



787 Systems and Performance

Tim Nelson

Flight Operations Engineering
Boeing Commercial Airplanes

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**

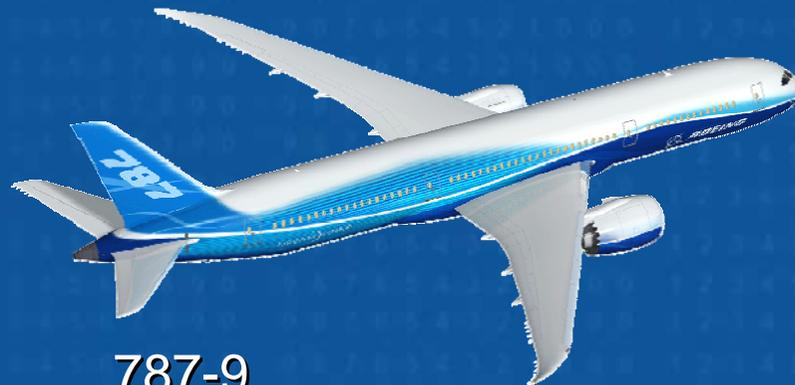
The 787 Is a Complete, Flexible, Efficient Family



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

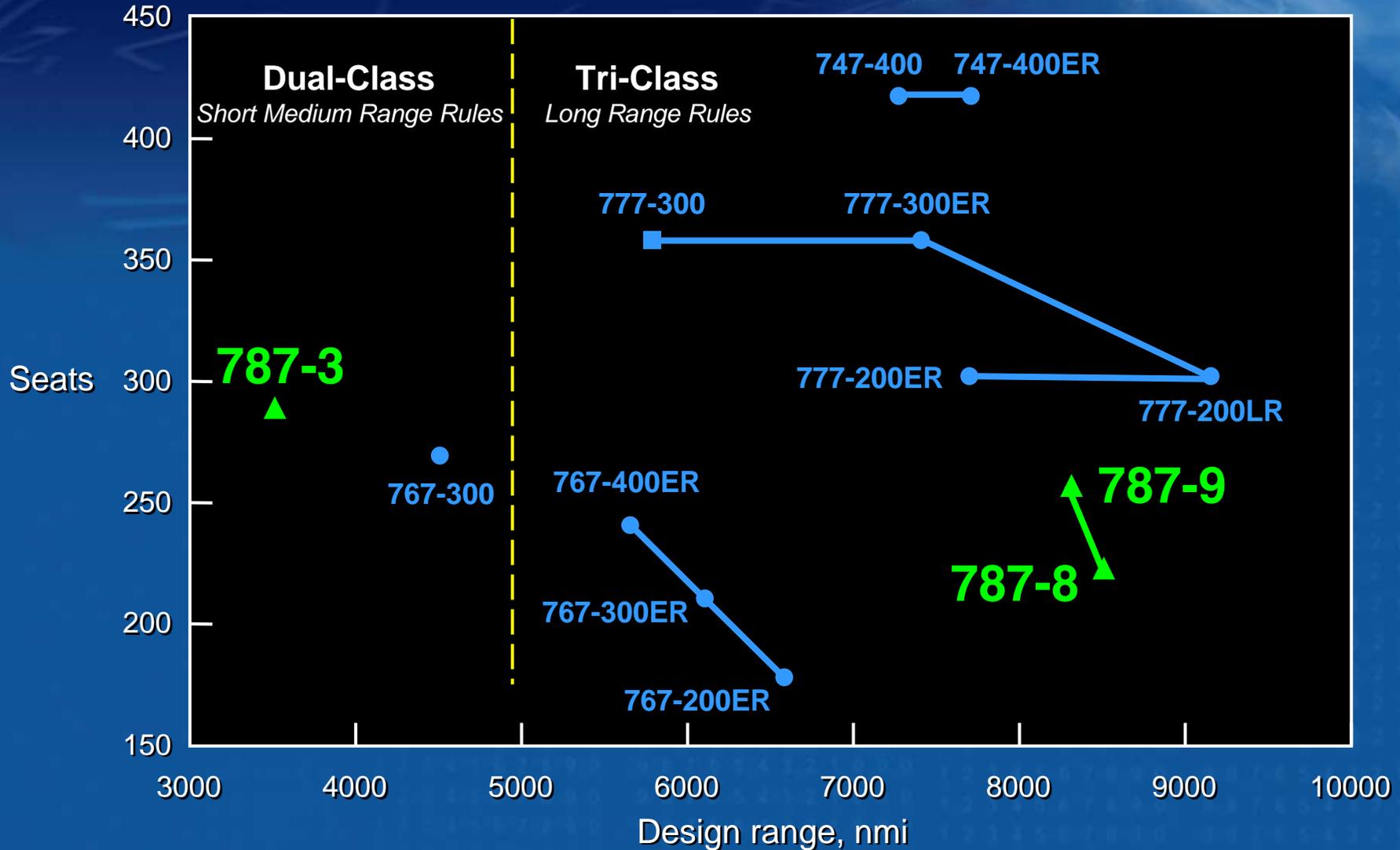


787-3
296 passengers (two-class)
3,500 nmi / 6,500km



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

Efficiency for Medium — and Long-Haul Markets



Creating New Non-Stop Routes

The 787 can efficiently connect more than 450 new city pairs



Possible New Airport Pairs

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

Quiet for Airport Communities

85 dB Noise Contours at Heathrow



**London
Heathrow**

60% less area affected
than the A330 and A340

787 noise footprint
stays in the airport
property

A340-300

A330-200

A330-300

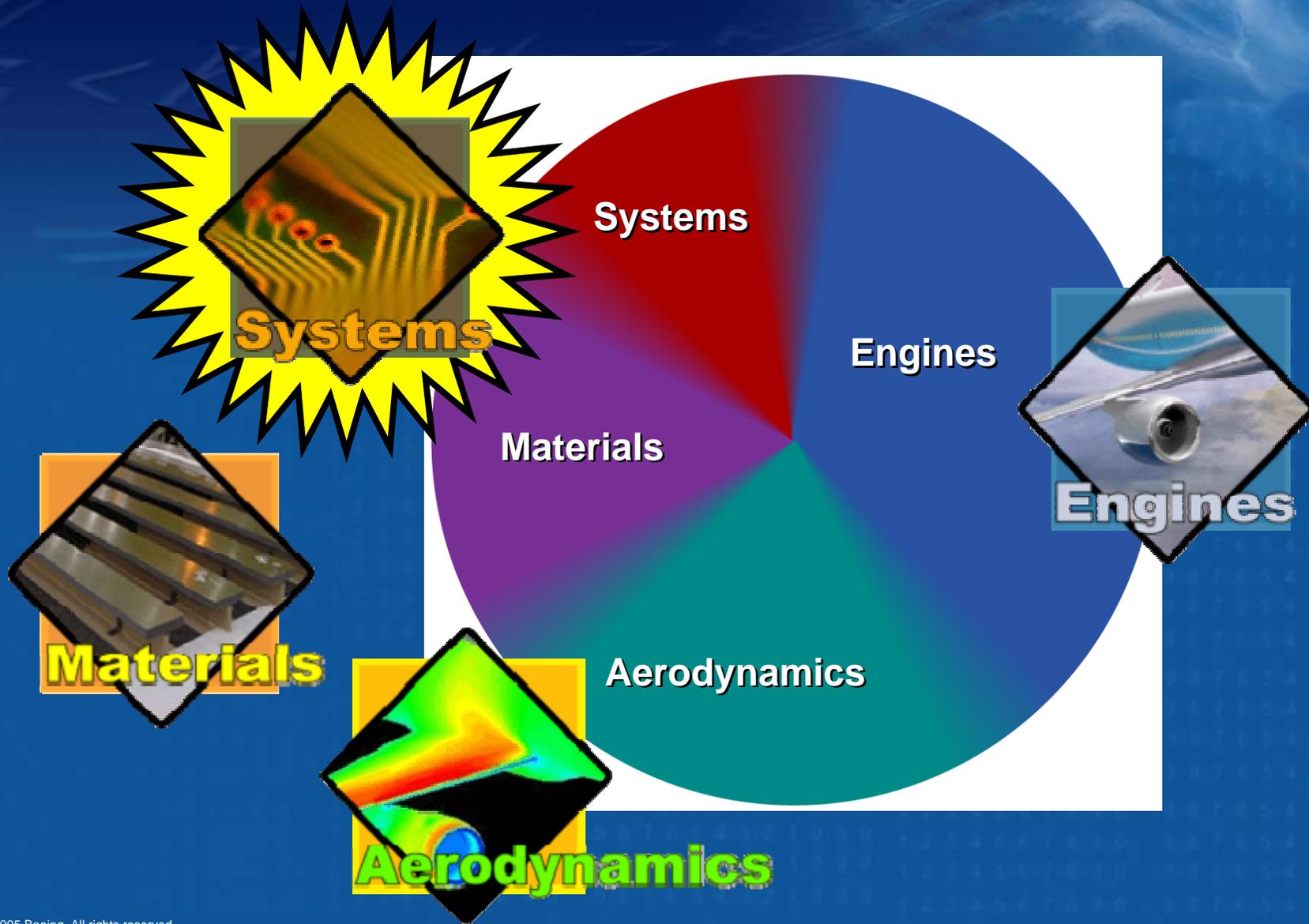
767-300

787-8

Source MS Mappoint, (c) Microsoft, Inc.

- 85 dBA contours
- 3,000 nmi mission

Breakthrough Technologies Reduce Fuel Burn Per Seat by 20%



Engine Technology Advancements



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

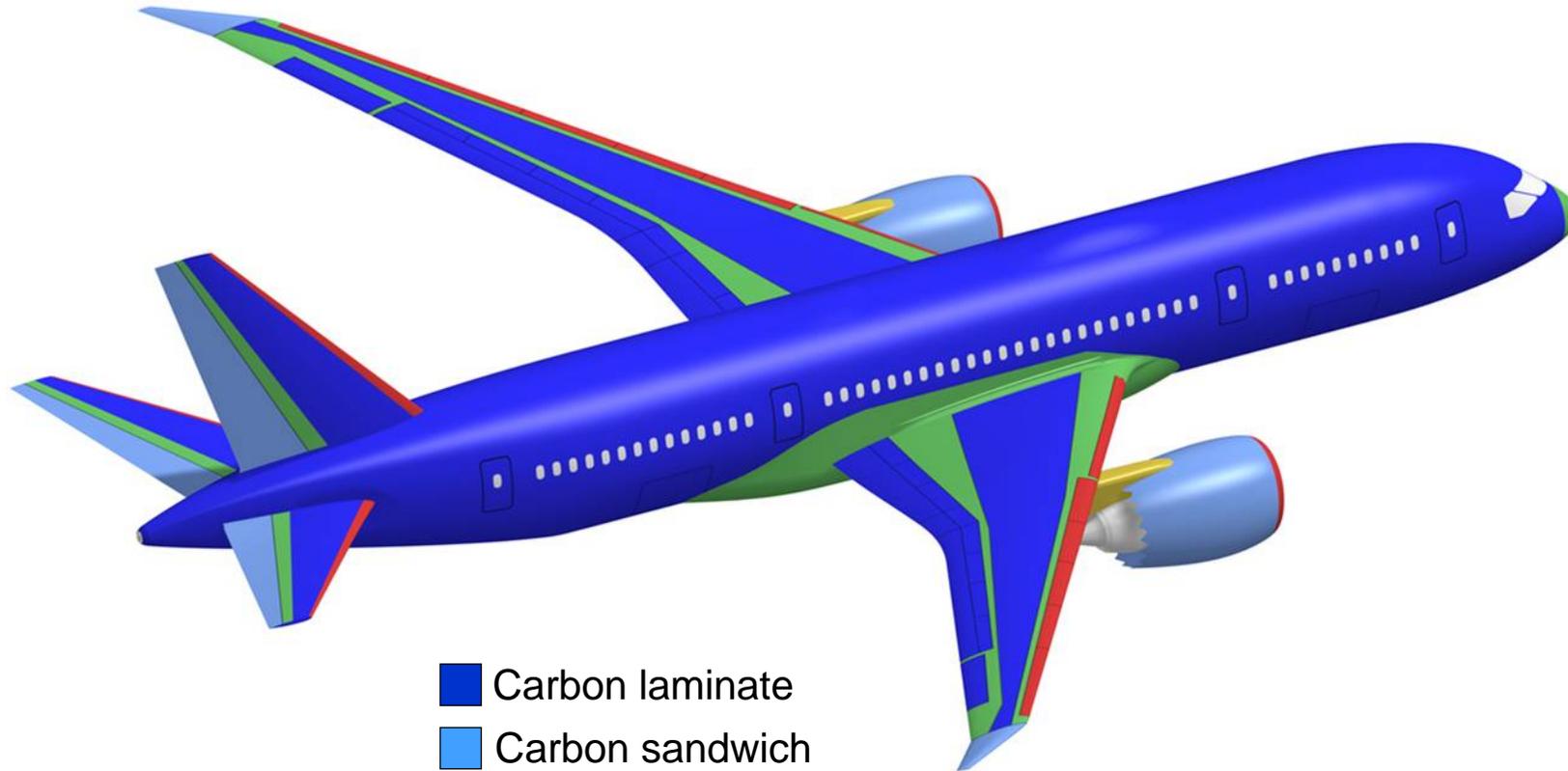
- Higher bypass ratio and higher pressure ratio compressor
- High-flow low-speed fan
- Advanced materials and coatings
- No-engine-bleed systems architecture
- Low-noise nacelles with chevrons
- Engine types are interchangeable at wing / pylon interface

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

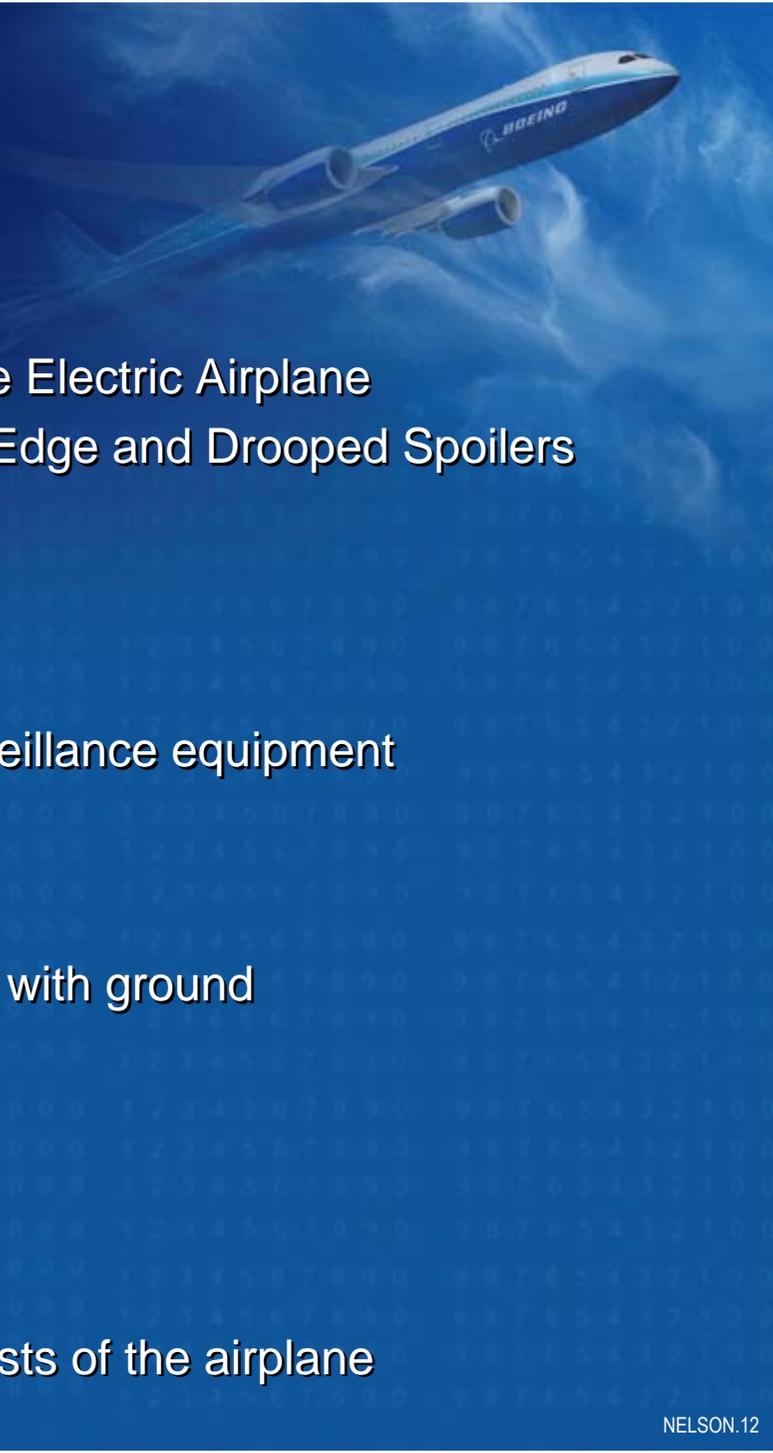


- Carbon laminate
- Carbon sandwich
- Fiberglass
- Aluminum
- Aluminum/steel/titanium pylons

Starting the Second Century of Powered Flight



787 Advanced Systems



Efficient Airplane Systems

- Advanced Energy Management – The More Electric Airplane
- 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

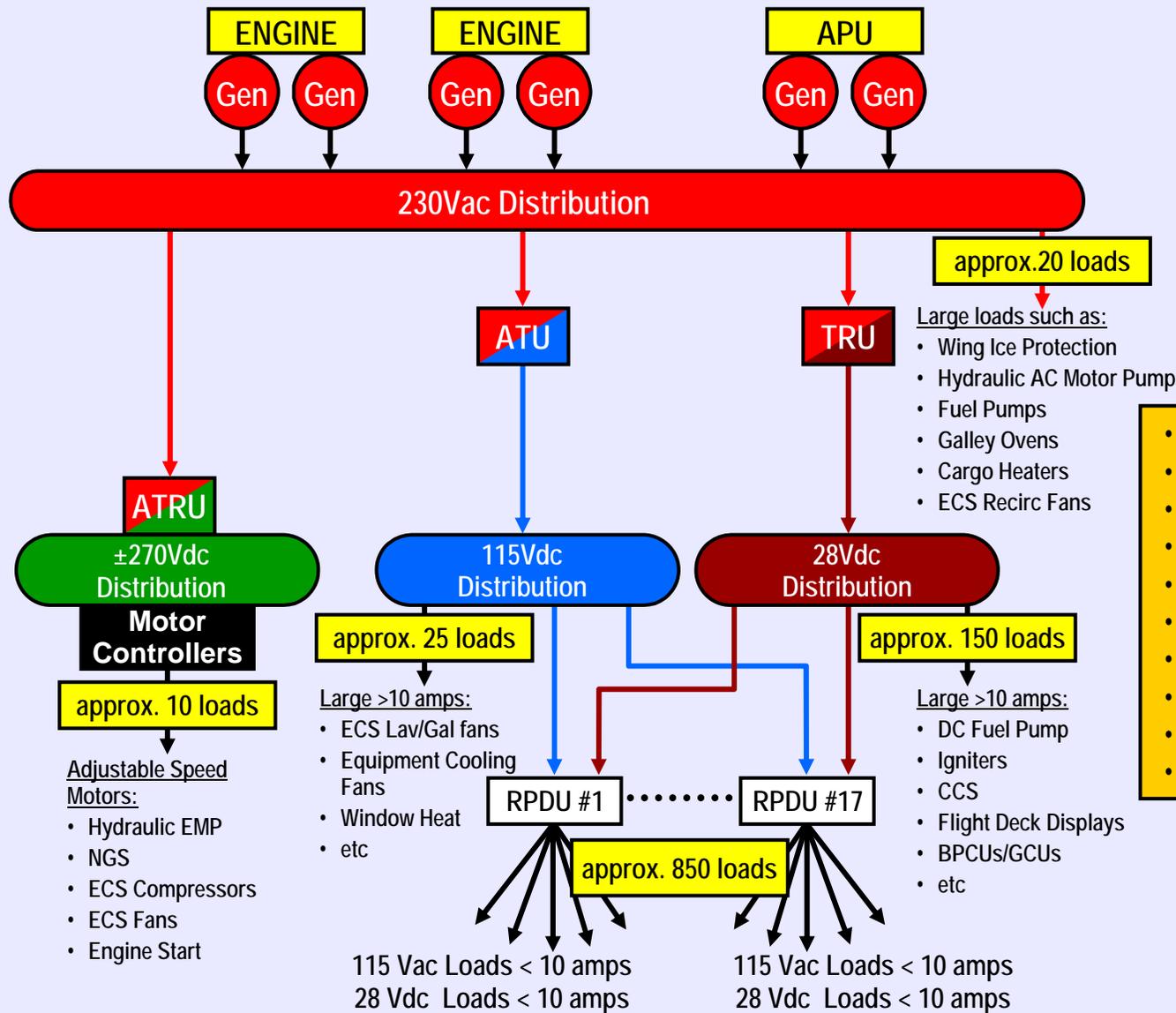
Two 250 kVA Variable Frequency
Starter/Generators per engine

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

Electronic Circuit Breakers

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

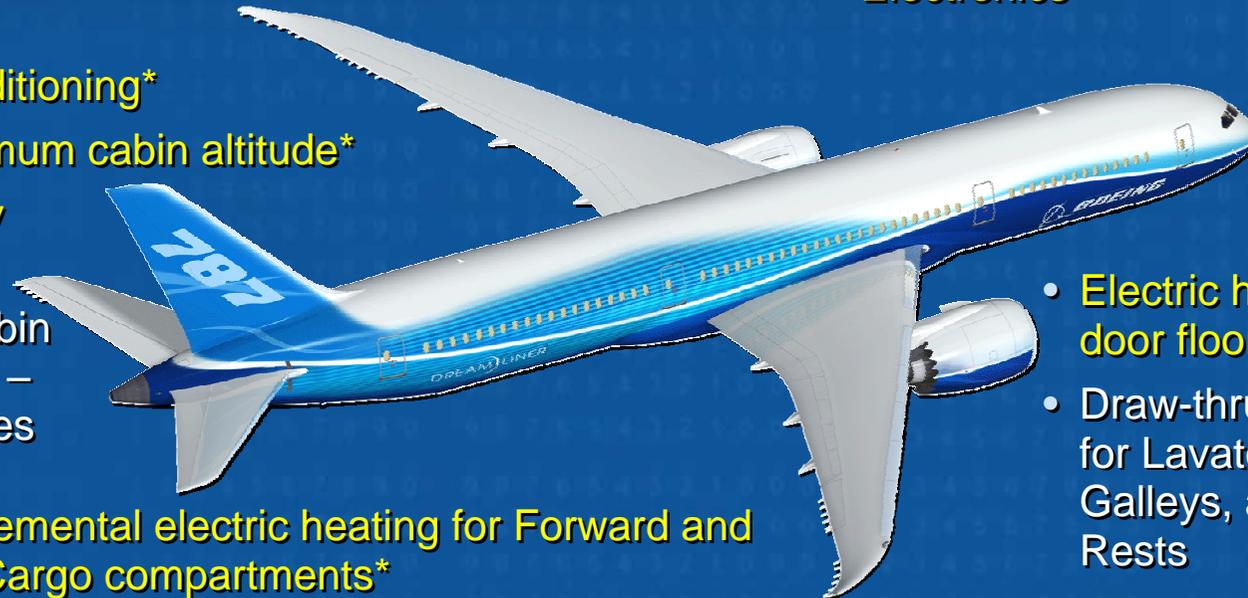
SYS MENU	FLIGHT DECK CB	NON-NORMAL CB	CB BY STATE	CB SEARCH
CB BY ATA	CB BY BUS	CB BY LOCATION	RECENT USED CB	CB CUSTOM LIST
CE2100713	CIRCUIT BREAKER NAME 1	TRIPPED	DETAILS	CONTROL ▲
CE2100714	CIRCUIT BREAKER NAME 2		DETAILS	CONTROL ↑
CE2100715	CIRCUIT BREAKER NAME 3		DETAILS	CONTROL
CE2100701	CIRCUIT BREAKER NAME 4		DETAILS	CONTROL
CE2100702	CIRCUIT BREAKER NAME 5		DETAILS	CONTROL
CK2100780	CONTACTOR NAME 6	TRIPPED	DETAILS	CONTROL 1
CE2100716	CIRCUIT BREAKER NAME 7	UNK	DETAILS	CONTROL
CE2100717	CIRCUIT BREAKER NAME 8		DETAILS	CONTROL
CE2100718	CIRCUIT BREAKER NAME 9	DO NOT CLOSE	DETAILS	CONTROL
CE2100719	CIRCUIT BREAKER NAME 10		DETAILS	CONTROL
CE2100703	CIRCUIT BREAKER NAME 11	INOP	DETAILS	CONTROL 2
CE2100721	CIRCUIT BREAKER NAME 12		DETAILS	CONTROL
CE2100722	CIRCUIT BREAKER NAME 13	DO NOT CLOSE	DETAILS	CONTROL
CE2100723	CIRCUIT BREAKER NAME 14	UNK	DETAILS	CONTROL
CK2100724	CONTACTOR NAME 15		DETAILS	CONTROL ↓
CE2100725	CIRCUIT BREAKER NAME 16		DETAILS	CONTROL ▼

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**
- 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 Air Conditioning***
- **6,000 foot maximum cabin altitude***
- **Integrated galley refrigeration***
- Conventional cabin pressure control – two outflow valves

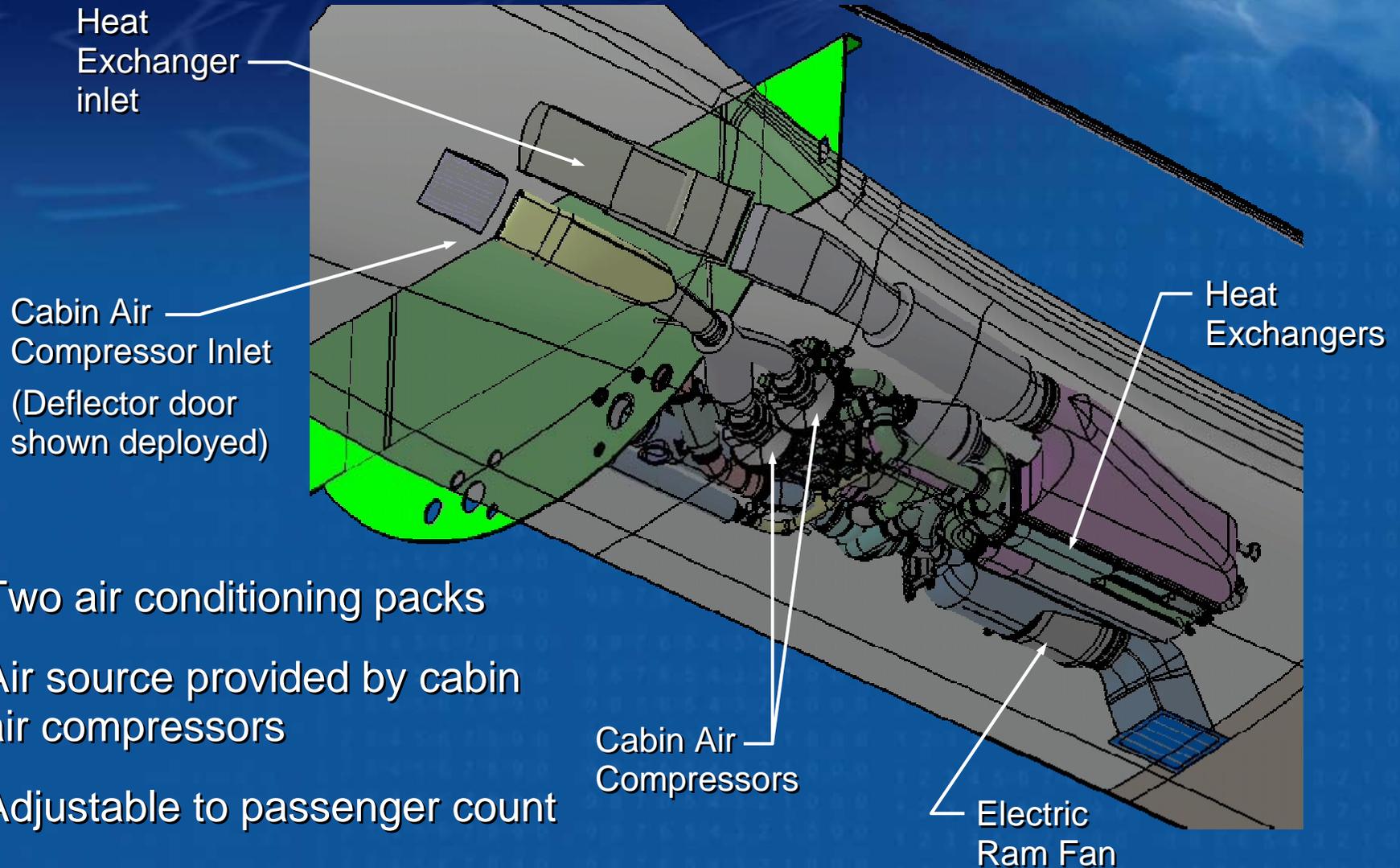


- **Supplemental electric heating for Forward and Bulk Cargo compartments***
- **Forward*** and Bulk Cargo heating and ventilation for animal carriage
- Optional Forward Cargo air conditioning

- **Electric heating for door floor areas***
- Draw-thru ventilation for Lavatories, Galleys, and Crew Rests

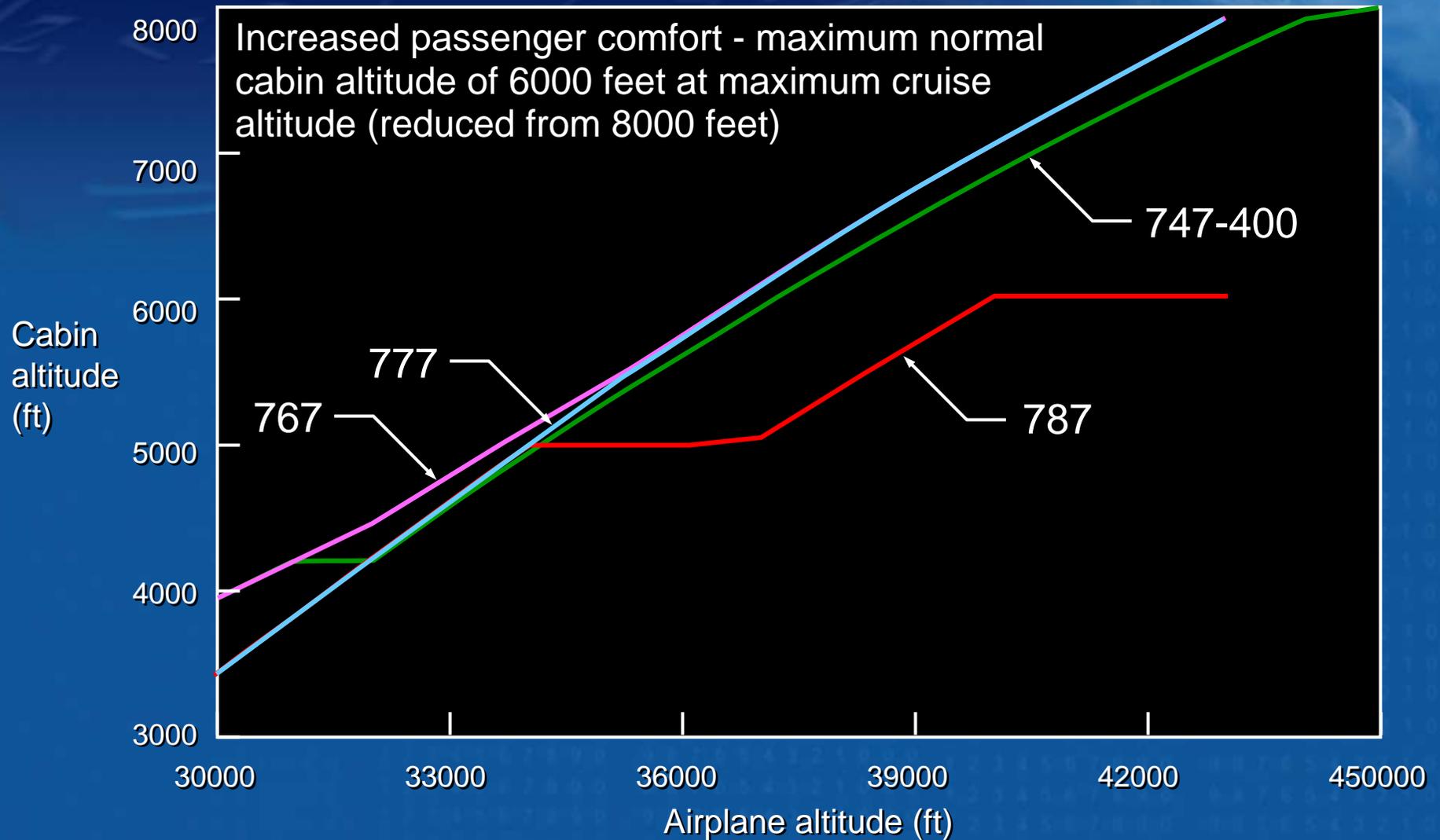
*** Different from 777**

Cabin Air Conditioning System



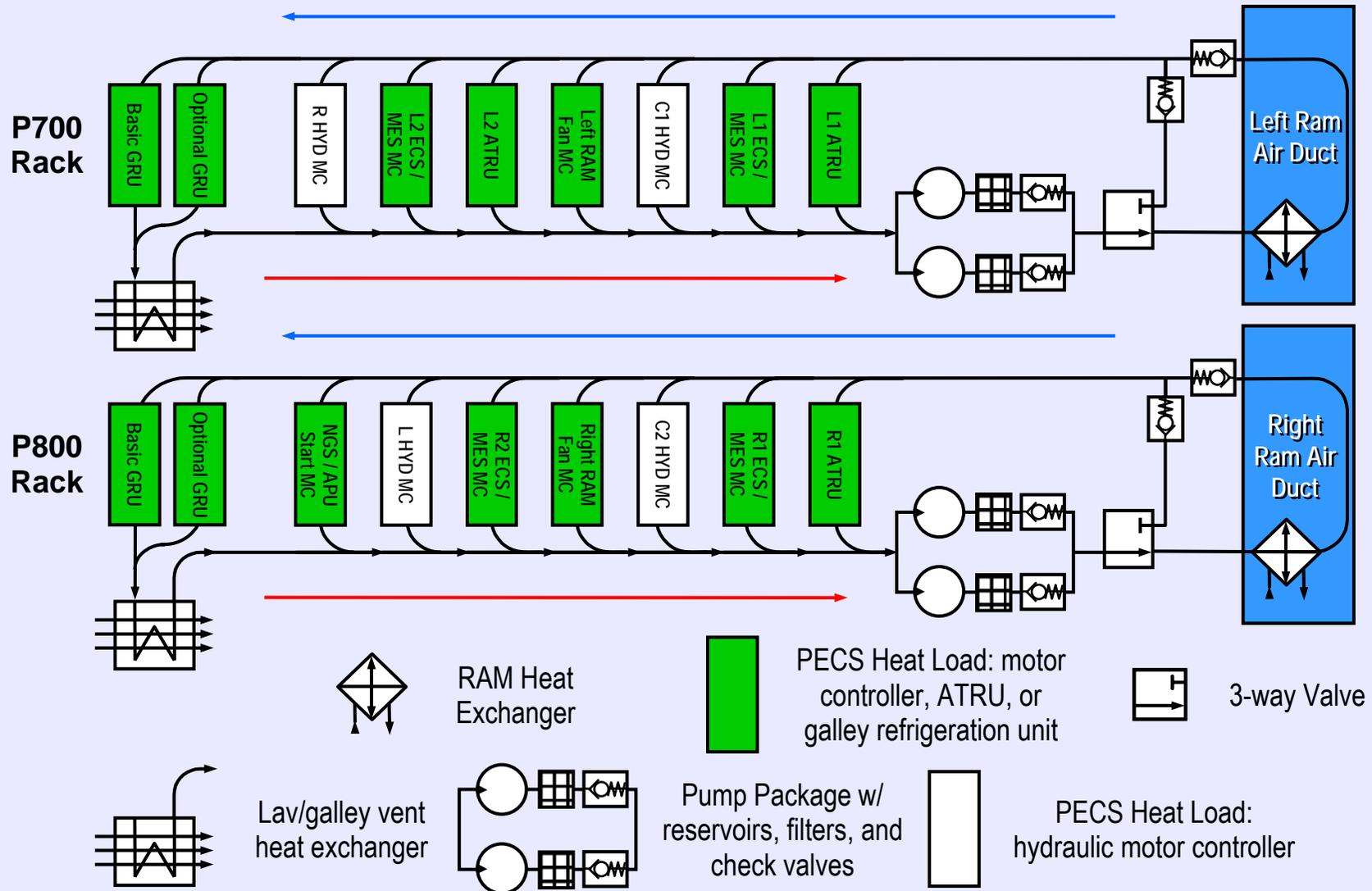
- Two air conditioning packs
- Air source provided by cabin air compressors
- Adjustable to passenger count

Cabin Pressurization Schedule

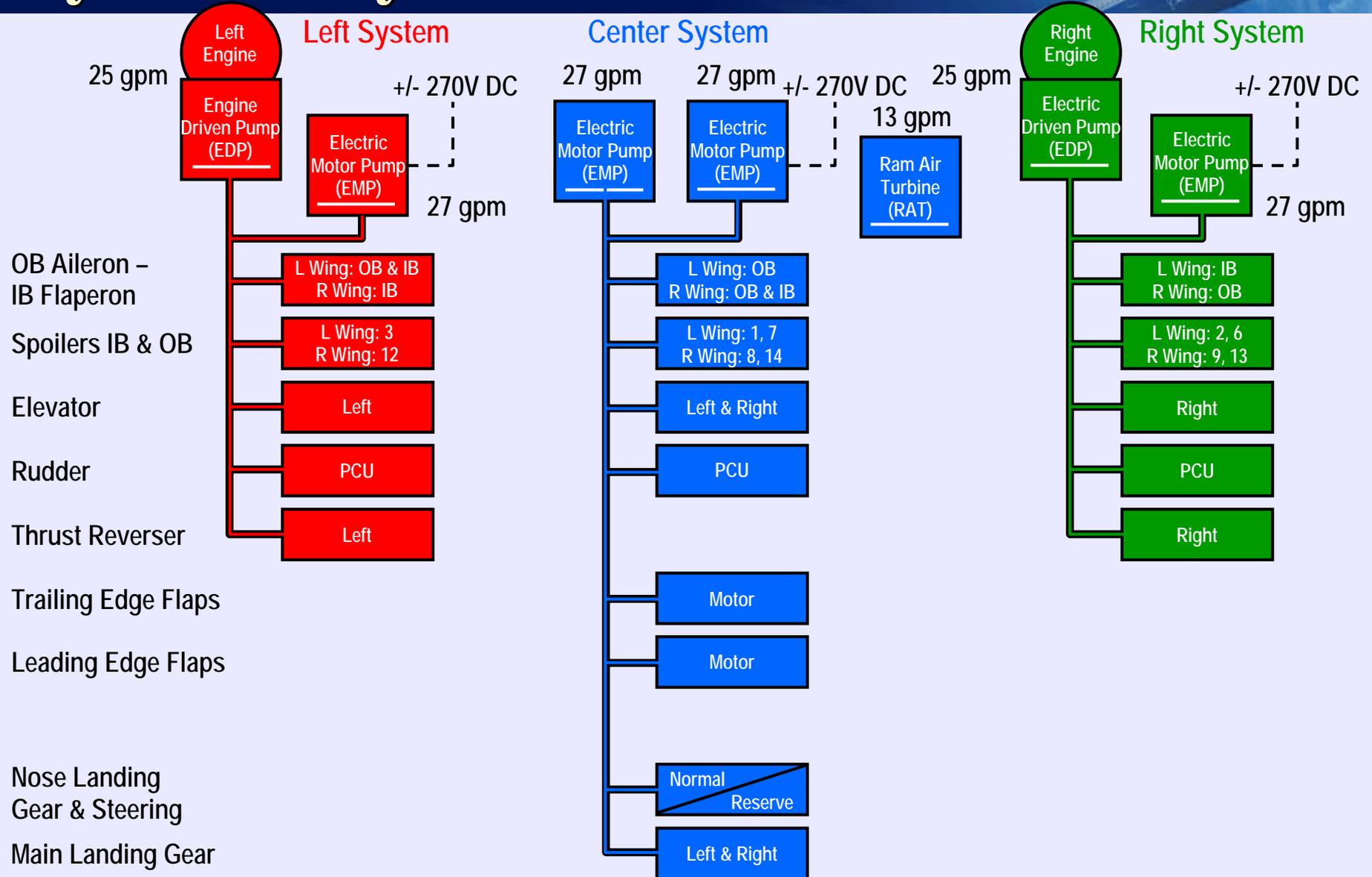


Equipment Cooling System

Power Electronics Cooling System



Hydraulic System Architecture



5000 psi systems with common pumps

787 Fly-by-Wire Flight Controls

All Surfaces Fly-By-Wire

- Eliminates cables
- Reduced weight
- Improved functionality

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)

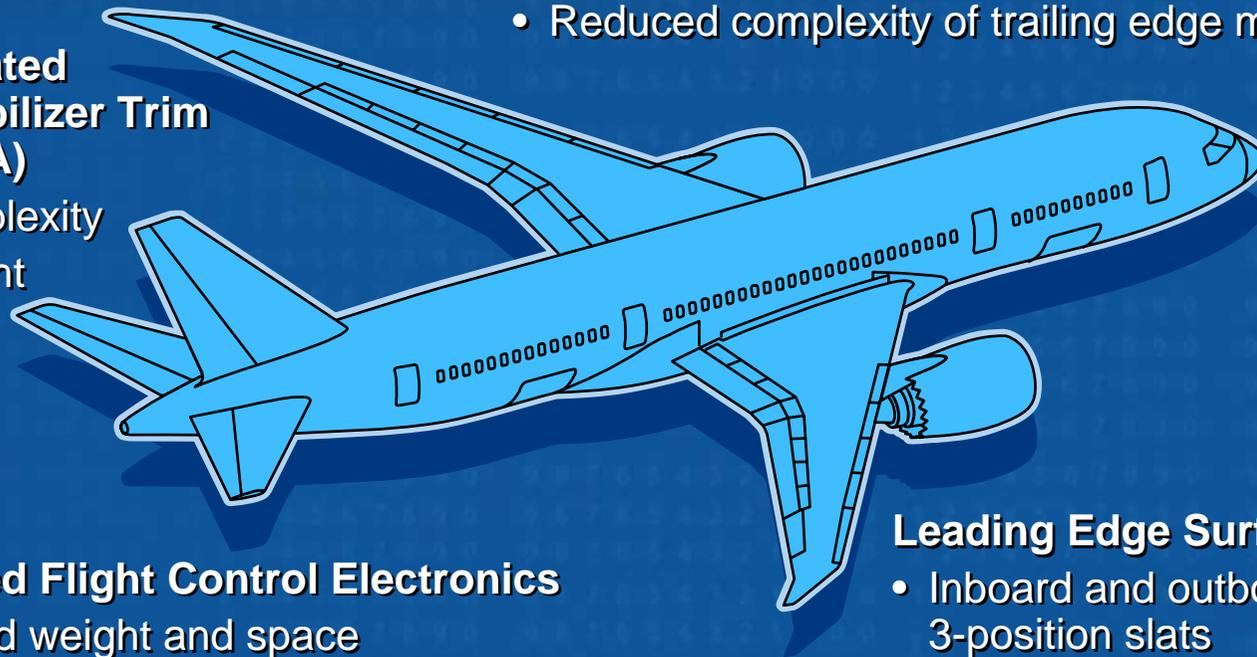
- Reduced complexity
- Reduced weight

Integrated Flight Control Electronics

- Reduced weight and space

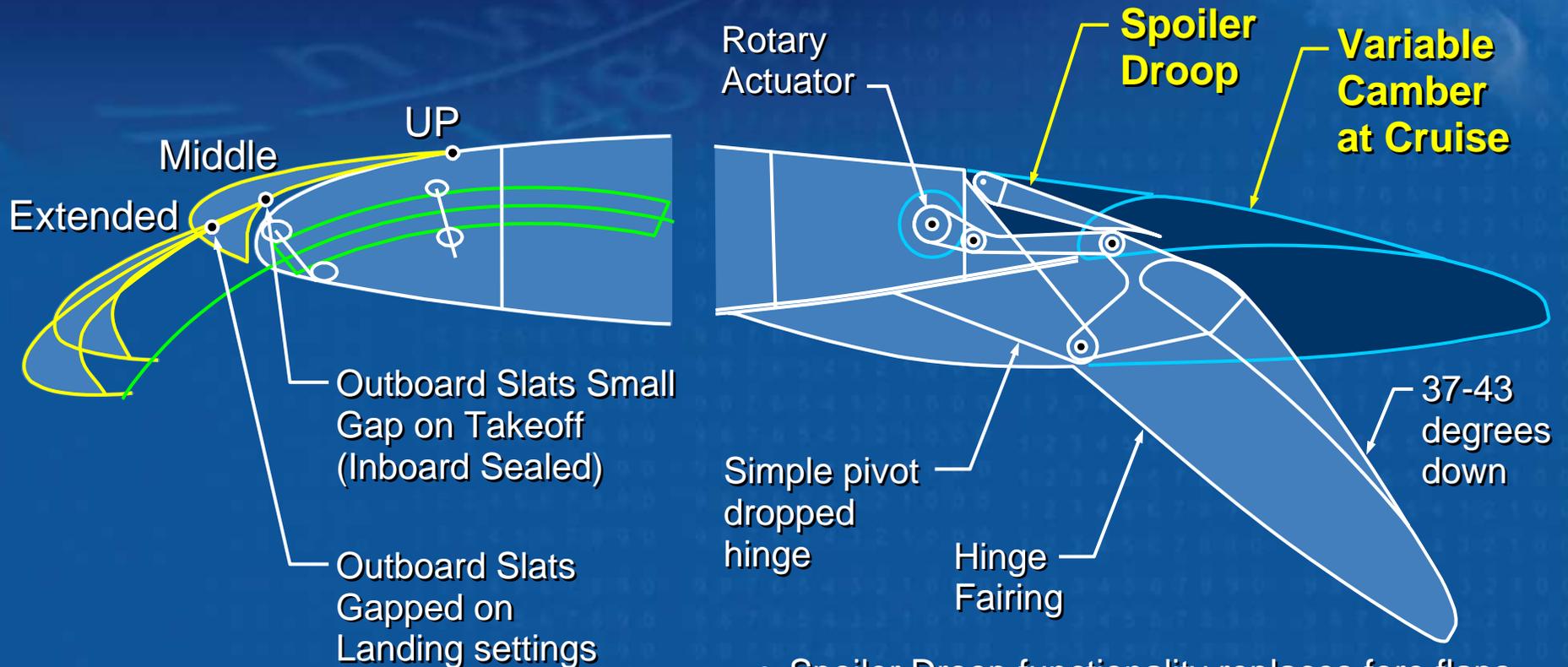
Leading Edge Surfaces

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



High Lift Function

- Leading Edge and Trailing Edge Kinematic Motion



- Spoiler Droop functionality replaces fore flaps and maintains gap and overlap requirements.
- Spoilers driven down via fly-by-wire control.

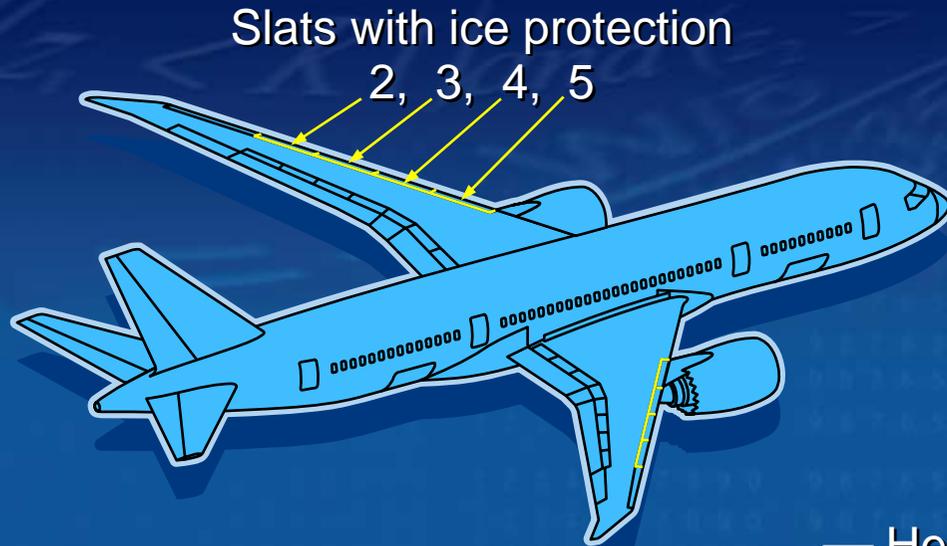
Landing Gear Systems

New Control-by-Wire

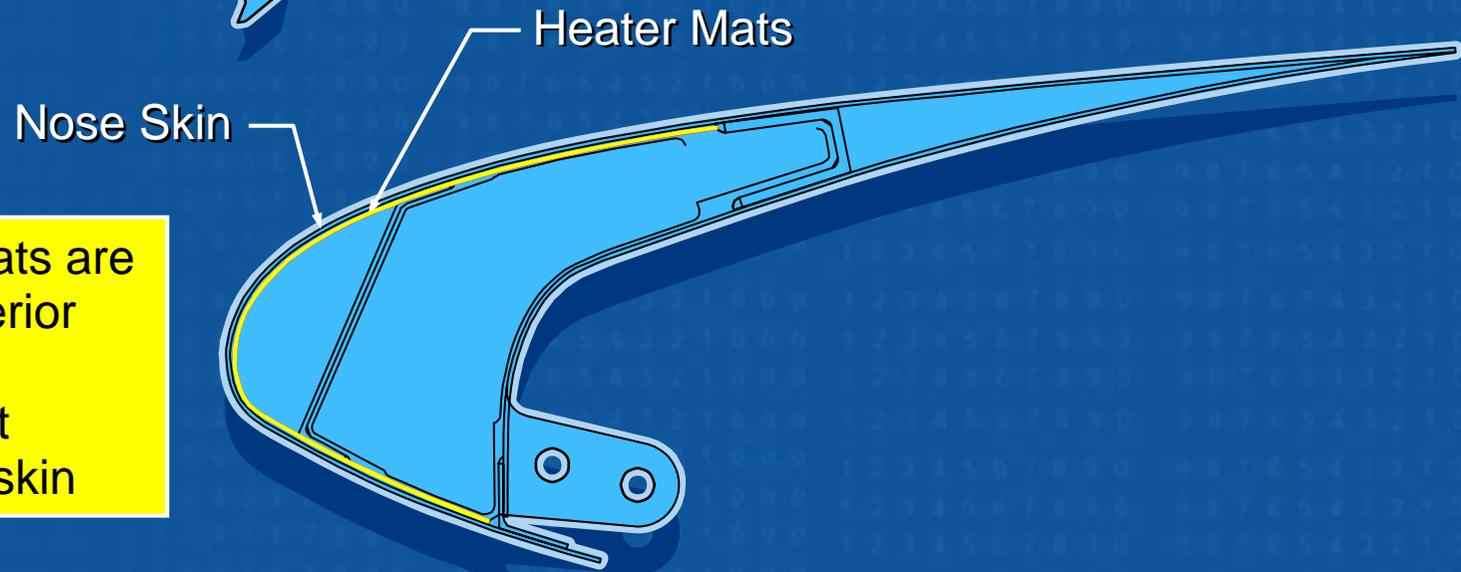
- Landing Gear Actuation
 - Electronic control and sequencing of landing gear and doors
 - Dedicated proximity sensors to monitor gear and door position, and to control sequencing
 - Alternate landing gear extension electrically controlled and hydro-mechanically released
- Brake Control
 - Control-by-wire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



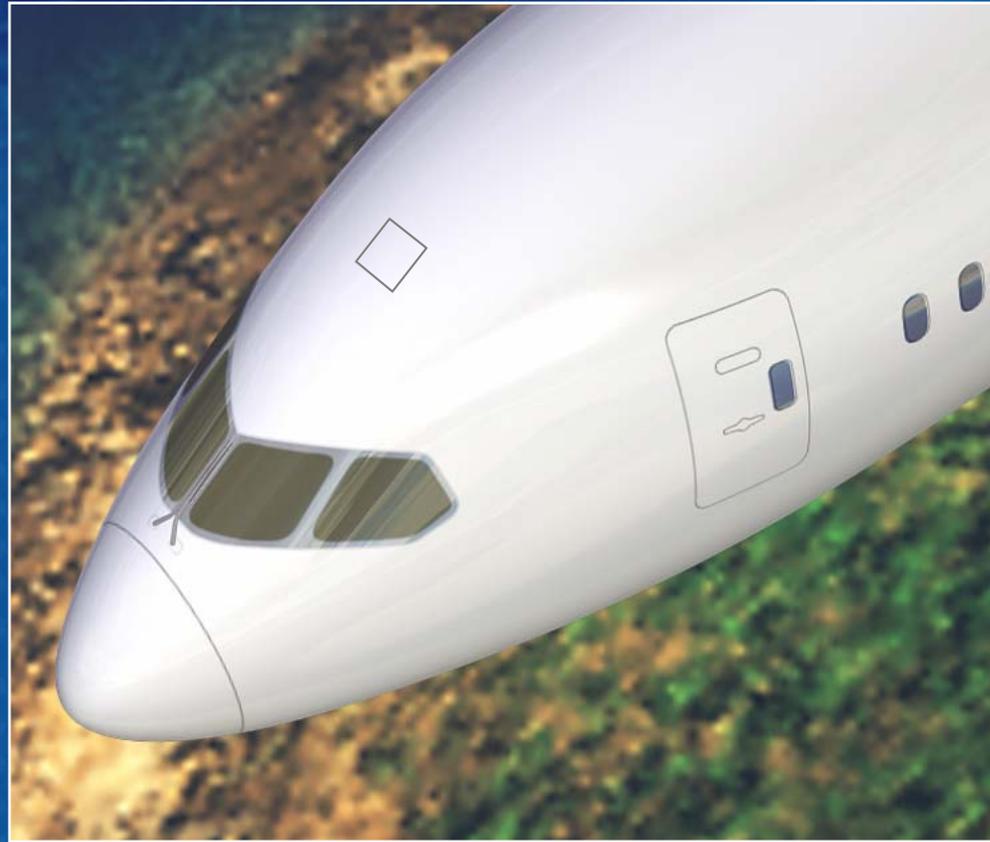
- Electrical Power – no engine bleed air
- Six heater mats in each heated slat
- Aluminum cap to protect leading edge surface



The heater mats are bonded to interior surface of the composite slat leading edge skin

Final Nose Configuration

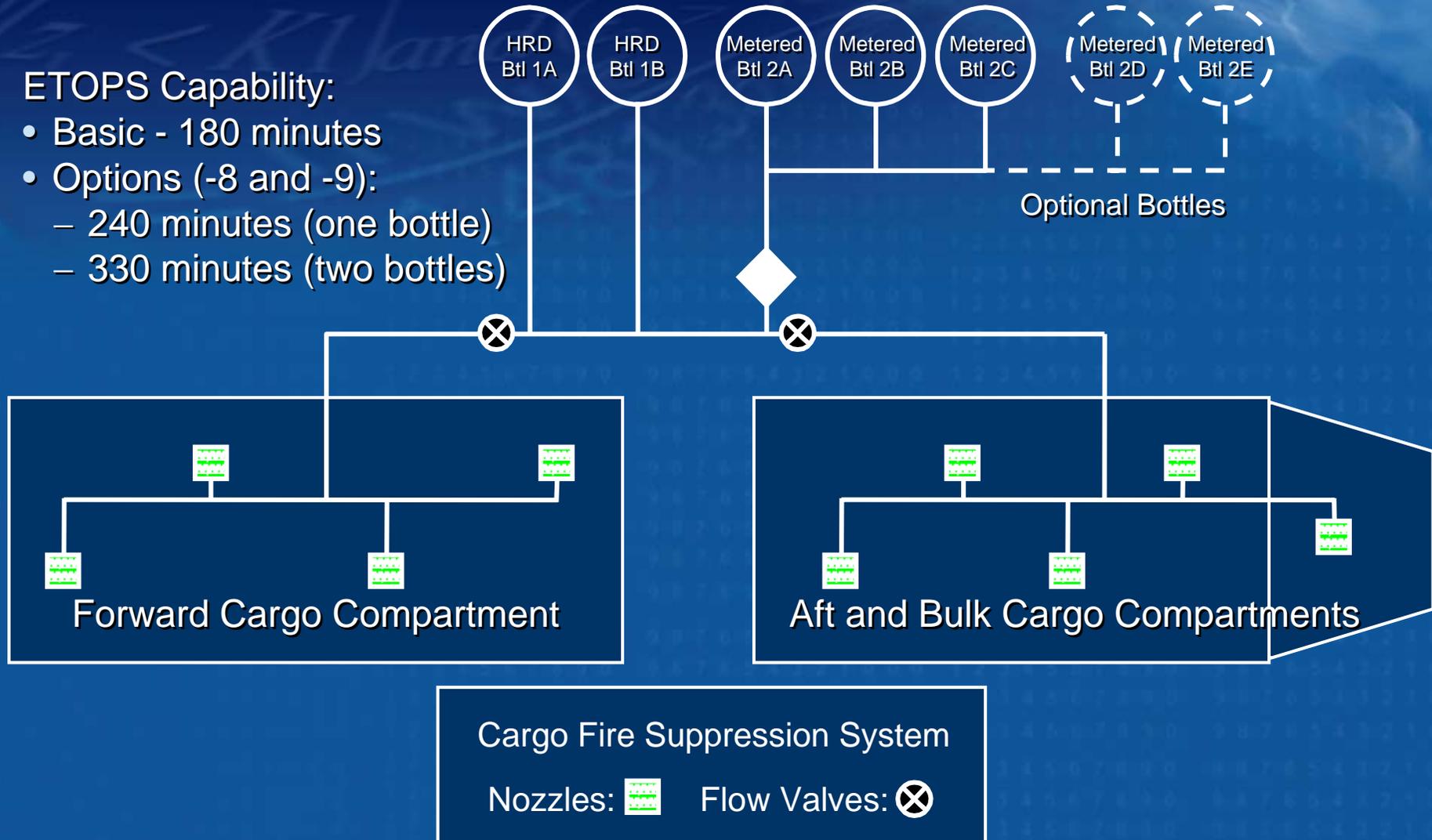
- Four windows, fewer posts
- Pilot vision similar to 777
- Non-opening windows
- Crew escape door
- Vertically stowed wipers
- Windshield washer



Cargo Fire Protection

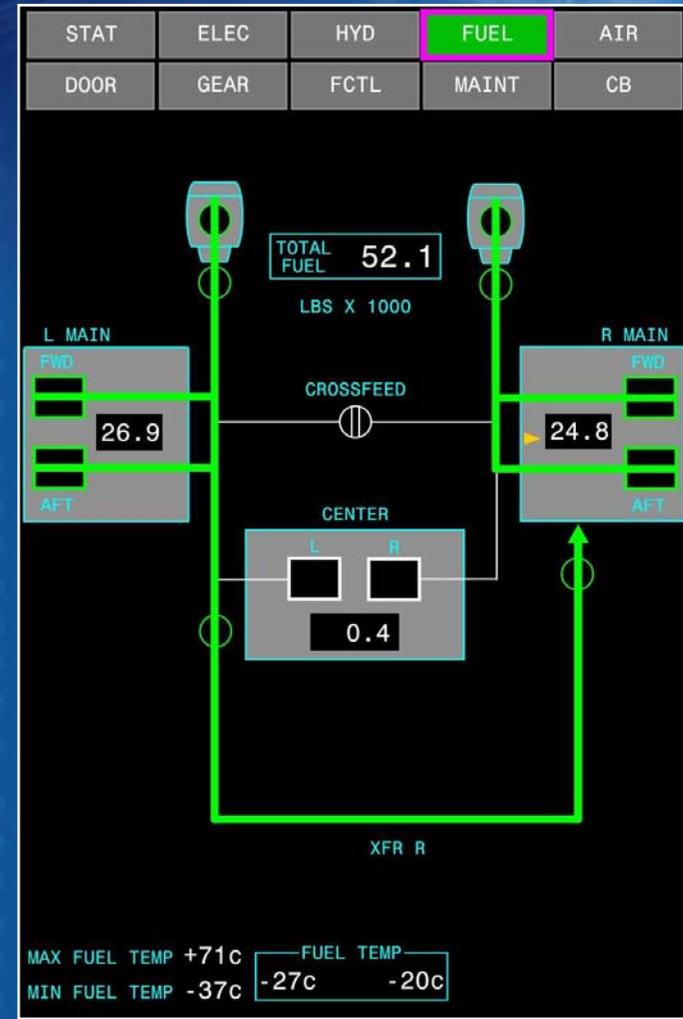
ETOPS Capability:

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



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



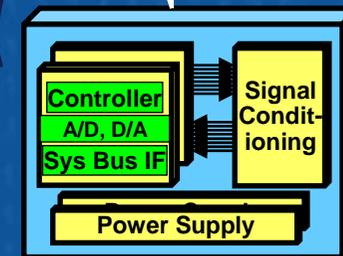
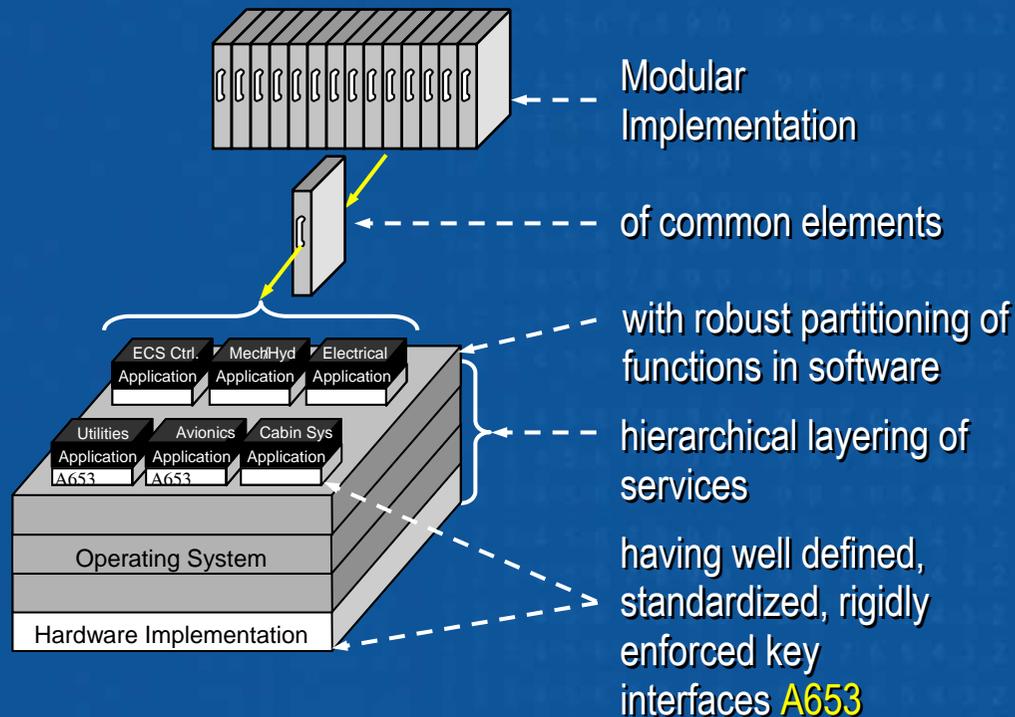
Common Core System Benefits

Common Data Network

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

Common Computing Resource

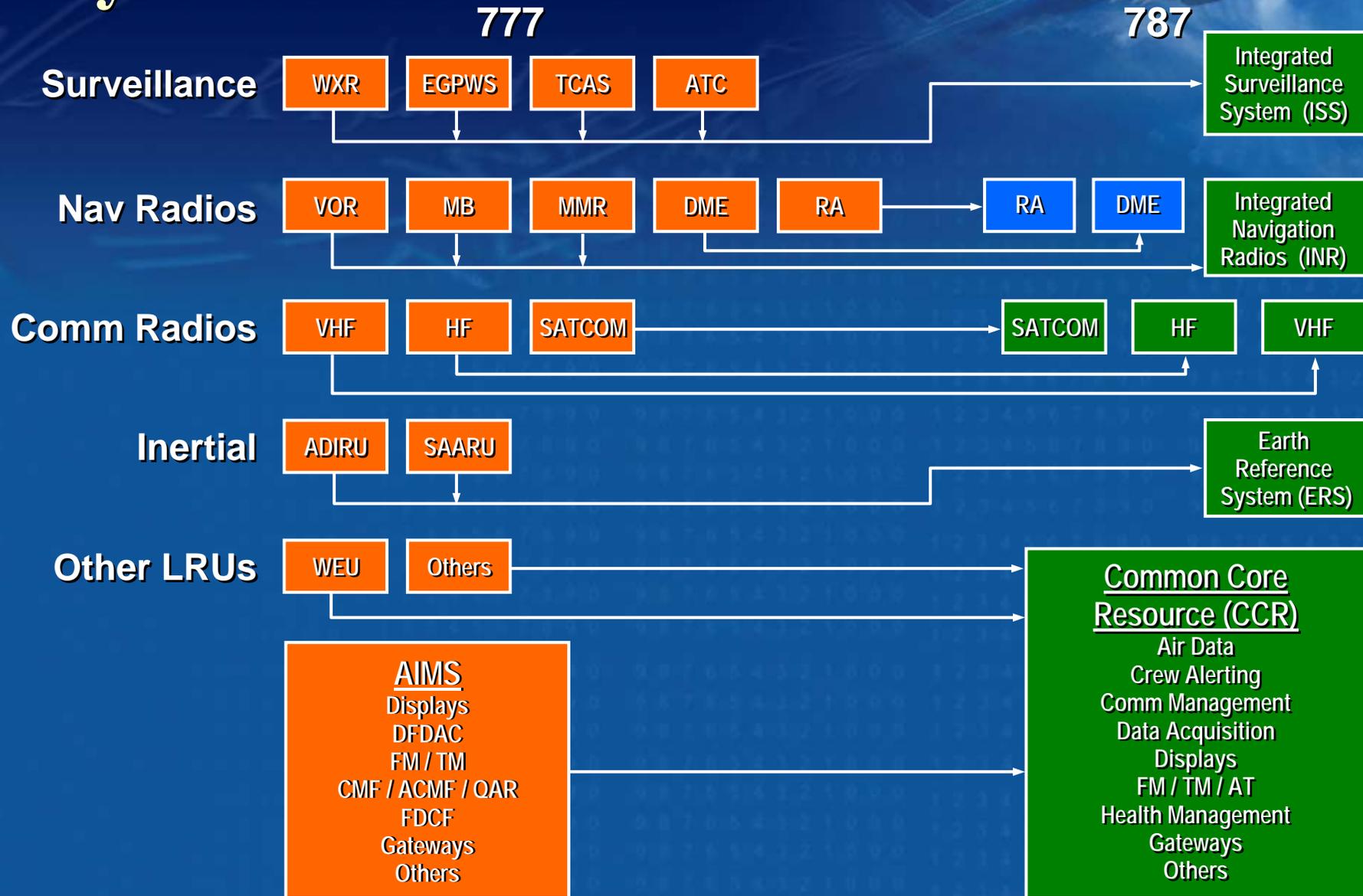
- Based on Open System Architecture Principles



Remote Data Concentrators

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

Avionics Integration Beyond 777



Flight Deck



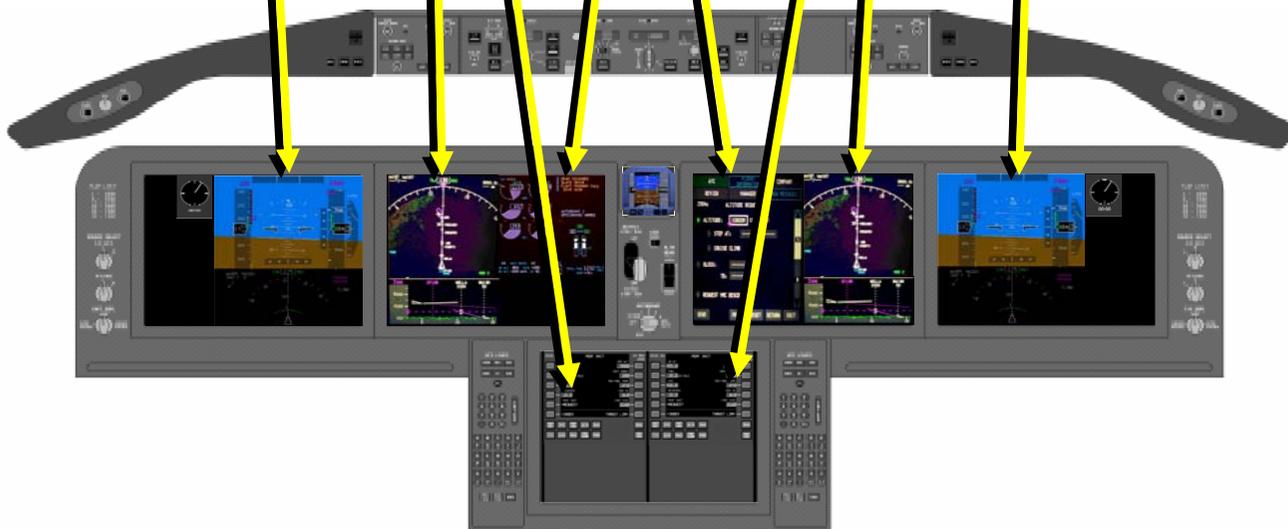
- Boeing look, feel and procedures flow
- Familiar Boeing controls
- Familiar display formats
- All 777 functions and features
- Large format displays

Display Layout Comparison

777



787



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

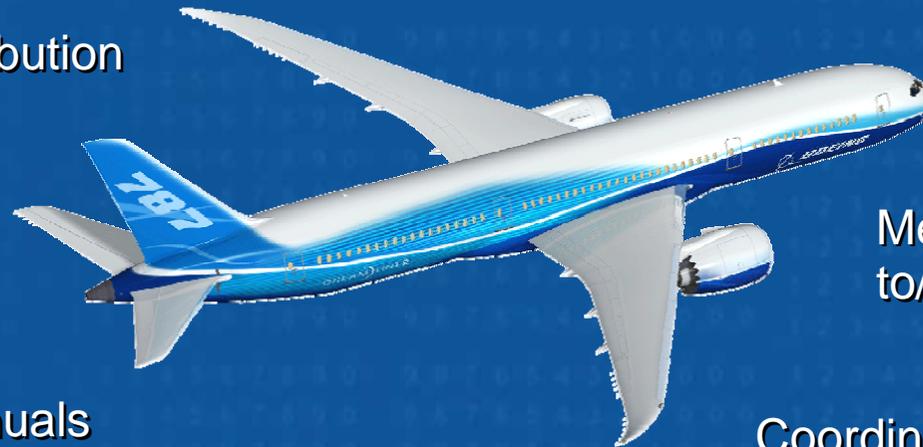
Crew Information System — Onboard Health Management

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

Fault Prediction

Coordinated airplane
and ground processing
approach

787 Program Schedule



Thank You

