LEAP TECHNOLOGY - ON THE CUTTING EDGE

PRESENTED BY:

WILLIAM H. BROWN
GENERAL MANAGER, CFM/LEAP MARKETING

The Power of Flight
On the cutting edge

LEAP Technology

SpeedNews®
Conferences since 1987

SpeedNews 28th Annual
Commercial Aviation Industry Suppliers Conference
March 3-5, 2014 • Beverly Wilshire • Beverly Hills, CA
LEAP performance, execution and technology

**Performance**
... fuel burn, maintenance cost, reliability, emissions & residual value

**Execution**
... 21 CFM service entries on time, on spec

**Technology**
... future of engine materials and aerodynamics
LEAP fuel efficiency already demonstrated

Engine efficiency proven in service

CFM56-5B/7B  GE90 (scaled)*  GEnx (scaled)*  LEAP

8% better  15% better  15% better

*Installed comparative SFC taking size effects into consideration
Engine core drives maintenance cost

Total maintenance cost contribution

Fan and booster

Core and front LPT stages
- Debris rejection system
- Low temp. profile combustor
- Cooling, coatings and CMC's
- Same metal temp. CFM56

LEAP focused on core to control maintenance cost
Low-pressure system kept simple, low temp. and low-speed
LEAP designed for engine reliability

LEAP accessory gear box
- Fan mounted
- Proven design
- All single aisle engines
- Lower temp.
- No soak back heat issues
- Easy access
  - 1 person, 2 minutes

Departure Delay
(per million departures)

Source: Airframer historical reliability data
CFM experience supports LEAP program execution

21 entries into service in 30 years … 600+ million flight hours experience
all on time and to spec
8 engine upgrades certified
24,000+ engines delivered
LEAP development on time

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>LEAP-1A</td>
<td></td>
<td>Design freeze</td>
<td>1st engine to test</td>
<td>Certification</td>
<td>Entry into service</td>
<td></td>
</tr>
<tr>
<td>Airbus A320neo</td>
<td>On time</td>
<td>On time</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LEAP-1C</td>
<td></td>
<td>Design freeze</td>
<td>1st engine to test</td>
<td>Certification</td>
<td>Entry into service</td>
<td></td>
</tr>
<tr>
<td>Comac C919 sole source</td>
<td>On time</td>
<td>On time</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LEAP-1B</td>
<td></td>
<td>Design freeze</td>
<td>1st engine to test</td>
<td>Certification</td>
<td>Entry into service</td>
<td></td>
</tr>
<tr>
<td>Boeing 737MAX sole source</td>
<td>On time</td>
<td>On time</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

LEAP development on time

- LEAP-1A: Airbus A320neo
  - Design freeze: On time
  - 1st engine to test: On time
  - Certification: On time
  - Entry into service: On time

- LEAP-1C: Comac C919 sole source
  - Design freeze: On time
  - 1st engine to test: On time
  - Certification: On time
  - Entry into service: On time

- LEAP-1B: Boeing 737MAX sole source
  - Design freeze: On time
  - 1st engine to test: On time
  - Certification: On time
  - Entry into service: On time
1st Engine to Test fired Sept. 4\textsuperscript{th} … 2 days early

FETT early to date set 3 years ago

Achieved 50\% power on first day

Full power achieved after a few break-in runs

Run at power above full rated thrust of 33,000 lbs.

400 cycles, 300 hours

Same engine performed early icing tests
Performance
Execution
Technology
Carbon fiber fan blade ... less weight, more durable

- No relube
- No dovetail wear
- More impact resistant
- 1000 pounds less weight
- Lighter fan disk
- Lighter containment
- Lighter structures

18+ years in service
30+ million flight hours
0 AD’s airworthiness directives
Debris rejection ... core protection

System ejects debris before entering the core
... sand & dirt exits through inward opening doors
... protects compressor & turbine

Detailed view
High compression ratio ... fuel efficiency

- Advanced sweep airfoils
- End wall contouring
- Balanced stage loading
- Bowed stators
- 22:1 High pressure compression ratio
Lean burn combustor … cooler combustion

Lean burning LEAP combustor

- Lean flame reduces peak temperature
- Improves turbine durability for better time on wing & maintenance cost

Typical rich burn combustor

- Combustion air injected thru liner creates local hot spots
- Hot spots impact downstream part durability
Ceramic Matrix Composites … beyond metals

LEAP
Stage 1 CMC Shroud

1/3
the weight of metal

20%
greater thermal capability

less
cooling air
needed

2x
material strength
Harsh environment technology & testing

Learn
- CFM56 improvements incorporated
- GE90 / GEnx system reduces core debris ingestion

Design
- Rugged High Pressure Compressor
- CMAS resistant combustor coating
- Eliminate cooling passage blockage

Prove
- GE/CFM dust ingestion rig completed
- Raw Gobi Desert dust used for ingestion testing
LEAP technology extends to manufacturing
... additive manufacturing

Design freedom
• Complex parts not typically possible

Time savings
• Fast turnarounds
• Grow complex parts in one build

Material strength
• Achieve fully dense properties

Lighter weights
• Achieve strength while reducing weight
Thank you