NASA/GE Collaboration on Open Rotors - High Speed Testing

A low-noise open rotor system is being tested in collaboration with General Electric and CFM International, a 50/50 joint company between Snecma and GE. Candidate technologies for lower noise will be investigated as well as installation effects such as pylon integration.

Current test status for the 8x6 SWT high speed testing is presented as well as future scheduled testing which includes the FAA/CLEEN test entry. The tunnel blockage and propeller thrust calibration configurations are shown.
NASA/GE Collaboration on Open Rotors - High Speed testing

Dale Van Zante
Project Engineer for Propulsion
Environmentally Responsible Aviation
Integrated Systems Research Program

Acoustics Technical Working Group
April 21-22, 2011
Outline

- ERA Goals/Program Structure
- The Open Rotor test program
- High-speed testing
  - Blockage calibration
  - Thrust calibration
  - Acoustic plate
- Test status
- Summary

Testing is supported by the Environmentally Responsible Aviation Project
Data analysis efforts are supported by the Subsonic Fixed Wing Project
Facility support is from the Aeronautics Test Program

8x6 installation with Historical Baseline blade set
NASA C-2011-611
NASA’s Subsonic Transport System Level Metrics

Sumarizing the potential technology payoff …

…. Innovative technology for dramatically reducing noise, emissions and fuel burn

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Noise (cum below Stage 4)</td>
<td>-32 dB</td>
<td>-42 dB</td>
<td>-71 dB</td>
</tr>
<tr>
<td>LTO NOx Emissions (below CAEP 6)</td>
<td>-60%</td>
<td>-75%</td>
<td>better than -75%</td>
</tr>
<tr>
<td>Performance: Aircraft Fuel Burn</td>
<td>-33%</td>
<td>-50%**</td>
<td>better than -70%</td>
</tr>
<tr>
<td>Performance: Field Length</td>
<td>-33%</td>
<td>-50%</td>
<td>exploit metro-plex* concepts</td>
</tr>
</tbody>
</table>

***Technology Readiness Level for key technologies = 4-6. ERA will undertake a time phased approach, TRL 6 by 2015 for “long-pole” technologies

**RECENTLY UPDATED. Additional gains may be possible through operational improvements

* Concepts that enable optimal use of runways at multiple airports within the metropolitan area
ERA Project Leadership Team

Environmentally Responsible Aviation (ERA) Project

1.0 Project Management
- Project Manager (PM): Fayette S. Collier
- Deputy PM: Gaudy Bezos-O’Connor
- Chief Technologist: Anthony Washburn
- Chief Engineer: Mark Mangelsdorf

2.0 Airframe Technology
- Sub-Project Manager: Pamela Davis
- Sub-Project Engineer: Heather Maliska

2.1 Lightweight Structures
- Element Lead: Dawn Jegley

2.2 Flight Dynamics and Control
- Element Lead: Timothy Risch

2.3 Drag Reduction
- Element Lead: Rudy King

2.4 Noise Reduction
- Element Lead: Medhi Khorrami

3.0 Propulsion Technology
- Sub-Project Manager: Ken Suder
- Sub-Project Engineer: Dale Van Zante

3.1 Combustor Technology
- Element Lead: Chi-Ming Lee

3.2 Propulsor Technology
- Element Lead: Brian Fite

3.3 Core Technology
- Element Lead: James Heidmann

4.0 Vehicle Systems Integration
- Sub-Project Manager: Hamilton Fernandez
- Sub-Project Engineer: Russel Thomas

4.1 Systems Analysis
- Element Lead: Craig Nickol

4.2 Propulsion Airframe Integration
- Element Lead: Steve Smith

4.3 Propulsion Airframe Aeroacoustics
- Element Lead: Russ Thomas

4.4 Advanced Vehicle Concepts
- Element Lead: Craig Nickol
## Test Program Overview

<table>
<thead>
<tr>
<th>NASA/GE 9x15 Low Speed Wind Tunnel</th>
<th>NASA/GE 8x6 High Speed Wind Tunnel</th>
<th>NASA/GE/FAA(CLEEN) 8x6/9x15</th>
</tr>
</thead>
<tbody>
<tr>
<td>GE Gen-1 Blade Designs</td>
<td>GE Gen-2 Blade Designs</td>
<td></td>
</tr>
</tbody>
</table>

### Takeoff and Approach Conditions

- **Aerodynamic performance**
- **Acoustics**
- **Hot Film flowfield measurements**

### ERA Diagnostics

- Acoustic phased array
- Farfield Acoustics with Pylon
- Pressure Sensitive Paint
- Stereo Particle Image Velocimetry
- Acoustic Shielding

### Cruise Conditions

- **Aerodynamic performance**
- Near field unsteady pressure

### TO/Approach and Cruise Conditions

- Aero and acoustic performance of optimized blade designs at low and high speed.
8x6 Tunnel Blockage Calibration

Blockage configuration with wall, floor and rig mounted pitot-static rakes. The corrections are described in AIAA-88-2055 Porous Wind Tunnel Corrections for Counterrotation Propeller Testing.
A static tube is used to determine Mach number through test section with propeller thrust.

- 3 rows of 30 statics
- Floor or ceiling mount

8x6 Tunnel Thrust Calibration

ORPR with Historical Baseline
Blade Set
NASA C-2011-625
Acoustic Plate Installation

ORPR with Historical Baseline
Blade Set
NASA C-2011-620
Objectives: Aerodynamic performance and near field unsteady pressure measurements at cruise Mach number. P(t) is processed to produce the cross-spectral matrix.

Code by Cliff Brown, Don Braun, David Stephens.

There are 17 Kulite XCL-093 in an axial line down the center of the plate.

(Note: the Kulite numbering is reversed for the current installation. No. 17 is at the forward end of the plate.)
A instrumentation problem with the forward rotor force balance occurred on April 6. Testing is on hold until the issue can be resolved.
Summary

• The 8x6 tunnel calibration activities were described.
• The cruise efficiency testing is on hold following the forward rotor force balance instrumentation problem.
• Options for the 8x6 test and the FAA CLEEN/NASA/GE Gen-2 blade entry are pending.

8x6 installation with Historical Baseline blade set
C-2011-610
Partners

GE

The Power Of Flight

CFM

Federal Aviation Administration


