FAA CLEEN

November 2011

Agenda

- Geared Turbofan™ Engine Development & Certification Status
- FAA CLEEN Technologies
- FAA CLEEN Program Status

GTF Development & Certification Status

Customers Want:

Lower Engine Cash Operating Cost

Cost drivers

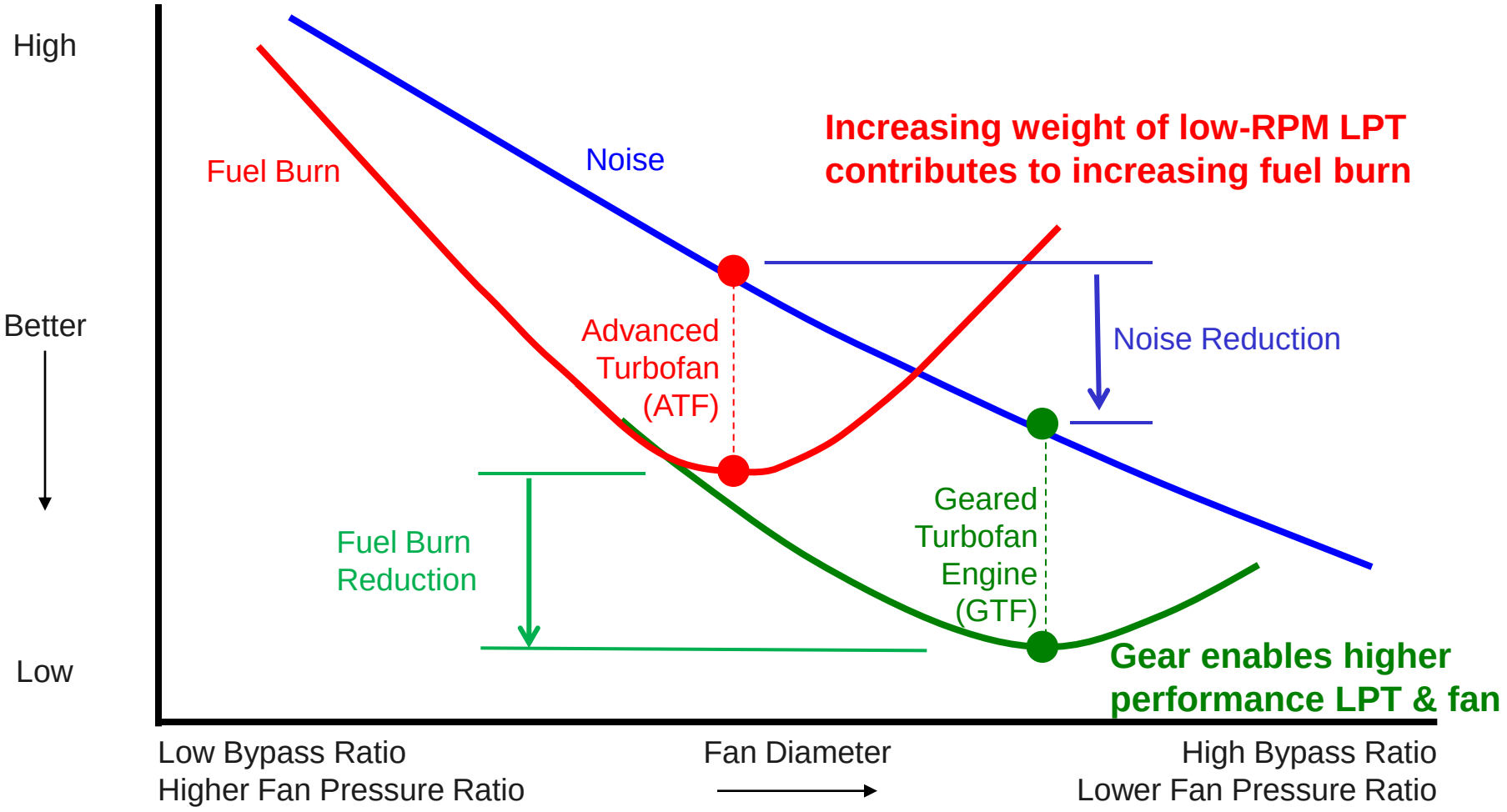
- Fuel
- Maintenance cost
- Noise
- Emissions
- Reliability

The Solution – Geared Turbofan (GTF)

PurePower® PW1000G is the Complete and Comprehensive Solution

GTF Engine Expands Design Space

Paradigm Shift for Reduced Fuel Burn and Noise



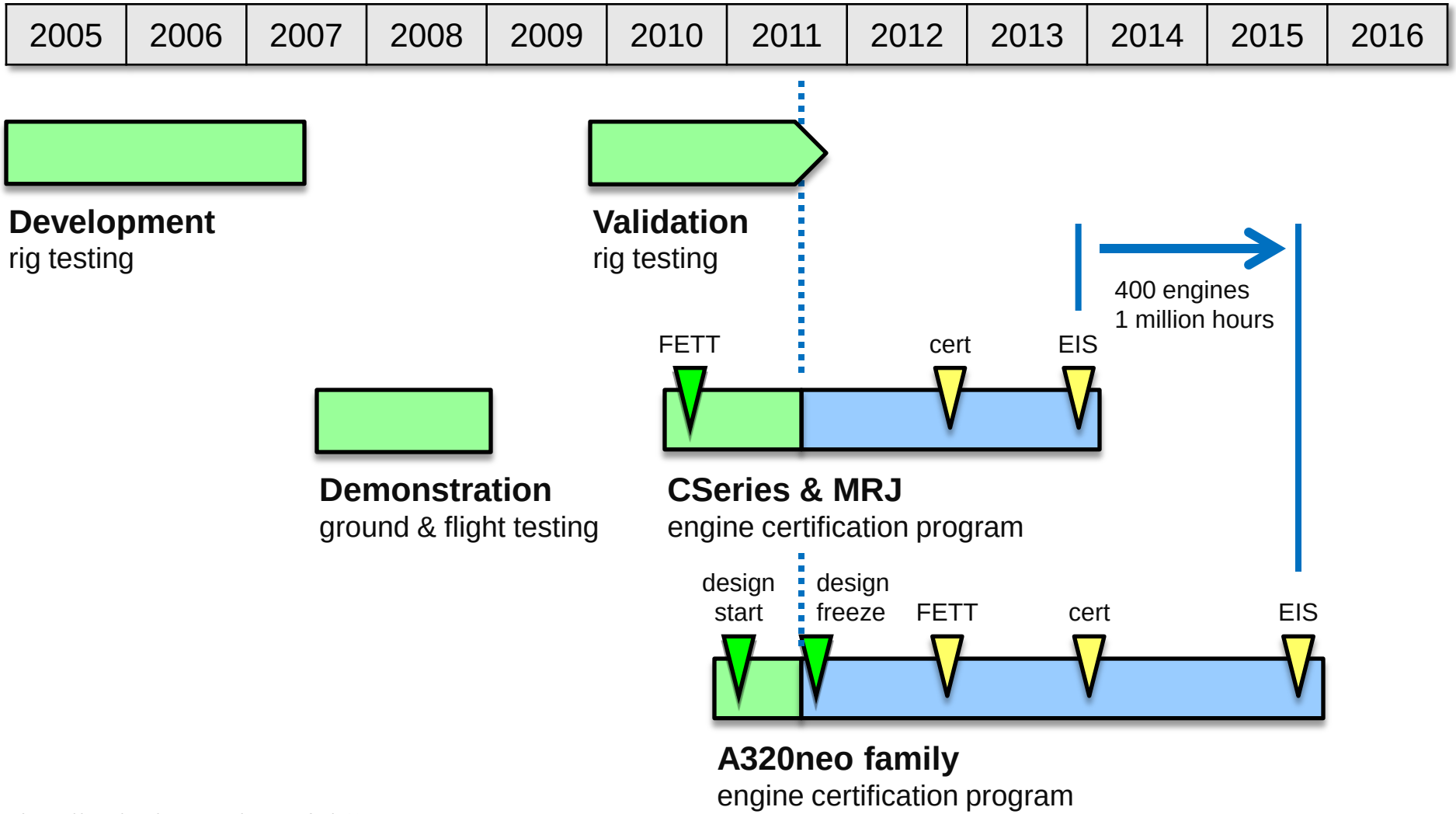
PurePower® For The Next Generation

PurePower® PW1000G Engine Family Covers Wide Thrust Range

Advanced core Geared architecture

PW1000G Engine Development Schedule

Mature Engine Family

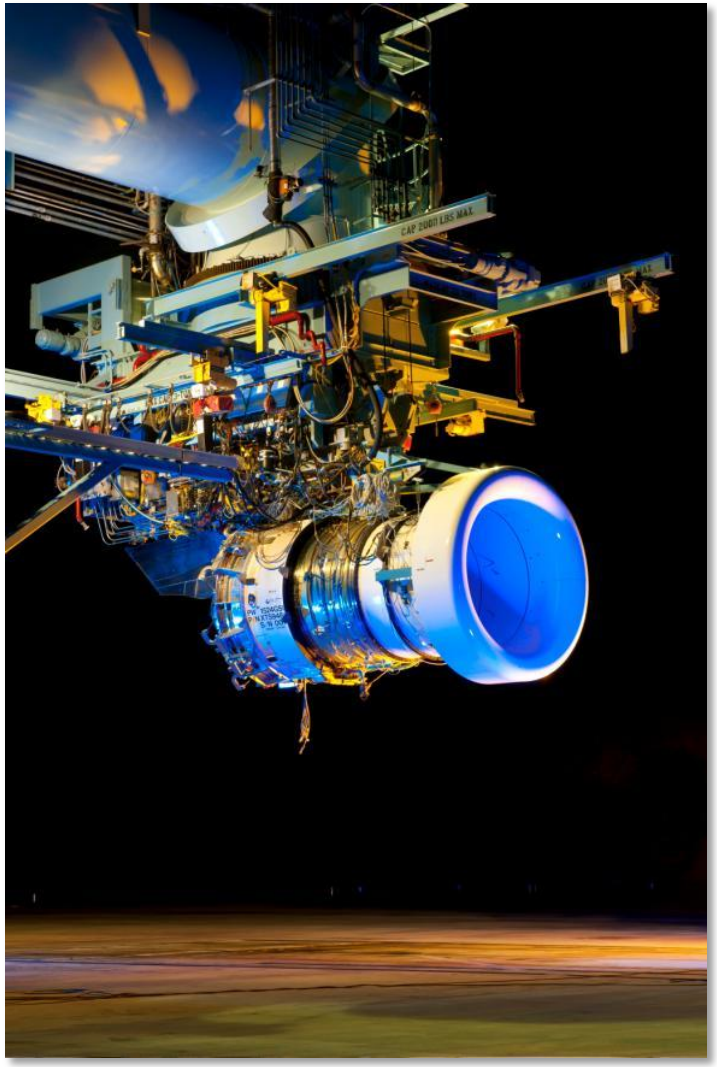


Engines and hours based on P&W estimate as of July 2011.

PurePower PW1500G First Engine To Test

First Engine To Test Exceeded Expectations

- Initial light-off Sep 25th 2010
- Accumulated nearly 250 hours
- FETT Successfully completed:
  - Structural evaluation
  - Performance
  - Noise
  - Emissions testing
  - Rotor dynamics
  - Fuel & lubrication systems validation
  - Icing testing



Initial Flight Test Program Completed

Successful Flight Test Program Validating Sea Level Results

- First flight completed June 20th
- Excellent engine operation enabling expanded test program:
  - 25 flights completed
  - 115 hours flight time
  - Early 2012 testing completed ahead of schedule
- Engine is back at West Palm Beach test stand for continued sea-level testing

X802 mounted in C-11 (Florida)

X802 Installation onto 747SP FTB

PW1200G First Engine To Test

Completes Initial Ground Test Program

- P1200G FETT ground test accumulated more than 300 hours and 1,100 cycles
- Cyclic endurance testing completed
- Tests successfully validated
  - Airfoil stresses
  - Performance
  - Noise
  - Emissions

PurePower PW1500G Benefits

	PW1500G	CLEEN Goals
Fuel Burn	>15%	33%*
Noise	Stage 4 – 20 dB	Stage 4 – 32 dB*
NOx	CAEP6 – 50%	CAEP6 – 60%

* Aircraft level

PW1000G Test Summary

Validation and Certification on Track, 900+ Hours Completed

MRJ engine ground test
PW1217G for MRJ90

CSeries engine ground runs
PW1524G for CS300

CSeries engine flight test
PW1524G for CS300

PW1200G engines	PW1500G engines
✓ 1st engine ground test completed	✓ 1st engine ground test & ice test completed
✓ 2nd engine performance test in progress	✓ 2nd engine flight test completed
✓ Core test completed	✓ 3rd engine high rotor test completed
✓ 2 engines in build	✓ 4th engine shipped to X8 test stand
✓ 350+ hours completed	✓ 1 engine in build
	✓ 550+ hours completed

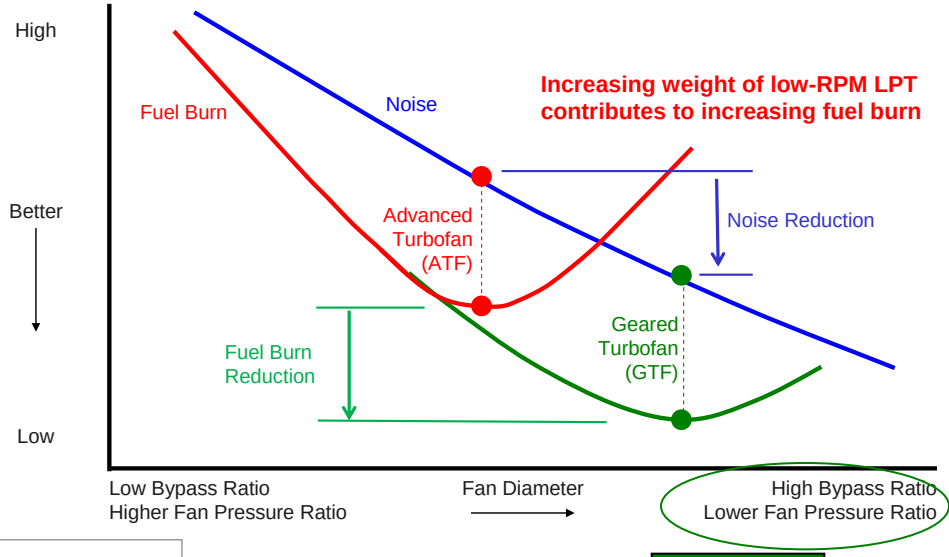
FAA CLEEN Technologies

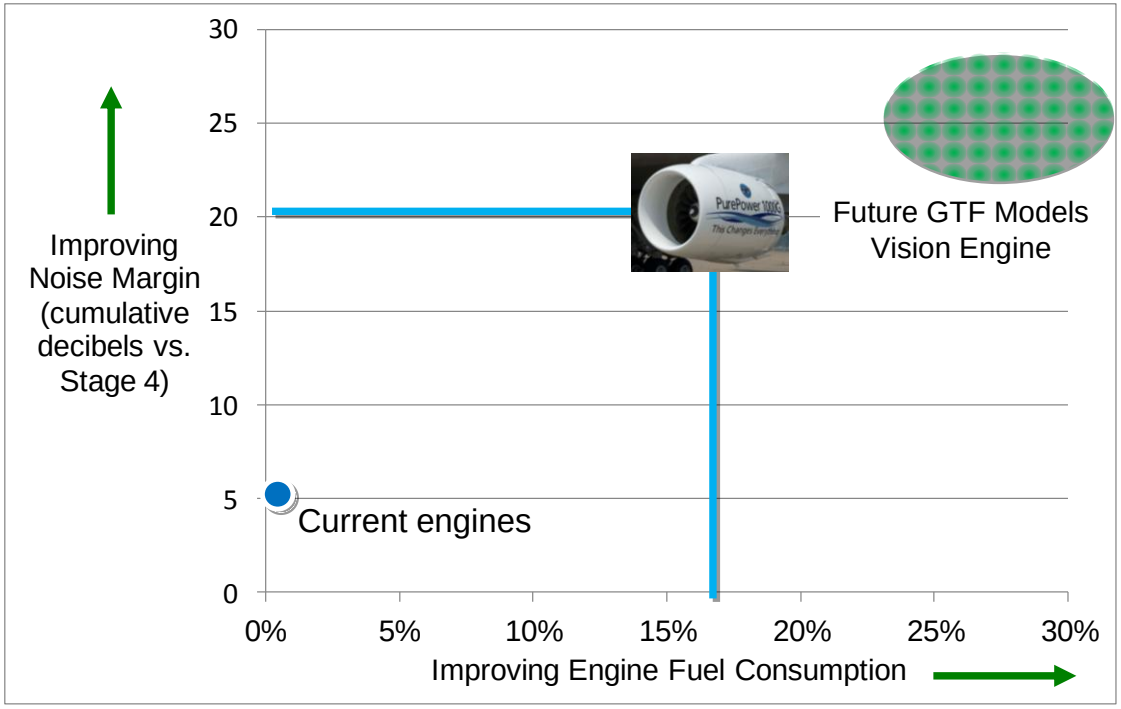
FAA CLEEN Technologies

Company	Technology	Goal Impact	Projected Performance
P&W	Ultra-high bypass ratio Geared Turbofan w/ advanced fan system with reduced weight and drag	Fuel-burn	> 20% reduction
		Emissions	60% reduction in NOx (re: CAEP 6)
		Noise	25 EPNdB reduction (re: Stage 4)

- UHB GTF technologies that leverage the overall GTF system benefits which we anticipate the market will demand in 2020 or beyond.

FAA CLEEN Technology





FAA CLEEN Demonstrator

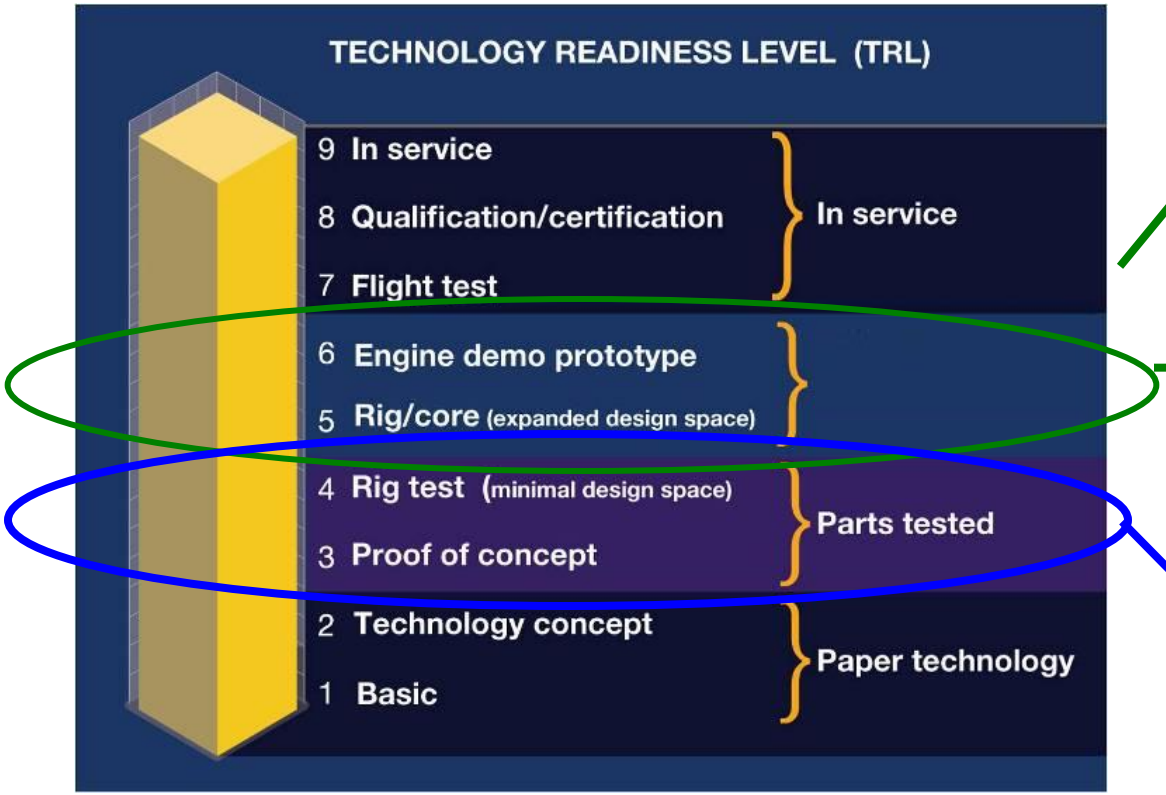
+

additional technologies

Technology Maturation in CLEEN

Technology Demonstration Will Follow Proven Process

FAA CLEEN



NASA Fan Rig

Test Asset Identified – Engine on Test Now

C Series PW1500G Platforms

PW1519G
19,000lbs

CS100

PW1521G
21,000lbs

CS100

CS300

PW1524G
23,300lbs

CS100 ER

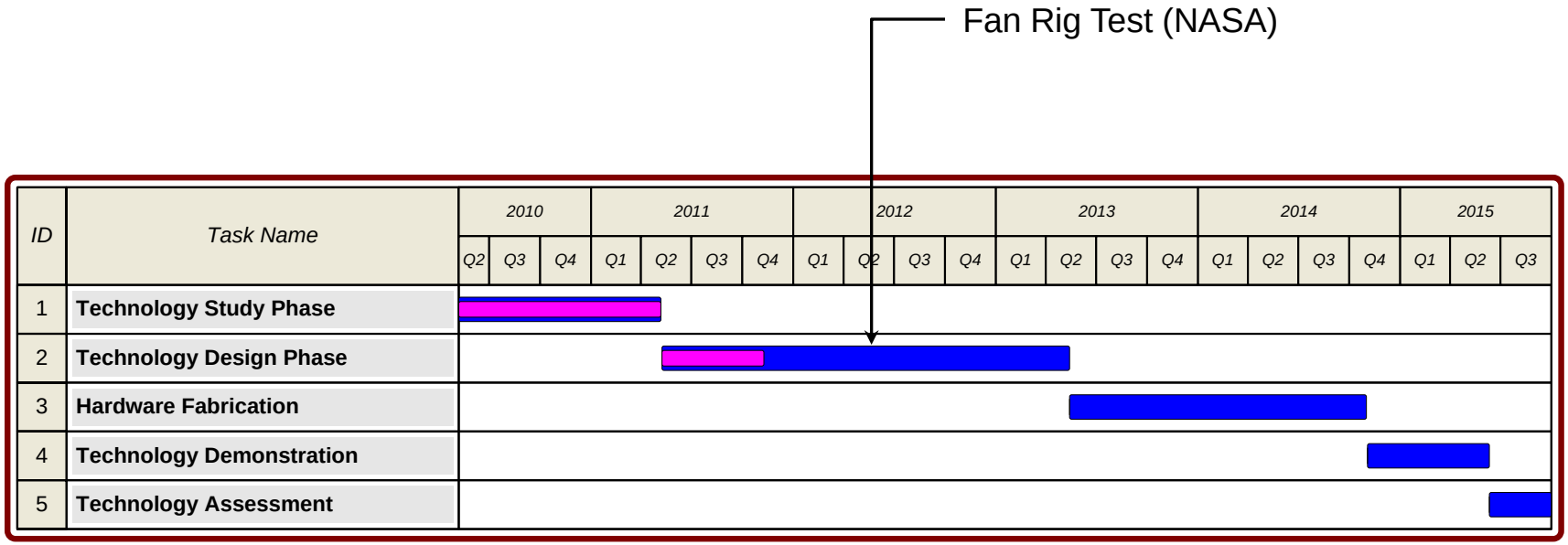
CS300 ER

CS300 XT

FAA CLEEN Program Status

FAA CLEEN Program Status

Program on Track for Successful Completion

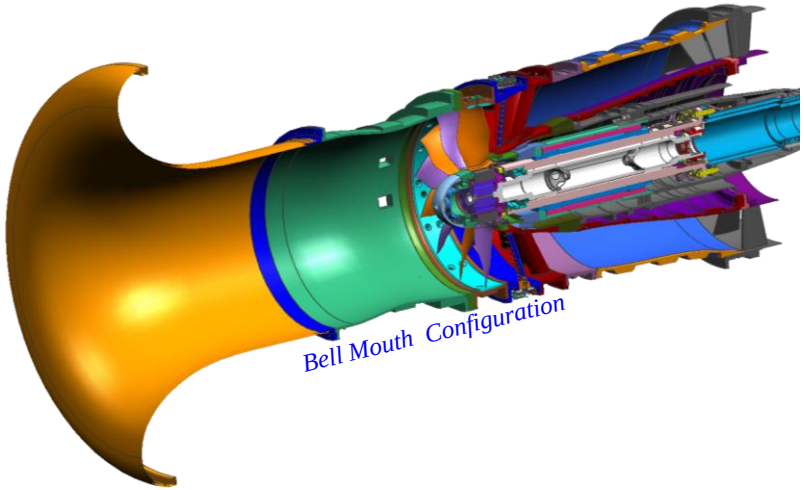


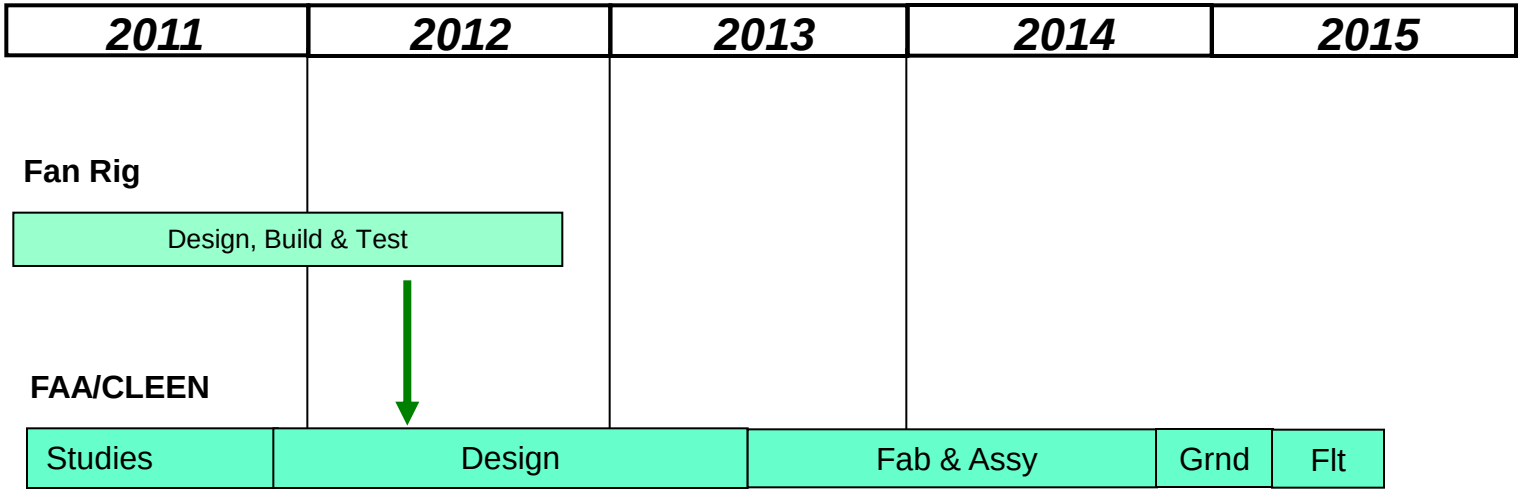
- Technology plan in place
- System studies show no major technical risks
- Test engine identified
- Close monitoring of NASA 22” fan rig

22” NASA Fan Rig

Fan Rig Will Provide Early Learning for CLEEN Technologies

- Fan system performance
- Aeromechanic response
- Operability mapping
- Acoustics





Studies Identify Test Engine Configuration

Studies Provide Path for Successful Preliminary Design

- Achieve required technology design space
- Maintain compatibility with existing flight test installation
- Meet operability requirements
- Within scope
- Configuration Options
  - Fan Design
  - Nacelle Design

- Evaluate
  - Performance
  - Operability
  - Safety
  - Cost

Configuration selected that meets all criteria and satisfies FAA CLEEN goals

FAA CLEEN Vision Engine

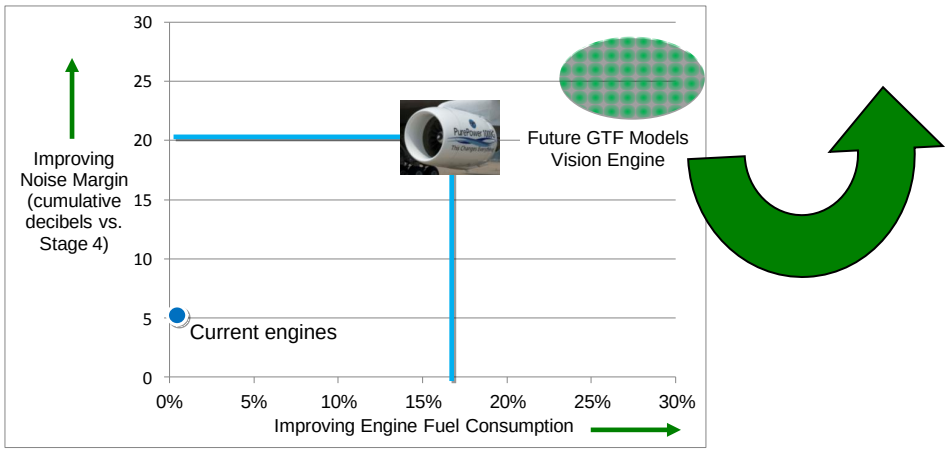
Propulsor
- High Bypass Ratio
- Improved Propulsor Efficiency
- Advanced Fan Drive Gear System

Core (HPC)
- Increased OPR
- Aero efficiency package

Core (HPT)
- Aero Efficiency Package
- Physics Based Design and Lifing Systems

LPT
- Aero Efficiency Package

Combustor
- Enhanced TALON X



Summary

- PW1000G family of engines demonstrating expected benefits of GTF architecture
  - Excellent foundation for achieving FAA CLEEN Goals
- PW1500G engine ideal candidate for high bypass ratio technology demonstrator vehicle
  - Asset identified for FAA CLEEN testing
- P&W progressing in maturing high bypass ratio technologies through ground & flight testing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