The Promise And Challenges Of Ultra High Bypass Ratio Engine Technology and Integration

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Propulsion Technology Element
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Geared Turbofan Technology Enables a Step-Change in Ultra High Bypass Propulsion

Lower fuel consumption so
- Lower CO₂
- Lower NOₓ
- Lower Cost

GTF Engine
Ultra high bypass

Engine certification date


Courtesy Pratt & Whitney
**NASA’s Subsonic Transport System Level Metrics**

Summarizing the potential technology payoff ...

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

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

- **Thrust Specific Fuel Consumption** – Need Higher Propulsive Efficiency, Which is Achieved with Higher Bypass Ratio, Lower Fan Pressure Ratio

- **Weight** – Need:
  - Advanced, Lighter Materials
  - Advanced, Smaller Core Components and More Compact Designs

- **Nacelle Drag** – Need Thinner, Shorter Nacelles as Engine Bypass Ratio and Fan Diameter Grow

- **Installation** – Need Special Designs to Integrate Bigger Engines and Minimize Impact on Aircraft Performance
Propulsive Efficiency Trend with Fan Pressure Ratio
Geared Turbofan Technology Enables Paradigm Shifts

![Diagram illustrating the benefits of geared turbofan technology. The diagram shows a trade-off between noise, fuel burn, fan size, and thrust specific fuel consumption. Current Turbofan and Next Gen GTF (2020) technologies are compared, highlighting improvements in weight, drag, and fuel efficiency.](image)
NASA/P&W Partnership on Geared Turbofan Technology

- Collaborative Research Technology Areas
  - Low-Speed
  - Low-Pressure
  - High-Bypass-Ratio Fan
  - Low-Emissions Combustor
  - Fan Drive Gear System
    - Gear Ratio ~ 3
  - High-Speed, Compact, Low Spool
GTF Emissions Reduction Goals

Gen 1 (2013 EIS)

- NOISE (cum margin to Ch 4): -20 EPNdB
- LTO NOX (below CAEP 6): -60%
- FUEL BURN (rel to A320/V2500): -15%

Projected Based on Demonstrated Technology

Gen 2 (2020 to 2025 EIS)

- NOISE (cum margin to Ch 4): -25 EPNdB
- LTO NOX (below CAEP 6): -75%
- FUEL BURN (rel to A320/V2500): -25% to -30%

Projected Based on Demonstrated Technology
Ultra High Bypass Technology Development Roadmap

- **GTF Gen 1 Engine**
  - Ground Test Demo

- **22” GTF NG Tech Dev**
  - Aero/Acoustic Test
  - GRC 9’x15’ WT

- **22” UHB Advanced OTR / SV**
  - Aero/Acoustic Test
  - GRC 9’x15’ WT

- **FAA/NASA/P&W CLEEN Engine Demo**

**Timeline:**
- **2008**
- **2009**
- **2010**
- **2011**
- **2012**
- **2013**
- **2014**
- **2015**

- **GTF Gen 1 Engine**
  - Flight Test Demo

- **UHB BPR=18**
  - 11% Semi-Span
  - Nacelle/Wing Installation Test
  - ARC 11’ WT

- **22” UHB Shaped Memory Alloy Variable Area Nozzle**
  - Development Test
  - GRC 9’x15’ WT

- **UHB Technology Engine Demo**
Summary

- Ultra High Bypass Technology has the potential for significant reductions in fuel burn, noise and emissions.

- Geared Turbofan Technology can enable these benefits by optimizing fan and core operation and allowing a reasonable engine and core size.

- The first generation Geared Turbofan was successfully demonstrated under NASA/P&W partnership. Significant contribution toward ERA N+1 Goals was achieved.

- A second generation technology to further improve performance to meet ERA N+2 Goals is being planned collaboratively by NASA/P&W. GTF NG technology ground test engine demonstrations are planned as part FAA/NASA/P&W CLEEN partnership in 2014 and possibly 2015.

- Future long range plans (to 2020) are looking for opportunities to collaboratively conduct engine and flight demonstrations to validate both ERA UHB and P&W GTF NG technologies.