NASA Aeronautics Research

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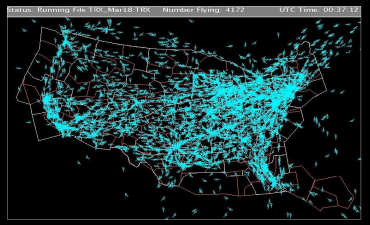
Aviation's Economic Impact

The aviation industry is vital to the nation's economic well-being

- Aviation directly or indirectly provides 997,000 Americans with jobs
- In 2006, aviation manufacturing and services accounted for $445B in direct and indirect economic activity
- In the U.S., more than 60 certified domestic carriers operate every day
  - They operate more than 6500 aircraft
  - They service almost a million travelers daily on 28,000 flights
  - In 2008, they had an annual operating revenue for commercial flights of $168B
- In 2008, aviation provided the nation with a trade surplus of $57.4B



Sources: The International Trade Administration, U.S. Department of Commerce
U.S. DOT Bureau of Transportation Statistics Research and Innovative Technology Administration
"The Economic Impact of Civil Aviation on the U.S. Economy", October 2008, FAA Air Traffic Organization

Challenges in Aeronautics Still Exist

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

Impacts of Aviation Challenges

In 2008, U.S. major commercial carriers burned 19.6B gallons of jet fuel, and DoD burned 4.6B gallons. At an average price of $3.00/gallon, fuel cost was $73B

U.S. commercial carriers and DoD release more than 250 million tons of CO_2 into the atmosphere each year

In 2007, aircraft in the U.S. spent 213 million minutes taxiing and in ground holds

Airline delays in the U.S. cost industry and passengers $32.9B in 2007

The high cost of certification for new or upgraded aviation systems is prohibitive

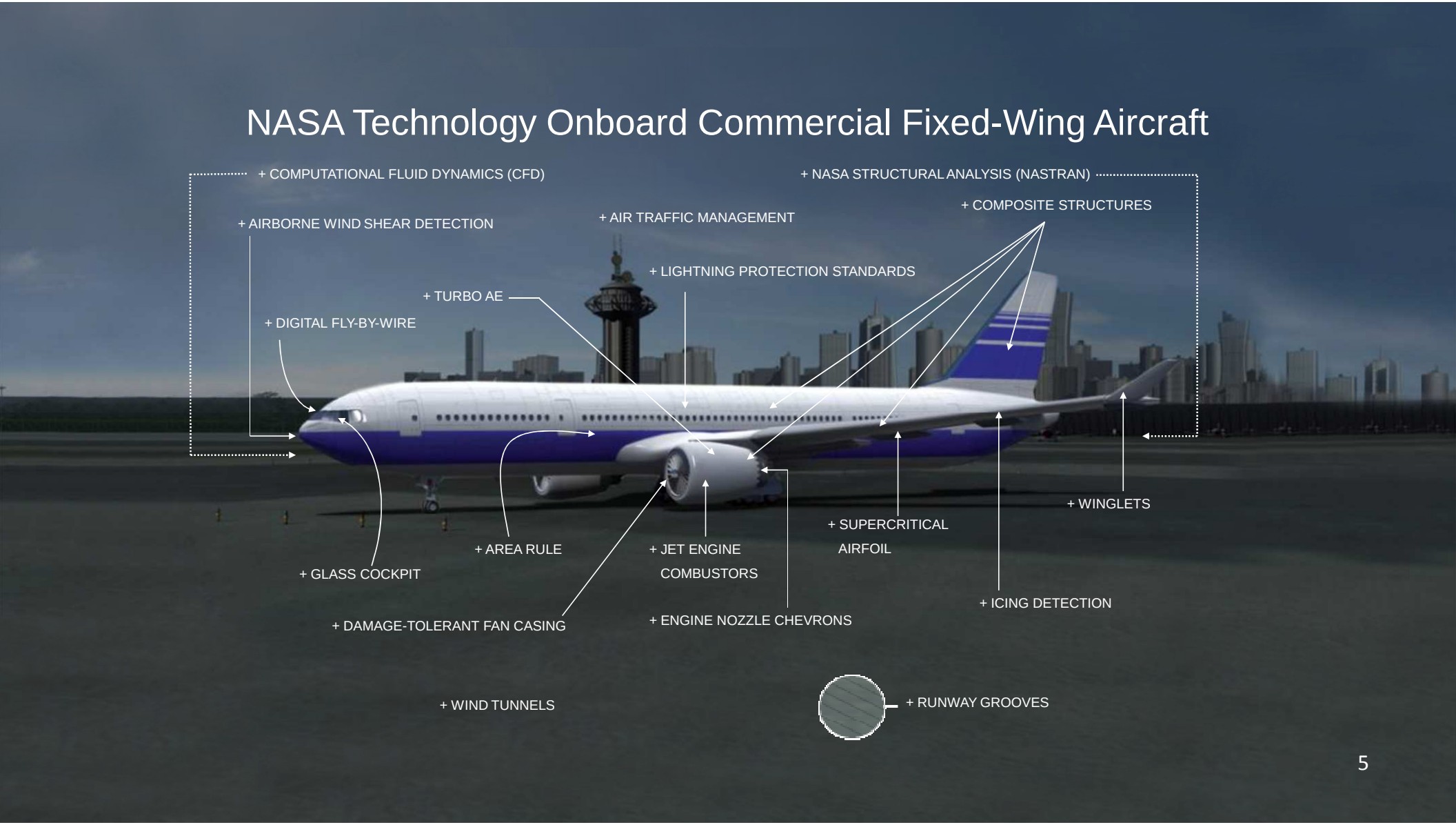
40 of the top 50 U.S. airports are in areas that do not meet EPA local air quality standards

Aircraft noise continues to be regarded as the most significant hindrance to NAS capacity growth

FAA's attempt to reconfigure New York airspace resulted in 14 lawsuits due to noise complaints

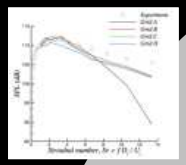
Since 1980 FAA has invested over $5B in airport noise abatement programs in homes

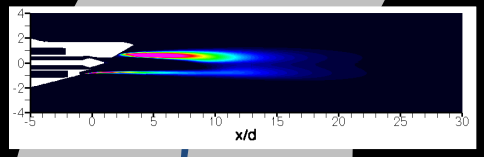
NASA Technology Onboard Commercial Fixed-Wing Aircraft

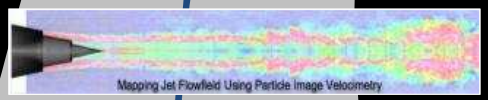


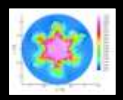
Chevrons - The Road From Idea to Deployment

Initial service entry, 2002









Systems Assessment: 2001-2005
- *Ground-test evaluation in engine test stands*
- *Flight evaluation in relevant environments*

Fundamental Research: 1996-2000
- *Computational and experimental research to develop a fundamental understanding of the fluid mechanics governing the effectiveness of the concept*
- *Development of practical implementations (chevrons)*

Seedling Idea: 1994-1996

Basic studies on jet mixing suggest that tabs can enhance jet mixing, with the potential to reduce noise

Boeing 747-8 with Chevron Nozzles

Source: The Boeing Company

Alignment with National Goals

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

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 and Related Infrastructure

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

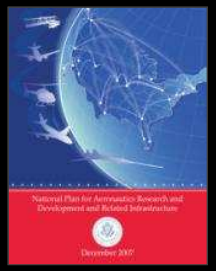
Vision 100 Century of Aviation Reauthorization Act and the Integrated Work Plan (IWP)

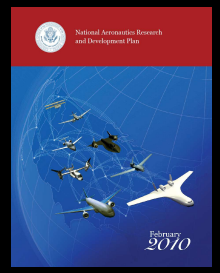
Vision100: Public Law 108-176, December 2003

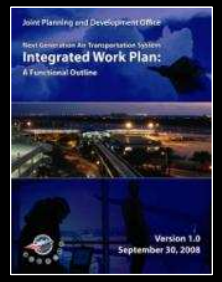
- Established the Joint Planning and Development Office (JPDO) to engage multiple agencies to plan, develop and implement the Next Generation Air Transportation System (NextGen)

IWP: Version 1.0 Released September 2008

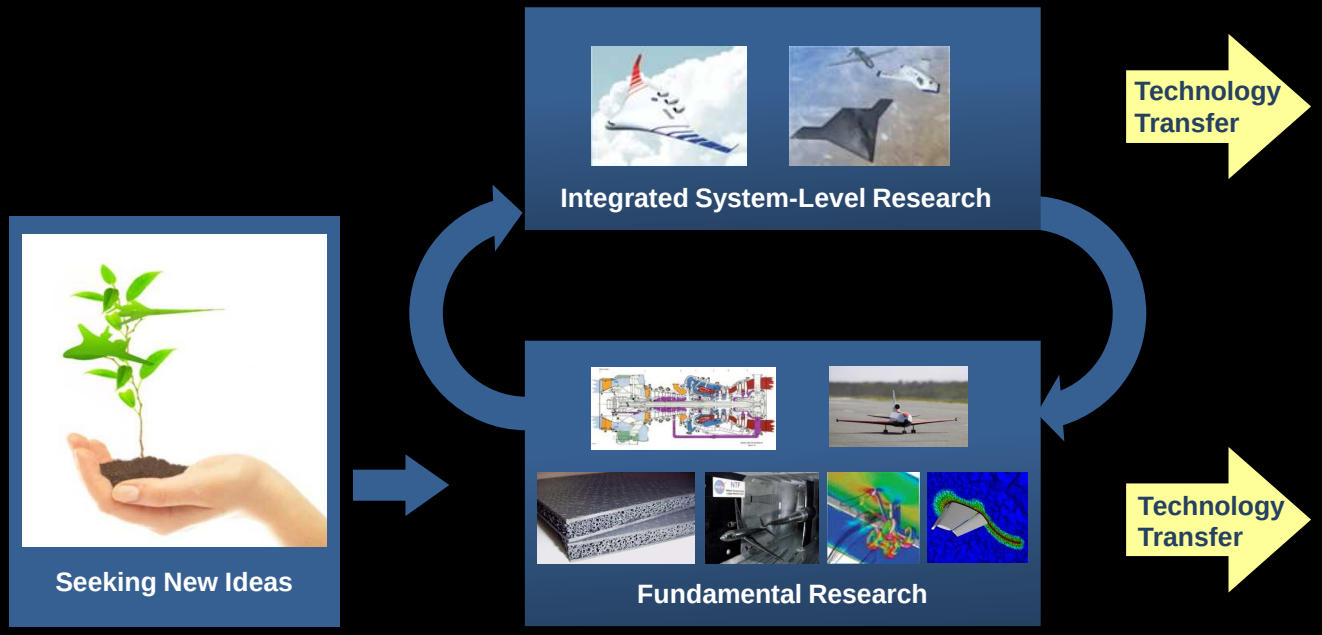
- Functional outline of activities needed to achieve the NextGen Vision







NASA Aeronautics Investment Strategy



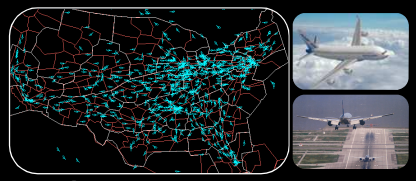
Enabling “Game Changing” concepts and technologies from advancing fundamental research ultimately to understand the feasibility of advanced systems

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.

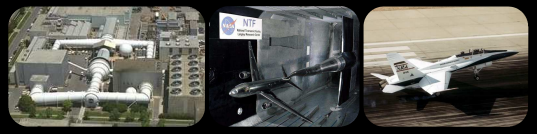
Integrated Systems Research Program

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



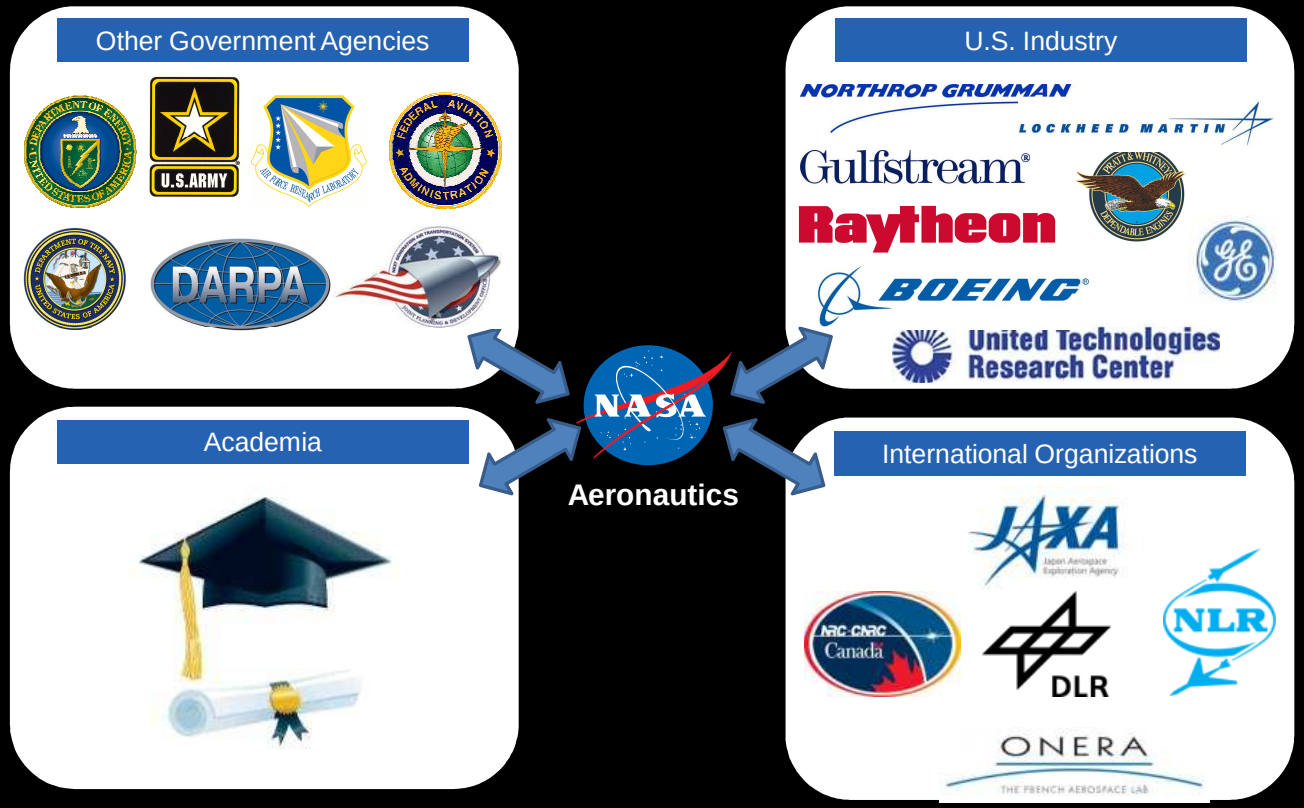
Airspace Systems Program
Directly address the fundamental ATM research needs for NextGen by developing revolutionary concepts, capabilities, and technologies that will enable significant increases in the capacity, efficiency and flexibility of the NAS.

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.

Collaboration with External Partners



FY 2011 Budget Request

($ Millions)	FY 2009 Actual 1/	FY 2010 Enacted 2/	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
Aeronautics Total	**$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

1/FY 2009 shows the July Operating Plan including the American Recovery and Reinvestment Act.
2/FY 2010 shows the Consolidated Appropriation Act, 2010 (PL 111-117) without the Administrative transfers.

NextGen Operations

Problem

Current ground delay policy at SFO can lead to excessive unrecoverable delays due to fog

$ 0.5M FAA Collaborative Agreement Contribution

San Francisco Bay area air traffic flows

Approach

Conducted a simulation recommending Ground Delay Program (GDP) parameters for SFO airport. Merges National Weather Service real-time data with Air Traffic Control departure scheduling.

Results

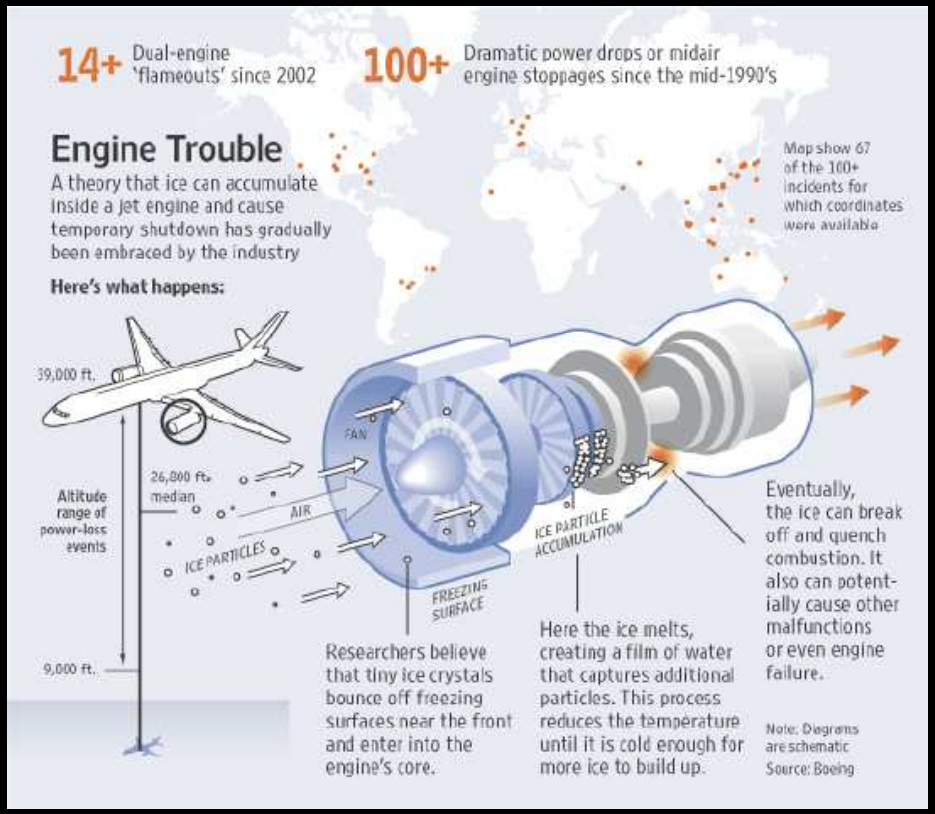
Significant near-term reduction in ground delays at San Francisco Airport.

Next Steps

•Brief FAA Air Traffic Control System Command Center (Dec. 2010)
•Delivery of implementation plan (Jan. 2010)

Partners: FAA, Mosaic ATM, and MIT Lincoln Laboratory

High Ice Water Content Research



Understanding Power Loss due to High-Altitude Engine Icing

•Hundreds of engine power loss events have occurred in the last 15 years.

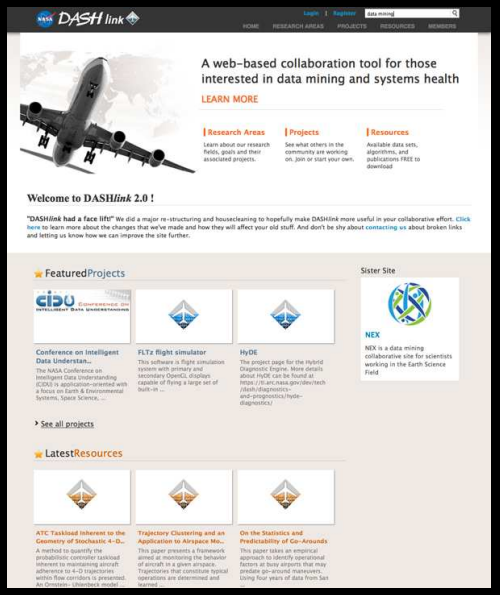
•NASA will fly specially- instrumented aircraft in High Ice Water Content (HIWC) regions near Australia to better understand icing particle physics and compare to ground-based weather detection schemes

•FAA is a primary partner in the flight campaign, scheduled for 2QFY13 in Darwin, Australia.

•Additional partners include Boeing, NCAR, NRCC, and the Australian Bureau of Meteorology

Data Mining for Aviation Safety

- NASA has open-sourced key data mining software for analyzing flight data recorder output through DASHlink, a collaborative website with over 300 members
- Southwest Airlines acquired sequenceMiner and Orca, two advanced anomaly detection techniques, through DASHlink
- Early application of these techniques to data from 7200 flights uncovered flight events specified in SWA's Flight Operations Manual that were not caught by SWA's existing analysis methods
- Events flagged by these software tools will be added to SWA's daily operations review to improve operational performance
- Southwest plans to incorporate these software tools into daily use – 1600 flights/305 planes.
- Five year non-reimbursable Space Act Agreement is being drafted



SOUTHWEST
FLIGHT OPS SAFETY
Flight Data Analysis Program

Environmentally Friendly Vehicles

Since July 2007, NASA has conducted more than 80 flights of the Hybrid Wing Body X-48B aircraft, in partnership with the U.S. Air Force, Boeing, and Cranfield Aerospace Ltd.

Benefits to the Public

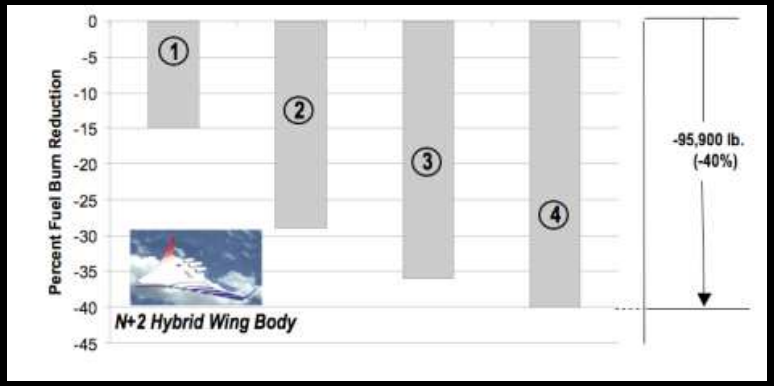
Fuel burn savings**:**
Over 40% reduction from current aircraft

Emissions reduction:
Local air quality: 50% less NOx
Global climate: 40% less CO_2

Noise reduction
1/6th the objectionable ground noise footprint of current aircraft

Vehicle
Estimated Fuel Savings*

Achieving Significantly Reduced Fuel Burn Will Require Integration of Multiple Technologies



1 = Hybrid wing configuration
2 = + advanced engine and airframe technologies
3 = + embedded engines with BLI inlets
4 = + laminar flow

** NASA systems analysis results. Reductions relative to B777 with GE90 engines.*

NextGen Systems Study

NASA conducted a systems study into the integration of advanced vehicles and concepts into NextGen. This consisted of two $6M, 18-Month NASA studies to understand tradeoffs involved for both vehicles and the ATM system, including safety considerations, system performance, environmental constraints.

Raytheon Company: Supersonic Business Jets, Very Large Transports, Very Light Jets and Un-crewed Aerial Vehicles.

Sensis Corporation: Cruise Efficient Short Take-Off & Landing, Large Tilt-Rotor, Supersonic Transports, Very Light Jets and Un-crewed Aerial Vehicles

Advanced Vehicles System Study

Description: Completed four 18-month “Advanced Concept Studies for Commercial Subsonic Transport Aircraft Entering Service in the 2030-35 Period”. Study is intended to stimulate far-term thinking towards future aircraft needs and identify key technology needs to meet the challenges.

Results:

- Lower cruise speeds at higher altitude (~40-45k ft)
- Heading toward BPR 20 (or propeller) with small, high efficiency core
- Higher wing aspect ratio and laminar flow to varying degrees
- Uniquely enabling concepts/technologies emerged (strut/truss, double bubble, hybrid-electric (battery) propulsion for example)
- Broadly applicable technology advances needed (for example lightweight materials, high-temp materials, gust load alleviation)

Boeing, GE, Georgia Tech

Impact: Results used as key information to guide future investment in the SFW project. Phase 2 investigations to follow.

MIT, Aurora, P&W, Aerodyne

Aeronautics Test Program Overview

The Aeronautics Test Program (ATP) was established to:

•Retain and invest in NASA aeronautics test capabilities considered strategically important to the agency and the Nation

•Establish a strong, high-level partnership to expand cooperation between NASA and DoD to facilitate an integrated national strategy for management of their respective facilities. This has been established as the National Partnership for Aeronautics Testing (NPAT).

The ATP strategic plan includes these four areas:

1.Provide recommendation to Aeronautics and Center management regarding the facilities

2.Represent the strategic interest of NASA and the Nation regarding the facilities

3.Provide direction to NASA test capability managers

4.Provide financial support to NASA test capabilities to ensure the right capabilities are available at the right time to meet the needs of NASA and the Nation

X-51 Scramjet readied for flight tests in LaRC 8' HTT (NASA/AFFRL)

ATP Facilities

AMES RESEARCH CENTER

Unitary Plan Wind Tunnel

GLENN RESEARCH CENTER

Icing Research Tunnel
10x10 Supersonic Unitary Tunnel
8x6 Supersonic Wind Tunnel
9x15 Low Speed Wind Tunnel
Propulsion Systems Lab

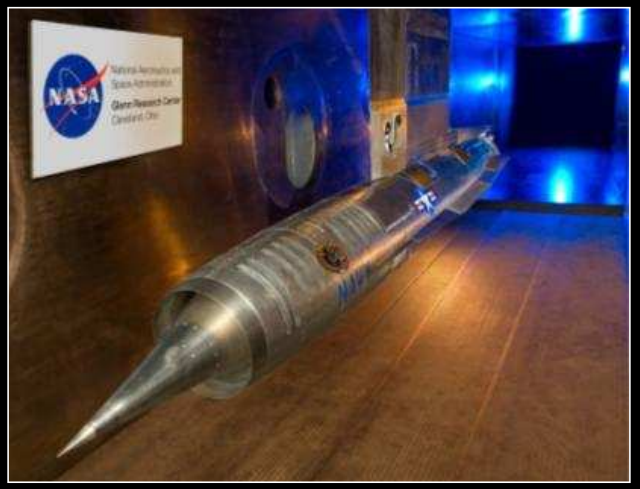
LANGLEY RESEARCH CENTER

National Transonic Facility
8-foot High Temperature Tunnel
Langley Aerothermodynamics Lab
14x22 Subsonic Wind Tunnel
Transonic Dynamics Tunnel
4-foot Supersonic Unitary Tunnel
20-foot Vertical Spin Tunnel

DRYDEN FLIGHT RESEARCH CENTER

Western Aeronautical Test Range
Support & Test Bed Aircraft

Flight Loads Laboratory
Research Aircraft Integration Facility



10 x 10 Supersonic Unitary Wind Tunnel
Revolutionary Approach to Time-Critical Long Range Strike – RATTLRS

Summary

ARMD has experienced tremendous success through the past years by committing to the following core principles:

- Valuing innovation and technical excellence
- Aligning our research to ensure a strong relevance to national needs
- Transferring technology in a timely and robust manner
- Maintaining strong partnerships with other government agencies, industry and academia
- Inspiring the next generation of engineers and researchers

Our planned research for the upcoming years will continue to provide valuable benefit to the aviation community and the Nation.