



# Boeing CLEAN II Program Update

## *Compact Nacelle (CN)*

**Consortium Plenary Session**  
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# Compact Nacelle – Motivation

## General Engine Characteristics

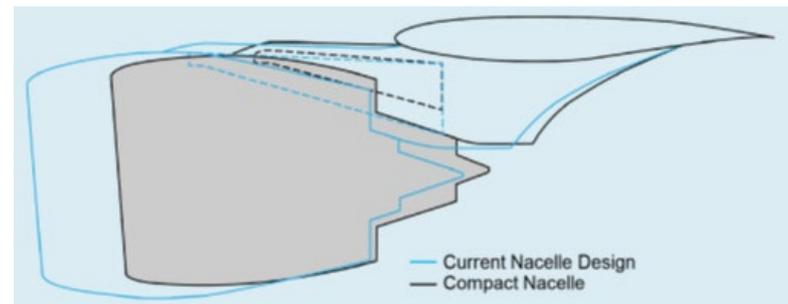
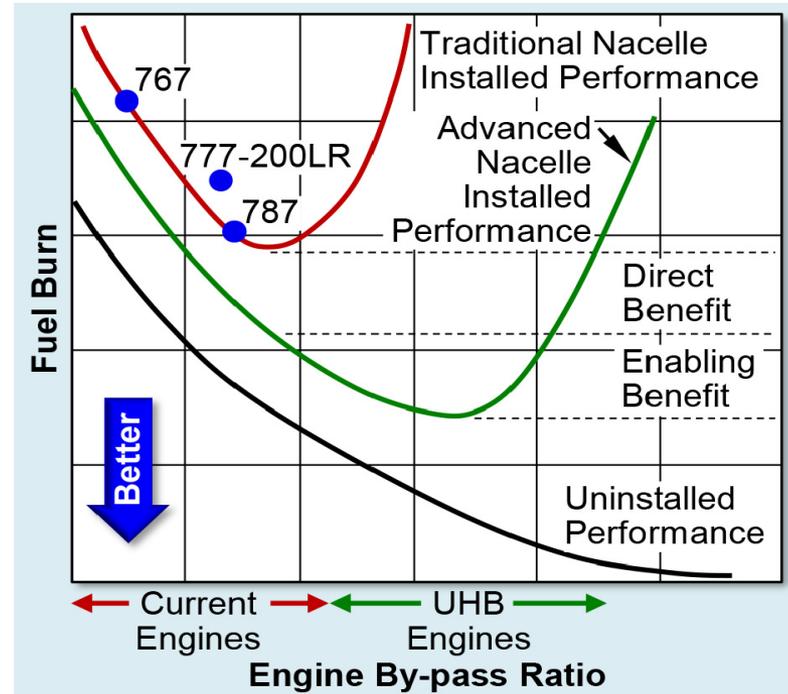
- 2025 EIS
- Geared Low Pressure Ratio Fan
- Bypass Ratio of 12 to 14
- Large Fan, Small Core
- Core Mounted Accessories

## Nacelle Technologies Required

- 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



New



# Compact Nacelle - Overview

## Short Inlet Aerodynamics Ground Test



Ground Testing

Reporting



Flight Demonstration (RR FTB)

2017

2018

2019

2020

Acquisition of TR



ATP

PDR



DDR



S2F



ecoD 2020

Flight Test



Final Report



Concept Dev

H/W Dev

FT & Reporting

*Aft Duct  
Acoustics noise  
reduction*



## Compact Nacelle (CN) - Short Inlet



## Anticipated Benefits:

*Cumulative predicted impact over 20 years:*

- *Enables advanced engines with 2025 EIS*
  - *14%-16% reduction in fuel consumption on 125-seat and larger aircraft yielding ~400M tons of fuel saved*
  - *CO2 production avoidance of ~1200 M tons*
- *Achieve 1% Block Fuel savings through weight and drag reductions*

## Objectives:

- *Measure effects of inlet flow distortion at the fan face in cross wind.*
- *Validate Short Inlet design tools for transition to Boeing's next development program.*

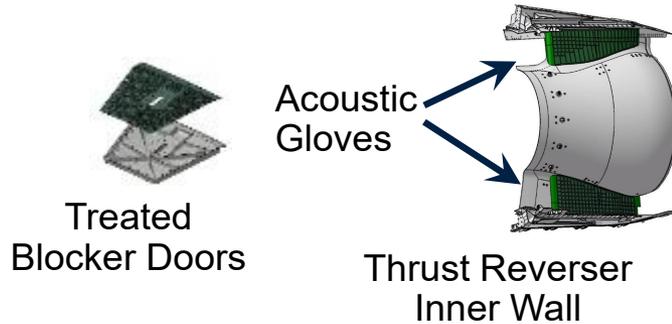
## Work Statement:

*Conduct ground crosswind test of a Boeing Short inlet installed on a Trent 1000 engine in collaboration with Rolls-Royce at their Stennis, Mississippi test facility.*

## Accomplishments since project launch:

- ✓ *Project Launched – Apr '17*
- ✓ *Short Inlet delivered to Stennis – Apr '17*
- ✓ *Kickoff Meeting / Test Plan review – Jul '17*
- ✓ *Block 1 testing completed – Aug '17*
- ✓ *Baseline Inlet delivered to Stennis – Dec '17*
- ✓ *Block 2 TRR completed – Dec '17*
- ✓ *Block 2 testing completed – Mar '18*
- ✓ *Final Briefing – Sep '18*
- ✓ *Limited Rights Report – Oct '18*
- ✓ *Public Report – Nov '18*
- ✓ *Program End – Nov '18*

## Compact Nacelle (CN) – Aft 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 2020 ecoDemonstrator*

## Accomplishments/Plan:

- ✓ *Surplus Hardware Obtained – 1Q '19*
- ✓ *Concepts developed – 2Q '19*
- ✓ *Interim Project Phase Launched – Jul '19*
- ✓ *ATP – Oct '19*
- ✓ *PDR – Oct '19*
- *H/W on Dock at Boeing Field – Q2 '20*
- *ecoD 2020 Flight Test – Q3 '20*
- *Limited Rights Flight Test Report – Q3 '20*
- *Public Test Report – Q3 '20*
- *Program End – Q4 '20*

# 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 conceptual designs & airplane level sensitivity analyses (for Aft fan tones & broadband)***
- ***Generated moldlines for acoustics fairings***
- ***Completed CFD, CDUCT Attenuation analysis***
- ***Developed Draft test plan for 2020 ecoDemonstrator***
- ***Completed Preliminary Design Review – Oct '19***

# Next Steps

- ***Thrust Reverser Prototype Design Complete – Q1 '20***
- ***Safe-to-Fly Approval – Q1 '20***
- ***Final Test Plans – Q1 '20***
- ***Hardware on Dock Boeing Field – Q2 '20***
- ***ecoD 2020 Flight Test – Q3 '20***
- ***Limited Rights Flight Test Report – Q3 '20***
- ***Public Test Report – Q3 '20***
- ***Program End – Sep '20***

# Summary

- Short Inlet Ground Test was successfully completed in 2018, achieving TRL 6.
- Rolls-Royce will use the Boeing Short Inlet to conduct a Flight demonstration on their FTB (under RR CLEEN II contract).
- A project to implement improvements to nacelle aft duct acoustics was launched earlier this year.
- This new project leverages existing hardware to save costs.
- Preliminary design of the acoustic improvements is complete.
- The experimental prototype hardware will be flown on the Boeing 2020 ecoDemonstrator.
- 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.

# 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



# Thank you



