Pratt & Whitney

A United Technologies Company

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CLEEN II: HIGH-PERFORMANCE CORE,ULTRA-HIGH BYPASS RATIO,GEARED DUCTED PROPULSION SYSTEM

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HIGH-PERFORMANCE CORE

Topics for Discussion

Program Overview

HPT Technology Status

HPC Technology Status

Technology Impact

Discussion

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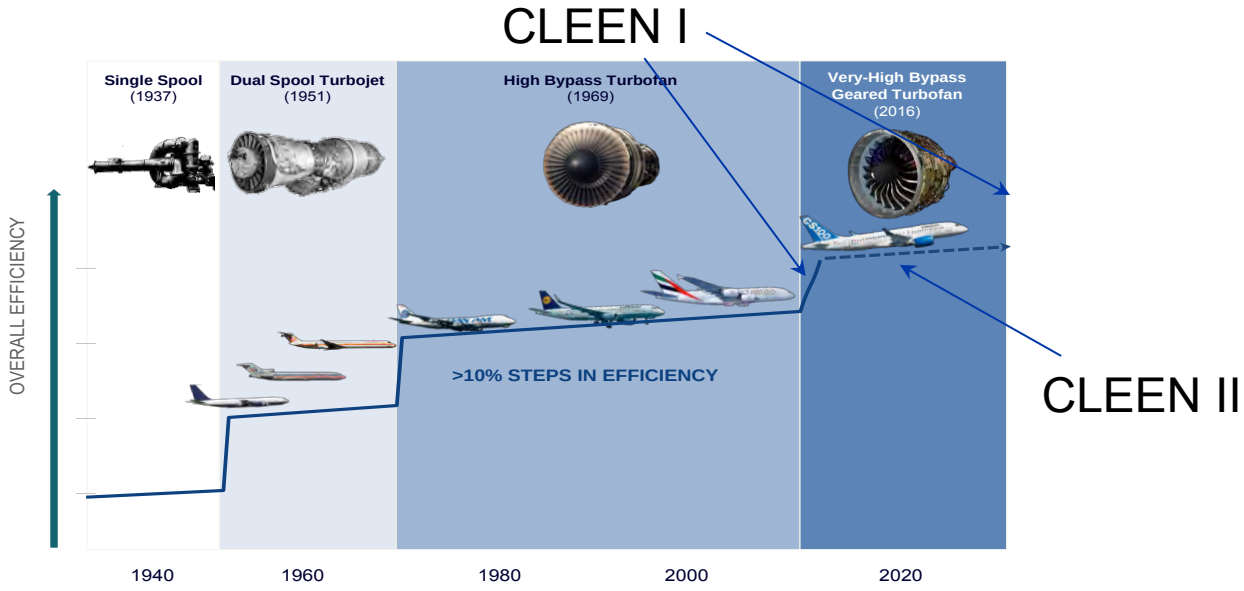
HIGH-PERFORMANCE CORE

Entering A New Era of Engine Architecture

Very-high bypass enabled by PurePower® Geared Turbofan™ architecture

CLEEN II Effort Enhances Performance of GTF System



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HIGH-PERFORMANCE CORE

Program Overview : 1 – 2 % Fuel Burn Improvement

Compressor and Turbine Technology Maturation

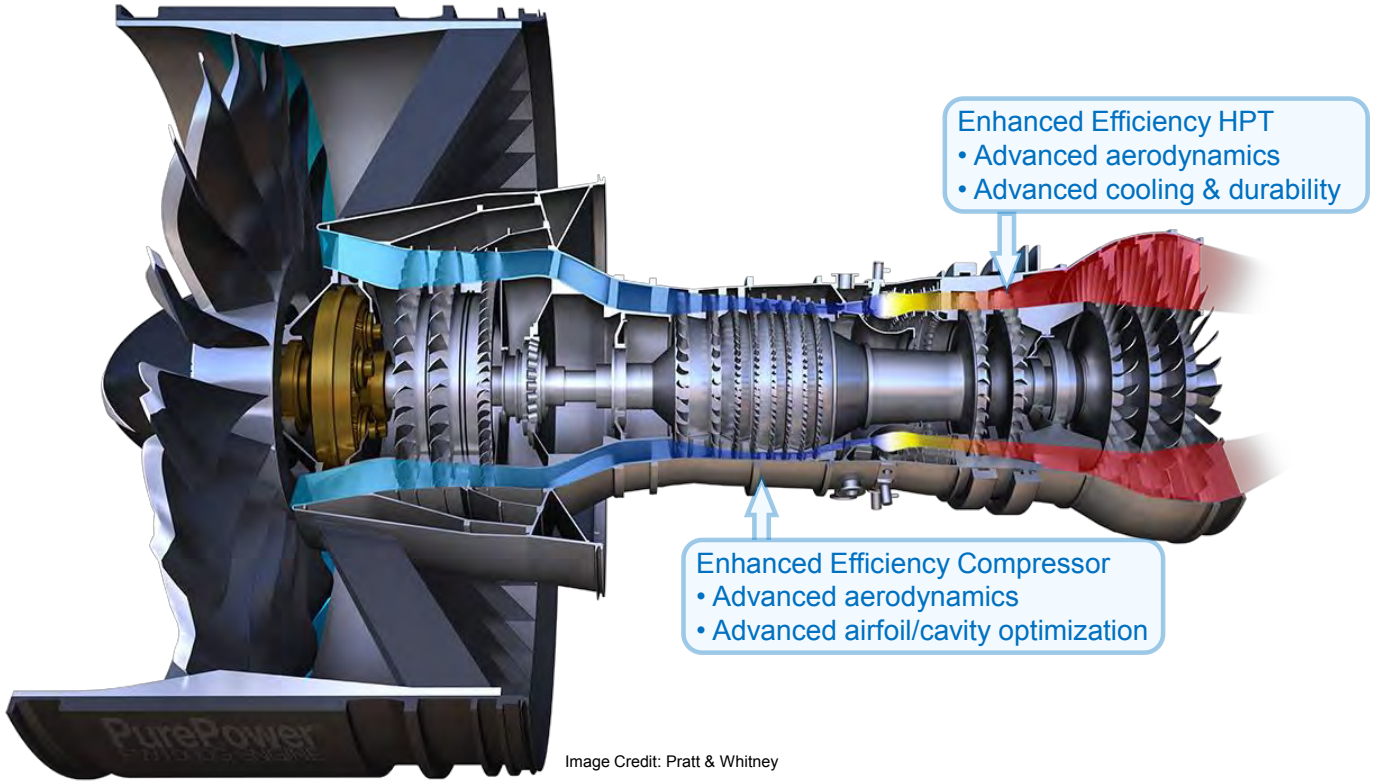

Image Credit: Pratt & Whitney

Technologies can be transitioned to PurePower® Geared TurboFan™ (GTF) engines

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HIGH-PERFORMANCE CORE

Program Overview

Compressor and Turbine Technology Maturation

	2015	2016	2017	2018	2019	2020
Program	Jan Submittal; Oct Start; Task Plan	HPT Rig PDR; HPT Rig DDR; Risk Assessment; HPC TRR	HPC Rig Test Report	HPT TRR	HPT Test Report	Prg End; Final Reports
HPC Techs.	Fab/ Assembly; Rig Test; Redesign; Fabrication / Assembly; Engine Development Program					
HPT Techs.	Design; Base Fab; Base Testing; Fab; Testing					

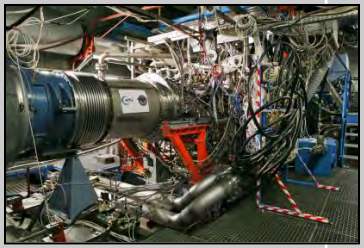
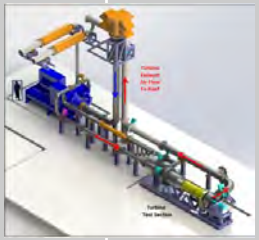


Photo Credit: MTU



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HIGH-PERFORMANCE CORE

Program Overview – Summary Status

Program resources identified and assigned

- All key subcontracts in place

HPT aero downselection completed

- Facility upgrades initiated

HPC rig hardware fabricated

- Assembly initiated
- Progressing towards August test start

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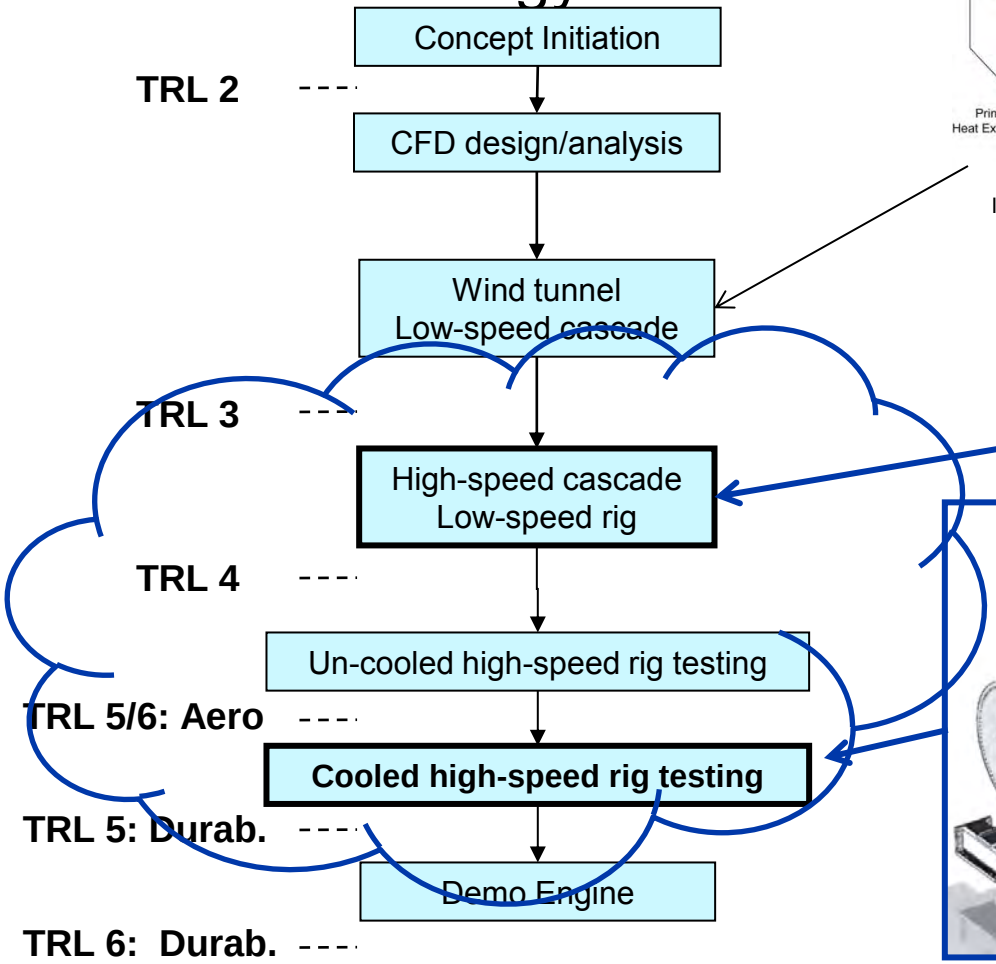
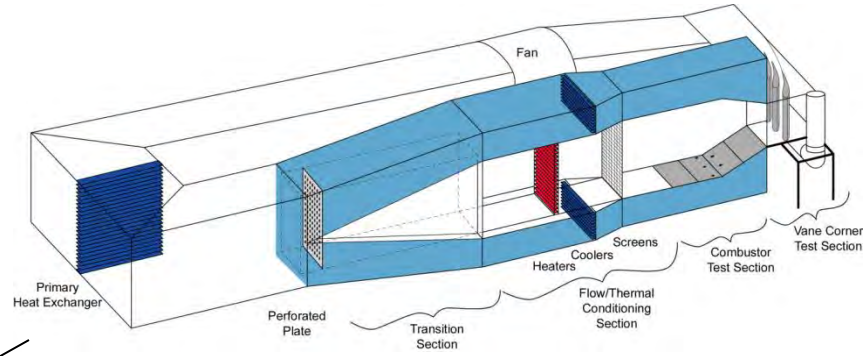
HIGH-PERFORMANCE CORE

HPT Technology Status

Maturation Strategy





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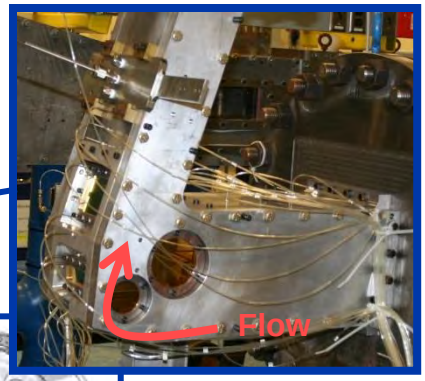
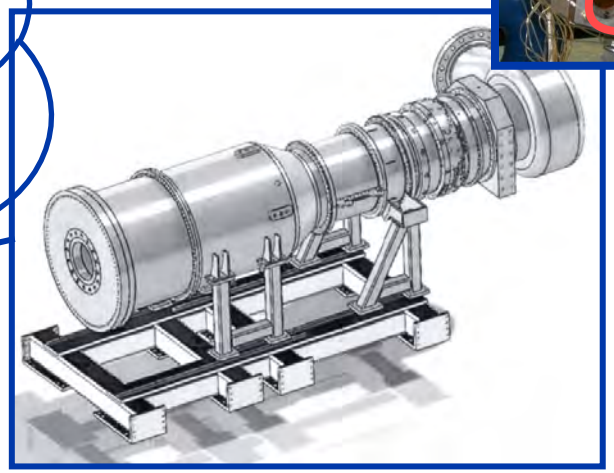


Photo Credit: United Technologies Research Center



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HIGH PERFORMANCE CORE

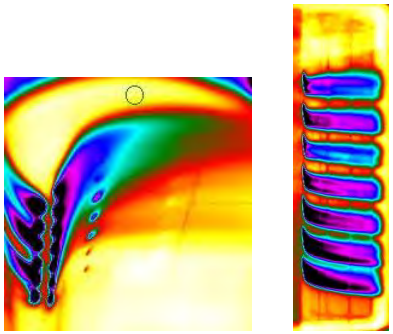
HPT Technology Status – Cascade Testing

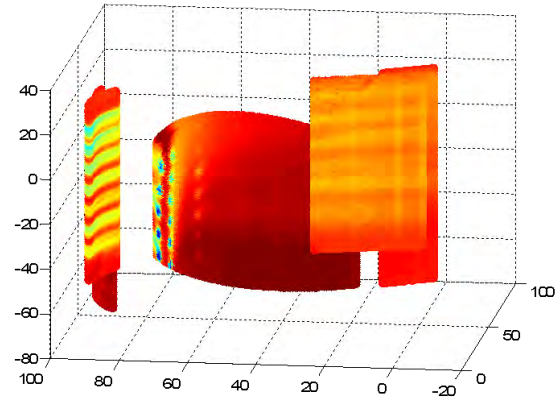
Aero / thermal concepts evaluated, aero design completed

- Significant reduction in heat load achieved
- Maintained aero performance

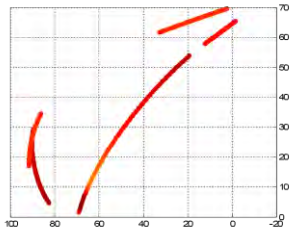
Rig special test equipment design initiated

Final stage of facility benchmarking using NASA CW-22 cascade data





Raw IR image processing



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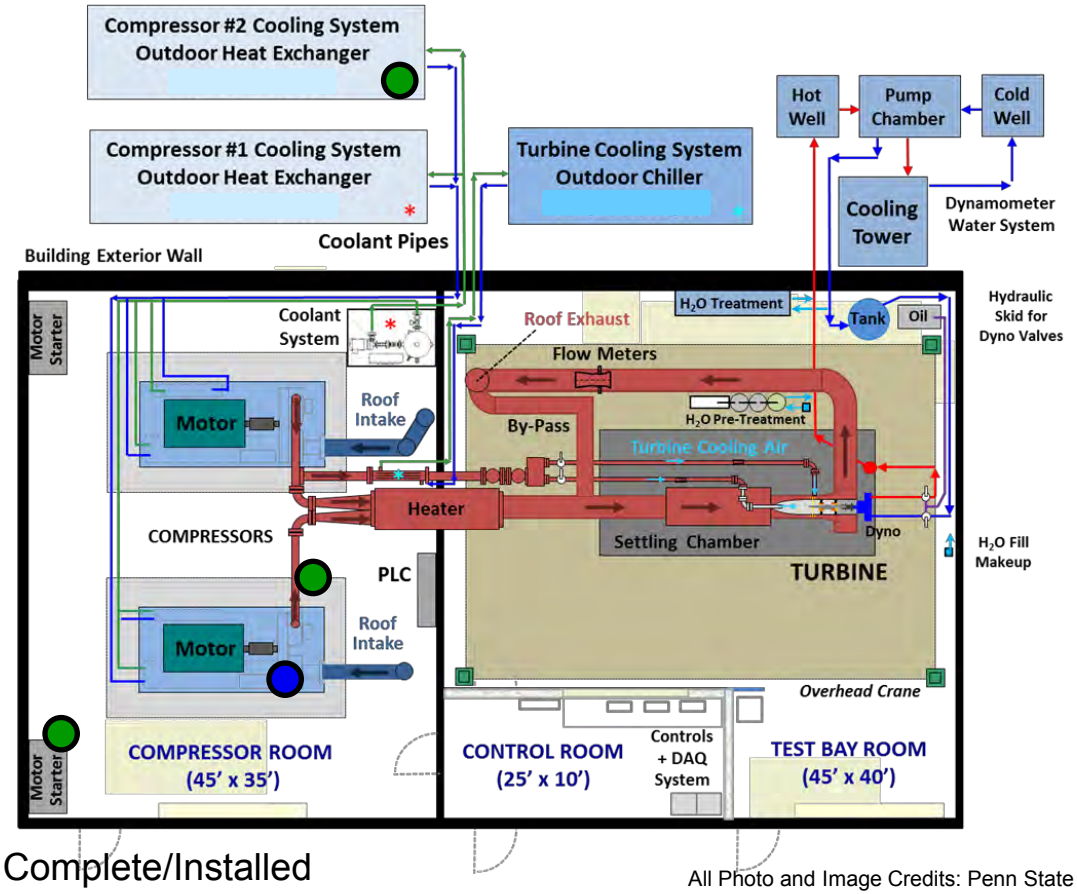
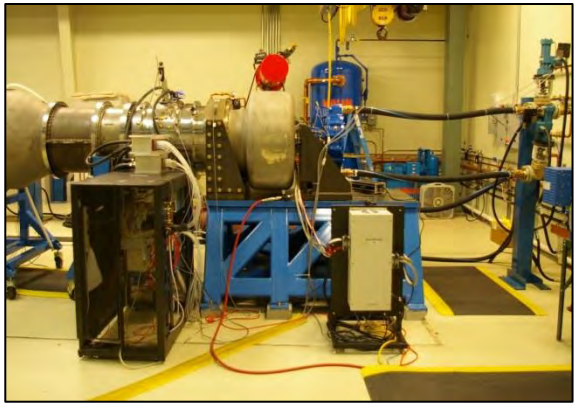
HIGH PERFORMANCE CORE

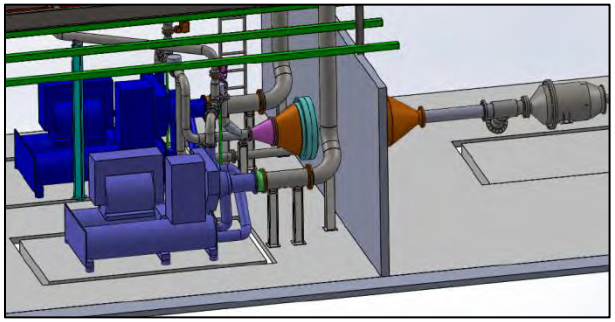
HPT Technology Status – High Speed Rig Testing

Major facility upgrade progressing – full span, multi-stage, cooling capability





Current Half-Span Turbine Rig



Second Compressor Facility Integration

Complete/Installed

Hardware Delivered

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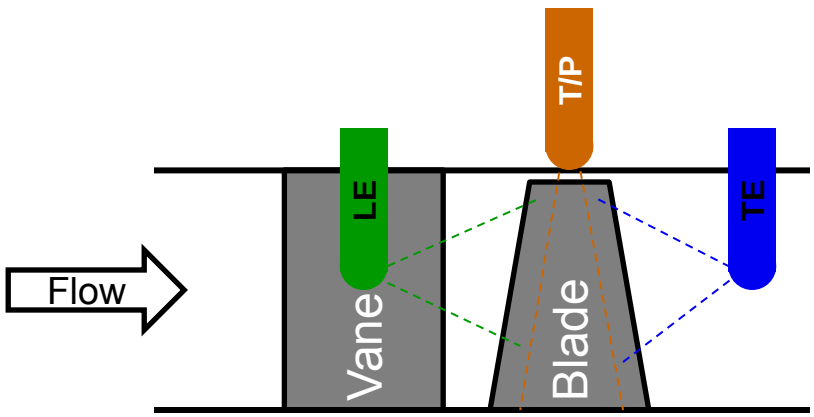
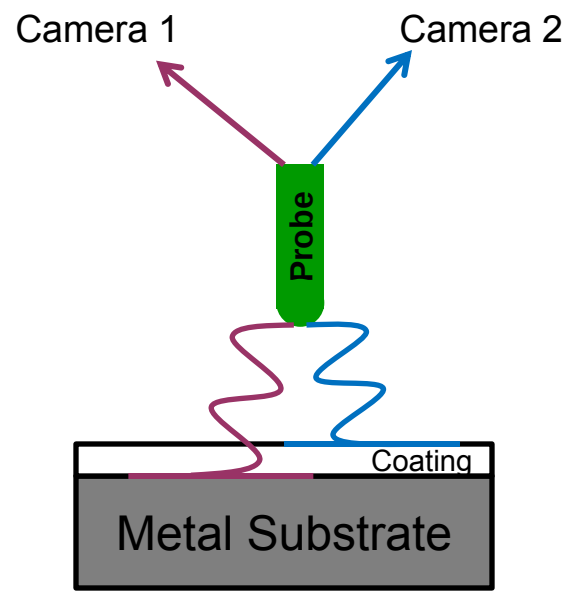
HPT Technology Status – High Speed Rig Testing

Preliminary design of new IR camera measurement technique and optics

Simultaneous blade surface temperature and heat transfer coefficient measured in-situ





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HPT Technology – Near Term Milestones

Initiate and advance UTRC cascade fabrication

Deliver majority of PSU START rig hardware for baseline test

Initiate and progress preliminary design for technology blade for PSU START rig

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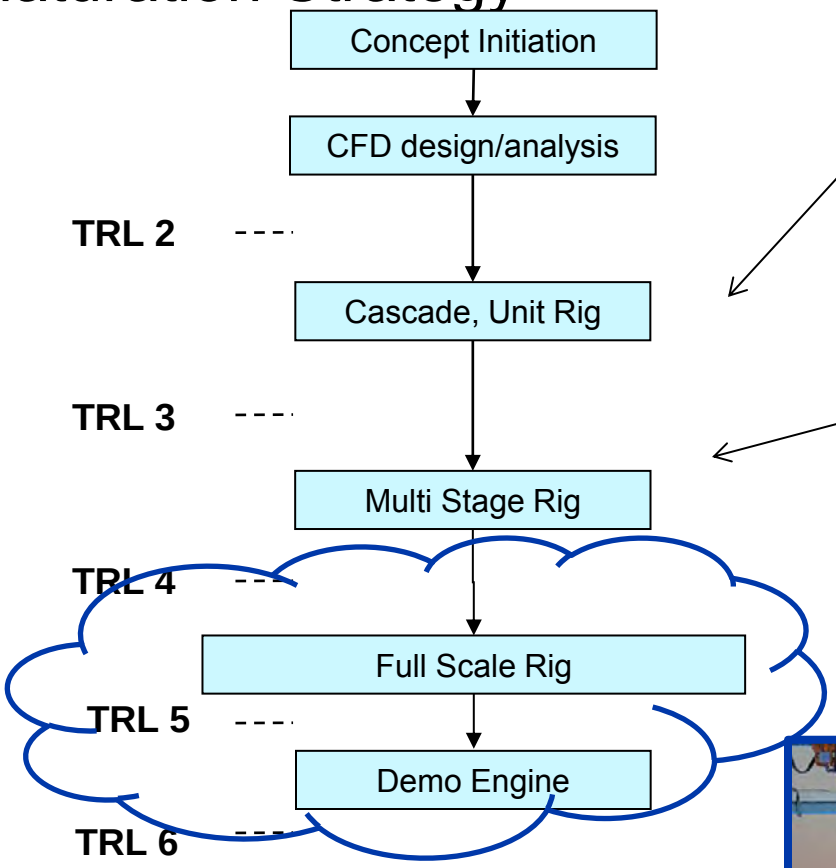
HPC Technology Status

Maturation Strategy



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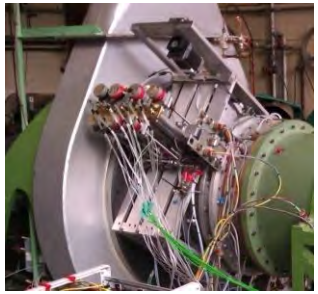

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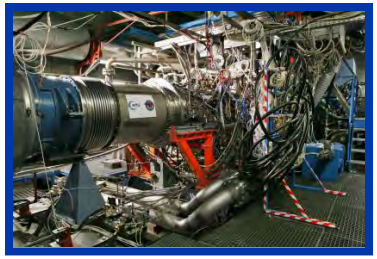

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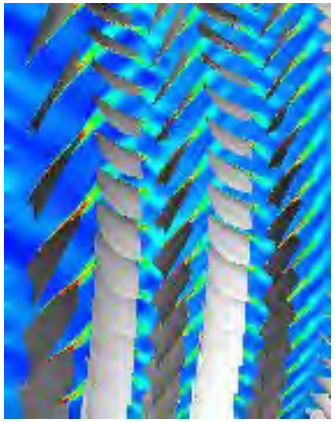
HPC Technology Status – Key Attributes

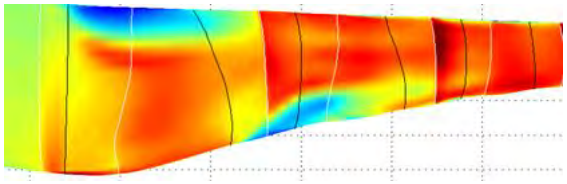
Engine representative hardware



Multi-stage optimization over range of operating conditions

Aerodynamic & operability

Broad range of engine sensitivities



Comprehensive instrumentation set

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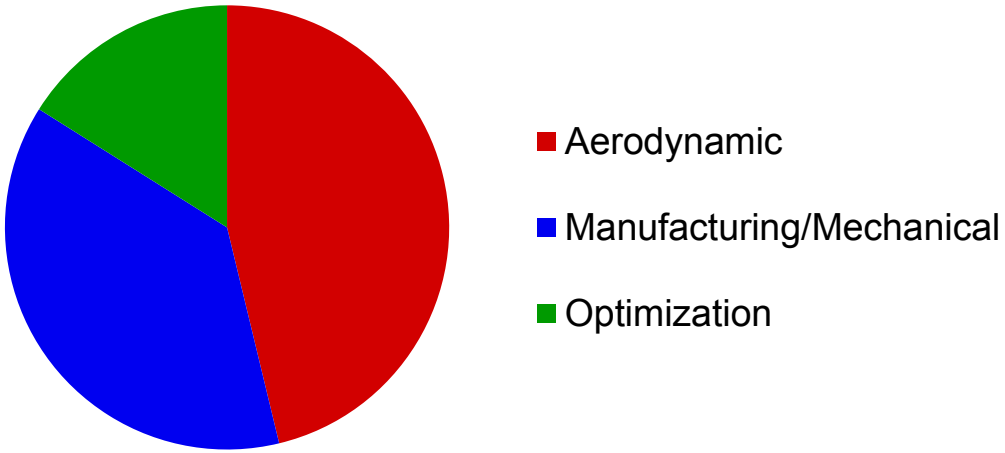
HPC Technology Status – Benefit Contributions

Performance benefits from both technology maturation and compressor optimization

- Aero technologies
- Manufacturing technologies
- Mechanical design technologies



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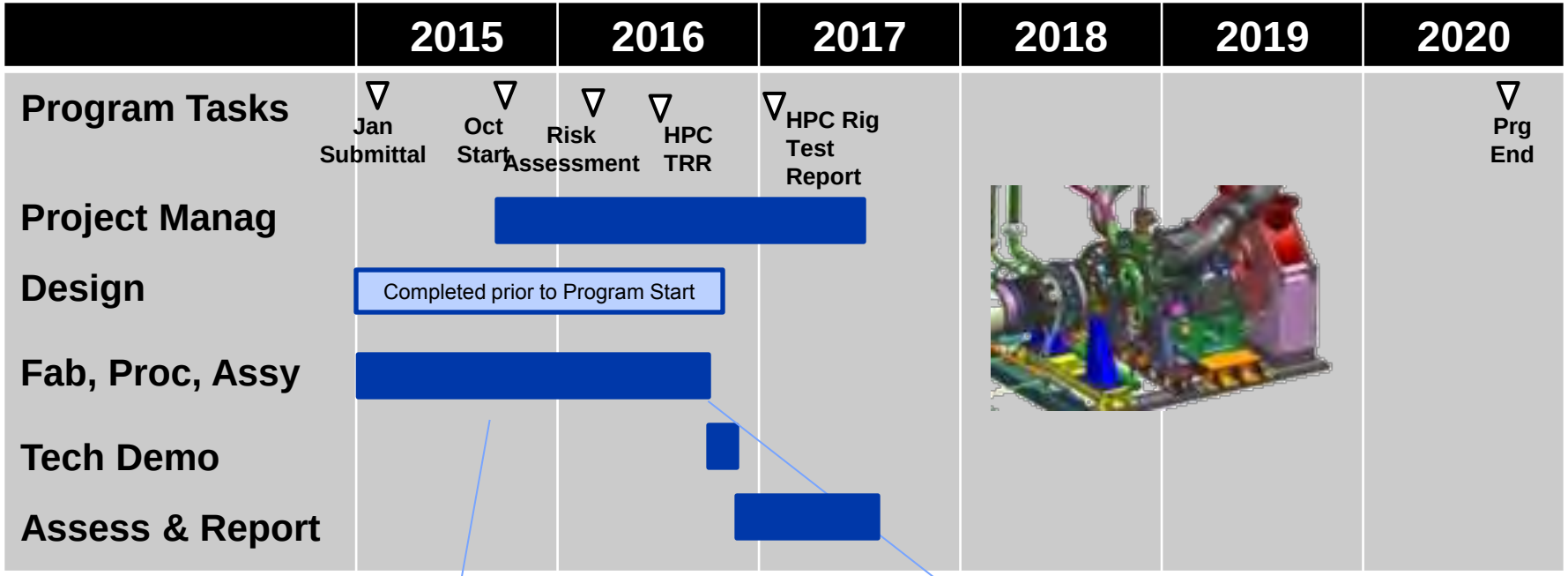
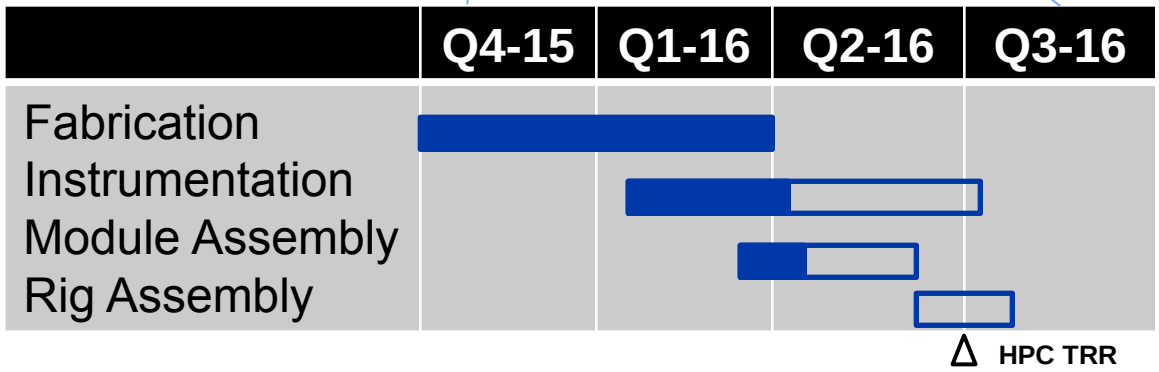
HPC Technology Status - Schedule





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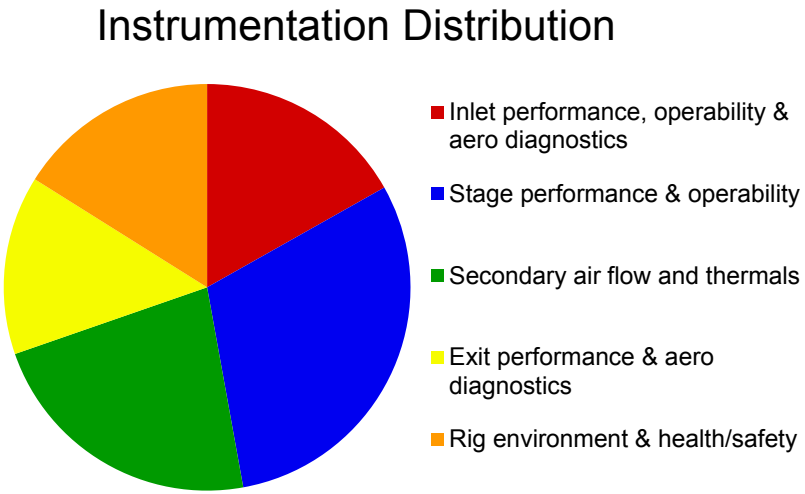
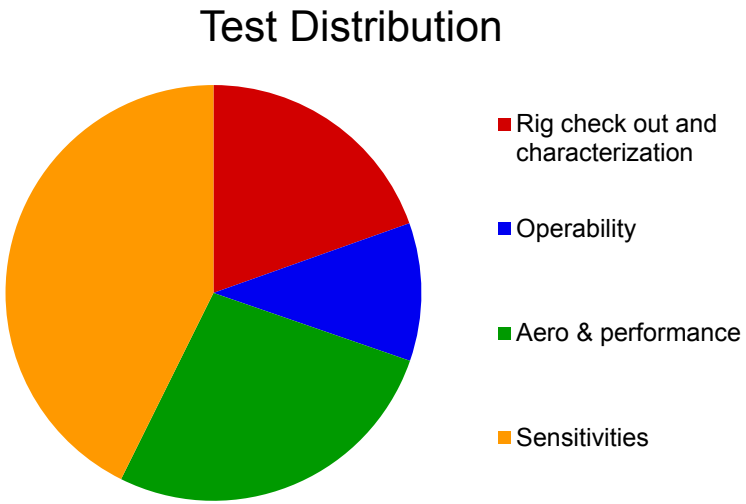
HPC Technology Status – Test and Instrumentation

Extensive instrumentation suite for compressor characterization and technology optimization

Testing focused on technology maturation and compressor optimization

Instrumentation installation burndown & rig assembly on target to support Q3 2016 test





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HPC Technology – Near Term Milestones

Complete instrumentation and module assembly

Complete rig assembly and module installation

Complete test readiness review

Execute rig test program

Preliminary data assessment

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Compressor Aero-Efficiency Techs.

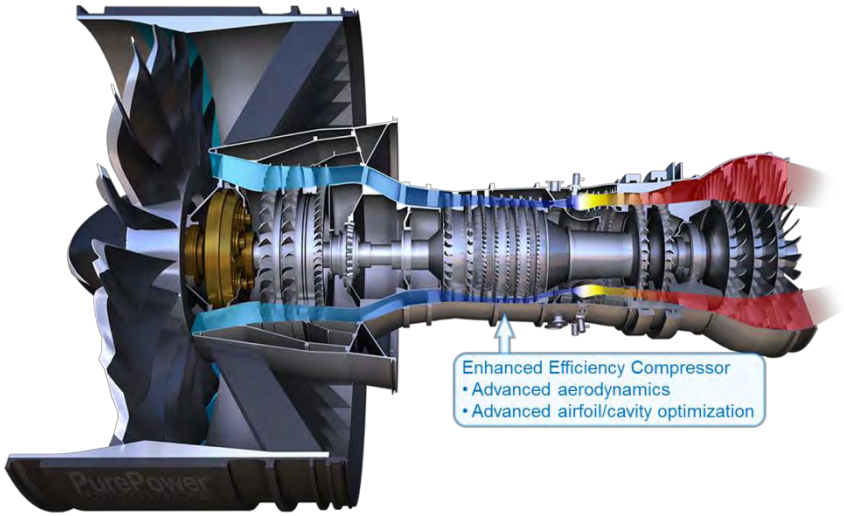


Image Credit: Pratt & Whitney

Benefits:

- Improved thermal efficiency
  - ~ 0.8 – 1.0% fuel burn reduction

Risks/Mitigations

- Achievement of performance and operability targets
  - Utilize multi-stage rigs for early validation
  - Execute redesign, if needed, and utilize lower-level rigs for progressive validation before engine demo

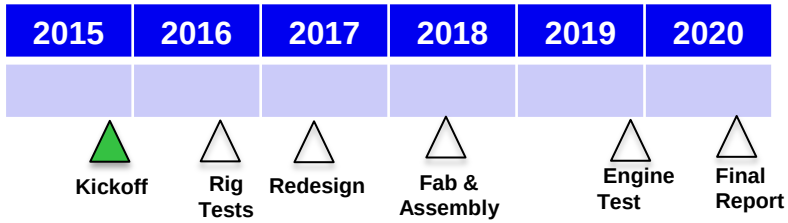
Objectives: *Demonstrate improved high pressure compressor efficiency via advanced aerodynamic airfoil optimization*

Work Statement: Continue the TRL advancement of compressor aero-efficiency technologies via detailed design, fabrication, full-scale rig tests, and engine validation.

Prior Accomplishments:

- Completed hardware fabrication
- Completed HPC rotor assembly

Schedule & Planned Milestones:



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Turbine Aero-Efficiency & Durability

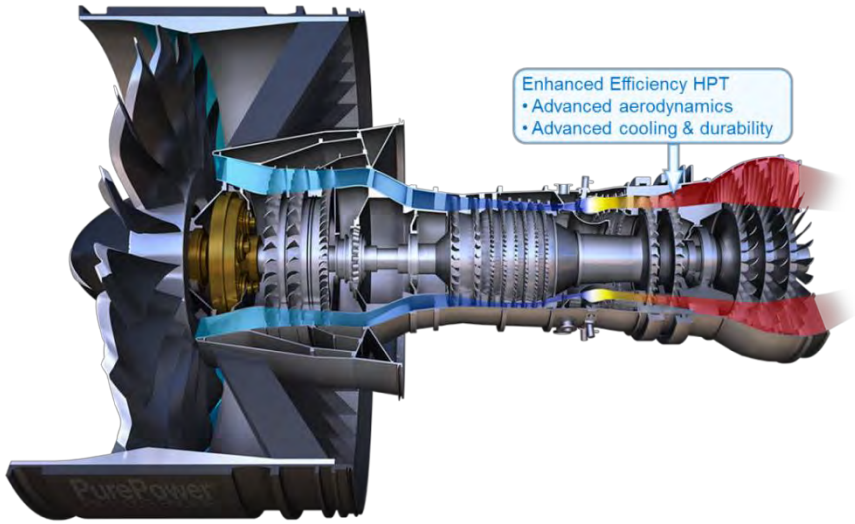


Image Credit: Pratt & Whitney

Benefits:

- Improved thermal efficiency
  - ~ 0.8 – 1.0% fuel burn reduction

Risks/Mitigations

- Technology interaction prevents assessment of contribution of individual items
  - Execute additional rig trials to isolate
- Testing compromised due to assembly delays
  - Procure additional rig hardware for assembly

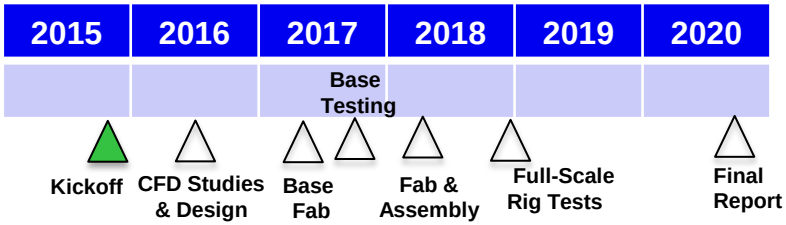
Objectives: *Demonstrate improved high pressure turbine efficiency via advanced aerodynamic airfoil and durability optimization*

Work Statement: Continue the TRL advancement of turbine aero-efficiency and durability technologies via CFD studies, detailed design, fabrication, and full-scale rig tests.

Prior Accomplishments:

- Completed aero design down select
- Initiated START rig upgrade design
- Released rig airfoil drawings

Schedule & Planned Milestones:



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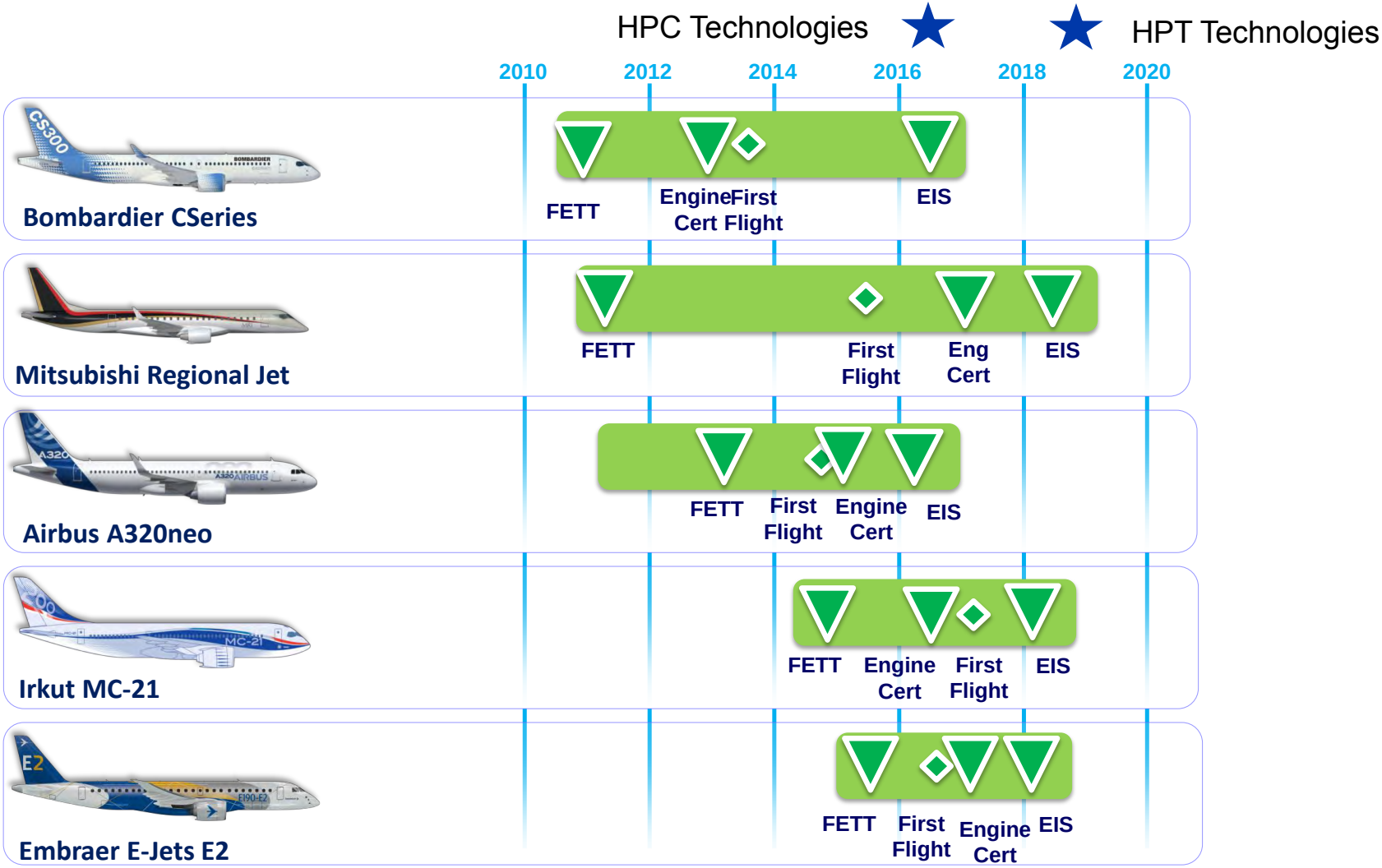
PUREPOWER GTF ENGINE APPLICATIONS

70+ Customers/7000+ Engine Orders



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HIGH PERFORMANCE CORE

Summary

P&W CLEEN II program progressing to plan

Benefits are achievable

HPT technology facility upgrades accelerating

HPC technology rig demonstration on target for 2016 test

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