Integrated Propulsion System (IPS)
THRUST REVERSER TECHNOLOGY DEMONSTRATOR

Presenter: Louis Jutras
November 2, 2016

CONTINUOUS LOWER ENERGY, EMISSIONS AND NOISE (CLEEN II)
CLEEN II Consortium Public Session
OUTLINE

UTC/UTC Aerospace Systems company overview
Elevator Speech
Technologies
Project Schedule
Year 1 Achievements
Year 2 Plans
Summary
Leading provider of high technology systems for the commercial building and aerospace industries

Employs approximately 220,000 people in more than 4,000 locations

Located in approximately 70 countries around the world

2015 net sales of $56B
UTC AEROSPACE SYSTEMS

Business Units

- Aerostructures
- ISR & Space Systems
- Landing Systems
- Sensors & Integrated Systems
- Interiors, Actuation & Propeller Systems
- Environmental Control Systems & Electric Systems
UTC Aerospace Systems – Aerostructures is a leading independent supplier and integrator of nacelles and pylons, offering complete life cycle design/build/support for large commercial and regional jet customers around the world.
ELEVATOR SPEECH

Case for action

**UHBR: Fuel burn benefit**

<table>
<thead>
<tr>
<th>Bypass Ratio (BPR)</th>
<th>% Delta Fuel burn</th>
<th>Conventional Nacelle</th>
<th>ecoIPS Nacelle</th>
<th>Engine</th>
<th>Future</th>
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<tbody>
<tr>
<td>Legacy 5:1</td>
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<td>Current 12:1</td>
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Weight and drag of increasingly larger conventional nacelle offsets performance benefit of lower fan pressure ratio

- Inlet/fan cowl (Fanlet)
- Novel thrust reverser architecture (FAA CLEEN II demonstrator)
- Short, clean fan duct
- Hybrid laminar flow
- Tailored acoustics
- Advanced manufacturing
- Innovative materials

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CLEEN II demonstrator – key to mature technologies

<table>
<thead>
<tr>
<th>Technology Name</th>
<th>Goal Impact</th>
<th>Benefits and Application</th>
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<tbody>
<tr>
<td>Short, integrated fan duct thrust reverser</td>
<td>Fuel burn</td>
<td>~1.0% reduction. Demo designed for 25,000-40,000 lb thrust-class engines with expected entry into service by 2025.</td>
</tr>
<tr>
<td>Advanced acoustics</td>
<td>Noise</td>
<td>~2.5 EPNdB reduction. (to offset short fan duct)</td>
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CLEEN II SCHEDULE

Thrust reverser demonstration on P&W GTF Engine

Major Program Milestones

<table>
<thead>
<tr>
<th>Award</th>
<th>Task Plan</th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
<th>2018</th>
<th>2019</th>
<th>2020</th>
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TRL5 Rig-Airflow

- PDR
- TRL5 Rig-Structure
- DDR

TRL6 Engine Ground Test

Final Test Report

Major Program Phases

- Config Def & System Trades
- Preliminary Design
- Detail Design
- Tool Design and Hardware Fab
- Test Planning & Engine Assy
- Ground Testing
- Analysis & Reporting
YEAR 1 ACHIEVEMENTS

2012 – 2015 IRAD
30+ Short/Clean Duct Configs.

2 Short/Clean Duct Configs.

Q1
- Demo Config. Down Select
- TRL4 Acoustics

Q2
- T/R Test Rig Design for TRL4

Q3
- Demo Concept Design
- Test Engine/Pylon Integration Workshop

Q4
- Demo Models Stress, Aero, Acoustics

2016

Shorter Thrust Reverser then legacy designs
YEAR 2 PLANS

<table>
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<tr>
<th>Quarter</th>
<th>Activities</th>
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<tbody>
<tr>
<td>Q1</td>
<td>Ground Test Demo Final Aerolines</td>
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<tr>
<td>Q2</td>
<td>TRL4 ecoIPS T/R</td>
</tr>
<tr>
<td>Q3</td>
<td>T/R Structure Test Rig Design for TRL5</td>
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<tr>
<td>Q4</td>
<td>CLEEN II PDR</td>
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<tr>
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<td>T/R Airflow Tests for TRL5</td>
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TRL5 Acoustics

2017
PROJECT TECHNOLOGY

Short-Duct Thrust Reverser

Anticipated Benefits:
~1% fuel burn reduction
~2.5 EPNdB noise reduction

Risks/Mitigation Plans:
Achievement of performance targets
• Integrated technology development plans
• Metrics and integration assessments
• Design options and rig testing

Objectives: Demonstrate benefits of a reduced-drag, short fan duct integrated thrust reverser with improved acoustic treatments

Accomplishments:
Defined short-duct thrust reverser configuration
Performed preliminary performance analyses
Designed TRL4 structure validation rig
Achieved TRL4 for acoustic technologies

Work Statement: Continue the TRL advancement of integrated thrust reverser technologies via material & process development, rig tests, and engine ground test

Schedule:

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<td>PDR</td>
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<td>DDR</td>
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SUMMARY

Supports CLEEN II lower energy and noise initiatives

Integrated thrust reverser to be matured to TRL6

Maximizes efficiency of next generation ultra-high bypass ratio propulsion systems

Technologies applicable to next generation nacelles for Next Generation Single Aisle and New Midsize Airplane

Selected technologies applicable to performance insertion on current production programs