GE Aviation
CLEEN Systems Integration

Presenter: Jeff Bult

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Overview

Energy, Emissions & Noise Reduction Objectives

	Status
• FMS Efficiency improvements	
– Dynamic Quiet Climb	Complete
– FMS Wind Input Optimization	Complete
• FMS/ATM Integration	
– Trajectory Synchronization	Complete
– Trajectory Optimization Tasks	Ongoing
• FMS/Engine Integration	
– Adaptive Engine Control	Ongoing
– Integrated Vehicle Health Management	Ongoing
– Integrated Flight-Propulsion Control	Ongoing

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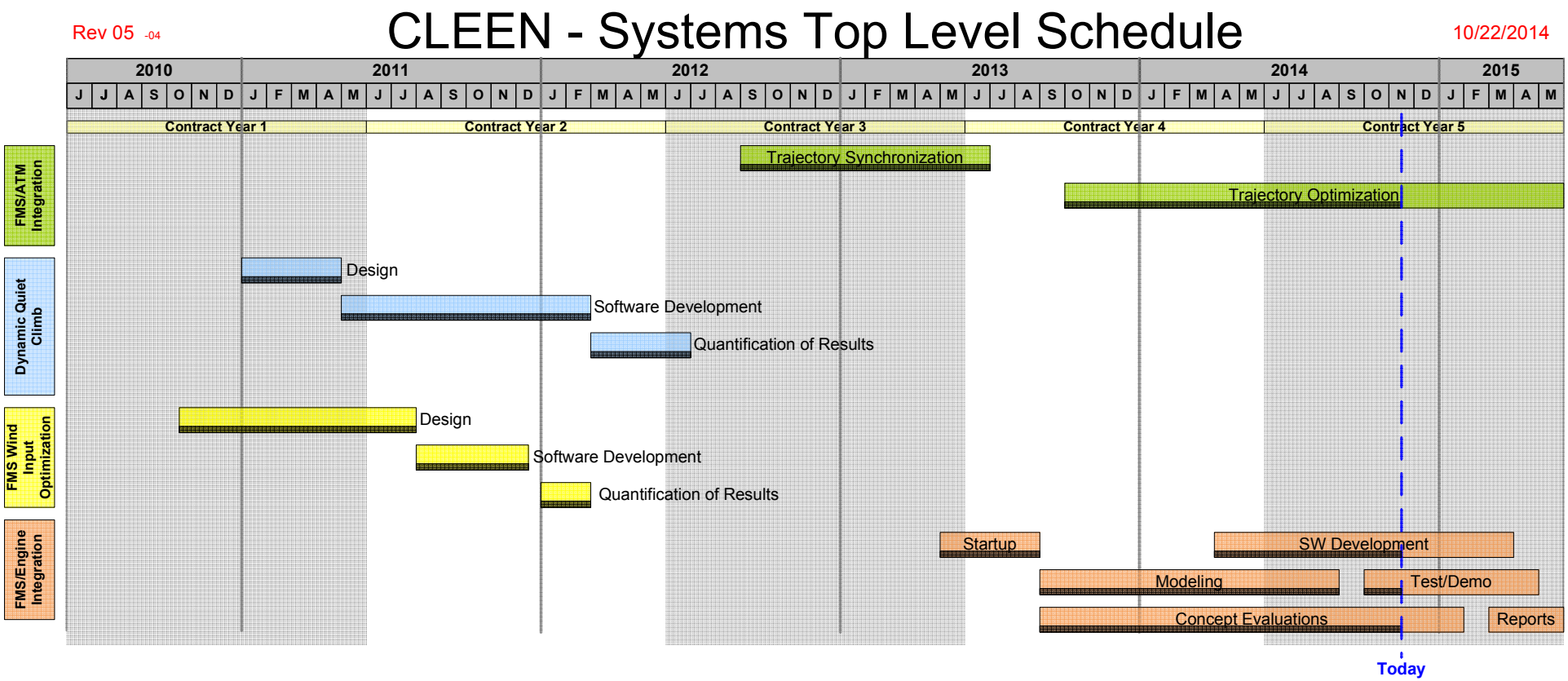
Schedule for GE Aviation Systems Led Efforts



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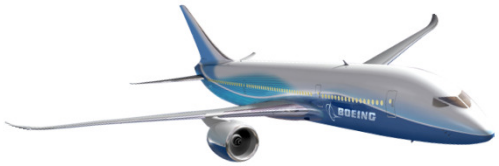
Trajectory Optimization

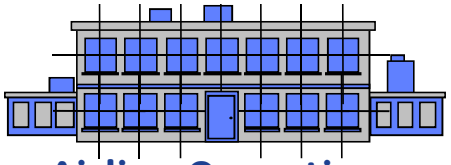


Using knowledge from ATC on flow management constraints, other traffic, and weather, decision support tools at AOC can recommend more efficient vertical and lateral routing and speeds to reduce fuel & emissions

Trajectory Optimization Technologies

CLEEN FMS-ATM Tasks

Optimized altitudes, speeds, flight routing



Airline Operations Center Decision Support Tools (DSTs)

Airspace constraints, traffic management initiatives, etc..

ATC

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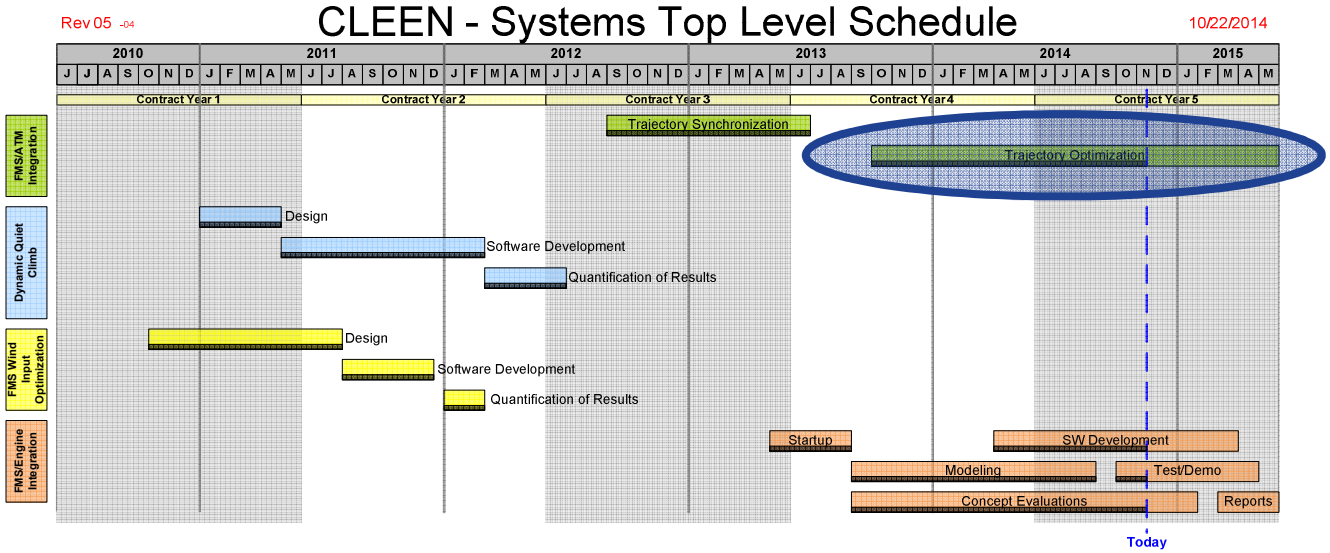
Status

- Current efforts focused on arrival flow management
- Simulation environment stood up
  - Handles RNP/RNAV equipped and non-equipped
  - Accounts for aircraft under AOC control as well as other traffic
  - Incorporates performance database to handle numerous aircraft
  - Provides RTA for optimal chance of conflict-free arrival/descent
- Currently completing system integration and running scenarios for fuel savings quantification benefit assessment



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FAA CLEEN
Fuel-Burn Reduction
(FMS-Engine Integration)

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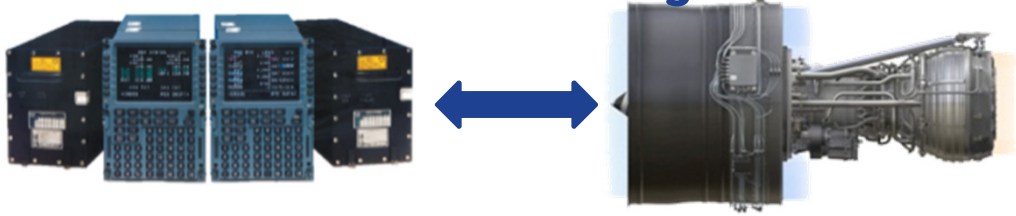
FMS-Engine Integration Technologies – 3 Primary Focus Areas:

- Integrated Flight-Propulsion Control (IFPC) - Synergistic optimization of engine and aircraft
- Adaptive Engine Control – Uses knowledge of aircraft state and engine health to optimize performance
- Integrated Vehicle Health Management (IVHM) - Uses knowledge of engine health to optimize aircraft performance

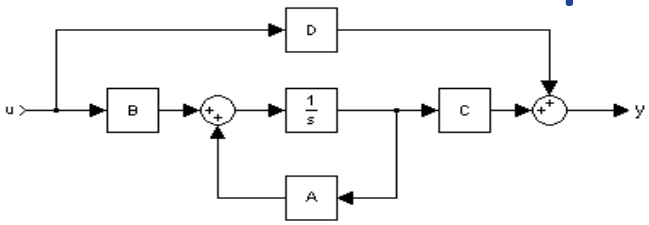
State-awareness is key aspect of FAA CLEEN technology development & maturation

Information sharing



Engine & Avionics

New control concepts and methods



Unified Model

- **Guidance & Navigation**
- **Flight Controls**
- **Engine Controls**

Simulation Controls

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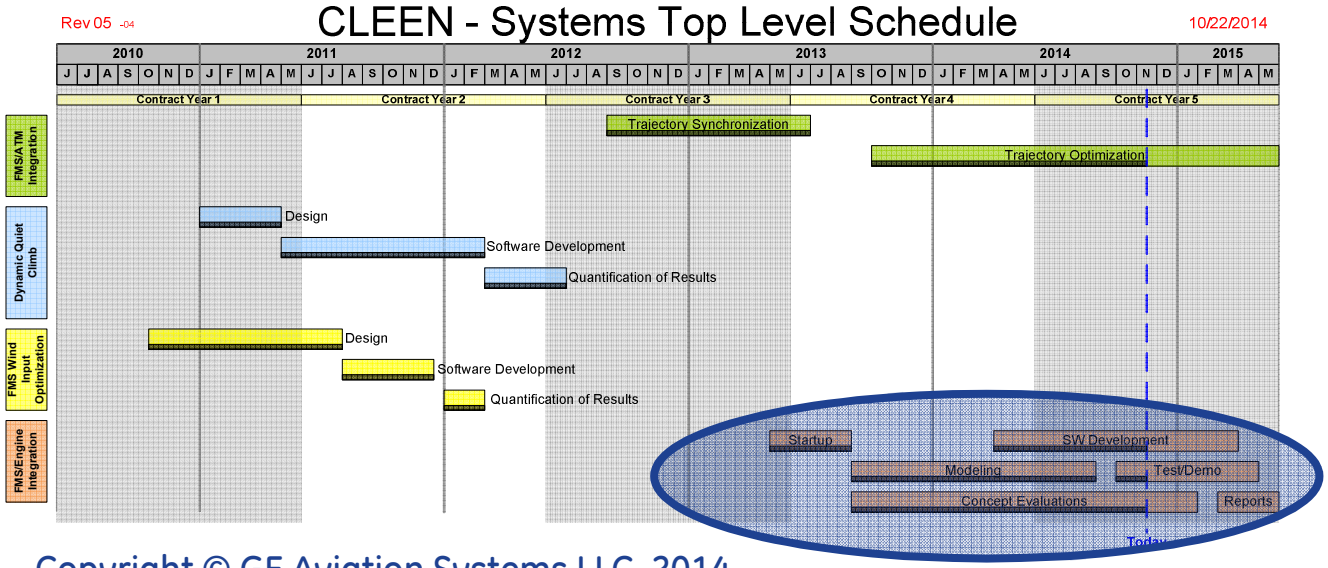
Thirteen FMS-Engine technologies being evaluated

- Eight led by GE Aviation Engines
- Five led by GE Aviation Systems

Execution Plan

- Modeling - Create integrated models of aircraft, FMS, and engine (TRL 3)
- Concept Evaluations - Analyze each idea to assess feasibility (TRL 3)
- Software Development - Modify software (TRL 4-5)
- Test/Demo - Perform hardware-in-the-loop laboratory tests and demonstrate benefits (TRL 6)



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Status

- Engine, 6 DOF aircraft, FMS, and avionics modeling completed — NPSS model of CFM56 and LEAP-1B
- Benefit assessment by computer simulation underway (TRL 4)
  - Preliminary assessments of the first 2 of the 5 technologies already indicating ~1% fuel savings relative to legacy system (using standardized 800 mile mission)
  - Initial benefit calculations on the remaining 3 technologies still in the concept development stages look promising to significantly increase savings
- Prototype system development underway (TRL 6)
  - Model-based design and machine-generated code
  - Requirement specification completed
  - Airworthy hardware
  - Test planning completed, test procedure development and validation underway

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FAA CLEEN
Fuel-Burn Reduction Using FMS-Engine Integration

Presenter: Shreeder Adibhatla

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FMS-Engine Integration Technologies – 3 Primary Focus Areas:

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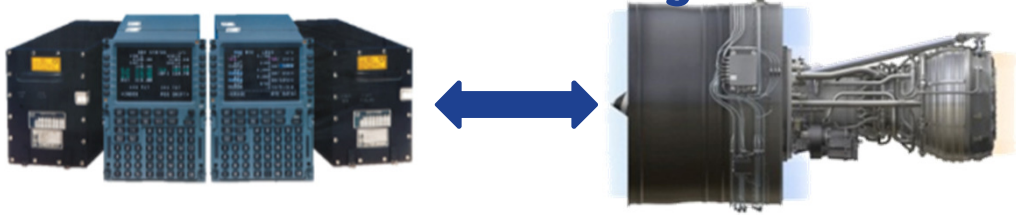

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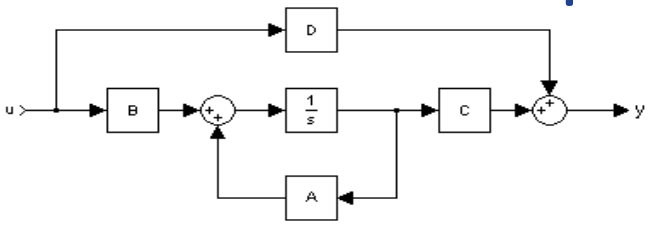

Unified Model

- Guidance & Navigation
- Flight Controls
- Engine Controls

Simulation Controls

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Progress

Engine modeling effort completed, on-engine testing is continuing.

Integrated aircraft-engine-FMS model has been completed.

Control logic design for ground-engine testing has been completed, rig testing is in process.

Detailed design for controls hardware has been completed.

Hardware is being acquired for concepts that require engine hardware modifications for on-engine demonstration of fuel burn reduction concepts.

Engine testing is scheduled for 2Q2015.

Now working to schedule flight testing for lower-risk concepts to demonstrate acceptability for introduction into product.

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