ASCENT Project 37

CLEEN II System Level Assessment

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Cost Share Partner: Georgia Institute of Technology

Objective:

To support the FAA through independently modeling and assessing the technologies that are being developed under the CLEEN II at the system and fleet levels.

Project Benefits:

This project will quantify the expected U.S. fleet wide reductions in aviation fuel burn, airport community noise, and NOx emissions projected from inclusion of CLEEN II technologies on future aircraft.

Research Approach:

- Perform modeling of individual CLEEN II fuel burn, noise, and emissions technologies
- Incorporate these models into vehicle level performance analyses
- Include a demand forecast, fleet replacement matrix, and set of technology introduction scenarios
- Evaluate the fuel burn, noise, and emissions performance of the US fleet across each of these scenarios to articulate the efficacy of the CLEEN programs

Major Accomplishments (to date):

Of the 18 technologies in CLEEN II:

- 9 have been fully modeled
- 3 are in final contractor review
- 6 are awaiting data

Preliminary fleet fuel burn assessment completed

Future Work / Schedule:

- Completion of remaining technology modeling
- Incorporation of final technologies into fleet analysis
- Initiation of CLEEN III technology modeling

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CLEEN II Overview

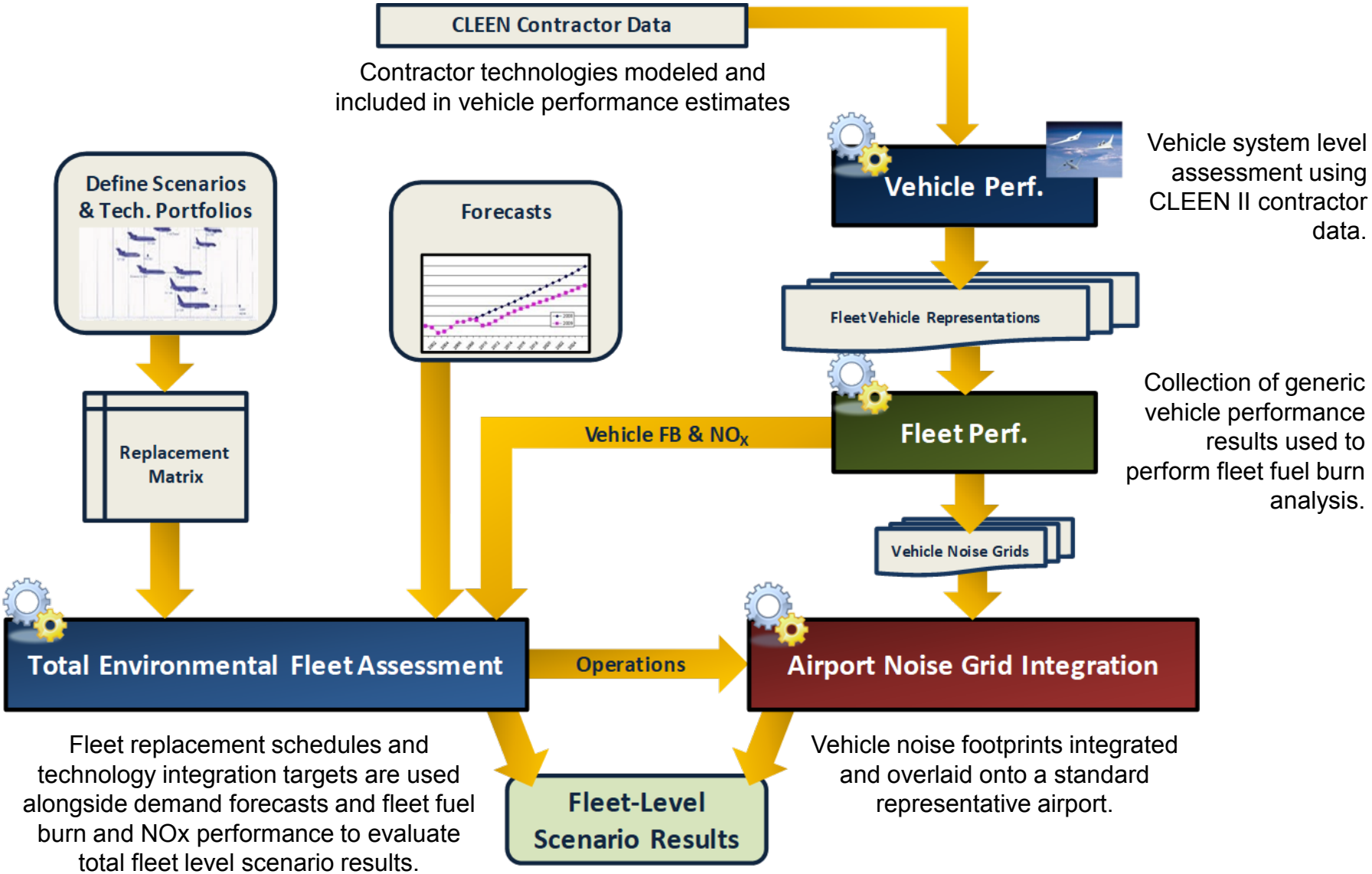
Purpose:

- Mature previously conceived noise, emissions and fuel burn reduction technologies for civil subsonic airplanes from Technology Readiness Levels (TRL) 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 technologies expected to be on a path for introduction into commercial aircraft by 2026.

	CLEEN I	CLEEN II	
Noise *(cum below Stage 4)*	-32 dB	-32 dB	*and/or reduces the noise contour area in absolute terms*
LTO NOx Emissions *(below CAEP 6)*	-60%	-75% *(-70% vs. CAEP/8)*	*and/or reduces absolute NOx production over the aircraft's mission*
Aircraft Fuel Burn	-33%	-40%	*and/or supports the FAA's goal to achieve a net reduction in climate impact from aviation*

System Level Assessment



Technology Impact Management

Objective: Prior to proceeding into CLEEN III system level assessment, audit all technology scenario (e.g. EV, AG, AG-C, etc.) to ensure technology impact traceability and fleet assessment repeatability.

Fleet Analysis

- EDS Analyses across 5 vehicles with 16 cases each.
- Technology impacts communicated to EDS through design of experiments (DoE)

✓ Baseline DoE updated with impacts from the 9 technologies of CLEEN I

✓ Preliminary CLEEN II fleet analysis updated DoE with impacts from 7 technologies within CLEEN II

❑ Final CLEEN II fleet analysis to include 7 additional technologies

❑ CLEEN III fleet analyses to include 10+ additional technologies

Technology Impact Matrix (TIM): a rigorous, transparent, reproducible management tool for organizing the impacts of all of the technologies used in ASDL's CLEEN Program effort.

TIM Constructed for all 5 Vehicles:

✓ Performed comprehensive review of technology impacts and associated DoEs considered to date

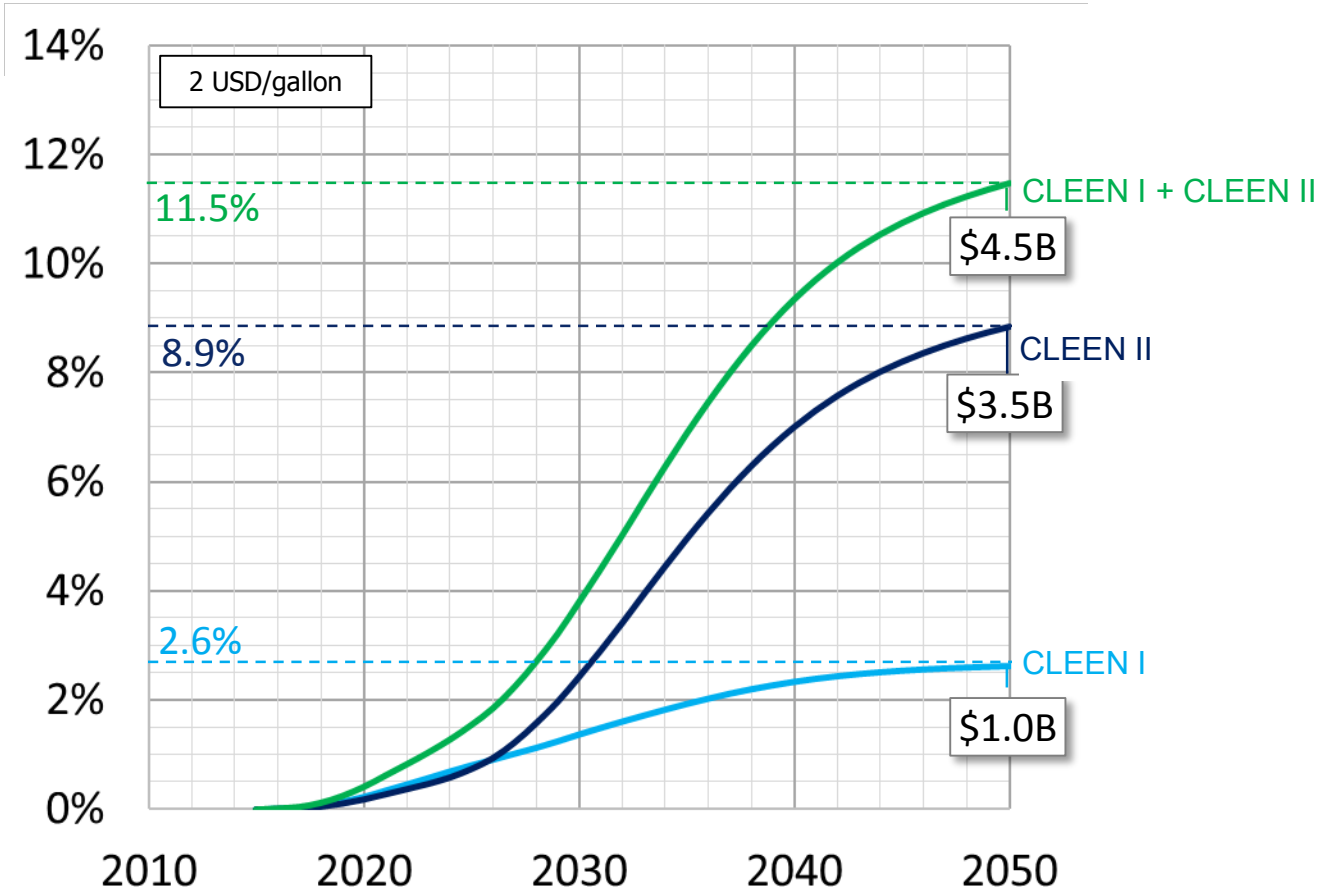
✓ Updates made based on this review

❑ Fleet analysis updated

Fuel Consumption: CLEEN I and II

Preliminary

CLEEN Cost Savings relative to Evolutionary Scenario



Not all technologies are modeled/included at this time.

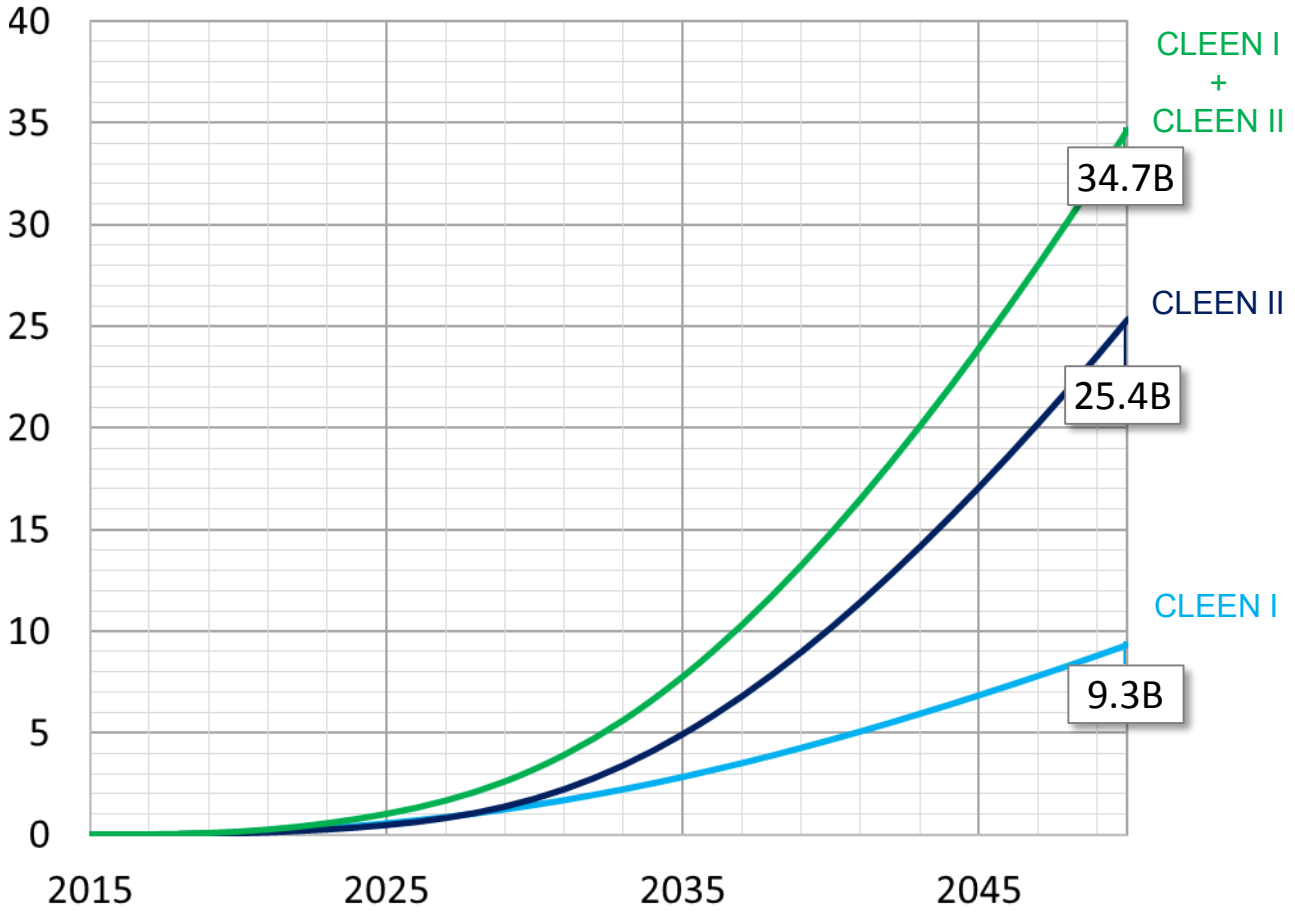
Note: CLEEN II contributions are shown as instantaneous and not cumulative benefit.

Note: Results assume constant fuel cost at 2 USD/gallon.

Cumulative Fuel Savings

Preliminary

Cumulative CLEEN Fuel Savings relative to Evolutionary Scenario (Billion Gallons)



CO_2 emissions reduced by 404 million metric tons by 2050 - equivalent to removing 2.9 million cars from the road from 2020-2050

Not all technologies are modeled/included at this time.

Note: Results assume constant fuel cost at 2 USD/gallon.

Summary & Next Steps

CLEEN II Technology Portfolio:

- Modeled
  - Boeing Aurora D8 Fuselage
  - Boeing structurally efficient wing, compact nacelle
  - Delta/MDS/America's Phenix Leading Edge Protective Cooling (FAA)
  - GE MESTANG, FMS, and TAPS III Low NOx combustor
  - Honeywell Turbine Blade Outer Air Seal
  - Pratt & Whitney Compressor and Aero-Efficiency Technologies
  - Collins Aerospace: Slim Nacelle
- Awaiting Data/Tests
  - GE Low PR advanced acoustic
  - Honeywell Compact Combustor, Acoustic Fan Rotor/Liner Technologies, Advanced HPC
  - Collins Aerospace: Noise Liner Technologies
  - Boeing compact nacelle acoustics
  - Rolls-Royce: Advanced Rich Quench Lean Low NOx Combustor

Next Steps:

- Complete Technology Modeling for CLEEN II
- Extend Current Fleet Level Assessments to include all CLEEN II technologies
- Complete CLEEN II noise benefits assessment
- Establish working relationships with CLEEN III contractors and begin technology modeling

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