CLEEN Consortium Open Session

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GE CLEEN Technologies

1. Open Rotor

2. TAPS II Combustor

3. FMS/ATM Integration

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FAA CLEEN Program Goals

	N+1 (2015) CONVENTIONAL CONFIGURATION RELATIVE TO 1998	N+2 (2020-25) UNCONVENTIONAL CONFIGURATION RELATIVE TO 1998	N+3 (2030-35) ADVANCED CONCEPTS RELATIVE TO 2005
NOISE	-32 dB cum below Stage 4	-42 dB cum below Stage 4	-71 dB cum below Stage 4
LTO NOX EMISSIONS (BELOW CAEP 6)	-60%	-75%	better than -75%
AIRCRAFT FUEL BURN	-33%	-50%	better than -70%

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

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GE CLEEN Program Goals
Timeframe: CY 2010-2015

Open Rotor

- 26% fuel burn reduction (relative to CFM56-7B)
- 17 EPNdB noise reduction (relative to stage 4)

TAPS II Combustor

- Emissions 60% below CAEP/6

FMS & ATM

- 7% fuel burn/CO2 reduction
- 22% landing noise reduction (area of 60 EPNdB footprint)

GE Open Rotor Overview

Goal

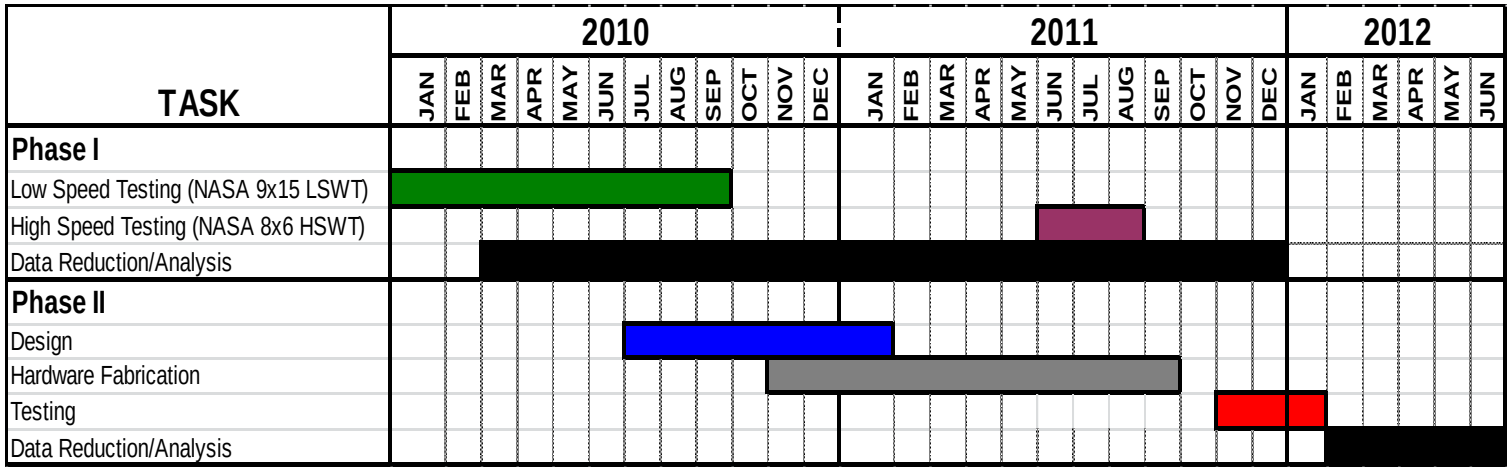
- 26% fuel burn reduction (relative to CFM56-7B)
- 15 to 17 EPNdB noise reduction (relative to stage 4)

OR Program has two work elements:

- Blade aero-acoustic assessment and
- Pitch Change Mechanism (PCM) including control system integration

Open Rotor Blades Proposed Program Plan

- Develop advanced technology blade designs
- Refine designs thru aero-acoustics model tests
- Project blade model data to full-scale application



UPDATED: 21 Oct 2011

Open Rotor PCM System Definition

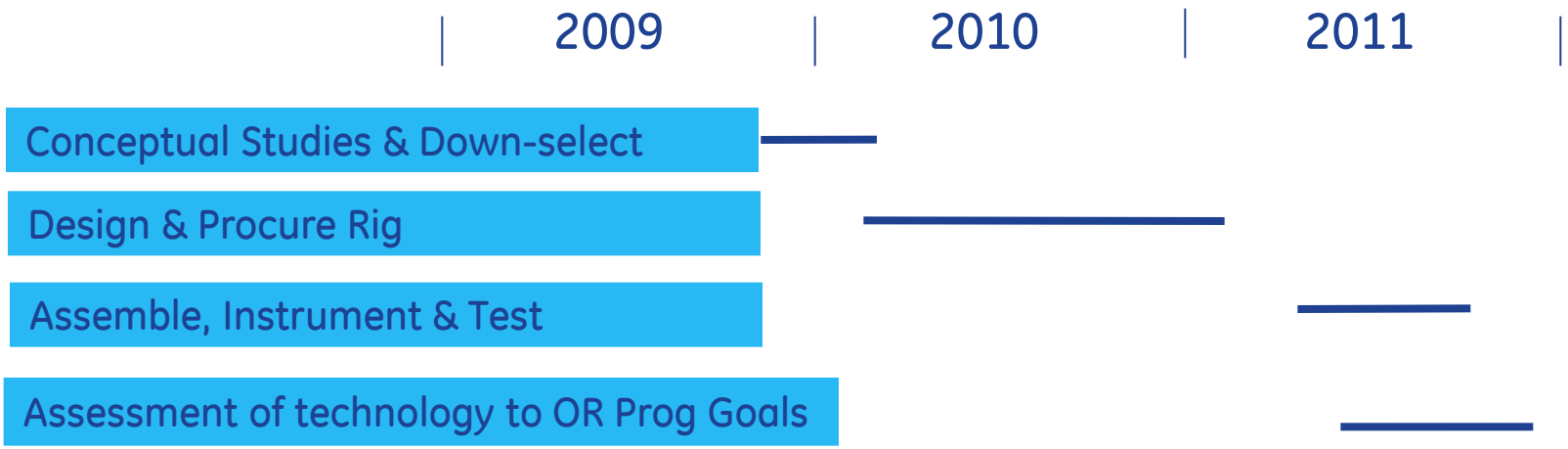
Selected Hydraulic System for Improved Reliability and Weight Savings

Technical Issues and Challenges

- Transfer of fluid from stationary to rotating system
  - Control system modeling ongoing
  - Hydraulic Transfer testing
- Integration of PCM hydraulics into engine oil system
  - Heat dissipation evaluated
  - Defined prelim system architecture

Open Rotor Hyd PCM Transfer testing

- Validation of hydraulic oil transfer mechanism single channel rig
- Technology Maturation



- Status: Static testing complete, rotating FW48

FAA CLEEN Combustion System Goals

✓ LTO NOx emissions	60% margin to CAEP/6
• Cruise NOx emissions	< 9 g/Kg fuel
• Solid Particulate Matter	90% margin to CAEP/6 (based on Smoke no.)
• Scale TAPS system	Narrow body, regional & business jets

✓ FAA CLEEN Goal
• GEA goal

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TAPS II Development Program

2010 2011 2012 2013

Technology Maturation

- Conceptual Design
- Flame tube test
- Combustion Dynamics Enabling Technology

System Engineering/Integration

- 5 Cup sector test #1
- 5 Cup sector test #2
- TCA and HTP Test
- Full annular Test
- Test Report

Technology Demonstration

- Core Engine Test
- Baseline Engine Test Data
- Test Report

Technology Assessment

- Final Report

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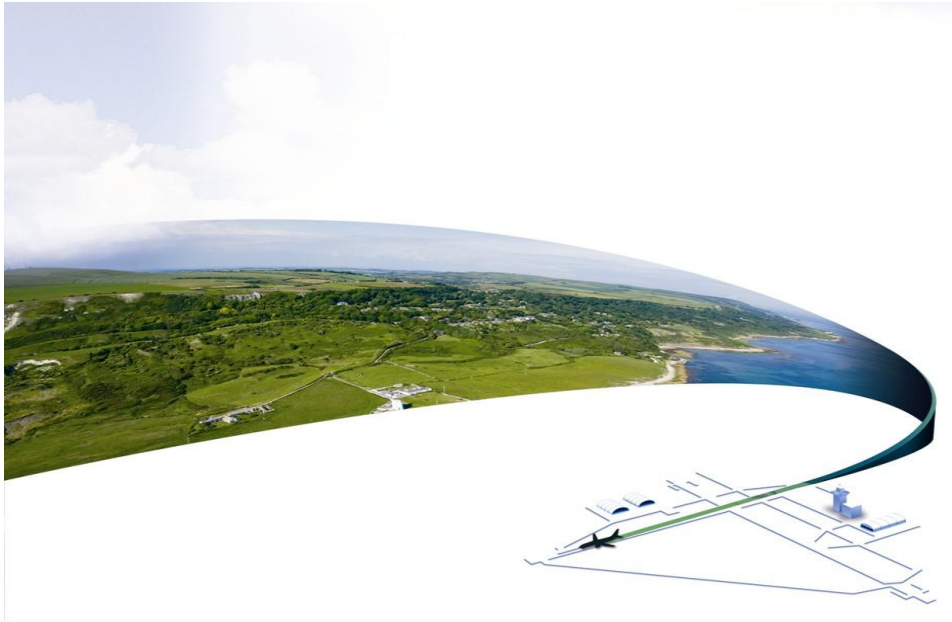
TAPS II Development Status

- Completed combustor sub-component testing… flame tube, 5 cup sector, and tunable combustor acoustic rig
- Completed full annular combustor rig test
- Currently running core engine test

Key remaining tests … emissions and altitude relight on the core engine



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Overview

Energy, Emissions & Noise Reduction Objectives

- FMS/ATM Integration
  - Trajectory Sync & Negotiation
- FMS Efficiency improvements
  - Dynamic Quiet Climb
  - FMS Wind Input Optimization

Partners/Expertise

- Lockheed Martin* / ATM Technology
- GE Global Research Center / Sync & Negotiation
- AirDat / Weather Modeling & Predictions
- Alaska Airlines / Next Generation Technology Pioneer

** supporting partner (separate contract)*

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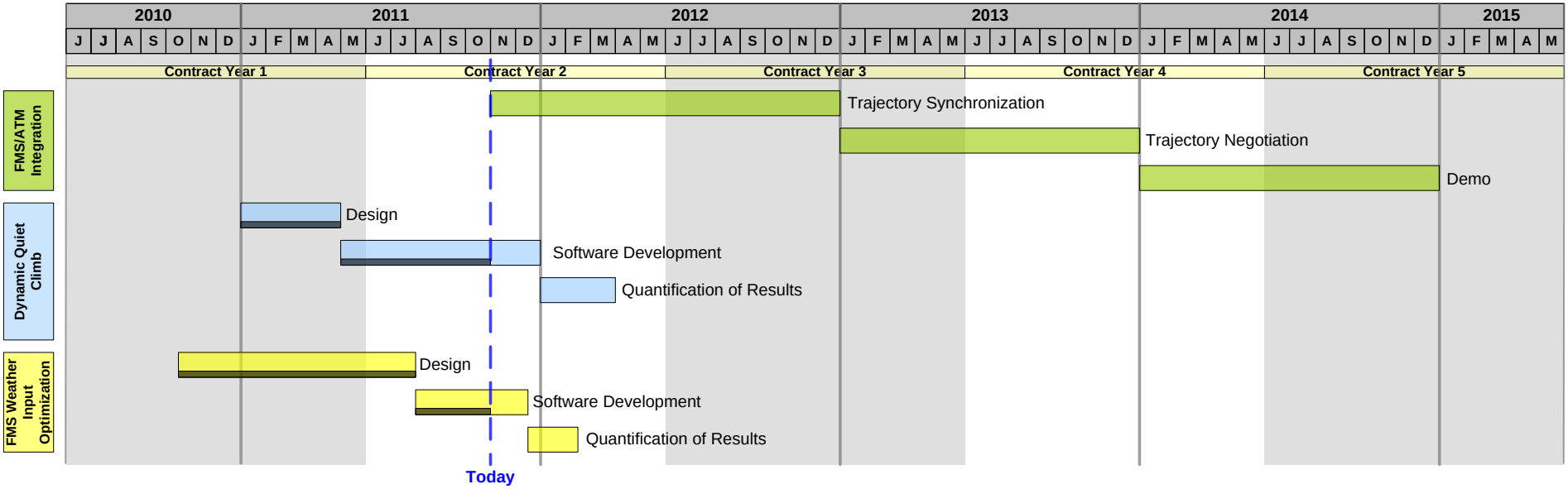
CLEEN Top Level Schedule



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FMS efficiency improvements

Dynamic Quiet Climb

- *What*: Improved noise abatement takeoff trajectory
- *Why*: Tailored thrust profile reduces fuel burn
- *Status*: HLRs/LLRs complete, SW development underway
- *Next*: Analysis using AEDT; Flight demo planned 2012

FMS Wind Input Optimization

- *What*: Wind/temp selection tailored to trajectory
- *Why*: Reduce thrust and speed brake use in descent
- *Status*: TRL 7 prototype complete, V&V underway
- *Next*: Benefits study

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FMS/ATM Integration

FMS

Trajectory Predictors

Trajectory Sync:
- What data to exchange
- When to exchange it
- Improve aircraft predictability

Trajectory Negotiation:
- Negotiate new trajectories that consider user preferences

ATC constraints, wind/weather

Aircraft data, Business optimum trajectory

ATM

Time Based Flow Management (TBFM)

Metering Tools

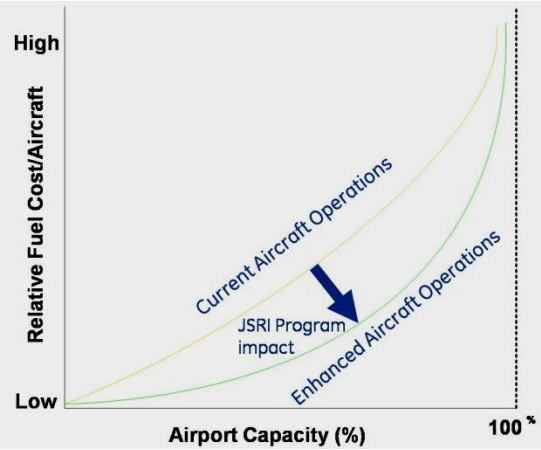
En-Route Automation Modernization (ERAM)

Conflict Probe

Trajectory Predictors

Trajectory Sync

Trajectory Negotiation



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