Boeing CLEEN II Program Update
Compact Nacelle (CN)

Consortium Plenary Session
Jennifer Kolden
May 13, 2020
Compact Nacelle – Motivation

**General Engine Characteristics**
• 2025 EIS
• Geared Low Pressure Ratio Fan
• Bypass Ratio of 12 to 14
• Large Fan, Small Core
• Core Mounted Accessories

**Nacelle Technologies Required**
• PAI Optimization
• Short Inlet (0.4 L/D or less)
• Advanced T/R Configuration
• Improved Acoustic Solutions
  • Advanced Manufacturing
  • New High-temp materials
  • Advanced Bleed Systems
Compact Nacelle - Overview

Short Inlet Aerodynamics Ground Test

Ground Testing

Reporting

Flight Demonstration (RR FTB)

Aft Fan Duct Acoustics noise reduction

2017 2018 2019 2020 2021

Acquisition of TR

ATP PDR DDR S2F HW O/D

Concept Dev H/W Dev

FT & Rept

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Compact Nacelle (CN) – Aft Fan Duct Acoustics

Anticipated Benefits:

• 0.4 to 1.2 EPNdB for future applications to UHB-configured aircraft entering service in the 2025 time frame
• 0.2 to 0.6 EPNdB as retrofit potential for some existing models.

Objectives:

• Develop acoustic treatment concepts for aft duct of compact nacelle architectures
• Validate design concepts through flight demonstration for transition to new and existing products

Work Statement:

• Develop prototype TR hardware
• Conduct flight demonstration on the Boeing 737 Max 9 ecoDemonstrator

Accomplishments/Plan:

✓ Surplus Hardware Obtained – 1Q ‘19
✓ Concepts developed – 2Q ‘19
✓ Interim Project Phase Launched – Jul ‘19
✓ ATP – Oct ‘19
✓ PDR – Oct ‘19
✓ DDR – Jan ‘20
✓ Engineering Complete – Mar ‘20
• H/W on Dock at Boeing Field – Q3 ‘20
• ecoD Flight Test – Q3 ’21
• Limited Rights Flight Test Report – Q4 ’21
• Public Test Report – Q4 ’21
• Program End – Q4 ’21
## Advanced Acoustic Treatment

<table>
<thead>
<tr>
<th>Region</th>
<th>Improvement</th>
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<tbody>
<tr>
<td>Bifurcations</td>
<td>60% acoustic yield</td>
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<tr>
<td></td>
<td>35% full-depth area</td>
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<tr>
<td>Blocker Doors</td>
<td>70% acoustic yield</td>
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Experimental TR has significantly more acoustic area than Production
Demonstration Approach

- Leverage existing hardware
  - An existing TR will be modified and provided for LHS installation
  - TR locked out for ease of manufacture
  - Increase acoustic treated area by 50% to 80% with prototype fairing and treatment on blocker doors
  - All hardware designed and modified by Boeing

- Collect community noise acoustic flyover data at Moses Lake, WA Grant County Airport.
  - Using ground based acoustic instrumentation
  - Ground based microphones and 4-ft microphones to be distributed under the flight path
  - Ground based phased array

- Aircraft level attenuation measurements to be projected to 2025+ EIS engine technologies using analytical predictions
Accomplishments

- Acquired T/R Hardware, shipped to Charleston, SC
- Completed CFD, CDUCT Attenuation analyses
- Developed Draft test plan for ecoDemonstrator Flight Test
- Completed Preliminary Design Review – Oct ’19
- Completed Detailed Design Review – Jan ’20
- All engineering released – Mar ‘20
- Hardware production launched – Mar ‘20
- Completed Safe-to-Fly Engineering – Apr ‘20
Acoustic flight test timing is a function of weather window, causing 12 month slide

Current environment drives ecoDemonstrator Delay

Baseline Plan

Interim Phase Launch
CLEEN II
ATP
PDR
DDR

Hardware On-Dock
Flight Test
PoP End

Flight Test Window

Project ‘Pause’

Reconvene
Flight Test
PoP End

Replan

Flight Test Slide

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Next Steps

- **Final Test Plans** – Q2 ‘20
- **Hardware on Dock Boeing Field** – Q3 ’20
- **- Pause -**
- **ecoD 737 Max 9 Flight Test** – Q3 ‘21
- **Limited Rights Flight Test Report** – Q4 ‘21
- **Public Test Report** – Q4 ‘21
Summary

- A project to implement improvements to nacelle aft duct acoustics was launched in 2019.
- This new project leverages existing hardware to save costs.
- Engineering of the acoustic improvements is complete and production is underway.
- The experimental prototype hardware will be flown on the Boeing ecoDemonstrator.
  - Current environment delays flight testing to Q3 2021
- Results from this project will inform current and future nacelle designs and contributes to the FAA’s CLEEN II goal of reducing aircraft and community noise exposure.
Thank you
<table>
<thead>
<tr>
<th>Acronyms</th>
<th>Description</th>
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<tbody>
<tr>
<td>ATP</td>
<td>Authority To Proceed</td>
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<tr>
<td>CDUCT</td>
<td>Boeing ducted fan noise propagation code</td>
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<tr>
<td>CFD</td>
<td>Computational Fluid Dynamics</td>
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<tr>
<td>CN</td>
<td>Compact Nacelle</td>
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<tr>
<td>DDR</td>
<td>Detailed Design Review</td>
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<tr>
<td>EIS</td>
<td>Entry Into Service</td>
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<tr>
<td>EPNdB</td>
<td>Effective Perceived Noise, Decibels</td>
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<td>H/W</td>
<td>Hardware</td>
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<td>Kickoff</td>
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<tr>
<td>L/D</td>
<td>Length to Diameter ratio</td>
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<tr>
<td>LHS</td>
<td>Left Hand Side</td>
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<tr>
<td>O/D</td>
<td>On Dock</td>
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<td>Outlet Guide Vanes</td>
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