FAA CLEEN

October 27, 2010
Atlanta, GA

UTC

Business and Technology

Hamilton Sundstrand

Pratt & Whitney

Sikorsky

Otis

UTC Fire & Security

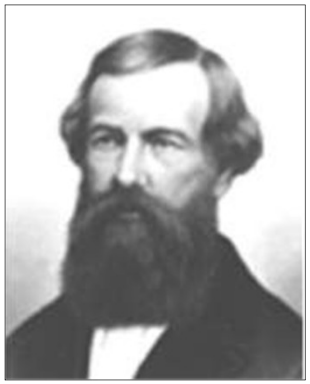
UTC Power

Carrier

UTC

Pioneers

Willis Carrier



Elisha Graves Otis

Igor Sikorsky

Fred Rentschler

Thomas Hamilton

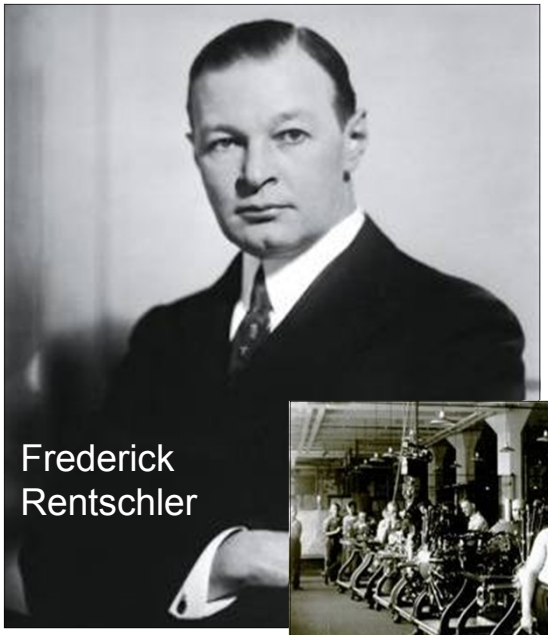
David Sundstrand

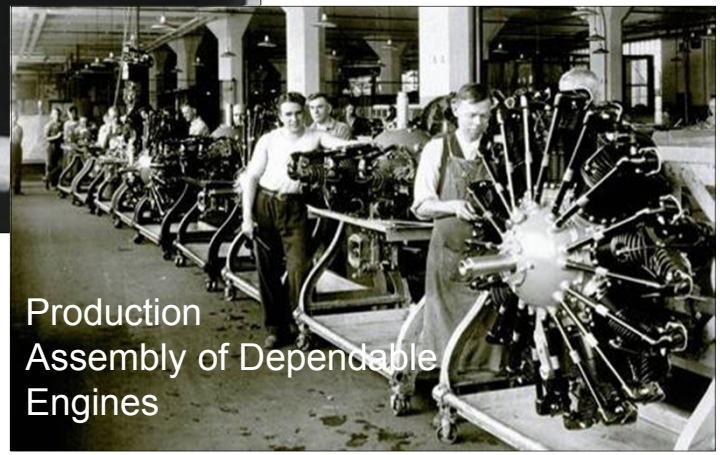
Charles Chubb

Walter Kidde

History

Dependable Engines

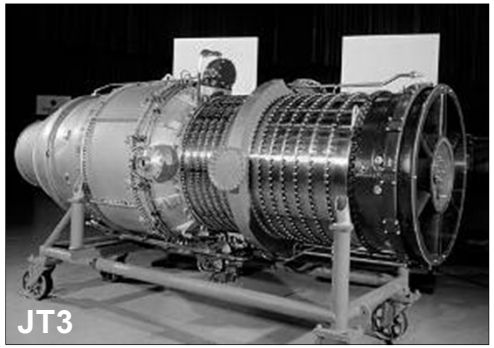

Frederick Rentschler


Production Assembly of Dependable Engines

"The best airplanes can only be designed around the best engines." - Frederick Rentschler

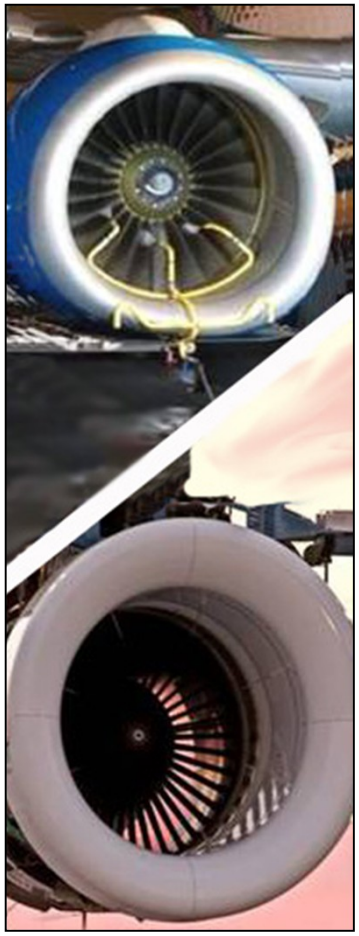
Innovation

Milestones



Pratt & Whitney

Leading Industry Change



Commercial Engines and Global Services

P&W Rocketdyne

Power Systems

P&W Canada

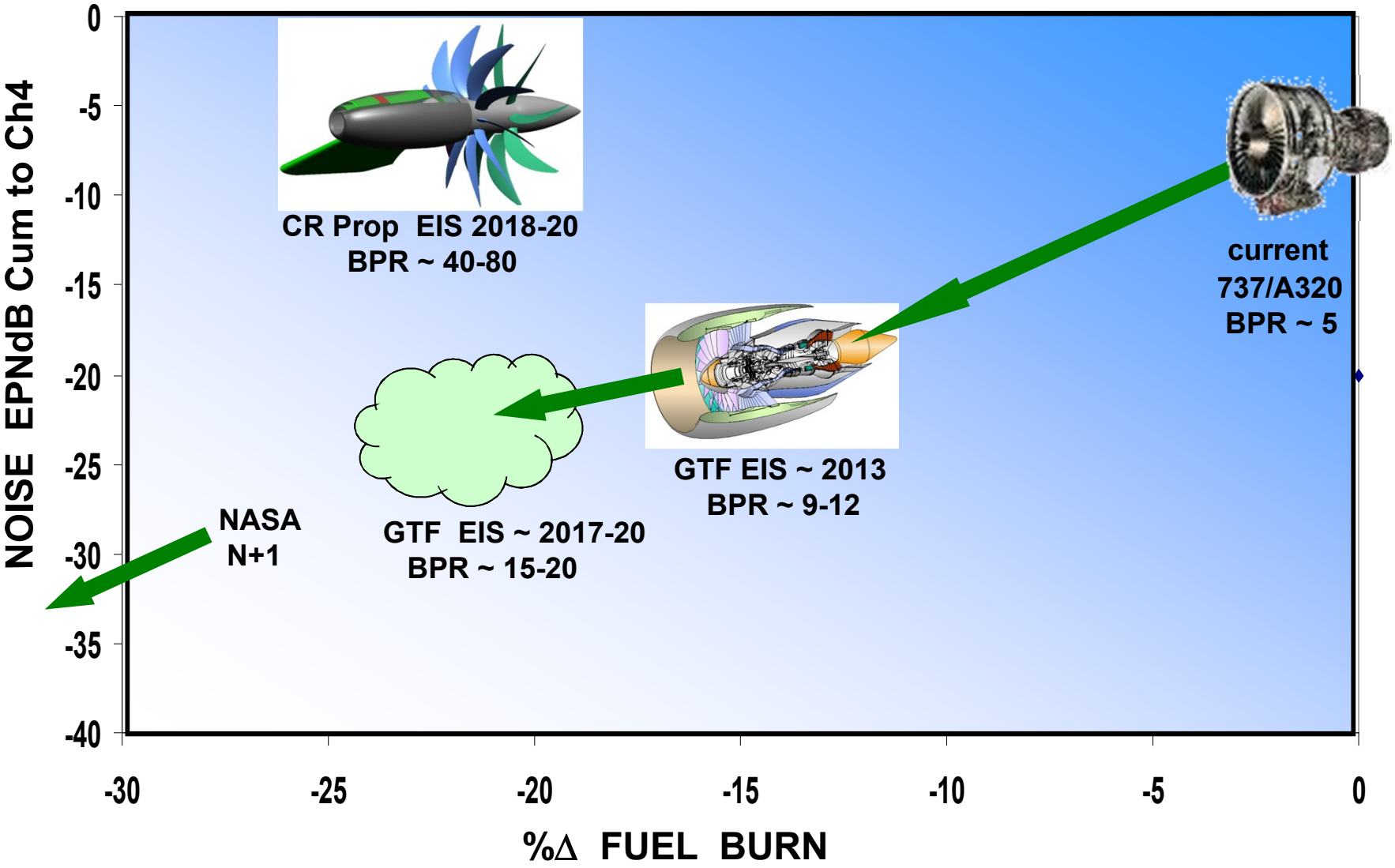
Military Engines

GTF Development On-Track

October – First Engine to Test

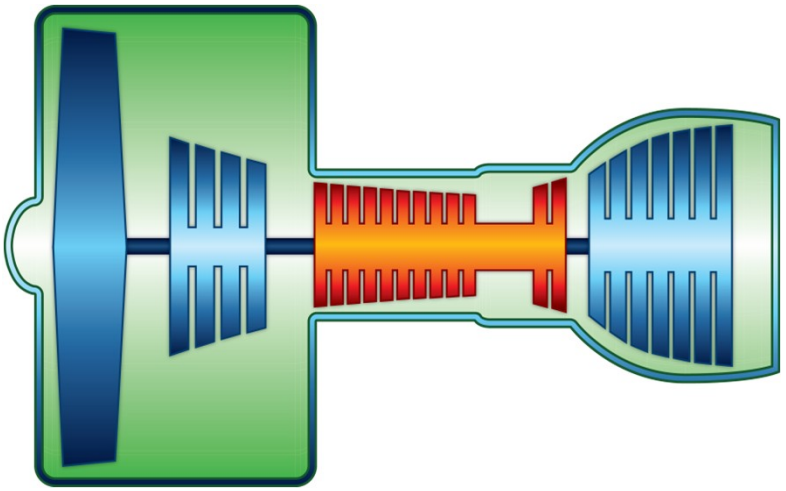
GTF Propulsion Architecture

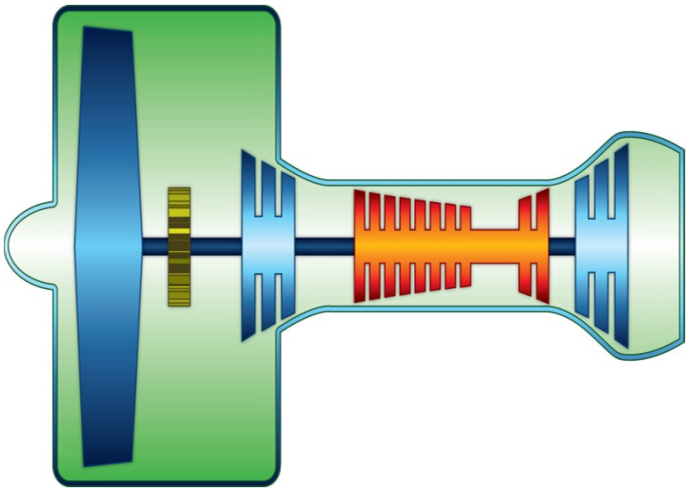
Lowest Fuel Burn + Noise



Why the Geared Turbofan?

Geared Turbofan Relative to Direct Drive

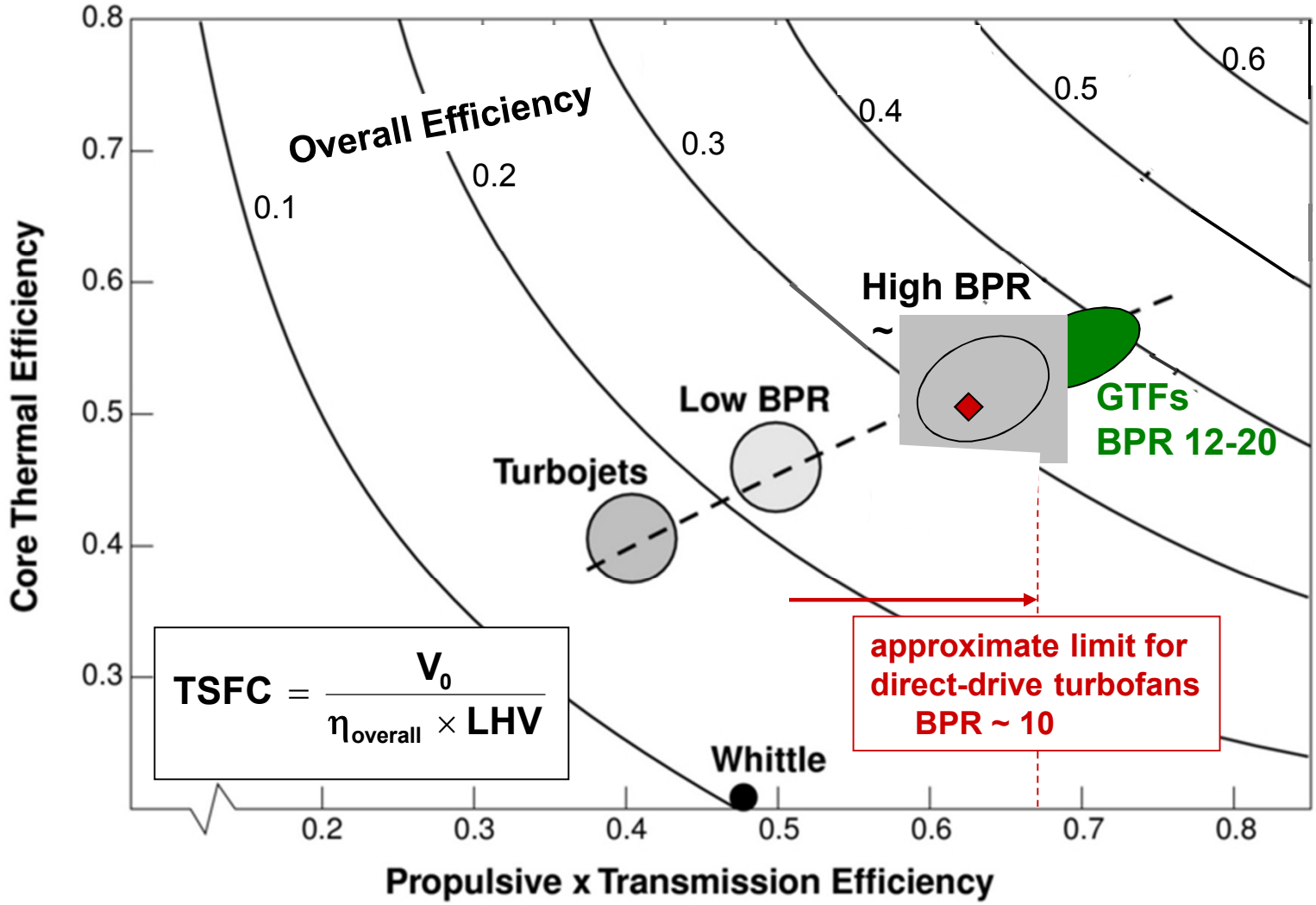




fuel maint. noise

Fuel Efficiency Drives Engine Thermodynamic Cycle

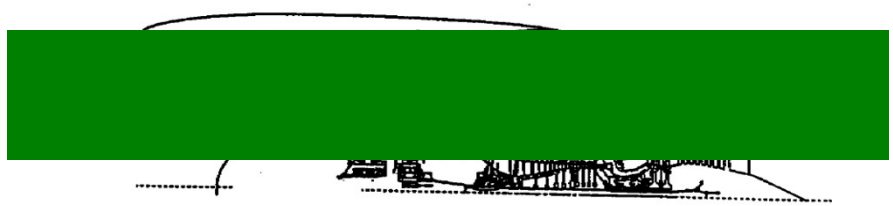
Thermal Efficiency → High OPR, T4 Propulsive Efficiency → Low FPR
GTFs Enable Further Increase in Propulsive Efficiency Beyond DDTF Limit
Combine with High-OPR Advanced Core for Max Overall TSFC Improvement



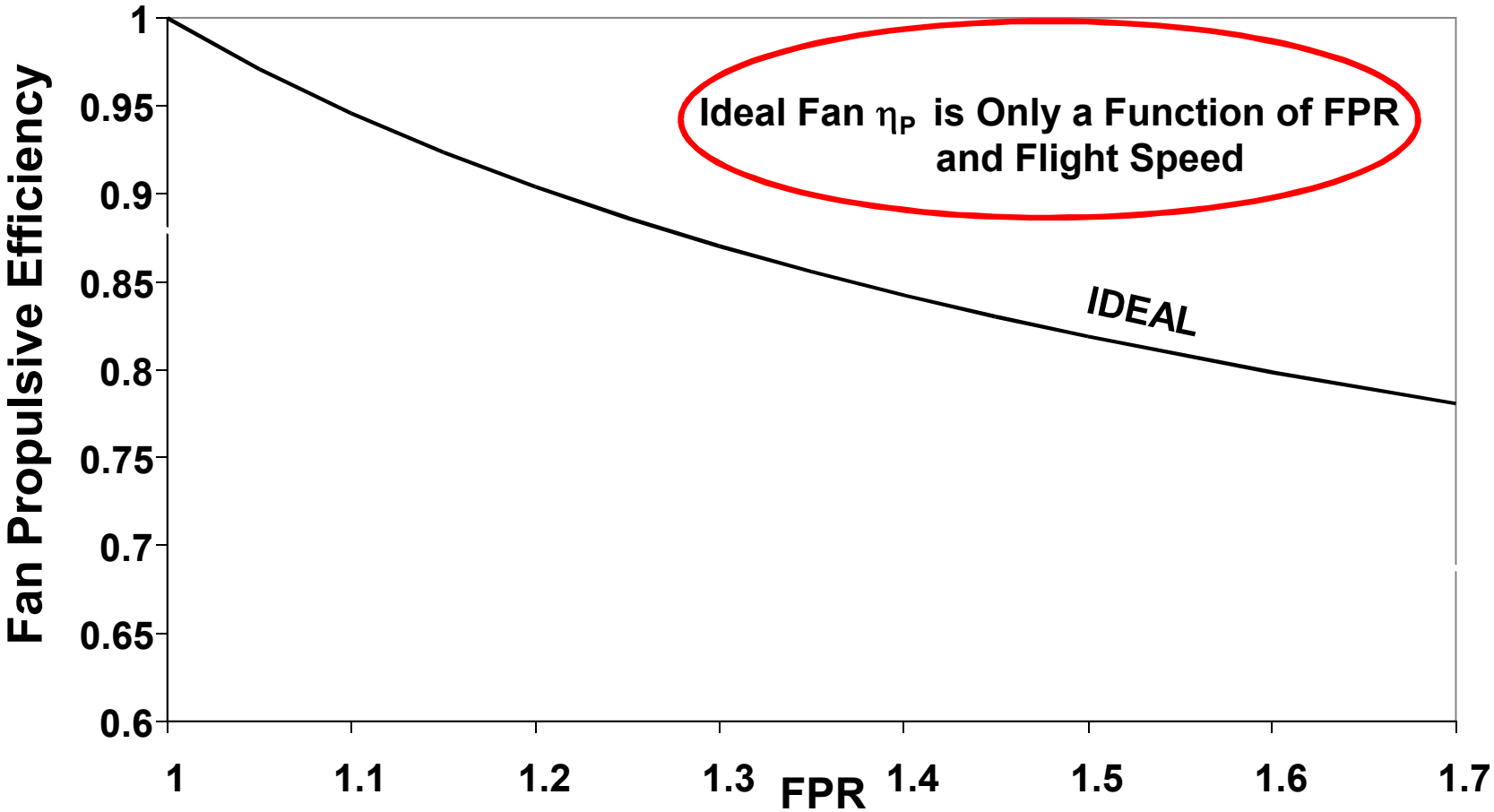
$$TSFC = \frac{V_0}{\eta_{overall} \times LHV}$$

Propulsive Efficiency for Fan Bypass System

Flight Mach = 0.80

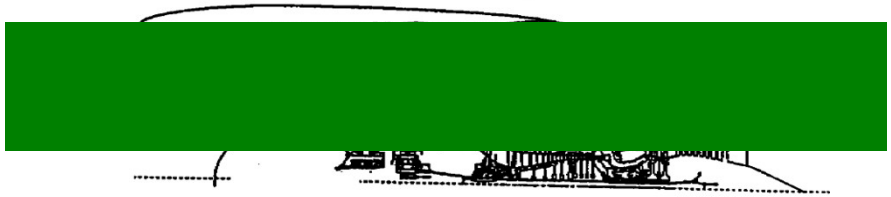


$$\eta_{Pfan} = \frac{F_{Nfan} V_0}{SHP_{fan}}$$

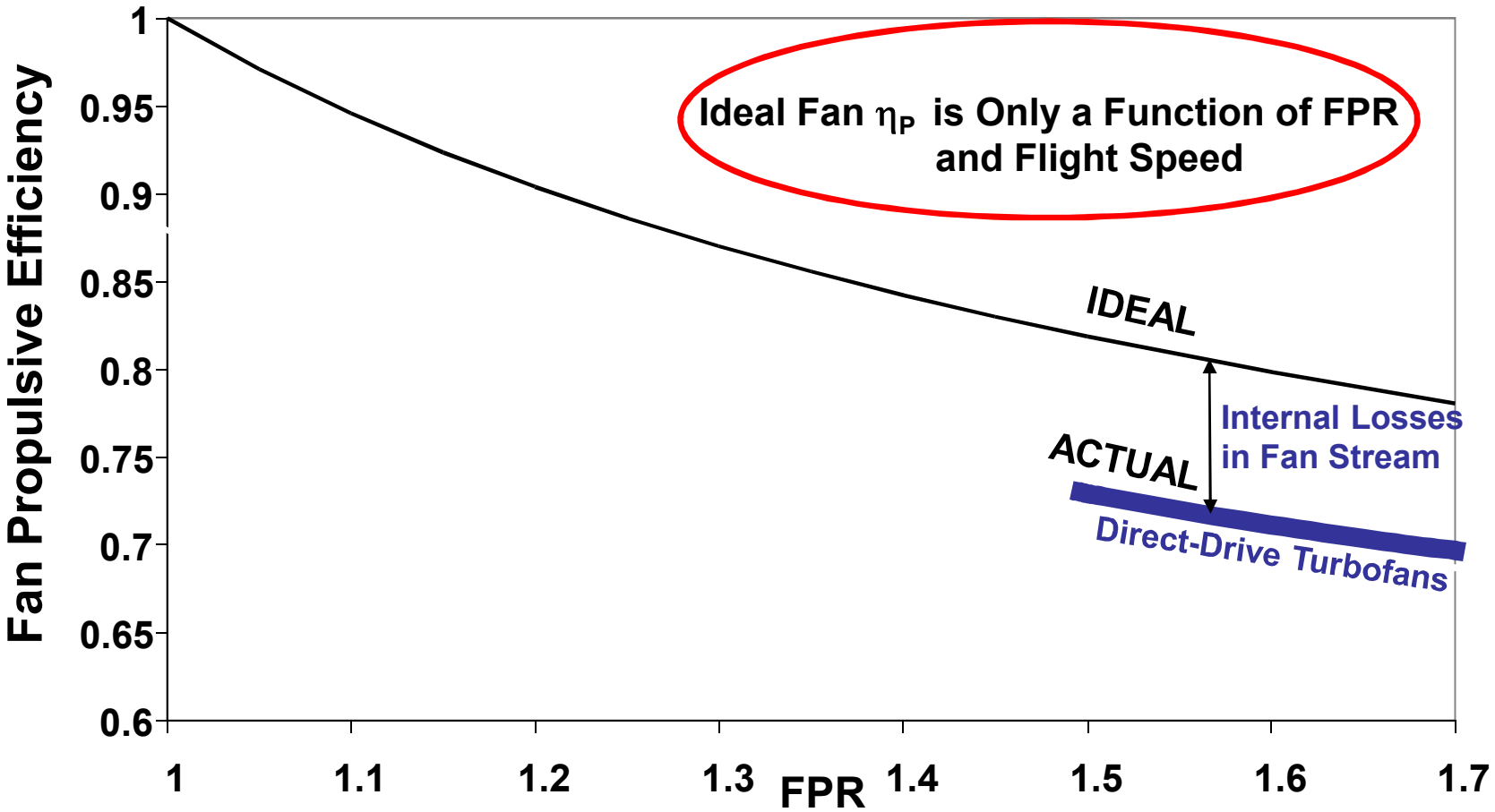


Propulsive Efficiency for Fan Bypass System

Flight Mach = 0.80

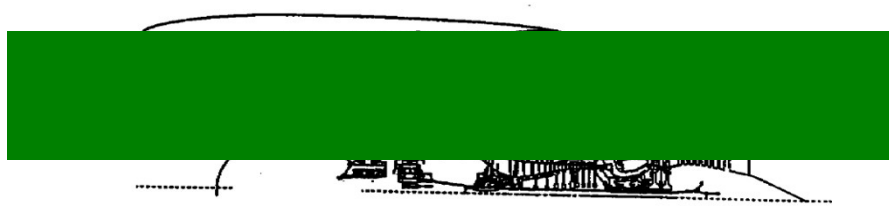


$$\eta_{Pfan} = \frac{F_{Nfan} V_0}{SHP_{fan}}$$

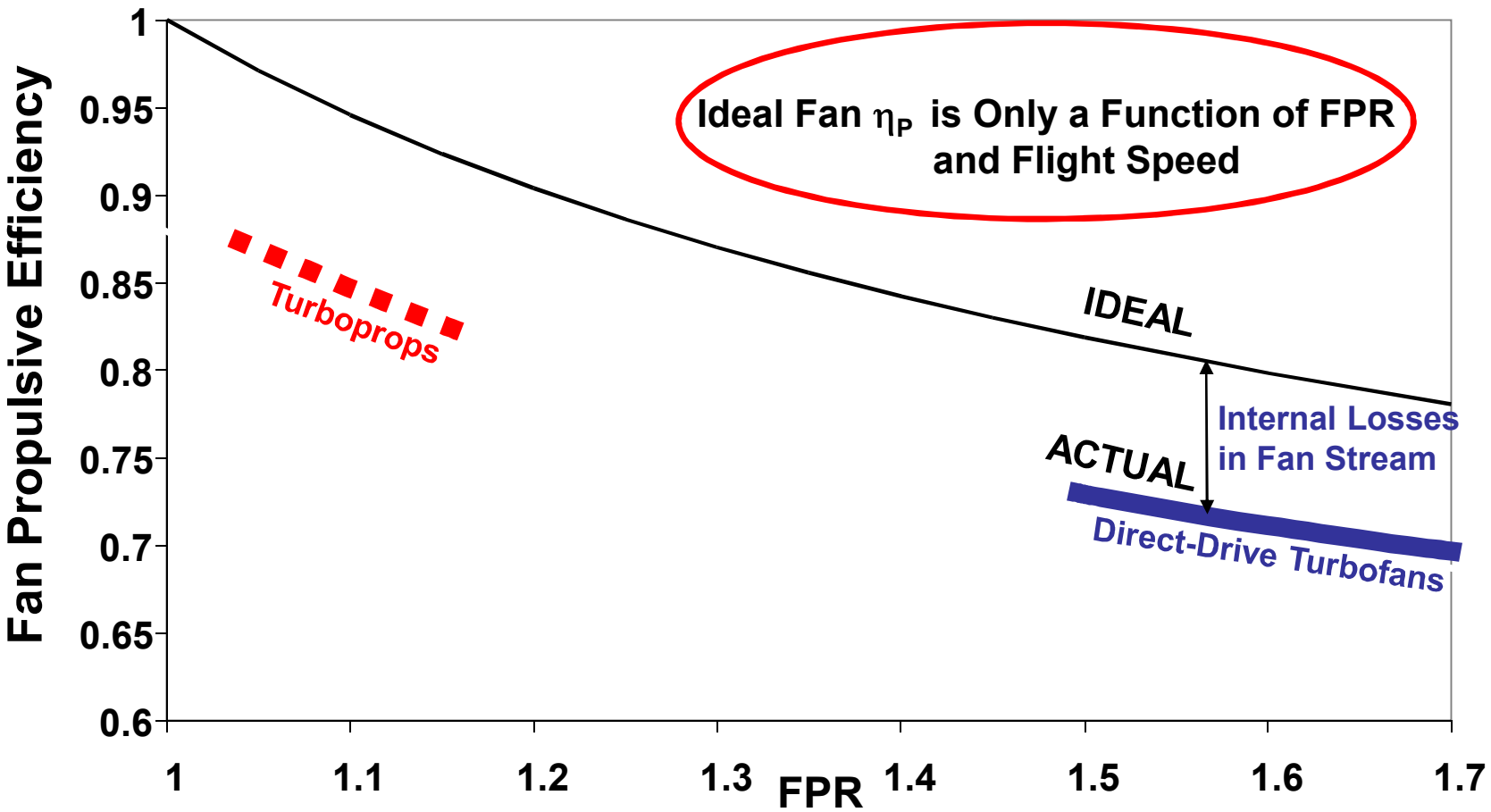


Propulsive Efficiency for Fan Bypass System

Flight Mach = 0.80

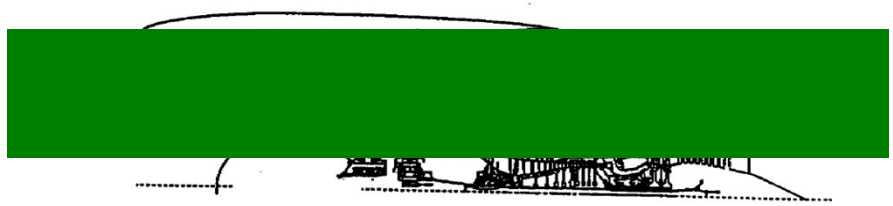


$$\eta_{Pfan} = \frac{F_{Nfan} V_0}{SHP_{fan}}$$

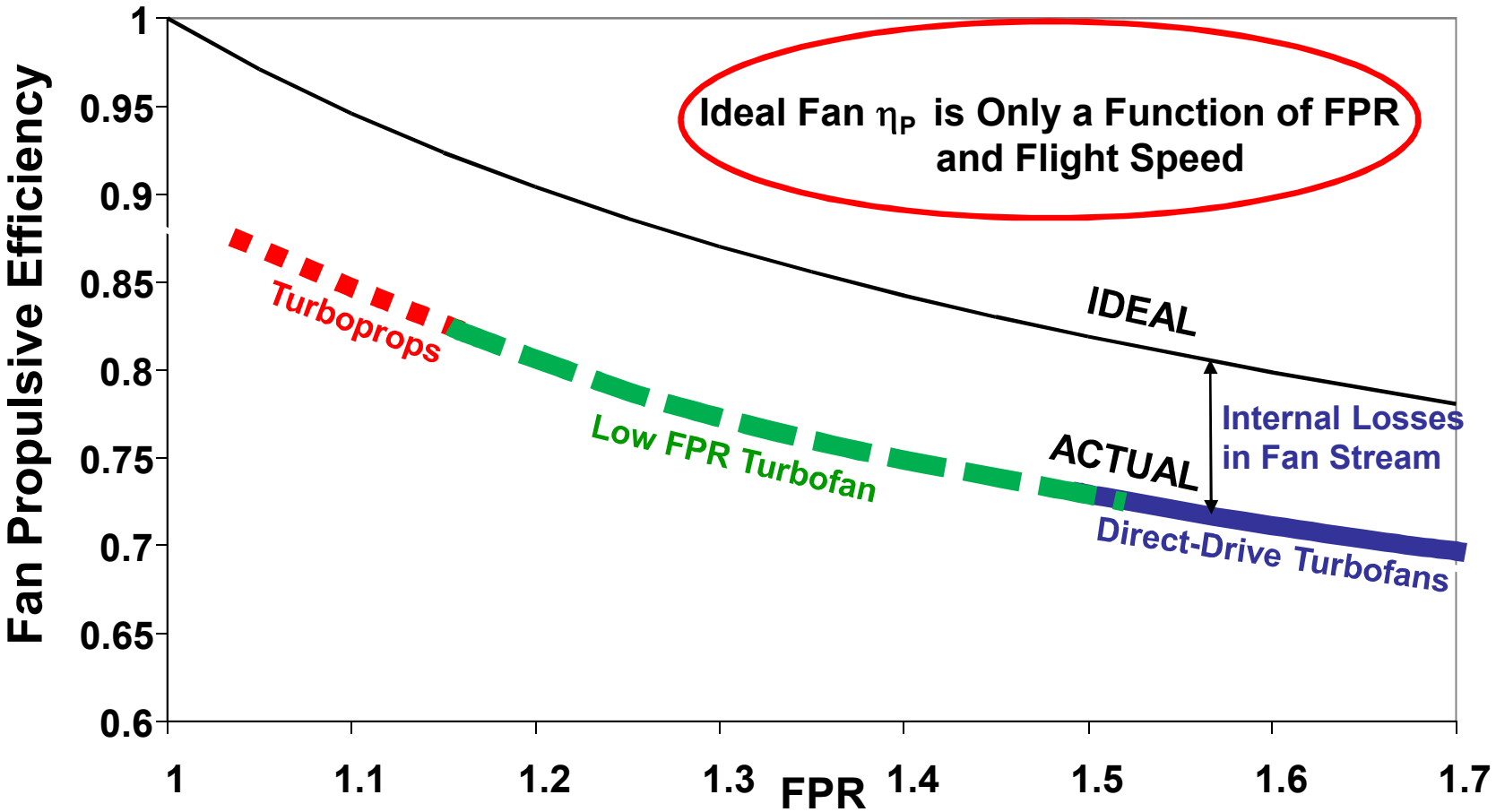


Propulsive Efficiency for Fan Bypass System

Flight Mach = 0.80

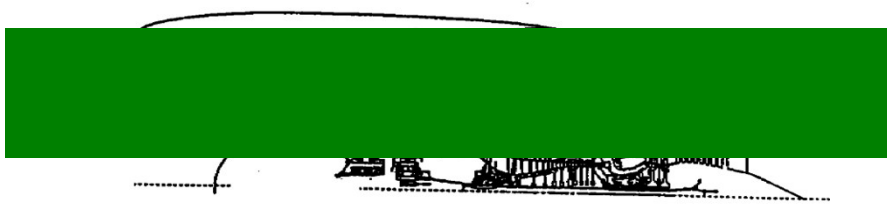


$$\eta_{Pfan} = \frac{F_{Nfan} V_0}{SHP_{fan}}$$

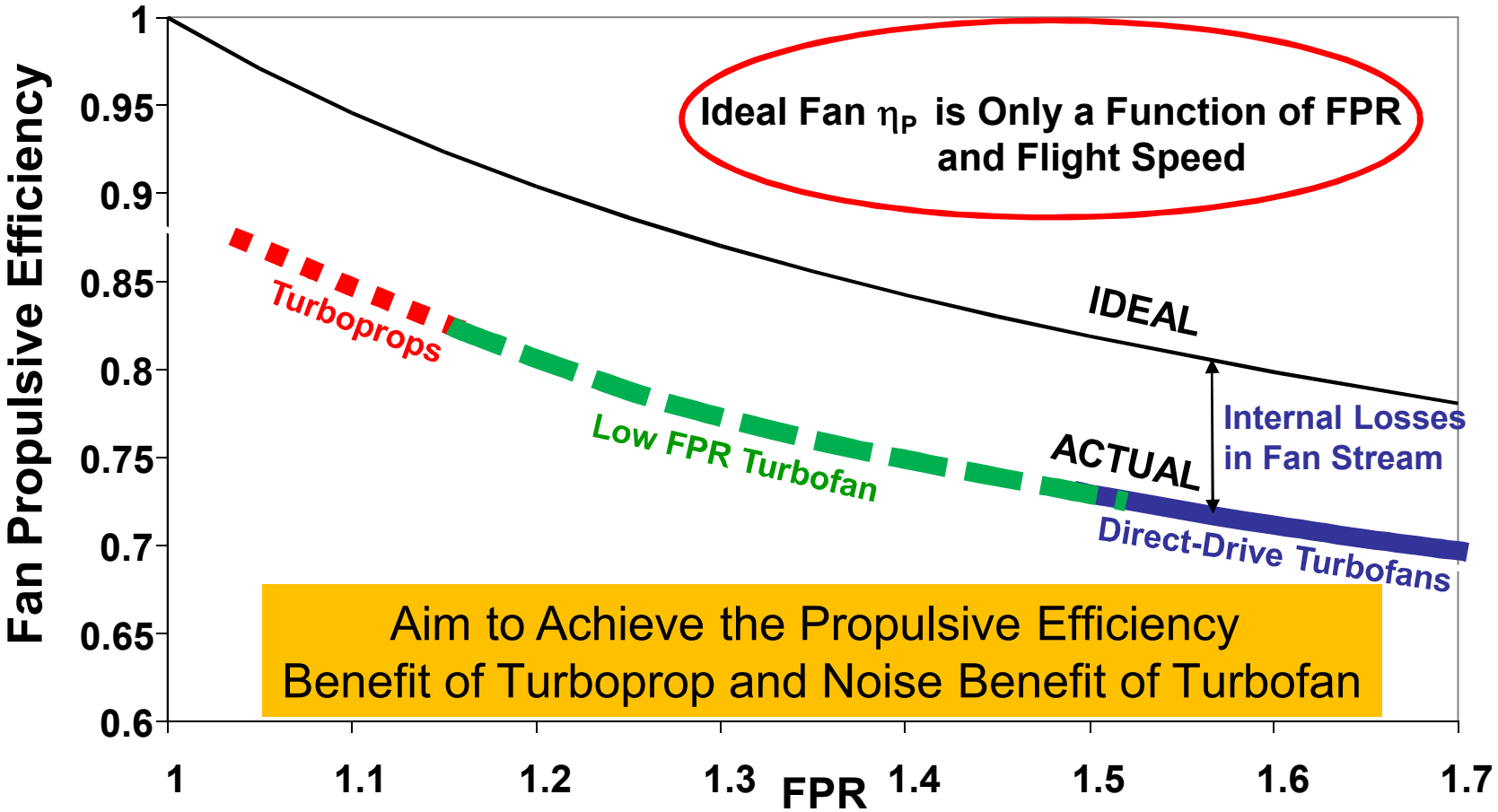


Propulsive Efficiency for Fan Bypass System

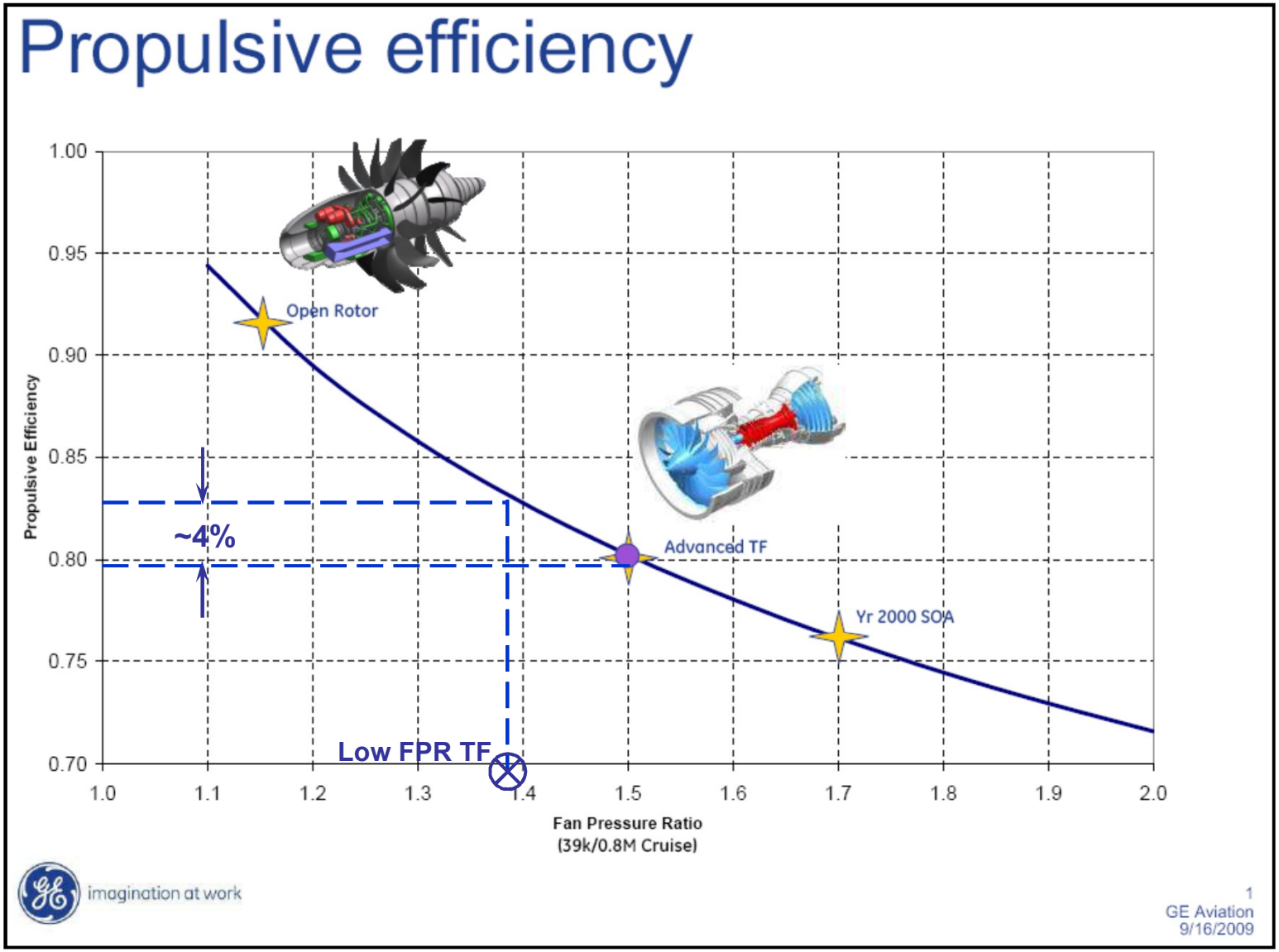
Flight Mach = 0.80



$$\eta_{Pfan} = \frac{F_{Nfan} V_0}{SHP_{fan}}$$

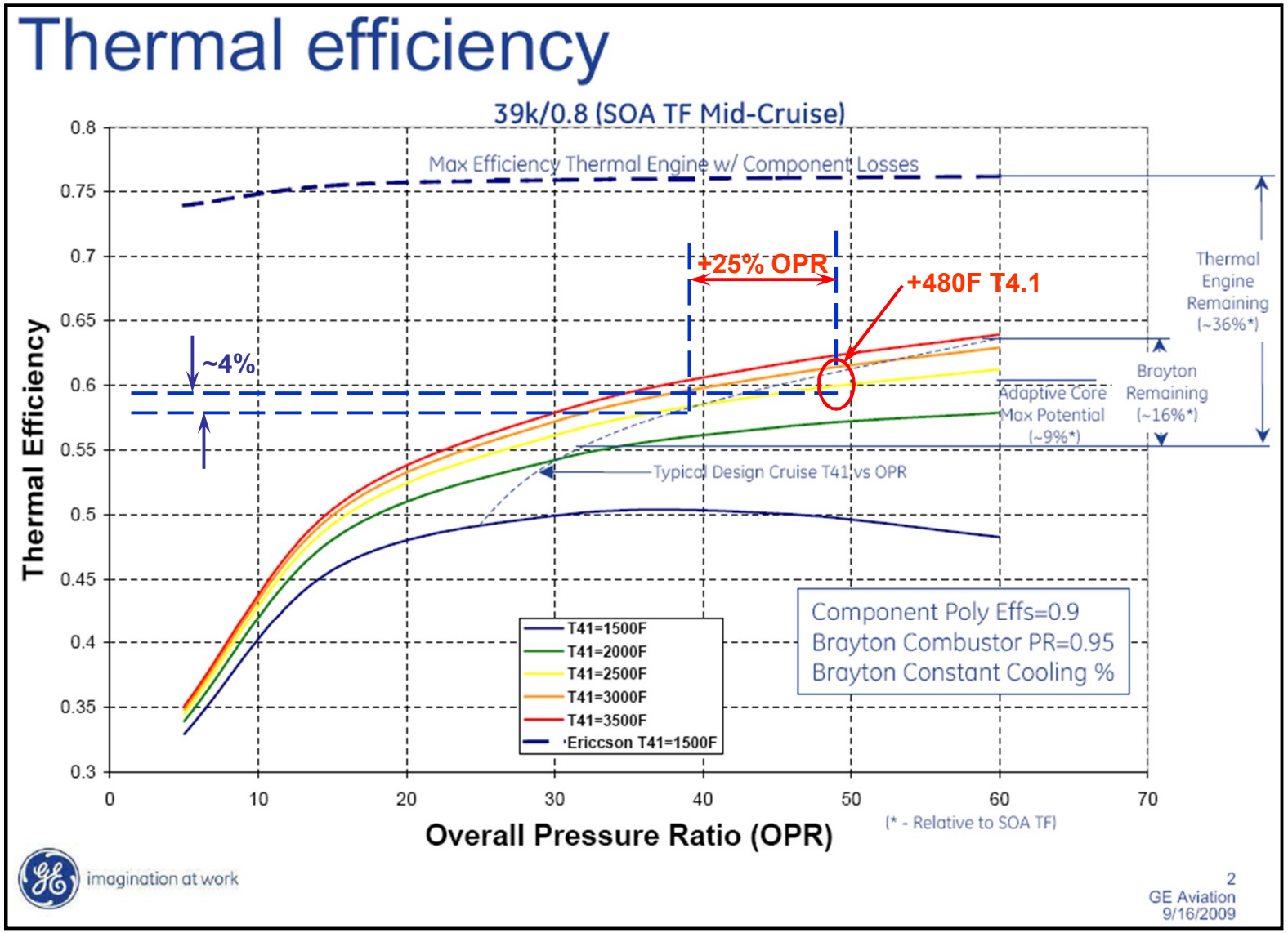


Propulsive Efficiency – Another Perspective



Source: 19th ISABE Conference, Montreal, CANADA, September 2009

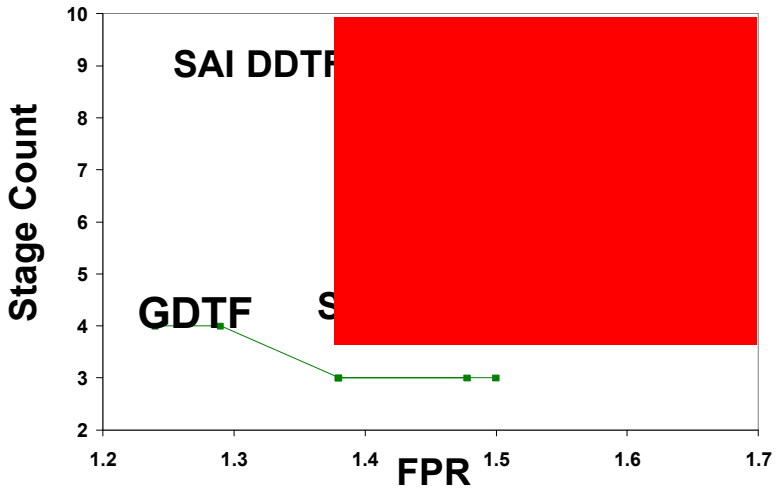
Thermal Efficiency – Another Perspective



Source: 19th ISABE Conference, Montreal, CANADA, September 2009

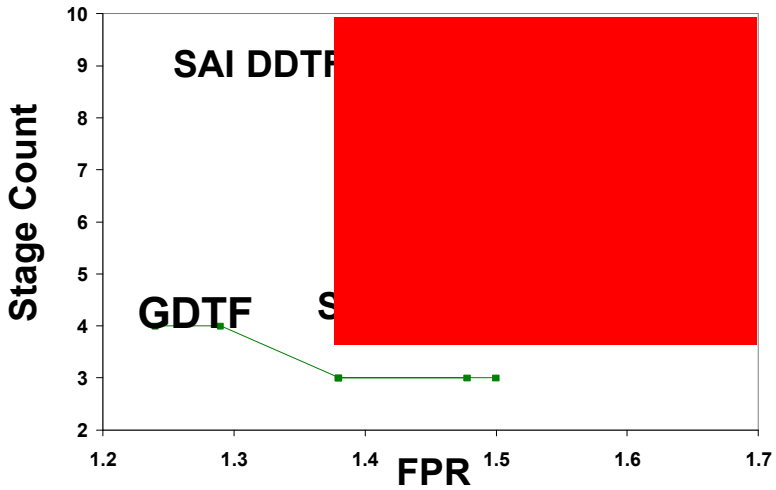
Power Turbine / Transfer Efficiency

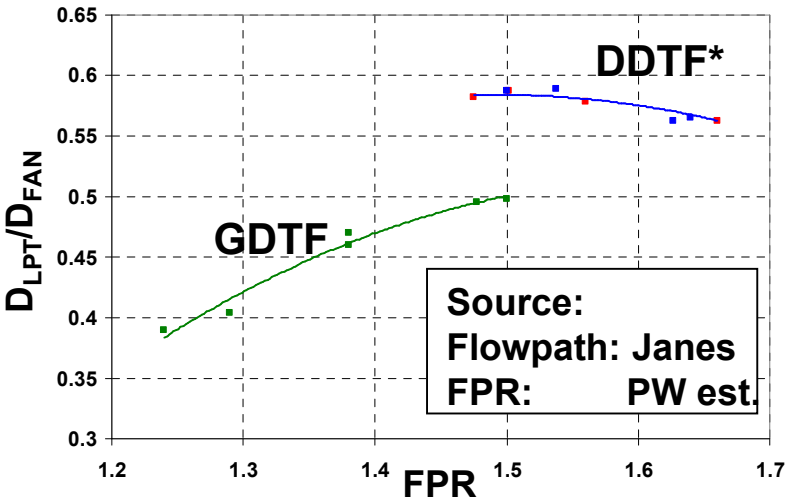
High-Speed Power Turbine Enables Installation, Low Weight and High Efficiency



Power Turbine / Transfer Efficiency

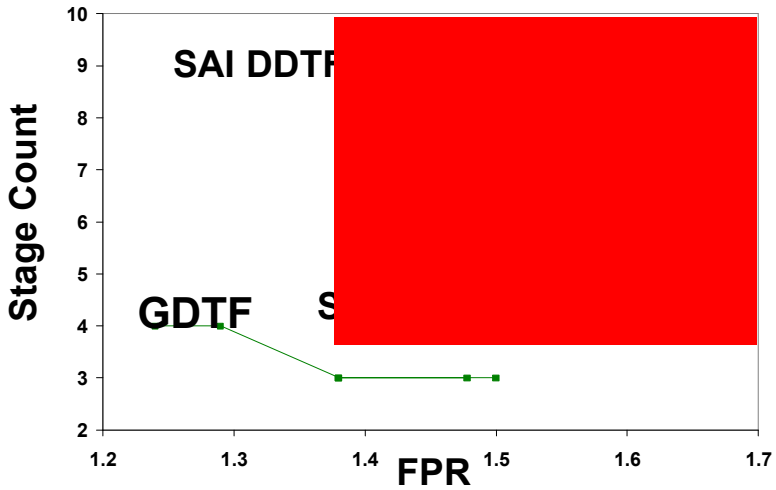
High-Speed Power Turbine Enables Installation, Low Weight and High Efficiency

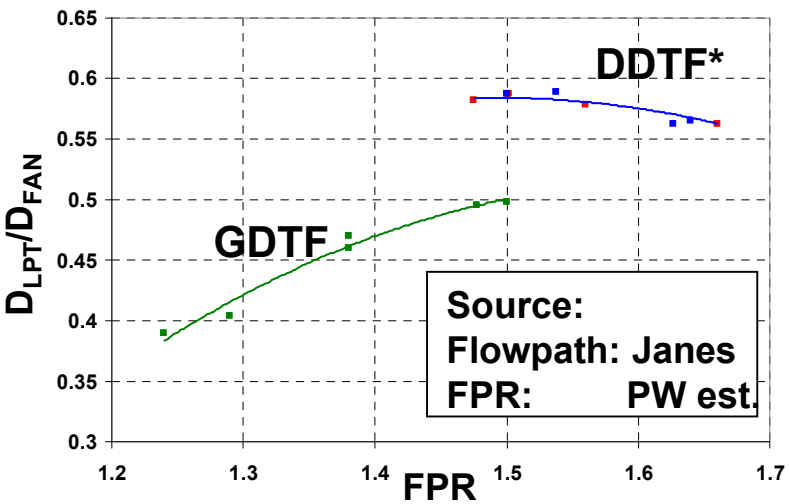


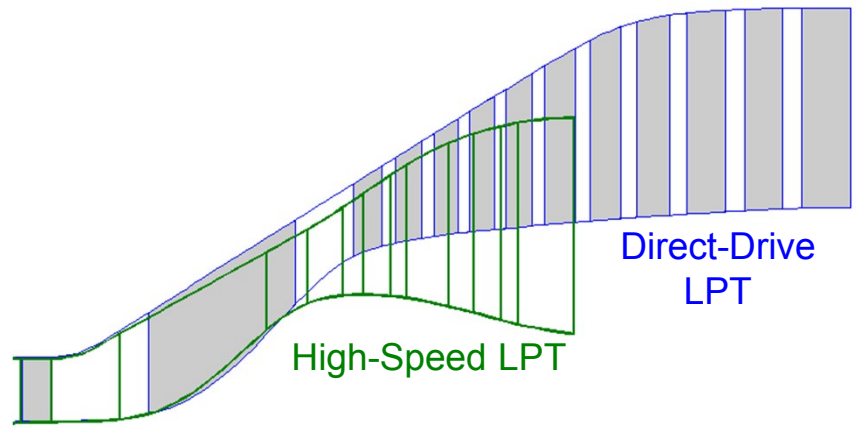


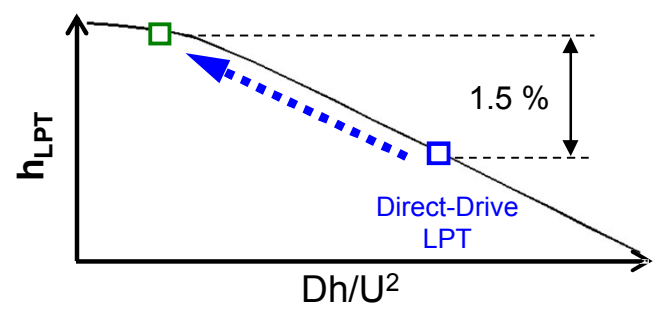
Power Turbine / Transfer Efficiency

High-Speed Power Turbine Enables Installation, Low Weight and High Efficiency



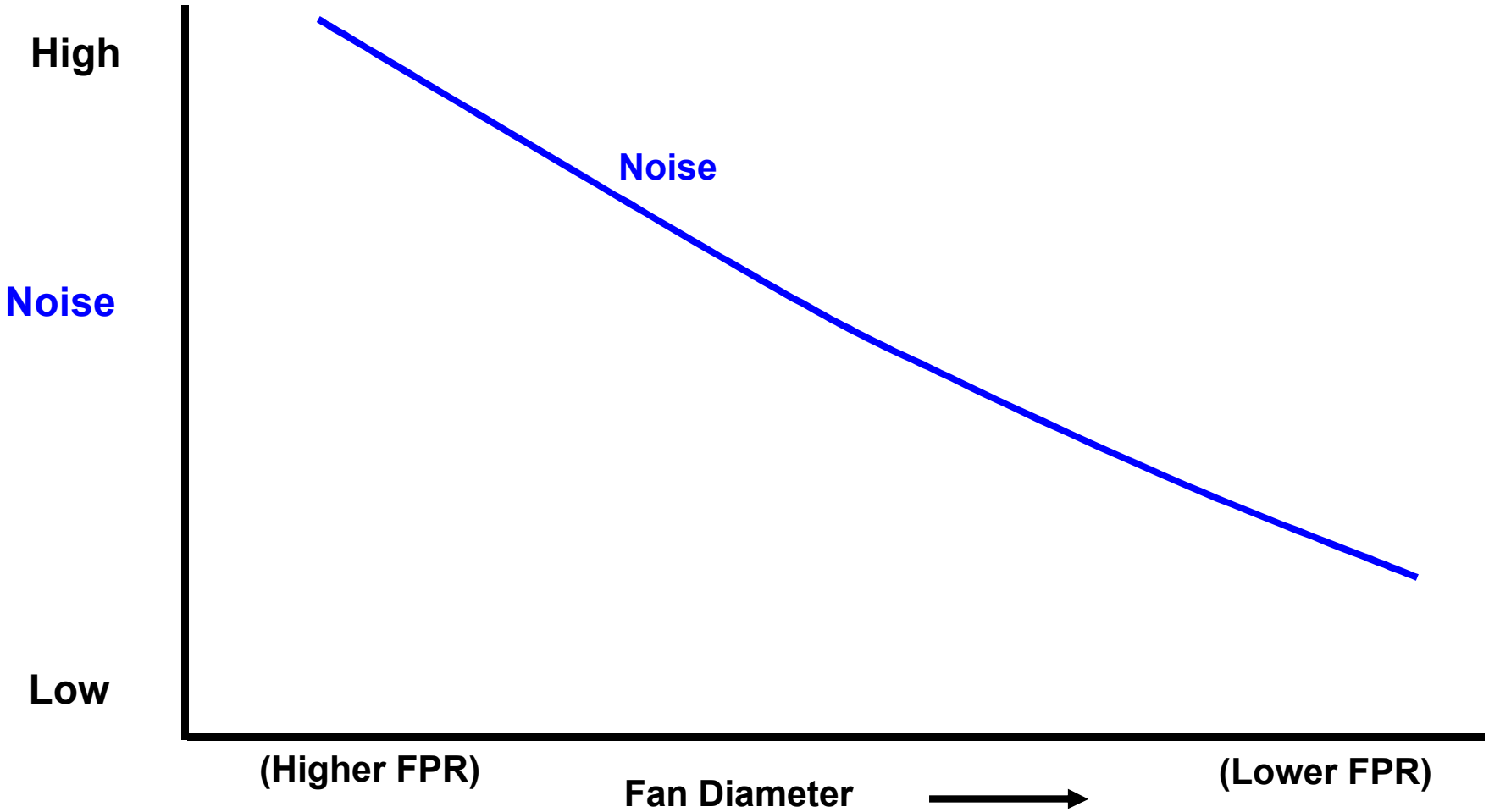






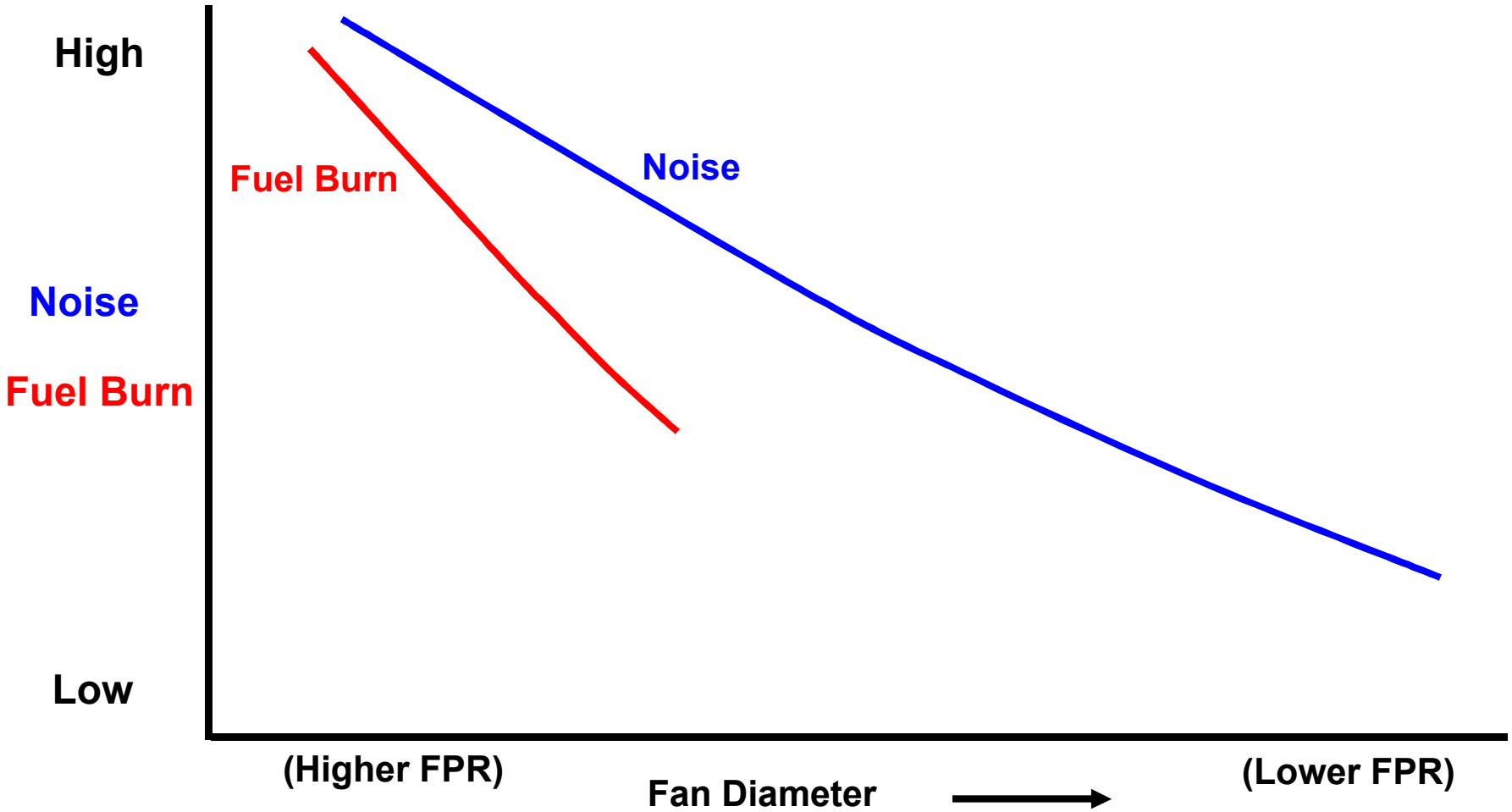
Fundamental Propulsion System Characteristic

Gear Driven Propulsor Enables Improved Fuel Burn and Lower Noise



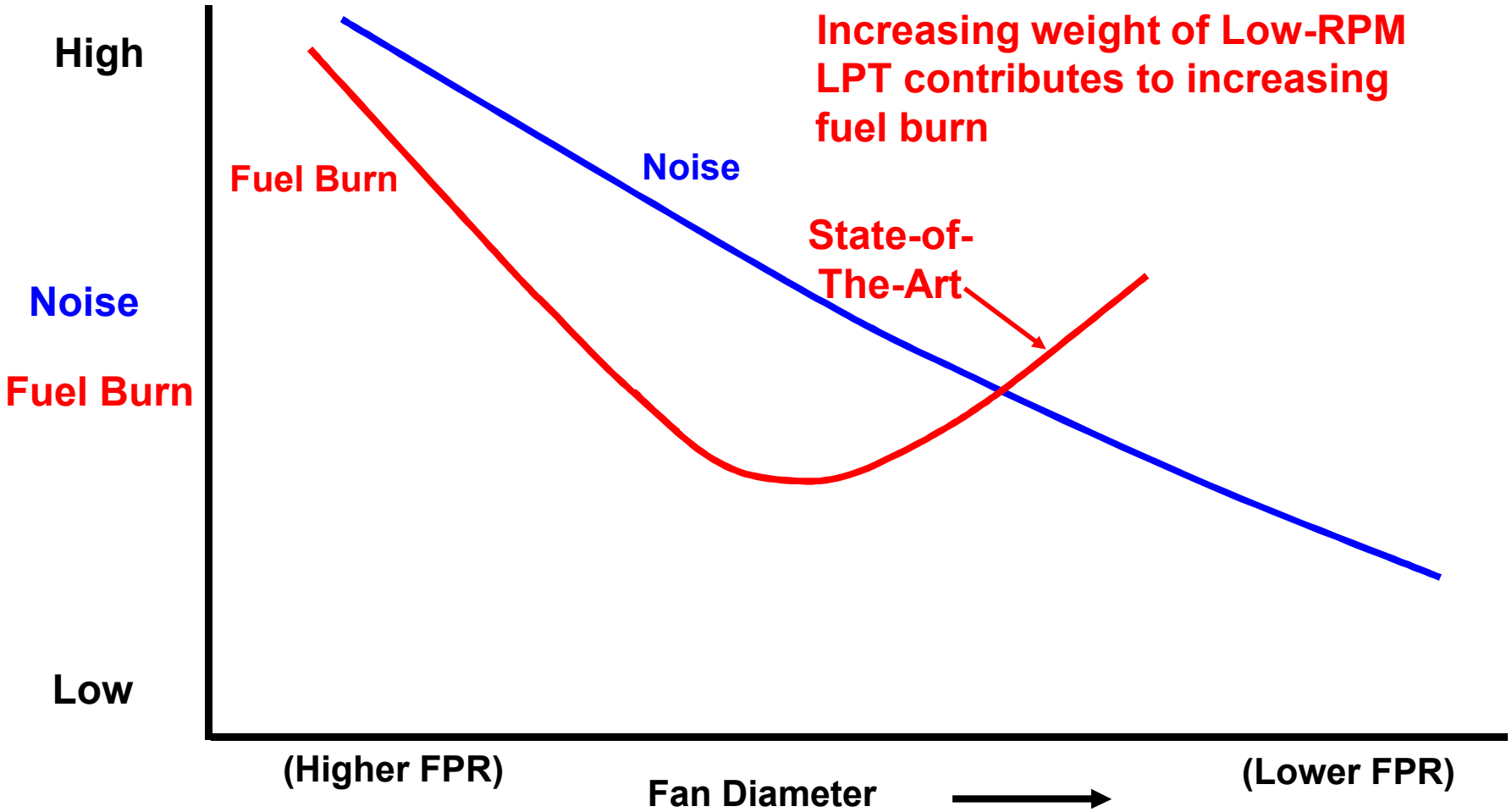
Fundamental Propulsion System Characteristic

Gear Driven Propulsor Enables Improved Fuel Burn and Lower Noise



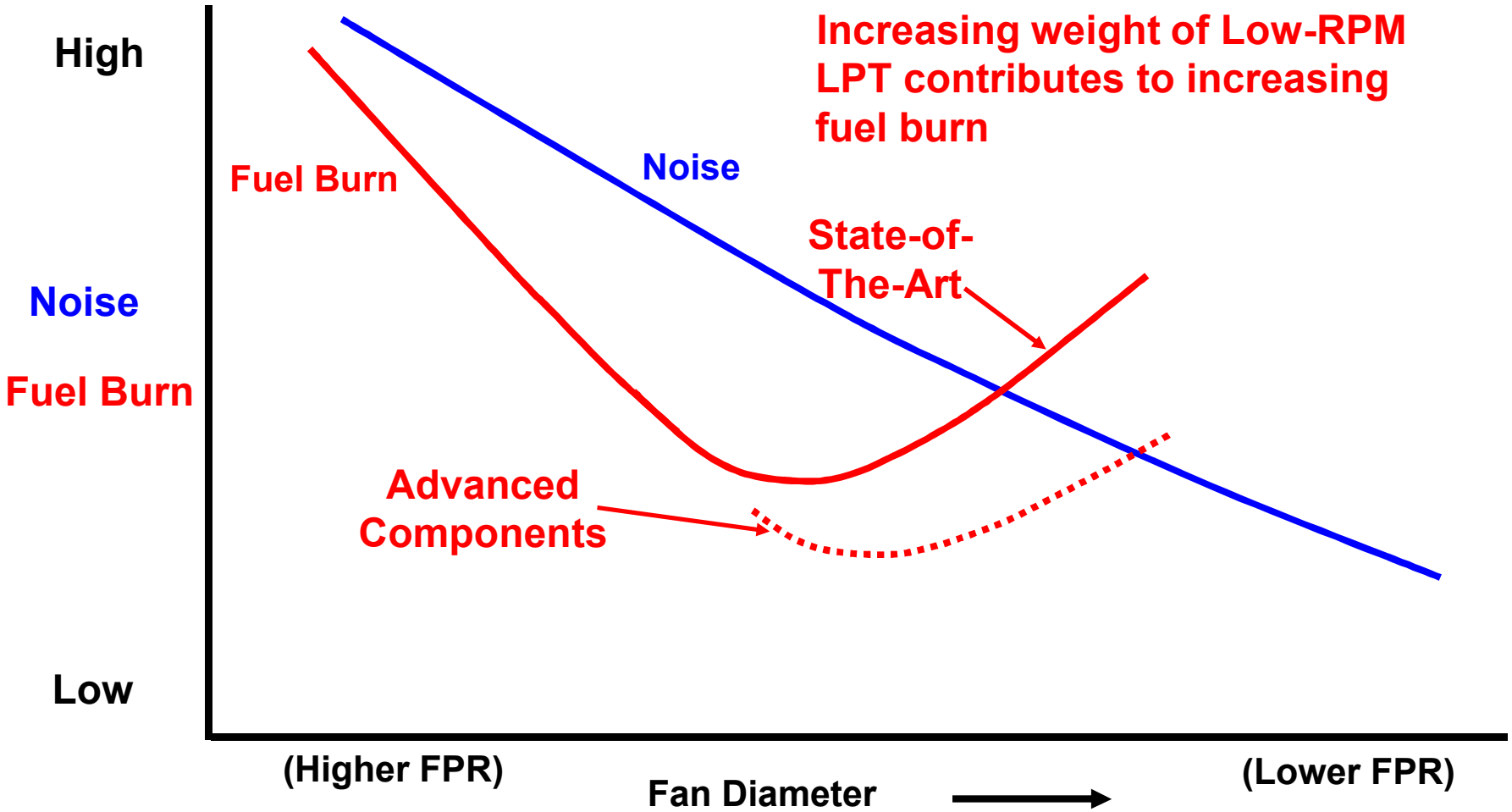
Fundamental Propulsion System Characteristic

Gear Driven Propulsor Enables Improved Fuel Burn and Lower Noise



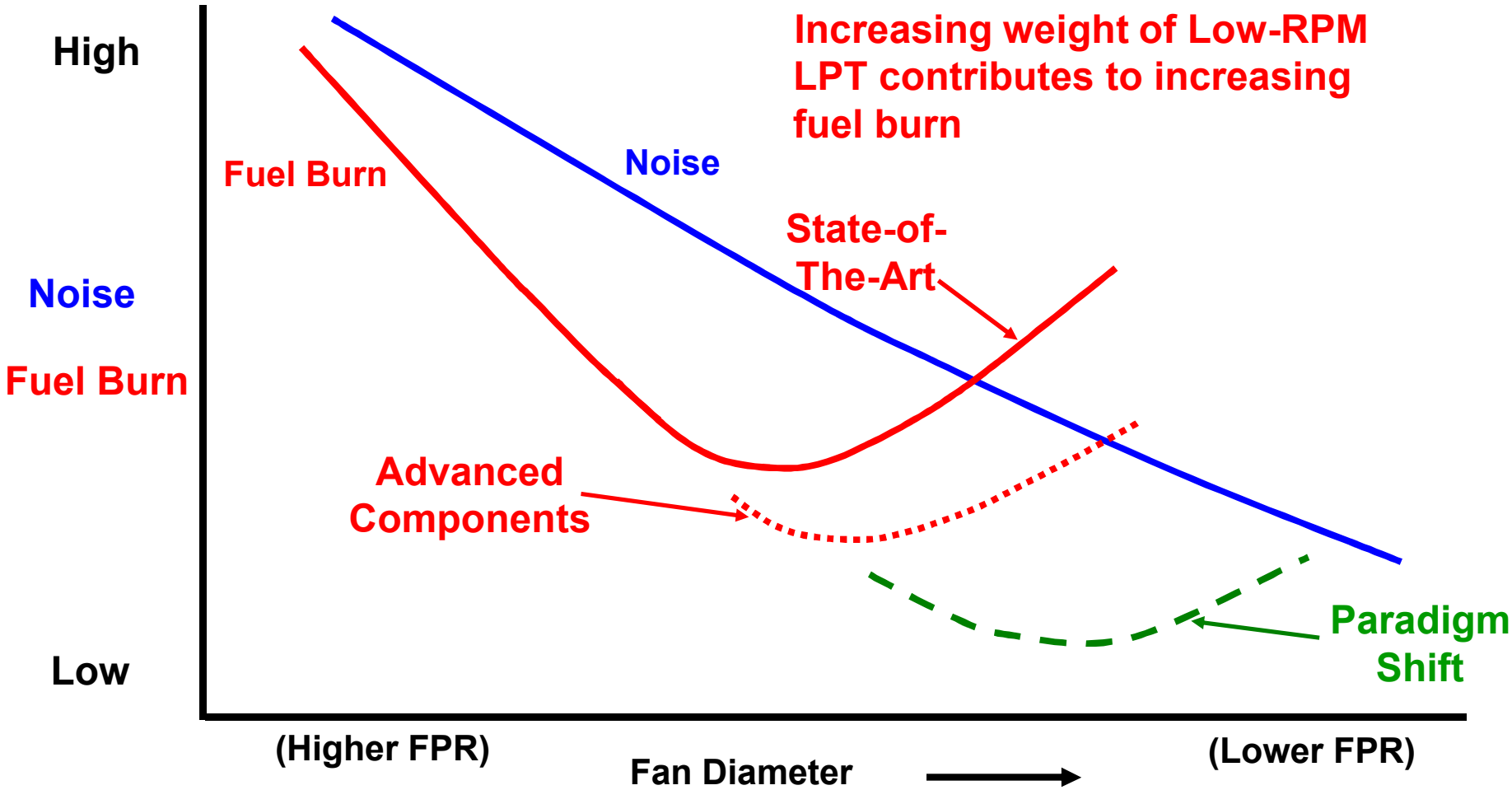
Fundamental Propulsion System Characteristic

Gear Driven Propulsor Enables Improved Fuel Burn and Lower Noise



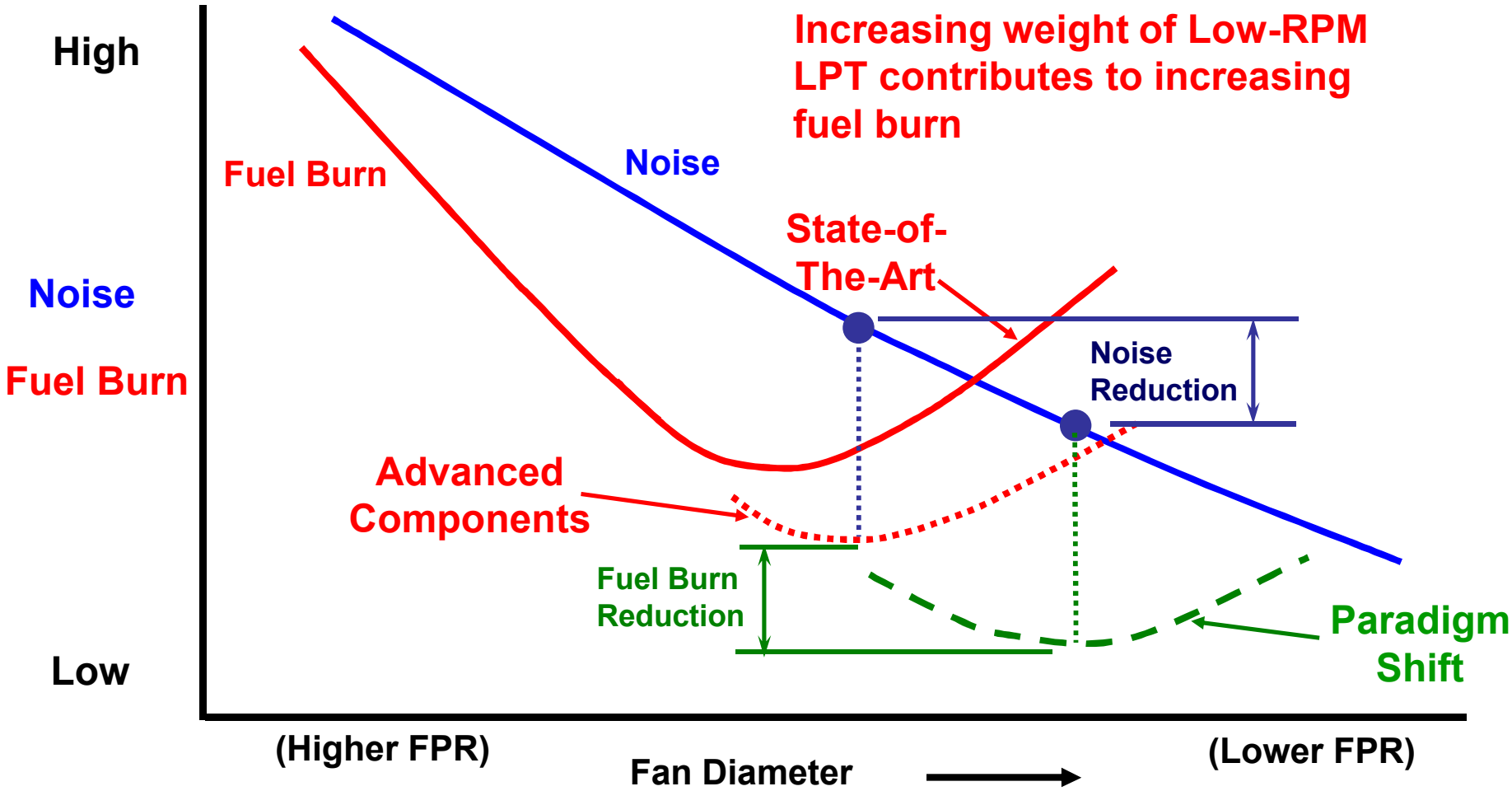
Fundamental Propulsion System Characteristic

Gear Driven Propulsor Enables Improved Fuel Burn and Lower Noise



Fundamental Propulsion System Characteristic

Gear Driven Propulsor Enables Improved Fuel Burn and Lower Noise



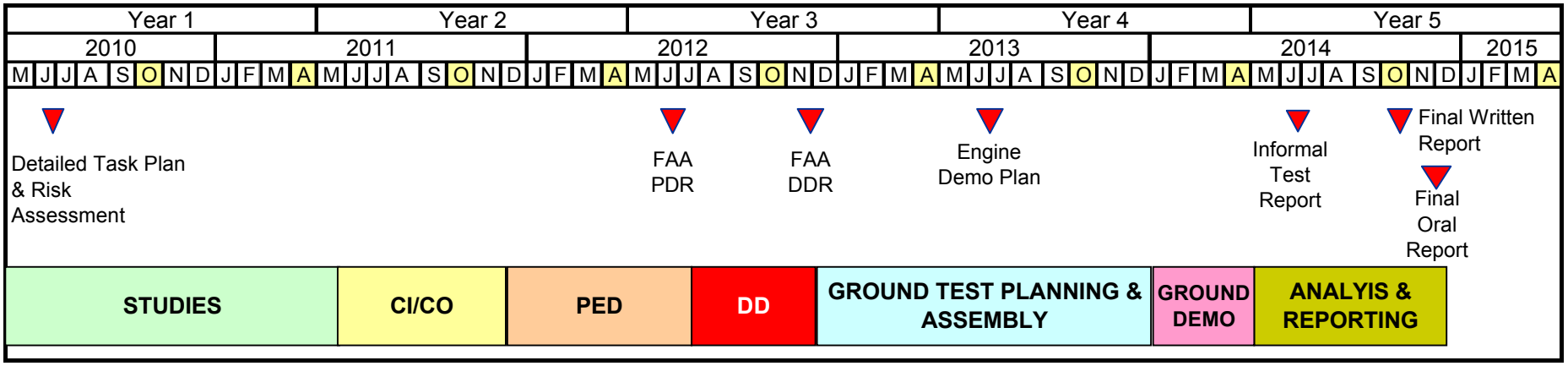
FAA CLEEN Technologies

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)

- Represents commercialized product implementing UHB GTF fan technologies in CLEEN plus other technologies that leverage the overall GTF system benefits, which we anticipate the market will demand in 2020 or beyond.

Level 1 Schedule

P&W 5-Year Plan Supports FAA CLEEN Goals



Summary

- Lower fan pressure ratio = higher bypass ratio
- Ultra-high bypass ratio is key to future engines
- Max benefits from integrated system
  - *Potential Workshop: How to maximize benefits of UHB?*
- *Objective: Demonstrate ultra-high bypass ratio system to validate enabling technologies*

PRATT & WHITNEY

DEPENDABLE ENGINES