Ultra High Bypass Ratio Engine Research for Reducing Noise, Emissions, and Fuel Consumption

Presentation Abstract

A pictorial history of NASA development of advanced engine technologies for reducing environmental emissions and increasing performance from the 1970s to 2000s is presented. The goals of the Subsonic Fixed Wing Program portion of the NASA Fundamental Aeronautics Program are discussed, along with the areas of investigation currently being pursued by the Ultra High Bypass Partnership Element of the Subsonic Fixed Wing Program.
Ultra High Bypass Ratio Engine Research for Reducing Noise, Emissions, and Fuel Consumption

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Strong History of Technology Development

1970s

- Single Rotation Propfans
  - Significant improvement in fuel burn

SR-5 Fan in Glenn 8’x6’ Wind Tunnel

Large Advanced Propeller
Full Scale Static Test

Propeller Test Assessment Aircraft Demo
1980s

- Counter Rotation Propfans
  - Reduce installation effects, improve efficiency

Counter Rotation Propeller in Glenn 8’x6’ Wind Tunnel

GE Unducted Fan / 727 Flight Demo
Strong History of Technology Development

1990s

- Ultra High Bypass Engine Cycle concept
  - Reduce noise and fuel burn

17” Advanced Ducted Propulsor in Glenn 8’x6’ Wind Tunnel

22” Advanced Ducted Propulsor in Glenn 9’x15’ Wind Tunnel
1990s

- Advanced noise reduction technologies for turbofans
  - Increased rotor-stator spacing
  - Reduced fan tip speed
  - Swept / Leaned stator vanes

Swept stators

Leaned stators

Swept & leaned stators
1990s

- Advanced noise reduction technologies for turbofans
  - Fan blade tip flow management
  - Active and passive liners
  - Active noise control
2000s

- Advanced noise reduction technologies for turbofans
  - Highly swept fan blade
  - Fan trailing edge blowing
Today’s Challenges

- Refining and improving on previous noise reduction and performance improvement technologies and demonstrating their combined effectiveness is necessary to meet the aggressive SFW goals for “N + 1” aircraft
  - Noise: -42 cum below Stage 3
  - Emissions: -70% LTO NOx below CAEP/2
  - Performance: -15% Fuel Burn below B737/CFM56

- However, limited goals trading is possible

<table>
<thead>
<tr>
<th>Noise</th>
<th>Current SOA (N)</th>
<th>N + 1 Optimized for Performance</th>
<th>N + 1 Optimized for Noise</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cum below Stage 3</td>
<td>-14 dB</td>
<td>-30 dB</td>
<td>-42 dB</td>
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<tr>
<th>Emissions</th>
<th>Current SOA (N)</th>
<th>N + 1 Optimized for Performance</th>
<th>N + 1 Optimized for Noise</th>
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</thead>
<tbody>
<tr>
<td>LTO NOx below CAEP/2</td>
<td>-25%</td>
<td>-70%</td>
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<tr>
<th>Performance</th>
<th>Current SOA (N)</th>
<th>N + 1 Optimized for Performance</th>
<th>N + 1 Optimized for Noise</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aircraft Fuel Burn relative to 737/CFM56</td>
<td>Ref.</td>
<td>-15%</td>
<td>-21%</td>
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Current Areas of Investigation

➢ Noise Reduction

• Acoustically treated fan casing – “Over-The-Rotor” metal foam insert
• Acoustically treated stator vanes – “Soft Stators”
Current Areas of Investigation

➢ Performance

• Nacelle/Airframe Integration Aerodynamics

• Counter Rotation fans (Bypass Ratio >30)
  – NASA Glenn rig being refurbished now

➢ Emissions

• Alternative fuels
Objective

- Demonstrate and validate Ultra High Bypass engine cycle noise, emissions and performance improvement technologies in full scale applications

Through collaboration with Industry, the SFW Program goals can be achieved