



Introducing the 787

- *Effect on Major Investigations*
- *And Interesting Tidbits*

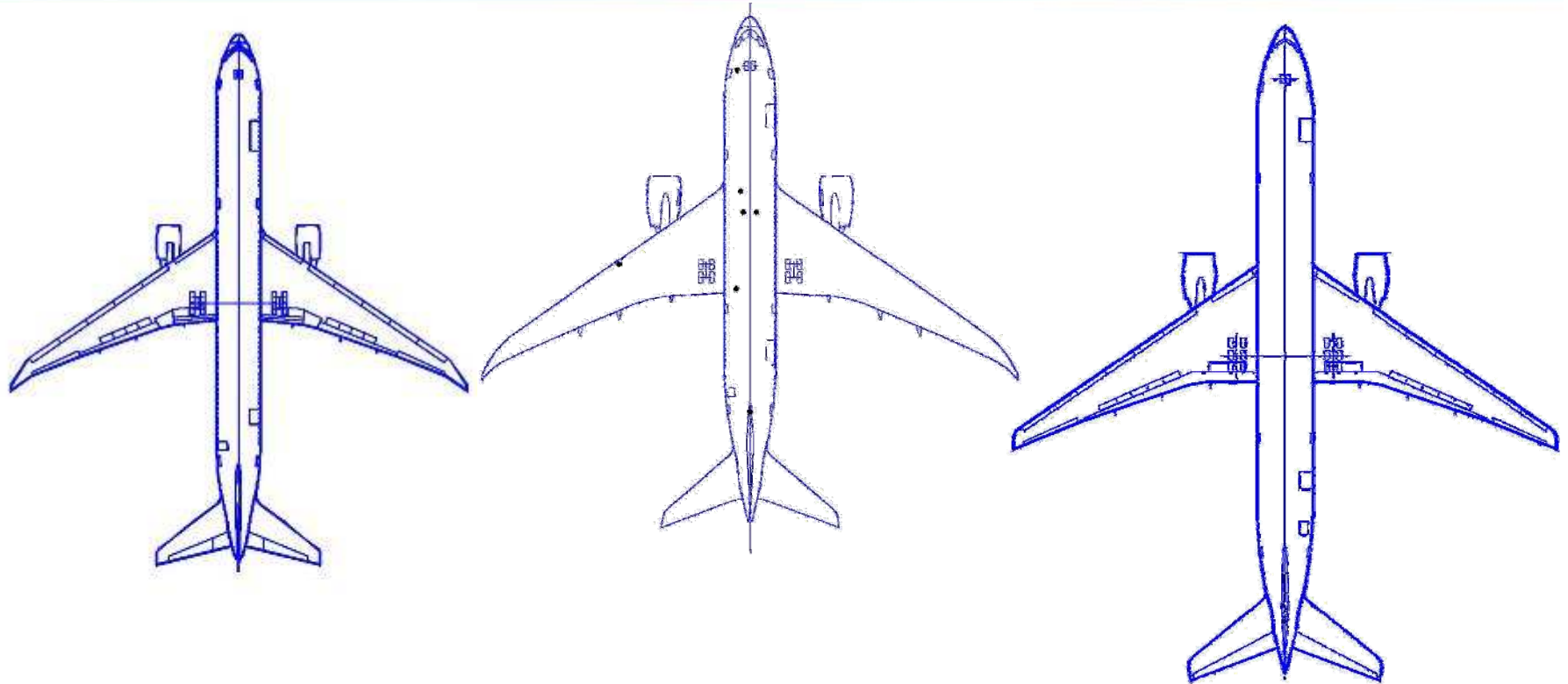


Tom Dodt

Chief Engineer – Air Safety Investigation

ISASI September, 2011

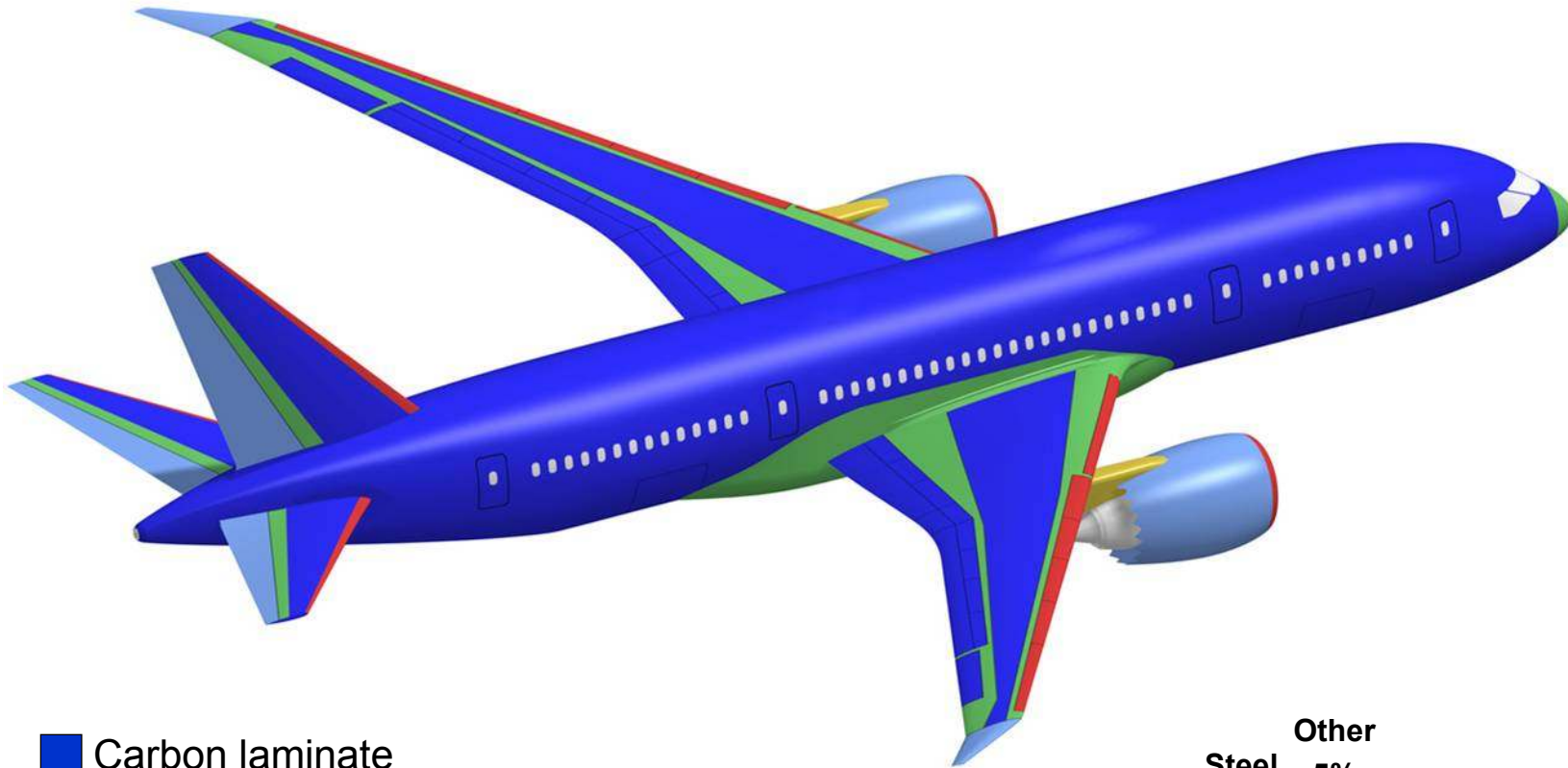
787 Size Comparison



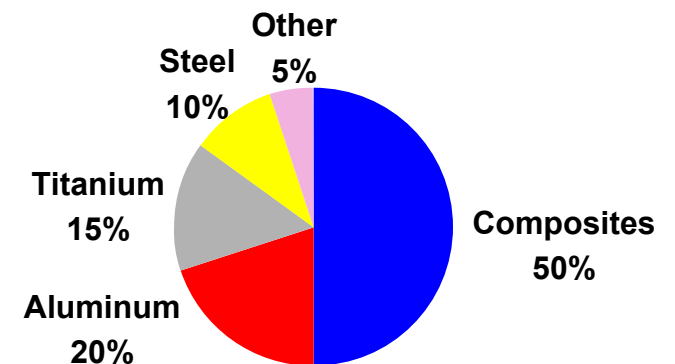
	767-400	787-8	777-300
~Pax 3-Class	245	250	368
~Span	170 ft	197 ft	200 ft
~Length	201 ft	186 ft	242 ft
~MTGW	450,000 lbs	500,000 lbs	660,000 lbs
~Range	5,600 NM	7,650 NM	6,000 NM
Cruise Mach	0.80	0.85	0.84

Composite Structure

By weight	787	777
- Composites	50%	12%
- Aluminum	20%	50%



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





787 Wing Flex - On-Ground



787 Wing Flex - 1G Flight



787 Wing Flex



Ultimate-Load ~26 ft

1G Flight ~12 ft

On-Ground 0 ft



Max-Load

787 Static Load Test @ Ultimate Load



Investigations with Composite Materials

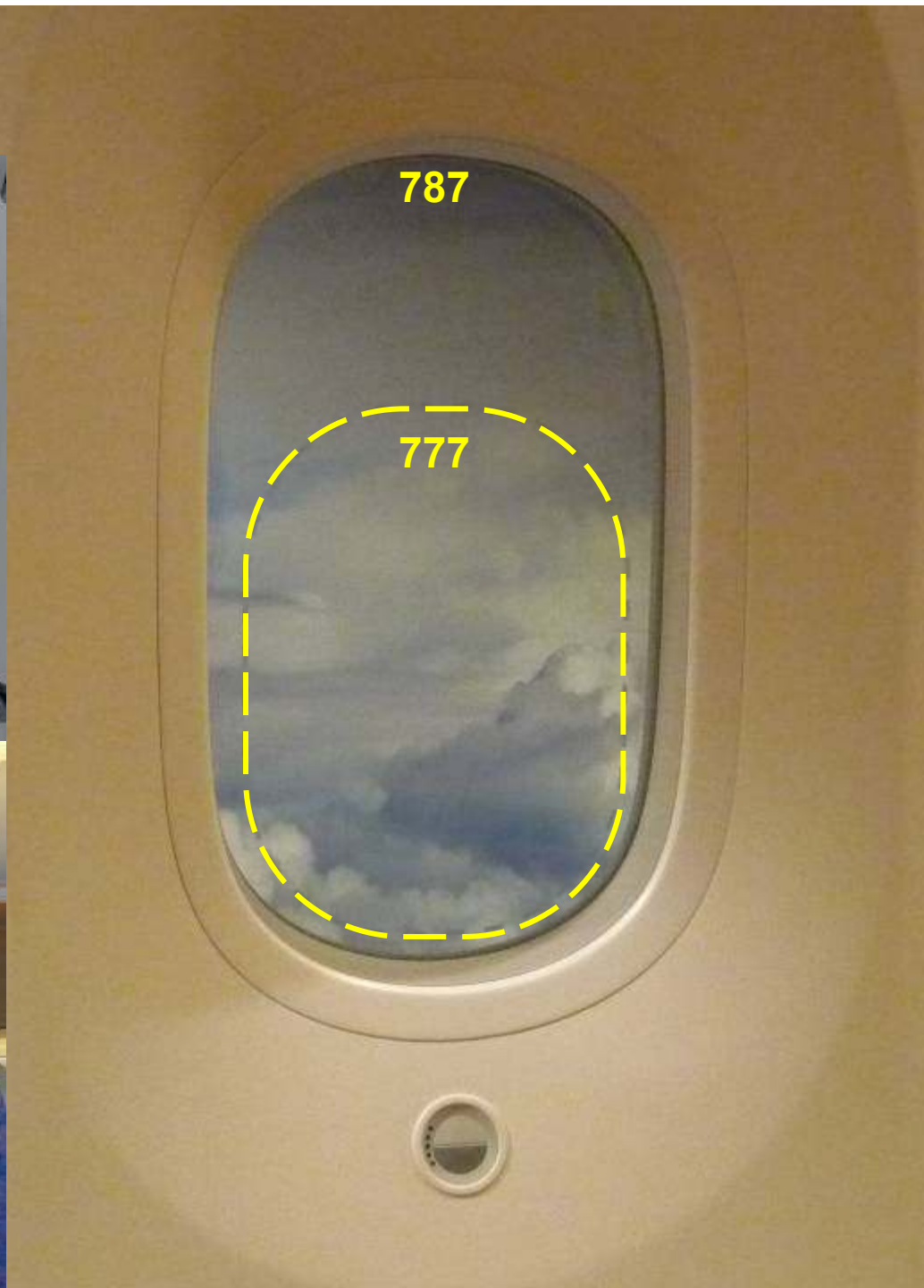
- Terms:

<u>Composites</u>	<u>Aluminum</u>
disbond	fatigue
delaminate	beach marks
inter-laminar shear	striation counts
water absorbsion	corrosion
fiber architecture	metallurgical prop.
- Material Forensics Techniques will be different
- On-Site with Exposed Composite Fibers
 - Eyes - goggles or full face protection
 - Nose - HEPA filter
 - Hands - gloves
 - Exposed Skin - coveralls

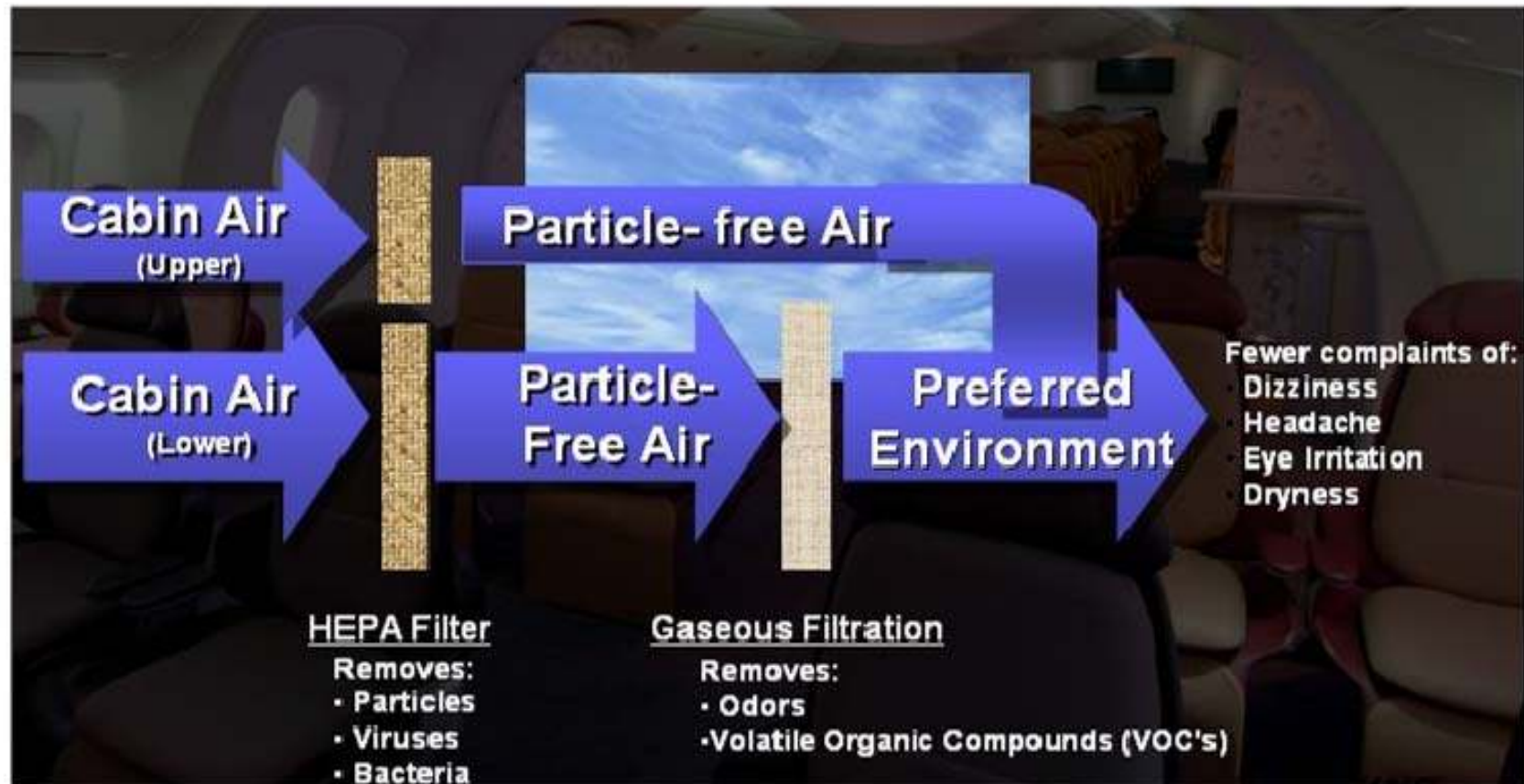


787 Cabin Experience

787 Windows



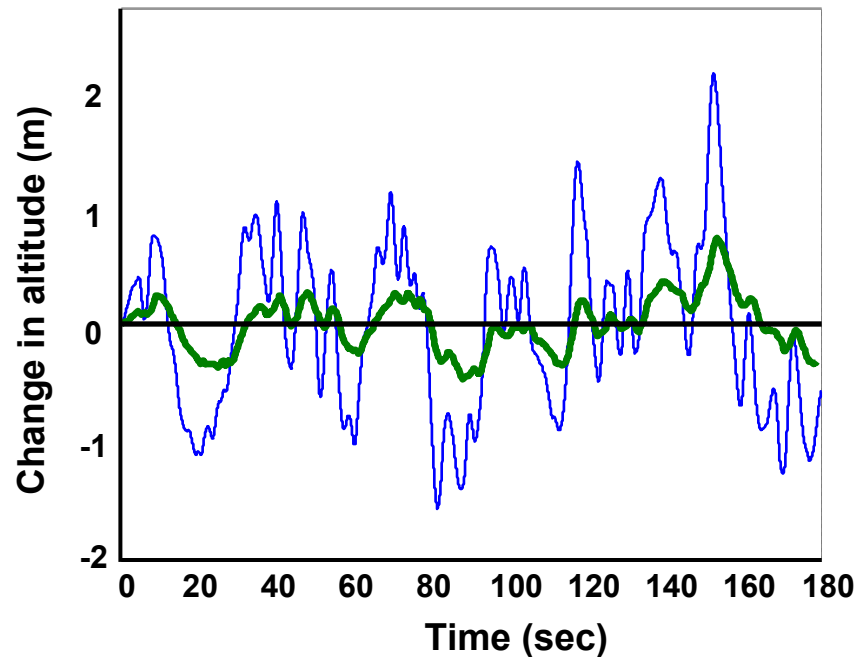
Cleaner Cabin Air



HEPA (high efficiency particulate air) recirculation filters and gaseous air purification filters produce air that is essentially particle free and odor free. The HEPA filters are highly effective in removing bacteria, viruses, and fungi. The gaseous filtration system removes odors and volatile organic compounds.

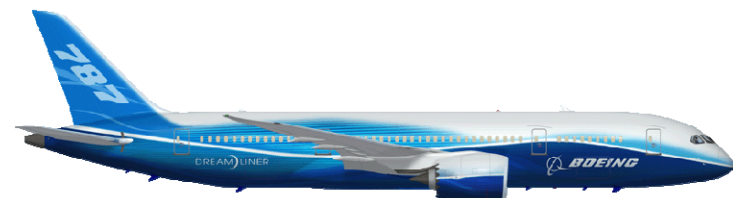
Ride Quality - Smoother Ride

Vertical Gust Suppression



- With Enhanced Gust Suppression
- Without Enhanced Gust Suppression

- Uses the flaperons and elevators
- Counters light to moderate turbulence to improve ride quality
- Passengers have a more comfortable flight



787 Cabin Experience

Windows - Larger

Pressure - Lower

Humidity - Higher

Air Quality - Improved

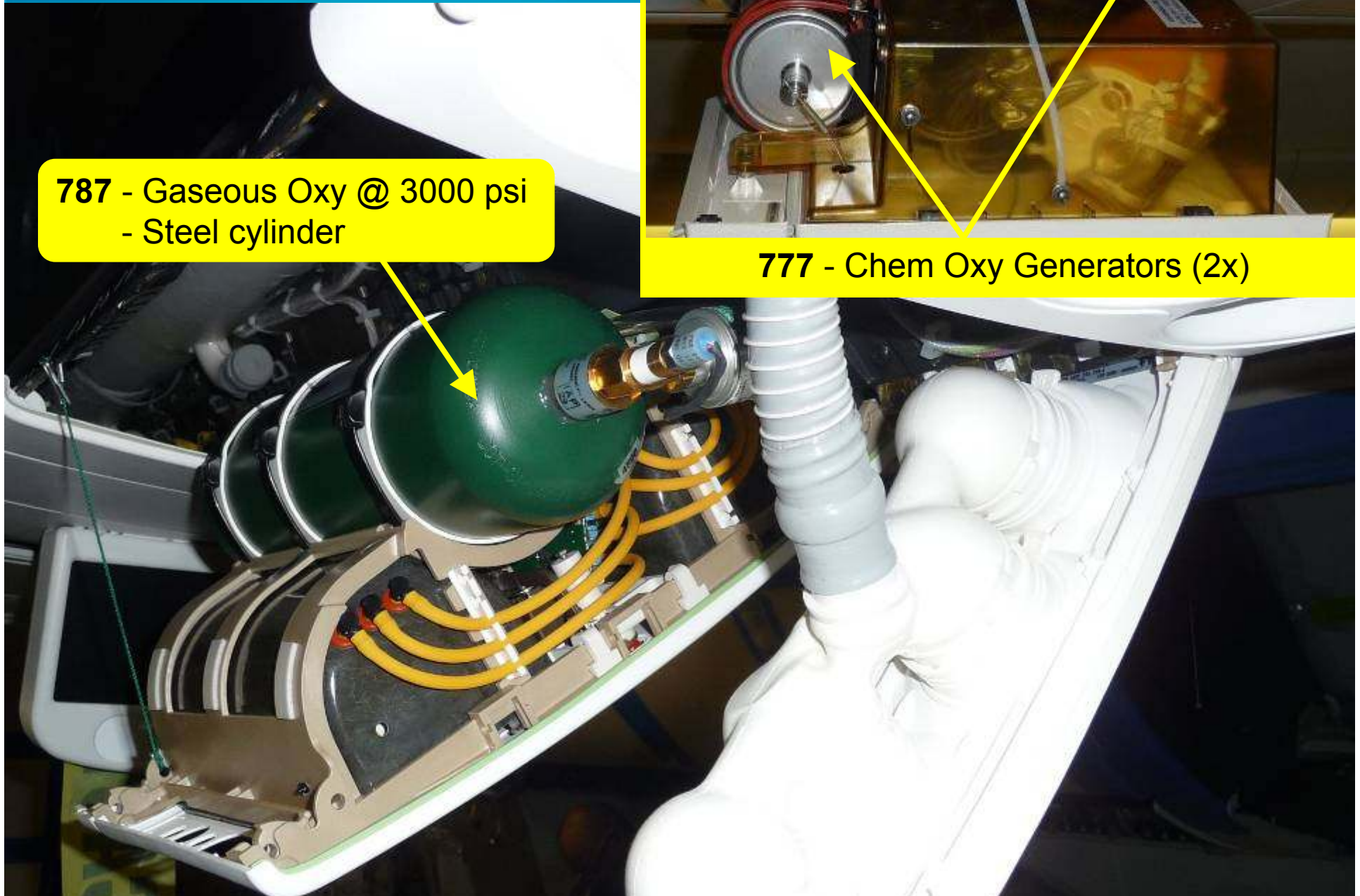
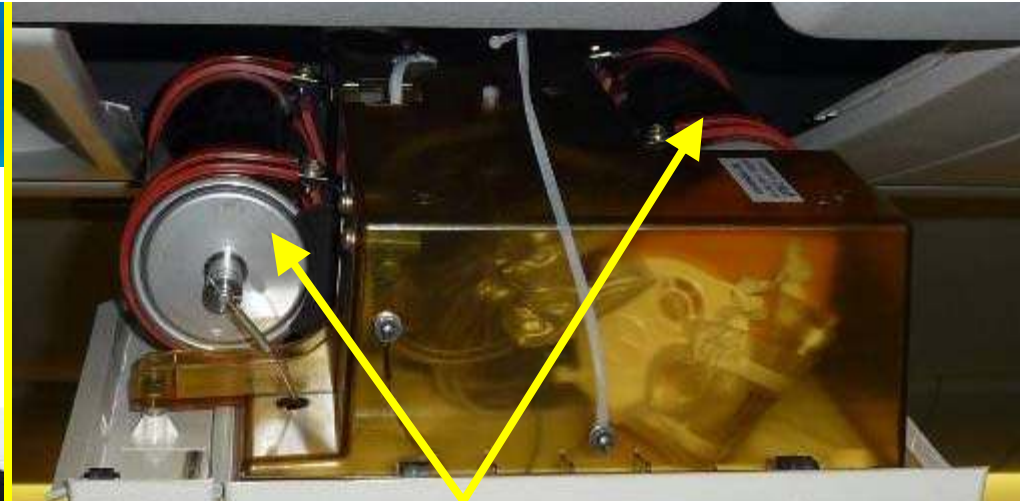
Ride Quality - Improved

Food Service - Unchanged (sorry)

787 Pax Oxygen

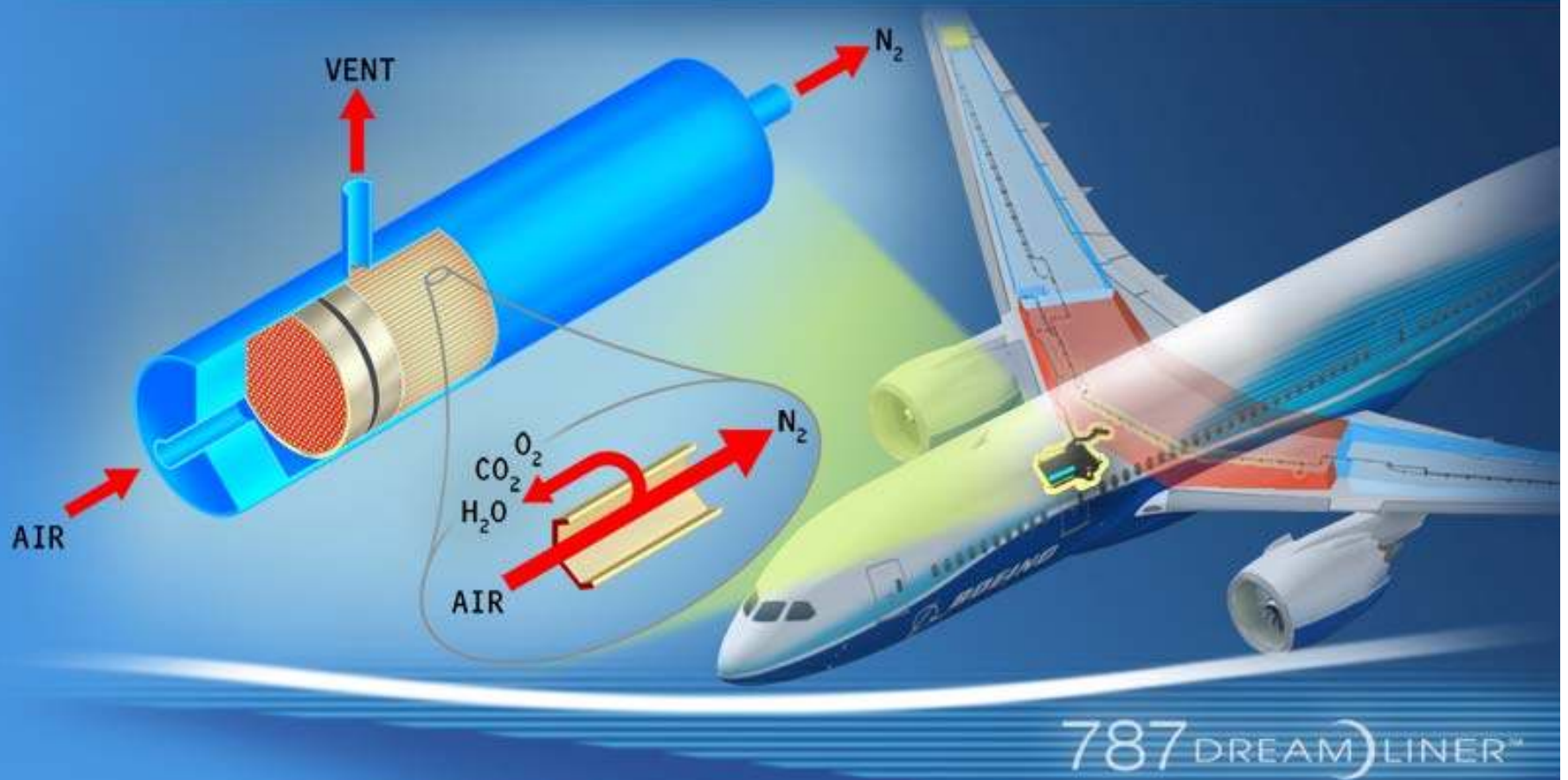
787 - Gaseous Oxy @ 3000 psi
- Steel cylinder

777 - Chem Oxy Generators (2x)



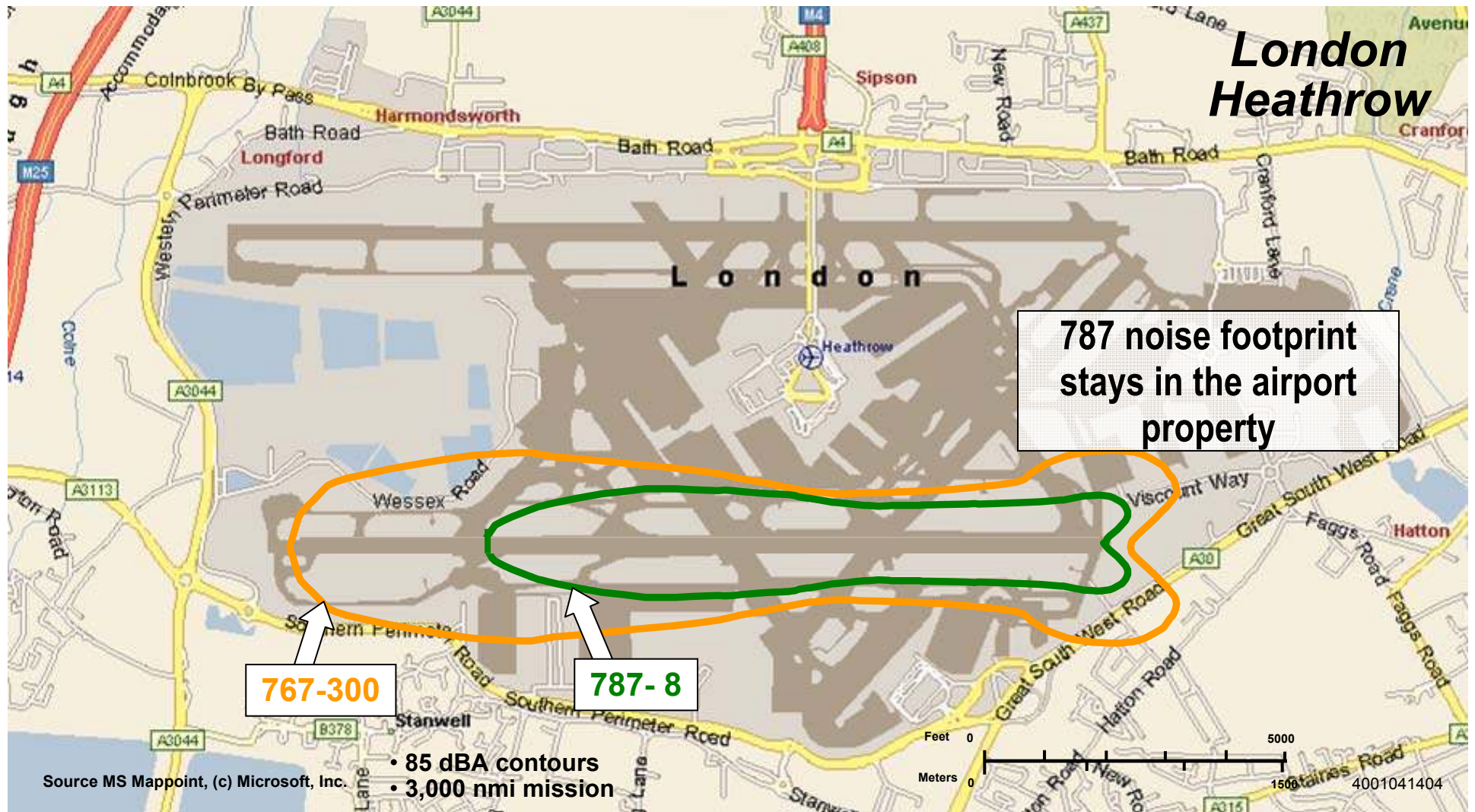
787 Fuel Tank Inerting

Nitrogen Generation



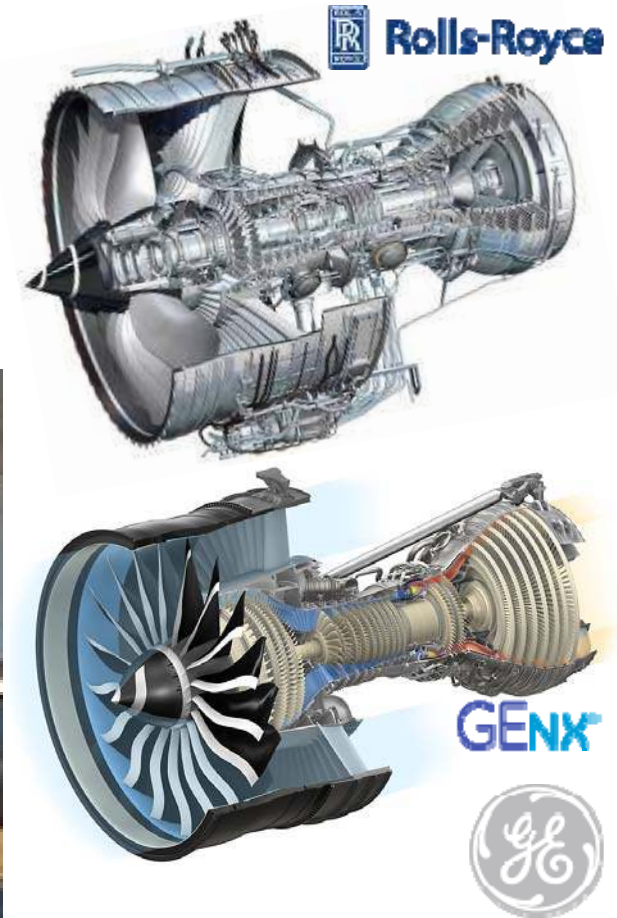
Quiet for Airport Communities

85 dB Noise Contours at Heathrow



Engine Technology Advancements

- No-engine-bleed-air systems architecture
- Higher bypass ratio
- Low-noise nacelles with chevrons



Airplane/Engine Architecture

- No-engine-bleed-air systems

Wing LE Anti-Ice
Air Conditioning
Cabin Pressure
Engine start

777
bleed air
bleed air
bleed air
bleed air

787
electric
electric
electric
electric

- Engine Generators

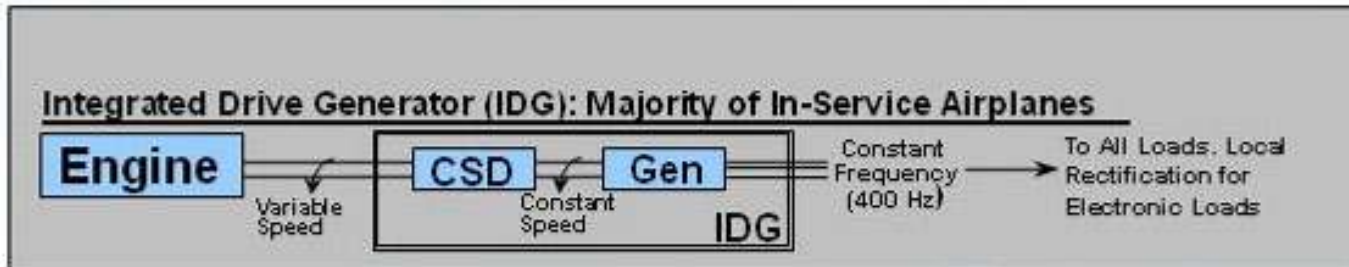
777
240 kVA
(2 @ 120 kVA)

Generators

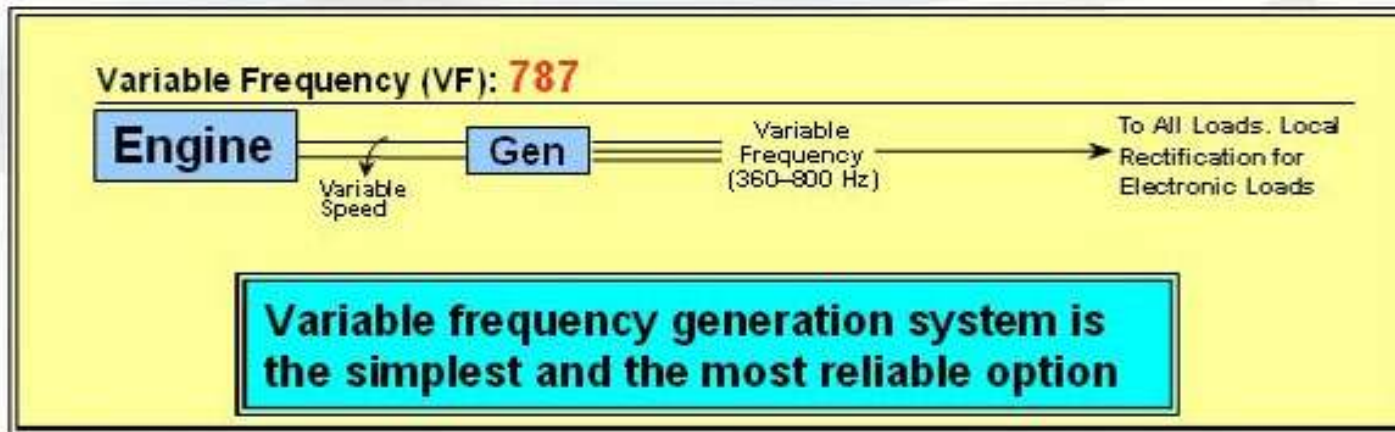
787
1000 kVA
(4 @ 250 kVA)

Starter/Gen's

Variable Frequency Power Generation

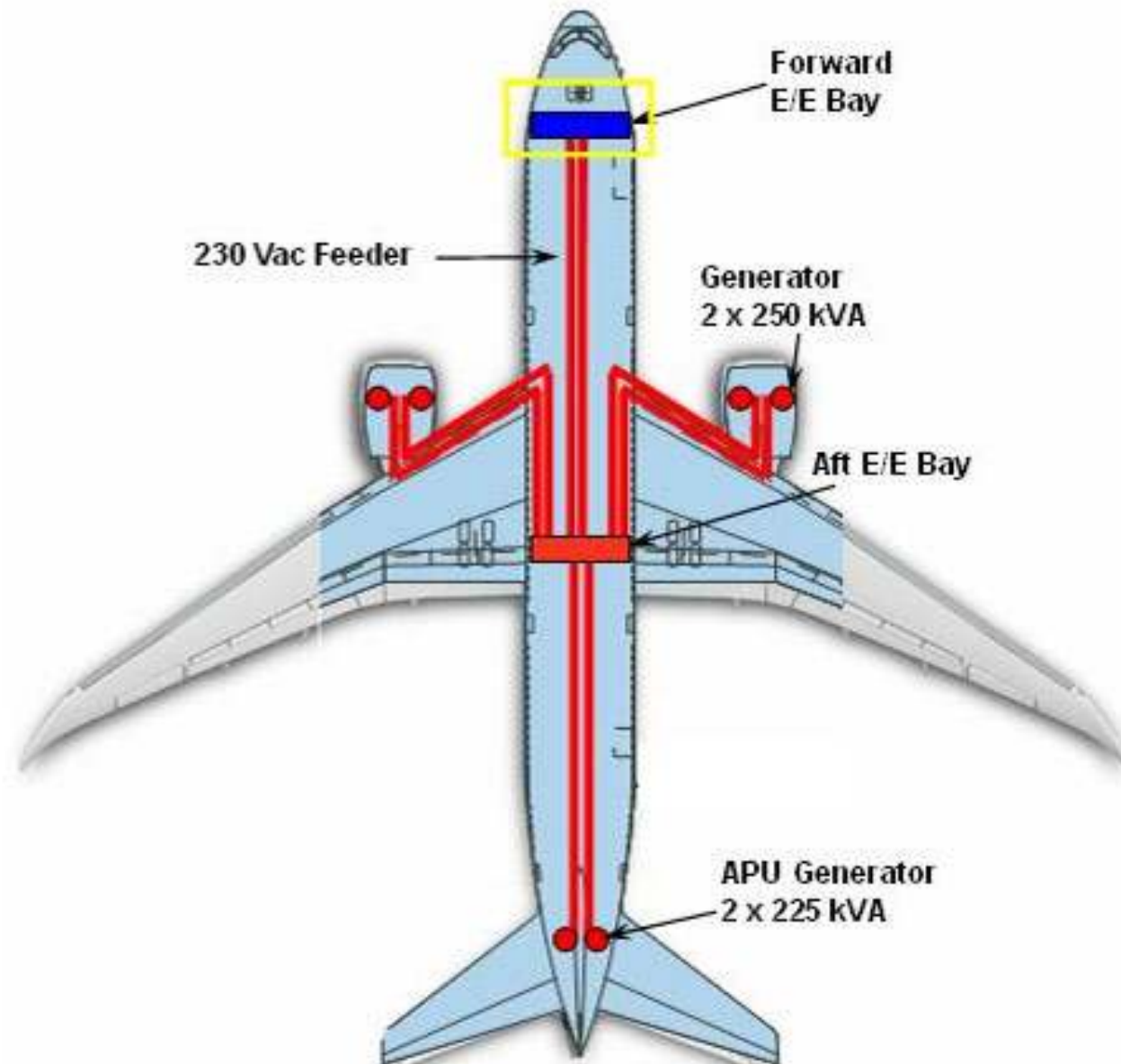


777
115 VAC
400 Hz



787
230 VAC
360-800 Hz

EE vs Pneumatic Power Distribution



Electronic Circuit Breakers

- No physical CBs in Flight Deck
- CB control and state indication are display based.
- Accessible on Multi-Function Display (MFD) and maintenance access devices
- A few Thermal CB are located in the Fwd EE-Bay

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
CE2100716 CIRCUIT BREAKER NAME 7		UNK	DETAILS	CONTROL
CE2100717 CIRCUIT BREAKER NAME 8			DETAILS	CONTROL
CE2100718 CIRCUIT BREAKER NAME 9			DETAILS	CONTROL
CE2100719 CIRCUIT BREAKER NAME 10			DETAILS	CONTROL
CE2100703 CIRCUIT BREAKER NAME 11			DETAILS	CONTROL
CE2100721 CIRCUIT BREAKER NAME 12			DETAILS	CONTROL
CE2100722 CIRCUIT BREAKER NAME 13			DETAILS	CONTROL
CE2100723 CIRCUIT BREAKER NAME 14		UNK	DETAILS	CONTROL
CK2100724 CONTACTOR NAME 15			DETAILS	CONTROL
CE2100725 CIRCUIT BREAKER NAME 16			DETAILS	CONTROL

Overhead Panels - Circuit Breakers

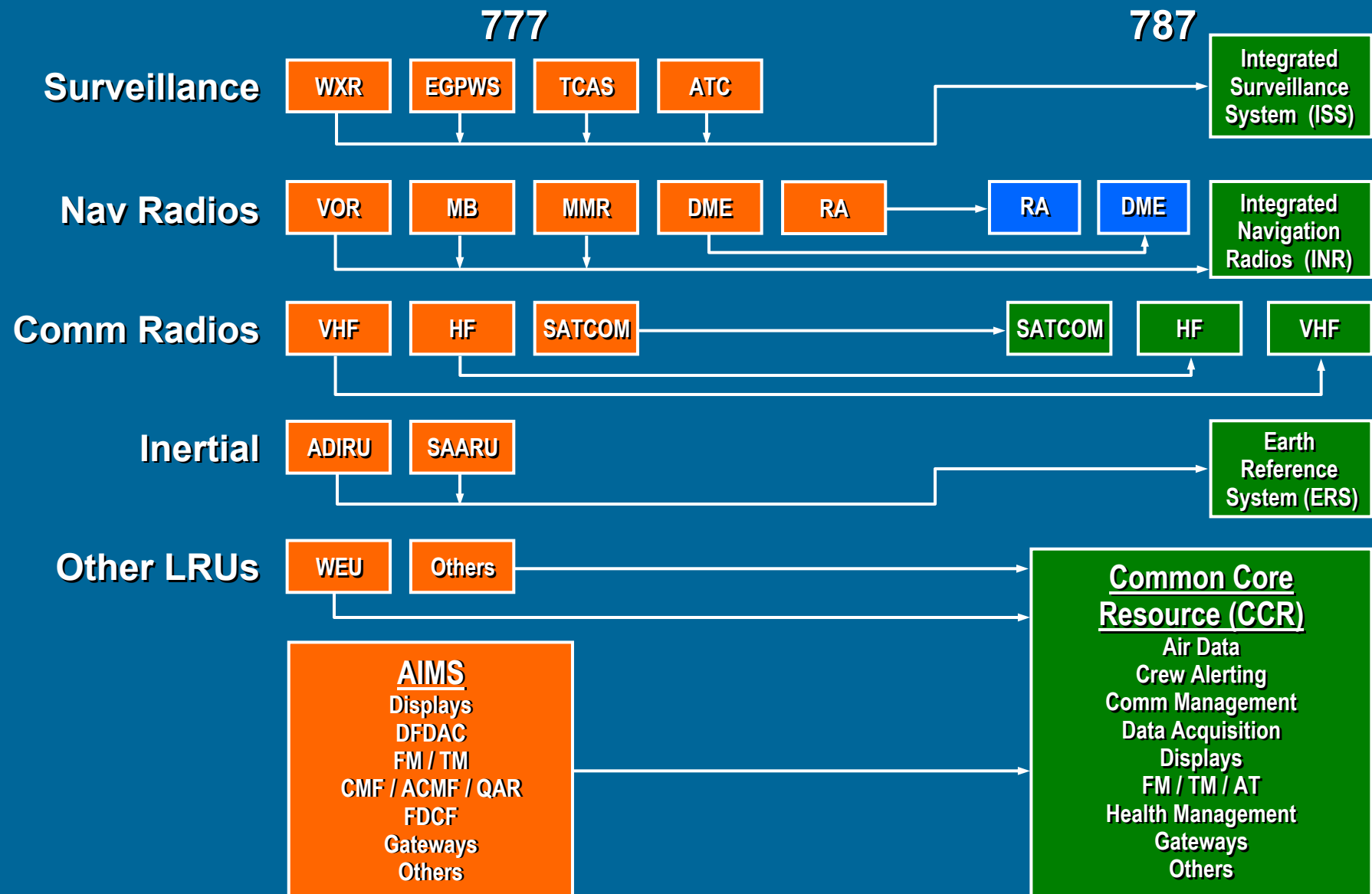
787



777

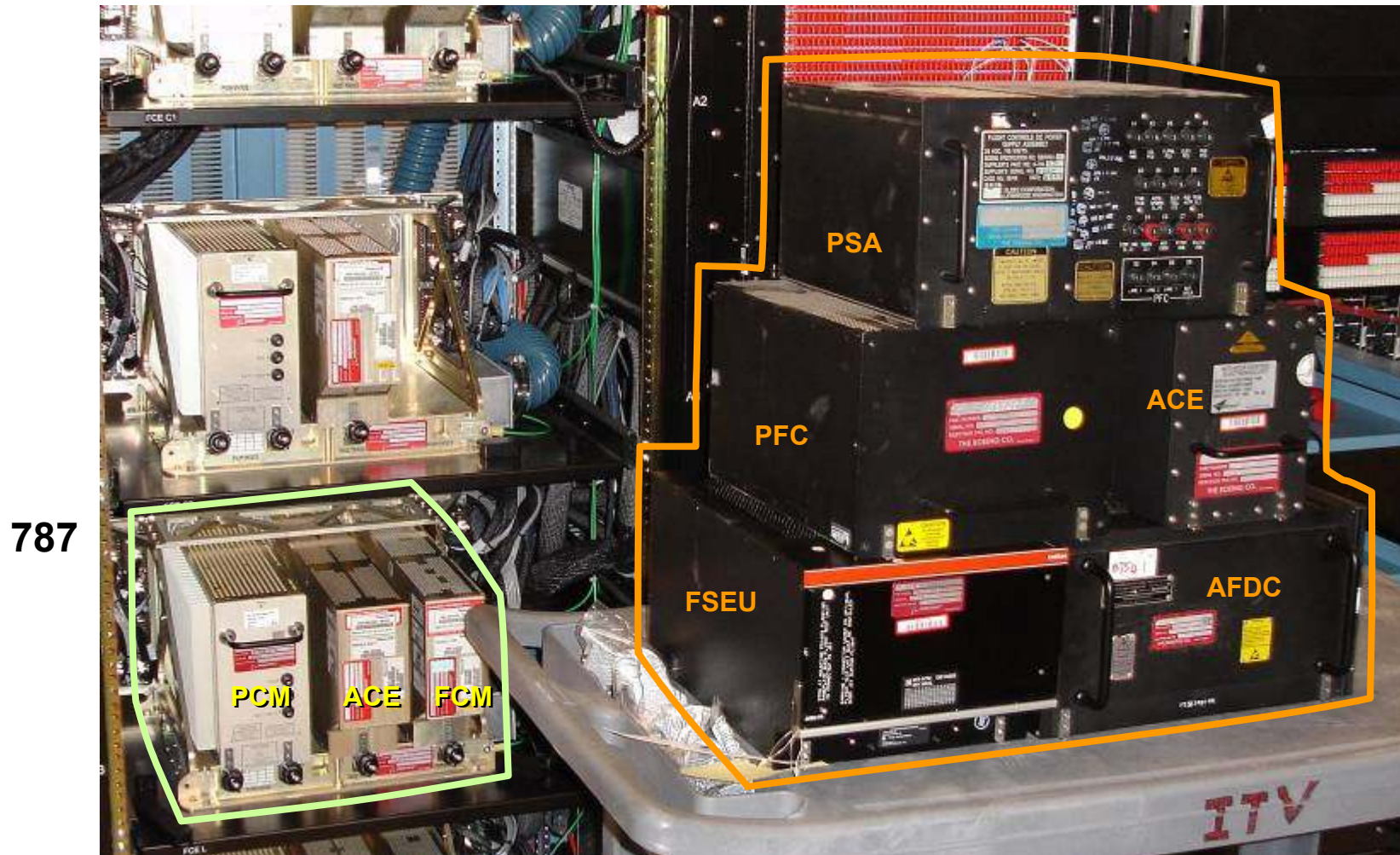


Avionics Integration



Integrated FCE

Equivalent Channel of Flight Controls and High Lift



Common Core System

Common Computing Resource

- High integrity computing resources for hosted systems applications

Common Data Network

- High Integrity Network
- Open industry standard interfaces A664

Remote Data Concentrators

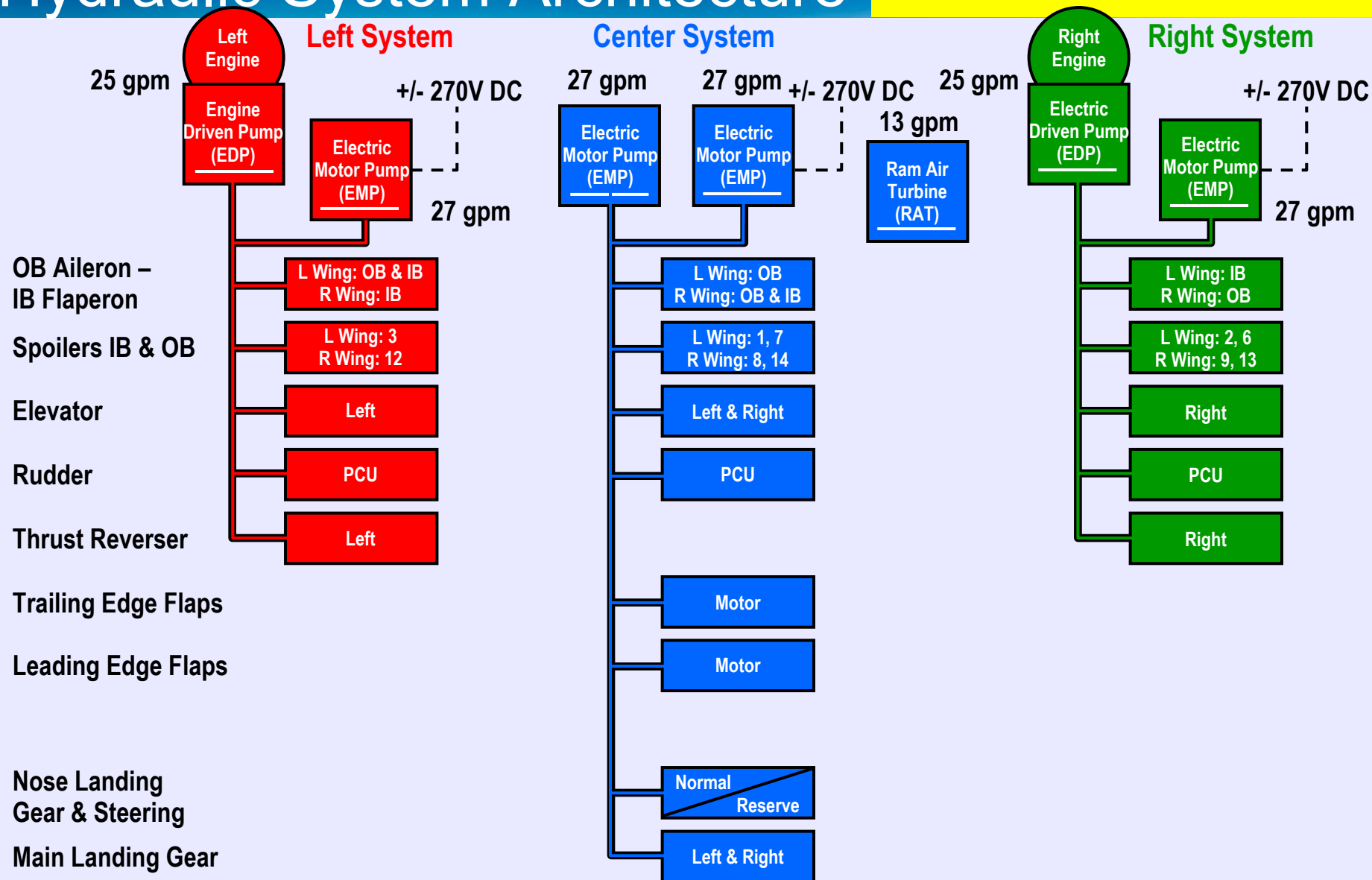
- 21 RDCs
- Remote I/O capability
- Reduces airplane wiring

CCS Hosted Functions

- Avionics Communication and Audio
- Avionics Flight Management and Navigation
- Avionics Thrust Management and Auto-throttle
- Avionics Primary Display Function
- Avionics Crew Alert/Warning and Surveillance
- Avionics Crew Information Services
- Avionics Maintenance and Data Loading
- Cabin Management and Air Show
- Environmental Control System Functions: Power Electronics and Other Equipment Liquid/forced air Cooling, Air Conditioning, Cabin Pressurization, Ice & Rain Protection, Air Distribution, Galley Refrigeration, Low Pressure Systems, Cargo Heat, Wheel Well Fire Detection and Cargo Fire Detection/Protection
- Electrical Utility System Control Functions Remote Power Distribution System (RPDS), Power Distribution Panels (PDPs), Generator/Bus Power Control Units (GCU/BPCU), Proximity Sensors, Window Heat, Tail Strike, Emergency Passenger Assist System (EPAS), Exterior Lighting
- Data Interface to Flight Controls Electronics (FCE)
- Interface to Flight Deck Panels and Switches
- Fuel Management and Fuel Quantity Indication
- Hydraulics Control
- Mechanical System Interface Functions in Brakes, Landing Gear, Nose Wheel Steering
- Payloads Interface Functions in Galleys, Water & Waste, Emergency Lighting
- Data Interface to Propulsion Controls in EEC, Engine Fire Detection/Protection, Thrust Reverser
- Specific functionality supported by the CCS is described in the CCS SDD (Ref. 4) as well as in individual 787 CCS hosted function System Description
- Documents (SDDs) identified in their respective certification plans listed in Ref. 4.).

Hydraulic System Architecture

5000 psi systems



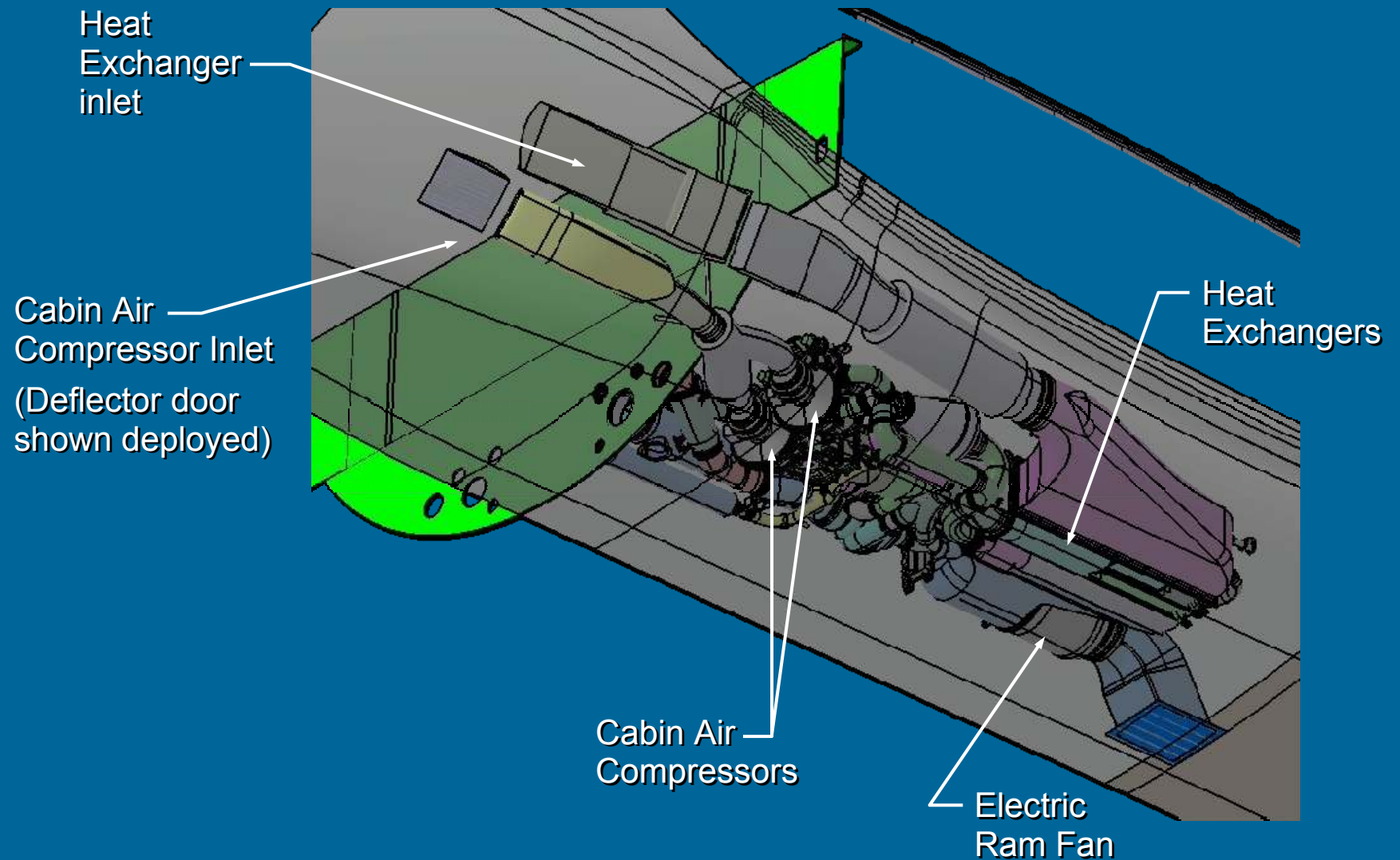
Landing Gear Systems

New Control-by-Wire

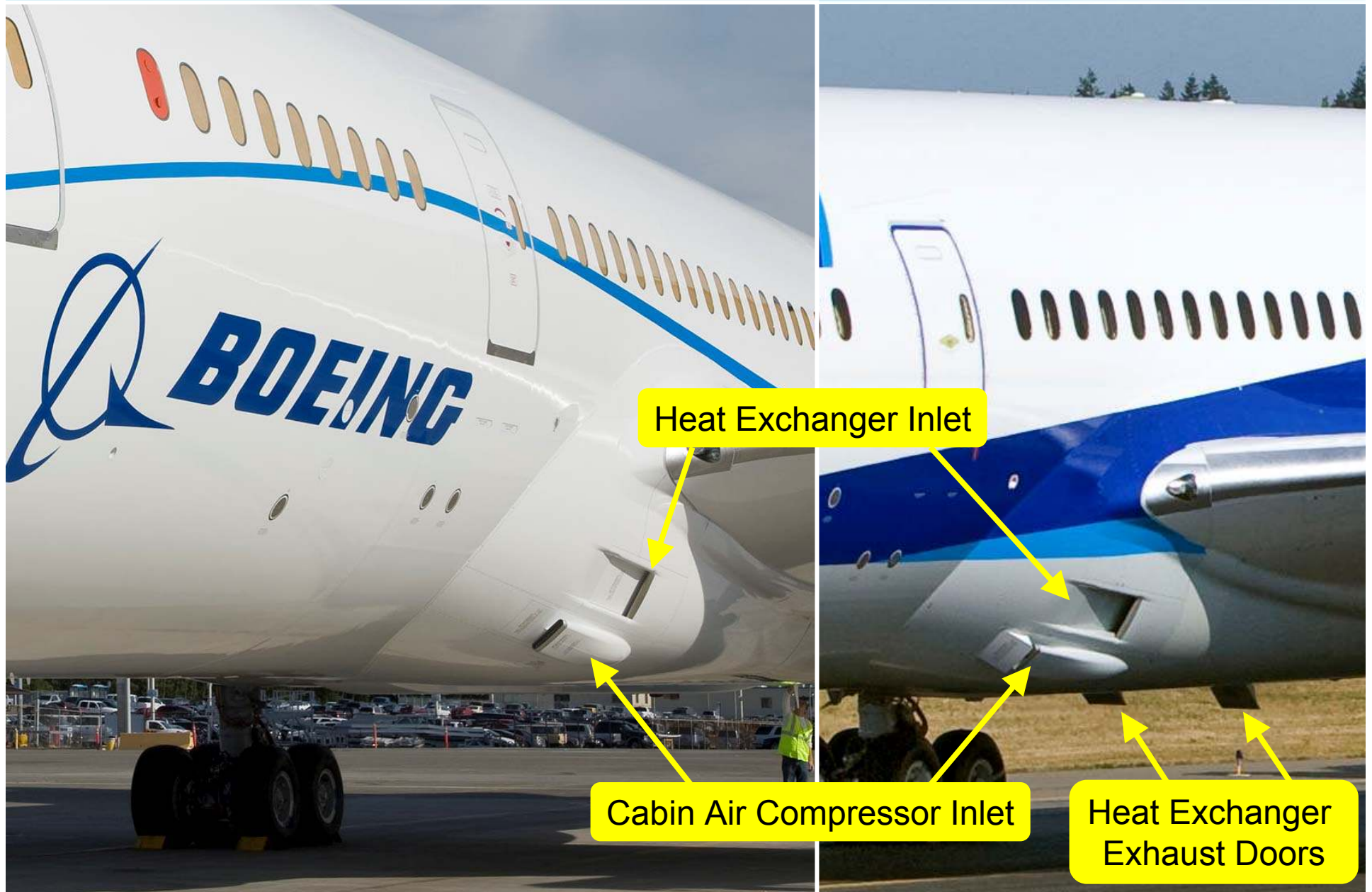
- Landing Gear Actuation
 - Electronic control and sequencing of landing gear and doors
- Brake System
 - Control-by-wire brakes, autobrake and anti-skid
 - Electric Brake Actuators
- Nose Gear Steering
 - Control-by-wire (pedals & dual tillers)
 - Hydraulic actuation



Cabin Air Conditioning System



External Air Sources



787 EAFR

Enhanced Airborne Flight Recorder

- Dual-Combi Architecture
- Both recorders are same P/N
 - self contained acquisition function
 - FRED file in memory (Flight Rec. Elec. Doc. - ARINC 647)
 - flight data 25 hours minimum
 - voice - 2 hours
 - datalink
- FWD EAFR
 - RIPS for voice recording only
- AFT EAFR
 - no RIPS

Forward EAFR & RIPS



Aft Recorder



Recording Format

- EAFR Flight Data recording format
 - ARINC 767
 - raw data file size ~800 MB (zips to 200 MB)
 - Approx equivalent to 5000+ WPS recorder
- The 787 “QAR”
 - called "Continuous Parameter Logging" (CPL)
 - stored on the mass storage devices (server)
 - ARINC 767 recording format

Flight Controls - 777 / 787 Common Functionality



Common 777 / 787 Fly-by-wire Functionality

- Stall Protection
- Overspeed Protection
- Bank Angle Protection
- Tail Strike Protection
- Thrust Asymmetry Compensation
- Yaw Damping, Over-yaw Protection
- Gust Load Alleviation
- Fin Load Alleviation
- Flap Load Relief & Autogap
- Lateral Gust Suppression
- Modal Suppression

Flight Controls - 787 New Features

- P-Beta control law
- Vertical Gust Suppression (turbulence)
- Enhanced Stall Protection
 - Limits high angles of attack
- Enhanced Thrust Asymmetry Compensation
 - Adds inertial yaw detection on ground
 - Generates rudder & steering for yaw disturbances

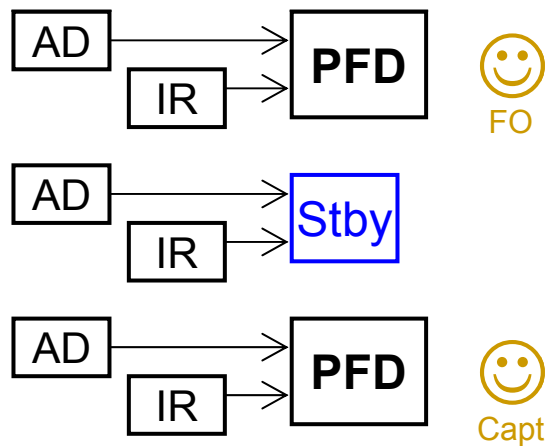
P – Beta Control Law



- Wheel commands roll rate (P)
- Pedals command sideslip angle (Beta)
- Opposes disturbances
- Coordinates lateral and directional control
- Automatic aileron & rudder trim
 - No aileron trim switch

Air Data System Design Philosophy

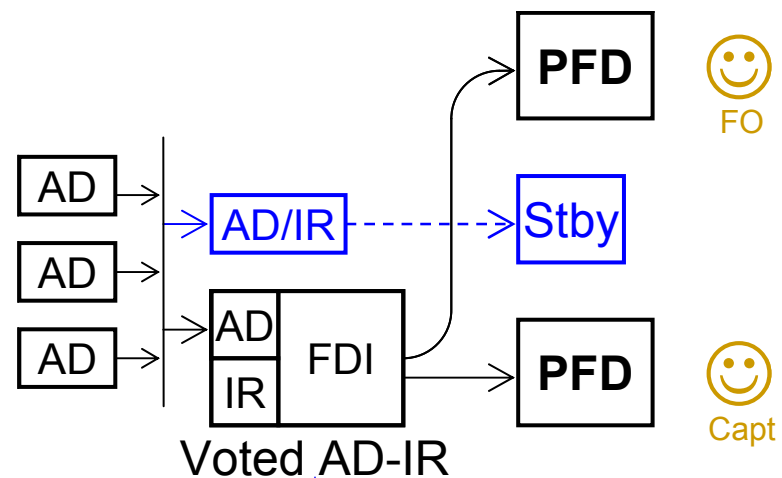
Federated AD & IR (all previous models)



Fault arbitration
by **CREW**

AD = Air Data
IR = Inertial Reference
FDI = Fault Detection & Isolation
PFD = Primary Flight Display

Voted AD & IR (777, 787)



Fault arbitration
by **SYSTEM**

Air Data System - Common Mode Vulnerability

- **Common Mode Hazards to Pitot-Static sensors**

- Mud Daubers
- Volcanic Ash
- Radome failure
- Pitot covers
- Maintenance errors
(pneumatic plumbing)
- Icing
- Hail
- Birds
- Taped Static Ports

- **787 new capabilities for protection**

- Synthetic airspeed
- GPS altitude
- Common Mode Monitor

787 Synthetic Airspeed

- **Calculated from angle of attack and inertial data**
 - AOA – voted dual sensors plus inertial data
 - Accurate Coefficient of Lift (C_L)
 - Airplane Mass from FMC - Validated after Takeoff
- **Algorithm developed for enhanced stall protection**
- **Avoid displaying data known to be bad**
 - Loss of valid voted V_{CAS} = Display synthetic airspeed V_{SYN}
 - Loss of valid voted P_{STATIC} = Display GPS altitude

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

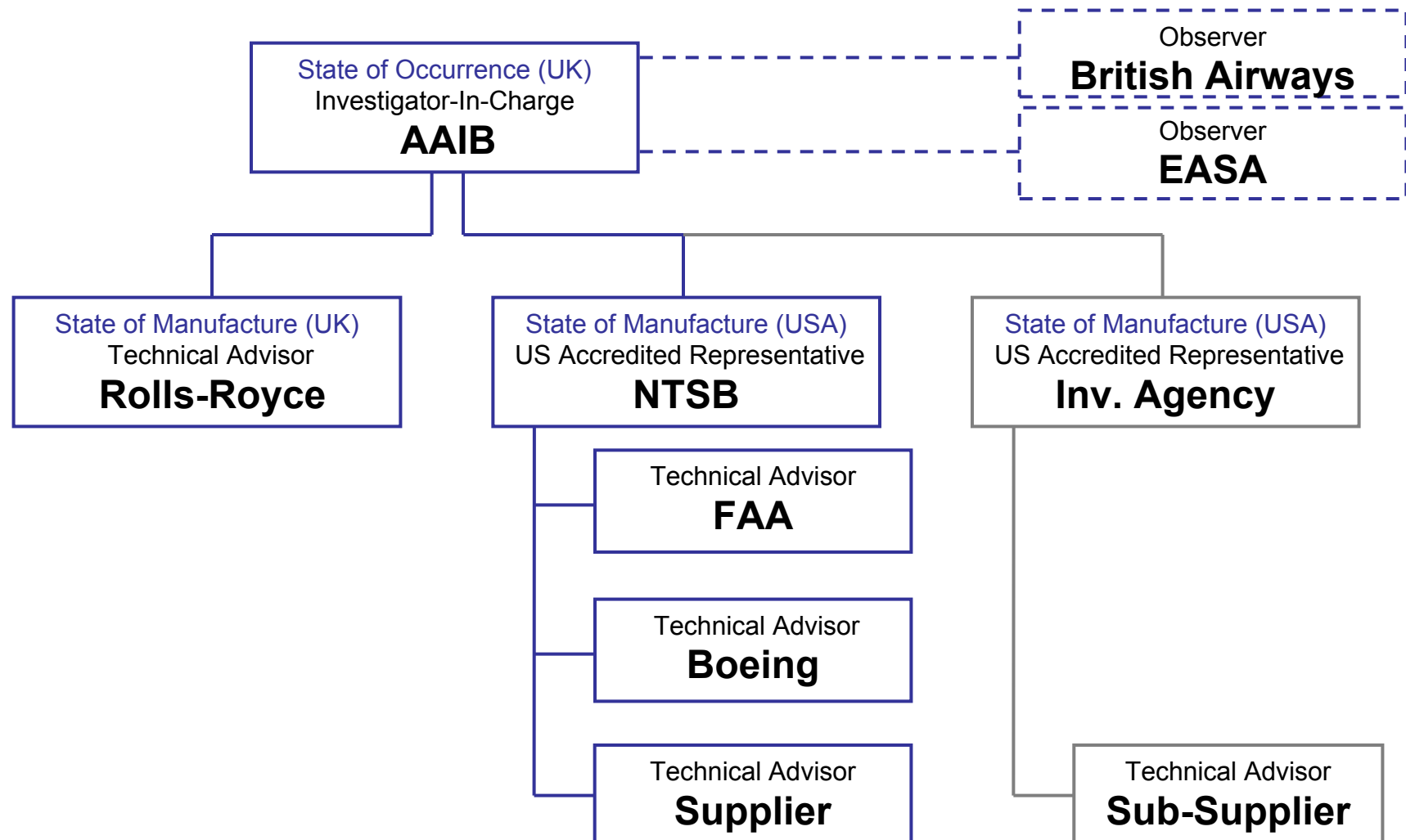
Fault Prediction

Coordinated airplane
and ground processing
approach



Sat Comm

G-YMMM Investigation Organization



 **BOEING**



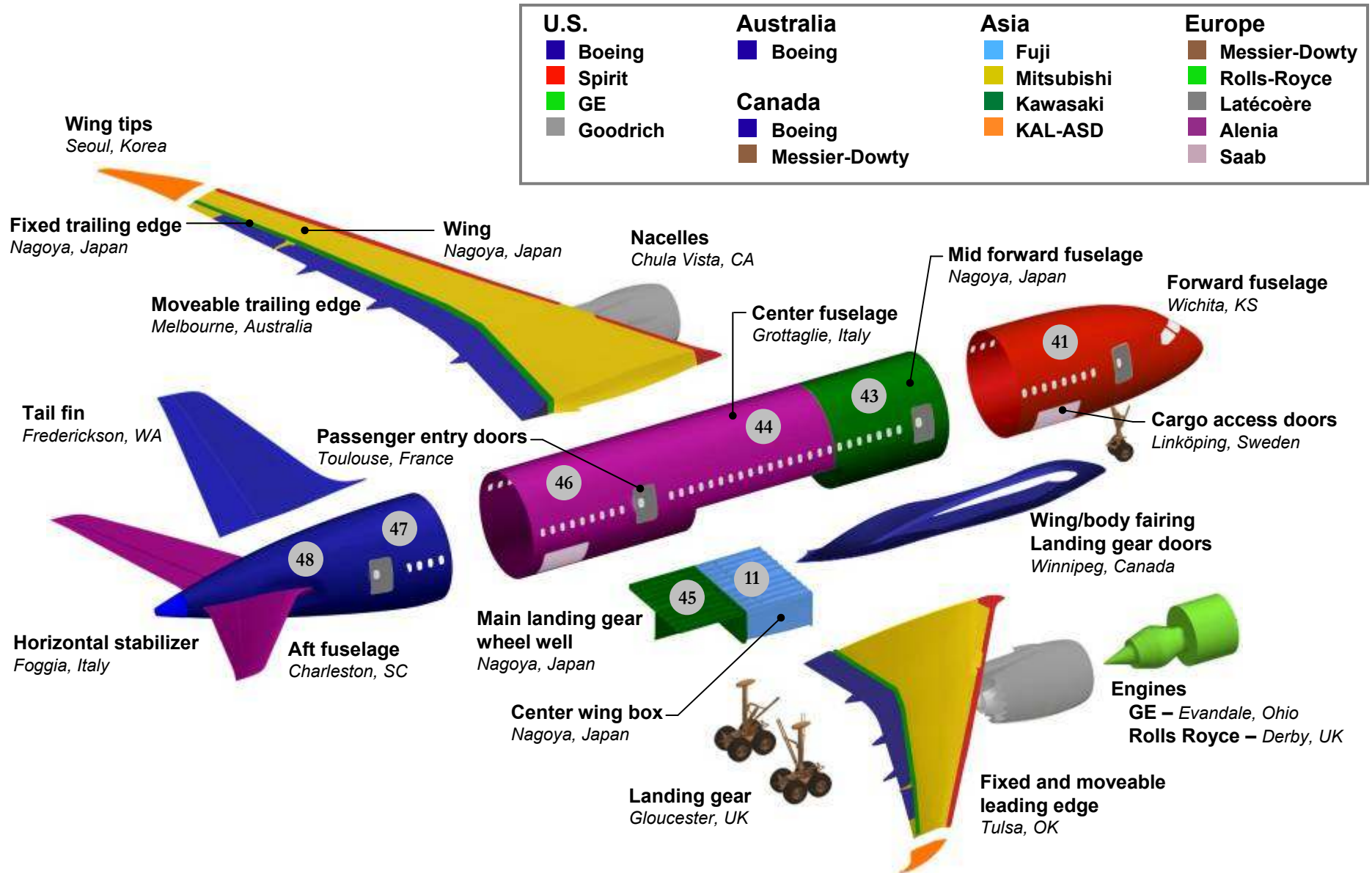




747

Dream Lifter

Partners Across the Globe are Bringing the 787 Together



Dreamlifter Route Structure



Dreamlifter Enables Global Operations

- **Efficient transport of 787 major sub-assemblies from international partners**
- **Main deck is 65,000 cubic feet**
 - 3x capacity of 747-400 Freighter
- **Reduced transportation times versus surface transportation**
 - Dramatically reduced final assembly flow times
 - Less inventory











787 Structure from Asia

Fuji Heavy Industries



Kawasaki Heavy Industries



Mitsubishi Heavy Industries



Korean Air



International partners providing key 787 structure

787 Structure from Europe



International partners providing key 787 structure

787 Structure from North America



International partners providing key 787 structure