787 Systems and Performance

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Boeing Commercial Airplanes

\[
P_1 = 3.89 \times 10^{-2}
\]

\[
P_2 = 0.794 \times 10^{-3}
\]

\[
P_2 = 0.05 \times 10^{-7}
\]
Configured for Success

787-8 Design Features

- Advanced wing design
- Breakthrough passenger cabin
- Overhead crew rests
- Enhanced flight deck
- Innovative systems technologies
- Composite primary structure
- Large cargo capacity
- Advanced engines and nacelles
The 787 Is a Complete, Flexible, Efficient Family

787-8
223 passengers (three-class)
8,500 nmi / 15,700 km

787-9
259 passengers (three-class)
8,300 nmi / 15,400 km

787-3
296 passengers (two-class)
3,500 nmi / 6,500 km
Creating New Non-Stop Routes

The 787 can efficiently connect more than 450 new city pairs

Possible New Airport Pairs

- Vancouver - Sao Paulo
- Seattle - Shanghai
- San Francisco - Manchester
- Boston - Athens
- Tel Aviv - Montreal
- Munich - Nairobi
- Geneva - Singapore
- Dubai - Taipei
- Madrid - Manila
- Auckland - Beijing
Quiet for Airport Communities

85 dB Noise Contours at Heathrow

- 60% less area affected than the A330 and A340
- 787 noise footprint stays in the airport property

- A340-300
- A330-200
- A330-300
- 767-300
- 787-8

Source MS Mappoint, (c) Microsoft, Inc.
Breakthrough Technologies Reduce Fuel Burn Per Seat by 20%

- Systems
- Materials
- Aerodynamics
- Engines
Engine Technology Advancements

Engine and nacelle features (Common to RR and GE engines)

• Higher bypass ratio and higher pressure ratio compressor
• High-flow low-speed fan
• Advanced materials and coatings
• No-engine-bleed systems architecture
• Low-noise nacelles with chevrons
• Engine types are interchangeable at wing / pylon interface
Advanced Aerodynamics

• State of the art 3-D aerodynamic analysis and design tools provide:
  − Advanced transonic wing design for improved speed and lift
  − High performance, but mechanically simplified high lift system for high reliability and reduced maintenance cost
  − Multi-disciplinary optimization for best combination of weight, drag and engine performance

• Tightly integrated packaging of systems to reduce the size of aerodynamic fairings for reduced weight and drag

• Advanced aerodynamic features validated through extensive wind tunnel test program at both high and low Reynolds number facilities

• Laminar flow nacelles

• Variable camber trailing edge
Composite Solutions Applied Throughout the 787

- Carbon laminate
- Carbon sandwich
- Fiberglass
- Aluminum
- Aluminum/steel/titanium pylons
Starting the Second Century of Powered Flight
787 Advanced Systems

Efficient Airplane Systems
- Flight Controls – Variable Camber Trailing Edge and Drooped Spoilers

Highly Integrated Avionics
- Common Core Systems open architecture
- Integrated Flight Controls Electronics
- Integrated Communication/Navigation/Surveillance equipment
- Integrated Airplane Systems control

e-Enabled Airplane
- Broadband connectivity within airplane and with ground
  - Flight Deck
  - Crew Information System
  - Onboard Health Maintenance
  - Cabin systems

Trade Study decisions assume Life Cycle Costs of the airplane
Advanced Energy Management

Generate, Distribute, and Consume energy in an effective and efficient manner.

Hybrid AC and DC Primary Distribution Systems (230 Vac, 115 Vac, ±270 Vdc, 28 Vdc)

Elimination of Pneumatic Bleed System

Electric Wing Ice Protection

Liquid Cooled Power Electronics

Two 250 kVA Variable Frequency Starter/Generators per engine

APU with Two 225 kVA Starter/Generators

Adjustable Electric Air Conditioning

Adjustable Speed Motors and Motor Controllers
Electrical Systems Overview

- **ATRU – Auto Transformer Rectifier Unit**
- **ATU – Auto Transformer Unit**
- **TRU – Transformer Rectifier Unit**
- **NGS – Nitrogen Generating System**
- **EMP – Electric Motor Pump**
- **ECS – Environmental Control System**
- **RPDU – Remote Power Distribution Unit**
- **CCS – Common Core System**
- **BPCU – Bus Power Control Unit**
- **GCU – Generator Control Unit**

**115 Vac Loads < 10 amps**
- 28 Vdc Loads < 10 amps

**230Vac Distribution**

**28Vdc Distribution**

**Approximately 25 loads**

**Large loads such as:**
- Wing Ice Protection
- Hydraulic AC Motor Pump
- Fuel Pumps
- Galley Ovens
- Cargo Heaters
- ECS Recirc Fans

**Approximately 20 loads**

**Approximately 150 loads**

**Approximately 850 loads**

**Adjustable Speed Motors:**
- Hydraulic EMP
- NGS
- ECS Compressors
- ECS Fans
- Engine Start

**Large >10 amps:**
- ECS Lav/Gal fans
- Equipment Cooling Fans
- Window Heat
- etc.
Electronic Circuit Breakers

• Display-based control and indication of breaker state
• Accessible on Multi-Function Displays (MFDs) and maintenance access devices
Environmental Control Systems

- Overhead cabin air distribution
- Upper and lower air recirculation
- HEPA Filters and Gaseous Air Purification* for recirculated air
- Personal Air Outlet (Gasper) System* - Basic
- Conventional cabin pressure control – two outflow valves
- Electric Air Conditioning*
- 6,000 foot maximum cabin altitude*
- Integrated galley refrigeration*
- Optional Flight Deck Humidification System

- Forced air cooling for essential E/E equipment
- Draw-thru cooling for minor E/E equipment
- Liquid cooling for Power Electronics*
- Electric heating for door floor areas*
- Draw-thru ventilation for Lavatories, Galleys, and Crew Rests
- Supplemental electric heating for Forward and Bulk Cargo compartments*
- Forward* and Bulk Cargo heating and ventilation for animal carriage
- Optional Forward Cargo air conditioning

*Different from 777
Cabin Air Conditioning System

• Two air conditioning packs
• Air source provided by cabin air compressors
• Adjustable to passenger count
Cabin Pressurization Schedule

### Increased passenger comfort - maximum normal cabin altitude of 6000 feet at maximum cruise altitude (reduced from 8000 feet)

<table>
<thead>
<tr>
<th>Airplane</th>
<th>Altitude (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>747-400</td>
<td>4000</td>
</tr>
<tr>
<td>777</td>
<td>5000</td>
</tr>
<tr>
<td>767</td>
<td>6000</td>
</tr>
<tr>
<td>787</td>
<td>7000</td>
</tr>
<tr>
<td>787</td>
<td>8000</td>
</tr>
</tbody>
</table>

- **747-400**: Maximum normal cabin altitude is reduced from 8000 feet to 6000 feet.
- **777**: Maximum normal cabin altitude.
- **767**: Maximum normal cabin altitude.
- **787**: Maximum normal cabin altitude.

![Cabin Pressurization Schedule](image-url)
Hydraulic System Architecture

5000 psi systems with common pumps

Left System
- Left Engine
- Engine Driven Pump (EDP)
- Electric Motor Pump (EMP)
- L Wing: OB & IB
  - L Wing: 2, 6
  - R Wing: 8, 14
- L Wing: OB
  - L Wing: 1, 7
  - R Wing: 8, 14
- L Wing: IB
- Ram Air Turbine (RAT)
- PCU
- Left & Right

Center System
- Center Engine
- Electric Motor Pump (EMP)
- L Wing: OB
  - L Wing: 2, 6
  - R Wing: 8, 14
- L Wing: IB
- Ram Air Turbine (RAT)
- PCU
- Left & Right

Right System
- Right Engine
- Electric Motor Pump (EMP)
- L Wing: IB
  - L Wing: 2, 6
  - R Wing: 9, 13
- R Wing: OB & IB
- L Wing: OB & IB
- Electric Motor Pump (EMP)
- PCU
- Right

OB Aileron – IB Flaperon
- Spoilers IB & OB
- Elevator
- Rudder
- Thrust Reverser
- Trailing Edge Flaps
- Leading Edge Flaps
- Nose Landing Gear
- Gear & Steering
- Main Landing Gear

Left System
- 25 gpm
- +/- 270V DC

Center System
- 27 gpm
- +/- 270V DC

Right System
- 25 gpm
- +/- 270V DC

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787 Fly-by-Wire Flight Controls

All Surfaces Fly-By-Wire
- Eliminates cables
- Reduced weight
- Improved functionality

Leading Edge Surfaces
- Inboard and outboard 3-position slats
- Sealing Krueger Flap at pylon

Integrated Flight Control Electronics
- Reduced weight and space

Trailing Edge Surfaces
- Inboard and outboard single slotted flaps
- Single outboard ailerons
- Single flaperons
- Seven spoiler pairs with droop function
- Trailing Edge Variable Camber (TEVC)
- Reduced complexity of trailing edge mechanism

Electric Integrated Horizontal Stabilizer Trim Actuator (HSTA)
- Reduced complexity
- Reduced weight
High Lift Function

- Leading Edge and Trailing Edge Kinematic Motion

Outboard Slats Small Gap on Takeoff (Inboard Sealed)

Outboard Slats Gapped on Landing settings

UP

Middle

Extended

Rotary Actuator

Spoiler Droop

Variable Camber at Cruise

37-43 degrees down

Simple pivot dropped hinge

Hinge Fairing

- Spoiler Droop functionality replaces fore flaps and maintains gap and overlap requirements.
- Spoilers driven down via fly-by-wire control.
Landing Gear Systems
New Control-by-Wire

• Landing Gear Actuation
  - Electronic control and sequencing of landing gear and doors
  - Dedicated proximity sensors to monitor gear and door position, and to control sequencing
  - Alternate landing gear extension electrically controlled and hydro-mechanically released

• Brake Control
  - Control-by-wire for brake, autobrake, and anti-skid functions
  - Electric Brake Actuators

• Steering Control
  - Control-by-wire rudder pedals and dual tillers

• Brake Temperature Monitoring System – baseline
• Tire Pressure Indication System – baseline
Wing Anti-Ice System Overview

- Electrical Power – no engine bleed air
- Six heater mats in each heated slat
- Aluminum cap to protect leading edge surface

The heater mats are bonded to interior surface of the composite slat leading edge skin.
Final Nose Configuration

• Four windows, fewer posts
• Pilot vision similar to 777
• Non-opening windows
• Crew escape door
• Vertically stowed wipers
• Windshield washer
Cargo Fire Protection

ETOPS Capability:
- Basic - 180 minutes
- Options (-8 and -9):
  - 240 minutes (one bottle)
  - 330 minutes (two bottles)

Cargo Fire Suppression System

Nozzles: Flow Valves:
Fuel Systems Improvements

• Improved Fuel Quantity availability (measuring sticks removed)

• Highly capable center tank fuel scavenge system

• Improved lateral balance correction without need to turn off fuel pumps

• Redundant jettison path of main tank fuel

• Improved anti-ignition safety using all-tank Nitrogen inerting and compliance to latest ignition prevention regulations
Common Core System Benefits

**Common Data Network**
- Open industry standard interfaces A664
- Eliminate multiple standards & protocols
- Fiber Optic Network media

**Common Computing Resource**
- Based on Open System Architecture Principles

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Remote Data Concentrators
- Reduces airplane wiring/weight,
- Ease of system upgrade/modification
- Highly reliable

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Common Data Network
- Modular Implementation of common elements with robust partitioning of functions in software
- Hierarchical layering of services having well defined, standardized, rigidly enforced key interfaces A653

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Flight Deck

- Boeing look, feel and procedures flow
- Familiar Boeing controls
- Familiar display formats
- All 777 functions and features
- Large format displays
Display Layout Comparison
Class III EFB Overview

- One installed for each pilot – basic
- Avionics quality LCD
- Accessible via touchscreen, bezel keys, cursor control device and keyboard

- Interfaces to:
  - Other Avionics (e.g. Flight Management)
  - Communication systems
  - Flight Deck printer
On-board Performance Tool

• Calculates limit weights, V speeds, thrust and more
• Performance optimization and flexibility
  - Optimum flap
  - Multiple intersections
  - Calculates assumed temperature thrust reduction
  - MEL and CDL item entry
  - Airport NOTAM entry
• Data from FMC
  - Origin airport, QNH, OAT
• Simplified weight and balance
Crew Information System — Onboard Health Management

Objective: Reduce schedule interruptions and maintenance costs

- Integrated data load and configuration reporting
- Airplane level fault consolidation and correlation, and data collection
- Electronic Distribution of Software
- Media-less data transfer to/from ground stations
- Electronic link to maintenance manuals
- Coordinated airplane and ground processing approach
- Fault Prediction
787 Program Schedule

Airplane Announcement: 2002
Authority to Offer: 2003
Program Launch: 2004
Firm Configuration: 2005
First Flight: 2007
Certification and Delivery: 2008
Thank You