Boeing CLEEN Phase III Program Update

Consortium Plenary Session

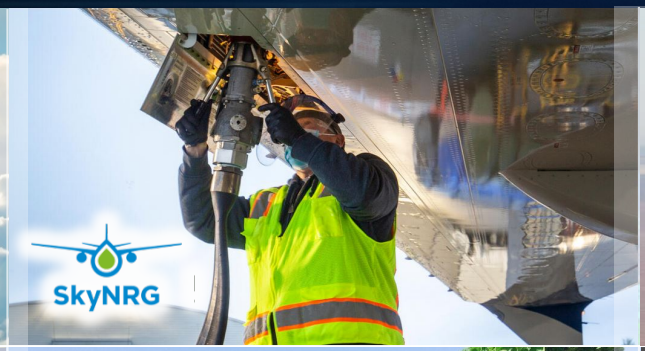
Jennifer Kolden

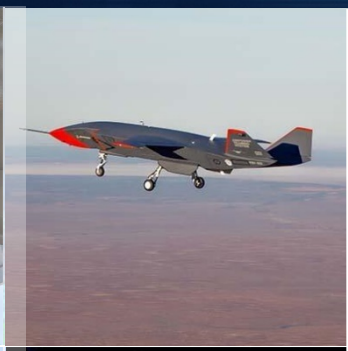
May 4, 2022

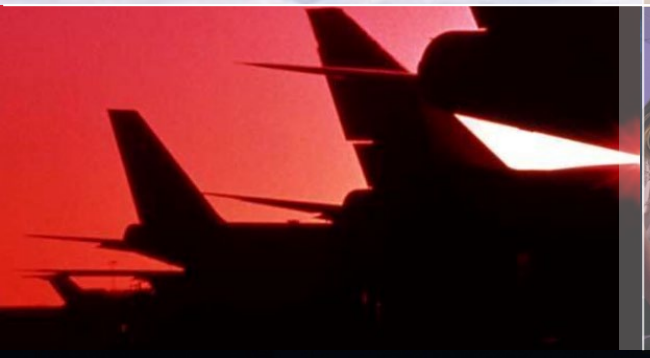
PARTNERING FOR

SUSTAINABLE AEROSPACE

SUSTAINABLE AEROSPACE 2050







FLEET RENEWAL

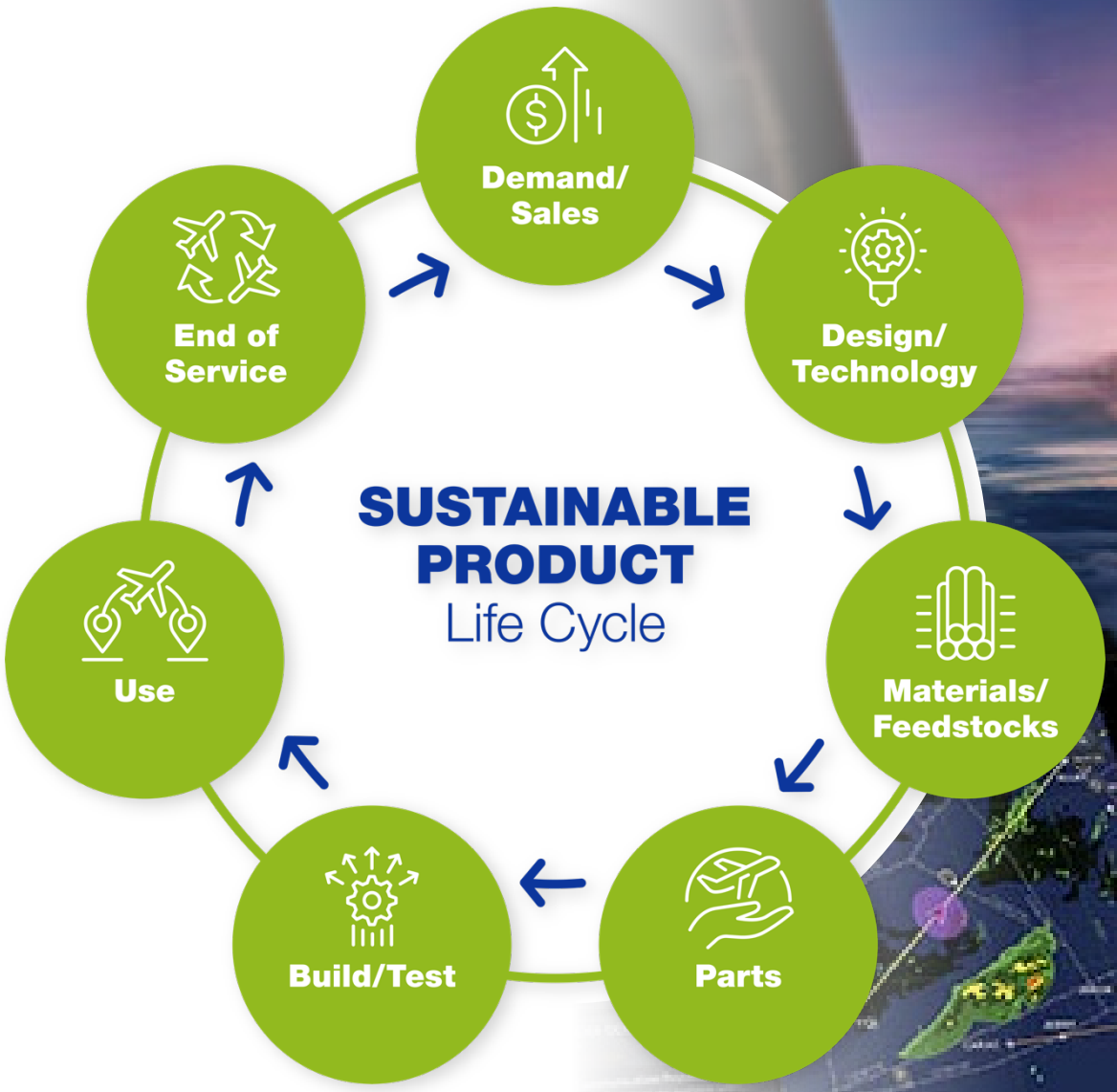
OPERATIONAL EFFICIENCY

RENEWABLE ENERGY

ADVANCED TECHNOLOGY

People, Partnerships, Policy

SUSTAINABILITY IS BUILT IN



2021 Sustainability Report:

Boeing: 2021 Sustainability Report

Boeing Program
CLEEN Phase III

Quiet High-Lift

"Reducing Airframe Noise"

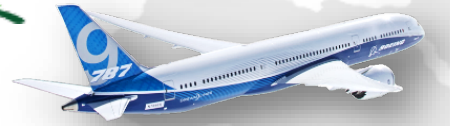
"Enabling Quieter, Advanced Propulsion"

Quiet Landing Gear

Next Generation Inlet

737 MAX 10

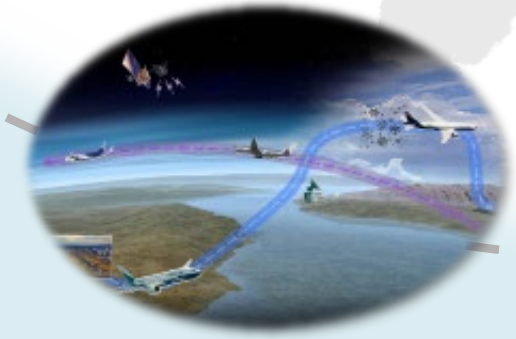
eco Demonstrator PROGRAM



787 9 (RR)

"Improving How the Airplane is Operated"

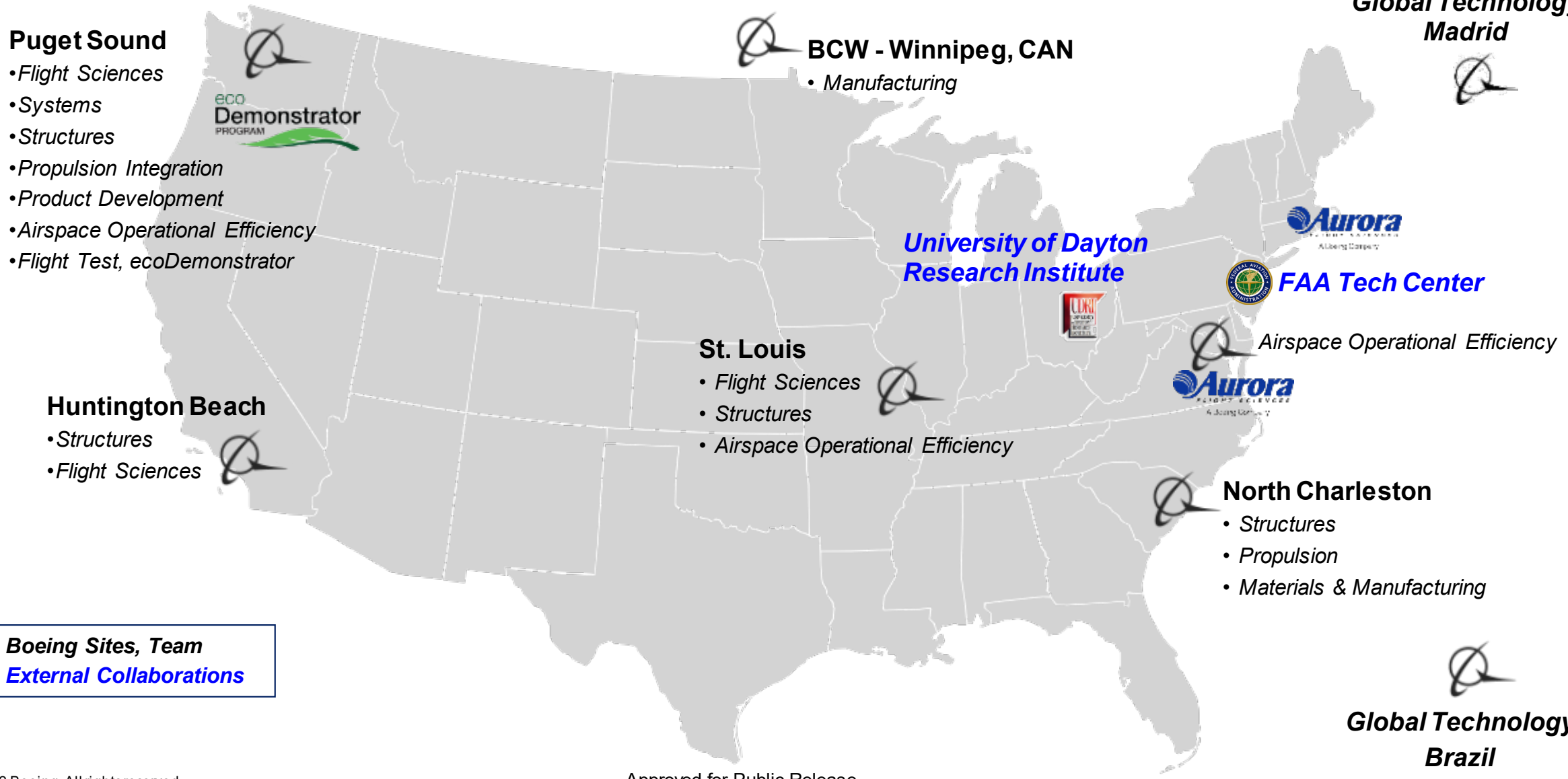
Intelligent Operations



Sustainable Aviation Fuels

"Accelerating SAF Uptake to meet CO2 goals"

Program Team – "Best of Boeing" & Industry Partners



Puget Sound
- *Flight Sciences*
- *Systems*
- *Structures*
- *Propulsion Integration*
- *Product Development*
- *Airspace Operational Efficiency*
- *Flight Test, ecoDemonstrator*

BCW - Winnipeg, CAN
- *Manufacturing*

Global Technology Madrid

University of Dayton Research Institute

FAA Tech Center

Airspace Operational Efficiency

St. Louis
- *Flight Sciences*
- *Structures*
- *Airspace Operational Efficiency*

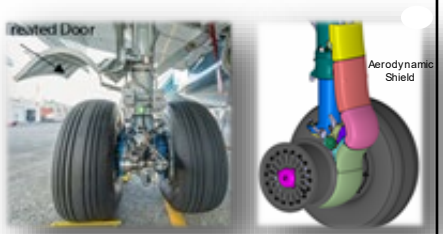
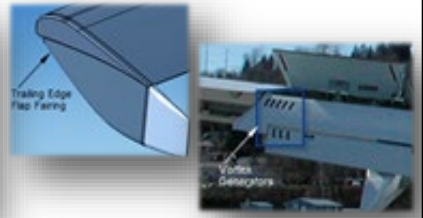
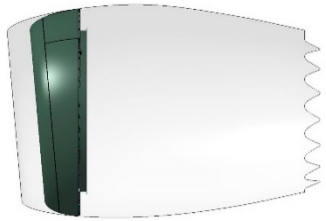
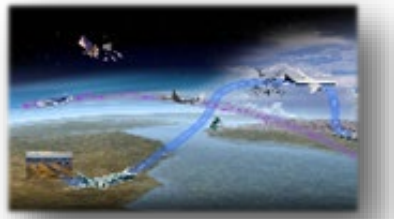
Huntington Beach
- *Structures*
- *Flight Sciences*

North Charleston
- *Structures*
- *Propulsion*
- *Materials & Manufacturing*

Global Technology Brazil

- ***Boeing Sites, Team***
- ***External Collaborations***

Projects & Benefits

	Quiet Landing Gear	Quiet High-Lift	Next Generation Inlet	Intelligent Operations	Sustainable Aviation Fuels
Technology	 • Acoustically Treated Main Gear Door • Perforated Strut Shield	 • Outboard Flap TE Fairings • TE Vortex Generators	 • New Structural Architecture • New Ice Protection System • Maximize Acoustic Treated Area	 • Noise-Optimized Flight Paths • Integrate into ATC and A/C Systems	 • Higher Performing Blends • Drop-in Compatibility • Support Scale-up
Impact	Reduce Community Noise	Reduce Community Noise	Enable New Engines, Reduce Community Noise, Fuel Burn	Reduce Community Noise, Fuel Burn	Reduce Fuel Burn, Emissions
Airframe Benefits / Metrics	Up to 0.5 EPNdB	Up to 0.5 EPNdB	1.5 EPNdB 2.0% Block Fuel	3-5 peak dBA 2% T/O Block Fuel 5% APP Block Fuel	2%-3% SFC
Projected Fleet Impact	Reduce 65 dB community noise contours	Reduce 65 dB community noise contours	Community Noise, 82M Metric ton, CO2 reduction	Community Noise, 28M Metric ton, CO2 reduction	2950M Metric ton, CO2 reduction
Transition	2030 , 2035 Retrofit	2030 , 2035	2030 (partial) , 2035	2030 , 2035 Retrofit , BGS EFB	2030 , 2035 Retrofit

Program Schedule

Major Program Elements

ATP | Today | 737 Flight Demo (TBD) | 787 Flight Demo | Final Report

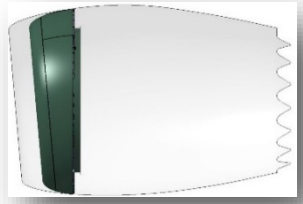
2021 | 2022 | 2023 | 2024 | 2025

Technologies

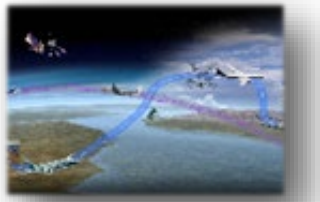
Quiet High-Lift

Quiet Landing Gear

Next Generation Inlet

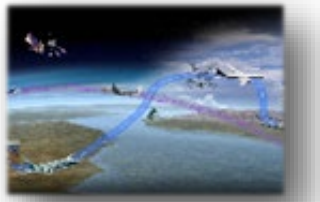


Sustainable Aviation Fuels



Intelligent Operations

Intelligent Operations

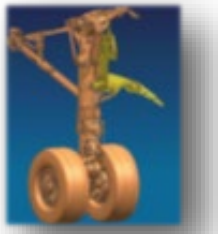


Legend
Noise Reduction
Fuel Burn
Alt Fuel Transition

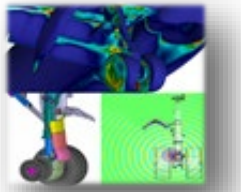
Quiet Landing Gear Project

Conceptual Design → Preliminary Design → Detailed Design → Fabrication Assembly → Flight Testing → Reporting

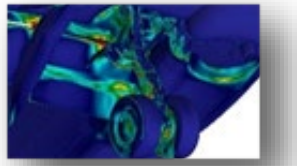
Objective:
Develop landing gear (airframe) noise reduction technology to reduce aircraft noise at approach



Detailed Gear Geometry Defined
Jul



Conceptual Design Review (CoDR)
Nov



Baseline Gear CFD/CAA
Jan

ecoDemonstrator Gate B
Feb

ATP
May

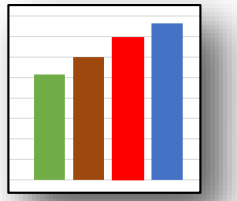
2021

2022

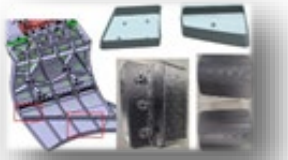
Oct
ecoDemonstrator Gate A

Jul
Initial Shield Layout

Feb
System Noise



Apr
Fabrication Risk Reduction Trials

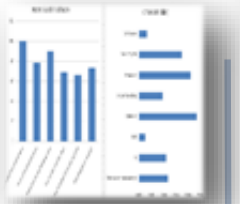


Quiet High-Lift Project

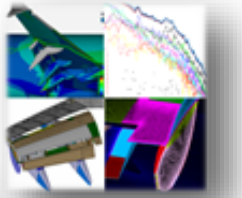
Conceptual Design → Preliminary Design → Detailed Design → Fabrication Assembly → Flight Testing → Reporting

Objective:
Develop outboard trailing edge flap (airframe) noise reduction technology to reduce aircraft noise at approach

Initial Vortex Generator (VG) Layout
Jul



VGs Parametrics
Dec



Conceptual Design Review (CoDR)
Jan

ecoD Gate B
Feb

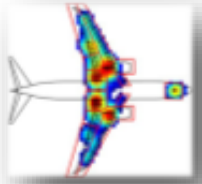
ATP
May

2021

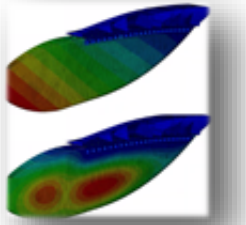
2022

Oct
ecoDemonstrator Gate A

Jan
Airframe Noise Model



Apr
Fairing Trades

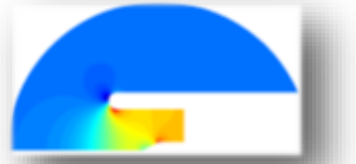


Jul
Initial Fairing Layout

Next Generation Inlet Project

Conceptual Design → Preliminary Design → Detailed Design → Fabrication Assembly → Flight Testing → Reporting

Objective:
Develop inlet (engine) noise reduction technology with reduced weight & drag to reduce aircraft noise at take-off & approach and address reduced-length inlet integration challenges of UHB engines



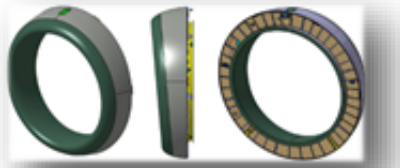
ATP
May

Surface Reloft
Sep

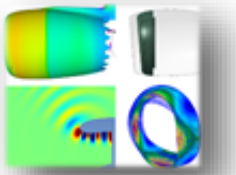
CFD/CAA
Nov

2021 | **2022**

Jun
CAD models (ICMs/Layouts)



Feb
NGI CoDR

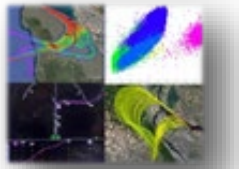


Mar
Ice Protection System (IPS) Subcomponent Trials

Intelligent Operations Project

Conceptual Design → Preliminary Design → Detailed Design → Fabrication Assembly → Flight Testing → Reporting

Objective:
Develop aircraft operational noise reduction technology to reduce aircraft noise at take-off & approach



Systems Requirement Review (SRR)
Nov

CONOPs
Sep

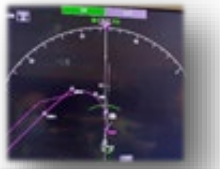
ecoD Gate B
Feb

ATP
May

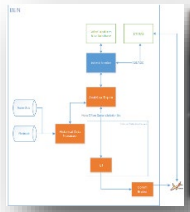
2021 | **2022**

Oct
ecoDemonstrator Gate A

Jul
Procedures Exploration



Mar
Software Drop 1 / Simulation



Sustainable Aviation Fuels Project

Conceptual Design → Preliminary Design → Detailed Design → Fabrication Assembly → Flight Testing → Reporting

Objective:
Address long term compatibility of fuel systems materials with low aromatic fuels in order to promote uptake and sustainability

ATP
May

University of Dayton Research Institute (UDRI) Phase 1 Test Start
Dec

ecoD Gate B
Feb

2021 | 2022

Oct
ecoDemonstrator Gate A

Jan
UDRI Steady State Test Start

Apr
UDRI Phase 1 Test Complete

Summary & Next Steps

Summary

- CLEEN Phase III aligned with Boeing vision for Sustainable Aerospace
- Under CLEEN Phase III, Boeing is executing 5 projects developing technology to reduce airframe, engine, and flight operational noise, as well as Drop-in SAF
- All projects have completed the Conceptual Design Phase and developing flight test hardware
- All projects on-track to meet noise reduction, fuel burn & Drop-In SAF goals

Next Steps

- Complete Preliminary & Detailed Design Phases & Design Reviews
- Complete Fabrication Planning & Hardware Procurements

Acronyms

A/C	Aircraft
APP	Approach
ATC	Air Traffic Control
ATP	Authority to Proceed
BGS	Boeing Global Services
CAA	Computational Aero-Acoustics
CFD	Computational Fluid Dynamics
CoDR	Conceptual Design Review
dBA	Decibels, A-weighted
EFB	Electronic Flight Bag
EPNdB	Effective Perceived Noise, Decibels
HW	Hardware
SFC	Specific Fuel Consumption
SRR	System Requirements Review
TE	Trailing Edge
T/O	Take-Off
UDRI	University of Dayton Research Institute