps associated with pilot roles in NAS efficiency" 2014 NARP Status: On schedule

NextGen - Weather Technology in the Cockpit Program Progress in FY 2014:

- ✓ The FAA and Delta airlines demonstrated and evaluated an Eddy Dissipation Rate (EDR) and Graphical Turbulence Guidance (GTG) viewer uplink. As part of this demonstration and evaluation, the iPad and Microsoft Surface were found to operate effectively as viewers. Aircrew operational procedures on the use of the EDR/GTG viewer were developed and evaluated with crew feedback being very positive. The initial benefits assessments indicated significant reduction in crews using the ATC chat room and high acceptance of using the viewer as the primary decision driver for turbulence resulting in reduced frequency congestion and ATC workload. In addition, most crews reported better crew management with regard to turbulence encounters.

- ✓ Developed trade spaces quantifying the relationships between wind errors and selected NextGen operational performance through laboratory simulations. RTCA and other stakeholders are already invoking these final trade spaces, and other research results, into RTCA standards. In addition, the research results are being used as inputs to develop performance specifications for the selected NextGen operations (including time of arrival procedures and interval management) in varying wind conditions.

2.4.2 Weather Program (RE&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 below, followed by a summary of the significant progress made in FY 2014 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 (NGIP))	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	Milestone was revised to reflect the actual scope of work. Old wording: "Demonstrate and evaluate lightning prediction prototype capability" 2014 NARP Status: On schedule
2016	Transition global turbulence forecast capability for implementation	On schedule	
2016	Transition High Resolution Rapid Refresh weather forecast model to the National Weather Service for operational implementation	Completed	Milestone completed ahead of schedule due to the necessary upgrading of computer infrastructure being unexpectedly hastened with funds resulting from Hurricane Sandy. 2014 NARP Status: On schedule
2017	Transition convectively-induced turbulence forecast capability for implementation (as detailed in the NAS infrastructure portfolio section of the NextGen Implementation Plan (NGIP))	Deleted	Milestone is deleted. An assessment is needed to determine if the development of a convectively-induced turbulence forecast capability is viable 2014 NARP Status: On schedule
2018	Transition Alaska turbulence forecast capability for implementation (as detailed in the NAS infrastructure portfolio section of the NextGen Implementation Plan (NGIP))	On schedule	
2018	Transition North American Rapid Refresh Ensemble weather forecast model (13km) to the National Weather Service for operational implementation	On schedule	New milestone
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 (3km with 1km nests) to the National Weather Service for operational implementation	On schedule	New milestone

Weather Program Progress in FY 2014:

- ✓ Completed the transition from the High Resolution Rapid Refresh (HRRR) weather forecast model to the National Weather Service where it was implemented into operations in the 4th quarter 2014. The HRRR is a storm-scale model running at three kilometer resolution. It has the granularity that depicts convective weather storm cells with the permeability information necessary to provide sufficient guidance for ATM to make critical traffic flow decisions during convective storms.

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 – 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 those 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 below, followed by a summary of the significant progress made in FY 2014 towards achieving the R&D goal.

Table 2.5.1: Airport Cooperative Research Program – Capacity Milestones

Year	Milestone	Status	Notes
2014	Identify best practices and develop tools, techniques, and training aids for working in or near airport movement areas	Completed	ACRP project 09-02 is completed and the final report is available at: http://www.trb.org/Main/Blurbs/170760.aspx. 2014 NARP Status: Delayed from 2013 to 2014
2014	Develop guidance for defining and measuring aircraft delay and airport capacity thresholds	Completed	ACRP project 03-20 is completed and the final report is available at: http://www.trb.org/main/blurbs/170348.aspx. 2014 NARP Status: Delayed from 2013 to 2014
2014	Assess the factors that drive airline service decisions and passenger choice in multi-airport regions	Completed	ACRP project 03-26 is completed and the final report is available at: http://www.trb.org/ACRP/Blurbs/170194.aspx. 2014 NARP Status: Delayed from 2013 to 2014
2014	Develop methods and tools necessary to improve integration of rail services with airports	Completed	ACRP project 03-23 is completed and the final research report is in editorial review. 2014 NARP Status: Delayed from 2013 to 2014

Year	Milestone	Status	Notes
2014	Identify, test, and evaluate methods for obtaining aircraft operations counts at non-towered airports	Completed	ACRP project 03-27 is completed and the published report is expected 12/2014. 2014 NARP Status: On schedule
2014	Develop a guidebook to plan general aviation facilities	Completed	ACRP project 07-10 is completed and the final report is available at: http://www.trb.org/ACRP/Blurbs/171315.aspx . 2014 NARP Status: On schedule
2014	Produce guidance to evaluate cost-saving and energy reduction technologies for escalators and moving walks at airports	Completed	ACRP project 07-11 is completed and the published report is expected 12/2014. 2014 NARP Status: On schedule
2014	Develop guidance to determine the location, number, size, and configuration of airport terminal restroom facilities to best meet customer needs	Completed	ACRP project 07-12 is completed and the published report is expected early 2015. 2014 NARP Status: On schedule
2014	Provide guidance to help airports identify optimal lighting solutions for parking garage facilities	Completed	ACRP project 09-03 is completed and the published research report is expected early 2015.
2014	Develop a guidebook that will help airports prepare for, operate during, and recover from disruptive winter events as well as manage airport user expectations	Completed	ACRP project 10-15 is completed and the final report is in publication review. 2014 NARP Status: On schedule
2015	Develop a primer on the benefits of a whole-building systems lifecycle approach to airport operations and maintenance optimization and recommissioning	Delayed	Milestone is delayed from 2014 to 2015 due to underestimation of project complexity (ACRP project 09-04). 2014 NARP Status: On schedule
2015	Create guidance on successful Computer Maintenance Management Systems selection and practices	Delayed	Milestone is delayed from 2014 to 2015 due to underestimation of project complexity (ACRP project 09-05). 2014 NARP Status: On schedule
2015	Quantify the national aggregate value of airports to communities and to aviation stakeholders	Delayed	Milestone is delayed from 2014 to 2015 due to underestimation of project complexity (ACRP project 03-28). 2014 NARP Status: On schedule
2015	Estimate the economic impact of air cargo at airports	Delayed	Milestone is delayed from 2014 to 2015 for final report review (ACRP project 03-16). 2014 NARP Status: Delayed from 2013 to 2014
2015	Prepare guidance to assist airports in using benefit-cost analysis and other analytical techniques to make airport capital investment decisions	Delayed	Milestone is delayed from 2014 to 2015 for final report review (ACRP project 03-19). 2014 NARP Status: Delayed from 2013 to 2014

Year	Milestone	Status	Notes
2015	Develop guidelines for air cargo facility planning and development at airports	Delayed	Milestone is delayed from 2014 to 2015 as Phase II of the research is underway (ACRP project 03-24). 2014 NARP Status: Delayed from 2013 to 2014

Airport Cooperative Research Program – Capacity Progress in FY 2014:

- ✓ Researched effective tools and techniques to measure and value the contribution of air cargo activity to local, regional, and national economies, allowing improved response to changing global market conditions.

2.5.2 Airport Technology Research Program – Capacity (AIP)

The Airport Technology Research Program – 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 next-generation heavy aircraft and makes pavement design standards available to users worldwide.

The research milestones and their statuses are shown in Table 2.5.2 below, followed by a summary of the significant progress made in FY 2014 towards achieving the R&D goal.

Table 2.5.2: Airport Technology Research Program – Capacity Milestones

Year	Milestone	Status	Notes
2014	Complete the Accelerated Airport Pavement Test Vehicle	Completed	2014 NARP Status: Delayed from 2013 to 2014
2014	Complete construction of High Temperature Pavement Test Facility	Deleted	Milestone is deleted since it is a duplicate. 2014 NARP Status: On schedule
2014	Complete upgrade of all pavement software to Windows Presentation Foundation	Deleted	Milestone is deleted since it is a duplicate. 2014 NARP Status: On schedule
2014	Complete definition of airport pavement failure for the 40-Year Pavement Life project	Deleted	Milestone is deleted since it is a duplicate. 2014 NARP Status: On schedule
2014	Complete scheduled software engine version 4.2 and 4.3 for the Airport and Airspace simulation model	Completed	2014 NARP Status: On schedule
2014	Complete the update of the Airfield Modeling Database with all new runway, taxiway, and gate data	Completed	2014 NARP Status: On schedule
2014	Complete beta version of FAARFIELD 1.4	Completed	2014 NARP Status: On schedule

Year	Milestone	Status	Notes
2014	Complete construction and performance data for 8 large and medium hub runways to the 40-year life PAVEAIR data warehouse	Completed	2014 NARP Status: On schedule
2014	Complete tests on subgrade, and aggregate samples collected from 3 airport construction projects	Completed	2014 NARP Status: On schedule
2014	Finalize the work underway to determine values of in-service airport pavement roughness using the Mike Monroney Aeronautical Center Boeing B-737 simulator	Completed	2014 NARP Status: On schedule
2014	Perform reflective cracking pavement Tests	Completed	2014 NARP Status: On schedule
2015	Complete development of display playback animation software for the Airport and Airspace Simulation Model	Delayed	Milestone is delayed from 2014 to 2015 due to a change in scope. 2014 NARP Status: On schedule
2015	Perform economic analysis of heated pavements at selected airports	On schedule	
2015	Study the effect of high tire pressure on performance of Hot Mix Asphalt (HMA) pavement under heavy aircraft wheel load	On schedule	New milestone
2015	Character the performance of Warm Mix Asphalt (WMA) and compare it with the performance of standard P-401 HMA	On schedule	New milestone
2015	Study the effects of Polymer Modified Binder on the performance/life of P-401 HMA	On schedule	New milestone
2016	Complete full-scale test on CC-7 Perpetual Pavements at the NAPTF to validate/modify/refine HMA fatigue failure model in FAARFIELD	On schedule	New milestone
2017	Pavement Roughness index for Airports	On schedule	New milestone
2018	New method to calculate Aircraft Classification Number (CAN) and Pavement Classification Number (PCN)	On schedule	New milestone
2019	Standardization of the Life-Cycle Cost Analysis (LCCA) process	On schedule	New milestone
2020	Long term full scale testing of concrete pavement for 40 Year Life	On schedule	New milestone

Airport Technology Research Program – Capacity Progress in FY 2014:

- ✓ The test methods being studied include vane shear (for in-situ shear strength), light weight deflectometer (for resilient modulus), dirt portable seismic properties analyzer (for elastic modulus), and repeated load triaxial tests (for laboratory resilient modulus). Resilient modulus, in combination with a measure of strength such as shear, could displace California Bearing Ratio as a means of characterizing subgrade soils. The study demonstrated the application potential of different testing techniques for airport pavement unbound material characterization. This is a part of long term study and the work effort will continue.

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 to a level that does not constrain growth.

Five R&D goals support R&D Principle 3 - Reduce Environmental Impacts with work spread across three budget appropriations (RE&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 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>
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In FY 2016, 20 percent of total FAA R&D funding is allocated to R&D Principle 3 - Reduce Environmental Impacts. Program funding levels for the 2015 Enacted and 2016 President's Budget are shown in Table 3.0.2. Percent of Program reflects the part of each program's contribution towards R&D Principle 3 in the 2016 President's Budget. Table 3.0.2 also lists the section and page number reference for each budget narrative within the FY 2016 CJ for the President's Budget Request. The FY 2016 CJ is available at http://www.dot.gov/sites/dot.gov/files/docs/FY2016-BudgetEstimate-FAA.pdf.

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

2016 BLI	Program	CJ Reference (Section /Page)	Appropriation Account	2015 Enacted ($000)	2016 President's Budget ($000)	2016 Percent of Program
A11.m	NextGen - Alternative Fuels for General Aviation	3C/53	RE&D	6,000	5,833	100%
A12.c	NextGen - Weather Technology in the Cockpit	3C/62	RE&D	405	412	10%
A13.a	Environment and Energy	3C/69	RE&D	14,921	15,061	100%
A13.b	NextGen - Environmental Research - Aircraft Technologies, Fuels, and Metrics	3C/72	RE&D	23,014	23,823	100%
A14.a	System Planning and Resource Management	3C/75	RE&D	210	238	10%
1A08	Next Generation Transportation System - Environment Portfolio	3B/50	F&E	5,500	1,000	100%
4A08	Center for Advanced Aviation System Development (CAASD)	3B/316	F&E	0	3,000	5%
--	Airport Cooperative Research Program - Environment	3D/37	AIP	5,000	5,000	100%
--	Airport Technology Research Program - Environment	3D/26	AIP	1,513	1,576	100%
	Total ($000)			**56,563**	**55,943**	

**CAASD R&D budget totals for 1) FY 2015 assume 33% for Safety, 67% to Efficiency, and 0% for Environmental and 2) FY 2016 and outyears assume 31% for Safety, 64% for Efficiency, and 5% for Environmental (subject to FFRDC Executive Board FY 2016 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 (RE&D - A13.a)

The Environment and Energy Program supports Environment and Energy Goals 1, 2, and 3 by characterizing aircraft noise and emissions and their consequential impacts on the environment. The program then provides guidance on mitigating these impacts. The program provides fundamental knowledge and develops and validates methodologies, models, metrics, and tools. It analyzes and balances the interrelationships between noise and emissions, considers local to global impacts, and determines 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 below, followed by a summary of the significant progress made in FY 2014 towards achieving the R&D goals.

Table 3.1.1: Environment and Energy Program Milestones

Year	Milestone	Status	Notes
2014	Obtain direct measurements of aircraft particulate matter data to support development of internationally approved methodology	Completed	2014 NARP Status: On schedule
2014	Refine methods and tools to estimate impacts of global aviation emissions on surface air quality	Completed	2014 NARP Status: On schedule
2015	Advance the understanding of noise impacts on social welfare and health	On schedule	
2015	Develop approved method for measuring particulate matter from gas turbine engines	On schedule	
2015	Develop methods to account for regional climate impact of aviation emissions	On schedule	
2015	Improve understanding of the impacts of aircraft emissions in urban airshed area	On schedule	Milestone was revised to better reflect the research scope and focus. Old wording: "Improve understanding of the impacts of aircraft emissions in the airport vicinity." 2014 NARP Status: On schedule

Year	Milestone	Status	Notes
2016	Advance the understanding of noise impacts on social welfare and health	On schedule	
2016	Develop new standards and methodologies to quantify and assess the impacts of aviation emissions	On schedule	Milestone was revised to clarify the research. Old wording: "Develop new standards and methodologies to quantify and assess the impact of aircraft noise and aviation emissions" On schedule
2017	Refine methods for estimation of aircraft contribution to climate change and implement them in analytical tools.	On schedule	Milestone is delayed from 2016 to 2017 for more mature progress in the complex area of climate research and implementation in tools and is revised to clarify the research. Old wording: "Refine the estimates of aircraft contribution to climate change using the latest methods and knowledge" 2014 NARP Status: 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	New milestone
2019	Develop new standard for particulate matter emissions	On schedule	
2019	Explore appropriate metric for aircraft surface noise levels	On schedule	New milestone
2020	Enhance methodology for estimation of aviation contribution to climate change	On schedule	New milestone

- ✓ Environment and Energy Program Progress in FY 2014:Conducted research on an ongoing basis to better understand the relationship between aviation noise and different non-auditory responses and its effects on social welfare and overall health, specifically cardiovascular disease and sleep disturbance. The FAA has explored annoyance beyond fixed wing aircraft, to include annoyance from rotorcraft and from the potential supersonic civil aircraft market. Additionally, the FAA studied the characteristics of rotorcraft aircraft to determine noise abatement procedures, and exploring the human response to different shaped sonic booms to determine if there is a potential for acceptability of certain low booms. The FAA has made progress on understanding annoyance on two fronts. In anticipation of the possibility of low boom civil aircraft flights, a study of annoyance of low booms found that loudness is clearly a factor in interference, but it is the ability of the noise to interfere with an ongoing activity that appears to drive the annoyance response. For civil jets, a survey instrument was reviewed and methodology was developed to support the FAA's review of day-night level 65 decibels.

- ✓ The Aerospace Information Report 6241 (AIR 6241) compliant Non-Volatile Particulate Matter (nvPM) measurement system is currently undergoing a thorough evaluation. During FY 2015, the North American reference system will be compared with engine manufacturers' nvPM system to inform the development of the Aerospace Recommended Practice (ARP). The ARP is currently scheduled to be balloted in 2015 by the Society of Automotive Engineers Aircraft Exhaust Measurements Committee (SAE E31). Measurement campaigns are planned at Rolls-Royce, Indiana; General Electric Aviation, Ohio; and Pratt and Whitney, Connecticut to characterize engine nvPM emissions and to perform inter-comparison of measurement systems. Results will inform the development of ARP and ensure a timely completion of the document.

- ✓ Developed a combination community multi-scale air quality model equipped with the direct decoupled method and a statistical approach to measure impacts of aviation emissions contributing to over 99 percent of the total fuel burn. Health impacts due to aviation emissions are mainly due to PM2.5 and Ozone that are formed as the emissions interact with the background. This tool can then be exercised on a yearly basis to track urban airshed specific impacts and to understand the result of various policy options.

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 and Noise/Emission Reduction Program supports Environment and Energy Goals 1, 2, and 3 by supporting development and implementation of the NextGen Environmental Management System (EMS). 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 Aviation Environment Design Tool (AEDT), improved environmental impacts and economics capabilities in the Aviation Environment Portfolio Management Tool, and the integration of these environmental assessment capabilities with NAS design tools and simulation models and performance monitoring systems. These environmental modeling capabilities are being used with a combination of the FAA Terminal Area Forecast, improvements in operational procedures including those from NextGen incorporation, fleet technology advancement, and estimates of future alternative jet fuel penetration to estimate the current and future environmental performance of the NAS. Through 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.

Additional information on this F&E program can be found by referencing the NAS Enterprise Architecture.

The research milestones and their statuses are shown in Table 3.1.2 below.

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

Year	Milestone	Status	Notes
2015	Assess NAS-wide environmental benefits of Continuous Lower Emissions, Energy, and Noise (CLEEN) aircraft technologies	Deleted	Milestone is deleted since it duplicates the milestone directly below. 2014 NARP Status: On schedule
2015	Assess NAS-wide impacts of environmental standards for aircraft noise and emissions and other policy measures to limit aircraft emissions and noise and increase fuel efficiency	Deleted	Milestone is deleted since this work was not funded under the FY 2015 F&E budget. 2014 NARP Status: On schedule
2015	Submit a report on development of the initial operational version of NextGen environmental management system (EMS) framework	On schedule	
2015	Develop a report on demonstration of Flight Management System/ATM Integration for Trajectory Optimization	On schedule	
2015	Update report on assessments of NAS-wide environmental benefits of new aircraft technologies including those from the CLEEN program	On schedule	
2015	Develop a report on assessments of environmentally and energy efficient gate-to-gate operational procedures	On schedule	
2015	Develop a report on assessments of NAS-wide impacts of environmental standards and policy measures	Deleted	Milestone is deleted since this work was not funded under the FY 2015 F&E budget. 2014 NARP Status: On schedule
2016	Submit a report on enhancements to Aviation Environmental Design Tool (AEDT) terminal area capabilities to enable the evaluation of environmental impacts from NextGen	On schedule	New milestone
2016	Submit a final report on integration of NextGen simulation models and data with AEDT software version 2b	On schedule	New milestone

3.1.3 NextGen - Environmental Research - Aircraft Technologies, Fuels, and Metrics (RE&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 below, followed by a summary of the significant progress made in FY 2014 towards achieving the R&D goals.

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

Year	Milestone	Status	Notes
2014	Demonstrate Continuous Lower Energy, Emissions and Noise Ceramic Matrix Composite nozzle technology	Completed	2014 NARP status: On schedule
2014	Evaluate the environmental and economic sustainability of future alternative turbine engine fuels	Completed	2014 NARP status: On schedule
2015	Demonstrate Continuous Lower Energy, Emissions and Noise Engine Weight Reduction and High Temperature Impeller technologies	On schedule	
2015	Evaluate novel future alternative jet fuels to ensure their compatibility with existing aircraft and fueling infrastructure	On schedule	
2015	Assess the environmental benefits of the first round of Continuous Lower Energy Emissions and Noise airframe and engine technologies	On schedule	
2015	Initiate Continuous Lower Energy, Emissions and Noise Phase II activities to demonstrate technologies that can reduce energy use, emissions, and noise	On schedule	
2016	Refine the estimates of aircraft contribution to climate change using the latest methods and knowledge	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	Demonstrate Continuous Lower Energy, Emissions and Noise Ultra High Bypass Ratio Gear Turbo Fan Technology	Deleted	Milestone is deleted as the program has not yet selected or funded a company for the demonstration. 2014 NARP Status: On schedule
2017	Demonstrate Continuous Lower Energy, Emissions and Noise Advanced Turbine Components	On schedule	
2017	Demonstrate technologies that can reduce energy use, emissions, and noise via the second phase of the Continuous Lower Energy, Emissions and Noise program	On schedule	
2018	Advance approval methodology for alternative jet fuels	On schedule	

Year	Milestone	Status	Notes
2019	Advance the understanding of alternative jet fuel composition and environmental performance	On schedule	
2020	Assess the environmental benefits of the second round of Continuous Lower Energy Emissions and Noise airframe and engine technologies	On schedule	New milestone

NextGen - Environmental Research - Aircraft Technologies, Fuels, and Metrics Program Progress in FY 2014:

- ✓ Achieved several key significant milestones through the CLEEN program – the FAA's principal NextGen environmental effort to accelerate the development of new aircraft and engine technologies and advance sustainable alternative jet fuels while working closely with the industry on 1:1 cost-share basis. Achievements included the targeted maturation of Ceramic Matrix Composite (CMC) Acoustic Nozzle technology to Technology Readiness Level 7) through flight demonstration. In addition, ground level engine tests were completed for two other CLEEN technologies (CMC Turbine Blade Tracks and Engine Weight Reduction and High Temperature Impeller). Detailed design reviews were also completed for CLEEN Flight Management System-Air Traffic Management Integration and ultra high-bypass Geared Turbo Fan technologies. Under the CLEEN alternative fuel efforts, fuels were tested for auxiliary power units, for ground and altitude chamber conditions, and for combustor.

- ✓ Continued working with manufacturers and fuel producers through CLEEN and the Aviation Sustainability COE (ASCENT) to test and demonstrate alternative jet fuels. In June 2014, the third alternative jet fuel was approved for use by ASTM International, Synthesized Iso-Paraffins are jet fuels made from sugar. Their approval is due, in part, to the testing and evaluation activities funded by the FAA. There are an additional six fuels currently under testing and evaluation via FAA funded programs that could be approved in the next two years.

- ✓ Kicked off a new project under ASCENT to continue efforts to model and assess the environmental benefits of aircraft technology, including those under the FAA's CLEEN Program. This effort will continue modeling of CLEEN technologies, building upon those modeled previously under the Partnership for Air Transportation Noise and Emissions Reduction (PARTNER) COE Project 36, with input from the companies developing these technologies. The project works with government, industry, and academia experts to establish consensus on scenarios and associated assumptions to be evaluated. This will inform any additional technology and aircraft modeling work that will be completed to enable these assessments.

- ✓ Released the Screening Information Request for the Continuous Lower Energy, Emissions and Noise II (CLEEN II) program. CLEEN II is a follow on program to CLEEN and will focus on developing aircraft technology to reduce energy, emissions and noise and the advancement of alternative jet fuels.

3.1.4 NextGen - Weather Technology in the Cockpit (RE&D - A12.c)

The NextGen - Weather Technology in the Cockpit Program supports Environment and Energy Goals 1, 2, and 3 by developing, verifying, and validating requirements to support airworthiness standards for improving the quality and quantity of MET information to the aircraft to reduce environment impacts (e.g., lower fuel consumption) of current and NextGen operations.

The research milestones and their statuses are shown in Table 3.1.4 below.

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	Milestone was revised to align with the broader scope of WTIC service analyses to identify potential efficiency improvements. Old wording: "Complete service analysis on the weather information and presentations in the cockpit to enhance NAS efficiency in adverse weather" 2014 NARP Status: On schedule

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 – Environment 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 the study of airport specific aviation noise and emissions and their environmental impacts, developing strategies and guidance for green airports via reduction in noise and emissions, infrastructure, and benefits of alternative aviation fuels at airport facilities, deicing management, and advanced noise and emissions databases.

The research milestones and their statuses are shown in Table 3.2.1 below, followed by a summary of the significant progress made in FY 2014 towards achieving the R&D goal.

Table 3.2.1: Airport Cooperative Research Program – Environment Milestones

Year	Milestone	Status	Notes
2014	Identify and evaluate metrics for and conditions under which aircraft noise affects student learning	Completed	ACRP project 02-26 is completed and the final report is available at http://www.trb.org/main/blurbs/170328.aspx. 2014 NARP Status: Delayed from 2013 to 2014.
2014	Provide practical mitigation alternatives for managing nuisance microbial communities caused by airport deicing activities	Completed	ACRP project 02-32 is completed and the published report is expected 12/2014. 2014 NARP Status: Delayed from 2013 to 2014
2014	Develop an interactive electronic tool to assist airport stakeholders in estimating airport construction emissions	Completed	ACRP project 02-33 is completed and the final report is available at: http://www.trb.org/Main/Blurbs/170234.aspx. 2014 NARP Status: Delayed from 2013 to 2014
2014	Develop and validate a research protocol for a large-scale study of aircraft noise exposure-annoyance response relationships across the U.S.	Completed	ACRP project 02-35 is completed and the final report is available at http://www.trb.org/ACRP/Blurbs/170979.aspx. 2014 NARP Status: Delayed from 2013 to 2014

Year	Milestone	Status	Notes
2014	Assess the predictive accuracy of the FAA's Integrated Noise Model for general aviation aircraft	Completed	ACRP project 02-37 is completed and the final report is available at http://www.trb.org/Main/Blurbs/171516.aspx. 2014 NARP Status: Delayed from 2013 to 2014
2014	Create best practices for aviation safety associated with planning, developing and constructing energy production and transmission technologies at and around airports	Completed	ACRP project 02-38 is completed and the final report is available at http://www.trb.org/Main/Blurbs/170609.aspx. 2014 NARP Status: On schedule
2014	Develop a method for estimating aircraft takeoff thrust settings for a wide variety of commercial and general aviation aircraft, suitable for use in preparing airport emissions inventories	Completed	Milestone is delayed from 2014 to 2015 due to underestimation of project complexity (ACRP project 02-38). 2014 NARP Status: On schedule
2014	Develop a process to evaluate sustainability practices as they relate to the impacts on day-to-day airport operations and maintenance	Completed	ACRP project 09-06 is completed and the final report is available at http://www.trb.org/Publications/Blurbs/170580.aspx. 2014 NARP Status: On schedule
2014	Develop tools and guidance for airports that identify and evaluate storm water management options and provide a set of best management practices to minimize hazards posed to aviation by wildlife	Completed	ACRP project 09-08 is completed and the published report is expected in early 2015. 2014 NARP Status: On schedule
2014	Develop a primer to help airports address federal and state threatened and endangered species issues on or near their airport	Completed	ACRP project 11-02 is completed and the published report is expected in early 2015. 2014 NARP Status: On schedule
2015	Develop a decision tool for airports to identify, evaluate, prioritize, and select sustainability practices	Completed	ACRP project 02-28 is completed and the published report is expected 12/2014. 2014 NARP Status: Delayed from 2013 to 2015
2015	Improve, enhance, and update the Sustainable Aviation Guidance Alliance website with new and existing sustainable practices data	On schedule	2014 NARP Status: Delayed from 2014 to 2015
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	Delayed	Milestone is delayed from 2014 to 2015 due to underestimation of project complexity (ACRP project 02-44). 2014 NARP Status: On schedule

Year	Milestone	Status	Notes
2015	Assess the current body of knowledge regarding the impact of airport operations on air quality and public health	Delayed	Milestone is delayed from 2014 to 2015 due to underestimation of project complexity (ACRP project 02-42). 2014 NARP Status: Delayed from 2013 to 2014
2015	Produce guidance on the application of whole effluent toxicity testing to airport deicing runoff	Delayed	Milestone is delayed from 2014 to 2015 due to underestimation of project complexity (ACRP project 02-39). 2014 NARP Status: On schedule
2015	Develop an inventory methodology to help airports quantify aircraft lead emissions at airports	Delayed	Milestone is delayed from 2014 to 2015 due to underestimation of project complexity (ACRP project 02-34). 2014 NARP Status: Delayed from 2013 to 2014
2015	Assess the accuracy of the NOx ($NO+NO_2$) emissions and speciation methods used in the Emissions Dispersion Modeling System/AEDT (i.e., OLM, ARM, and PVMRM) to predict NO_2 concentrations, develop and assess alternative methods, and recommend a preferred method for predicting NO_2 concentrations resulting from airport emissions	Completed	ACRP project 02-08 is completed and the final report is available at: http://www.trb.org/Publications/Blurbs/167479.aspx. 2014 NARP Status: On schedule

Airport Cooperative Research Program – Environment Progress in FY 2014:

- ✓ Explored conditions under which aircraft noise affects student learning and evaluated alternative noise metrics that best define those conditions.
- ✓ Explored alternative research methods for field studies to assess the relationship between aircraft noise and sleep disturbance for U.S. airports.
- ✓ Developed an evaluation process and cost-benefit tool that demonstrates how to use data from an example project.

3.2.2 Airport Technology Research Program – Environment (AIP)

The Airport Technology Research Program – Environment 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 covering 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 below.

Table 3.2.2: Airport Technology Research Program – Environment Milestones

Year	Milestone	Status	Notes
2014	Develop the test plan and selection of surveyed airports for the Aircraft Noise and Annoyance Study	Completed	2014 NARP Status: Delayed from 2013 to 2014
2015	Develop and gain approval for a survey instrument to collect data for the Aircraft Noise and Annoyance Study	Delayed	Milestone is delayed from 2014 to 2015 due to extended review time. 2014 NARP Status: On schedule
2015	Complete the study on analyzing air quality samples from forcible entry testing on composite materials	On schedule	
2015	Evaluate the effectiveness of using artificial turf in Runway Safety Areas to mitigate the burrowing of the protected Gopher Tortoise	On schedule	
2016	Complete data collection for the Aircraft Noise and Annoyance Study	Delayed	Milestone is delayed from 2015 to 2016 due to approval delays. 2014 NARP Status: On schedule
2016	Complete updates to the dose-response curves for U.S. airports using data collected from the Aircraft Noise and Annoyance Study	On schedule	

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

The Center for Advanced Aviation System Development (CAASD) supports R&D Aviation Environmental R&D Goal 2 by conducting analyses and assessments of surface metering, designed to reduce fuel burn associated with runway queuing.

CAASD made the following progress in FY 2014 towards Aviation Environment R&D Goal 2:

- ✓ The CAASD conducted analysis to inform the tradeoff between several key parameters used in Surface Collaborative Decision Making (S-CDM) processes, procedures, and policies (P3). This work provided a framework to inform decisions regarding P3 parameter settings to balance the benefits and risks of S-CDM at Phoenix Sky Harbor International Airport (PHX). The framework can also be applied to other airports and to projected future traffic levels. S-CDM reduces the size of long queues of aircraft waiting at the departure runway end, thereby reducing fuel and emissions, and potentially increasing operator flexibility.

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 (RE&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 below, followed by a summary of the significant progress made in FY 2014 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	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	New milestone

NextGen - Alternative Fuels for General Aviation Program Progress in FY 2014:

- ✓ The request for candidate fuels, or Screening Information Request (SIR), closed July 1, 2014. A Piston Aviation Fuels Initiative informational briefing was given in December 2013 at the ASTM fuel meeting, a webinar held on April 16, 2014, and updates provided at the ASTM fuel meeting on June 23, 2014 and EAA Airventure meeting on July 28, 2014.

- ✓ Formed a Technical Evaluation Committee (TEC), reporting directly to the FAA, to serve as the primary evaluator of fuel proposals furnished in response to the SIR. The TEC met

July 15 through 18, 2014 to select fuels to enter Phase 1 testing. Nine fuels were submitted from five companies and four fuels from three companies (TOTAL, SHELL, SWIFT x2) were selected for entrance into Phase 1.

- ✓ Identified specific aircraft material part number lists for elastomers, sealants, and metals along with associated test. Ecological assessments and literature surveys of proposed fuels are currently underway.

- ✓ Formed the Piston Aviation Fuels Initiative Technical Advisory Committee (TAC) to facilitate industry "in-kind" support. The TAC membership includes the primary OEM product manufacturers, user groups, producers, and airports representatives. Eleven work requests have been submitted to the TAC. The final list of Phase I laboratory test methods, and identification of rigs was agreed to by the TAC.

- ✓ Developed the Phase I rig testing procedures, which will be used to evaluate the four candidate fuels in fit-for-purpose testing.

4.0 R&D Business Management

This chapter reviews the FAA R&D portfolio according to the FY 2016 President's Budget submission. It also summarizes the four budget appropriation accounts, shows how much the FAA is spending on R&D, and describes its R&D program execution.

The FAA R&D portfolio supports regulation, certification, and standards development; modernization of the NAS; and policy and planning. To support FAA R&D principles and goals, the R&D addresses the specific needs of sponsoring organizations, including Aviation Safety, Air Traffic Organization, Airports, NextGen, and 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: RE&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 (RE&D)

The RE&D appropriation account funds R&D programs that improve the NAS by increasing its safety, security, productivity, capacity, and environmental compatibility to meet the expected air traffic demands of the future. The RE&D appropriation account funds roughly 40 percent 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 and 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 groups of 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 Airport Cooperative Research Program (ACRP) and the Airport Technology Research Program (ATRP).

The ACRP organization, its procedures, and its 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

[7] FAA Order 2500.8B, Funding Criteria for Operations, Facilities and Equipment (F&E), and Research, Engineering and Development (RE&D) Accounts, dated October 1, 2006.

Administrator of the FAA. The purpose of the ACRP is to research problems shared by airports 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 safety, 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 FAA R&D budget by appropriation, program sponsor, R&D category, performance goal, and NextGen R&D. It presents the FY 2015 Enacted and FY 2016 President's Request, and planned funding for FY 2017 through 2020, which are estimates and subject to change. The amounts shown for F&E programs in FY 2015 reflect only R&D activities: they do not include acquisition, operational testing, or other non-R&D activities. The amounts shown for F&E programs in FY 2016 and beyond are increased to reflect the entire budget for those portfolios. This increase is due to the reclassification of existing work to better align with OMB Circular A-11 Research Definitions. The amount shown for CAASD in FY 2015 includes only the R&D portion of the total CAASD line item amount. R&D represents 27.6% in FY 2015. The amount shown for CAASD in FY 2016 and beyond is increased to reflect the entire budget for the program. This increase is 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 shows the FAA R&D FY 2015 Enacted and FY 2016 President's Request budgets and the estimated funding through FY 2020, 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 shows the FAA R&D FY 2015 Enacted and FY 2016 President's Request budgets and the estimated funding through FY 2020, 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 shows the FAA R&D portfolio according to these categories with the percent of applied R&D for FY 2015 through 2020.

[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).

4.2.4 Performance Goal

Table 4.2.4 shows the FAA R&D budget by the performance goals defined in Exhibit II of the FAA President's Request for FY 2016. The R&D programs apply to three of the goals in the U.S. Department of Transportation's Strategic Plan for Fiscal Years 2014–2018, *Transportation for a New Generation*. 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 2015. For Table 4.2.4, System Planning and Resource Management (A14.a) is considered part of Mission Support for the RE&D appropriation account and is pro-rated across the three DOT goals as follows: Safety at 65 percent; Economic Competitiveness at 25 percent; and Environmental Sustainability at 10 percent. William J. Hughes Technical Center Facility (A14.b) is also considered part of Mission Support and is pro-rated between Safety at 72 percent and Economic Competitiveness at 28 percent.

4.2.5 NextGen R&D

Funded by both RE&D and F&E appropriations, the FAA NextGen R&D portfolio is a subset of the FAA R&D portfolio, reported in the NARP. The FAA NextGen R&D portfolio represents 35 percent of the total requested R&D budget reported in the NARP for FY 2016, and it represents 15 percent of the FAA NextGen portfolio. The FAA R&D portfolio includes the entire RE&D contribution to NextGen, but only part of the F&E contribution to NextGen. Table 4.2.5 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	2015 Enacted ($000)	2016 President's Budget ($000)	2017 Estimate ($000)	2018 Estimate ($000)	2019 Estimate ($000)	2020 Estimate /1 ($000)
Research, Engineering and Development (RE&D)								
A11.a	Fire Research and Safety	RE&D	6,000	6,643	6,782	6,947	7,038	7,157
A11.b	Propulsion and Fuel Systems	RE&D	2,000	3,034	3,087	3,160	3,173	3,206
A11.c	Advanced Materials/Structural Safety	RE&D	2,909	3,625	3,687	3,773	3,787	3,825
A11.d	Aircraft Icing/Digital System Safety	RE&D	5,500	6,920	7,043	7,210	7,246	7,325
A11.e	Continued Airworthiness	RE&D	9,619	8,987	9,151	9,368	9,424	9,534
A11.f	Aircraft Catastrophic Failure Prevention Research	RE&D	1,500	1,433	1,458	1,492	1,498	1,513
A11.g	Flightdeck/Maintenance/System Integration Human Factors	RE&D	6,000	9,947	10,136	10,379	10,464	10,602
A11.h	System Safety Management	RE&D	7,970	6,063	6,179	6,327	6,379	6,464
A11.i	Air Traffic Control/Technical Operations Human Factors	RE&D	5,400	5,995	6,147	6,304	6,460	6,621
A11.j	Aeromedical Research	RE&D	8,300	10,255	10,476	10,734	10,894	11,090
A11.k	Weather Program	RE&D	14,847	18,253	18,525	18,948	18,895	18,994
A11.l	Unmanned Aircraft Systems Research	RE&D	14,974	9,635	9,790	10,016	10,024	10,102
A11.m	NextGen - Alternative Fuels for General Aviation	RE&D	6,000	5,833	5,939	6,080	6,115	6,186
A12.a	NextGen - Wake Turbulence	RE&D	8,541	8,680	8,836	9,044	9,095	9,198
A12.b	NextGen - Air Ground Integration Human Factors	RE&D	9,697	8,875	9,036	9,250	9,306	9,415
A12.c	NextGen - Weather Technology in the Cockpit	RE&D	4,048	4,116	4,195	4,296	4,336	4,397
A12.d	Commercial Space Transportation	R,E&D	0	3,000	3,043	3,113	3,100	3,113
A13.a	Environment and Energy	RE&D	14,921	15,061	15,300	15,654	15,655	15,770
A13.b	NextGen - Environmental Research - Aircraft Technologies, Fuels, and Metrics	RE&D	23,014	23,823	24,248	24,821	24,948	25,223
A14.a	System Planning and Resource Management	RE&D	2,100	2,377	2,424	2,480	2,510	2,549
A14.b	William J. Hughes Technical Center Laboratory Facility	RE&D	3,410	3,445	3,518	3,604	3,653	3,716
	RE&D TOTAL	**RE&D**	**156,750**	**166,000**	**169,000**	**173,000**	**174,000**	**176,000**

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

2016 BLI	Program	Appropriation Account	2015 Enacted ($000)	2016 President's Budget ($000)	2017 Estimate ($000)	2018 Estimate ($000)	2019 Estimate ($000)	2020 Estimate ($000) /1
Facilities & Equipment (F&E)								/2
1A01A	Runway Incursion Reduction Program	F&E	3,500					
1A01B	System Capacity, Planning and Improvements	F&E	6,000					
1A01C	Operations Concept Validation and Infrastructure Evolution	F&E	4,000					
1A01D	Major Airspace Redesign	F&E	5,000					
1A10E	New Air Traffic Management Requirements	F&E	4,980					
4A08	Center for Advanced Aviation System Development (CAASD)	F&E	16,560	60,000	60,000	60,000	65,000	65,000 /3
1A01	Advanced Technology Development & Prototyping	F&E		21,300	41,100	45,400	37,100	41,100
1A02	NAS Improvement of System Support Laboratory	F&E		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
1A04	William J. Hughes Technical Center Infrastructure Sustainment	F&E		12,200	10,300	10,000	10,000	11,600
1A05	Next Generation Transportation System - Separation Management Portfolio	F&E		26,500	26,800	27,000	40,000	42,500
1A06	Next Generation Transportation System - Improved Surface/TFDM Portfolio	F&E		17,000	53,000	90,600	116,300	100,800
1A07	Next Generation Transportation System - On Demand NAS	F&E		11,000	14,500	17,000	18,000	32,000
1A08	Next Generation Transportation System - Environment Portfolio	F&E	5,500	1,000	1,000	0	0	0
1A09	Next Generation Transportation System - Imp Multiple Runway OPS Portfolio	F&E		8,000	9,500	5,000	4,000	5,000
1A10	Next Generation Transportation System - NAS Infrastructure	F&E		11,000	14,000	15,200	13,000	15,000
1A11	Next Generation Support Portfolio	F&E		10,000	12,000	13,000	13,000	13,000
	F&E TOTAL	**F&E**	**45,540**	**198,050**	**262,200**	**303,200**	**336,400**	**346,000**
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	12,714	13,248	13,248	13,248	13,248	13,248
--	Airport Technology Research Program - Environment	AIP	1,513	1,576	1,576	1,576	1,576	1,576
--	Airport Technology Research Program - Safety	AIP	15,523	16,176	16,176	16,176	16,176	16,176
	AIP TOTAL	**AIP**	**44,750**	**46,000**	**46,000**	**46,000**	**46,000**	**46,000**
	GRAND TOTAL		**$247,040**	**$410,050**	**$477,200**	**$522,200**	**$556,400**	**$568,000**

Notes:

/1 The funding levels listed for years 2017 to 2020 are estimates and subject to change.

/2 The amounts shown for F&E programs in FY 2015 reflect only R&D activities: they do not include acquisition, operational testing, or other non-R&D activities. The amounts shown for F&E programs in FY 2016 and beyond are increased to reflect the entire budget for those portfolios. This increase is due to the reclassification of existing work to better align with OMB Circular A-11 Research Definitions.

/3 The amount shown for CAASD in FY 2015 includes only the R&D portion of the total CAASD line item amount. R&D work represents 27.6% in FY 2015 and it is estimated that this percentage will carry forward into the outyears.
The amount shown for CAASD in FY 2016 and beyond is increased to reflect the entire budget for the program. This increase is due to the reclassification of existing work to better align with OMB Circular A-11 Research Definitions.

Table 4.2.2: Planned R&D Budget by Requesting Organization

2016 BLI	Program	Appropriation Account	2015 Enacted ($000)	2016 President's Budget ($000)	2017 Estimate ($000)	2018 Estimate ($000)	2019 Estimate ($000)	2020 Estimate ($000) /1
Aviation Safety (AVS)								
A11.a	Fire Research and Safety	RE&D	6,000	6,643	6,782	6,947	7,038	7,157
A11.b	Propulsion and Fuel Systems	RE&D	2,000	3,034	3,087	3,160	3,173	3,206
A11.c	Advanced Materials/Structural Safety	RE&D	2,909	3,625	3,687	3,773	3,787	3,825
A11.d	Aircraft Icing/Digital System Safety	RE&D	5,500	6,920	7,043	7,210	7,246	7,325
A11.e	Continued Airworthiness	RE&D	9,619	8,987	9,151	9,368	9,424	9,534
A11.f	Aircraft Catastrophic Failure Prevention Research	RE&D	1,500	1,433	1,458	1,492	1,498	1,513
A11.g	Flightdeck/Maintenance/System Integration Human Factors	RE&D	6,000	9,947	10,136	10,379	10,464	10,602
A11.h	System Safety Management	RE&D	7,970	6,063	6,179	6,327	6,379	6,464
A11.j	Aeromedical Research	RE&D	8,300	10,255	10,476	10,734	10,894	11,090
A11.l	Unmanned Aircraft Systems Research	RE&D	14,974	9,635	9,790	10,016	10,024	10,102
	AVS TOTAL		**64,772**	**66,542**	**67,789**	**69,406**	**69,927**	**70,818**
NextGen (ANG)								
A11.m	NextGen - Alternative Fuels for General Aviation	RE&D	6,000	5,833	5,939	6,080	6,115	6,186
A12.a	NextGen - Wake Turbulence	RE&D	8,541	8,680	8,836	9,044	9,095	9,198
A12.b	NextGen - Air Ground Integration Human Factors	RE&D	9,697	8,875	9,036	9,250	9,306	9,415
A12.c	NextGen - Weather Technology in the Cockpit	RE&D	4,048	4,116	4,195	4,296	4,336	4,397
A14.a	System Planning and Resource Management	RE&D	2,100	2,377	2,424	2,480	2,510	2,549
A14.b	William J. Hughes Technical Center Laboratory Facility	RE&D	3,410	3,445	3,518	3,604	3,653	3,716
	Subtotal	**RE&D**	33,796	33,326	33,948	34,754	35,015	35,461
1A10E	New Air Traffic Management Requirements		4,980	0	0	0	0	0
1A01	Advanced Technology Development & Prototyping	F&E		21,300	41,100	45,400	37,100	41,100
1A02	NAS Improvement of System Support Laboratory	F&E		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
1A04	William J. Hughes Technical Center Infrastructure Sustainment	F&E		12,200	10,300	10,000	10,000	11,600
1A05	Next Generation Transportation System - Separation Management Portfolio	F&E		26,500	26,800	27,000	40,000	42,500
1A06	Next Generation Transportation System - Improved Surface/TFDM Portfolio	F&E		17,000	53,000	90,600	116,300	100,800
1A07	Next Generation Transportation System - On Demand NAS Portfolio	F&E		11,000	14,500	17,000	18,000	32,000
1A08	Next Generation Transportation System - Environment Portfolio	F&E	5,500	1,000	1,000	0	0	0
1A09	Next Generation Transportation System - Imp Multiple Runway OPS Portfolio	F&E		8,000	9,500	5,000	4,000	5,000
1A10	Next Generation Transportation System - NAS Infrastructure Portfolio	F&E		11,000	14,000	15,200	13,000	15,000
1A11	Next Generation Support Portfolio	F&E		10,000	12,000	13,000	13,000	13,000
	Subtotal	**F&E**	10,480	138,050	202,200	243,200	271,400	281,000 /2
	ANG TOTAL		**44,276**	**171,376**	**236,148**	**277,954**	**306,415**	**316,461**
Air Traffic Organization (ATO)								
A11.i	Air Traffic Control/Technical Operations Human Factors	RE&D	5,400	5,995	6,147	6,304	6,460	6,621
A11.k	Weather Program	RE&D	14,847	18,253	18,525	18,948	18,895	18,994
	Subtotal	**RE&D**	20,247	24,248	24,672	25,252	25,355	25,615
1A01A	Runway Incursion Reduction Program	F&E	3,500	0	0	0	0	0
1A01B	System Capacity, Planning and Improvements	F&E	6,000	0	0	0	0	0
1A01C	Operations Concept Validation and Infrastructure Evolution	F&E	4,000	0	0	0	0	0
1A01D	Major Airspace Redesign	F&E	5,000	0	0	0	0	0
4A08	Center for Advanced Aviation System Development (CAASD)	F&E	16,560	60,000	60,000	60,000	65,000	65,000 /2
	Subtotal	**F&E**	35,060	60,000	60,000	60,000	65,000	65,000 /3
	ATO TOTAL		**55,307**	**84,248**	**84,672**	**85,252**	**90,355**	**90,615**

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

2016 BLI	Program	Appropriation Account	2015 Enacted ($000)	2016 President's Budget ($000)	2017 Estimate ($000)	2018 Estimate ($000)	2019 Estimate ($000)	2020 Estimate /1 ($000)
Commercial Space Transportation (AST)								
	Commercial Space Transportation	R,E&D	0	3,000	3,043	3,113	3,100	3,113
	Subtotal	**RE&D**	0	3,000	3,043	3,113	3,100	3,113
	AST Total		**0**	**3,000**	**3,043**	**3,113**	**3,100**	**3,113**
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	12,714	13,248	13,248	13,248	13,248	13,248
--	Airport Technology Research Program - Environment	AIP	1,513	1,576	1,576	1,576	1,576	1,576
--	Airport Technology Research Program - Safety	AIP	15,523	16,176	16,176	16,176	16,176	16,176
	ARP TOTAL		**44,750**	**46,000**	**46,000**	**46,000**	**46,000**	**46,000**
Policy, International Affairs, and Environment (APL)								
A13.a	Environment and Energy	RE&D	14,921	15,061	15,300	15,654	15,655	15,770
A13.b	NextGen - Environmental Research - Aircraft Technologies, Fuels, and Metrics	RE&D	23,014	23,823	24,248	24,821	24,948	25,223
	APL TOTAL		**37,935**	**38,884**	**39,548**	**40,475**	**40,603**	**40,993**
	GRAND TOTAL		**$247,040**	**$410,050**	**$477,200**	**$522,200**	**$556,400**	**$568,000**

Notes:

/1 The funding levels listed for years 2017 to 2020 are estimates and subject to change.

/2 The amount shown for CAASD in FY 2015 includes only the R&D portion of the total CAASD line item amount. R&D work represents 27.6% in FY 2015 and it is estimated that this percentage will carry forward into the outyears.
The amount shown for CAASD in FY 2016 and beyond is increased to reflect the entire budget for the program. This increase is due to the reclassification of existing work to better align with OMB Circular A-11 Research Definitions.

/3 The amounts shown for F&E programs in FY 2015 reflect only R&D activities: they do not include acquisition, operational testing, or other non-R&D activities. The amounts shown for F&E programs in FY 2016 and beyond are increased to reflect the entire budget for those portfolios. This increase is due to the reclassification of existing work to better align with OMB Circular A-11 Research Definitions.

Table 4.2.3: Planned R&D Budget by Research Category

2016 BLI	Program	Appropriation Account	2015 Enacted ($000)	2016 President's Budget ($000)	2017 Estimate ($000)	2018 Estimate ($000)	2019 Estimate ($000)	2020 Estimate ($000) /1
Applied Research								
A11.a	Fire Research and Safety	RE&D	6,000	6,643	6,782	6,947	7,038	7,157
A11.b	Propulsion and Fuel Systems	RE&D	2,000	3,034	3,087	3,160	3,173	3,206
A11.c	Advanced Materials/Structural Safety	RE&D	2,909	3,625	3,687	3,773	3,787	3,825
A11.d	Aircraft Icing/Digital System Safety	RE&D	5,500	6,920	7,043	7,210	7,246	7,325
A11.e	Continued Airworthiness	RE&D	9,619	8,987	9,151	9,368	9,424	9,534
A11.f	Aircraft Catastrophic Failure Prevention Research	RE&D	1,500	1,433	1,458	1,492	1,498	1,513
A11.g	Flightdeck/Maintenance/System Integration Human Factors	RE&D	6,000	9,947	10,136	10,379	10,464	10,602
A11.h	System Safety Management	RE&D	7,970	6,063	6,179	6,327	6,379	6,464
A11.i	Air Traffic Control/Technical Operations Human Factors	RE&D	5,400	5,995	6,147	6,304	6,460	6,621
A11.j	Aeromedical Research	RE&D	8,300	10,255	10,476	10,734	10,894	11,090
A11.k	Weather Program	RE&D	14,847	18,253	18,525	18,948	18,895	18,994
A11.l	Unmanned Aircraft Systems Research	RE&D	14,974	9,635	9,790	10,016	10,024	10,102
A11.m	NextGen - Alternative Fuels for General Aviation	RE&D	6,000	5,833	5,939	6,080	6,115	6,186
A12.a	NextGen - Wake Turbulence	RE&D	8,541	8,680	8,836	9,044	9,095	9,198
A12.b	NextGen - Air Ground Integration Human Factors	RE&D	9,697	8,875	9,036	9,250	9,306	9,415
A12.c	NextGen - Weather Technology in the Cockpit	RE&D	4,048	4,116	4,195	4,296	4,336	4,397
A12.d	Commercial Space Transportation	R,E&D	0	3,000	3,043	3,113	3,100	3,113
A13.a	Environment and Energy	RE&D	14,921	15,061	15,300	15,654	15,655	15,770
A13.b	NextGen - Environmental Research - Aircraft Technologies, Fuels, and Metrics	RE&D	23,014	23,823	24,248	24,821	24,948	25,223
A14.a	System Planning and Resource Management	RE&D	2,100	2,377	2,424	2,480	2,510	2,549
A14.b	William J. Hughes Technical Center Laboratory Facility	RE&D	3,410	3,445	3,518	3,604	3,653	3,716
	Subtotal	**RE&D**	156,750	166,000	169,000	173,000	174,000	176,000
--	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	12,714	13,248	13,248	13,248	13,248	13,248
--	Airport Technology Research Program - Environment	AIP	1,513	1,576	1,576	1,576	1,576	1,576
--	Airport Technology Research Program - Safety	AIP	15,523	16,176	16,176	16,176	16,176	16,176
	Subtotal	**AIP**	44,750	46,000	46,000	46,000	46,000	46,000
	Applied Research TOTAL		**201,500**	**212,000**	**215,000**	**219,000**	**220,000**	**222,000**
	Applied Research PERCENT		**81.6%**	**51.7%**	**45.1%**	**41.9%**	**39.5%**	**39.1%**

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

2016 BLI	Program	Appropriation Account	2015 Enacted ($000)	2016 President's Budget ($000)	2017 Estimate ($000)	2018 Estimate ($000)	2019 Estimate ($000)	2020 Estimate ($000)	/1
Development									
1A01A	Runway Incursion Reduction Program	F&E	3,500	0	0	0	0	0	
1A01B	System Capacity, Planning and Improvements	F&E	6,000	0	0	0	0	0	
1A01C	Operations Concept Validation and Infrastructure Evolution	F&E	4,000	0	0	0	0	0	
1A01D	Major Airspace Redesign	F&E	5,000	0	0	0	0	0	
1A10E	New Air Traffic Management Requirements	F&E	4,980	0	0	0	0	0	
4A08	Center for Advanced Aviation System Development (CAASD)	F&E	16,560	60,000	60,000	60,000	65,000	65,000	/2
1A01	Advanced Technology Development & Prototyping	F&E	0	21,300	41,100	45,400	37,100	41,100	
1A02	NAS Improvement of System Support Laboratory	F&E	0	1,000	1,000	1,000	1,000	1,000	
1A03	William J. Hughes Technical Center Facilities	F&E	0	19,050	19,000	19,000	19,000	19,000	
1A04	William J. Hughes Technical Center Infrastructure Sustainment	F&E	0	12,200	10,300	10,000	10,000	11,600	
1A05	Next Generation Transportation System - Separation Management	F&E	0	26,500	26,800	27,000	40,000	42,500	
1A06	Next Generation Transportation System - Improved Surface/TFDM	F&E	0	17,000	53,000	90,600	116,300	100,800	
1A07	Next Generation Transportation System - On Demand NAS Portfolio	F&E	0	11,000	14,500	17,000	18,000	32,000	
1A08	Next Generation Transportation System - Environment Portfolio	F&E	5,500	1,000	1,000	0	0	0	
1A09	Next Generation Transportation System - Imp Multiple Runway OPS	F&E	0	8,000	9,500	5,000	4,000	5,000	
1A10	Next Generation Transportation System - NAS Infrastructure	F&E	0	11,000	14,000	15,200	13,000	15,000	
1A11	Next Generation Support Portfolio	F&E	0	10,000	12,000	13,000	13,000	13,000	
	Subtotal	**F&E**	45,540	198,050	262,200	303,200	336,400	346,000	/3
	Development TOTAL		**45,540**	**198,050**	**262,200**	**303,200**	**336,400**	**346,000**	
	Development PERCENT		**18.4%**	**48.3%**	**54.9%**	**58.1%**	**60.5%**	**60.9%**	
	GRAND TOTAL		**$247,040**	**$410,050**	**$477,200**	**$522,200**	**$556,400**	**$568,000**	

Notes:

/1 The funding levels listed for years 2017 to 2020 are estimates and subject to change.

/2 The amount shown for CAASD in FY 2015 includes only the R&D portion of the total CAASD line item amount. R&D work represents 27.6% in FY 2015 and it is estimated that this percentage will carry forward into the outyears.
The amount shown for CAASD in FY 2016 and beyond is increased to reflect the entire budget for the program. This increase is due to the reclassification of existing work to better align with OMB Circular A-11 Research Definitions.

/3 The amounts shown for F&E programs in FY 2015 reflect only R&D activities: they do not include acquisition, operational testing, or other non-R&D activities. The amounts shown for F&E programs in FY 2016 and beyond are increased to reflect the entire budget for those portfolios. This increase is due to the reclassification of existing work to better align with OMB Circular A-11 Research Definitions.

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

2016 BLI	Program	Appropriation Account	2016 Contract Costs ($000)	2016 Personnel Costs ($000)	2016 Other In-house Costs ($000)	2016 President's Budget ($000)	/1
1. Safety							
A11.a	Fire Research and Safety	RE&D	2,833	3,700	110	6,643	
A11.b	Propulsion and Fuel Systems	RE&D	2,217	807	10	3,034	
A11.c	Advanced Materials/Structural Safety	RE&D	2,685	885	55	3,625	
A11.d	Aircraft Icing/Digital System Safety	RE&D	4,824	2,016	80	6,920	
A11.e	Continued Airworthiness	RE&D	5,961	2,916	110	8,987	
A11.f	Aircraft Catastrophic Failure Prevention Research	RE&D	1,055	368	10	1,433	
A11.g	Flightdeck/Maintenance/System Integration Human Factors	RE&D	5,914	3,953	80	9,947	
A11.h	System Safety Management	RE&D	3,556	2,427	80	6,063	
A11.i	Air Traffic Control/Technical Operations Human Factors	RE&D	233	5,642	120	5,995	
A11.j	Aeromedical Research	RE&D	3,776	6,309	170	10,255	
A11.k	Weather Program	RE&D	17,494	714	45	18,253	
A11.l	Unmanned Aircraft Systems Research	RE&D	8,022	1,413	200	9,635	
A11.m	NextGen - Alternative Fuels for General Aviation	RE&D	5,517	301	15	5,833	
A14.a	System Planning and Resource Management	RE&D	618	650	166	1,545	/2
A14.b	William J. Hughes Technical Center Laboratory Facility	RE&D	1,117	1,580	48	2,480	/2
	Subtotal	**RE&D**	65,822	33,681	1,299	100,648	
--	Airport Cooperative Research Program - Safety	AIP	4,903	97	0	5,000	
--	Airport Technology Research Program - Safety	AIP	14,303	1,873	0	16,176	
	Subtotal	**AIP**	19,206	1,970	0	21,176	
	1. Safety TOTAL		**85,027**	**35,651**	**1,299**	**121,824**	
2. Economic Competitiveness							
A12.a	NextGen - Wake Turbulence	RE&D	8,244	311	125	8,680	
A12.b	NextGen - Air Ground Integration Human Factors	RE&D	8,305	531	39	8,875	
A12.c	NextGen - Weather Technology in the Cockpit	RE&D	3,241	848	27	4,116	
A12.d	Commercial Space Transportation	RE&D	3,000	0	0	3,000	
A14.a	System Planning and Resource Management	RE&D	158	166	42	594	/2
A14.b	William J. Hughes Technical Center Laboratory Facility	RE&D	285	403	12	965	/2
	Subtotal	**RE&D**	23,233	2,259	246	26,230	
4A08	Center for Advanced Aviation System Development (CAASD)	F&E	60,000	0	0	60,000	/3
1A01	Advanced Technology Development & Prototyping	F&E	21,300	0	0	21,300	
1A02	NAS Improvement of System Support Laboratory	F&E	1,000	0	0	1,000	
1A03	William J. Hughes Technical Center Facilities	F&E	19,050	0	0	19,050	
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	26,500	0	0	26,500	
1A06	Next Generation Transportation System - Improved Surface/TFDM Portfolio	F&E	17,000	0	0	17,000	
1A07	Next Generation Transportation System - On Demand NAS Portfolio	F&E	11,000	0	0	11,000	
1A08	Next Generation Transportation System - Environment Portfolio	F&E	1,000	0	0	1,000	
1A09	Next Generation Transportation System - Imp Multiple Runway OPS Portfolio	F&E	8,000	0	0	8,000	
1A10	Next Generation Transportation System - NAS Infrastructure Portfolio	F&E	11,000	0	0	11,000	
1A11	Next Generation Support Portfolio	F&E	10,000	0	0	10,000	
	Subtotal	**F&E**	198,050	0	0	198,050	/4
--	Airport Cooperative Research Program - Capacity	AIP	4,903	97	0	5,000	
--	Airport Technology Research Program - Capacity	AIP	11,714	1,534	0	13,248	
	Subtotal	**AIP**	16,617	1,631	0	18,248	
	2. Economic Competitiveness TOTAL		**237,900**	**3,891**	**246**	**242,528**	

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

2016 BLI	Program	Appropriation Account	2016 Contract Costs ($000)	2016 Personnel Costs ($000)	2016 Other In-house Costs ($000)	2016 President's Budget ($000) /1
4. Environmental Sustainability						
A13.a	Environment and Energy	RE&D	12,952	1,934	175	15,061
A13.b	NextGen - Environmental Research - Aircraft Technologies, Fuels, and Metrics	RE&D	23,379	429	15	23,823
A14.a	System Planning and Resource Management	RE&D	249	262	67	238 /2
	Subtotal	**RE&D**	36,580	2,625	257	39,122
--	Airport Cooperative Research Program - Environment	AIP	4,903	97	0	5,000
--	Airport Technology Research Program - Environment	AIP	1,393	183	0	1,576
	Subtotal	**AIP**	6,296	280	0	6,576
	4. Environmental Sustainability TOTAL		**42,876**	**2,904**	**257**	**45,698**
	GRAND TOTAL		**$365,803**	**$42,446**	**$1,801**	**$410,050**

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 65%; Economic Competitiveness at 25%; and Environmental Sustainability at 10%. William J. Hughes Technical Center is considered part of Mission Support; it is pro-rated between Safety at 72% and Mobility at 28%.

/3 The amount shown for CAASD in FY 2016 reflects the entire budget for the program. This increase from past years is due to the reclassification of existing work to better align with OMB Circular A-11 Research Definitions. R&D work is estimated to represent 27.6% of the total CAASD budget in FY 2016 and beyond.

/4 The amounts shown for F&E programs in FY 2016 reflect the entire budget for those portfolios. This increase from past years is due to the reclassification of existing work to better align with OMB Circular A-11 Research Definitions.

Table 4.2.5: NextGen R&D Funding

2016 BLI	Program	Appropriation Account	2015 Enacted ($000)	2016 President's Budget ($000)	2017 Estimate ($000)	2018 Estimate ($000)	2019 Estimate ($000)	2020 Estimate ($000) /1
NextGen - F&E								/2
1A05	Next Generation Transportation System - Separation Management Portfolio	F&E	0	26,500	26,800	27,000	40,000	42,500
1A06	Next Generation Transportation System - Improved Surface/TFDM Portfolio	F&E	0	17,000	53,000	90,600	116,300	100,800
1A07	Next Generation Transportation System - On Demand NAS Portfolio	F&E	0	11,000	14,500	17,000	18,000	32,000
1A08	Next Generation Transportation System - Environment Portfolio	F&E	5,500	1,000	1,000	0	0	0
1A09	Next Generation Transportation System - Imp Multiple Runway OPS Portfolio	F&E	0	8,000	9,500	5,000	4,000	5,000
1A10E	New Air Traffic Management Requirements	F&E	4,980	0	0	0	0	0
1A10	Next Generation Transportation System - NAS Infrastructure Portfolio	F&E	0	11,000	14,000	15,200	13,000	15,000
1A11	Next Generation Support Portfolio	F&E	0	10,000	12,000	13,000	13,000	13,000
	F&E TOTAL	**F&E**	**10,480**	**84,500**	**130,800**	**167,800**	**204,300**	**208,300**
NextGen - RE&D								
A11.l	Unmanned Aircraft Systems Research	RE&D		9,635	9,790	10,016	10,024	10,102
A11.m	NextGen - Alternative Fuels for General Aviation	RE&D	6,000	5,833	5,939	6,080	6,115	6,186
A12.a	NextGen - Wake Turbulence	RE&D	8,541	8,680	8,836	9,044	9,095	9,198
A12.b	NextGen - Air Ground Integration Human Factors	RE&D	9,697	8,875	9,036	9,250	9,306	9,415
A12.c	NextGen - Weather Technology in the Cockpit	RE&D	4,048	4,116	4,195	4,296	4,336	4,397
A13.b	NextGen - Environmental Research - Aircraft Technologies, Fuels, and Metrics	RE&D	23,014	23,823	24,248	24,821	24,948	25,223
	RE&D TOTAL	**RE&D**	**51,300**	**60,962**	**62,044**	**63,507**	**63,824**	**64,521**
	NextGen R&D TOTAL		**$61,780**	**$145,462**	**$192,844**	**$231,307**	**$268,124**	**$272,821**

Notes:

/1 The funding levels listed for years 2017 to 2020 are estimates and subject to change.

/2 The amounts shown for F&E programs in FY 2015 reflect only R&D activities: they do not include acquisition, operational testing, or other non-R&D activities. The amounts shown for F&E programs in FY 2016 and beyond are increased to reflect the entire budget for those portfolios. This increase is due to the reclassification of existing work to better align with OMB Circular A-11 Research Definitions.

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. This process helps the FAA establish research priorities to meet its strategic goals and objectives. To 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 also 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: NAS operations, airport technology, aviation safety, human factors, and environment and energy. During 2014, the REDAC held 2 committee meetings and 10 subcommittee meetings and produced two reports documenting their recommendations. The following link (click on the 'REDAC' tab) provides the recommendations from these reports: 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 such domains 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 about COMSTAC, see: http://www.faa.gov/about/office_org/headquarters_offices/ast/advisory_committee/.

Transportation Research Board

The National Research Council established the Transportation Research Board (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. It fulfills this mission 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 2015 projects in July 2014. The selected research projects will examine different research areas that target near-term solutions to problems facing airport operators and industry stakeholders. The projects will report on the state of the practice in critical areas within the industry. The selected research areas include environmental management, training and modeling as well as airport emergency planning and the use of lockdown systems. For more information, see: http://www.trb.org/ACRP/Public/.

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

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 this 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. 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 that creates a legally binding commitment and may require the obligation of funds. An MOA may include interagency agreements (IAs), which are 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 the 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, and to encourage new technical development efforts in these areas. For more information, see: http://www.fican.org/.

Global Earth Observation System of Systems

The Global Earth Observation System of Systems (GEOSS) provides an umbrella for 15 federal departments and agencies and several White House offices to work collaboratively to address a wide range of environmental issues, including those pertaining to aviation. These include enhanced weather observation; modeling; and forecasting and air and water quality monitoring, modeling, and emissions. Under GEOSS, the FAA works with the Environmental Protection Agency to address air quality and emissions issues facing aviation. For more information about the GEOSS, see: http://www.epa.gov/geoss/.

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 (Pub. 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 DOT. The FAA contributes by assessing and identifying potential measures to reduce fuel consumption and greenhouse gas emissions and by conducting research to support USGCRP, leveraging research with other U.S. Government agencies to reduce uncertainties surrounding aviation emissions and their effect on climate change. For more information, see: 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 for which 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, International Civil Aviation Organization (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 the DoD.

General Aviation Joint Steering Committee

As part of the Safer Skies Focused Safety Agenda launched in 1998, the FAA and the general aviation (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 the 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 the National Weather Service.

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. CRDAs are a highly effective way to meet congressionally mandated technology transfer requirements. For more information, see: http://faa.gov/go/techtran. For detailed information on active CRDAs in FY 2014, see: http://www.faa.gov/about/office_org/headquarters_offices/ang/offices/tc/about/campus/faa_host/RDM/media/pdf/FAA_Active_FY2014_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, see: http://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, see: http://sbir.gov 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, see: 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 - representing 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, see: 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 Centers of Excellence (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

Section 9205 of Public Law 101-508 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. Information on active aviation research grants in FY 2014 is available at http://www.faa.gov/about/office_org/headquarters_offices/ang/offices/tc/about/campus/faa_host/RDM/media/pdf/FAA_Active_FY2014_Agreements.pdf.

5.3.3 Air Transportation Centers of Excellence

The FAA recognizes the critical need to develop the nation's technology base while educating the next generation of aviation professionals. Following a rigorous competitive process, the Administrator selects a university team to serve as a COE in mission-critical topic areas. The COEs are established through long-term cooperative agreements with the nation's premier universities and members, with their affiliates, conduct research and development over a period of 10 years.

The COE program encourages collaboration between government, academia, and industry to advance aviation technologies and expand FAA research capabilities through congressionally required matching contributions. COE university members match FAA grant awards, dollar for

dollar, with contributions from nonfederal sources, and may also provide additional contributions through cost-share contracts.

Through these long-term cost-sharing efforts, 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. The COE universities with their nonfederal affiliates have provided more than $250 million in matching contributions to augment critical FAA research efforts.

During FY 2014, the FAA COE Program Management Office (PMO) conducted significant pre-award activities in preparation for the establishment of a new COE for UAS. The activities included hosting a public meeting, with the sponsoring organization, for 373 registered participants, and issuing a Final Solicitation to seek proposal submissions. Additionally, the COE PMO completed a competition enabling the FAA Administrator to select the new COE for Alternative Jet Fuels & Environment (AJFE) team in FY 2014; entered into 16 new cooperative agreements with COE AJFE member universities with Washington State University serving as the Lead, and MIT serving as the Co-Lead. Post-award COE PMO activities included the conduct of a final 10-year evaluation to prepare for phase down of the COE for Cabin Environment / Intermodal Research; and a Phase I assessment of the COE for Commercial Space Transportation. The FAA awarded $15.4 M in support of 125 COE projects, issued 173 amendments, executed other transactions in support of COE related activities, and generated more than $20 million in matching contributions from industry and other nonfederal sources.

The COE cooperative agreements provide for base funding in support of research and related COE activities over a period of 10 years. Following orderly close out, the FAA intends for each partnership to meet COE requirements by becoming a self-sufficient national aviation resource. 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: alternative jet fuels and environment; commercial space transportation; general aviation safety, accessibility and sustainability; advanced materials; airliner cabin environment and intermodal transportation research; aircraft noise and aviation emissions mitigation; general aviation 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 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 Chicago O’Hare International Airport.

In addition to conducting a competition to establish a COE for UAS, in 2014 the FAA sponsored six active public-private research centers throughout the U.S. with academic institutions and their industry and other affiliates. These are:

- 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 Intermodal Transport Environment
- Joint COE for Advanced Materials
- COE Partnership for AiR Transportation Noise and Emission Reduction

Additional information is available at www.faa.gov/go/coe. Specific and detailed information on FY 2014 COE Grant Awards may be found at http://www.faa.gov/about/office_org/headquarters_offices/ang/offices/management/coe/grant_awards/.

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 Alternative Jet Fuels and Environment or ASCENT. The R&D efforts of ASCENT 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, 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 supported 38 projects and awarded $9.3 million to the 16 member universities late in FY 2014 to begin Phase I of this research partnership. The ASCENT members initially generated $4.6 million in matching contributions from non-federal sources. For additional information, see: http://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: space launch traffic management and launch operations; launch vehicles, operations, technologies and payloads; human spaceflight; and industry viability, including commercial, policy, international, legal, and regulatory viability. Florida Institute of Technology serves as the administrative coordinator with eight university members, including New Mexico State University, Stanford University, the University of Florida, the New Mexico Institute of Mining and Technology, Florida State University, the University of Central Florida, University of

Colorado, and the University of Texas - Medical Branch. The COE added additional non-funded members who work collaboratively to augment FAA research and provide matching contributions, including: McGill University, Baylor College of Medicine, Embry-Riddle Aeronautical University, the National Space Transportation Research (NASTAR) Center, SatWest, and the University of Nebraska Lincoln. The FAA supported 26 related tasks awarding $681,000 in grants through cooperative agreements with the nine member universities. Since its inception, the FAA has awarded $5.5 million in grants, and the COE core universities with their affiliates have provided excess matching contributions of $10.8 million. The nine COE cooperative agreements are in effect through 2015 and are expected to be renegotiated for a second five-year period through 2020. For additional information, see: 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 - The Partnership to Enhance General Aviation Safety, Accessibility and Sustainability (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: The Ohio State University, Iowa State University, Georgia Institute of Technology, Florida Institute of Technology, and Texas A&M University. The FAA supported 26 projects, awarded $3.3 million to the 6 member universities in FY 2014, while the COE generated more than $3 million in matching contributions from nonfederal sources. For additional information, see: https://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 serving 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, it was renamed the COE for Research in the Intermodal Transport Environment (RITE). This COE conducts R&D on cabin air quality, chemical and biological threats, and other related topics.

In FY 2014, the COE PMO conducted a final evaluation and extended the cooperative agreements with each of the COE members in preparation for the COE becoming self-sufficient. Under the on-going administrative leadership of Auburn University and current technical leadership of Kansas State University, core members include Boise State University, Harvard School of Public Health, Purdue University, and the Rutgers University School of Biomedical and Health Services. Over the past decade, the FAA has awarded $21 million to support research at this COE, the members and affiliates have generated more than $28 million in matching contributions, and have prepared for close-out activities. For additional information, see: http://www.acer-coe.org/.

Joint COE for Advanced Materials

In 2003, the FAA Administrator, Marion Blakey, selected the Joint COE for Advanced Materials (JAMS) with the University of Washington and Wichita State University as the lead members. 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, cabin safety, life management of materials, and nanotechnology for composite structures. Member universities include: Edmonds Community College, Northwestern University, Oregon State University, Purdue University, University of California at Los Angeles, University of Delaware, Florida International University, University of Utah, Tuskegee University, and the Washington State University. In FY 2014, 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. For additional information, see: http://www.jams-coe.org/.

COE Partnership for AiR Transportation Noise and Emissions Reduction

In 2003, the FAA Administrator, Marion Blakey, selected the COE Partnership for AiR Transportation Noise and Emissions Reduction (PARTNER) with Massachusetts Institute of Technology serving as the lead member. This COE has been co-sponsored by NASA and Transport Canada and conducts R&D to identify, understand, measure, and mitigate the impacts of aircraft noise and aviation emissions. COE PARTNER seeks to reduce uncertainty in issues dealing with climate impact and the health and welfare effects of emissions to actionable levels. Core member universities include: Harvard University, Pennsylvania State University, Purdue University, Stanford University, Missouri University of Science and Technology (formerly University of Missouri - Rolla), University of North Carolina - Chapel Hill, Georgia Institute of Technology, Boston University, University of Illinois at Urbana-Champaign, and the University of Pennsylvania. The FAA awarded $120,000 to this COE during the final research phase and the COE continues to prepare for close-out activities. For additional information, see: http://partner.mit.edu/.

COE for General Aviation Research

Established in 2001, Embry-Riddle Aeronautical University served as the lead member for the COE for General Aviation Research (CGAR). This COE has conducted safety related R&D with application to non-commercial aviation in the following areas: NextGen ADS-B, weather in the cockpit, safety management systems, remote airport lighting systems, training standards, and UAS. Core university members have included Wichita State University, University of North Dakota, and the University of Alaska - Fairbanks and Anchorage. Over the life of this COE, the FAA awarded $16.8 million in grants, $5 million in support of contract tasks, and the center generated matching contributions in excess of $20 million. The COE for GA research closed out in FY 2014. For more information, see: http://www.cgar.org/about.asp.

COE for Airport Technology

In 1995, the FAA Administrator selected the COE for Airport Pavement Research with the University of Illinois at Urbana-Champaign as the lead member and North Carolina A&T University as a participating member. This COE initially focused 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. Over the life of this COE, the FAA awarded $17.4 million in grants and the COE provided matching contributions in excess of $18 million. This COE is self-sufficient and continues to work closely with Chicago O'Hare International Airport on modernization efforts. The FAA initiated final close-out activities during FY 2013. For further information, see: http://www.ceat.uiuc.edu/.

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 European Organisation for the Safety of Air Navigation (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 they 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, see: 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 en route oceanic. Demonstrations have resulted in savings in fuel and emissions across all three of these domains. For more information, see: 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, see: 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 ANSPs 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, see: 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 percent 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 the Helicopter Association International, the American Helicopter Society International, the 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 percent since 2001-2005. For more information, see: http://www.ihst.org/Default.aspx?tabid=1507&language=en-US.

Acronyms and Abbreviations

Acronym	Definition
A	
AC	Advisory Circular
ACAS-X	Airborne Collision Avoidance System X
ACER	Airliner Cabin Environment
ACRP	Airport Cooperative Research Program
ADS-B	Automatic Dependent Surveillance-Broadcast
AEDT	Aviation Environmental Design Tool
AIP	Grants-In-Aid for Airports Appropriation
AIRE	Atlantic Interoperability Initiative to Reduce Emissions
AJFE	COE for Alternative Jet Fuels and Environment
Al-Li	Aluminum-Lithium
AOA	Angle of Attack
AOPA	Aircraft Owners and Pilots Association
AOV	Air Traffic Oversight
ARFF	Aircraft Rescue and Firefighting
ARP	Aerospace Recommended Practice
ASCENT	Aviation Sustainability Center of Excellence
ASDE-X	Airport Surface Detection Equipment, Model X
ASIAS	Aviation Safety Information Analysis and Sharing
AsMA	Aerospace Medical Association
ASPIRE	Asia and Pacific Initiative to Reduce Emissions
ASTM	American Society for Testing and Materials
ATC	Air Traffic Control
ATL	Hartsfield-Jackson Atlanta International Airport
ATM	Air Traffic Management
ATO	Air Traffic Organization
ATRP	Airport Technology Research Program
AVSI	Aerospace Vehicle Systems Institute
B	
B/Ep	Boron/Epoxy
BLI	Budget Line Item
C	
CAAFI	Commercial Aviation Alternative Fuels Initiative
CAASD	Center for Advanced Aviation System Development
CAF	Compressed Air Form
CAMI	Civil Aerospace Medical Institute

Acronym	Definition
CDTI	Cockpit Displays of Traffic Information
CEAT	Center of Airport Technology Research
CFR	Code of Federal Regulations
CGAR	COE for General Aviation Research
CIP	Current Icing Product
CIP	Capital Investment Plan
CJ	Congressional Justification
CLEEN	Continuous Lower Energy, Emissions and Noise
CMAS	Computational Modeling of Aircraft Structures
CMC	Ceramic Matrix Composite
COE	Center of Excellence
COMSTAC	Commercial Space Transportation Advisory Committee
ConOps	Concept of Operations
CRDA	Cooperative Research and Development Agreement
CVG	Cleveland/North Kentucky Airport
D	
DARWIN®	Design Assessment Of Reliability With Inspection
DoD	U.S. Department of Defense
DOT	U.S. Department of Transportation
E	
EDR	Eddy Dissipation Rate
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
FAA	Federal Aviation Administration
FAARFIELD	FAA Rigid and Flexible Iterative Elastic Layered Design
FACET	Future ATM Concepts Evaluation Tool
FASTER	Full-Scale Aircraft Structural Test Evaluation and Research
FCM	Flow Contingency Management
FDM	Flight Data Monitoring
FEA	Finite Element Analysis
FEM	Finite Element Method
FIP	Forecast Icing Product
FOD	Foreign Object Debris
FRAT	Facility Risk Assessment Tool
FSF	Fire, Smoke or Fume

Acronym	Definition
FY	Fiscal Year
G	
GA	General Aviation
GAARD	General Aviation Airborne Recording Device
GAJSC	General Aviation Joint Steering Committee
GEOSS	Global Earth Observation System of Systems
GTG	Graphical Turbulence Guidance
H	
HiRes	High Resolution
HITL	Human-in-the-Loop
HMA	Hot Mix Asphalt
HRRR	High Resolution Rapid Refresh
HSI	Human-System Integration
I	
ICAO	International Civil Aviation Organization
IDA	Integrated Domain Assessment
IHST	International Helicopter Safety Team
ISAM	Integrated Safety Assessment Model
J	
JAMS	Joint COE for Advanced Materials
JOCA	Jointly Optimal Collision Avoidance
JPDO	Joint Planning and Development Office
JRC	Joint Resources Council
JUP	Joint University Program
K	
KEA	Knowledge Elicitation Activities
L	
LAS	Las Vegas International Airport
LCGS	Low Cost Ground Surveillance
LOSA	Line Operations Safety Assessment
LVO/SMGCS	Low Visibility Operations/Surface Movement Guidance and Control System
M	
MET	Meteorological
MMPDS	Metallic Materials Properties Development and Standardization
MOA	Memorandum/a of Agreement
MOC	Memorandum/a of Cooperation
MOU	Memorandum/a of Understanding
MPAR	Multifunctional Phased Array Radar

Acronym	Definition
N	
NAIRAS	Nowcast of Atmospheric Ionizing Radiation System
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
NextGen	Next Generation Air Transportation System
NEXTOR	National Center of Excellence for Aviation Operations Research
NOx	Nitrogen Oxide
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	
OEM	Original Equipment Manufacturer
OMB	Office of Management and Budget
ORD	Chicago O'Hare International Airport
P	
P3	Processes, Procedures, and Policies
PARTNER	Partnership for AiR Transportation Noise and Emissions Reduction
PDARS	Performance Data Analysis and Reporting System
PDC	Polymer Derived Ceramics
PEGASAS	Partnership to Enhance General Aviation Safety, Accountability and Sustainability
PHX	Phoenix Sky Harbor International Airport
PMO	Program Management Organization
R	
R&D	Research and Development
RE&D	Research, Engineering and Development Appropriation
REB	Research and Development Executive Board
REDAC	Research, Engineering, and Development Advisory Committee
RECAT	Re-Categorization of Wake Turbulence Categories
RITE	COE for Research in the Intermodal Transport Environment
RMP	Research Management Plan

Acronym	Definition
RSA	Runway Safety Area
RTCA	Radio Technical Commission for Aeronautics
S	
S-CDM	Surface Collaborative Decision Making
SAA	Sense and Avoid
SASS	Small Airport Surveillance Sensor
SBIR	Small Business Innovation Research
SESAR	Single European Sky ATM Research
SIR	Screening Information Request
SME	Subject Matter Expert
SWIM	System Wide Information Management
T	
TAC	Technical Advisory Committee
TAS	Terminal Area Safety
TEC	Technical Evaluation Committee
TMI	Traffic Management Initiative
TORA	Take-Off Run Available
TPS	Thermal Protection System
TRACON	Terminal Radar Approach Control
TRB	Transportation Research Board
TSA	Transportation Security Administration
U	
UAS	Unmanned Aircraft System
UAV	Unmanned Aerial Vehicle
U.S.	United States
U.S.C.	United States Code
USGCRP	U.S. Global Change Research Program
V	
V&V	Validation and Verification
W	
WCET	Worst Case Execution Time
WiSC	Wildlife Surveillance Concept
WMA	Warm Mix Asphalt
WTMD	Wake Turbulence Mitigation for Departures