FAA Office of Environment & Energy – Continuous Lower Energy, Emissions and Noise (CLEEN) Program

CLEEN Phase III Update

Presented to: ASCENT Advisory Committee Meeting

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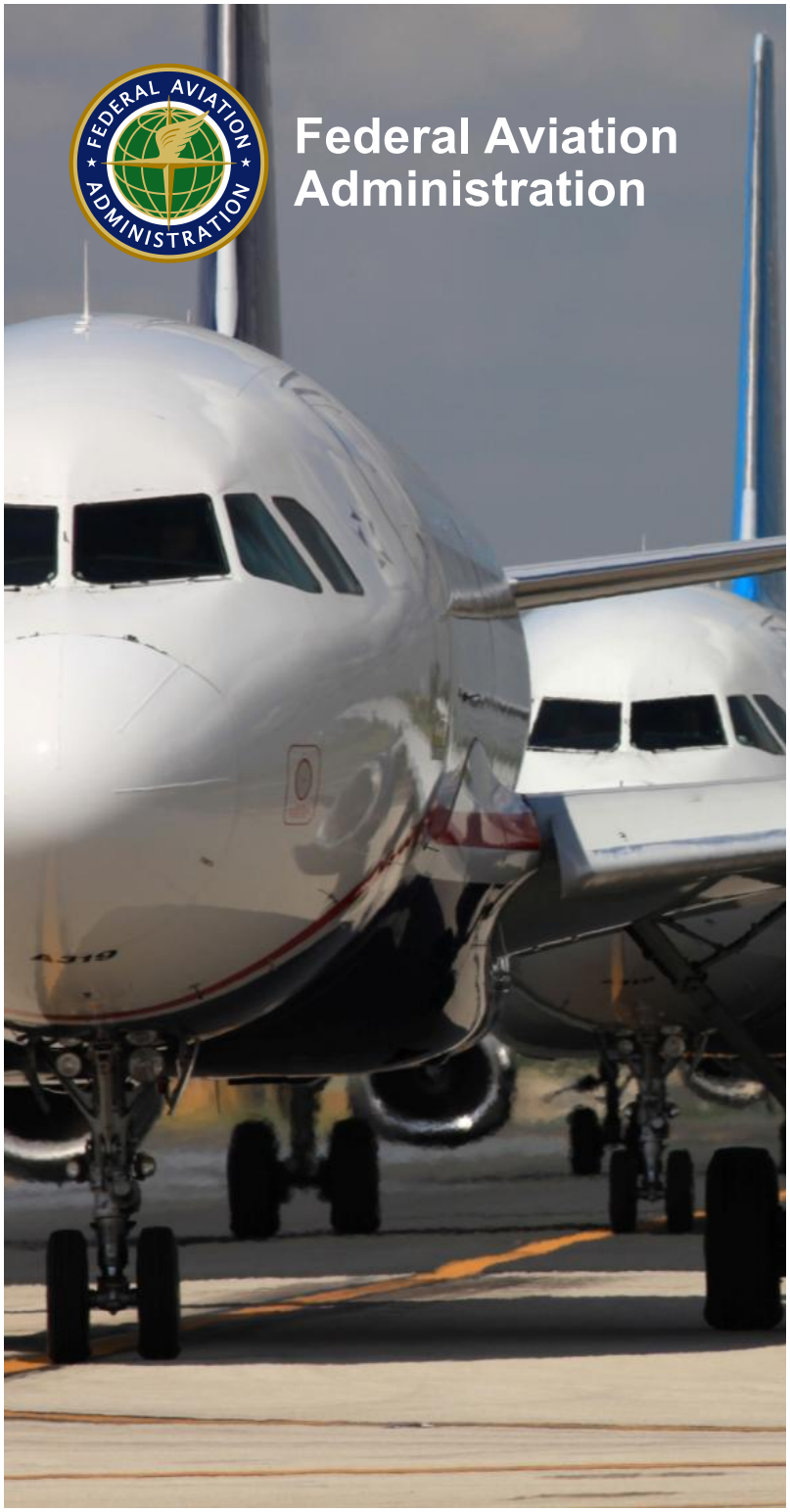


Outline

- **CLEEN Program Overview**
- **CLEEN Highlights**
- **CLEEN Phase III**
  - Overview
  - Goals
  - Outlook
- **Summary**

Continuous Lower Energy, Emissions & Noise (CLEEN)

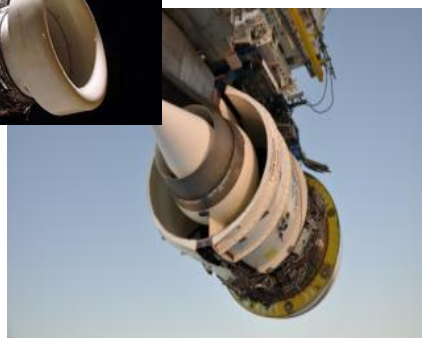
- FAA led public-private partnership with 100% cost share from industry
- Reducing fuel burn, emissions and noise via aircraft and engine technologies and alternative jet fuels
- Conducting ground and/or flight test demonstrations to accelerate maturation of certifiable aircraft and engine technologies

	Phase I	Phase II
Time Frame	2010-2015	2016-2020
FAA Budget	~$125M	~$100M
Noise Reduction Goal	25 dB cumulative noise reduction relative to Stage 5 ***and/or reduces community noise exposure***	
NO_X Emissions Reduction Goal	60% landing/take-off NO_X emissions (-60% re: CAEP/6)	70% landing/take-off NO_X emissions (-70% re: CAEP/8)
Fuel Burn Goal	33% reduction	40% reduction
Entry into Service	2018	2026

- Industry partners to date:
  - Aurora Flight Sciences
  - Boeing
  - Collins Aerospace
  - Delta/MDS Coating Technologies/America's Phenix
  - GE Aviation
  - Honeywell Aerospace
  - Pratt & Whitney
  - Rolls-Royce

For more information on CLEEN program: http://www.faa.gov/go/cleen

CLEEN Highlights



CLEEN Phase I

- GE TAPS II Combustor entered fleet in 2016 on LEAP engine; FMS-Engine integration tech onboard 737 MAX, A320neo, and slated for 777X
- Pratt & Whitney Gen 2 geared turbofan propulsor technology successfully engine tested
- Boeing ceramic matrix composite nozzle flight tested on a 787 aircraft

CLEEN Phase II

- Aurora Flight Sciences tested key structural subcomponent that enables mass-efficient double bubble fuselage
- America's Phenix/Delta TechOps/MDS Coating Technologies currently conducting flight evaluation of fan blade leading edge protective coating on revenue service MD-88s
- Boeing completed ground engine test of compact nacelle technology
- GE achieved TRL 6 emissions demonstration of TAPS III combustor fuel-air mixer technology that meets the CLEEN NOX goal—on target for 2020 production engine entry-into-service

CLEEN Phase III Overview

- **CLEEN Phase III: Follow-on to CLEEN Phase I and Phase II Programs focusing on aircraft noise, emissions and energy**
- **Purpose:**
  - Mature previously conceived noise, emissions and fuel burn reduction technologies for civil subsonic and supersonic 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
    - Includes consideration of the extent to which new airframe and engine technologies may be used to retrofit or re-engine aircraft so as to increase the level of penetration into the commercial fleet
  - Assess jet fuels that could be compatible with the current fleet of aircraft (i.e., they are “drop-in” fuels) that could provide reductions in emissions or improvements in efficiency, including fuels that enable advancements in aircraft and engine design. This includes both conventional and alternative jet fuels.

CLEEN Phase III Overview (cont.)

- **Planned Funding**
  - FAA contribution: $100M over 2020-2025 timeframe
  - 1:1 Minimum cost share requirement
    - $200M(+) Program with cost share included
- **Five year duration: 2020-2025**
- **CLEEN Phase III technologies expected to be on a path for introduction into commercial aircraft in the 2025-2031 timeframe**

CLEEN Phase III Goals

	Phase I	Phase II	Phase III*	
Time Frame	2010-2015	2016-2020	2021-2025	
FAA Budget	~$125M	~$100M	TBD	
Noise Reduction Goal	25 dB cumulative noise reduction relative to Stage 5 ***and/or reduces community noise exposure***			→ **Tier 1**
NO_X Emissions Reduction Goal	60% landing/take-off NO_X emissions (-60% re: CAEP/6)	70% landing/take-off NO_X emissions (-70% re: CAEP/8 Std.)**		→ **Tier 3**
Fuel Burn Goal	33% reduction	40% reduction	-20% re: CAEP/10 Std.	→ **Tier 2**
Entry into Service	2018	2026	2031	

***Notional**
**** This must be achieved while limiting or reducing other gaseous and particulate matter emissions.**

Tier 4: Certifiable aircraft technology that reduces LTO noise and/or NOx for civil *supersonic* airplanes

Tier 5: Advance the development and introduction of "drop in" jet fuels for aviation, with particular focus on options that could reduce the emissions from aviation, including greenhouse gas footprint. This includes fuel blends.

CLEEN Phase III Outlook

- Notional CLEEN Phase III timeline (actual timeline in flux due to budget uncertainty)
- Market Survey: https://faaco.faa.gov/index.cfm/announcement/view/31002
- Industry Day: https://faaco.faa.gov/index.cfm/announcement/view/31885
- Industry Day Follow up: https://faaco.faa.gov/index.cfm/announcement/view/32134

In Summary

- CLEEN technology development and alternative fuels projects are progressing under CLEEN Phase II
- Next CLEEN II Consortium Meetings:
  - May 7-9, 2019: Cleveland, OH (NASA Glenn)
  - Nov 19-21, 2019: Washington, DC (location TBD)
  - May 5-7, 2020: Phoenix, AZ (Honeywell)
  - Nov 17-19, 2020: Washington, DC (location TBD)
- In the process of initiating CLEEN Phase III (2020-2025)
  - Market Survey was conducted in summer of 2018
  - Industry day took place on December 10, 2018
- For more on CLEEN https://www.faa.gov/go/cleen