Agenda – Part II

• Next Generation Turbofan design objectives
• GTF™ technology development & validation
  - GTF™ Demonstrator
  - Mitsubishi Regional Jet & Bombardier CSeries engine program
## Next Generation Turbofan design objectives

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Existing engine</th>
<th>Objective</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuel burn</td>
<td>Base</td>
<td>&gt; -12% to 15%</td>
</tr>
<tr>
<td>Noise</td>
<td>-2 to -4 dB rel ICAO stg.4</td>
<td>&gt; -20dB rel ICAO stg.4</td>
</tr>
<tr>
<td>Emissions</td>
<td>-40% rel ICAO 96</td>
<td>-60% rel ICAO 96</td>
</tr>
<tr>
<td>Maintenance cost</td>
<td>Base</td>
<td>- 20%</td>
</tr>
<tr>
<td>Reliability</td>
<td>Base</td>
<td>better than Base</td>
</tr>
</tbody>
</table>

Source: P&W

- **Fuel burn** is the most critical objective because of its most significant impact on airlines’ operating costs and on the ability to meet the emerging CO2 standards.
- **Community noise** is becoming more and more an economic factor for airlines.
- **Reliability** and **maintenance cost** will continue to be amongst the most important focus areas and can not be compromised.
  - Overall objective for airlines is minimum **cost of ownership**
  - Overall objective for engine manufacturer is highest **customer value**
• Next Generation Turbofan design objectives
• GTF™ technology development & validation
  - GTF™ Demonstrator
  - Mitsubishi Regional Jet & Bombardier CSeries engine program
GTF™ demonstrator engine configuration

Configuration from new high speed low spool and a PW6000 core

Thrust class 28K
Configuration 1-G-3-6-1-3

3 stage high speed LPC
solid fan blades
3 stage high speed LPT
star FDGS
PW6000 core PW6000 FADEC
GTF product representative
Not GTF product representative
The PW1000G Pure Power® New Engine Concept and Its Impact on MRO

GTF™ demonstrator program milestones

- Build Start: May 2007
- Start Ground Test: Nov 2007
- 747 FTB 1st Flight: July 2008

Technology readiness achieved end of 2008 to support product EIS end of 2012
Results & achievements

Accumulated run time

~ 400 hrs total running time all phases, ~ 120 hrs flight time, more than half at AI FTB A340

Metrics

- Thrust capability - Full thrust requirement achieved
- Noise - ICAO Stage 4 – 20 EPNdB requirement achieved
- Performance - Engine only as predicted, FDGS and total low spool better than predicted
- Operability - Fan & LPC operability and transient response within expectations

Customer attention

„I think it’s going to be a good engine (the P&W-GTF™). We don’t think the gearbox is going to be a problem. They’ve done their homework to make sure it’s going to work“ says Mike Bair, VP Boeing Commercial Airplanes Business Strategy and Marketing (Aviation Week & Space Technology, September 1st, 2008)

Key product relevant learning accomplished, gained significant attention
Agenda – Part II

- Next Generation Turbofan design objectives
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### PW1217G for the Mitsubishi Regional Jet MRJ 70/90

<table>
<thead>
<tr>
<th>Mitsubishi Regional Jet</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pratt &amp; Whitney launches Geared Turbofan engine with Mitsubishi</td>
</tr>
<tr>
<td></td>
<td>London, October 09, 2007</td>
</tr>
<tr>
<td></td>
<td>Mitsubishi launches MRJ programme</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Geared Turbofan PW1217G</th>
<th>Order book (# engines)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total contracts: 130 / 120</td>
</tr>
<tr>
<td></td>
<td>All Nippon Airways (ANA)</td>
</tr>
<tr>
<td></td>
<td>Trans States</td>
</tr>
</tbody>
</table>
### PW1524G for the Bombardier CSeries CS100/CS300

<table>
<thead>
<tr>
<th>BA CSeries CS100/CS300</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Geared Turbofan PW1524G</strong></td>
<td>Pratt &amp; Whitney Geared Turbofan™ engine to power CSeries aircraft for Lufthansa</td>
</tr>
<tr>
<td></td>
<td>Farnborough, July 13, 2008</td>
</tr>
<tr>
<td></td>
<td>Lufthansa's CSeries discussions with Bombardier advance</td>
</tr>
<tr>
<td></td>
<td>ATI, November 19, 2008</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Order book (#engines)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total contracts: 180 / 180</td>
</tr>
<tr>
<td>Lease Corporation International (LCI)</td>
</tr>
<tr>
<td>Lufthansa</td>
</tr>
<tr>
<td>Republic Airways</td>
</tr>
</tbody>
</table>
The first GTF™ products

**PW1217G**
- Thrust class [k lbs]: 17
- Configuration: 1-G-2-8-2-3

**PW1524G**
- Thrust class [k lbs]: 24
- Configuration: 1-G-3-8-2-3

- Fan drive gear system
- 3-stage high speed LPT
- 2-stage high speed LPC
- 3-stage high speed LPC
- Advanced 8-stage HPC scaled from NGSA rig
- Talon X combustor
- Advanced high efficiency cooled 2-stage HPT
- Re-usable & scalable core at different core size for MRJ and CSeries
Excellent P&W Reduction Gearbox Experience

29,338 PT6A series engine in service over 235 Million operating hours

8,169 PT6T turboshaft engines in service over 33 Million operating hours

4,845 PW100 series engines in service over 70 Million operating hours

Sikorsky Helicopters Gear Reduction Units to 10,000 SHP

> 42,000 engines
> 460 Mio Op. hrs

<table>
<thead>
<tr>
<th>Gearbox</th>
<th>GTF (Estimate)</th>
<th>Turboprop (Typical)</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Reduction Ratio</td>
<td></td>
</tr>
<tr>
<td></td>
<td>IFSD (1,000 Hours)</td>
<td>3:1</td>
</tr>
<tr>
<td></td>
<td>MTBUR (Hours)</td>
<td>0.0004</td>
</tr>
<tr>
<td>Variable Pitch Mechanism</td>
<td>IFSD (1,000 Hours)</td>
<td>No Variable Pitch Mechanism</td>
</tr>
<tr>
<td></td>
<td>MTBUR (Hours)</td>
<td>250,000</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.0090</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2,500</td>
</tr>
</tbody>
</table>
Fan Drive Gear System Development

20+ Years Technology Maturation, +3500 Hours of Testing

- PropFan Demo Engine 13K SHP
  Counter Rotating System
  Ground and MD80 Tested
  '87 – ‘89

- ADP Demo Engine 40K SHP
  Planetary System
  Ground, Wind Tunnel and Rig Testing - 600 Hours
  '92 – ‘93

- Flight Weight Design 32K SHP
  Planetary & Star Systems
  4 Builds - 1000 Hours Testing
  '94 – ‘98

- PWC ATFI Demo 11K SHP
  Star System 276 Hours
  '01-'02

- GTF Demo 28K SHP Star System
  1762 Hours
  ‘09

MTU HPC Systematic Technology Development

<table>
<thead>
<tr>
<th>Model</th>
<th>Characteristics</th>
<th>Year(s)</th>
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</thead>
<tbody>
<tr>
<td>NGPF/PW810</td>
<td>High Pressure Ratio/High efficiency</td>
<td>'2006-08</td>
</tr>
<tr>
<td>PW6000</td>
<td>Low weight, Low cost</td>
<td>'2004</td>
</tr>
<tr>
<td>ATFI2</td>
<td>High efficiency</td>
<td>'2000</td>
</tr>
<tr>
<td>EJ200</td>
<td>Low Stage Count</td>
<td>'1990</td>
</tr>
<tr>
<td>Military</td>
<td>High Performance</td>
<td></td>
</tr>
</tbody>
</table>

![Chart](chart.png)
High Speed LPT Technology Development

- Technology development addressing high speed LPT challenges
- Maturation plans to protect product EIS end of 2012
PW1000G – GTF™ design for low maintenance cost

- Ultra high by pass ratio:
  - Low core deterioration
- Large fan design:
  - Reduced FOD risk
- Fan drive gear system:
  - No life limits
- All airfoils accessible via borescope locations
- IBR’s all accessible for borescope blending
- High speed 3 stage LPC:
  - Reduced airfoil count
  - Robust IBR design
- HPT advanced materials and coatings
- High-speed 3 stage LPT
- 25,000 cycle LLPs

Source: Pratt & Whitney
Gas Generator testing completed in June 2010 exceeding expectations
PW1524G FETT @ test, first light-up to idle on 09/25/2010

PW1217G & PW1524G on track for EIS
## Core engine testing

### Test highlights

- Very successful test campaign
- Accumulated > 260 hrs run time
- HPC & HPT aero test plan completed
- Combustor performance confirmed

### HPC results

- **Efficiency**: Pre-test prediction & efficiency projection confirmed
- **Stability**: SVS schedule optimization demonstrated and SM slightly exceeding pre-test

Testing successfully completed in June 2010 exceeding expectations
PW1524G FETT @ test

All HPC H/W delivered to PWA

LPT module delivered to PWA after last bolt ceremony

Core assy complete

Men at work
The Geared Turbofan is the only concept which allows both significant reduction in fuel burn and noise.
Significant Reduced Noise Emission

Munich International Airport (MUC)

Today’s Aircraft
Noise Simulation: Pratt & Whitney
SEL Contour Source: Wyle Laboratories

Geared Turbofan Powered
Next Generation Aircraft

72% Reduction in 75dB Single Event Noise Contour