Mission Directorate: Aeronautics Research

Overview

NASA research continues to contribute directly to aeronautics breakthroughs. As the agency's lead organization for aeronautics research, NASA's Aeronautics Research Mission Directorate (ARMD) oversees cutting-edge research whose goal is to generate the innovative concepts, tools and technologies that will enable revolutionary advances in future aircraft, as well as to the airspace in which they will fly. NASA has put together a robust research portfolio that addresses these advances and the challenges facing our nation as it transforms its air transportation system to meet growing capacity needs. In addition, the portfolio ensures aeronautics research and critical core competencies will continue to play a vital role in supporting NASA's manned and robotic space exploration activities.

Growth in the air transportation system is vital to the well being of our nation, indirectly or directly providing 997,000 American jobs. (1) In 2006, aviation manufacturing and services accounted for $445B in direct and indirect economic activity, an increase of $9B since 2004. (2) In the United States, 66 certified domestic carriers fly 6,758 aircraft, servicing almost a million travelers every day, and annual operating revenue for commercial flight stands at $186 billion in 2008. (1)

Future needs will exceed the limited solutions that aviation currently offers, requiring improvements in capacity, environmental compatibility, robustness and freedom of mobility throughout the global airspace while simultaneously transferring safety of flight from reactionary to anticipatory (how to avoid accidents before they occur) practices. In the next two decades, we must develop advances that improve aircraft and system efficiency, reduce aviation's impact on the environment and allow more people to utilize air travel in ways that are more significant than all the gains realized over the last three decades.

NASA's aeronautics programs can enable the realization of these advances. Each of NASA's five programs - Aviation Safety, Airspace Systems, Fundamental Aeronautics, Integrated Systems Research and Aeronautics Test - uniquely addresses specific aeronautical-research needs while taking an integrated approach on addressing critical long term challenges. By continuing to expand the boundaries of aeronautical knowledge for the benefit of the nation through NASA's partnering arrangements in academia, industry and other government agencies, NASA's programs are also helping to foster a collaborative research environment in which ideas and knowledge are exchanged across all communities.

NASA Aeronautics currently administers a robust fundamental research program that is well aligned with the principles, goals and objectives of the National Aeronautics Research and Development (R&D) Policy and Plan and directly supports the development of the Next Generation Air Transportation System (NextGen). NASA's commitment to technical excellence and strong partnerships will ensure our continued focus on those challenges needed to support the needs of the nation's air transportation system and the Agency's space exploration vision.

(1) U.S. DOT Bureau of Transportation Statistics Research and Innovative Technology Administration
(2) "The Economic Impact of Civil Aviation on the U.S. Economy", October 2008, FAA Air Traffic Organization

FY 2011 Budget Request

Budget Authority ($ millions)	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
FY 2011 President's Budget Request	**650.0**	**507.0**	**579.6**	**584.7**	**590.4**	**595.1**	**600.3**
Aeronautics	650.0	507.0	579.6	584.7	590.4	595.1	600.3
FY 2010 President's Budget Request	**650.0**	**507.0**	**514.0**	**521.0**	**529.0**	**536.0**	**--**
Aeronautics	650.0	507.0	514.0	521.0	529.0	536.0	--
Total Change from FY 2010 President's Budget Request	**0.0**	**0.0**	**65.6**	**63.7**	**61.4**	**59.1**	**--**

Note: In all budget tables, the FY 2011 President's Budget Request depicts the July 2009 Operating Plan including American Recovery and Reinvestment Act for the FY 2009 Actual column and the Consolidated Appropriations Act, 2010 (P.L. 111-117) without the Administrative transfers for the FY 2010 enacted column.

Plans for FY 2011

Aeronautics Research

Aeronautics

New Initiatives:

NASA will begin the following three new initiatives in FY 2011:
- Research that will enhance NASA's ability to verify and validate complex software-based systems with a focus on promoting reliable, secure and safe use in the national airspace;
- Research to address operational and safety issues related to the integration of unmanned aircraft systems into the national airspace; and
- Research and technology development efforts, including grants and cooperative agreements, to support NASA's environmentally responsible aviation program.

Major Changes:

None

Major Highlights for FY 2011

In FY 2011, NASA will continue its commitment to conducting long-term cutting edge research for the benefit of the broad aeronautics community. Each of the five programs within Aeronautics will play a significant role in FY 2011 in addressing the challenge of meeting the growing capacity needs of the Next Generation Air Transportation System (NextGen) as well as contributing to the R&D challenges in aviation safety, promising new flight regimes, and aviation environmental impacts. Specifically:

- The Fundamental Aeronautics Program focuses on conducting cutting-edge research to achieve technological capabilities necessary to overcome national challenges in air transportation including reduced noise, emissions, and fuel consumption, and increased mobility through a faster means of transportation.

- The Airspace Systems Program will develop and enable future concepts, capabilities, and technologies that will enable major increases in air traffic management efficiency and flexibility while maintaining safety, to meet capacity and mobility requirements of the NextGen.

- The Aviation Safety Program will take a proactive approach to safety challenges with new and current vehicles and with operations in the nation's current and future air transportation system. In addition, the Program will continue the effort to examine key challenges in verifying and validating flight critical systems.

- The Integrated Systems Research Program's initial effort will conduct research on promising concepts and technologies at an integrated system-level and explore, assess and demonstrate their benefits in a relevant environment.

- The Aeronautics Test Program will ensure the strategic availability, accessibility, and capability of a critical suite of aeronautics ground test facilities and flight operations assets necessary to meet Agency and national aeronautics testing needs.

Mission Directorate:	Aeronautics Research
Theme:	Aeronautics

Theme Overview

FY 2011 Budget Request

Budget Authority ($ millions)	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
FY 2011 President's Budget Request	**650.0**	**507.0**	**579.6**	**584.7**	**590.4**	**595.1**	**600.3**
Aviation Safety	89.3	75.0	79.3	78.9	81.2	81.9	82.7
Airspace Systems	121.5	80.0	82.2	82.9	85.9	86.6	87.4
Fundamental Aeronautics	307.6	220.0	228.5	231.4	236.0	241.8	244.6
Aeronautics Test	131.6	72.0	76.4	76.4	75.6	77.4	78.2
Integrated Systems Research	0.0	60.0	113.1	115.1	111.7	107.4	107.4
FY 2010 President's Budget Request	**650.0**	**507.0**	**514.0**	**521.0**	**529.0**	**536.0**	**--**
Aviation Safety	89.3	60.1	59.6	59.2	61.7	62.5	--
Airspace Systems	121.5	81.4	82.9	83.9	87.2	88.3	--
Fundamental Aeronautics	307.6	228.4	230.0	233.6	239.0	245.9	--
Aeronautics Test	131.6	74.7	77.1	77.2	76.6	78.7	--
Integrated Systems Research	0.0	62.4	64.4	67.1	64.4	60.5	--
Total Change from FY 2010 Request	**0.0**	**0.0**	**65.6**	**63.7**	**61.4**	**59.1**	**--**

Relevance

Relevance to national priorities, relevant fields, and customer needs:

NASA's aeronautics research programs are focused on the technologies that support the realization of the Next Generation Air Transportation Systems (NextGen), including the air traffic management system and the vehicles that operate in this system. The research conducted by NASA addresses aviation safety, energy efficiency and environmental compatibility, and airspace capacity and operational efficiency to ensure the nation's future aviation industry competitiveness. It also addresses the long-term research needs in access-to-space technologies that will be required for future NASA missions. The Office of Science and Technology Policy (OSTP) National Science and Technology Council (NSTC) Committee on Technology chartered an Aeronautics Science and Technology (AS&T) Subcommittee in September 2005. NASA's Associate Administrator for Aeronautics is a co-chair of the Subcommittee, which drafted the Nation's first Aeronautics Research and Development Policy, released by the White House in December 2006. The policy establishes a set of U.S. aeronautics research objectives, defines the appropriate role of the federal government in aeronautics research and development (R&D), defines the roles and responsibilities of the various departments and agencies in aeronautics R&D, addresses R&D test and evaluation infrastructure, and addresses the coordination of aeronautics research across the federal government. NASA's efforts are aligned with the policy. In December 2007, the first National Plan for Aeronautics R&D and Related Infrastructure was approved, and in December 2008, a Technical Appendix to the Plan was released. The Aeronautics research portfolio is closely aligned with this National Plan and includes research content as the key areas called outreach plan of mobility, energy and environment, safety and national security.

Relevance to education and public benefits:

NASA's aeronautics programs ensure long-term focus in fundamental research in both traditional aeronautical disciplines and relevant emerging fields for integration into multidisciplinary system-level capabilities for broad application. This approach will enable revolutionary changes to both the airspace system and the aircraft that fly within it, leading to a safer, more environmentally friendly, and more efficient national air transportation system. Furthermore, NASA will disseminate all of its research results to the widest practicable extent. Through this process, we are able to bring numerous professors and students (graduate research and scientists) into the NASA aeronautics research programs.

NASA uses the NASA Research Announcement (NRA) process to foster collaborative research partnerships with the academic and private sector communities. They are encouraged to spend time at NASA centers in order to enhance the exchange of ideas and expand the learning experience for everyone involved. NASA has focused its educational activities and resources to better attract the nation's best and brightest students to aeronautics. These activities include design competitions and the establishment of graduate and undergraduate scholarships and internships.

Performance Achievement Highlights:

The Airspace Systems Program and the University of California at Santa Cruz successfully demonstrated a prototype separation-assurance system in the presence of time-based constraints. In real-time high-fidelity simulations, ground-based automation was able to maintain safe separation for the entire Fort Worth Center airspace above 10,000 feet. Traffic demand was increased up to twice that of today, and system performance was found to be comparable or better than today. At critical merge points in transition airspace where demand exceeded capacity the system efficiently sequenced and spaced aircraft for arrival. Modeling uncertainties included wind, aircraft performance and trajectory intent.

The Aviation Safety Program disseminated data mining technology, which has resulted in NASA methods being deployed in a prognostic way in a real, operational airline environment. NASA has open-sourced many of its key data mining algorithms for analysis of data from flight data recorders through DASHlink, our Web 2.0 portal. Southwest Airlines sought sequenceMiner and Orca, two advanced anomaly detection techniques. Initial application of these algorithms in their own safety data analysis system has discovered operationally significant events that would not be triggered by their existing methods alone. The airline plans to incorporate these algorithms into their daily operations.

The Fundamental Aeronautics Program made significant research progress to enable more effective use of alternative fuels and in increased knowledge of fuel characterization and performance. Lab and field experiments were conducted to evaluate new synthetic and biofuels for aviation applications. NASA partnered with DoD, EPA, and FAA in this effort. An experiment to examine the performance and emissions of alternative fuels was conducted with the NASA Dryden Flight Facility DC-8 aircraft. During this experiment, several Fischer/Tropsch (FT) fuels were tested. This test resulted in an extensive dataset related to jet engine performance and emissions. Researchers found that burning FT fuel did not appreciably affect engine performance, but did lead to aircraft and storage tank fuel leaks due to seal shrinkage from exposure to these fuels. The most profound effect of the alternative fuels was to reduce engine black carbon number density and mass emissions by more than 75% compared to JP-8, the current aviation fuel of choice. FT fuels also reduced Hazardous Air Pollutant emissions (HAPs) and the fuel's lack of sulfur impurities reduced formation of volatile aerosols in the test engine exhaust. NASA is also developing a database for alternative fuels. The database has all standard properties for 19 alternative fuels/fuel blends and can provide reports on fuels, fuel properties, or ranges of fuel properties that can be printed or exported for further processing.

In FY 2009 the Aeronautics Test Program (ATP), with Rand Corporation, developed a five-year Strategic Plan to ensure the continuous availability of a set of NASA-owned wind tunnels/ground test facilities which are strategically important to the nation. The program continued its strategic initiative to establish the National Force Measurement Technology Capability to improve operation efficiencies. This activity is intended to address the severe erosion of NASA's capability to utilize strain gage balances in wind tunnel testing. During FY 2009, ATP staff co-authored a technical paper highlighting the issue and the ATP strategy for restoring the national capability in this area. The paper was presented at the 47th annual American Institute of Aeronautics and Astronautics Aero-Sciences Conference in January 2009. ATP is collaborating with DoD communities of practice in this initiative, standardizing and developing a best-practices guide, re-capitalizing the NASA strain-gage balance inventory, and increasing research and development investment in critical force measurement technologies and capabilities.

Independent Reviews:

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Relevance	Expert	10/2008	An assessment of NASA's aeronautics research portfolio was performed by the National Research Council (NRC) to determine how NASA is addressing the research challenges identified in the NRC Decadal Survey of Civil Aeronautics. The assessment found that NASA is addressing most of the 51 challenge areas but noted concerns about the lack of research in several areas, including UAS integration in the NAS. NASA has worked to address these concerns by including UAS research in ARRA funded activities.	N/A

Mission Directorate:	Aeronautics Research
Theme:	Aeronautics
Program:	Aviation Safety

FY 2011 Budget Request

Budget Authority ($ millions)	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
FY 2011 President's Budget Request	**89.3**	**75.0**	**79.3**	**78.9**	**81.2**	**81.9**	**82.7**
Aviation Safety	**89.3**	**75.0**	**79.3**	**78.9**	**81.2**	**81.9**	**82.7**
FY 2010 President's Budget Request	**89.3**	**60.1**	**59.6**	**59.2**	**61.7**	**62.5**	**--**
Aviation Safety	**89.3**	**60.1**	**59.6**	**59.2**	**61.7**	**62.5**	**--**
Changes from FY 2010 Request	**0.0**	**14.9**	**19.7**	**19.7**	**19.5**	**19.4**	**--**

Mission Directorate:	Aeronautics Research
Theme:	Aeronautics
Program:	Aviation Safety

Program Overview

By 2025, air traffic within American airspace may double or triple.(1) Radical innovation will be required to meet such demand. The goal of the NextGen is to make passage through increasingly crowded skies efficient and speedy while maintaining or increasing safety. NextGen will achieve its mandates with state-of-the-art networking technology, continually updating its data and sharing that information with pilots and controllers. Aircraft will be able to immediately adjust to changing factors such as weather, traffic congestion, the position of other aircraft, flight trajectories and any terrestrial or airborne security concerns.

NASA's Aviation Safety Program (AvSP) helps to realize NextGen's full potential by examining concerns to further reduce risk in any complex, dynamic operating domain. AvSP's contribution ranges from providing fundamental research in known safety concerns, to working with partners to address the challenges created as we transition to NextGen, where we expect significant increases in air traffic, introduction of new vehicle concepts, continued operation of legacy vehicles, increased reliance on automation, and increased operating complexity.

AvSP is looking at hardware and software systems that will operate in the NextGen. The program is initiating an effort to examine key challenges in verifying and validating (V&V) that flight-critical systems meet the extremely high levels of safety required for NextGen operations. The program seeks to provide increasing capabilities to predict and prevent safety issues, to monitor for safety issues in-flight and mitigate against them should they occur, to analyze and design safety issues out of complex system behaviors, and to constantly analyze designs and operational data for potential hazards. These technologies can be leveraged to support safety in other complex systems, such as NASA long-duration missions in space science and exploration.

For example, one goal of AvSP is to develop validated tools, technologies and techniques for automated detection, diagnosis and prognosis of adverse events that occur in flight. Another goal is pursing flight-deck-related technologies to ensure crew workload and situational awareness are both safely optimized and adapted to the NextGen operational environment.

The program also advances state-of-the-art design tools to detect, avoid, and protect against loss-of-control due to potential adverse events including atmospheric and vehicle system factors, and develops advanced capabilities for detection and mitigation of aging-related hazards before they become critical.

For more information, see http://www.aeronautics.nasa.gov/programs_avsp.htm.

(1) Joint Planning and Development Office, http://www.jpdo.gov/nextgen.asp

Plans For FY 2011

AvSP has developed 5-year research plans with milestones and metrics in four research areas. Research into integrated vehicle health management (IVHM) addresses the challenge of using a prognostic approach to vehicle health management, in particular the integration, processing, and effective use of large amounts of data across highly integrated and complex flight critical systems. Aircraft aging and durability (AAD) research addresses the challenge of improving the operational resiliency of future structures and advanced materials against aging related hazards. The research into integrated intelligent flight deck (IIFD) technologies addresses the future challenges to ensure the proper integration of the human operator in a highly automated and complex operational environment. The integrated resilient aircraft control (IRAC) research seeks to prevent loss-of-control incidents through better understanding of upset flight conditions due to a variety of causes, including icing and structural degradation, and through detection, avoidance, and mitigation methods.

Research into verification and validation of flight critical systems seeks to provide the fundamental knowledge required to safely manage increasing complexity by the development of theories and methods capable of verifying and validating a wide range of complex, flight-critical systems with confidence and in a cost- and time-effective manner. Highlighted here are key performance deliverables for FY 2011.

AvSP will demonstrate self-healing material concepts to mitigate damage in structural elements. In 2011, the program will develop an integrated system concept for the future production of commercial self-healing metallic structural elements.

The program will develop an aging mitigation technique that demonstrates a 25% improvement over the 2007 baseline, and in 2011 will develop corrosion resistant coatings for Ni-base Superalloy disks that will prevent corrosion pitting damage during hot corrosion and reduce the corrosion debit on 704ºC fatigue life by at least 25%.

The program will evaluate selected results from NextGen-based simulator or flight environment experiments and, based on these results, revise concepts of operation for display, decision support, and human-automation designs. In 2011, the program will evaluate solution concepts specified for flight deck system function allocation, decision-support, and human-automation interactions during 4-D trajectory-based operations in the terminal area; to include operations and conceptual system designs for displays, flight management tasks, role/responsibility assignments, and technology/human functions, as well as the performance metrics that the solution concepts seek to improve. Concepts and performance metrics will be derived from results of high-fidelity simulation studies and/or flight testing.

AvSP will also be developing designs and tools that detect or avoid the onset of loss of control as well as mitigate its effects, and will assess strategies for avoidance and recovery from potential loss-of-control conditions.

Project Descriptions and Explanation of Changes

Integrated Vehicle Health Management

The goal of the IVHM research is to advance the state of highly integrated and complex flight-critical health management technologies and systems. These technologies will enable nearly continuous onboard situational awareness of the vehicle health state for use by the flight crew, ground crew, and maintenance depot. Improved safety and reliability will be achieved by onboard systems capable of performing self-diagnostics and self-correction of anomalies that could otherwise go unattended until a critical failure occurs in structures, propulsive systems, avionics hardware, or software. A key enabling technology will be the ability for sharing and processing large amounts of information among the various vehicle subsystems to more accurately diagnose the system health state and execute the logic to self-correct any critical anomalies detected. This data mining capability can also be applied to operational data about both aircraft and airspace.

Aircraft Aging and Durability

The goal of the AAD research is to develop advanced diagnostic and prognostic capabilities for detection and mitigation of aging-related hazards. The research and technologies to be pursued will decrease the susceptibility of current and next generation aircraft and onboard systems to premature deterioration, thus greatly improving vehicle safety and mission success. Emerging civilian and military aircraft are introducing advanced material systems, fabrication techniques, and structural configurations for which there is limited service history. There will be an emphasis on new material systems/fabrication techniques and the potential hazards associated with aging-related degradation. The intent is to take a proactive approach to identifying aging-related hazards before they become critical, and to develop technology and processes to incorporate aging mitigation into the design of future aircraft. Foundational research in aging science will ultimately yield multidisciplinary subsystem and system-level integrated, and mitigation/management of aging-related hazards for future civilian and military aircraft.

Integrated Intelligent Flight Deck

The goal of the IIFD research is to develop tools, methods, principles, guidelines, and technologies for revolutionary flight deck systems. In doing so, the program seeks to expand our ability to predict and create the comprehensive set of developments (technologies, procedures, and specifications for crew training) demanded for truly novel concepts of operation, such as those proposed for the Next Generation Air Transportation System (NextGen). Trajectories may be defined in distinctly new ways, pilots' tasks may expand to include collaboration and negotiation with other aircraft and with air traffic controllers, and may require managing large disparate sets of information to support a wide range of decisions made both individually and collaboratively. Current projections for NextGen operations also prescribe an increased use of automation, much of which will need to interact with, and support, the cognitive activities of pilots and air traffic controllers. The scope of the IIFD research also includes the development of a comprehensive surveillance system design that enables robust detection of external hazards with sufficient time-to-alarm for safe maneuvering to avoid the hazards. The products of the IIFD research should enable system designers to eliminate the safety risk of unintended consequences when introducing new and advanced systems into an operational environment.

Integrated Resilient Aircraft Control

The goal of the IRAC research is to advance our ability to detect, avoid and prevent loss-of-control in flight. Taking into account the advanced automation and autonomy capabilities as envisioned by NextGen, the research will pursue methodologies to enable an aircraft to automatically detect, mitigate, and safely recover from an off-nominal condition that could lead to a loss of control. Key components of the research will be to develop technologies that would enable an aircraft control system to avoid or mitigate the effects of loss-of-control and the rigorous verification and validation of such software-based flight-critical systems. Likewise, research seeks to better understand causes of upset flight conditions, including icing and this structural degradation, and to detect the existence of degraded conditions.

V&V of Flight Critical Systems

The goals of verification and validation of flight critical systems research include providing methods for rigorous and systematic high-level validation of system safety properties and requirements from initial design through implementation, maintenance and modification, as well an understanding of trade-offs between complexity and verification methods for supporting robustness and fault-tolerance in distributed systems, especially considering effective human-interaction. Further, the development of tools to reduce cost and increase safety through improved software assurance and dependability, as well as analysis and testing capabilities of systems-of-systems, will be pursued.

Program Commitments

Commitment/Output FY 2011	Program/Project	Changes from FY 2010 PB Request
In 2012, demonstrate forecasting technology that can predict known anomalies in large data sources	Aviation Safety	Same
In 2012, develop life-prediction methodologies for refined physics based models for composite structural components	Aviation Safety	New
In 2012, compare test results to models of human-automation interaction concepts for NextGen	Aviation Safety	Same
In 2012, assess flight planning and control strategies for aircraft recovery from adverse conditions	Aviation Safety	Same
Deliver validated tools and methods that enable implementation of aircraft aging mitigations by 2016	Aviation Safety	Same
In 2016, deliver tools and flight deck technologies to enable advanced automation to support NextGen	Aviation Safety	Same
Demonstrate sensors, software and guidelines that will enable implementation of onboard IVHM by 2016	Aviation Safety	Same
Deliver multidisciplinary adaptive control design tools for loss-of-control and recovery by 2016	Aviation Safety	Same

Program Management

The ARMD Associate Administrator has oversight responsibility for the program. The Program Director oversees program portfolio formulation, implementation, evaluation, and integration of results with other ARMD/NASA programs.

Project	Management Responsibility	NASA Center Performers	Cost-Sharing Partners
Aviation Safety	Program Director	LARC, GRC, ARC, DFRC	FAA, JPDO, CAST (Commercial Aviation Safety Team), NOAA, DoD, Moog, and Boeing , JCAA (Joint Council on Aging Aircraft), Center for Rotorcraft Innovation, Alcoa, Williams International and Luna Innovations, National Research Council Canada, Air Force Research Lab (AFRL), American Kestrel Company, Goodrich

Acquisition Strategy

The Aviation Safety Program spans research and technology from foundational research to integrated system-level capabilities. This broad spectrum necessitates the use of a wide array of acquisition tools relevant to the appropriate work awarded externally through full and open competition. Teaming among large companies, small businesses, and universities is highly encouraged for all procurement actions.

A full and open NASA Research Announcement (NRA) is used as the means to solicit innovative proposals in key research areas that compliment NASA expertise. One of the main objectives of the NRA investment is to stimulate close collaboration among NASA researchers and NRA award recipients to ensure effective knowledge transfer. The AvSP will award approximately $8.0 million in FY 2011 in grants, contracts, and cooperative agreements, including renewals of multi-year awards made under previous NRAs, primarily with industry, academia and non-profit institutions. These awards will also help to strengthen the research capabilities that are of interest to NASA within the recipient organizations and institutions.

Mission Directorate:	Aeronautics Research
Theme:	Aeronautics
Program:	Aviation Safety

Independent Reviews

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Performance	Expert Review	11/2009	The 12-month review is a formal independent peer review. Experts from other government agencies will report on their assessment of technical and programmatic risk and/or program weaknesses. Their recommendations will be received in a timely fashion and a response will be developed no later than the next quarterly review.	11/2010
Relevance	National Research Council	Ongoing	The review will assess whether the program: (a) has well-defined, prioritized, and appropriate research objectives; (b) is properly coordinated with the safety research programs of the FAA and other relevant Federal agencies; (c) has allocated appropriate resources to each of the research objectives; and (d) suitable mechanisms exist for transitioning the results from the program into operational technologies/ procedures and certification activities in a timely manner.	N/A

Mission Directorate:	Aeronautics Research
Theme:	Aeronautics
Program:	Airspace Systems

FY 2011 Budget Request

Budget Authority ($ millions)	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
FY 2011 President's Budget Request	**121.5**	**80.0**	**82.2**	**82.9**	**85.9**	**86.6**	**87.4**
Airspace Systems	**121.5**	**80.0**	**82.2**	**82.9**	**85.9**	**86.6**	**87.4**
FY 2010 President's Budget Request	**121.5**	**81.4**	**82.9**	**83.9**	**87.2**	**88.3**	**--**
Airspace Systems	**121.5**	**81.4**	**82.9**	**83.9**	**87.2**	**88.3**	**--**
Changes from FY 2010 Request	**0.0**	**-1.4**	**-0.7**	**-0.9**	**-1.4**	**-1.7**	**--**

Program Overview

The Airspace Systems Program (ASP) focuses on mastery, intellectual stewardship, and technical excellence in fundamental air traffic management research. The ASP directly addresses the air traffic management research needs of the Next Generation Air Transportation System (NextGen) in collaboration with the member agencies of the Joint Planning and Development Office (JPDO). NASA is working closely with the JPDO as well as other government, industry, and academic partners to enable the formation, development, integration, and demonstration of revolutionary concepts, capabilities, and technologies allowing significant increases in capacity, efficiency, and flexibility of the National Airspace System (NAS). These goals are in direct support of the guidelines in the National Aeronautics research and development policy and plan.

Increasing the capacity and efficiency of the air transportation system in a manner that does not negatively impact the environment or safety is critically important for the nation's economic well-being. More than half of the nation's busiest airports are already at capacity or will reach capacity limits in the next 10-20 years. Creating new capacity en route or on the airport surface is extraordinarily expensive and can take decades to complete, particularly if environmental constraints and safe separation standards are at issue. Specifically, environmental concerns forced 12 major commercial airports to cancel or indefinitely postpone expansion projects since the 1990s. Despite these constraints, air traffic is expected to continue to increase substantially in the next 20 years. All other factors remaining constant, increases will mean longer delays at airports already experiencing delays and create congestion delays at airports not currently experiencing any. The associated environmental impact and economic inefficiencies have been predicted by some to cost the nation tens of billions of dollars annually. The risk of loss of aircraft separation both during airborne and ground operations could increase as the volume of air traffic exceeds the capacity of the airspace and airports to safely and efficiently accommodate the increased growth.

For more information, please see http://www.aeronautics.nasa.gov/programs_asp.htm.

Plans For FY 2011

ASP conducts research into NextGen concepts and technology development and NextGen systems analysis, integration and evaluation.

The NextGen concept and technology development research focuses on developing capabilities in traffic flow management, dynamic airspace configuration, separation assurance, super density operations, and airport surface operations. Key aspects include optimization for traffic scheduling and route planning, and balanced allocation of resources to maximize airspace productivity in response to arrival, departure, and surface traffic demands. Selected non-normal and off-nominal situations, including system failures, emergency events, and weather impacts will be studied. Technical concepts contributing to this activity will include continuous descents, runway balancing, precision terminal area scheduling and control, surface optimization, efficient flow management, and merging and spacing. Specifically, in FY 2011 ASP will conduct the initial evaluation of terminal tactical conflict prediction and resolution functions. This research will assess the air traffic controller and flight crew acceptability of the initial automated tactical conflict avoidance functionality in dense terminal airspace. It will further determine the acceptability of the initial avoidance function in terms of workload, situational awareness, and perceived safety using mid-fidelity air traffic control and flight deck simulators.

The NextGen systems analysis, integration, and evaluation research will focus on transition from the laboratory to the field of key systems concepts currently being pursued within the NextGen concept and technology development area (i.e., surface, terminal, transitional airspace, and en route domains) that will provide operational benefits, and demonstrate these integrated capabilities in relevant flight environments. Through systems analysis, key concepts will be down-selected based on their potential benefit towards improving operational efficiency, and then matured and tested in both fast-time and real-time full mission simulations to determine their technical viability. From this testing, a sub-set of these integrated concepts will be further demonstrated and evaluated through field tests integrating both air and ground capabilities. This work will continue in FY 2011 with analysis elements, advancing over several years to culminate in relevant field experiments and demonstrations. This work will be coordinated with the FAA, the JPDO, and the Research Transition Teams to ensure transition of NASA concepts, technologies and procedures to the field to help enable the transition of today's air transportation system to NextGen. Specifically, in FY 2011 ASP will determine the initial specification of operational requirements for performing Multi-Sector Planning (MSP) functions in the mid-term, including technical and conceptual requirements, with consideration of how requirements might change as the NAS evolves towards NextGen.

Both research activities contribute to ASP's High Priority Performance Goal to increase efficiency and throughput of aircraft operations during arrival phase of flight. Specifically, in FY 2011, ASP will conduct a field test, where an Enroute Descent Advisor (EDA) prototype will be deployed for real-time decision-making by presenting speed and path adjustment advisories on air traffic controllers' displays. EDA helps save hundreds of pounds of fuel and carbon dioxide emissions per participating flight, while also reducing noise over surrounding communities by selecting optimal descent speeds and paths for arriving aircraft under heavy traffic conditions. EDA provides advanced decision support to controllers, and is a key component of the FAA's 3D-Path Arrival Management Program and NextGen. The primary mechanism for deployment is the NASA-FAA Research Transition Team (RTT), through which NASA will deliver EDA Technology Transition Documentation to the FAA in FY 2012.

Project Descriptions and Explanation of Changes

NextGen Concepts and Technology Development

Researchers focused on NextGen concepts and technology will develop and explore fundamental concepts that address the optimal allocation of ground and air automation technologies necessary for NextGen. The program will focus NASA's technical expertise and world-class facilities to address the question of where, when, how, and the extent to which automation can be applied to moving aircraft safely and efficiently through the National Airspace System (NAS) including airport surfaces. Research in ASP will address Four-Dimensional Trajectory Operations, including advances in the science and applications of multi-aircraft trajectory optimization that solves the demand/capacity imbalance problem while taking into account weather information and forecast uncertainties, and keeping aircraft safely separated. The program's research will develop and test concepts for advanced traffic flow management to provide trajectory planning and execution across the spectrum of time horizons from "strategic planning" to "separation assurance." The program will also conduct research to explore dynamic airspace configuration that addresses the technical challenges of migrating from the current structured, static homogenous airspace to a dynamic, heterogeneous airspace that adapts to user demands and meets changing constraints of weather, traffic congestion, and a highly diverse aircraft fleet. Ultimately, the roles and responsibilities of humans and automation influence every technical area and will be addressed thoroughly. The program will respond to the need to achieve the maximum possible productivity in the combined use of gates, taxiways, runways, terminal airspace, and other airportal resources. Since every airport is a unique environment, and demand is not expected to increase equally at each airport as the system grows.

Specific technical goals include:
- Increasing capacity through dynamic allocation of airspace structure and controller resources
- Effectively allocating demand through departure-time management, route modification, adaptive speed control, etc., in the presence of uncertainty
- Developing algorithms, automation prototypes, and procedures that relieve the capacity constraints imposed by human-controlled separation of aircraft in transition and cruise airspace
- Quantifying the performance-enhancing effects of emerging airborne technologies
- Optimizing surface traffic operations to enable capacity enhancements
- Exploring transformational approaches, enabled by NextGen capabilities, for increasing airportal throughput
- Maximizing the capacity of individual runways and multiple runways with airspace and taxi interactions (closely-spaced parallel and converging/intersecting runways)
- Minimizing runway incursion threats in all weather conditions
- Balancing arrival and departure traffic management to enable capacity improvements.

NextGen Systems Analysis, Integration, and Evaluation

The high-level goal of the NextGen systems analysis, integration, and evaluation research is to conduct systems analysis, integration, and evaluation of key concepts currently being pursued within the surface, terminal, transitional airspace, and en route domains that will provide operational benefits, and demonstrate these integrated capabilities in a relevant environment. Through system analysis, key concepts will be down-selected based on their potential benefit towards increasing efficiency, and then matured and tested in both fast-time and real-time full mission simulations to determine their technical viability. From this testing, a sub-set of these integrated concepts will be further demonstrated and evaluated through field tests integrating both air and ground capabilities. To accomplish this goal, the following technical objectives will be satisfied:
- Define operational issues, factors and concerns that must be considered in conducting system analysis
- Assess collective impact of these technologies using fast-time modeling and simulation and feed back results into the baseline program to enhance and validate research concepts
- Examine the feasibility of the integrated concepts and technologies using human performance models and human-in-the-loop simulations
- Demonstrate the impact of the integrated concepts and technologies using field trials
- Assess alternate fleet implications on trajectory based operations
- Collaborate with industry and government partners to transition technologies that enable increases in capacity and efficiency, while maintaining safety and environmental conditions

Program Commitments

Commitment/Output FY 2011	Program/Project	Changes from FY 2010 PB Request
By 2016, integrate and evaluate systems performance of future concepts, capabilities, and technologies for NextGen operations.	Airspace Systems	Same
By 2016, develop future concepts, capabilities, and technologies for NextGen operations.	Airspace Systems	Same

Program Management

The ARMD Associate Administrator has oversight responsibility for the program. The Program Director oversees program portfolio formulation, implementation, evaluation, and integration of results with other ARMD/NASA programs.

Project	Management Responsibility	NASA Center Performers	Cost-Sharing Partners
Airspace Systems	Program Director	ARC, LARC	FAA, JPDO, DOT, Air Force Research Lab (AFRL), Lockheed Martin, Air Services Australia and Eurocontrol

Mission Directorate:	Aeronautics Research
Theme:	Aeronautics
Program:	Airspace Systems

Acquisition Strategy

The Airspace Systems Program spans research and technology from foundational research to integrated system capabilities. This broad spectrum necessitates the use of a wide array of acquisition tools relevant to the appropriate work awarded externally through full and open competition. Teaming among large companies, small businesses, and universities is highly encouraged for all procurement actions.

A full and open NASA Research Announcement (NRA) is used as the means to solicit innovative proposals in key research areas that complement NASA expertise. One of the main objectives of the NRA investment is to stimulate close collaboration among NASA researchers and NRA award recipients to ensure effective knowledge transfer. The Airspace Systems Program will award approximately $15.1 million in FY 2011 in grants, contracts, and cooperative agreements, primarily with industry, academia and non-profit institutions. These awards will also help strengthen the research capabilities that are of interest to NASA within the recipient organizations and institutions.

Independent Reviews

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Performance	Expert Review	10/2009	The 12-month review is a formal independent peer review. Experts from other government agencies will report on their assessment of technical and programmatic risk and/or program weaknesses. Their recommendations will be received in a timely fashion and a response will be developed no later than the next quarterly review.	11/2010

Mission Directorate:	Aeronautics Research
Theme:	Aeronautics
Program:	Fundamental Aeronautics

FY 2011 Budget Request

Budget Authority ($ millions)	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
FY 2011 President's Budget Request	**307.6**	**220.0**	**228.5**	**231.4**	**236.0**	**241.8**	**244.6**
Fundamental Aeronautics	**307.6**	**220.0**	**228.5**	**231.4**	**236.0**	**241.8**	**244.6**
FY 2010 President's Budget Request	**307.6**	**228.4**	**230.0**	**233.6**	**239.0**	**245.9**	**--**
Fundamental Aeronautics	**307.6**	**228.4**	**230.0**	**233.6**	**239.0**	**245.9**	**--**
Changes from FY 2010 Request	**0.0**	**-8.4**	**-1.4**	**-2.1**	**-3.0**	**-4.2**	**--**

Program Overview

The Fundamental Aeronautics Program (FAP) focuses on conducting cutting-edge research to achieve technological capabilities necessary to overcome national challenges in air transportation including reduced noise, emissions, and fuel consumption, increased mobility through a faster means of transportation, and the ability to ascend/descend through planetary atmospheres. These technological capabilities enable design solutions for performance and environmental challenges of future air vehicles. FAP is dedicated to the mastery and intellectual stewardship of the core competencies of aeronautics for the Nation across all flight regimes. Research in revolutionary aircraft configurations, lighter and stronger materials, improved propulsion systems, and advanced concepts for high lift/drag reduction all target the efficiency and environmental compatibility of future air vehicles. The program also develops physics-based, multidisciplinary design, analysis and optimization tools to enable evaluation of new vehicle designs and to assess, with known uncertainties, the potential impact of design innovations on a vehicle's overall performance. All of these advances will realize revolutionary improvements in noise, emissions and performance enabling a new generation of air vehicles to meet the challenges of the NextGen air transportation system.

Fundamental Aeronautics conducts research across four specific flight regimes. The subsonic fixed wing research focuses on new aircraft configurations, advanced propulsion systems, and enabling technologies to dramatically reduce noise, emissions, fuel burn, and runway field length for a variety of vehicles. The subsonic rotary wing research focuses on speed and range increases, payload capacity, noise reduction, propulsive efficiency, and rotorcraft unique technologies to enable development of new configurations that enhance mobility of the future air transportation system. Technologies to meet the environmental challenges specifically associated with supersonic flight, such as sonic boom and gaseous emissions, are addressed by the supersonics research. Elimination of these barriers will realize practical commercial supersonic cruise vehicles that can fly over land. Finally, the hypersonics research focuses on long-range, fundamental and multidisciplinary research to enable air-breathing launch vehicles with improved reliability for lower-cost and more routine access to space.

For more information, please see http://www.aeronautics.nasa.gov/fap.

Plans For FY 2011

Subsonic rotary wing research will result in the demonstration of new technologies and analysis methods to ensure that large rotorcraft will have sufficient crashworthiness characteristics to be viable commercial transport vehicles. The goal of using rotorcraft to carry as many passengers as current regional jets adds a level of safety consideration to the rotorcraft airframe design that is a much greater challenge than is currently considered in small rotary wing designs. Unlike fixed wing transports or automobiles, rotorcraft have the possibility of both vertical and horizontal velocities during impact. This unusual environment will be addressed through a combination of analytical tools and experimental validation using NASA's unique test facilities. New energy absorbing materials and techniques will be developed, and the goal of certification by analysis will be advanced through careful correlation between modeling and experimental verification.

Subsonic fixed wing research will result in the completion and validation of the second generation of a multi-disciplinary analysis and design toolset to evaluate the trades between noise, emissions, and performance of future aircraft. Accuracy of the toolset will be assessed by comparing predictions of noise, emissions, fuel-burn, takeoff/landing performance, and aircraft weight to known characteristics from single-aisle (B737/CFM56) and twin-aisle (B777/GE90) aircraft. The toolset will then be used to predict the performance benefits of unconventional aircraft configurations (such as hybrid wing-body) to guide the development of enabling technologies for such configurations.

Supersonics research will enable the completion of a multidisciplinary analysis and design system that enables the simultaneous achievement of high cruise efficiency and low sonic boom in future civil supersonic cruise aircraft. The system will integrate analysis tools of varying fidelity in a computational framework that allows rapid, accurate communication of data and control of the analysis and design processes. Higher order analysis tools, based on computational fluid dynamics (CFD) and rapid grid generation will be incorporated in the framework to reduce the uncertainty in the results of the design process. New tools for creating and optimizing the design targets for the sonic boom minimization will also be included. The goal for the design system is to reduce the time required to optimize an aircraft for low sonic boom from months to approximately two weeks. Such a reduction in time will enable the consideration of much more design detail early in the design process.

Hypersonics research will allow CFD predictions of ramjet-to-scramjet mode-transition and compare the predictions to available wind tunnel and/or flight data. The ability to accurately predict scramjet performance under mode-transition fueling levels is a key enabler for the design of efficient high-speed propulsion systems. This CFD assessment activity will validate and verify the accuracy of two CFD codes (WIND and VULCAN) against available data from HIFiRE Flight 2 (Hypersonic International Flight Research Experimentation) wind tunnel tests and the upcoming HIFiRE Flight 2 flight test.

Project Descriptions and Explanation of Changes

Subsonic Fixed Wing

The projected growth of the air transportation system over the next 20 years will increase emissions of greenhouse gases, such as carbon dioxide (CO2), nitrogen oxide (NOX), water vapor, and particulates, and the number of people exposed to airport noise. To meet the mobility needs of the future, the Next Generation Air Transportation System (NextGen) will also rely on the expanded use of secondary and reliever airports and may employ a new class of vehicles that are capable of short take-off and landing (STOL). Efforts in this area consist of conducting long-term, cutting-edge research in the core competencies of the fixed wing regime, thereby producing knowledge, data, capabilities, technologies, and design tools at the foundational, discipline, multidiscipline and system levels that will enable improved prediction methods and technologies for lower noise, lower emissions (including NOx, CO2, water vapor, volatiles, unburned hydrocarbons, particulate matter, and soot), and higher performance for subsonic aircraft. The emphasis is in technology for enabling advances to future generations of fixed-wing vehicles starting with N+1 (the generation after the current one, represented by the Boeing-787), all the way to N+3 (two generations beyond that; expected to enter into service in the 2030-35 period). Higher performance includes energy efficiency to reduce fuel burn and operability technologies that enable takeoff and landing on shorter runways. Alternative fuels research includes characterization of synthetic and biofuels to understand the impact of these fuels on combustor design, performance, and emissions and also the development and application of fluid and mass transport models for use in enhancing the growth of biomass feedstocks for use in refining of biofuels. The goal of this research is to provide technologies, novel test methods, and validated prediction tools that can be used to improve system trades for advanced concepts capable of meeting longer-term noise, emissions, and performance targets. The following objectives address the overall goals:

- Improvements in prediction tools and new experimental methods that provide fundamental properties and establish validation data
- Noise prediction and reduction technologies for airframe and propulsion systems enabling up to -71 dB cumulative, below Stage IV (1)
- Emissions reduction technologies and prediction tools enabling more than 70 percent reduction in landing and take-off NOx below the sixth state of regulation recommended by the Committee on Aviation Environmental Protection
- Improved vehicle performance through design and development of lightweight, multifunctional and durable structural components, low drag aerodynamic components, and higher bypass ratio engines with efficient power plants, and advanced aircraft configurations enabling a fuel burn reduction of more than 70% as compared to state of the art commercial subsonic transport
- Reduce take off and landing field length requirements to optimize utilization of all available runways within metropolitan areas (more than 50% reduction)
- Multi-disciplinary design and analysis tools and processes to enable design of advanced aircraft configurations with greater degree of confidence.

Since NASA does not design or manufacture aircraft that can operationally show these improvements, we will use demonstrated component technologies and system-level assessments to show that the goals could be operationally achieved.

Footnotes:
(1) Stage IV refers to a limit imposed by the International Civil Aviation Organization on the maximum allowable noise levels for current aircraft.

Subsonic Rotary Wing

Advanced rotorcraft can alleviate the capacity problems in the air transportation system by using simultaneous, non-interfering (SNI) approaches that includes non-primary runways, taxiways, and aprons. This approach would require a large, high-speed rotorcraft configuration with capability for 300+ knots cruise. The limiting factor for the cruise speed of tiltrotors has been propeller efficiency, as the designer trades cruise efficiency for hover performance, with a proprotor speed reduction of nominally 15 percent from hover to cruise. The primary limiting factor for the cruise speed of helicopter configurations has been the dynamic stall encountered on the retreating side of the rotor as the forward speed is increased.

Efforts in this area consist of conducting long-term, cutting-edge research in the core competencies of the rotary wing regime, thereby producing knowledge, data, capabilities, technologies, and design tools at the foundational, discipline, multidiscipline, and system levels that will enable improved prediction methods and technologies for lower noise, lower emissions, and higher performance for rotary wing aircraft. The FA program has set aggressive goals to develop technologies that enable high-speed, efficient rotorcraft of various sizes and configurations to be viable commercial vehicles operating in the NextGen airspace system. Research in the subsonic rotary wing area includes the following goals:

- Enable variable-speed rotor concepts that incorporate the ability to change rotor rotational speed by 50% without performance or handling qualities penalties to enable optimum rotor aerodynamic performance in both hover and higher forward flight speeds than currently attainable, making rotorcraft competitive with fixed wing aircraft for short and medium-range missions within the NextGen.
- Contain the external noise within the landing area and reduce internal noise to less than 77 dB, and develop scenarios for low-noise rotorcraft flight operations.
- Assess multiple active rotorcraft concepts for effectiveness in simultaneously increasing aerodynamic efficiency, controlling dynamic stall control for high speed conditions, reducing vibration, and reducing noise. The goal for high speed is to increase the state-of-the-art cruise speed for any rotary wing configuration by 100 knots while maintaining low vibration and low noise characteristics.
- Advance technologies such as crashworthiness, safe operations in icing conditions, and condition-based maintenance methodologies that are essential for rotary wing vehicles to be viable commercial transport concepts.

Supersonics

Supersonic air travel has been possible for decades, but has not been commercially viable because of the significant environmental and performance challenges inherent in this speed regime including overland sonic boom annoyance, high fuel consumption, and NOx emission at high altitudes Efforts in this area consist of conducting long-term, cutting-edge research in the core competencies of the supersonic regime, thereby producing knowledge, data, capabilities, technologies, and design tools at the foundational, discipline, multidiscipline and system levels that will address the technical challenges for practical supersonic cruise aircraft.

The supersonics research is organized along the following major technical challenges: efficiency (supersonic cruise, light weight and durability at high temperature); environmental challenges (airport noise, sonic boom, high altitude emissions); performance challenges (aero-propulso-servo-elastic analysis and design, cruise lift/drag ratio); and multidisciplinary design, analysis and optimization challenges.

The FA program will develop technologies to enable overland supersonic cruise with civilian and military applications at acceptable environmental impacts (no greater than subsonic fixed wing aircraft). Research in supersonics includes the following 10-year goals:

- Cruise efficiency improvements in the airframe and propulsion system leading to approximately 30 percent improvement in aircraft range factor vs. the final NASA High-Speed Research (HSR) program baseline;
- Approximately 15 EPNdB (effective perceived noise, in decibels) of jet noise reduction relative to an unsuppressed jet;
- A reduction of loudness on the order of 30 PLdB (perceived loudness, in decibels) relative to typical military aircraft sonic booms
- Minimization of impact from high-altitude emissions.

Hypersonics

The hypersonics research is motivated by the fact that all access to Earth or planetary orbit, and all entry from orbit into Earth's atmosphere or any planet with an atmosphere, requires flight through the hypersonic regime. Efforts in this area consist of conducting long-term, cutting-edge research in the core competencies of the hypersonics regime, thereby producing knowledge, data, capabilities, and design tools at the foundational, discipline, multidiscipline, and system levels that will address the technical challenges for two high-payoff NASA missions: Airbreathing Reusable Launch Vehicle (RALV) and Planetary Atmospheric Entry Systems (PAES).

Cutting-edge hypersonics research on RALV will enable sustained hypersonic flight through the atmosphere with space-access applications. The research focused on PAES will result in the development of technologies and concepts that can enable the safe and accurate delivery of large payloads to the surface of Mars as well as other bodies with an atmosphere. This effort will focus on the entry, descent, and landing (EDL) phase of both human and robotic planetary missions and is closely aligned with the long-term goals of NASA's space exploration activities.

The FA Program will focus its hypersonics research on addressing some of the hardest challenges including:

- The development of materials for airframe and propulsion applications that can withstand the severe temperatures encountered in hypersonic flight for extended periods of time.
- The development of accurate predictive models for high-speed compressible flow including turbulence, heating, ablation, combustion, and their interactions in order to reduce the uncertainty in predictions of aerodynamic heat loads during the design of hypersonic vehicles. This improved knowledge and predictive capability will result in lower vehicle weight due to reduced design margins for thermal structures and thermal protection systems.
- Airbreathing propulsion systems that operate efficiently over a very wide speed range by integrating high-speed turbine engines or rockets with scramjets.
- Integrating all of the close interactions among the airframe, inlet, nozzle, and propulsion systems using a physics-based multidisciplinary design analysis and optimization approach.

The RALV mission class will help enable new air-breathing launch vehicle such as Two-Stage-to-Orbit Turbine-Based Combined-Cycle systems to eventually provide more routine low-cost access to space. The PAES mission research will push EDL technology beyond the state of the art in hypersonic atmospheric entry to successfully land payloads on Mars with masses up to two orders of magnitude greater than is practically realizable today.

Program Commitments

Commitment/Output FY 2011	Program/Project	Changes from FY 2010 PB Request
By 2012 demonstrate a rotor concept incorporating the ability to change rotor speed without penalty	Fundamental Aeronautics	Same
By 2013 develop framework for analysis and design of supersonic aircraft that are efficient with low noise and emissions	Fundamental Aeronautics	Same
In 2013 develop Gen 1 integrated simulation tool for reusable airbreathing launch vehicles	Fundamental Aeronautics	New

Program Management

The ARMD Associate Administrator has oversight responsibility for the FA program. The Program Director oversees program portfolio formulation, implementation, evaluation, and integration of results with other ARMD/NASA programs.

Project	Management Responsibility	NASA Center Performers	Cost-Sharing Partners
Fundamental Aeronautics	Program Director	ARC, DFRC, GRC, LaRC	Air Force Research Lab (AFRL), Boeing, Pratt & Whitney, Northrop Grumman, A.R. Associates, ENrG Inc., General Electric Aviation, Gulfstream Aerospace, and United Technologies Corporation, Office of the Secretary of Defense, U.S. Army, U.S. Air Force, Center for Rotorcraft Innovation (CRI), Bell Helicopter, Sikorsky, Boeing, DARPA, FAA, Polyumac, Technocore, and ONERA, JAXA, DLR, Lockheed martin, Aerion Corporation, U.S. Air Force Office of Scientific Research (AFOSR), U. S. Navy, Deputy Undersecretary of Defense for Science and Technology

Acquisition Strategy

Acquisitions within the program provide the basic elements for fundamental research, tools and methods development, enabling technologies, and validation and verification of research results. This broad spectrum necessitates the use of a wide array of acquisition tools relevant to the appropriate work awarded externally through full and open competition. Teaming among large companies, small businesses, and universities is highly encouraged for all procurement actions.

A full and open NASA Research Announcement (NRA) is used as the primary means to solicit innovative proposals in key research areas that compliment NASA expertise. One of the main objectives of the NRA investment is to stimulate close collaboration among NASA researchers and NRA award recipients to ensure effective knowledge transfer. The Fundamental Aeronautics Program will award at least $30M million in FY 2011 in grants, contracts, and cooperative agreements, primarily with industry, academia and non-profit institutions. These awards will also help to strengthen the research capabilities that are of interest to NASA within the recipient organizations and institutions.

Independent Reviews

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Performance	Expert Review	12/2009	The 12-month review is a formal independent peer review of the program. Experts from other government agencies will report on their assessment of technical and programmatic risk and/or program weaknesses. Their recommendations will be received in a timely fashion and a response will be developed no later than the next 6-month review.	12/2010

Mission Directorate:	Aeronautics Research
Theme:	Aeronautics
Program:	Aeronautics Test

FY 2011 Budget Request

Budget Authority ($ millions)	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
FY 2011 President's Budget Request	**131.6**	**72.0**	**76.4**	**76.4**	**75.6**	**77.4**	**78.2**
Aeronautics Test	**131.6**	**72.0**	**76.4**	**76.4**	**75.6**	**77.4**	**78.2**
FY 2010 President's Budget Request	**131.6**	**74.7**	**77.1**	**77.2**	**76.6**	**78.7**	**--**
Aeronautics Test	**131.6**	**74.7**	**77.1**	**77.2**	**76.6**	**78.7**	**--**
Changes from FY 2010 Request	**0.0**	**-2.7**	**-0.7**	**-0.9**	**-1.0**	**-1.3**	**--**

Mission Directorate:	Aeronautics Research
Theme:	Aeronautics
Program:	Aeronautics Test

Program Overview

The Aeronautics Test Program (ATP) is a long-term, funded commitment by NASA and the Aeronautics Research Mission Directorate (ARMD) to retain and invest in test capabilities that are strategically important to both the Agency and the nation. ATP capabilities are located at the Ames Research Center (ARC), Dryden Flight Research Center (DFRC), Glenn Research Center (GRC), and Langley Research Center (LaRC). ATP offers government agencies, corporations, and academic institutions unmatched basic and applied research and experimental opportunities that reflect four generations of accumulated aerospace skill and experience encompassing every aspect of aerospace ground and flight testing and engineering. ATP's vision for the future is a portfolio of aeronautics ground and flight test capabilities that advance U.S. leadership in aeronautics in the short and long term.

Before ATP was established in 2006, a shrinking customer base and cuts in available test resources were diminishing NASA's aeronautics research capabilities. Lacking were both the strategic support and the financial resources to ensure that important national test capabilities were adequately maintained and accessible. Each of the NASA research Centers was fully responsible for its respective aeronautics test facilities, thereby limiting the potential ability to pursue agency-wide approaches and inter-Center collaboration. Occupancy costs for facilities were at risk of becoming unstable and incommensurate with the value provided to users; test customers were being increasingly burdened with broader, non-recurring infrastructure costs; and U.S. test capabilities were in danger of becoming inferior to foreign capabilities.

ATP began addressing national aeronautics test concerns by leading in the implementation of consistent processes, procedures, and pricing structures across the test capabilities within its portfolio. ATP strives to ensure safe, efficient, and cost-effective operation of its national aeronautics test assets through investments in facility workforce, maintenance, and technology development. ATP also provides leadership through national partnerships and collaborative activities, such as the National Partnership for Aeronautics Testing (NPAT) involving the Department of Defense (DoD) and the NASA ARMD.

Looking to the future, ATP will continue maturation through implementing its strategic plan with its four thrusts: (1) provide management guidance and recommendations to the NASA ARMD Associate Administrator and Research Center Directors concerning NASA aeronautics ground and flight test capabilities; (2) represent the strategic interest of NASA and the nation with respect to stewardship of NASA ground and flight test capabilities; (3) provide direction to NASA test capability managers; and, (4) provide financial support to NASA test capabilities.

For more information, see http://www.aeronautics.nasa.gov/atp.

Plans For FY 2011

Strategic initiatives for FY 2011 include the finalization of a Capability Reliance Framework, which is a top-level view of the suite of capabilities that ATP oversees and supports. This framework will inform decision makers about capability needs, which facilities and resources operated by NASA and other entities could serve those needs, and condition and life-cycle costs. The framework will integrate a number of results from measures and initiatives to allow ATP and NASA to quickly identify areas of potential concern, for example, gaps in capabilities, redundancies, and potential opportunities for consolidation. In FY 2011, ATP will incorporate data produced by other ATP initiatives, such as the ATP/NPAT Hypersonic and Subsonic test facility studies that will be finished in FY 2010, to complete the Capability Reliance Framework.

ATP Test Technology investments develop and implement new technologies that will increase aeronautics test capability, improve productivity and efficiency, and improve data quality. In FY 2011, the National Force Measurement Technology Capability will shift to full cost recovery and away from ATP funding. Also in FY 2011 and through the NPAT, ATP will lead a national test technology strategy involving the Arnold Engineering Development Center, Air Force Research Lab, and programs within the ARMD. The objective will be to make strategic investments based on customer requirements and the priorities set by ATP's Facility Capability and Reliability Framework as outlined in ATP's Strategic Plan.

Mission Directorate:	Aeronautics Research
Theme:	Aeronautics
Program:	Aeronautics Test

Project Descriptions and Explanation of Changes

Aero Ground Test Facilities

The aeronautics ground test facilities are different classes of facilities including low speed wind tunnels, transonic wind tunnels, supersonic wind tunnels, and hypersonic wind tunnels. The four primary efforts to support the long term viability of the facilities and to continually improve on the efficiency and effectiveness of operations are:

- Facility operations support, which provides a portion of the fixed costs for ground test facilities to ensure facility and staff availability and user price stability.
- Facility maintenance and upgrades, which provides funding for maintenance and the upgrades that correct known deficiencies in facility safety, reliability, and productivity and enable the facilities to meet near-term and future testing requirements. These activities will result in improved facility productivity and reduced operational cost.
- Facility test technology, which provides funding to develop and implement new technologies that increase test capability, improve productivity and efficiency, and improve data quality.
- Facility related research, whose activities are competed openly with a strong desire to involve universities with experimental work in major facilities. It is anticipated that one or more ATP assets will be utilized to develop technologies that will support either the facility operation or other ARMD research programs.

Flight Operations and Test Infrastructure

The flight operations and test infrastructure consists of an integrated set of elements including the Western Aeronautical Test Range (WATR), support aircraft maintenance and operations, and the testbed aircraft that provide the resources required for research flight and mission support projects. The goal is to provide up to 100 percent of the facility fixed costs for these flight facilities to ensure facility and staff availability and user price stability.

The activity also includes the simulation and flight loads laboratories, a suite of ground based laboratories that support research flight and mission operations. The goal is to provide up to 20 percent of the fixed costs for labs to ensure facility and staff availability and user price stability.

Program Commitments

Commitment/Output FY 2011	Program/Project	Changes from FY 2010 PB Request
By 2012, deliver at least 90% of on-time availability for operations and research facilities	Aeronautics Test	Same

Program Management

The ARMD Associate Administrator has oversight responsibility for the program. The Program Director oversees program portfolio formulation, implementation, evaluation, and integration of results with other ARMD/NASA programs.

Project	Management Responsibility	NASA Center Performers	Cost-Sharing Partners
Aeronautics Test	Program Director	ARC, DFRC, GRC, and LaRC	DoD and Boeing

Acquisition Strategy

Acquisitions supporting ATP activity will be performed at each of the test sites consistent with the Federal Acquisition Regulation (FAR) and the NASA FAR Supplement (NFS). Each Center will be responsible for coordinating major acquisitions supporting ATP activities through the ATP Office as required by the ATP Director. Acquisitions that support the ATP facilities are usually less than $0.5 million and are initiated as early as possible in the fiscal year.

Independent Reviews

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Relevance	Expert Panel	07/2009	Periodic reviews are carried out by the NASA Advisory Council (NAC) and the U.S. users of ATP facilities. The last ATP review was carried out by the Aeronautics Committee of the NAC in July 2009; no major findings were reported. The last major community outreach meeting was held in September 2008 with NASA, DoD and U.S. aerospace industry users at the Ohio Institute of Aerospace. The next meeting is planned for April 2010.	03/2010
Performance	Expert Panel	12/2009	The 12-month review is a formal independent peer review. Experts from other government agencies will report on their assessment of technical and programmatic risk and/or program weaknesses. Recommendations will be addressed and a response will be developed no later than the next quarterly review.	12/2010

Mission Directorate:	Aeronautics Research
Theme:	Aeronautics
Program:	Integrated Systems Research

FY 2011 Budget Request

Budget Authority ($ millions)	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
FY 2011 President's Budget Request	**0.0**	**60.0**	**113.1**	**115.1**	**111.7**	**107.4**	**107.4**
Green Aviation	**0.0**	**60.0**	**83.1**	**85.1**	**81.7**	**77.4**	**77.4**
UAS Integration in the NAS	**0.0**	**0.0**	**30.0**	**30.0**	**30.0**	**30.0**	**30.0**
FY 2010 President's Budget Request	**0.0**	**62.4**	**64.4**	**67.1**	**64.4**	**60.5**	**--**
Green Aviation	**0.0**	**62.4**	**64.4**	**67.1**	**64.4**	**60.5**	**--**
Changes from FY 2010 Request	**0.0**	**-2.4**	**48.7**	**48.0**	**47.3**	**46.9**	**--**

Mission Directorate:	Aeronautics Research
Theme:	Aeronautics
Program:	Integrated Systems Research

Program Overview

The Integrated Systems Research Program (ISRP) will conduct integrated system-level research on promising concepts and technologies and explore, assess or demonstrate their benefits in a relevant environment. The research in this program will be coordinated with on-going long-term, foundational research within the three other research programs, as well as efforts within other government agencies. ISRP will explore new vehicle concepts and enabling technologies through system-level experimentation and will focus specifically on maturing and integrating technologies in major vehicle systems/subsystems for accelerated transition to practical application. As the NextGen evolves to meet the projected growth in demand for air transportation, researchers must address the national challenges of mobility, capacity, safety, and energy and the environment to meet the expected growth in air traffic.

The number of flight operations at many of the nation's largest airports is projected to increase in the future. Environmental concerns over noise and emissions will limit the growth capacity of those airports, and therefore limit the capacity of the entire system. Recently, there have been several mandates, directives and recommendations issued to NASA by the National Research Council, Congress, the Executive Office of the President, and the NASA Advisory Council. These recommendations cite the need for NASA to develop a "green aircraft initiative" and advance the development of technologies and operational procedures to decrease the significant environmental impacts of the aviation system. These mandates and recommendations clearly point out the need for NASA to take the initiative to conduct system research and experiments of promising vehicle concepts and technologies that will simultaneously reduce fuel burn, noise and emissions.

NASA will also initiate a research and development effort to understand how advanced environmental technologies can best work in an integrated vehicle/aviation operations system. NASA will engage the external research community by beneficially including traditional and non-traditional research partners. NASA will initiate research activities to expand our current role in aviation alternate and bio-fuels research and will perform activities to determine if, and how, advances in air traffic management technologies can be used to limit aviation's effect on the environment.

In addition, ISRP will focus on delivering validated data and technology which could enable routine operations for Unmanned Aircraft Systems (UAS) of all sizes and capabilities in the National Airspace System (NAS) and NextGen. Requirements will be developed and validated for all sizes and classes of airports and improvised locations necessary to support UAS operations.

Mission Directorate:	Aeronautics Research
Theme:	Aeronautics
Program:	Integrated Systems Research

Plans For FY 2011

Researchers working on environmentally responsible aviation technologies will develop a hot jet test technique, will complete acoustic upgrades to the Langley 14x22 Subsonic Wind Tunnel, will begin the low speed performance assessment of a Hybrid Wing Body (HWB) aircraft, and will begin to test the ability of the aircraft architecture to shield aircraft engine noise during simulated takeoff and approach conditions. The program will develop combustor concepts that offer the potential of reducing NOx emissions levels below those attainable with current technologies, and will partner with industry to conduct flametube tests to evaluate fuel injector designs for advanced Low NOx combustor concepts, and will design and fabricate combustor sector hardware to enable emissions testing at realistic engine conditions in FY 2012. Test hardware of a full-scale, multi-bay, pressurized, noncircular fuselage section utilizing an advanced lightweight stitched composite concepts will be fabricated and delivered for evaluation in FY 2012. In addition, flight tests will begin on a drag reduction approach using distributed roughness elements (DRE). The flight test will be conducted by using an experimental aircraft with DREs on a specially designed glove. Finally, near term work in propulsor technology will be conducted on an ultra high bypass (UHB) geared turbofan. The experiments will establish performance and acoustic characteristics.

Project Descriptions and Explanation of Changes

Green Aviation

The goal of the green aviation research is to explore and assess new vehicle concepts and enabling technologies through system-level experimentation to simultaneously reduce fuel burn, noise, and emissions and thus reduce the impact of aviation on the environment. The program will mature the concepts and technologies and evaluate their performance at the system and sub-system level in a relevant environment, as well as identify and assess issues relative to safety. Through system-level analysis, promising N+2 vehicle and propulsion concepts and technologies will be down-selected based on their potential benefit towards the stated national goals. These concepts and technologies will then be matured and their performance will be evaluated at the system and sub-system level in relevant environments. Among the technologies to be explored are the following:

- Non-conventional aircraft architectures that enable reduced drag and shielding of propulsion system noise,
- Drag reduction through laminar flow,
- Advanced composite structural concepts for weight reduction,
- Low NOx combustors, and
- Propulsion/airframe integration for noise reduction and fuel burn improvements.

The program will expand the well-informed design trade space for these types of technologies, and will transfer knowledge outward to the aeronautics community so that aircraft and propulsion system manufacturers can confidently transition these technologies into new products. The program also has the potential to transfer knowledge back into to the Fundamental Aeronautics Program so that concepts and technologies which do not yield predicted performance benefits can be further investigated and developed at a foundational level. This would occur only after an evaluation of such concepts and technologies indicates that further fundamental research is warranted.

UAS Integration in the NAS

Addressing the challenges associated with all UAS sizes and capabilities will be formidable. With the removal of the pilot, UAS can become significantly smaller than existing aircraft and thus operate in flight regimes far different than aircraft do today. Issues associated with how the human interacts with such systems, reliability, spectrum management, separation assurance, and pilot qualifications are among the major issues requiring attention. Addressing these issues could also have a direct benefit to the safety of piloted aircraft through advances in technology and procedures.

Initial program milestones will be scoped for public UAS access as a confidence builder on the path to enabling routine civil UAS access to NextGen. Because public UAS can be self-certified by the public agency, they do not need to wait for formal rules to be established by the FAA, which can take several years. The validated data and technologies delivered by this program would be a key enabler, and dramatically reduce the time required for the rule making process.

This work will be conducted in close coordination with efforts underway in the UAS Executive Committee (ExCom), comprised of senior executives from the FAA, DOD, NASA, and DHS, to ensure the products of this work are transitioned in to application.

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Program Commitments

Commitment/Output FY 2011	Program/Project	Changes from FY 2010 PB Request
By FY 2012, conduct tests to validate low-noise characteristics of energy efficient unconventional aircraft concepts	Integrated Systems Research	New
By FY 2012, demonstrate a low-weight, damage-tolerant stitched composite structural concept on a large scale structure in a combined loads test facility	Integrated Systems Research	New

Program Management

The ARMD Associate Administrator has oversight responsibility for the program. The Program Director oversees program portfolio formulation, implementation, evaluation, and integration of results with other ARMD/NASA programs.

Project	Management Responsibility	NASA Center Performers	Cost-Sharing Partners
Integrated Systems Research	Program Director	ARC, DFRC, GRC, and LaRC	Boeing R&T, GE Aviation, Pratt & Whitney, AFRL

Acquisition Strategy

The Integrated Systems Research Program will develop and further mature promising technologies to the integrated system-level. This necessitates the use of a wide array of acquisition tools relevant to the appropriate work awarded externally through full and open competition. Teaming among large companies, small businesses, and universities is highly encouraged for all procurement actions.

A full and open NASA Research Announcement (NRA) is used as the means to solicit innovative proposals in key research areas that complement NASA expertise. One of the main objectives of the NRA investment is to stimulate close collaboration among NASA researchers and NRA award recipients to ensure effective knowledge transfer. The Integrated Systems Research Program will award approximately $10.5 million in FY 2011 in grants, contracts, and cooperative agreements, primarily with industry, academia and non-profit institutions. These awards will also help strengthen the research capabilities that are of interest to NASA within the recipient organizations and institutions

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Independent Reviews

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Relevance	Subject Matter Experts	05/2009	The National Research Council of the National Academies is convening a meeting of experts to review NASA's plans for system-level research in Environmentally Responsible Aviation. The purpose of the review is for NASA to collect comments and observations from subject matter experts in the areas of aviation operations, vehicles and environmental impact. NASA will consider the comments and observations it receives in future refinement of its plans.	N/A
Relevance	Expert Review	09/2009	The Formulation Review is an internal and external review. The external component serves as a formal independent peer review. Experts from other government agencies give a recommendation to the ARMD Associate Administrator on whether or not the technical plans address relevant challenges and can achieve the stated objectives and schedule within the allocated resources. This recommendation decides whether or not the program and project are ready to move from formulation into implementation.	N/A
Performance	Review Panel	N/A	The 12-month review is a formal independent peer review. Experts from other government agencies will report on their assessment of technical and programmatic risk and/or program weaknesses. Their recommendations will be received in a timely fashion and a response will be developed no later than the next quarterly review.	11/2010