Boeing CLEEN II Program Update

Compact Nacelle (CN)

Consortium Plenary Session
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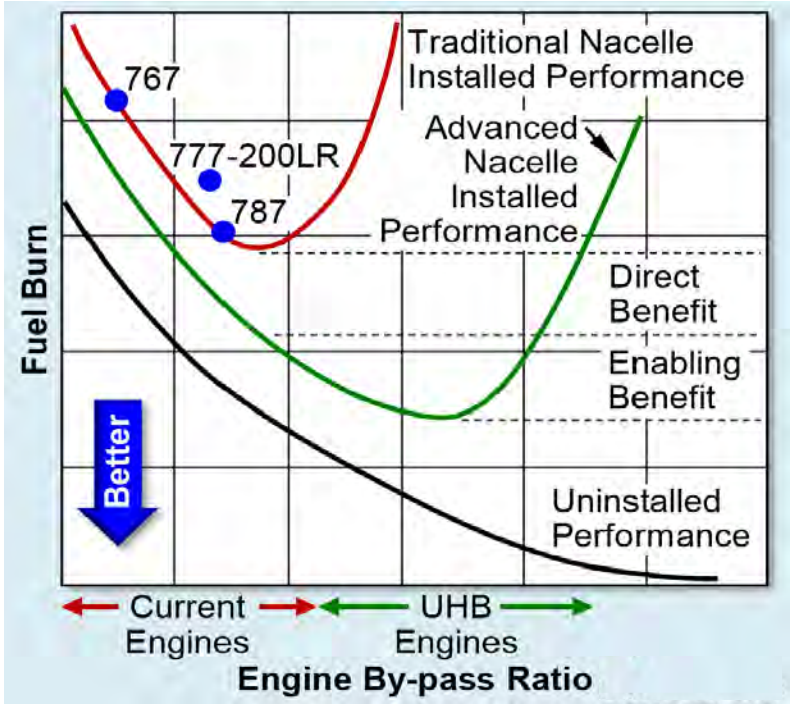
Compact Nacelle – Motivation

General Engine Characteristics

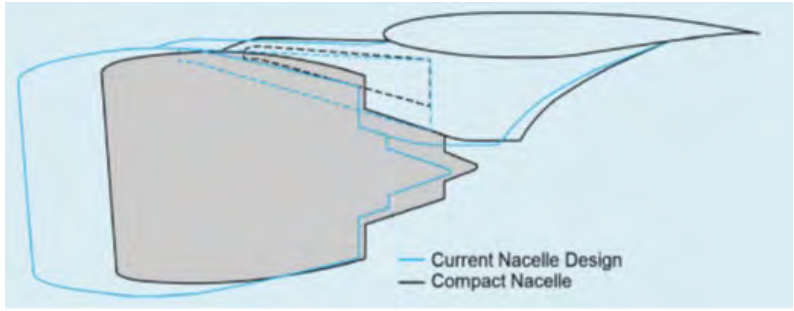
- **2025 EIS**
- **Geared Low Pressure Ratio Fan**
- **Bypass Ratio of 12 to 14**
- **Large Fan, Small Core**
- **Core Mounted Accessories**



Nacelle Technologies Required

Complete
- **PAI Optimization**
- **Short Inlet (0.4 L/D or less)**

Current
- **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

Rolls-Royce

Flight Demonstration (RR FTB)

2017	2018	2019	2020	2021

Aft Fan Duct Acoustics noise reduction

Acquisition of TR ◆ ATP ◆ PDR ◆ DDR ◆ S2F ◇ HW O/D ◇

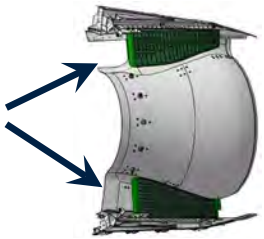
Concept Dev → H/W Dev → FT & Rept

Flight Test ◇◇ Final Report ◇

eco Demonstrator PROGRAM

Compact Nacelle (CN) – Aft Fan Duct Acoustics

Treated
Blocker Doors



Thrust Reverser
Inner Wall

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*

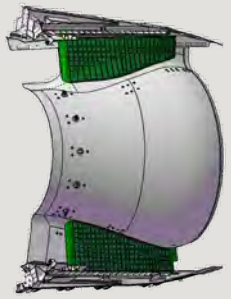
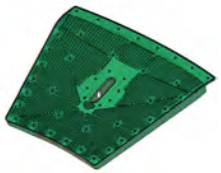
Work Statement:

- *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

Region		Improvement
Bifurcations		60% acoustic yield 35% full-depth area
Blocker Doors		70% acoustic yield

Experimental TR has significantly more acoustic area than Production

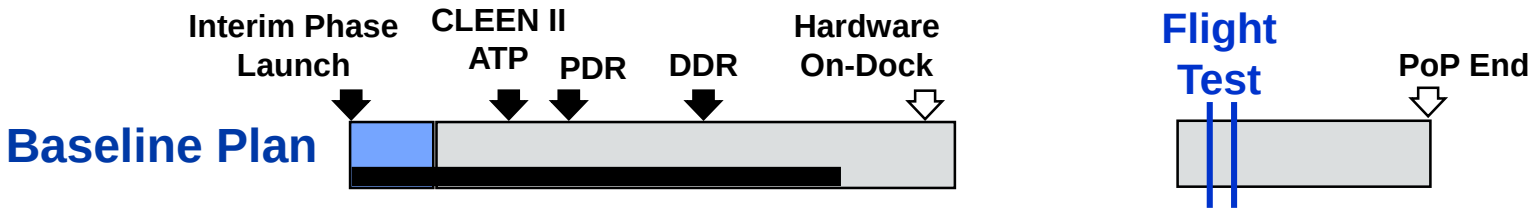
Demonstration Approach

- **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

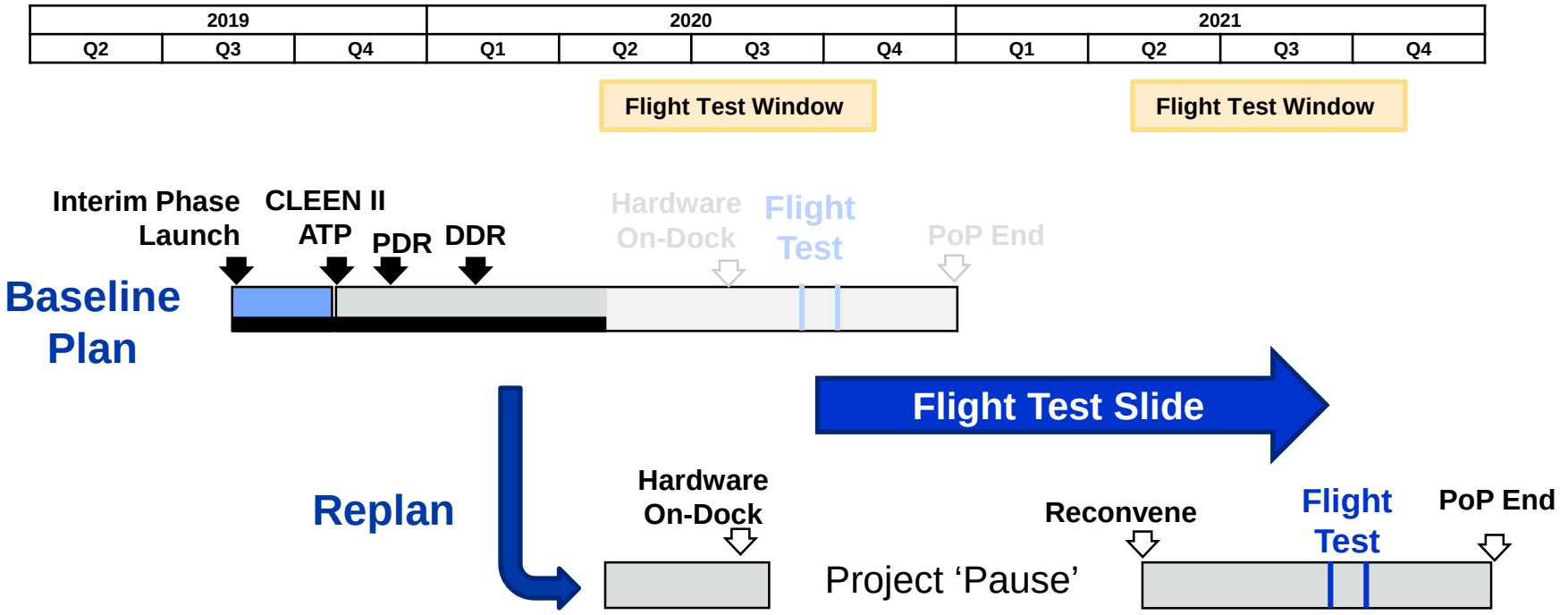
- **Aircraft level attenuation measurements to be projected to 2025+ EIS engine technologies using analytical predictions**

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*

Current environment drives ecoDemonstrator Delay



Acoustic flight test timing is a function of weather window, causing 12 month slide

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

Acronyms

ATP	Authority To Proceed
CDUCT	Boeing ducted fan noise propagation code
CFD	Computational Fluid Dynamics
CN	Compact Nacelle
DDR	Detailed Design Review
EIS	Entry Into Service
EPNdB	Effective Perceived Noise, Decibels
H/W	Hardware
K/O	Kickoff
L/D	Length to Diameter ratio
LHS	Left Hand Side
O/D	On Dock
OGV	Outlet Guide Vanes
PAI	Propulsion Airframe Integration
PDR	Preliminary Design Review
RR	Rolls-Royce
S2F	Safe To Fly
SRR	System Requirements Review
T/R	Thrust Reverser
UHB	Ultra High Bypass