

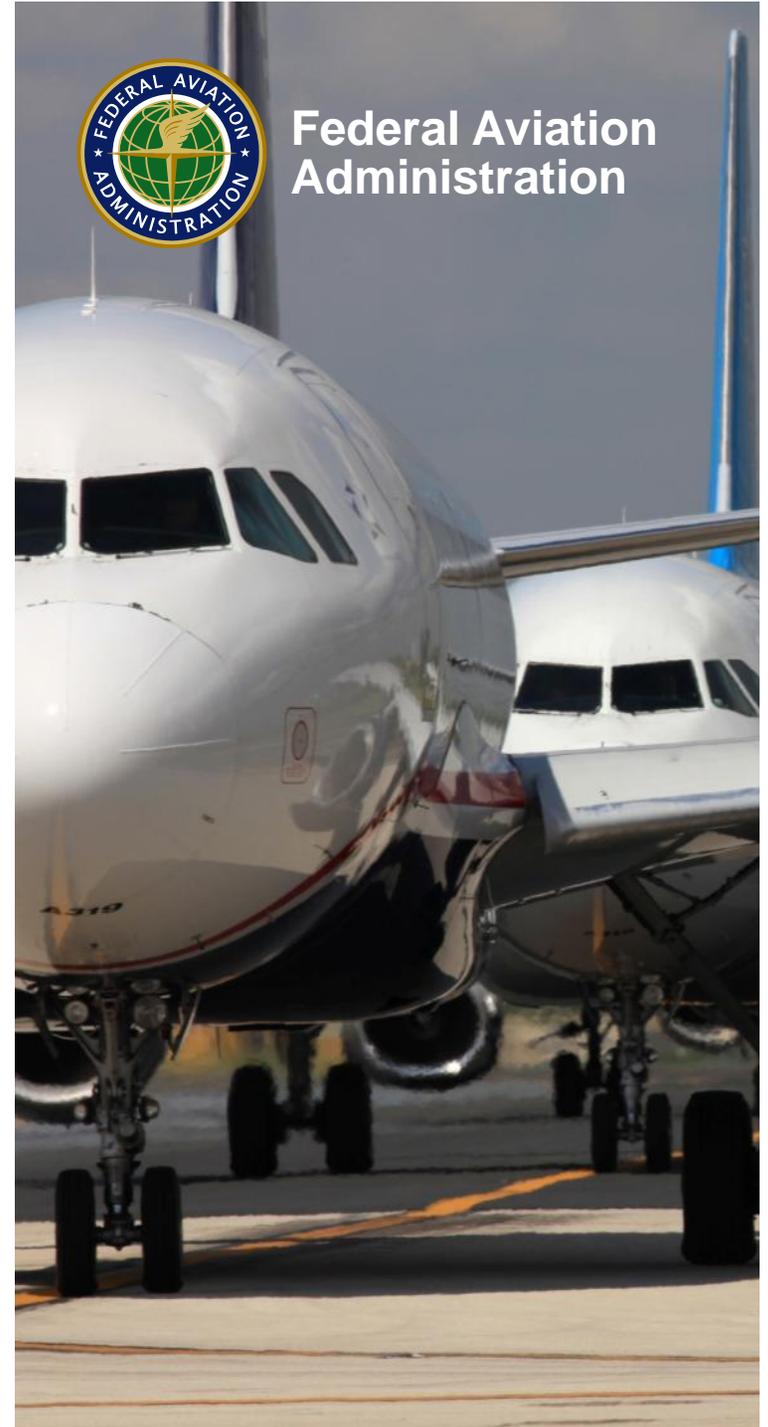
CLEEN Consortium

CLEEN Program Overview & CLEEN II Update

Presented to: CLEEN Consortium

By: Levent ILERI, CLEEN Program

Date: November 19, 2014



Outline

- **CLEEN Overview and Goals**
- **CLEEN Demonstrations**
- **CLEEN Benefits So Far**
- **Summary**
- **CLEEN II Timeline**



Aviation Environmental Goals and Solutions

NOISE



AIR QUALITY



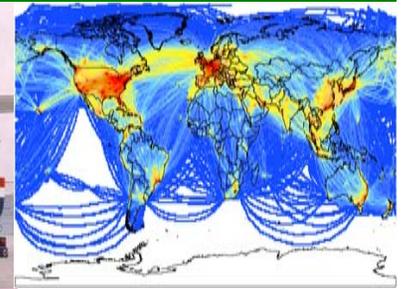
WATER QUALITY



ENERGY



GLOBAL CLIMATE



NextGen Environmental Goals

- Absolute reduction of significant *community noise* and *air quality* emissions impacts
- Improve NAS *energy* efficiency and, supply of and access to, alternative fuel sources
- Limit or reduce the impact of aviation Greenhouse Gas (GHG) emissions on the *global climate*
- Reduce significant aviation impacts associated with *water quality*

NextGen 5 Pillar Env. Approach

- P1: Improved Scientific Knowledge and Integrated Modeling
- P2: New Aircraft Technologies
- P3: Sustainable Alternative Aviation Fuels
- P4: Air Traffic Management Modernization and Operational Improvements
- P5: Policies, Environmental Standards, and Market Based Measures



Federal Aviation
Administration



CLEEN Overview and Impact

- **Initial five year CLEEN program (2010-2015)**
 - To help achieve NextGen Environmental Goal of attaining environmental protection that allows sustained aviation growth
 - Cost share maturation (TRL 6 to 7) of previously conceived noise, emissions and fuel burn reduction technologies
 - Enable industry to expedite introduction into current and future aircraft and engines
 - Cost share advancing the development and introduction of alternative “drop in” jet fuels for aviation



Continuous Lower Energy, Emissions and Noise (CLEEN)

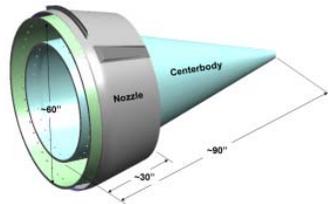


NextGEN

- 5 year effort to accelerate technology maturation & AJF
- Reduces aircraft fuel burn, emissions and noise
- 50% cost share; total FAA budget: ~\$125M

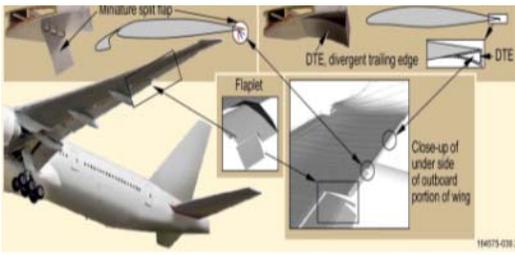
Boeing

- Ceramic Matrix Composite Nozzle



Honeywell

- Lighter weight, higher temp engine



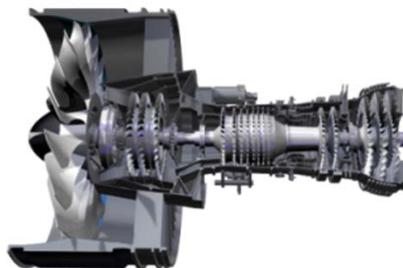
- Adaptive Trailing Edge

Rolls-Royce

- Ceramic Matrix Composite Blade Tracks
- Dual-Walled Turbine Airfoils

Pratt & Whitney

- Ultra-high Bypass Ratio Geared Turbofan



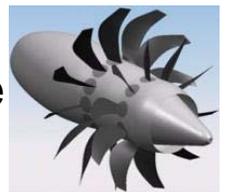
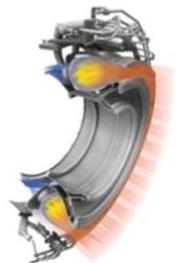
General Electric

- Flight Management System / Air Traffic Integration

- Flight Management System / Engine Integration

- Twin Annual Premixing Swirler (TAPS) II Low NOx Combustor

- Open Rotor Engine



CLEEN Program Goals

Develop and demonstrate (TRL 6-7) certifiable aircraft technology

CORNERS OF THE TRADE SPACE	CLEEN (N+1) (EIS 2015-18) Ref: B737/CFM56-7B	N+2 (2020)* Ref: B777-200/GE-90	N+3 (2025)*
Noise (cum below Stage 4)	-32 dB	-42 dB	-71 dB
LTO NO _x Emissions (Below CAEP 6)	-60%	-75%	better than -75%
Aircraft Fuel Burn	-33%	-50%	better than -70%

* Technology Readiness Level for key technologies = 4-6

Advance use of “drop-in” renewable alternative fuels



Federal Aviation
Administration

Completed Technology Demos (2011-2013)

Met CLEEN Goal

Landing and
Takeoff NOx
reduced 60% re
CAEP 6



TAPS II Core Engine Test
(TRL 6)



Open Rotor Wind Tunnel
Tests (TRL 5)



Ground Demonstration
(TRL 6)

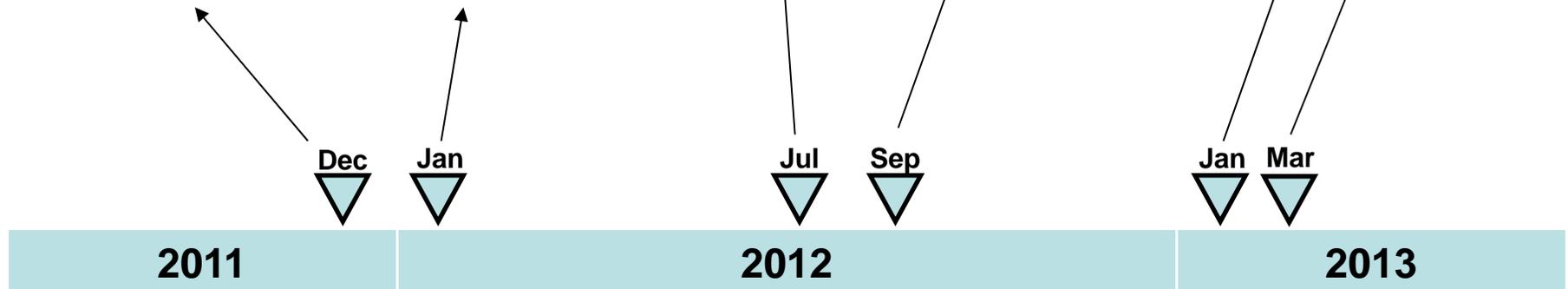


Flight Demonstration
(TRL 7)



Ceramic Matrix
Composite Nozzle
Ground Test (TRL 6)

Dynamic
Synchronization
Simulation
(TRL 6)



Completed Technology Demos in 2014



RR CMC Turbine
Blade Track Engine
Ground Testing



P&W Fan Rig Wind
Tunnel Test



Boeing CMC Flight
Test on ecoDemonstrator
(TRL 7)

May



Jul



2014



Federal Aviation
Administration

CLEEN Benefits So Far

Boeing

Adaptive Trailing Edge and CMC Acoustic Nozzle

~2% fuel burn reduction

Honeywell

Fuel Burn Technologies

CLEEN techs contributed to ~5% fuel burn reduction from CLEEN tech, as part of a 15.7% fuel burn reduction engine package

Pratt & Whitney

Geared Turbofan Technologies

CLEEN techs expand design space for engine with ~ 20% fuel burn reduction, 25 EPNdB cumulative noise margin to Stg. 4

General Electric

TAPS II Combustor

CLEEN 60% margin to CAEP/6 LTO NOx was achieved

FMS/Engine and FMS/ATM Integration

Benefits are being assessed

Open Rotor

~26% reduction in fuel burn (re: 737-800) and ~15-17EPNdB cumulative noise margin to Stg. 4

Rolls Royce

Ceramic Matrix Composite Turbine Blade Track

CMC blade tracks offer > 50% reduction in cooling and component weight.

Rolls-Royce – Dual Wall Turbine Airfoil

Dual Wall turbine airfoils provide > 20% reduction in cooling and increased operating temperature capability.

CLEEN techs will provide ~1% fuel burn reduction

Upcoming Demos (2015-2016)

- **GE**
- **Honeywell**
- **Pratt & Whitney**
- **Rolls Royce**



In Summary

- CLEEN has already successfully accelerated aircraft technology development to reduce fuel burn, emissions and noise
- Technology assessment continues to play an important role in our aircraft technology activities
- CLEEN has helped and is helping to accelerate alternative jet fuel development
- CLEEN II is coming



CLEEN II Overview

- **CLEEN II: Follow-on to initial CLEEN Program**
- **Purpose:**
 - Mature previously conceived noise, emissions and fuel burn reduction technologies for civil subsonic airplanes from TRLs of 3-5 to TRLs of 6-7 to enable industry to expedite introduction of these technologies into current and future aircraft and engines
 - Assess the benefits and advance the development and introduction of “drop-in” alternative jet fuels, including blends



CLEEN II Overview (continued)

- **Planned Funding**

- FAA contribution: \$100M over 2015-2020 timeframe
- 1:1 Minimum cost share requirement
 - \$200M(+) Program with cost share included

- **Five year duration: 2015-2020**

- **CLEEN II technologies expected to be on a path for introduction into commercial aircraft in the 2020-2025 timeframe**



Planned CLEEN II Timeline (stc)

Released
CLEEN II SIR
Sep 29, 2014

