FAA CENTER OF EXCELLENCE FOR ALTERNATIVE JET FUELS & ENVIRONMENT

CLEEN II System Level Assessment

Project 37

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CLEEN Program Overview

- CLEEN Program (2010-2015)
  - Industry partners: Boeing, General Electric, Honeywell, Pratt & Whitney, Rolls-Royce

- CLEEN II Program (2015-2020)
  - Industry partners: Aurora Flight Sciences, Boeing, Delta/MDS/America's Phenix, General Electric, Honeywell, Pratt & Whitney, Rohr/UTC Aerospace Systems, and Rolls-Royce

- More information on CLEEN I & II:
  - https://www.faa.gov/about/office_org/headquarters_offices/apl/research/aircraft_technology/cleen/

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 II Program Goals

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

	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

Advance use of "drop-in" renewable alternative fuels

Bio feedstock

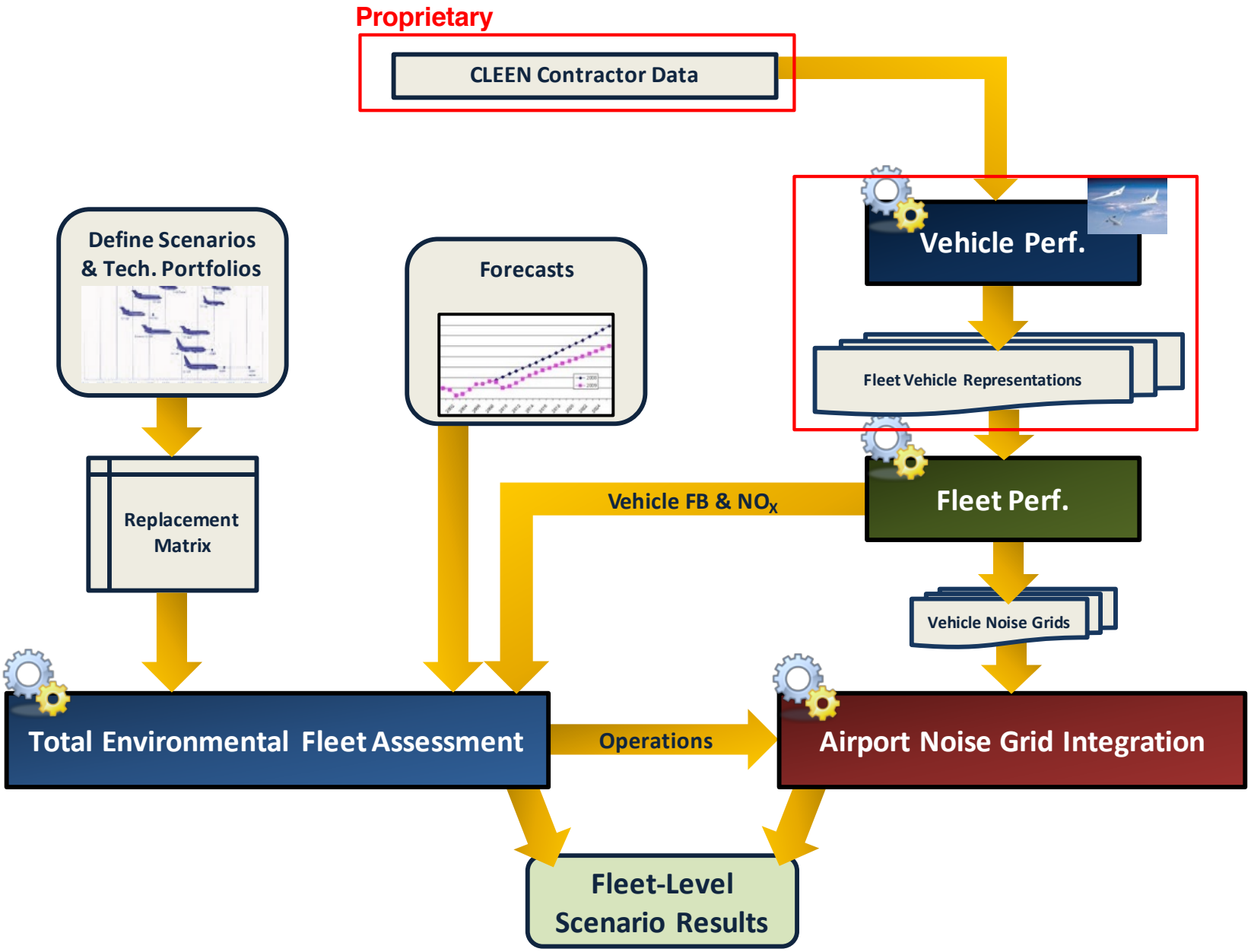
Fuel Production

Jet fuel

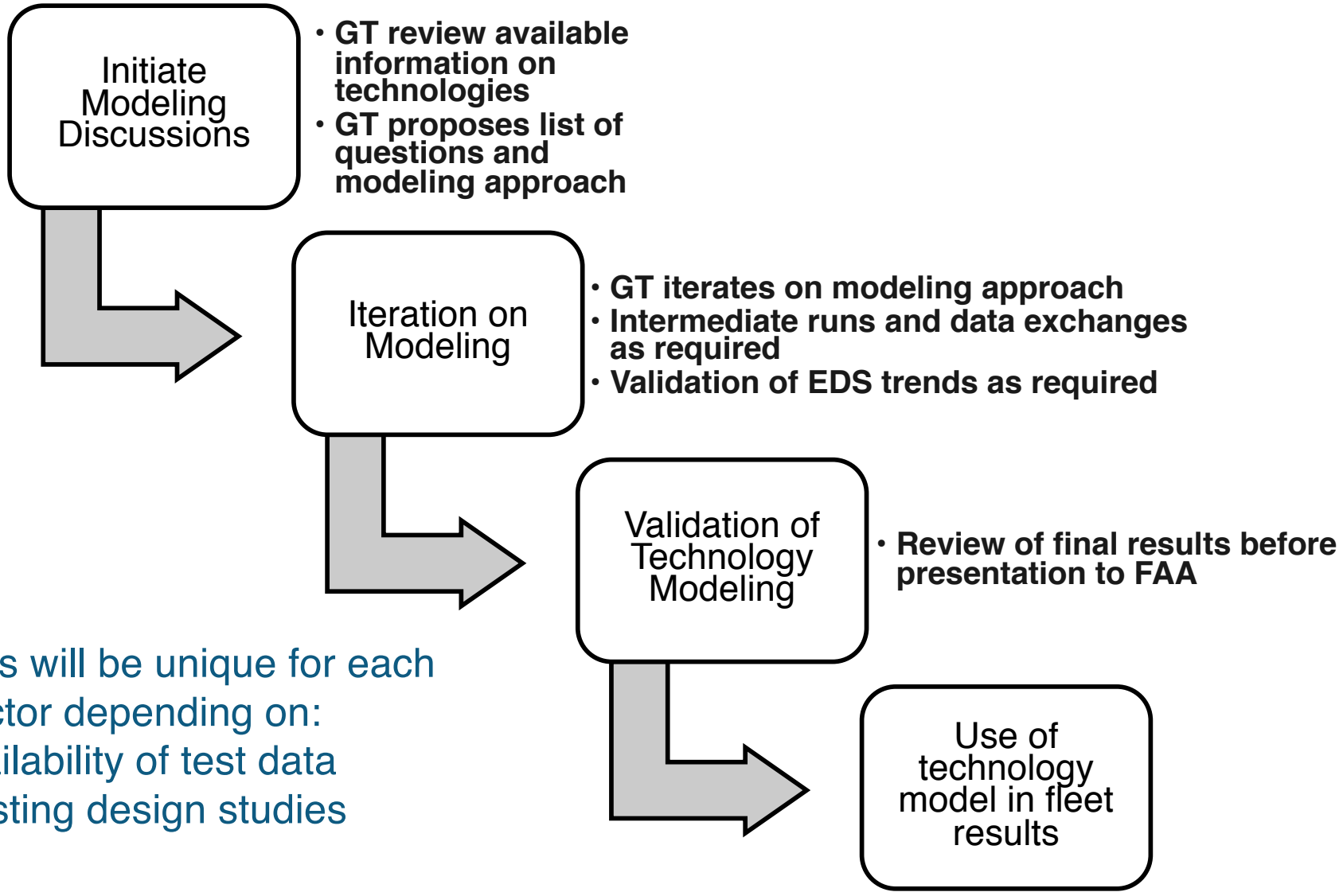
ASCENT 37 – CLEEN II Assessment

- Following similar model to CLEEN I:
- Exchange of proprietary data with CLEEN II companies to accurately represent their technologies at the subsystem and vehicle level
- Vehicle and fleet-level assessment of CLEEN II and other complementary technologies impacts to fuel burn, emissions, and noise
- More involvement by FAA with in-house use of tools. Divide and conquer modeling with GT to cover 8 companies

CLEEN II Assessment Flow



Modeling and Assessment Process



Process will be unique for each contractor depending on:

- Availability of test data
- Existing design studies

Technology Scenario Definitions

- Before defining specific technology packages GT & FAA developed three scenarios
- Each scenario subdivided into near-term and mid-term introduction
- Aggressive w/o CLEEN I/II can be compared to Aggressive to identify CLEEN I/II contribution

Scenario	Description
Fixed Technology	Continue to replace retired aircraft with best-in-class current in-production; use current in-production through 2050 for new aircraft
Evolutionary	'Normal' technology evolution
Aggressive	Represents higher rate of technology development Includes all CLEEN Techs in near term
Aggressive w/o CLEEN II	Identical to aggressive with all CLEEN I technologies removed
Aggressive w/o CLEEN I & II	Identical to aggressive with all CLEEN I & II technologies removed

Technology Packages

- Defined several technology scenarios through iteration with FAA
  - Extends CLEEN I for first set of preliminary runs
- Naming convention
  - EV – Evolutionary
  - AG – Aggressive
  - (2) indicates N+2 version
  - '-C' indicates package with CLEEN technologies removed (meant to show impact of CLEEN)

Technology	Packages					
GE FMS Air Traffic Management					AG2	
Aurora Double Bubble (Only Single Aisle)					AG2	
Boeing SEW					AG2	
Boeing Compact Nacelle					AG2	
Delta/MDS/America's Phenix Leading Edge Protective Coati	EV	EV2	AG		AG2	
TAPS III Low NOx Combustor (Only Twin Aisle)		EV2	AG		AG2	
GE MESTANG					AG2	
GE FMS					AG2	
GE LPR Advanced Acoustic						
Honeywell Compact Combustor						
Honeywell Turbine Blade Outer Air Seal						
Pratt & Whitney Compressor and Turbine Aero-Efficiency Technologies						
Collins Slim Nacelle						
Collins Noise Liner Technologies						
Rolls-Royce Advanced RQL Low NOx Combustor						

Current Status

- AEDT Definition Generation (CLEEN I rerun)
  - Have re-run CLEEN I vehicles with current version of EDS and AEDT to assess any shifts in performance from changes in modeling assumptions
    - Minimal changes (<0.5%) due to EDS updates
  - Running GREAT (fleet) analysis to determine shifts in CLEEN I due to AEDT / GREAT updates
- CLEEN II Vehicles
  - AEDT definitions created for packages on prior slide
  - Still performing GREAT assessment
  - Individual impacts proprietary

Summary & Next Steps

- Preliminary CLEEN II fleet impacts very soon
- Technology modeling work nearing completion
  - Next 6 - 9 months
  - Might make minor updates as CLEEN II contractors wrap-up testing
- Extend fleet analysis
  - ASCENT 10 Fleet Scenarios
  - Extended noise assessment (multiple airports)