NASA Integrated Systems Research with an Environmental Focus

Green Aviation Summit
Integrated Systems Research Program
NASA Ames Research Center
September 8-9, 2010

Jean Wolfe
Program Director (Acting)
Integrated Systems Research Program
Aeronautics Research Mission Directorate

Dr. Fay Collier
Project Manager
Environmentally Responsible Aviation Project
Integrated Systems Research Program
Aeronautics Research Mission Directorate
Outline

• NASA Aeronautics Investment Strategy
• Overview of Integrated Systems Research Program and its Projects
• E&E Challenges and Program/Project Alignment with National Goals
• Selection Criteria for ISRP Projects
• Innovative Concepts for Aviation
• Environmentally Responsible Aviation
NASA Aeronautics Investment Strategy
Integrated Systems Research Program Focus

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

Environmentally Responsible Aviation (ERA): Explore and assess new vehicle concepts and enabling technologies through system-level experimentation to simultaneously reduce fuel burn, noise, and emissions.

UAS Integration in the NAS: Contribute capabilities that reduce technical barriers related to the safety and operational challenges associated with enabling routine UAS access to the NAS.

Innovative Concepts for Aviation (ICA): Spur innovation by offering research opportunities to the broader aeronautics community through peer-reviewed proposals, with a focus on making aviation more eco-friendly. Establish incentive prizes similar to the Centennial Challenges and sponsor innovation demonstrations of selected technologies that show promise of reducing aviation’s impact on the environment.
Energy and Environmental Challenges

1. Fuel Efficiency
2. Emissions
3. Noise
The National Policy and Plan

—“Assuring energy availability and efficiency is central…” and “The environment must be protected…”
Criteria for ISRP Projects

• Technology has attained enough maturity in the foundational research program that they merit more in-depth evaluation at an integrated system level in a relevant environment
• Technologies which systems analysis indicates have the most potential for contributing to the attainment of goals
• Technologies identified through stakeholder input as having potential for the attainment of goals
• Research not being done by other government agencies and appropriate for NASA to conduct
• Result of a budget augmentation
Outline for ERA

- Tech Challenges
- NASA E&E Metrics
- Key technologies and systems analysis
- Examples of research/accomplishments in FY10
- Impact of the Research
Technical Challenges for ERA

• Develop advanced vehicle concepts and technologies that *simultaneously* reduce:
  – Community noise
  – LTO and Cruise NO$_x$
  – Mission fuel burn

• Assess the impact of vehicle concepts and technologies at the fleet level
## NASA Subsonic Transport System Level Metrics

*… technology for dramatically improving noise, emissions, & performance*

### CORNERS OF THE TRADE SPACE

<table>
<thead>
<tr>
<th></th>
<th>N+1 (2015)***</th>
<th>N+2 (2020)***</th>
<th>N+3 (2025)***</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Noise</strong> (cum below Stage 4)</td>
<td>-32 db</td>
<td>-42 db</td>
<td>-71 db</td>
</tr>
<tr>
<td><strong>LTO NOx Emissions</strong> (below CAEP 6)</td>
<td>-60%</td>
<td>-75%</td>
<td>Better than -75%</td>
</tr>
<tr>
<td><strong>Performance:</strong> Aircraft Fuel Burn</td>
<td>-33%**</td>
<td>-50%**</td>
<td>Better than -70%</td>
</tr>
<tr>
<td><strong>Performance:</strong> Field Length</td>
<td>-33%</td>
<td>-50%</td>
<td><em><em>Exploit metroplex</em> concepts</em>*</td>
</tr>
</tbody>
</table>

*** Technology Readiness Level = 4 – 6, ERA pushing TRL to 6 for key technologies by 2015

** Additional potential gains from operational improvements

* Optimal use of available runways in metropolitan areas.
Key Technologies

• Advanced resin infused, composite structural concepts for lower weight and damage tolerance
• Laminar flow and flow control concepts for drag reduction
• Ultra high bypass ratio engines for increased propulsive efficiency
• Acoustic shielding for significant noise reduction
FY10 Accomplishments

• Completed Low Speed Flight Control Flight Demonstration on X-48B
• Completed mid-fidelity acoustic shielding assessment in the Boeing Low-Speed Acoustic Facility
• Initiated Fuel Flexible, Low NO$_x$ Combustor Tech Development Effort
• Initiated Advanced Vehicle Concept Dev.
Impact of the Research - Noise

NASA N+2 Goal = 42dB

Advanced Technology
Tube-and-Wing, 29dB
From AIAA 2009-3144
Note: Included a BPR 16 engine

Delta dB below Stage 4

45
40
35
30
25
20
15
10
5
0

SOA

HWB

10.3 dB

42.4 dB (C11)

40.0 dB (C7)

31.6 dB (C2)

22.0 dB (C1)

Technology that reduces noise sources and relocates sources to be more effectively shielded

Simple shielding from moving engines upstream on aircraft

Lower noise of baseline HWB from: simple shielding of inlet noise, lower approach speed, absence of flap noise, flight path effects
Impact of the Research – Fuel Burn

Reference Fuel Burn = 279,800 lbs

- Fuselage – composite + configuration
- Wing & Tails – composite
- PRSEUS Concept
- Advanced Engines
- HLFC (Wing, Tails, and Nacelles)
- Riblets, Variable TE Camber, Increased AR
- Subsystem Improvements

N+2 adv. "tube-and-wing"
- Fuel Burn = 159,500 lbs
- N+2HWB300
- Fuel Burn = 140,400 lbs

- Fuselage
  - Fuel Burn = 279,800 lbs
  - N+2 adv. "tube-and-wing"
  - Fuel Burn = 159,500 lbs
  - N+2HWB300
  - Fuel Burn = 140,400 lbs

Fuel Burn = 159,500 lbs
-120,300 lbs (-43.0%)

Fuel Burn = 140,400 lbs
-139,400 lbs (-49.8%)
Impact of the Research – Fleet Emissions

Forecasted Carbon Emissions Growth (Without improvements)

- Technology Development—Ongoing Fleet Renewal
- Operational Improvements—ATC/NowGen/
- Additional Technology Advancement and Low Carbon Fuels

Carbon neutral growth

Baseline reduced by 50%

Baseline

CO₂ Emissions

Carbon overlap

2005

2020

2050

With Improvement

Carbon Neutral Growth and Reduction Timeline