NASA Aeronautics Research

Thomas Irvine
Deputy Associate Administrator
NASA Aeronautics Research Mission Directorate

ASEB
April 5, 2011

Challenges in Aeronautics/Aviation

Air Traffic Congestion

The current system cannot deal well with today's air traffic, and projected traffic growth will make this problem worse.

Safety

Air transportation is the safest mode of transportation. However, as aircraft and air traffic systems become more automated and complex, failure to maintain and even improve on this enviable safety record would be unacceptable to the flying public.

Environmental Impacts

Local noise and air quality concerns are inhibitors to air traffic growth.

Solutions to these problems require innovative technical concepts.

International competition in the field of aviation is intense.

The U.S. competitive edge in aviation can only be sustained through appropriate industry AND government R&D.

Alignment with National Goals

How do we know we are working on the right challenges?

National Aeronautics Research and Development Policy

"NASA and in consultation with other Federal agencies shall develop a national aeronautics policy to guide the aeronautics programs of the Administration through 2020" – Science, State, Justice, Commerce, and Related Agencies Appropriation Act, 2006 (Public Law 109 – 108 - November 22, 2005)

- Executive Order signed by President Bush, December 2006
  - Outlines principles to follow in order for the U.S. to "maintain its technological leadership across the aeronautics enterprise"

National Plan for Aeronautics Research and Development

Original plan signed by White House December 2007; Biennial update signed Feb 2010

- Goals and objectives for mobility, national security and homeland defense, aviation safety, energy and the environment (except workforce which is being worked under a separate activity)
- Summary of system-level challenges identified with specific quantitative targets

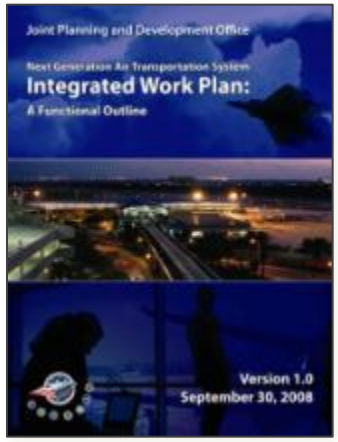
Vision 100 Century of Aviation Reauthorization Act and the Integrated Work Plan (IWP)

Vision100: Public Law 108-176, December 2003

- Established the Joint Planning and Development Office (JPDO) to engage multiple agencies to plan, develop and implement the Next Generation Air Transportation System (NextGen)

IWP: Version 1.0 Released September 2008

- Functional outline of activities needed to achieve the NextGen Vision



NASA Authorization Act of 2010

These increased research areas for FY 2012 are well-aligned with the goals in the National Aeronautics and Space Administration Authorization Act of 2010. The following shows the alignment with the Authorization Act.

From Public Law 111-267:

SEC. 902. AERONAUTICS RESEARCH GOALS.

The Administrator should ensure that NASA maintains a strong aeronautics research portfolio ranging from fundamental research through systems research with specific research goals, including the following:

(1) AIRSPACE CAPACITY.—NASA's Aeronautics Research Mission Directorate shall address research needs of the Next Generation Air Transportation System, including the ability of the National Airspace System to handle up to 3 times the current travel demand by 2025.

- *Efficient and safe airport surface operations*

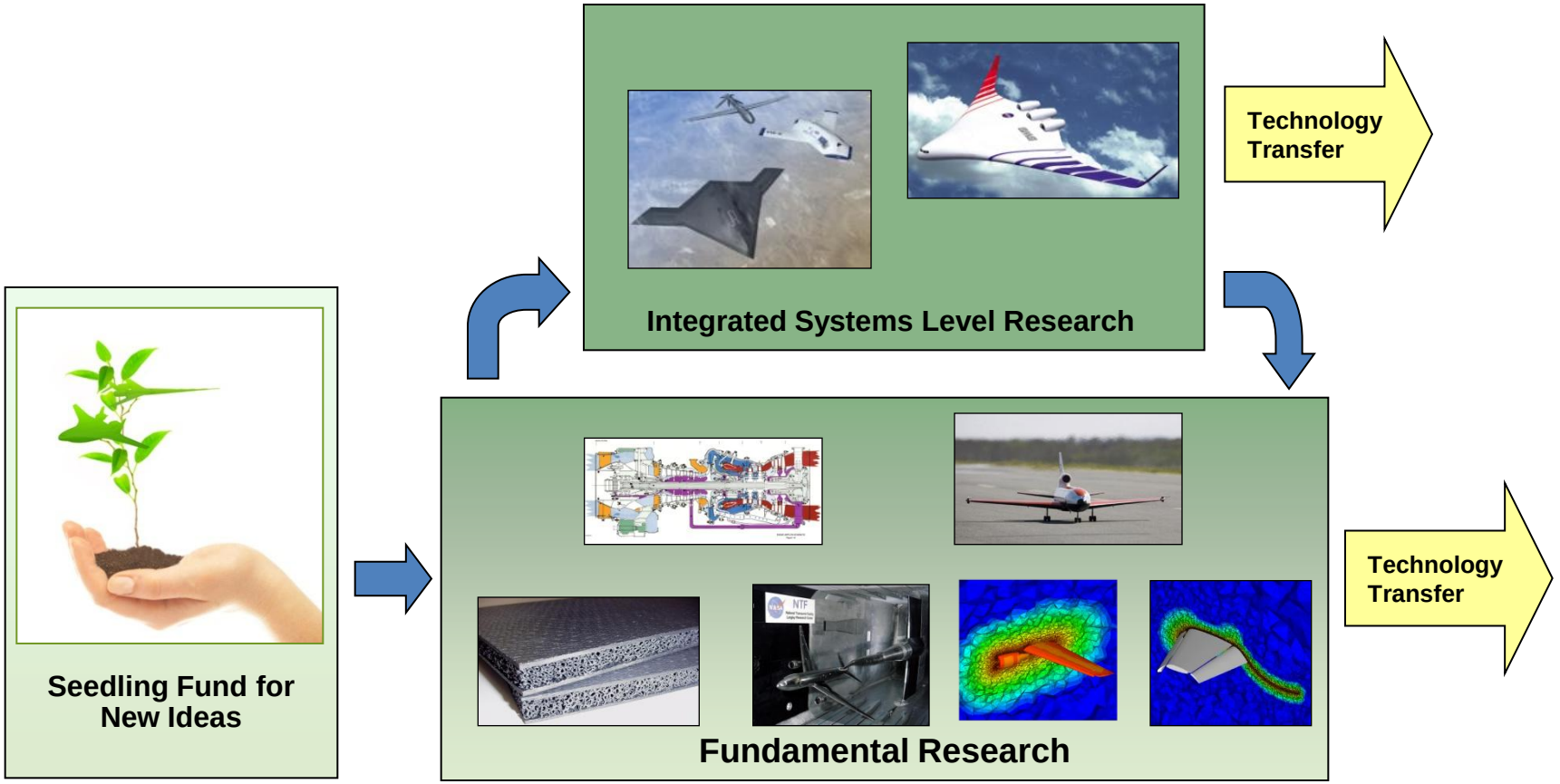
(2) ENVIRONMENTAL SUSTAINABILITY.—The Directorate shall consider and pursue concepts to reduce noise, emissions, and fuel consumption while maintaining high safety standards and shall pursue research related to alternative fuels.

- *Composite structures and materials*
- *Utilization and understanding of alternative fuels for fuel-flexible aircraft engine development*

(3) AVIATION SAFETY.—The Directorate shall proactively address safety challenges with new and current air vehicles and with operations in the Nation's current and future air transportation system.

- *The effects of high altitude ice crystals on aircraft*
- *The effects of lightning strikes on composite materials*

Aeronautics R&D Strategy



- Foster revolutionary ideas with Seedling fund
- More robust technology transfer to industry and other government agencies through innovative fundamental research and further maturation of technologies and concepts in system level research
- Conduct integrated systems research in relevant environments (e.g., flights, full simulations) to realize next set of technological breakthroughs and inspire next generation

NASA Aeronautics Programs



Fundamental Aeronautics Program

Conduct cutting-edge research that will produce innovative concepts, tools, and technologies to enable revolutionary changes for vehicles that fly in all speed regimes.

Integrated Systems Research Program

Conduct research at an integrated system-level on promising concepts and technologies and explore/assess/demonstrate the benefits in a relevant environment.





Airspace Systems Program

Directly address the fundamental ATM research needs for NextGen by developing revolutionary concepts, capabilities, and technologies that will enable significant increases in the capacity, efficiency and flexibility of the NAS.


Aviation Safety Program

Conduct cutting-edge research to produce innovative concepts, tools, and technologies to improve the intrinsic safety attributes of current and future aircraft and air traffic management systems.




Aeronautics Test Program

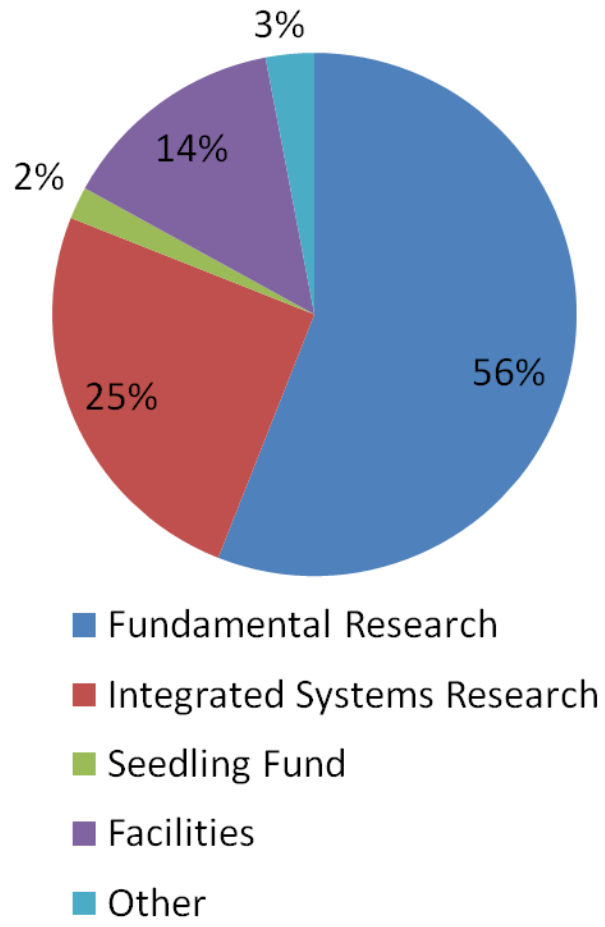
Preserve and promote the testing capabilities of one of the United States' largest, most versatile and comprehensive set of flight and ground-based research facilities.

FY12 Budget Overview

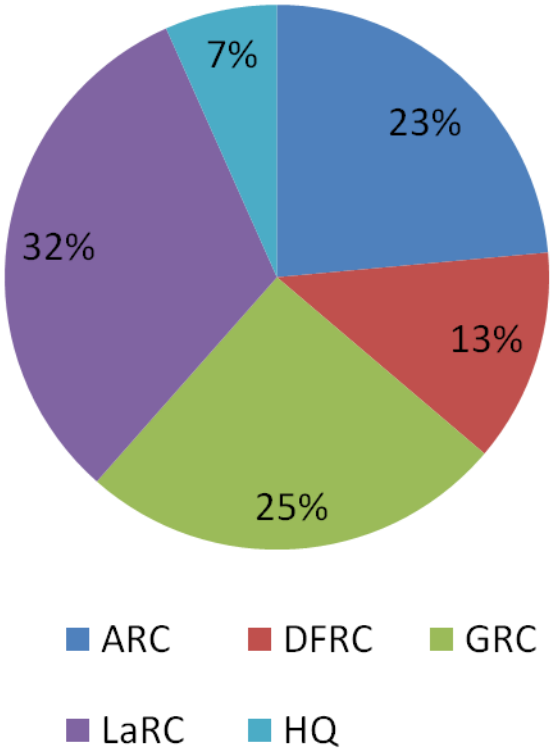
ARMD FY 2012 Budget Request

($ in Millions)	FY 2012	Outyears are Notional FY 2013	FY 2014	FY 2015	FY 2016
Aeronautics Total	**$569.4**	**$569.4**	**$569.4**	**$569.4**	**$569.4**
Aviation Safety	79.6	79.8	80.0	80.3	80.6
Airspace Systems	92.7	92.3	91.7	90.9	90.1
Fundamental Aeronautics	186.3	187.3	189.0	190.9	193.0
Aeronautics Test	79.4	79.4	79.5	79.6	79.7
Integrated Systems Research	104.2	103.7	102.7	101.7	100.6
Aeronautics Strategy and Management	27.2	26.9	26.5	26.0	25.4

Budget by Research Category



Budget by Center



Overview of FY 2012 Budget Request

- The 2012 Budget for NASA Aeronautics strongly endorses NASA's contributions to aviation.
- The budget increases research in:
  - The utilization of advanced ground-based and flight deck technologies and automation for efficient and safe airport surface operations
  - The effects of high altitude ice crystal on aircraft
  - Composite structures and materials
  - Utilization and understanding of alternative fuels for fuel-flexible aircraft engine development
- Continues support for new FY 2011 initiatives into the integration of unmanned aircraft systems into the National Airspace System and the validation and verification of complex aviation systems.
- Focuses hypersonics research on foundational research where NASA possesses unique competencies relied upon by other agencies.

Areas of Increased Research

Beginning in FY 2012 ARMD will increase research in the following areas

- Efficient and safe airport surface operations
  - Technologies will be integrated from the current NASA portfolio to further advance greater utilization of ADS-B application technologies.
  - Provides optimization of airport surface movements with precise scheduling to reduce surface and en-route traffic delays and enhance safety.
- The effects of high altitude ice crystals on aircraft
  - The objective of this research is to support community response to rule-making and thus increase aviation safety in a timely manner.
- Composite structures and materials
  - These efforts will develop new materials and structural analysis capabilities to be effectively utilized in new aircraft designs.
  - Research will also be conducted into the effects of lightning strikes on composite materials in order to support development of sensor concepts, advanced models, and protection methods.

Areas of Increased Research, Continued

- Utilization and understanding of alternative fuels for fuel-flexible aircraft engine development
  - Research to advance the use of alternative fuels in aircraft, including follow-on efforts to continue the Alternative Aviation Fuel Experiment (AAFEX) research that extend to flight testing with in-flight measurement of emissions characteristics and fuel performance
- Flight research that focuses on low-cost, simple, short-term flight demos aimed at enhancing aviation safety and airspace efficiency

Refocus of Hypersonics Research

ARMD's hypersonics research has been reduced to focus on goals outlined in the National Aeronautics R&D Plan

- The research will be in areas where NASA possesses unique competencies relied upon by other agencies
- The research will be foundational in nature and focused on knowledge development and tool creation , including:
  - Improving our understanding and capability to predict aerothermal heating and boundary layer transition, which is critical to hypersonic systems
  - Developing tools and knowledge to support the design of advanced air breathing propulsion systems
  - Research on foundational materials technologies to enable structurally integrated thermal protection systems
- To conduct the foundational research, reduced or eliminated areas include entry, descent and landing (EDL) materials development, new vehicle concepts, turbine-based combined cycle engines, and flight and propulsion system controls.

Significant Technical Accomplishments

- Successfully advocated and received approval for new initiatives in FY 2011 President Budget
  - UAS integration to NAS
  - V&V of flight critical systems
  - Innovative concepts for aviation
- Transferred project management responsibility to the centers
- Achieved significant technical progress

Fundamental Aeronautics Program
Subsonic Rotary Wing Project: UH-60 Airloads Test

PROBLEM
- Limited understanding of blade behavior and flowfield phenomena
- Constrained rotor design and prediction methods

OBJECTIVE
- Acquire high quality integrated data
- Validate computational predictions
- Enable design of highly efficient advanced rotors

APPROACH
- UH-60A Airloads Test in NFAC 40x80ft Wind Tunnel (w/ the Army)
- Measured blade pressures, loads, deformations, rotor performance, rotor wake visualizations

RESULTS
- First test of production UH-60 rotor at high advance ratios and slowed rpm operations
- Successful acquisition of PIV data over the largest area (4ft by 13ft) ever attempted
- Most highly-instrumented rotor test ever conducted in the NFAC
- Measurement of detailed blade deformations via unique photogrammetry technique

SIGNIFICANCE
- Provides complete set of full-scale experimental data for comparison to rotor performance and load simulations
- Opportunity to identify physical phenomena that have limited rotor design and prediction methods.

UH-60A Airloads test configuration in the NFAC 40x80ft Wind Tunnel

Laser-illuminated flow visualization to image and measure rotor wake velocities

Optical targets for elastic blade bending measurements

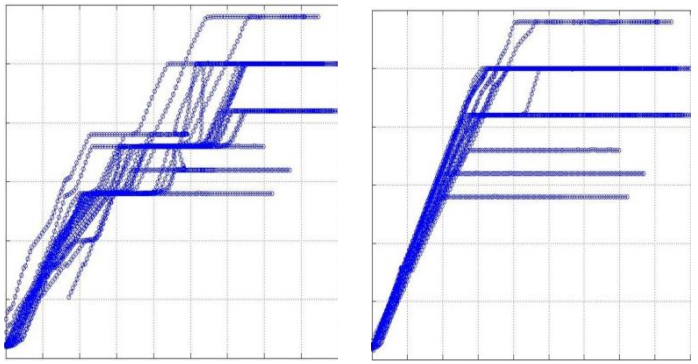
Airspace Systems Program

PROBLEM

- Air traffic controller-generated clearances force aircraft to arrive at a “meter fix” at a scheduled time
- Inefficient trajectories and descent profiles for aircraft.

OBJECTIVE

- En-Route Descent Advisor (EDA) tool proposes speed and path changes to controller
  - Reduced noise, emissions, and flight time/fuel consumption
  - Maximize throughput/avoid path conflicts
- Validate system benefits to enable EDA technology transfer



Descent Profiles: Without EDA and with EDA

APPROACH

- Partner with the FAA, United Airlines, and Continental Airlines to deliver EDA results/documentation to FAA

RESULTS

- Results of the September field trial used to improve EDA model
- Evaluated ability to resolve separation conflicts while satisfying time-based metering constraints at the terminal airspace boundary
- Arrival time accuracy improved: 12 seconds vs today’s one minute

SIGNIFICANCE

- Enables fuel and noise efficient descent procedures in heavy traffic
- Advanced decision support to controllers
  - Optimal descents for arriving aircraft
  - Increased airport capacity

Fundamental Aeronautics Program
N+3 Concept Studies

OBJECTIVE
- Address challenges for commercial aircraft with EIS in 2035 (N+3)
- Identify advanced airframe and propulsion concepts and enabling technologies

APPROACH
- Stimulate thinking in industry and academia on revolutionary aircraft solutions
- Determine high-payoff technologies and research opportunities
- NRA-competed awards for N+3 Concept Studies
  - Four subsonic aircraft teams/two supersonic aircraft teams
  - Address energy efficiency, environmental compatibility, operations goals

RESULTS
- Broadly applicable, critical technologies: flow control, light weight/higher temperature materials, aeroelastic structures

Subsonic aircraft:
- Uniquely enabling concepts/technologies: strut/truss-braced wing, double-bubble aircraft, hybrid electric propulsion
  - Engine bypass ratios approaching 20 (or propellers) with small, high efficiency core engines
  - Higher aspect ratio and laminar flow wings for vehicles cruising at lower speeds and higher altitudes (~40-45k ft)
- Alternative energy: conventional/biofuel/hybrid electric

Supersonic aircraft:
- Highly integrated configurations with unique shaping to practically eliminate sonic boom and permit supersonic overland flight
- Variable flowpath propulsion systems to lowering takeoff and landing noise/maximize cruise efficiency

SIGNIFICANCE
- Guidance for future NASA investments including key advanced technology roadmaps

Actions from NRC Review of Aviation Safety Research

- ARMD is improving and developing new processes for prioritization, innovation and collaboration
  - Continue to improve coordination and collaboration
    - Re-established systems analysis capability to support top-down decisions and enhance cross-cutting collaboration in all program areas
    - Comprehensive systems study on NextGen vehicles and operations across three Programs
  - Maintaining a robust and comprehensive review process
    - Annual reviews with multiple gov't agency participants
    - Aeronautics Committee of the NASA Advisory Council
    - Meetings of Experts on specific areas: UAS in the NAS; V&V of Complex Systems
  - Fostering innovation
    - Establishing a Seedling Fund for exploratory research
    - Committed to the NRA process where the "best and the brightest" compete
    - Re-alignment of Program, Project and Center roles to foster innovative research approaches
- Aviation Safety Program has been re-organized to streamline and focus on community-relevant issues, with improved goal definition, internal prioritization, and external coordination
  - Top-down set of goals and prioritization
    - Rigorous assessment of "tall poles" or key safety challenges
    - Flexibility to address emerging/data-driven topics (e.g.: HIWC, V&V methods, LOC)
    - Managing by technical challenges that focus teams on goals to solve key problems rather than organizing by disciplines
  - On-going comprehensive safety needs assessments and coordination with the aviation safety community
    - Other gov't agencies for National Aeronautics R&D Plan and JPDO National Aviation Safety Strategic Plan
    - Joint roadmap with FAA for human factors application to NextGen
    - Member of CAST, JIMDAT, etc.
    - Direct consultation with community on key topics (e.g.: V&V methods, LOC issues)

NRC Flight Research Study

Purpose:

- Assess and make recommendations about how best to integrate flight research into NASA Aero Research fundamental research activities and integrated systems research

Approach:

- Identify research challenges where program success can be achieved most effectively through flight research
- Identify goals and challenges that may be limited due to an anticipated lack of available flight research capability
- Review current portfolio of ARMD flight research activities and the flight research needs; identify programmatic and research requirements gaps
- Review capabilities and limitations of the current fleet of NASA aeronautics research aircraft
- Consider how research opportunities might be pursued in an economical, affordable, and technically rigorous way (e.g., by partnering with the Science Mission Directorate, other U.S. government Ds and As, industry, the National Research Council of Canada (NRCC), and other international partners)
- Recommend how NASA might maintain a robust flight research program within defined budget scenarios.