HONEYWELL CLEEN PHASE III

Consortium Meeting

May 4, 2022

HONEYWELL OVERVIEW

NYSE: **HON** | ~**919** sites | ~**110,000** employees | **Charlotte, N.C.** headquarters | **Fortune 100** | **~$32.6B (2020 Sales)**

Aerospace
$11.5B

Our products are used on virtually every commercial and defense aircraft platform worldwide and include aircraft propulsion, cockpit systems, satellite communications, and auxiliary power systems.

Building Technologies
$5.2B

Our products, software, and technologies are in more than 10 million buildings worldwide, helping customers ensure their facilities are safe, energy efficient, sustainable, and productive.

Performance Materials and Technologies
$9.4B

We develop advanced materials, process technologies, automation solutions, and industrial software that are revolutionizing industries around the world.

Safety and Productivity Solutions
$6.5B

We improve enterprise performance and worker safety and productivity with automated material handling and voice scanning and mobile computing technology, software solutions, and personal protective equipment and sensing technology.

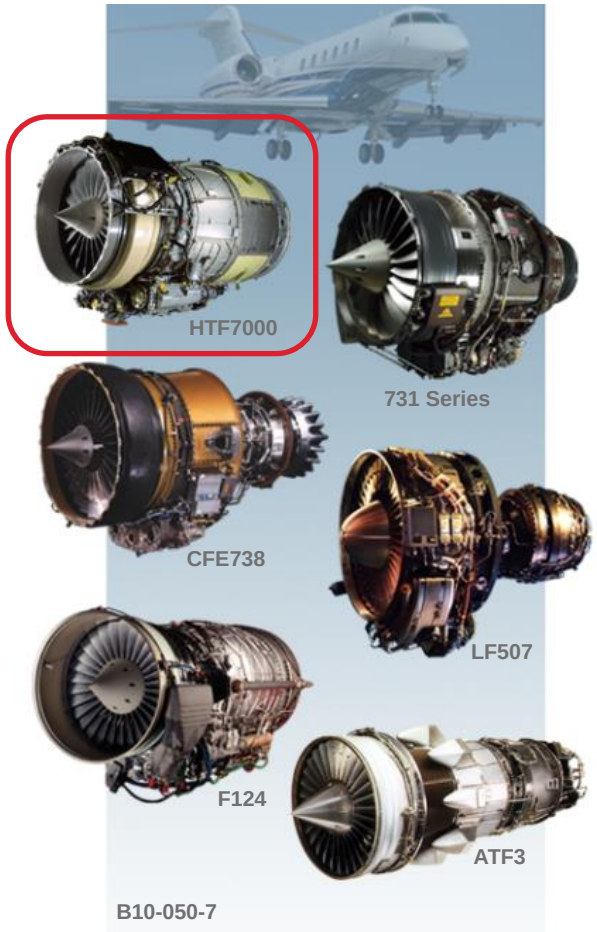
A Global Diversified Technology Company

HONEYWELL ENGINES AND PLATFORMS

Turbofan Engines

3,000 to 10,000 lb thrust

Commercial business jets
Military trainers



Turboprop Engines

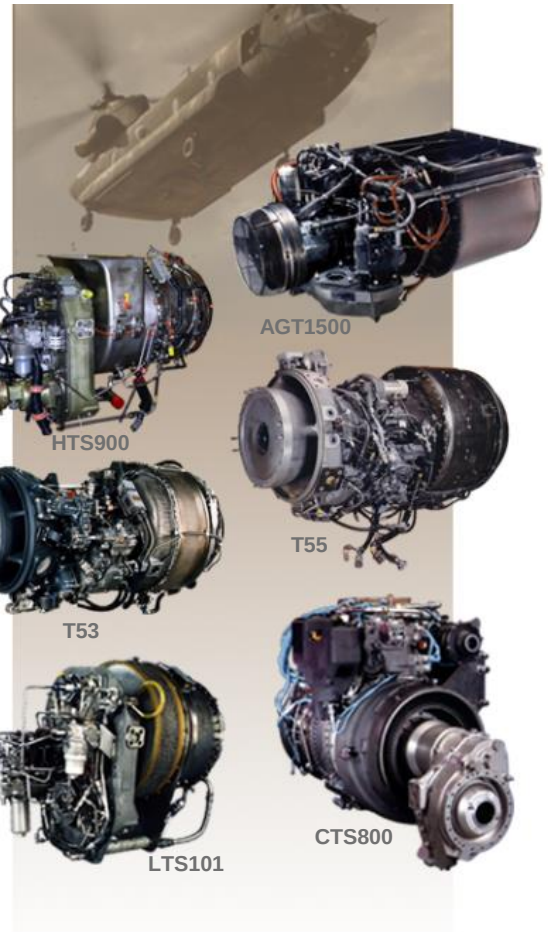
575 to 1,600 shp

Commercial turboprops
Military UAV

Turboshaft Engines

500 to 5,000 shp

Military & commercial helo/rotorcraft
Military surface vehicles/tanks



Over 80,000 Turbine Engines Delivered

NEXT GENERATION TURBOFAN WILL BENEFIT FROM CLEEN III TECHNOLOGIES TO REDUCE FUEL BURN, EMISSIONS AND NOISE

- State-of-the-art (SOA) performance
- Industry leading dispatch reliability
- Quantum leap in value: cost and durability
- Versatile technology for the Business Aviation Market
- Seven aircraft applications to date
  - > 2500 engines in service
  - > 7 million cumulative flight hours
  - > 4 million cumulative flight cycles

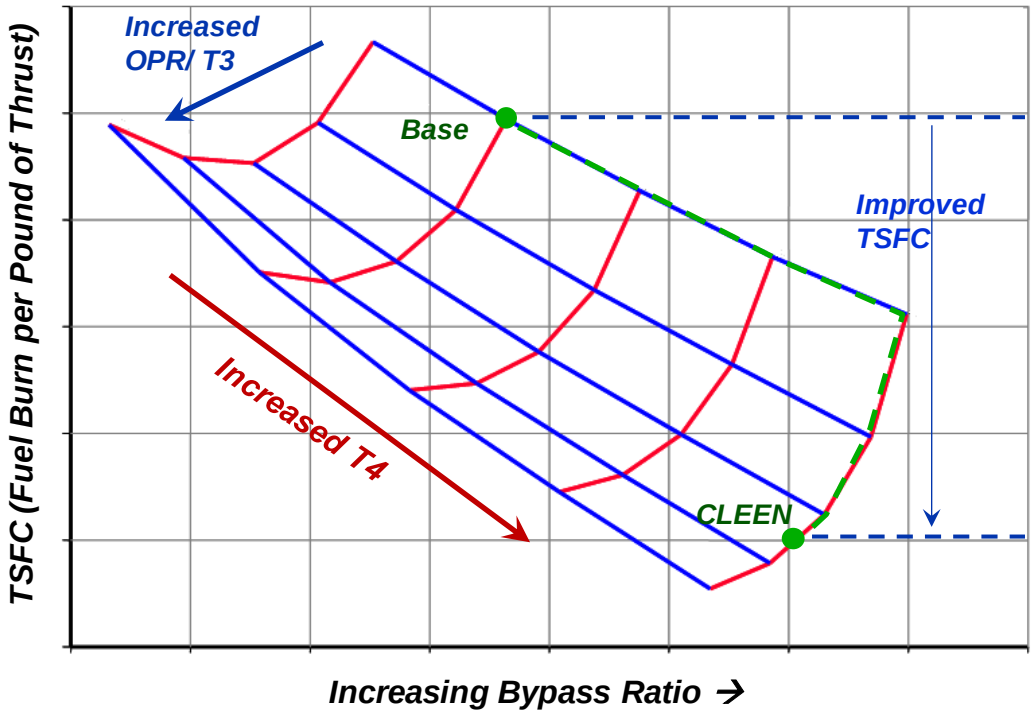
Bombardier CL300	Gulfstream G280	Bombardier CL350	Embraer Legacy 450/500	Cessna Longitude	Embraer Praetor 500/600
					
2004	2012	2014	2014 - 2015	2018	2019

CLEEN III Technologies Enhance Future Product Capabilities

CLEEN III ENGINE SYSTEM OPTIMIZATION

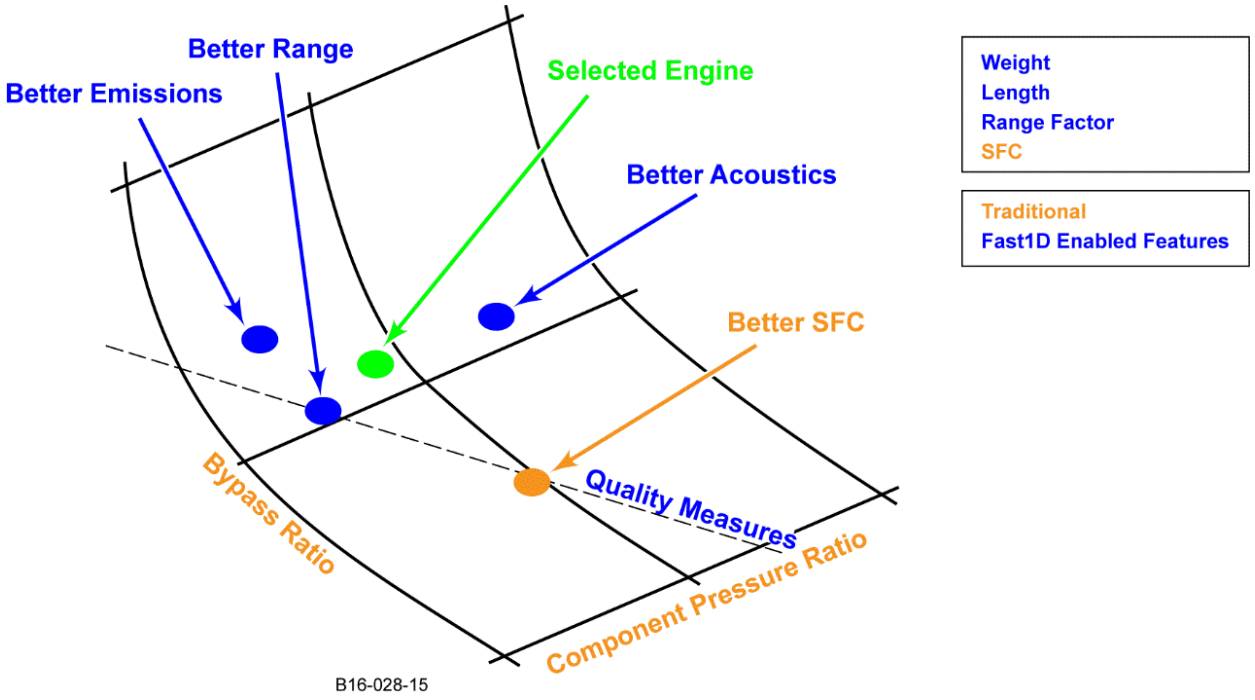
System integration study focused on infusing technologies to reduce mission fuel burn

Technologies focus on engine core, increasing Compressor and Turbine temperature capability (T3 and T4) to enable reductions in aircraft mission fuel burn



The CLEEN III cycle selection is a balance of Range, TSFC and Acoustics for optimal engine performance

System optimization provides a holistic, simultaneous look at basic engine performance + mission range and fuel, acoustic, emissions, engine geometry, length, weight and quality measures (loadings, stress, etc.)



Big Benefit Comes from a System Solution Optimization

MISSION/FLEET BENEFIT ASSESSED FOR TSFC, EMISSIONS, & NOISE

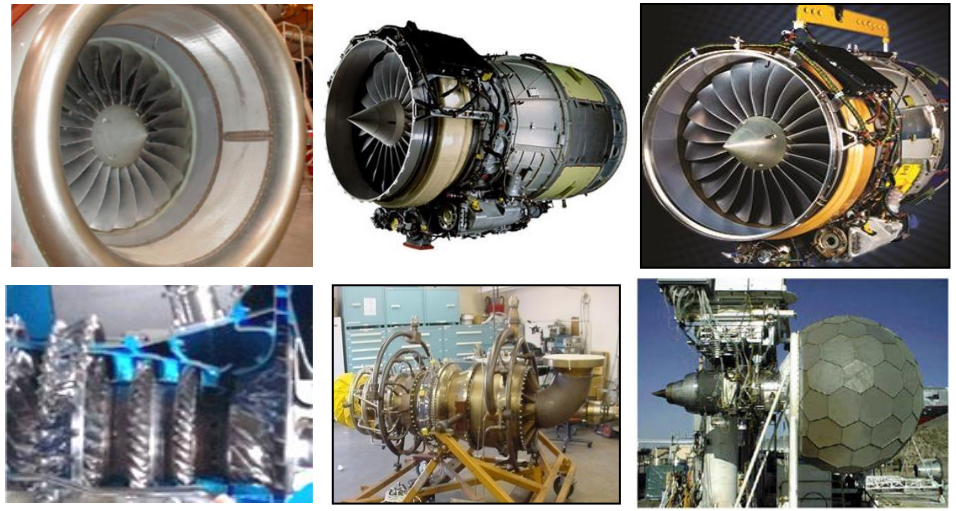
Generate cycle-based benefit predictions for CLEEN engine

- Predictions to be completed for CLEEN cycle with & without TSFC tech applied

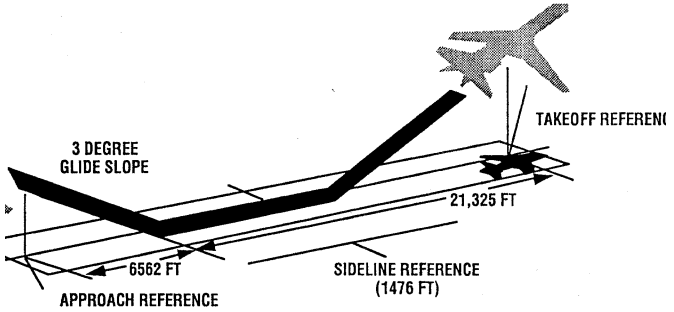
Provide input to Georgia Tech for fleet wide technology benefit assessment

Work with airframer to quantify benefit for aircraft mission

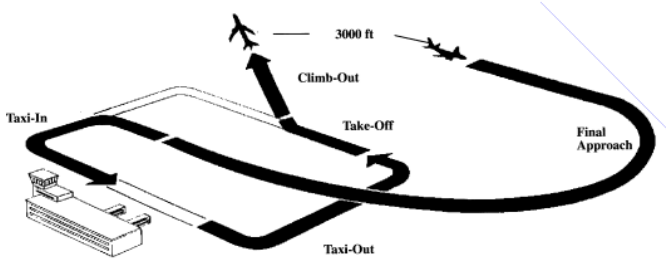
Engine TSFC/Emissions/Noise Prediction + Measured Technology Benefits



Fleet Benefits Assessments



ICAO
Landing/Takeoff (LTO) Emissions Cycle

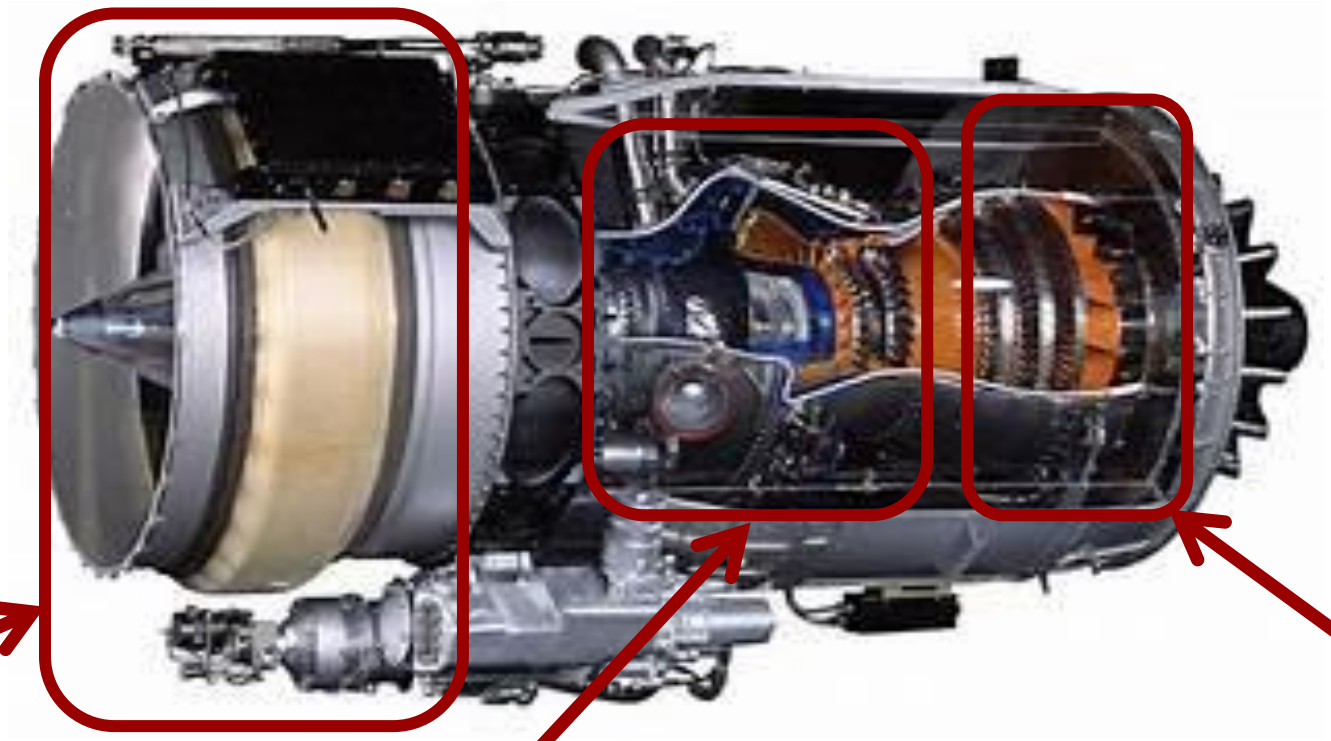


Aircraft Mission Benefit Assessment

Global Benefit of CLEEN III Technology will be Quantified

HONEYWELL CLEEN III TECHNOLOGIES

<u>Elevator Speech:</u> Honeywell's CLEEN III program is maturing advanced propulsion engine technologies for improved fuel burn, reduced emissions and noise.



Highly Efficient Fan Module

Efficient High-Pressure Green Core

High Work / High Lift Low Pressure Turbine

CLEEN III Technologies lead to lower fuel burn, reduced noise and emissions

HIGHLY EFFICIENT FAN MODULE

Technology Description

High Efficiency Fan and Booster Rotors

Over-the-rotor (OTR) acoustic treatment

Optimized Fan Exit Guide Vanes

Optimized Booster Stators

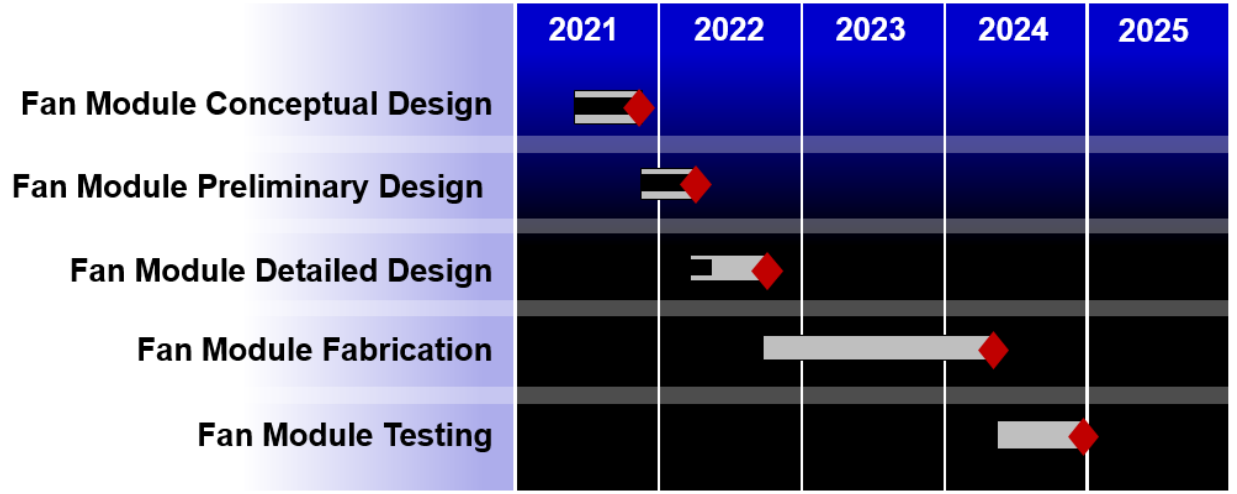
Benefits and Application

- **Noise:** 1.5 EPNdB
- **Fuel:** 1.5% fuel burn reduction
- **Application:** Super mid-sized business jet
- **Entry into service (EIS):** 2031

Accomplishments/Milestones

- **Concept and Preliminary Design Reviews Complete**
  - Fan Module design on track to meeting aerodynamic and mechanical goals; Final refinement during DDR
  - Booster rotor designed for increased overall pressure ratio and reduced weight
  - Over-The-Rotor treatment concept design has been identified to reduce fan module noise and efficiency penalty associated with conventional approaches

Program Schedule



Preliminary Fan Module Design Underway and Progressing Well

EFFICIENT GREEN HIGH-PRESSURE CORE

Technology Description

Advanced High-Pressure Compressor (HiPR)

Low NOx, nvPM Emissions Combustor

Efficient High-Pressure Turbine (HPT)

High Temperature HPT Materials

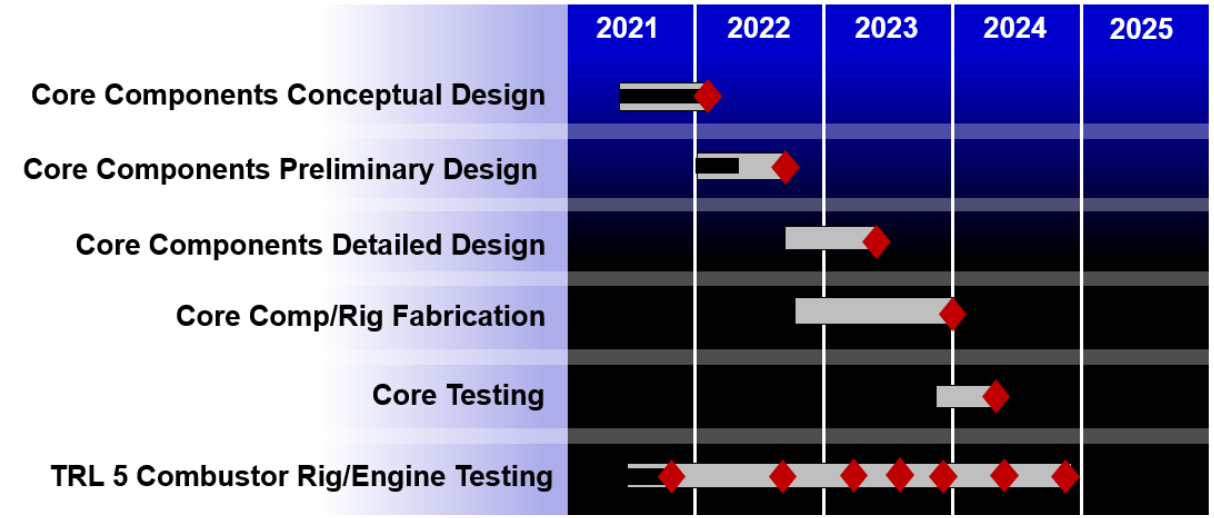
Benefits and Application

- **Noise:** 3 EPNdB reduction
- **Fuel:** 8.3% fuel burn reduction
- **Emissions:** 70% margin to CAEP/8 NOx; reduction in nvPM
- **Application:** Super mid-sized business jet
- **Entry into service (EIS):** 2031

Accomplishment/Milestones

- All Core Component Concept Design Reviews complete with good progress toward Preliminary Design later this year
- HPC PDR complete. Go-forward configuration shows improvement in HPC pressure recovery, noise reduction and fuel burn improvement
- Initial Combustor Design Rig Test complete showing good progress toward lower NOx and nvPM
- HPT Materials and Coating Testing showing promising results for thermal capability and thermal protection

Program Schedule



Core Technology Development showing good progress

EFFICIENT GREEN LOW-PRESSURE TURBINE

Technology Description

Advanced Low-Pressure Turbine (LPT)

Optimized for Reduced Weight

Advanced Aerodynamics for efficiency

Optimized for Reduced Noise

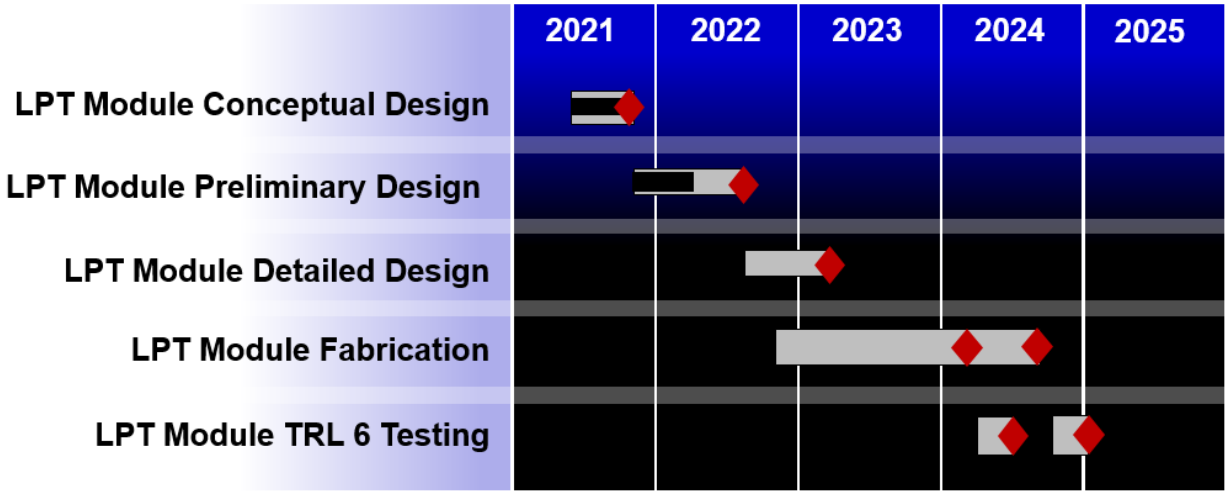
Benefits and Application

- **Noise:** 0.5 EPNdB
- **Fuel:** 2.5% fuel burn reduction
- **Application:** Super mid-sized business jet
- **Entry into service (EIS):** 2031

Accomplishments/Milestones

- LPT Stage airfoil design well positioned from completed Concept Design Review (CDR) to incorporate advanced aerodynamic concepts
- LPT Noise to be reduced through aerodynamic loading/configuration optimization and application of advanced acoustic treatment

Program Schedule

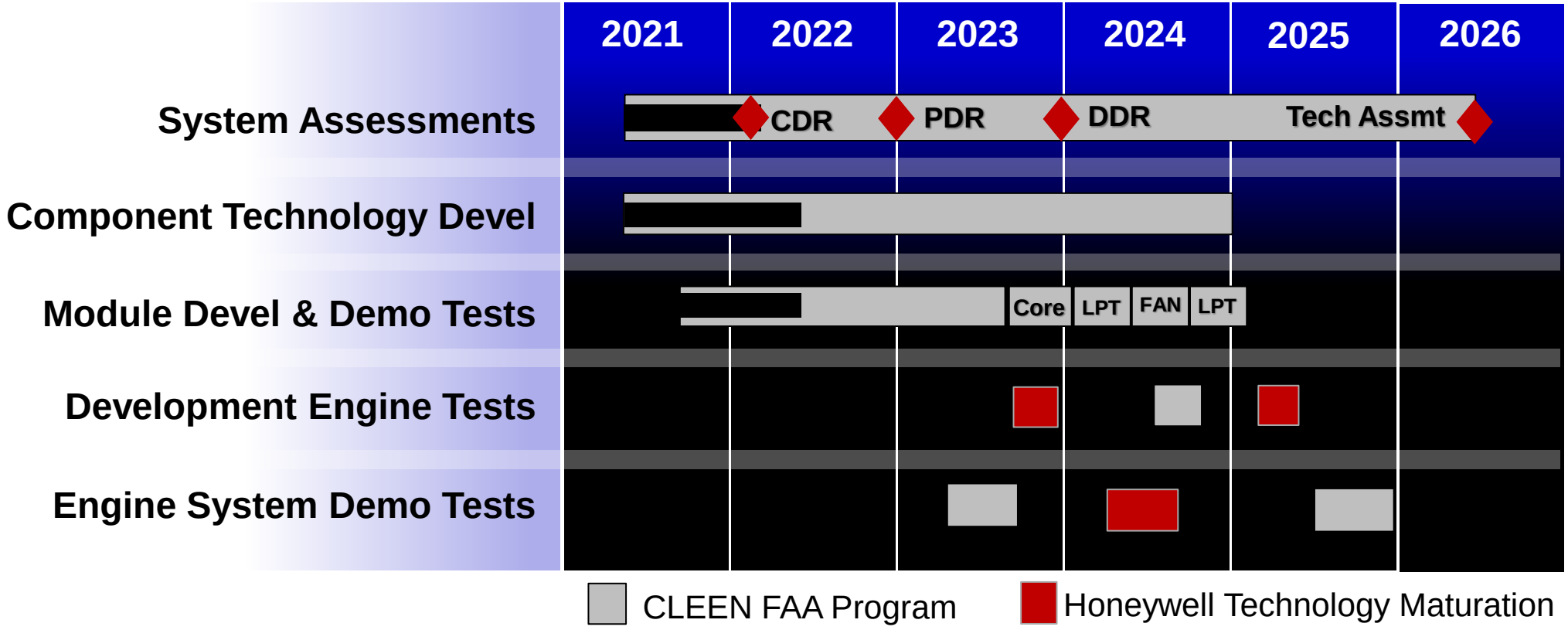


Preliminary LPT Module Concept Designs Complete Leading to PDR

CLEEN III OVERALL SYSTEM SCHEDULE

Analysis and Technology Demonstration Testing | **Component Technology and System Development Testing** | **Engine Demonstration and Validation Testing**

TRL 3 *TRL 4* *TRL 5* *TRL 6*



Acoustic/Dev Engine Testing

Dev/Demo Engine Testing

CLEEN III Technology Maturation to Demonstrate FAA Goals

PROGRAM SUMMARY

- **CLEEN III Technologies lead to lower fuel burn, reduced noise and emissions**
- **Significant benefit comes from a system optimization approach**
- **Technology Status:**
  - Preliminary Fan Module Design underway and progressing well
  - Core Component Technology development work showing good progress
  - Preliminary LPT Module Concept Design complete leading to PDR
- **The benefits of CLEEN III Technology will be quantified thru TRL 4-6 testing and demonstrate technology maturation toward FAA Goals**

THANK YOU!