Introducing the 787

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

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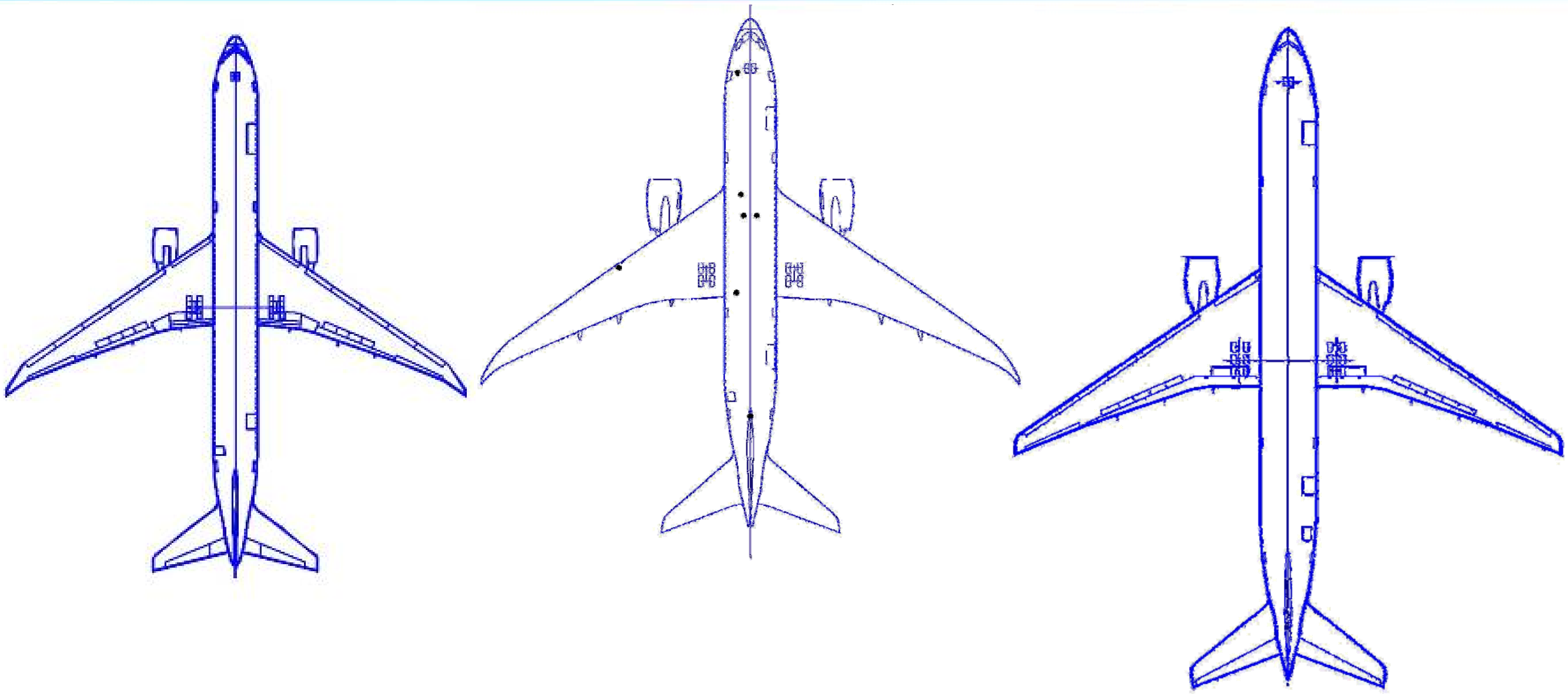
ISASI September, 2011

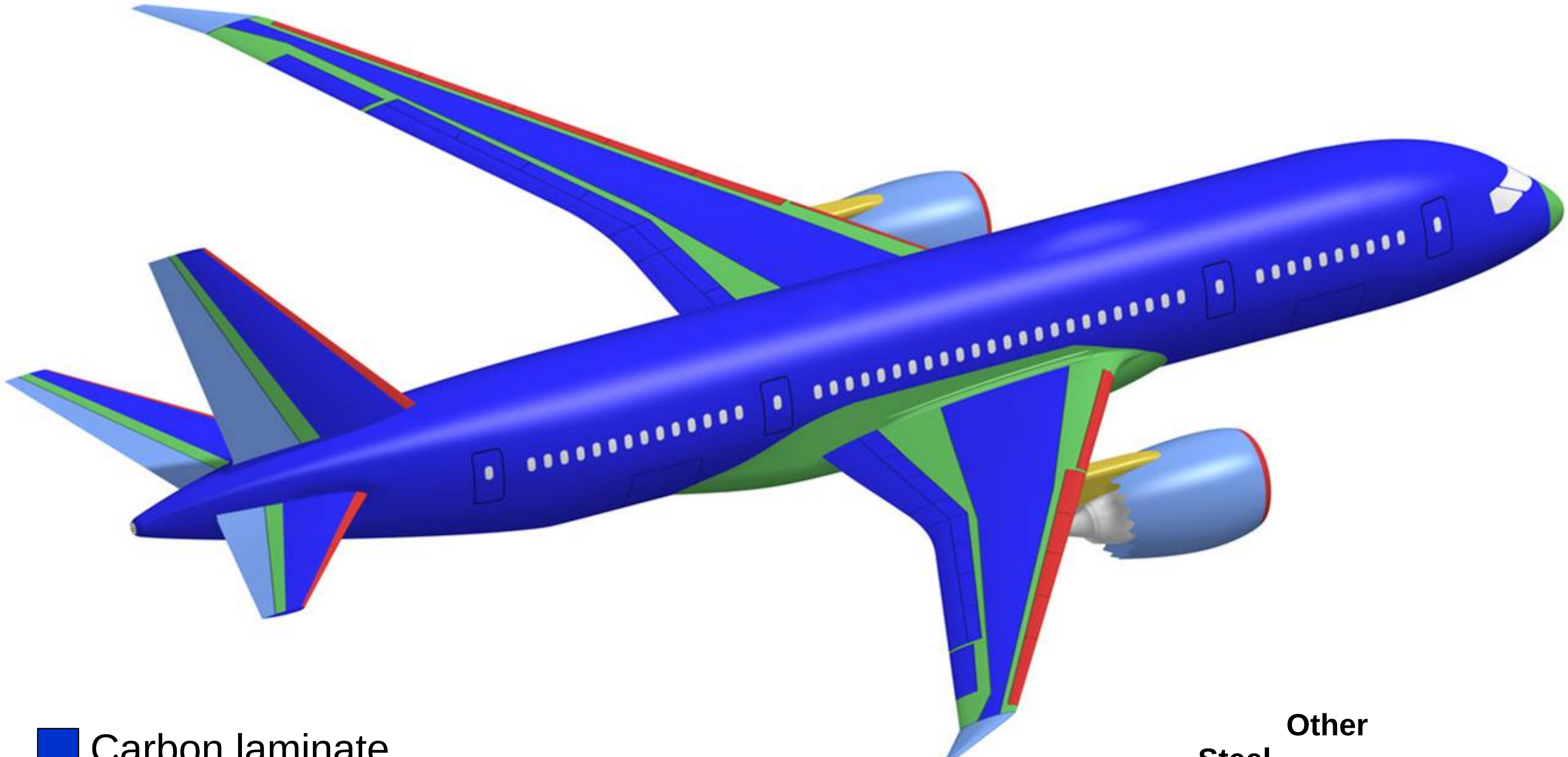
787 Size Comparison



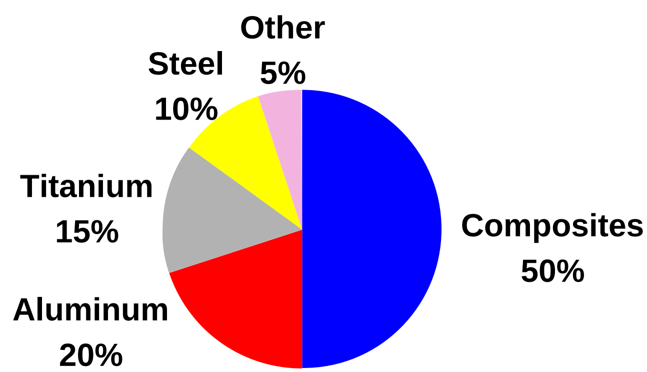
	767-400	787-8	777-300
~Pax 3-Class	245	**250**	368
~Span	170 ft	**197 ft**	200 ft
~Length	201 ft	**186 ft**	242 ft
~MTGW	450,000 lbs	**500,000 lbs**	660,000 lbs
~Range	5,600 NM	**7,650 NM**	6,000 NM
Cruise Mach	0.80	**0.85**	0.84

Composite Structure

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



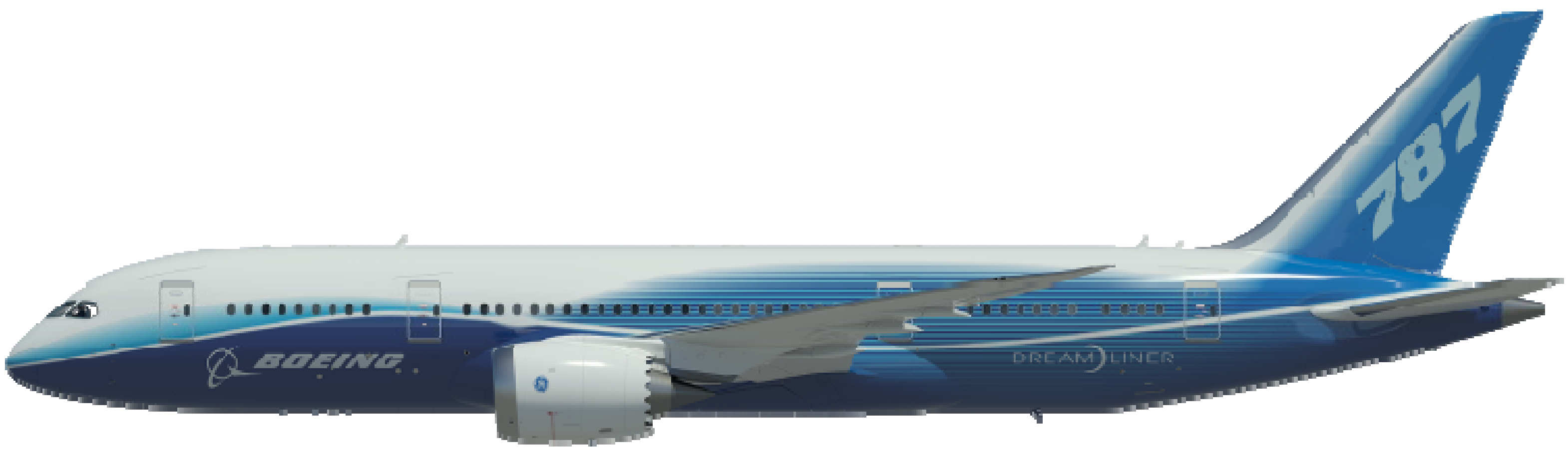
- Carbon laminate
- Carbon sandwich
- Fiberglass
- Aluminum
- Aluminum/steel/titanium pylons



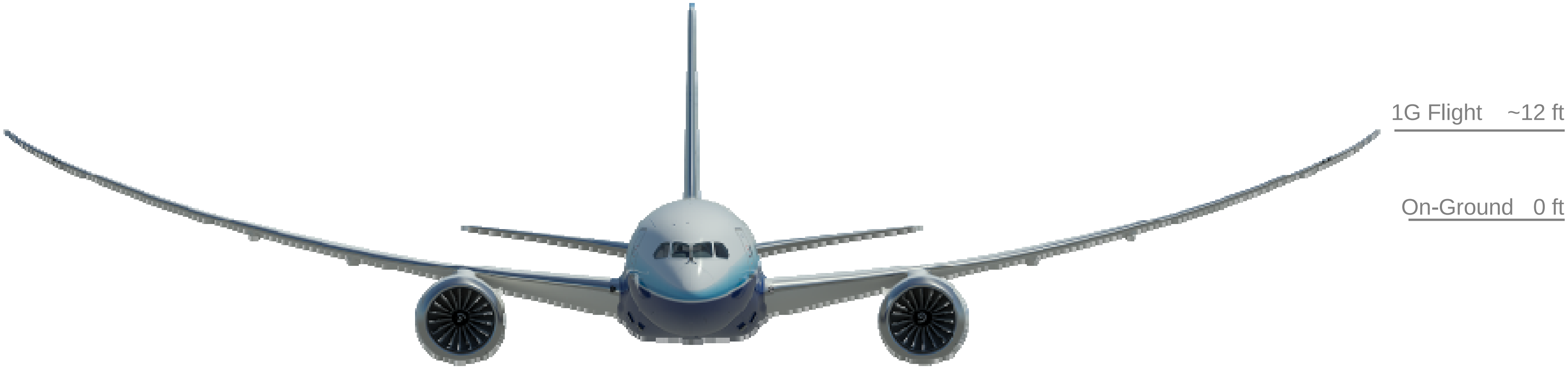

DREAM)LINER

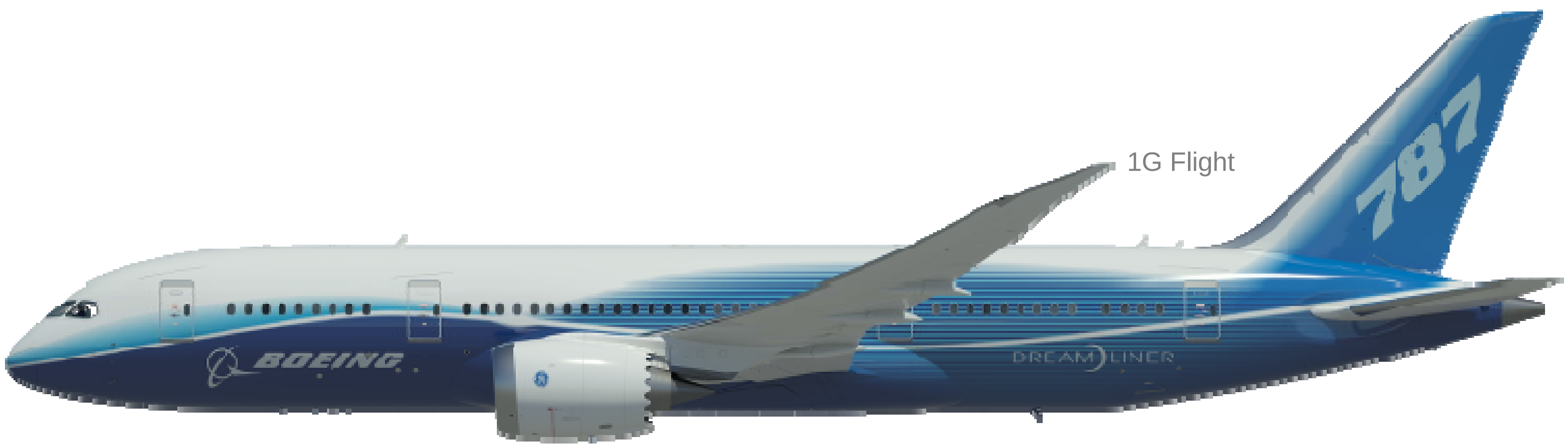
787 Wing Flex - On-Ground

On-Ground 0 ft



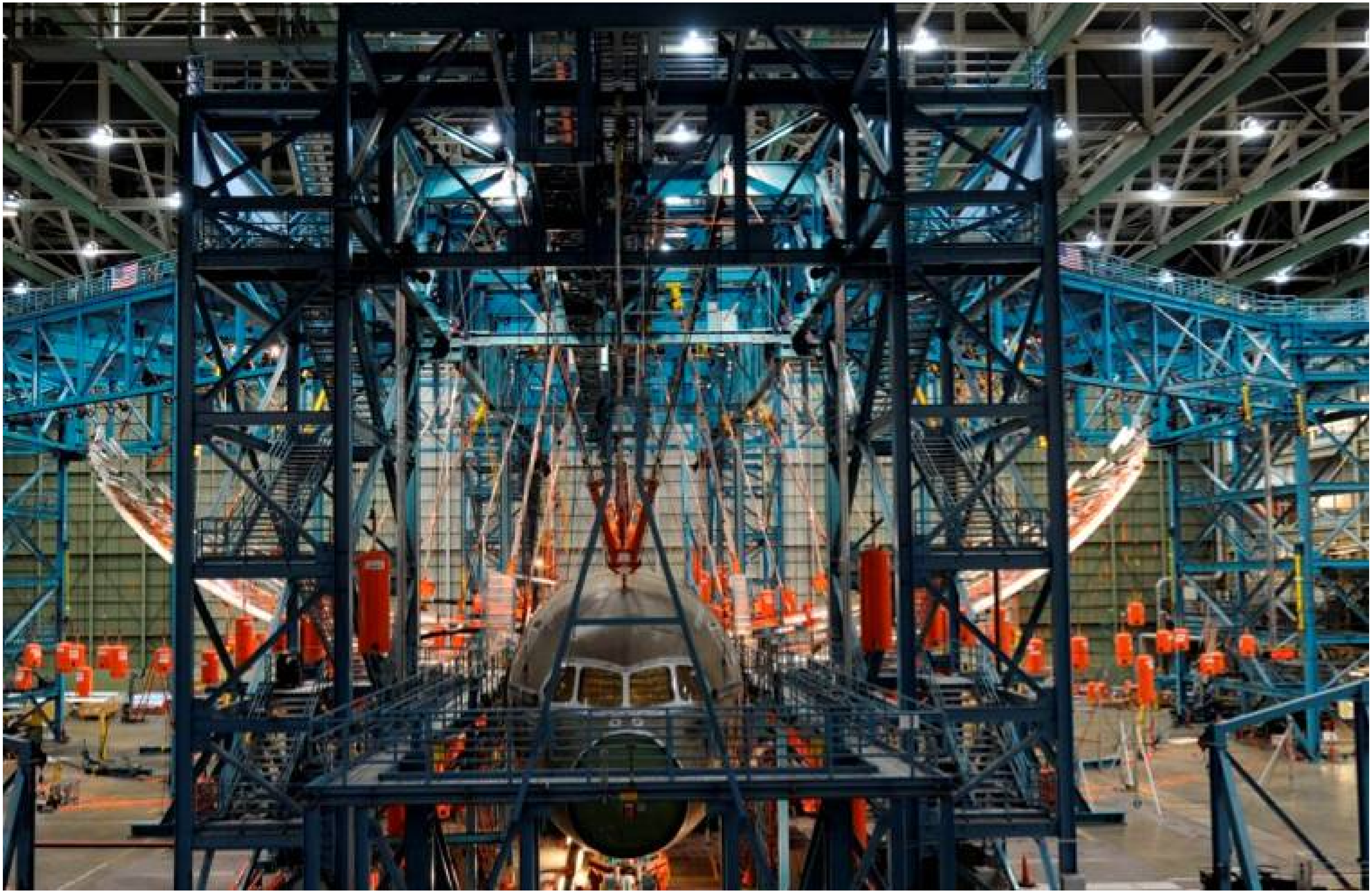
787 Wing Flex - 1G Flight





787 Wing Flex

787 Static Load Test @ Ultimate Load



Investigations with Composite Materials

- Terms:

	Composites	Aluminum
	disbond	fatigue
	delaminate	beach marks
	inter-laminar shear	striation counts
	water absorbsion	corrosion
	fiber architecture	metallurgical prop.

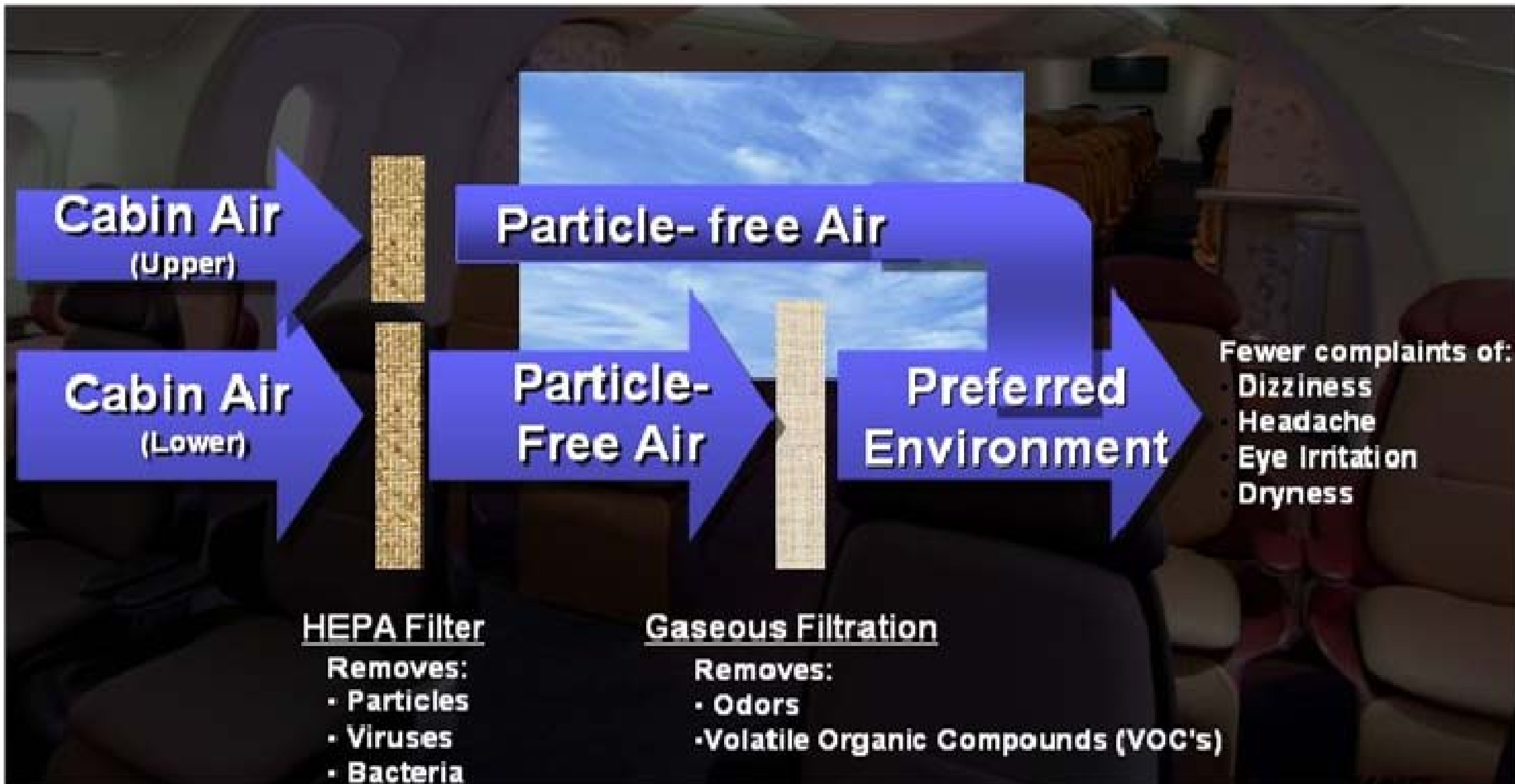
- Material Forensics Techniques will be different

- 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

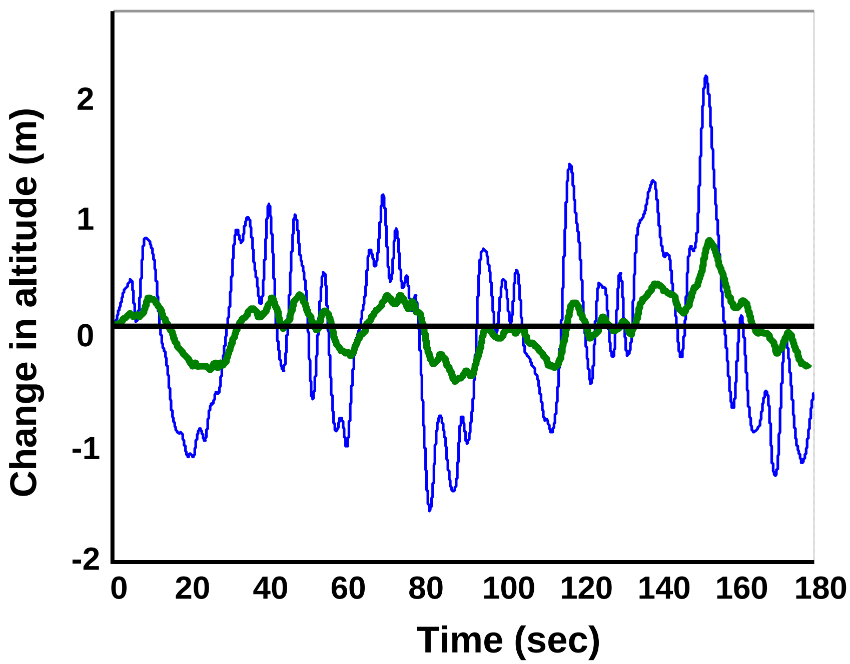
Cleaner Cabin Air



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



- 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

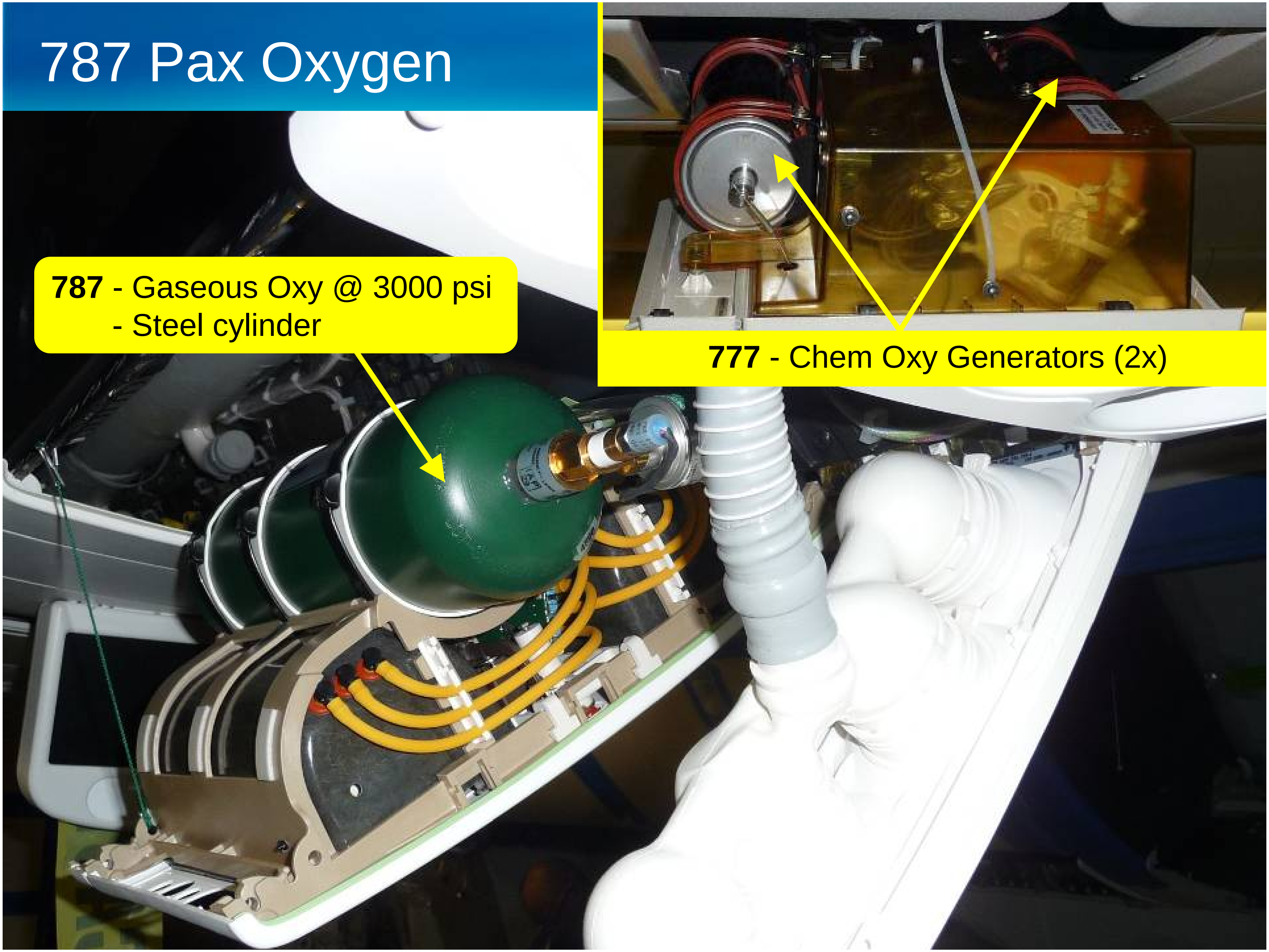
Humidity - Higher

Air Quality - Improved

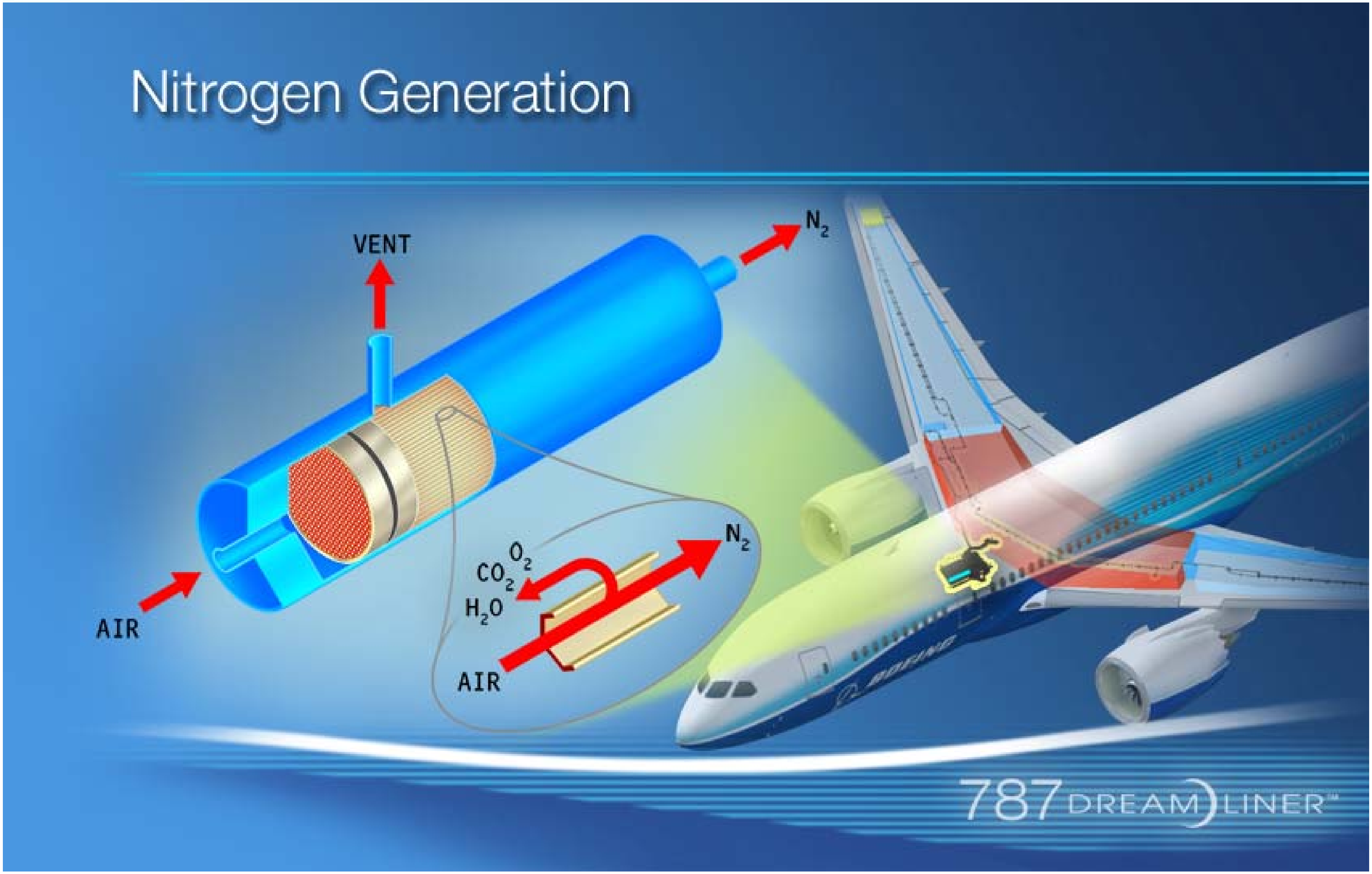
Ride Quality - Improved

Food Service - Unchanged (sorry)

787 Pax Oxygen

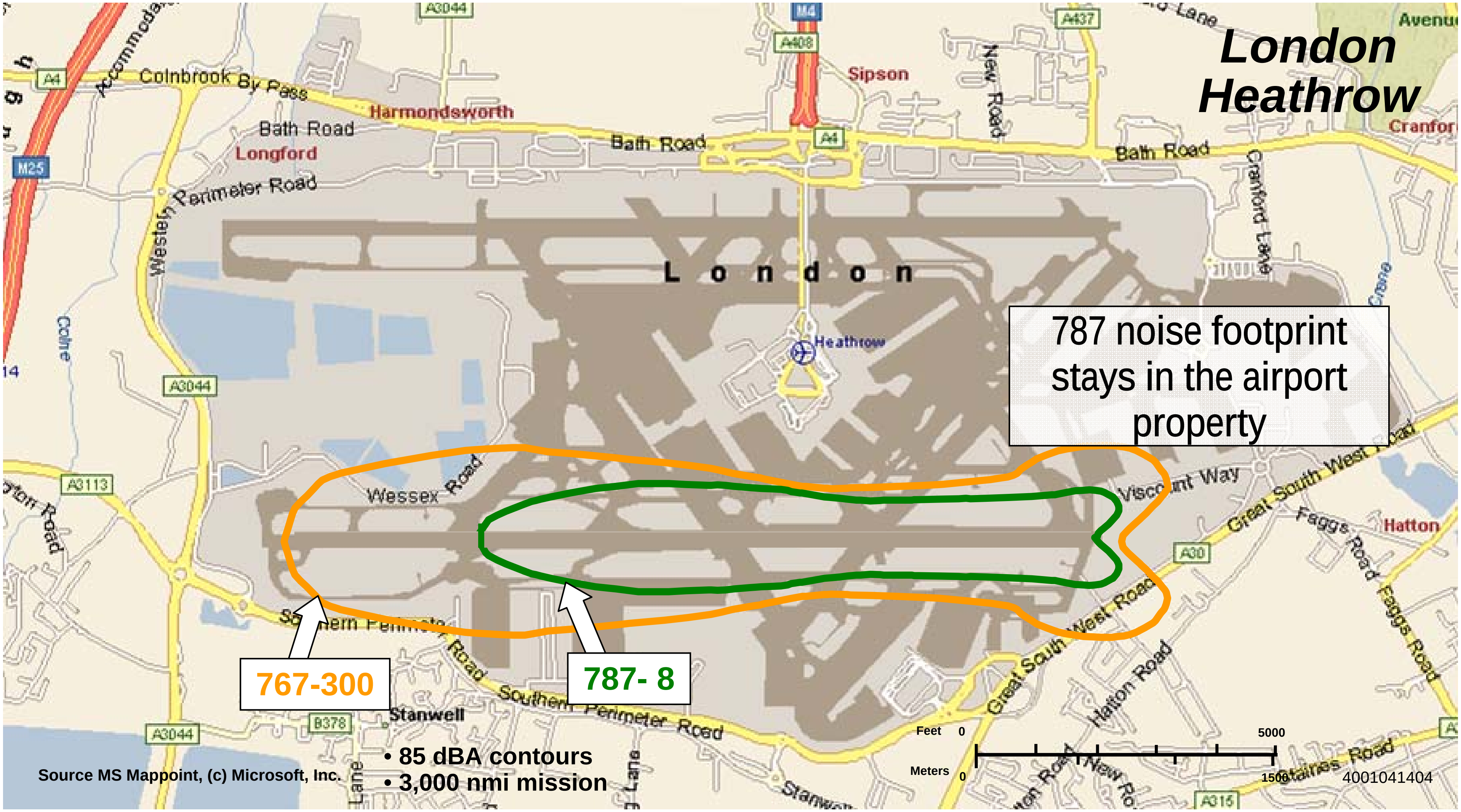


787 Fuel Tank Inerting



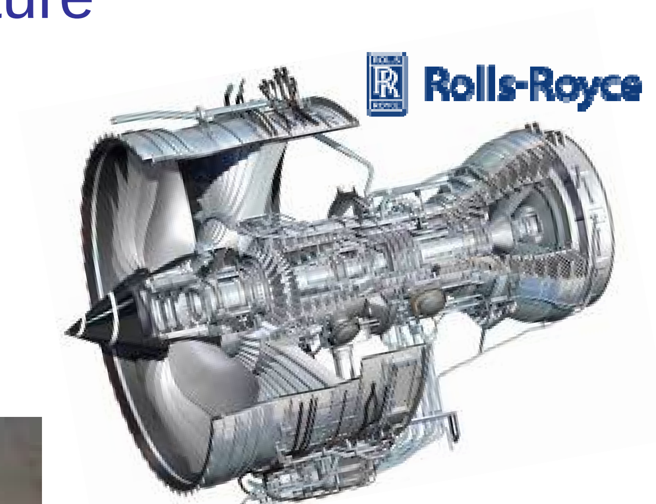
Quiet for Airport Communities

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

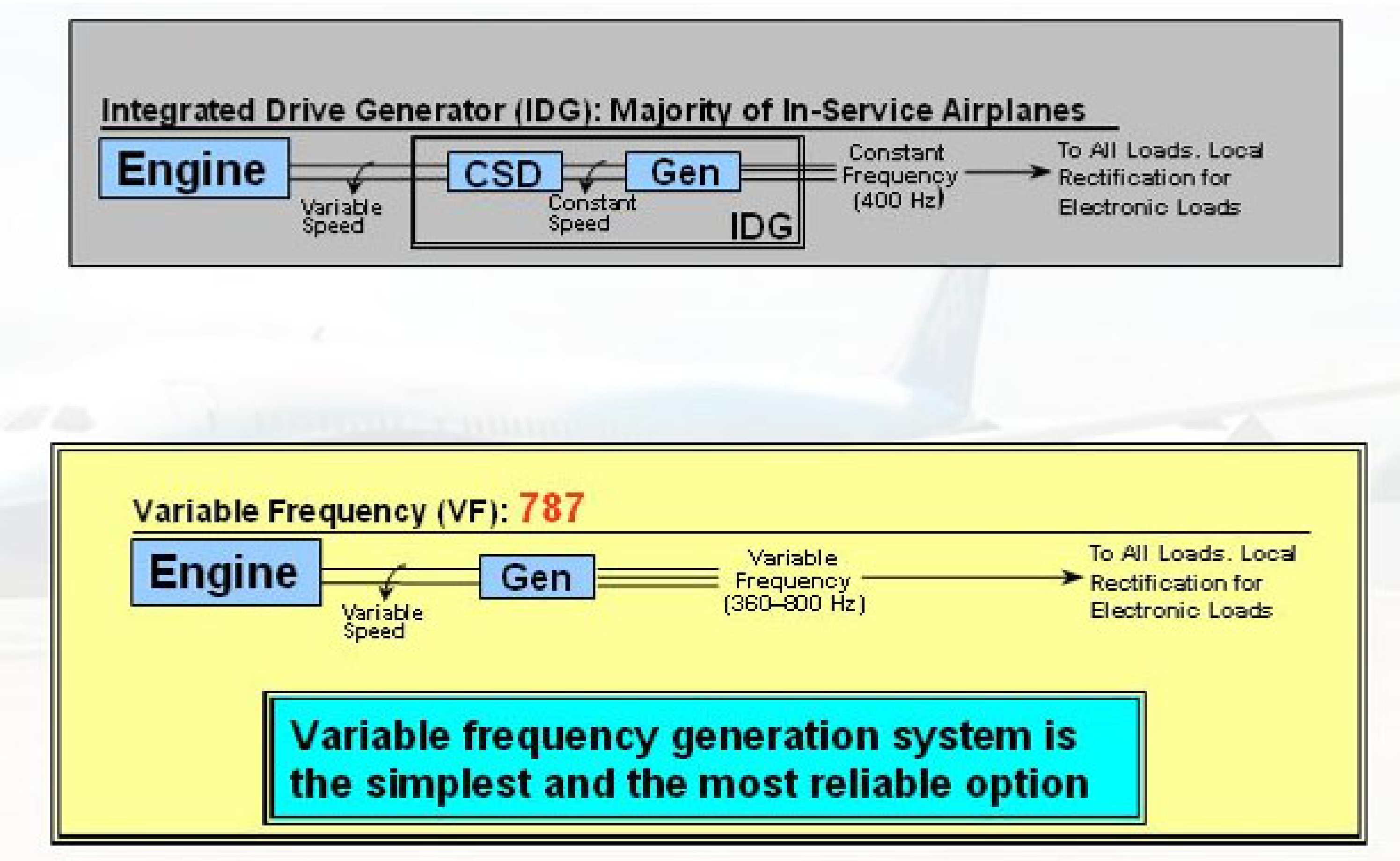
- No-engine-bleed-air systems

	777	787
Wing LE Anti-Ice	bleed air	electric
Air Conditioning	bleed air	electric
Cabin Pressure	bleed air	electric
Engine start	bleed air	electric

- Engine Generators

	777	787
	240 kVA (2 @ 120 kVA)	1000 kVA (4 @ 250 kVA)
	Generators	Starter/Gen's

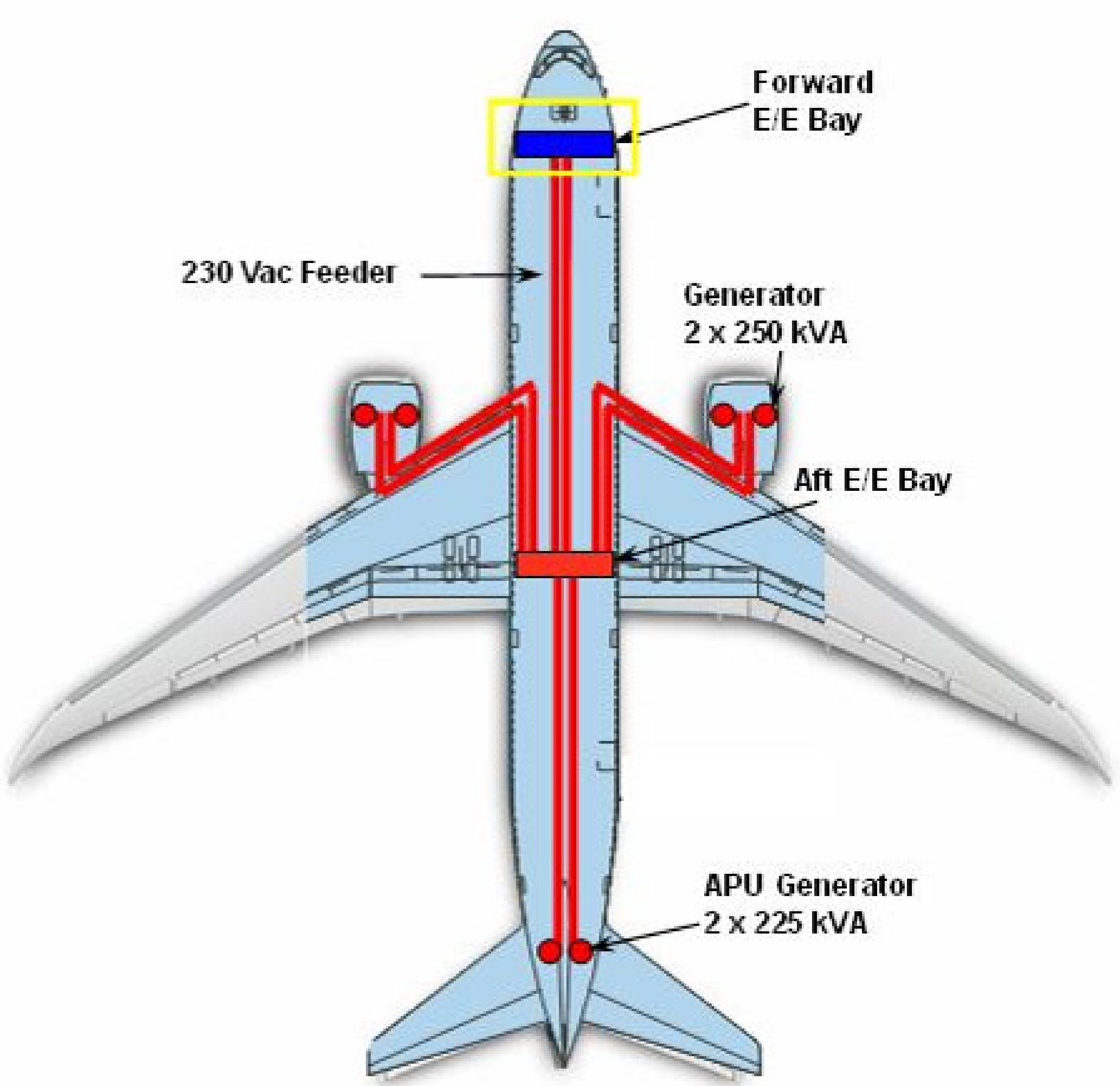
Variable Frequency Power Generation



777
115 VAC
400 Hz

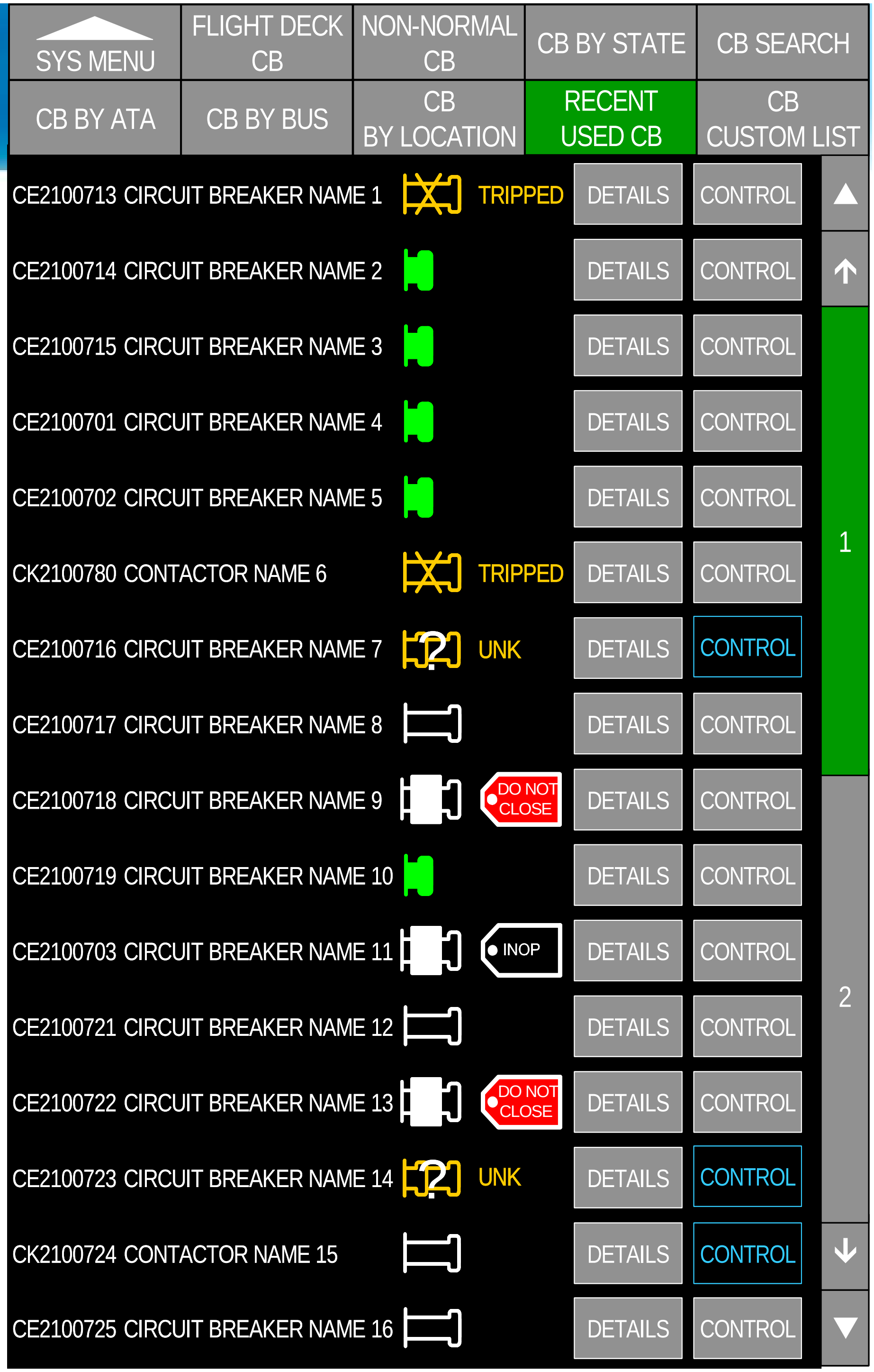
787
230 VAC
360-800 Hz

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

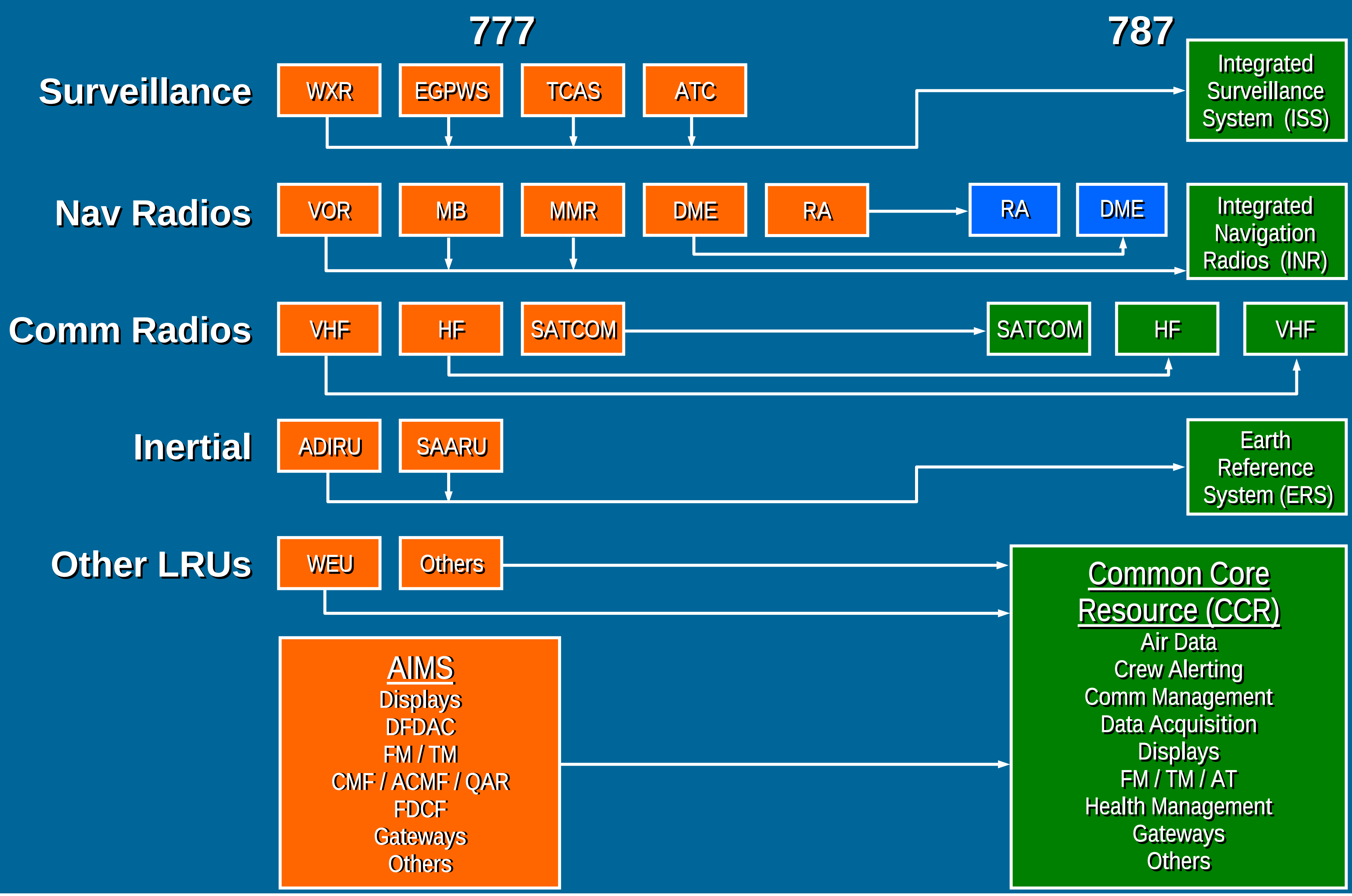


Overhead Panels - Circuit Breakers

787

777

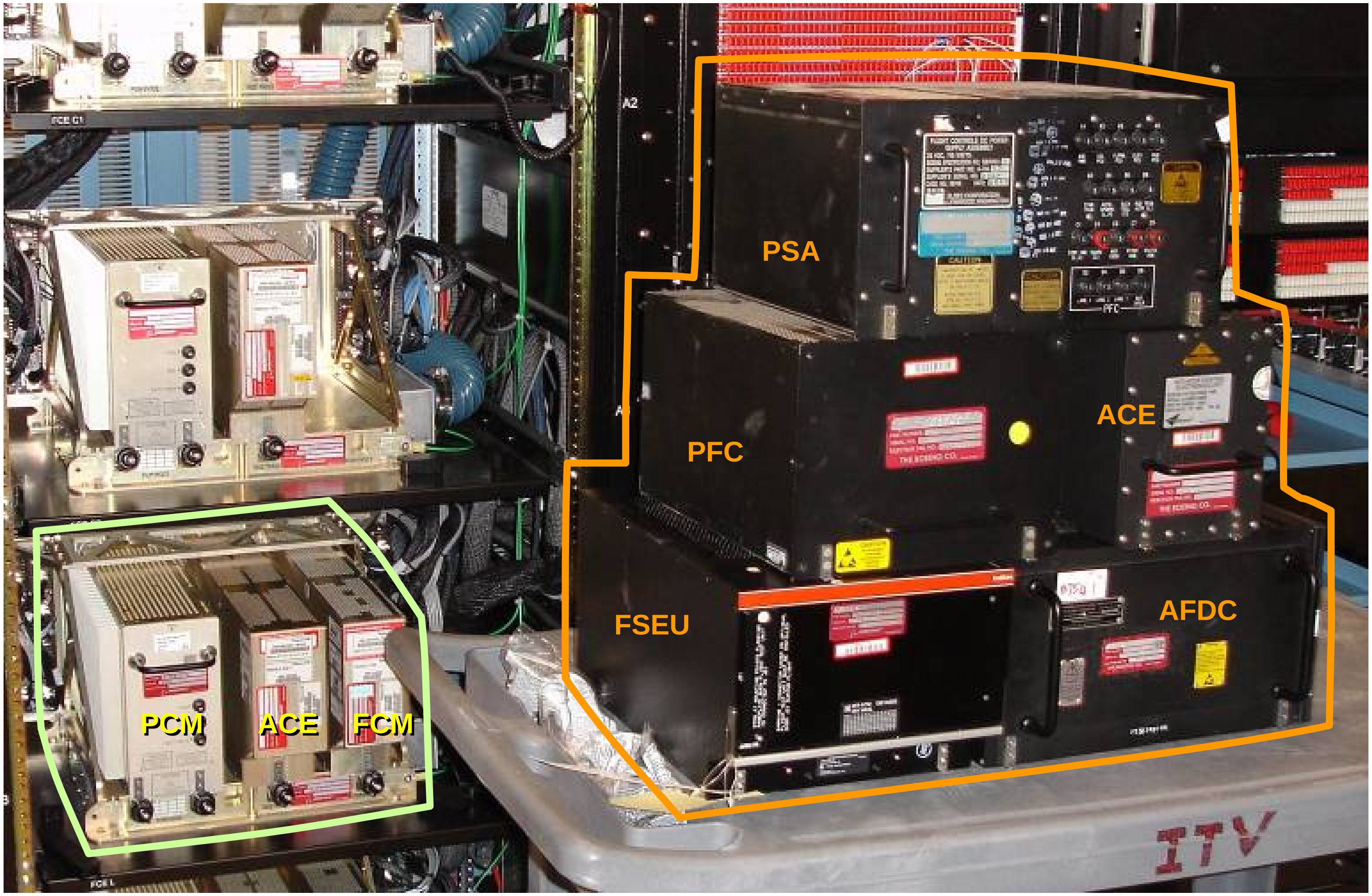
Avionics Integration



Integrated FCE

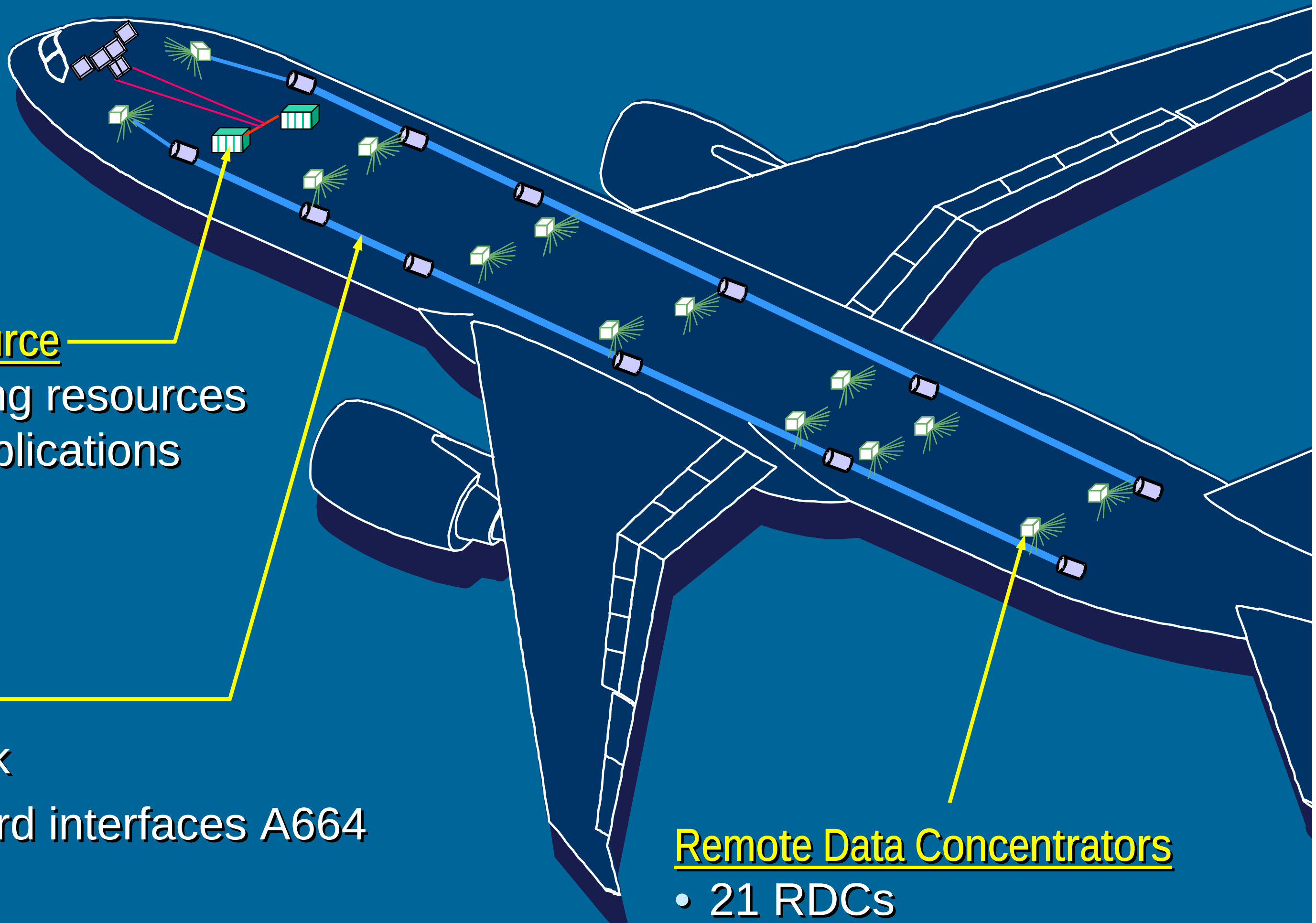
Equivalent Channel of Flight Controls and High Lift

787



777

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

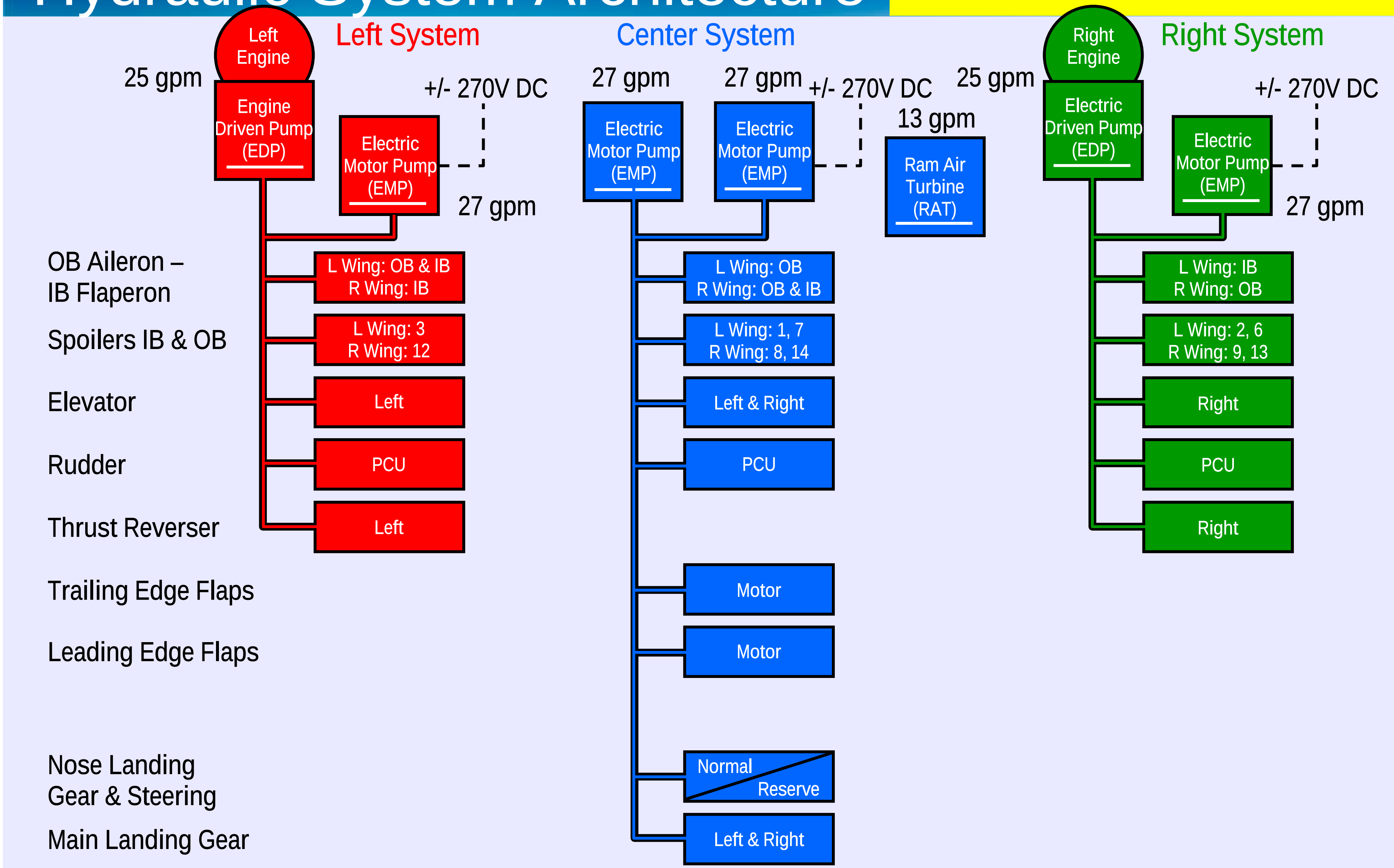
Remote Data Concentrators
- 21 RDCs
- Remote I/O capability
- Reduces airplane wiring

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



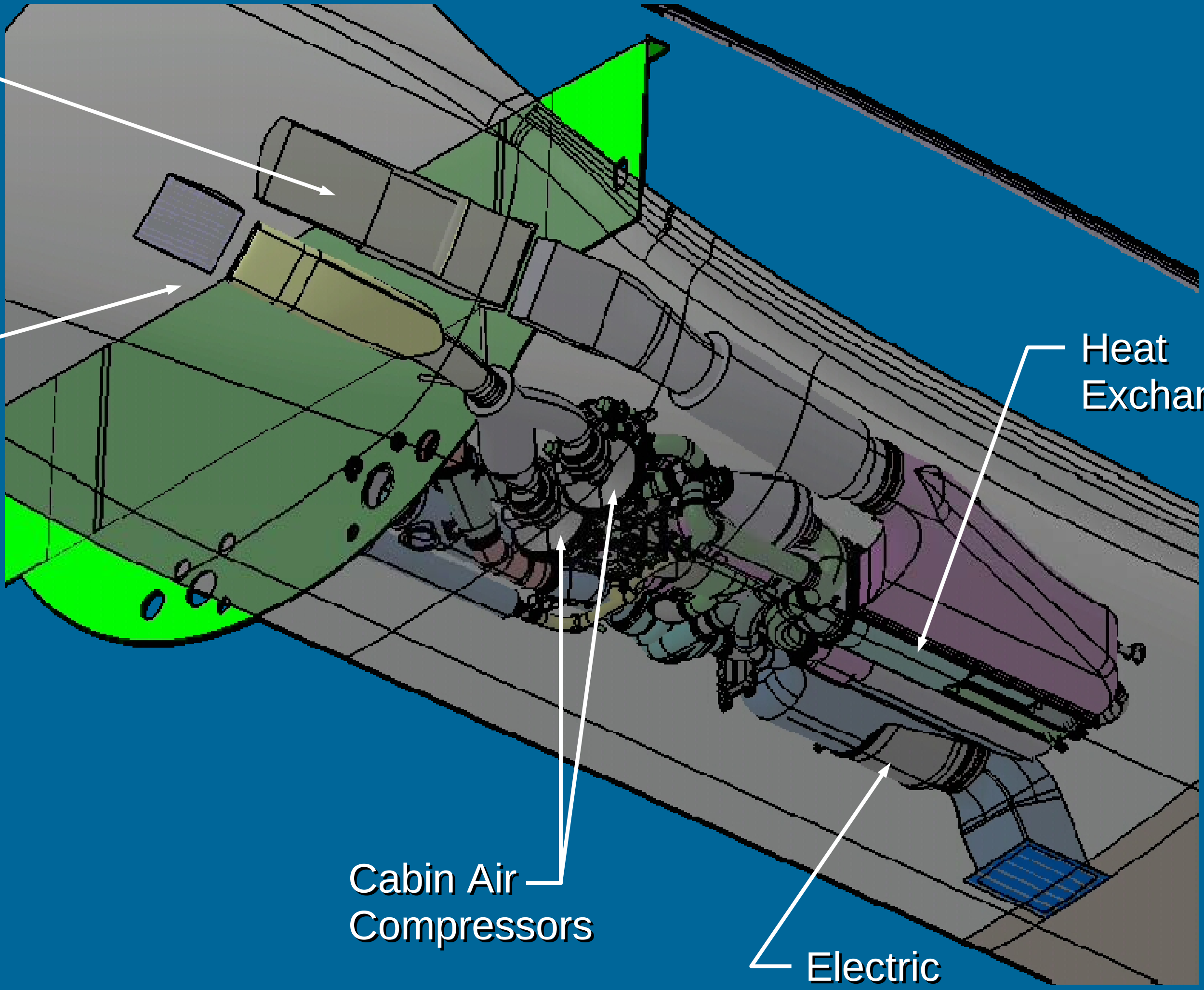
Landing Gear Systems
New Control-by-Wire

- Landing Gear Actuation
  - Electronic control and sequencing of landing gear and doors

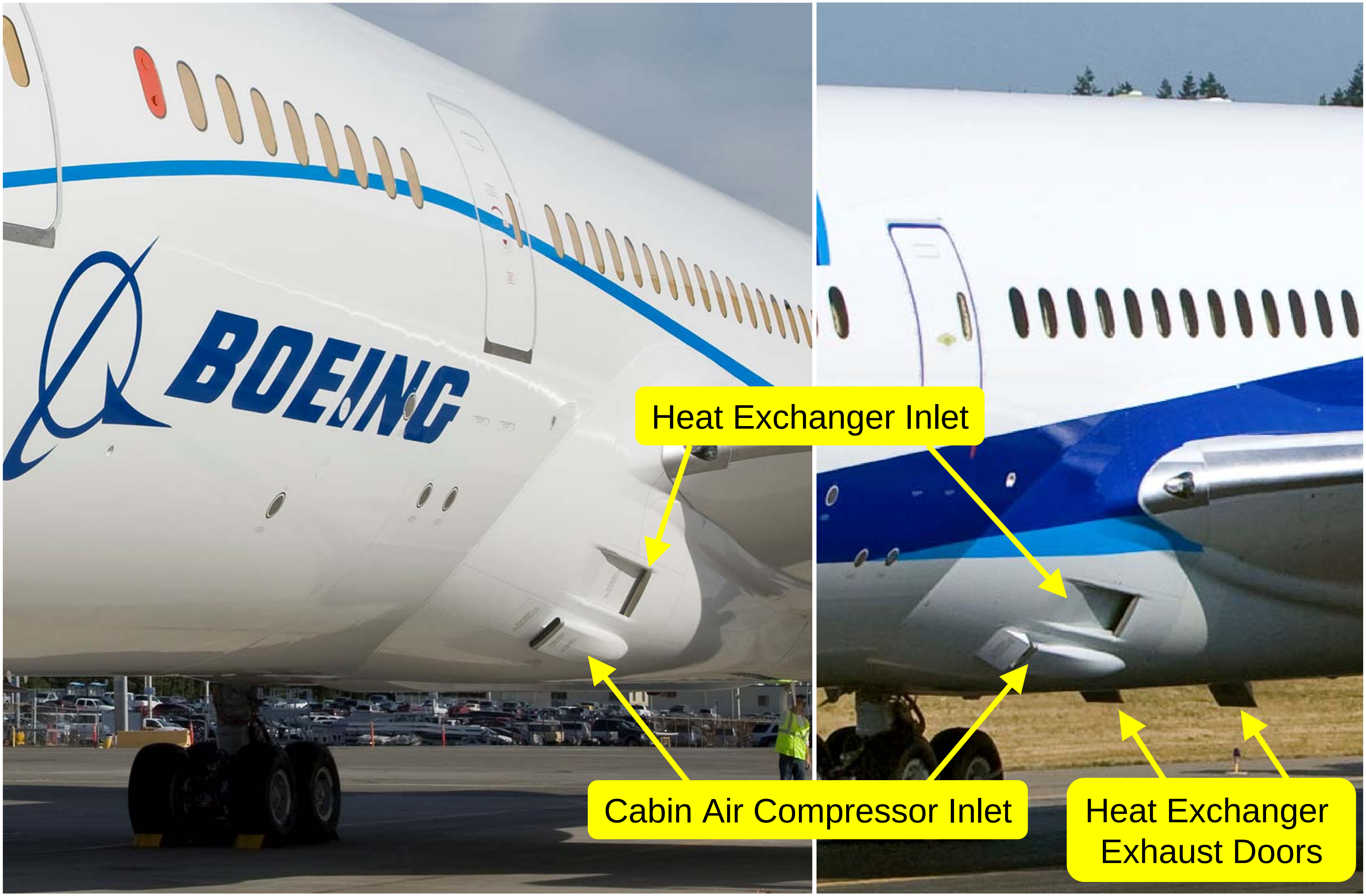
- Brake System
  - Control-by-wire brakes, autobrake and anti-skid
  - Electric Brake Actuators

- 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 (**F**light **R**ec. **E**lec. **D**oc. - 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

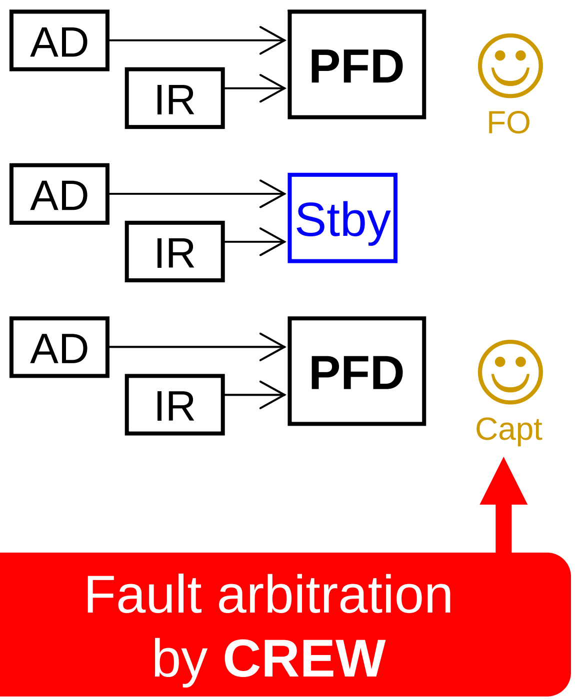
- P-Beta control law
- Vertical Gust Suppression (turbulence)
- Enhanced Stall Protection
  - Limits high angles of attack
- Enhanced Thrust Asymmetry Compensation
  - Adds inertial yaw detection on ground
  - Generates rudder & steering for yaw disturbances

P – Beta Control Law

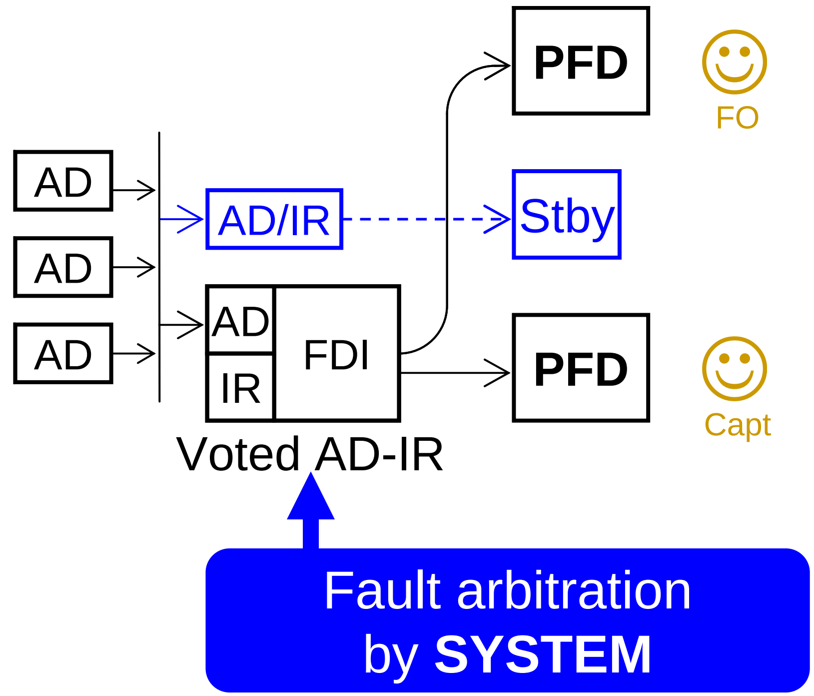
- Wheel commands roll rate (P)
- Pedals command sideslip angle (Beta)
- Opposes disturbances
- Coordinates lateral and directional control
- Automatic aileron & rudder trim
  - No aileron trim switch

Air Data System Design Philosophy

Federated AD & IR
(all previous models)



Voted AD & IR
(777, 787)



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

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

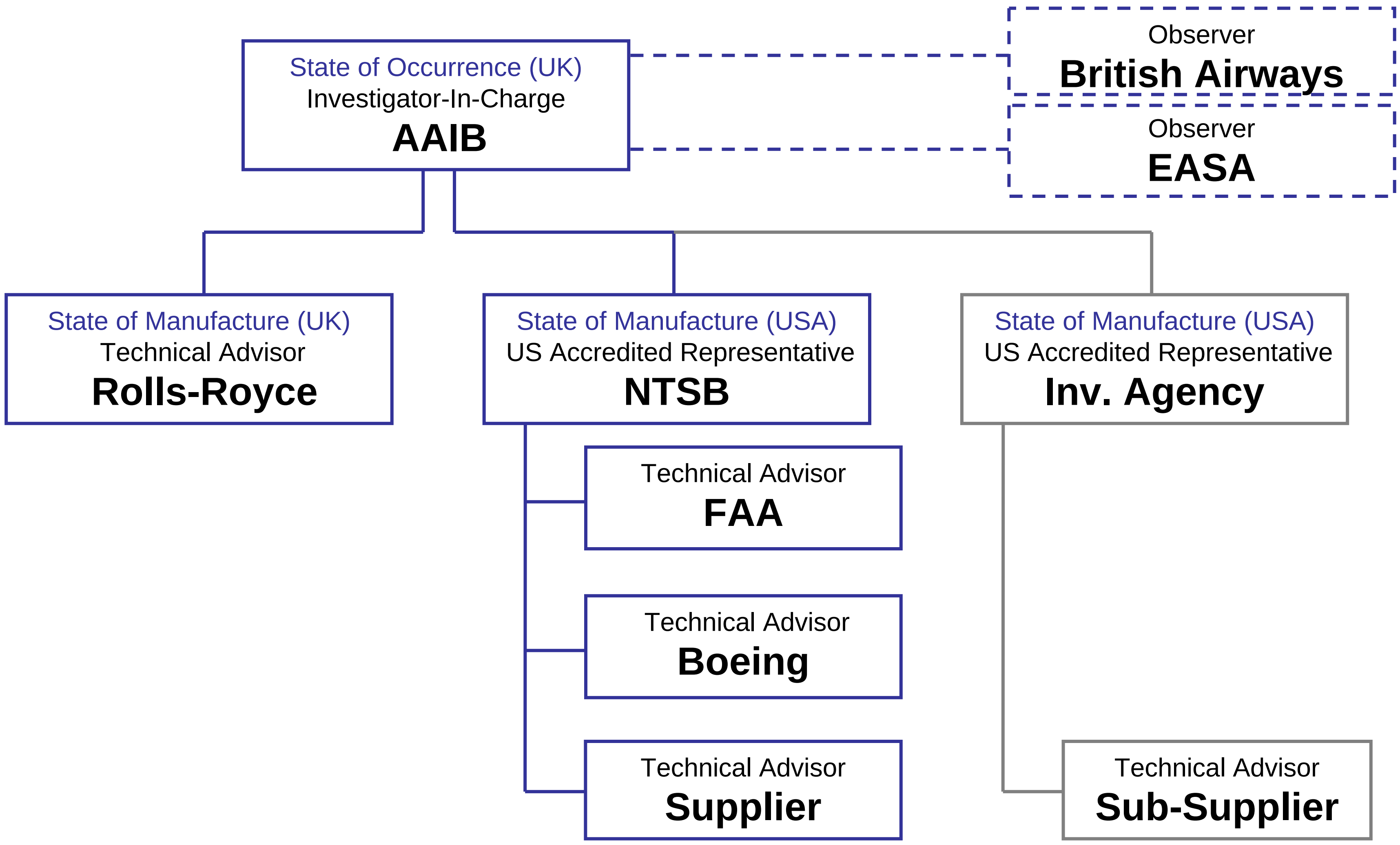
Electronic link to maintenance manuals

Coordinated airplane and ground processing approach

Fault Prediction

Sat Comm

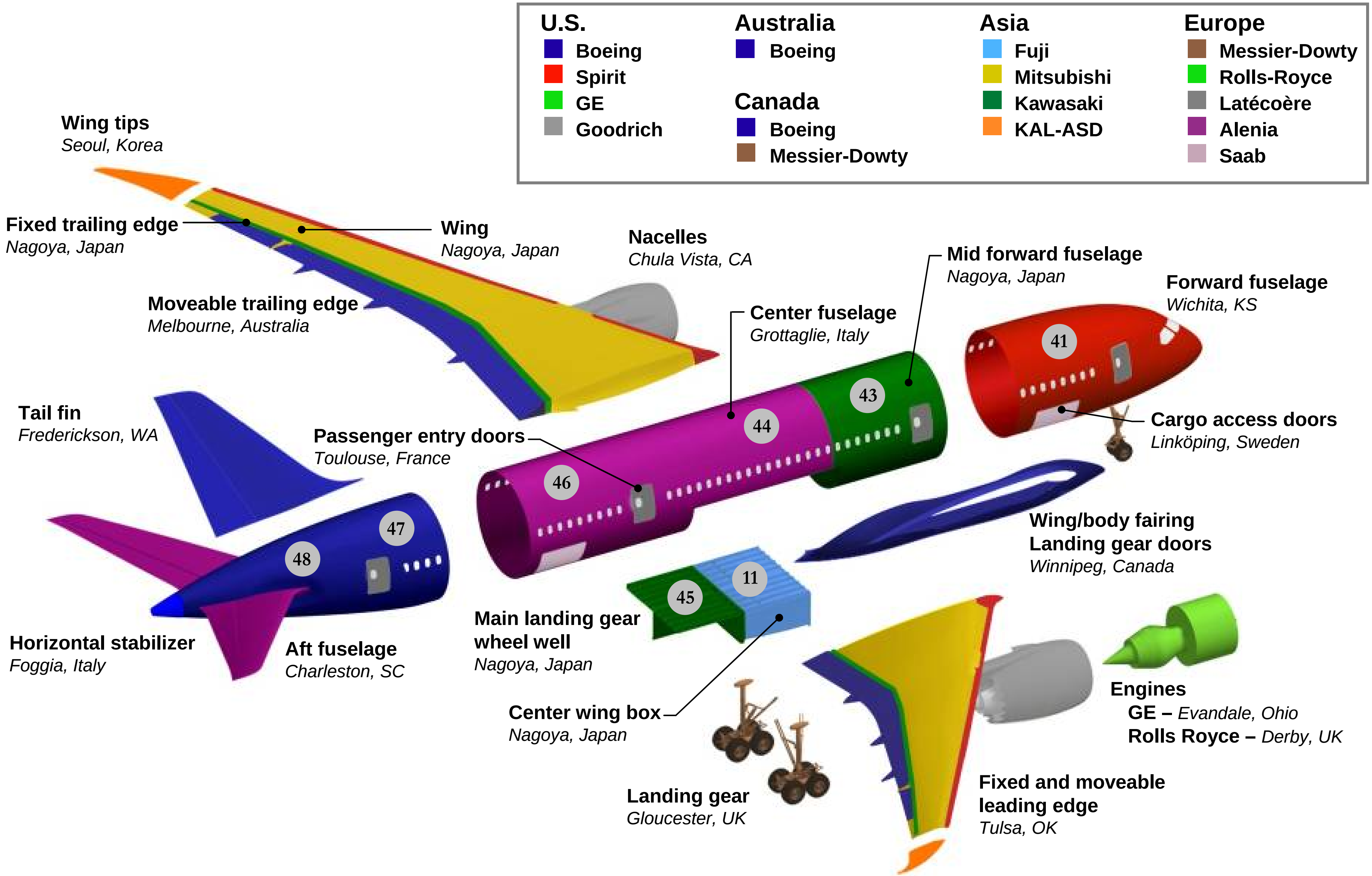
G-YMMM Investigation Organization




BOEING
787
BOEING
N7874
DREAMLINER

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**


DREAMLIFTER


TLD
DREAMLIFTER


TLD
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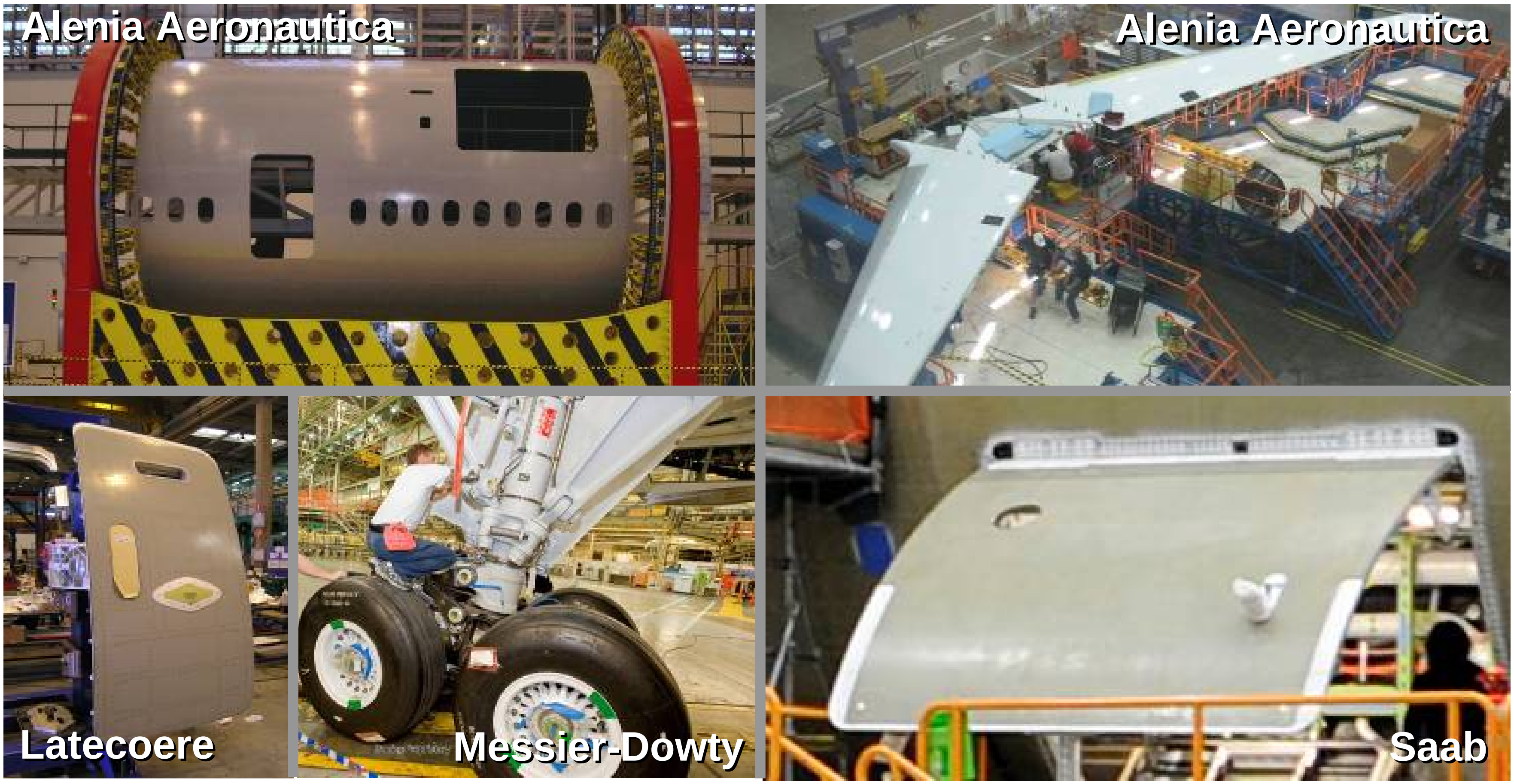
DREAM LIFTER

787 Structure from Asia

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