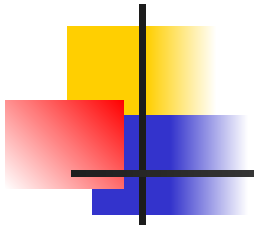
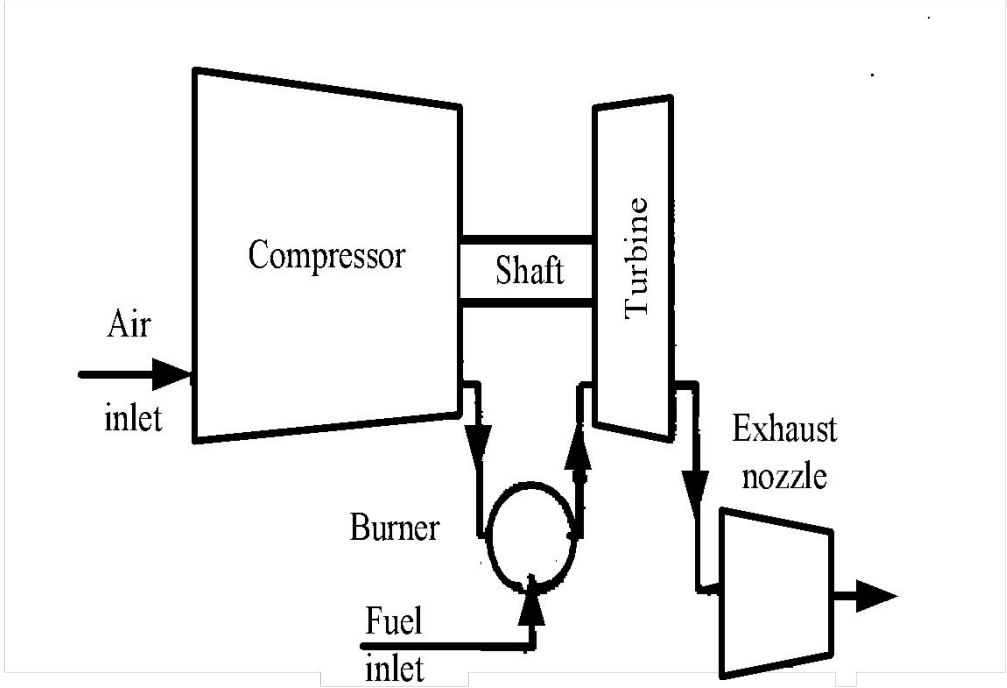
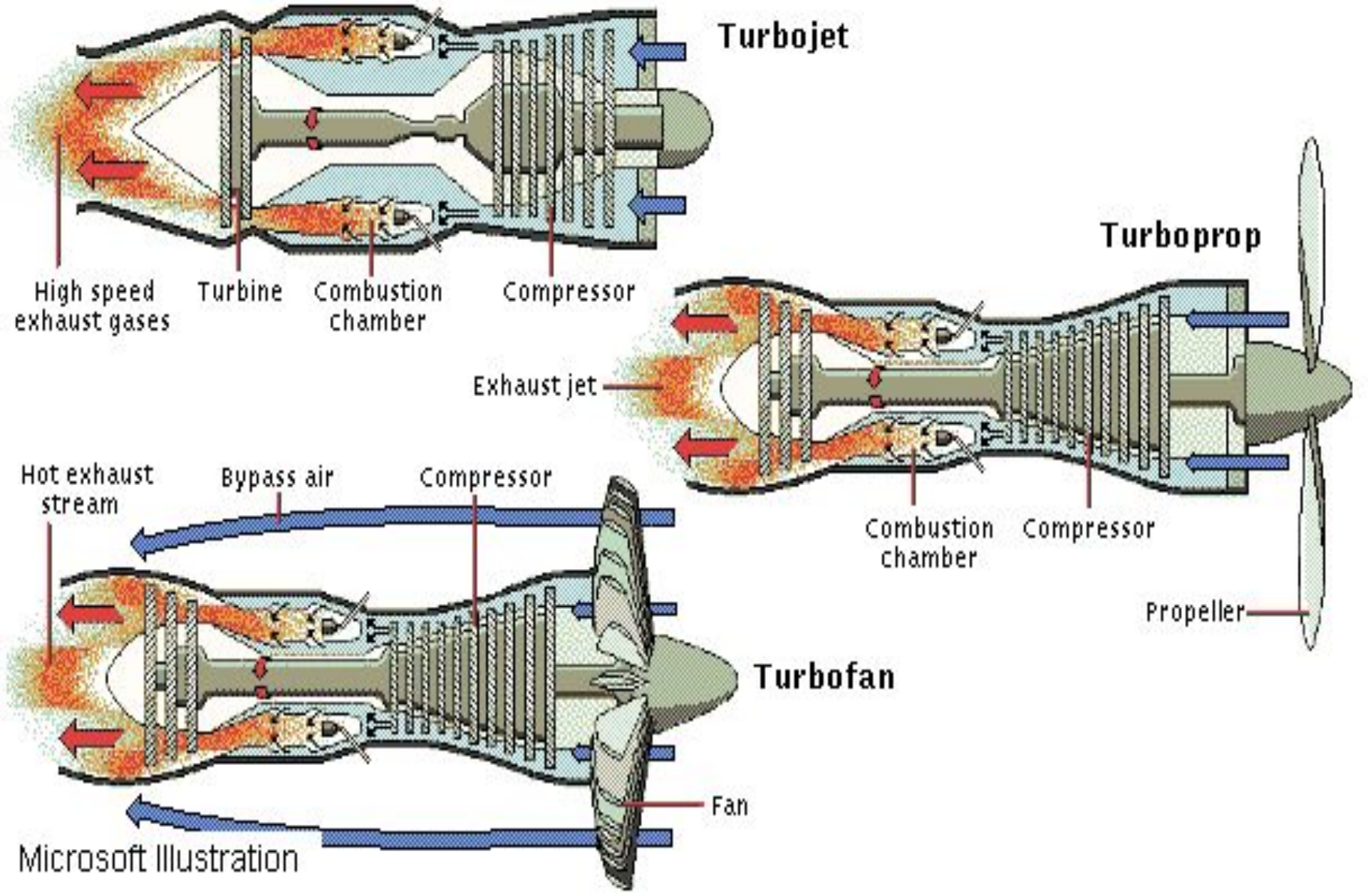


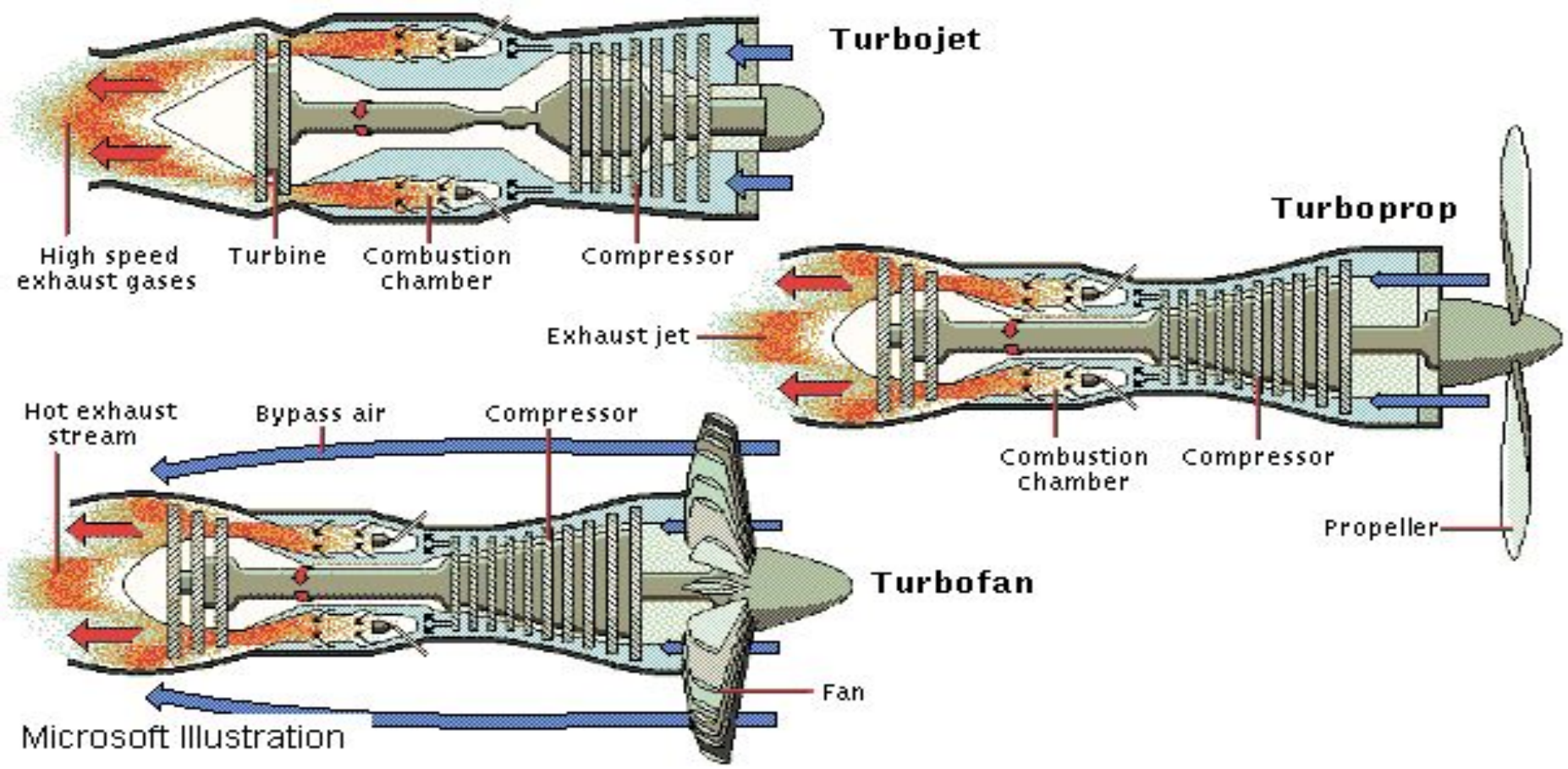
AIRCRAFT ENGINES

The first look



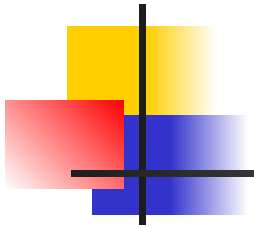
Basically, a gas turbine engine consists of five major sec tions: an ***inlet duct***, a ***compressor***, a ***combustion chamber*** (or chambers), a ***turbine wheel*** (or wheels), and an ***exhaust duct***. In addition to the five major sections, each gas turbine is equipped with an accessory section, a fuel system, a starting system, a cooling system, a lubrication system, and an ignition system.


Turbojet
High speed exhaust gases
Turbine
Combustion chamber
Compressor
Turboprop
Exhaust jet
Combustion chamber
Compressor
Propeller
Hot exhaust stream
Bypass air
Compressor
Turbofan
Fan
Microsoft Illustration

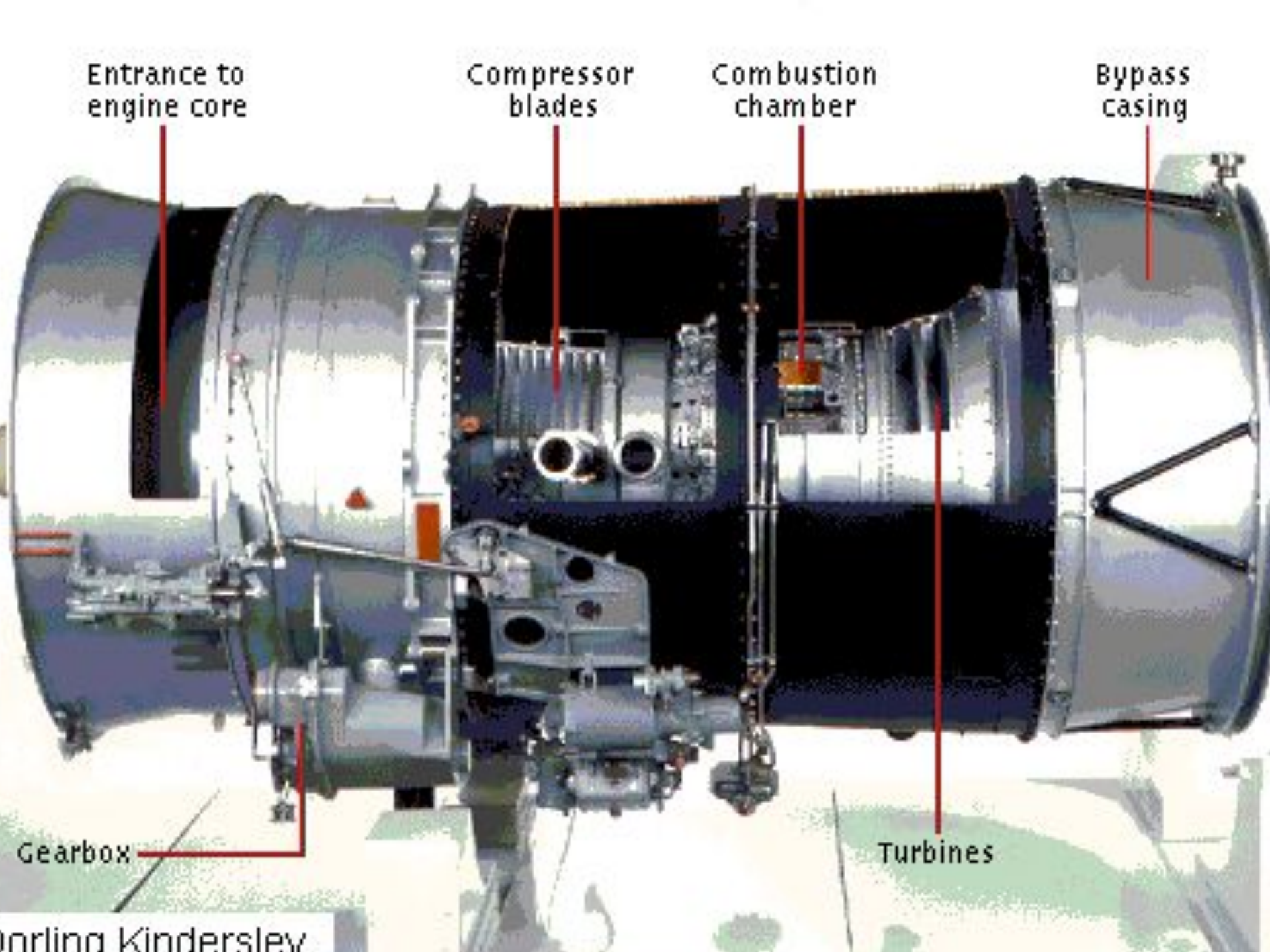


Jet Engines

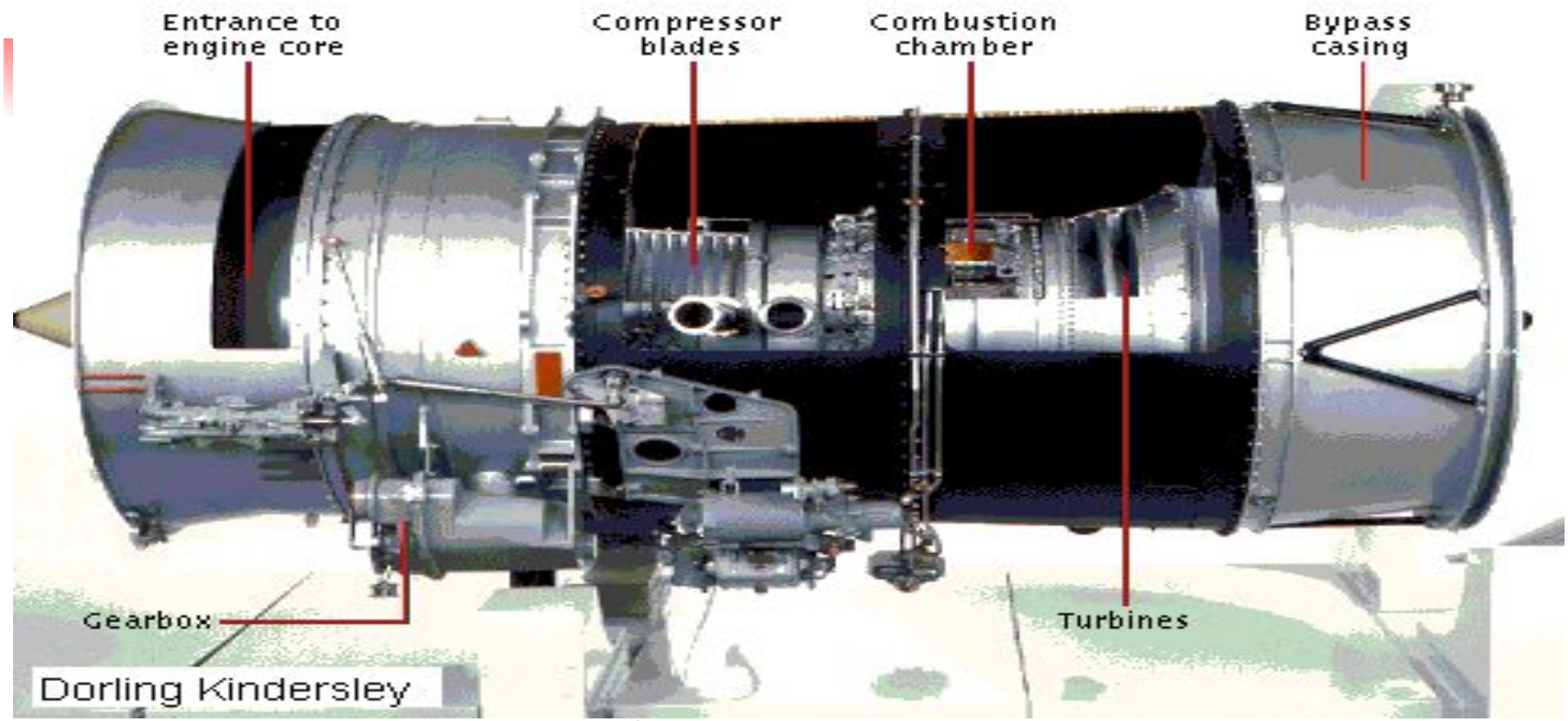
The three most common types of jet engines are the **turbojet, turboprop**, and **turbofan**. Air entering a **turbojet** engine is compressed and passed into a combustion chamber to be oxidized. Energy produced by the burning fuel spins the turbine that drives the compressor, creating an effective power cycle. **Turboprop** engines are driven almost entirely by a propeller mounted in front of the engine, deriving only 10 percent of their thrust from the exhaust jet. **Turbofans** combine the hot air jet with bypassed air from a fan, also driven by the turbine. The use of bypass air creates a quieter engine with greater boost at low speeds, making it a popular choice for commercial airplanes.



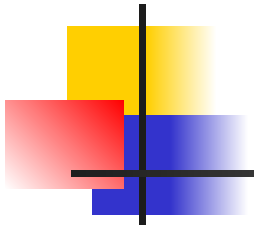
Turbofan Engine


Entrance to engine core
Compressor blades
Combustion chamber
Bypass casing
Gearbox
Turbines

Turbofan Engine



This Rolls-Royce Tay turbofan engine pushes nearly three times as much air through the bypass ducts as it pushes through the central core of the engine, where the air is compressed, mixed with fuel, and ignited. Turbofan engines like the Rolls-Royce Tay are not as powerful as turbojets, but they are quieter and more efficient.



BOEING ENGINES

717-200

BOEING

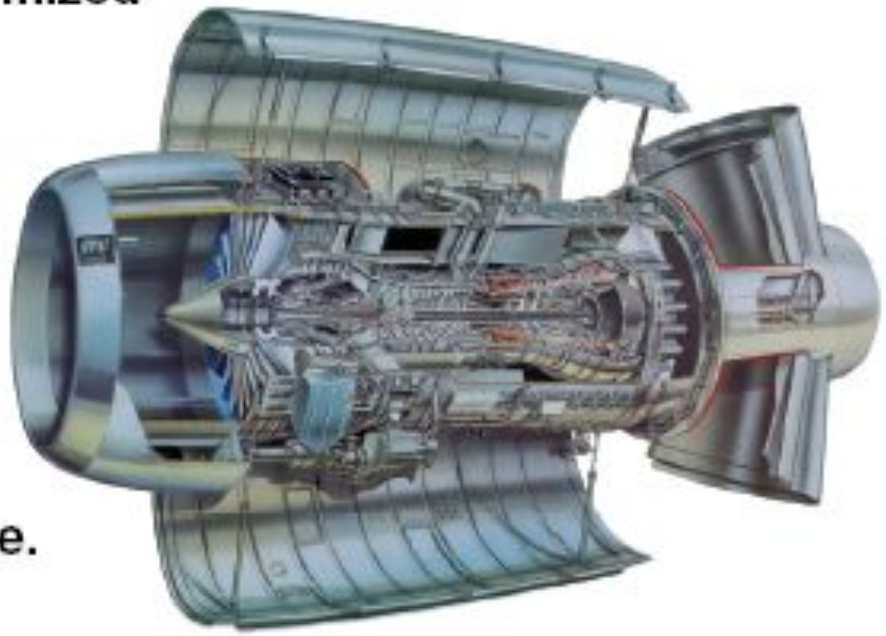
BOEING 717 ENGINE

BR715 Benefits for Operators

Cost-Effective Technology With Low Risk

The only new-generation engine optimized for 80- to 130-seat airplanes offers

- Low cost.
- Low fuel consumption.
- Low maintenance costs.
- Low noise and emissions.
- Low-risk design philosophy.
- Proven BR700-series performance.



The Efficient BR715: Two Engines in One

BR715 features:

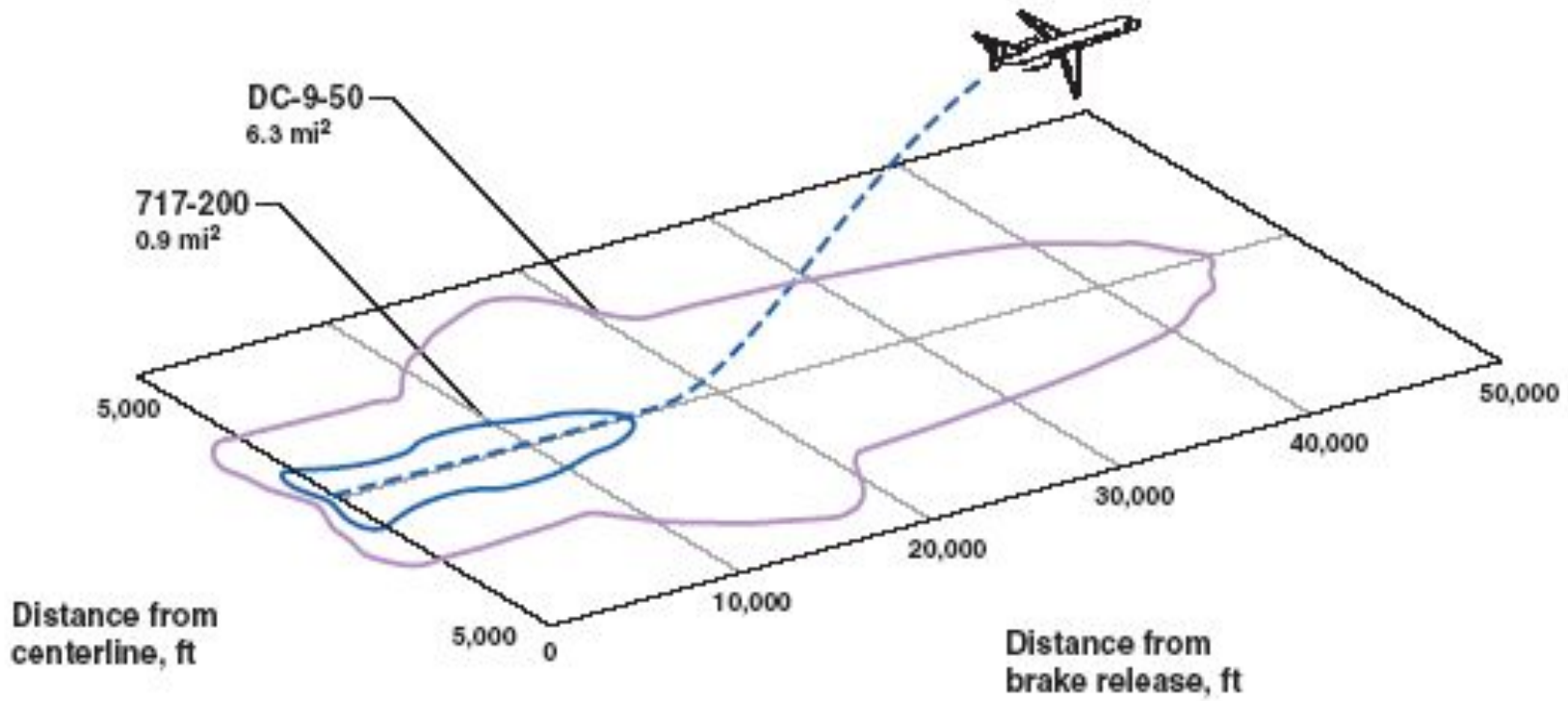
- Durable, 58-inch-wide chord, FOD-resistant fan
- Low-emission combustor
- Modular design for low maintenance cost

The engine is available for the 717 at two thrust ratings:

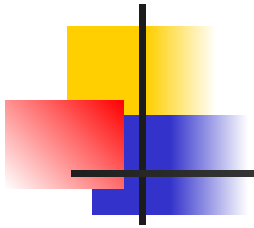
- 18,500 lb (82.3 kN)
- 21,000 lb (93.4 kN)

Changing between thrust ratings involves *no* hardware.

717-200 Noise Area Reduced by 85% Over DC-9-50



- Maximum TOGW; 100% load factor
- 85-dBA contour comparison; takeoff with cutback



BOEING 737 FAMILY

737

BOEING

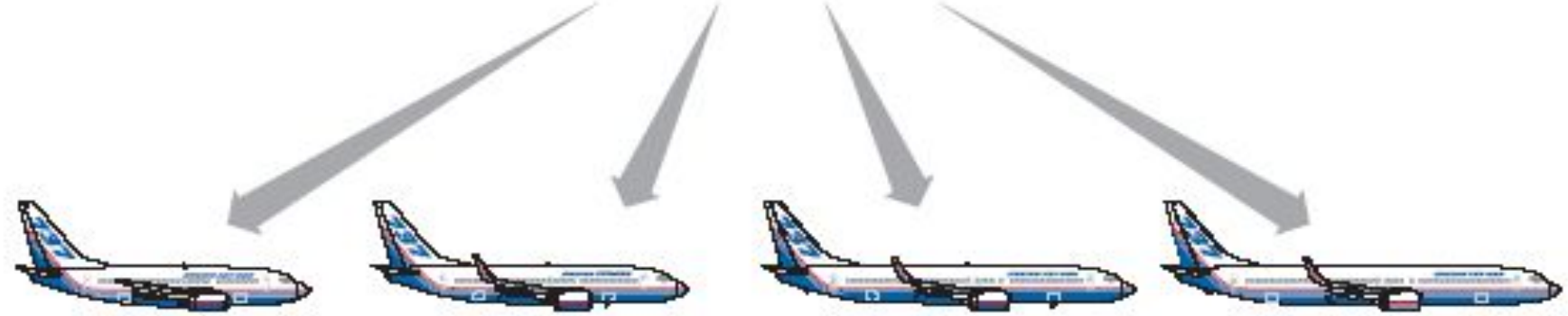
New Common Engine Improves Performance and Reduces Costs

Improved performance

- Higher thrust
- Reduced noise
- Increased range

Reduced costs

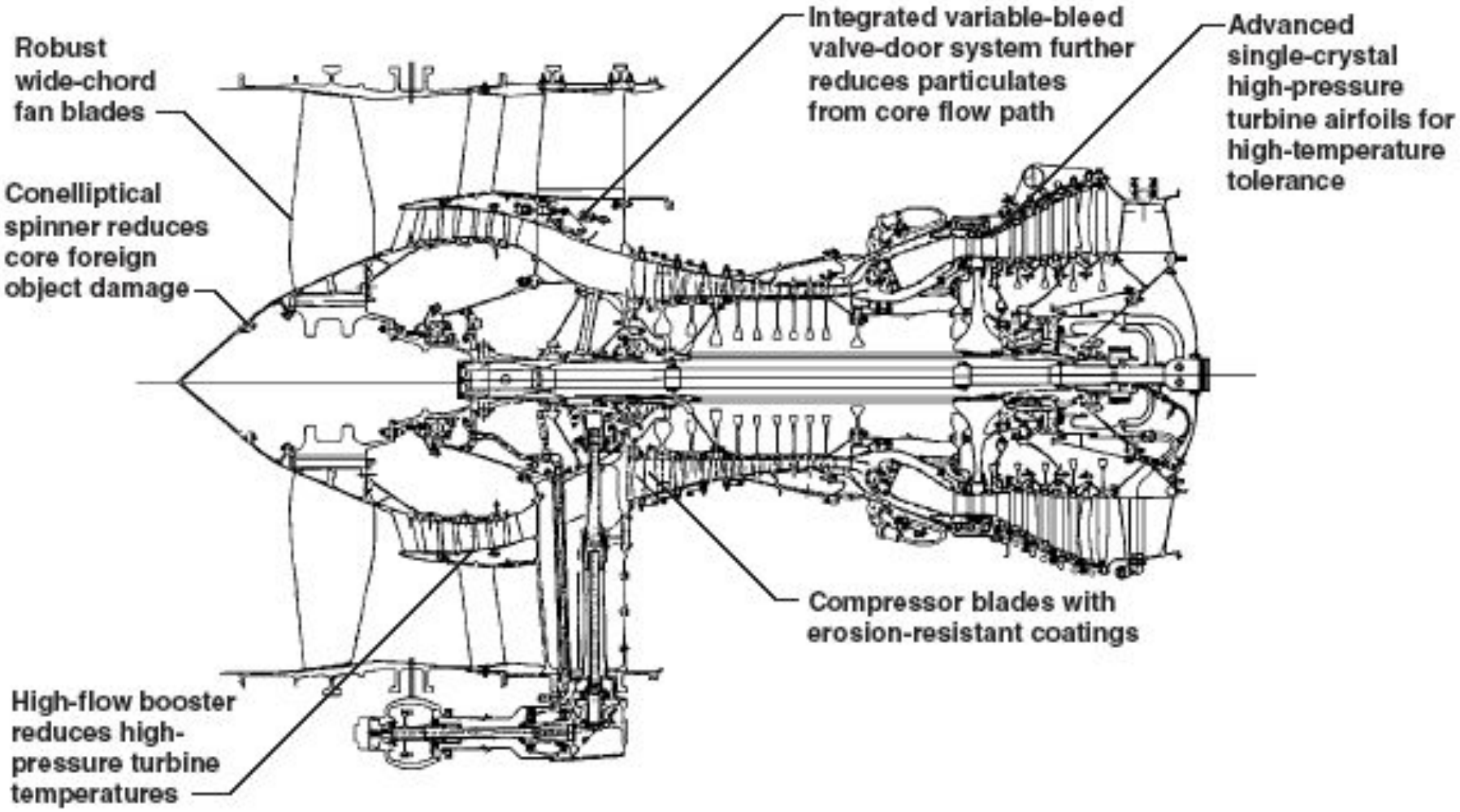
- Up to 15% lower maintenance costs
- Up to 9% lower fuel burn
- Improved systems access
- Reduced change time



-7B18	-7B20	-7B22	-7B24	-7B26	-7B27

Thrust rating options

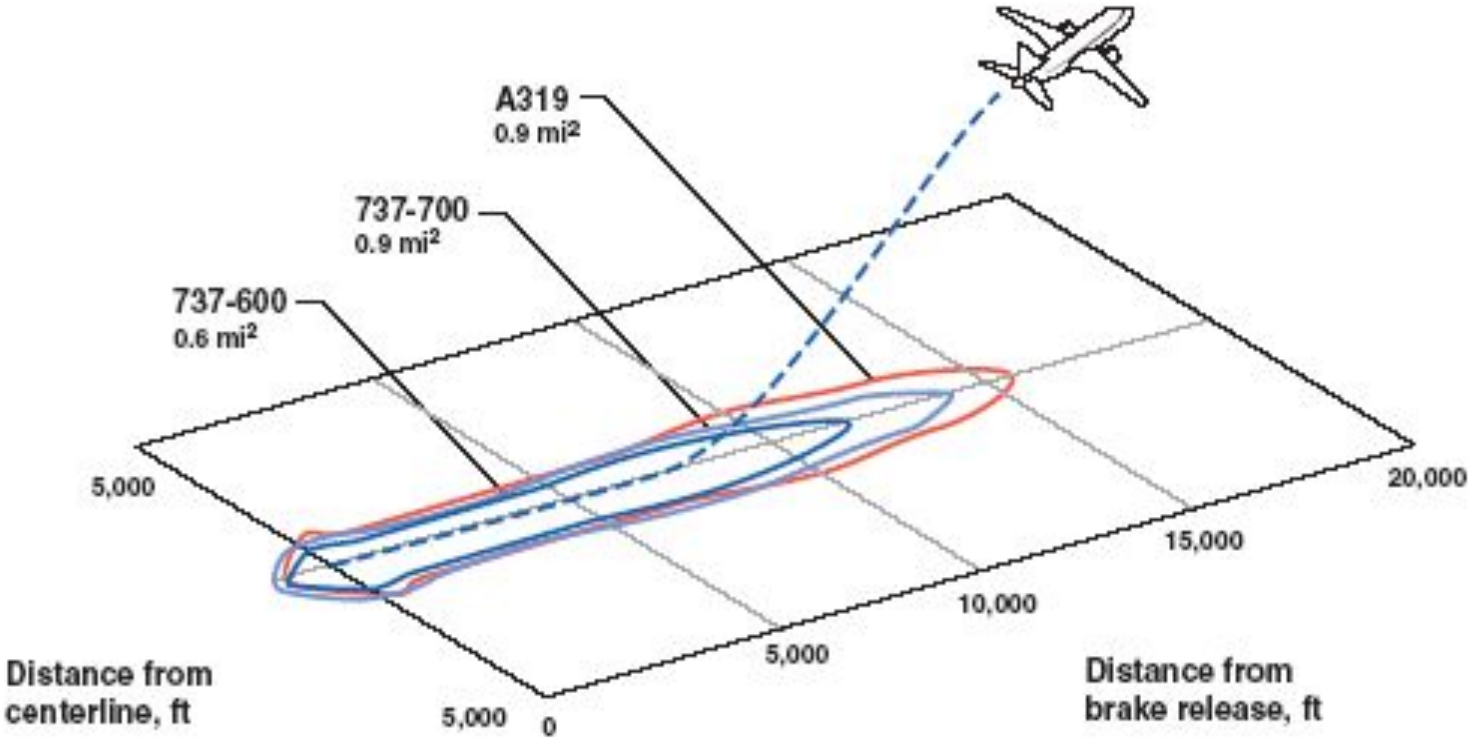
The CFM56-7B Engine Is Designed for High Reliability and Low Maintenance



- FADEC II
- Increased cooling capacity

Takeoff Noise Area Comparison

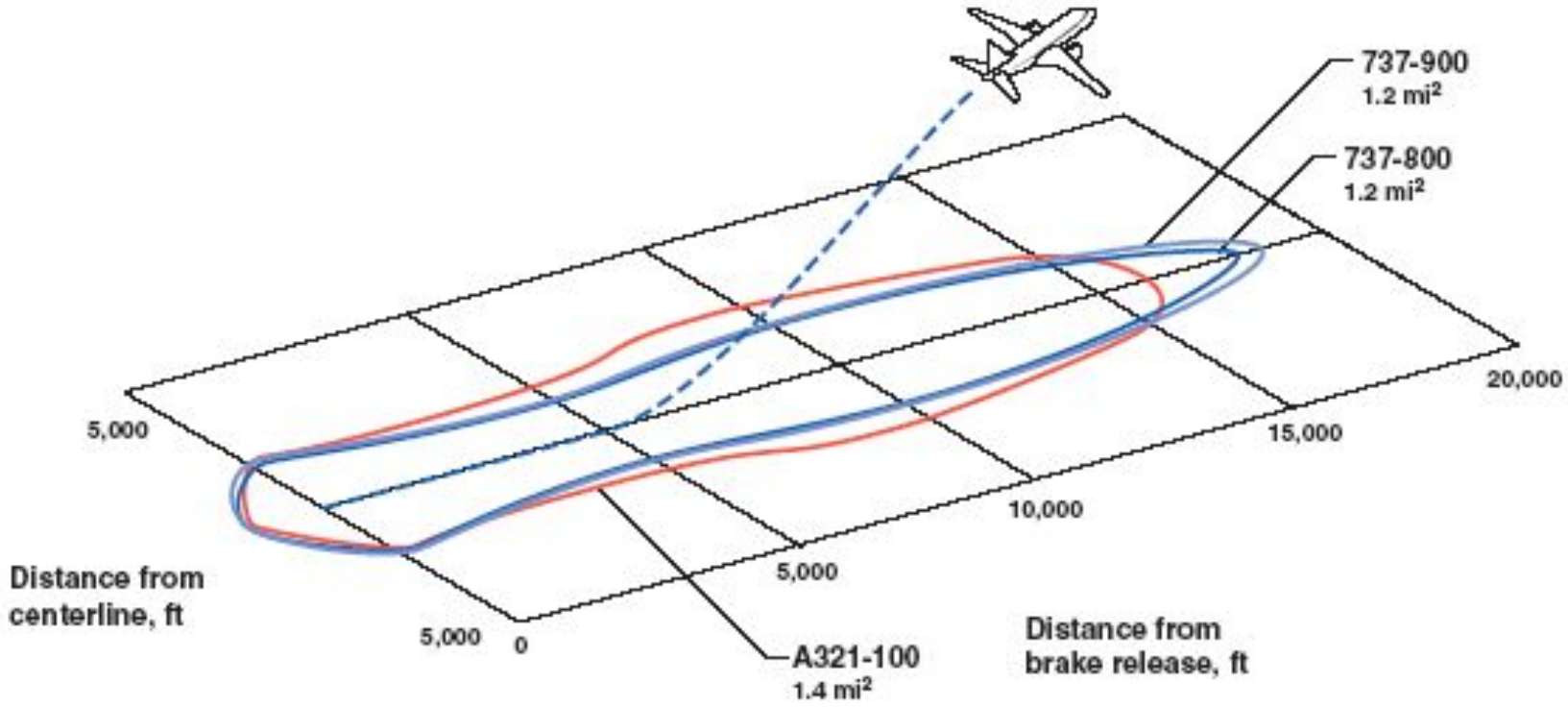
737-600 Noise Area Reduced by 33% Over A319



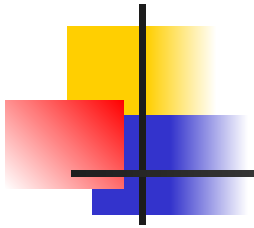
- Maximum TOGW; 100% load factor; without winglets
- 85-dBA contour comparison; takeoff with cutback

Takeoff Noise Area Comparison

737-800 Noise Area Reduced by 14% Over A321-100



- Maximum TOGW; 100% load factor; without winglets
- 85-dBA contour comparison; takeoff with cutback

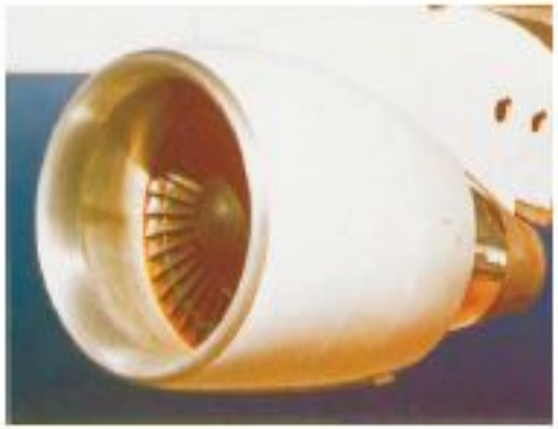


BOEING 747 FAMILY

747

BOEING

Engines From Three Major Manufacturers Are Available on the 747-400



PW4000

CF6-80C2

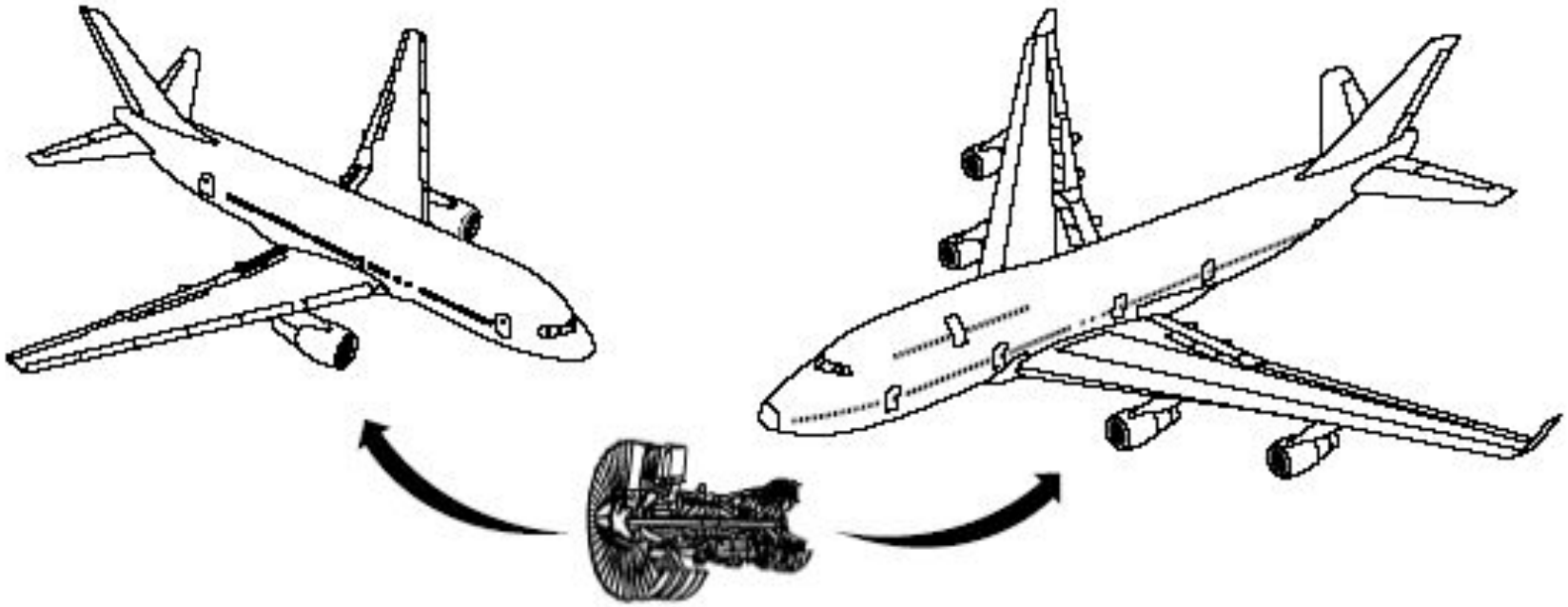
RB211-524G/H-T

747-400 Family Engine Offerings

Engine model	Boeing equivalent thrust, lb	Sea level flat rate temperature °F (°C)	Status
Pratt & Whitney			
PW4056	57,100	92 (33)	Certified
PW4062*	63,000	86 (30)	Certified
General Electric			
CF6-80C2B1F	56,500	92 (32)	Certified
CF6-80C2B5F*	62,100	86 (30)	Certified
Rolls-Royce			
RB211-524G2-T	56,400	86 (30)	Certified
RB211-524H2-T	59,500	86 (30)	Certified

Engine Commonality

Same Basic Engines, Different Rating



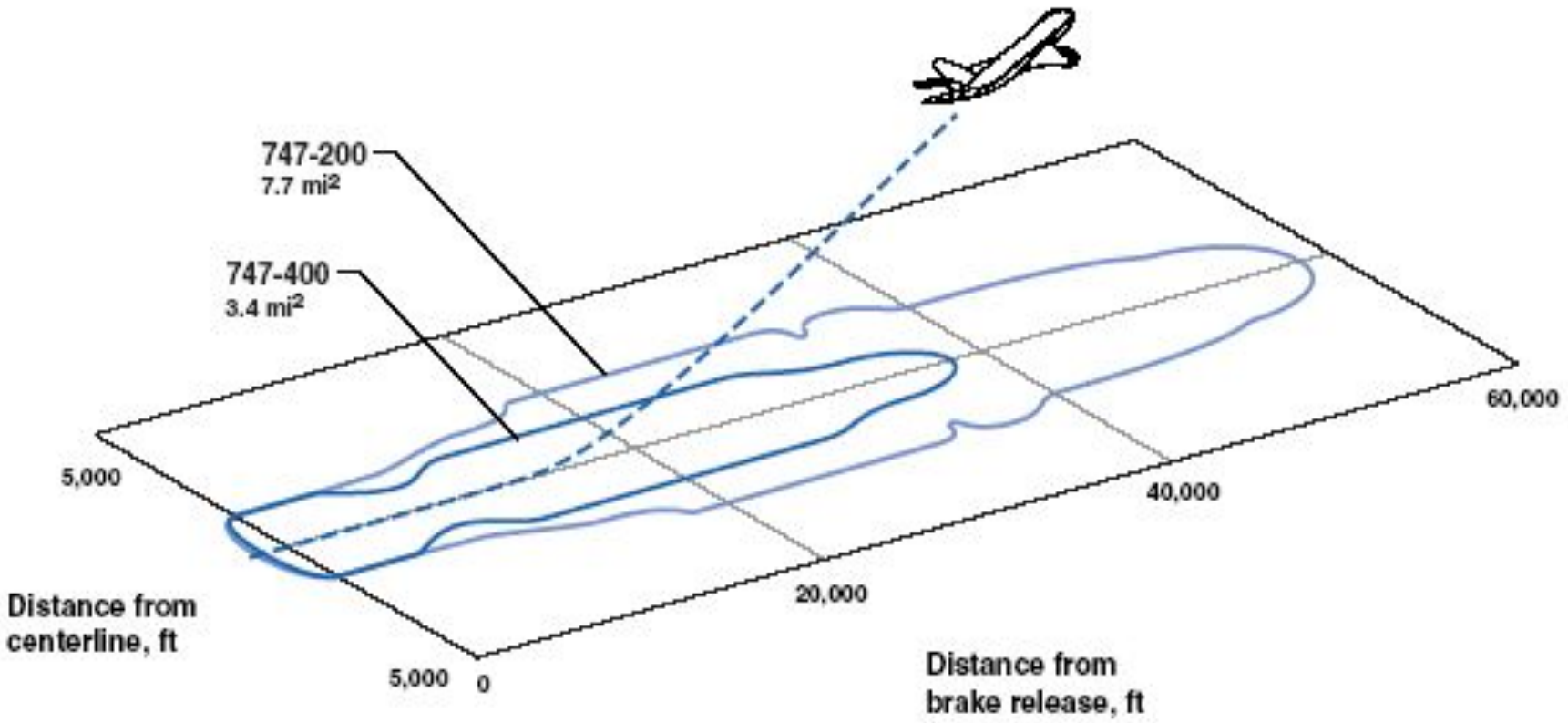
747 and 767 engines are interchangeable within the same basic engine model.

- Same engine buildup
- Common nacelles
- Common generators
- Same tools

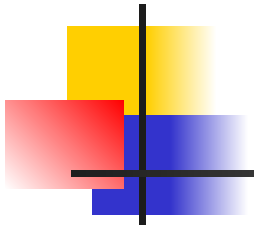
The total number of spare engines required to support combined fleets of 767s and 747-400s is substantially reduced.

Takeoff Noise Area Comparison

747-400 Noise Area Reduced by 56% Over 747-200



- Maximum TOGW; 100% load factor
- 85-dBA contour comparison; takeoff with cutback



BOEING 757 FAMILY

757-200

BOEING

Two Engine Manufacturers to Satisfy Airline Requirements

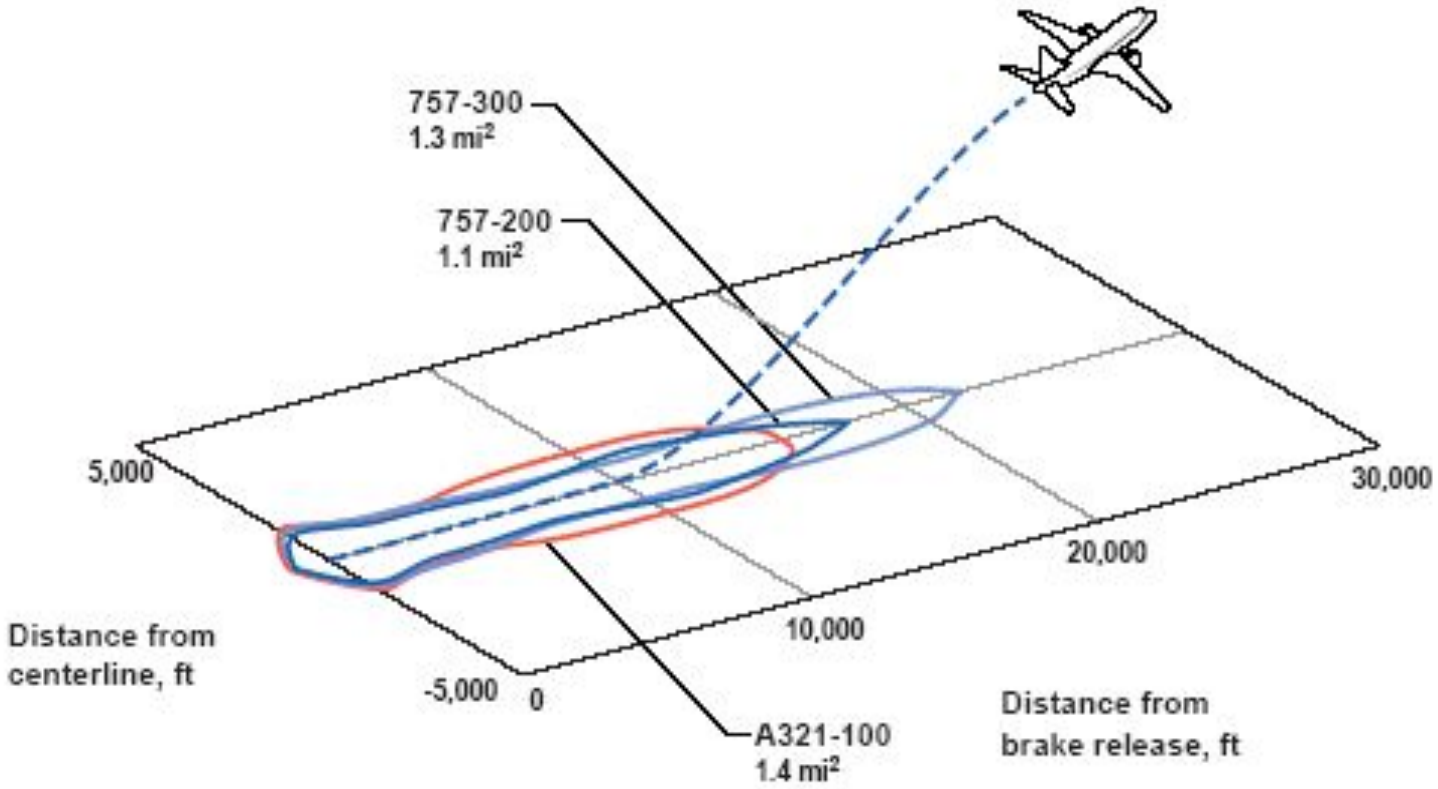
757 Engine Options

Engine model	Thrust rating BET,* lb	Flat-rated temperature, °F (°C)	757 models -200	-200PF/F	-300
Pratt & Whitney					
PW2037	36,600	87 (31)	✓	✓	
PW2040	40,100	87 (31)	✓	✓	✓
PW2043	42,600	96 (36)			✓
Rolls-Royce					
RB211-535E4	40,200	84 (29)		✓	✓
RB211-535E4-B	43,500	77 (25)	✓	✓	✓

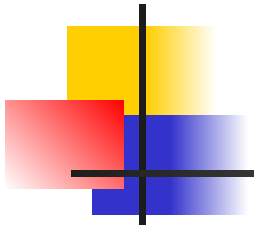
* BET (Boeing-equivalent thrust) is based on takeoff installed net thrust at Mach 0.25. It is included only as reference, not as a guarantee of performance.

Takeoff Noise Area Comparison

757-200 Noise Area Reduced by 20% Over A321



- Maximum TOGW 100% load factor
- 85-dBA contour comparison; takeoff with cutback



BOEING 767 FAMILY

767-300

BOEING

All 767 Engines Are 180-Minute FAA and JAA Approved for ETOPS Operations

PW4000

CF6-80C2

RB211-524G/H
767-300ER only

747/767 engine options

767 Engine Offerings

Engine model	Approximate Boeing-equivalent thrust (BET*), lb	Temp °F (°C)	767 -200ER	767 -300ER	767 -300F	767 -400ER
General Electric						
CF6-80C2B2F**	50,600	90 (32)	●	●		
CF6-80C2B4F**	56,500	90 (32)	●	●		
CF6-80C2B6F	60,200	86 (30)	●	●	●	
CF6-80C2B7F	62,100	86 (30)	●	●	●	○
CF6-80C2B8F	63,500	86 (30)				●
Pratt & Whitney						
PW4052	52,300	92 (33)	●	●		
PW4056	57,100	92 (33)	●	●		
PW4060	60,200	92 (33)	●	●	○	
PW4062	63,300	86 (30)	○	●	○	○
Rolls-Royce						
RB211-524G4-T	56,400	86 (30)		○		
RB211-524H2-T	59,500	86 (30)		○	○	

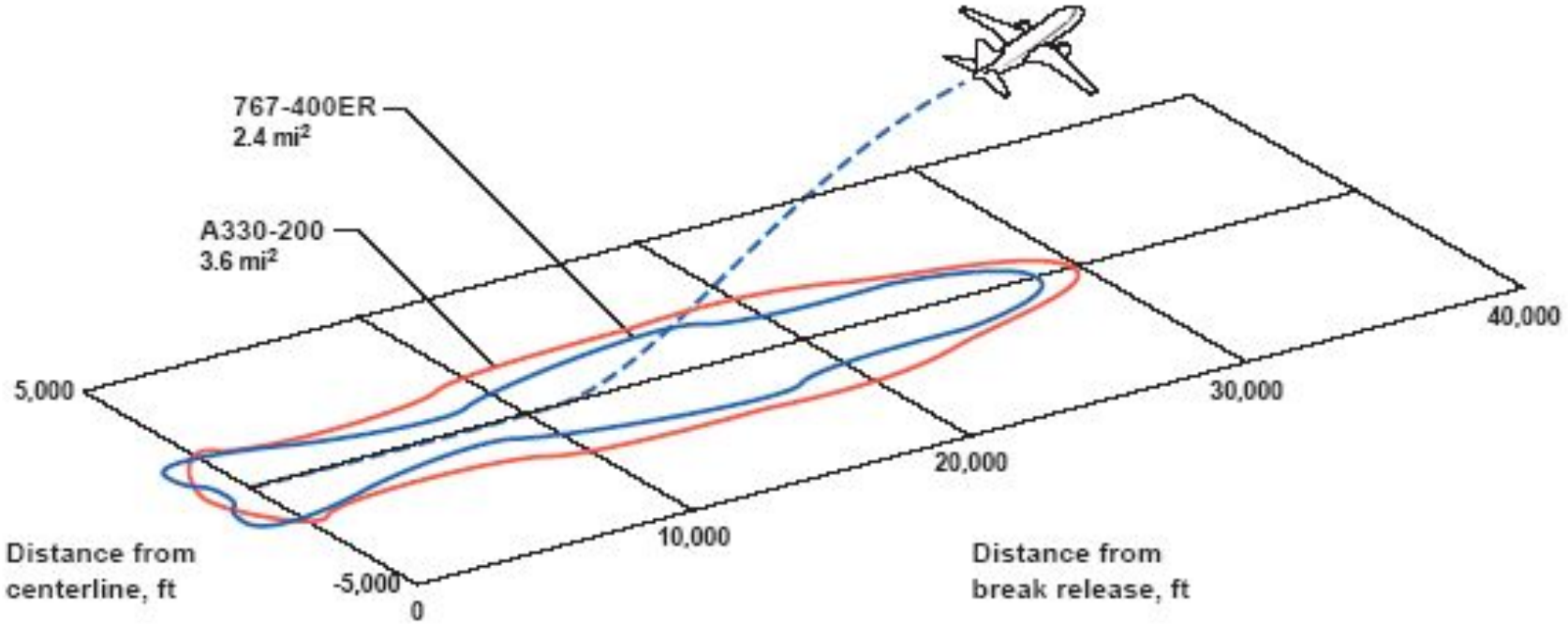
● In service
◑ Sold
○ Offerable

*BET is based on takeoff installed net thrust at Mach 0.25.
It is included only as a reference, not as a guarantee of performance.

**Available based on GE quotes

Takeoff Noise Area Comparison

767-400ER Noise Area Reduced by 33% Over A330-200



- Maximum MTOW 100% load factor
- 85-dBA contour comparison; takeoff with cutback

777

BOEING

Available Engine Options Supporting the 777 Family

	Pratt & Whitney	General Electric	Rolls-Royce
	Takeoff thrust, lb	Takeoff thrust, lb	Takeoff thrust, lb
777-200	74,400 (PW4074)[1] 74,400 (PW4074D)[2] 77,000 (PW4077)[1] 77,000 (PW4077D)[2]	77,000 (GE90-77B)[3]	73,400 (Trent 875)[4] 76,000 (Trent 877)[4]
777-200ER	84,400 (PW4084) 84,400 (PW4084D)[2] 90,000 (PW4090) 97,900 (PW4098)[6]	84,700 (GE90-85B)[3] 90,000 (GE90-90B)[3] 93,700 (GE90-94B)	83,600 (Trent 884)[4] 90,000 (Trent 892)[4] 93,400 (Trent 895)
777-200LR		110,100 (GE90-110B1)[5]	
777-300	90,000 (PW4090) 97,900 (PW4098)	93,700 (GE90-94B)[7]	83,600 (Trent 884)[4] 90,000 (Trent 892)[4] 93,400 (Trent 895)[6]
777-300ER		115,300 (GE90-115B)	

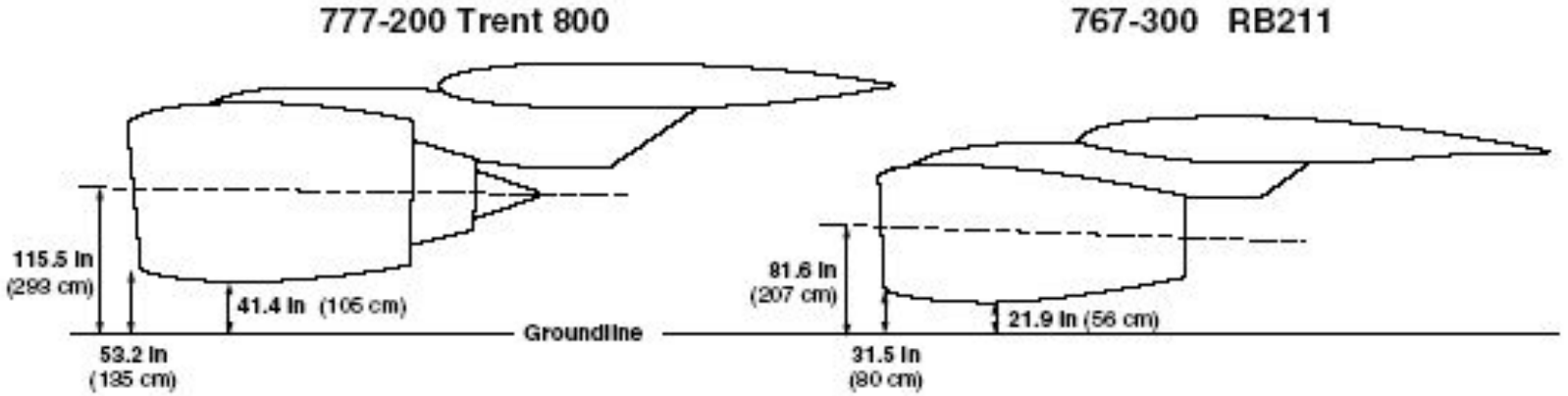
• All thrusts are Boeing equivalent.
[1]PW4084 bill of materials
[2]PW4090 bill of materials
[3]GE90-94B bill of materials
[4]Trent 895 bill of materials
[5]GE90-115B bill of materials
[6]Subject to certification lead times
[7]Subject to engineering and certification lead times

777-PP-0027-
11-15-01-JWG/JLL

Conventional Airframe-Engine Integration

Engine installations similar to previous Boeing twin-engine airplanes

- Adequate ground clearance
- No landing gear length penalty
- Minimal aerodynamic interference drag
- Foreign object damage susceptibility equivalent to existing below-wing configurations

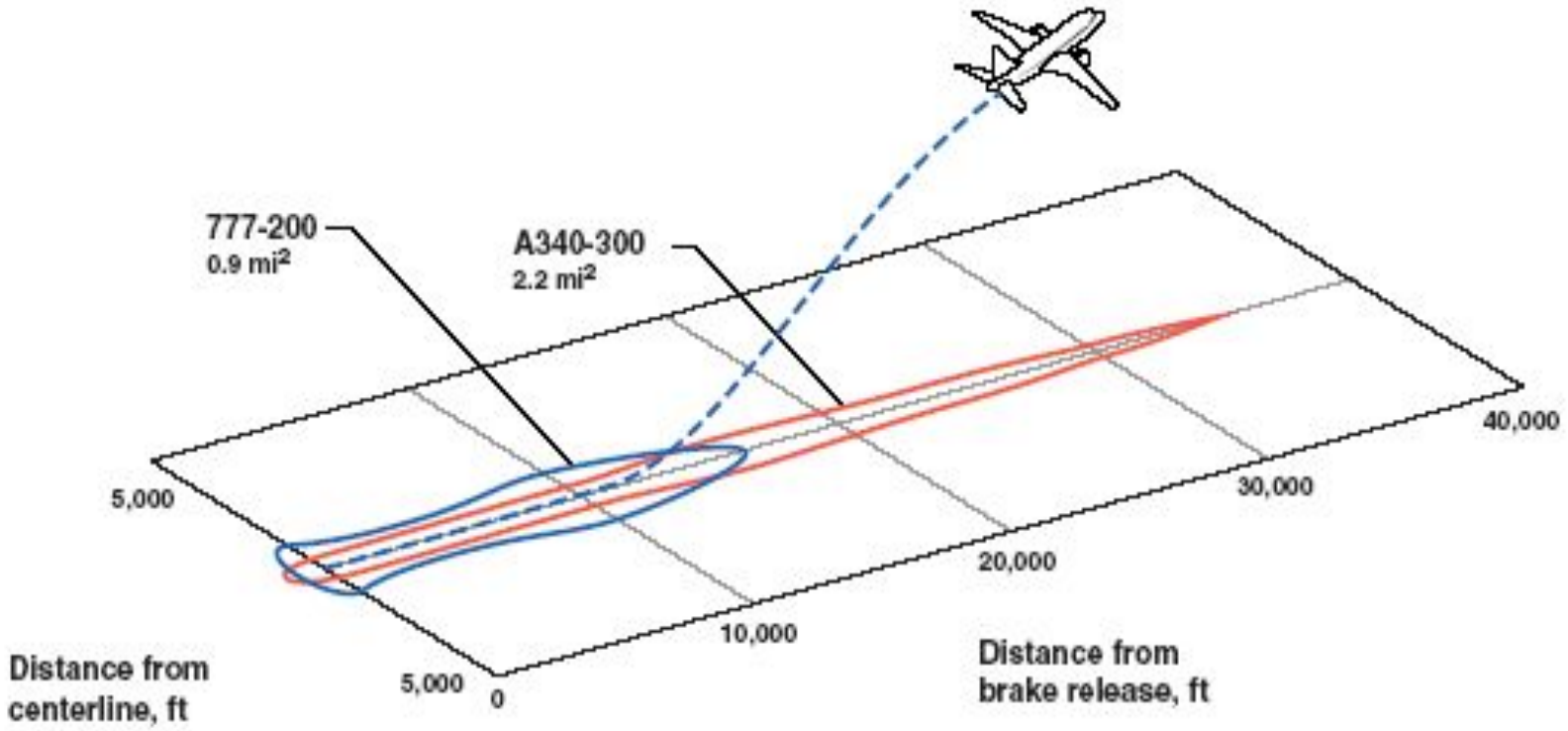


Engine	Hilite clearance	Minimum ground clearance
PW4000	48.0 in (122 cm)	36.2 in (92 cm)
Trent 800	53.2 in (135 cm)	41.4 in (105 cm)
GE90	43.5 in (110 cm)	32.1 in (82 cm)

Airplane	Average hilite clearance	Average minimum ground clearance
737-300	27.9 in (71 cm)	18.0 in (46 cm)
757	43.7 in (111 cm)	32.7 in (83 cm)
767-300	31.5 in (80 cm)	21.9 in (56 cm)

Takeoff Noise Area Comparison

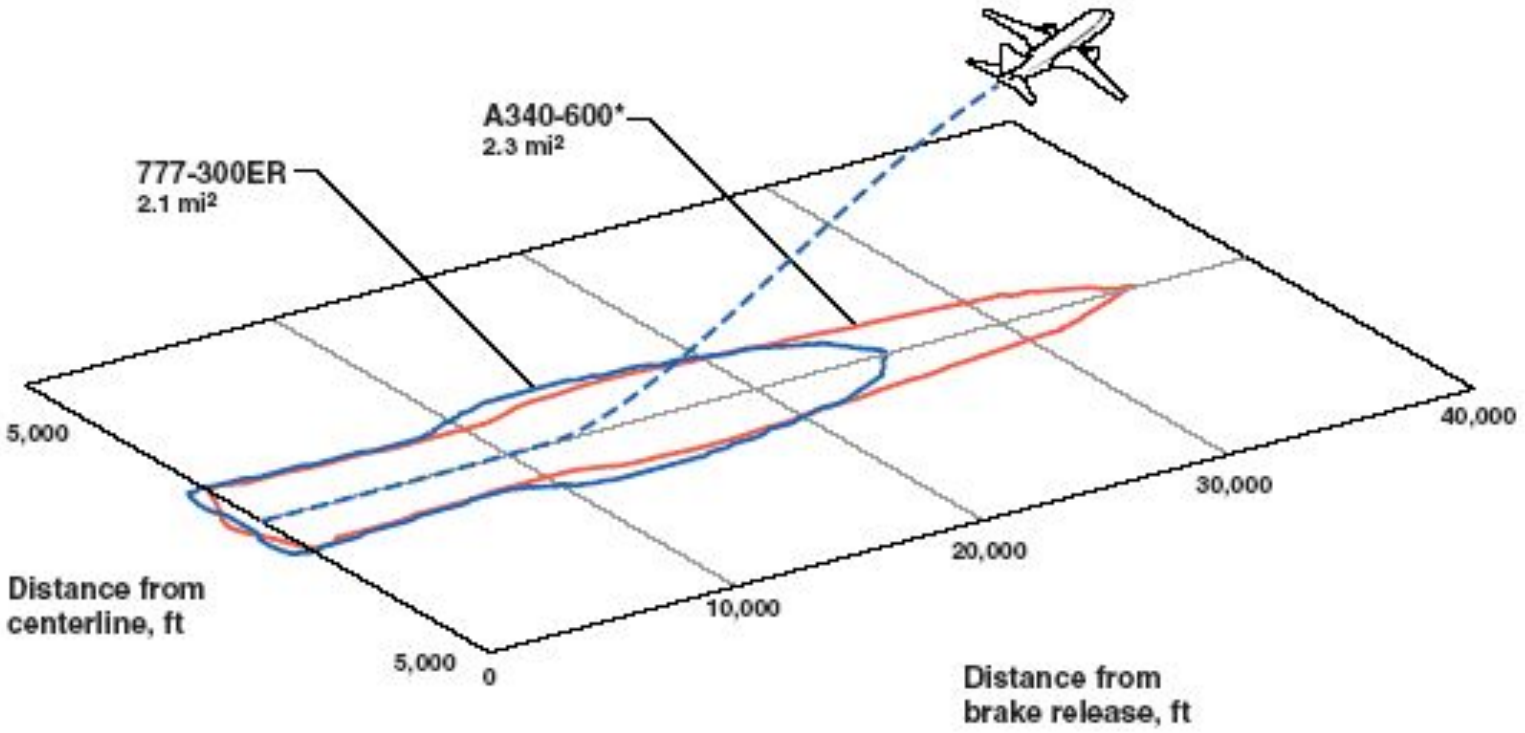
777-200 Noise Area Reduced by 41% Over A340-300



- Maximum TOGW; 100% load factor
- 85-dBA contour comparison; takeoff with cutback

Takeoff Noise Area Comparison

777-300ER Noise Area Reduced by 10% Over A340-600



- Maximum TOGW; 100% load factor
- 85-dBA contour comparison; takeoff with cutback

* Estimated airplane and engine performance

BOEING 7E7

BOEING®

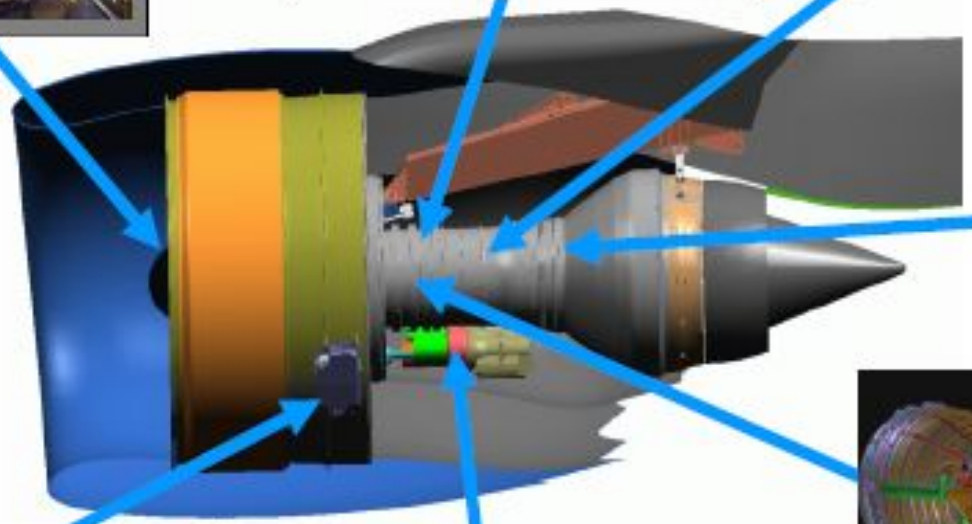
7E7 DREAM LINER

Candidate Propulsion Team

Wichita

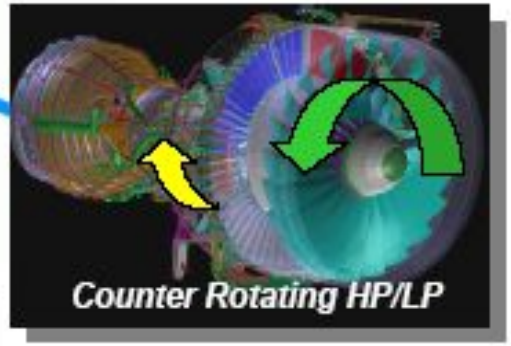
PW-EXX Proven Technology and Innovation

- Focused on Life Cycle Cost



- 6th Generation FADEC
- Advanced Health Monitoring
- On-board Maintenance Micro Server

- One Layer Deep LRUs
- Dual 225 KVA Starter Generators



GENX: Next Generation on a Proven Architecture

777-200

GE90-76B

777-200ER

GE90-85B

777-200ER

GE90-94B

777-200LR / -300ER

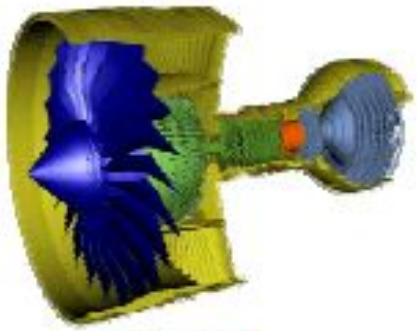
GE90-115B

GP7000

GE90 Architecture Family Firsts

- Composite Fan Blade
- 23:1 P/P HPC in 10 Stages
- Pioneered Performance Retention Features
  - Coniptical Spinner
  - "Buried" Booster Inlet
  - Inward Opening VBVs
  - Short, Stiff Core
- Propulsor Maintenance Concept
- Raised the Bar on ETOPS
- World Record Thrust

7E7

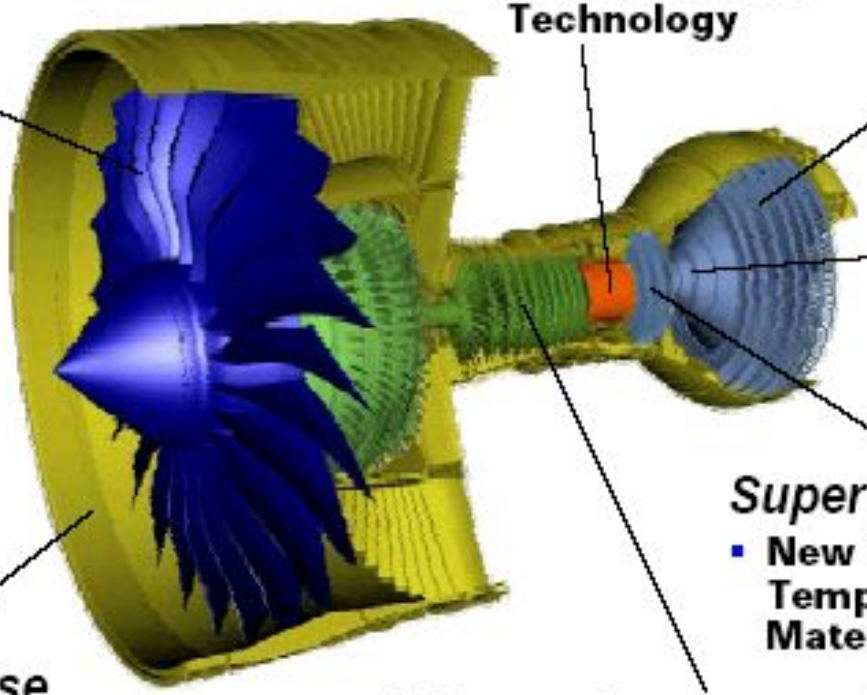


GENX

Taking it to the next level . . .
Advancing Technology on a
State-of-the-Art Engine Architecture

GENX Offers the Latest Technology with the Lowest Risk

GENX... A New Engine



Combustor
- New Lean-Burn, Low Emissions Technology

Turbines
- 3D Aerodynamics for Efficiency

Composite fan
- Weight, Efficiency & Noise Reduction

Counter-rotating HP and LP Spools
- Efficiency and part count reduction

Super alloys and coatings
- New High-Temperature Disc Material

Composite fan case
- Braided Structure for Low Weight

Advanced compression technology
- High Pressure Ratio & Improved Efficiency

High Customer Value Through Advanced Mature Technologies

Best product with lowest risk

Trent family

Optimum performance with minimum risk

New technology

Vision10

SILENCE®

Balanced approach

Trent '7E7'

Long range performance and short range economics

- Highest customer value at the lowest possible risk
- New technology included on a reward versus risk basis

Rolls-Royce

Unique IP system power offtake

IP system power offtake

- Unique 3-shaft solution
- Power generation driven by IP system instead of HP system
- De-risks further increases in aircraft power requirements

Benefits

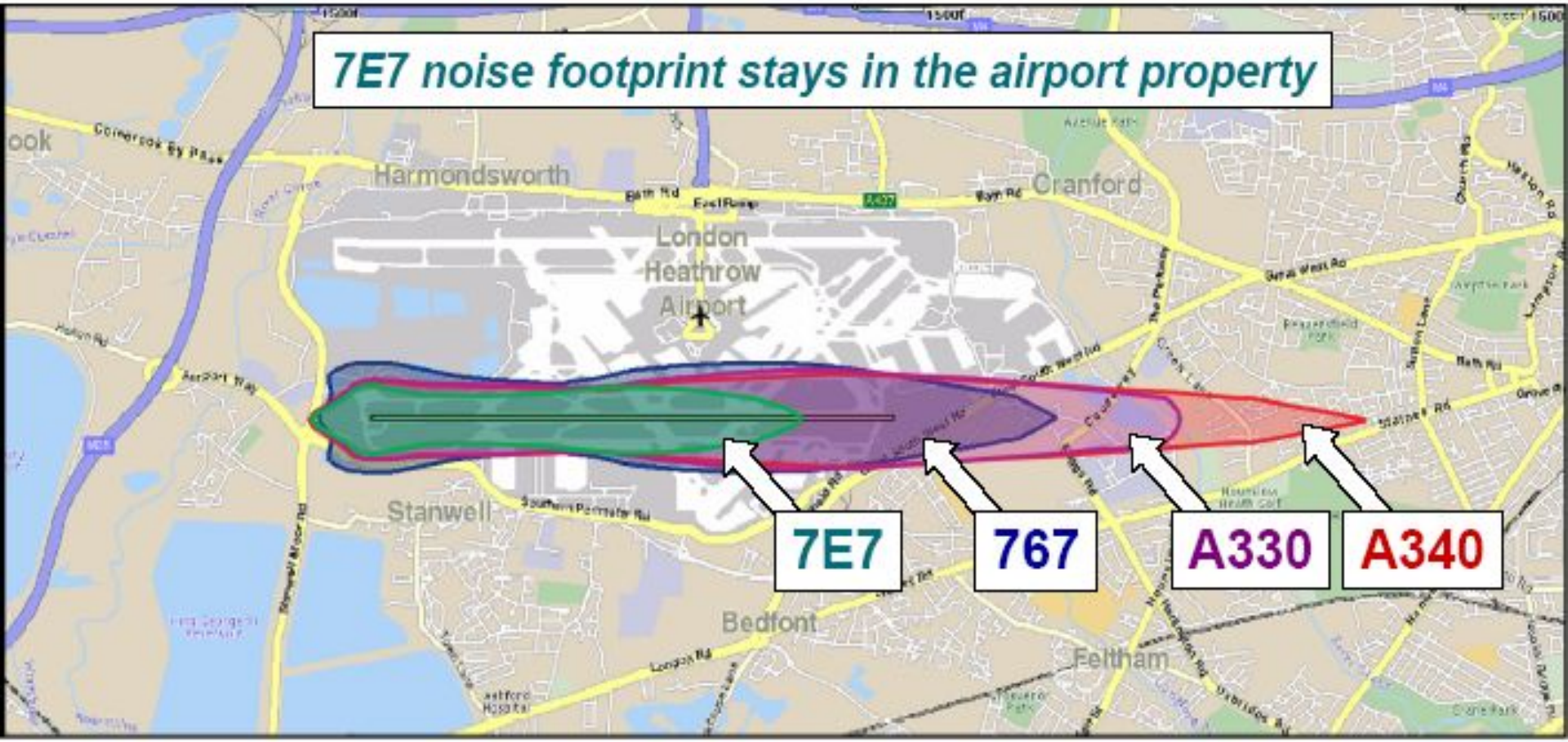
- Better long and short range economics and capability
- Significantly lower fuel burn on short range operation
- Low idle thrust delivers lower brake wear
- Better noise

Long range performance and short range economics from one engine

Rolls-Royce

7E7 DREAMLINER

Quiet for the Community



- 85 dBA contours
- 3,000 nmi mission

BOEING