Aeronautics Committee Report to the NASA Advisory Council

Ms. Marion Blakey (Chair)

August 5, 2010

Areas of Interest Explored at Current Meeting

Next Generation Air Transportation System (NextGen) Technical Challenges in:

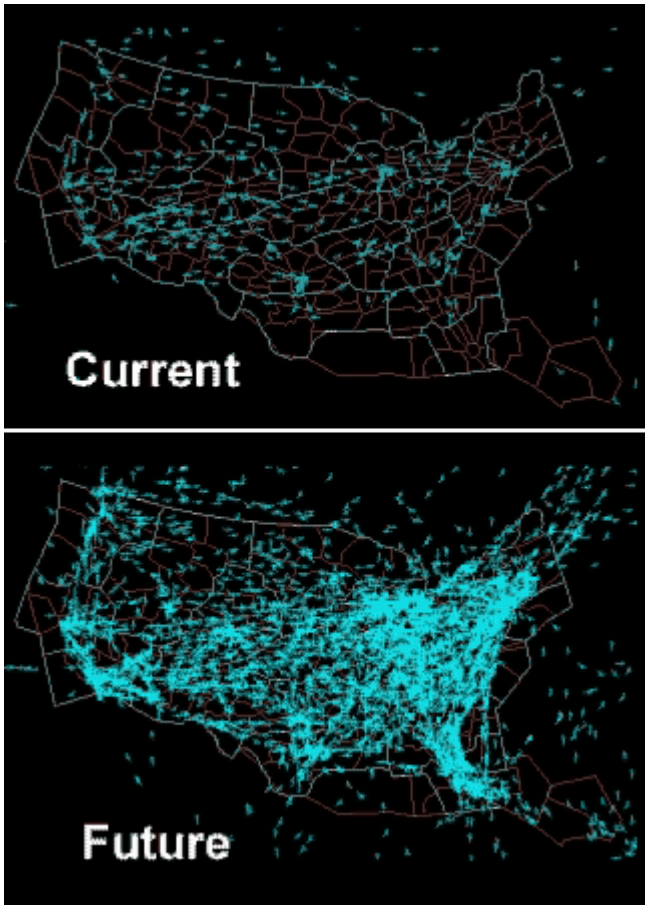
- Mobility
- Energy and Environment
- Safety

Verification & Validation (V&V) Meeting of Experts Outbrief and Planning

Current NextGen Challenges in Mobility

Technical Barriers To Meeting Air Transportation System Needs :

- System is governed by manual process
- Limited automation and decision support tools
- Lack of up-to-date infrastructure for better surveillance, navigation and communications



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Approach to Remove Barriers

- **Advanced concepts and technologies will provide:**
  - Increased system capacity by bringing to bear available resources and capacity to where demand exists
  - Mitigation for impact of adverse weather and system disruptions
  - Efficient operations will reduce noise, emissions, and fuel consumption and increase capacity
- **Integrated solutions for:**
  - Gate-to-gate trajectory based operations using flight deck and ground-based interoperable trajectories to maximize throughput and efficiency
- **Transition technologies and integrated solutions to stakeholders (e.g., Federal Aviation Administration (FAA), industry)**

NextGen Challenges in Energy and Environment

Fuel Efficiency

•In 2008, U.S. major commercial carriers burned 19.6B gallons of jet fuel. Department of Defense (DoD) burned 4.6B gallons

• At an average price of $3.00/gallon, fuel cost was $73B

Emissions

•40 of the top 50 U.S. airports are in non-attainment areas that do not meet Environmental Protection Agency local air quality standards for particulate matter and ozone

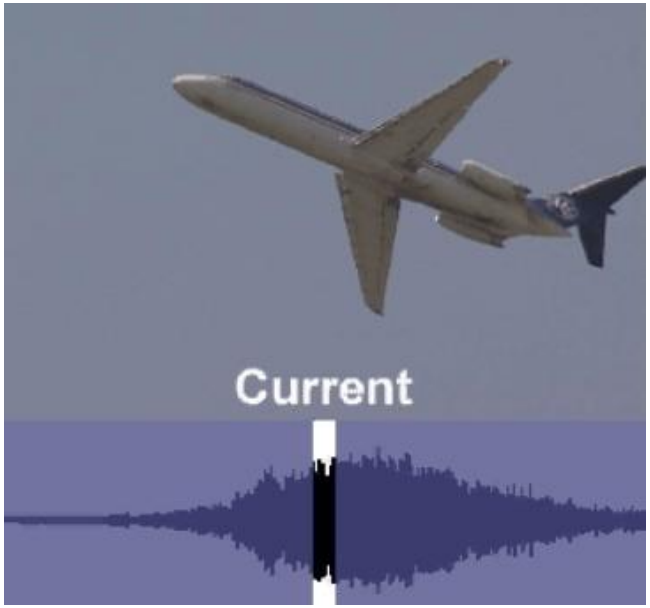
•The fuel consumed by U.S. commercial carriers and DoD releases more than 250 million tons of carbon dioxide (CO_2) into the atmosphere each year

Noise

•Aircraft noise continues to be regarded as the most significant hindrance to national airspace system capacity growth.

•FAA's attempt to reconfigure New York airspace resulted in 14 lawsuits.

•Since 1980 FAA has invested over $5B in airport noise reduction programs



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Subsonic Fixed Wing Project Technical Challenges

- Reduced Noise Aircraft
- Reduced Emission Aircraft
- Reduced Drag Aircraft
- Reduced Weight Aircraft
- Reduced Thrust Specific Energy Consumption
- Enable Advanced Operation of Vehicles
- Improved Computational and Experimental Tools and Methods

Supersonics Project Technical Challenges

- Environmental Challenges - No greater impact than subsonic fleet
  - Sonic Boom: Understand community impact, reduce to a level acceptable for overland supersonic flight
  - Airport Noise: Acceptable levels without weight or performance penalty
  - High Altitude Emissions: Emissions impact minimized or eliminated
- Efficiency Challenges - 30 % Improvement over High Speed Research Program
  - Supersonic Cruise Efficiency: Highly efficient configurations with low sonic boom noise
  - Light Weight and durable materials and structures for high temperature operations

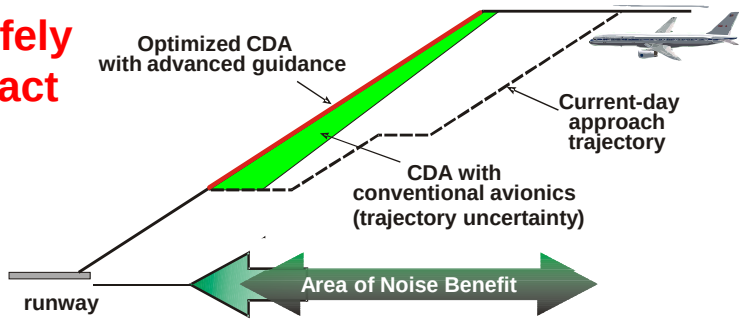
N+1 "Conventional"

N+2 Small Supersonic Airliner

N+3 Efficient, Multi Mach Aircraft

Green Operations

Develop & demonstrate novel operation concepts to safely increase throughput while reducing environmental impact



Today:
Continuous Descent Approaches (CDA's) only flown at off-peak hours or in low-congestion airspace

Tailored Arrivals & Enroute Descent Advisor (EDA)

- EDA combines scheduling with CDA to generate green solutions that maximize runway throughput and avoid conflicts
- Tailored Arrivals optimize CDA's to individual aircraft performance capability

Airborne Merging and Spacing

- Merging and spacing will be delegated to the flight deck instead of current ground-based process
- Will enhance EDA through closer spacing and eliminating missed slots

Energy navigation concept (eNAV)

- Optimized fuel burn, noise, and emissions reduction by commanding pilots when to deploy flaps, gear, engine power settings, etc.

Development Partners:
FAA, Boeing, United Airlines, US Air, UPS

Early Adapters of Tailored Arrivals:
United Airlines, Quantas, Air New Zealand, Japan Airlines

Rotorcraft Project Technical Challenges

- Integrated Aeromechanics/Propulsion System:
  - Develop and demonstrate technologies enabling variable-speed rotor concepts
  - Enables very high-speed, efficient cruise; efficient hover; reduced noise, increased range
- Actively-Controlled, Efficient Rotorcraft:
  - Simultaneously increase aerodynamic efficiency, control dynamic stall, reduce vibration, reduce noise

Open Rotor Research

Open Rotor Baseline Dataset Completed

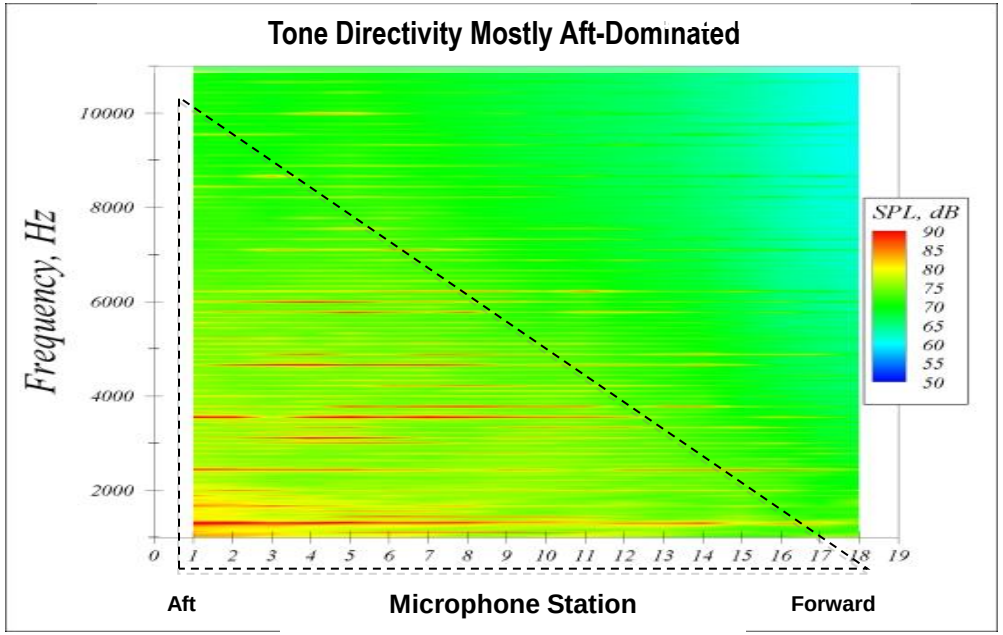
Challenge: Develop lower noise concepts while maintaining high propulsive efficiency from counter-rotating open rotor propulsors

NASA/General Electric (GE) cooperative program is evaluating lower noise rotor design concepts as well as installation effects such as pylon-rotor interaction effects which potentially increase noise

Results: Aerodynamic performance and acoustics measurements at low-speed (representing takeoff/landing) are 95% complete in Glenn Research Center 9'x15' tunnel

Impact: Rotor geometry, aero performance, and acoustic data for baseline configuration openly available to the community for use in design code validation exercises

NASA has internal-use access to similar data from GE-proprietary advanced designs for use in developing advanced analysis methods

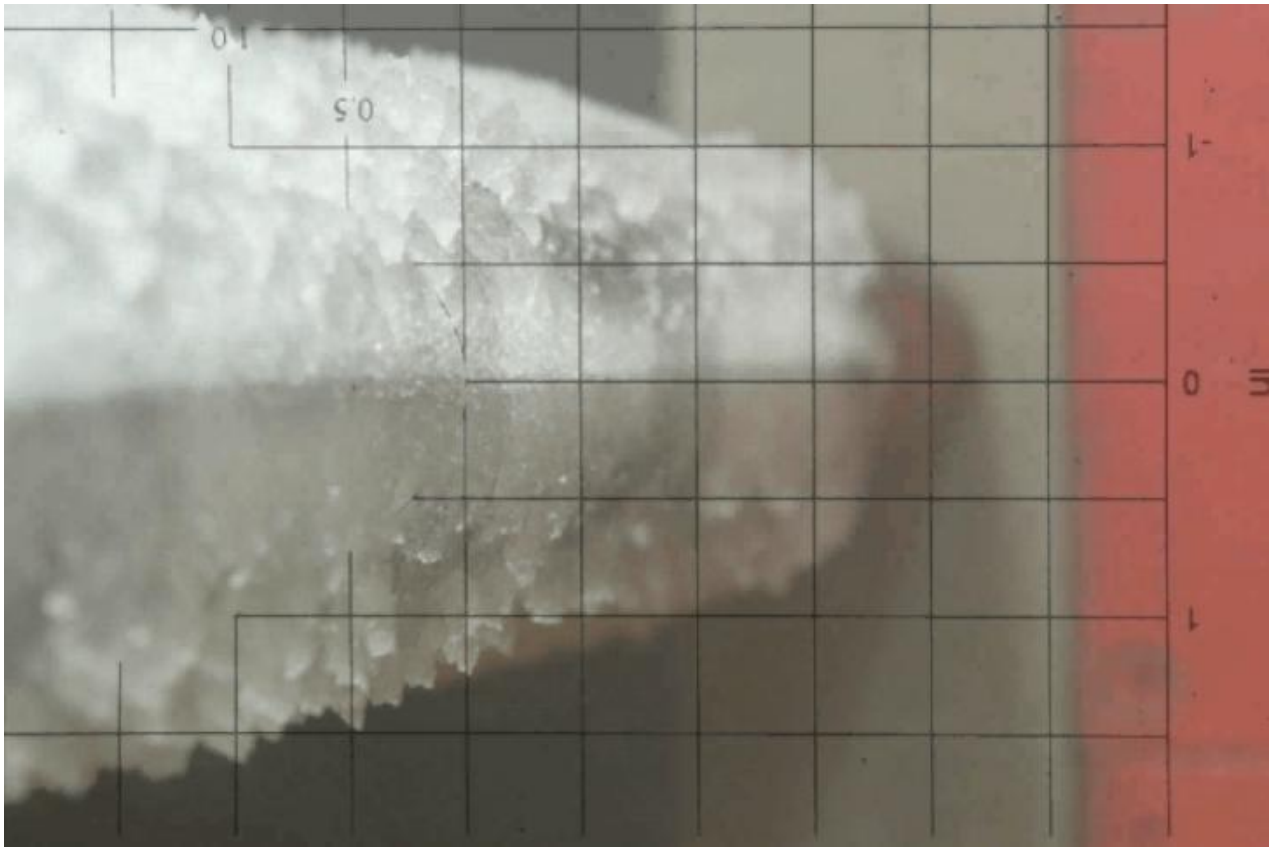


Typical Sideline Spectrum

NextGen Challenges in Safety

1. V&V of Flight Critical Systems
2. Reasoning with data; decision making
3. Human impact to safety
4. Strategies for loss of control
5. Health management; airworthiness
6. Situational awareness
7. In-flight icing
8. Other hazard sensing

Growth of Glaze Ice on Wing Leading Edge



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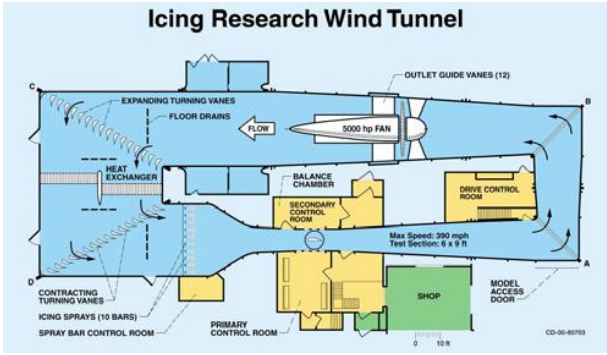
Icing Research Tunnel (IRT)

World's Largest Refrigerated Wind Tunnel Dedicated to the Study of Aircraft Icing



Goal

•Improve aircraft safety by providing a cost effective test facility and expert staff dedicated to the study of aircraft icing.

Approach

•Supports fundamental studies of icing physics for computer code development and validation
•Supports aircraft industry needs for ice protection system development and certification testing.
•Supports a diverse group of customers: NASA, Boeing, Bombardier, Bell, Sikorsky, U.S. Army, U.S. Air Force, U.S. Navy.

Impact

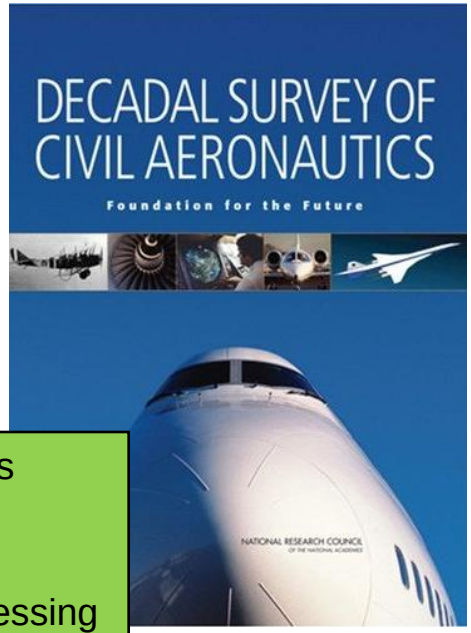
•The IRT is in high demand, typically operating100-150 days/year of customer testing.
•Current schedule is full into 2ndquarter FY12

Research Areas:

Ice accretion (Supercooled Large Droplet and Swept Wings); Ice physics and icing scaling studies; Validation databases; Test

V&V is a Widely Recognized Concern

"Developers do not have effective ways to model and visualize software complexity, including the possible range of interactions, especially unexpected and anomalous behaviors that can occur among software and hardware components.
Developers also do not have time- or cost-effective ways to test, validate, and certify that software-based systems will perform reliability, securely, and safely as intended, particularly under attack or in partial failure."
President's Council of Advisors on Science and Technology (PCAST) Report, 2007



<u>Recommendation 4</u>: Fundamental research is needed to create the foundations for practical certification standards for new technologies

- methods and models are needed for assessing the safety and reliability of complex, large-scale, human-interactive, nondeterministic software intensive systems

Critical Gap in V&V Methods

V&V for Flight Critical Systems Objectives

Argument-based Safety Assurance

Integrated Distributed Systems

Authority and Autonomy

Software Intensive Systems

Verification and Validation for Flight Critical Systems Objectives:

- Develop methods to **reduce cost and increase safety** through improved safety assurance and dependability
- Provide **advanced analytical, architectural, and testing capabilities** to enable sound assurance of safety-critical properties for distributed systems-of-systems
- Improve the ability to **design for safety**, and constrain the burdens of dealing with safety in new and more complex systems, i.e., the cost of flight critical software.
- Develop methods that ensure flight-critical systems' **assignment of authority and autonomy are comprehensive, lack conflict and ambiguity**, and correspond to agents' capabilities and accountability

V&V Planning Approach in Aviation Safety Program

- Assessment of research needs
  - Flight Critical Systems
  - Common themes
  - Focus on critical research areas
  - Common integrated experiments
- Integrate in reorganized Program
  - Supports system-wide view of safety technologies
  - Connections to vehicle systems safety technologies
  - Connections to activities outside of Program

V&V Meeting of Experts (July 8, 2010) Outcome

- Significant breadth of comments and advice from Panel of Experts
  - All panel members and public were engaged with NASA presenters
- Key points
  - No major gaps
    - Nothing clearly missed
    - Right people at NASA are involved
    - Modifications based on general/specific comments can be made, i.e.: no show-stoppers
  - Areas for improvement
    - Syncing the terminology with the community
    - Connection of top-level objectives to specific research components
    - Better story on improvement over current state of the art
    - Need clear identification of deliverable(s) in each area
    - Need clear identification of the customer
    - Unclear what the priorities are among the four research areas
    - Suggest identifying consciously what we are *not* doing
    - Better understanding/connection to FAA processes
    - Pay attention to timing of tech transfer

Committee Findings

1) With regard to ASP's NextGen work, the committee suggests that greater emphasis be placed on environmental and energy aspects rather than on capacity problems to reflect the increasing importance of these emerging issues.

2) We support the new research focused on broader benefits of Automatic Dependent Surveillance Broadcast (ADS-B) and urge that ASP carefully survey complimentary research before committing to specific research.

Committee Observations

1) Judging by the presentations to the committee that were focused on the process and program alignment, ARMD's NextGen research is very well connected to national research goals. In order to make a more complete assessment, the committee has requested further discussions be focused on technical content and measures of success.

2) V&V is an important new area of research within aeronautics for NASA. From the information presented, the committee could not determine the focus and technical content of the research in the V&V of flight critical systems. The committee looks forward to a more substantive discussion of the V&V program plan and the practical application of this research.

Committee Information

- Members:
  - Ms. Marion Blakey (Chair)*
  - Dr. Ilan Kroo*
  - Dr. Mark Lewis*
  - Mr. Preston Henne
  - Dr. R. John Hansman*
  - Mr. Mark Anderson
  - Dr. Harry McDonald*
  - Mr. Paul Adams
  - Dr. Ray Colladay (ex-officio)
- Plans for next meeting: Face-to-face Committee Meeting at Ames Research Center in early September.

* in attendance at meeting