Training & Flight Services

737-7/-8/-9
SYSTEMS

737-7/8/9 Training Manual

The Boeing Company

FS009

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About This Book

This document presents a general technical description of the Boeing 737 MAX. It is based on the standard airplane, but also includes details of some of the most popular options.

For detailed information, or information on a specific customer airplane, refer to these publications:

- Airplane Flight Manual
- Operations Manual
- Wiring Diagram Manual
- Airplane Maintenance Manual
- Configuration Specification Document
- Configuration Control Document.

If the information in this book does not agree with the information in any of these publications, the publications should be used.

OVERVIEW

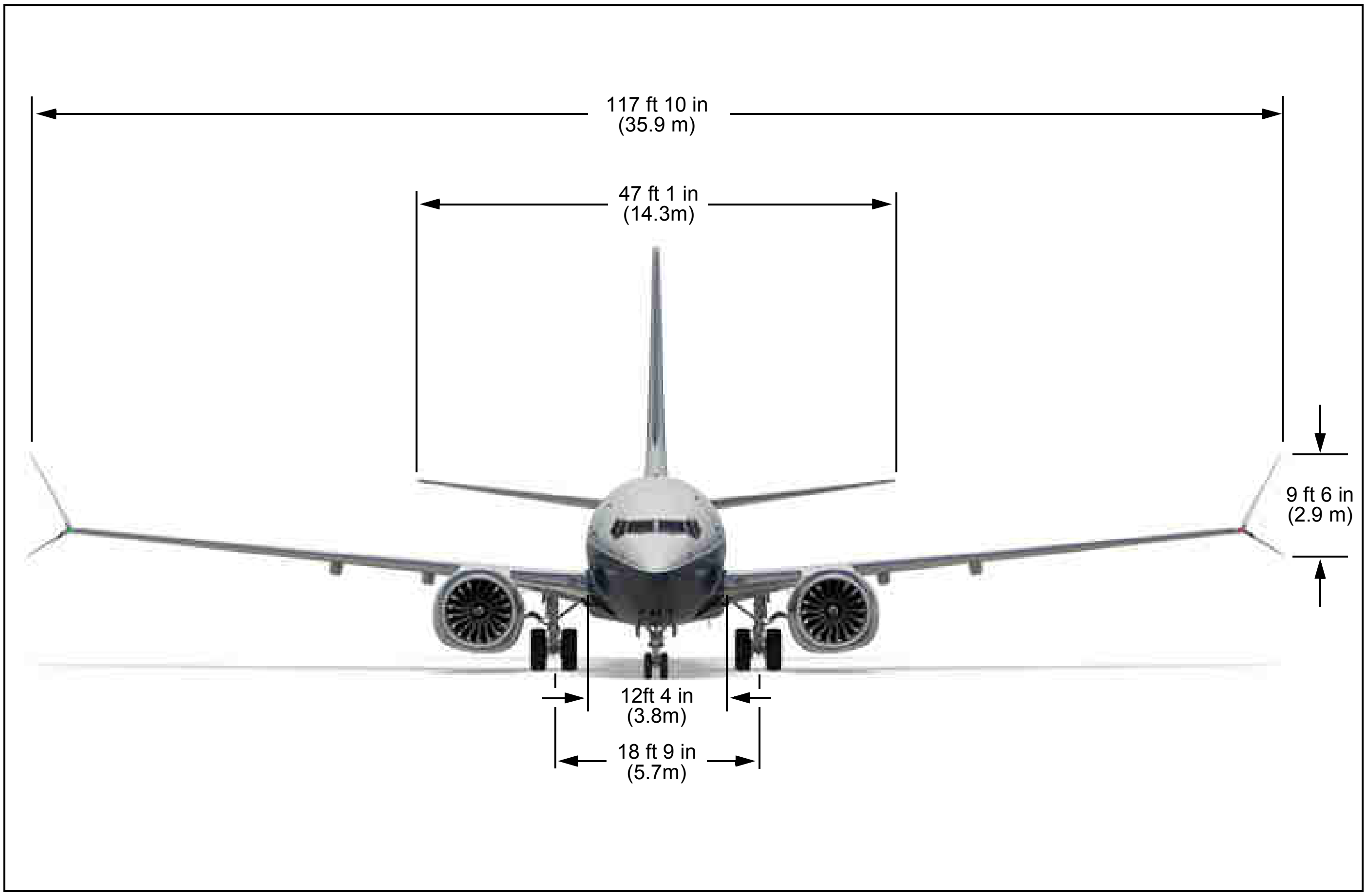
To understand the airplane, it is necessary to understand the airplane systems. This document gives an introduction to the systems in the 737 MAX.

Each system is shown from a component, installation, and operational view. Flight compartment instruments and panel data help show system operation.

Principal Characteristics

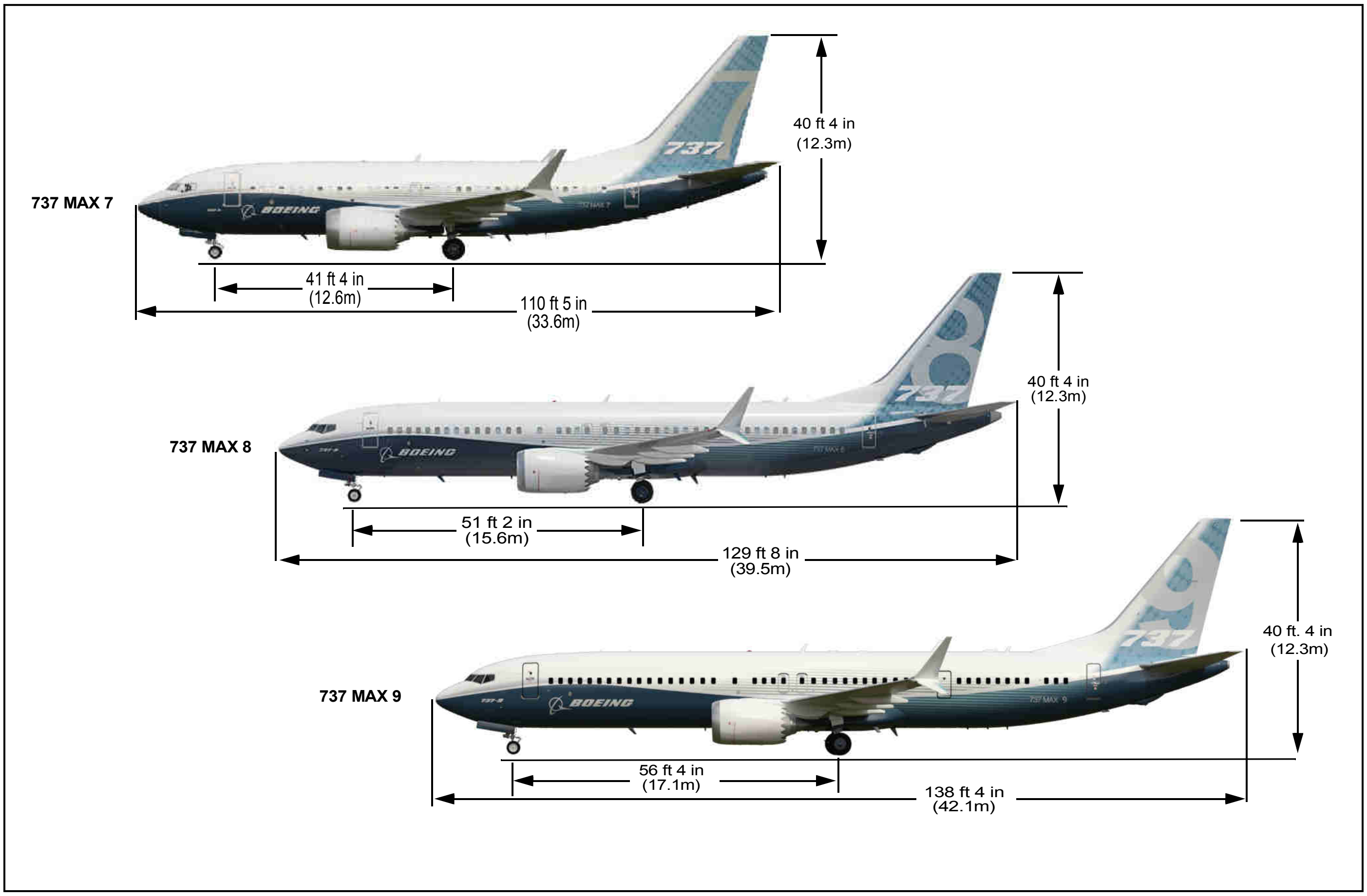
The main characteristics and major structural differences of the 737-7, -8, and -9 are shown on the subsequent pages. Each airline selects different options. All options are not shown in this manual. Most of the systems are similar between models; only the major differences are covered.

Introduction



Airplane Dimensions

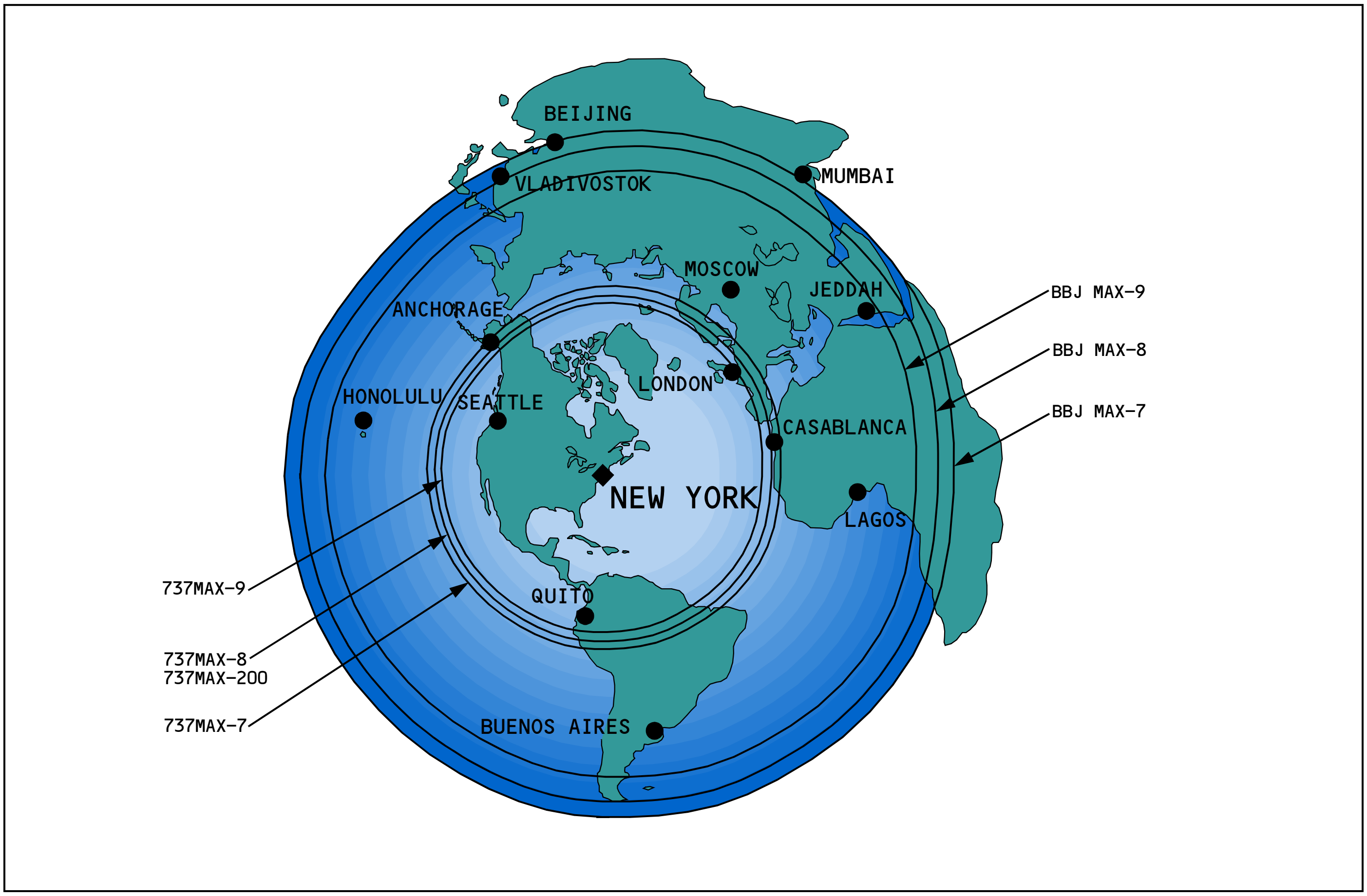
The wing span and horizontal tail span is the same for all models in the MAX family. The dimensions are shown above.



Airplane Dimensions

The longitudinal and vertical dimensions for the 737 MAX 7, 737 MAX 8 and 737 MAX 9 are shown above.

Introduction



Operating Experience

The 737 MAX models now in service have a high dispatch reliability. The 737 MAX flies a large number of short length flights. It can also fly longer range flights. The airplane use rate is very high. The use rates are shown this way:

- Average daily utilization 8.7 hr
- Average flight length 1.9 hr
- Schedule reliability 99.45%.

The 737 MAX-7/-8/-9 design improves on previous 737 NG model designs. These are the improvements:

- Larger payload
- Higher service ceiling
- More range
- Improved fault isolation
- Improved systems design
- Flight compartment common display system.

The range map above shows the typical range of the 737MAX with a full passenger payload and 85% annual winds. Ranges for all 737 models are:

- 737MAX-7 range of 3,850 NM or 7126 KM with up to 149 passengers
- 737MAX-8 range of 3,660 NM or 6775 KM with up to 189 passengers
- 737MAX-9 range of 3,630 NM or 6720 KM with up to 204 passengers
- 737MAX-200 range of 3,660 NM or 6775 KM with up to 200 passengers.
- BBJ MAX-7 range of 6,978 NM or 12,917 KM with up to 19 passengers. Note: This assumes auxiliary fuel tanks fitted.
- BBJ MAX-8 range of 6,603 NM or 12,223 KM with up to 19 passengers. Note: This assumes auxiliary fuel tanks fitted.
- BBJ MAX-9 range of 6,110 NM or 11310 KM with up to 19 passengers. Note: This assumes auxiliary fuel tanks fitted.

Characteristic	737 MAX-7	737 MAX-8	737 MAX-200	737 MAX-9
Maximum Gross Weight				
Taxi Pounds (Kilograms)	138 700 to 160 000 (62 913) (72 574)	159 900 to 181 700 (72 529) (82 417)		168 700 to 195 200 (76 521) (88 541)
Takeoff	138 200 159 500 (60 328) (69 400)	159 400 181 200 (72 302) (82 190)		168 200 194 700 (76 294) (88 314)
Landing	134 400 135 500 (60 962) (61 461)	150 300 152 800 (68 174) (69 308)		155 700 163 900 (70 624) (74 343)
Zero Fuel	127 500 128 600 (57 833) (58 331)	142 900 145 400 (64 818) (65 952)		148 300 156 500 (67 267) (70 987)
Engine Thrust, lbs Basic Option Option	LEAP-1B21 21 500 LEAP-1B23 23 000 LEAP-1B25 25 000 LEAP-1B27 26 900	LEAP-1B25 25 000 LEAP-1B27 26 900 LEAP-1B28 27 900	LEAP-1B27 26 900 LEAP-1B28 27 900	LEAP-1B25 25 000 LEAP-1B27 26 900 LEAP-1B28 27 900
Fuel capacity U.S. Gallons (Liters)	6853 (25940)			
Passengers Two Class All Tourist, 32-in Pitch All Tourist, 30-in Pitch All Tourist, 28-in Pitch	126 140 148 -	162 175 189 -	- - - 200	180 192 220 -
Lower Hold Volume, ft3 (m3)	Fwd Aft Total	Fwd Aft Total		Fwd Aft Total
ft3 (m3)	376 580 957 (10.6) (16.4) (27.0)	662 883 1545 (18.7) (25.0) (43.7)		820 996 1816 (23.2) (28.2) (51.4)
Speed Capacity Maximum Operating Airspeed, Knots (KCAS) 340 Maximum Operating Mach Number 0.82		**Service Ceiling** 41 000 feet 12 497 meters		

Principal Characteristics

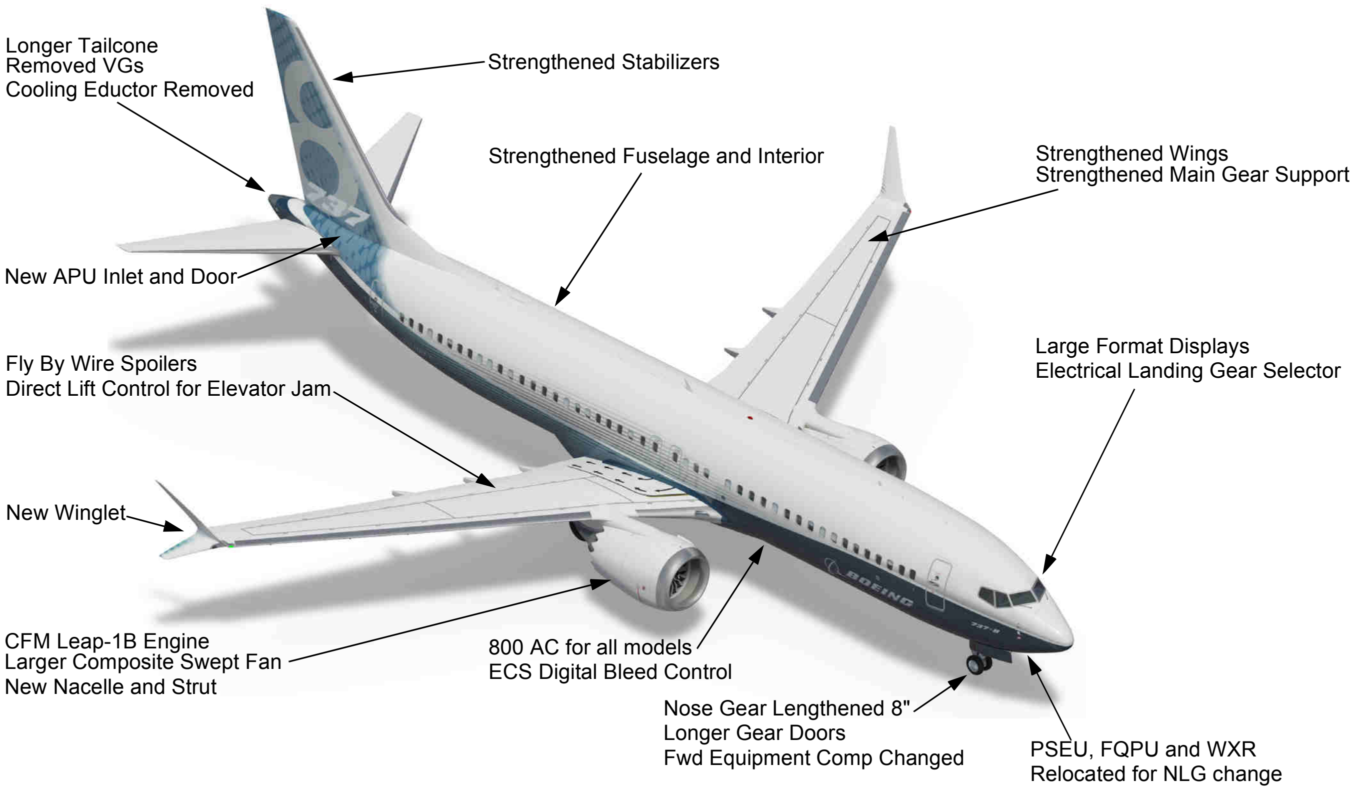
The 737 MAX characteristics are shown in the chart above detailing the following :

- Airplane weights
- Engine thrusts per model
- Fuel capacity
- Passenger numbers
- Lower hold volumes
- Speed constraints
- Altitude constraints.

737 MAX 9 Auxillary Tanks

The fuel capacity can be increased by 960 gallons (3633 liters) of usable fuel in the aft cargo compartment. One or two auxillary tanks can be installed. If two auxillary tanks are installed, there will be 750 cubic feet of aft cargo volume.

Introduction

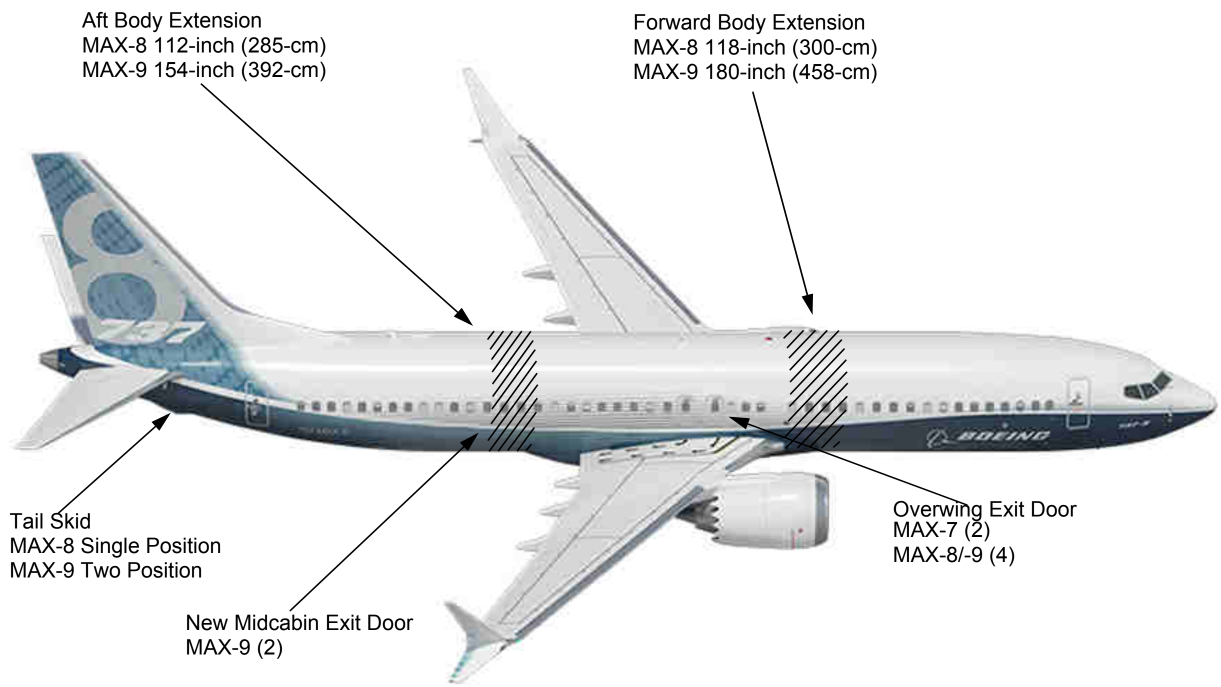


Major 737MAX Changes

Principal Characteristics

The following changes were made to the 737MAX model compared to older variants:

- Longer tailcone
- Aft body VGs removed
- APU cooling eductor removed
- Strengthened wing, fuselage and stabalizers
- Large format displays
- Electrical landing gear selector
- Relocated PSEU, WXR and FQPU
- Nose landing gear 8" longer
- Longer nose landing gear doors
- Redesigned forward equipment compartment
- 800 NG A/C in all models
- Digital bleed air control system
- Updated CFM56 Leap-1B engines
- Larger engine composite fan blades
- Redesigned engine nacelle and strut
- Redesigned winglets
- Fly-By-Wire flight spoilers
- Direct lift control for spoilers
- New APU inlet and door
- Strengthened landing gear



737MAX-7/-8/-9

737MAX-7

The 737MAX-7 is 110 feet 5 inches (33.7M) long.

The 737MAX-7 has one emergency exit door over each wing.

Differences 737MAX-8

The 737MAX-8 is 230 inches (584 centimeters) longer than the -7. This is accomplished by installing two plugs fore and aft of the wing.

The 737MAX-7 has two emergency exit doors over each wing.

In addition, the 737MAX-8 can have a tail skid installed.

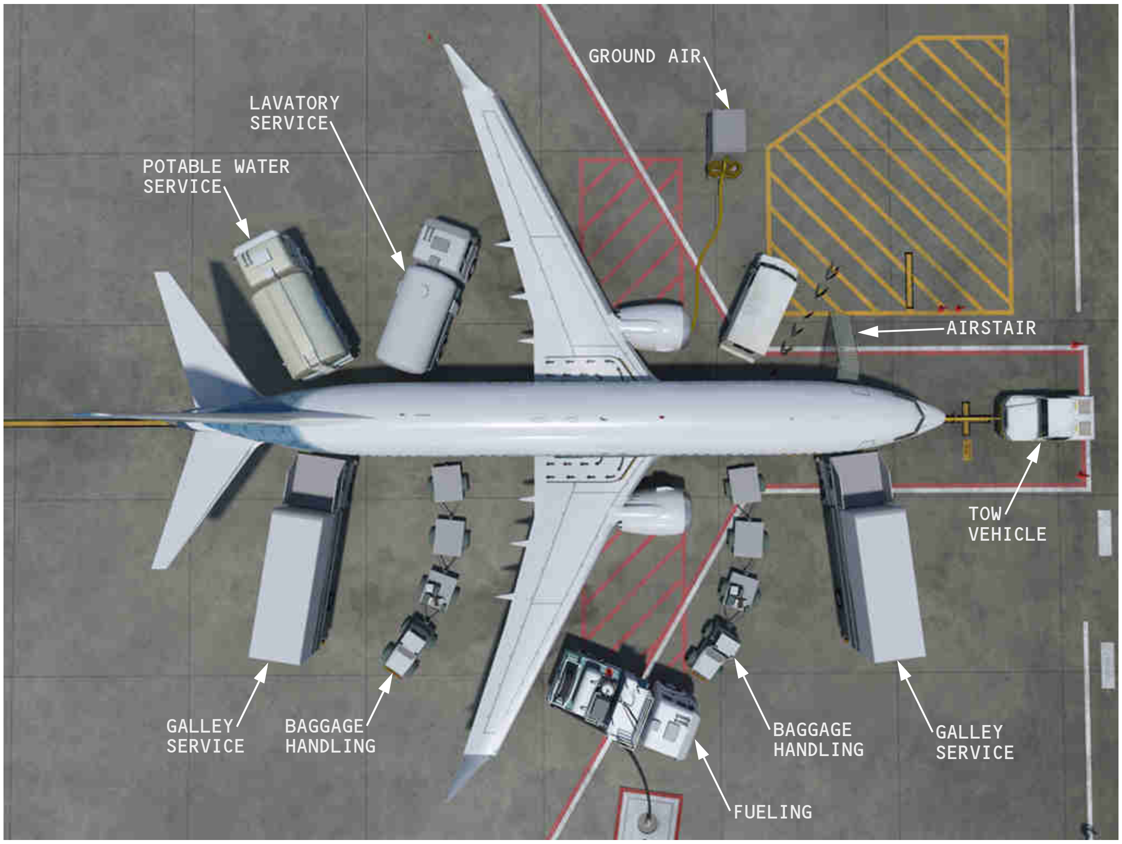
Differences 737MAX-9

The 737MAX-9 is 104 inches (264 centimeters) longer than the -8. This is accomplished by installing two longer plugs fore and aft of the wing.

The 737MAX-9 also has two additional emergency exit doors aft of the wing on either side of the fuselage.

In addition, the 737MAX-9 can have a two position tail skid installed.

Introduction



Airplane Servicing

SELF-SUFFICIENCY

The airplane can operate at improved and unimproved airports. These are the systems that make the airplane self sufficient:

- The APU supplies on-ground or in-flight electrical power
- The APU supplies air for engine starting
- The APU can maintain an air-conditioned cabin during ground operations
- The APU can be started from the airplane battery
- Multiple systems allow dispatch with inoperative systems
- Two or more systems which have equal function but one system operates at a time which reduces maintenance time
- Self-contained airstair (option).

EYE-LEVEL MAINTENANCE

The operator benefits from minimum maintenance cost and low ramp turnaround times. Less money is spent to purchase maintenance equipment.

Main engines and the APU can be changed without expensive ground equipment. Hand operated hoists attach to the airplane engine struts to remove and install engines.

COMPONENT AND SYSTEM ACCESS

The major hydraulic components, are in the main landing gear wheelwell and can be maintained at ground level.

The air-conditioning units are easy to reach. They are behind two doors under the wing center section.

Access doors, forward and aft of the nose wheelwell, give access to electronic equipment compartments.

Extension of forward and aft wing high lift devices permit access to other system components.

Potable water and lavatory systems are easy to maintain because of ground access to their service panels.

BUILT-IN-TEST

Built-in test (BITE) and checkout function for systems simplify fault isolation. Many airframe/engine modules and most avionics modules include BITE. BITE access is at the face of the module or through the flight compartment control display units (CDU).

- **Features**
- **Fuselage**
- **Wing**
- **Stabilizers**
- **Composites**

Features

BASIC STRUCTURAL DESCRIPTION

The airplane is a low wing twin engine design. The engines are below the wings on struts. It has full cantilever wings and tail surfaces. The fuselage is a semi-monocoque design.

HIGH-FATIGUE DESIGN LIFE

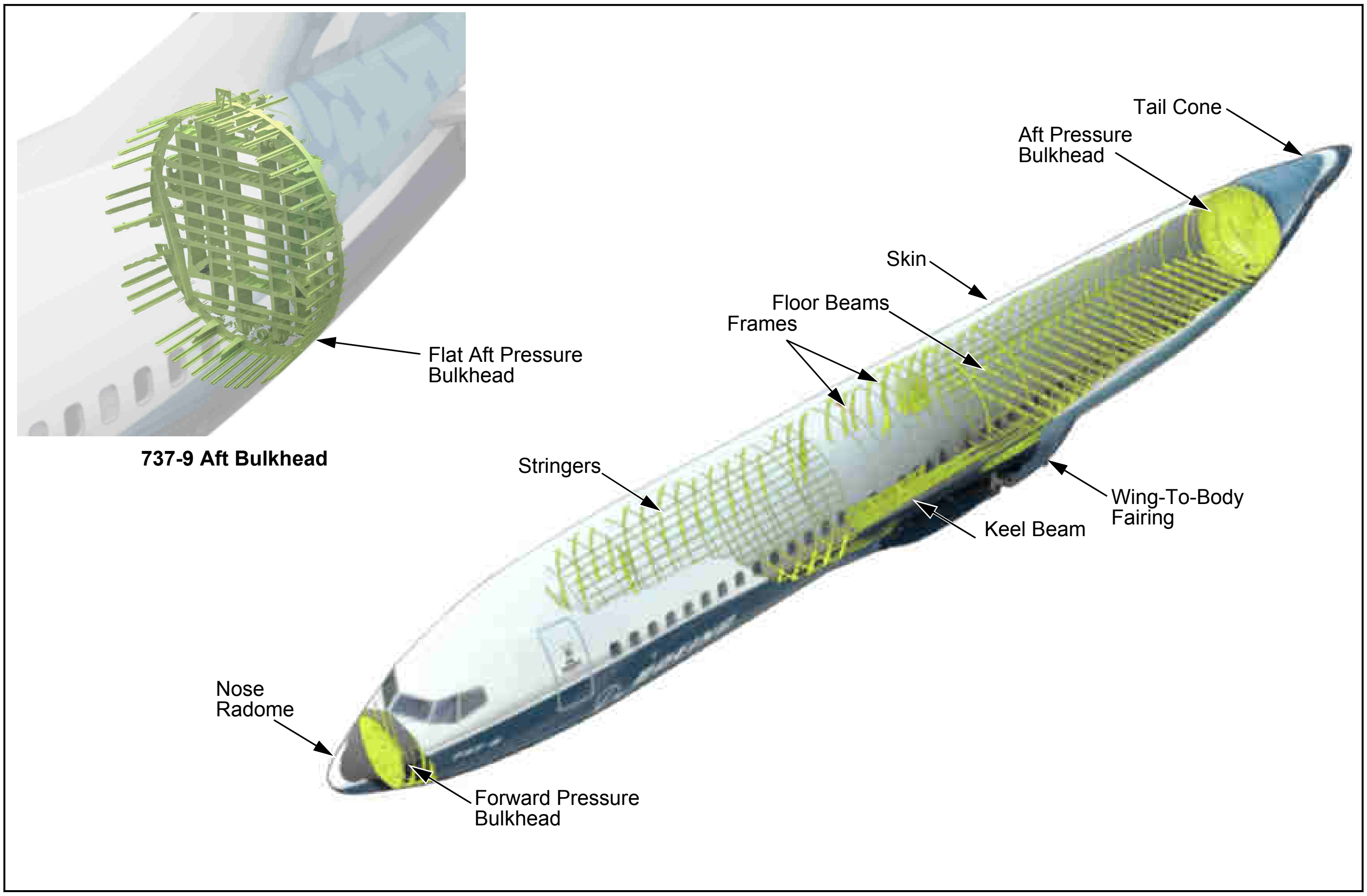
The design service objective is 75,000 flight cycles. For typical airline operations, the aircraft reaches this objective after 25 years of service.

CORROSION PREVENTION

Years of extensive in-service experience lead to an optimum airframe design. This knowledge along with new material technology gives the operator an airframe that results in:

- Minimal corrosion
- Longer in service periods
- Less maintenance costs.

Structures



Fuselage

The fuselage is a pressurized semi-monocoque structure. The primary materials for the fuselage are aluminum alloys.

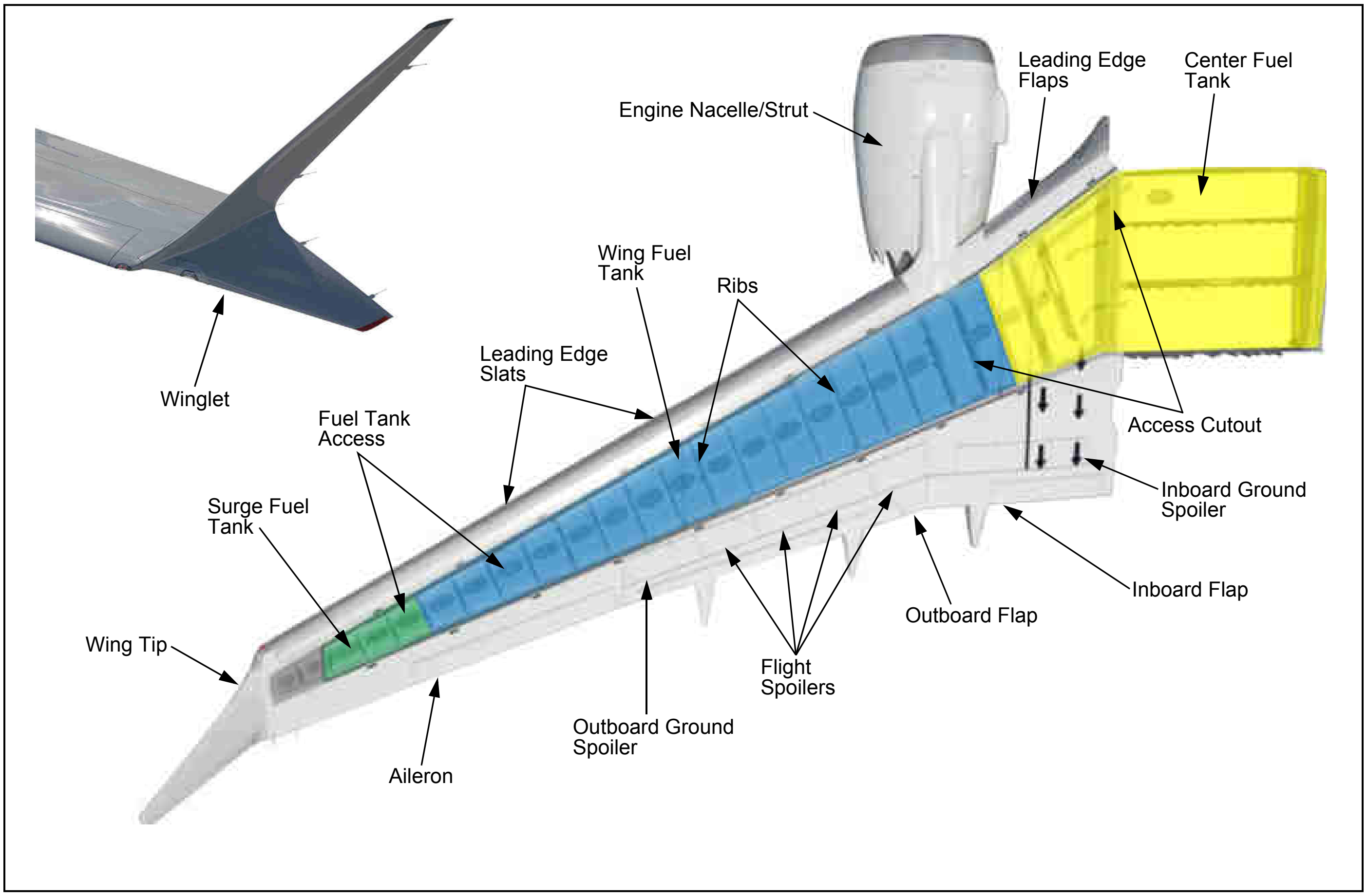
The fuselage structure is made up of:

- Frames
- Stringers
- Floor beams
- Keel Beam
- Fuselage skin
- Forward pressure bulkhead
- Aft pressure bulkhead.

These auxiliary structures attach to fuselage:

- Nose radome
- Wing-to-body fairing
- Tail cone.

Normally the aft pressure bulkhead is a dome shaped structure. However, on the 737 MAX-9, a flat aft pressure bulkhead is installed to provide more space in the fuselage for passenger seating.



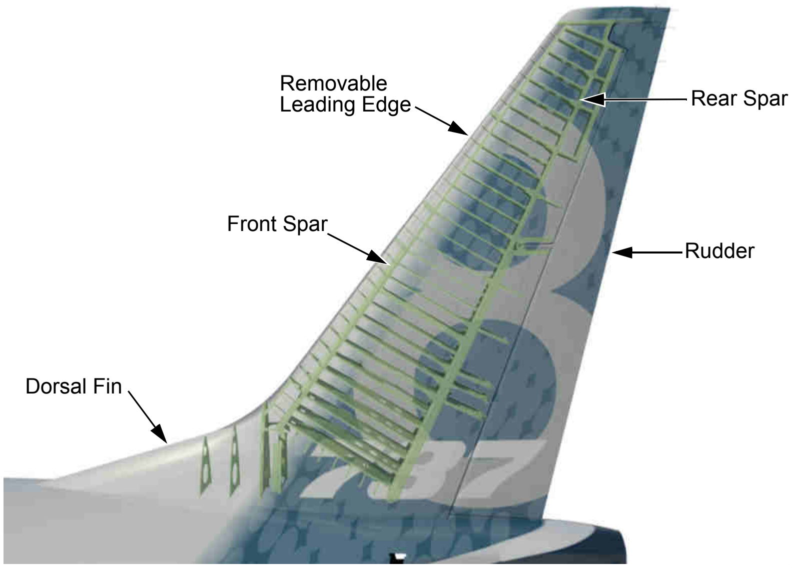
Wing

The wing is a cantilever structure. The basic wing structure is aluminum. The wing has these features:

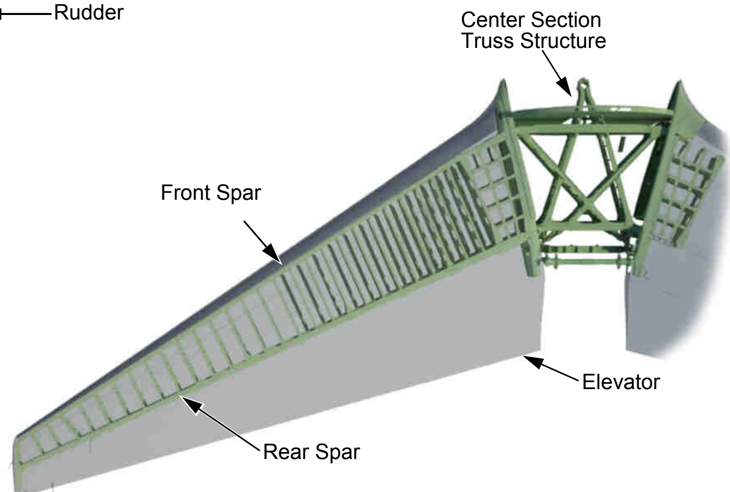
- Stores fuel
- Contains fuel system components
- Attach points for the engine strut, landing gear and flight control surfaces.

Fuel tank access panels on the bottom wing skin permit access to the fuel tanks.

Structures



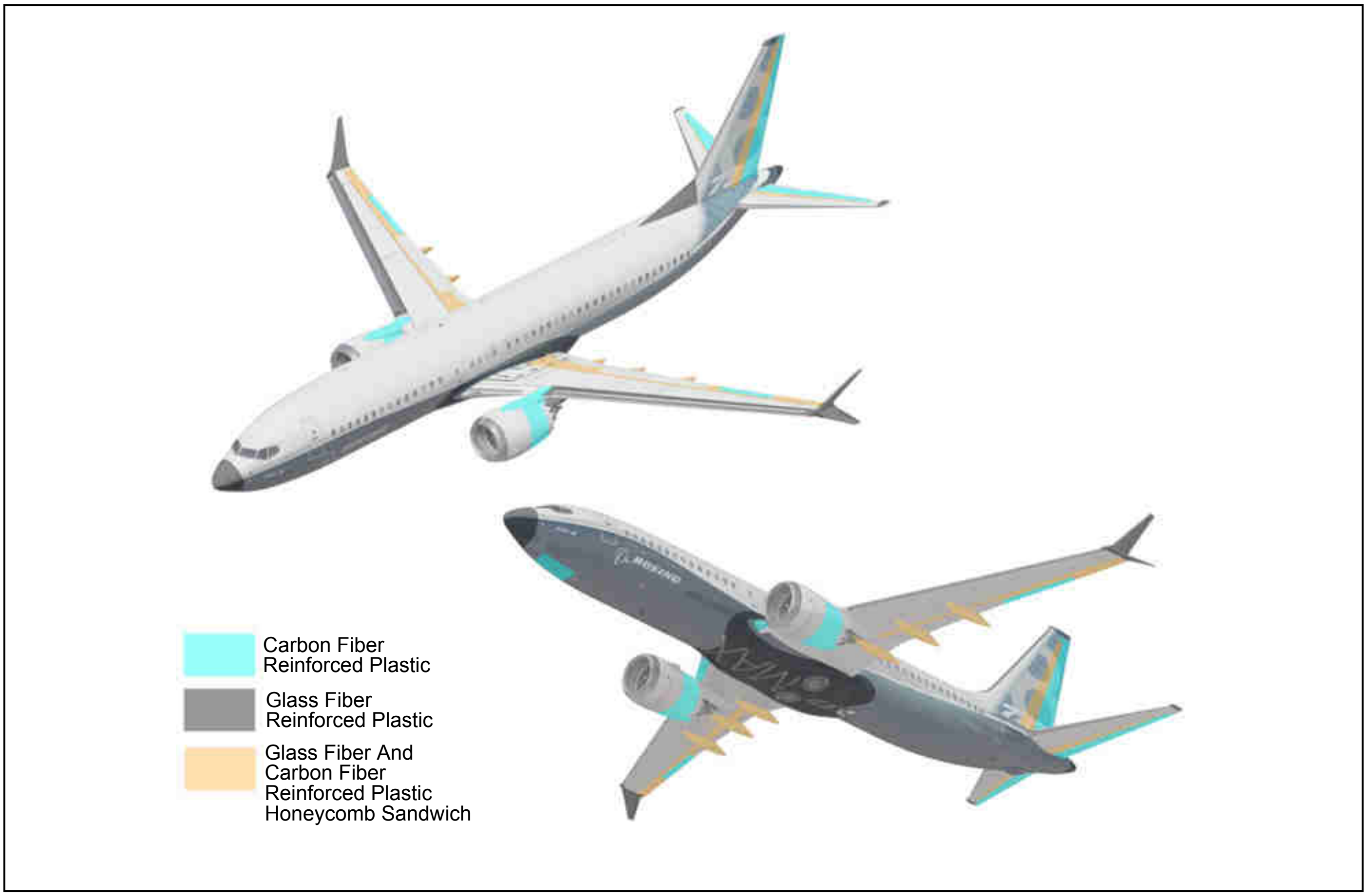
Vertical Stabilizer



Horizontal Stabilizer

Stabilizers

The horizontal and vertical stabilizers are made of aluminum alloys. The elevator and rudder are made of composite material.



Composites

Some airplane structure and parts are made from composite materials. These are some advantages of composite materials:

- High strength
- Corrosion resistant
- Increased fatigue life
- Light weight.

Equipment Centers

- **Features**
- **Electronic Equipment**
- **Electronic Equipment Rack E1**
- **Electronic Equipment Rack E2, E3, and E4**
- **Electronic Equipment Rack E5**
- **Optional Electronic Equipment Racks**

Features

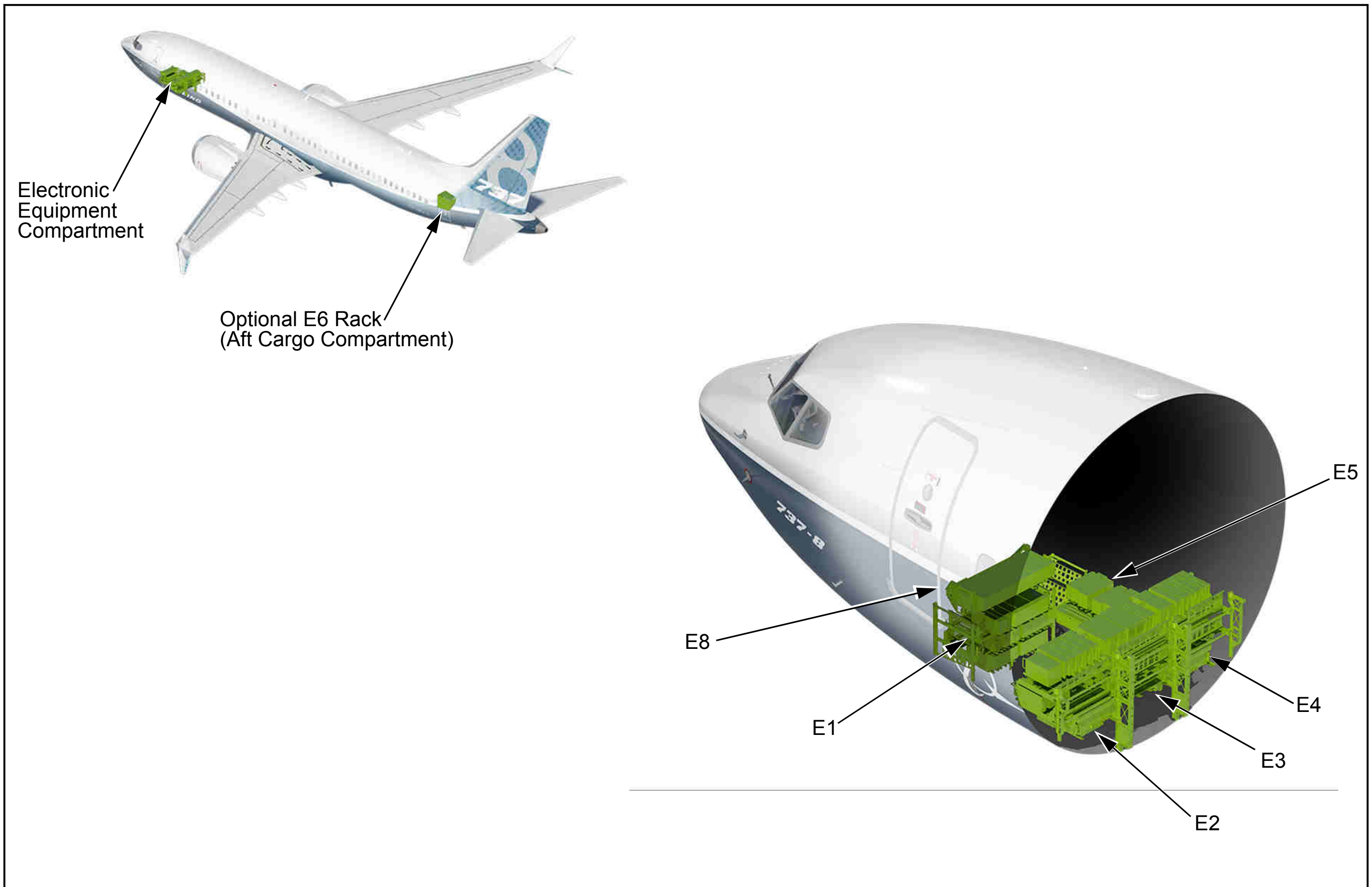
ACCESSIBLE LOCATION

Most electronic equipment is in a compartment below the cabin floor aft of the nose wheel well. This compartment is easily accessible from ground level.

TRANSVERSE RACK

The electronic equipment compartment includes 3 equipment racks. The main equipment rack is a transverse rack across the aft end of the compartment. Equipment removal and installation is easy due to the rack design. Interconnecting wiring, mounts, and accessory boxes are accessed through panels in the forward cargo compartment.

Equipment Centers



Electronic Equipment

Electronic equipment is in a compartment below the main cabin floor aft of the nose wheel well.

On the ground, you enter this electronic equipment (EE) compartment through a door in the bottom of the fuselage.

There are five standard equipment racks. These are the E1, E2, E3, E4, and E5 racks. More equipment racks may be needed on airplanes with optional systems.

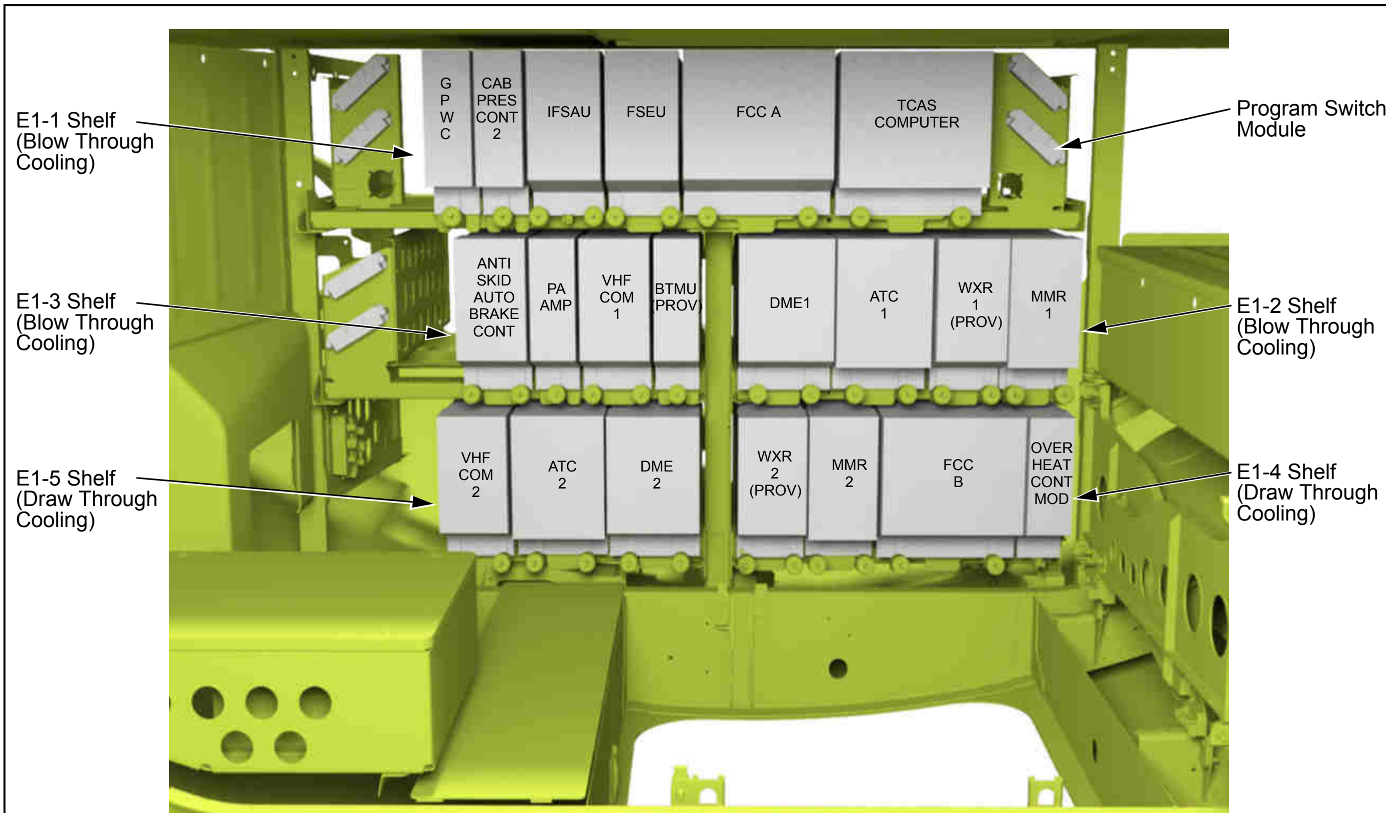
Shelf assemblies have equipment mounts, interconnected wiring, and accessory boxes. They are easy to remove. This makes troubleshooting and modification easier. Equipment that installs boxes on shelves is adjustable. Access to the most frequently used boxes is improved.

Most equipment rack shelves are cooled with air. Air is blown through or drawn through the equipment racks.

There is a drip shield over the racks to protect the equipment from moisture condensation.

There is also an optional E6 equipment rack in the lower aft cargo compartment.

There is also an optional E8 rack that can be installed over the E1 rack.



Electronic Equipment Rack E1 (Typical Arrangement)

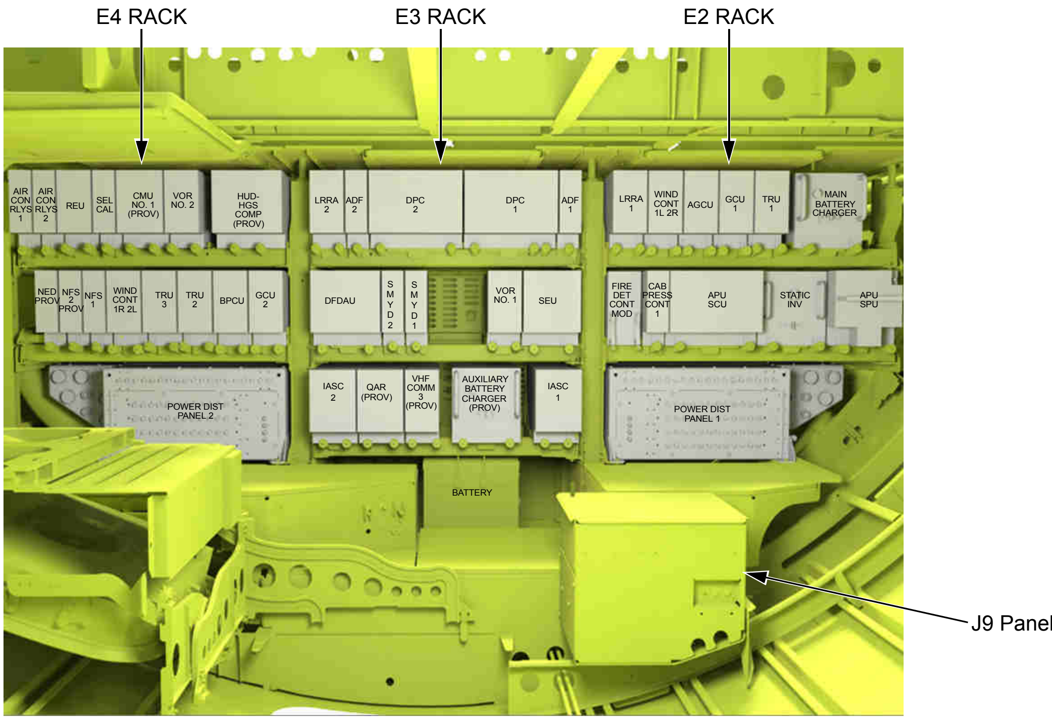
Electronic Equipment Rack E1

The E1 rack is made up of five shelves with mostly avionics systems components.

Each shelf has a source of cooling, either draw through or blow through.

There are also program switch modules. These modules allow maintenance personnel to quickly set certain options for specific systems.

Equipment Centers



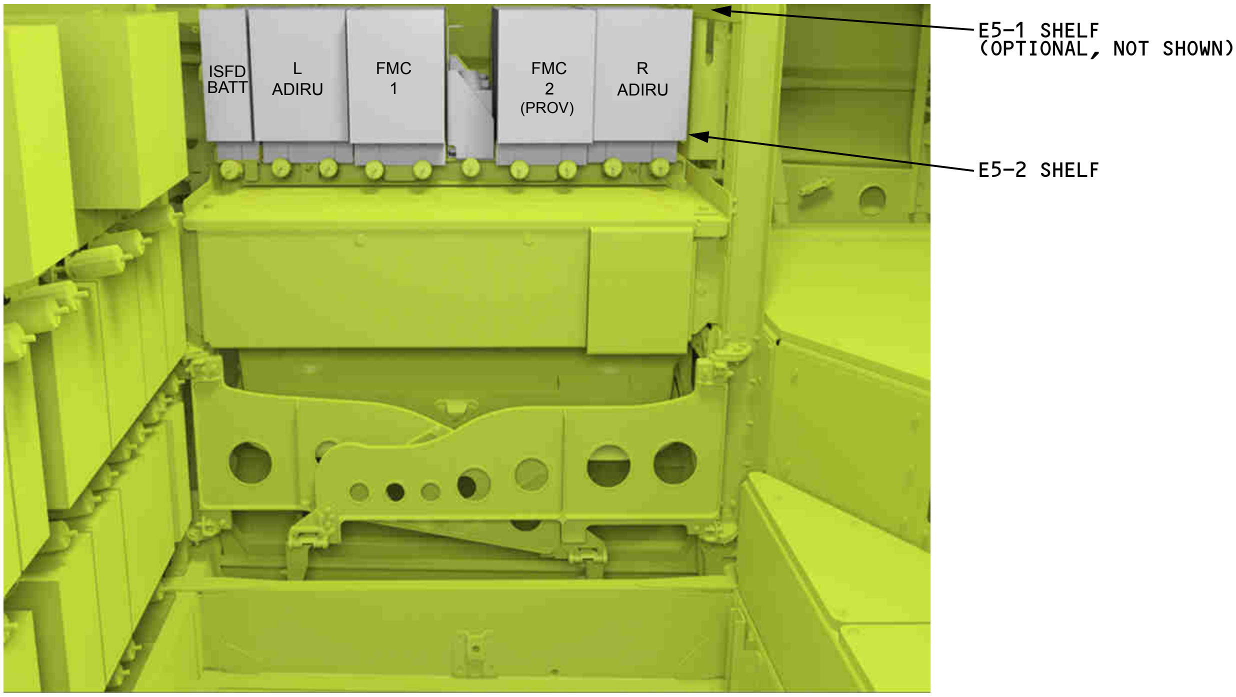
Electronic Equipment Racks E2, E3, and E4 (Typical Arrangement)

Electronic Equipment Rack E2, E3, and E4

The E2, E3 and E4 racks are made up of mostly airframe systems components.

There are also main electrical power panels, miscellaneous panels. The main airplane battery is located below the E3 rack.

Each shelf has a source of cooling, either draw through or blow through.

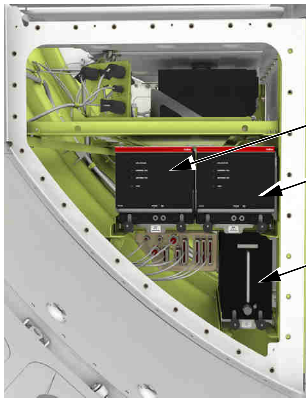


Electronic Equipment Rack E5

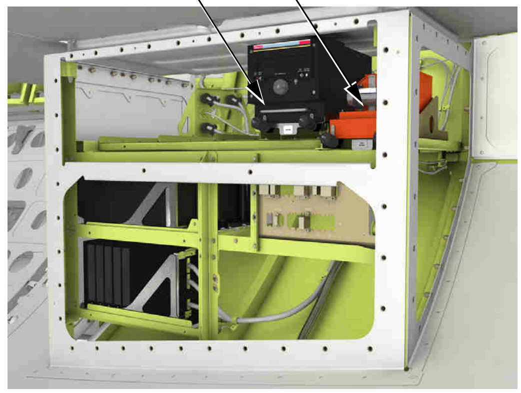
The E5 rack has the flight management computers, the air data inertial reference units and the integrated standby flight display dedicated battery/charger.

The shelf uses both draw through and blow through cooling.

Equipment Centers



E6 Rack
(No Cooling)
(Aft Cargo Compartment)



E6 Rack
(No Cooling)
(Aft Cargo Compartment)

E8-1
(Blow Through Cooling)
(EE Compartment)

Optional Electronic Equipment Racks

Two optional equipment racks are available when more space is necessary.

The E8-1 shelf is above the E1 rack in the EE compartment. The E8-1 shelf has blow-through cooling. The E8-1 shelf option is available when airstairs are not installed.

The E6 rack is in the aft cargo compartment. The E6 rack is not cooled.

Airplanes that do not have the optional E6 rack have a mount in the aft cargo compartment for the voice recorder and the APU electronic control unit (ECU). This mount location is the same as the E6 location.

Flight Compartment

- **Features**
- **Flight Compartment Main Panels**
- **Glareshield Panel**
- **Captain Instrument Panel**
- **First Officer Instrument Panel**
- **Center Instrument Panel**
- **Forward Electronic Panel**
- **Control Stand**
- **Aft Electronic Panel**
- **Aft Overhead Panel**
- **Forward Overhead Panel**
- **Flight Compartment Components**
- **Other Flight Compartment Components**
- **Crew Seats**

Features

DESIGN PHILOSOPHY

The flight compartment maintains the same type-rating as all previous 737s, while integrating refinements proven on the 737 with advanced 787 technologies.

LARGE FORMAT DISPLAY UNITS

The four large format display units need less power and have a larger display area than previous display units.

INTEGRATED STANDBY FLIGHT DISPLAY

The Integrated Standby Flight Display is now standard.

Flight Compartment

Flight Compartment Main Panels

The main instrument panel has three panels. These are the panels:

- P1
- P2
- P3.

The P7 glareshield panel is above the main instrument panels.

These are the aisle stand panels:

- P8 aft electronics panel
- P9 forward electronics panel
- Control stand.

These are the two overhead panels:

- P5 forward overhead panel
- P5 aft overhead panel

Glareshield Panel

The glareshield panel is the P7 panel. The P7 panel contains these panels:

- Digital flight control system mode control panel (MCP)
- EFIS control panels
- System annunciation lights
- Master caution lights
- Fire warning lights
- Chronograph switches.

The MCP uses integrated LED light switch assemblies. This design improves the reliability and maintainability of the mode control panel.

The EFIS control panels are on the glareshield panel for easier access by the pilots.

Flight Compartment

Captain Instrument Panel

The captain instrument panel is the P1 panel. The P1 panel has these features:

- Left outboard display unit
- Left inboard display unit
- Autoflight status annunciator
- Conditioned air outlet controls
- Lighting controls
- System annunciator lights.

First Officer Instrument Panel

The first officer instrument panel is the P3 panel. The P3 panel also has these features:

- Right outboard display unit
- Right inboard display unit
- Autoflight status annunciator
- Conditioned air outlet controls
- Ground proximity module
- System annunciator lights.

Flight Compartment

Center Instrument Panel

The center instrument panel is the P2 panel. The P2 panel has these items:

- Integrated Standby Flight Display
- Landing gear lever and position indicators
- Alternate nose wheel steering switch.

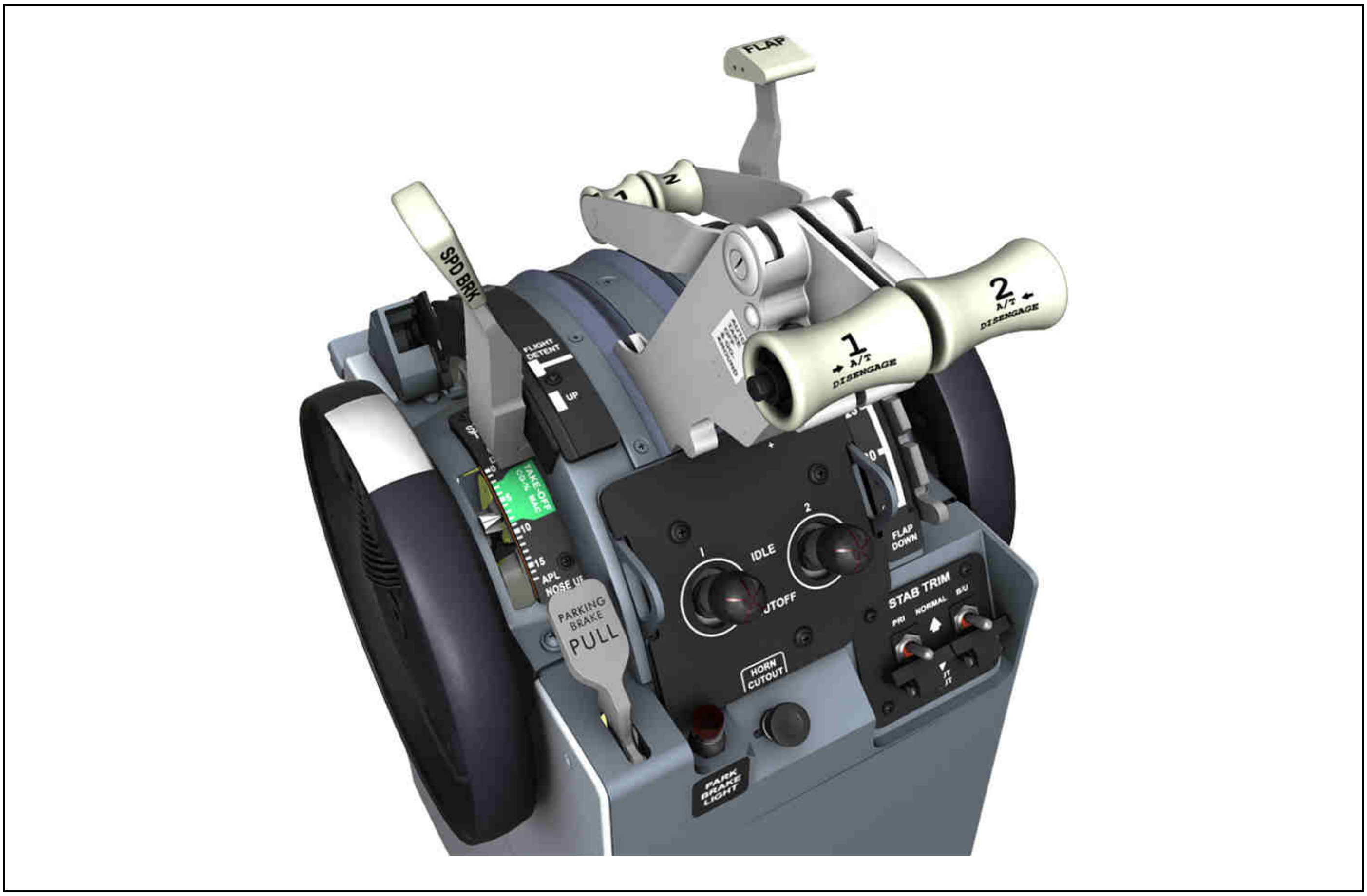
The integrated Standby Flight Display (ISFD) is a liquid crystal display unit that replaces and integrates the features of separate standby instruments.

Forward Electronic Panel

The forward electronic panel is the P9 panel. The P9 panel contains these items:

- Multifunction control display units
- Autobrake selector and annunciator
- Antiskid annunciator
- Brake temperature annunciator
- Brake pressure indicator
- Tire pressure annunciator
- Fuel flow display switch
- MFD ENG/SYS switches
- Captain and First Officer cursor controls.

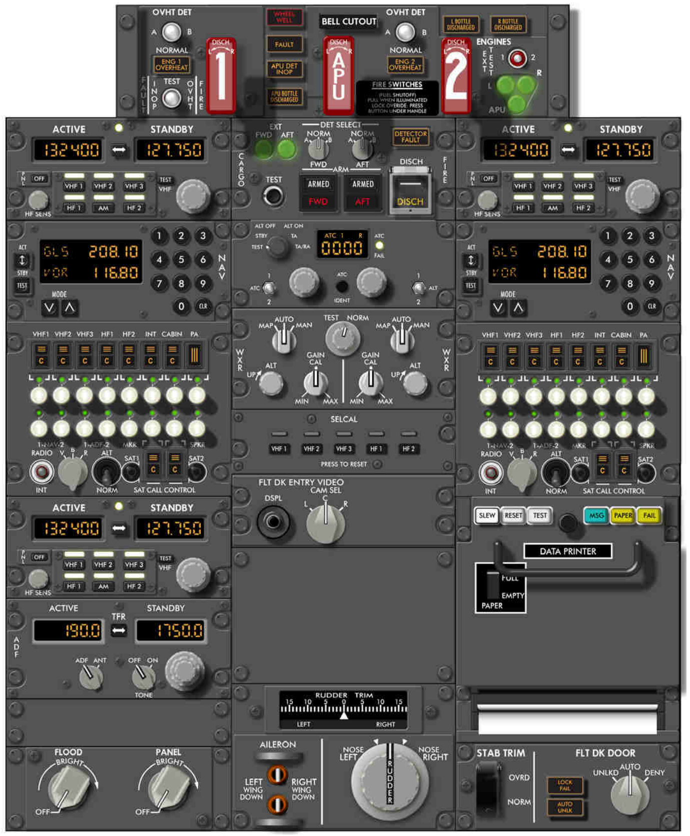
Flight Compartment



Control Stand

The control stand has these controls and indications:

- Forward thrust levers
- Reverse thrust levers
- Takeoff/go-around switches
- Autothrottle disengage switches
- Speed brake lever
- Horizontal stabilizer manual trim wheels
- Parking brake lever and indication light
- Flap lever
- Stabilizer trim cutout switches
- Horn cutout
- Engine start levers.



Aft Electronic Panel

The aft electronic panel is the P8 panel. The P8 panel has these features:

- Radio tuning panels
- Navigation control panels
- Audio control panels
- ADF control panel
- ATC control panel
- Cargo fire panel
- SELCAL control panel
- Aileron and rudder trim panel
- Lighting controls
- Weather radar control panel
- Flight deck door panel

The radio tuning panels tune the VHF and HF radios from one control panel.

Optional audio control panels without Satellite Communication capability are available.

Optional navigation control panel has rotary dial tuning.

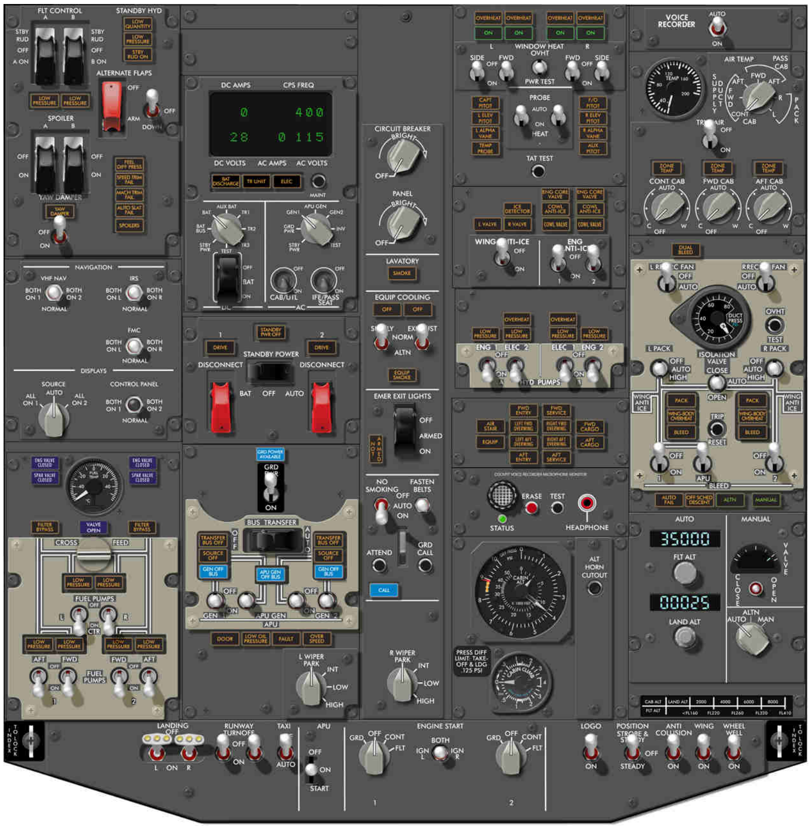
Flight Compartment

Aft Overhead Panel

The P5 aft overhead panel has controls that are used less frequently in flight.

The P5 aft overhead panel has these controls and Indications:

- Emergency locator transmitter control panel
- Leading edge devices annunciator panel
- Inertial system display unit
- IRS mode selector unit
- Service interphone switch
- Dome light switch
- Observer's audio control panel
- Reverser fault lights
- Engine control lights
- Electronic engine control (EEC) alternate mode light/switches
- Passenger and crew oxygen system control panel
- Flight recorder test panel
- Aux landing gear down and locked indicator lights
- Mach/airspeed warning test panel
- Stall warning test panel
- Broadband system panel
- Elevator jam landing assist
- MAINT light



Forward Overhead Panel

The forward overhead panel is the P5 panel. Because of its central location, either pilot can reach any of the systems controls. The panel has controls for these systems:

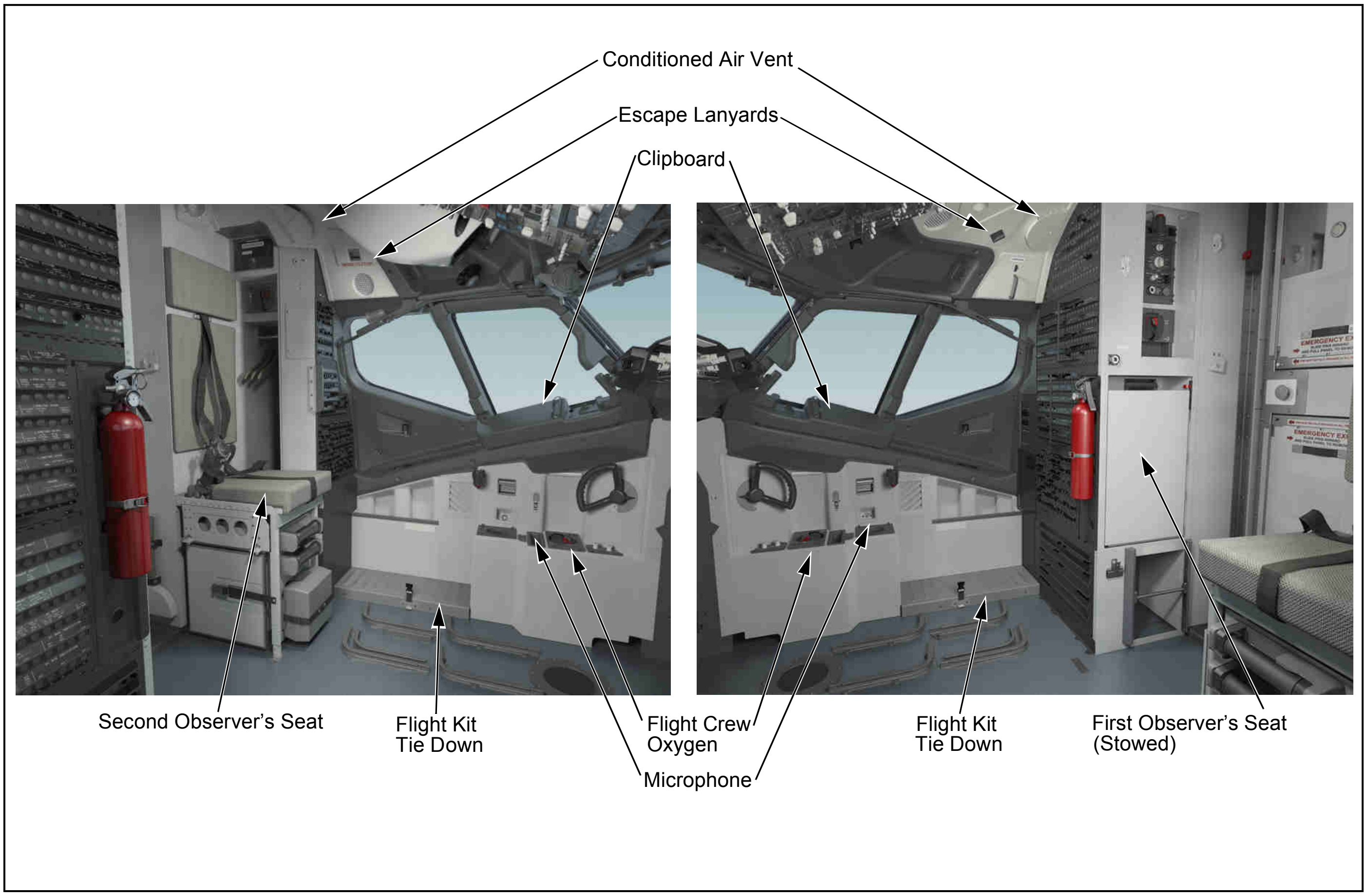
- Flight controls
- Instrument switching
- Fuel
- Electrical
- Window and air data probe heat
- Engine and wing anti-ice
- Hydraulics
- Door warning
- Voice recorder
- Air-conditioning
- Pressurization.

The forward overhead panel has switches for these functions:

- Overhead panel lights
- Equipment cooling
- Emergency exit lights
- Passenger signs
- Rain removal
- Exterior lights
- APU
- Engine start.

The primary system control panels, fuel, electrical, hydraulic and air conditioning are light grey.

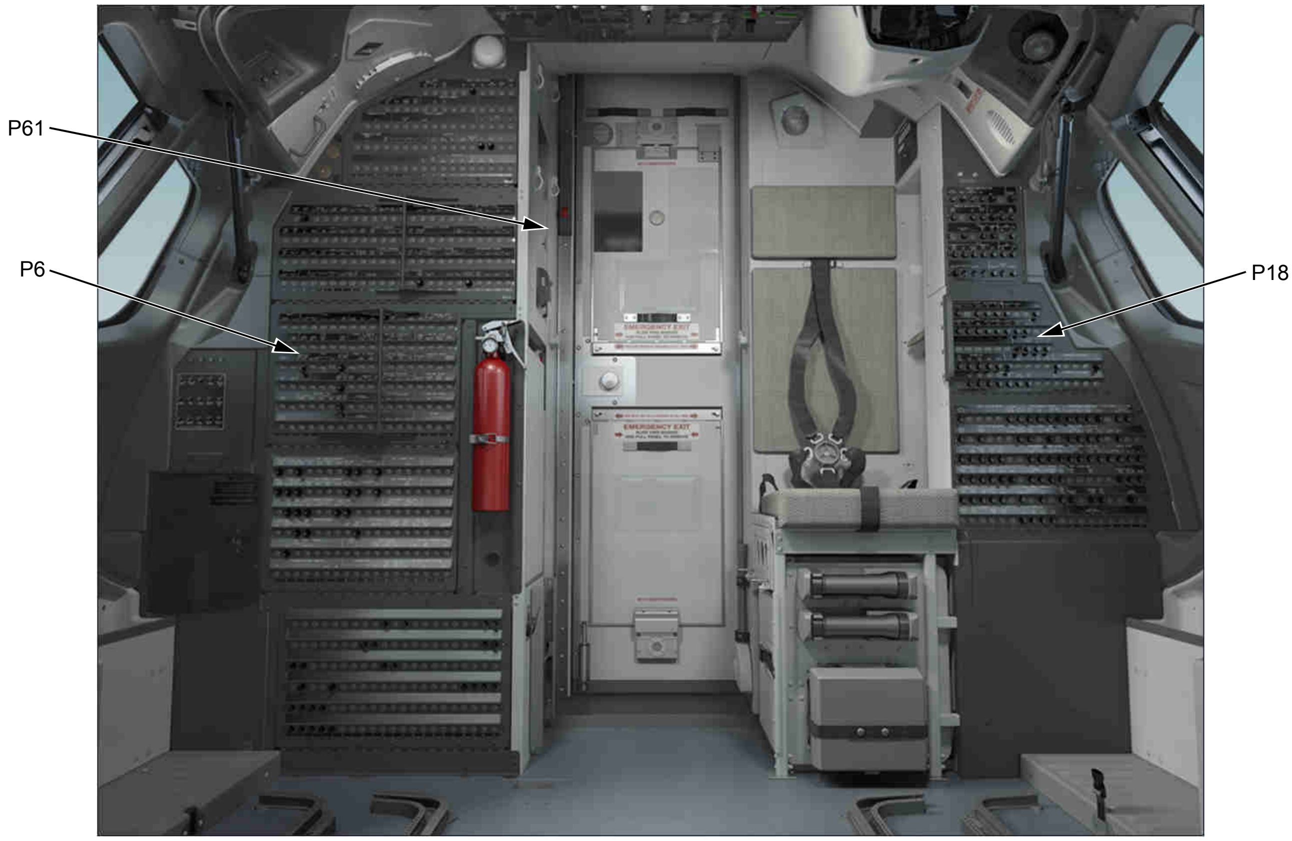
Flight Compartment



Flight Compartment Components

Necessary equipment in the flight compartment includes:

- Emergency equipment
- Flight kit stowage
- Oxygen masks
- Clipboards
- Conditioned air vents.



Other Flight Compartment Components

The main circuit breaker panels are behind the first officer and captain. The P6 and P18 have the component load circuit breakers. Circuit breakers are organized by airplane systems.

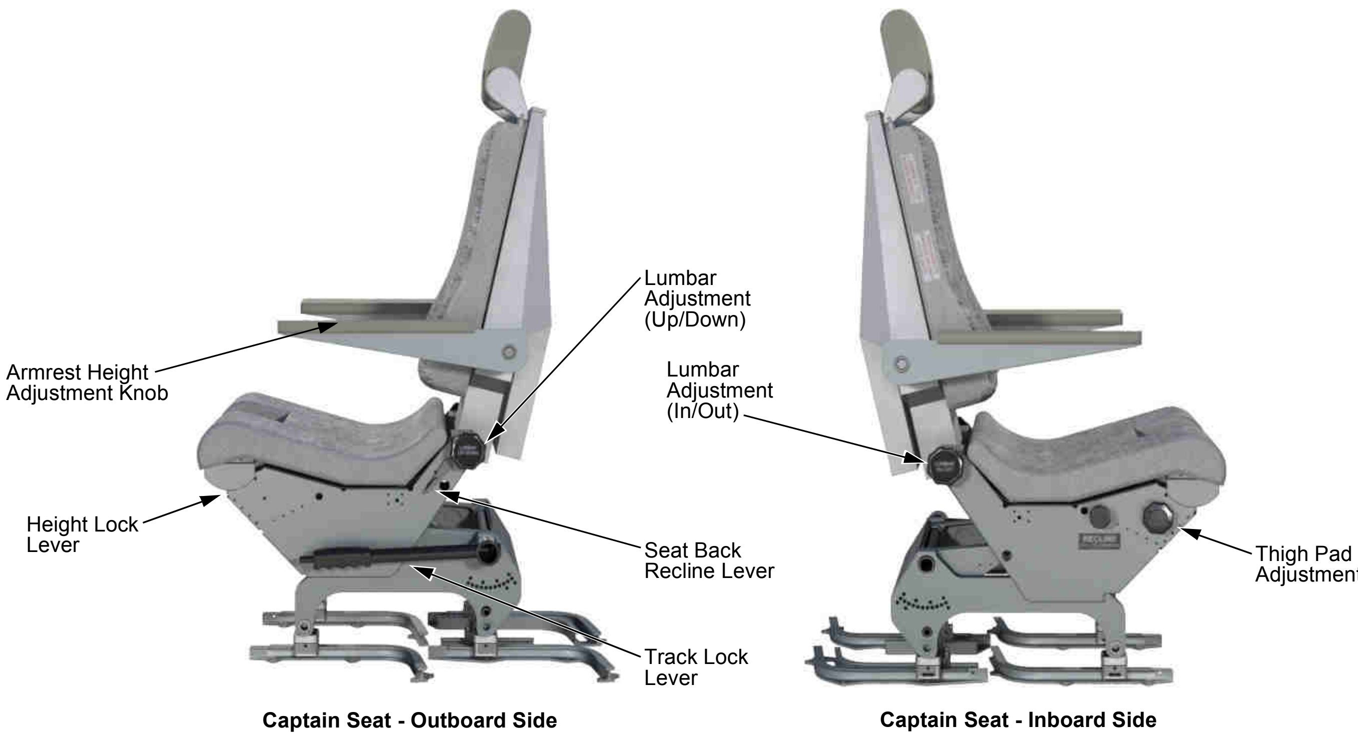
Emergency equipment is placed within easy reach of the crew. Emergency equipment includes these items:

- A fire extinguisher on the P6 panel
- A crash axe on the P18 panel
- Escape lanyards above the sliding windows.

The Maintenance/BITE Panel and data loader control panel is on the P61 panel.

The bulkhead and sidewalls have provisions for stowing crew luggage, flight manuals, coats, and hats.

Flight Compartment



Crew Seats

Captain and first officer seats have many adjustments for the flight crew.

The seat base has controls for seat fore/aft position.

The upper seat has controls for these adjustments:

- Seat height
- Thigh pad position
- Seat recline
- Armrest height and stowage
- Lumbar support
- Headrest position.

Features

INTEGRATED FUNCTIONS

The MAX display system (MDS) shows flight and engine data to the flight crew. The data that the MDS shows includes:

- Air data
- Inertial reference data
- Navigation data
- Flight mode annunciations
- Engine parameters
- Hydraulic system data
- Flight control surface positions (option)
- Brake temperature (option)
- Tire pressure (option)
- Flight deck entry video (option).

RELIABILITY

The system configuration gives protection for safe operation. The software configuration gives a high level of function and precision. The software functions are isolated to increase safety.

REDUNDANCY

There are two display processor computers (DPCs). One DPC can give display data to all four of the display units.

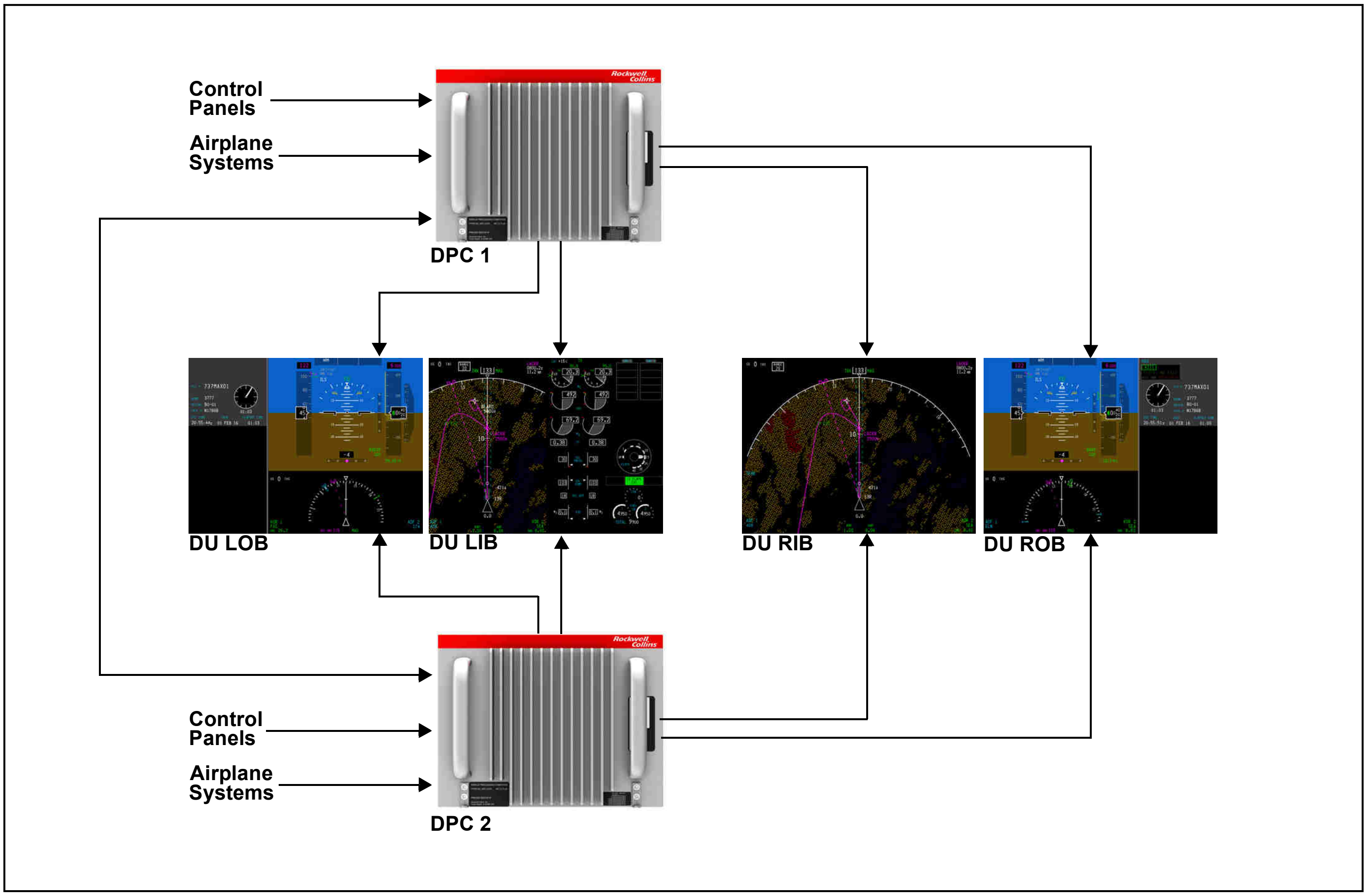
DISPLAY MANAGEMENT

The multi-function panel and the lighting control modules let the crew manually manage the displays on the MDS. Some displays move automatically when there is a display unit failure.

BITE

Fault data shows on the MDS maintenance pages.

MAX Display System



MAX Display System

The MAX display system (MDS) shows data on four liquid crystal displays (LCD). These display units (DUs) show primary flight, navigation and engine data to the crew.

The MDS has these components:

- Display processing computer (2)
- Display unit (4)
- EFIS control panel (2)
- Multi-function panel
- Lighting control module (2)
- Instrument switching module.

The MDS normally shows the primary flight data on the outboard DUs. The primary flight data can show on the inboard DUs if necessary.

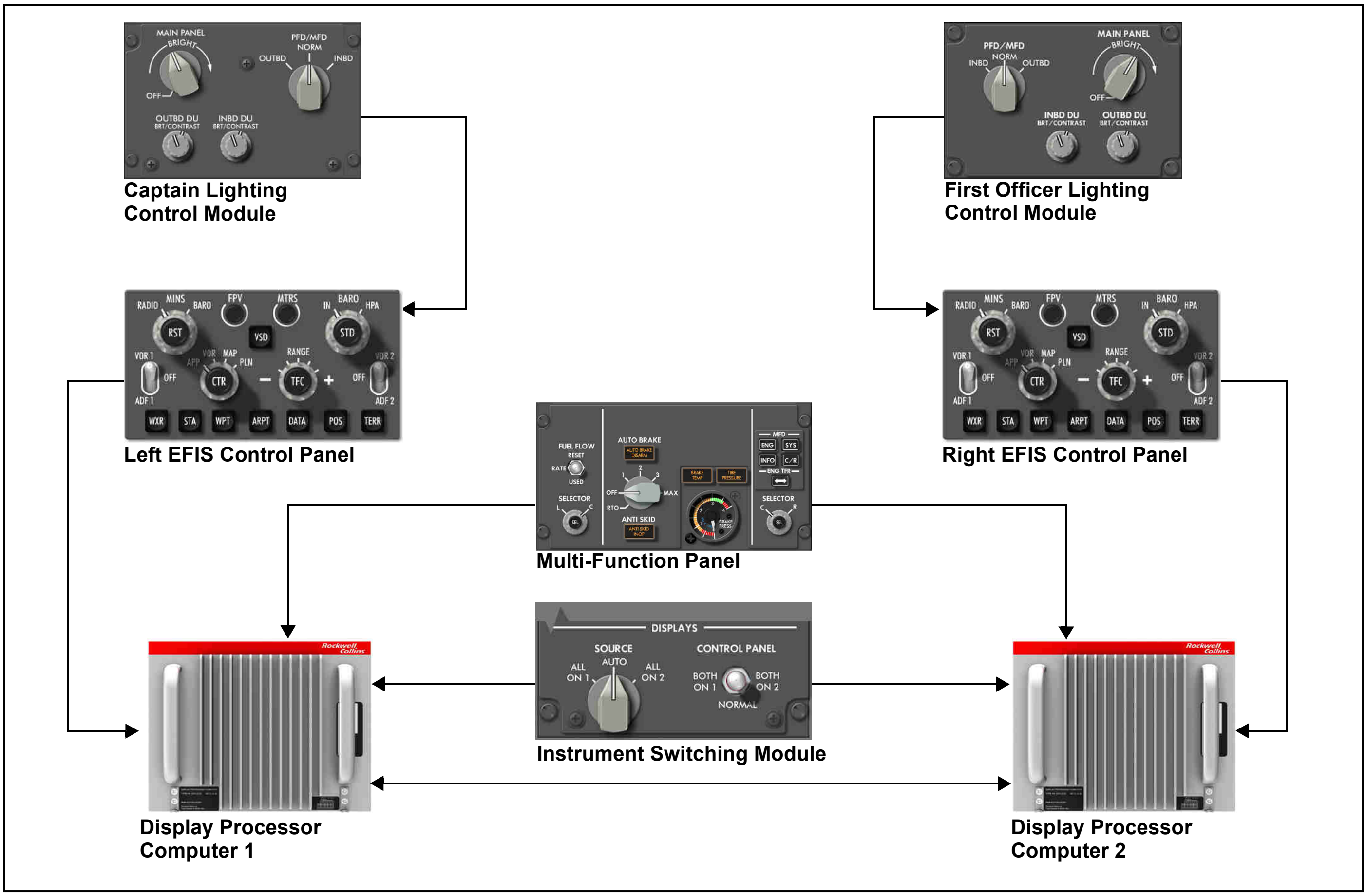
The MDS normally shows the navigation data on the inboard DUs. The navigation data can show on the outboard DUs if necessary.

The MDS normally shows the engine indication (EI) display on one of the two inboard DUs. The EI display can show on one of the outboard DUs if necessary.

The display processing computers (DPCs) receive inputs from the avionics and airframe systems.

Each DPC uses data from the airplane systems to make the MDS displays. Each DPC then sends the display data to all four DUs.

If there is a failure of one DPC, the other DPC can make all the displays for the four DUs.



Control Panels

The control panels let the pilots set the type of data and the location for the displays.

These are the control panels:

- EFIS control panels
- Multi-function panel
- Lighting control modules
- Instrument switching module.

The EFIS control panels control the primary flight data and the navigation data. They let the pilots control this display data:

- Radio and barometric minimum altitude
- Barometric reference
- Metric altitude display
- Weather radar
- TCAS traffic display
- Navigation display modes
- Navigation display information
- VOR/ADF display.

The multi-function panel (MFP) lets the crew change the multi-function display (MFD) and the fuel flow display data. The MFP also lets the crew move the engine indication (EI) display and control the display cursor.

The lighting control modules let the crew manually move displays from one display unit to a different display unit. The lighting control modules also let the crew adjust the brightness for the display units.

The two DISPLAYS switches on the instrument switching module let the crew change the operation of the MAX display system. The SOURCE switch can set one display processing computer as the source for all four displays. The CONTROL PANEL switch can give control of the left side and right side displays to one EFIS control panel.

MAX Display System

LEFT OUTBOARD
PRIMARY FLIGHT DISPLAY/MINIMAP-NORMAL

RIGHT OUTBOARD
PRIMARY FLIGHT DISPLAY/MINIMAP-NORMAL

Primary Flight Display

FEATURES

The two outboard display units normally show the primary flight display/mini-map display (PFD/MM) and the auxiliary outboard (AOB) display. In this normal condition, the PFD shows on the inboard part of the display and above a mini map display. The AOB shows on the outboard part of the display.

This data shows on the PFD:

- Airspeed
- Attitude
- Barometric altitude
- Vertical speed
- Radio altitude
- Flight mode annunciations
- Lateral and vertical deviations.

This data shows on the mini map:

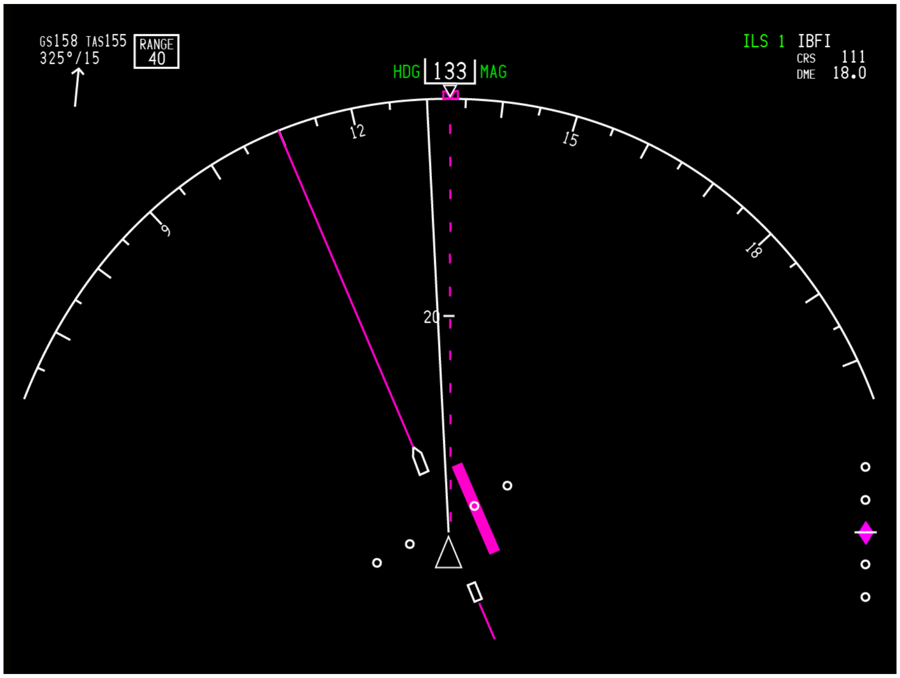
- Heading
- Selected heading
- Active flight plan
- Groundspeed
- True airspeed.

When the navigation display does not show on the same side of the flight deck, this information can also show on the mini map:

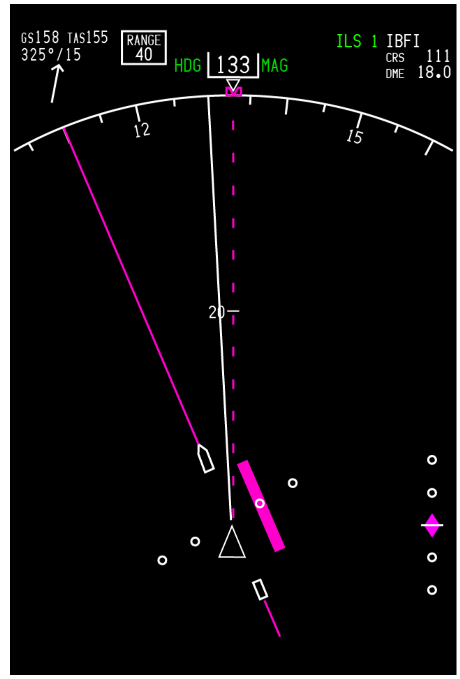
- Automatic direction finder (ADF)
- VHF omnidirectional ranging (VOR)
- Traffic alert and collision avoidance system (TCAS)
- Weather radar (WXR)
- Terrain awareness.

This data shows on the AOB:

- Flight number
- Transponder code
- SELCAL code
- Tail number
- Universal time coordinated (UTC) time
- UTC date
- Elapsed time
- Chronograph.



Full-Screen APP Display



Half-Screen APP Display

Approach Display

The Approach (APP) mode display can show in a full-screen or half-screen format. The APP display can also show in an expanded view and a center view

The expanded full screen mode shows 140 degrees of the compass rose. The expanded half screen mode shows 60 degrees of the compass rose. The airplane symbol, localizer deviation scale, and bar are at the bottom with the glideslope deviation scale and pointer on the right side of the displays.

The center full screen and center half screen modes show 360 degrees of the compass rose. The airplane symbol, localizer deviation scale and bar are in the center with the glideslope deviation scale and pointer on the right side of the displays.

This ILS information shows on the display:

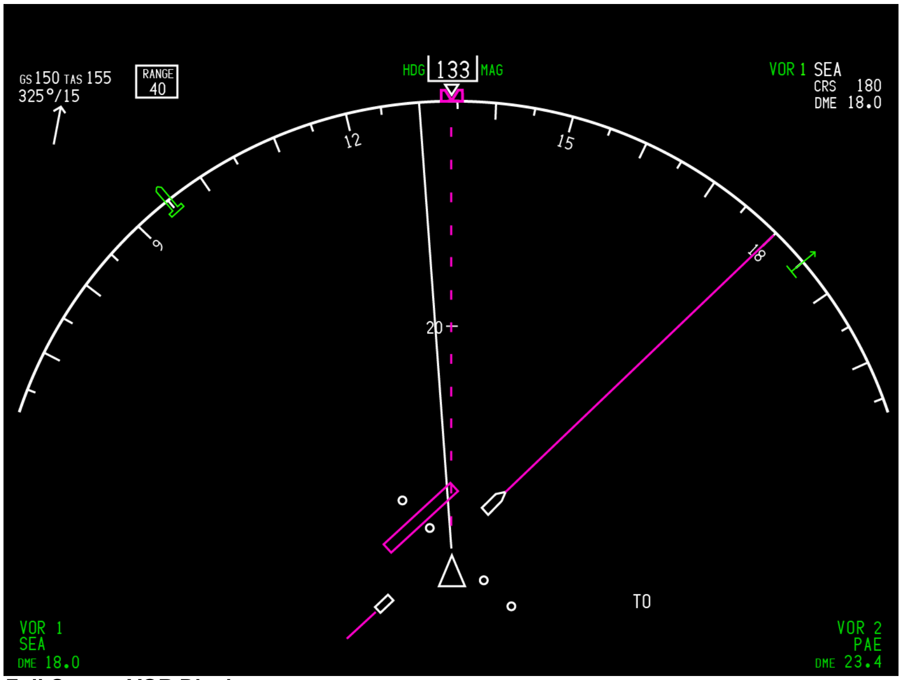
- Localizer deviation
- Glide slope deviation
- System source annunciation
- Station identifier or frequency
- Selected runway heading
- DME distance.

This additional information shows:

- Ground speed
- True airspeed
- Wind speed and direction
- Range setting

.

MAX Display System



Full-Screen VOR Display

Half-Screen VOR Display

VOR Display

The very high frequency (VHF) omnidirectional ranging (VOR) mode can show in a full-screen or half-screen format. The VOR display can also show in an expanded view and a center view.

The expanded VOR mode shows 140 degrees of the compass rose. The airplane symbol with the VOR deviation scale and deviation bar show at the bottom.

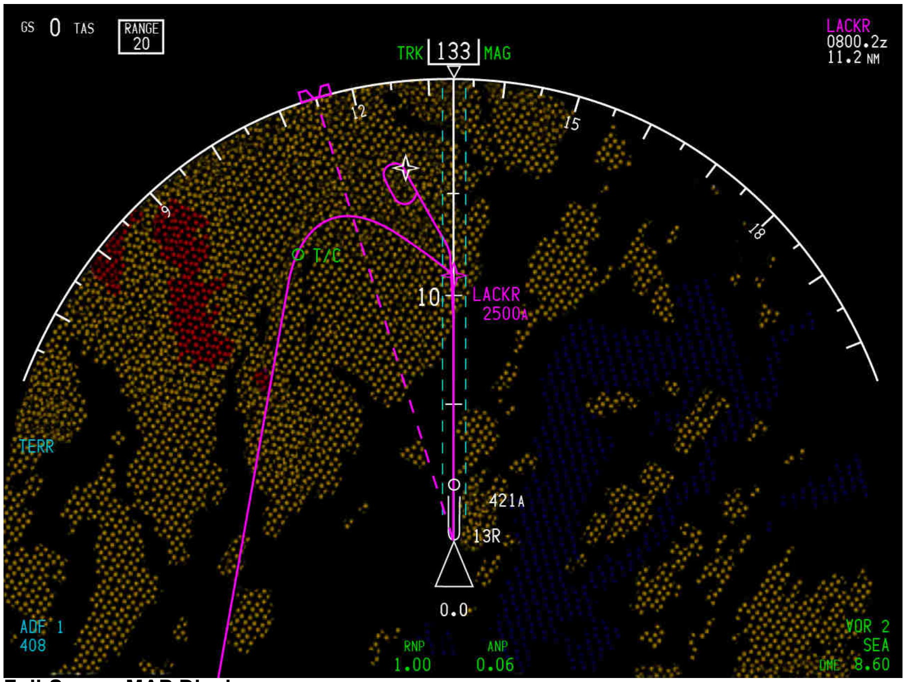
The center VOR mode shows 360 degrees of the compass rose. The airplane symbol with the VOR deviation scale and deviation bar show in the center.

This VOR data shows on the VOR display:

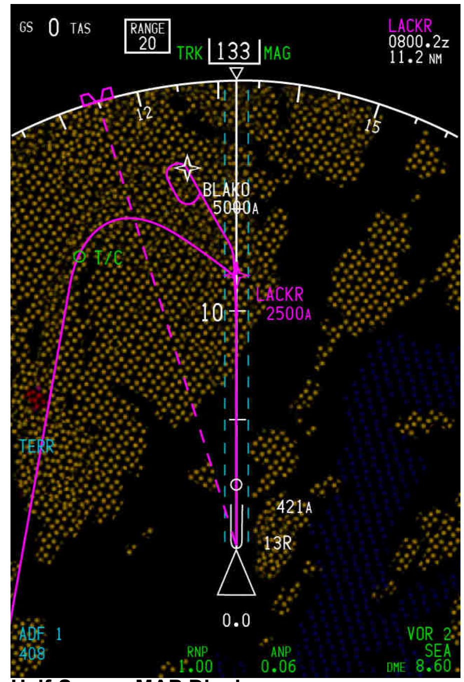
- VOR deviation scale and deviation bar
- To/from annunciation
- System source annunciation
- Station identifier or frequency
- Station bearing
- Selected course
- Distance measuring equipment (DME) distance to the VOR station.

This additional data shows on the VOR display:

- Ground speed
- True airspeed
- Wind speed and direction
- Range setting (expanded view only).



Full-Screen MAP Display



Half-Screen MAP Display

MAP Mode

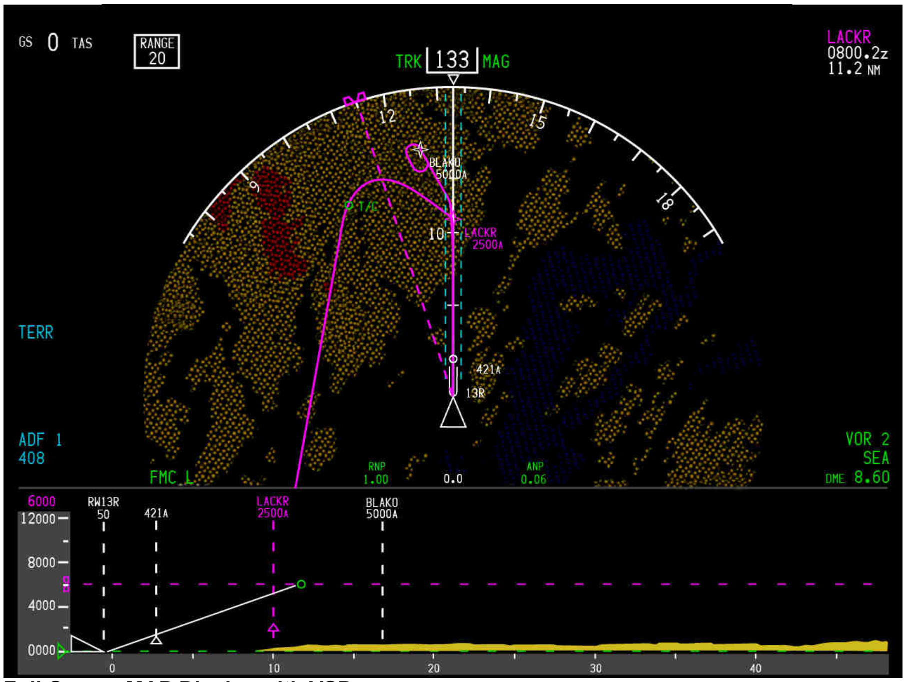
The map mode can show in a full-screen or half-screen format. The full-screen map mode can only show on an inboard display unit. The half-screen map mode can show on the inboard side of the outboard display unit or the outboard side of the inboard display unit.

The map mode can show in a center view or an expanded view. The map mode can show with the vertical situaltion display (VSD) or without the VSD.

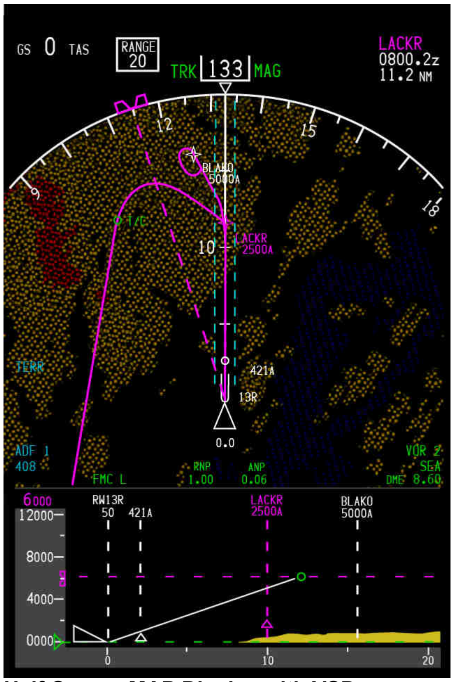
This data can show in the map mode:

- Airplane track
- Airplane heading
- Flight plan data
- Active waypoint data
- Navigation aids
- Waypoints
- Airports
- Vertical path deviation
- Trend vectors
- Groundspeed
- True airspeed
- Wind data
- Automatic direction finder (ADF)
- VHF omnidirectional ranging (VOR)
- Traffic alert and collision avoidance (TCAS)
- Weather radar (WXR)
- Terrain awareness.

MAX Display System



Full-Screen MAP Display with VSD



Half-Screen MAP Display with VSD

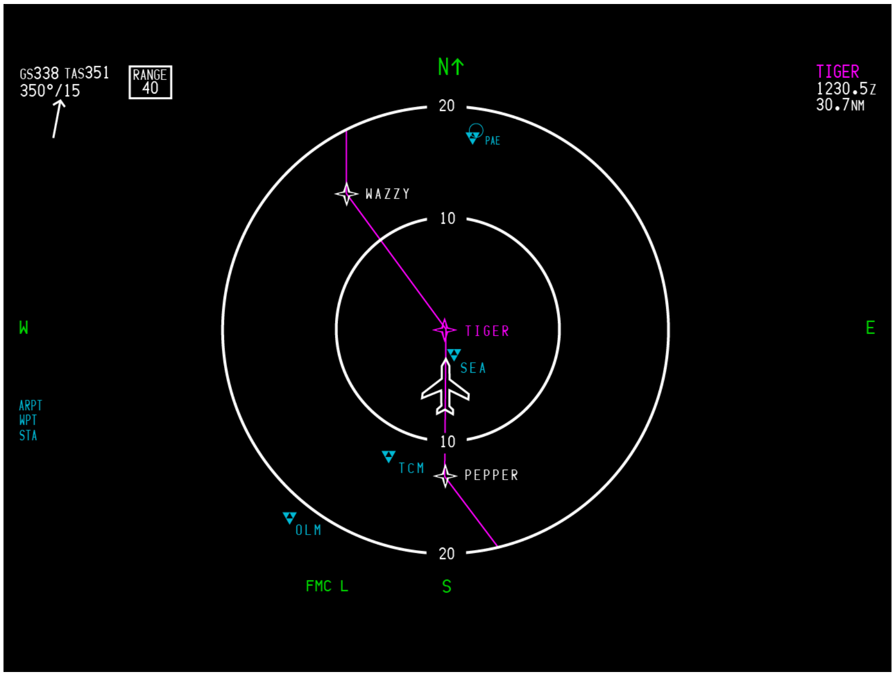
Map Display with VSD option

The vertical situation display (VSD) shows a side view of the airplane and the ground below the current airplane track. The VSD is provided to enhance the flight crew's situational awareness. It is not intended to be a control display.

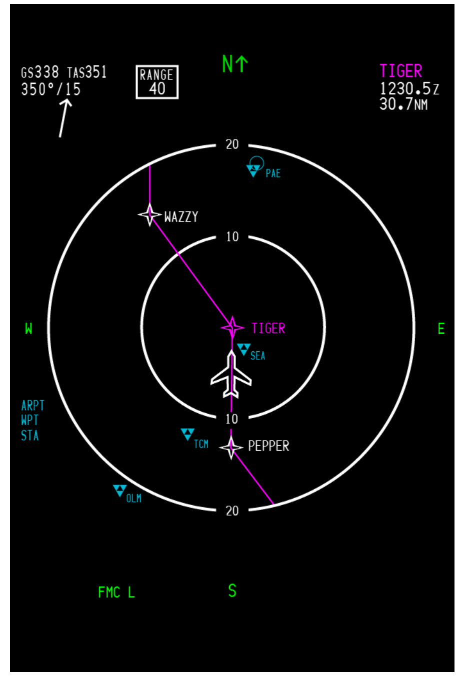
The lower 35% of the MAP display is used for the VSD and the upper display area shows the expanded or center MAP display. VSD is selected by first selecting MAP as the display mode and then pushing the VSD pushbutton on the EFIS control panel.

This data can be displayed on the VSD:

- Airplane altitude
- Vertical flight path vector
- Selected vertical speed
- Selected altitude
- Waypoints
- Waypoint altitude constraints
- Destination runway
- VNAV final descent angle
- Terrain data.



Full-Screen PLN Display

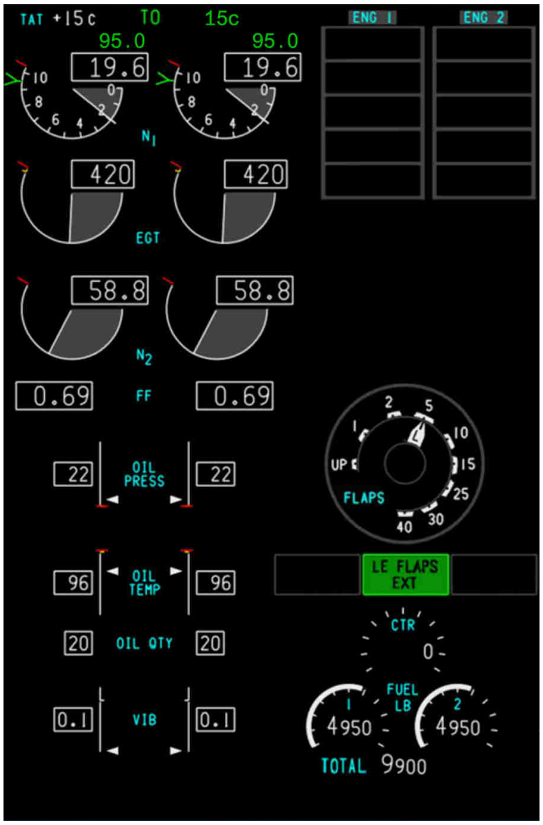


Half-Screen PLN Display

Plan Mode

The flight crew uses the plan mode to create, view or change a flight plan. The display is a north up display. The airplane symbol shows present position and FMC track.

MAX Display System



Engine Indication Display

The engine indication (EI) display normally shows on the left or right inboard display unit. The EI display can show on an outboard display unit if the inboard display unit on that side has a failure.

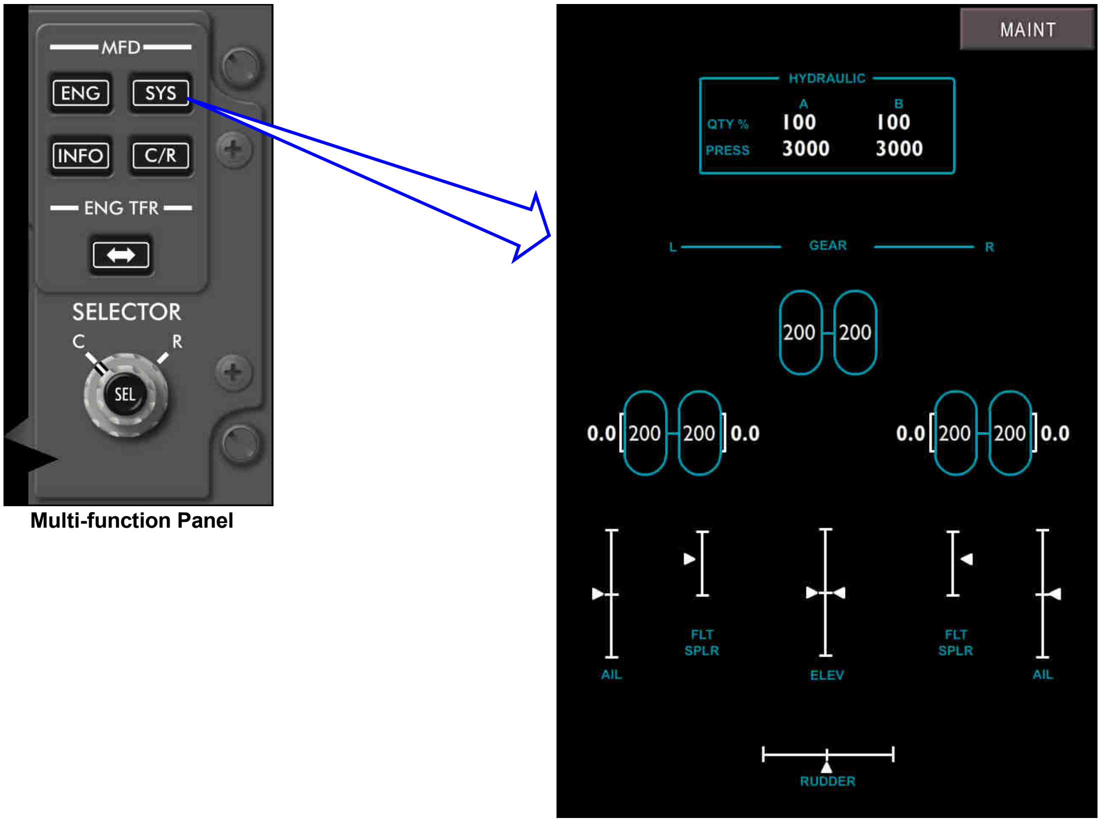
This data shows on the EI display:

- N1
- Exhaust gas temperature
- N2
- Fuel flow
- Oil pressure
- Oil temperature
- Oil quantity
- Engine vibration
- Crew alert messages
- Flaps data
- Fuel quantity
- Total air temperature
- Thrust mode annunciation
- Selected air temperature.

The EI display can also show in a decluttered format. You use the ENG push-button on the multi-function panel (MFP) to change between the normal EI display and the decluttered IE display. When the decluttered EI display shows, these indications do not show:

- N2
- Fuel flow (can show full time)
- Oil pressure
- Oil temperature
- Oil quantity
- Engine vibration

BOEING PROPRIETARY



Multi-function Panel

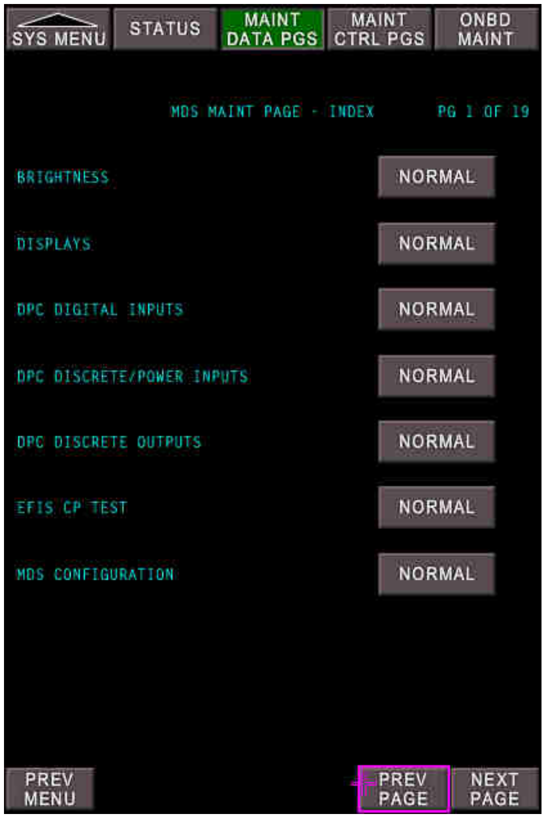
Systems Display

The systems display shows when you push the MFD - SYS (multifunction display - system) pushbutton on the multifunction panel. The systems display can show on an inboard or outboard display unit.

This data shows on the systems display:

- Hydraulic quantity
- Hydraulic pressure
- Brake temperature
- Tire pressure
- Flight control surface positions.

MAX Display System

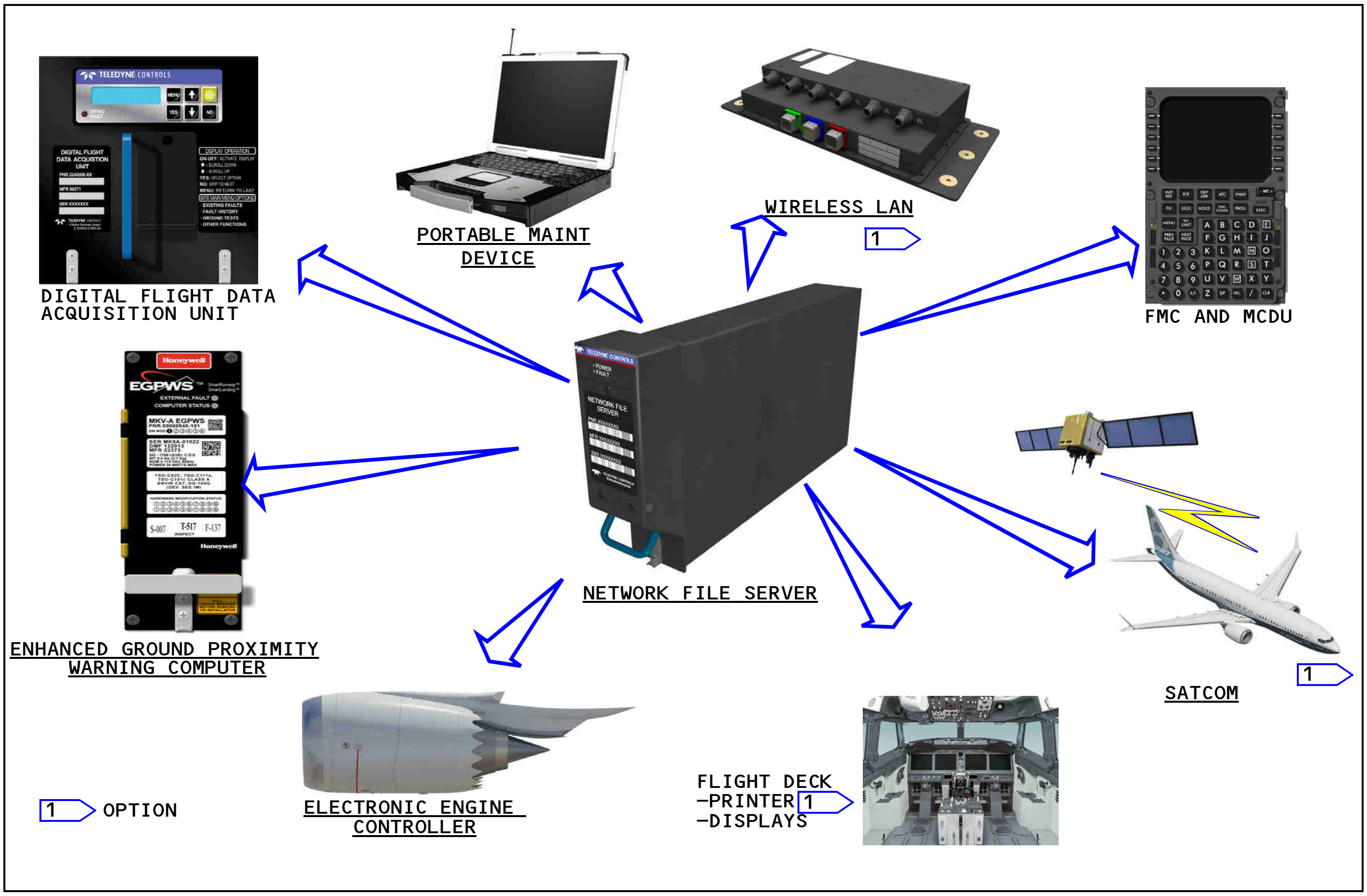


MDS MAINT PAGE - INDEX

MDS Maintenance Pages

Maintenance data shows on the MDS maintenance pages. The maintenance data includes:

- BRIGHTNESS
- DISPLAYS
- DPC DIGITAL INPUTS
- DPC DISCRETE/POWER INPUTS
- DPC DISCRETE OUTPUTS
- EFIS CP TEST
- MDS CONFIGURATION.



Onboard Network System

GENERAL

The onboard network system (ONS) is an airplane based server that provides:

- Data collection/storage/analysis
- Data loading
- Off-board connectivity
- e-Enabling capability
- Fault reporting
- Engine health management
- Engine vibration analysis/ balance.

Depending on airplane configuration, optional connected interfaces and software applications are available. The ONS can support these typical applications:

- Electronic logbooks
- MyBoeingFleet (MBF)
- Airplane health management system (AHMS)
- File transfer system (FTS).

COMPONENTS

The primary components of the ONS are:

- Network file server (NFS)
- P61 Maintenance/BITE panel
- Dataload select panel.

Optional equipment or connections for the system can include:

- Airplane wireless LAN unit
- Crew wireless LAN unit
- SATCOM
- Printer.

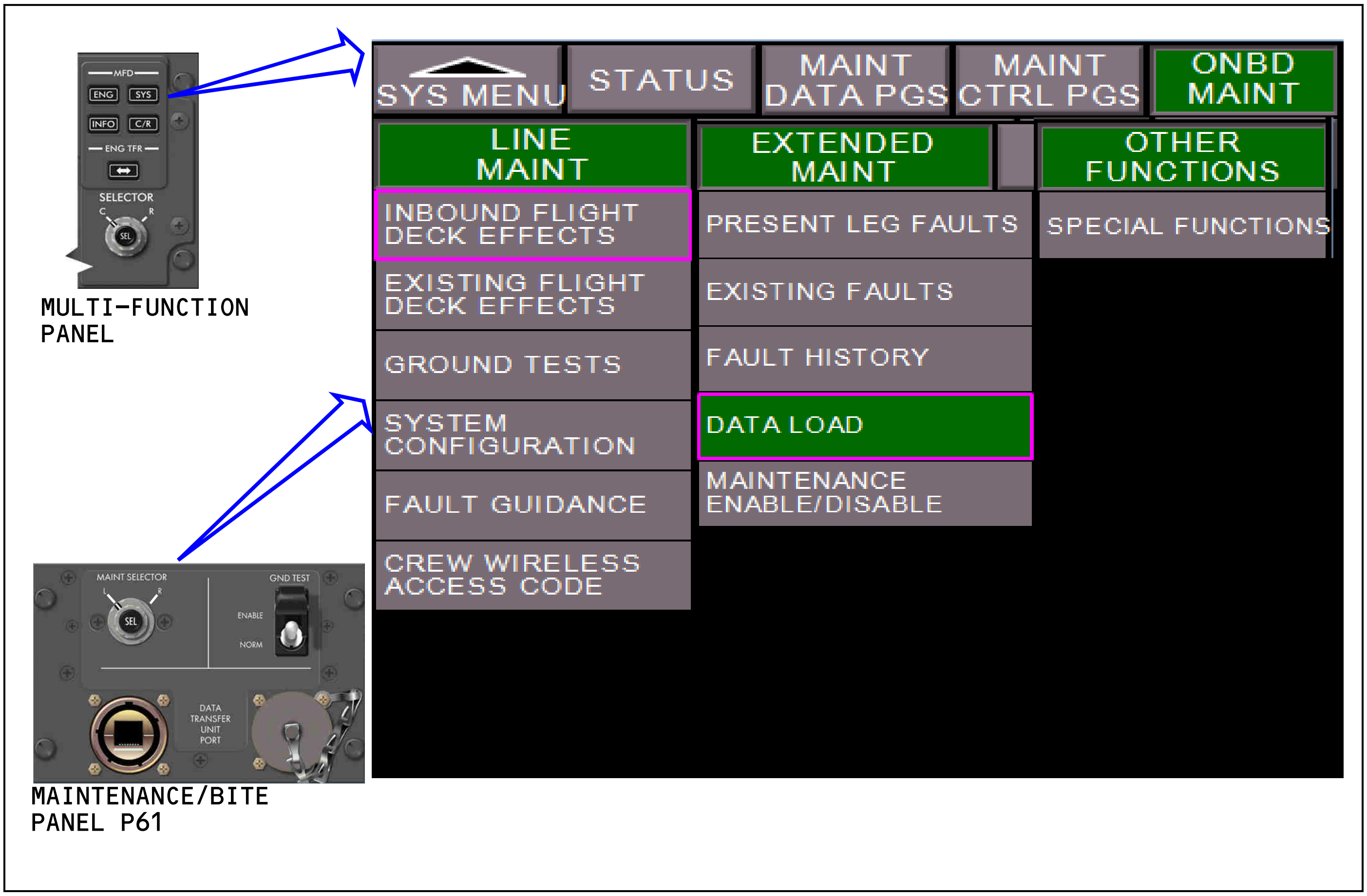
The airplane wireless LAN unit (AWLU) will allow for on ground connection between the airplane and ground stations. This system uses cellular or wireless connectivity.

The crew wireless LAN unit (CWLU) allows wireless communication between the system and portable equipment. For example, a pilots tablet can connect to the ONS for electronic flight bag software updates. Also the portable maintenance device can connect via wireless network for maintenance work.

The SATCOM system connection allows for in flight communication with ground stations.

The printer is used to print reports generated by the ONS.

MAX Display System



Onboard Maintenance Function

MAX DISPLAY SYSTEM

The MAX display system has a multi-function display select panel (P9) that allows access to the onboard maintenance function (OMF) menus using the display units.

Use the multi-function display select panel, select the system (SYS) function on the display. The maintenance personnel will use the tabber device on the Maintenance/ BITE panel (P61) to control the cursor and select the onboard maintenance (ONBD MAINT) function.

ONBOARD MAINTENANCE FUNCTION

The three primary menus are:

- Line Maintenance
- Extended Maintenance
- Other Functions.

LINE MAINTENANCE

The line maintenance menu has these sub menus available:

- Inbound flight deck effects
- Existing flight deck effects
- Ground tests
- System configuration
- Fault guidance
- Crew wireless access code.

EXTENDED MAINTENANCE

The three primary menus are:

- Present leg faults
- Existing faults
- Fault history
- Data load
- Maintenance enable/disable.

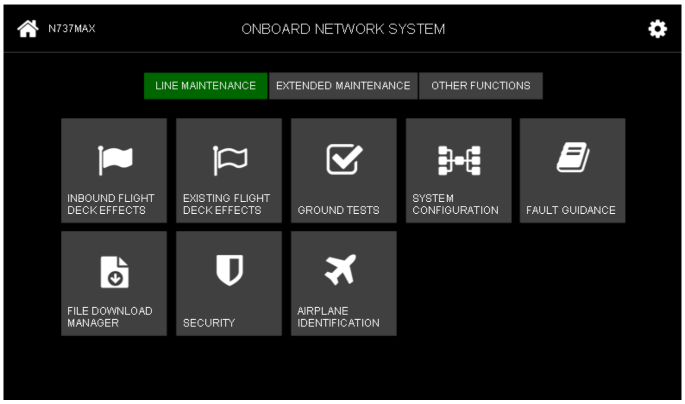
OTHER FUNCTIONS

The other functions menu only has one sub menu titled Special Functions.

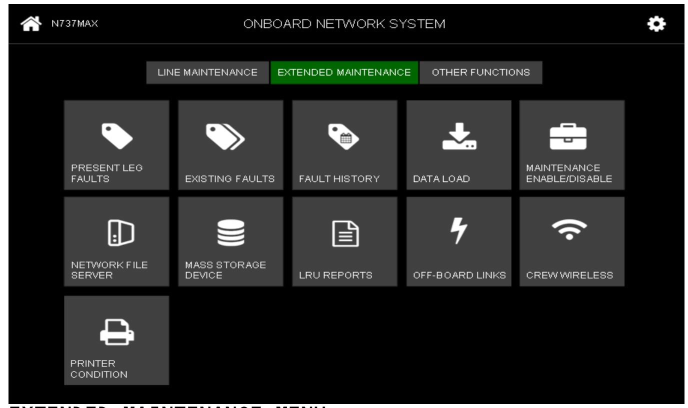
PORTABLE MAINTENANCE DEVICE

A portable maintenance device (PMD) such as a laptop can be connected to the airplane and allows access to the onboard maintenance function (OMF) menus. The PMD has the display OMF menus and additional applications available for in-depth maintenance actions.

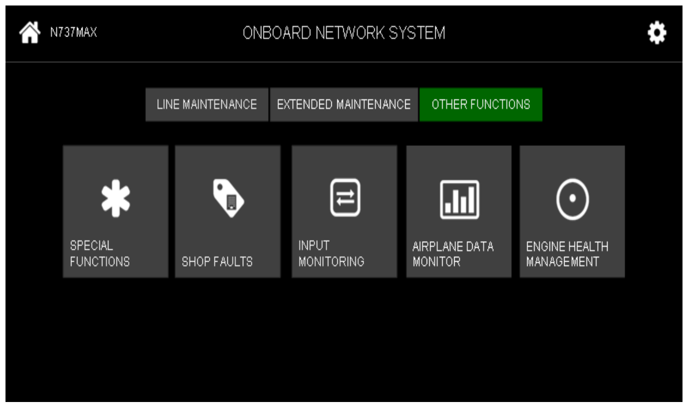
BOEING PROPRIETARY



LINE MAINTENANCE MENU



EXTENDED MAINTENANCE MENU



OTHER FUNCTIONS MENU

Portable Maintenance Device

EQUIPMENT

The portable maintenance device (PMD) can be a laptop, tablet, or similar device that has sufficient hardware, proper software installed and correct security certificates.

The PMD has a menu driven screen with the same selections as the MAX display system OMF menus plus additional applications to allow for control, monitoring and testing.

PMD MAINTENANCE MENU

The three primary menus are:

- Line Maintenance
- Extended Maintenance
- Other Functions.

LINE MAINTENANCE

The line maintenance menu has these sub menus available:

- Inbound flight deck effects
- Existing flight deck effects
- Ground tests
- System configuration
- Fault guidance
- Download manager
- Security
- Airplane ID.

EXTENDED MAINTENANCE

The three primary menus are:

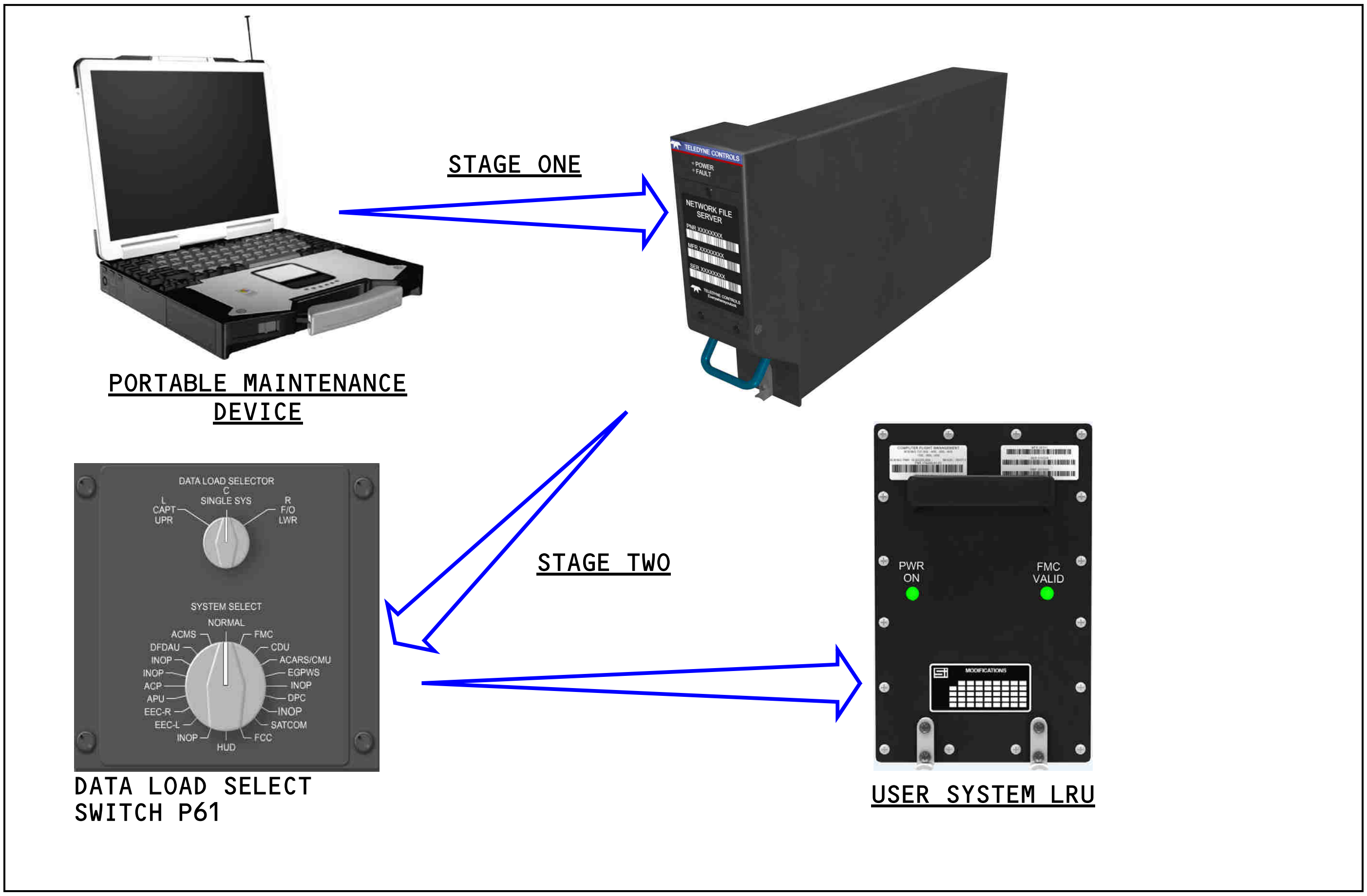
- Present leg faults
- Existing faults
- Fault history
- Data load
- Maintenance enable/disable
- Network file server
- Mass storage device
- LRU reports
- Off board links
- Crew wireless
- Printer condition.

OTHER FUNCTIONS

The other functions menu only has these sub menus available:

- Special functions
- Shop faults
- Input monitoring
- Airplane data monitoring
- Engine health management.

MAX Display System



Loadable Software Airplane Parts (LSAP)

LOADING SOFTWARE

To load the LSAPs into the airplane requires two steps or stages. Stage one loads data from the portable maintenance device (PMD) to the network file server (NFS). Stage two loads data from the NFS to the user line replaceable unit (LRU).

STAGE ONE

Use the portable maintenance device (PMD) to upload the data to a mass storage device where the information will reside on the airplane until required.

There are three choices available for the mass storage device depending on airplane configuration.

- Network file server
- Cabin services system
- Aircraft information management system (AIMS).

The NFS is the main storage point on the airplane for all current software. This would include one time uploaded files such as operational software used on a LRU. LSAPs that are changed under specific time frames would also be stored here such as:

- FMC 28 day NAV data base
- EGPWS 60 day updates.

STAGE TWO

Moving the LSAP from the mass storage device to the LRU. The information is transferred either by ARINC 429 or Ethernet (ARINC 615A) data bus.

For ARINC 429 data, the data load select switch on P61 is used to select the receiving LRU. The MAX display system or portable maintenance device is used to control the transfer of the LSAP.

Ethernet (ARINC 615A) is directly connected from the NFS to the LRU. The dataload select switch can be used to send a discrete to the LRU to enable software loading.

- Features
- Flight Interphone System
- Service Interphone
- Flight and Ground Crew Call System
- Passenger Address System
- Emergency Locator Transmitter
- VHF Communication System
- HF Communication System
- SELCAL (Optional)
- ACARS (Optional)
- Voice Recorder System
- Flight Data Recorder System
- Aural Warning System
- Digital Clocks
- Satellite Communication (SATCOM) System (Optional)
- FDEVSS

Features

DIGITAL AUDIO CONTROL

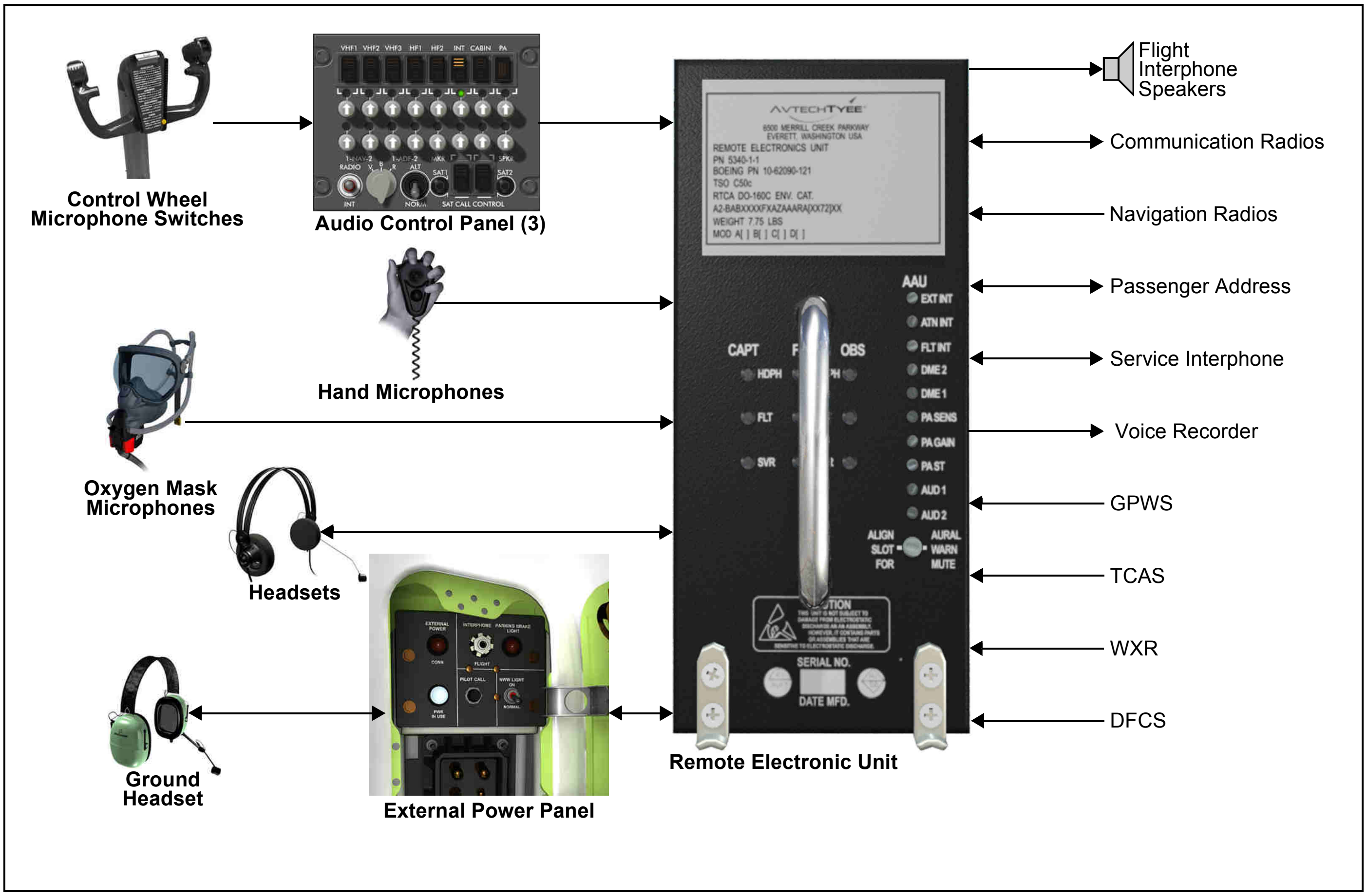
The flight Interphone is a system that processes all audio information to, from, and in the airplane.

HF COMMUNICATIONS (OPTIONAL)

AIRCRAFT COMMUNICATIONS ADDRESSING AND REPORTING SYSTEM (ACARS) (OPTIONAL)

ACARS is a digital data link that supplies communication between the airplane and ground operations with the VHF, HF or SATCOM systems.

Communications and Recording



Flight Interphone System

The flight interphone system lets the crew members in the flight compartment communicate with each other. It also connects with the audio communication system and the ground crew.

There are three independent systems, one for each flight crew station and the observer station. The captain system is shown on the graphic.

The flight crew selects a system on the audio control panel (ACP) to transmit or receive audio. These are the systems that the pilot can select:

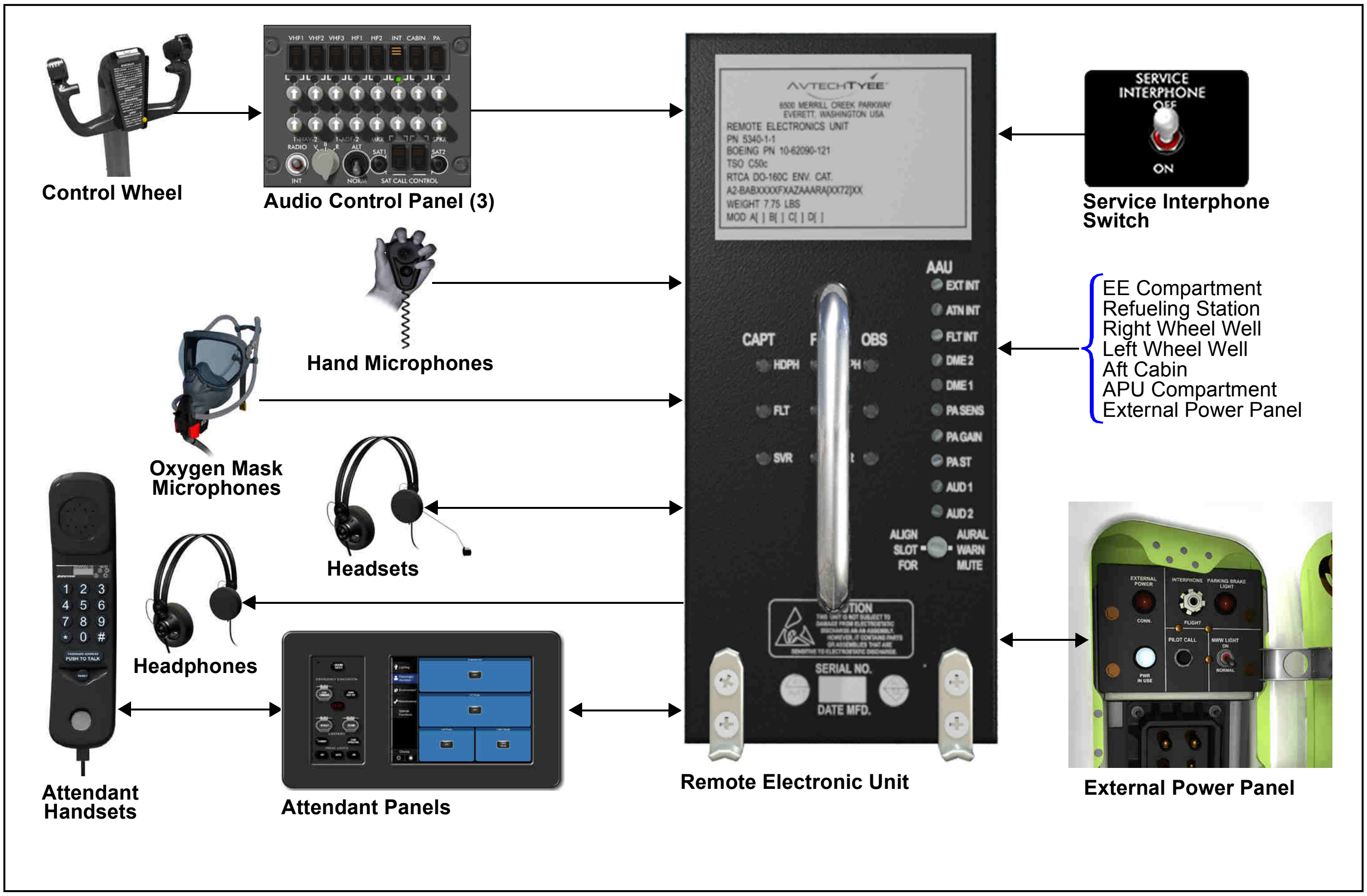
- Communication radios
- Navigation receivers
- Cabin interphone
- Passenger address
- Flight and service interphone.

When the pilot selects a system on the ACP, the remote electronics unit (REU) sends audio from the hand microphones, boom microphones or oxygen mask microphones to that system. The REU also sends the audio from the system to the headsets and speakers.

The REU also integrates and sends warning audio to the headsets and speakers. The warning audio comes from these systems:

- Ground proximity warning system
- Traffic alert and collision avoidance system
- Weather radar system
- Digital flight control system.

The interphone/radio push-to-talk (PTT) switches are on the control wheels for use with the oxygen mask or boom microphones. The RADIO - INT switch on the audio control panel does a similar function.



Service Interphone

The service interphone system is for communication between these personnel:

- Flight crew
- Cabin attendants
- Maintenance personnel.

They are in different areas around the airplane.

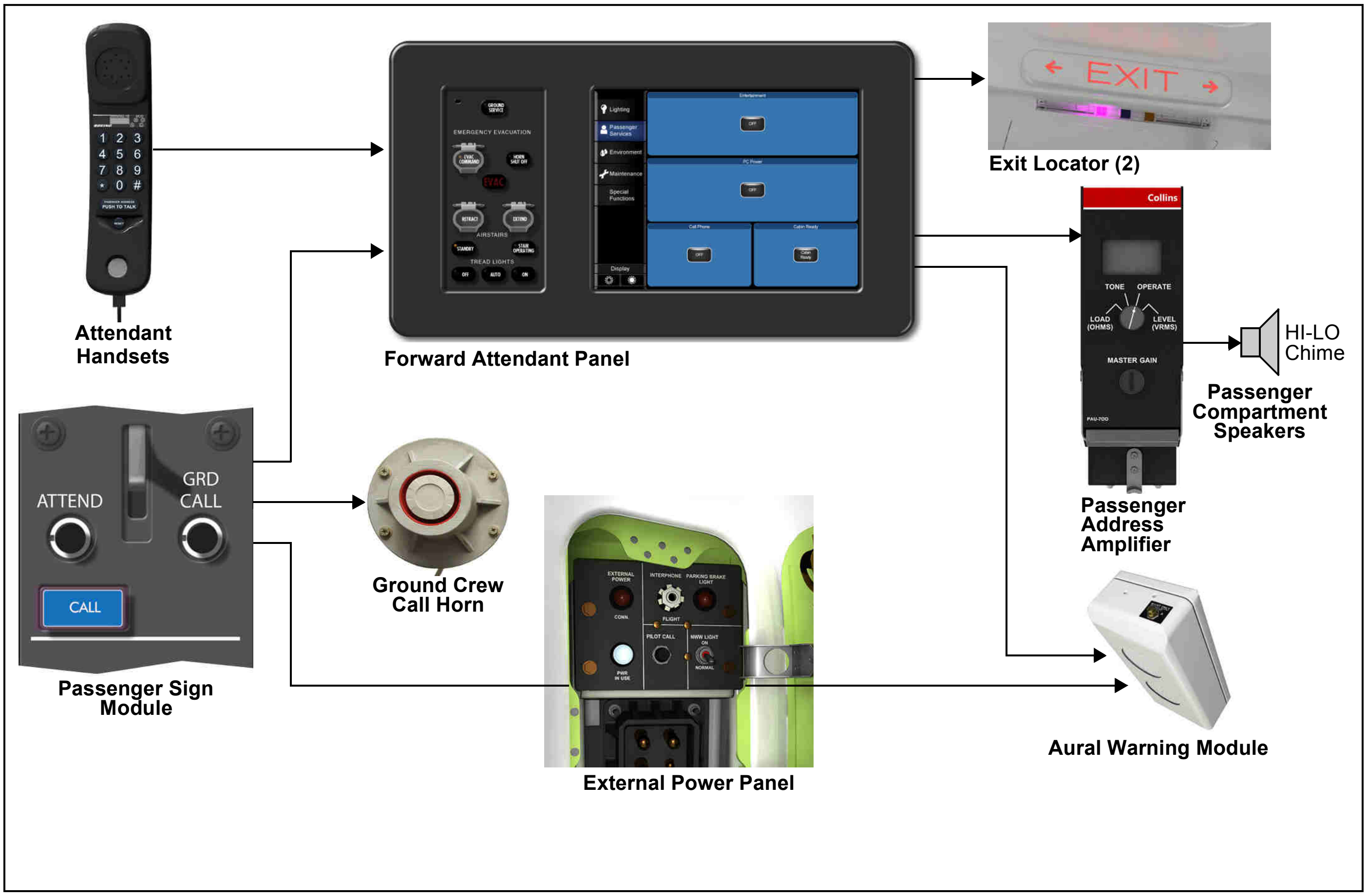
Attendants use handsets at each attendant station to communicate on the service interphone system. The flight crew selects service interphone on the audio control panel.

The handsets send audio to the remote electronics unit (REU). The REU amplifies the audio and sends it back to the handsets.

A toggle switch in the flight compartment connects the external service interphone headset jacks to the service interphone. Service interphone headset jacks are in these areas:

- EE compartment
- Refueling station
- Main wheel well
- Aft cabin ceiling
- APU compartment
- External power panel.

Communications and Recording



Flight and Ground Crew Call System

The flight and ground crew call system permits call signals between these areas:

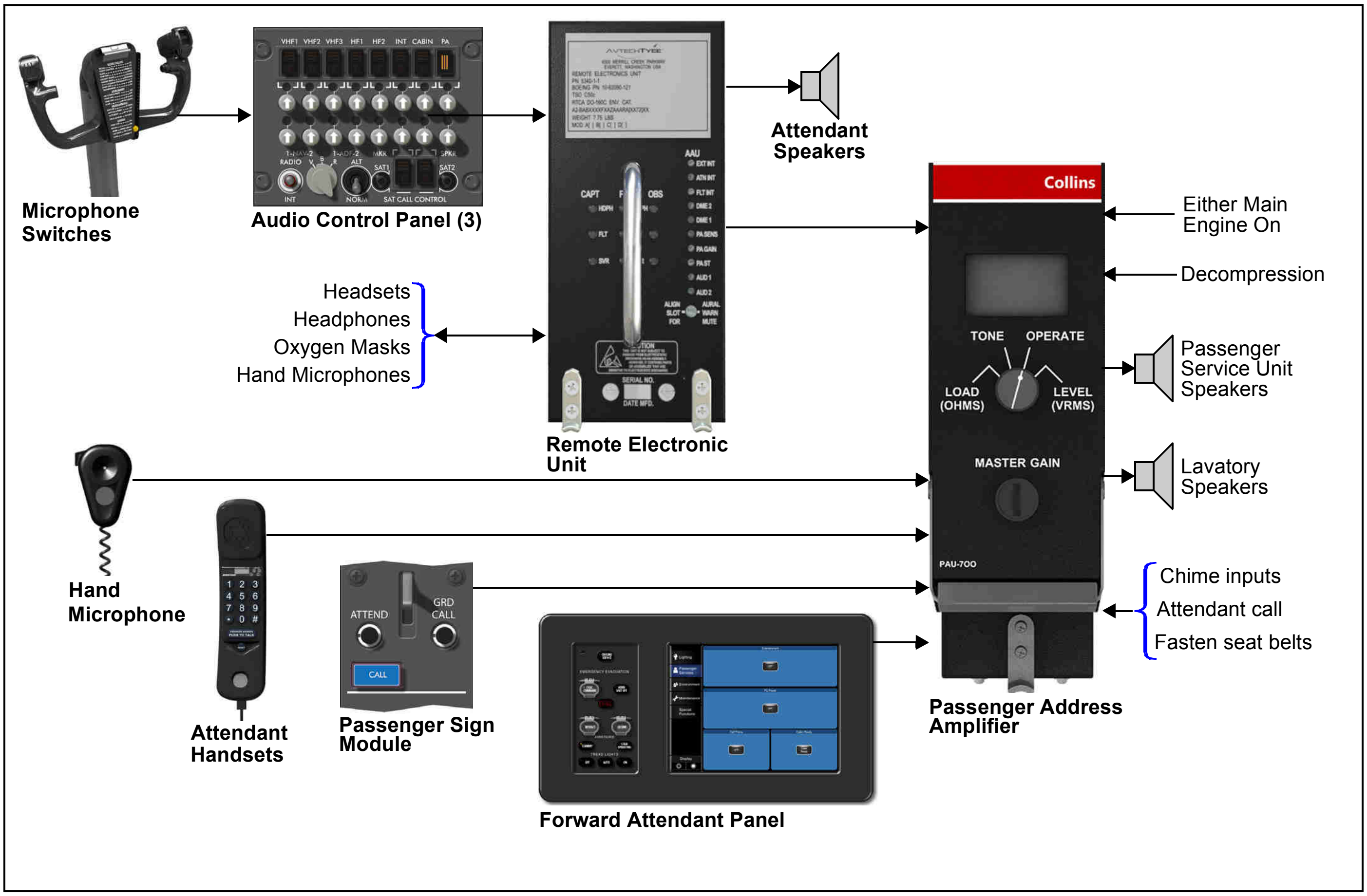
- Flight compartment and cabin attendant stations
- One cabin attendant station to another cabin attendant station
- Flight compartment and ground crew.

The flight compartment can call a cabin attendant station with the ATTEND switch on the forward overhead panel. A pink light at the forward and aft exit locator signs turn on and there is a two-tone chime from the passenger address system. A cabin attendant can call another attendant station with the 5 push-button on the handset. The exit locator pink light at the called station comes on and there is a chime from the passenger address system.

A cabin attendant pushes the 2 push-button on the handset to call the flight compartment. A call light on the forward overhead panel comes on and there is a chime from the aural warning module.

A crew member pushes the GRD CALL switch in the flight compartment to call the ground crew. The switch is on the forward overhead panel. A horn in the nose wheel well comes on when the pilots use this switch.

The ground crew pushes the PILOT CALL switch on the external power panel to call the flight compartment. A call light on the forward overhead panel comes on and there is a chime from the aural warning module.



Passenger Address System

The passenger address (PA) system gives announcements and music to the passenger compartment.

The pilots or cabin attendants can make announcements. The pilot announcements have the highest priority. The pilots make announcements with the microphones and the PA selection on the audio control panel.

Attendant announcements have second priority. An attendant pushes the eight push-button and the PA push-to-talk switch on a handset to make announcements.

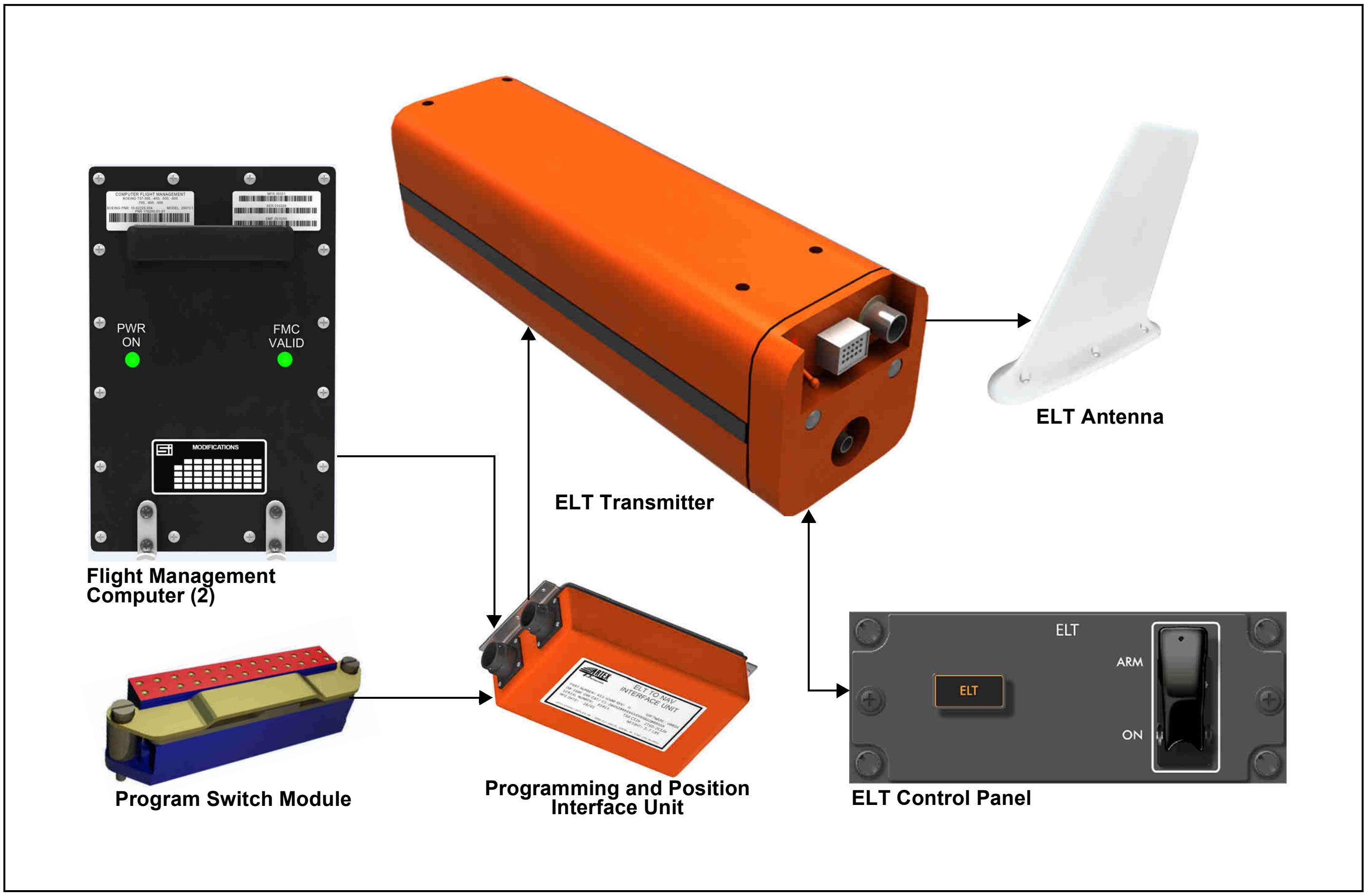
Prerecorded announcements from the forward attendant panel have third priority. Boarding music from the forward attendant panel has fourth priority.

The PA amplifier sends the highest priority audio to all the speakers in the passenger compartment.

The PA amplifier increases the output level of the audio when the engines are on or if the airplane depressurizes.

The PA amplifier supplies audio for the attendant area speakers through the remote electronics unit. An attendant announcement mutes this audio to stop microphone feedback.

The PA amplifier also supplies the chimes. Chimes are superimposed over any audio.



Emergency Locator Transmitter

The emergency locator transmitter (ELT) system has these components:

- Control panel
- Transmitter
- Antenna
- Programming and position interface unit (PPIU)
- Program switch module.

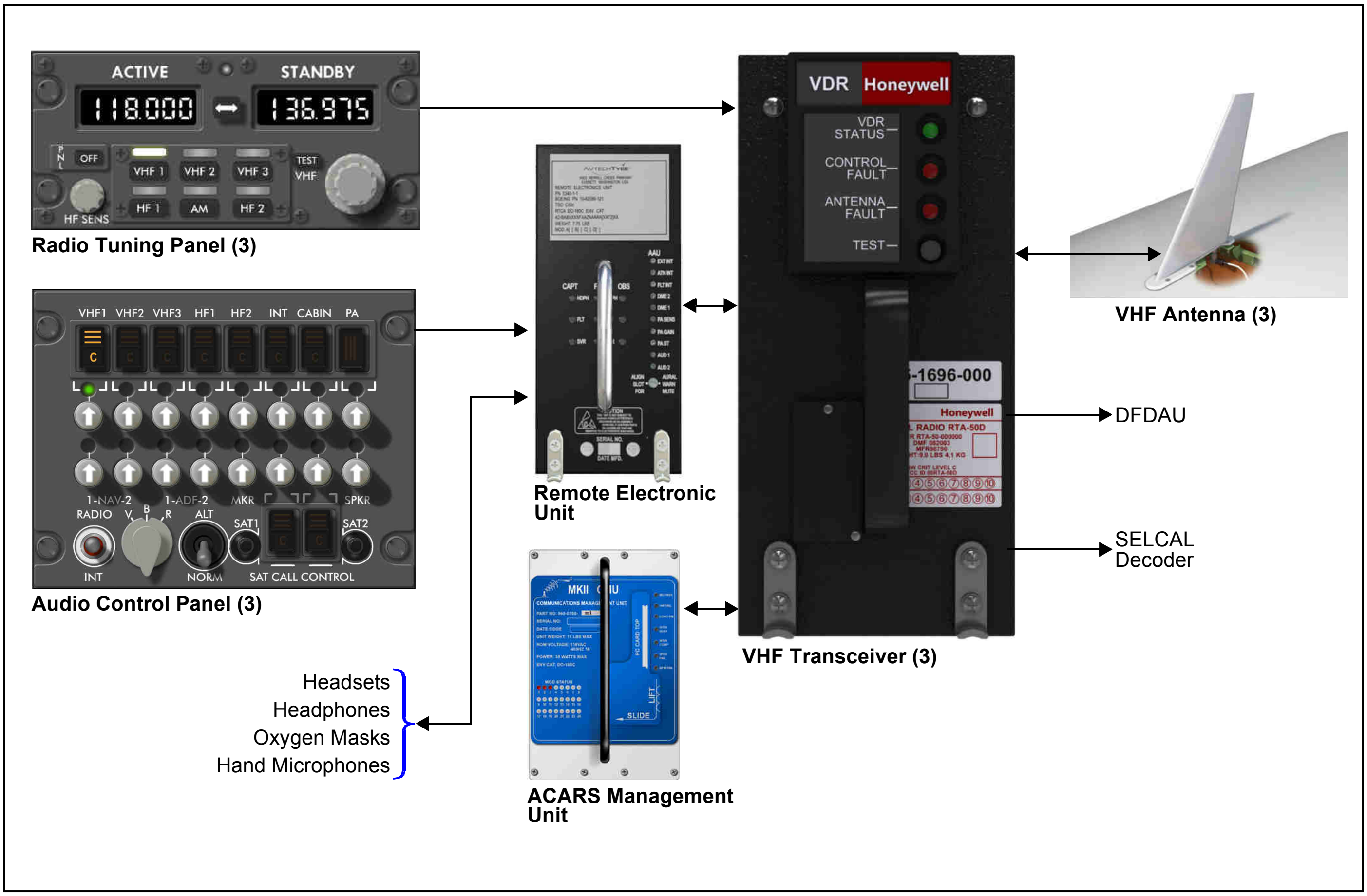
The control panel has a switch that is used to start the ELT manually. There is also an annunciator to indicate that the ELT is in operation.

The program switch module provides airplane identification to the PPIU. The PPIU supplies airplane identification and position data to the ELT transmitter.

The ELT transmitter has two sections.

One transmits on VHF channels 121.5 MHz and 243 MHz. These are used for the homing signal.

The other transmitter sends digital identification and position data every 50 seconds on the UHF 406 MHZ channel.



VHF Communication System

The very high frequency (VHF) communication system supplies line of sight voice and data communications from air-to-ground or air-to-air.

A radio tuning switch, on a radio tuning panel (RTP) selects one of the transceivers. The frequency selectors select the desired frequency. This shows on the liquid crystal display standby frequency window. The frequency transfer switch moves the standby frequency to the active frequency. The RTP sends tuning data to the selected transceiver.

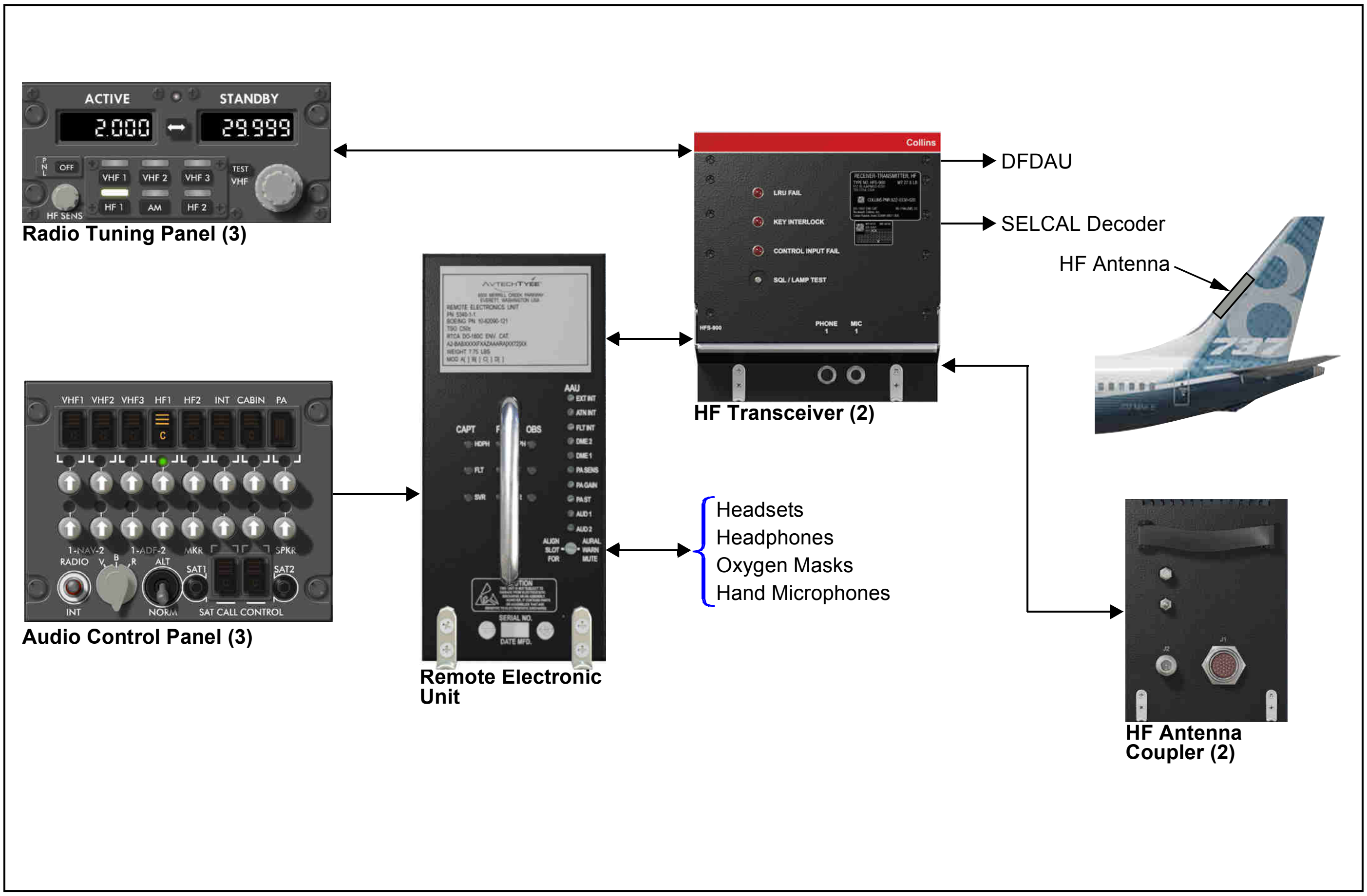
The transceiver sends and gets audio and data from the antenna.

The remote electronics unit does these functions for transmissions with inputs from the audio control panel:

- Microphone selection
- Headphone or speaker monitoring
- PTT.

The aircraft communications addressing and reporting system (ACARS) controls data to an optional third VHF communication system. ACARS is an optional system. When installed, ACARS uses the VHF transceiver to get and send digital data to and from a ground station.

Communications and Recording



HF Communication System

The high-frequency (HF) communication system is for long-range voice communications.

Each HF communication system has these units:

- HF transceiver
- HF antenna coupler
- Shared antenna.

A radio tuning switch on the radio tuning panel (RTP) selects one of the transceivers. The frequency selectors select the desired frequency. This shows on the liquid crystal display standby frequency window. The frequency transfer switch moves the standby frequency to the active frequency. The RTP sends tuning data to the selected transceiver.

The transceiver sends and gets the audio.

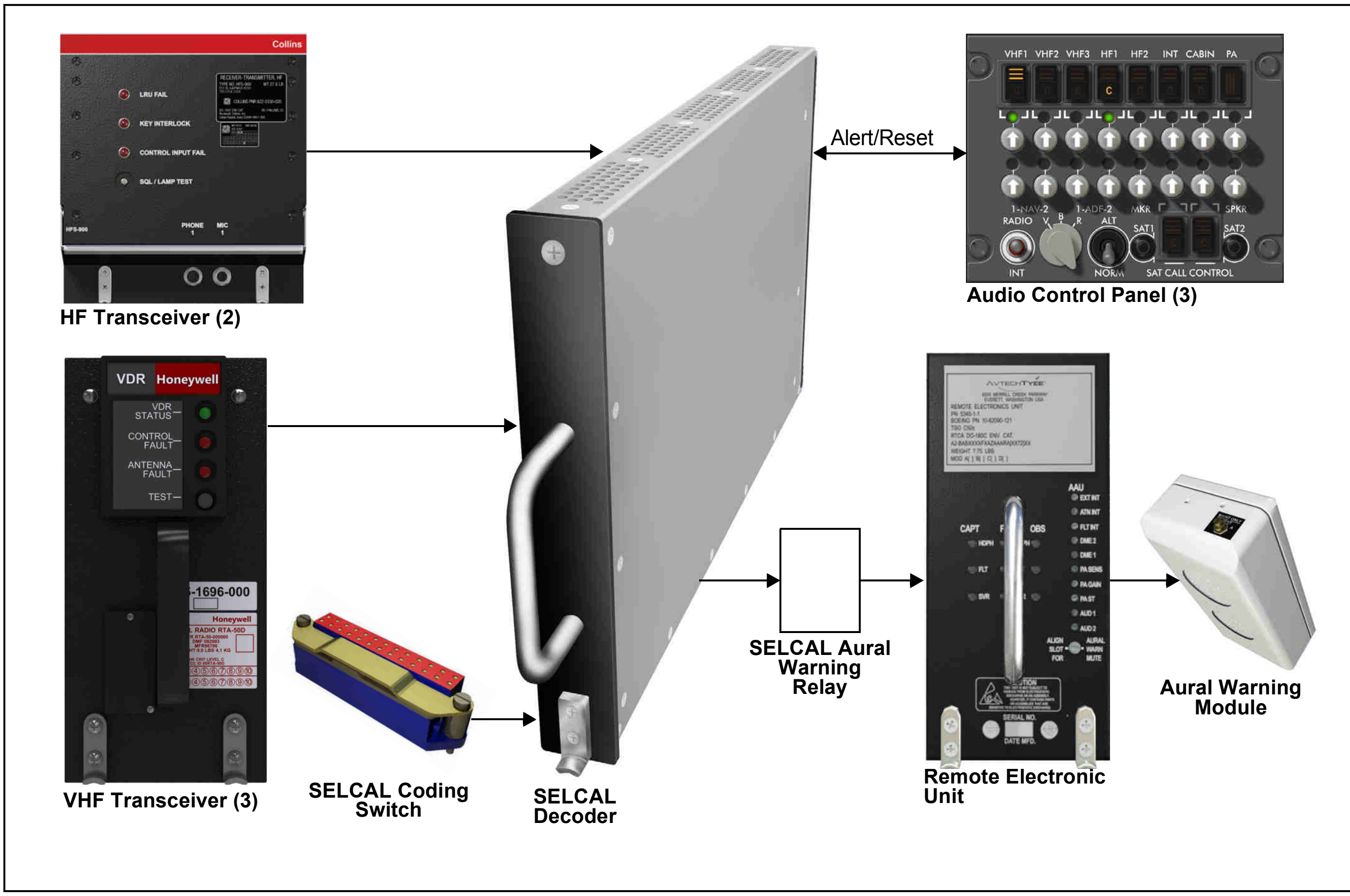
The remote electronics unit does these functions with audio control panel selections:

- Microphone selection
- Headphone and speaker monitoring
- PTT.

The antenna and the antenna couplers are in the vertical stabilizer.

The antenna coupler matches the impedance of the antenna to the impedance of the transceiver. The coupler tunes when you first key the HF transmitter.

BOEING PROPRIETARY



SELCAL (Optional)

The selective calling (SELCAL) system monitors all communication radios on the airplane. The system alerts the flight crew when it gets a ground call with the correct airplane code. This reduces the flight crew workload because they do not have to continuously listen to the airline communication frequencies.

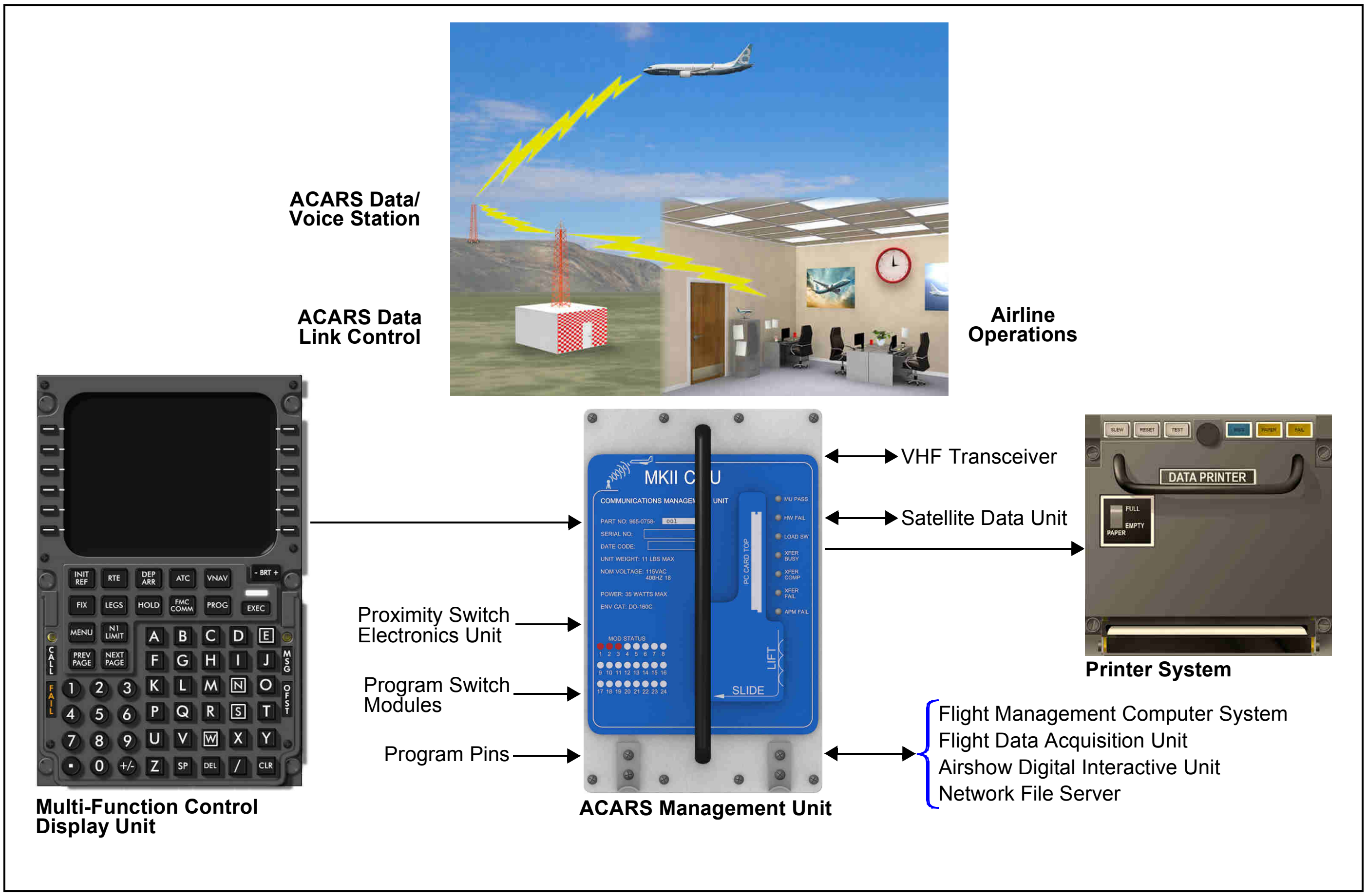
The SELCAL decoder gets audio signals from the VHF and HF communication systems. The SELCAL decoder gives signals to the flight crew if the signal received has the airplane unique SELCAL code. The airplane unique SELCAL code comes from the SELCAL coding switch.

When the SELCAL gets a call, these things occur:

- Call light on the audio control panel
- SELCAL chime from the aural warning module.

When the flight crew selects a PTT for the applicable radio, the light goes off and the system resets.

Communications and Recording



ACARS (Optional)

The aircraft communication addressing and reporting system (ACARS) gives a high-speed digital datalink between the airplane and ground facilities. ACARS reduces flight crew workload by automatically transmitting and receiving data.

This is the type of data the ACARS transmits and receives:

- Airplane identification
- Flight identification
- Out of gate, off the ground, on the ground, into the gate (OOOI) reports
- Delay reports
- Fuel reports
- Weather
- Airplane operating data.

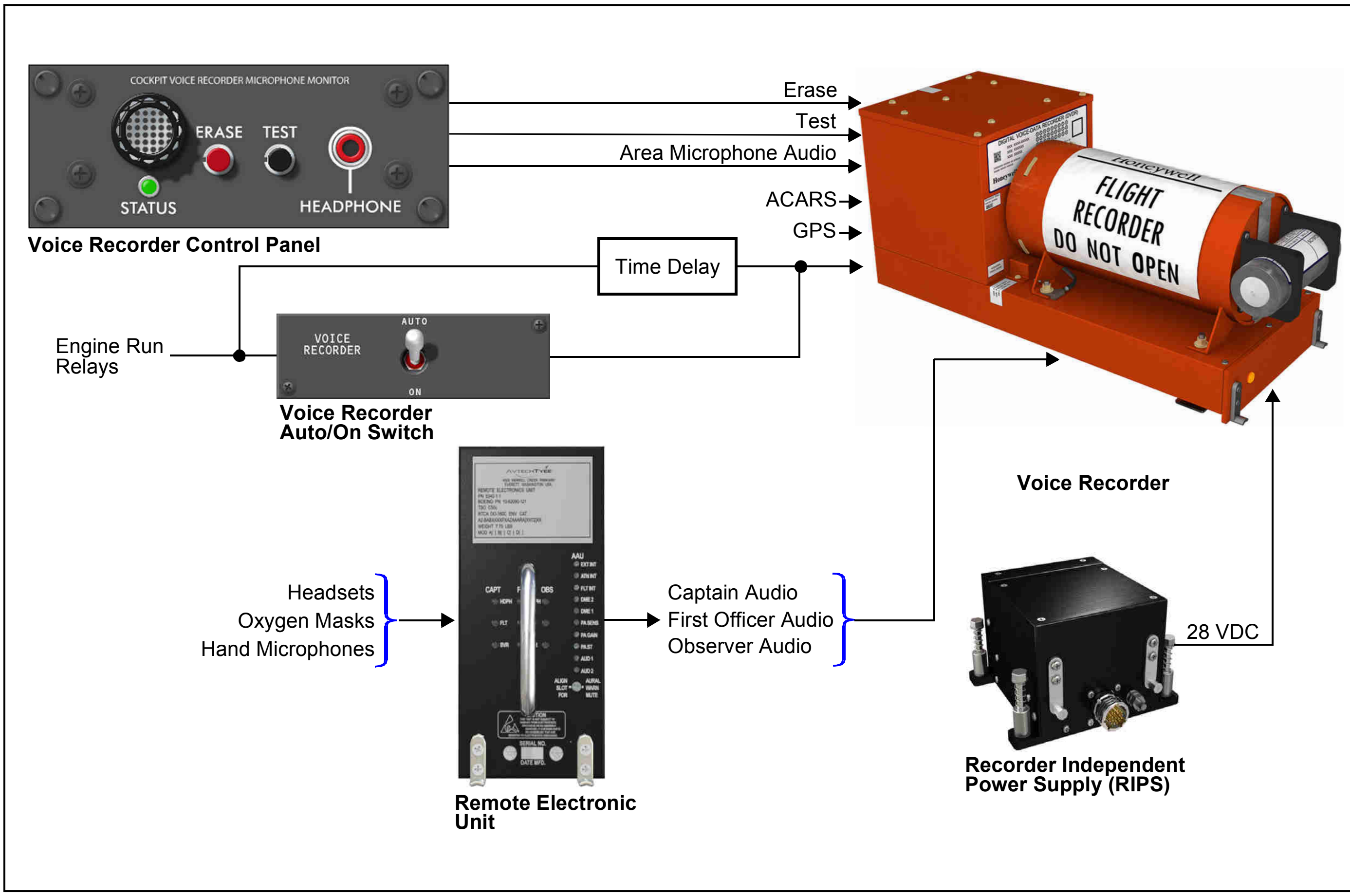
ACARS also provides voice telephone patch communication between the airplane and ground telephone circuits. ACARS uses VHF 3 or the SATCOM system using the satellite data unit to transmit and receive data messages. These systems interface with airline land lines, ARINC lines, and telephone systems.

The main ACARS component is the ACARS management unit (MU). The MU uses program pins and a program switch module for airline identification and the proximity switch electronics unit (PSEU) to define the OOOI event parameters. The MU uses VHF transceiver 3 or the satellite data unit to receive and transmit data.

The flight crew controls the system with a Multi-function control display unit (MCDU).

The flight crew uses the multi-purpose printer to print ACARS reports stored in the MU.

A call light in the flight compartment comes on, and there is a chime when ACARS receives a voice request from a ground station. The MCDU shows the requested voice communication frequency to the flight crew. The flight crew can use the MCDU to tune the VHF transceiver to make a voice call to the ground.



Voice Recorder System

The voice recorder makes a continuous record of the last 120 minutes of flight crew communications.

The voice recorder records four audio channels. These are the four channels:

- Captain microphone
- First officer microphone
- First observer microphone
- Area microphone on the voice recorder control panel.

Microphone inputs from the captain, first officer and first observer go to the remote electronic unit (REU). The REU amplifies the audio and sends it to the voice recorder. The audio from the area microphone is amplified in the control panel and goes directly to the voice recorder.

Aircraft communications addressing and reporting system (ACARS) signals are also sent to the voice recorder.

The test switch on the control panel does a functional check of the system.

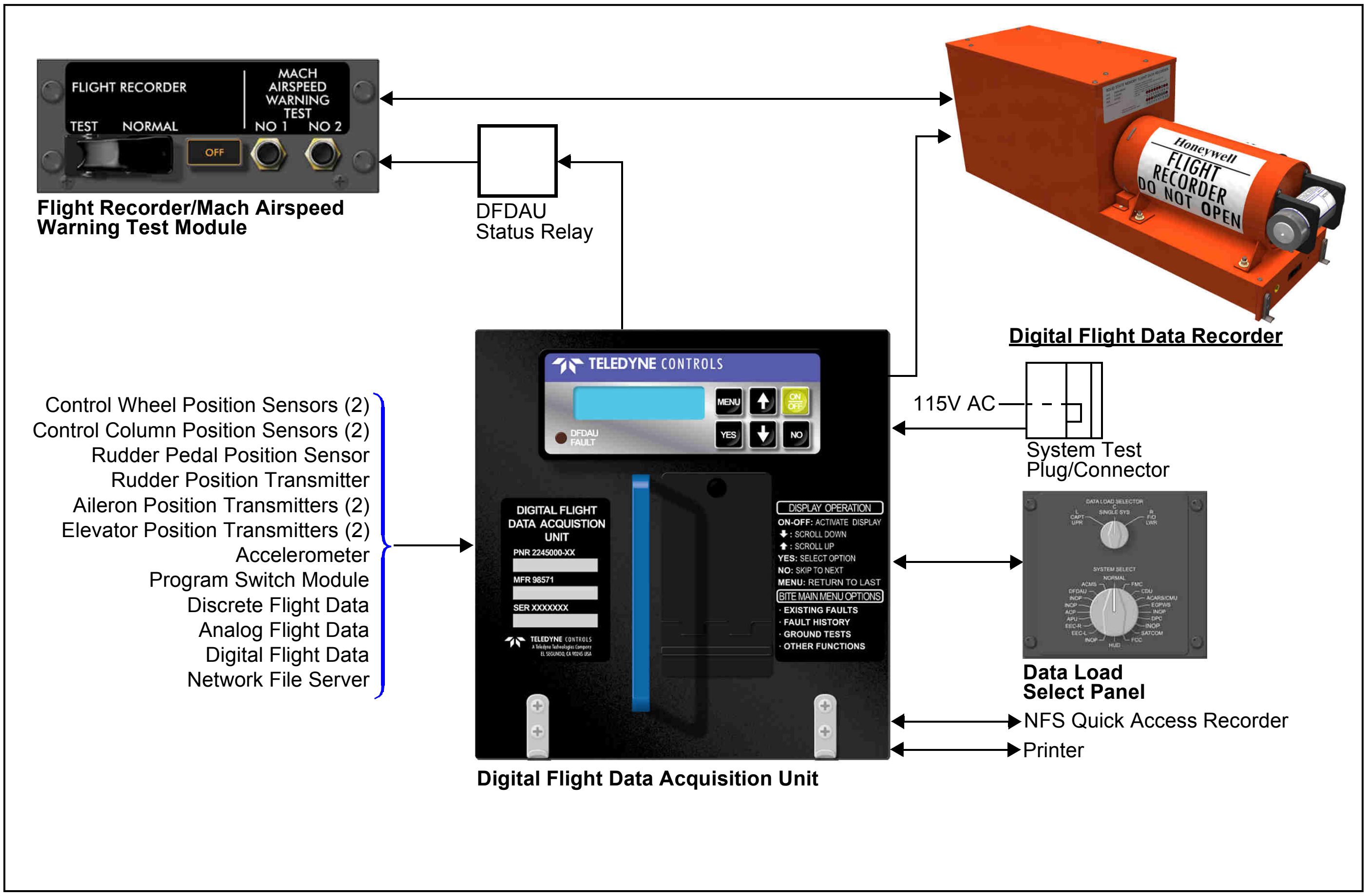
The ERASE switch on the control panel erases all stored audio in the voice recorder. The erase function is enabled when the airplane is on the ground with the parking brake on.

The voice recorder auto/on switch controls power to the voice recorder. In the ON position, the voice recorder is on. In the AUTO position, the voice recorder is on when one or both engines are on. The AUTO position keeps power on the voice recorder for 5 minutes after engine shutdown through the time delay relay.

The recorder independent power supply (RIPS) supplies 10 minutes of auxiliary power to the voice recorder when aircraft power systems are off.

An underwater locator beacon is on the front of the voice recorder.

Communications and Recording



Flight Data Recorder System

The flight data recorder system (FDRS) records the last 25 hours of flight parameters in a crash proof container. It records parameters that are required by regulatory agencies and requested by the airline.

The flight data recorder system operates automatically when either engine is operating or the airplane is in the air.

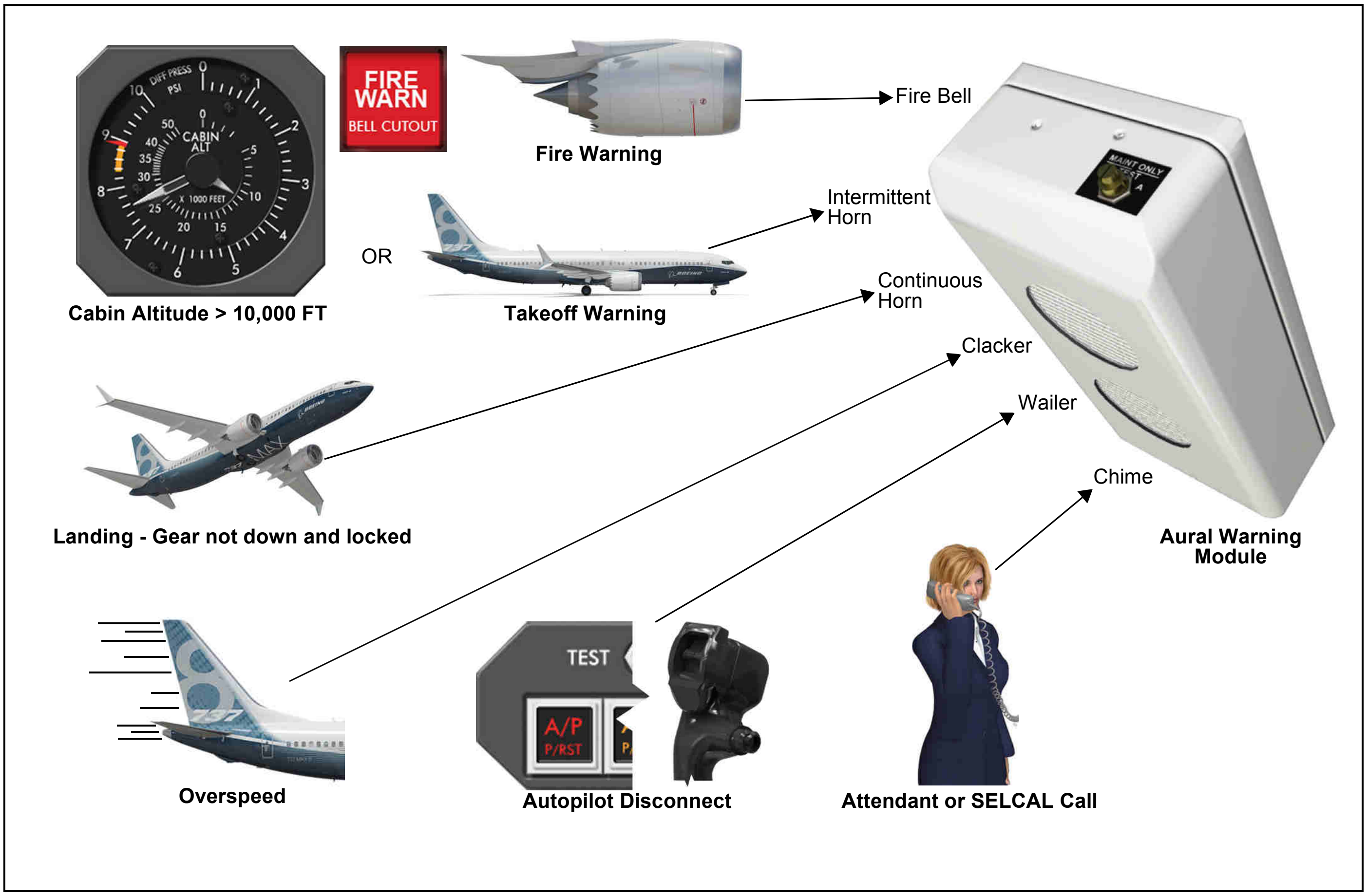
A flight recorder panel shows the status of the flight recorder system. If there is a system fault, an OFF light shows. The OFF light also comes on if the system is off.

The flight recorder panel also has a TEST/NORMAL switch. When the switch is in the TEST position, the recorder receives power on the ground.

Airplane systems send digital, discrete and analog data to the flight data acquisition unit (DFDAU). The DFDAU formats the data. The DFDAU sends the data to the flight data recorder (DFDR).

The DFDR records the data in a fire and crash resistant LRU. An underwater locator beacon is on the front of the DFDR.

The DFDAU can also collect data for the airplane condition monitoring system (ACMS). The DFDAU saves the ACMS data on an internal storage card. The DFDAU can also send the ACMS data to a quick access recorder (QAR) within the network file server (NFS) system. Some QARs have a wireless capability that can transmit data over cell phone towers when the airplane is at the gate.



Aural Warning System

The aural warning system tells the flight crew of incorrect airplane system conditions with aural indications. The system also provides the aural indication for SELCAL and crew calls.

The aural warning module monitors several airplane systems. The airplane systems send a signal to the aural warning module if they detect an unsafe condition.

The aural warning module supplies these aural indications:

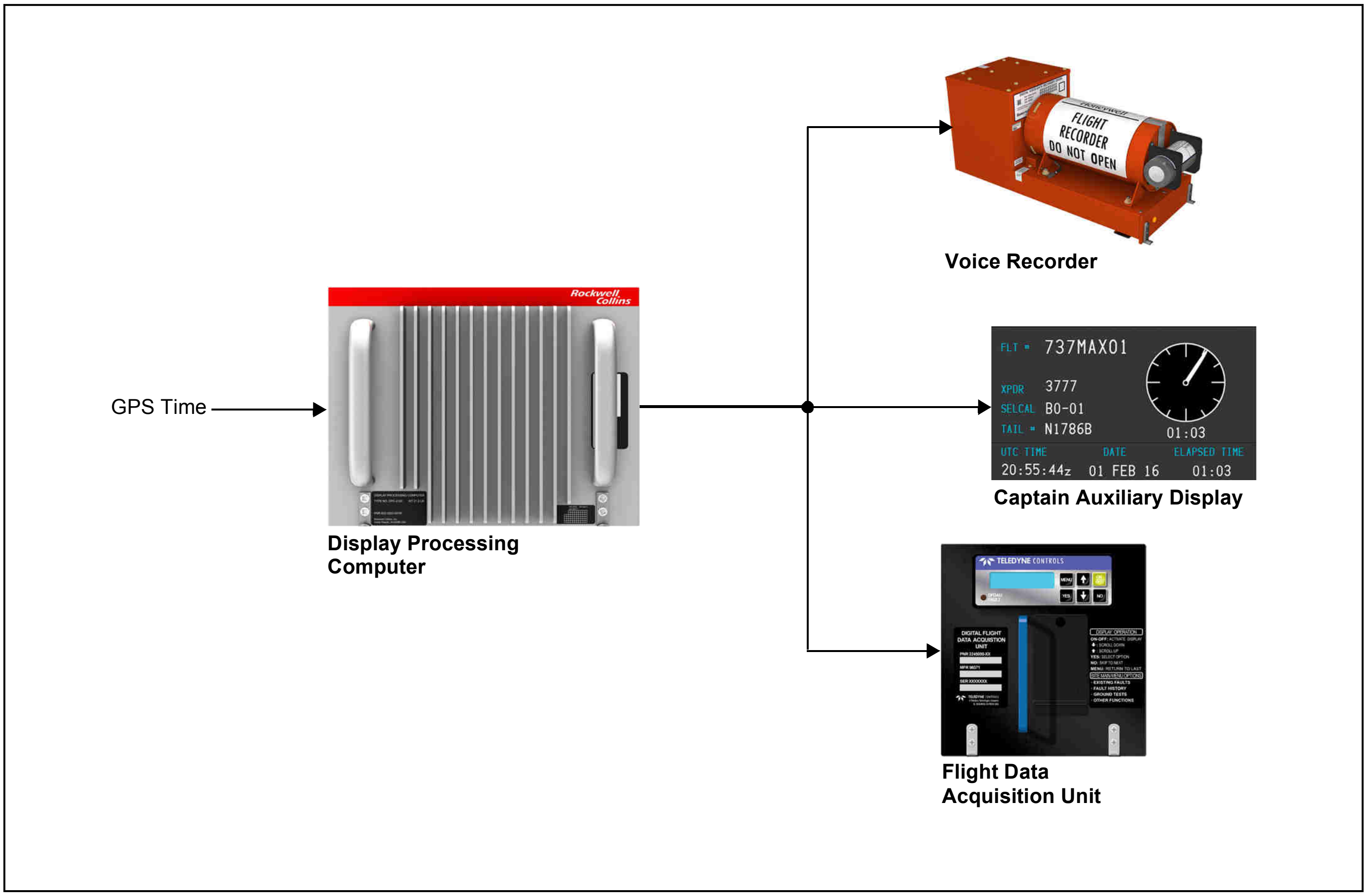
- Bell for a fire
- Intermittent horn for a unsafe takeoff configuration or cabin altitude too high
- Steady horn for unsafe landing configuration
- Clacker for overspeed
- Wailer for autopilot disconnect
- Chimes for crew call and SELCAL.

For an unsafe condition, there are also visual indications. The caution lights and the fire warning lights are the visual indications. These lights come on when airplane systems detect an unsafe condition.

There are other independent warning systems. These systems are not part of the aural warning system:

- The ground proximity warning system
- The traffic collision and avoidance system
- The digital flight control system.
- The weather radar system.

Communications and Recording



Digital Clocks

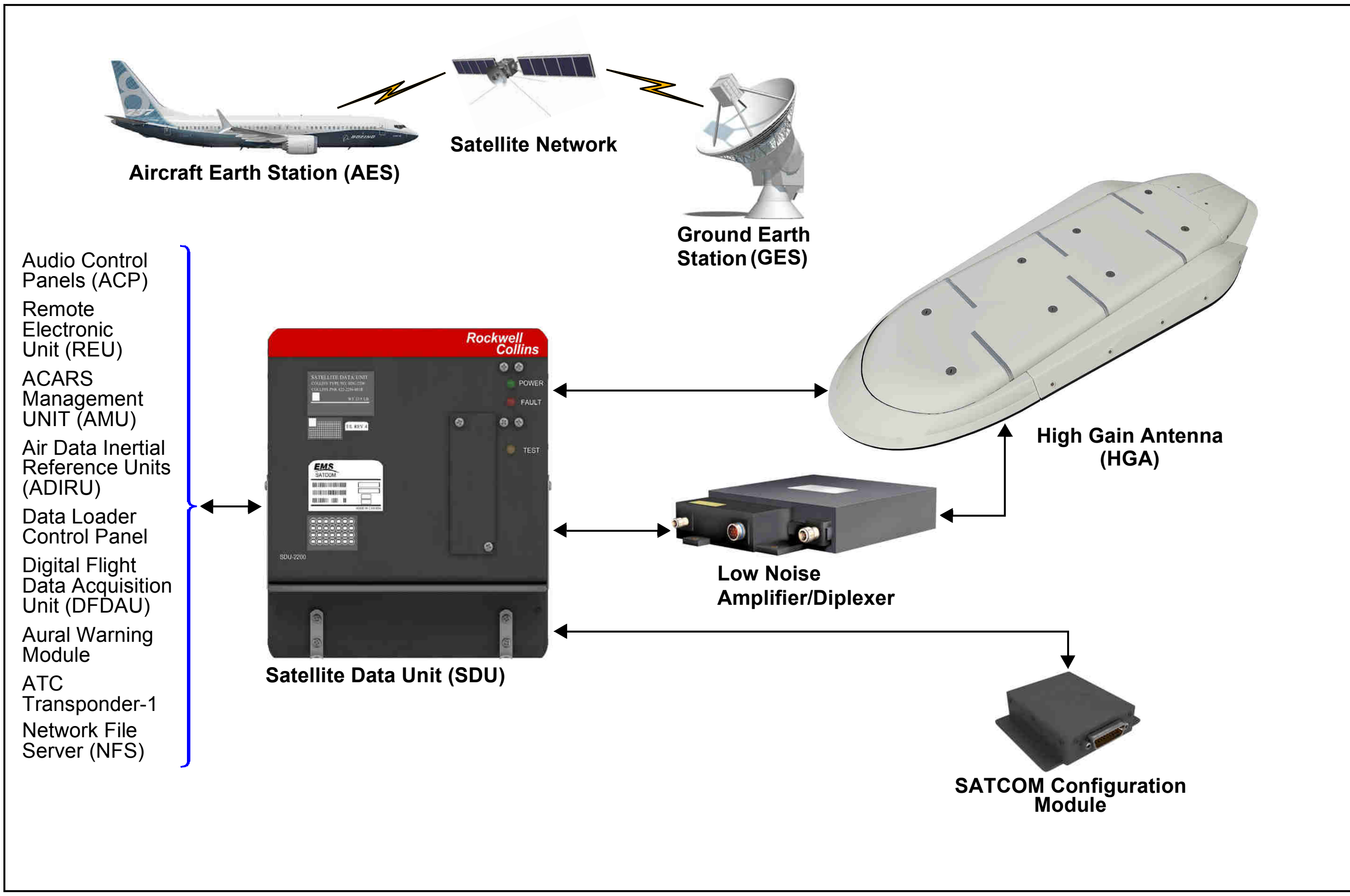
There are two clock indications in the flight compartment, one on the captain auxiliary display and one on the first officer auxiliary display. The clock function is provided by the display processing computer (DPC)

Each clock indication shows this information:

- UTC Time in hours, minutes and seconds
- Date
- Elapsed time in hours and minutes
- Chronograph time in minutes and seconds.

The DPC sends clock information on an ARINC 429 digital output bus to the digital flight data acquisition unit (DFDAU) and the cockpit voice recorder (CVR).

The clocks are updated by the global positioning system (GPS).



Satellite Communication (SATCOM) System (Optional)

The SATCOM system sends and gets data and voice messages. The system uses satellites as relay stations for long distance communication. SATCOM is more reliable than HF communication because it is not affected by atmospheric conditions.

The system is made up of the satellite network, the ground earth station (GES) and the aircraft earth station (AES).

The satellite network relays radio signals between the AES and the GES. Each GES is a fixed radio station that interfaces with communication networks through ground links and the aircraft earth stations through the satellite. The AES is the SATCOM system on the airplane that interfaces with various onboard communication systems and the ground earth stations.

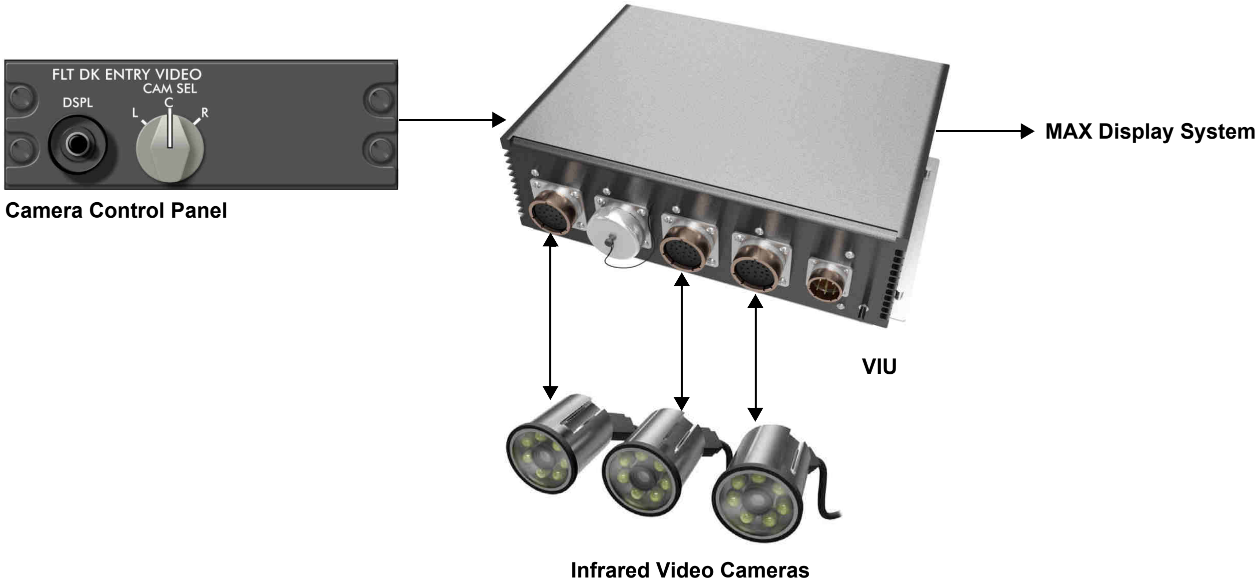
The basic SATCOM configuration is a high-gain system with high-gain antenna.

The satellite data unit (SDU) is the interface between all other related airplane systems and the SATCOM system.

The low noise amplifier (LNA) and diplexer are one unit. The diplexer couples transmit signals from the SDU to the antenna. The LNA amplifies the low level L-band signal from the antenna.

The SATCOM configuration module gives configuration data to the SDU.

Communications and Recording



FDEVSS

The flight deck entry video surveillance system (FDEVSS) lets the flight crew identify persons before they let them into the flight compartment. The surveillance area is the flight compartment door and forward galley area.

The video os shown on the large format displays, and is comprises of the following components:

- Camera control panel (CCP)
- Infrared video cameras (3)
- Video interface unit (VIU).

There is a camera control panel (CCP) on the P8 aft electronic panel. The CCP allows the flight crew to turn the FDEVSS on/off and select which view they want to see.

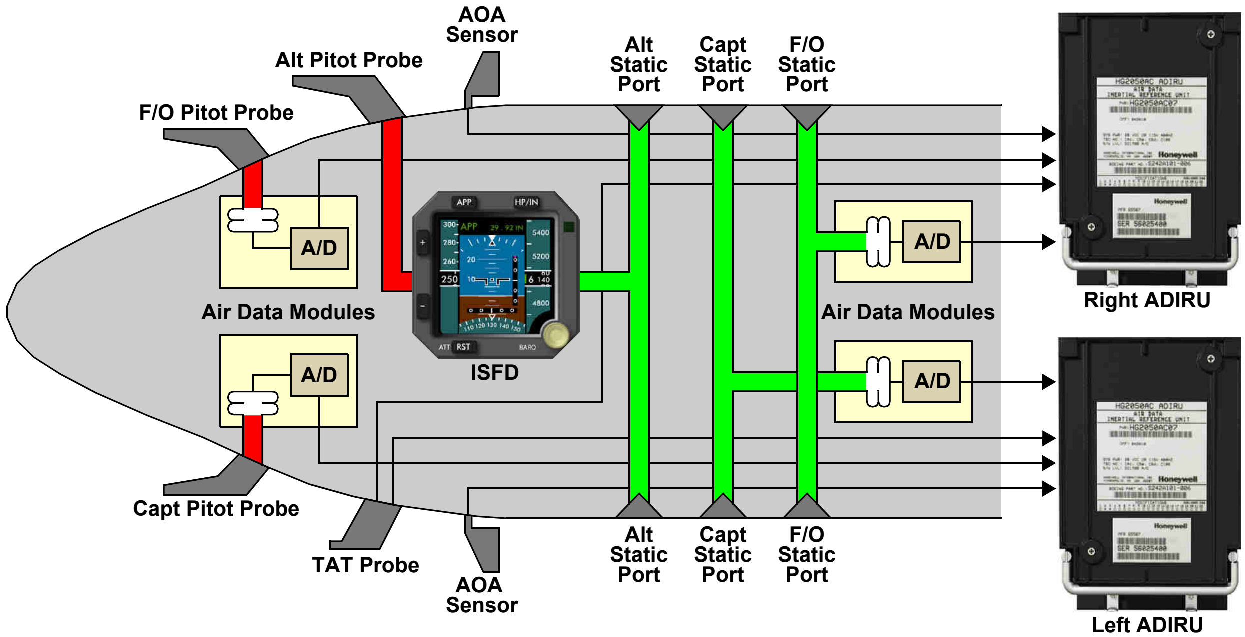
Features

UPGRADED AVIONICS

The RDR-4000 Weather Radar is now standard on the 737-MAX. This results in increased capabilities and reliability.

COMMON COMPONENTS

The 737-MAX uses many navigation system units that are common with the 747, 777, 787 and 737-NG. This reduces the cost of maintenance and spares.



Air Data Inertial Reference System

The air data inertial reference system (ADIRS) has two separate functions in a single line replaceable unit. The two functions use the same power supply. All other operations are separate. The air data function is active when electrical power is on. The inertial reference function is active when the pilots select it on.

AIR DATA FUNCTION

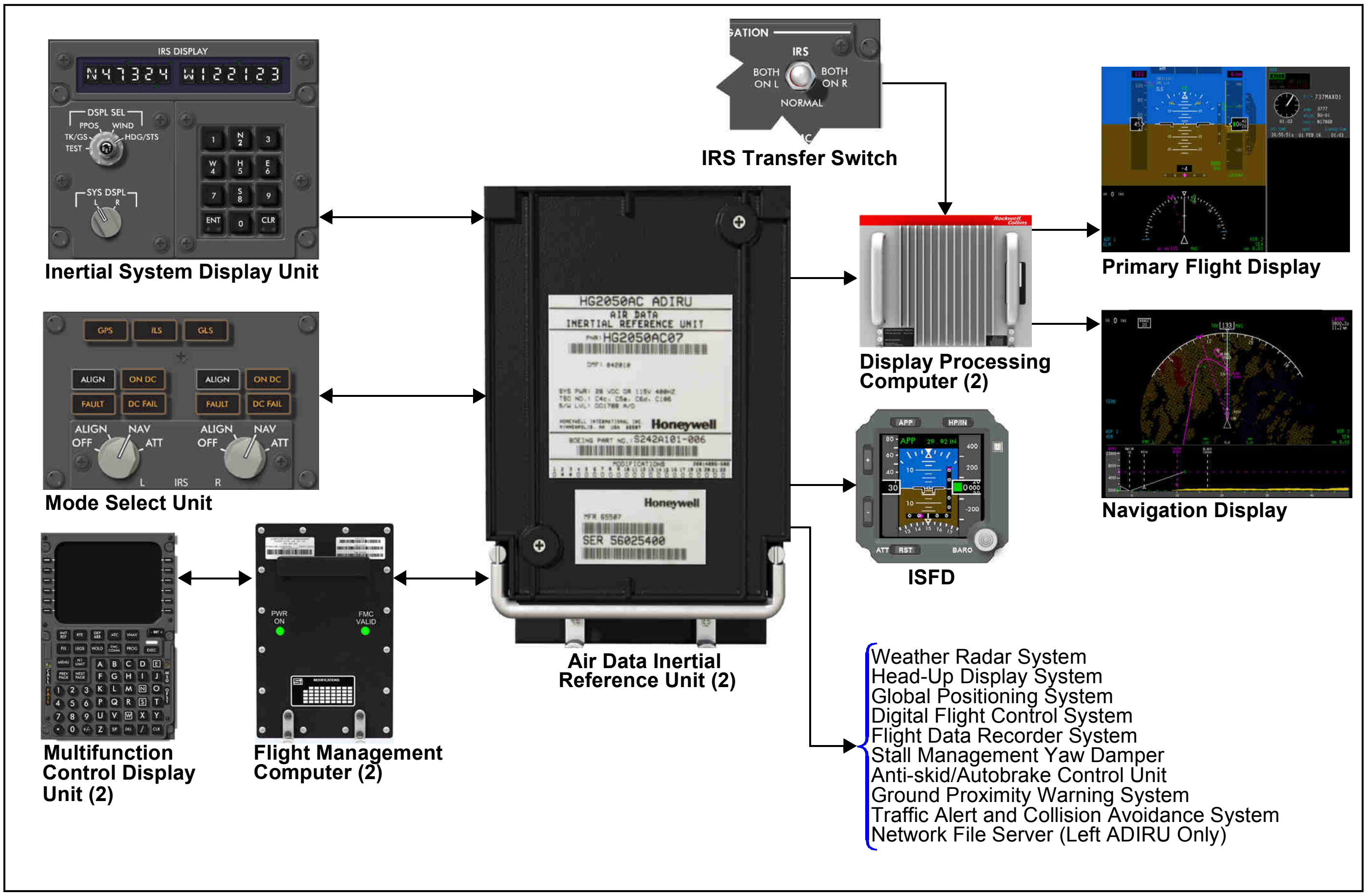
The air data modules (ADMs) give pitot and static pressure data to the air data inertial reference unit (ADIRU). The ADMs convert pressure to digital data. The total air temperature (TAT) probe gives TAT to the ADIRU. The angle-of-attack (AOA) sensors give AOA data to the ADIRU.

The ADIRU uses the ADM, TAT and AOA data to calculate these values:

- Altitude
- Computed Airspeed
- Mach
- Air temperature
- Angle-of-attack
- Baro-corrected altitude
- Maximum allowable airspeed
- True airspeed
- Altitude rate
- Static air temperature.

The ADIRU sends these values on digital data buses to the systems that use calculated air data.

The alternate pitot probe and the alternate static ports send the pressure to standby instruments. The cabin pressure control system also uses alternate static pressure.



Air Data Inertial Reference System

INERTIAL REFERENCE FUNCTION

The ADIRS inertial reference function uses laser gyros and accelerometers to measure airplane movement. The inertial reference function uses the gyro and accelerometer data to calculate these values:

- Attitude (pitch, roll, yaw)
- Position (latitude, longitude)
- True heading
- Magnetic heading
- Inertial velocity vectors
- Linear accelerations
- Angular rates
- Track angle
- Wind speed and direction
- Inertial altitude
- Vertical speed
- Ground speed
- Drift angle
- Flight path angle.

The inertial reference function has these components:

- ADIRUs (2)
- Mode select unit (MSU)
- Inertial system display unit (ISDU)
- IRS transfer switch.

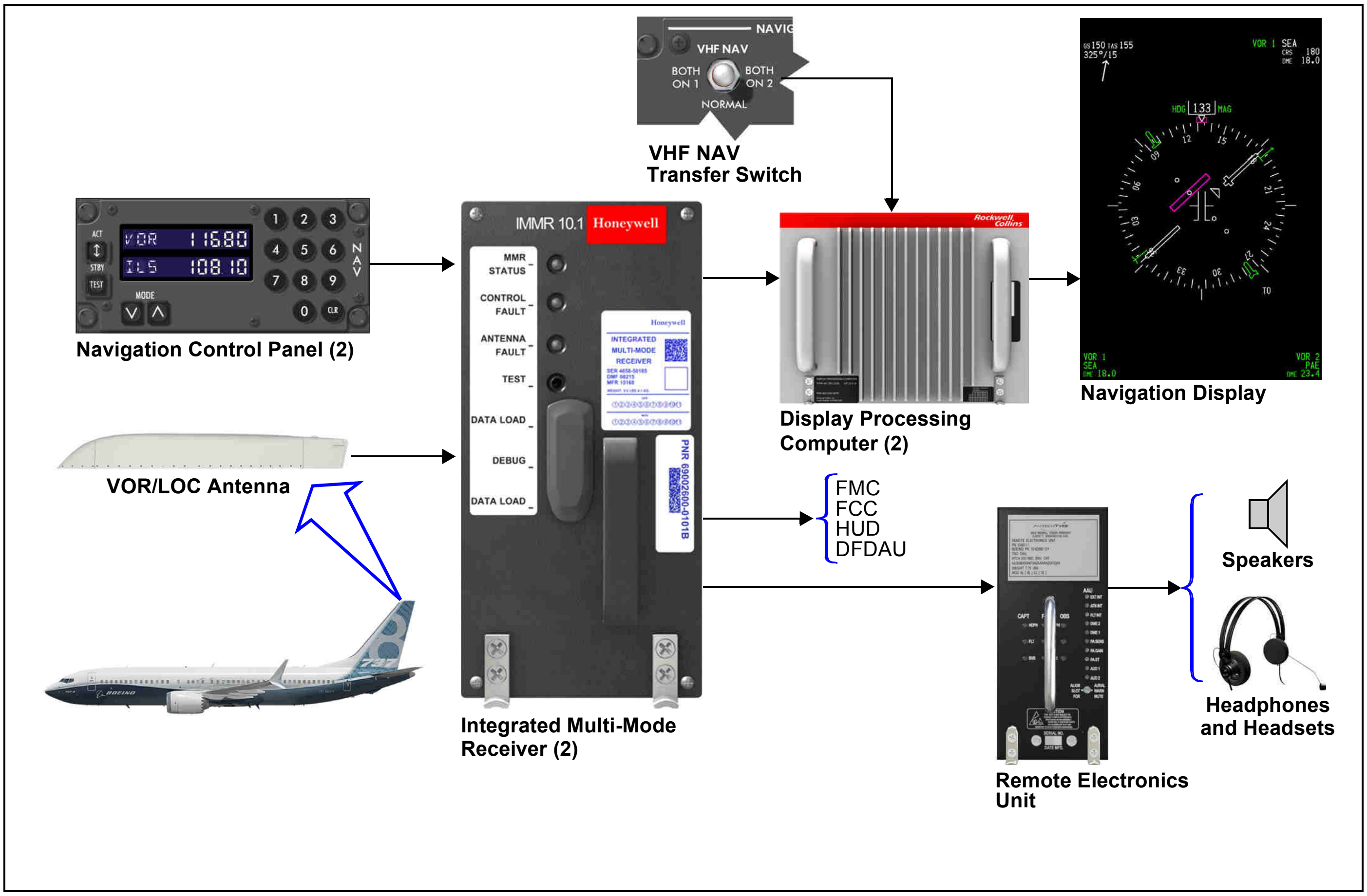
The MSU is used to select the mode of operation for the ADIRU inertial reference function. These modes can be selected:

- Off
- Align
- Navigate
- Attitude.

Before the ADIRUs can operate in the navigation mode, they must do an alignment. The airplane must not move during the alignment. The flight management computer (FMC) multifunction control display unit (MCDU) or the ISDU are used to put the airplane present position into the ADIRU.

Inertial reference data shows on the MAX display system (MDS) display units, the HUD, and the integrated standby flight display (ISFD). Navigation, autoflight and other airplane systems also use inertial reference data.

The IRS transfer switch selects the ADIRU that gives inertial reference data to the display system. When the switch is in the NORMAL position, the left ADIRU gives information to the captain displays and the right ADIRU gives information to the first officer displays. Moving the switch to BOTH ON LEFT or BOTH ON RIGHT causes one ADIRU to provide information to all displays.



VHF Omnidirectional Range (VOR) System

For the Honeywell system, the VHF omnidirectional range (VOR) reciever is located inside the intergrated multi-mode reciever (IMMR). For the Collins sytem the VOR receiver is a seperate line replaceable unit (LRU).

The VOR system gives bearing information to ground stations. The pilots and the airplane systems use this information.

The pilots use the navigation control panel to tune the VOR receiver.

The VOR system receives the signals from the ground station and calculates magnetic bearing to the station.

These units use the VOR information:

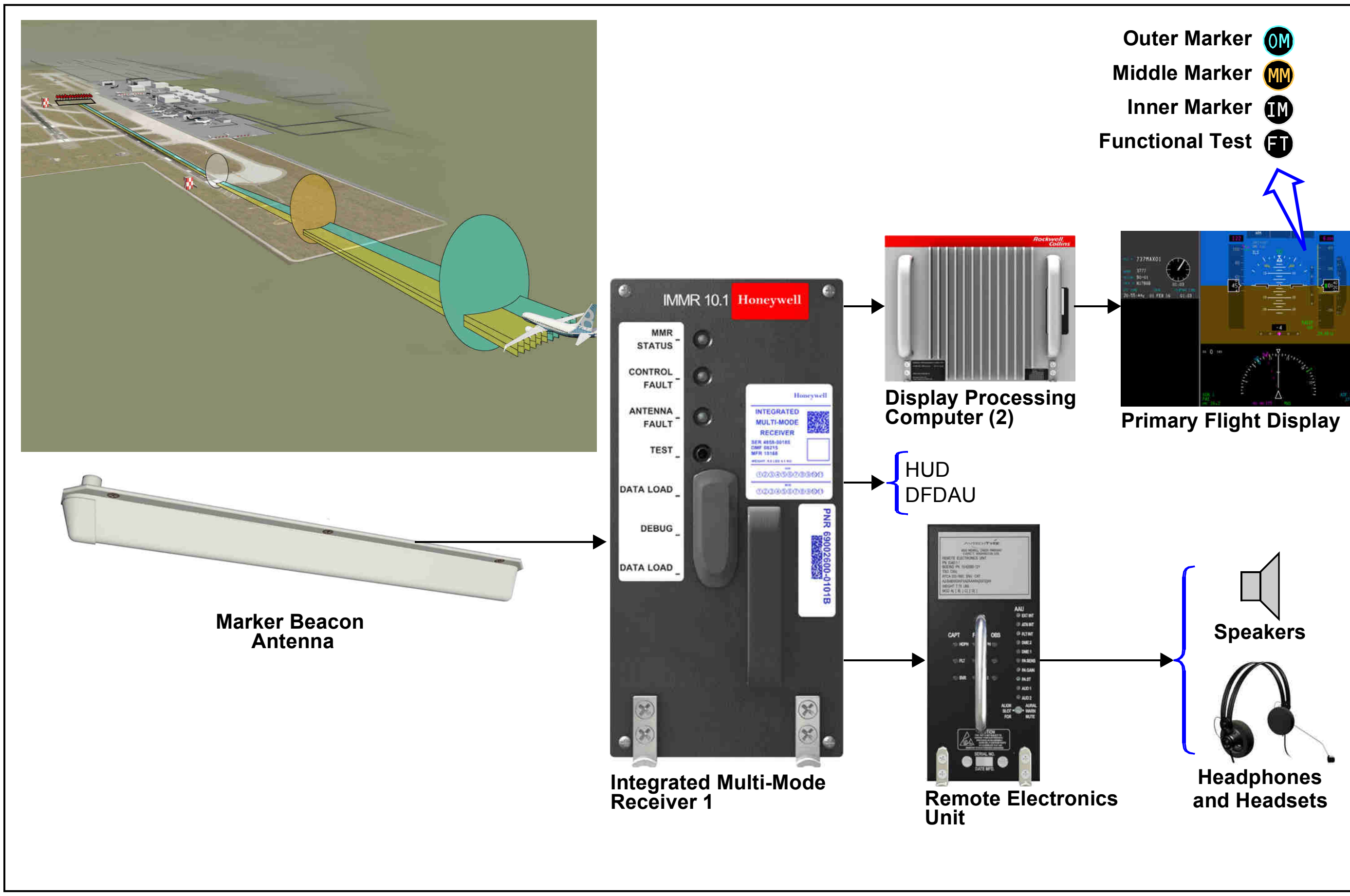
- Flight control computer (FCC)
- Flight management computers (FMC)
- MAX display system display processing computer (MDS DPC).
- Digital flight data acquisition unit (DFDAU)
- Head-up display system (HUD).

Magnetic bearing shows on the MAX display system (MDS) display units.

The MDS DPCs use the selected course from the DFCS mode control panel to calculate VOR course deviation.

The VHF NAV transfer switch selects the VOR data that shows on the CDS display unit. In the NORMAL position, VOR 1 data shows on the captain display unit and VOR 2 data shows on the first officer display unit. You move the switch to BOTH ON 1, or BOTH ON 2 to cause one VOR receiver to give data to the captain and first officer.

The VOR receivers send audio from the VOR station to the remote electronics unit (REU). The REU sends the audio to the flight compartment speakers and pilot headsets.



Marker Beacon

For the Honeywell system, the marker beacon receiver Integrated Multi-Mode Receiver (IMMR). For the Collins system the marker beacon receiver is a separate line replaceable unit (LRU).

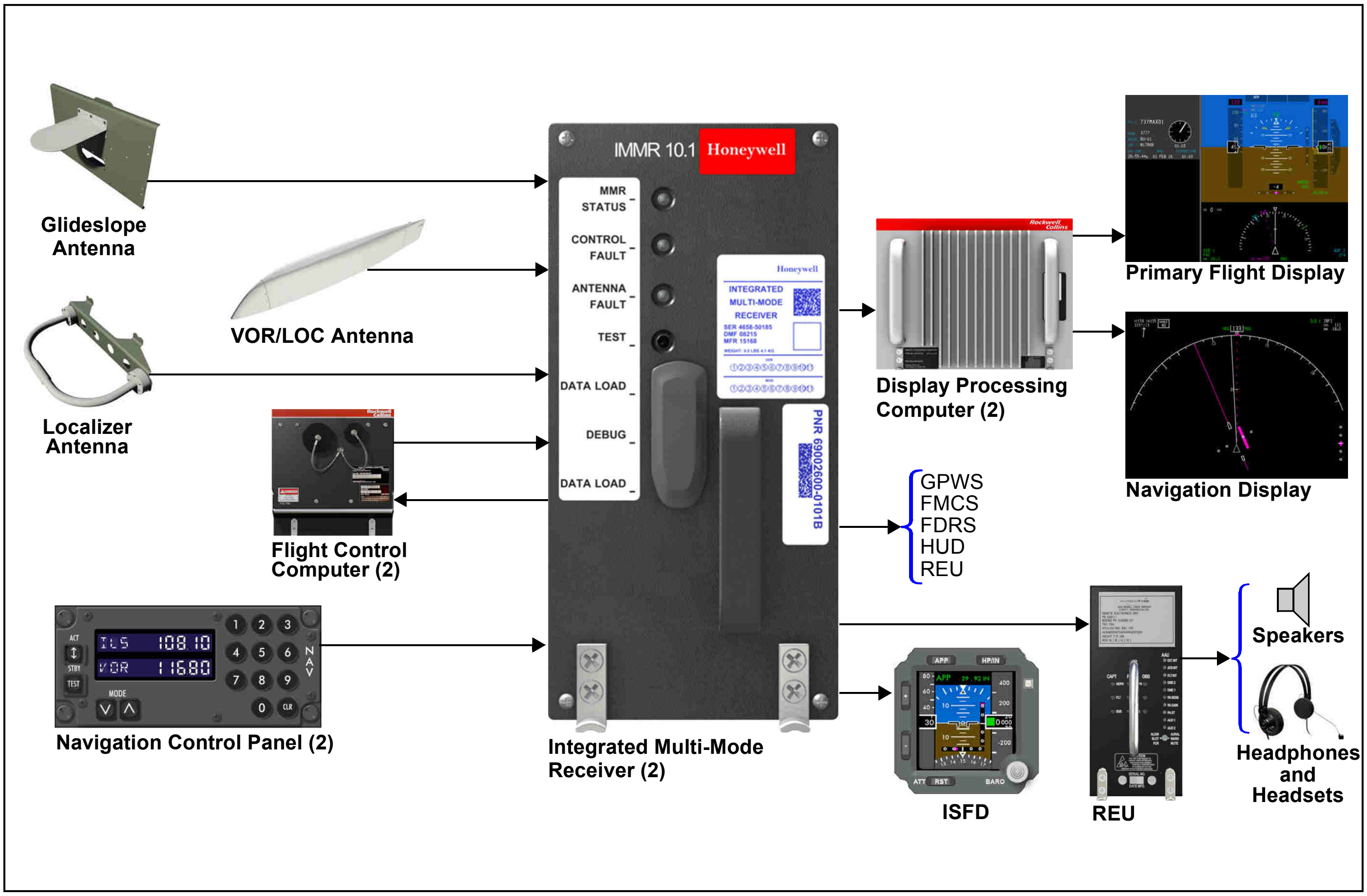
The marker beacon system gives aural and visual indications in the flight compartment as the airplane flies over a marker beacon transmitter during the approach to land.

Marker beacon transmitters are on flight paths and runway approach paths. The transmitter sends a narrow, vertical radio frequency beam with an audio tone. Marker beacon transmitters on runway approach paths send one of three different audio tones.

As the airplane flies over the beam, the marker beacon system receives the audio tone. The marker beacon system then sends the aural and visual indications to the common display system, digital flight data acquisition unit (DFDAU) and the head-up display (HUD) system.

Each IMMR or VOR receiver has a marker beacon module. The marker beacon functions only in IMMR 1 or VOR receiver 1.

Navigation



Instrument Landing System

The instrument landing system (ILS) gives precision approach guidance on instrument approaches. The ILS gives position information relative to the glidepath and runway center line.

Two ILS systems are on the airplane.

The ILS system is active when a pilot selects an ILS frequency on the navigation control panel.

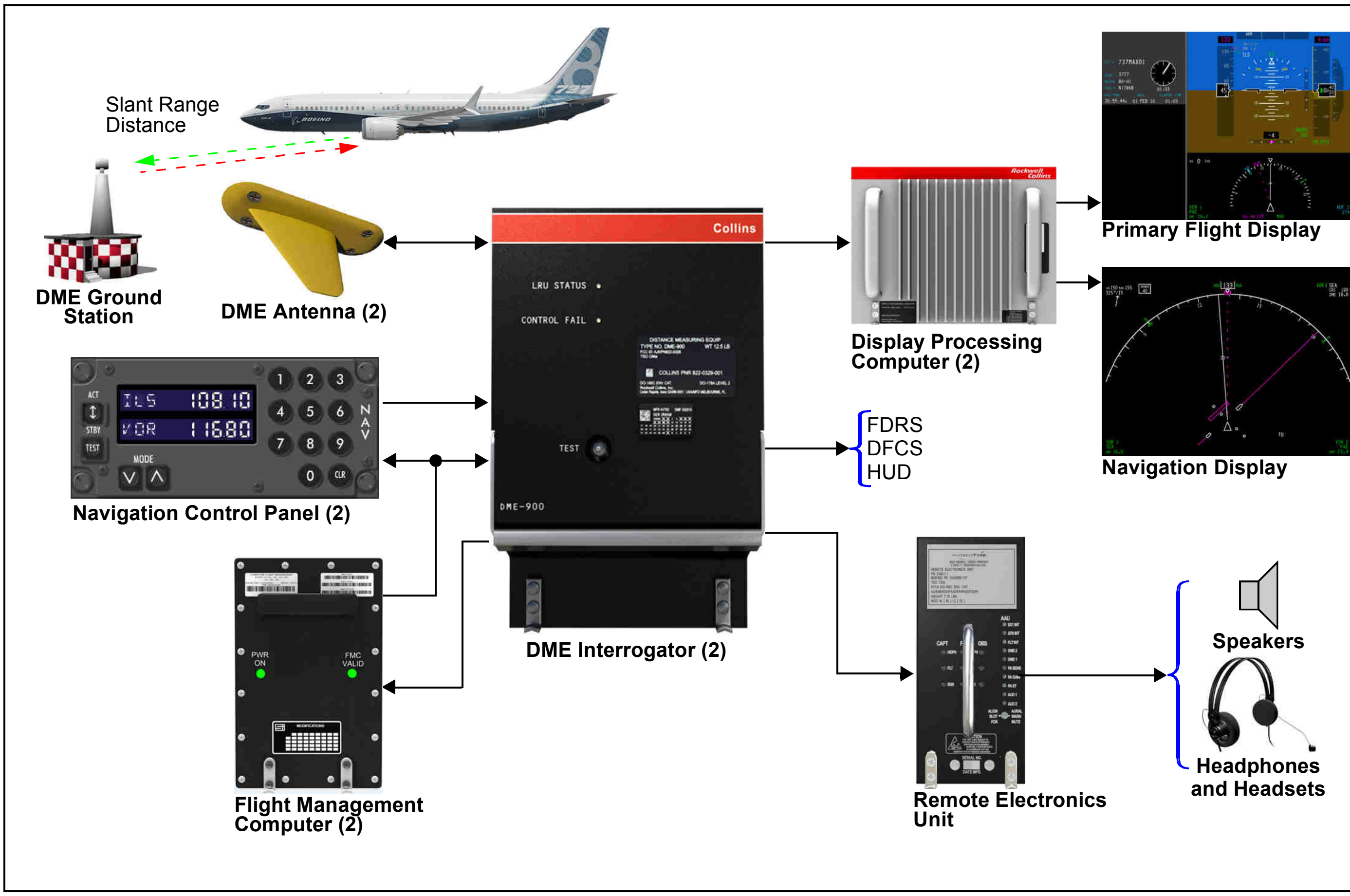
The integrated multi-mode receivers (IMMRs) calculate vertical deviation from the signal they receive from the glideslope antenna and lateral deviation from the signal they receive from the localizer antennas.

The IMMRs use the VOR/ localizer antenna on the vertical stabilizer until the flight control computer (FCC) sends the command to switch the IMMRs to the localizer antenna under the radome. This occurs during approach.

These units use ILS information:

- Flight control computers (FCC)
- Standby attitude indicator (if installed)
- Integrated standby flight display (ISFD) if installed
- Ground proximity warning unit (GPWS)
- Flight management computer system (FMCS)
- Flight data recorder system (FDRS)
- MAX display system display processing computer (MDS DPC)
- Head-up display (HUD) computer.

ILS audio goes to the remote electronics unit (REU). The REU sends audio to the flight compartment speakers and headsets.



Distance Measuring Equipment System

The distance measuring equipment (DME) system gives the pilots distance to a DME ground station.

There are two DME systems are on the airplane.

These units use the distance information:

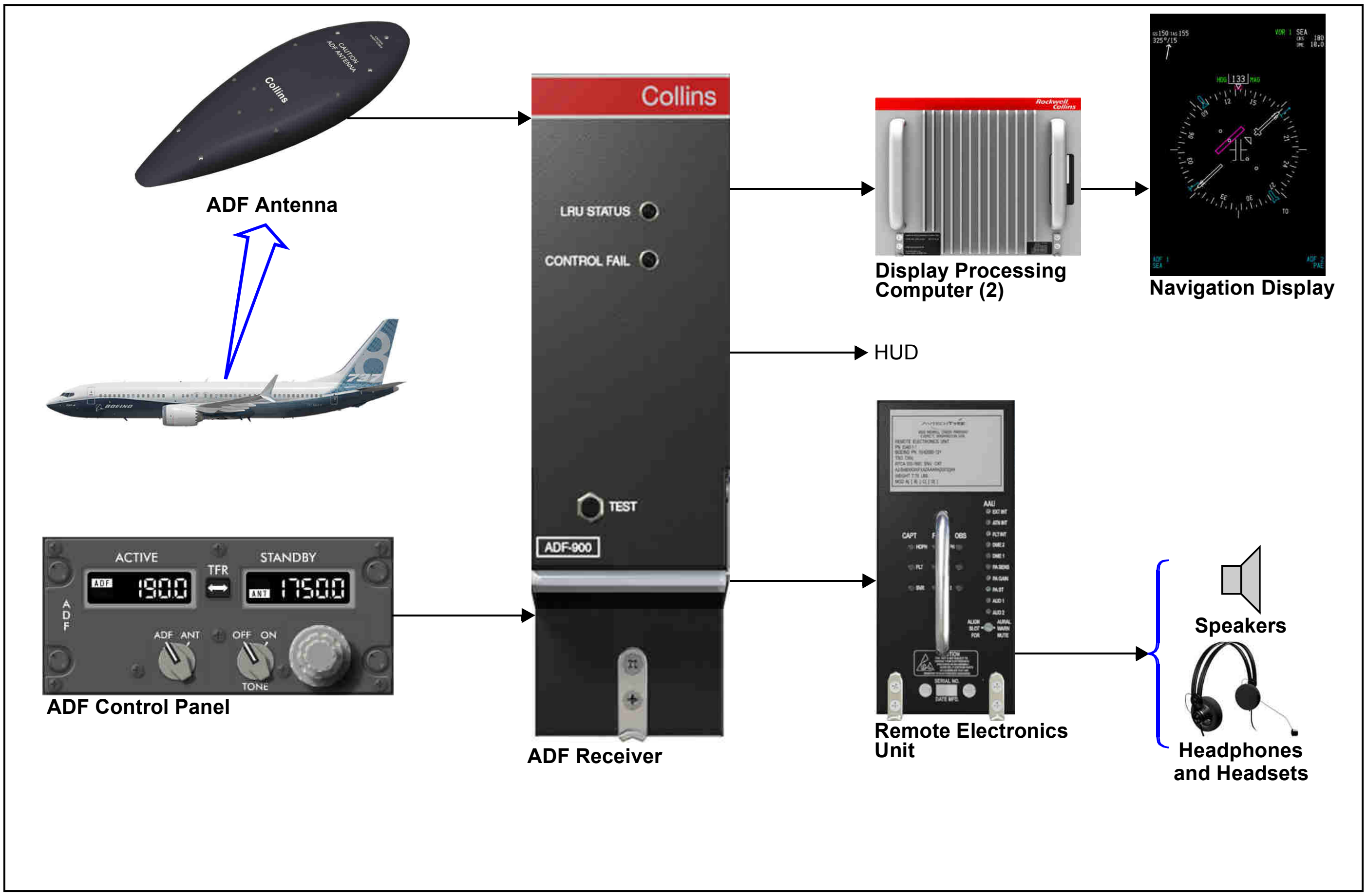
- Digital flight control system (DFCS)
- Flight data recorder system (FDRS)
- MAX display system display processing computers (MDS DPC)
- Flight management computer system (FMCS)
- Head-up display (HUD) computer.

The pilot can tune one DME station with the navigation control panel. This DME distance shows on the MDS display units. The FMC, HUD and the DFCS also use this distance.

The FMC can tune up to four DME stations at the same time. The FMCS and the DFCS use these DME distances.

DME audio goes to the remote electronics unit. The pilots can hear the audio on the flight compartment headsets and speakers.

Navigation



Automatic Direction Finder System

The automatic direction finder (ADF) system is a navigation aid that receives radio signals from ground stations. The ADF calculates bearing information to a ground station. It can also provide audio to the pilots.

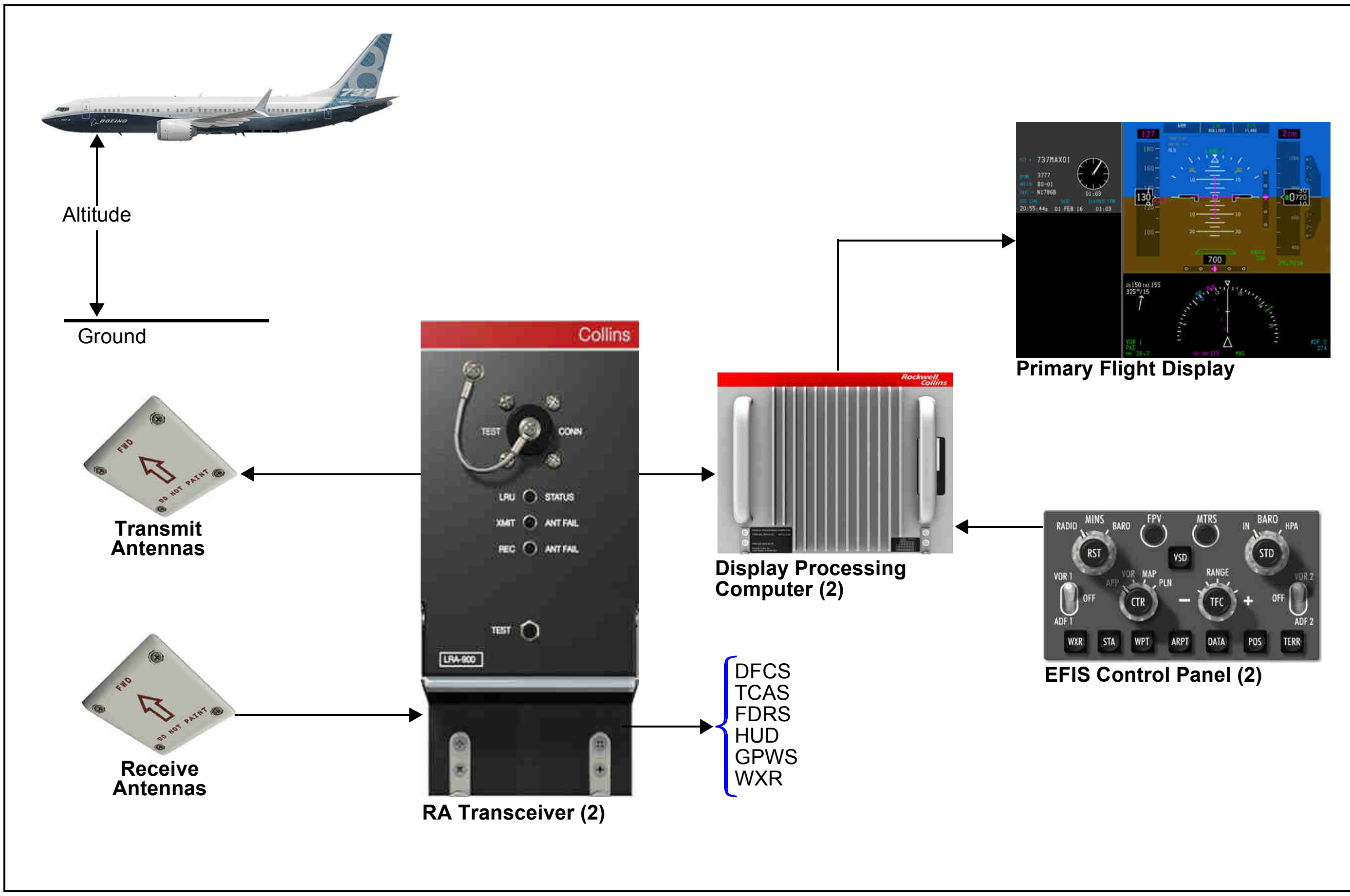
The audio is a station identifier or a broadcast from a radio station. Some ADF stations also supply weather information.

The ADF system has these components:

- ADF receiver
- Control panel
- Combined loop and sense antenna.

You can tune the ADF receiver to receive and calculate bearing to any radio transmitter with a frequency between 190 and 1750 kHz.

Bearing shows on the MAX display system display units and the head-up display (HUD). The receiver sends audio to the remote electronics unit (REU).



Radio Altimeter System

The radio altimeter (RA) system gives the pilots and airplane systems the altitude of the airplane above the ground or above ground level (AGL). The RA system operates from 0 to 2500 feet.

The system has two RA transceivers. Each transceiver has a transmit antenna and a receive antenna. The transmit antenna sends a signal to the ground which comes back to the receive antenna.

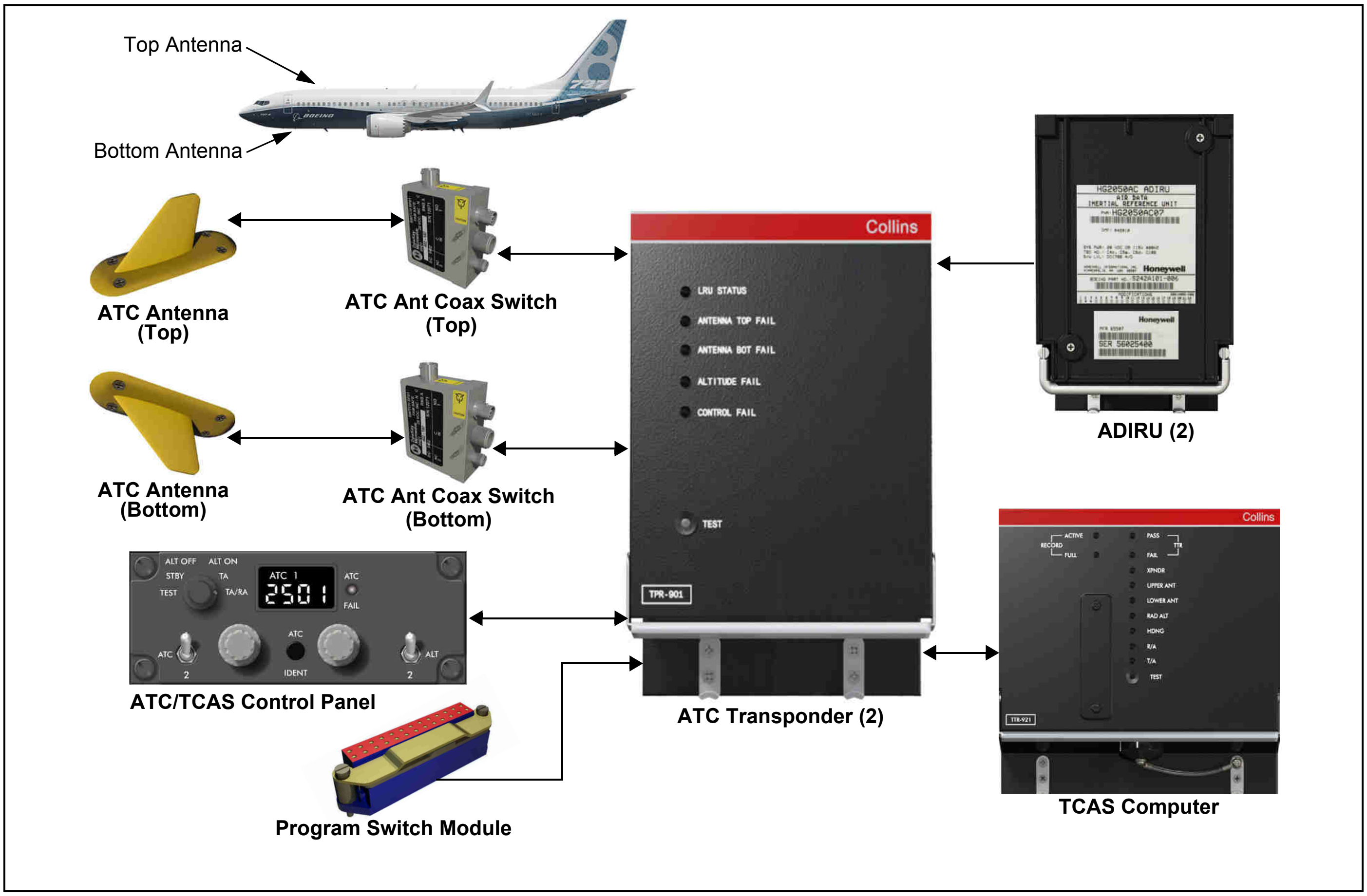
The transceiver uses the time between transmission and reception to calculate the altitude above the ground. Radio altitude shows on the MAX display system (MDS) display units when radio altitude is 2500 feet or less.

These units use radio altitude:

- MAX display system display processing computer (MDS DPC)
- Digital flight control system (DFCS)
- Traffic alert and collision avoidance system (TCAS) computer
- Flight data recorder system (FDRS)
- Head-up display (HUD) computer
- Weather radar (WXR) transceiver
- Ground proximity warning system (GPWS).

Each pilot can set a radio minimums altitude on the EFIS control panel. The radio minimums shows on the MDS display unit and on the HUD. When the radio altitude is equal to or less than the radio minimums, the radio minimums and radio altitude change color and size, and momentarily flash.

Navigation



Air Traffic Control System

The air traffic control (ATC) system has the airborne components that the traffic alert and collision avoidance system (TCAS) computers and the ground facilities use to track the airplane movement.

The ATC transponder replies to interrogation signals from the ground and from TCAS airplanes. The reply to most ground stations is airplane code (mode A) or airplane altitude (mode C).

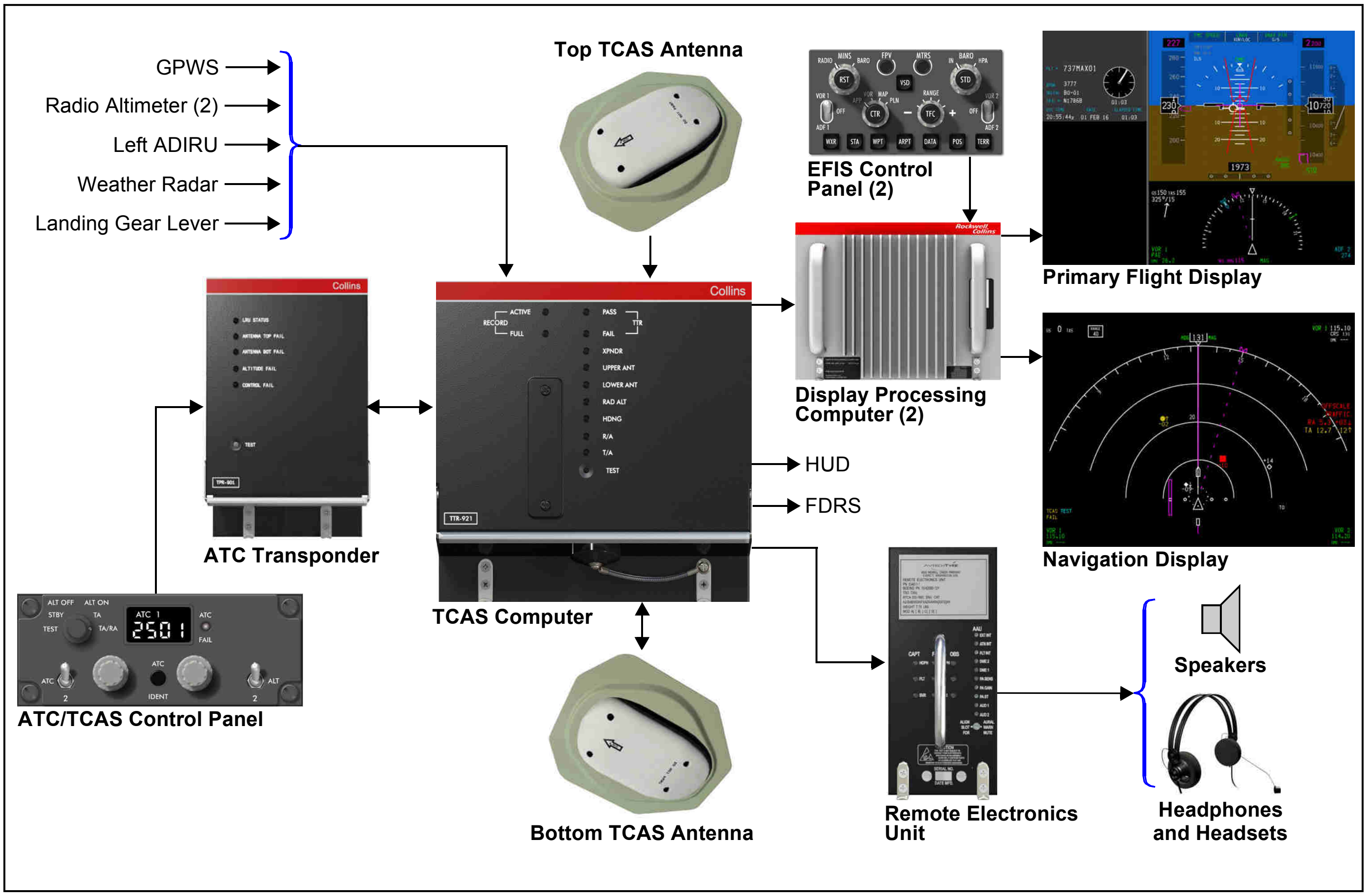
Selective calling (mode S) ground stations enhance the operation of the ATC system because it adds a discrete interrogation capability and a data link feature.

You use the ATC control panel to set the airplane code, select transponder 1 or 2 and start an identification pulse. The altitude source select switch on the control panel selects the air data inertial reference unit (ADIRU) that supplies altitude to the transponder.

Only one ATC transponder is active at a time. Antenna switches connect the ATC antennas to the active transponder.

A program switch module supplies the airplane identification data to the transponder.

The ATC transponder also works with TCAS.



Traffic Alert and Collision Avoidance System

The traffic alert and collision avoidance system (TCAS) gives aural and visual indications to the flight crew. The indications are advisories. The traffic display shows other airplanes and possible collision conditions.

TCAS uses the ATC/Mode S transponder system to send TCAS data to other TCAS airplanes.

The TCAS system has these units:

- TCAS computer
- Top antenna
- Bottom antenna
- Mode S ATC transponders (2)
- ATC control panel.

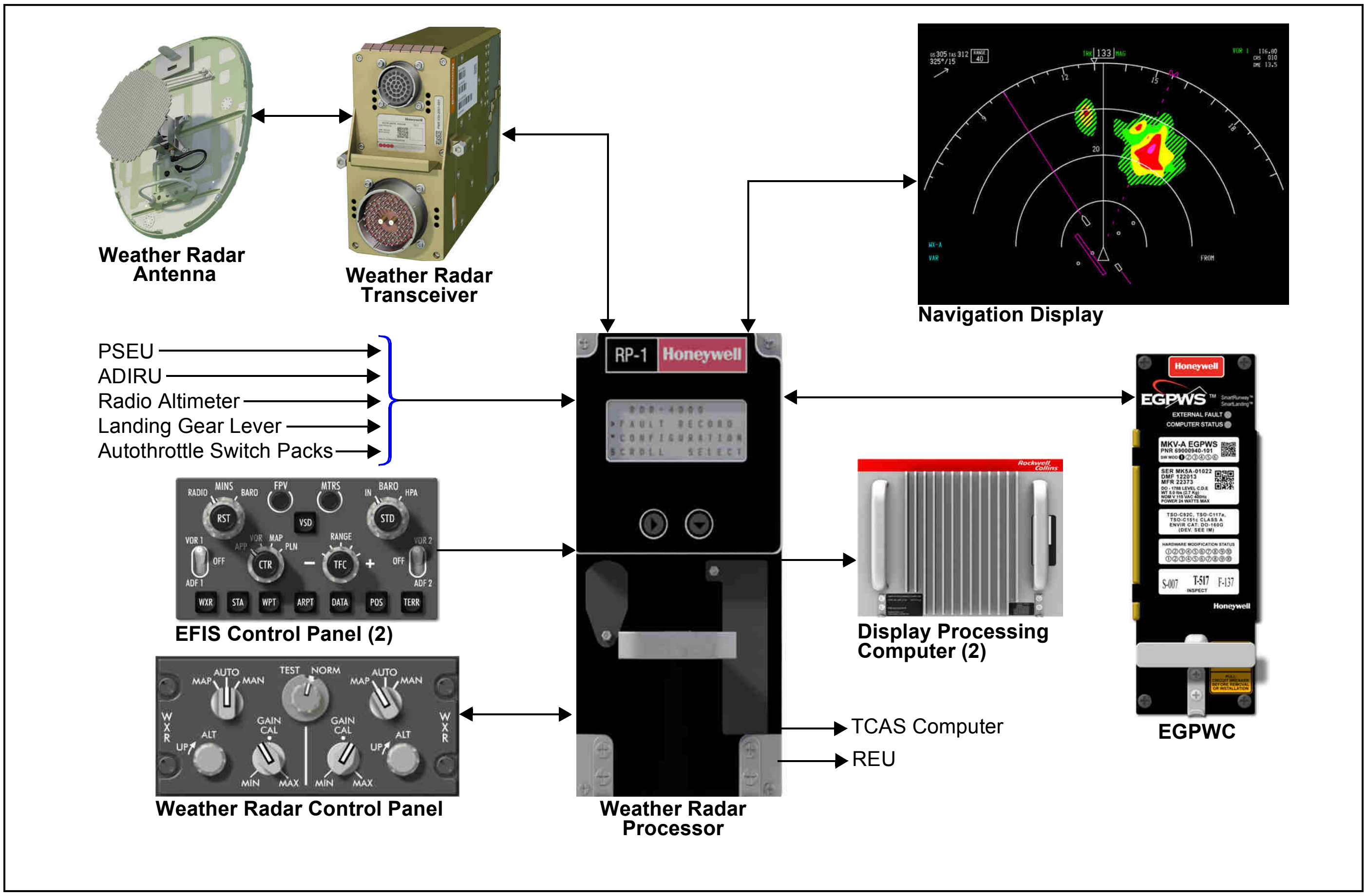
TCAS gives two types of advisories to the pilots. One type is the traffic advisory (TA) which tells of other airplanes in the area. The other type of advisory is the resolution advisory (RA). The RA gives the pilots directions to prevent a collision.

The TCAS computer sends data to the display processing computers (DPC) and the head-up display (HUD) computer. You push the traffic button on the EFIS control panel to show the location and track of other airplanes on the display units. The display units also show the pilots how to change or maintain vertical speed to prevent a collision. TCAS sends aural alerts to the flight compartment through the remote electronics unit.

The ground proximity warning system (GPWS) alerts have higher priority than TCAS advisories. When the two systems give warnings at the same time, you do not hear the TCAS warning.

The left air data inertial reference unit (ADIRU) gives heading data to the TCAS computer.

TCAS uses radio altitude to change the range limits of advisories at low altitudes. Radio altitude also helps TCAS to know if an airplane is on the ground.



Weather Radar System

The weather radar system shows the weather and non-clear air turbulence conditions along the flight path of the airplane. Weather can be shown out to a range of 320 nautical miles (NM). Non-clear air turbulence can be shown out to a range of 60 NM.

The weather radar transceiver sends weather data to the MAX display system display processing computers (MDS DPC). The DPC shows weather radar on the display units in five colors. The five colors define these conditions:

- Green - light weather
- Yellow - moderate weather
- Red - heavy weather
- Magenta - turbulence

The WXR button on the EFIS control panel is used to show weather radar on the onside MDS display unit.

The pilots use the weather radar control panel to set these functions:

- Mode of operation
- Gain control
- Antenna tilt angle.

The weather radar uses attitude signals from an air data inertial reference unit (ADIRU) to stabilize the antenna scan.

The weather radar transceiver uses EFIS control panel range for display of weather data on the display units. The pilots can set a different range on each EFIS control panel.

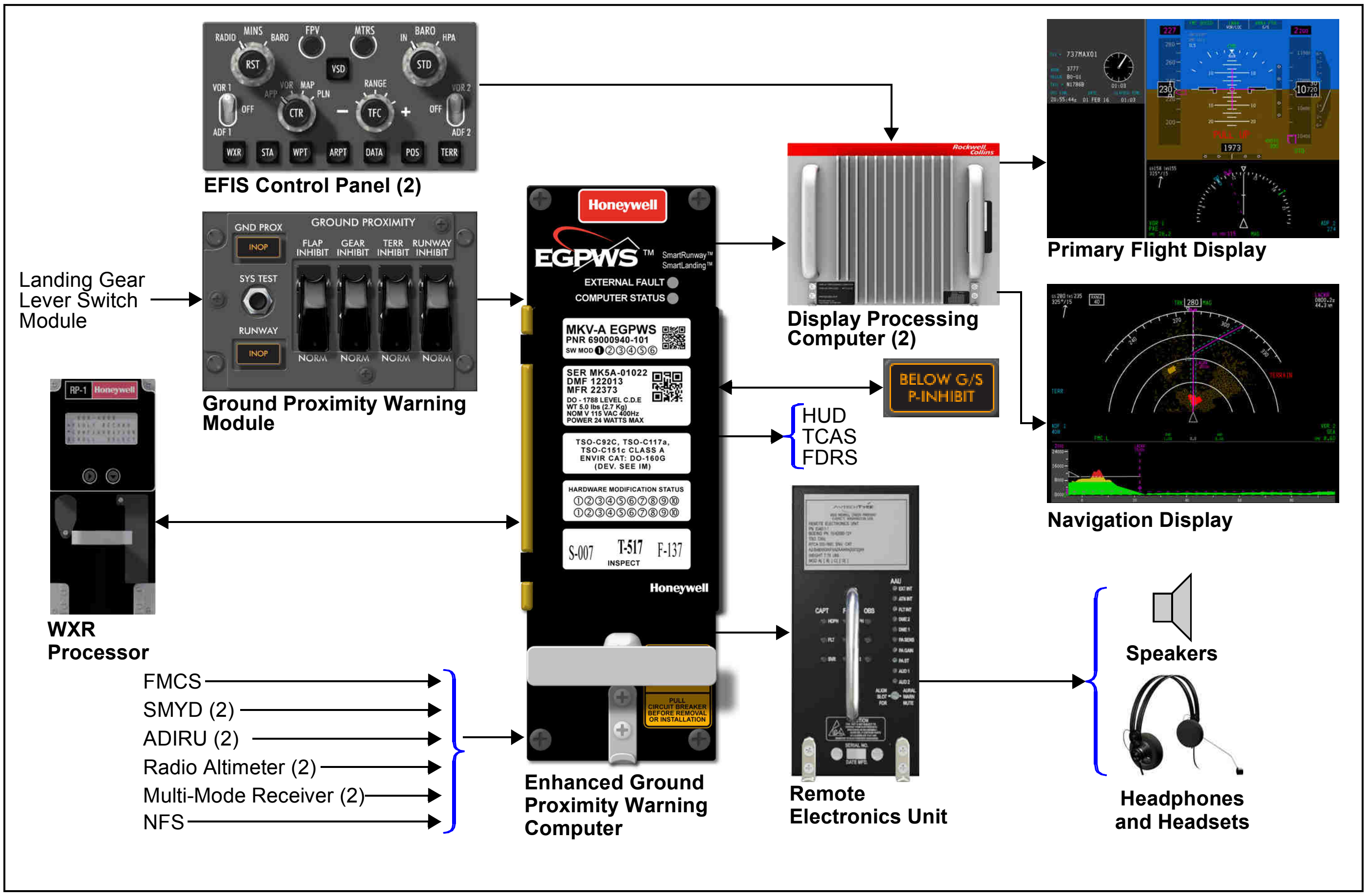
The weather radar system can show predictive windshear (PWS) messages on the display units.

PWS uses inputs from the radio altimeter and ADIRU to detect a windshear condition. PWS uses inputs from the proximity switch electronics unit (PSEU), landing gear lever switch and autothrottle switch packs to determine if the airplane is in a takeoff or approach mode.

PWS supplies information to the enhanced ground proximity warning system (GPWS) computer for types of messages and message priority. The GPWS computer supplies audio inhibit signals to the PWS function in the weather radar transceiver.

These are the different PWS annunciations that show on the display units:

- Windshear caution (yellow)
- Windshear warning (red)
- Windshear symbol bars (black and red)
- Windshear attention bars (yellow).



Enhanced Ground Proximity Warning System

The enhanced ground proximity warning system (EGPWS) gives the pilots aural and visual warnings of unsafe conditions. The warnings continue until the pilots correct the condition. The system operates when the airplane is less than 2450 feet above the ground.

The EGPWS displays terrain forward of the airplane and also alerts the flight crew of early descent when landing. The ground proximity warning computer sends terrain data to the common display system to show on the navigation displays.

The EGPWS uses inputs from these units to calculate warning conditions and for software loading:

- Landing gear lever switch module
- Radio altimeters
- Flight management computers (FMC)
- Air data inertial reference units (ADIRU)
- Stall management yaw damper (SMYD) computers
- Multi-mode receivers (MMR).
- Network file server (NFS).

There are inhibit switches on the ground proximity module. These prevent certain warnings and displays.

The FLAP INHIBIT switch sends a flaps down signal to the EGPWC.

The GEAR INHIBIT switch sends a landing gear down signal to the EGPWC.

The TERR INHIBIT switch stops the terrain information on the navigation displays.

The RUNWAY INHIBIT switch stops the runway awareness and advisory system (RAAS).

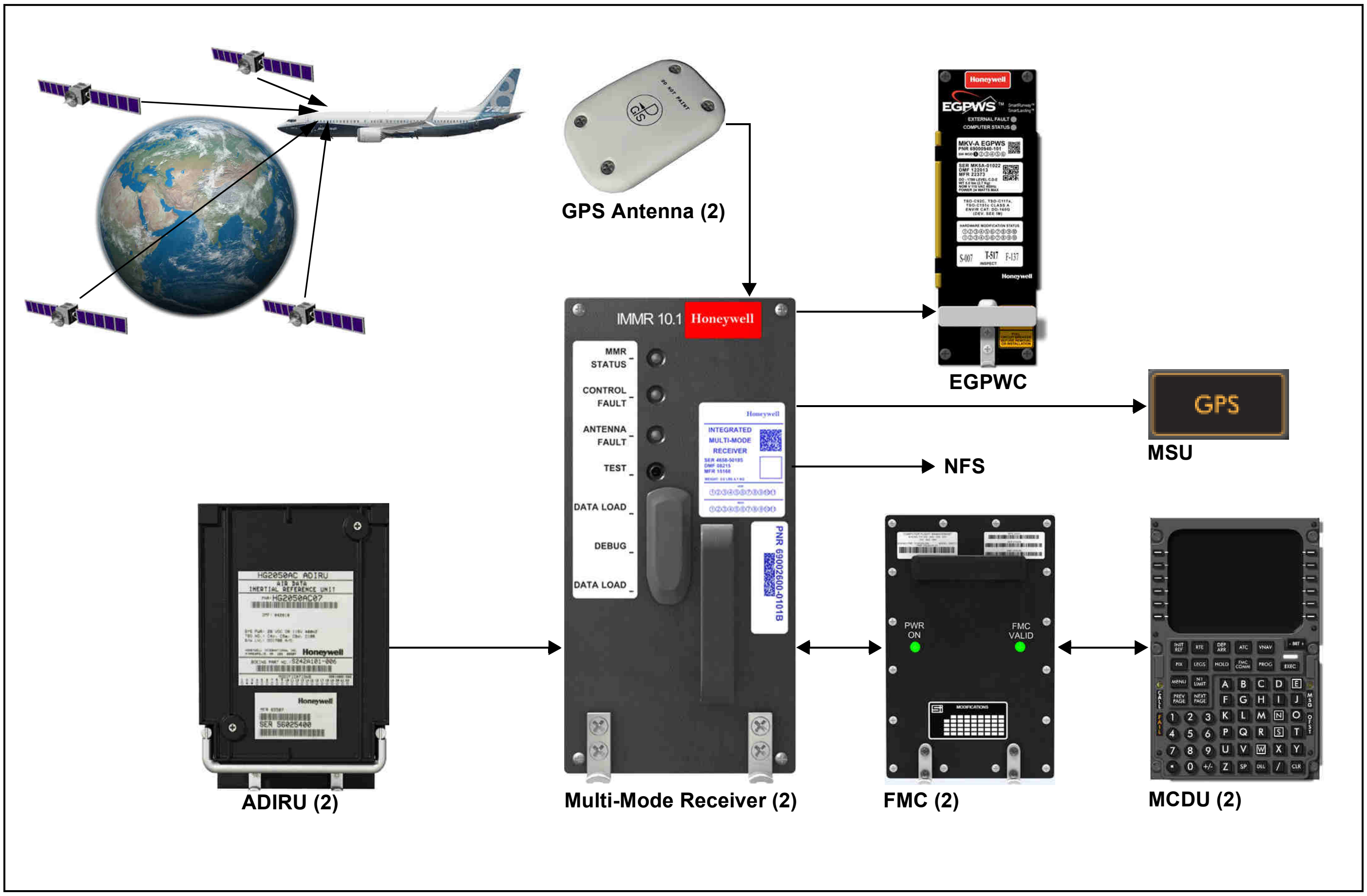
Many EGPWS visual cautions and warnings show on the MAX display system (MDS) display units and the head-up display (HUD) combiner. The below glideslope caution shows on the BELOW G/S annunciators. EGPWS aural warnings go through the remote electronics unit to the pilot headsets and speakers. The flight data recorder system records EGPWS cautions and warnings.

The EGPWS supplies a signal to the traffic alert and collision avoidance system (TCAS) to inhibit TCAS alerts when the two systems have an alert at the same time.

The weather radar (WXR) system sends predictive windshear (PWS) cautions and warnings to the EGPWS. The EGPWS uses this data to set the priority for PWS and

BOEING PROPRIETARY

EGPWS cautions and warnings. The EGPWS can send an inhibit signal to the WXR system to stop PWS aural annunciations.



Global Positioning System

The global positioning system (GPS) is a satellite radio navigation aid. The GPS receivers are in the intergrated multi-mode receivers (IMMR).

The GPS uses navigation satellites to give accurate airplane position to the flight management computers (FMC) and enhanced ground proximity warning computer (EGPWC). The GPS also gives accurate time and date data to the captain and first officer clocks and the network file server (NFS).

The air data inertial reference units (ADIRU) give inertial reference position data to the GPS. The GPS can use this position data to align more quickly. The GPS also uses this position data for certain modes of operation.

The MMR calculates these values:

- Airplane latitude
- Airplane longitude
- Airplane altitude
- Accurate time/date.

The FMC uses GPS data to help calculate airplane present position. The FMC multi-function control display unit (MCDU) shows GPS present position. The pilots can turn off the use of GPS data in FMC calculations with the FMC MCDU.

System faults will cause the GPS light on the Mode Select Unit (MSU) to come on.

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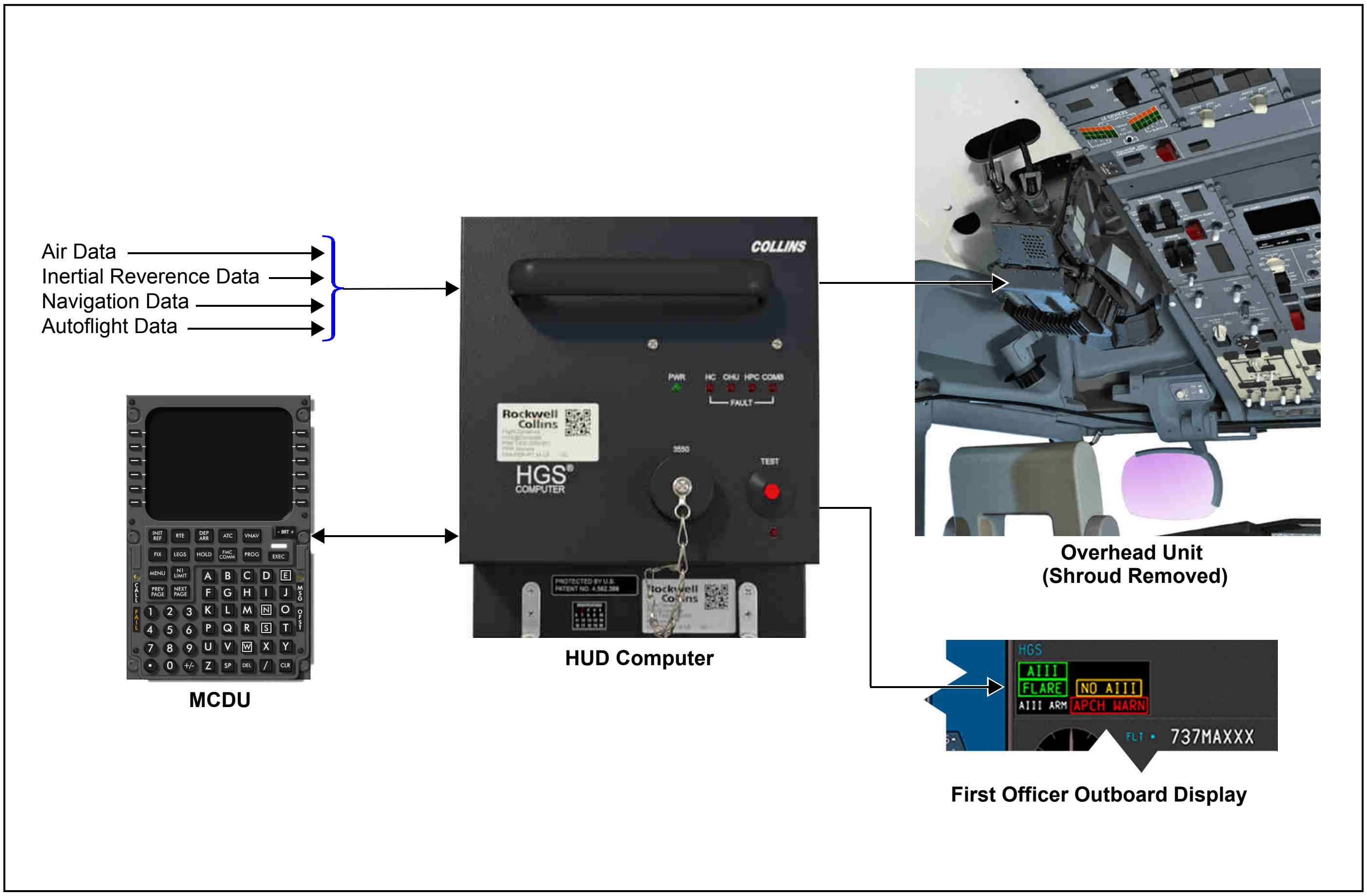


Head-Up Display System

OPERATION

The head-up display (HUD) system shows flight and guidance symbols. The flight crew uses the HUD for low visibility takeoffs and CAT IIIa approach and landings.

These components are in the HUD system:

- Computer
- MCDU
- Overhead unit (OHU)
- Combiner.

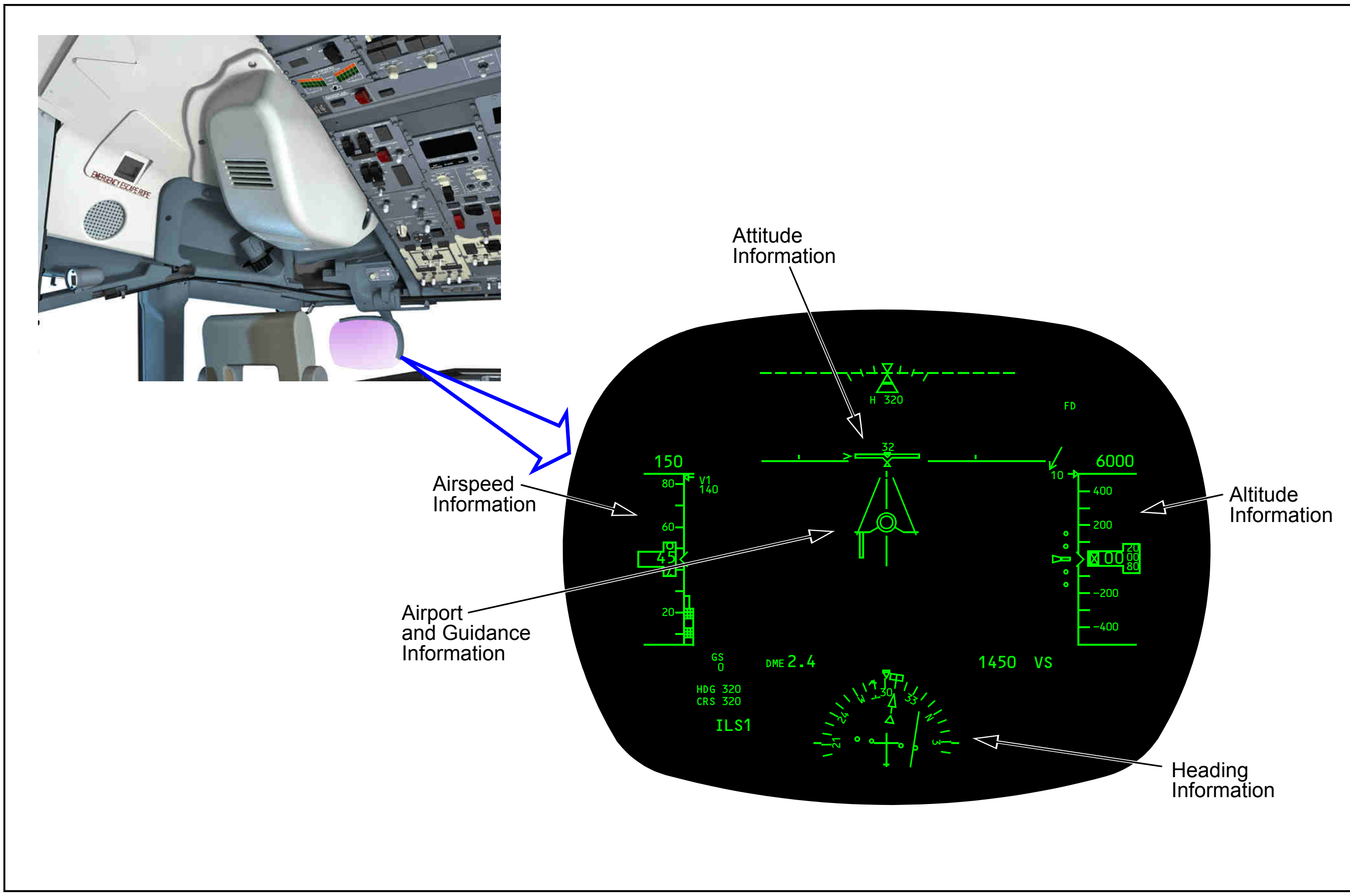
The HUD computer uses sensor data from other airplane systems to calculate the symbols and their position on the combiner.

There is a liquid crystal display (LCD) projector and an optics projection assembly in the overhead unit. These components project the symbols onto the combiner.

The combiner is a glass plate assembly. The assembly has two ground glass outer pieces with a special thin clear coating between them. The special coating reflects only the green symbol displays from the LCD. The combiner optically combines the symbols with the view through the captain windshield. The combiner also contains brightness controls.

Status and warning annunciations show on the outboard region of the First Officer's outboard display. The display supplies the First Officer with changes in HUD status during manual ILS approach and landing operations to CAT IIIa minimums.

The flight crew uses the MCDU to select and show HUD modes and to enter data. Maintenance personnel use the MCDU to operate system BITE.



Head-Up Display System

The graphic shows an example of the primary (PRI) display.

The horizon line shows an artificial horizon. When the horizon line and airplane reference symbol overlap, the airplane is in a level, zero degree pitch attitude.

Airplane reference shows the projected centerline of the airplane. The function of this symbol is equivalent in operation to the airplane symbol on a standard EADI.

Airspeed shows on the left side of the combiner.

Barometric altitude shows on the right side of the combiner.

A pitch scale shows above and below the horizon line.

The roll scale and pointer are above the airplane reference symbol. The scale shows bank angle.

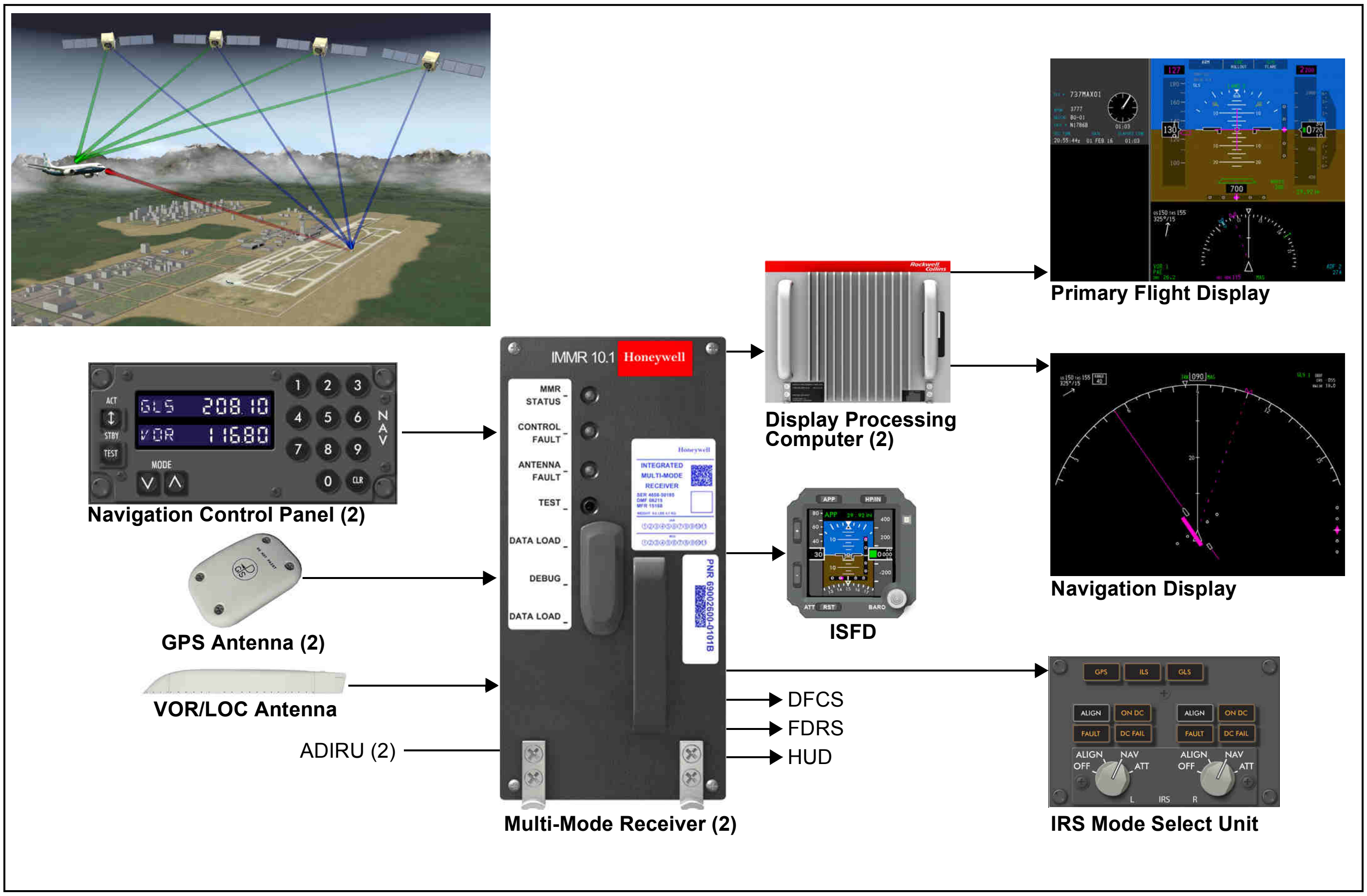
The flight path symbol shows the flight path vector of the airplane. This symbol gives an instant indication of where the airplane is going. The pilot can operate the airplane and fly a flight path to a desired point.

The guidance cue functions the same way as an integrated cue flight director. For the pilot, the objective is to capture the guidance cue inside the flight path symbol circle with pitch and roll control inputs.

Selected speed shows the airspeed the pilot sets on the digital flight control system mode control panel (MCP). It also shows the airspeed command set by the flight management computer system.

Selected altitude shows the altitude set on the MCP.

Navigation



GNSS Landing System

The global navigation satellite system (GNSS) landing system (GLS) uses satellite and ground-based navigation stations to give lateral and vertical guidance during landing. The GLS receivers are in the integrated multi-mode receivers (IMMRs).

These are the primary components of the GLS:

- Integrated multi-mode receiver (MMR)
- Navigation control panels (NCP)
- Dual VOR/LOC antenna
- Global positioning system (GPS) antennas.

The GLS receives GPS signals through the GPS antennas. These give position, velocity and time data for the GLS function.

The dual VHF omnidirectional ranging/localizer (VOR/LOC) antenna receives the VHF data broadcast (VDB) signals from the ground-based augmentation station (GBAS). This gives the differential corrections for the calculation of the GLS guidance commands.

The GBAS is near an airport and has a range of approximately 25 nautical miles. GBAS has reference GPS receivers that compare the GPS position with the location of the GBAS facility. Corrections are calculated and transmitted to an airplane on a VHF data broadcast (VDB) data link.

One GBAS can supply multiple landing approach data to different runways at an airport. This is based on the channel number selected on the NCP.

An airplane uses correct position data to make deviation displays on the primary flight displays, attitude indicators and navigation displays.

Navigation control panels provide channel selection. Air data inertial reference units (ADIRU) provide inertial data for GLS guidance.

These systems use GLS data:

- Digital flight control system (DFCS)
- MAX display system (MDS)
- Integrated standby flight display (ISFD)
- Flight data recorder system (FDRS)
- Head-up display (HUD) system.

Status of the GLS is annunciated on the IRS mode select unit.

Features

FLIGHT MANAGEMENT COMPUTER SYSTEM (FMCS)

The FMCS allows preplanned flight profile control and guidance for best performance and performance management.

DIGITAL FLIGHT CONTROL SYSTEM (DFCS)

The DFCS includes these functions:

- Autopilot
- Flight director
- Mach trim
- Speed trim
- Altitude alert.

AUTOTHROTTLE FUNCTION

The autothrottle controls the engines independently to get the best performance.

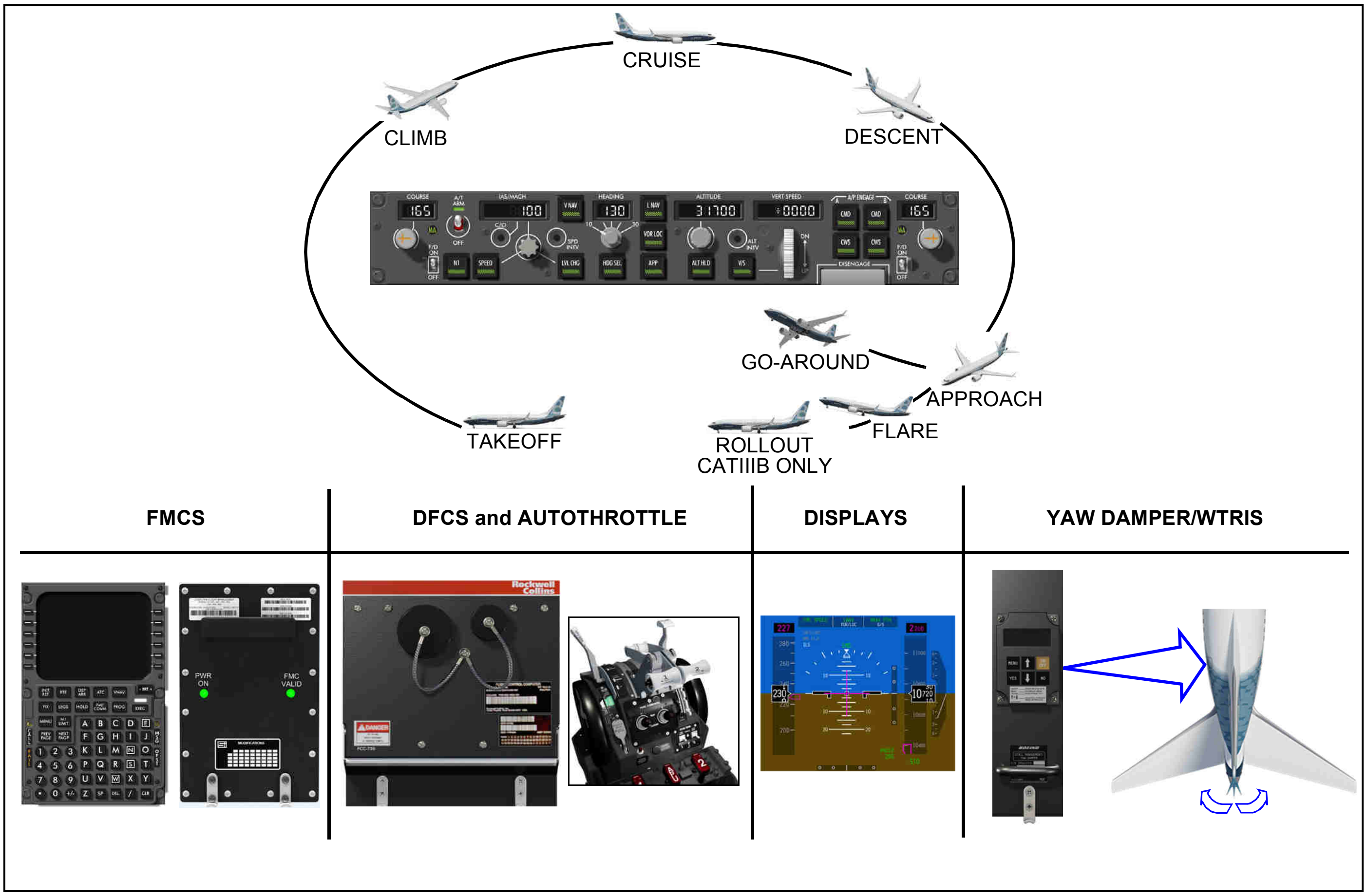
BUILT-IN TEST EQUIPMENT (BITE)

The BITE system gives fast and accurate troubleshooting of the main flight management system (FMS) components.

YAW DAMPER/WHEEL TO RUDDER INTERCONNECT SYSTEM (WRTIS)

The yaw damper decreases the yaw rates associated with dutch roll and turbulence. The WTRIS assists manual turns when both A and B hydraulic systems are in standby.

Autoflight



Autoflight Systems

The autoflight system is made up of these systems:

- Flight management computer system (FMCS)
- Digital flight control system (DFCS)
- Autothrottle system (A/T).

This group of systems operate together to decrease flight crew workload and provide automatic flight control and automatic landing capability.

Autoflight status information is displayed on the common display system display units and autoflight status annunciators.

There are two stall management yaw dampers (SMYD) installed which perform the yaw damper functions and also the wheel to rudder interconnect system (WTRIS).

FLIGHT MANAGEMENT COMPUTER SYSTEM (FMCS)

The central part of the flight management system are the two flight management computers (FMC).

The flight crew uses the multifunction control display unit (MCDU) to enter the route and performance data for the flight. The FMCs calculate the lateral and vertical components of the flight. It then sends these guidance commands to the DFCS to follow the flight plan.

DIGITAL FLIGHT CONTROL SYSTEM (DFCS)

The DFCS includes the autopilot, flight director, altitude alert, speed trim and mach trim functions. The DFCS can use commands from the FMCS or the flight crew can use the DFCS mode control panel (MCP) to control the airplane.

AUTOTHROTTLE (A/T) SYSTEM

The A/T system controls the engine thrust levers. The FMC sends thrust and speed targets to the autothrottle for best overall flight performance. The autothrottle function is inside the flight control computer A (FCC A).

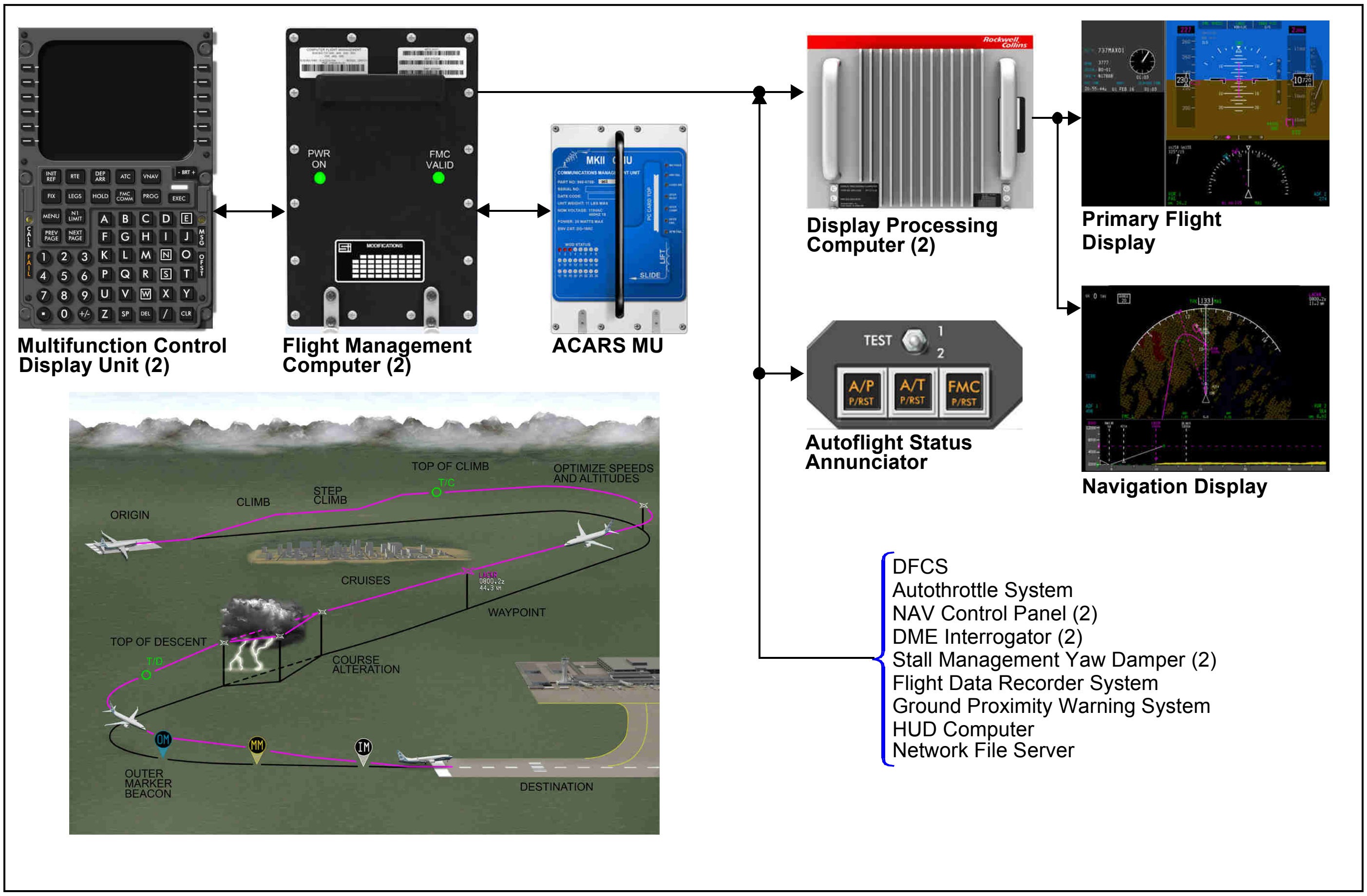
YAW DAMPER/WTRIS FUNCTION

The yaw damper gives commands to the rudder to decrease yaw rates from dutch roll and turbulence.

The WTRIS assists manual turns when only the standby hydraulic system is available.

BUILT IN TEST EQUIPMENT

The design of the system permits fast, accurate trouble-shooting and maintenance.



Flight Management Computer System (FMCS)

The flight management computer (FMC) is the main component of the flight management computer system. The flight crew uses the multifunction control display unit (MCDU) to enter the route and performance data for the upcoming flight. With this flight plan data and inputs from airplane sensors, the FMC performs these functions:

- Navigation
- Performance
- Guidance.

An optional connection to the aircraft communication and reporting system (ACARS) is available. It lets the FMC receive flight plan data from a ground station and send flight status to the ground station.

NAVIGATION FUNCTION

The navigation data base in the FMC memory includes all the navigation data for the area of operation. This data base is updated every 28 days. The pilot can preselect the entire flight plan from the navigation data base. Also, the flight crew can have the FMC fly an offset from the route. The required time of arrival (RTA) function is also available.

The FMC calculates the airplane position as the flight continues. It uses the inertial reference function and navigation aids, if available, to calculate the position. The FMC compares the calculated position with the planned position. Any deviation shows on the common display system.

PERFORMANCE FUNCTION

A performance data base in the FMC contains a performance model of the airplane and the engines. The flight crew enters gross weight, cruise altitude and cost index for the flight. The FMC uses this data to calculate the best economy speeds, best flight altitude and top of descent point. The MCDU and the flight displays show the target speeds and altitudes.

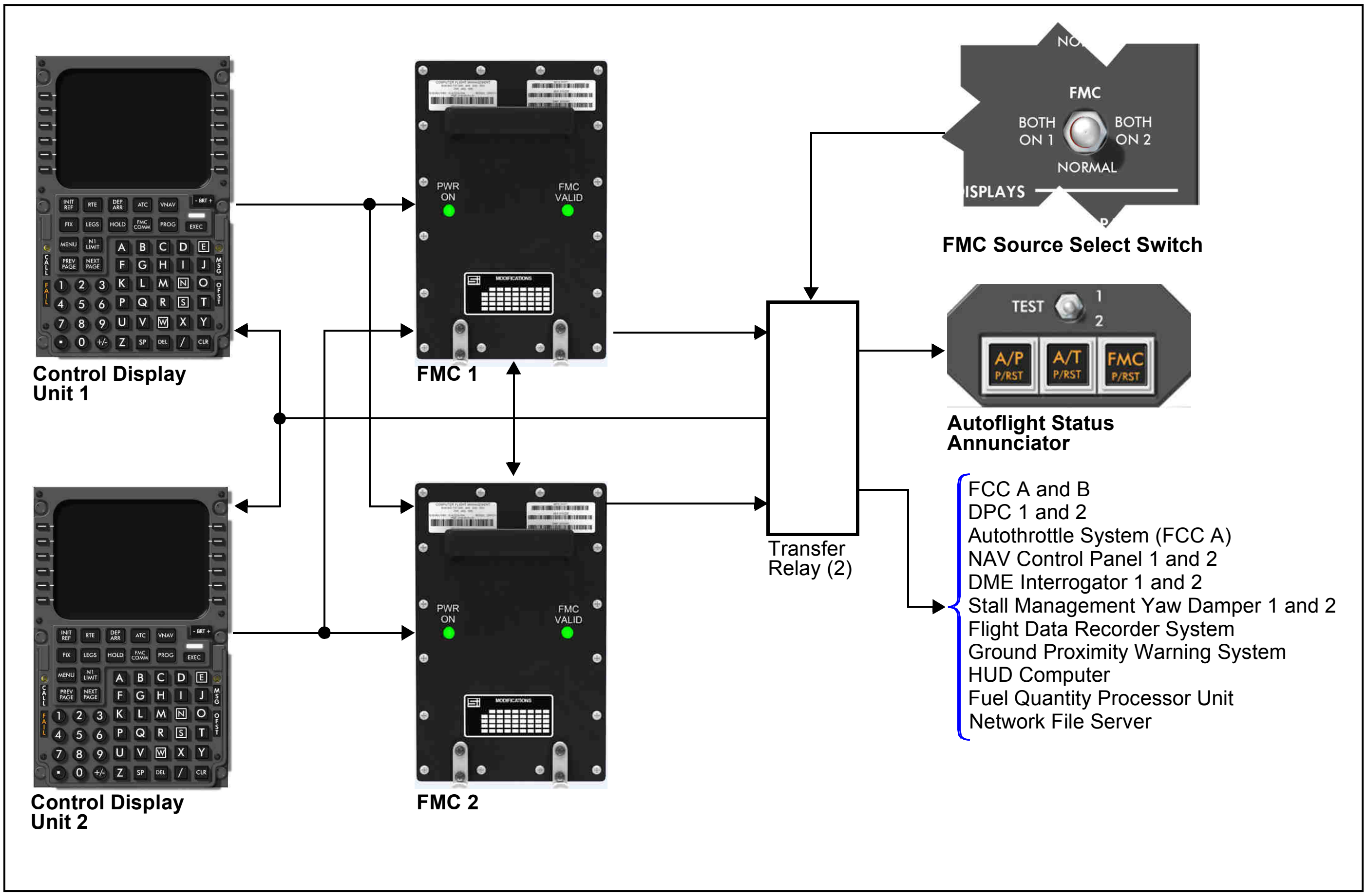
GUIDANCE FUNCTION

The FMC sends commands to the digital flight control system (DFCS) and the autothrottle (A/T) function. The DFCS and the A/T use these signals to control the airplane in the lateral (LNAV) and vertical (VNAV) parts of the flight plan.

Autoflight

BUILT-IN TEST EQUIPMENT (BITE)

The maintenance technician uses the MCDU to operate BITE for the FMC.



Flight Management Computer System

Dual is the usual flight management computer system (FMCS) configuration in the airplane. The main components are two flight management computers (FMC), two multifunction control display units (MCDU) and two transfer relays.

Each FMC calculates position data with different sets of navigation aids and ADIRU inputs. If navigation aids are not available, the FMCs only use separate ADIRU inputs for the calculation. The FMCs combine their calculations to calculate a best position. Both FMCs transmit this best position to the MDS and other user systems.

One FMC is the primary FMC and the other is the secondary. A transfer switch controls the system configuration through transfer relays. When the transfer switch is in NORMAL or BOTH ON LEFT, FMC 1 is primary and FMC 2 is secondary. When the transfer switch is in BOTH ON RIGHT, FMC 2 is primary and FMC 1 is secondary.

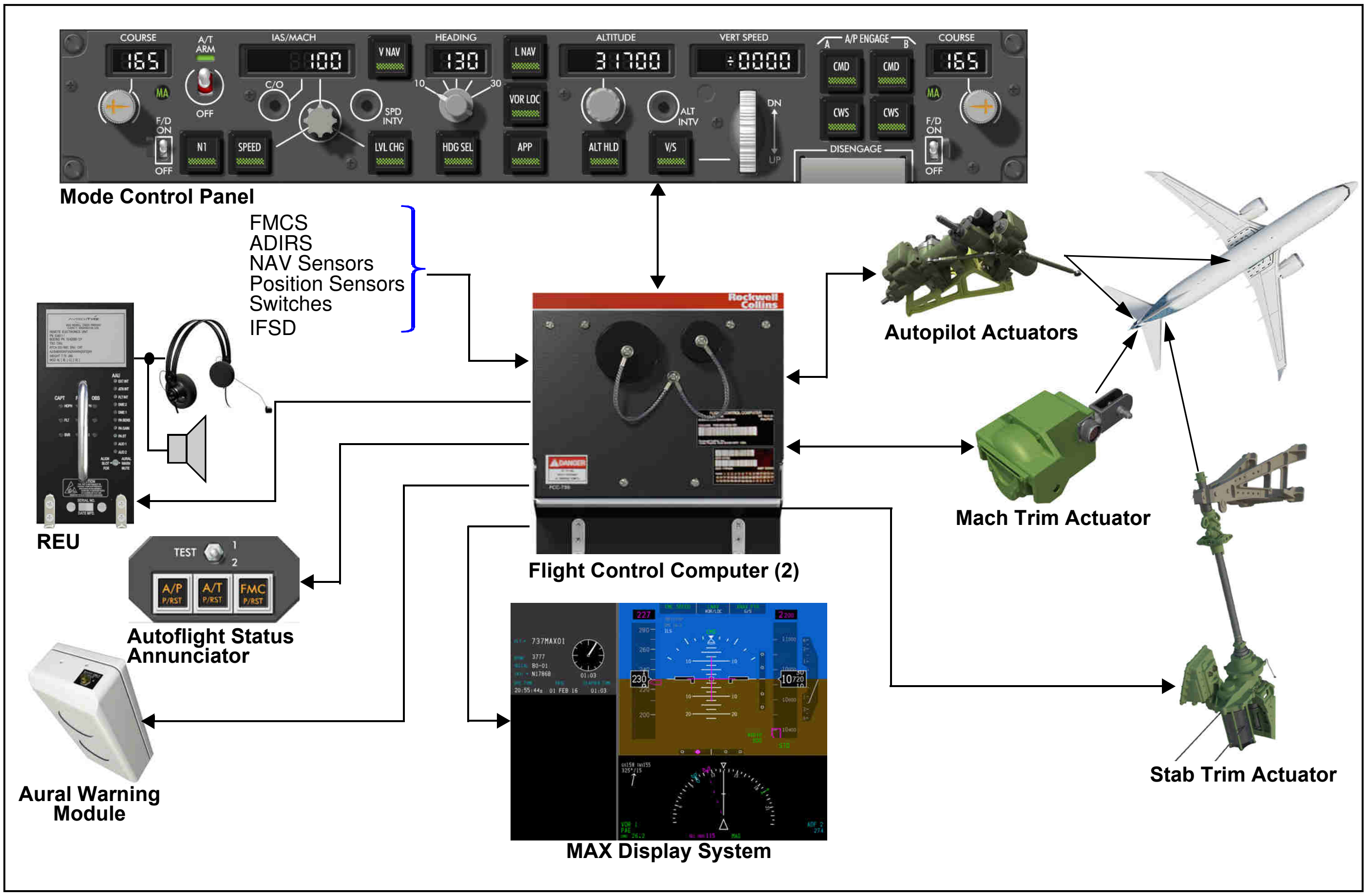
When the transfer switch is in NORMAL, FMC 1 sends data to all single systems and to the number 1 system of dual systems. The data from FMC 2 goes to the number 2 system of dual systems.

When the transfer switch is in BOTH ON LEFT, FMC 1 is the source for all outputs. When the transfer switch in BOTH ON RIGHT, FMC 2 is the source for all outputs.

The output of each MCDU connects to both FMCs. The primary FMC processes the MCDU inputs and sends the data to the secondary FMC. The display on both of the MCDUs is from the primary FMC.

The two FMCs compare inputs and outputs at all times. A large difference between the two causes the secondary FMC to conditionally fail and to alert the flight crew.

Autoflight



Digital Flight Control System (DFCS)

Two independent flight control computers (FCC) control these functions:

- Autopilot
- Flight director
- Altitude alert
- Mach trim
- Speed trim.

AUTOPILOT/FLIGHT DIRECTOR

The flight crew uses the mode control panel (MCP) to control the autopilot and the flight director. The flight crew engage the autopilot, turns on the flight director, selects the modes and selects the targets on the MCP.

For the autopilot function, the FCC sends commands to the autopilot aileron and elevator actuators to control the flight control surfaces. For the flight director function, the FCC sends pitch and roll guidance commands to the common display system. The status and the mode of operation of the autopilot and the flight director show on the common display system.

ALTITUDE ALERT

The altitude alert function uses the altitude selected on the MCP. The FCC alerts the flight crew when the airplane approaches or departs the selected altitude. There is an aural alert from the remote electronics unit (REU) and a visual alert on the common display system.

MACH TRIM AND SPEED TRIM

Mach trim and speed trim functions operate with no flight crew input.

For mach trim, the FCC controls the mach trim actuator. It moves the elevator to increase airplane stability at high air speeds.

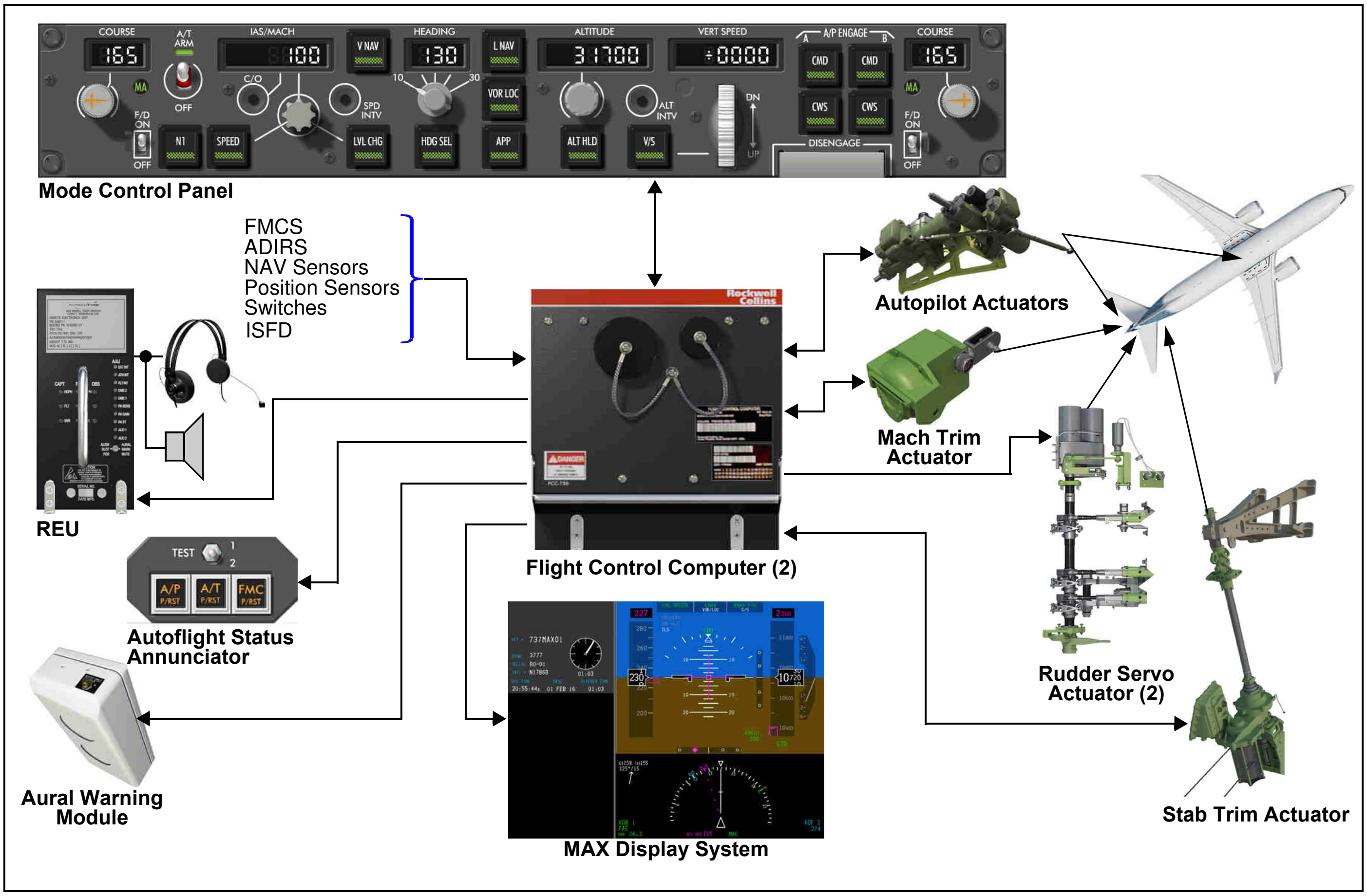
For speed trim, the FCC controls the stabilizer trim electric actuator. It moves the stabilizer to increase airplane stability at low air speeds.

DISENGAGE WARNING

There is a visual and an aural warning to alert the flight crew if the autopilot disengages. A red light on the autoflight status annunciator and the wailer from the aural warning module give the warning.

BITE

The flight control computer provides accurate, reliable, and fast built-in test (BITE) capability using the multifunction control display units (MCDU).



Digital Flight Control System with Category IIIB capability

The DFCS with Category IIIB Capability performs all the functions described earlier, and it also can operate in any weather up to and including CATIIIB weather minimums.

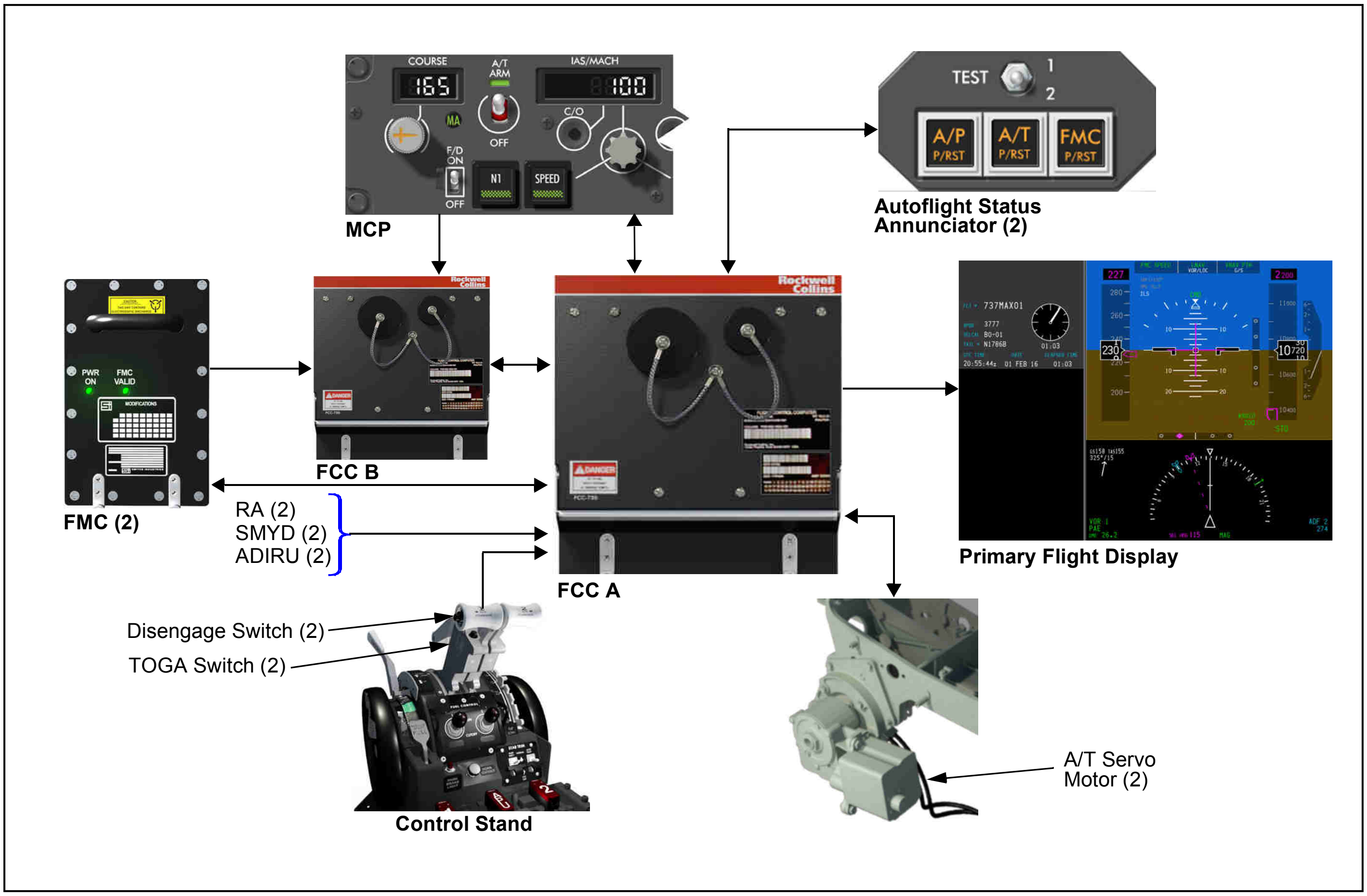
In this way, the DFCS operates as a fail operational system capable of completing approach, flare, touchdown and rollout maneuvers.

In order to be fail operational, the flight control computers (FCC) receive additional inertial reference data from the integrated standby flight display (ISFD).

In order to perform rollout maneuvers, the FCCs send signals to a rudder servo actuator.

Without this option activated, the DFCS operates as a fail passive system capable of completing approach, flare and touchdown maneuvers.

Autoflight



Autothrottle

The autothrottle (A/T) system can control the thrust levers from takeoff to touchdown. It gives maximum fuel conservation through smooth, precise thrust control. Like other flight management sub-systems, the autothrottle design gives maximum operational and cost benefits.

The A/T function is in flight control computer A (FCC A). The autothrottle operates the thrust levers through two independent servomotors. The A/T controls the engines independently to get the best performance from each engines. These are the A/T controls in the flight compartment:

- Arm switch on the mode control panel (MCP) arms the autothrottle
- Takeoff/go-around (TO/GA) switches select the takeoff or go-around modes
- Disengage switches disengage the autothrottle
- Mode select push-buttons on the MCP select thrust or speed control.

The flight crew can select the A/T mode with the mode select push-buttons on the MCP. Usually the digital flight control system selects the correct autothrottle mode for the flight phase. The active autothrottle mode shows on the common display system.

The A/T moves the thrust levers to control thrust or airspeed.

For thrust control, the FMC calculates the correct thrust setting for the flight phase.

For airspeed control, the A/T accepts mach and airspeed commands from the FMC or MCP. The A/T operates with the electronic engine control to give improved performance.

A light on the autoflight status annunciator gives a visual warning if the autothrottle disengages.

The autothrottle system has built-in test. This lets you do fast accurate maintenance. You do the tests of the autothrottle system with the MCDU. From the MCDU, you can select these functions:

- Current status
- Inflight faults
- Interactive
- Ident/Config.

Mode Control Panel

Control Stand

MAX Display System

Autoflight Displays and Controls

Mode selection and system engage switches for the autopilot, flight director and autothrottle are on the mode control panel (MCP).

The TO/GA switches select takeoff and go-around modes. They are on the thrust levers. The engage status and mode of operation show on the display units.

The takeoff mode is a combined flight director and autothrottle mode. The autothrottle sets engine thrust to the target value calculated by the flight management computer (FMC). The flight director gives commands to control the rate of climb and then to control the selected airspeed set on the MCP.

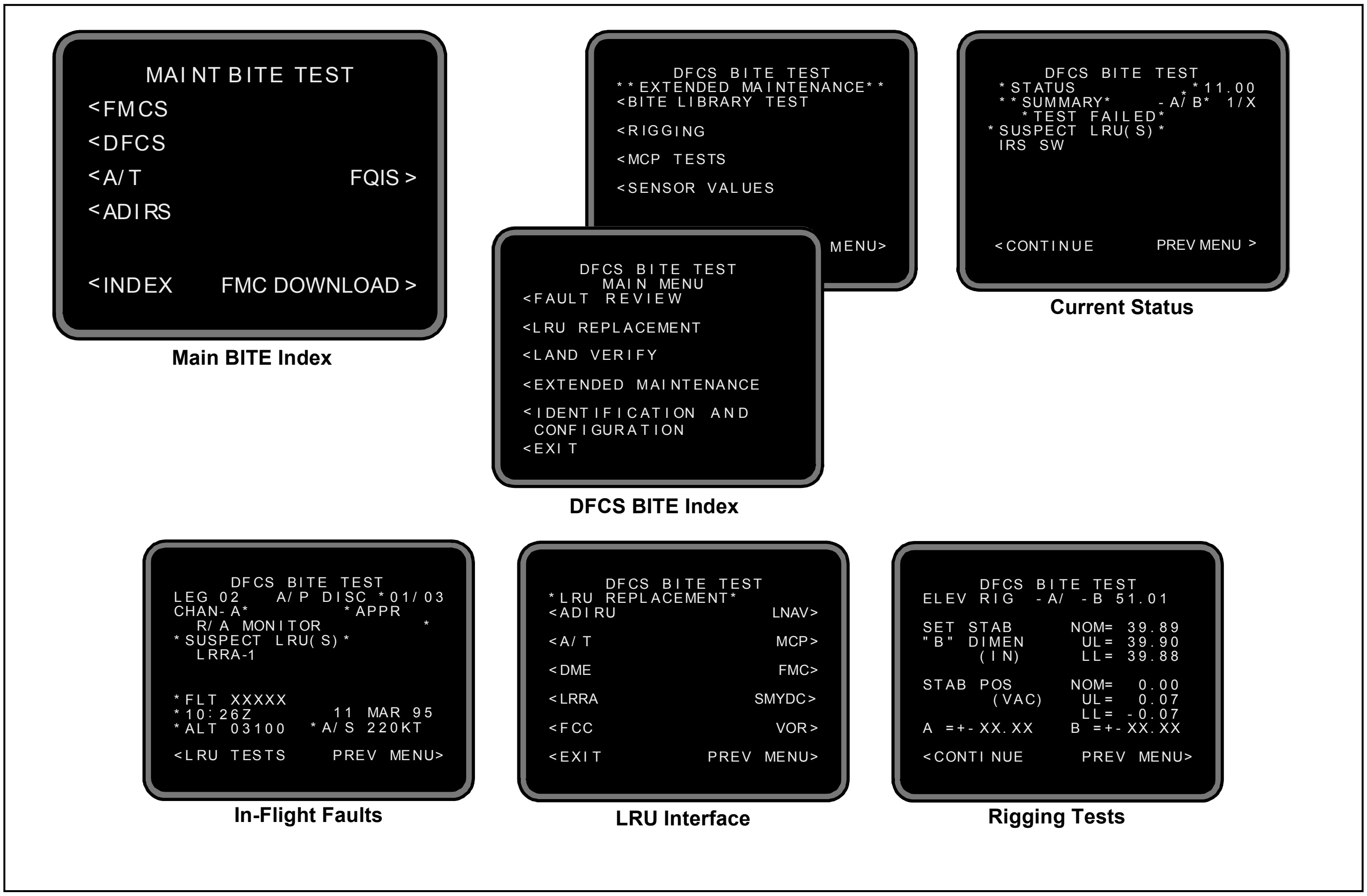
Vertical navigation (VNAV) and lateral navigation (LNAV) are the normal cruise modes. When these modes are selected, the FMC sends commands to the autopilot, flight director and autothrottle. The airplane flies the FMC route at the airspeed and altitude for the selected performance. The autopilot, flight director and autothrottle work together in these modes.

Other modes are available at the option of the crew. The crew can select modes to change and hold the airplane altitude and to fly a radio beam or heading. The crew uses the mode control panel to select the desired autopilot and flight director mode. The autopilot or flight director then sets the autothrottle mode that gives the best combined performance.

The approach mode (APP) is for landing. In the approach mode, the flight director and the autopilot use localizer and glideslope radio signals. When the approach mode is selected, you can engage both autopilots for an automatic landing. The autothrottle holds the MCP selected airspeed in approach.

In go-around, the autothrottle sets the thrust levers to go-around thrust. The flight director and, if available, the autopilot, control rate of climb, airspeed and track.

The flight mode annunciator (FMA) is on the primary flight display. Autopilot flight director status shows in the status field of the FMA. Autothrottle, pitch, and roll modes show in the other positions of the FMA.



Main BITE Index **DFCS BITE Index** **Current Status** **In-Flight Faults** **LRU Interface** **Rigging Tests**

Built-In Test Equipment (BITE)

The MCDU gives access to self-contained in-flight monitoring and ground test capabilities for these systems or components:

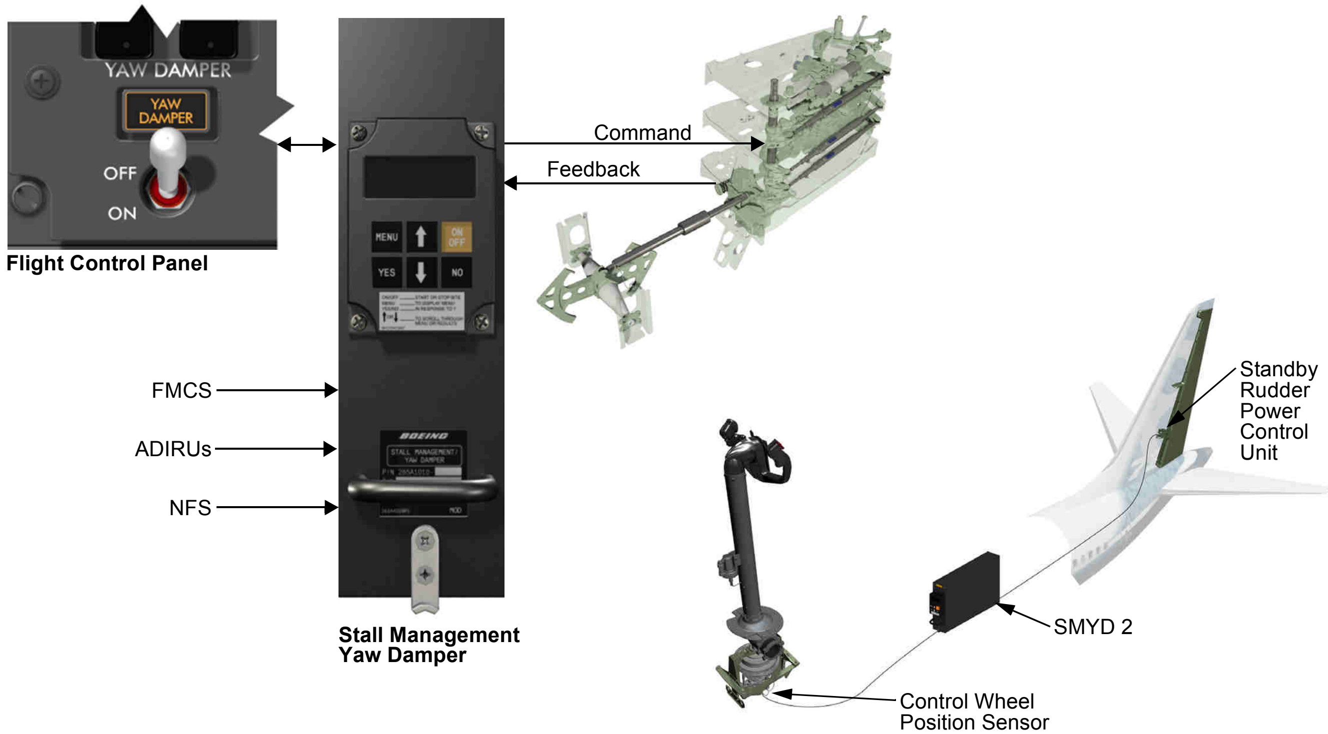
- Flight management computer system - FMCS
- Digital flight control system - DFCS
- Autothrottle - A/T
- Air data inertial reference system - ADIRS
- Fuel quantity indicating system - FQIS.

Each component contains tests for itself, its sensor inputs, and other interfaces. Also, each component stores in-flight fault data for analysis on the ground.

The technician selects test options from a menu and supplies interactive operator responses through the CDU. BITE does the tests and supplies data to the technician to do trouble-shooting. The technician uses the verification tests to do a test of the interfaces after replacement of a line replaceable unit (LRU).

The system allows fast, line maintenance fault isolation to a single line replaceable unit.

The FQIS prompt gives access to fuel quantity system fault and system information.



Yaw Damper Function

Wheel to Rudder Interconnect System

Yaw Damper/WTRIS

The yaw damper moves the rudder to decrease yaw rates that are related to dutch roll.

The wheel to rudder interconnect system (WTRIS) assists manual turns when the standby hydraulic system is on.

The yaw damper system connects to the main and standby rudder power control units to do the yaw damper function.

Stall management yaw damper (SMYD) 1 connects to the main rudder power control unit.

SMYD 2 connects to the standby rudder power control unit.

The WTRIS function is only in SMYD 2.

These are the yaw damper components in the flight compartment:

- Yaw damper switch
- Yaw damper light

The yaw damper is available for the full flight. The yaw damper and WTRIS are engaged with the yaw damper switch on the overhead panel. The yaw damper light goes off when the yaw damper is engaged.

The yaw damper uses inputs from the air data inertial reference units (ADIRU) to get airplane yaw rate and lateral acceleration. It also uses gross weight data from the flight management computer system (FMCS). The yaw dampers send commands to the rudder power control units to move the rudder and stop the dutch roll. The rudder pedals do not move when the yaw damper moves the rudder.

The WTRIS senses control wheel movement and sends commands to the standby rudder power control unit to move the rudder.

Monitor circuitry in the computer disengages the yaw damper/WTRIS for problems with the position feedback or with the servo.

You do a test of the yaw damper and WTRIS functions at the stall management yaw damper. A menu lets you select these BITE functions:

- Existing faults
- Fault history
- Ground tests
- Other functions.

You can also do ground test from the onboard maintenance function in the network file server (NFS).

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Features

AC AND DC POWER GENERATION

The airplane has three AC generators. Two generators are engine-driven and one is APU-driven. The APU makes the airplane self-sufficient. It supplies electrical power on the ground and in flight.

The airplane battery supplies power to the standby system when normal power fails. The battery supplies power to essential systems for a minimum of thirty minutes.

There is an option for two batteries which can supply essential systems for sixty minutes.

FLIGHT DECK COMPONENTS AND INDICATIONS

The P5 overhead panel contains components that give electrical system control and BITE. The P6 panel contains the standby power control unit and circuit breakers. The P18 panel also contains circuit breakers.

ELECTRONIC EQUIPMENT COMPARTMENT COMPONENTS

The electronic equipment (EE) compartment contains LRUs for control and BITE of the electrical system.

ELECTRICAL POWER SYSTEM DISTRIBUTION

The electrical power distribution system operates automatically from flight deck inputs. This system increases electrical power reliability and reduces pilot workload.

- **Features**
- **AC and DC Power Generation**
- **AC and DC Power Generation (cont'd.)**
- **Flight Deck Components and Indications**
- **Flight Deck Components and Indications (cont'd.)**
- **Flight Deck Components and Indications (cont'd)**
- **Electronic Equipment Compartment Components**
- **AC Power Distribution**
- **Bus Transfer System**
- **DC Power Distribution**
- **Standby Power**

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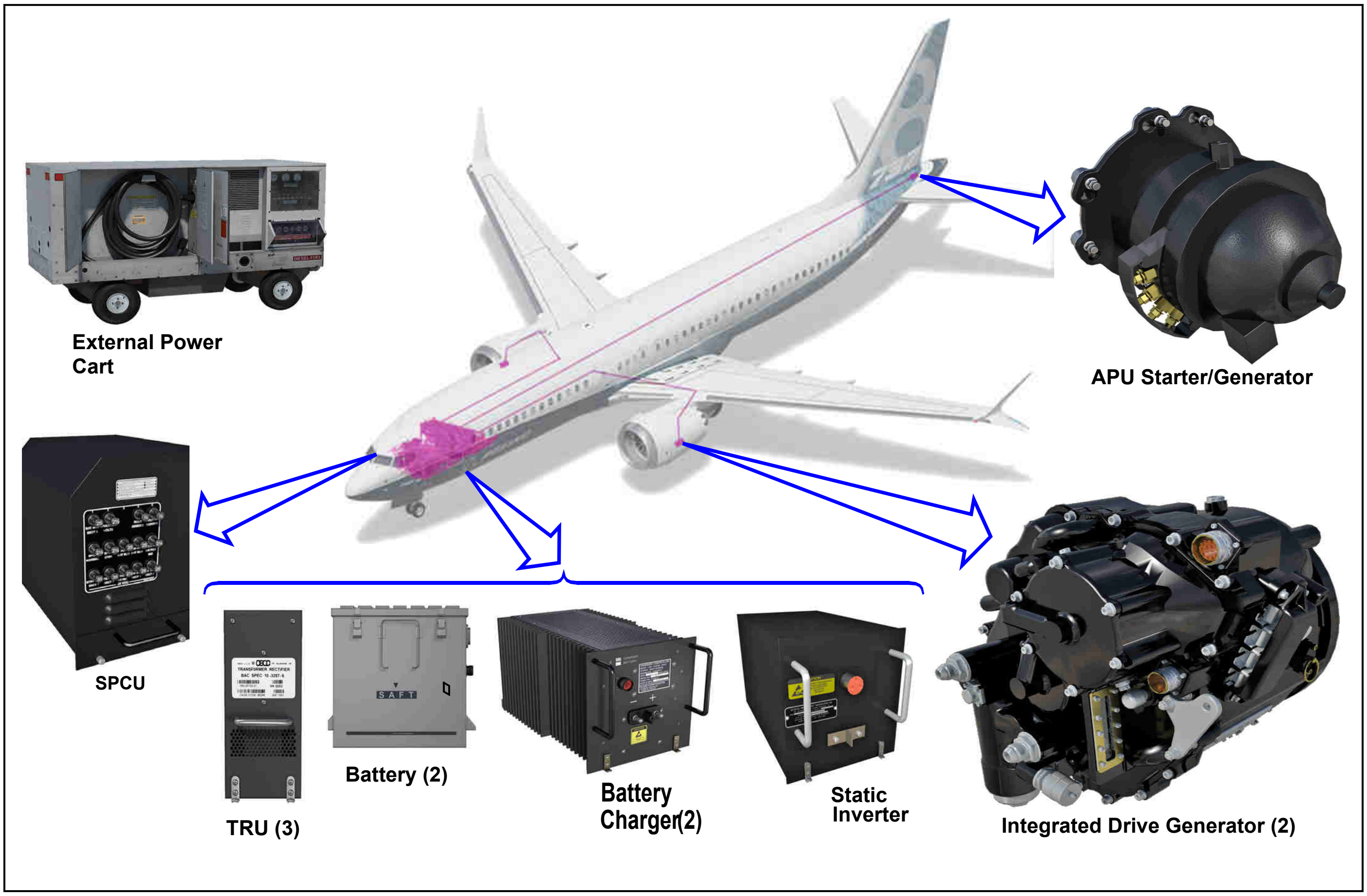
Electrical Power



AC and DC Power Generation

The electrical power system supplies 115v ac and 28v dc electrical power to the airplane.

AC power sources include these components:

- Two integrated drive generators (IDG), each driven by an engine, supply 115v ac. Each IDG supplies up to 90 KVA
- A starter-generator is a 90 KVA (to 32000 ft, 66 KVA above) generator and an electric starter for the APU
- External power receptacle rated at 90 KVA.
- Batteries
- Battery chargers
- Transformer rectifier units.

The IDGs are the normal source of power for the airplane. However, the APU starter generator is a convenient backup power source for flight operation. It also makes the airplane self-sufficient during ground operations.

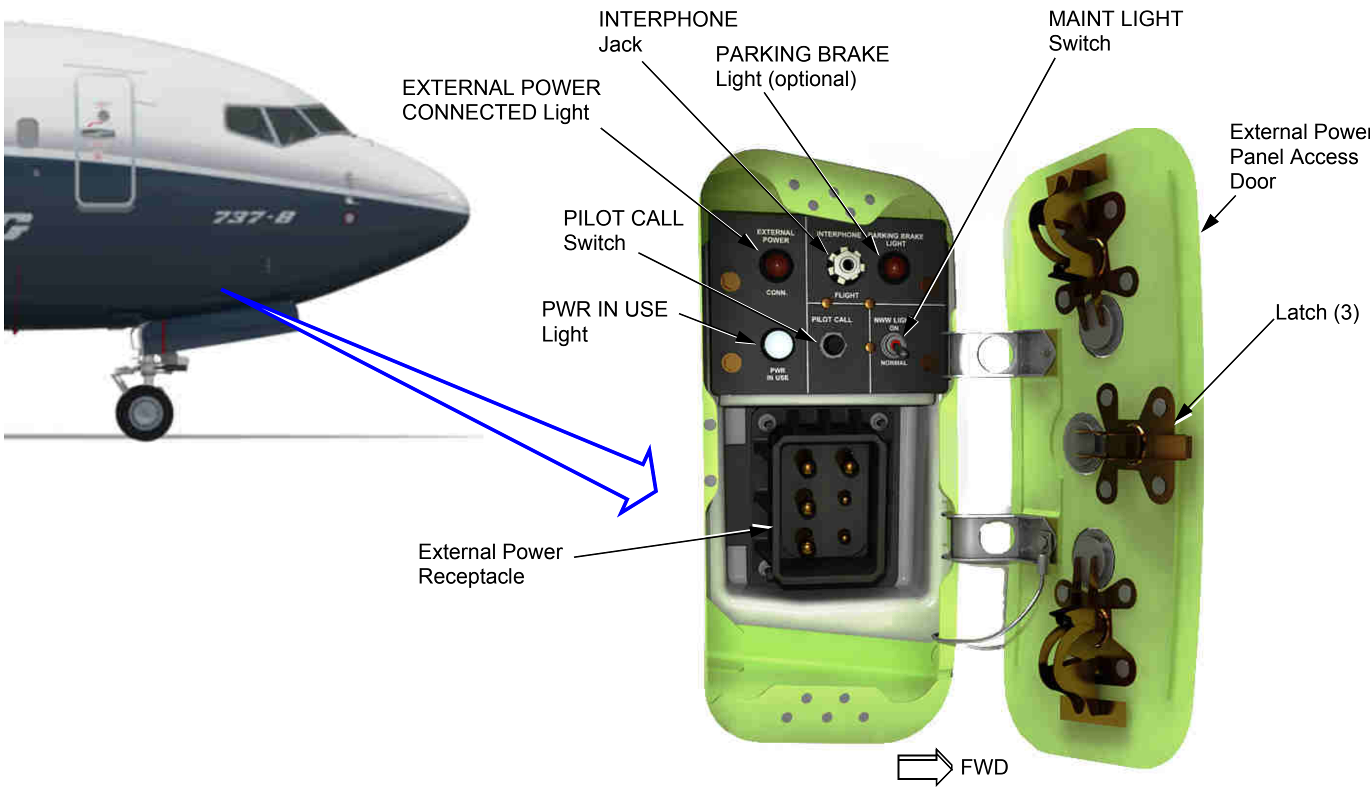
In addition, external 115v ac power connects through a receptacle on the forward right side of the airplane.

External power can be connected to the airplane system or just to cabin related service circuits and the battery chargers.

The following components give dc electrical power to the airplane:

The standby power system uses the batteries to give ac and dc power to the airplane if the ac generation system malfunctions. The standby power control unit controls the standby power system.

The static inverter changes battery dc power to standby system ac power.



P19 External Power Panel (shown with access door open)

AC and DC Power Generation (cont'd.)

The P19 external power panel has a receptacle to connect external ac power. The EXTERNAL POWER CONNECTED light comes on when you connect a live external power source. The PWR IN USE light comes on when you use external power on the airplane. The parking brake light is an optional item. If the parking brake light is not installed, the panel has two interphone jacks.

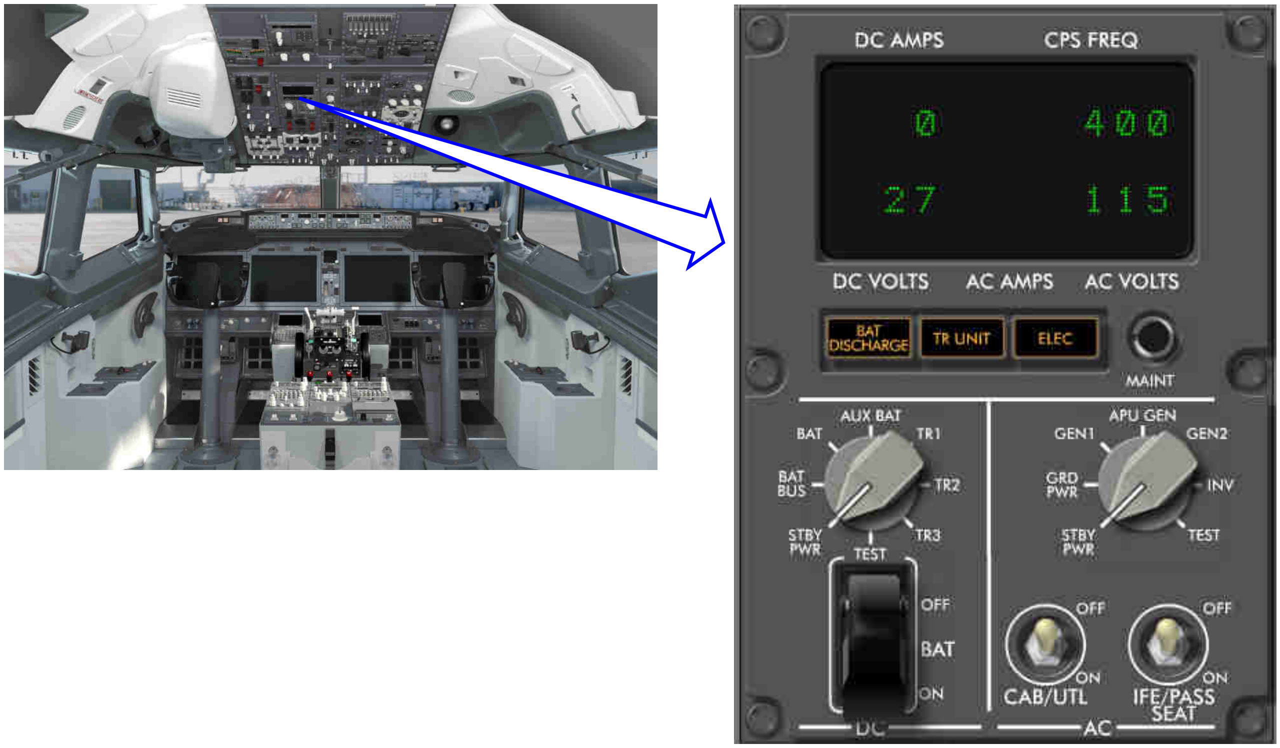
Interphone jacks let the ground crew talk and listen to the flight crew. They also let maintenance personnel talk and listen in different areas of the airplane.

The external power panel has a PILOT CALL switch. This switch causes a tone in the flight deck that tells the flight crew that ground personnel wish to speak to them.

The external power panel also has a MAINT LIGHT switch to give light to the nose wheel well during maintenance.

The external power panel is under the external power panel access door. You release three latches to open the door.

Electrical Power



Electrical Meters, Battery and Galley Power Module

Flight Deck Components and Indications

These electrical power controls and indications are on the electrical meters, battery and galley power module (P5).

The DC meter selector selects the dc source for the dc voltmeter and ammeter indications.

The DC AMPS meter shows the current of the source when the selector is in the TR1, TR2, TR 3 or BAT position.

The DC VOLTS meter shows the voltage of the source selected by the dc meter selector (all positions).

The BAT switch connects the switched hot battery bus and battery bus to the battery. The battery is then available for backup to the ac and dc standby buses.

The AC meter selector selects the ac source for ac volt and frequency indications.

The CPS FREQ meter shows the frequency of the source selected by the AC meter selector.

The AC VOLTS meter shows the voltage of the source selected.

The AC AMPS meter shows load current (phase B) of the generator source selected by the ac meter selector.

The CAB/UTIL switch supplies electrical power to the galleys and main buses.

The IFE/PASS SEAT switch supplies electrical power to the in-flight entertainment system.

The ELEC light shows that there is a fault in the dc or standby power system.

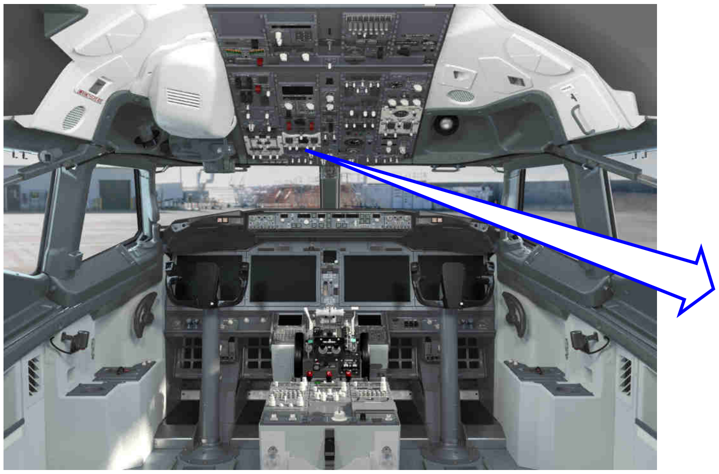
The TR UNIT light comes on when one or more of the TR units has a failure on the ground. It also comes on when TRU1 or TRU2 and TRU3 has a failure in the air.

The BAT DISCHARGE light comes on when a large current flow out of the battery occurs in a short time.

The TEST position on both meter selectors along with the MAINT switch allows troubleshooting of the DC and standby power systems.

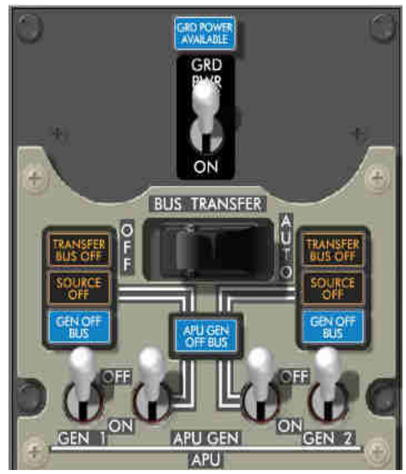
BITE messages can show on the display in the test mode. These are examples of BITE messages:

- BAT CHGR INOP
- AUX BAT CHGR INOP
- SPCU INOP
- PANEL FAILURE
- INTERFACE FAILURE
- STAT INV INOP.



P5 Forward Overhead Panel

Generator Drive and Standby Power Module



AC Systems, Generator and APU Module

Flight Deck Components and Indications (cont'd.)

The STANDBY PWR OFF light comes on when the standby ac or dc bus does not have power. The light also comes on when the battery bus does not have power and the battery switch is in the ON position.

The STANDBY POWER switch has these three positions:

- AUTO - Normal position. The battery or batteries automatically connect to supply the dc standby and ac standby buses with loss of all ac power in flight
- OFF - Turns off power to the standby power buses
- BAT - The battery or batteries supply power to the battery bus, dc standby bus and ac standby bus.

The DRIVE light comes on when:

- IDG 1 or 2 oil pressure is low
- IDG 1 or 2 has low frequency.

The DISCONNECT switch deenergizes IDG 1 or 2 and disconnects the input shaft. The engine start levers must be in the idle position for the disconnect to operate.

The GRD POWER AVAILABLE light comes on when ground power is connected to the receptacle. The quality of the ground power must also be good for the light to come on.

The TRANSFER BUS OFF lights come on when a transfer bus does not get power by any source.

The SOURCE OFF light comes on when a transfer bus does not get power by the selected engine, APU generator or external power.

The GEN OFF BUS light comes on when the IDG does not supply power to the transfer bus on the same side.

The APU GEN OFF BUS light comes on when the APU is in operation but the generator does not supply power to one or both transfer buses.

The GEN 1, APU GEN, and GEN 2 switches are three-position switches, momentary on/off and spring loaded to center.

The BUS TRANSFER switch has these two positions:

- AUTO (guard down) - Transfer bus automatically transfers to opposite power source if normal source is inoperative
- OFF - Isolates left and right sides and prevents bus transfer.

Electrical Power

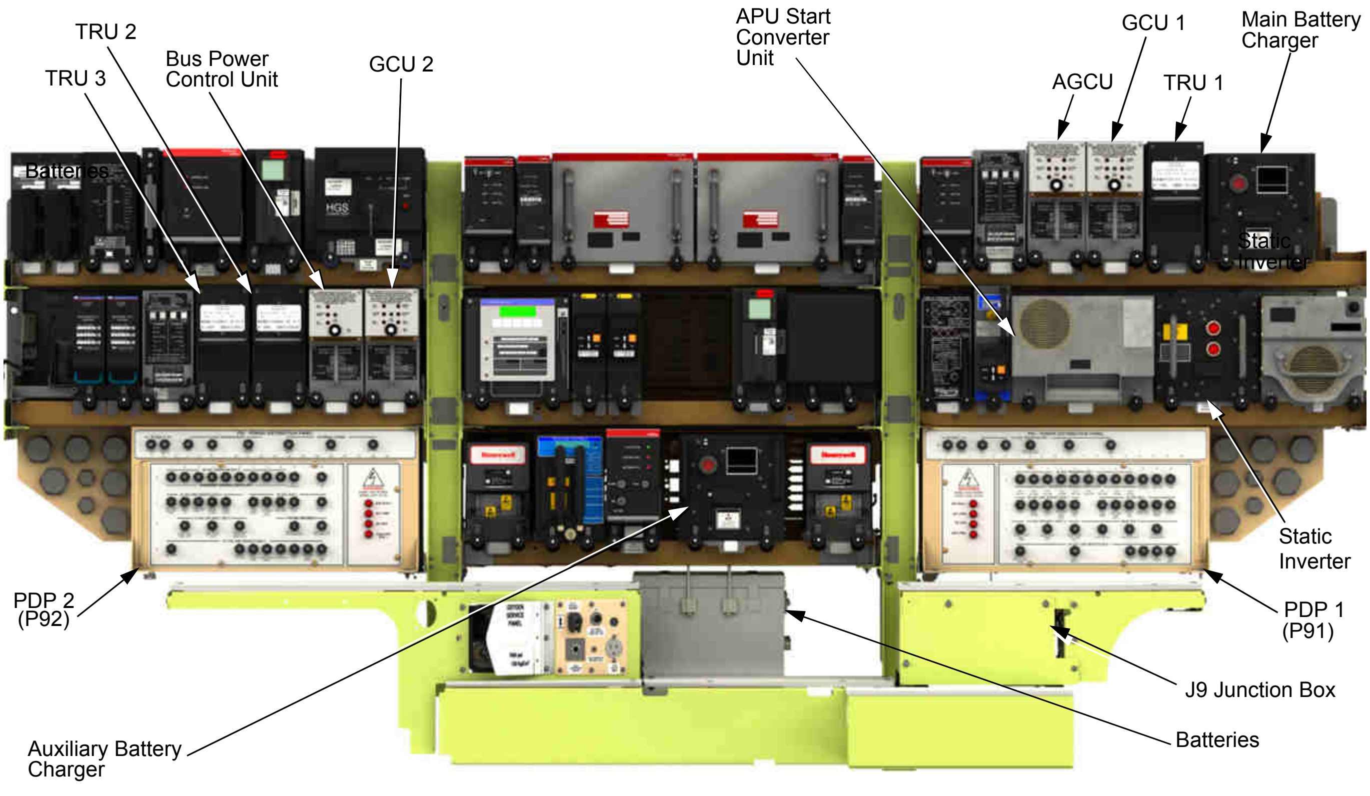
Flight Compartment (Looking Aft)

Flight Deck Components and Indications (cont'd)

The P6 and P18 panels contain circuit breakers for the ac and dc electrical systems on the airplane. They are on the aft bulkhead of the flight compartment. The P6 panel is behind the First Officer's seat. The P18 panel is behind the Captain's seat.

Most circuit breakers are usually closed (pushed in). You put collars around circuit breakers that must stay open. You must always follow the safety requirements of your company when you open or close circuit breakers.

The standby power control unit gives control of normal dc power and standby ac and dc power. The standby power system of the airplane operates when usual ac power sources are not available.



E2, E3, E4 Equipment Racks

Electronic Equipment Compartment Components

Two power distribution panels in the electronic equipment compartment have components for electrical power distribution. The power distribution panels are:

- PDP1 (P91)
- PDP2 (P92).

PDP1 has these components:

- BTB1
- GCB1
- AGB1
- Transfer bus 1
- Main bus 1.

PDP2 has these components:

- BTB2
- GCB2
- EPC
- Transfer bus 2
- Main bus 2.

The J9 junction box has these components:

- Static inverter RCCB
- Auxiliary battery RCCB.

Transformer rectifier units (TRU's) change 115v ac power to 28v dc power. There are three transformer rectifier units:

- TRU1
- TRU2
- TRU3.

Generator control units (GCU's) control generator power quality. They also let the GCB's close when system operation is correct. There are three GCU's:

- GCU1
- GCU2
- AGCU.

The bus power control unit (BPCU):

- Controls ac power distribution
- Controls external power
- Has front face BITE for external power
- Controls the load shed function.

The batteries provide dc power when the TRU's do not operate.

The battery chargers keep the batteries charged. They also give dc power to the airplane as necessary.

The static inverter gives ac power to the airplane when no other ac power source is available.

The APU start-converter unit gives power for APU start. It also helps control APU generator output quality.

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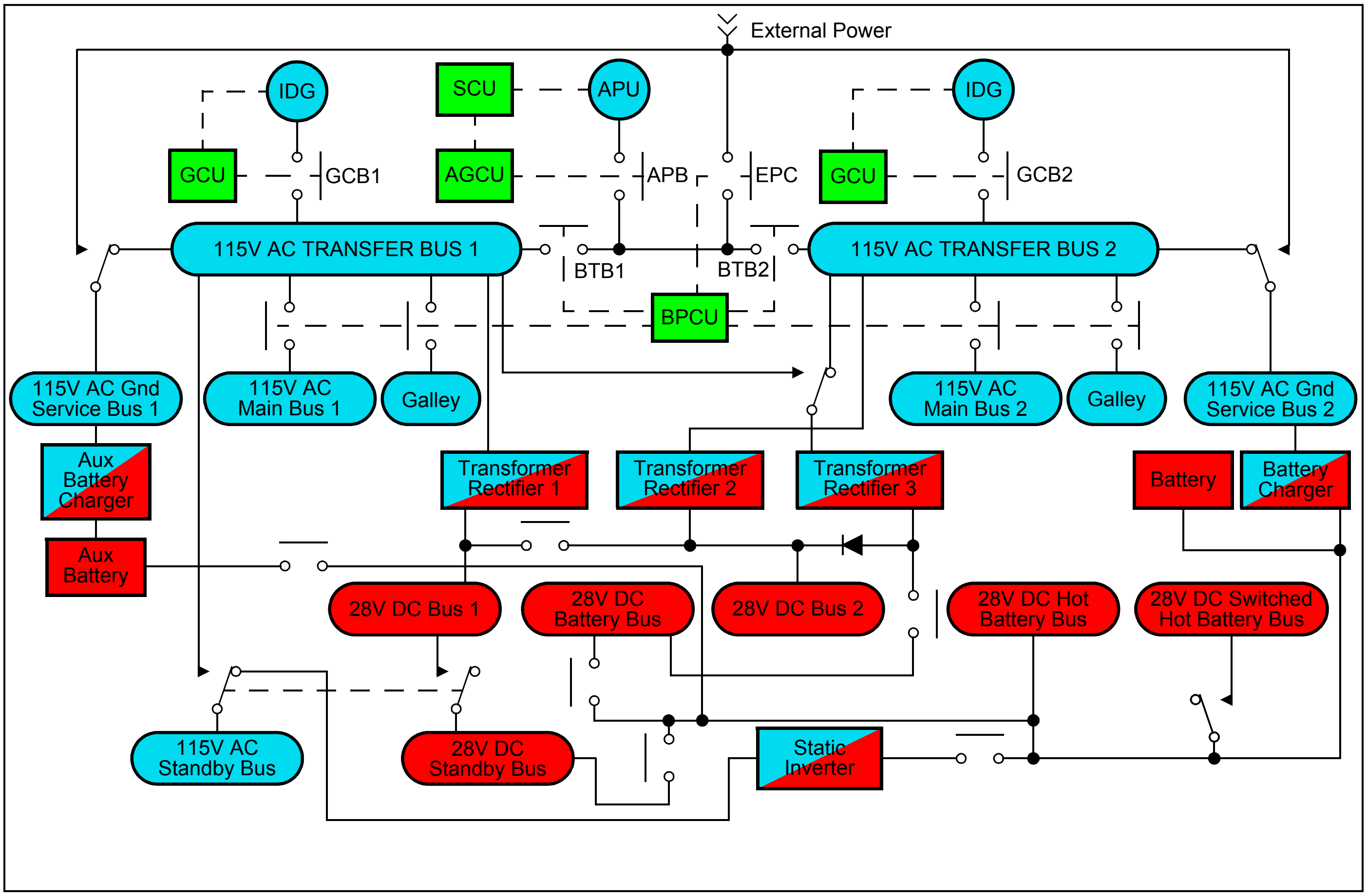
Electrical Power



AC Power Distribution

The electrical power distribution system normally operates as two separate systems. Normally the integrated drive generators (IDG) will supply their onside transfer buses.

The APU can supply power to both transfer buses on the ground and in flight. External power can supply both transfer buses on the ground.

Bus Transfer System

If either transfer bus loses power, the bus power control unit (BPCU) commands the engine generator control units (GCU) to close the bus tie breakers (BTB) to supply power from the opposite transfer bus.

BPCU controlled load shed relays shed loads as necessary in this condition. The APU can be started and used to supply power to a transfer bus.

DC Power Distribution

The 28v dc system has these components:

- Three transformer rectifier units (TRU). The TRUs convert 115v ac to 28v dc
- One 48 ampere-hour (AH) battery or optional, two 48 AH batteries
- Battery charger(s).

The main battery or the main battery charger supplies power to the hot battery bus and the switched hot battery bus.

TRU 3 normally supplies the battery bus. If TR 3 fails, the battery charger or the battery supplies power to the battery bus.

TRU 1 and TRU 2 normally supply power to dc buses 1 and 2. DC bus 1 is the normal source for the dc standby bus. The batteries alternately supplies the dc standby bus.

Standby Power

The standby power control unit (SPCU) provides automatic control of the standby system. The auxiliary battery and/or the main battery are the standby source of power. The standby system supplies ac and dc power to primary flight instruments, communication, navigation and other equipment. If all ac generators fail, standby power will provide the following:

- The batteries energize the dc standby bus
- The static inverter energizes the ac standby bus. The inverter uses battery power to create single phase 115v ac.

BOEING PROPRIETARY

Features

FUEL CAPACITY

Each of the two main tanks holds 8,630 pounds (3,915 kg) of fuel. The center tank holds 28,803 pounds (13,066 kg) of fuel.

UNDERWING REFUEL STATION

The refueling station is in the right wing. The maximum refuel rate is 2025 pounds (918 kg) per minute. The maximum refuel pressure is 55 psi.

FUEL QUANTITY INDICATING SYSTEM (FQIS)

The FQIS uses a variable capacitance system and an advanced microprocessor to measure fuel quantity.

FUEL TANK COMPONENT REPLACEMENT WITHOUT DEFUELING

Defueling is not necessary for removal of many fuel system components that are on the rear spar.

AUTOMATIC WATER SCAVENGE SYSTEM

An automatic water scavenge system removes water from both the center and main tanks.

AUTOMATIC CENTER TANK SCAVENGE

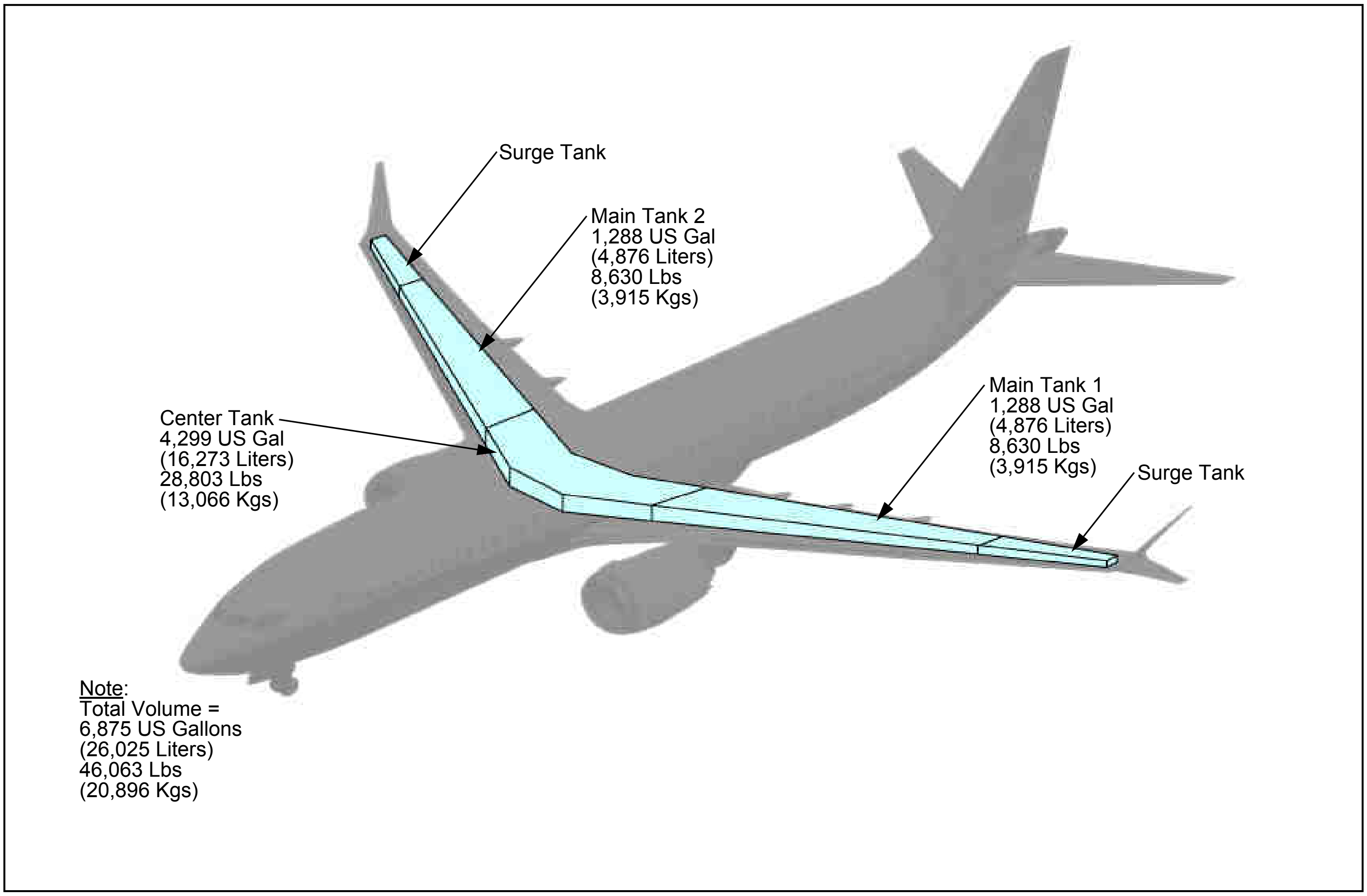
The automatic center tank scavenge system transfers residual center tank fuel to main tank 1. This increases the quantity of usable fuel.

AUXILIARY FUEL TANK SYSTEM

The auxiliary fuel tank system provides additional fuel storage to increase the range of the airplane.

There is no requirement for a fuel jettison system on the 737 as the maximum take off weight is not substantially higher than the maximum landing weight.

Fuel



Fuel Tanks

The fuel system has these fuel tanks:

- Main tank 1
- Main tank 2
- Center tank.

There is a surge tank at the outer end of main tank 1 and 2. The surge tanks are part of the wing structure.

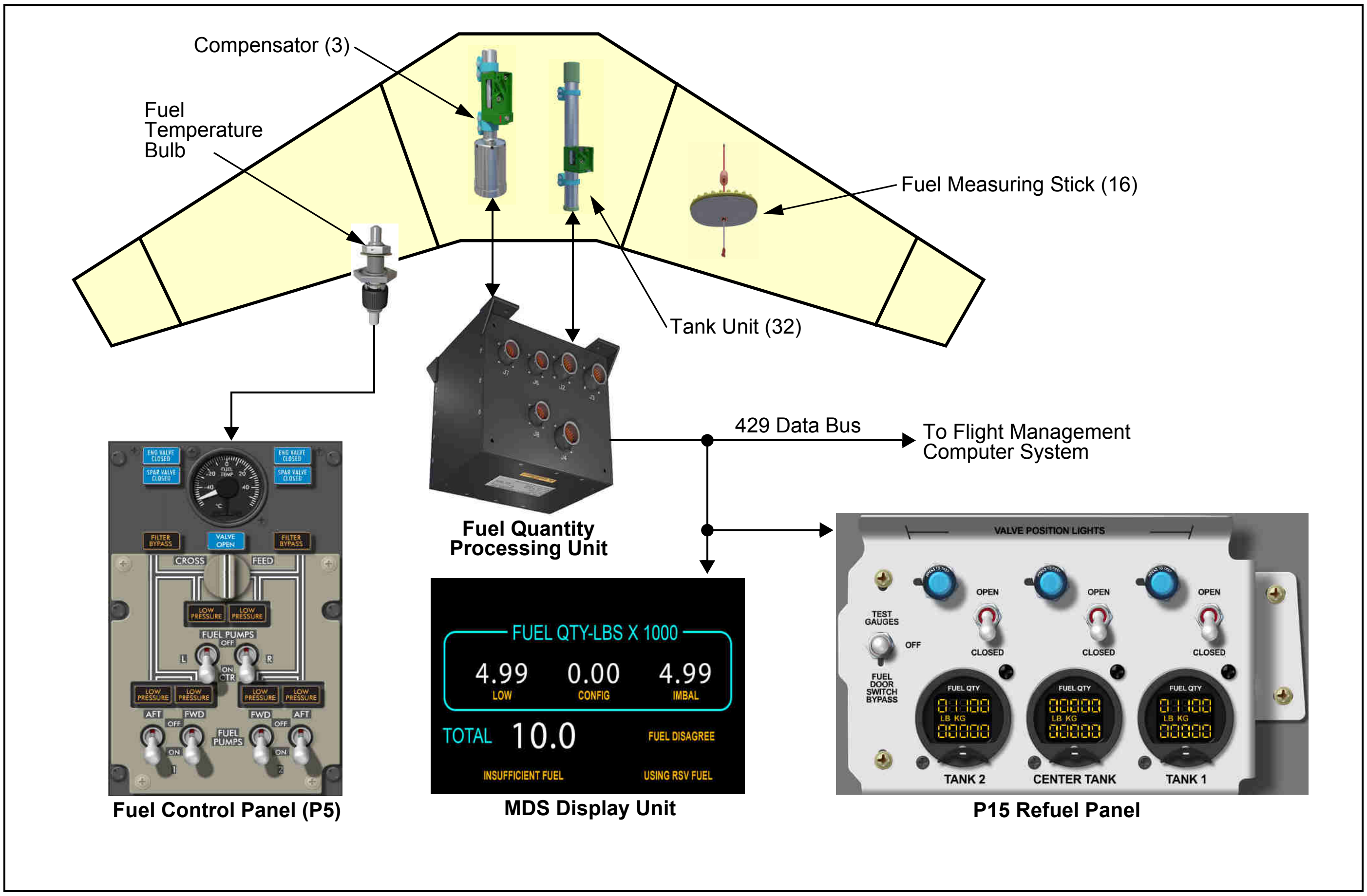
Most fuel system components are inside the tanks. The boost pumps and scavenge pumps are on the rear spar of the center tank. Most fuel system components can be removed without defueling.

Fuel Vent System

The fuel vent system keeps the fuel tanks at near ambient pressure during all phases of airplane operation. Each tank vents to the surge tanks through upper channels in the wing.

The vent channels also permit fuel overflow into the surge tank if necessary. There is a standpipe in the surge tank to prevent small amounts of fuel from spilling overboard. Any fuel in the surge tank normally drains back into the main tank.

The surge tank has the vent scoop and a pressure relief valve on the bottom of the wing.



Fuel Quantity Indicating System

The fuel quantity indicating system (FQIS) measures fuel quantity, calculates fuel weight and shows fuel weight. FQIS components include these components:

- Tank units
- Compensators
- Fuel quantity processor unit
- Densitometer (optional).

The tank units supply a capacitance signal that is equal to fuel height. This signal goes to the FQIS processor. The processor uses the ARINC 429 data bus to send a fuel weight signal to the MAX display system (MDS), the refuel panel and the flight management computer system (FMCS). There are 32 variable capacitance tank units in the three tanks.

The compensators supply an impedance signal that is proportional to fuel density. This signal goes to the processor to calculate fuel density. There is one compensator in each tank.

The fuel quantity processor unit does these functions:

- Calculates total fuel weight
- Calculates fuel weight in each tank
- Monitors the fuel system for faults
- Sends fault data to the control display units.

The fuel quantity processor also sends fuel weight information to the MDS and the P15 refuel panel. Fuel weight can show in either pounds or kilograms.

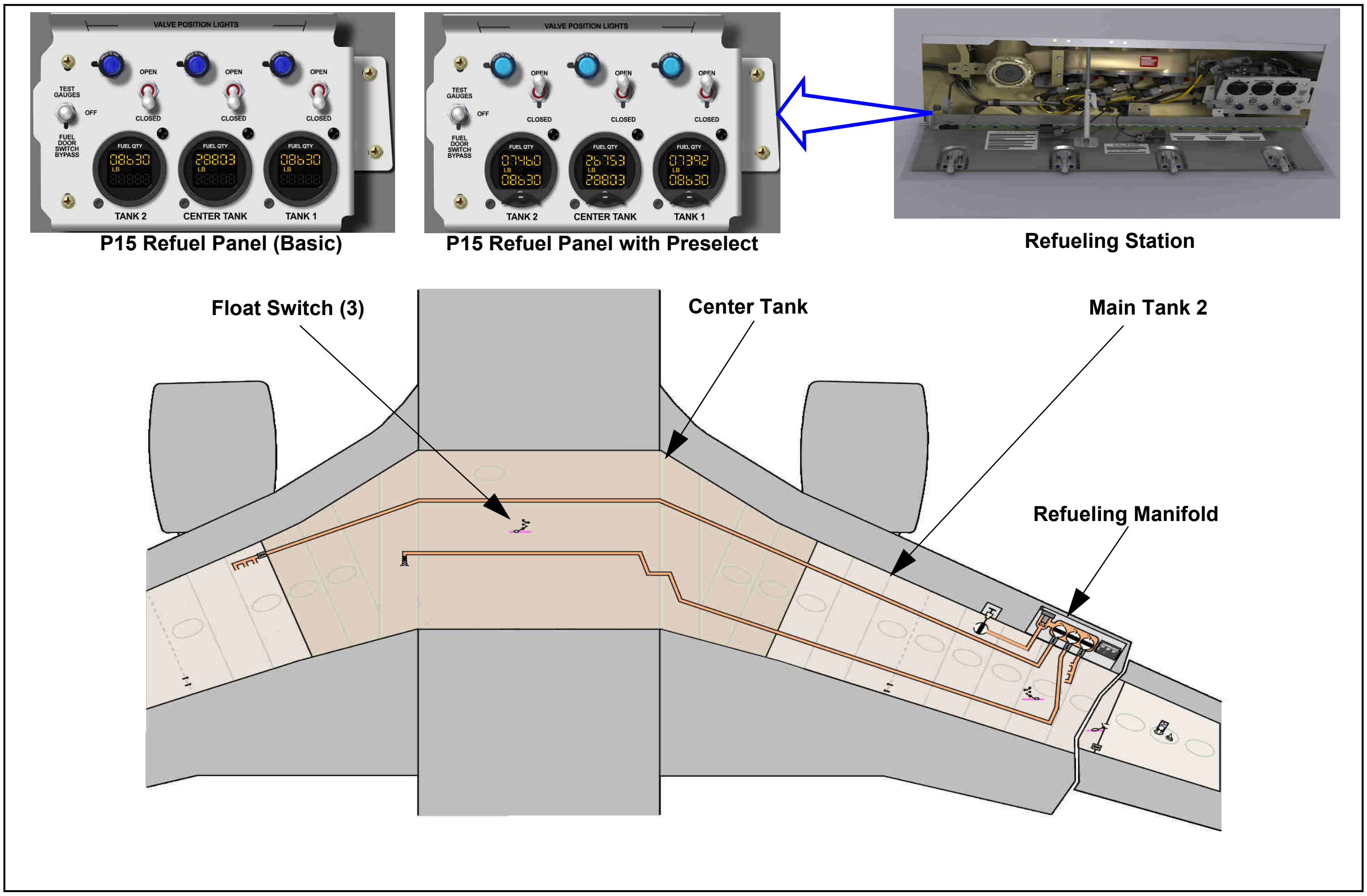
An optional densitometer supplies a signal that is equal to fuel density. There is one densitometer in each tank.

The fuel quantity indicators show on an inboard MDS display unit (DU) in the flight compartment. The MDS can also show these messages:

- LOW - when fuel quantity in a main tank is less than 2000lbs (907 kg) or 1000lbs (453kg) based on option selection
- IMBAL - when the fuel quantity between the two main tanks is different by more than 1000lbs (453 kg)
- CONFIG - when there is more than 1600 lbs (725 kg) in the center tank, both center tank boost pumps are off, and either or both engines are on.

Fuel measuring sticks in each fuel tank supply a direct indication of fuel quantity. The measuring stick is a calibrated, flat, bendable stick that is attached to the bottom surface of the wing.

Fuel



Pressure Refuel System

The refueling station is on the right wing.

The refueling station has these components:

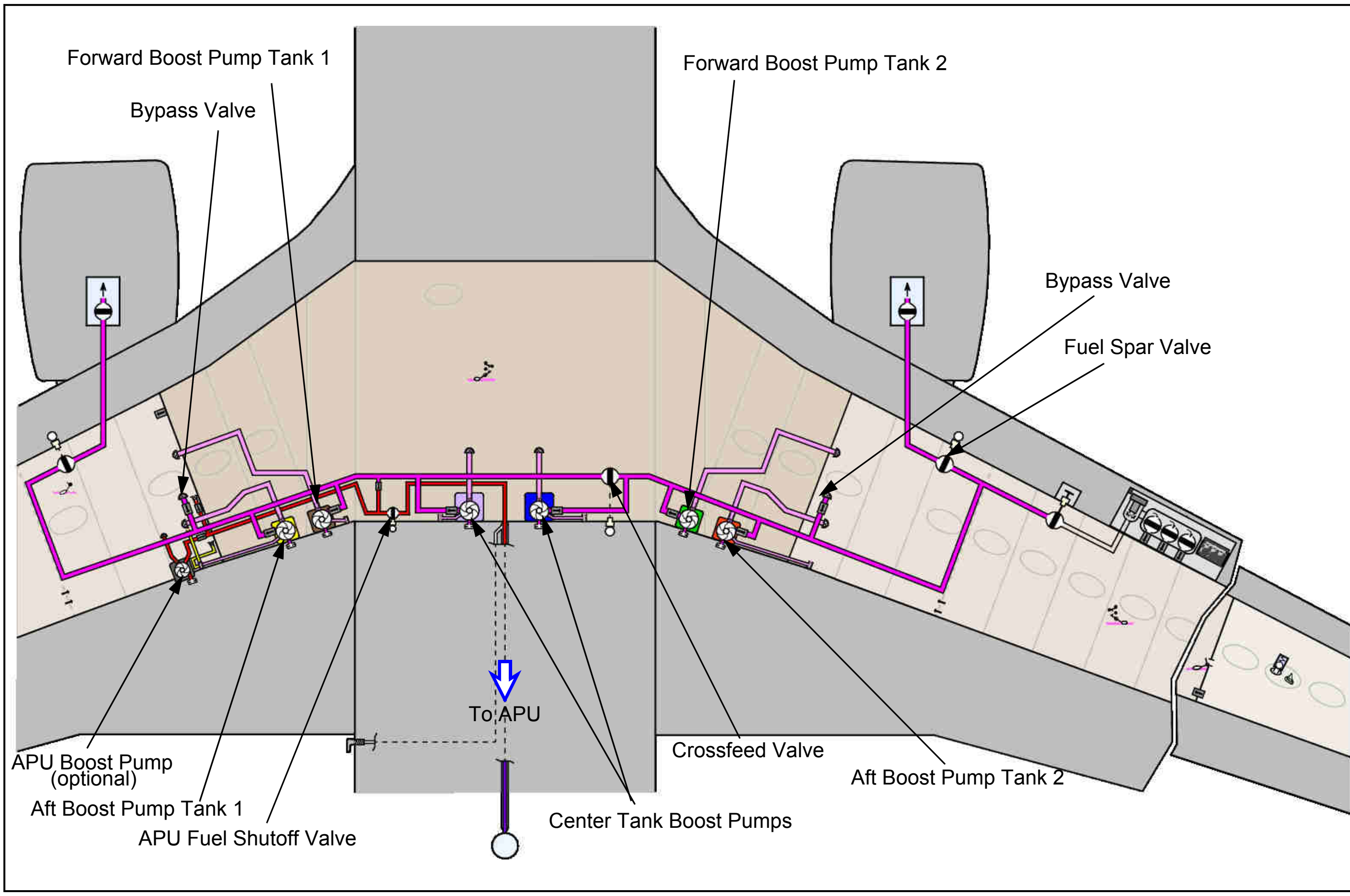
- Single refuel receptacle
- Individual fuel quantity indicators
- Fueling valve control switches
- Fueling valve open lights
- Fueling power control switch.

There is one fueling valve for each tank. The fueling valve control switches on the refuel panel control the fueling valves. A fueling float switch in each tank closes the fueling valves when the fuel quantity in each tank is at capacity. The fueling valves also operate manually.

The optional refuel panel with preselect switches allows preselection of fuel quantity for each tank. When the fuel quantity of the tank equals the preselect value, the tank fueling valve closes.

Fueling can occur for each tank individually or for all tanks at the same time.

Power for the refuel system comes from the battery bus, the hot battery bus and external power through the bus power control unit (BPCU) transformer rectifier.



Engine Fuel Feed System

There are two boost pumps each for main tank 1, main tank 2 and the center tank. The boost pumps supply fuel from the fuel tanks to the engines.

A crossfeed valve connects the left and right fuel feed manifold. This lets any tank supply fuel to any engine with the use of the applicable boost pumps.

The center tank boost pumps have a higher output pressure than the boost pumps in the main tanks. Because of this, the engines receive center tank fuel first. With only residual fuel in the center tank, the boost pumps in the main tanks supply fuel to the engines.

APU Fuel Feed System

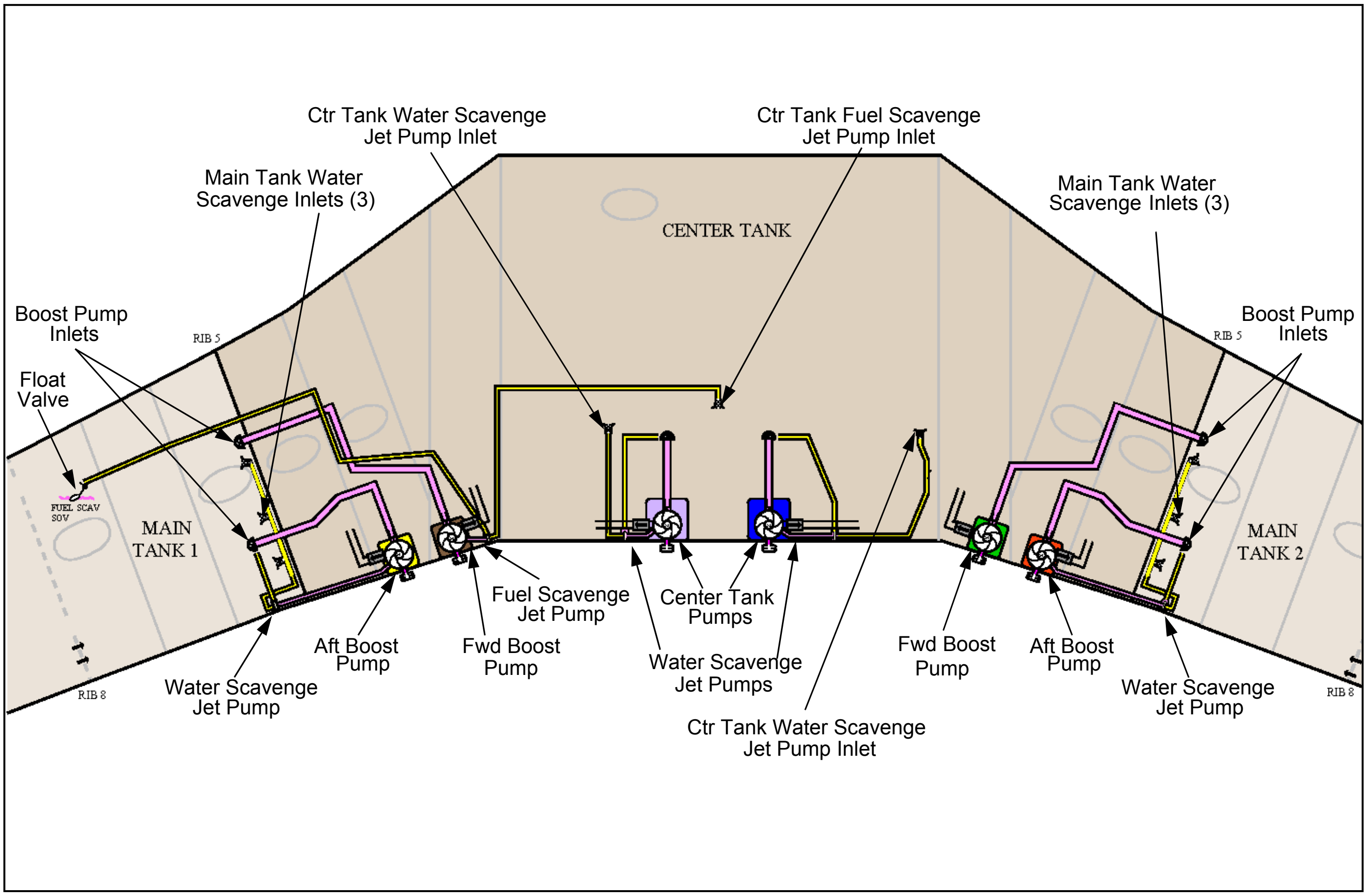
The APU can receive fuel from any tank with the use of the applicable boost pump and crossfeed valve.

When the boost pumps are off, the APU gets fuel from main tank 1.

An APU fuel shutoff valve lets fuel flow from the engine fuel feed manifold to the APU fuel manifold. The APU master switch, on the forward overhead panel, controls the APU fuel shutoff valve.

An optional APU DC fuel pump supplies fuel from main tank 1.

Fuel



Fuel Scavenge System

The fuel scavenge system removes remaining fuel in the center tank and transfers it to main tank 1. This increases the usable fuel quantity in the center tank.

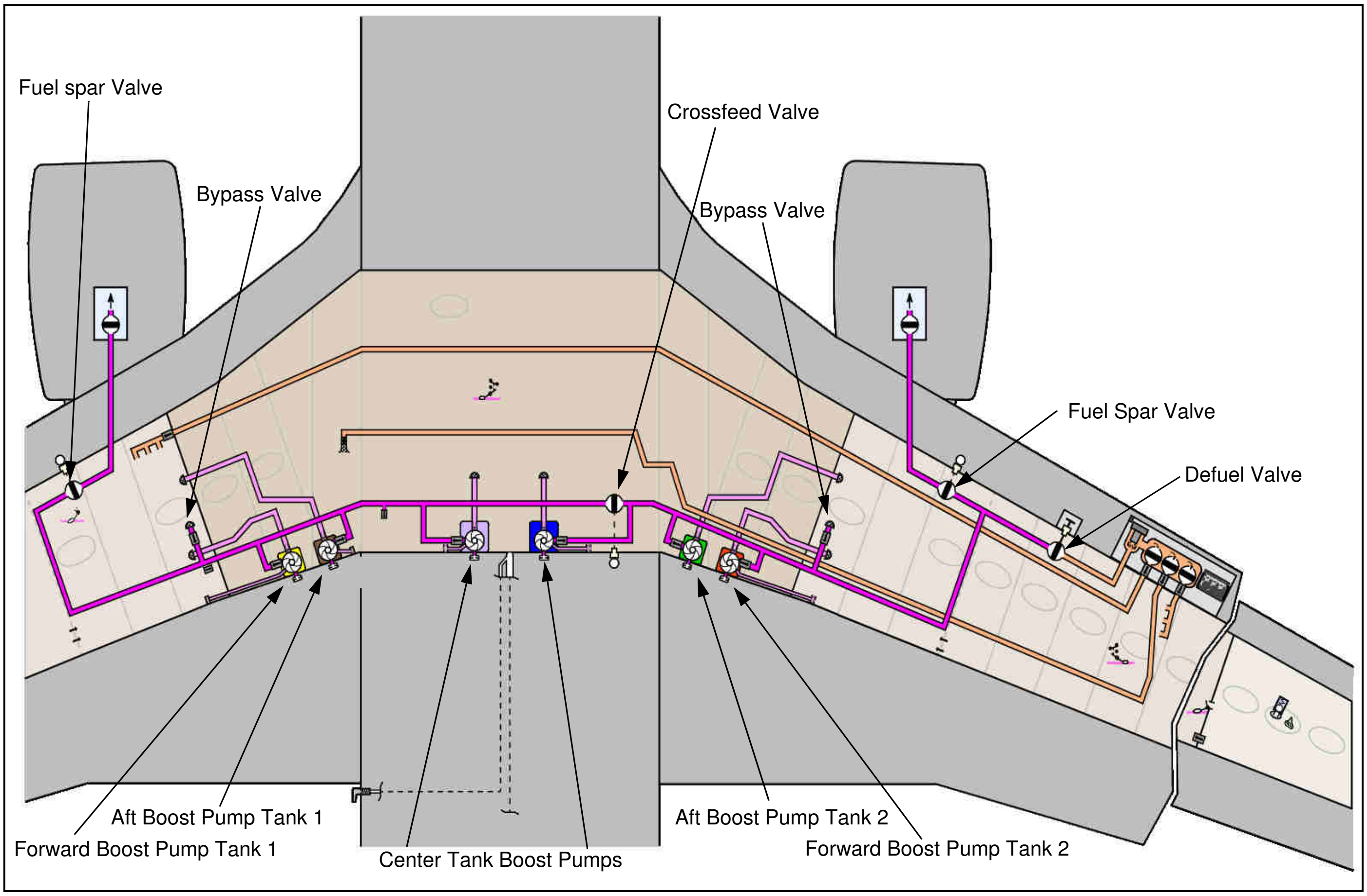
The forward boost pump in main tank 1 supplies motive flow to a jet pump. The jet pump removes fuel from the center tank and transfers it to main tank 1. A float valve controls fuel sent to main tank 1.

Water Scavenge System

The water scavenge system removes water from the low points in each tank to help prevent corrosion.

There is a jet pump in each main tank. The jet pumps in the main tanks use motive flow from the aft boost pumps. There are two jet pumps in the center tank. The jet pumps in the center tank use motive flow from both center tank boost pumps.

Each jet pump removes fuel and water from its related tank and discharges it to the boost pump inlet. The water mixes with the fuel and vaporizes during combustion.



Defuel System

The defuel system lets you remove of fuel from any or all tanks. It also lets you transfer fuel between tanks on the ground.

These components are used to transfer fuel between tanks:

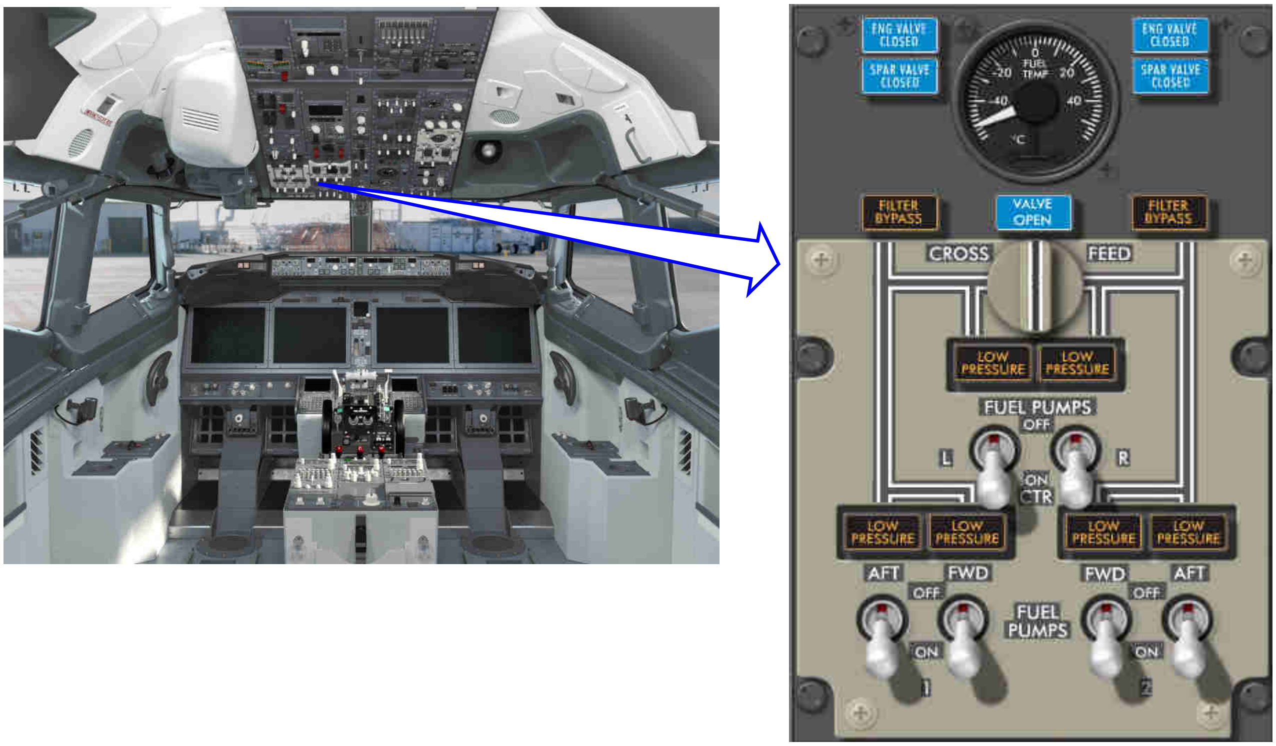
- Boost pumps
- Defuel valve
- Fueling valves.

Usually the fuel boost pumps are used to get fuel out of the tanks and into the fuel feed manifold. When the defuel valve is open, fuel transfers to the refueling station.

The defuel valve operates manually. It is on the right front spar near the refueling station.

A bypass valve in main tank 1 and main tank 2 permits suction defueling from those tanks.

Fuel



Fuel Control Panel

Fuel System Control

The fuel system control is on the P5 forward overhead panel.

Forward and aft fuel pump switches control boost pump operation in main tank 1 and main tank 2. LOW PRESSURE lights come on when the output pressure of the boost pump is low.

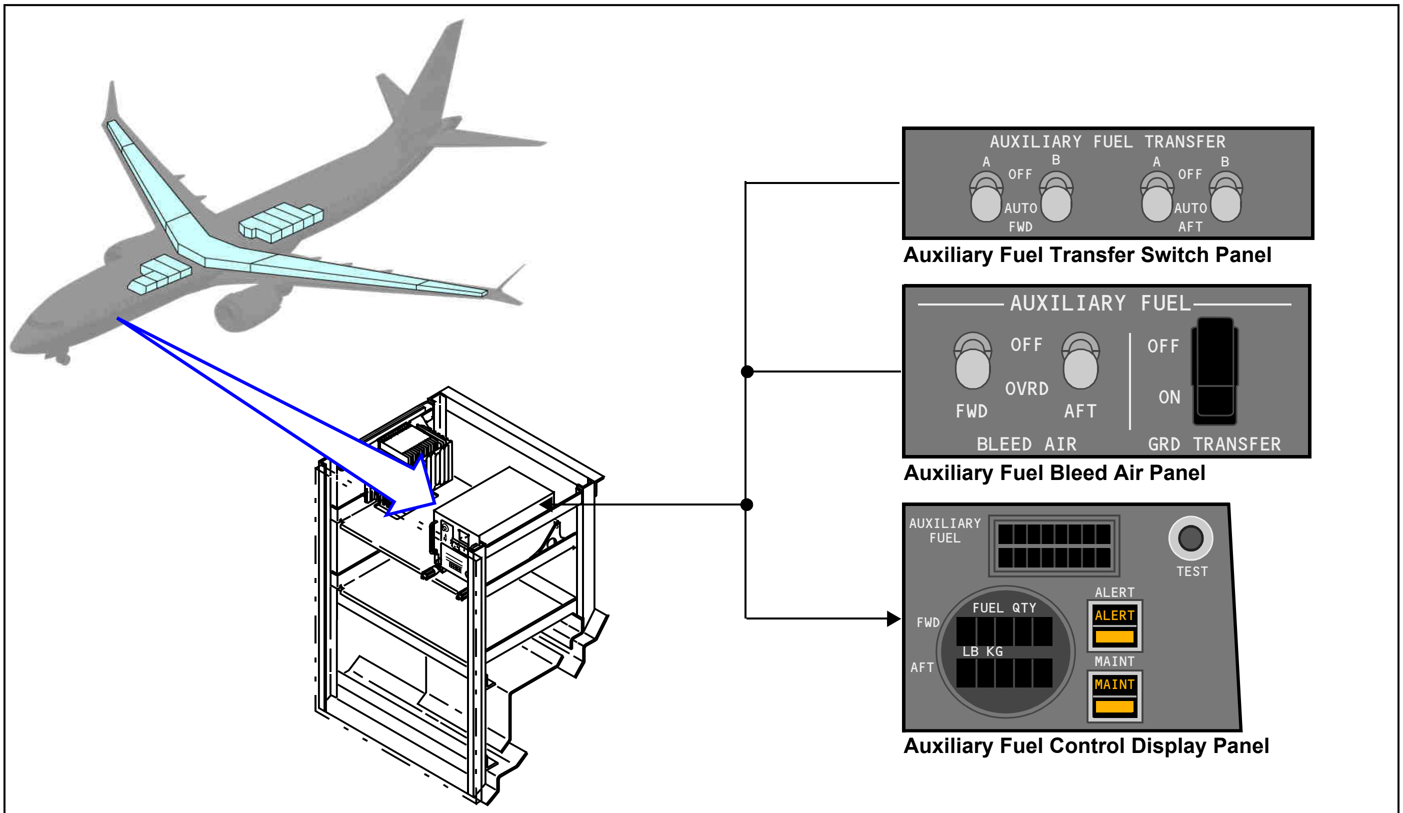
Center tank fuel pump switches control boost pump operation in the center tank. LOW PRESSURE lights come on when the output pressure of the pump is low and the fuel pump switch is ON.

A crossfeed selector controls crossfeed valve operation. The VALVE OPEN light comes on bright when the valve is in transit. The VALVE OPEN light comes on dim when the valve is open. The VALVE OPEN light is off when the crossfeed valve is closed, and the selector is in the OFF position.

The SPAR VALVE CLOSED light comes on bright when the valve is in transit. The SPAR VALVE CLOSED light is on dim when the valve is closed. The SPAR VALVE CLOSED light is off when the valve is closed,

The FILTER BYPASS lights come on when the filter is almost clogged. The fuel filter is on the engine fuel pump housing.

The fuel temperature indicator shows the fuel temperature in main tank 1.



Auxiliary Fuel Transfer Switch Panel
Auxiliary Fuel Bleed Air Panel
Auxiliary Fuel Control Display Panel
Auxiliary Fuel Control Unit

Auxiliary Fuel Tank System Introduction

The auxiliary fuel tank system provides additional fuel storage to increase the range of the airplane. The auxiliary fuel is transferred to the center tank as center tank fuel is used by the engines.

The auxiliary fuel is divided into two tank groups, one in the forward cargo compartment and one in the aft cargo compartment.

There are thirteen different configurations for the auxiliary fuel tank system.

The flight crew use the auxiliary fuel transfer switch panel to control fuel transfer.

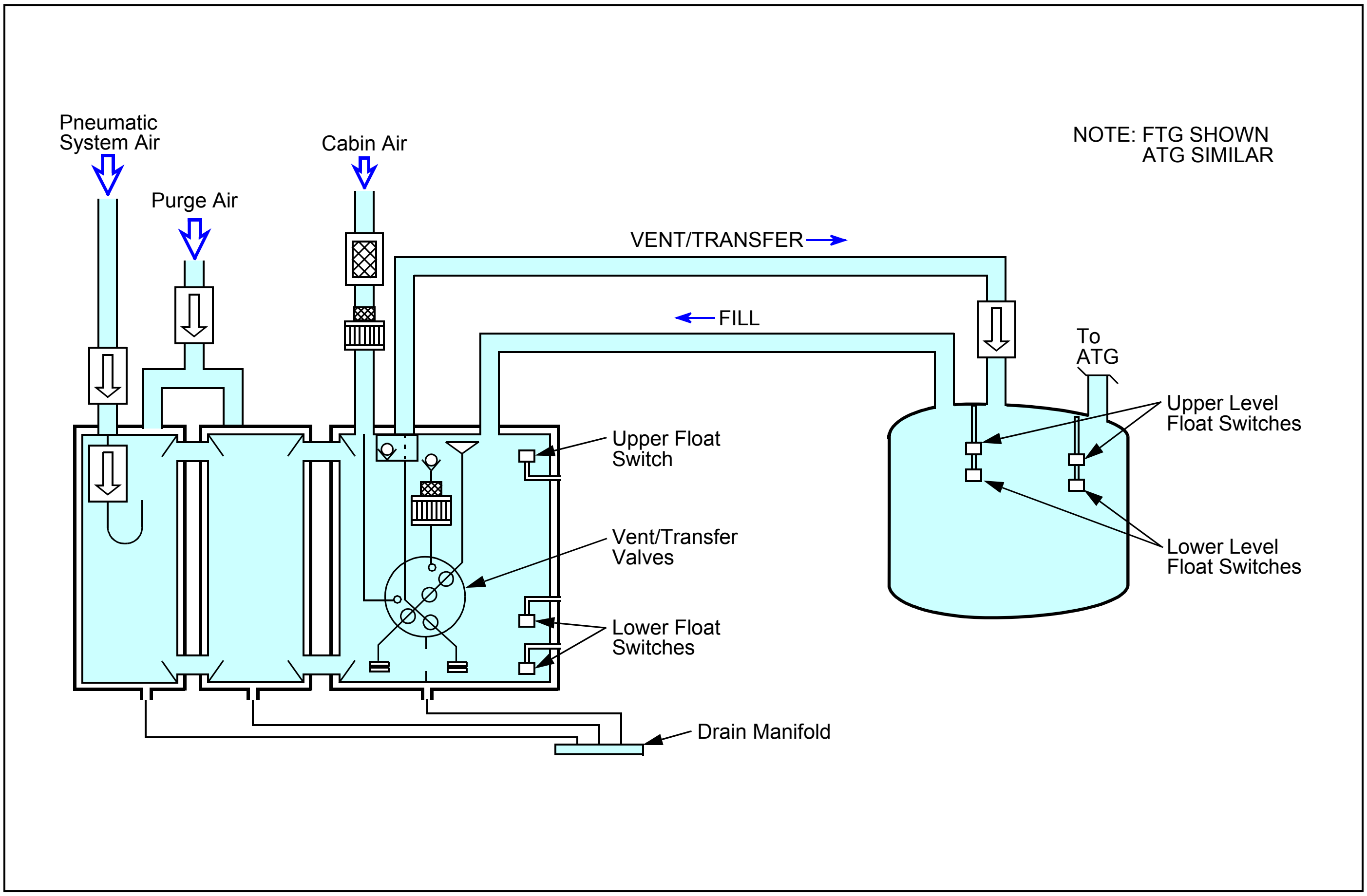
The auxiliary fuel bleed air panel allows the flight crew to use bleed air for fuel transfer when cabin air is not enough.

The auxiliary control display panel shows the fuel quantity in the auxiliary tanks. It also shows alert and maintenance messages.

The auxiliary fuel control unit (AFCU) controls the vent and transfer of fuel to the center tank.

BOEING PROPRIETARY

Fuel



Auxiliary Fuel Tank System

The auxiliary fuel tank system has one or two tank groups. Each tank group has a master fuel cell and a number of slave fuel cells.

The master fuel cell contains the components that are used for the vent and transfer of fuel.

The auxiliary fuel cells are double skinned with a honeycomb core. Purge air is used to vent this area to a drain manifold in the belly of the cargo compartments. This air is then vented overboard.

Air from the airplane pneumatic system or cabin air is used to transfer the fuel from the auxiliary tanks into the center tank. The usual source of air is the cabin.

The upper float switches in the master cell provide indication of tank full during refuel. The lower float switches provide indication of tank empty status.

The upper level float switches in the center tank control the transfer valves in the master cells to prevent overfilling of the center tank. The lower level float switches allow the transfer valves to open again during fuel transfer.

Features

The auxiliary power unit (APU) is an electrical and pneumatic power source for aircraft systems on the ground and in flight.

ELECTRICAL POWER

A 90 KVA starter generator supplies electrical power up to 32,000 feet altitude. Above 32,000 feet to 41,000 feet, the generator rating decreases to approximately 66 KVA.

PNUEMATIC POWER

The load compressor supplies pneumatic power up to 17,000 feet.

APU STARTING

A starter-generator can start the APU at altitudes up to 41,000 feet.

EDUCTOR COOLING SYSTEM

An eductor cooling system cools the APU compartment and the APU oil. It is highly reliable and there are no moving parts.

OPERABLE DURING REFUELING

The APU can supply electrical and pneumatic power during refueling.

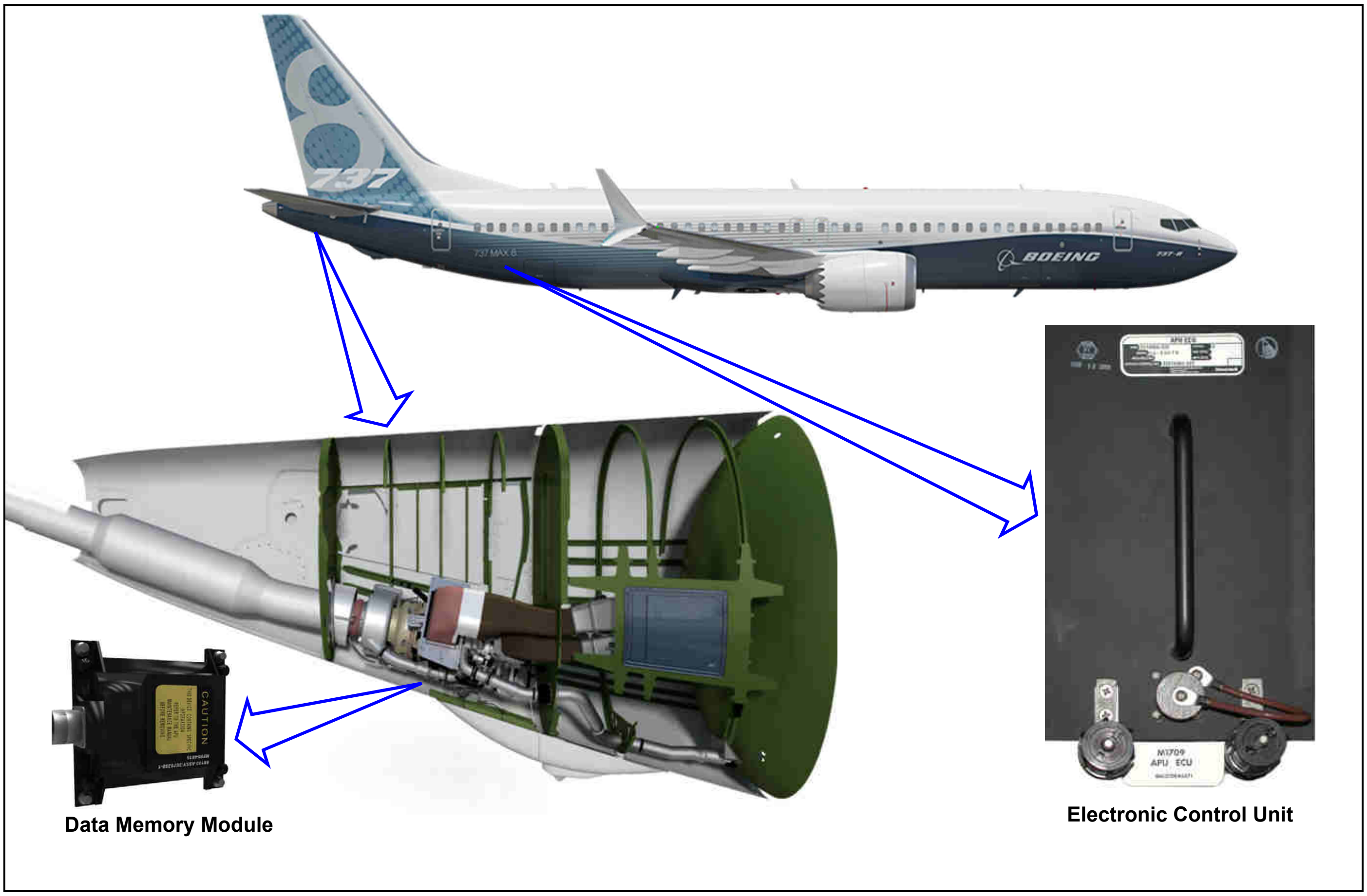
FULL AUTHORITY DIGITAL ELECTRONIC CONTROL

The electronic control unit (ECU) is a full authority, digital electronic control unit that controls APU operation.

ENHANCED HISTORICAL RECORDING

A data memory module records and keeps APU operational data.

Auxiliary Power Unit



Auxiliary Power System

The auxiliary power unit (APU) supplies electrical and pneumatic power to the airplane. The APU can start at all altitudes up to 41,000 feet. Electrical power is available up to 41,000 feet. Pneumatic power is available up to 17,000 feet.

The APU is a Honeywell 131-9(B). The APU has these features:

- Single-stage centrifugal compressor
- Two-stage axial turbine
- Separate single-stage centrifugal load compressor
- Modular design.

The APU is in the aft section of the fuselage.

ELECTRONIC CONTROL UNIT

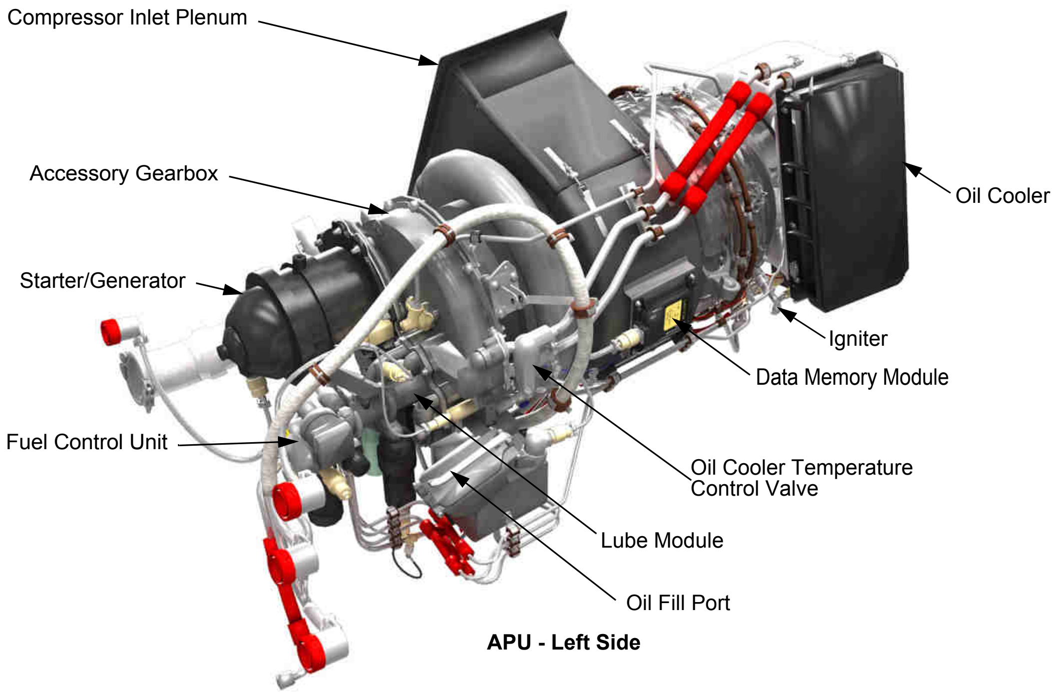
The electronic control unit (ECU) controls and monitors all phases of APU operation. It also stores system and fault information. System and fault information shows on the captain and first officer control display units (CDU).

The ECU also causes an APU protective shut down to prevent damage to the APU.

The ECU is in the aft cargo compartment, on the right side aft of the cargo door.

DATA MEMORY MODULE

A data memory module (DMM) records APU hours and starts. The DMM also keeps various APU component part and serial numbers. Programmed and recorded information shows on the MAX display system (MDS).



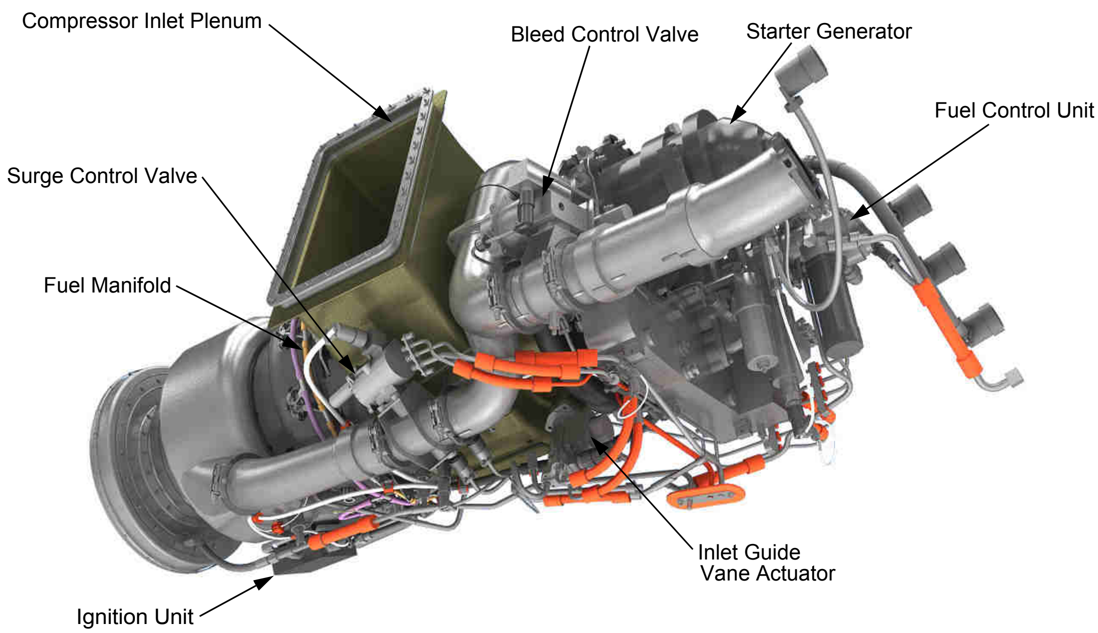
APU - Left Side

Auxiliary Power System

The APU has these components on the left side:

- Fuel control unit
- Lubrication module
- Oil fill port
- Oil cooler temperature control valve
- Data memory module
- Igniter
- Oil cooler.

Auxiliary Power Unit

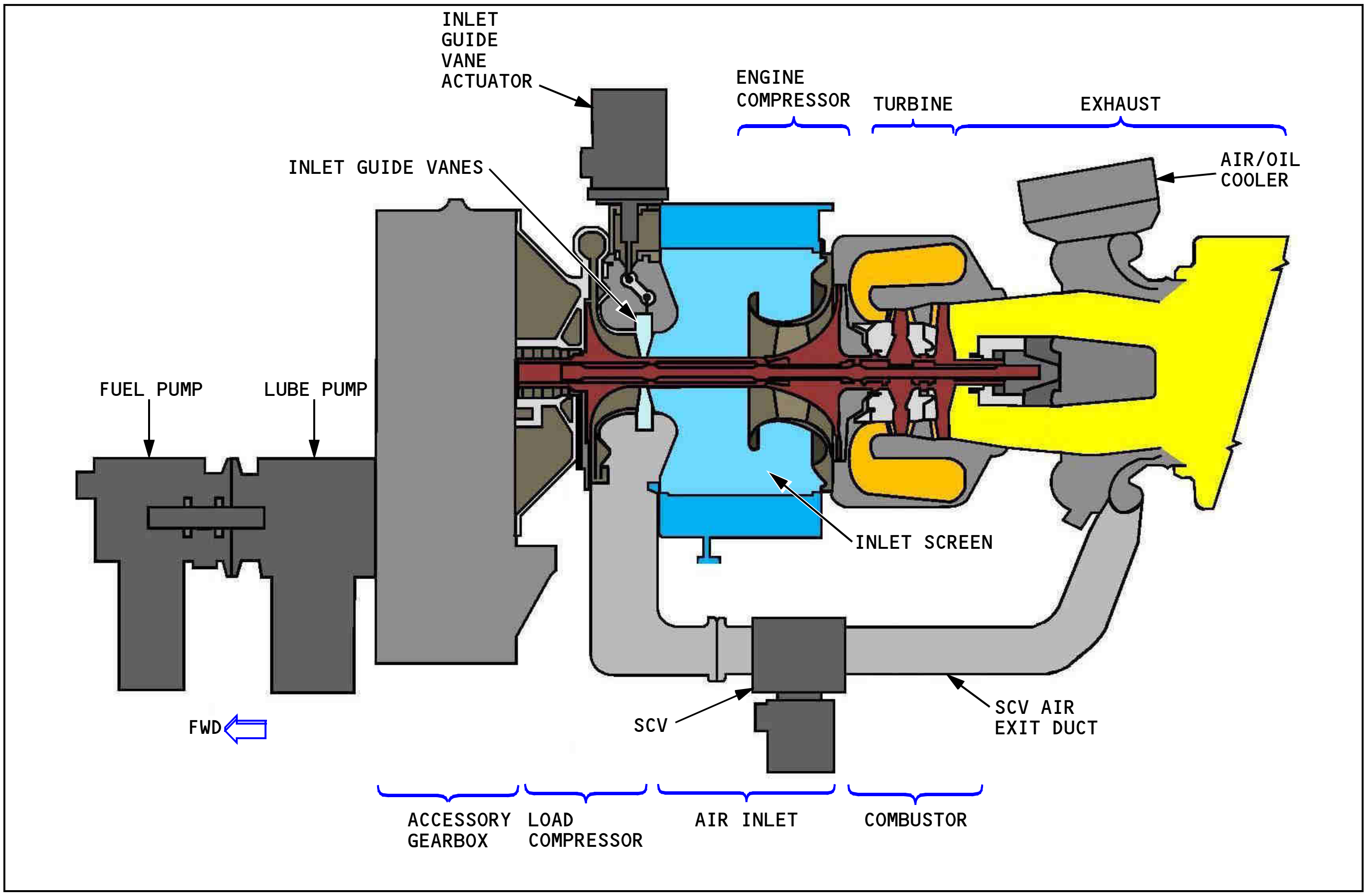


APU - Right Side

Auxiliary Power System

The APU has these components on the right side

- Ignition unit
- Fuel manifolds
- Surge control valve
- Bleed control valve
- Inlet guide vane actuator
- Starter generator.



APU Engine - Introduction

The APU engine supplies power to operate the load compressor and the APU starter-generator.

The APU engine has these main sections:

- Accessory gearbox
- Single-stage load compressor
- Single-stage engine compressor
- Combustor chamber
- Two-stage axial flow turbine.

All the components in the engine that turn are on a common shaft.

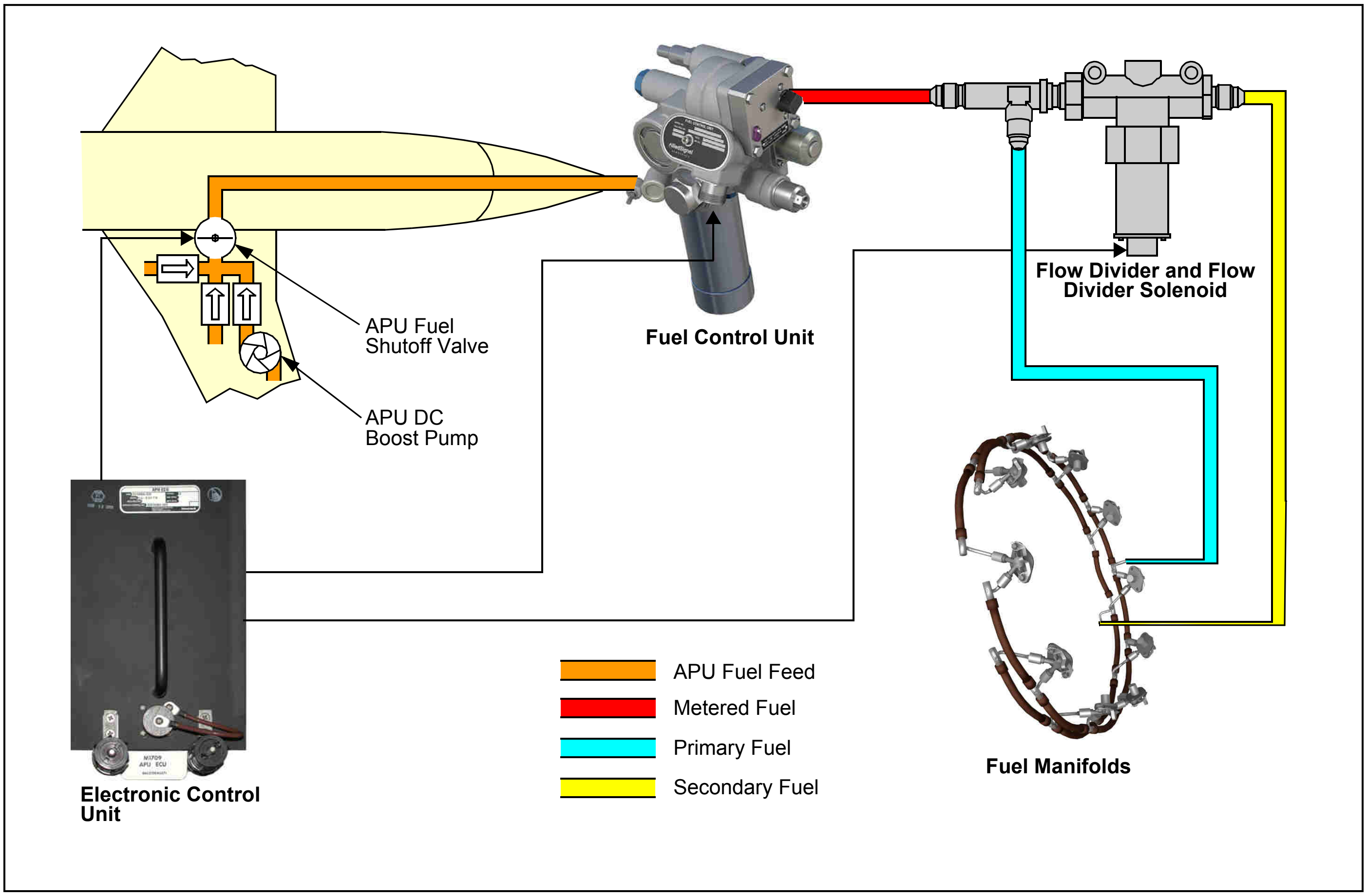
The shaft turns the accessory gearbox and the load compressor. The accessory gearbox turns the APU generator and other components.

The engine operates at a constant speed to provide 400 Hz generator output. The APU load compressor supplies air for airplane systems.

An inlet screen prevents foreign object damage (FOD) to the APU compressors.

BOEING PROPRIETARY

Auxiliary Power Unit



APU Fuel System

The APU fuel system receives fuel from any fuel tank. The APU fuel system has these major components:

- Fuel control unit
- Fuel flow divider
- Primary and secondary fuel manifolds.

FUEL CONTROL UNIT

The fuel control unit pressurizes, filters and meters fuel. The electronic control unit (ECU) sends fuel control signals to the fuel control unit. The fuel control unit uses these signals to meter fuel. The ECU controls fuel flow from start to shutdown.

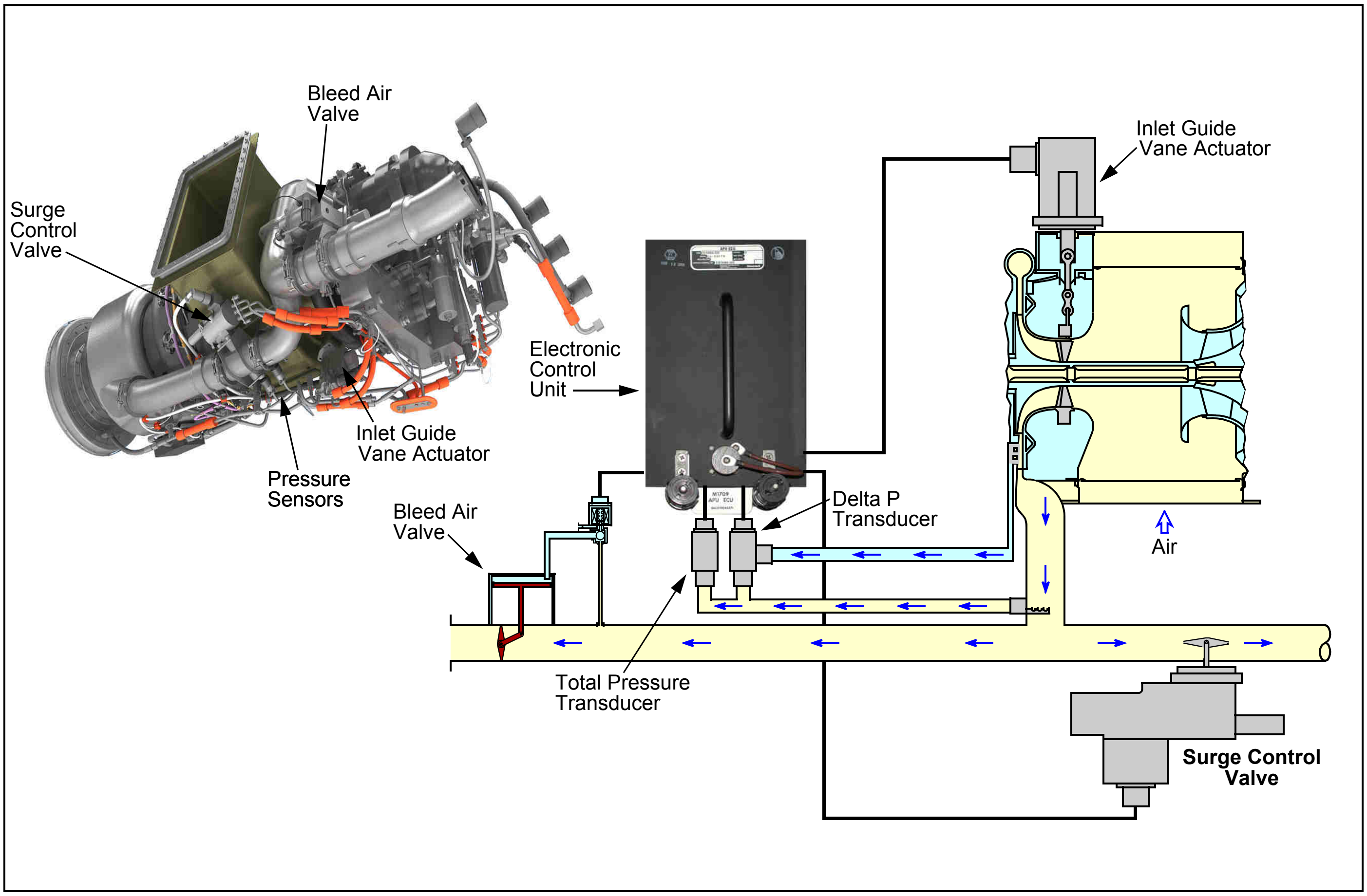
FUEL FLOW DIVIDER

The flow divider separates metered fuel to the primary and secondary fuel manifolds. The primary fuel manifold always supplies fuel when the APU is in operation. The flow divider supplies fuel to the secondary manifold when metered fuel flow pressures increases to a certain level. The ECU controls a solenoid on the flow divider to change the secondary manifold fuel supply with reference to altitude and APU speed.

The primary and secondary fuel manifolds supply fuel to the fuel injector nozzles.

INTERFACE

Regulated fuel pressure, from the fuel control unit, operates the inlet guide vanes and the surge control valve actuator.



APU Pneumatic System

The APU supplies pneumatic power for the environmental control system and for main engine start.

The air inlet door directs air into the inlet plenum. The APU takes inlet plenum air for use in two APU sections.

The APU has two separate compressors, an engine compressor and a load compressor. The engine compressor supplies compressed air to the combustor. The load compressor supplies compressed air to the airplane pneumatic system. The engine section operates the load compressor.

Inlet guide vanes control the amount of air that enters the load compressor. The electronic control unit (ECU) controls the inlet guide vanes with the inlet guide vane actuator.

A surge control valve lets enough air go through to the load compressor to prevent a compressor surge. The surge control valve sends excess pressurized air to the APU exhaust. This protects the load compressor from a surge. The ECU controls the surge control valve.

Both the inlet guide vane actuator and the surge control valve use regulated servo fuel pressure from the fuel control unit for operation.

The ECU senses the APU bleed switch position on the P5 panel in the flight compartment. When the bleed switch is in the ON position, the ECU energizes a solenoid on the bleed air valve. When the solenoid energizes, APU bleed air duct pressure causes the bleed air valve to move from the closed to the open position.

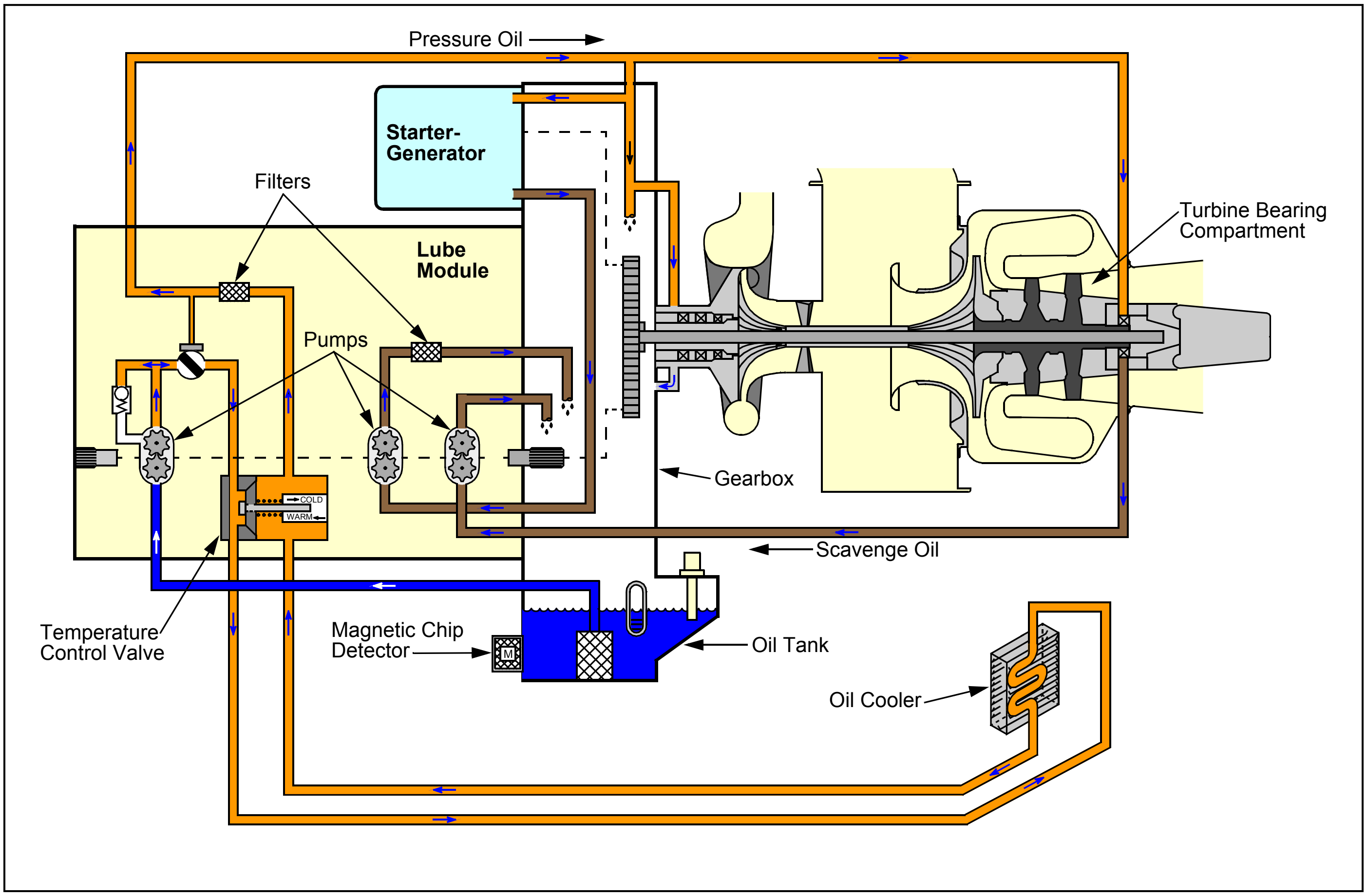
The ECU monitors the position of these components:

- Inlet guide vane actuator
- Surge control valve actuator
- Bleed air valve.

The position of these components also shows on the APU maintenance page of the MAX display system (MDS).

BOEING PROPRIETARY

Auxiliary Power Unit



APU Lubrication System

The lubrication system lubricates and cools the gears, bearings and shafts of these major components:

- Engine compressor
- Load compressor
- Gearbox.

The lubrication system also lubricates the APU starter-generator.

The lubrication module pressurizes, filters and scavenges the oil. The lubrication module contains these components:

- Pressure and scavenge pumps
- Pressure and scavenge filters.

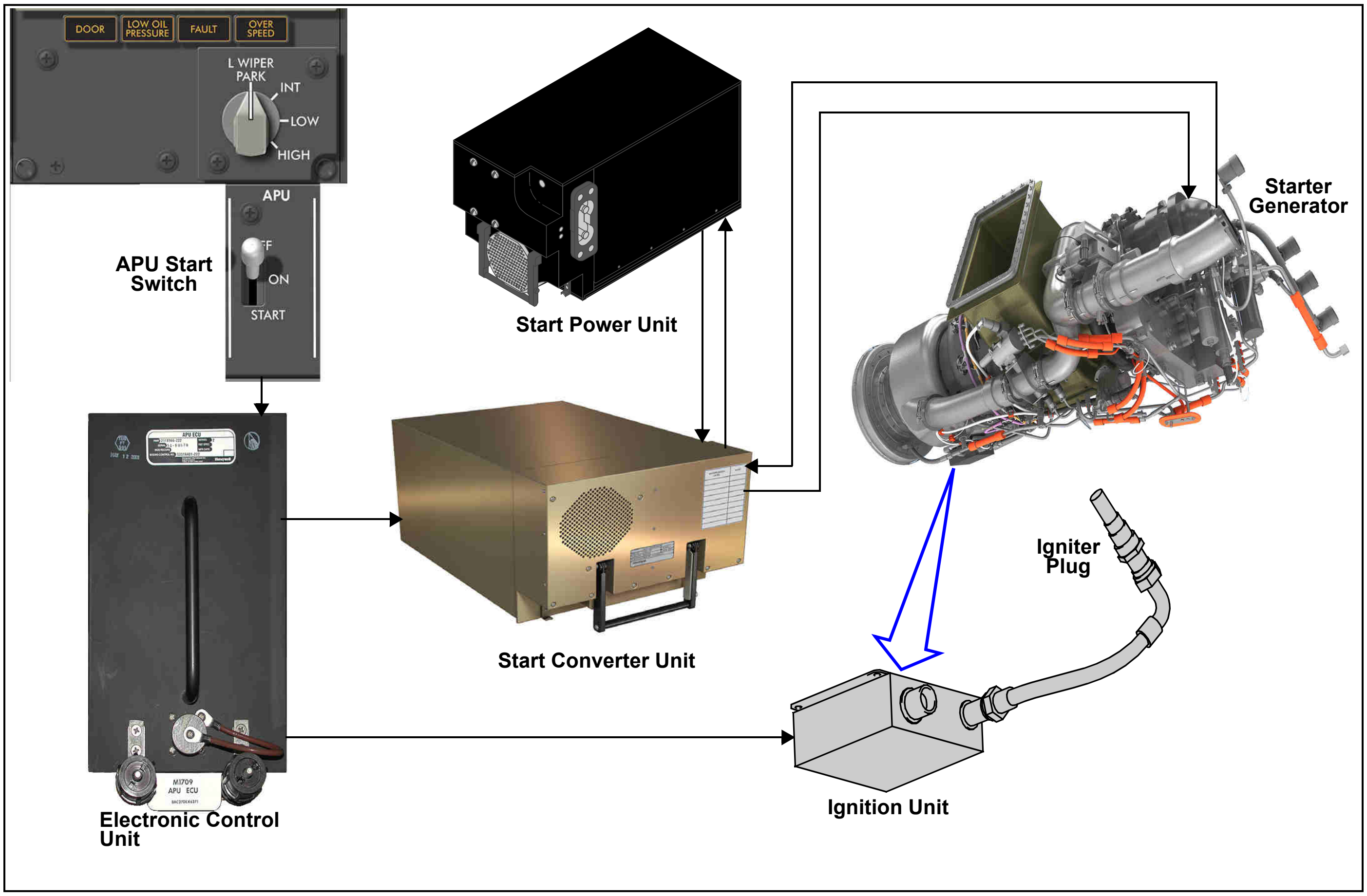
The gearbox sump is the oil reservoir. An oil fill port supplies oil to the reservoir. A sight glass shows oil quantity.

The gearbox vents to the APU exhaust.

From the reservoir, the oil is pressurized, filtered, and cooled before it goes to the major components and the starter-generator.

Scavenge pumps send oil to the scavenge filter before the oil returns to the reservoir.

The APU exhaust gas operates an eductor. The eductor pulls APU compartment air through the oil cooler to cool the oil and APU compartment. A temperature control valve regulates oil flow to and from the oil cooler.



APU Ignition and Start System

The ignition and start system supplies the combustion spark and starts the APU acceleration. The system includes these components:

- Starter-generator
- Start power unit
- Start converter unit
- Ignition unit
- Igniter.

The APU generator is also the APU starter.

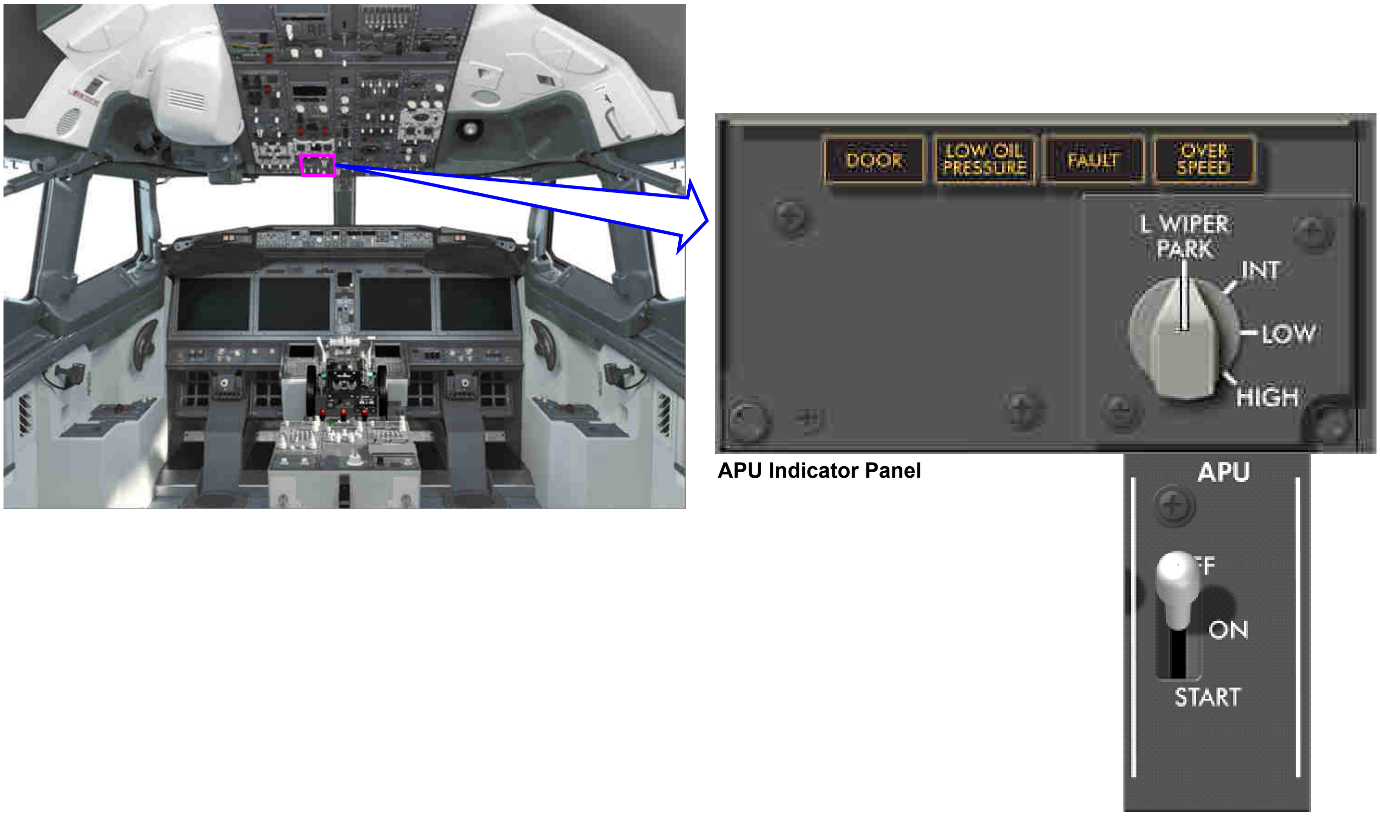
The start power unit (SPU) changes either AC or DC power to high voltage DC power. The SPU then sends this high voltage DC power to the start converter unit (SCU).

The SCU receives the high voltage DC power and changes it to AC. The SCU then matches phases and sends the AC power to the starter-generator.

The starter-generator uses AC power from the start converter unit to turn the APU gearbox and APU.

The ignition unit supplies electrical power to the igniter plug. The igniter plug supplies spark to the combustion chamber. The ECU controls the power to the ignition unit.

Auxiliary Power Unit



APU Indicator Panel

APU Control and Indication

The electronic control unit (ECU) controls these APU functions:

- Start and ignition
- Fuel control
- Inlet guide vane control
- Surge control
- Normal shutdown
- Protective shutdown
- APU indications
- BITE/fault recording
- Data storage.

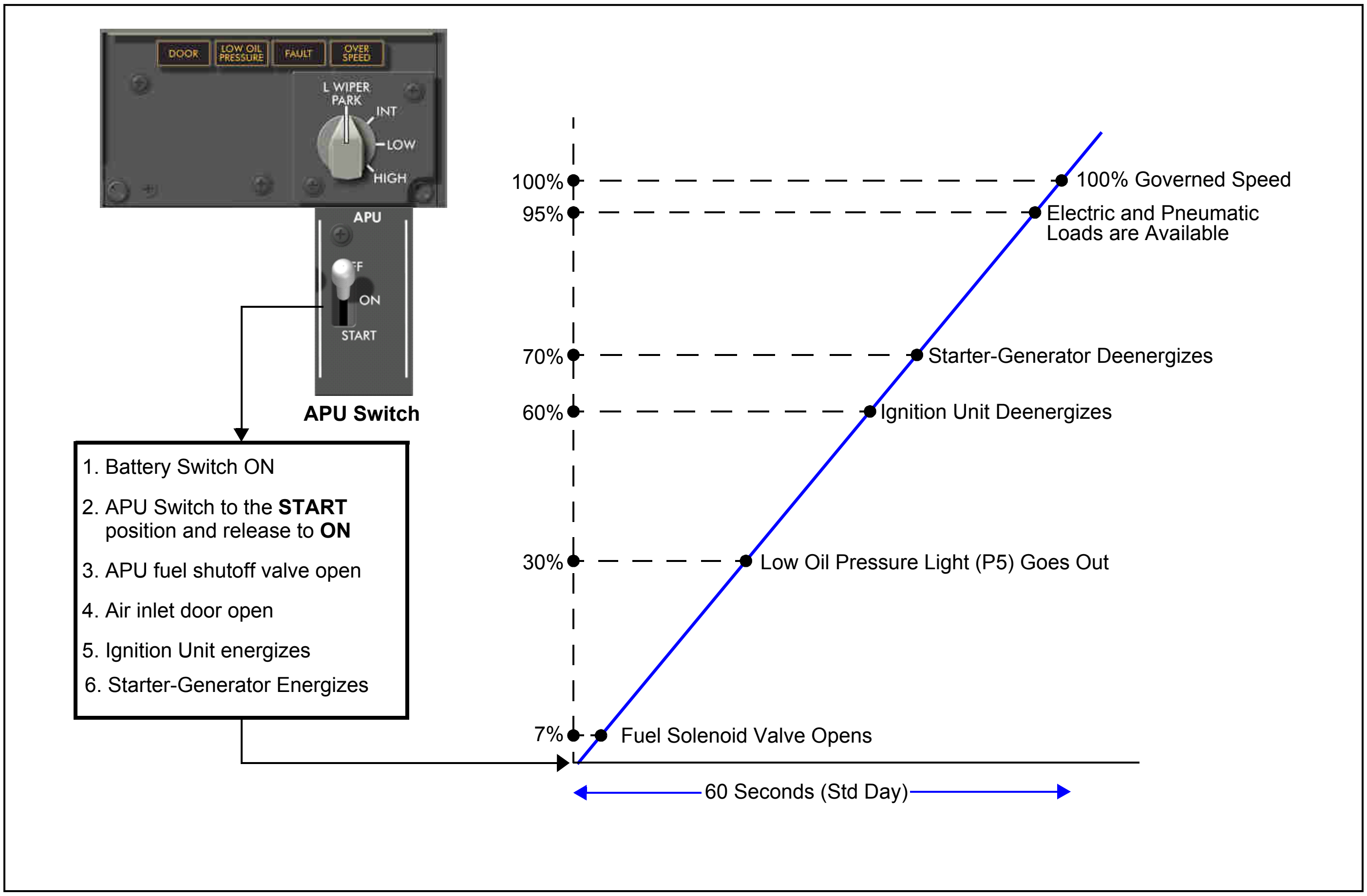
The APU switch on the P5 panel controls normal APU start and stop.

The DOOR light comes on when the APU air inlet door is not in the ECU commanded position. A door failure to open will prevent APU start.

The LOW OIL PRESSURE light comes on when the APU oil pressure is low. Low oil pressure causes a protective shutdown.

The FAULT light comes on when the APU has a fault that causes a protective shutdown.

The OVERSPEED light comes on when the APU speed is too high, and a protective shutdown occurs. The light also comes on when the overspeed protection test fails, and there is a loss of overspeed protection.



Airborne Auxiliary Power - Operation - Start

The APU can be started up to an altitude of 41,000 feet (12,500 meters).

The APU electronic control unit (ECU) controls these components:

- APU inlet door
- APU fuel shutoff valve
- APU fuel
- Ignition
- APU start system.

PRESTART

The battery switch must be ON before you can start and operate the APU. If AC power is available, operate one or more of the fuel boost pumps. This provides pressurized fuel to the APU. Pressurized fuel makes the APU start better.

APU START

The APU switch is moved to the START position and released. This sends a signal to the ECU. The ECU then opens the APU fuel shutoff valve and the APU air inlet door. The ECU also causes the LOW OIL PRESSURE light to come on. When the air inlet door is open, the door switch sends a signal to the ECU.

APU SEQUENCE

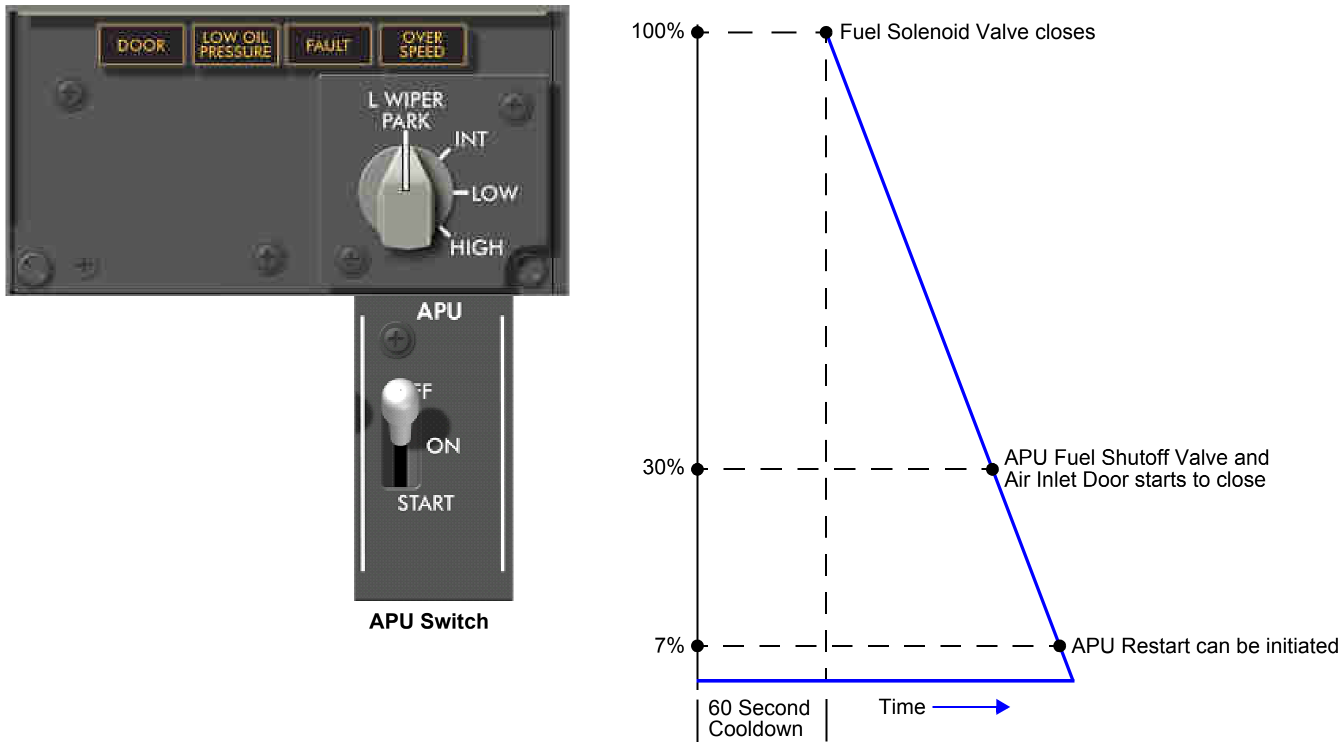
The ECU controls this APU start sequence:

- At 0 percent speed and before the start system is energized, the ECU energizes the ignition unit
- At 0 percent speed for start or 7 percent speed for restart, the ECU energizes the starter-generator
- At 7 percent speed, the fuel solenoid valve opens
- At approximately 30 percent speed, the LOW OIL PRESSURE light (P5) goes out.
- At 60 percent speed, the ignition unit deenergizes
- At 70 percent speed, the starter-generator deenergizes
- At 95 percent speed, the APU can supply electrical power and air
- The APU accelerates to, and stays at 100 percent speed.

Note: The inlet guide vanes (IGVs) close to 15 degrees with the APU bleed air valve closed. This keeps the load compressor cool when it does not have a load.

The BAT DISCHARGE light on the electrical meters, battery, and galley power module comes on when the APU start uses DC power. The BAT DISCHARGE light does not come on when the APU uses AC power to start.

Auxiliary Power Unit



APU Switch

Airborne Auxiliary Power - Operation - Shutdown

The APU electronic control unit (ECU) controls the APU shutdown. There are two types of shutdown, normal and protective.

When the APU switch is selected to OFF, the ON signal is removed from the ECU and an OFF signal goes to the ECU.

These steps occur when the APU is selected OFF:

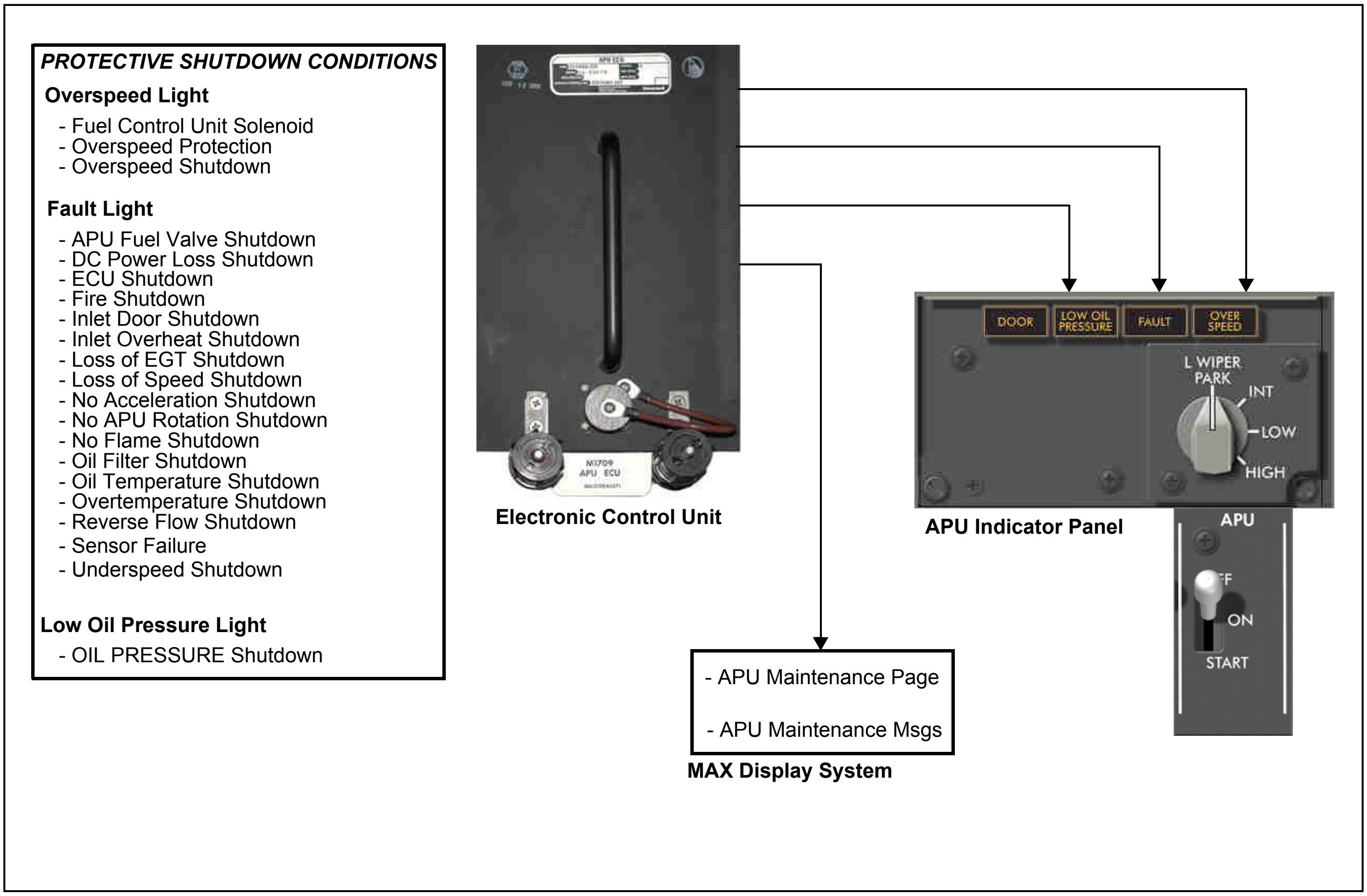
- The ready to load signal is removed
- The bleed air valve is closed
- The inlet guide vanes close
- The surge control valve opens
- The starter generator is deenergized
- The 60 second cooldown timer is started.

When the cooldown period has ended, the fuel solenoid valve is closed.

At 30 percent speed, the APU air inlet door starts to close.

At 7 percent, an APU restart can be initiated.

BOEING PROPRIETARY



Airborne Auxiliary Power - Protective Shutdown

A protective shutdown prevents damage to the APU or the airplane.

The electronic control unit (ECU) controls the automatic protective shutdown of the APU. If the ECU finds a fault, it does a protective shutdown.

There are three different protective shutdown indications in the flight compartment. These are the flight compartment protective shutdown indications:

- FAULT light
- OVER SPEED light
- LOW OIL PRESSURE light.

The cause for the shutdown shows on the MAX display system onboard maintenance (OMS) displays.

PROTECTIVE SHUTDOWN

These are the conditions that cause a protective shutdown and a FAULT light:

- Fuel shutoff valve not in commanded position
- Loss of dc power
- ECU failure
- APU fire
- Inlet door not in commanded position
- APU inlet overheat
- Loss of both EGT signals
- No speed signal
- No acceleration
- No APU rotation
- No flame (no ignition)
- Generator filter clogged
- High oil temperature
- Overtemperature (EGT)
- Reverse flow (load compressor)
- Oil temperature or inlet air temperature sensor failure
- Underspeed.

These are the conditions that cause a protective shutdown and an OVER SPEED light:

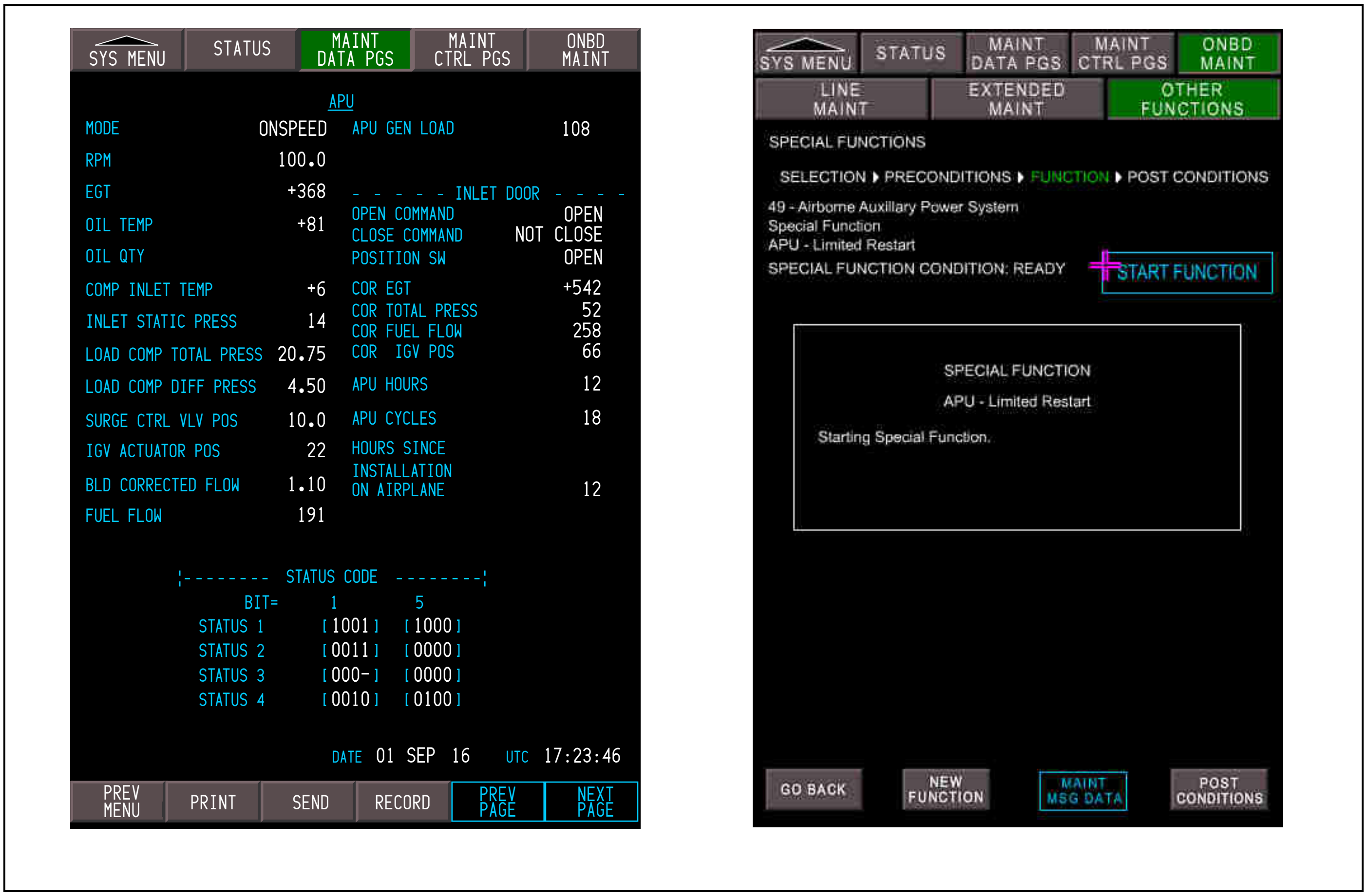
- Fuel control unit solenoid failure
- Loss of overspeed protection
- Overspeed.

Low oil pressure for 20 seconds causes a protective shutdown and a LOW OIL PRESSURE light.

When a protective shutdown occurs, the ECU removes electrical power from these components:

- Fuel solenoid valve
- Ignition unit
- SCU start signal
- Bleed air valve (BAV)
- Fuel control unit (FCU)
- Surge control valve (SCV).

The ECU sends maintenance page and fault data to the MAX display system.



APU Maintenance Data Page and BITE functions

The MAX display system (MDS) and the onboard maintenance function (OMF) provide maintenance data, fault isolation and special function capabilities for the APU system.

The maintenance light can also show faults in the APU system. The ECU sends display and fault data to the display processing computers (DPCs). APU sensor and operational data shows on the APU maintenance data page. The OMF shows and records faults from the ECU. Special functions, such as the APU limited restart reset function show above, allow maintenance access to all ECU BITE functions.

LEAP-1B Engine Features

THRUST

The LEAP-1B high bypass turbofan engine produces 21,500-27,900 pounds of thrust.

RELIABILITY AND EFFICIENCY

The LEAP-1B engine is a derivative of the GEnX and CFM56-7BE engines. The maintenance costs of the LEAP-1B are almost the same as on the CFM56-7BE.

The LEAP-1B engine uses less fuel than the CFM56-7BE engine, and its operation is cleaner.

MAINTENANCE

Maintenance personnel benefit from the 737 eye-level maintenance design. The cowls move easily outward and supply access for maintenance. This gives quick access to meet short turn around times.

Engine buildup is identical for left and right engines. Engine change is easier with these features:

- On wing hoist attachments
- Step-by-step manual
- Improved access.

Engine component and exceedance data are easy to access. The MAX display system (MDS) lets maintenance personnel do built-in tests. You do these tests with display screens on the P1, and P2 panels.

QUIET CABIN

A quiet cabin is made possible by these features:

- An advanced broadband acoustical liner
- No inlet guide vanes
- Fully lined fan duct
- Shroudless wide-chord fan blades
- High-bypass-ratio design.

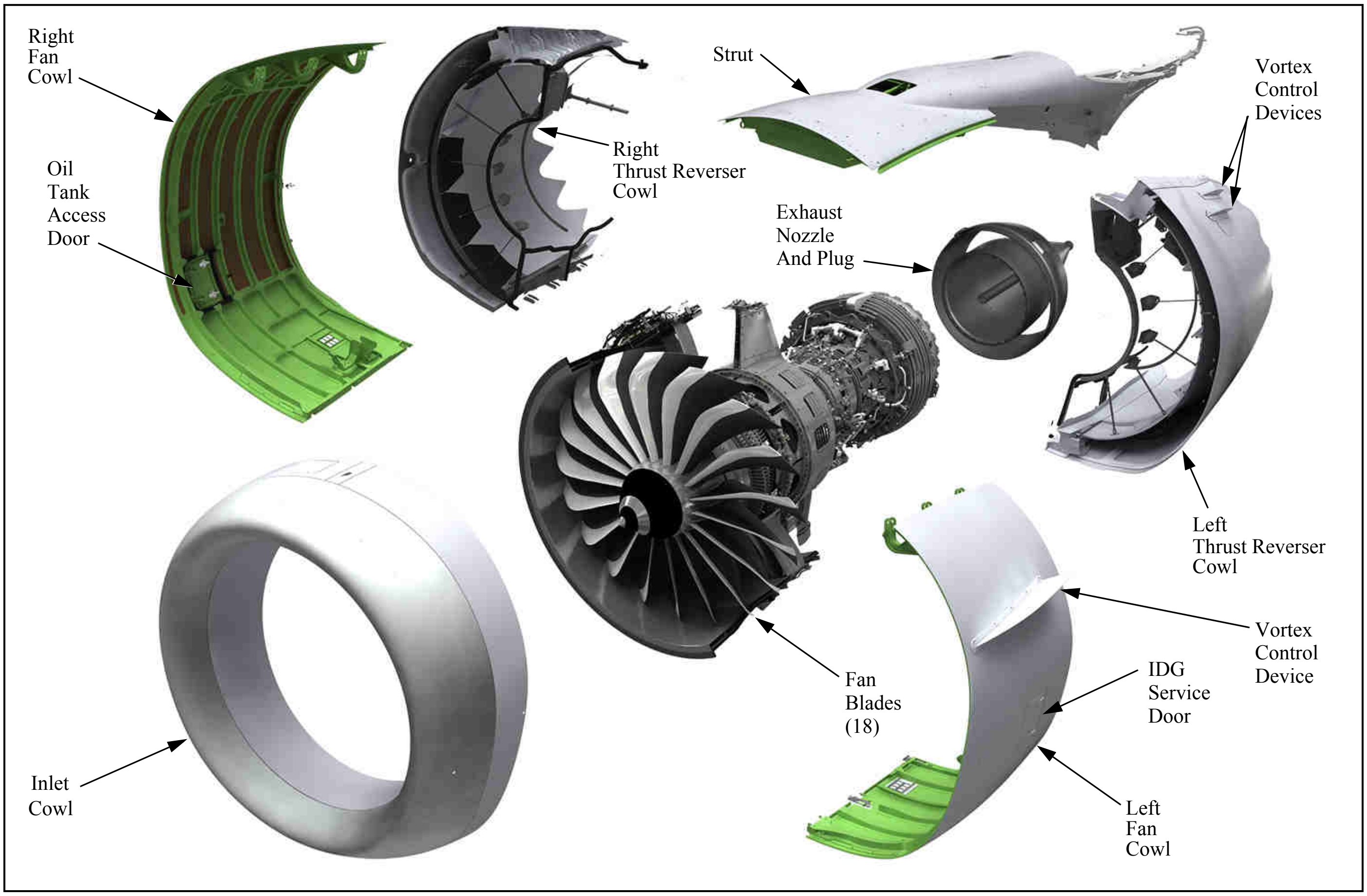
MAX DISPLAY SYSTEM

The new max display system (MDS) liquid crystal display units (DU) are on the P1, and P2 panels. They supply flight and maintenance crews with highly reliable messages that are easy to read.

NEW TECHNOLOGY

Two EEC channels for each engine increase fuel efficiency and engine response. A debris rejection system decreases airfoil erosion damage. A new compressor design increases thermal efficiency. Composite fan blades weigh less and can twist to aid engine airflow. The fan blades are protected by titanium leading edge caps. The fan case also contains composite materials to decrease weight.

Power Plant



LEAP-1B Engines

The 737 MAX airplane uses two CFM LEAP-1B high bypass-ratio turbofan engines that attach to the wing. The engine strut gives an attachment for the front and rear engine mounts. The engine cowls give a smooth surface around the engine. The inlet cowl attaches to the front of the engine fan case. The fan cowls attach to a support beam that is on top of the fan case. Thrust reverser cowls attach to the strut, and also transmit reverse thrust to the airplane after landing.

The inlet cowl has an access panel for the inlet temperature sensor. It also has an inlet for the fan compartment cooling.

The fan cowls have access panels for engine servicing. There is also an inboard vortex control device to improve airflow.

The thrust reverser cowls have these components:

- Titanium core compartment inner cowl
- Outer translating sleeve
- Blocker doors
- Drag links
- Thrust reverser actuators.

The engine exhaust has these parts:

- Outer exhaust nozzle
- Inner exhaust plug
- Oil vent tube extension.

The engine core uses a proven design with improvements based on new technology. Wide chord composite fan blades provide most of the engine thrust.

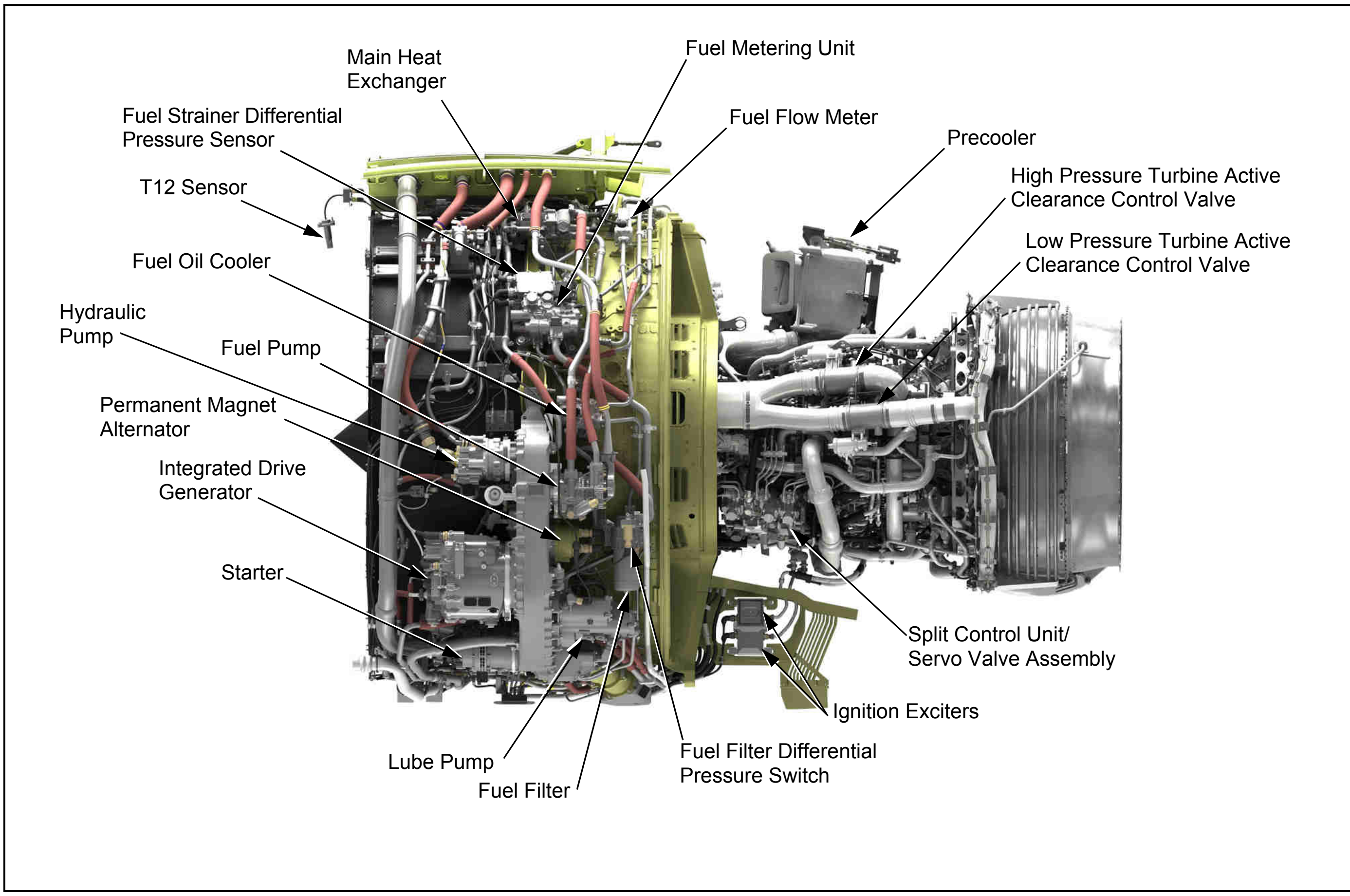
The main gearbox supplies power for aircraft and engine accessories. The main gearbox attaches to the side of the fan case. The high pressure section drives the gearbox.

Engine Installation

Engine bootstrap tooling attaches to the strut to permit lowering/raising the engine with the transportation stand. The fan cowl panels are quickly removed to give ground level access to the engine. The thrust reverser cowls stay with the airplane during engine change. The engine attaches to the strut with eight tension bolts and two thrust links. Electrical, pneumatic and hydraulic systems can be quickly connected and disconnected.

Engine Buildup

The buildup for both engines is the same except for the vortex control devices on the fan cowl and thrust reversers.

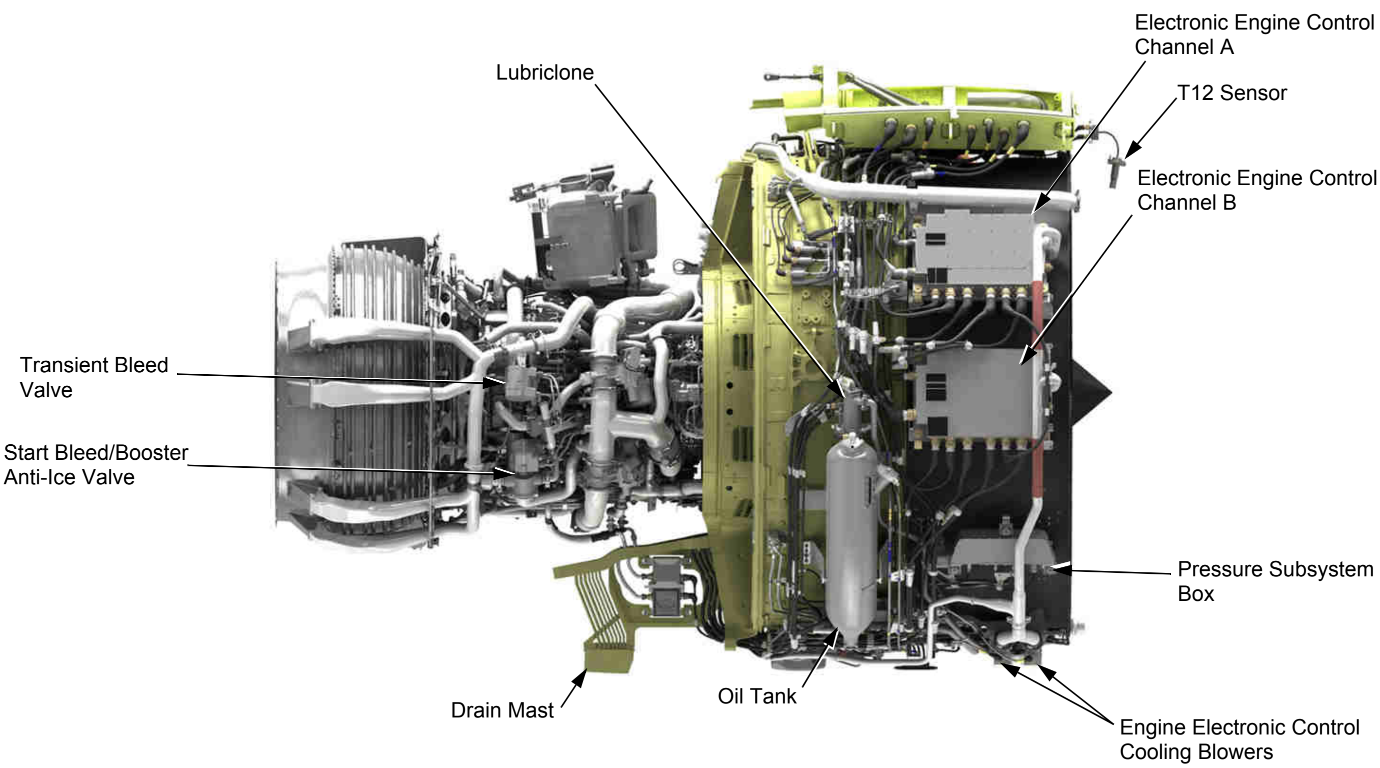


LEAP-1B Engines

The engine has these components on the left side:

- Main (fuel/oil) heat exchanger
- Fuel metering unit (FMU)
- Fuel flow meter
- Precooler (top mounted)
- High pressure turbine active clearance control (HPTACC) valve
- Low pressure turbine active clearance (LPTACC) control valve
- Split control unit/servo valve assembly (SCU)
- Ignition exciters (bottom mounted)
- Fuel filter differential pressure switch
- Fuel filter
- Lube pump
- Starter
- Integrated drive generator (IDG)
- Permanent magnet alternator (PMA)
- Fuel pump
- Fuel strainer diff. pressure sensor
- Hydraulic Pump
- Fuel Oil Cooler.

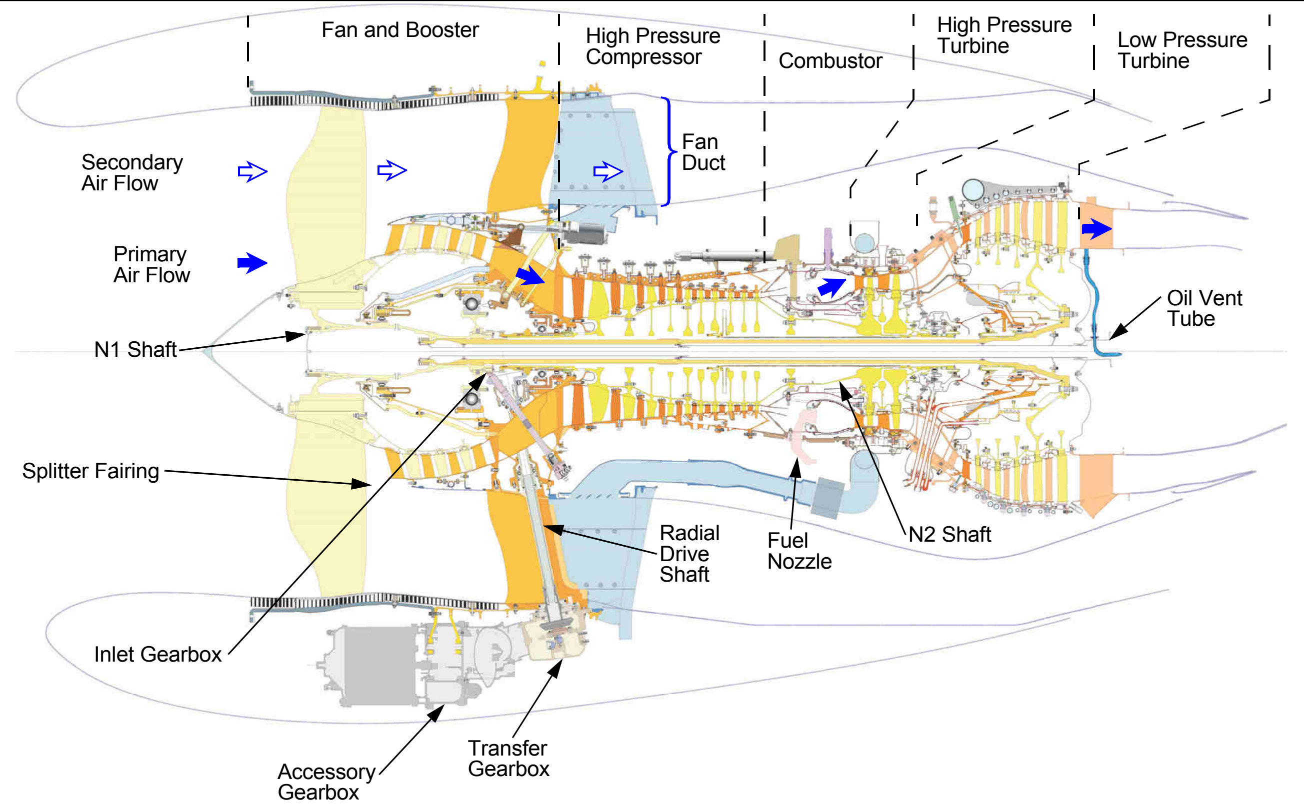
Power Plant



LEAP-1B Engines

The engine has these components on the right side:

- Electronic engine control channel A
- Electronic engine control channel B
- Pressure subsystem box
- Engine electronic control cooling blowers
- Lubriclone debris monitoring system
- Oil tank
- Drain mast
- Start bleed/booster anti-ice valve
- Transient bleed valve (TBV).



ENGINE LEFT SIDE VIEW SHOWN

Engine - General Description

The LEAP-1B is a high bypass, dual rotor, axial flow turbofan engine.

The engine has these sections:

- Fan and booster or low pressure compressor (LPC)
- High pressure compressor (HPC)
- Combustor
- High pressure turbine (HPT)
- Low pressure turbine (LPT)
- Accessory drive.

The fan and booster rotor and the LPT rotor are on the same low pressure shaft (N1).

The HPC rotor and the HPT rotor are on the same high pressure shaft (N2).

FAN AND BOOSTER (N1)

The fan and booster is a four-stage compressor. A splitter fairing divides the air into primary and secondary air flows. The primary air flow goes into the core of the engine. The booster increases the pressure of this air and sends it to the HPC. The secondary air flow goes in the fan duct. It supplies approximately 80 percent of the thrust during take-off.

HIGH PRESSURE COMPRESSOR (N2)

The HPC is a ten-stage compressor. It increases the pressure of the air from the LPC and sends it to the combustor. The HPC also supplies bleed air for the pneumatic system.

COMBUSTOR

The combustor mixes air from the compressors and fuel from the fuel nozzles. This mixture of air and fuel burns in the combustion chamber to make hot gases. The hot gases go to the HPT.

HIGH PRESSURE TURBINE (HPT)

The HPT is a two-stage turbine. It changes the energy of the hot gases into a mechanical energy. The HPT turns the HPC rotor and the accessory drive.

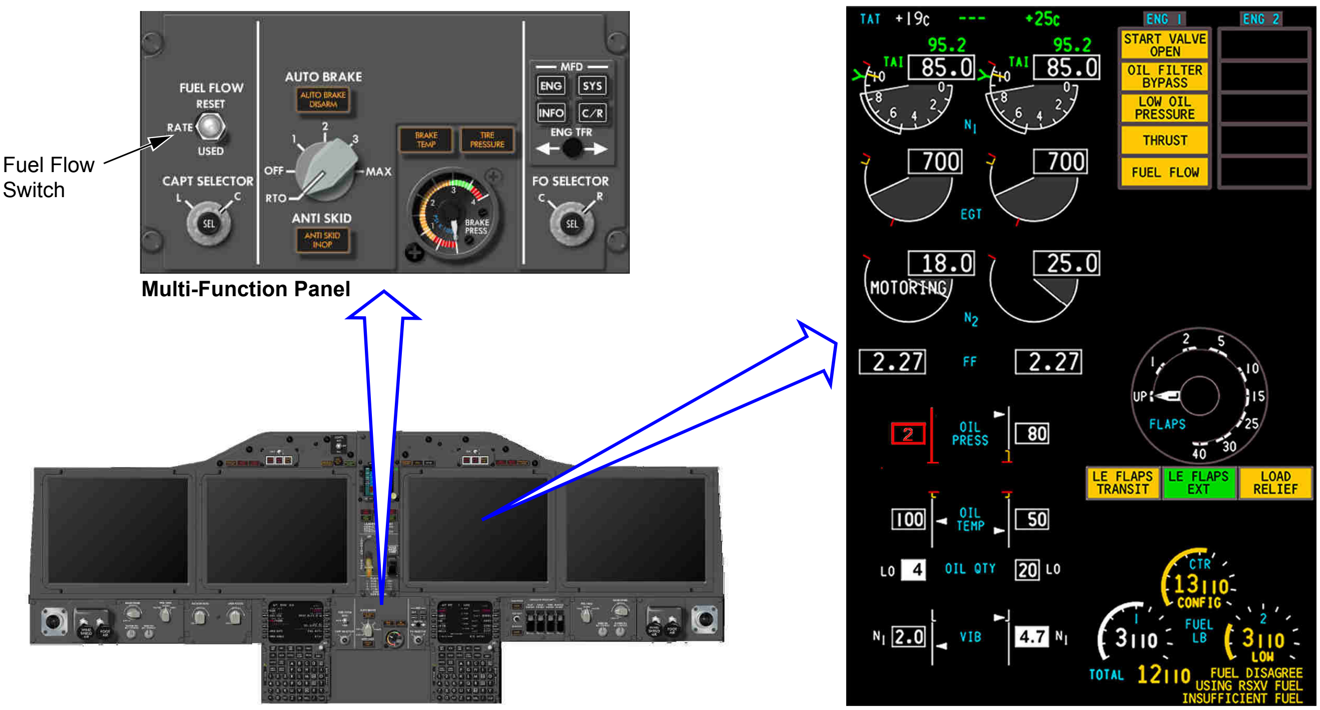
LOW PRESSURE TURBINE (LPT)

The LPT is a five-stage turbine. It changes the energy of the hot gases into a mechanical energy. The LPT turns the fan and booster rotor.

ACCESSORY DRIVE

The engine HPC shaft drives the accessory gearbox (AGB). The AGB holds and operates the airplane accessories and the engine accessories.

Power Plant



Multi-Function Panel

Flight Deck Forward Instrument Panel

Engine Indication Display

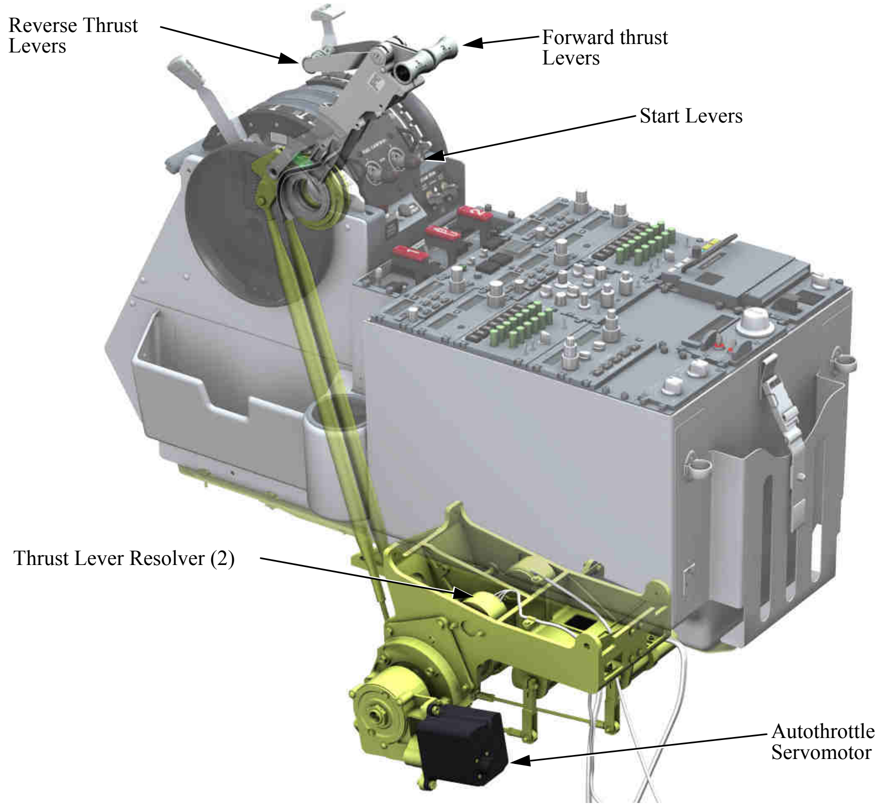
Max Display System (MDS)

Data given in the engine indication display includes the following:

- N1 shows the fan and low pressure compressor (LPC) speed in percent RPM.
- The N1 display becomes red when the LPC speed exceeds the limits.
- N2 shows the high pressure compressor (HPC) speed in percent RPM.
- The N2 display becomes red when the HPC speed exceeds the limits.
- Exhaust gas temperature (EGT) shows in degrees C.
- The box around EGT digital display flashes twice per second if a hot start occurs. The sides of the box also get thicker.
- The EGT display becomes red when the start and maximum temperature exceeds the limits. The display is amber when temperature goes to the maximum takeoff power range.
- A red box around each digital indication stays on after engine shutdown.
- Fuel flow indication shows fuel flow in weight of fuel per hour and also total fuel used per engine.
- Engine oil pressure in PSI
- Engine oil temperature in degrees C.
- The oil pressure and oil temperature displays become amber or red when there is an exceedance.
- Engine oil quantity is shown in quarts. The display becomes reverse video and a low message shows when the quantity is low.
- Engine vibration shows in scalar units.

You control the FUEL FLOW and FUEL USED displays with the FUEL FLOW switch on the multi-function panel.

- The USED position of this switch changes the indication from FUEL FLOW to FUEL USED. After 10 seconds, the FUEL USED display goes back to FUEL FLOW.
- The RESET position of this switch resets the fuel used counter to zero.



Control Stand

Engine Controls

The engine controls supply manual and automatic inputs to operate the engine. These are the components:

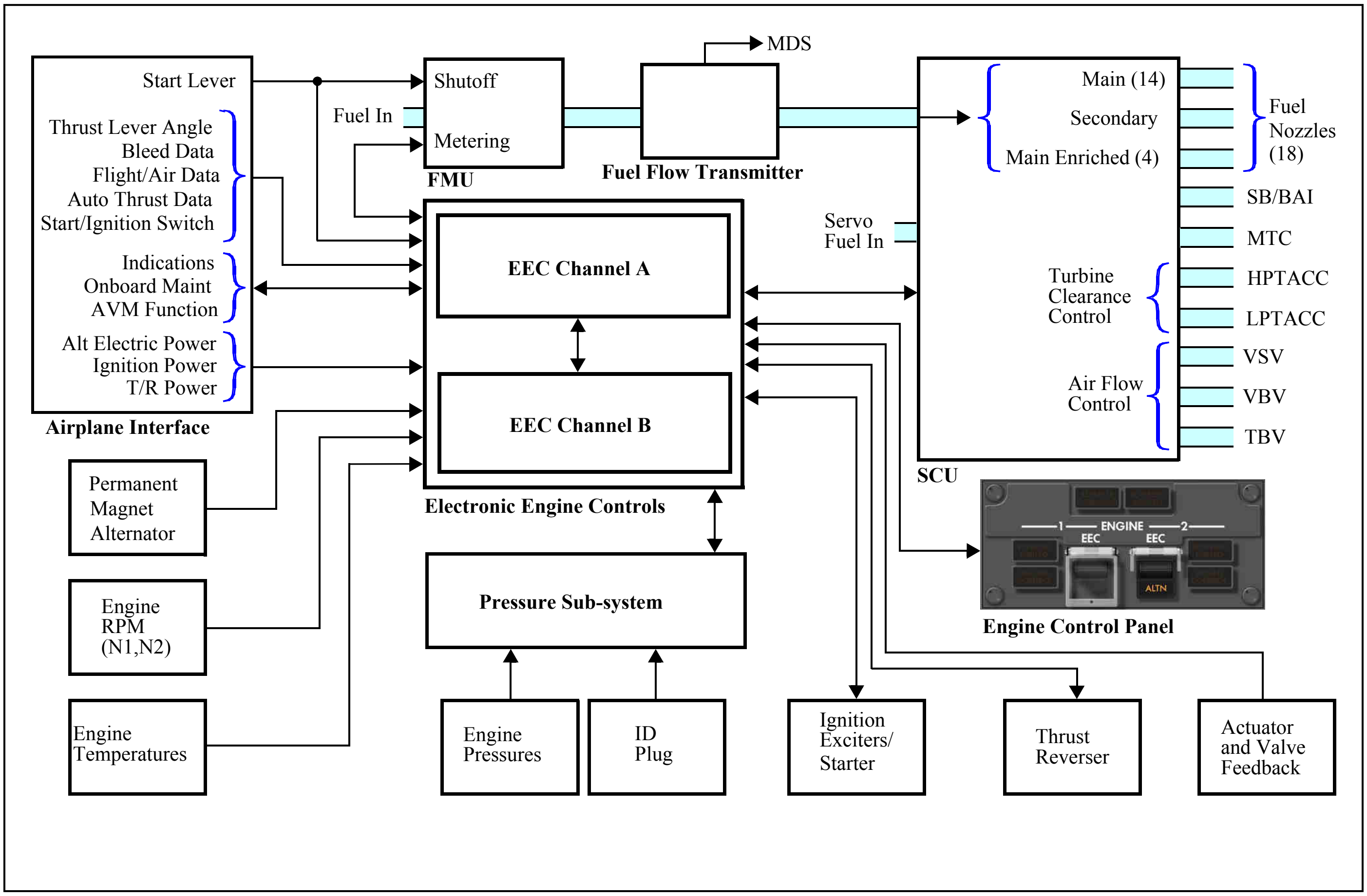
- Forward thrust levers
- Reverse thrust levers
- Thrust lever resolvers
- Start levers
- Autothrottle servomotor.

The thrust levers supply manual inputs to the thrust lever resolvers. The resolvers send this command signal to the electronic engine controls (EECs). The EECs use these signals to control engine thrust.

The engine start levers supply start and shutdown signals to different aircraft and engine systems.

The engines can also be controlled by the autothrottle system using the autothrottle servo motors (ASM).

Power Plant



Engine Control System

The engine control system has two electronic engine controls (EECs), channel A and channel B. Each channel is the same part number. A different channel in control is used for each flight. If that channel is unable to maintain a control function, the control system switches to the other channel to supply the control of engine functions for the rest of the flight.

The EECs control these engine functions:

- Fuel flow to meet thrust lever angle demand
- Engine servo controlled systems
- Engine fault detection and fault storage
- Engine communication with other airplane systems.

Control outputs go to the EECs from the start levers, start/ignition switches, and engine control panel.

Airplane control inputs come from the auto thrust system, MAX display system (MDS), and the onboard maintenance function (OMF).

The engine driven permanent magnet alternator supplies power to the EECs. The airplane electrical system supplies alternate power to the EECs. The airplane electrical system also supplies the power for engine ignition and thrust reverser control.

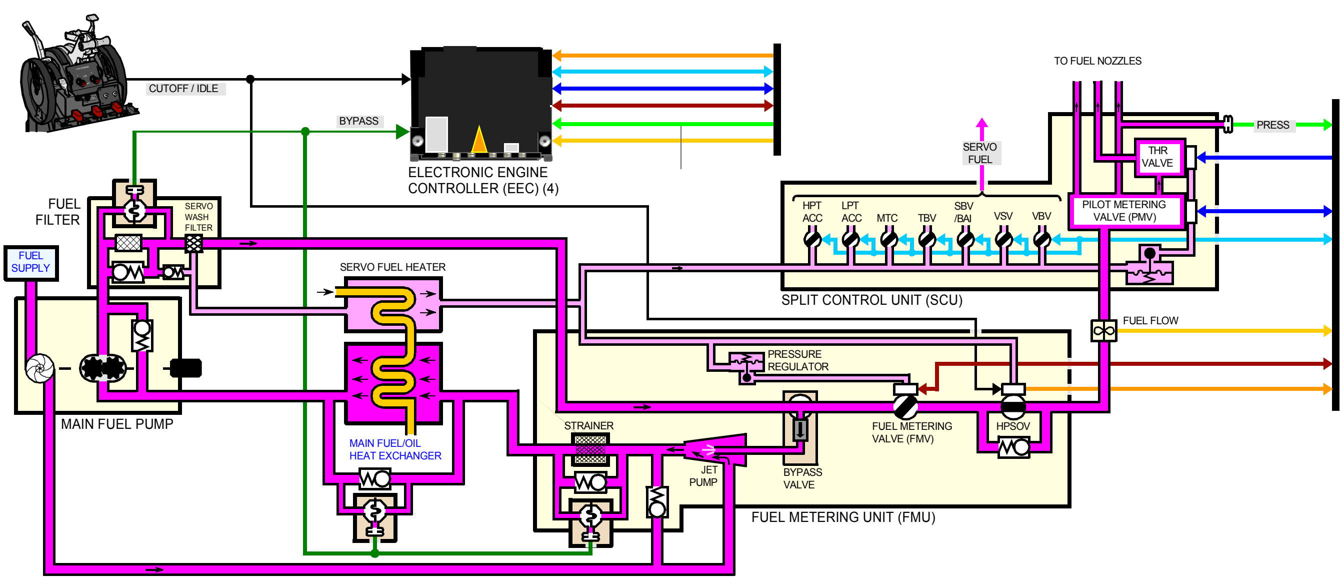
Engine sensors supply engine speeds, temperatures, and pressures to the EECs.

The EEC has normal and alternate modes of operation. If air data parameters become unavailable, the EEC goes to a soft alternate mode. You push a guarded switch on the engine control panel to put the engines in the hard alternate mode for the rest of the flight, or before dispatch.

The EECs control and monitor the split control unit (SCU). The SCU has servos that supply pressurized (servo) fuel to control these functions on the engine:

- Control of fuel flow to the nozzles
- Start bleed/booster anti-ice valve (SB/BAI)
- Modulated turbine cooling actuators (MTC)
- High pressure turbine active clearance control valve (HPTACC)
- Low pressure turbine active clearance control valve (LPTACC)
- Variable stator vane actuators (VSVs)
- Variable bleed actuators (VBVs)
- Transient bleed actuator. (TBV).

The EECs monitor the feedback from the valves and actuators for fault detection. The EECs also control and monitor the thrust reversers, and the starting and ignition functions.



Fuel System

The engine fuel system has these functions:

- Supply pressurized, heated, and filtered fuel to the engine fuel metering unit (FMU) for combustion
- Supply heated servo fuel to the split control unit (SCU) to control the engine system actuators and valves.

The engine start lever and the engine fire switch control the spar fuel shutoff valve and the high pressure shutoff valve (HPSOV). The spar fuel shutoff valve is on the front spar. The HPSOV is in the FMU.

Fuel tank boost pumps get fuel from the fuel tanks to supply the engine. This fuel flows through the spar fuel shutoff valve to a two-stage main fuel pump on the accessory gearbox of the engine.

Fuel moves from the first stage of the fuel pump through a jet pump and a strainer in the FMU. It then goes to the main fuel/oil heat exchanger. From the main fuel/oil heat exchanger the fuel goes to the second stage of the main fuel pump. Fuel can bypass the strainer or the main fuel/oil heat exchanger if there is a blockage.

The second stage of the fuel pump supplies high pressure fuel to the FMU and the SCU. The fuel goes through the fuel filter. After the fuel filter it divides into two flows.

The primary flow for the fuel nozzles goes from the fuel filter to the FMU metering valve. From the metering valve the fuel goes to bypass or through the metering valve to the HPSOV. When the HPSOV opens, the fuel flows through the fuel flow transmitter and the fuel temperature probe to the SCU. In the SCU the fuel divides into three fuel nozzle flows for combustion.

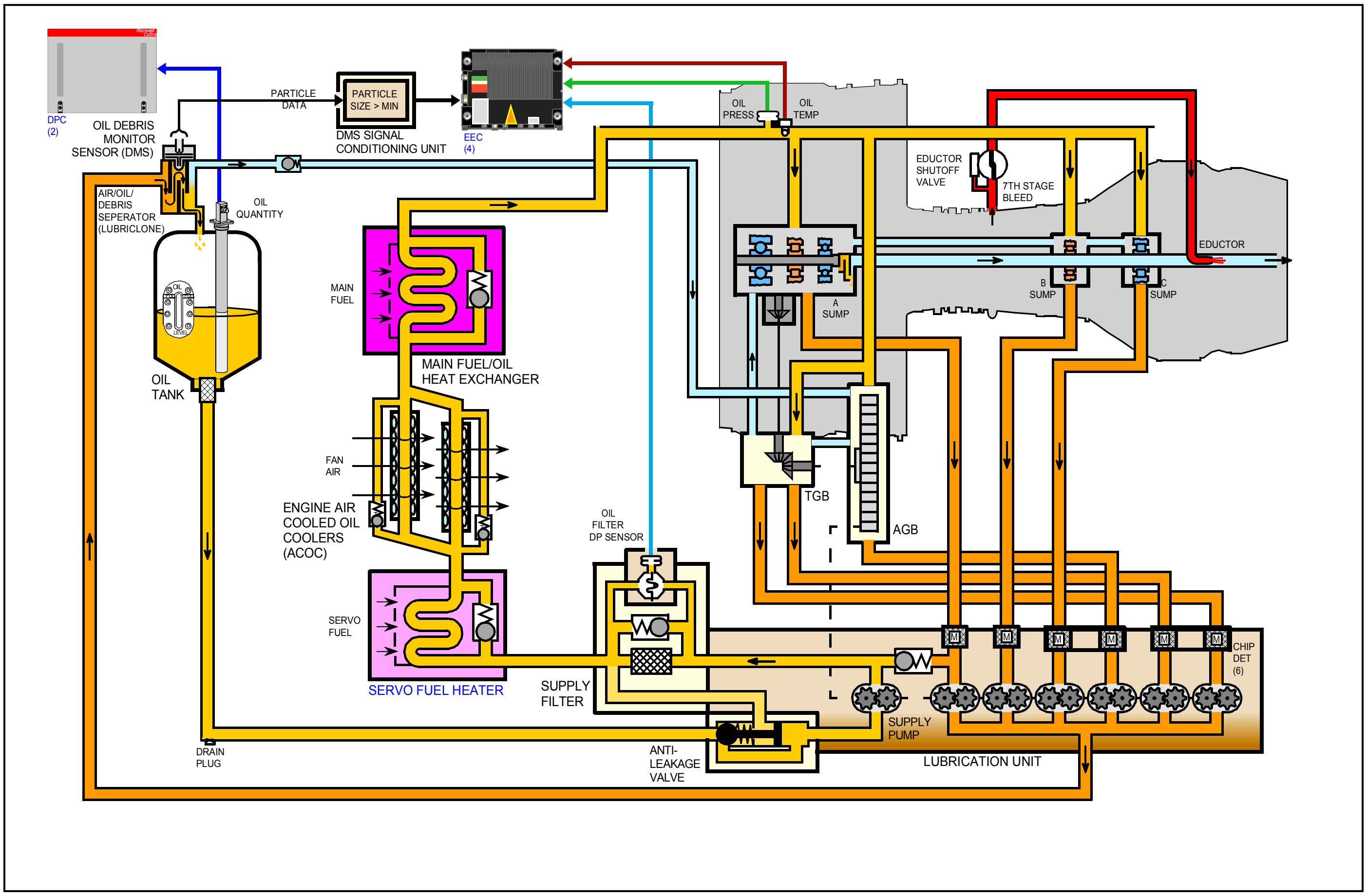
A secondary fuel flow after the fuel filter goes through a servo wash filter and a servo fuel heater. After the servo fuel heater the fuel goes to the FMU and SCU. This heated servo fuel goes to the FMU to operate the HPSOV and a pressure regulator. The servo fuel that goes to the SCU goes to the servo valves and nozzle control valves.

These indications come from the engine fuel system:

The ENG VALVE CLOSED light comes on dim blue on the P5 panel when the HPSOV closes. The SPAR VALVE CLOSED light comes on dim blue on the P5 panel when the spar valve closes. The amber FILTER BYPASS light on the P5 panel comes on before a fuel bypass occurs at the fuel filter. The fuel flow transmitter measures the

BOEING PROPRIETARY

rate of fuel flow to the SCU. Fuel flow shows on the MDS fuel flow indicator.



Oil System

The oil system lubricates, cleans, and removes heat from the engine.

Oil is kept in the engine oil tank. There is an oil quantity transmitter in the oil tank.

The oil tanks sends oil through an anti-leak check valve to the engine driven supply pump. The anti-leak check valve prevents oil hiding after shutdown. Pressure from the supply oil pump then goes through a supply oil filter. From the supply filter, oil then flows through three heat exchangers. There are oil pressure and oil temperature sensors after the heat exchangers. Oil pressure, oil temperature and oil quantity show on the max display system (MDS) engine display.

A LOW OIL PRESS indication shows on the engine display if the engine oil pressure gets below the red line. The indication is a flashing amber message.

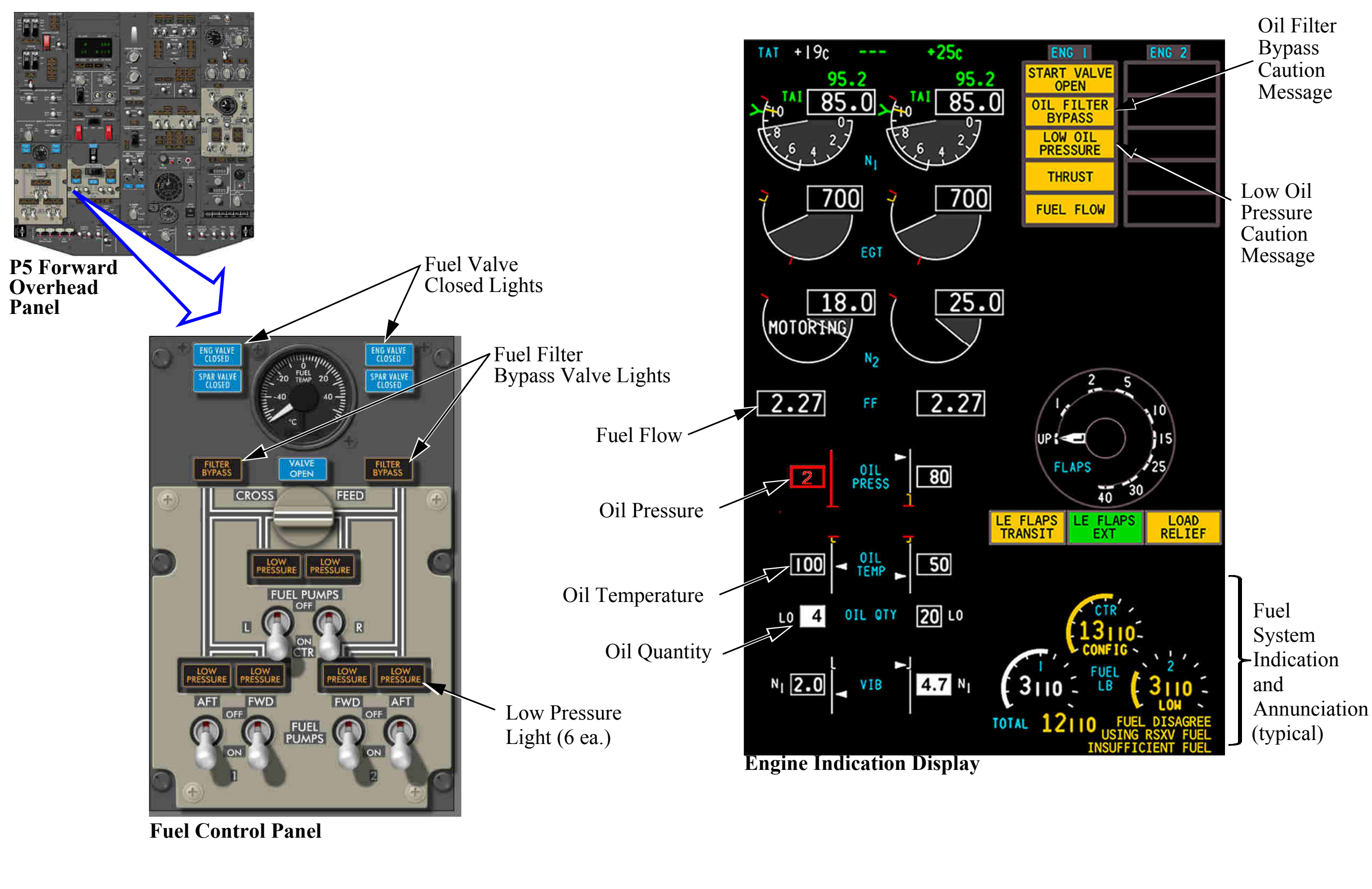
If the supply filter gets clogged, oil goes around the filter. An OIL FILTER BYP indication shows on the engine display. The indication is also an amber message.

Oil moves under pressure through to the three engine sumps to lubricate the engine bearings, accessory gearbox and transfer gearbox.

The six element, engine driven scavenge pump sends the oil back to the oil tank. The oil tank vents to the engine forward A sump. The oil tank has an air oil separator and a debris monitoring system (DMS) sensor. The DMS sensor sends a signal to the conditioner unit (DMS SCU). The EEC sends maintenance messages to the onboard maintenance function (OMF) when particles are detected.

The engine oil system vents through the center shaft, out through an extension in the center of the engine exhaust plug. The forward sump gets additional airflow for improved sealing from the mechanically operated eductor air valve when the engine is at low speed.

BOEING PROPRIETARY



Fuel and Oil Indication

The fuel control panel and the engine indication display give fuel system control, indication, and annunciation. You control six ac fuel pumps and the crossfeed valve from the fuel control panel.

The fuel control panel has many lights that give valve position and system annunciation. Two blue FUEL VALVE CLOSED and SPAR VALVE CLOSED lights show the condition of valves that give fuel to the engines. One blue VALVE OPEN light shows the condition of the crossfeed valve. Two amber FILTER BYPASS lights give the condition of each engine's fuel filter. Six LOW PRESSURE lights give the condition of the ac fuel pumps in the fuel tanks.

The engine indication display has fuel quantity indications and fault annunciations.

Fuel flow data for each engine is given near the center of the engine indication display as FF.

Engine oil system indications and annunciations are also avaiable on the engine indication display.

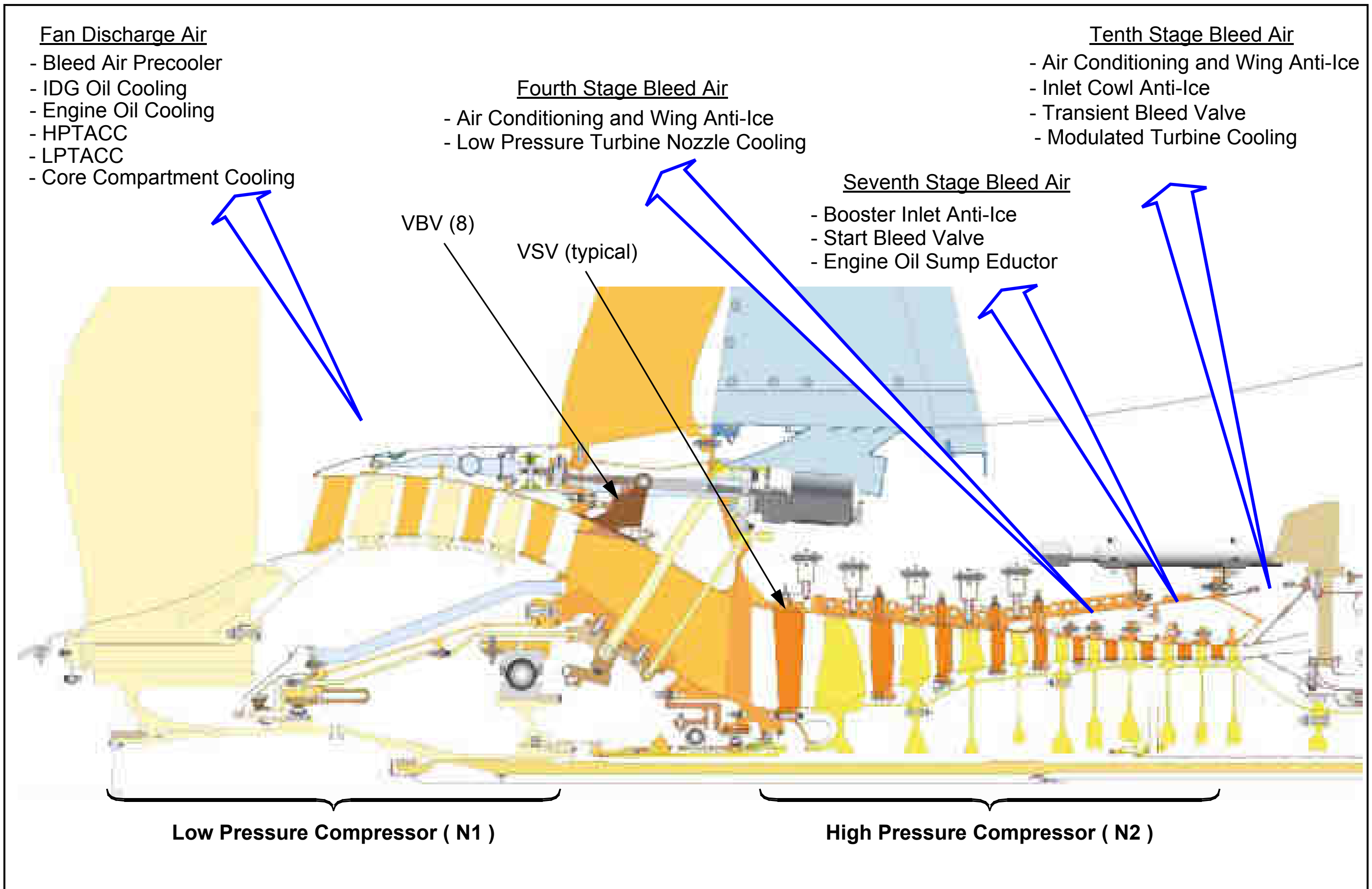
The system measures oil pressure immediately after the pump. Oil pressure shows on the engine indication display. The LOW OIL PRESS caution message shows when oil pressure is below safe limits.

The engine driven scavenge pumps send the oil through a scavenge filter. If the filter gets clogged, the oil goes around the filter. Before the oil goes around the filter, an OIL FILTER BYPASS caution message shows on the engine indication display.

An oil temperature sensor is in the oil supply line. Oil temperature shows on the engine indication display.

The oil quantity shows in quarts on the engine indication display.

Power Plant



Air System

BLEED AIR

Bleed air supply comes from the high pressure compressor (N2) for these systems:

- Air conditioning
- Cabin pressurization
- Wing and engine inlet cowl anti-ice.

Air comes from the fourth stage of the compressor at high power settings. Air comes from the tenth stage at low power settings.

N1 Fan discharge air gives cooling air for the following:

- Bleed air precooler
- Integrated drive generator heat exchangers
- High pressure turbine active clearance control (HPTACC)
- Low pressure turbine active clearance control (LPTACC).

TURBINE ACTIVE CLEARANCE CONTROL

Turbine active clearance control uses fan discharge air to cool and control expansion of the high and low pressure turbine shroud assembles.

COMPRESSOR AIRFLOW CONTROL SYSTEM

Compressor airflow control includes these systems:

- Variable stator vanes (VSV)
- Variable bleed valves (VBV)
- Start bleed valve (SBV)
- Transient bleed valve (TBV).

The VSVs control the flow of air that goes through the first five stages of the high pressure compressor. Operation is based mostly on engine speed.

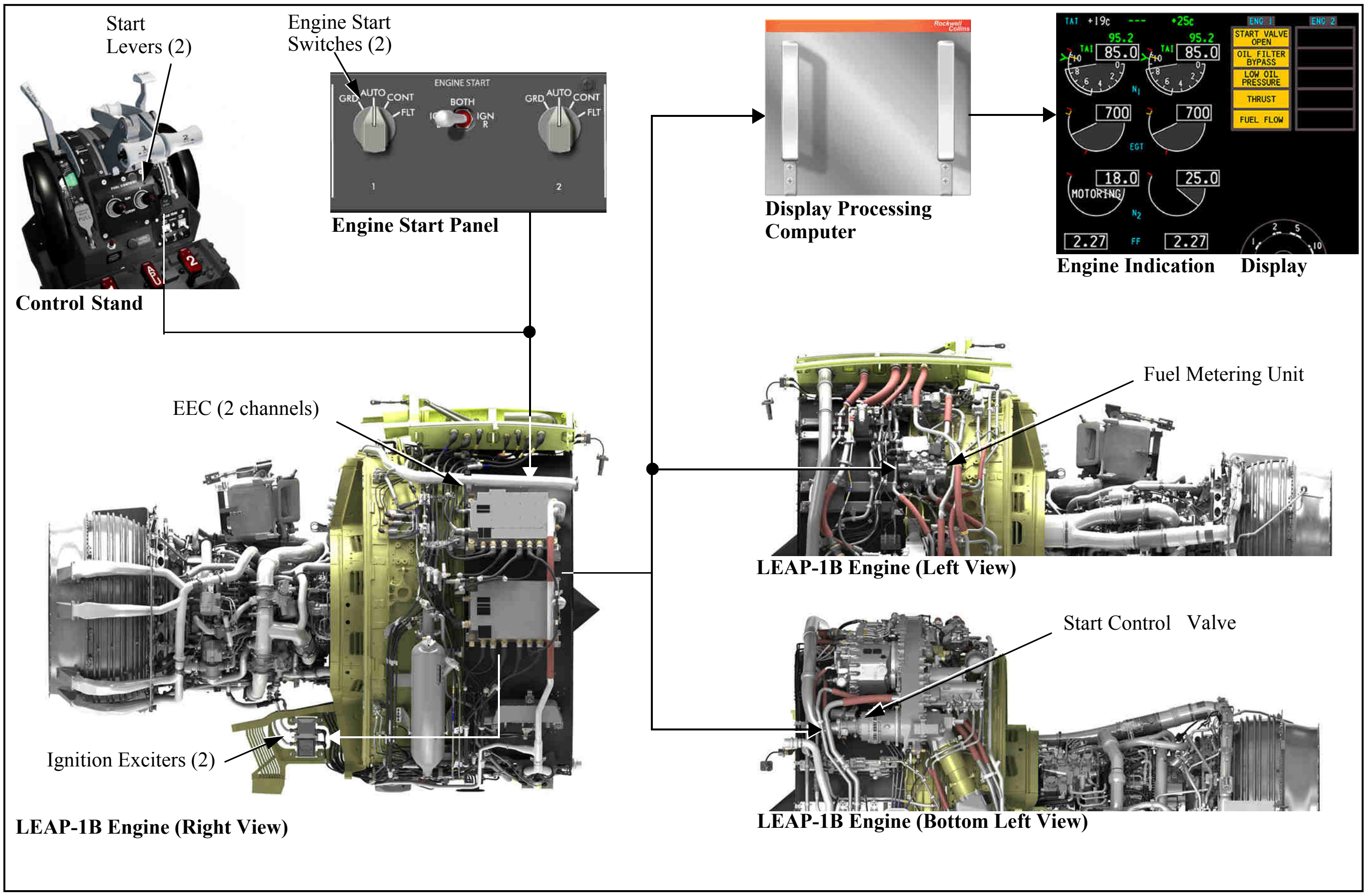
The VBVs prevent low pressure compressor stalls. Stalls may occur when the engine RPM changes. The VBVs discharge booster air into the fan air flow to unload the low pressure compressor. The VBVs also control the amount of air that goes to the HPC, relative to engine speed.

The SBV releases 7th stage high pressure compressor (HPC) air during start. This permits the compressor to rotate easier.

The TBV releases 10th stage high pressure compressor (HPC) air during start. This also permits the compressor to rotate easier. This valve also releases HPC air during transient mode operation to help make the engine more stable.

High pressure compressor air is also used for these engine funtions:

- Booster inlet anti-ice
- Turbine cooling
- Sump eductor.



Engine Start System

The engine start system uses air pressure and electric power for starter operation. The engines can start with air from any one of these sources:

- APU
- Ground source
- Engine cross bleed.

The start lever for each engine is on the control stand. The start lever energizes the ignition system, permits fuel flow and sends signals to the EECs and airplane systems.

With the engine start switch in GRD, the start control valve opens to let pneumatic power turn the starter. The starter is a air turbine motor that turns the high pressure compressor through the accessory drive gear system . When the start control valve is open, the amber START VALVE OPEN message shows.

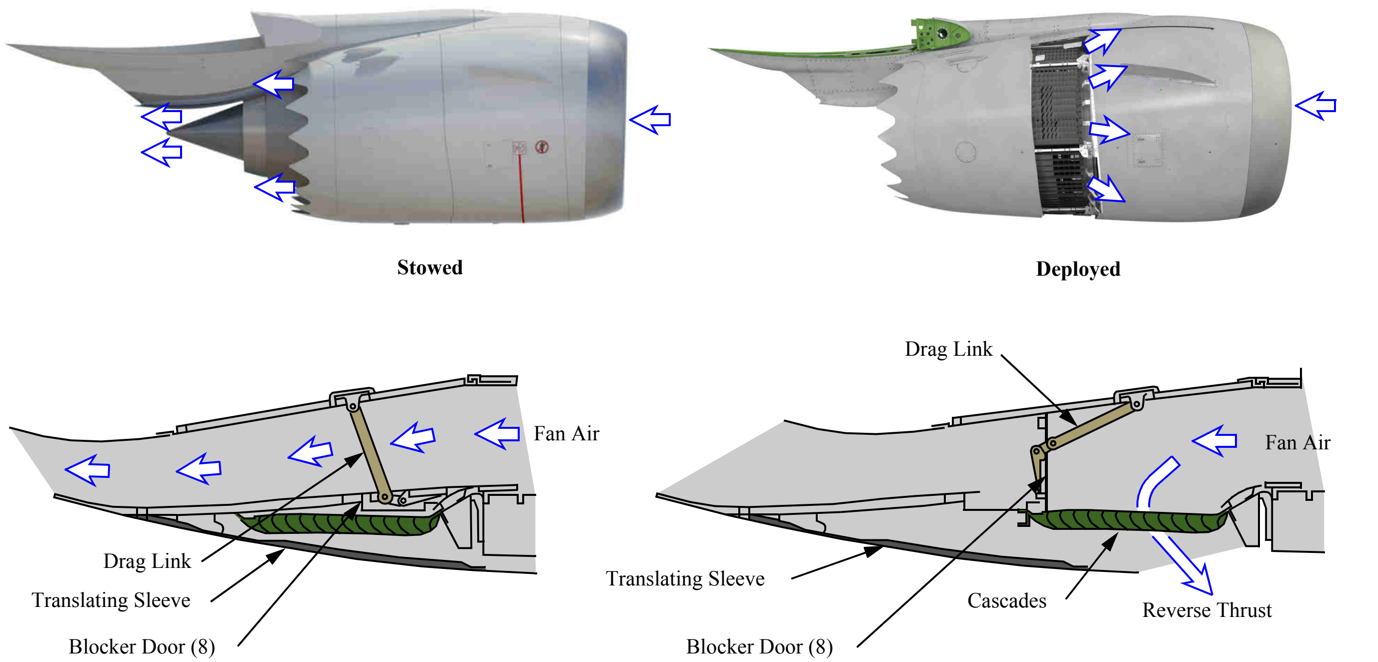
When the engine accelerates to 25 percent N2 RPM, you move the start lever to the RUN position. Additional time for engine thermal stabilization occurs during the motoring process. This is called the bowed rotor start logic. The logic keeps the engine speed below the fuel on speed until heat in the engine is made stable. After the fuel on speed is reached and you move the start lever to the run position, these events occur:

- Spar and engine fuel shutoff valves open
- Fuel metering unit supplies fuel to the combustor
- Exciters energize and send power to the igniters
- Start switch goes to back to the AUTO position at 50 percent N2 and ignition stops
- Start control valve closes and the START VALVE OPEN message goes off
- Engine stabilizes at idle.

IGNITION

Each engine has two high energy ignition systems. Both systems use ac power. The ignition select switch lets the operator use either the LEFT, RIGHT or BOTH igniters for ground (GRD) start. Air start always uses both igniters. The FLT position of the engine start switch also bypasses the ignition select switch and uses both ignition systems. You use the FLT position for air starting ignition without starter assist. You can use the CONT position for takeoff, landing, and in turbulence to operate the ignition system continuously.

Power Plant



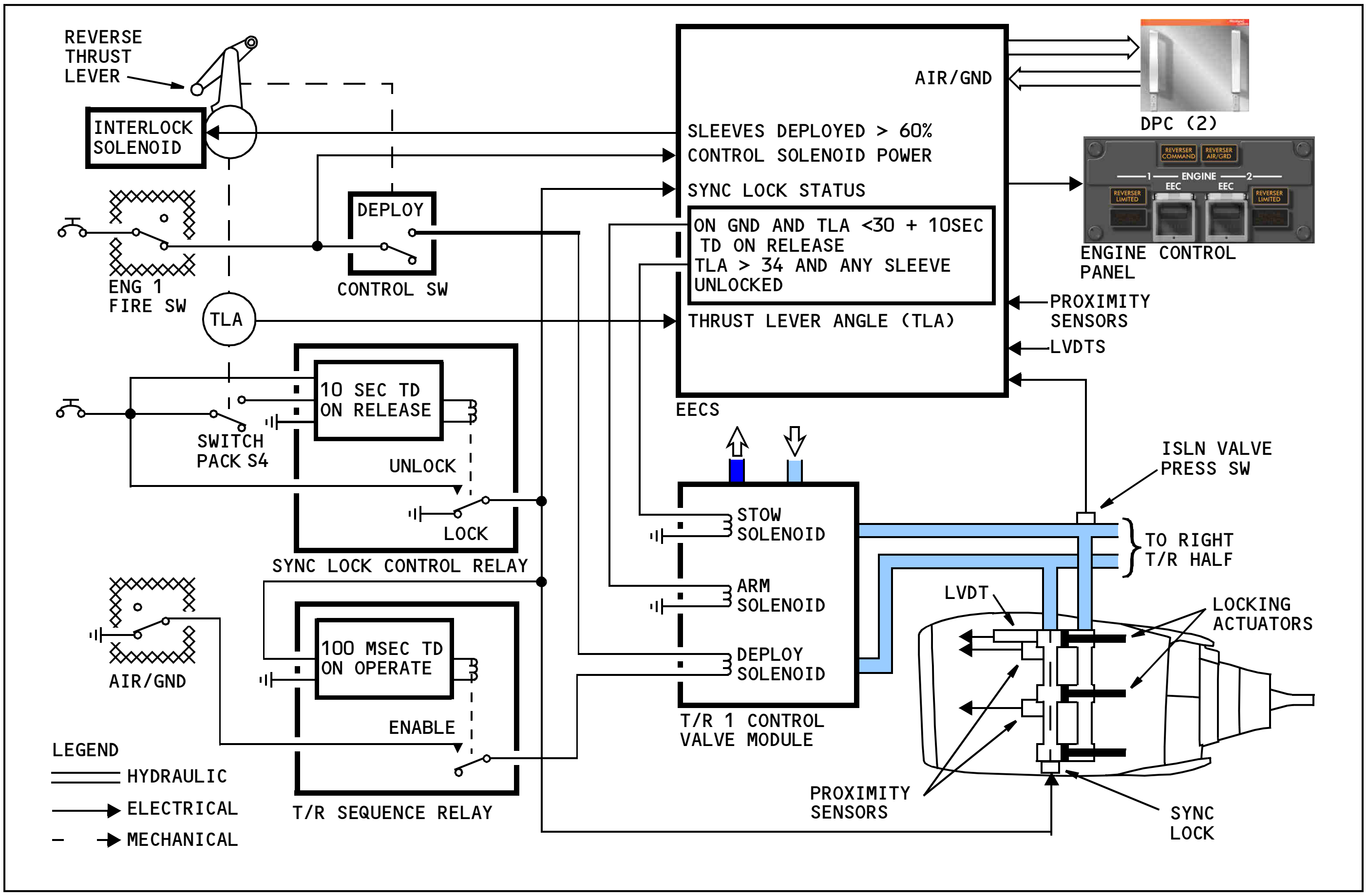
Thrust Reversers

The thrust reversers (TR) use electrical control and hydraulic power to operate. Both TRs are interchangeable between the two engines except for the cascades.

Reverse thrust occurs with a change of fan air direction. When the thrust reversers deploy, the blocker doors close and fan air goes out radially and forward.

When the translating sleeves extend, these events occur:

- Cascades uncover
- Blocker doors deploy
- Blocked fan air goes out through the cascades
- Cascades direct the fan air forward.



Thrust Reverser Operation

DEPLOY

The TR actuation system uses hydraulic actuators to position the T/R sleeves. Three actuators on each half are mechanically interlocked by a flexible sync shaft. The upper and center actuator on each half is a locking type actuator. Hydraulic fluid to the TR actuators comes from a control valve module in the wheel well. Solenoid valves in the control valve module send hydraulic fluid to unlock and deploy the sleeves. Each lower actuator has an electrically operated sync lock on it. The sync lock unlocks the flexible sync shaft when power comes from the sync lock control relay. The control relay energizes when switch S4 in the switch pack operates. The sequence relay then gets power from the sync lock control relay. A short delay lets the sync locks unlock before hydraulic power goes to the actuators.

The EECs use air/ground data and thrust lever angle to arm the system for deploy. The control switch in the thrust lever sends power to the deploy solenoid when the reverse thrust lever is pulled up. The deploy solenoid energizes through the air/ground system when enabled by the sequence relay. When the sleeves deploy, the EECs send power to the interlock solenoid, which then permits further movement of the reverse thrust lever above the reverse idle position.

STOW

Movement of the reverse thrust lever to the stow position changes the logic in the EECs. When the reverse thrust lever is in the stow position and any sleeve sensor indicates not stowed, the EECs energize the stow solenoid valve. This puts hydraulic pressure on the stow side of the actuators, which moves the sleeves to the stow position. The arm solenoid continues to get power for ten seconds; this gives time to move to the stow position. After ten seconds the locking actuators lock when hydraulic pressure goes away. The sync lock also locks after 10 seconds, when the sync lock control relay de-energizes.

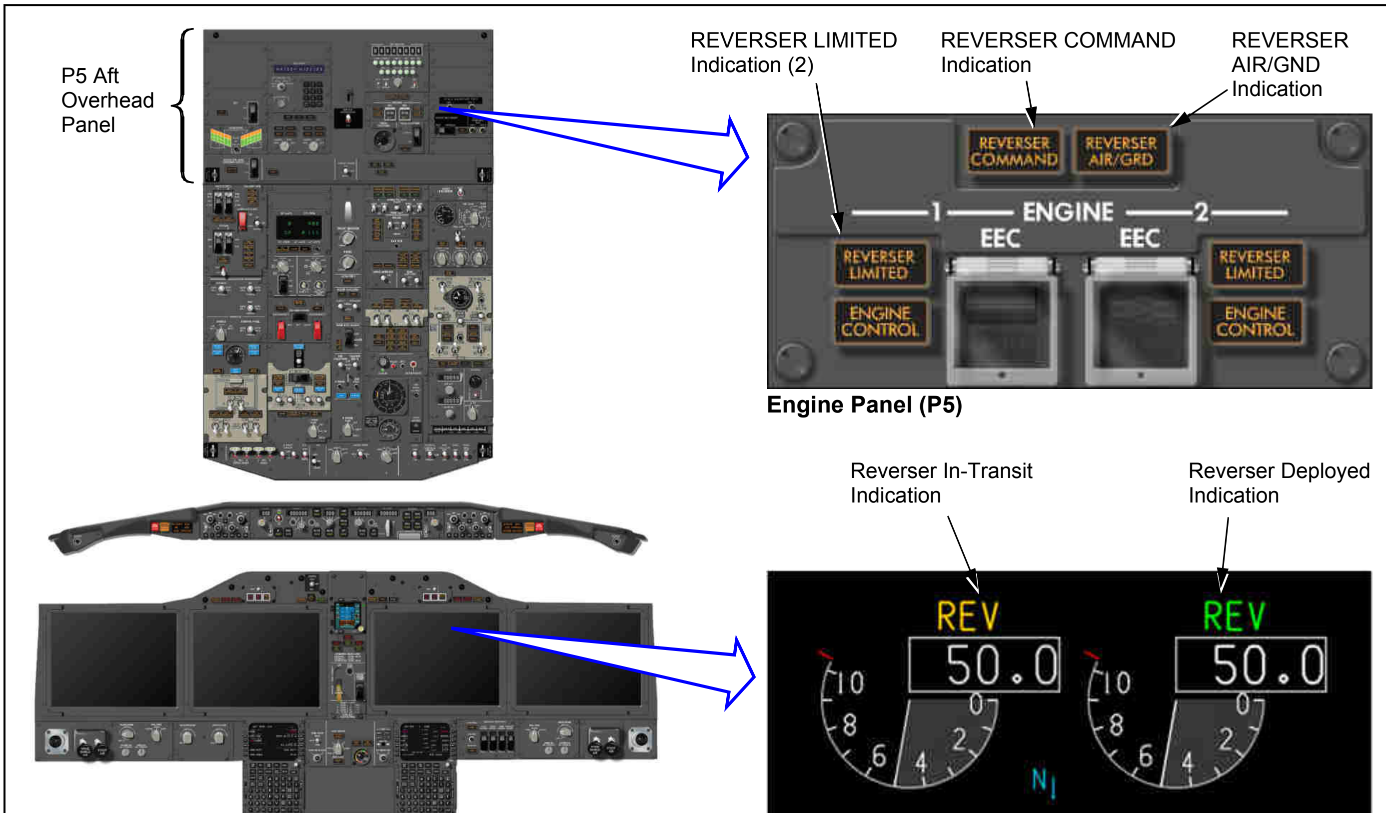
The EECs monitor the TR actuation system continuously for faults. These fault lights can show on the engine control panel:

- Reverser Limited
- Reverse Command
- Reverser Air/ground.

Each engine TR system gets power from separate hydraulic systems. Hydraulic system A supplies power to the left engine TR. System B supplies power to the right engine

TR. The standby hydraulic system supplies power to the left, right or both engine TRs if loss of the normal hydraulic system pressure occurs.

BOEING PROPRIETARY



Engine Panel (P5)

Flight Deck Panels

Engine Indication Display

Thrust Reverser Indication

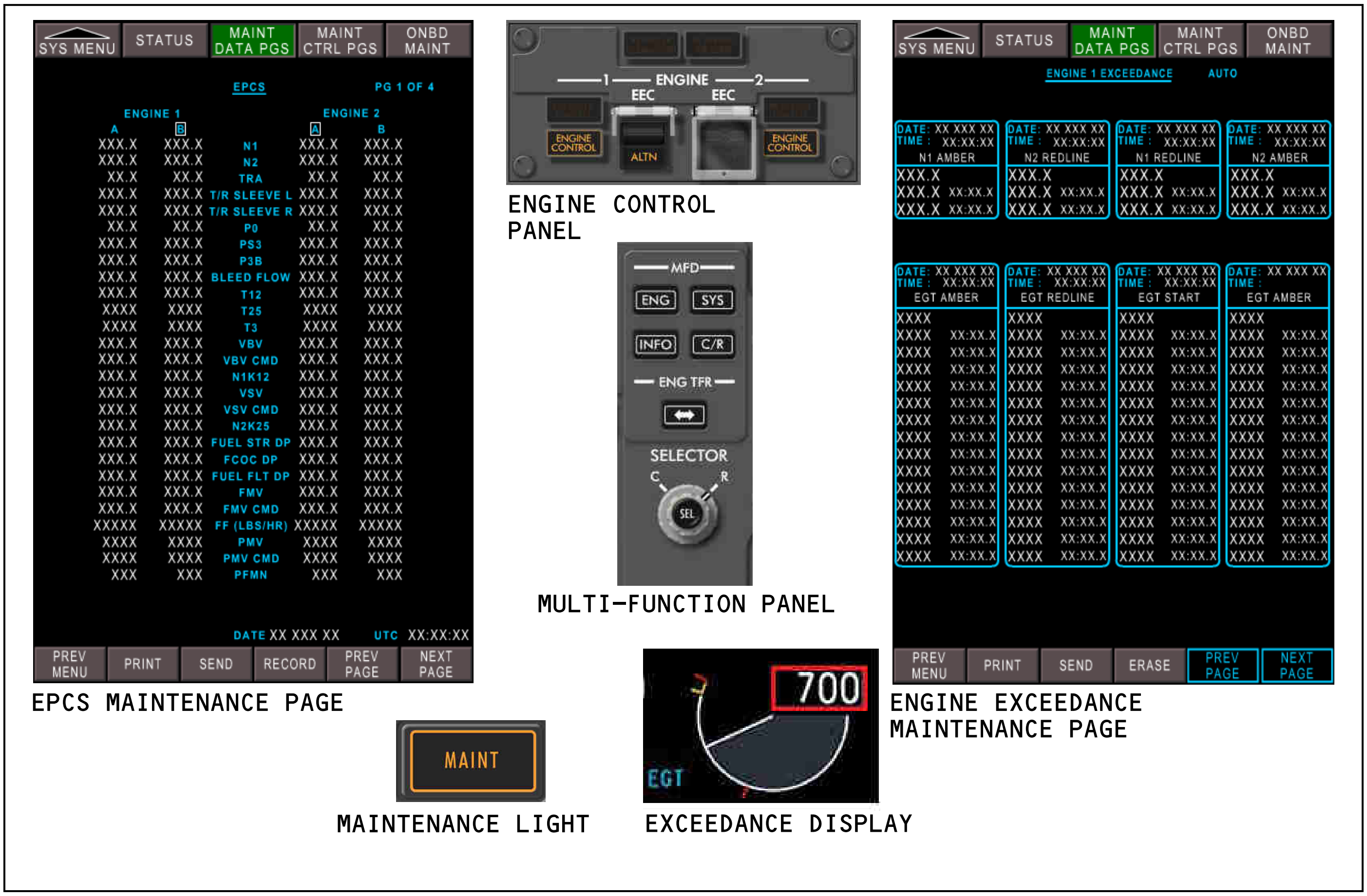
The electronic engine control (EEC) controls the thrust reverser system operation and flight deck indication.

The electronic engine control (EEC) senses thrust reverser sleeve position. The EEC sends a thrust reverser sleeve position signal to the digital processing computer (DPC). The DPC gives signals to the Max display system for indication.

A REV indication shows above the N1 indication on the engine indication display when the thrust reverser operates. The indication is amber when the thrust reverser translating sleeves are deployed more than 10 per cent. The indication is green when the thrust reverser is in the full deploy position. The indication is blank when the reverser is in the stow position.

The EEC controls fault lights on the engine panel. This panel is on the P5 overhead panel. The REVERSER COMMAND light comes on if a thrust reverser lever is not in STOW with the airplane in the air. The REVERSER AIR/GRD light comes on when air/ground protection for the thrust reverser system is unsatisfactory. The REVERSER LIMITED fault light comes on when the EEC finds a defect in the thrust reverser system.

You must correct or defer thrust reverser defects. You can do BITE with the Max display system.



SYSTEM FAULTS AND BITE

ENGINE FAULTS

There are different levels of faults that can impact the operation of the engine. Some faults impact only the economic operation of the engine. Other faults can have maintenance or flight crew action required.

The ENGINE CONTROL light comes on for a major engine fault. This light is on the aft P5 panel. The airplane must be on the ground for the light to come on. The engine may or may not be running.

Some air data faults cause the ALTN amber light to come on. For airplane dispatch, both EEC switches are put to ALTN. This procedure prevents unequal thrust and throttle stagger. The crew must be careful to not exceed the rated engine thrust in this mode.

MAX Display System (MDS)

Engine display and fault data is available on the MDS. You use the multi-function panel buttons and selectors to show the maintenance data and control pages, as well as the OMF pages and functions.

The MDS has four maintenance data pages that show engine sensor and component information. There is also an engine performance maintenance page that shows operational data for analysis.

The maintenance light or the engine control light tells the maintenance crew to check the onboard maintenance function (OMF) for the specific fault data. All fault messages have a number that is in the fault isolation manual (FIM). Past and present leg fault data can show. The OMF also has engine system ground tests and special functions.

The MDS shows exceedance data for each engine. A red box on an engine display shows that an exceedance event has occurred.

The MDS also supplies these engine functions with maintenance control pages:

- Electronic engine control power
- Engine serial number entry.

BOEING PROPRIETARY

Features

TRIPLE REDUNDANCY

System A has one engine-driven pump (EDP) and one electric motor driven pump (EMDP) for these systems:

- Flight controls
- Flight spoilers
- Landing gear
- Nose gear steering
- Alternate brakes
- Left thrust reverser
- Ground spoilers.

System B has one EDP and one EMDP for these systems:

- Flight controls
- Flight spoilers
- Normal brakes
- Trailing edge flaps
- Leading edge devices
- Right thrust reverser.

The standby system has one EMDP that supplies the third power source for the rudder control system. The standby system also supplies the second power source for these systems:

- Thrust reversers
- Leading edge devices.

MULTIPLE FILTRATION

The hydraulic fluid goes through filters while servicing and during operation of the system to increase reliability.

MODULAR COMPONENTS

Modules reduce the number of components, connections, and fittings. This makes the system more reliable and easier to service.

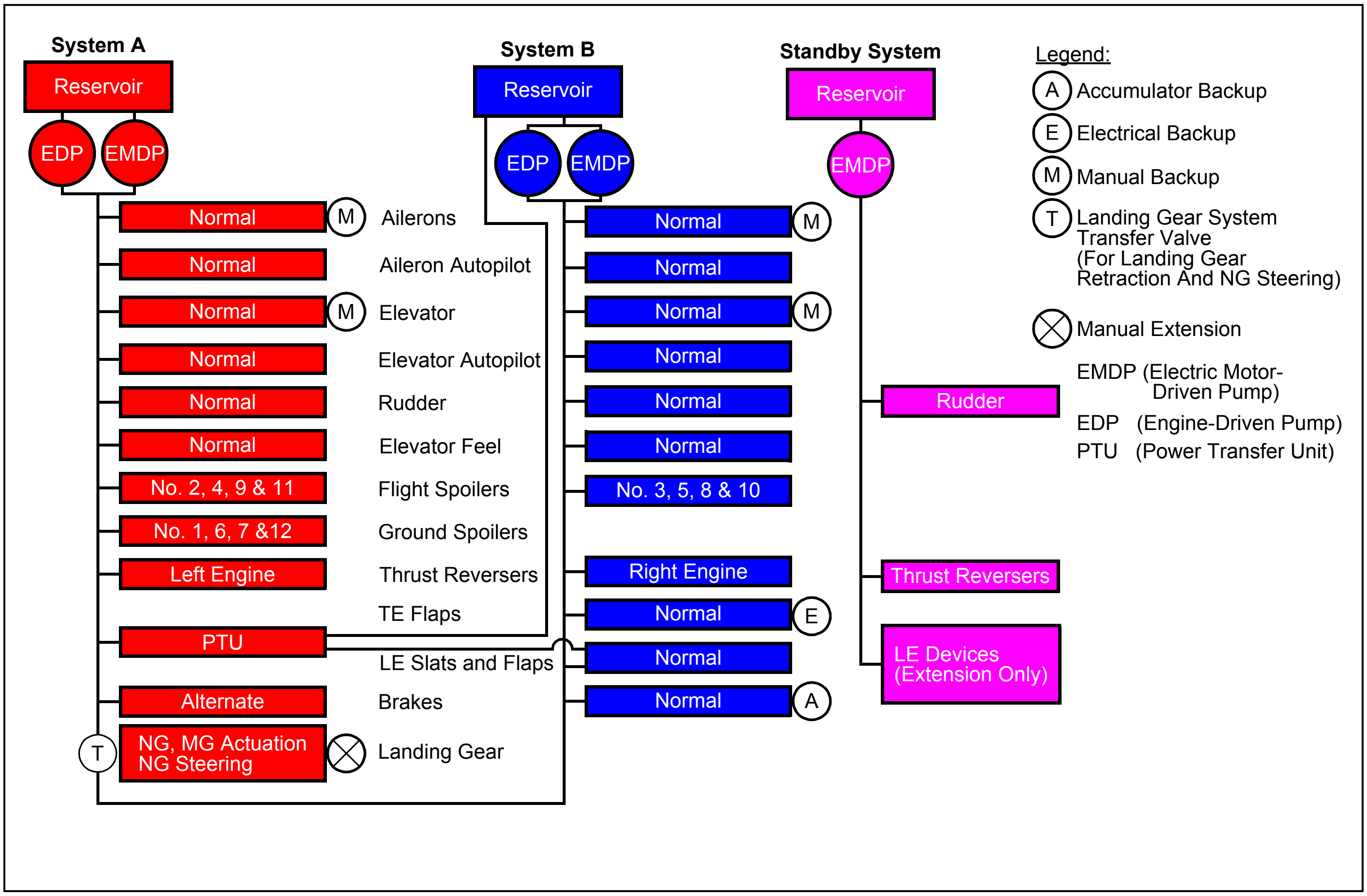
SINGLE-POINT SERVICE CONNECTION

A hydraulic service connection in the main landing gear wheel well makes it possible to service all three reservoirs from one location.

LEAK CONTROL FUSES

The system pressure lines have fuses to protect the hydraulic system from fluid loss if a major component fails or if a line leaks.

Hydraulics



Hydraulic Systems

There are three hydraulic systems that operate independently at 3000 psi nominal pressure.

The three systems are system A, system B and the standby system. Each system has a reservoir, pumps and filters.

The hydraulic systems use BMS 3-11 Type IV fluid. This fluid is phosphate ester based and is erosion and fire resistant.

SYSTEM A

System A uses one engine-driven pump (EDP) and one electric motor driven pump (EMDP). The system supplies hydraulic power to these systems:

- Flight controls
- Landing gear
- Nose gear steering
- Alternate brakes
- Flight and ground spoilers
- Left thrust reverser
- Power transfer unit (PTU).

SYSTEM B

System B uses one EDP and one EMDP. System B supplies hydraulic power to these systems:

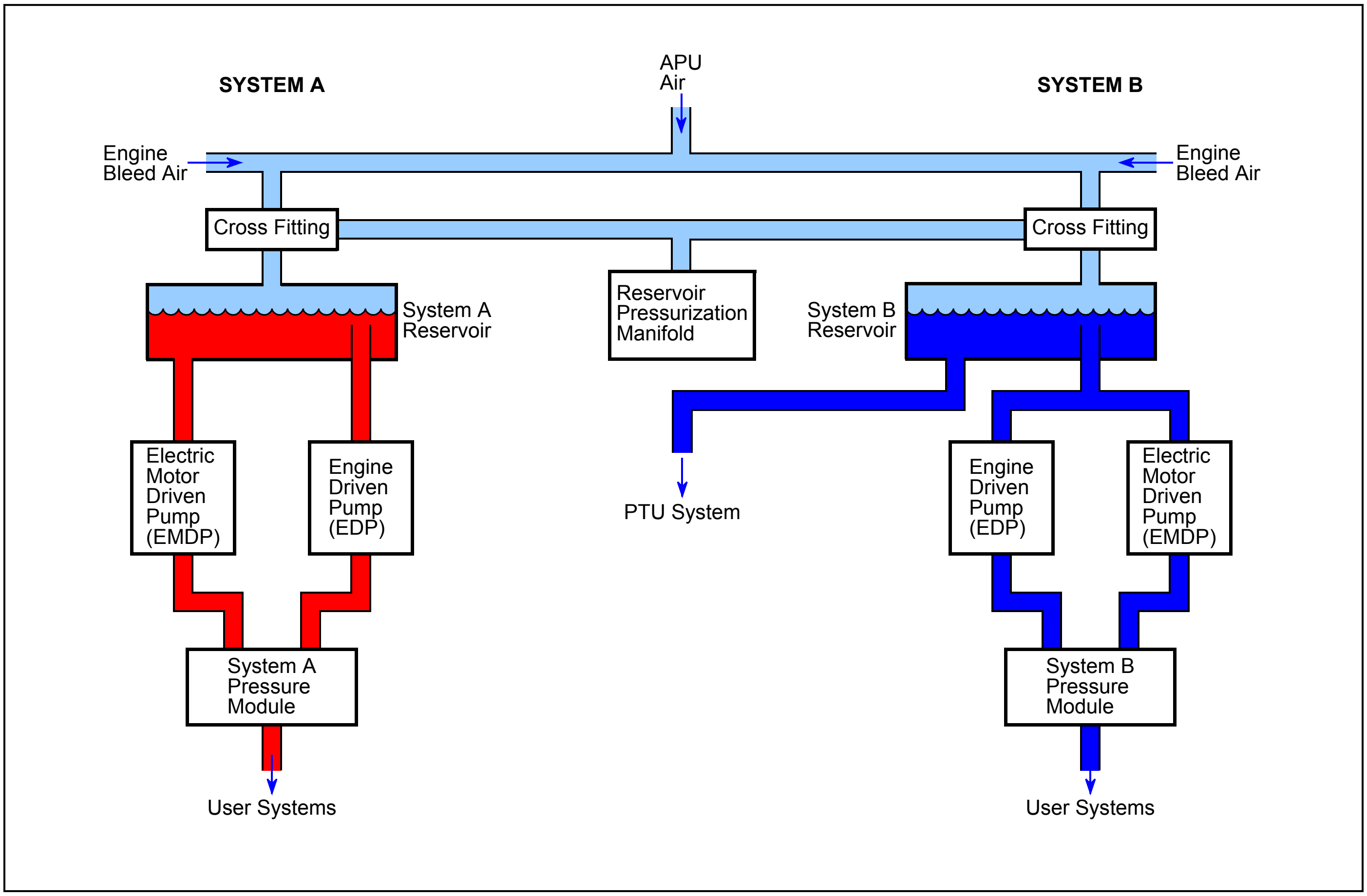
- Flight controls
- Normal brakes
- Trailing edge flaps
- Leading edge flaps and slats
- Right thrust reverser
- Flight spoilers
- Alternate nose gear steering
- Alternate gear retraction.

STANDBY SYSTEM

The standby system, which has a separate electric motor driven pump, is an auxiliary source of hydraulic power. Standby hydraulic power supplies pressure to these systems:

- Rudder control system
- Either or both thrust reversers
- Leading edge flaps and slats (full extend only) in the alternate flap mode.

For normal operation, system A and system B are on and the standby system is off.



Main Hydraulic Systems

The main hydraulic systems have these components:

- Reservoir pressurization system
- Reservoir
- Engine driven pump (EDP)
- Electric motor driven pump (EMDP)
- Pressure module.

The individual reservoirs supply hydraulic fluid to their respective EDPs and EMDPs.

Each reservoir has two supply ports, one of which has a standpipe.

The system A standpipe supplies fluid to the EDP. The system A EMDP is supplied from a port at the bottom of the reservoir.

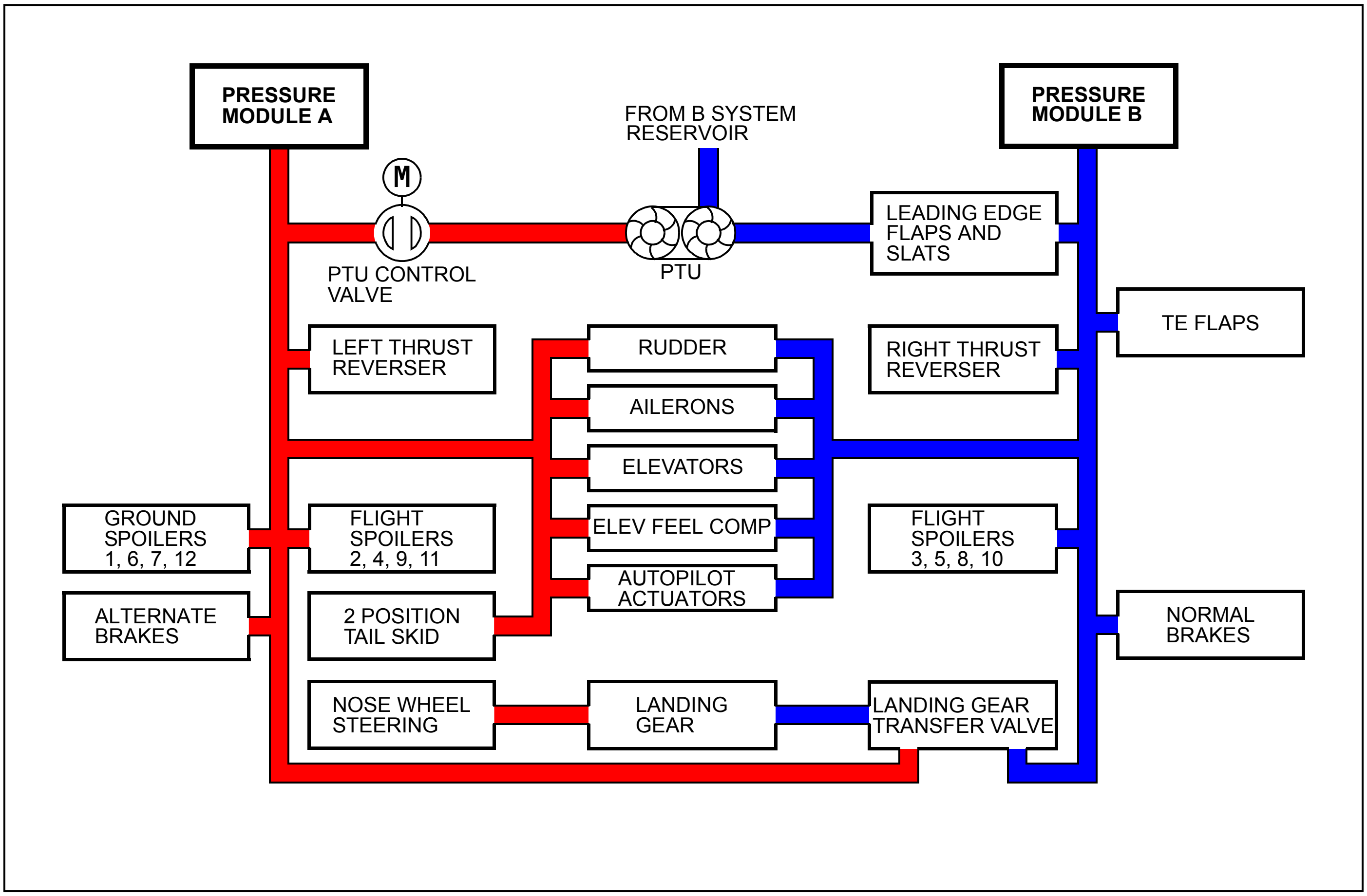
The system B standpipe supplies fluid to the EDP and the EMDP. The power transfer unit (PTU) system is supplied from a port at the bottom of reservoir B.

The reservoir pressurization system supplies regulated air pressure to the reservoirs. This ensures that there is a positive supply of fluid to the hydraulic pumps in each system.

The EDP and EMDP in each system supply pressure to the pressure modules. The pressure modules filter the fluid and supply the pressure to the user systems in the airplane.

BOEING PROPRIETARY

Hydraulics



System A & B Distribution

Hydraulic system A supplies pressure to these airplane systems:

- Power transfer unit control valve
- Left thrust reverser
- Rudder power control unit (PCU)
- Aileron PCU
- Elevator PCU
- Elevator feel computer
- Autopilot A actuators
- Two position tail skid (if installed)
- Ground spoilers 1, 6, 7 and 12
- Flight spoilers 2, 4, 9 and 11
- Alternate brakes
- Landing gear transfer valve.

Hydraulic system B supplies pressure to these airplane systems:

- Leading edge flaps and slats
- Trailing edge flaps
- Right thrust reverser
- Rudder PCU
- Aileron PCU
- Elevator PCU
- Elevator feel computer
- Autopilot B actuators
- Flight spoilers 3, 5, 8 and 10
- Normal brakes
- Landing gear transfer valve.

Flight Controls

Although system A and system B supply hydraulic power for the primary flight controls, either system alone will operate the ailerons, elevators and rudder.

The leading edge flaps and slats plus the trailing edge flaps normally receive power from system B. The standby system supplies a secondary means to fully extend the leading edge flaps and slats.

The power transfer unit (PTU) also supplies a backup source of hydraulic power for the leading edge flaps and slats.

Landing Gear and Brakes

System A normally supplies pressure for operation (extension and retraction) of the landing gear.

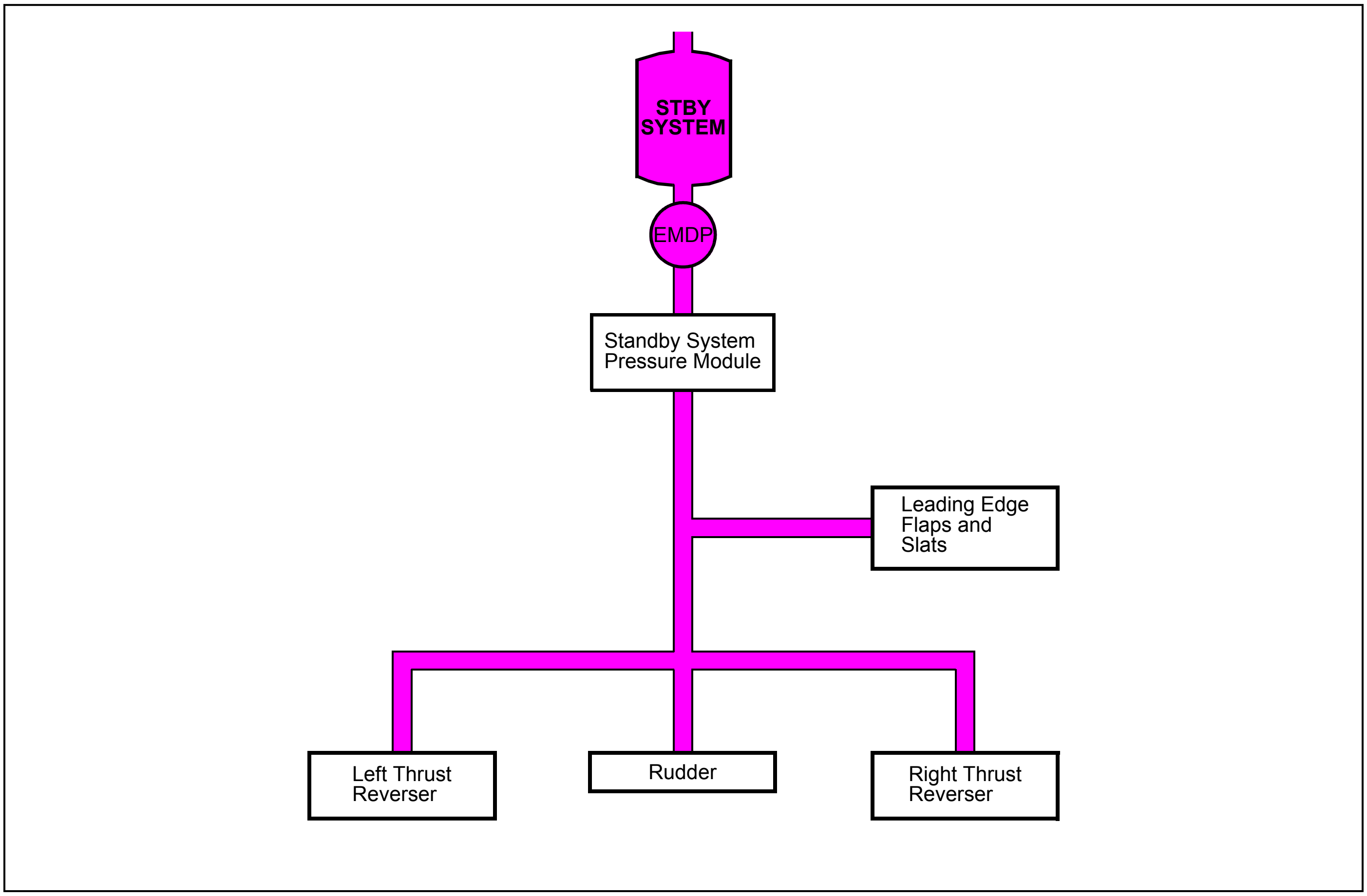
If engine 1 does not operate for takeoff, system B supplies pressure to retract the landing gear.

The normal brake system gets power from hydraulic system B and the alternate is system A.

Thrust Reversers

System A supplies power to the left thrust reverser and system B supplies power to the right thrust reverser.

BOEING PROPRIETARY



Standby Hydraulic System

The standby system, which has a separate electric motor driven pump, is an auxiliary source of hydraulic power.

The standby system operates by moving either of the FLT CONTROL switches on the P5 flight control panel to the STBY RUD position.

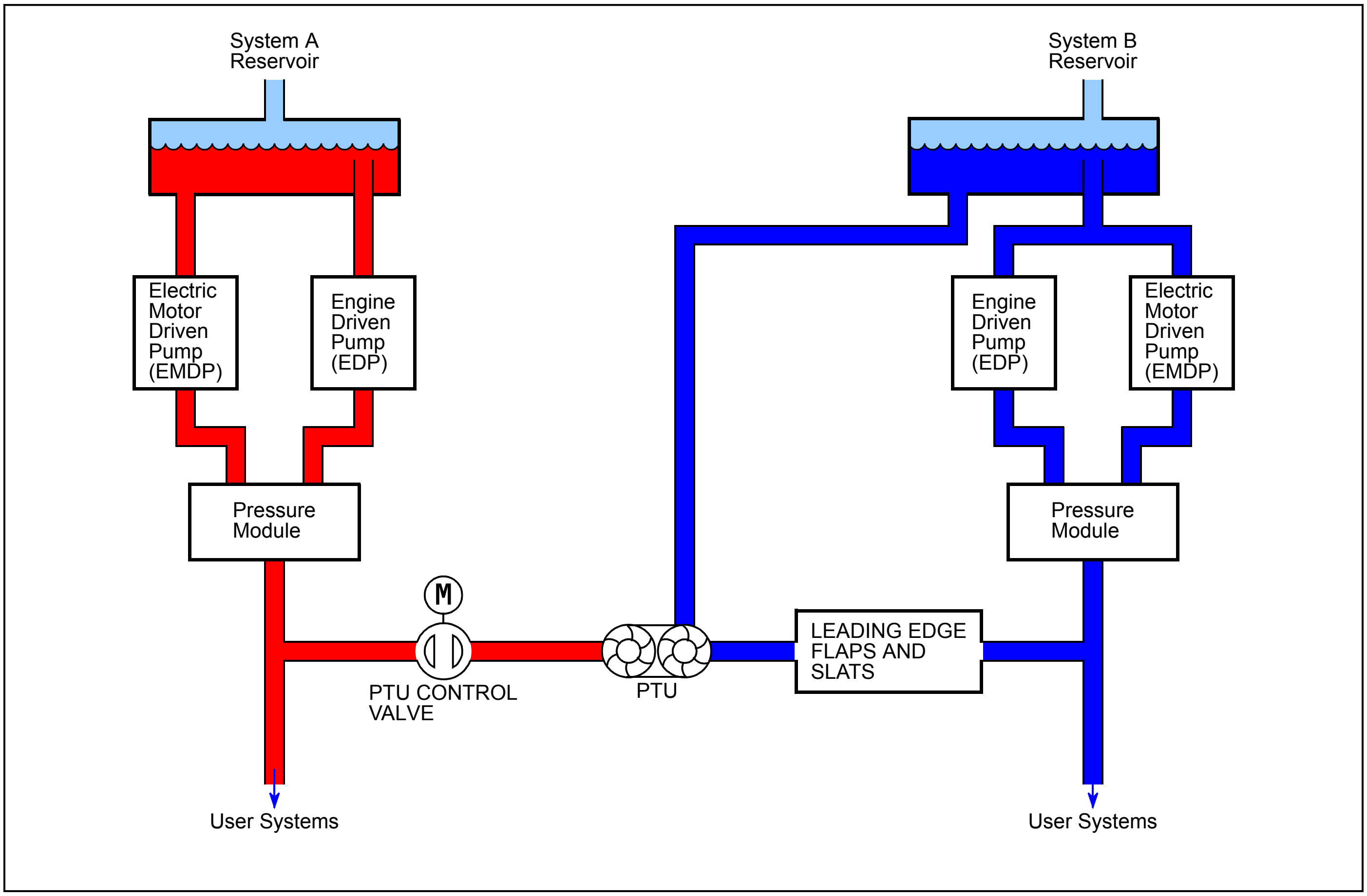
The standby system will also operate if the ALTERNATE FLAPS switch is set to the ARM position.

The standby system also operates automatically.

Standby hydraulic power supplies pressure to these systems:

- Rudder control system
- Either or both thrust reversers
- Leading edge flaps and slats (full extend only) in the alternate flap mode.

Hydraulics



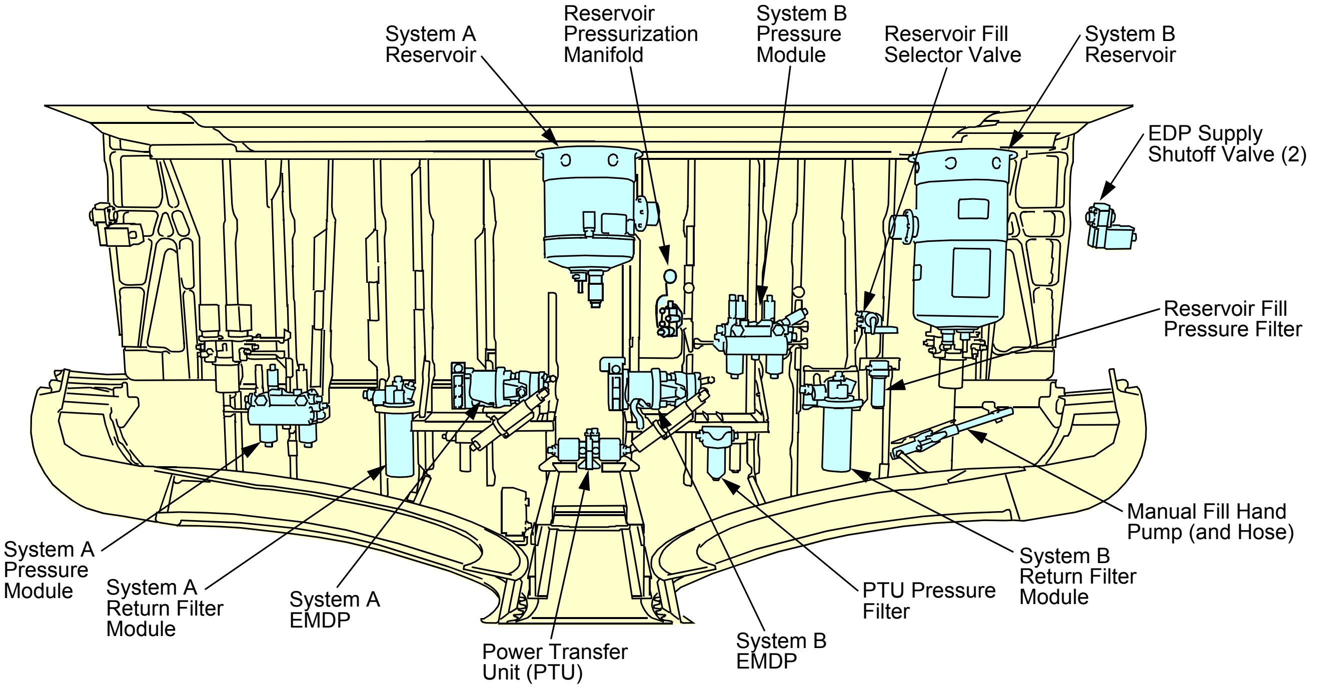
Power Transfer Unit System

The power transfer unit (PTU) supplies a backup source of hydraulic power for the leading edge flaps and slats.

The PTU has a hydraulic motor and pump on a common shaft. The PTU receives pressure from system A to turn the motor. The pump of the PTU receives fluid from the system B reservoir.

The PTU operates automatically when these conditions are true:

- Airplane in the air
- Trailing edge flaps not up
- System B engine-driven pump has low pressure.



Main Landing Gear Wheel Well
(Looking Forward)

Hydraulic Component Locations

These hydraulic components are on the forward bulkhead in the main wheel well:

- System A pressure module
- System A return filter module
- System A electric driven motor driven pump (EMDP)
- System A reservoir
- Power transfer unit (PTU)
- Reservoir pressurization manifold
- System B EMDP
- PTU pressure filter
- System B pressure module
- System B return filter module
- Reservoir fill selector
- Reservoir fill pressure filter
- Manual fill hand pump
- System B reservoir
- Engine-driven pump (EDP) shutoff valve (2).

Servicing

All three hydraulic reservoirs fill from a convenient single-point service connection in the right wheel well. These are the main components:

- Hand pump with suction hose
- Connection for ground cart pressure fill
- Selector valve.

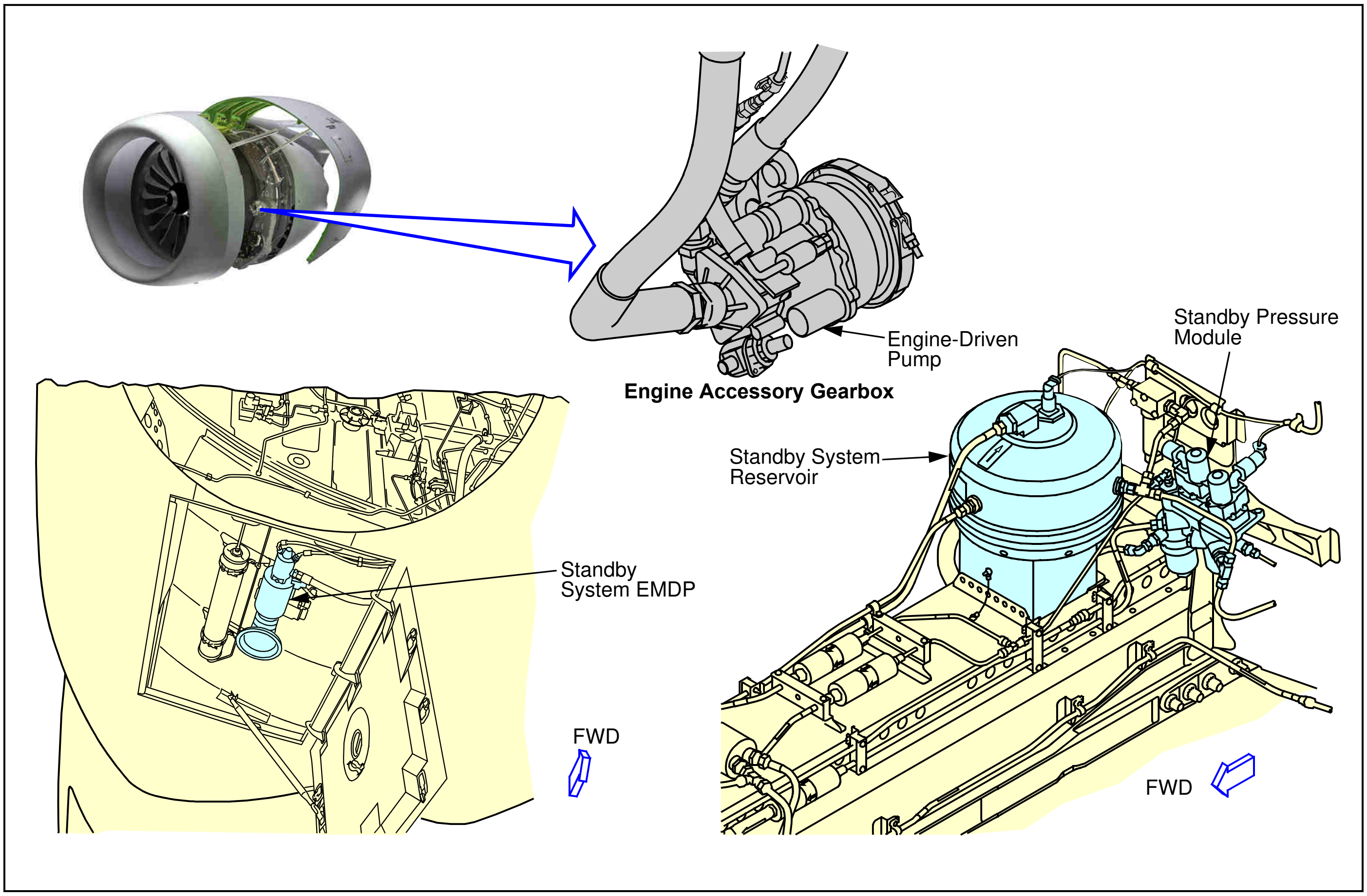
Electrical power is not necessary to read reservoir fluid quantity. System A and B reservoirs have mechanical quantity gauges that are visible from the servicing location.

To fill the hydraulic reservoir, maintenance personnel use either a ground cart that connects to the pressure fill connection or the hand pump and suction hose.

The system B reservoir fills through the standby reservoir. When the system B quantity indicator shows full, both system B and standby reservoirs are full.

Hydraulic system reliability is better because of filtration. System A and B have pressure, return and case drain filters. Individual filters in the system supply additional filtration for critical areas such as flight control power units. The standby system has pressure and case drain filters.

Hydraulics



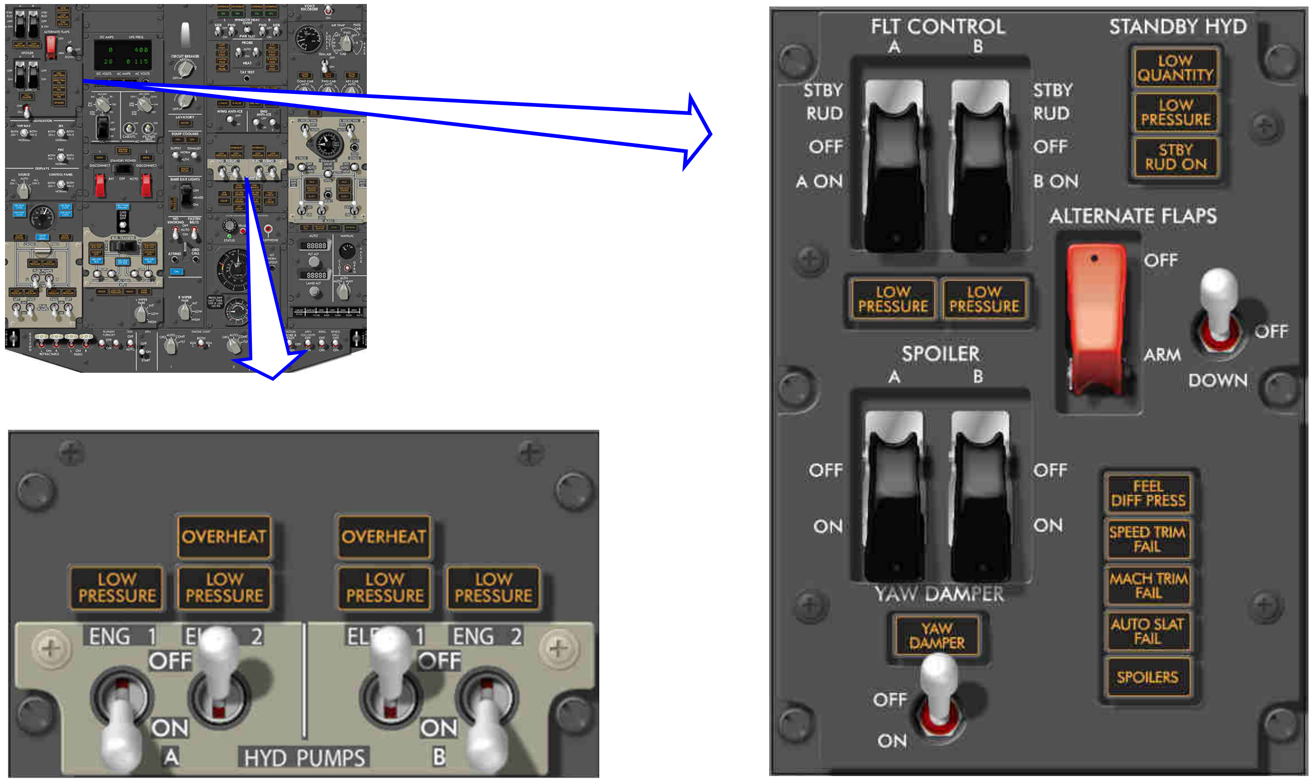
Hydraulic Component Locations

The engine-driven pumps (EDP) are located on the forward side of the engine accessory gearbox on the left side of the engine.

The standby electric motor driven pump is located behind the right main landing gear. It can be accessed through an access panel.

The standby hydraulic system reservoir and standby pressure module are located on the keel beam in the wheel well.

BOEING PROPRIETARY



Hydraulic Panel

Flight Control Panel

Hydraulic Panel

The ON position is the normal position for each engine-driven pump (EDP) switch. In this position, the depressurizing valve solenoid on the EDP is de-energized.

The electric motor driven pump (EMDP) switches turn the EMDPs on.

The LOW PRESSURE lights come on when the pump pressure is less than normal.

The OVERHEAT lights come on for system A and B EMDPs to show an overheat condition.

Flight Controls Panel

The flight control switches control hydraulic system pressure to ailerons, elevators, rudder and elevator feel system.

In the STDBY RUD position, The standby pump starts and the system A or B flight control shutoff valve closes.

The ON position provides normal pressure for system A or B to flight controls.

The OFF position stops hydraulic pressure for the primary flight controls.

The spoiler shutoff valve switches control hydraulic system pressure to the flight spoilers.

The alternate flaps arm switch starts the standby hydraulic pump and arms the alternate flaps control switch.

The standby hydraulic LOW QUANTITY light comes on when the standby hydraulic reservoir fluid quantity is less than 50% full.

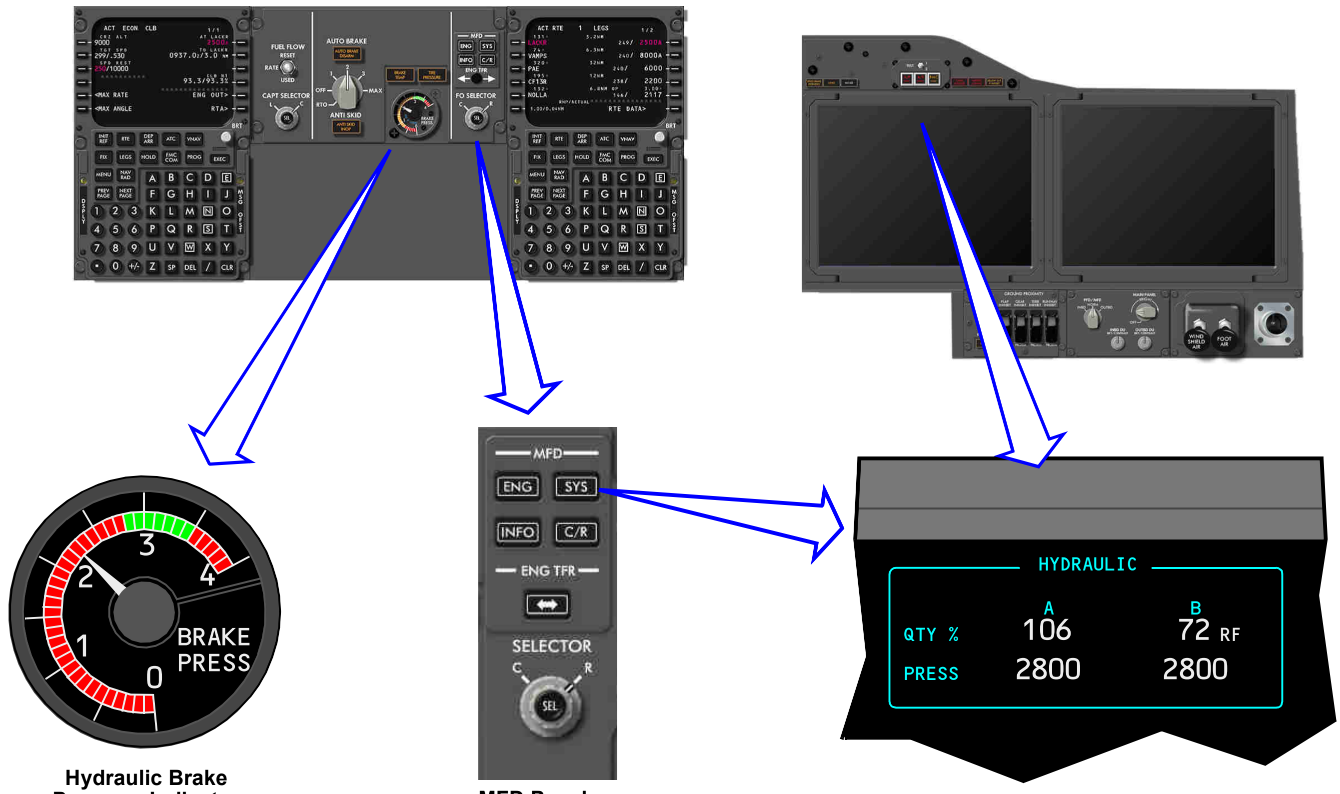
The standby hydraulic LOW PRESSURE light comes on when the standby pump pressure is too low. The light is armed when the standby hydraulic pump is operating.

The STBY RUD ON light comes on when the standby rudder PCU gets a command to operate.

The SPOILERS light comes on to show a fault in the fly-by-wire spoiler system.

BOEING PROPRIETARY

Hydraulics



Hydraulic Brake Pressure Indicator

MFD Panel

Systems Display

Hydraulic Indications

Hydraulic indications can be displayed on the MAX DISPLAY SYSTEM systems page. Select the SYS button on the MFD (multi-function display) panel. The systems display shows on the inboard part of the display unit.

The pressure indications for hydraulic system A and system B are shown.

The reservoir quantity for system A and system B show as percentage of full.

When the quantity is less than 76% an RF message shows adjacent to the quantity indication.

System A (center main panel):

- 100%-Full - 5.7 US gallons (21.6 liters)
- 76%-Refill - 4.7 US gallons (16.4 liters).

System B (center main panel):

- 100%-Full - 8.2 US gallons (31.1 liters)
- 76%-Refill - 6.9 US gallons (23.6 liters).

HYDRAULIC BRAKE PRESSURE INDICATOR

The hydraulic brake pressure indicator shows brake accumulator pressure. 3000 psi is the nominal brake pressure. It also shows the accumulator pressure if system B hydraulics is not pressurized.

Landing Gear

Features

MAIN GEAR WHEEL DOORS ARE NOT NECESSARY

A blade seal fits around the outboard wheel. The only doors are small segment doors attached to the shock strut. Complicated linkages and actuators are not necessary.

DUAL INDEPENDENT HYDRAULIC BRAKE SYSTEMS

Hydraulic system B operates the normal brake system. Hydraulic system A is the primary alternative and the brake accumulator is the secondary alternative.

PRESSURE-MODULATED ANTISKID SYSTEM

The antiskid system provides maximum brake force for different runway conditions.

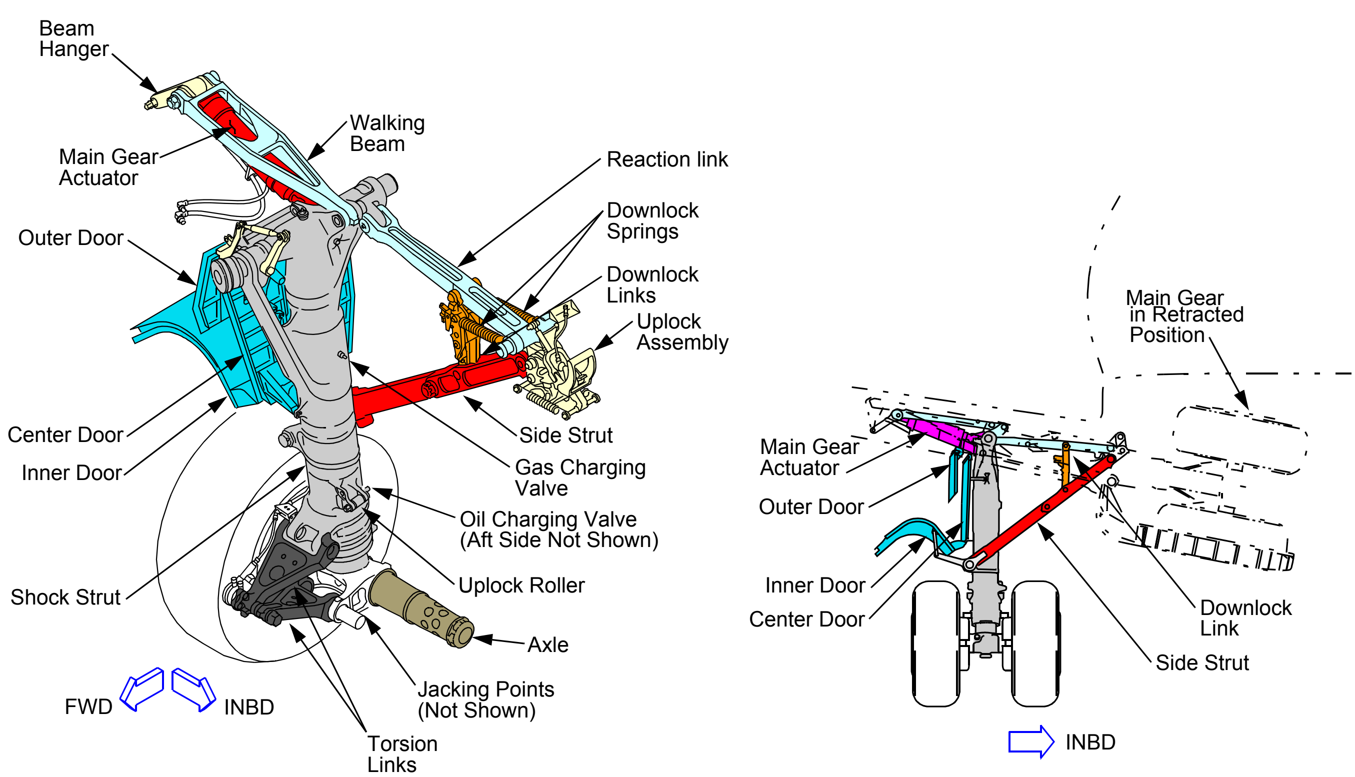
AUTOBRAKE SYSTEM

The autobrake system applies the brakes on landing or for a refused takeoff (RTO).

NOSE WHEEL STEERING

The pilot’s steering wheel and rudder pedals control the nose wheel steering.

Landing Gear



Main Landing Gear

The main landing gear is a dual-wheel, conventional landing gear. It has high operational reliability and a low maintenance design.

The main gear absorbs landing impacts with a nitrogen-oil strut. It also absorbs vibrations while the airplane moves on the ground. The shock and side struts transmit loads from the gear to the airplane structure.

Doors on the main gear are small segmented doors attached to the shock strut and hinged to the wing. The doors close when the MLG retract. The outer surface of the outboard tire aligns with the contour of the airplane to form the aerodynamic fairing for the wheel well opening.

Wheel well blade seals reduce noise and drag.

The main gear design offers the operator these advantages:

- Minimum spare inventory
- Mechanical gear doors eliminate sequencing valves and actuators
- Easy access to strut servicing valves.

NORMAL OPERATION

The main landing gear operates hydraulically. Extension uses system A. Retraction uses system A or system B if necessary.

Overcenter mechanical and hydraulic locks hold the gear in these positions:

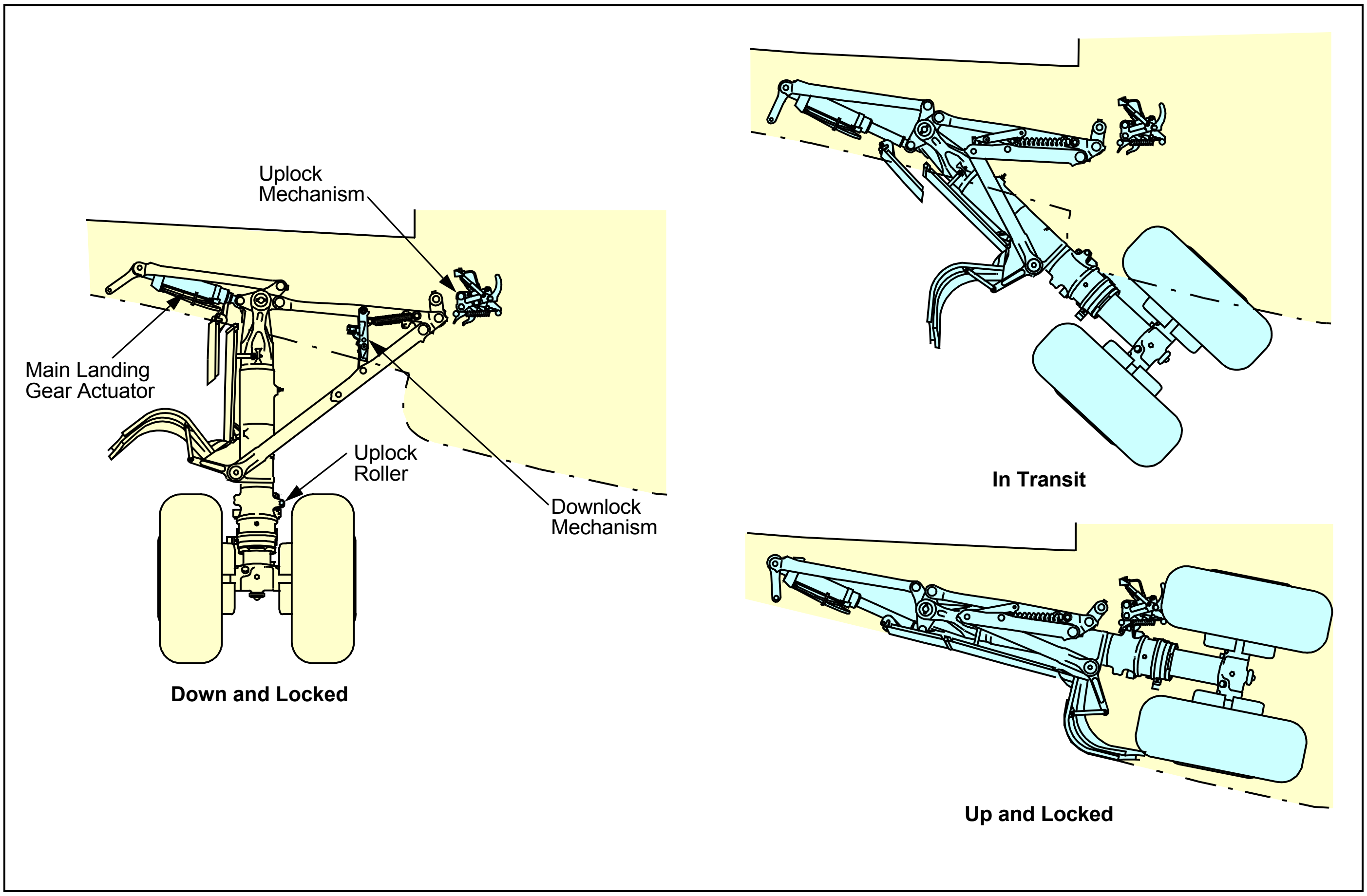
- Full extension
- Full retraction.

MANUAL EXTENSION

The manual extension system permits landing gear extension if hydraulic system A has no pressure.

A manual gear release from the flight compartment starts gear free fall to the down and locked position.

The forces that pull down the gear are gravity and wind loads.



MLG Extension and Retraction

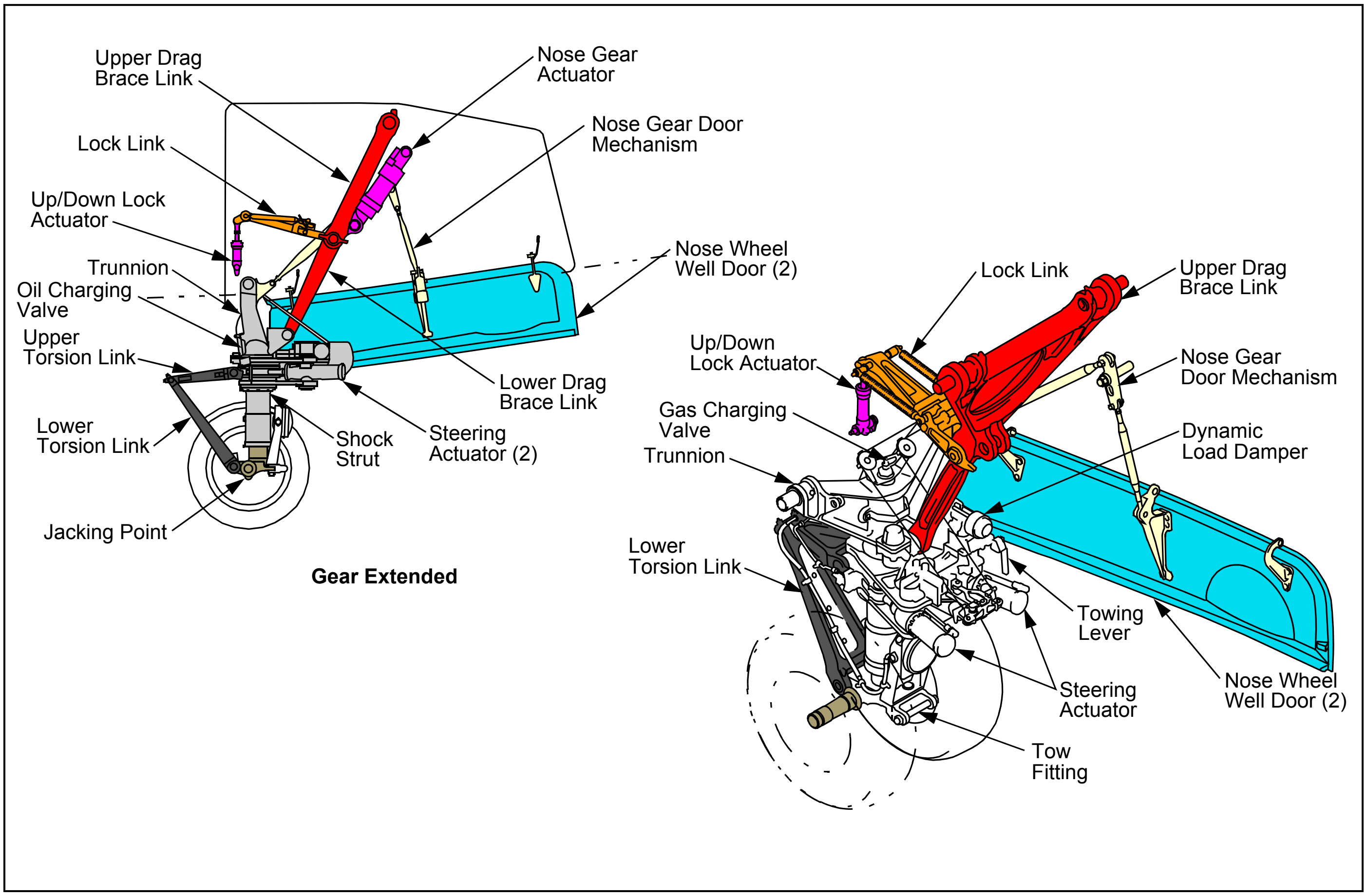
This is the retraction sequence for the main landing gear (MLG):

- Landing gear control lever moved to the UP position
- Downlock actuators extend
- Downlock mechanism unlocks
- The transfer cylinder goes to full stroke
- MLG actuators extend
- MLGs retract
- Uplock rollers move into uplock mechanisms
- Uplock mechanisms lock.

This is the extension sequence for the MLG:

- Landing gear control lever moved to the DN position
- Uplock actuators retract
- Uplock mechanisms unlock
- The transfer cylinders go to full stroke
- MLG actuators retract
- MLG extends
- Downlock actuators retract
- Downlock mechanisms lock.

Landing Gear



Nose Landing Gear

The nose gear is a dual wheel type which retracts forward and up into the wheel well.

The nose gear uses a nitrogen-oil strut. A folding drag brace transmits loads from the strut to the airplane structure. At full extension or retraction of the nose gear, the over-center mechanism of the lock links locks the drag braces.

The nose wheel well doors operate by mechanical linkages that connect to lugs on the trunnion. The doors stay open while the gear is down.

NORMAL OPERATION

The nose gear is hydraulically actuated. Extension uses system A. Retraction uses system A or system B if required.

MANUAL EXTENSION

The nose gear manual extension operates by manual release from the flight compartment. The nose gear free falls to the down and locked position when you pull the release.

NOSE WHEEL STEERING

The captain steering wheel controls the nose wheel movement to a maximum of 78 degrees in each direction. A first officer steering wheel is optional. The rudder pedals control the nose wheel movement to a maximum of 7 degrees in each direction.

Nose gear steering operates hydraulically by system A through the landing gear hydraulic extend line.

The steering wheel overrides the rudder pedal input. Rudder pedal steering is not available in the air.

Centering cams inside the nose gear strut center the gear before retraction.

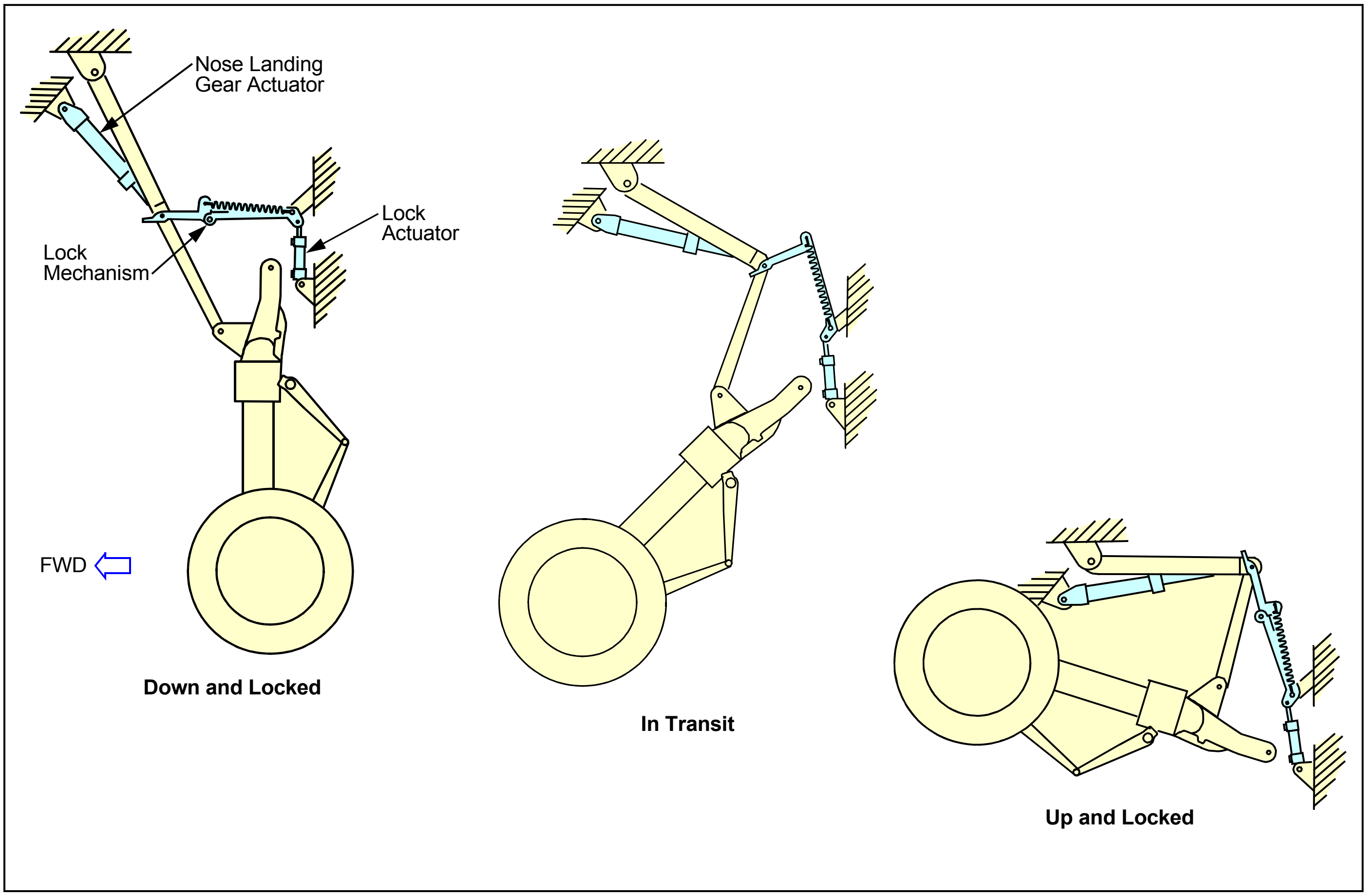
A dynamic load damper in the steering system reduces vibration.

A towing lever on the steering metering valve permits the airplane to tow throughout the full steering range.

ALTERNATE NOSE WHEEL STEERING

If hydraulic system A has no pressure, a switch in the flight compartment operates the landing gear transfer valve and permits steering with hydraulic system B.

BOEING PROPRIETARY



NLG Extension and Retraction

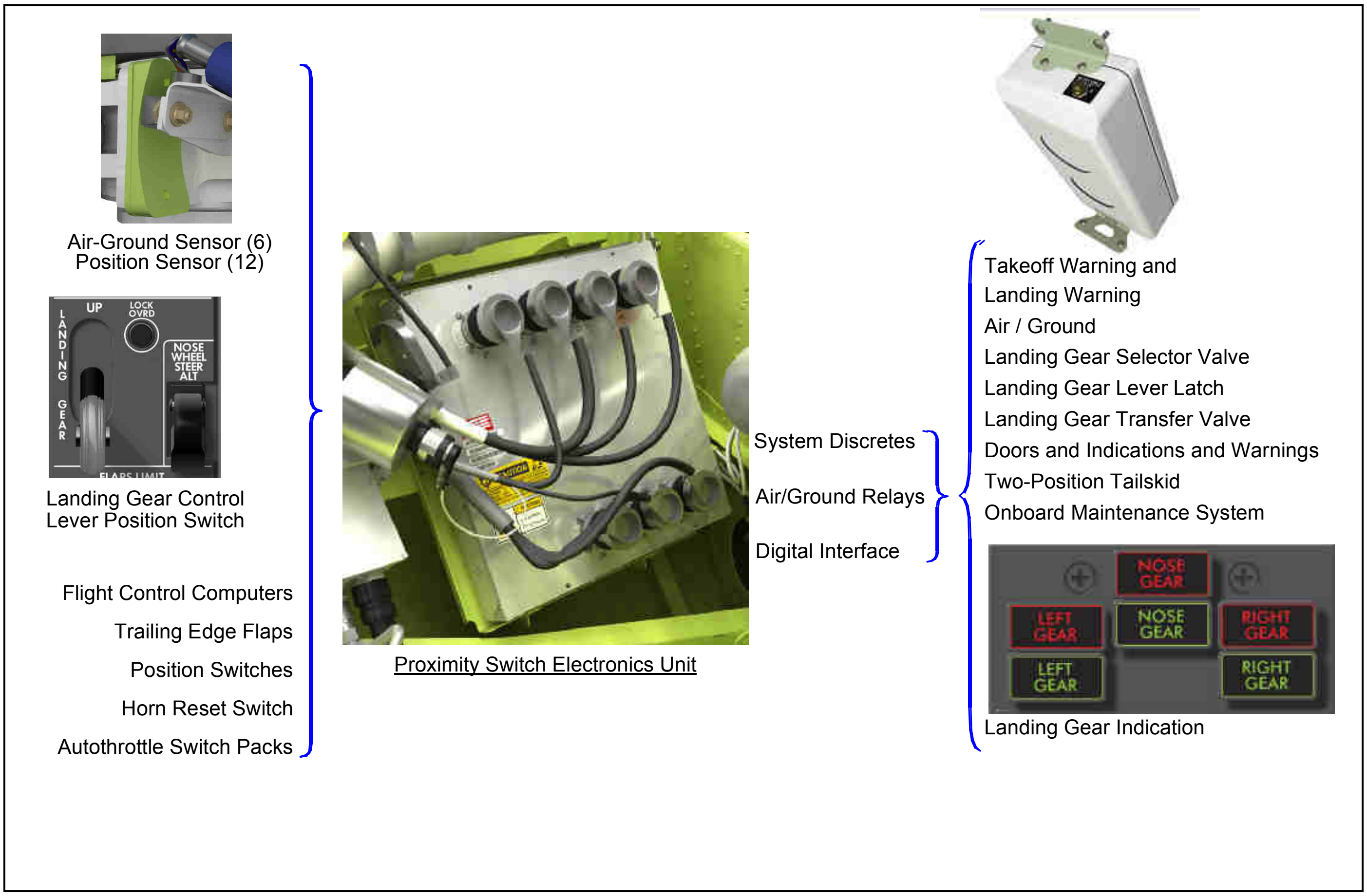
This is the retraction sequence for the nose landing gear (NLG):

- Landing gear control lever moved to the UP position
- Lock actuator retracts
- Lock mechanism unlocks
- The transfer cylinder goes to full stroke
- NLG actuator extends
- NLG retracts
- Lock actuator continues to retract
- Lock mechanism locks

This is the extension sequence for the NLG:

- Landing gear control lever moved to the DN position
- Lock actuator extends
- Lock mechanism unlocks
- The transfer cylinders go to full stroke
- NLG actuator retracts
- NLG extends
- Lock actuator continues to extend
- Lock mechanism locks.

Landing Gear



Air/Ground System

The air/ground system supplies air and ground mode signals to airplane systems.

Two air/ground sensors on each landing gear monitor the compression of the shock struts. Sensor signals go to the proximity switch electronics unit.

The system processes signals from the air/ground sensors and sends air/ground discretes and signals to operate air/ground relays.

Indication

Position sensors monitor the up and locked or down and locked positions of the nose and main landing gears.

Dual sensors at each location on the landing gear improves dispatch reliability. If one sensor does not operate, the system will still give correct indication.

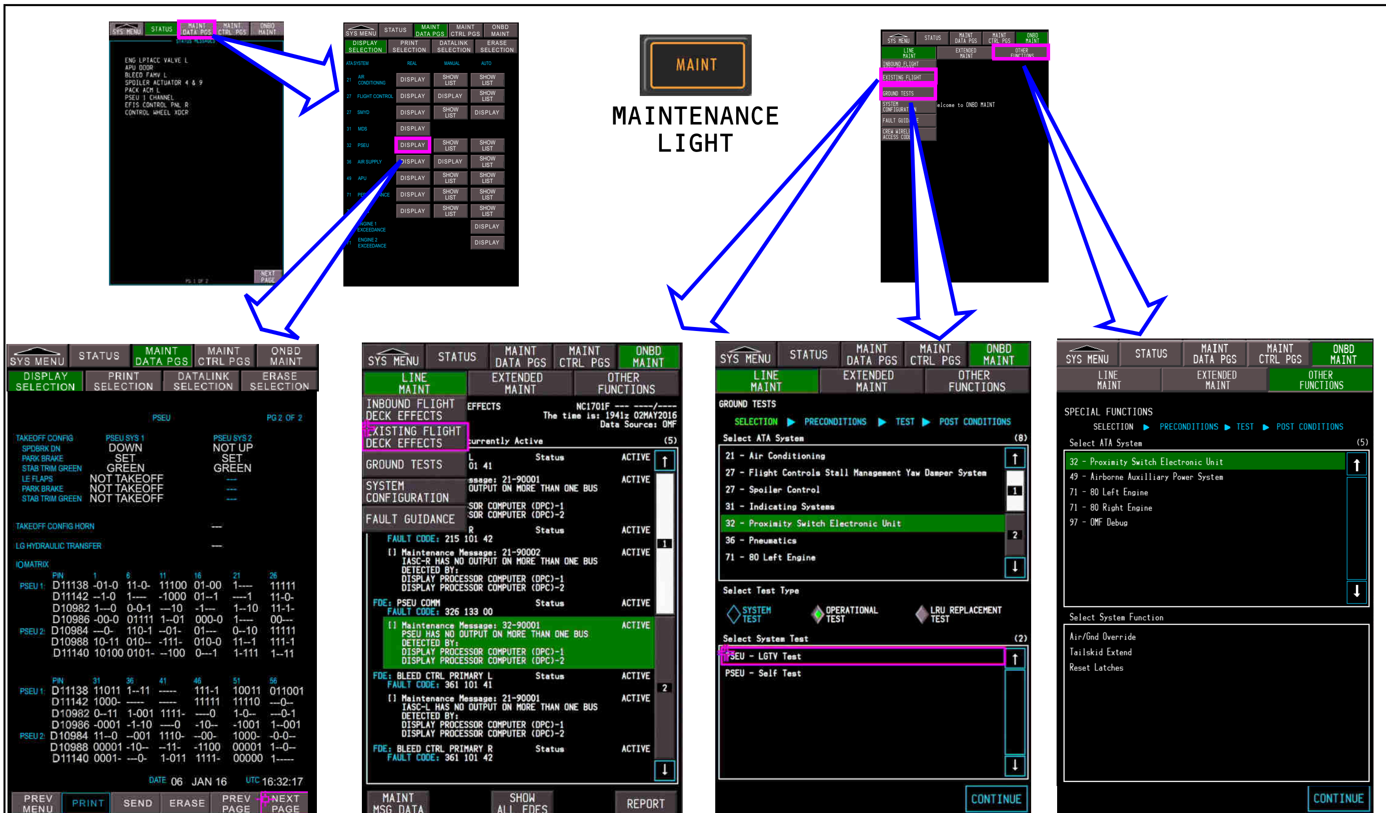
The proximity switch electronics unit (PSEU) processes all position sensor inputs and sends outputs to the landing gear position lights in the flight compartment.

Warning Systems

The PSEU gives takeoff and landing warnings to the aural warning module.

The PSEU uses these inputs to process the warnings:

- Landing gear lever position
- Landing gear position
- Airplane configuration (altitude, flaps position).



MAINT DATA PAGE (CONT MONITORING)

INBOUND FLIGHT DECK EFFECTS PAGE (CONT MONITORING)

GROUND TESTS PAGE (INITIATED GROUND TESTS)

SPECIAL FUNCTIONS PAGE (SPECIAL FUNCTIONS TESTS)

System Status and BITE

The proximity switch electronics unit (PSEU) has these BITE functions:

- Continuous monitoring
- Initiated ground tests
- Special functions.

Continuous monitoring is an automatic BITE operation. The MAINT DATA PGS and onboard maintenance pages show the status of the PSEU and its sensors.

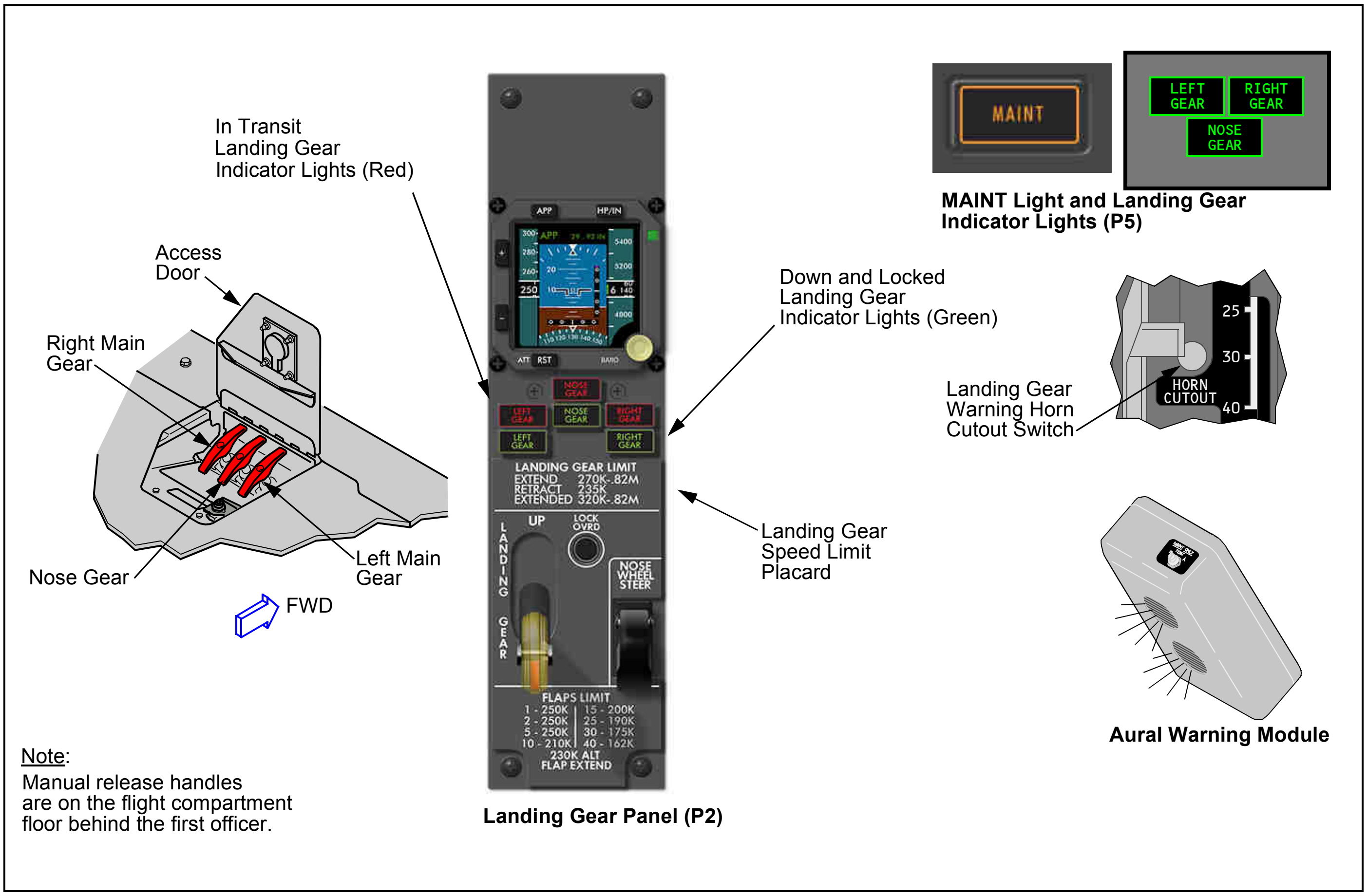
If BITE finds a fault, the MAINT light comes on. Maintenance pages in LINE MAINT and EXTENDED MAINT show the fault.

Initiated ground tests are tests that the operator uses to troubleshoot system faults. These ground tests are in LINE MAINT and OTHER FUNCTIONS.

The PSEU special function tests are in OTHER FUNCTIONS, SPECIAL FUNCTIONS. The special function tests lets you do these system tests:

- Air/Ground Override
- Tailskid Extend
- Reset Latches.

Landing Gear



Landing Gear Panel (P2)

MAINT Light and Landing Gear Indicator Lights (P5)

Aural Warning Module

Landing Gear Controls and Indication

These are the landing gear controls and indications in the flight compartment:

LANDING GEAR INDICATOR LIGHTS

There are one red and two green indicator lights for each gear.

The red light comes on for these conditions:

- The gear is not down and locked and either throttle is in the idle position with less than 800 feet altitude.
- Gear position does not agree with the landing gear lever position.

The green indicator lights come on when the related gear is down and locked.

MAINT LIGHT

When the proximity switch electronics unit finds a fault, the MAINT light comes on.

LANDING GEAR WARNING HORN

The landing gear warning horn operates when the airplane is in a landing configuration and the main landing gear is not down and locked.

The sound from the horn stops when the main landing gear is down and locked.

LANDING GEAR WARNING HORN CUTOUT SWITCH

This switch, on the control stand, stops the warning horn with trailing edge flaps and thrust lever(s) in certain positions. The horn stops automatically when the landing gear moves to the down and locked position.

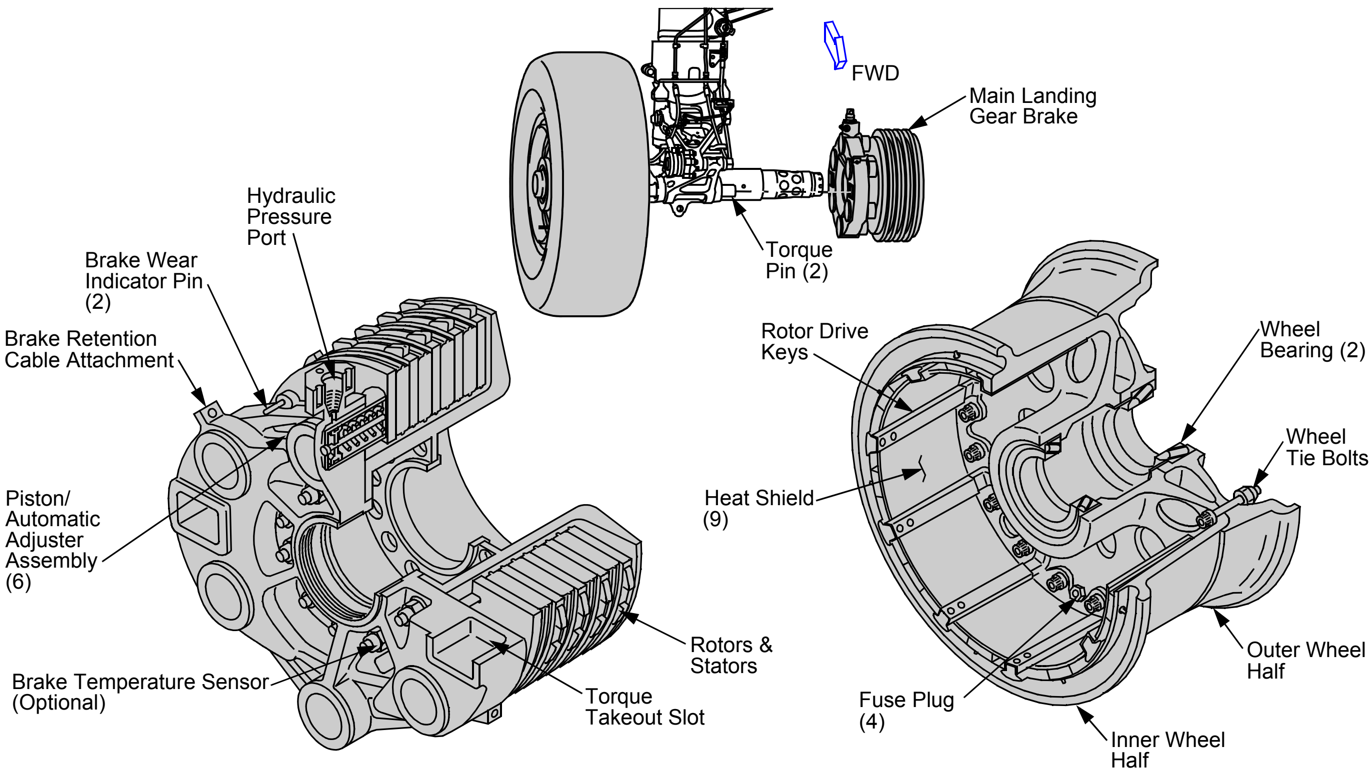
MANUAL RELEASE HANDLES

Three separate handles manually release all landing gear. These handles are in the flight compartment floor behind the first officer.

LANDING GEAR LEVER

This lever has two positions: UP and DN. A ground lockout solenoid inside the landing gear panel prevents the placement of the lever to the UP position while the airplane is on the ground.

The LOCK OVRD button, mechanically overrides the ground lockout solenoid. This allows a pilot to move the landing gear lever to the UP position if the ground lockout solenoid fails.



Main Landing Gear Brake **Main Landing Gear Wheel**

Tires, Wheels, and Brakes

The 737 MAX main gear wheels use radial tires.

The nose gear tire is the same size for all models.

The brakes are carbon and available from the two wheel suppliers.

Fuse plugs in the main gear wheels act as safety valves if the wheel temperature becomes too high. Excessive heat caused by unusual heavy use of brakes can cause above normal wheel temperature.

A pressure relief valve in all wheels releases tire pressure if it becomes too much.

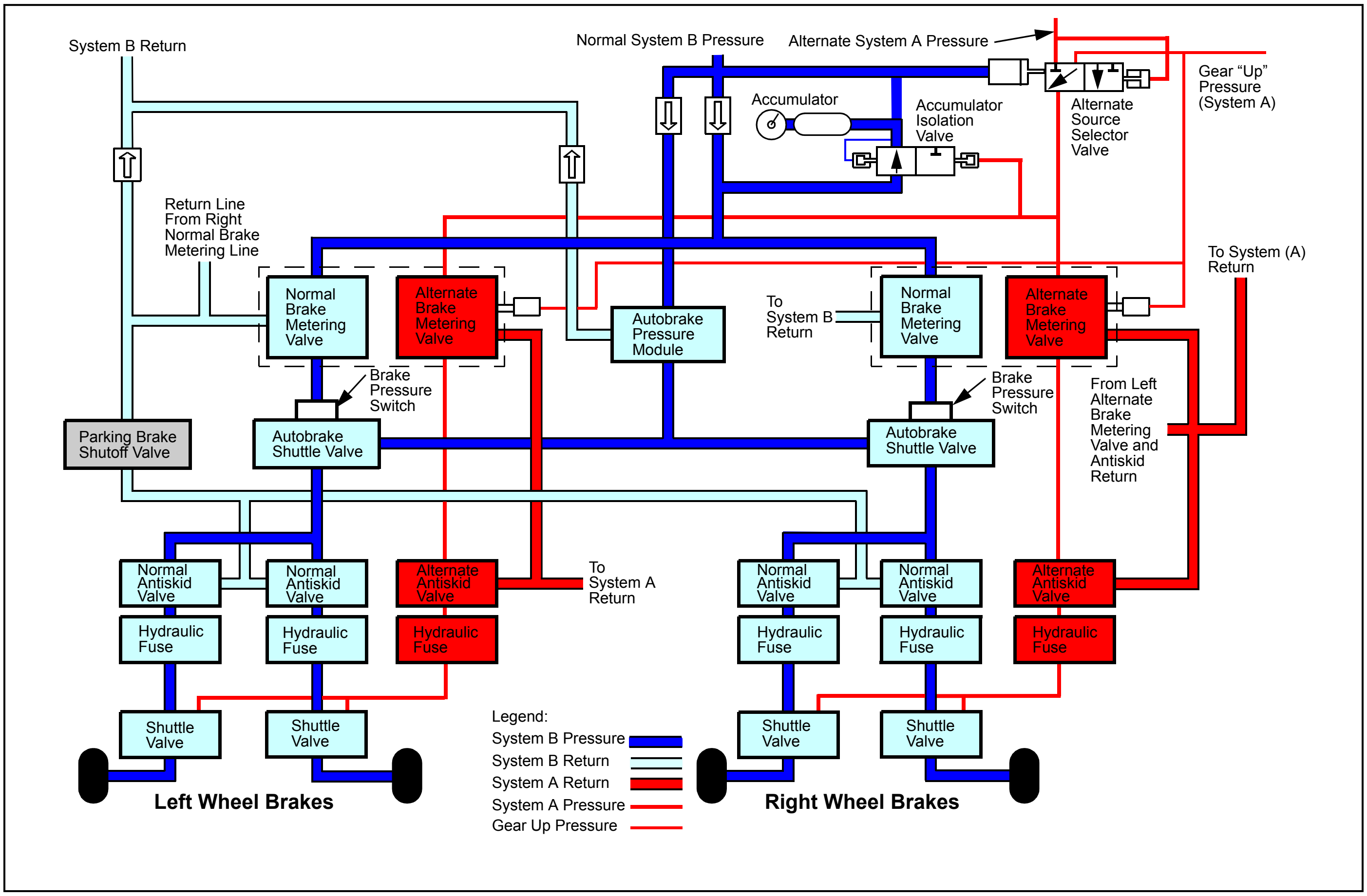
Brake System

The brake system includes multi-disc brakes for each main gear wheel. Hydraulic system B operates the normal brake system. Hydraulic system A is the primary backup and selected by the alternate brake selector valve if system B fails. If both the A and B systems fail, the accumulator isolation valve selects the accumulator as the secondary backup. The brake system has these features:

- Full anti-skid protection
- Auto-brakes for landing or RTO
- Easy brake service and maintenance requirements
- Identical brake control from either pilot station
- Directional control through differential braking
- Hydraulic brake line fuses limit fluid loss if there is a failure (external leak such as a broken hose to a brake) downstream of the fuse. A fuse closes when the volume of hydraulic fluid through the fuse increases more than normal.

When the gear retracts, the brakes are applied to stop the main gear wheel rotation. Spin brakes in the nose wheel well stop nose wheel rotation when the gear retracts.

Landing Gear



Brake System

The hydraulic brake system controls hydraulic pressure to the main landing gear brakes.

Hydraulic brake pressure selection uses the alternate brake selector valve and the accumulator isolation valve to select these brake pressure sources:

- Normal brakes (system B)
- Alternate brakes (system A)
- Brake accumulator.

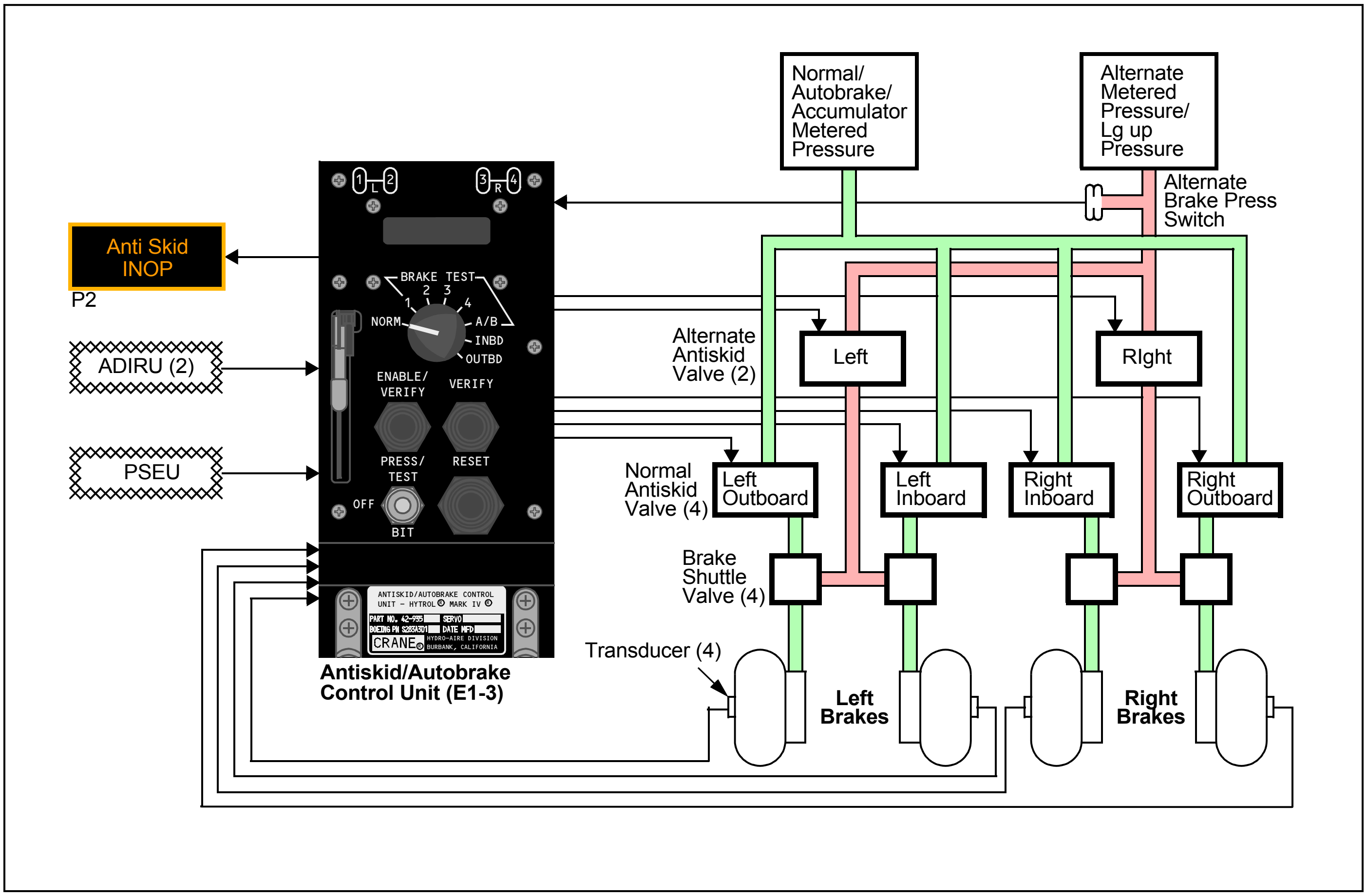
During landing gear retraction, the alternate brake system gets pressure to operate the main landing gear brakes to stop wheel rotation.

The brake metering valve assemblies contain both the normal and alternate metering valves. The brake pedals control the brake metering valves.

Normally with system B pressure available, the autobrake pressure module will supply the brake pressure to the autobrake shuttle valves and from there to the individual antiskid valves and the brake assemblies. Alternatively, the pilots can control braking using the brake pedals.

If system B pressure fails, the alternate source selector valve will allow system A pressure to the alternate brake metering valves and from there to the brake assemblies. The accumulator isolation valve holds pressure in the brake accumulator when system A is providing the brake pressure.

If both system A and system B have lost pressure, the brake accumulator will now supply pressure to the brakes.



Antiskid System

The antiskid system supplies safe brake control for all runway conditions. The system protects the airplane from a skid condition caused by a stop of wheel rotation.

The system has a speed transducer in each main wheel. A control unit in the EE compartment controls both the antiskid and autobrake systems. The system also has four normal antiskid valves and two alternate antiskid valves.

The antiskid system gets input from each wheel speed transducer when the wheels roll on the ground. The system automatically controls brake pressure to each main wheel.

If the pilot or autobrake system applies sufficient pressure to stop wheel rotation, the control unit reads wheel sensor speed inputs and sends applicable signals to the antiskid valves. The brake pressure reduces to prevent a skid, then reapplies to an optimum pressure. This operation repeats if skid conditions continue as brakes are applied.

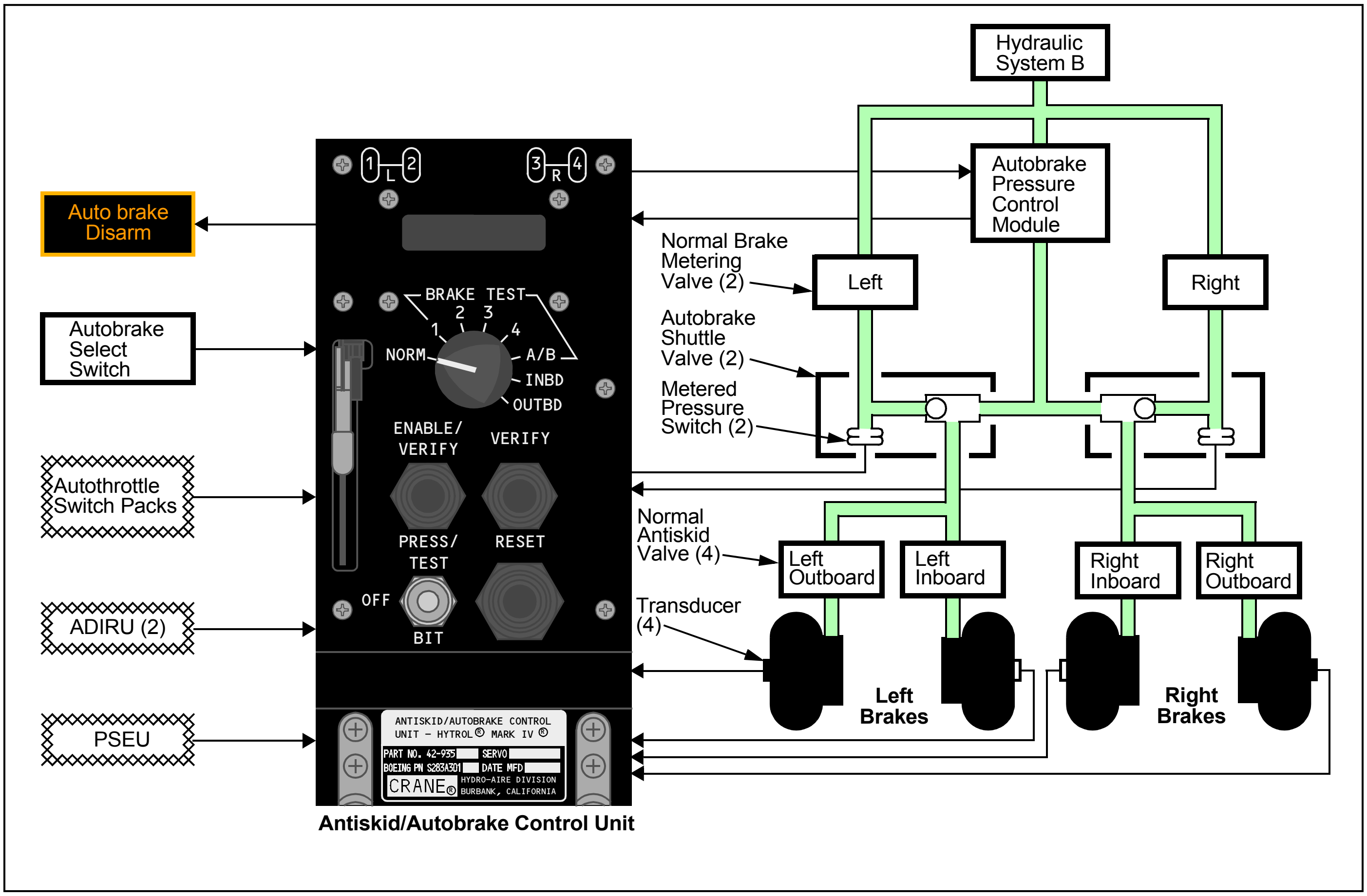
There is antiskid protection for each wheel when the normal brake system operates. When the alternate brake system operates, antiskid protection is for a pair of wheels.

The ANTISKID INOP light comes on when a fault in the system occurs during these conditions:

- Normal flight operation
- BITE test.

The light tells the pilots that antiskid may not operate when the aircraft lands and brakes are applied.

Ground test features are in the antiskid/autobrake control unit for maintenance.

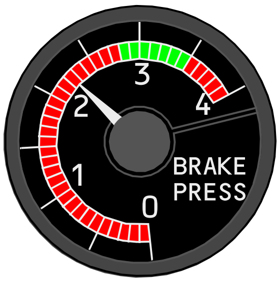


Autobrake System

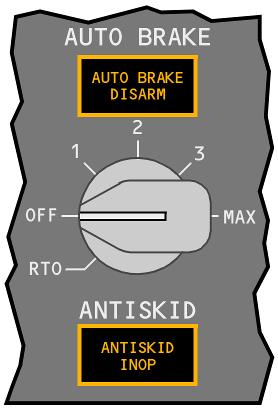
The autobrake system automatically applies the brakes to stop the airplane after it lands or if a rejected takeoff occurs.

The system has a pressure control module in the main landing gear wheel well. The autobrake select switch lets the pilots arm the system and select the level of auto braking. A control unit in the EE compartment controls the pressure control module.

The AUTO BRAKE DISARM light comes on when the pilot selects autobrakes and the system has been manually disarmed or a malfunction exists in the autobrake or antiskid systems.

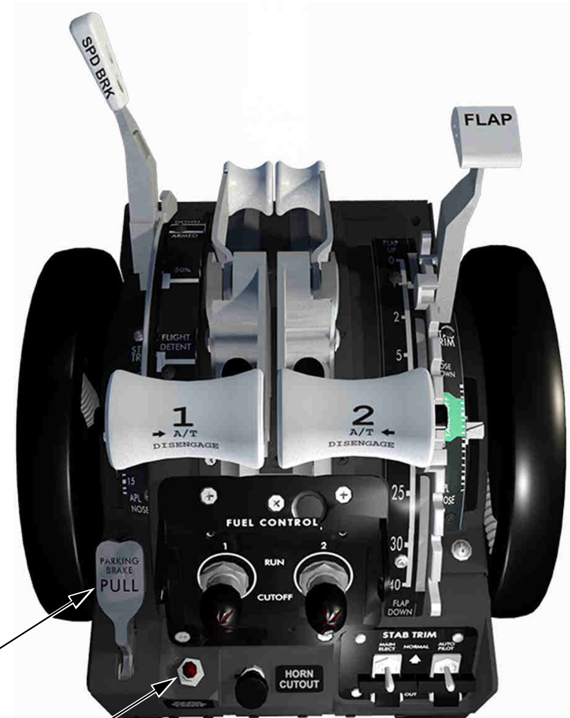


Hydraulic Brake
Pressure Indicator



Auto Brake/Antiskid
Panel (P2)

Parking Brake Lever



Parking Brake Lever

Parking Brake
Warning Light

Control Stand

Brake Controls and Indication

HYDRAULIC BRAKE PRESSURE INDICATOR

The indicator shows the pressure of the brake accumulator. Normal operating pressure is 3000 psi.

ANTISKID INOPERATIVE LIGHT

When the antiskid monitoring system finds a fault, the ANTISKID INOP light comes on.

PARKING BRAKE LEVER

When the brake pedals are applied and the parking brake lever is pulled, the parking brake linkage latches the brake pedal linkage in the pushed down position.

The LED parking brake warning light comes on when the parking brake shutoff valve is in the closed position.

AUTOBRAKE SYSTEM

The autobrake system applies pressure to all the brakes to slow the airplane at the rate selected by the pilot.

The pilot can select one of four deceleration levels before landing. The antiskid system operates normally during autobrake operation. Manual braking by the pilot will override and disarm the autobrake system.

The autobrake system also has a rejected takeoff (RTO) mode. The pilot selects RTO prior to takeoff. The system applies maximum brake pressure when the pilot aborts a takeoff.

As in the landing mode, manual braking overrides RTO. RTO autobrakes disarm at lift-off.

AUTOBRAKE DISARM LIGHT

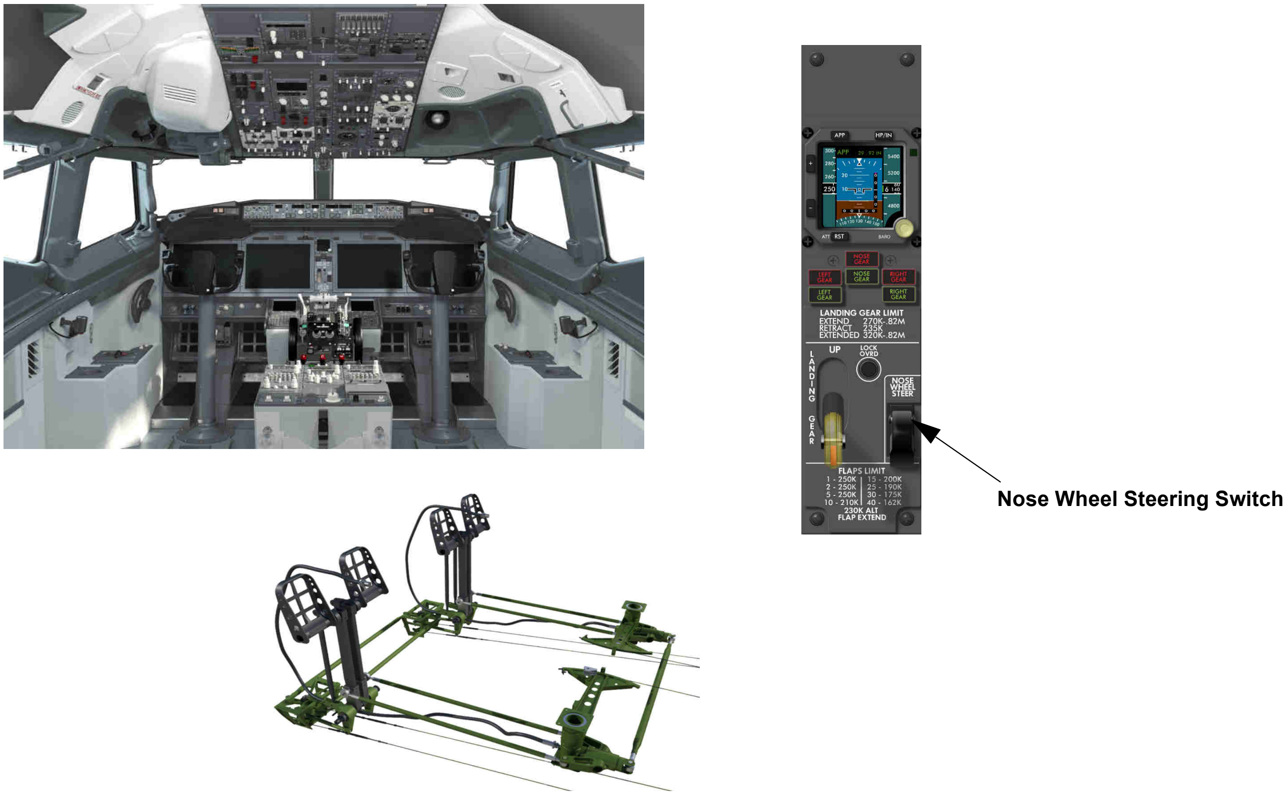
The AUTO BRAKE DISARM light comes on when the pilot selects autobrakes and any of these are true:

- There is a malfunction in the automatic brake system
- There is a malfunction in the antiskid system
- The system has been manually disarmed.

AUTOBRAKE SELECTOR SWITCH

This switch permits selection of the necessary level of auto brake and arms the system.

Landing Gear



Steering Controls and Indication

These are the controls for nose wheel steering in the flight compartment.

STEERING WHEEL

The captain steering wheel controls the nose wheel steering movement to a maximum of 78 degrees in each direction. A first officer steering wheel is optional.

A pointer on the steering wheel and a placard on the sidewall panel show the amount of steering movement.

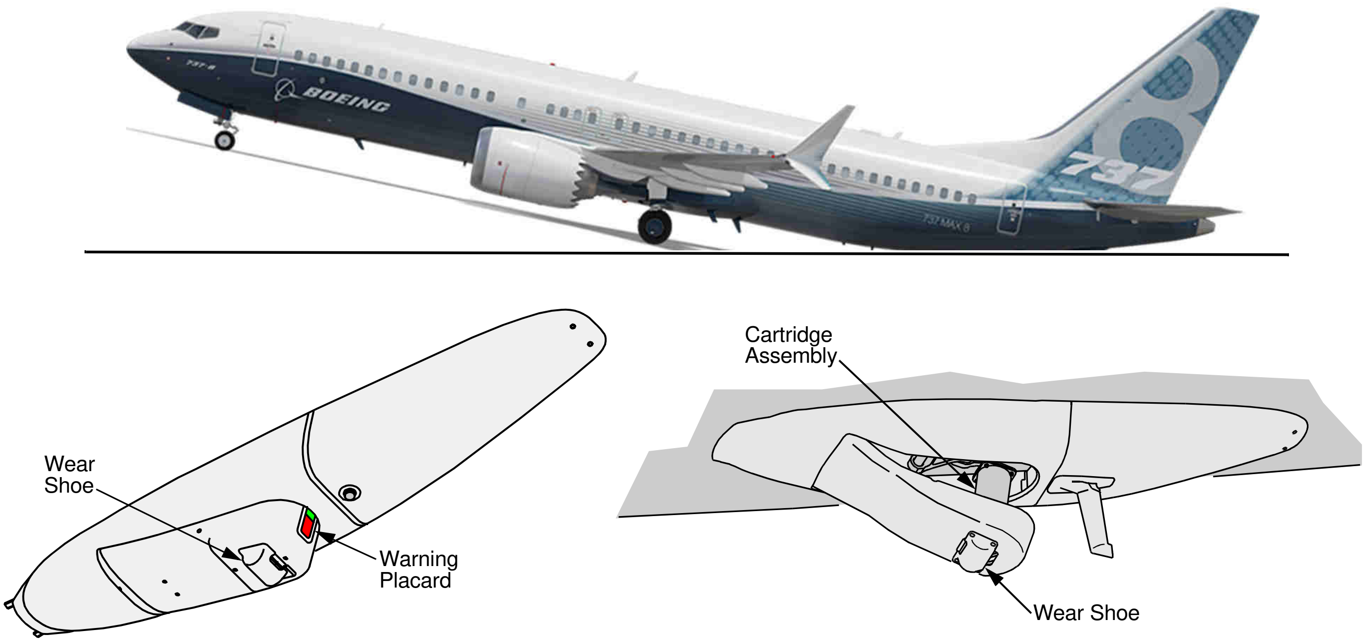
RUDDER PEDALS

The rudder pedals control the nose wheel steering movement to a maximum of 7 degrees in each direction. Rudder pedal steering input backdrives the steering wheel. Rudder pedals disconnect from nose wheel steering when the airplane goes into the air. Nose wheel steering cannot move the nose wheel when the airplane is in the air.

NOSE WHEEL STEERING SWITCH

Nose wheel steering normally receives pressure from hydraulic system A through landing gear extension. If hydraulic system A has no pressure, this switch in the flight compartment operates the landing gear transfer valve and permits steering with hydraulic system B.

BOEING PROPRIETARY



Fixed Position Tail Skid

Two Position Tail Skid

Tail Skid

The tail skid protects the airplane fuselage structure from ground contract if over rotation occurs during takeoff or landing.

There are fixed position or two position tail skids. The two position tail skid is used on airplanes with the short field performance package installed. A hydraulic actuator operates the two position tail skid.

Intentionally
Blank

Features

The flight control system has control surfaces to allow the airplane movement about all three axes.

HIGH-LIFT DEVICES

High-lift devices supply an increase in lift at slower speeds for takeoff and landing.

HYDRAULICALLY-POWERED AILERONS AND ELEVATORS

Hydraulic systems A and B operate the ailerons and elevators. If hydraulic power is lost, manual reversion (manual operation of flight controls) is available.

HYDRAULICALLY-POWERED RUDDER

Hydraulic systems A and B operate the rudder. Backup power comes from the standby hydraulic system.

ELECTRIC STABILIZER TRIM WITH MANUAL BACKUP

The horizontal stabilizer trim comes from an electric motor. Manual trim wheels, on the control stand, are backup.

HYDRAULIC HIGH LIFT SYSTEM WITH ELECTRIC AND STANDBY SYSTEM BACKUP

The trailing edge flap system and the leading edge flap/slat system usually operate from hydraulic system B. The trailing edge flaps have an electric motor backup. The leading edge flap/slat system uses the standby hydraulic system for backup.

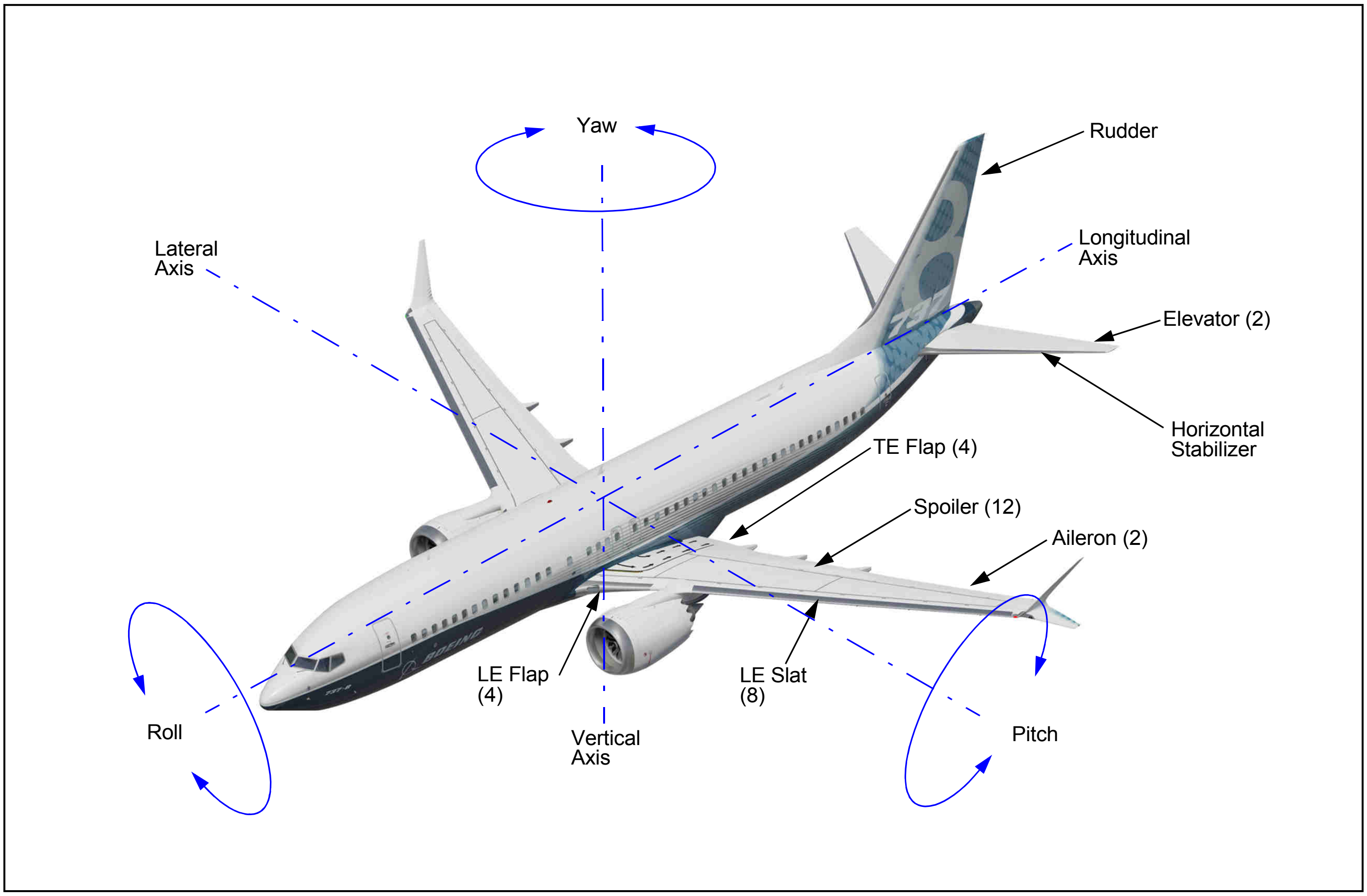
HYDRAULICALLY-POWERED SPOILERS

Hydraulic systems A and B operate the spoilers.

WHEEL-TO-RUDDER INTERCONNECT SYSTEM (WTRIS)

The rudder moves automatically for roll coordination during manual reversion of the ailerons (standby hydraulic system supplies power to the rudder).

Flight Controls



Flight Controls

The flight control system controls airplane movement around the lateral, longitudinal and vertical axes.

These are the primary flight controls:

- Ailerons
- Elevators
- Rudder.

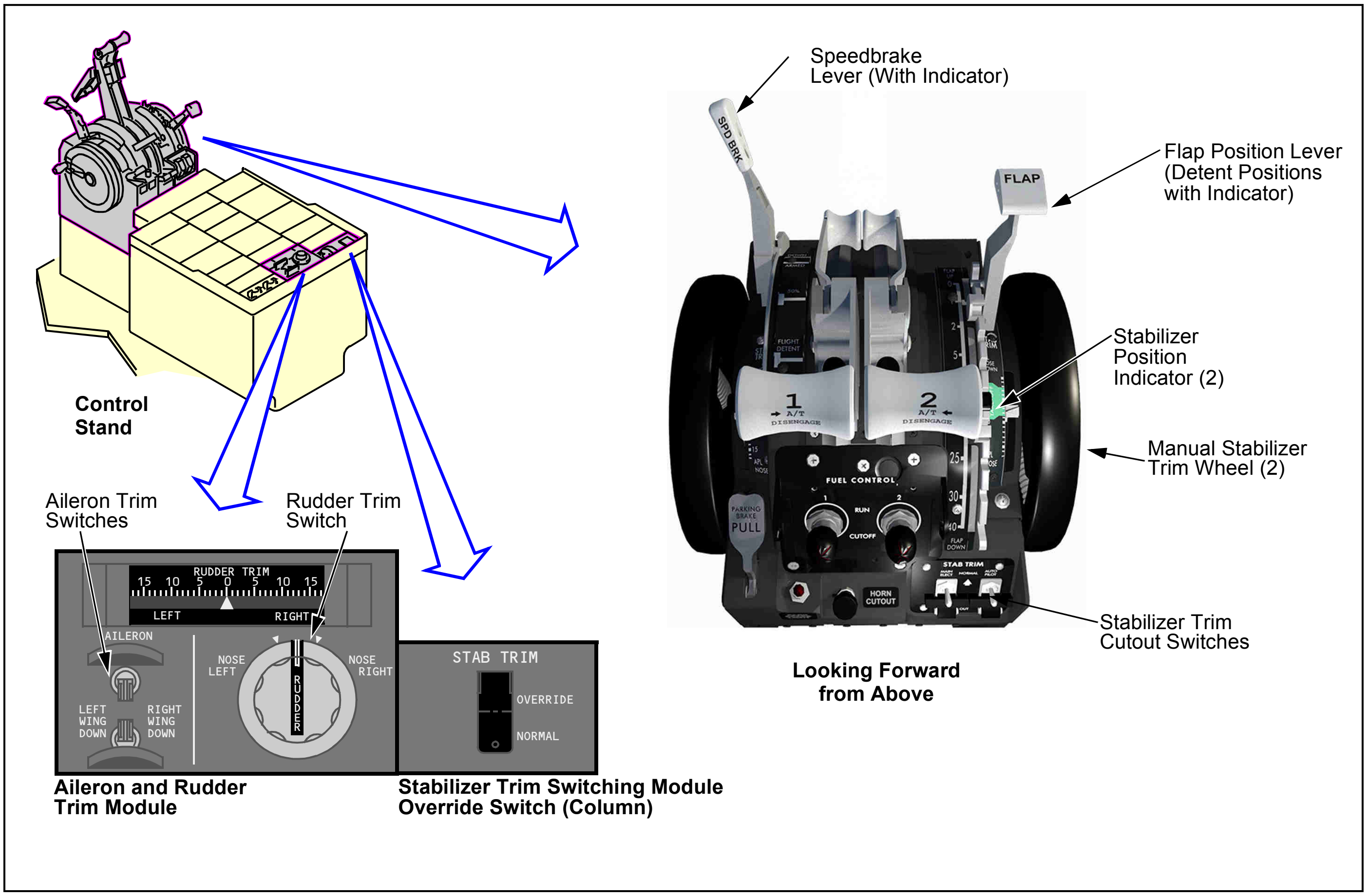
The ailerons control roll movement around the longitudinal axis. The elevators control pitch movement around the lateral axis. The rudder controls yaw movement around the vertical axis.

These are the secondary flight controls:

- Spoilers
- Horizontal stabilizer
- Leading-edge slats and flaps
- Trailing-edge flaps.

Primary flight controls get power form hydraulic system A and B. Either hydraulic system can supply power to all primary control surfaces.

If A and B systems lose hydraulic pressure, aileron and elevator control changes to a mechanical backup system (manual reversion). The backup for the rudder is the standby hydraulic system.



Control Stand

These are the controls for the flight controls on the control stand.

SPEEDBRAKE LEVER

The speedbrake lever moves flight spoilers up in air or on ground and ground spoilers up on ground.

- ARMED - Arms the speedbrake control system for landing
- FLIGHT DETENT - Maximum position of flight spoilers in air
- UP - Maximum position of flight spoilers on ground
- DOWN - All spoilers stow.

MANUAL STABILIZER TRIM WHEELS

Foldout cranks on each trim wheel permit either pilot to manually move the stabilizer.

STABILIZER POSITION INDICATOR

This shows the position of the horizontal stabilizer. The green band shows the permitted takeoff stabilizer trim positions. If you start a takeoff with the stabilizer out of the green band range, a takeoff warning horn operates.

STABILIZER TRIM CUTOUT SWITCHES

These switches are on the control stand.

- NORMAL - The main electric trim motor has power available
- CUTOUT - Removes power to the main electric trim motor.

FLAP LEVER

The flap lever controls the position of the leading edge devices and trailing edge flaps. It has nine detent positions.

RUDDER TRIM SWITCH

The rudder trim switch moves the rudder neutral position.

AILERON TRIM SWITCHES

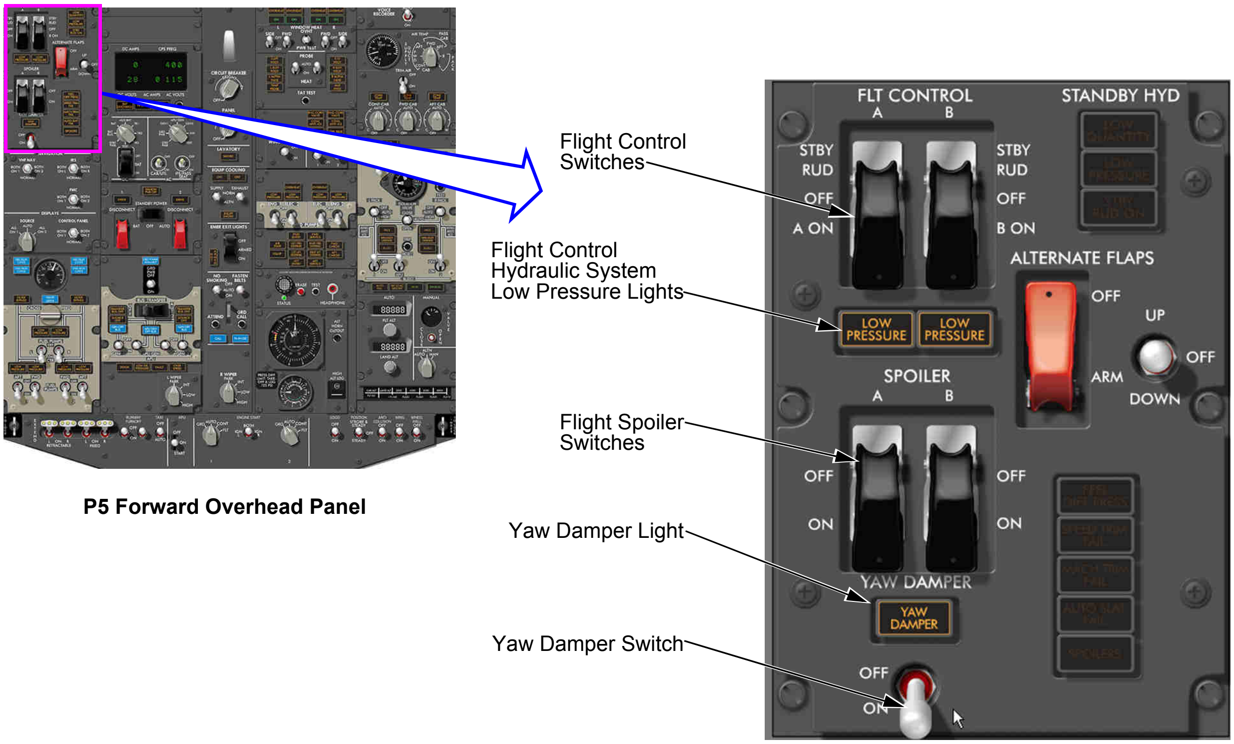
The aileron trim switches move the aileron neutral position. You can see the amount of trim input on the top of the control column.

STABILIZER TRIM COLUMN OVERRIDE SWITCH

This switch is on the control stand.

- NORMAL - Permits stabilizer trim through the column switching module
- OVERRIDE - Permits stabilizer trim in both direction if the column switching module fails.

Flight Controls



P5 Forward Overhead Panel

Flight Control Panel

Flight Control Panel

FLIGHT CONTROL SWITCHES

These switches control hydraulic system pressure to the primary flight controls. These are the switch positions:

- STBY RUD - In this position the standby pump operates and the standby rudder shutoff valve opens. This pressurizes the standby rudder power control unit.
- ON - In this position there is normal hydraulic system pressure to the primary flight controls.
- OFF - In this position hydraulic system pressure is off to the primary flight controls and the feel computer.

A LOW PRESSURE light comes on when hydraulic pressure to the primary flight controls is low.

When the flight control switches are in the STBY RUD position, the LOW PRESSURE lights show the position of the standby rudder shutoff valve. If the lights are on, the standby rudder shutoff valve is not in the commanded open position.

SPOILER SWITCHES

These switches control the position of the spoiler shutoff valves:

- ON - In this position the spoiler shutoff valve opens to supply hydraulic pressure to the flight spoilers.
- OFF - In this position the spoiler shutoff valve closes.

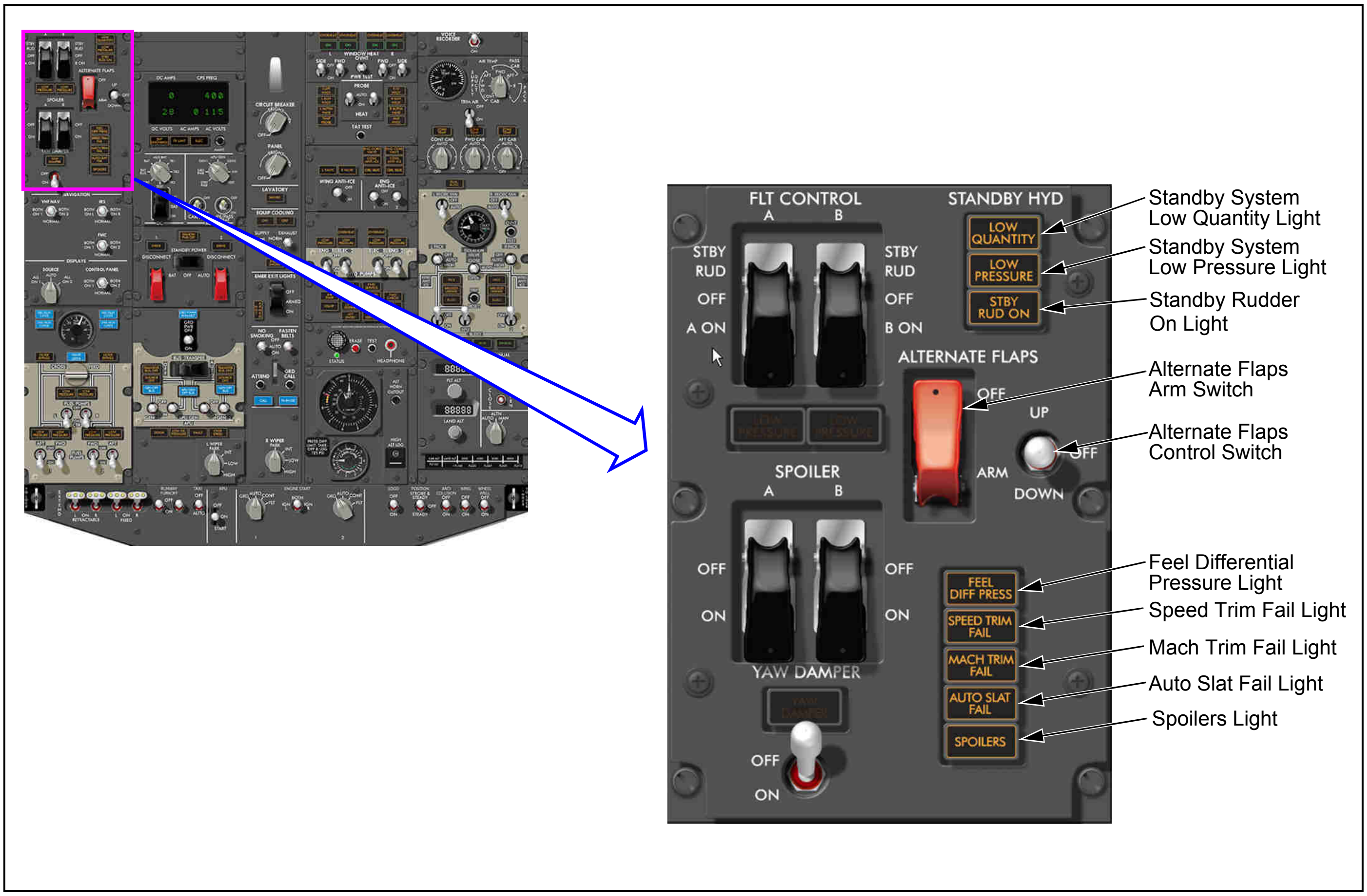
YAW DAMPER SWITCH

The YAW DAMPER switch controls the yaw damper.

When you move the switch to ON after loss of hydraulic system A and B, the wheel to rudder interconnect system (WTRIS) operates.

YAW DAMPER LIGHT

The light comes on when the yaw damper is not engaged.



Flight Control Panel

STANDBY HYD LIGHTS

The LOW PRESSURE light comes on when the standby system pressure is low. The light arms when the standby system operates.

The LOW QUANTITY light comes on when the standby system hydraulic fluid quantity is half full or less.

The STBY RUD ON light comes on when the standby rudder system is operating.

ALTERNATE FLAPS SWITCHES

When the alternate flap arm switch is in the ARM position, these functions occur:

- The standby pump supplies pressure
- The TE flap bypass valve moves to bypass
- The alternate flaps control switch arms.

If the alternate flaps arm switch is in the ARM position, and you move the alternate flaps control switch, these functions occur:

- DOWN - Electric motor extends the trailing edge flaps, and hydraulic power extends the leading edge devices.
- OFF - Stops the movement of the trailing edge flaps but not the leading edge devices. The spring-loaded switch moves to OFF from the DOWN position. It stays in the UP position until you put it back to OFF.
- UP - Electric motor retracts the trailing edge flaps. The leading edge devices do not retract with alternate operation.

FEEL DIFF PRESS LIGHT

The light comes on when the feel computer pressure for system A and system B are different by more than a set quantity.

SPEED TRIM FAIL LIGHT

The light comes on to show a fault of the speed trim function.

MACH TRIM FAIL LIGHT

The light comes on to show a fault of the mach trim function.

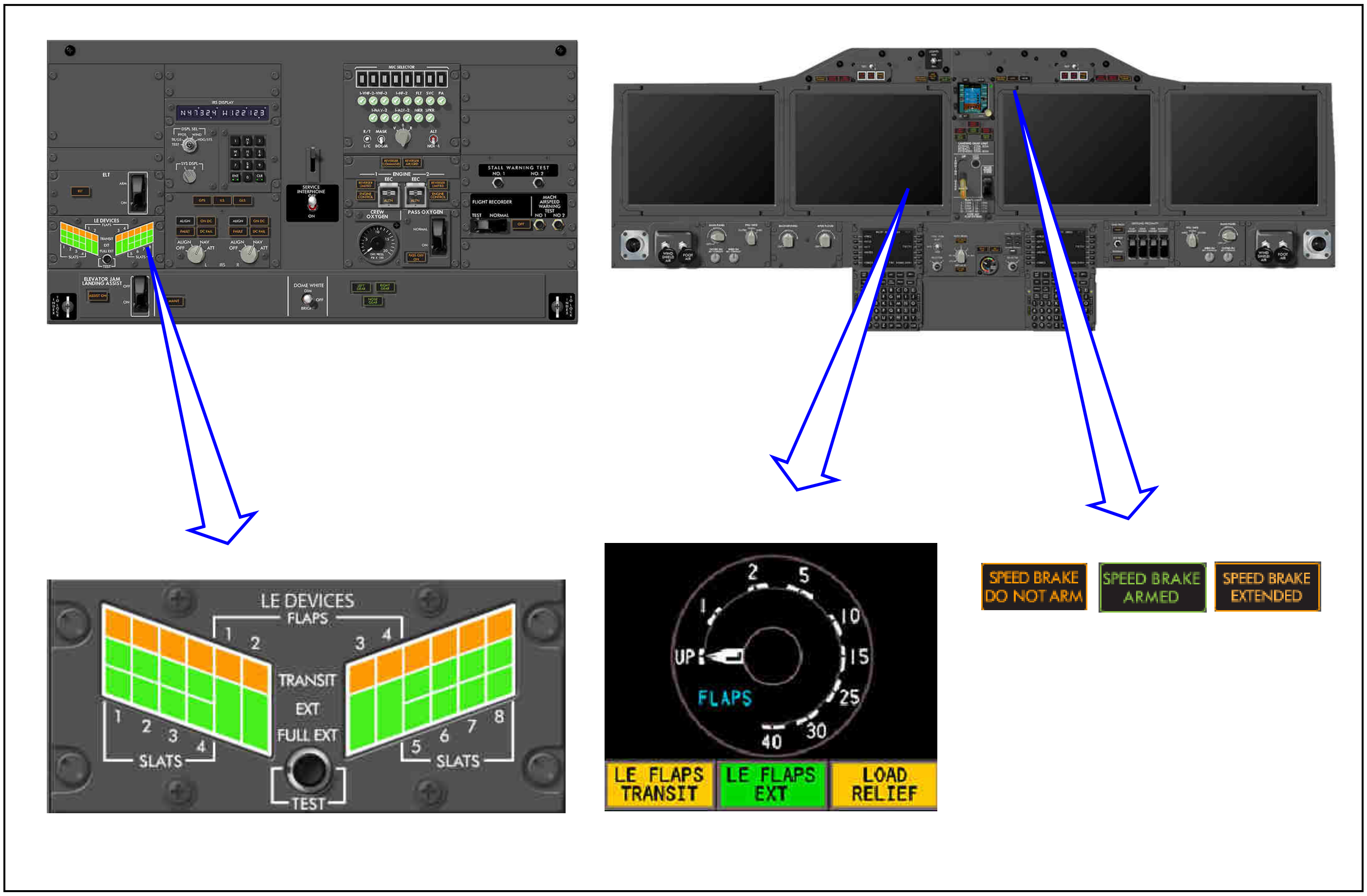
AUTO SLAT FAIL LIGHT

The light comes on to show a fault in the autoslat system.

SPOILERS Light

The light comes on to show a fault in the fly-by-wire spoiler system.

Flight Controls



Flight Controls and Indications

LEADING EDGE DEVICES ANNUNCIATOR PANEL

An annunciator panel on the aft overhead panel shows the leading edge flaps and slats position.

The lights come on when the leading edge devices are in these positions:

- TRANSIT—Leading edge devices are in transit or not in the selected position
- EXT—Leading edge slats and flaps in extend position
- FULL EXT—Leading edge slats are in the full extend position.

SPEEDBRAKES EXTENDED LIGHT

This light comes on when the spoilers go up, and all of these conditions occur:

- Airplane in the air
- Speedbrake lever is more than arm position
- Trailing edge flaps are at or more than 15 units or altitude is below 800 feet.

The light also comes on when the speedbrake lever is in the down position when the airplane is on the ground and the ground spoilers get hydraulic pressure.

TRAILING EDGE FLAP POSITION INDICATOR

The indicator is on the P2 center instrument panel. Different pointers show position of left (L) and right (R) wing trailing edge flaps.

LE FLAPS EXT LIGHT

The light comes on when the leading edge devices extend to the position selected by the flap lever.

LE FLAPS TRANSIT LIGHT

When the flap lever moves, this light comes on if the leading edge devices are in transit, or one or more is not in the selected position.

FLAP LOAD RELIEF LIGHT

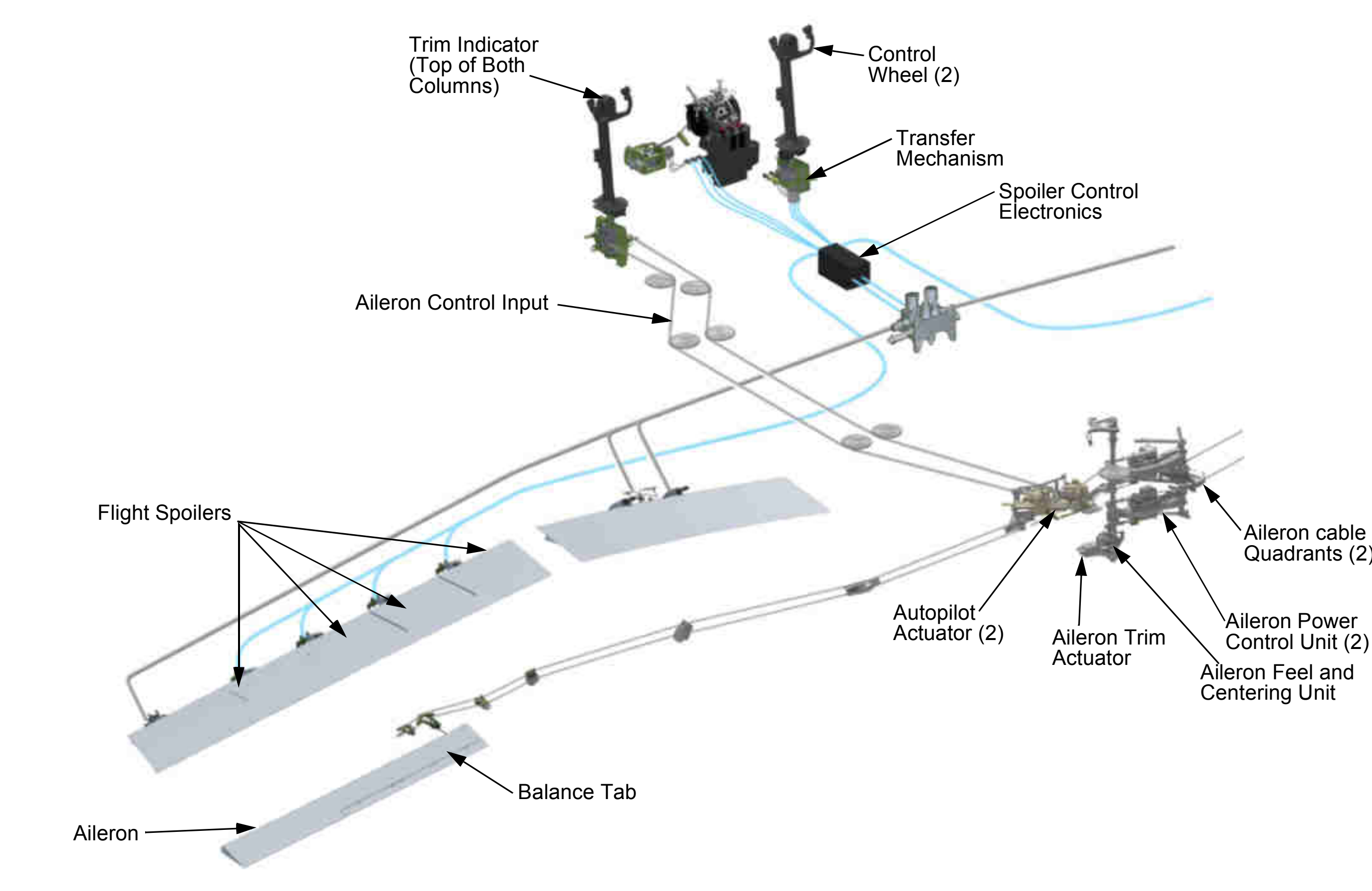
The light comes on when trailing edge flap load relief is commanded.

SPEEDBRAKE DO NOT ARM LIGHT

The light comes on when the speedbrake lever is in the armed position and there is a malfunction in the auto speedbrake system.

SPEEDBRAKE ARMED LIGHT

The light shows the pilot the auto speedbrake system is prepared to operate.



Roll Control

An aileron on each wing supplies primary roll control around the airplane longitudinal axis. Two independent hydraulic power control units (PCU) move the ailerons through cables. One PCU receives hydraulic power from system A and the other receives hydraulic power from system B. Either PCU can operate both ailerons to supply roll control. There is manual reversion for aileron control with both hydraulic system A and B off. Aileron balance tabs and balance panels keep the control forces to a minimum during manual reversion.

These are the inputs that move the ailerons:

- Pilot command
- Autopilot command
- Aileron trim.

Pilot input to the power control units is from the control wheels through a cable system. The aileron control cable system is the normal input path. Movement of the power control units operates a wing cable system which sets the position of the ailerons. A mechanical feel and centering unit with a centering cam, roller, and spring supplies control wheel feel force for the pilots.

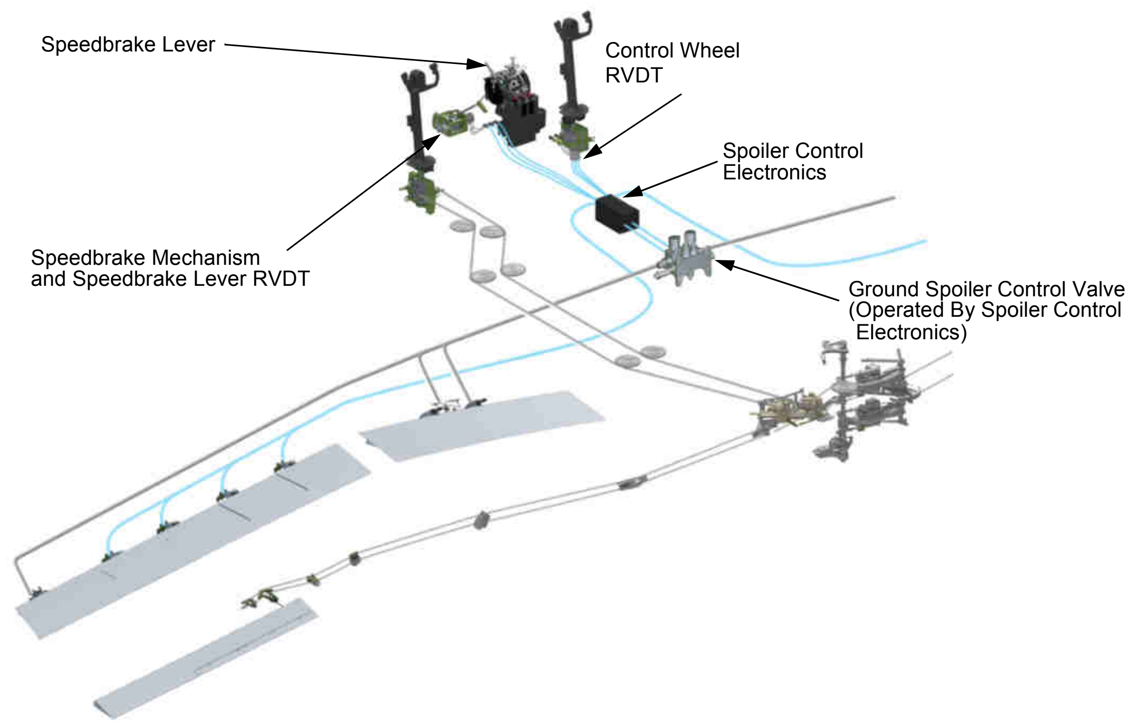
The autopilot, when engaged, controls the ailerons through autopilot actuators. These actuators supply input to the power control units and back drive the control wheels.

The aileron trim switches on the aft of the P8 aft electronic panel control the aileron trim. The trim switches command an electrical linear actuator which moves the feel and centering unit.

Four flight spoilers on each wing operate with the ailerons. When the control wheel turns, the spoilers operate to help the roll movement of the airplane. Hydraulic system A operates flight spoilers 2, 4, 9, and 11. System B operates flight spoilers 3, 5, 8, and 10.

A dual bus cable system connects the captain and the first officer (F/O) control wheels. This lets both control wheels rotate together. The flight spoilers also supply roll control if there is a jam in the aileron system. If a jam occurs, the transfer mechanism lets the F/O rotate the control wheel. This give an input to the spoiler control electronics (SCE). The SCE gives commands/ signals to the spoilers to give roll control.

The flight spoilers can also operate as speed brakes. This function is in the spoiler system description.



Note:
Flight Spoilers - 2, 3, 4, 5, 8, 9,10, and 11
Ground Spoilers - 1, 6, 7, and 12

Spoiler System and Speedbrakes

There are four flight spoilers and two ground spoilers on each wing. The flight spoilers operate in the air and on the ground. They assist the ailerons with roll control and also operate as speedbrakes to increase drag and decrease lift. The ground spoilers operate only on the ground to decrease lift and increase drag.

The speedbrake lever controls the flight spoilers in the air. The amount that the spoilers move depends on both the control wheel position and the speedbrake lever position. A spoiler control electronics receives electronic input from the control wheel rotary variable differentail transducer (RVDT) and the speedbrake lever (RVDT) to command give the correct spoiler extension on each wing from the two inputs. Aerodynamic forces can override actuator hydraulic pressure and limit spoiler panel extension to an amount in proportion to airspeed.

There are two ground spoilers on each wing. One ground spoiler is outboard of the flight spoilers the other is inboard of the nacelle. All the ground spoilers receive hydraulic power from system A.

The ground and flight spoilers operate together on the ground. The spoilers extend to reduce lift and increase aerodynamic drag. This helps stop the airplane in a shorter distance.

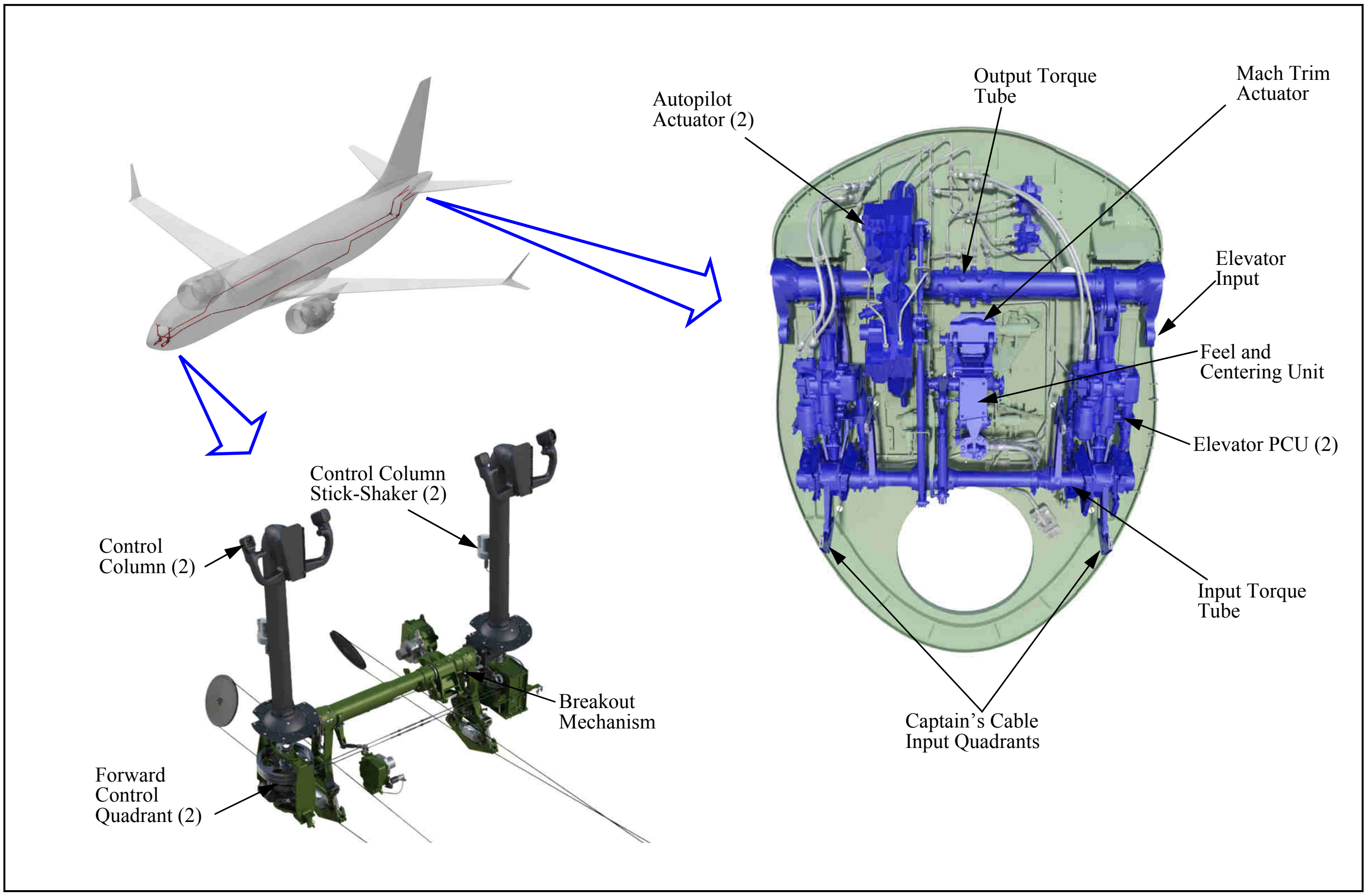
The spoilers operate either automatically or manually on the ground. Use the speedbrake lever to operate the spoilers manually. The spoilers extend automatically under these landing conditions:

- Speedbrake lever is in the ARMED position
- Airplane on the ground or wheel rotation is more than 60 knots.

All spoilers automatically retract, after automatic extension, when either thrust lever advances. The flight crew can manually move the speedbrake lever to override the automatic spoiler system.

During a refused takeoff (RTO), the spoilers extend if these two conditions occur:

- One of the two reverse thrust levers operates
- The airplane speed is more than 60 knots.



Elevator (Pitch) Control

The elevators supply primary pitch control about the airplane lateral axis. Two elevators connect to the aft end of the left and right horizontal stabilizer sections. Two independent hydraulic power control units (PCU) move the elevators. One PCU receives hydraulic power from system A and the other receives hydraulic power from system B. Either power control unit can operate both elevators to supply pitch control.

These are the inputs that move the elevators:

- Pilot command
- Autopilot command
- Neutral shift
- Mach trim.

Pilot input is from the control columns through a dual cable system and an input torque tube. The input torque tube connects to each PCU with two input rods. An output torque tube connects both power control units to both elevators. A hydraulic feel system supplies control column forces proportional to airspeed and stabilizer position. An elevator feel computer gets input of airspeed and stabilizer position and supplies the appropriate feel force. There is manual reversion for elevator control with hydraulic system A and B off.

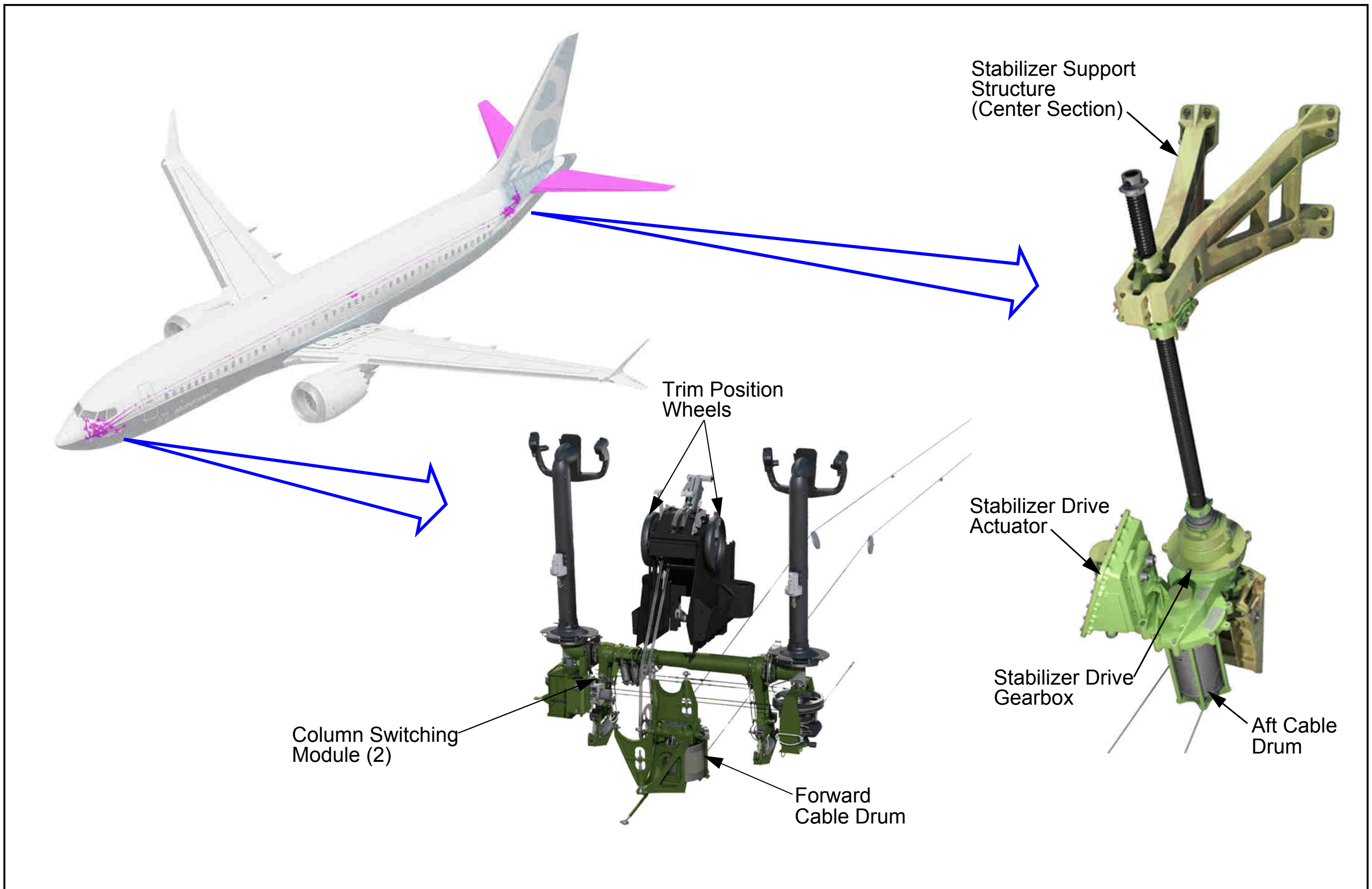
The autopilot, when engaged, controls the elevators through autopilot actuators. These actuators move the input torque tube which supplies input to the power control units.

Neutral shift moves the elevators to give a different elevator neutral position for different stabilizer positions. Neutral shift rods connect the stabilizer to the elevator feel and centering unit. The elevator's neutral position changes as the stabilizer moves.

The mach trim system commands the elevators at high speeds. The mach trim actuator moves the elevator feel and centering unit. This changes the elevator neutral position.

A stick shaker stall warning system gives the pilot the positive indication that the airplane is close to a stall. An electric motor attached to each control column shakes the column when the airplane comes near a stall condition.

Flight Controls



Stabilizer Trim

The moveable horizontal stabilizer provides pitch trim to the airplane. The horizontal stabilizer is a three piece assembly. A jackscrew assembly attaches to the center section. The jackscrew moves the stabilizer assembly. These are the inputs that control the jackscrew:

- Main electric trim inputs to the stabilizer trim motor
- Autopilot and speed trim inputs to the stabilizer trim motor
- Manual trim wheels through cables.

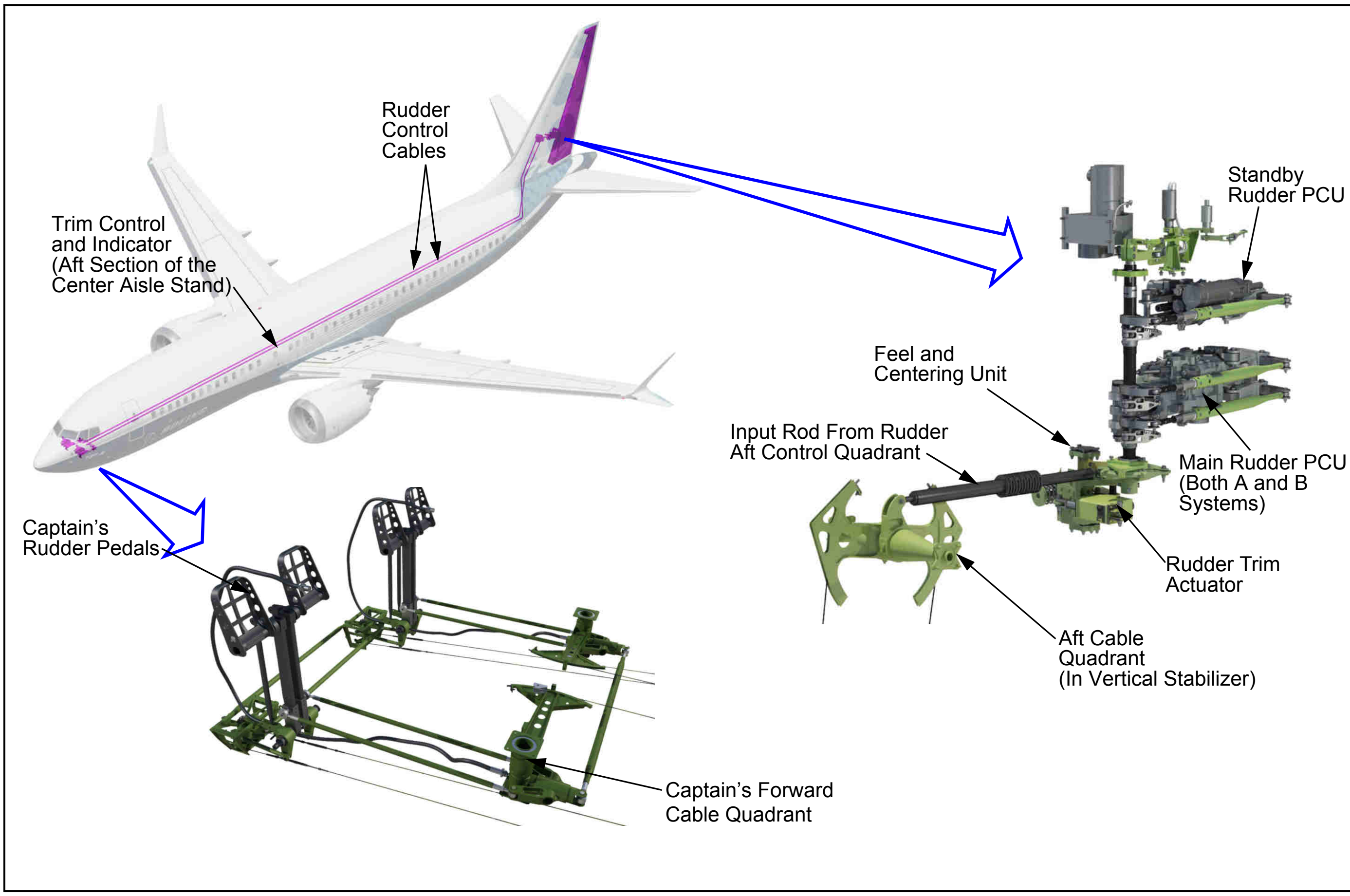
Thumb switches on either control wheel command the stabilizer trim motor for the main electric trim system. The motor operates at low speed with flaps up and high speed with flaps not up.

The autopilot and speed trim systems also give commands to the stabilizer trim motor. The autopilot trim motor speeds are slower than the thumb switch control speeds.

The electric trim system includes a column switch module to stop uncommanded stabilizer trim. If the pilot moves the control column opposite to the direction of the uncommanded trim, switches in the module stop the electric trim. An override switch on the aisle stand bypasses the column switch module if it malfunctions.

The manual stabilizer trim control wheels connect to the stabilizer gearbox with a forward and aft cable drum. Foldout handcranks on the trim wheels allow either pilot to manually trim the stabilizer. The cable system also operates trim position indicators next to the trim wheels on the control stand.

BOEING PROPRIETARY



Rudder (Yaw) Control

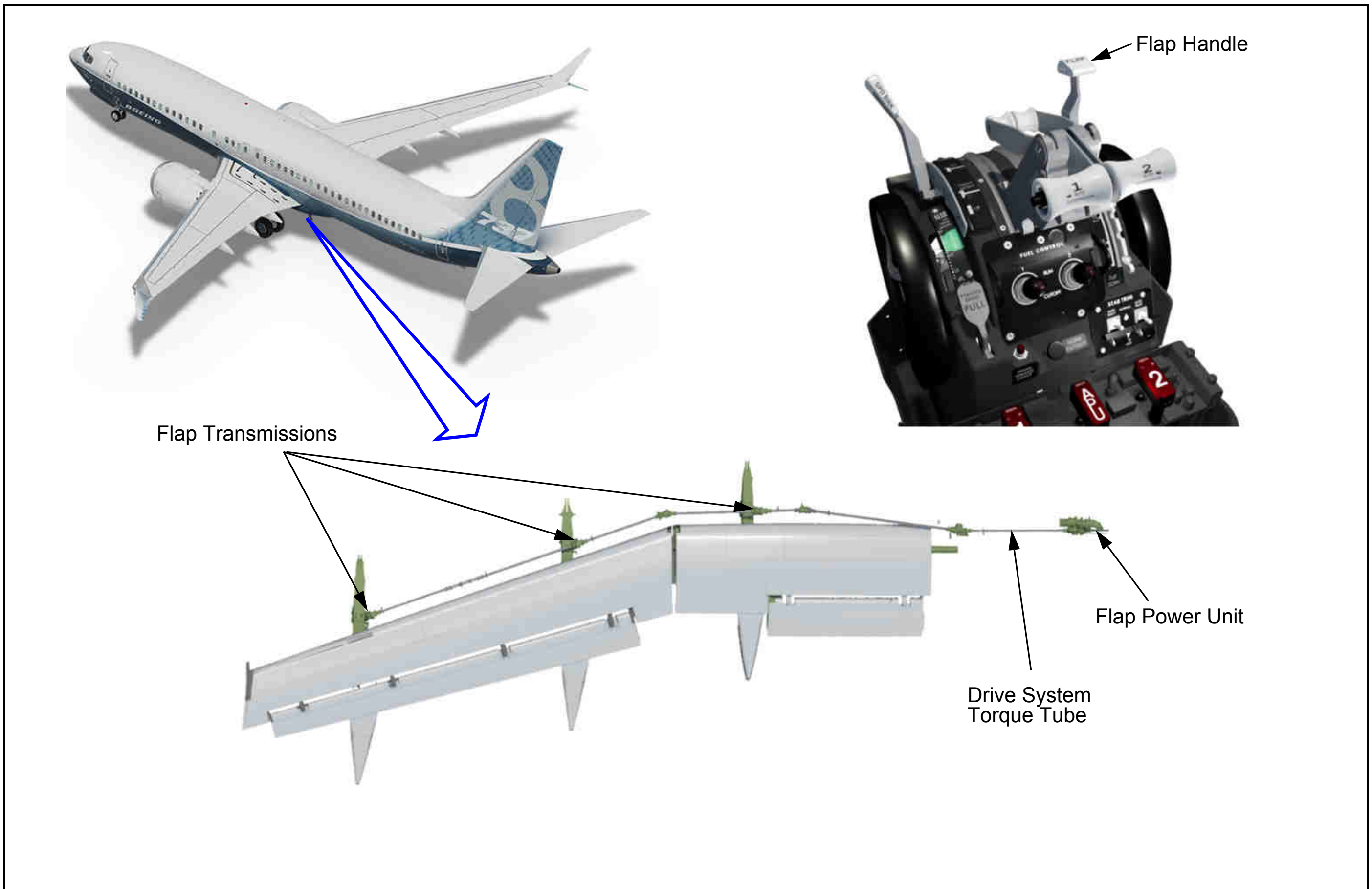
The rudder gives yaw control of the airplane around the vertical axis. The rudder is a single conventional rudder without tabs. The normal movement of the rudder is from the main rudder power control unit that uses hydraulic systems A and B.

A different power control unit, which uses standby hydraulic power, supplies backup movement. Each of the three hydraulic systems can supply rudder control. The pilot rudder pedals operate the power control units through cables. A mechanical feel and centering unit gives the pilot feel forces and puts the rudder to center.

An electric actuator on the feel and centering unit supplies rudder trim. A trim control switch on the aisle stand operates the trim actuator. Trim actuator movement gives an input to the power control unit (PCU) to move the rudder.

The yaw damper system moves the rudder to prevent dutch roll. This system operates through the hydraulic system B control section of the main rudder power control unit. The yaw damper operates independently of the rudder control system and does not give feedback to the rudder pedals.

The wheel to rudder interconnect system also controls the rudder through the standby power control unit. It is active only when hydraulic systems A and B do not have pressure. Movement of the control wheel sends a signal to the standby power control unit to move the rudder. This gives rudder assist to help turn the airplane when control of the ailerons is through manual reversion.



Trailing Edge Flap System

Trailing edge flaps have double-slotted inboard and outboard assemblies on each wing. Each assembly includes two mechanically linked segments that extend and separate to form a double-slotted surface for added lift. A hydraulic motor drives a flap power drive unit (gearbox) to operate all trailing edge flaps. A torque tube drive system transfers movement from the flap power drive unit to the flaps.

The flap alternate operation uses electric power to drive the flap system if a failure prevents normal hydraulic operation.

The hydraulic pressure shuts off to the hydraulic motor if any of these conditions occur:

- Flaps become asymmetric
- Flaps become skewed (inboard end of a flap does not align with outboard end of flap)
- Flaps have an uncommanded motion (UCM)
- Flaps operate with the alternate drive.

Takeoff flap positions supply high lift with low drag. Landing flaps produce high lift and high drag which help to decrease approach speeds.

The flap load relief system protects the trailing edge flaps from excessive airloads. The flaps move up one position for these conditions:

- Flaps are at 10, 15, 25, 30 or 40 units
- Airspeed exceeds a set speed.

The flaps return to the selected flap position when airspeed reduces.

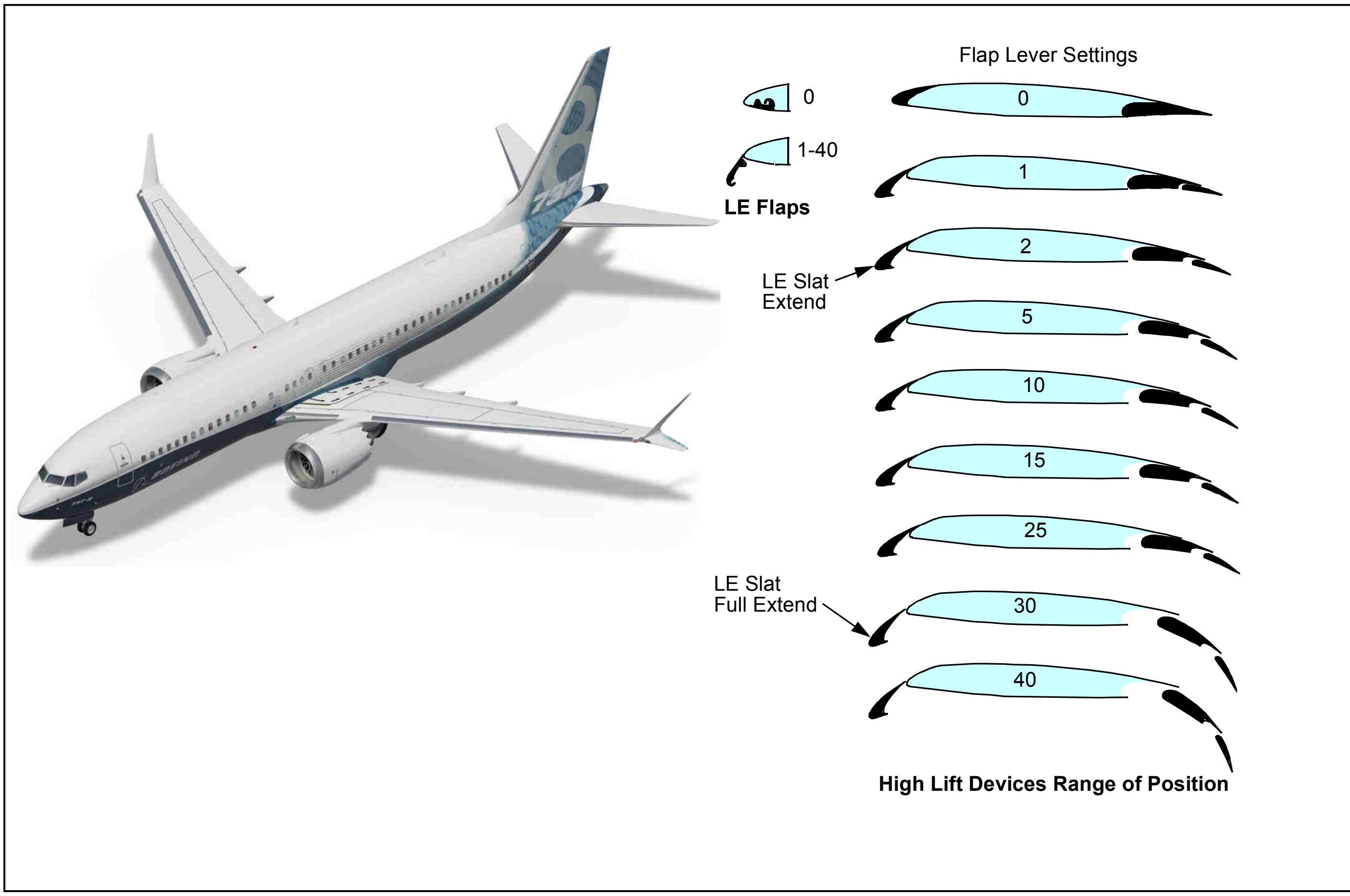
The flap design helps with durability and maintainability. The heavy-gage lower surface skin improves damage tolerance.

Flap Operation

For normal operations, the pilot selects the desired position with the flap lever on the control stand. Both leading edge devices and trailing edge flaps travel to the position selected. The possible flap lever positions are: UP, 1, 2, 5, 10, 15, 25, 30 and 40 units.

An alternate system operates when the normal hydraulic source (system B) is not available for leading edge and trailing edge operation. An electric motor supplies power during alternate operation to move the trailing edge flaps. The alternate flap arming switch and the alternate flaps control switch on the forward overhead panel operate the trailing edge flaps and leading edge devices.

BOEING PROPRIETARY



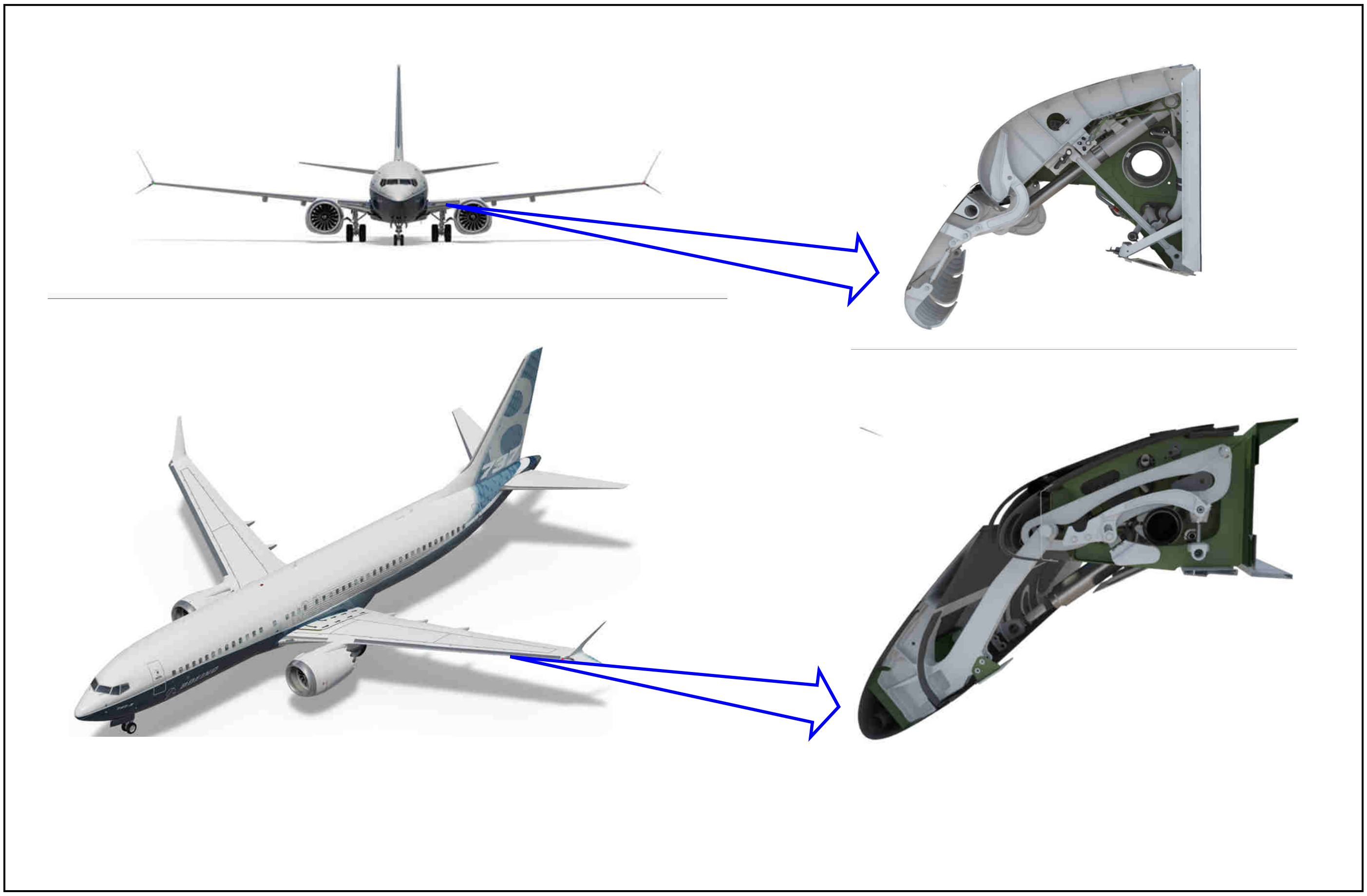
High Lift Devices

The high lift devices improve wing performance at low speeds. The high lift system includes leading edge flaps and slats and double-slotted trailing edge flaps. Hydraulic System B supplies power to the leading edge devices and the trailing edge flaps.

The leading edge flaps extend with the flap control lever in any position from 1 to 40. The leading edge slats move to an extend position with a flap lever position from 1 to 25. The slats move to a full extend position with a flap lever position at 30 or 40.

Autoslat operation automatically moves the slats from extend to the full extend position if the airplane approaches a stall.

Flight Controls



Leading Edge Flaps and Slats

Leading edge devices have two leading edge flaps inboard of each engine and four leading edge slats outboard of each engine. Normally the flap control lever is used to extend the leading edge devices.

Autoslat operation automatically moves the slats from extend to the full extend position if the airplane approaches a stall.

Normal operation of the leading edge flaps and slats comes from hydraulic system B.

However, if the engine driven pump for system B has low pressure and the trailing edge flaps are in takeoff position, the power transfer unit (PTU) automatically supplies a backup source of hydraulic system B power for normal and/or autoslat operation.

Features

PNEUMATIC

These sources supply the pneumatic manifold:

- Engine bleed air
- APU bleed air
- Ground source.

The system controls and indications reduce crew workload.

AIR CONDITIONING

The air conditioning system is a dual air cycle pack design.

The ram air system cools hot air in the pack.

The pack air cycle machines have air bearings. These bearings require no regular servicing.

Pack temperature control is automatic. Automatic overtemperature protection reduces crew workload.

System maintenance does not require ladders or special stands.

CONDITIONED AIR DISTRIBUTION

The distribution system distributes air in the flight and passenger compartments. A cabin air recirculation system reduces fuel consumption. The system automatically configures for ground and flight operations.

EQUIPMENT COOLING

The airplane uses two equipment cooling systems to cool equipment in the flight compartment and the EE compartment. Both systems have backup fans.

CARGO COMPARTMENT HEATING

The forward cargo compartment heating is by exhaust air from the equipment cooling system.

The aft cargo compartment heating is by outflow air from the passenger compartment.

PRESSURIZATION

The cabin pressure control system uses dual, automatic, digital pressure controllers. This increases reliability and reduces crew workload.

Pressure controllers have BITE.

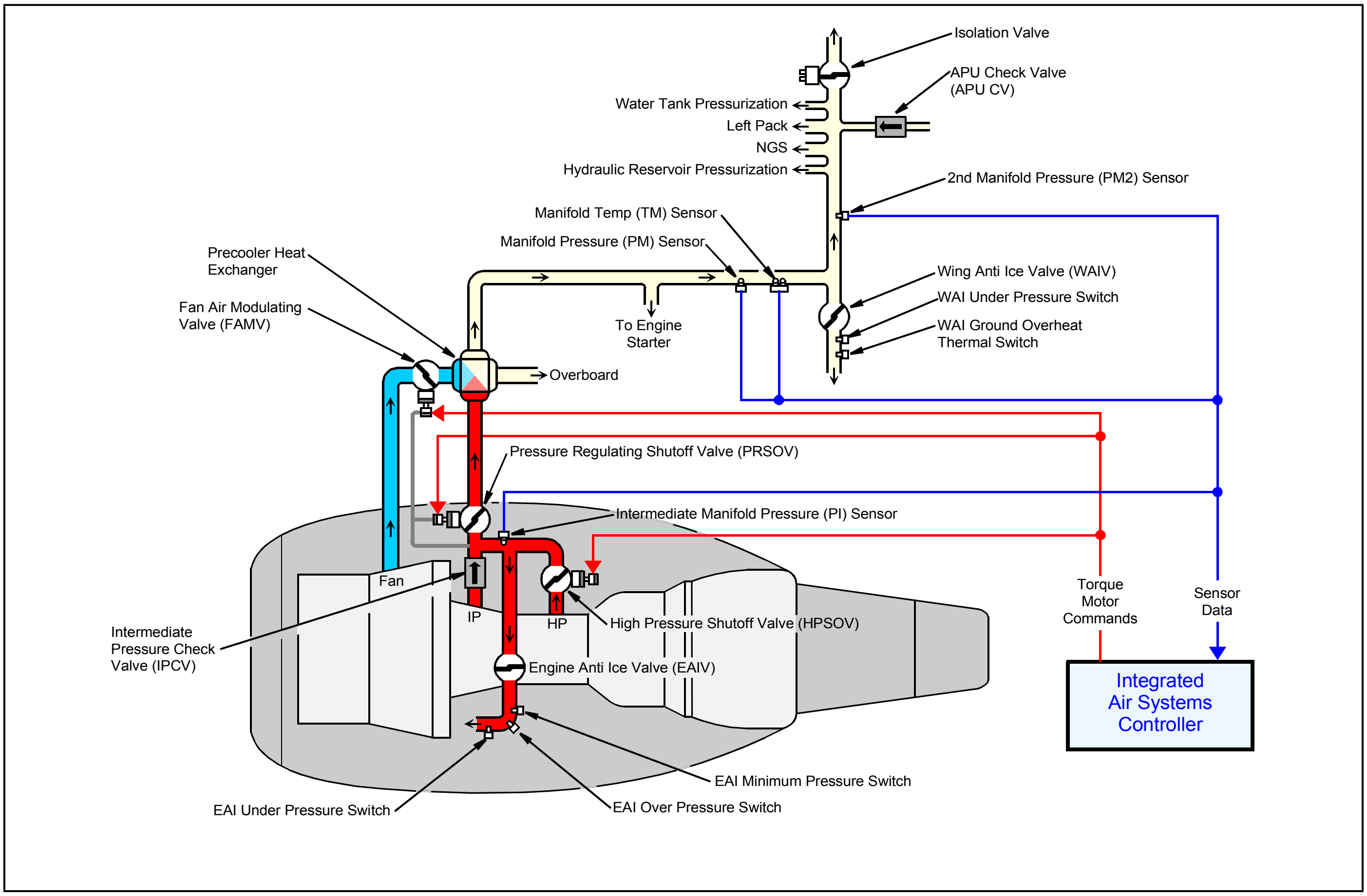
There is a manual backup pressure control system.

Independent, mechanical safety relief valves protect the airplane structure in any mode of pressure control.

NITROGEN GENERATION SYSTEM

The nitrogen generation system is an inert gas system that decreases the flammability of the center fuel tank.

Environmental Systems



Pneumatics

The pneumatic system supplies pressurized air to these systems and components:

- Engine starters
- Air conditioning packs
- Thermal anti-ice systems
- Hydraulic reservoirs
- Potable water system.

These are the sources of pneumatic power:

- External ground source
- APU load compressor
- Engine bleed air.

The APU regulates bleed air pressure from the APU load compressor. The APU is a primary source of bleed air on the ground. It eliminates the need for ground support equipment. The APU is a backup source of bleed air in flight.

Engine bleed air comes from the 4th or 10th stage of the high pressure compressor. The change from 10th to 4th is automatic. The pressure regulating and shutoff valves (PRSOV) regulate engine bleed air pressure.

The PRSOV, high-stage valve, and fan air modulating valve are controlled by the integrated air system controller (IASC) with inputs from system temperature and pressure sensors.

The precooler system cools the engine bleed air. The precooler is an air-to-air heat exchanger. It cools engine bleed air with engine fan air. The fan air modulating valve controls the flow of fan air.

The isolation valve isolates the pneumatic manifold into a left and right side when closed. This separates the pneumatic system into two systems. A single duct failure can be isolated. It will not effect the entire system. When open, the valve gives continuity to both sides of the pneumatic manifold. This allows a single source to power systems on one or the other side of the manifold (e.g. engine starting operations). The isolation valve operation can be automatic or manual.

Pressure transmitters and a gage on the P5 panel show right and left manifold pressures.

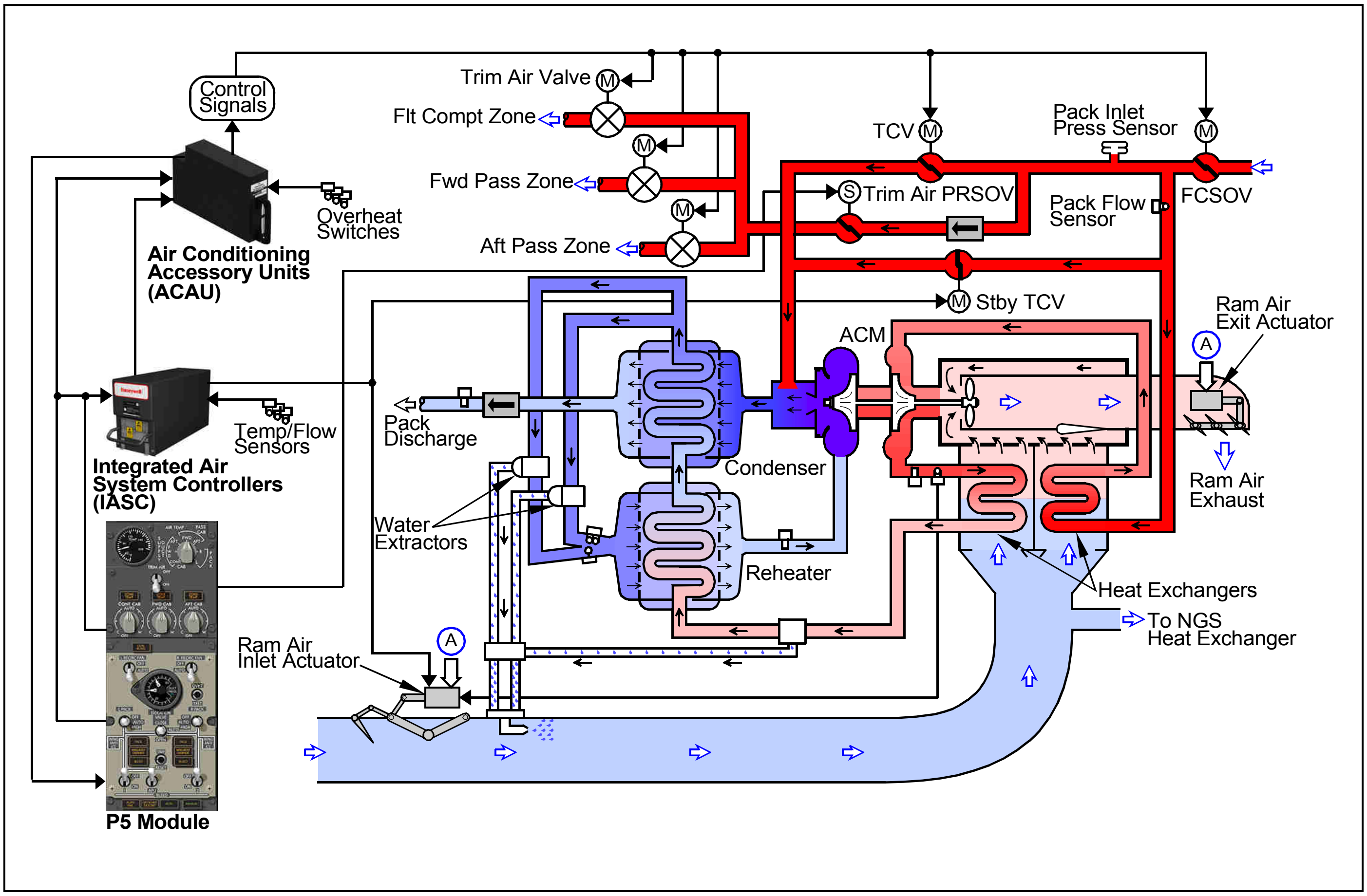
The pneumatic system control is from the P5 panel. Improvements of controls and indications decrease crew work load.

Automatic overtemperature and overpressure protection systems protect the airplane from system malfunctions.

Overheat sensing elements near the pneumatic ducts monitor the system for duct leaks.

BOEING PROPRIETARY

Environmental Systems



Air Conditioning

The air conditioning system uses two independent air-cycle cooling packs, a digital 3 zone cabin temperature control system, an air distribution system and a recirculation system.

The air conditioning packs are in the wing to body fairings beneath the wings.

The air conditioning packs discharge into the mix manifold of the distribution system. Air conditioning pack discharge is used for these purposes:

- Supply fresh air to the cabin at a comfortable temperature
- Pressurize the airplane
- Cool the electronic equipment
- Heat the cargo compartments.

The flow control and shutoff valves (FCSOV) control air flow through the packs.

Heat exchangers and expansion through an air cycle machine (ACM) cools pack air. The ACM has air bearings. Scheduled maintenance is not necessary.

System temperature control is automatic by the pack temperature control valves and trim air valves.

Two digital Integrated Air System Controllers (IASC) operate these components:

- Flow control & shutoff valve
- Temperature control valves
- Trim air valves.

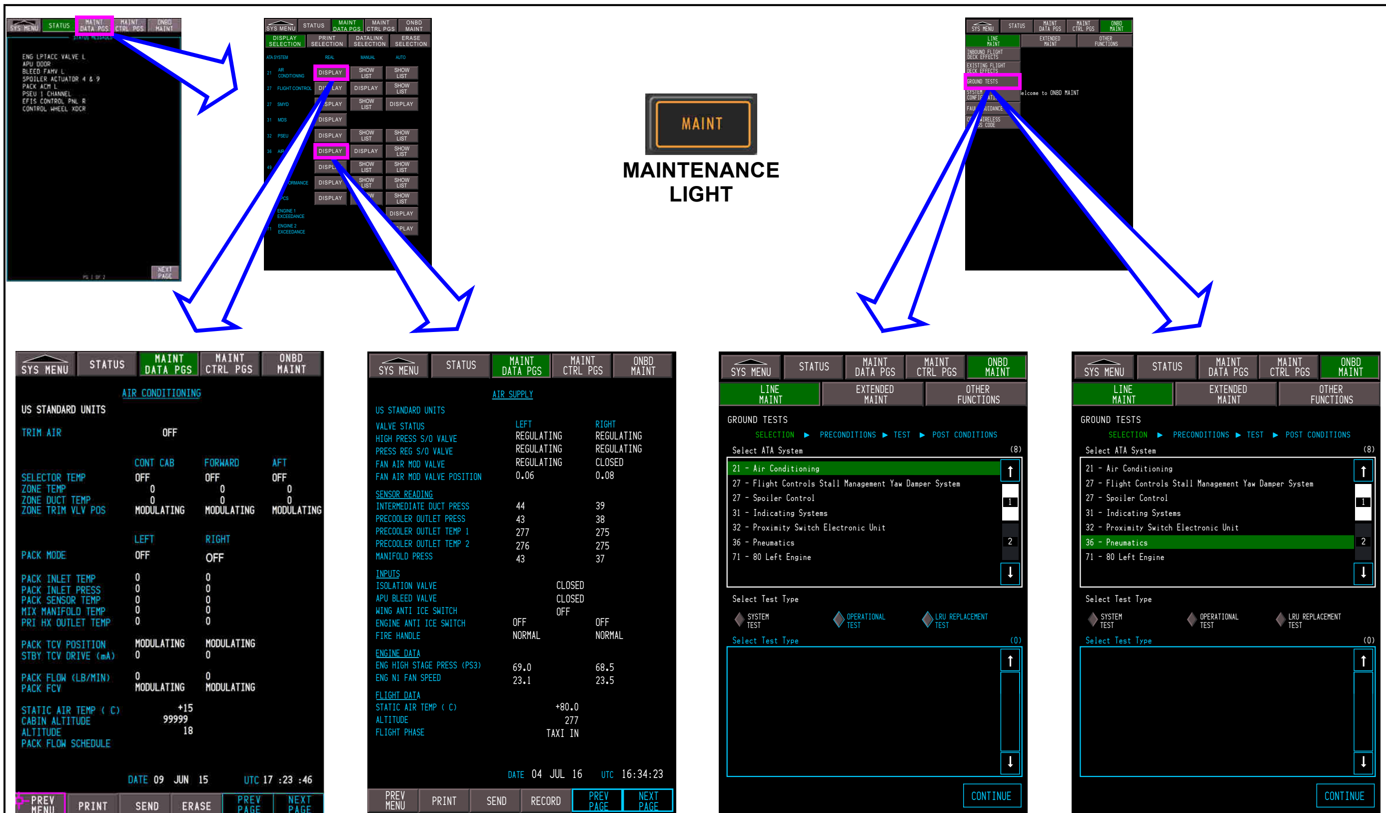
The normal pack output temperature control is by the temperature control valve (TCV).

The standby temperature control valve can control pack output temperature if the normal system fails. The temperature control valves control the amount of pack air that does not flow through the cooling components of the pack. This produces the proper discharge temperature. The cabin zone that requires the coolest air sets the pack output temperature. Hot trim air is then added to the ducts for the other two zones.

The pack high pressure water extractor system has a reheater/condenser/extractor assembly. This removes the water before it enters the ACM turbine.

The ram air system supplies a cooling flow of ambient air through the heat exchangers. The ram air system inlet panels move to keep drag to a minimum.

Improvement in controls and indications on the P5 panel reduce crew work load. There is automatic electronic control of pack flow rates. Temperature control and overheat protection is automatic.



AIR CONDITIONING MAINT DATA PAGE

AIR SUPPLY MAINT DATA PAGE

AIR CONDITIONING GROUND TESTS PAGE

PNEUMATICS GROUND TESTS PAGE

System Status and BITE

MAINTENANCE AWARENESS SYSTEM (MAS)

The air conditioning and pneumatics systems faults are captured in the integrated air systems controller (IASC). Faults from the IASC generate status messages in the MAS. There are 15 possible status messages for the air conditioning system. There are 29 possible status messages for the pneumatic system.

The air conditioning and pneumatic systems have viewable maintenance data pages in the MAS. You can view the pages in REAL (real-time), or during an AUTO or MANUAL event. Auto events are generated when the system has a fault. Manual events are generated by pressing the RECORD button on the system display page during real-time.

ONBOARD MAINTENANCE FUNCTION (OMF)

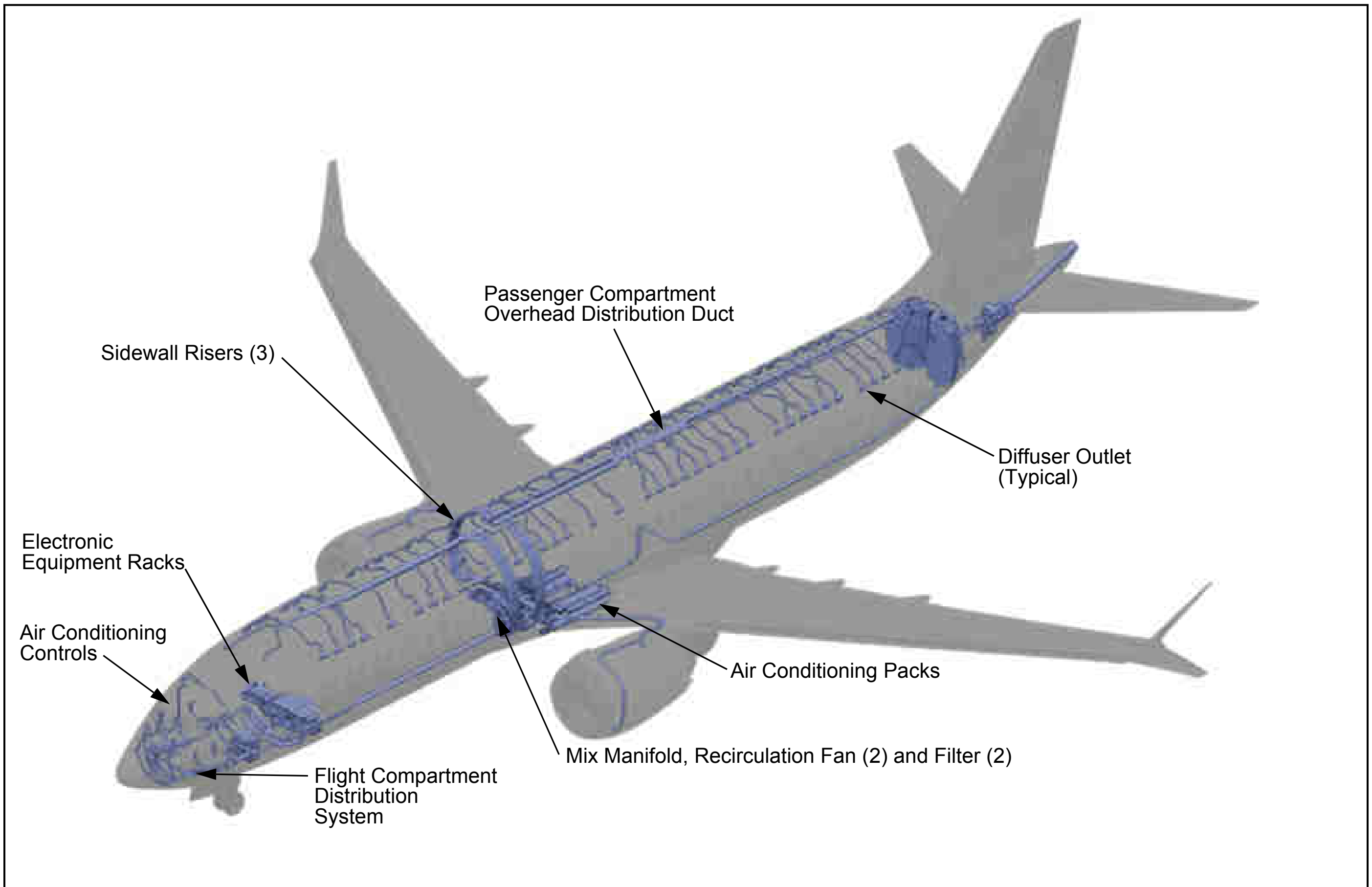
The MAINT light comes on 30 seconds after landing and STATUS messages are viewable. After viewing STATUS messages, press the ONBD MAINT button to access the OMF. Status messages correlate to maintenance messages. Under the LINE MAINT menu, you can view faults and perform ground tests.

There are 154 maintenance messages for the air conditioning system. There are 94 maintenance messages for the pneumatic system.

OMF - GROUND TESTS

Ground tests are available for the air conditioning and pneumatic systems. The air conditioning system has four system tests available. The pneumatic system has two system tests, two operational tests, and eight LRU replacement tests available.

Environmental Systems



Conditioned Air Distribution

GENERAL

The conditioned air distribution system distributes air conditioning pack outputs to the flight and passenger compartments. It also combines the air conditioning pack outputs with recirculated air. Recirculated air is distributed to the passenger compartment.

The mix manifold and recirculation components are aft of the forward cargo compartment.

The 737 MAX distribution system has these three independent temperature control zones:

- Flight compartment
- Forward passenger compartment
- Aft passenger compartment.

FLIGHT COMPARTMENT

The flight compartment receives conditioned air from the left pack discharge.

If the left pack is off, the flight compartment receives air from the right pack and the mix manifold.

Outlets and controls in the flight compartment supply conditioned air for these functions:

- Windshield defogging
- Foot warming
- Seat warming
- Shoulder warming
- Control panel gaspers
- Ceiling panel gaspers and anemostats.

Flight compartment air then moves through vents into the electronic equipment compartment.

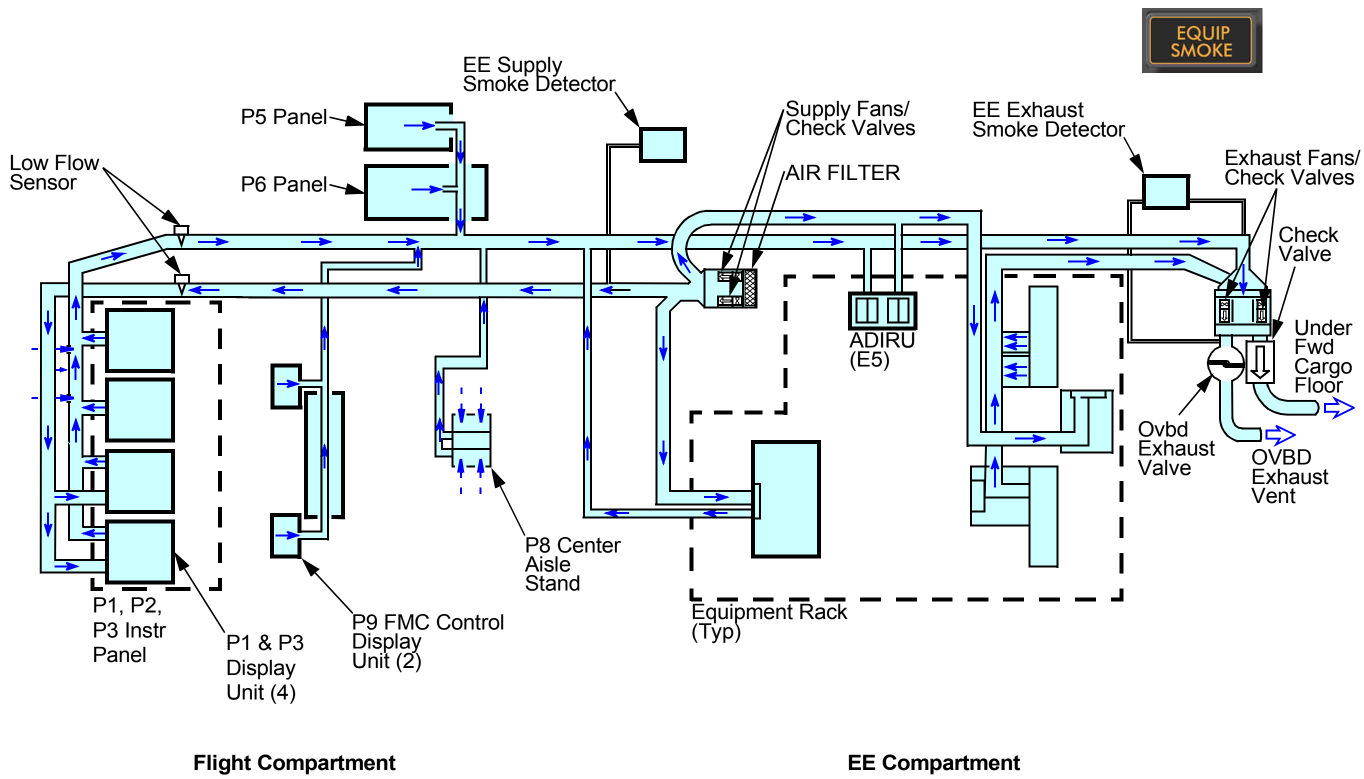
PASSENGER COMPARTMENT

Conditioned air from the mix manifold moves in sidewall ducts to an overhead distribution duct above the center aisle. The air comes out through these devices:

- Window diffuser outlets
- Passenger gasper outlets
- Galley ceiling gasper outlets
- Lavatory gasper outlets.

Passenger compartment air then moves through air return grills. This air then goes through a filtered recirculation system or goes overboard through the outflow valve.

Galley air goes overboard through fuselage vents.



Equipment Cooling

GENERAL

Electronic equipment is air-cooled. These systems supply air to the equipment cooling system:

- The supply system
- The exhaust system.

Cooling for critical electronic equipment is from both cooling systems. This causes double (push/ pull) cooling. Cooling for less critical equipment is by one system. Electronic equipment that does not require active cooling is not included in the cooling system.

Each system has two parallel fans (normal and alternate). Flow detectors monitor the quality of cooling air flow and give an indication of a failure. If the normal fan fails, the flight crew selects the alternate fan.

The fans, air filter, overboard exhaust valve, and smoke detectors are in the electronic equipment compartment. The flow detectors are in ducts in the forward equipment compartment. Connecting ducts, equipment rack channels, headers and plenums complete the cooling circuits.

Controls and indications are on the P5 forward overhead panel.

SUPPLY SYSTEM

The supply system pulls cooling air through a filter and pushes it over these components:

- Pilot primary display (2)
- E1 and E5 racks
- Pilot CDU
- Transverse rack.

The supply system pushes air over the equipment and into the exhaust system or into the electronic equipment compartment.

EXHAUST SYSTEM

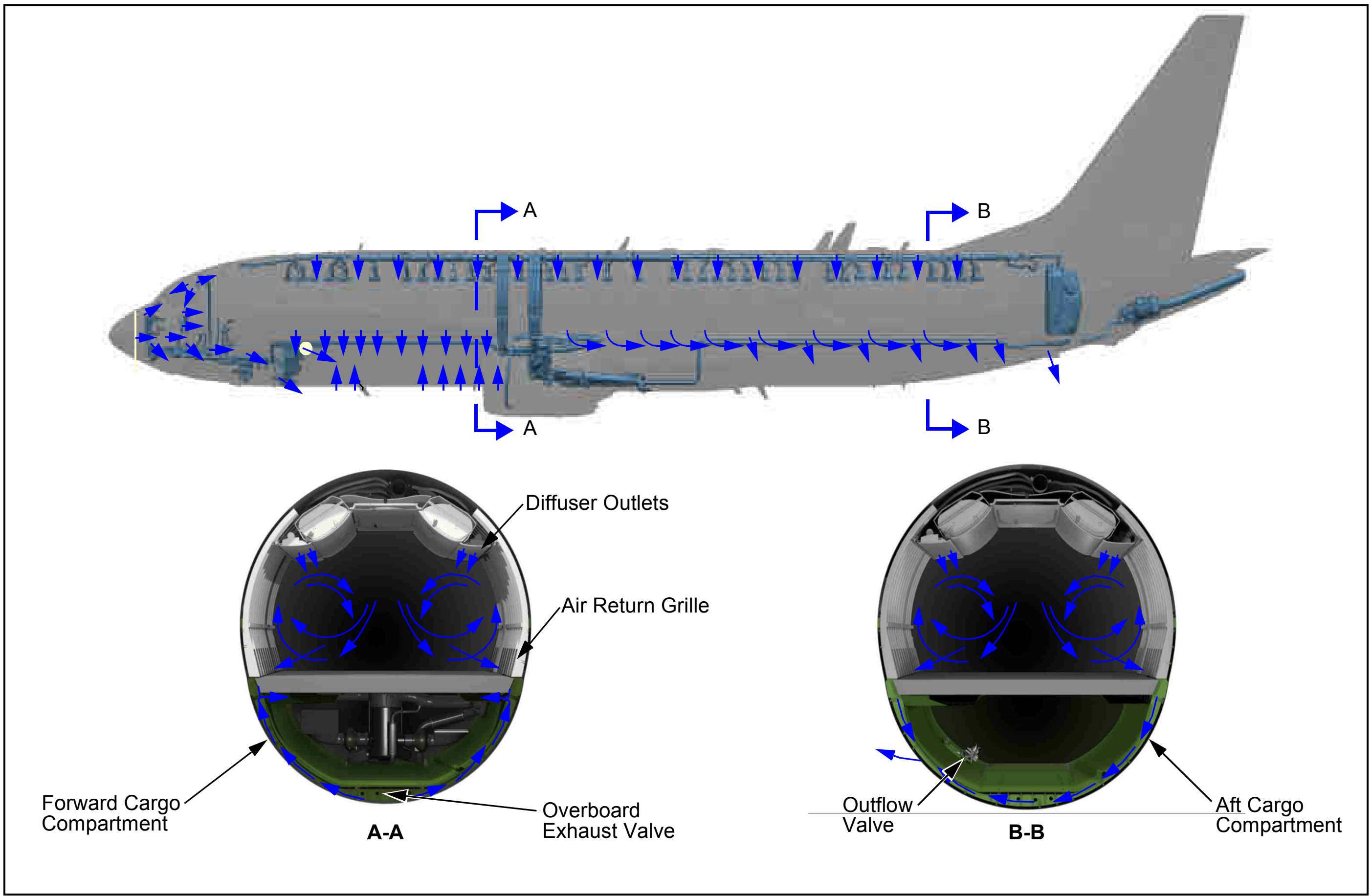
The exhaust system pulls cooling air over these items:

- Pilot/co-pilot primary display (4)
- P8 center aisle stand
- P6 panel
- P5 panel
- Pilot/co-pilot CDU
- E1 and E5 racks
- Transverse rack.

The exhaust air then goes overboard through the overboard exhaust valve. In flight, this valve is closed. The air flows under the forward cargo compartment floor for cargo heating.

SMOKE DETECTION

The smoke detectors monitor for smoke. The EQUIP SMOKE light comes on if either cooling system detects smoke.



Cargo Compartment Heating

GENERAL

The cargo compartments are not ventilated. There are sealed, fire resistant liners that prevent oxygen from sustaining a fire in a cargo compartment.

The volume of air in the cargo compartments is sufficient to sustain the life of animals with these conditions met:

- The biomass is not too great
- The flight duration is not too long
- The cargo volume does not displace too much air space.

Conditioned air circulated around the cargo liners warms the cargo compartments. This keeps the compartments warm enough to sustain life.

The cargo heat system is passive. It uses the differential pressures and heat energies of the air conditioning and pressurization systems.

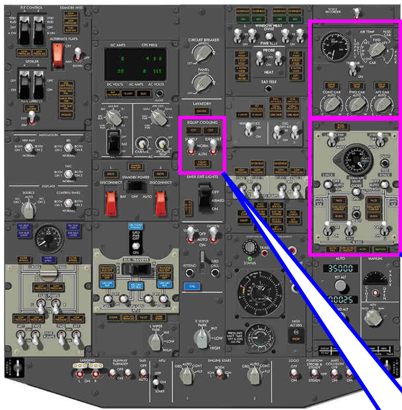
Cargo heating is automatic and controls, indications or servicing are not necessary.

FORWARD CARGO COMPARTMENT

The forward cargo compartment is heated only when the airplane is in the air. Most heating comes from the exhaust equipment cooling system.

AFT CARGO COMPARTMENT

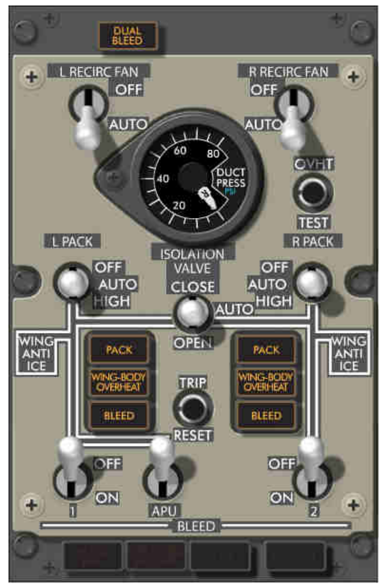
The aft cargo compartment is heated when the airplane is in the air and on the ground.



P5 Forward Overhead Panel

Cabin Temperature Panel

Equipment Cooling Panel



Air Conditioning Panel

Pneumatic and Air Conditioning Control Panels

GENERAL

The control panels are on the P5 forward overhead panel.

These are control panel features:

- Lighted gages
- Lightplates
- Positive position toggle switches and selector knobs
- System condition and caution lights.

PNEUMATIC CONTROLS

Toggle switches control these functions:

- Bleed air sources
- Pneumatic manifold isolation.

A dual needle pressure gage shows right and left duct pressures.

System indication lights show these conditions:

- Bleed trip off
- Wing-body overheats (duct leaks)
- Dual bleed
- Loss of equipment cooling.

Push-button switches control:

- Resets of trip off conditions
- Wing-body overheat tests.

AIR CONDITIONING CONTROLS

Switches control these functions:

- Pack flow scheduling
- The right and left recirculation fans
- Three temp selectors
- Trim air system control switch
- The equipment cooling fans.

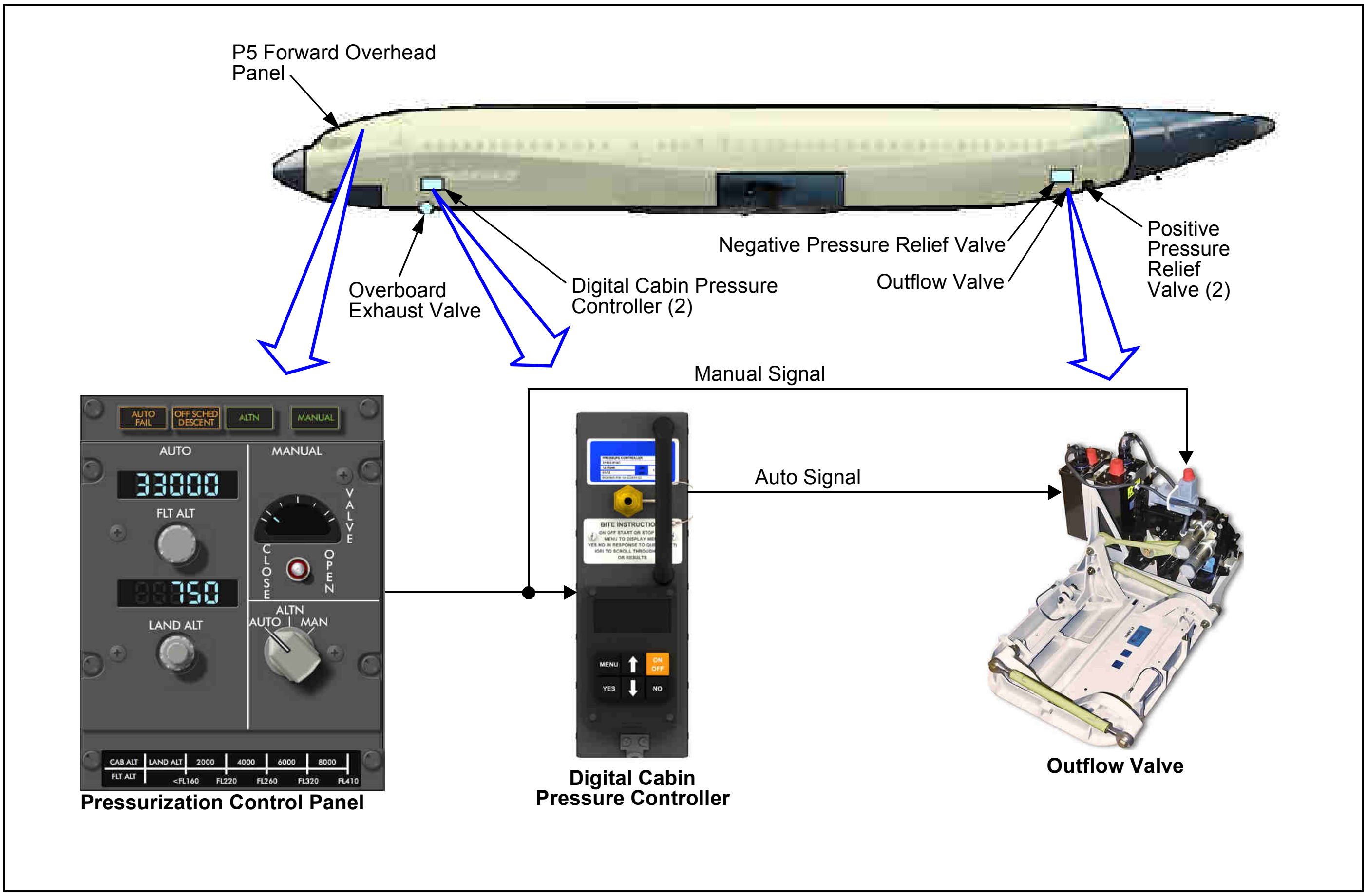
Temperature selectors give automatic pack temperature control for the three zones.

A temperature gage and source selector show the system temperatures.

System lights show these conditions:

- Pack trip off
- Three zone temp lights for overheat and fault indication.

Environmental Systems



Cabin Pressure Control

NORMAL OPERATION

The pressurization system controls the rate of air released from the cabin. The position of the outflow valve controls this rate.

The cabin pressurization system maintains a safe, comfortable cabin pressure altitude at all times. Under normal operations, cabin pressure altitude is around 8,000 feet.

The pilots can control airplane pressurization in these modes:

- Automatic mode
- Alternate mode
- Manual mode.

Controls for pressurization and indication are on the P5 forward overhead panel.

Two digital controllers are in the EE compartment. The controllers have LRU BITE. They use inputs from these to control cabin pressure:

- P5 panel settings
- Stall management computers
- Air data computers
- Aft outflow valve position transducer.

In the automatic modes (auto and alternate), the controllers automatically schedule cabin pressurization for all phases of flight. If both controllers fail, the pilot can control the valve manually.

The outflow valve is in the aft, lower right area of the airplane.

PRESSURE EQUALIZATION

Independent mechanical pressure equalization valves are in the bulkheads of the cargo compartments to allow for pressure changes in the cargo compartments.

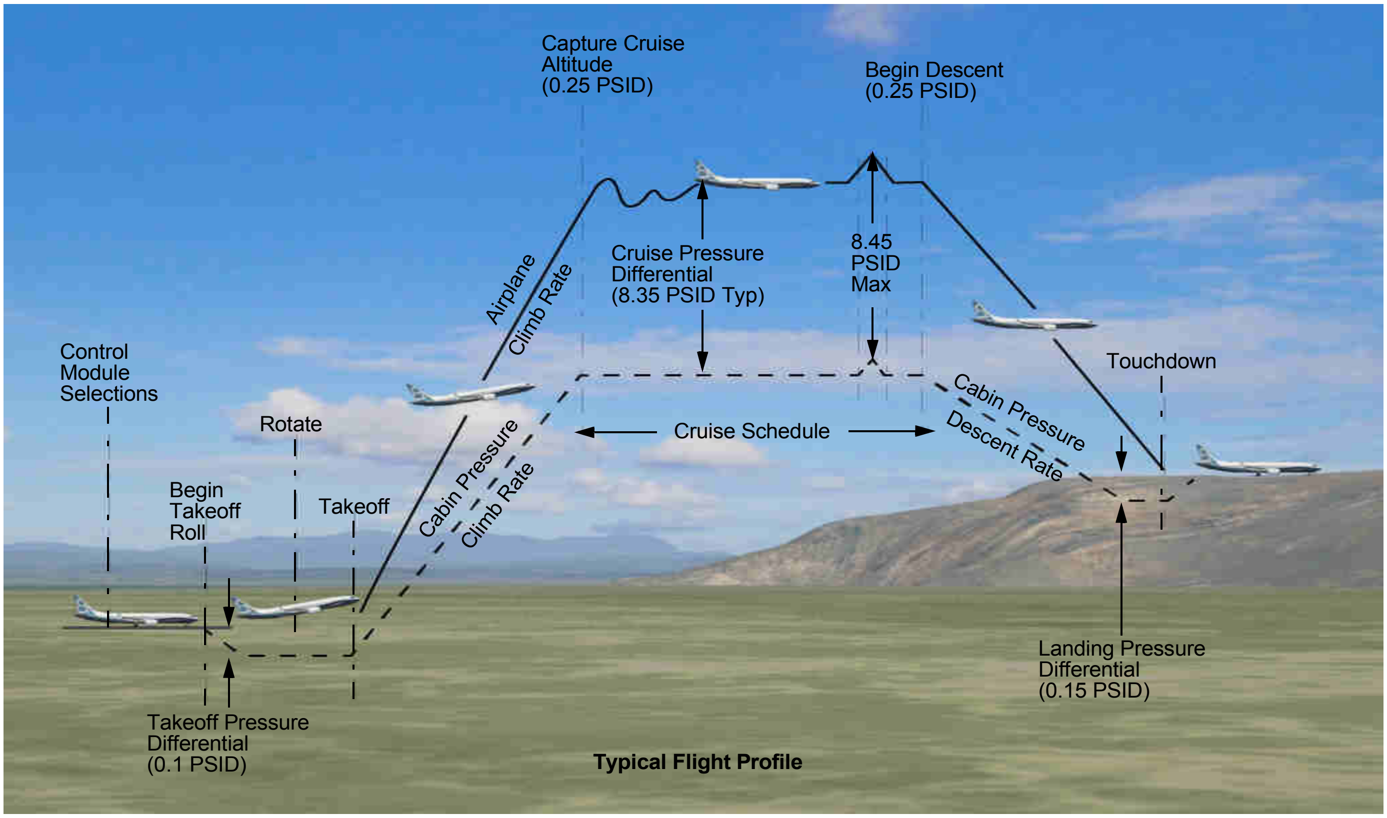
FAIL-SAFE DEVICES

If the systems fail, these valves protect the airplane structure from excessive pressure differentials:

- Positive pressure relief valve (2)
- Negative pressure relief valve
- Cargo compartment blowout panels.

ALTITUDE WARNING

A cabin altitude warning system tells the crew when the cabin pressure altitude goes to 10,000 feet. This system activates by two switches on the ceiling of the lower nose compartment. It operates an aural warning horn on the control stand. The horn cutout button is on the P5 forward overhead panel.



Typical Flight Profile

Cabin Pressure Schedule

The cabin pressure control system controls the airplane pressure automatically for these phases of flight:

- Ground
- Takeoff
- Climb
- Cruise
- Descent
- Landing.

In the ground phase, the outflow valve is open and the airplane is unpressurized.

In the takeoff phase, the system pressurizes the cabin to a value below field elevation. This prevents a pressure "bump" just after takeoff.

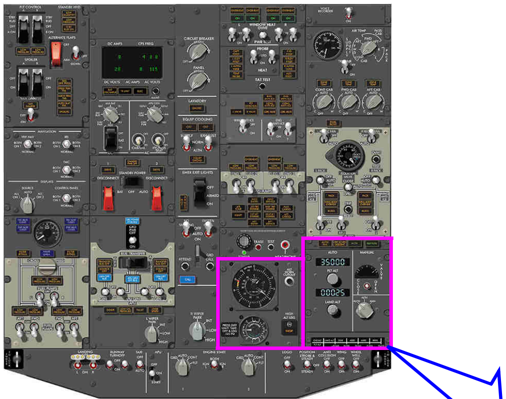
In the climb phase, the system controls the cabin rate of climb.

In the cruise phase, the system maintains a constant cabin altitude.

The maximum cabin altitude is 8000 feet.

In the descent phase, the system controls the cabin rate of descent. The cabin will be pressurized to a value below the landing altitude to prevent pressure "bumps" during landing.

When the airplane lands, the system depressurizes the cabin and the outflow valve opens.



P5 Forward Overhead Panel

Cabin Pressure Control Panels

Digital Cabin Pressure Control Panels

GENERAL

The pressurization control panels are on the P5 forward overhead panel.

These are the control panel features:

- Lighted indicators
- Lightplates
- Selectors
- LED outflow valve position and numerical displays
- Toggle switch
- Push-button switch
- System indication and caution lights.

PRESSURIZATION CONTROLS

There are controls for these functions:

- Pressurization mode
- Flight altitude
- Landing altitude.

LED digital displays show these settings:

- Flight altitude
- Landing altitude
- Outflow valve position.

There is a flight altitude/cabin altitude conversion placard below the controls. Manual calculations are not necessary.

A takeoff pressure differential limitation placard is for reference during manual operations.

A toggle switch is for control of the outflow valve during manual operations.

A dual-needle indicator shows this data:

- Cabin altitude (short needle)
- Differential pressure (long needle).

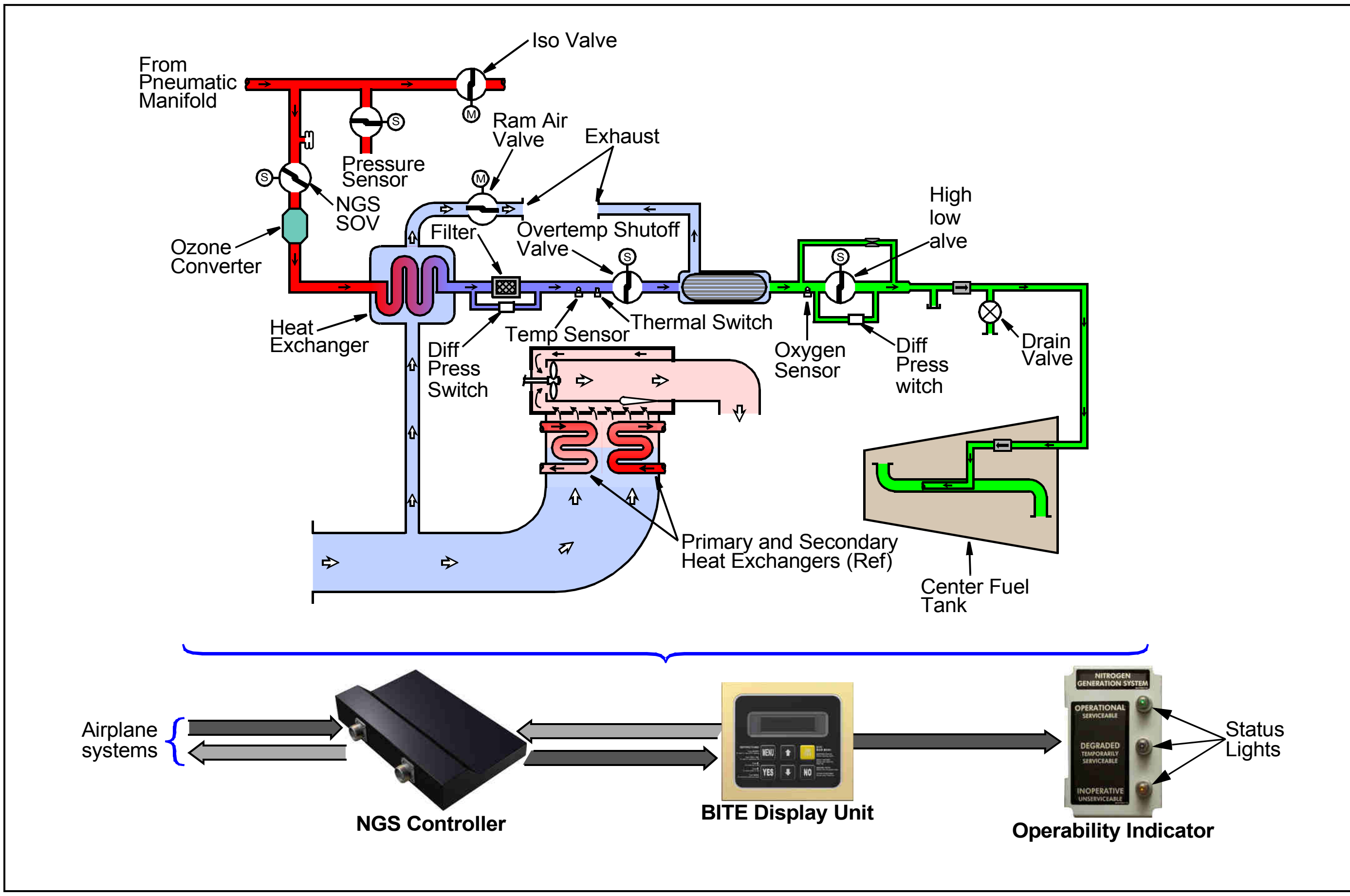
A cabin rate of climb indicator shows this data:

- Rate of cabin ascent
- Rate of cabin descent.

The push-button altitude horn cutout switch stops the cabin altitude 10,000 ft warning horn.

System indication and caution lights give these indications:

- Automatic control channel failure
- Aborted takeoff pressure scheduling if the airplane is off the scheduled descent
- Alternate channel automatic control of the outflow valve
- Manual control mode of the outflow valve.



Nitrogen Generation System

The nitrogen generation system (NGS) decreases the oxygen content of the air in the center fuel tank.

The NGS has these subsystems:

- Thermal control unit
- Air separation unit
- NGS distribution system
- Control system
- Operability indicator.

The NGS is automatic and is controlled by the NGS controller.

The NGS shutoff valve allows hot bleed air from the airplane pneumatic system to go to the ozone converter. A heat exchanger uses ram air to cool the bleed air.

The NGS controller monitors the air temperature and uses the ram air valve to keep the air temperature at a nominal temperature.

The air then passes through a filter to an over temperature shutoff valve.

This valve will close to protect the air separation module in the event that the NGS controller cannot maintain the correct temperature in the system.

The ASM removes oxygen from the air and this oxygen is exhausted overboard.

The NGS controller tests the NEA before it goes into the center fuel tank to ensure that the ASM is removing enough oxygen.

The nitrogen enriched air (NEA) now flows to the center fuel tank.

The BITE display unit lets maintenance personnel access the NGS controller for testing purposes.

The operability indicator is in the main wheelwell. It shows the condition of the NGS system by three status lights.

Intentionally
Blank

Features

ENGINE FIRE PROTECTION

The airplane structure uses firewalls and fireproof hardware in the fire zones.

A dual loop engine fire detection system gives high reliability and fault tolerance.

The fire detection control unit has BITE.

There are two fire bottles to extinguish engine fires.

The engine fire bottles use halon as the extinguishing agent.

APU FIRE PROTECTION

The APU torque box uses titanium plates.

The APU fire detection system uses single loop detectors. The detectors are on the firewall structure. This decreases the APU buildup time.

APU fire controls and indications are in the flight compartment on the engine and APU fire control panel (P8) and in the wheelwell on the remote APU control panel (P28). These panels give easy access for both flight crew and ground crew.

The APU fire bottle uses halon as the extinguishing agent.

DUCT LEAK OVERHEAT PROTECTION

The compartment overheat detection module has BITE.

The system detection loops simplify troubleshooting and maintenance requirements.

LAVATORY FIRE PROTECTION

Airplane lavatories have modular smoke detectors.

Airplane lavatories have automatic fire extinguisher bottles in the lower lavatory cabinet above the waste bins.

PORTABLE FIRE PROTECTION

The flight compartment and galleys have portable fire extinguishers.

CARGO FIRE PROTECTION

The cargo compartments have smoke detectors and fire bottles.

The smoke detectors give warning to the flight crew if there is smoke in a cargo compartment.

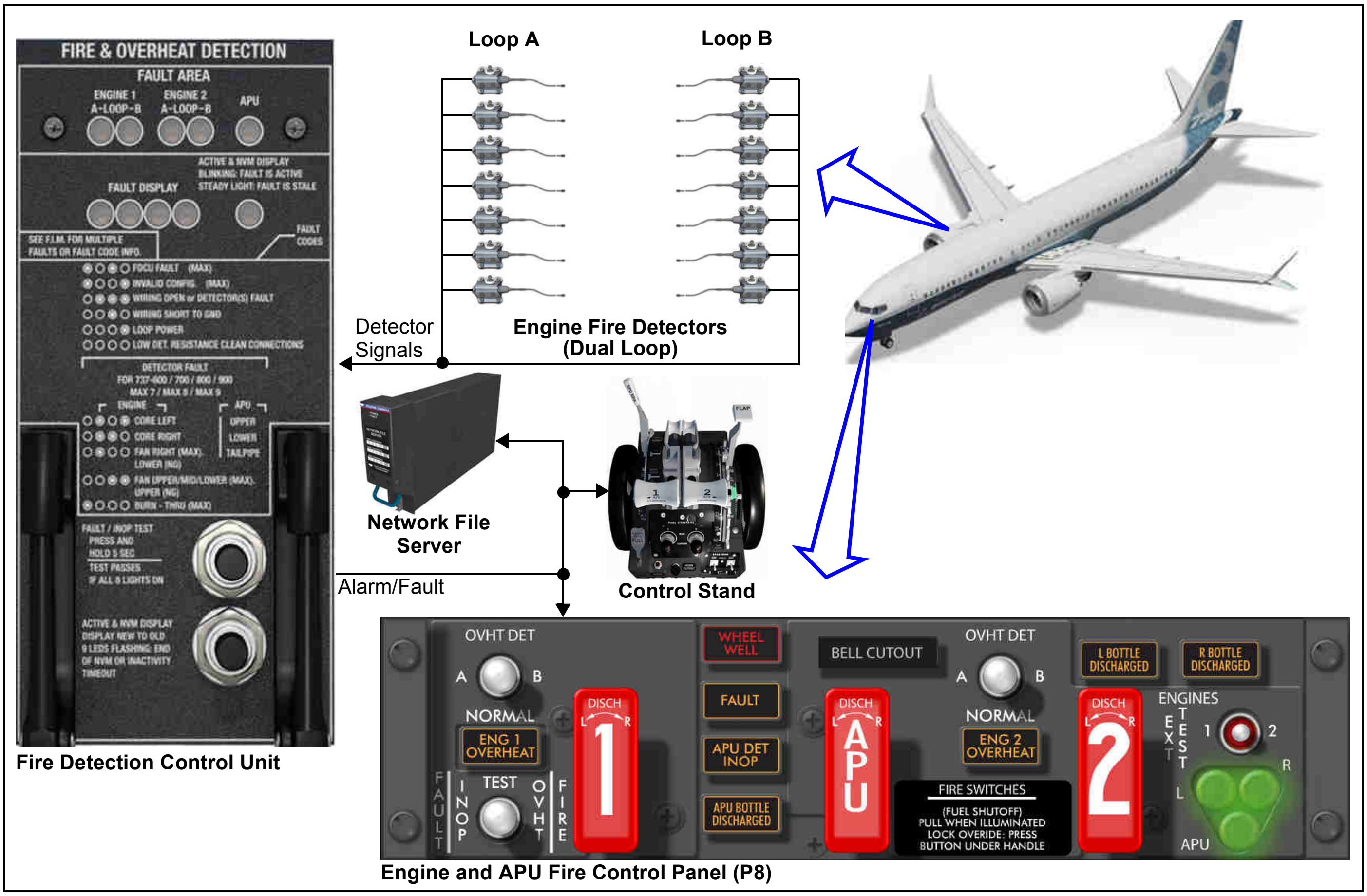
The cargo fire control panel is on the P8 panel. The panel gives both pilots easy access to the controls and indications.

One cargo electronic unit is in the ceiling of each cargo compartment inboard of the cargo door. The cargo electronic unit monitors the cargo compartment fire detectors and has BITE.

The cargo compartment fire bottles use halon as the fire extinguishing agent.

- **Features**
- **Engine Fire Protection**
- **Engine Fire Protection**
- **APU Fire Protection**
- **APU Fire Protection**
- **DLODS and Wheel Well Fire Detection**
- **Lavatory Fire Protection**
- **Portable Fire Protection**
- **Cargo Fire Protection**
- **Cargo Fire Protection**

Fire Protection



Engine Fire Protection

STRUCTURE AND MATERIALS

These features protect the airplane structure from fire:

- A vapor tight, insulated, stainless steel firewall isolates the engine from the wing
- The upper areas of the engine cowls have fire shielding
- Fire and fluid leakage zones have drains to prevent the collection of flammable fluids
- Fire zone hoses and hardware are fireproof.

ENGINE FIRE DETECTION

The engine fire detection system uses dual loop fire detectors for reliability. A single failure will not make the system inoperative.

Each engine detection loop has seven fire detectors in these areas:

- Fan right section
- Fan upper section
- Fan mid section
- Fan lower section
- Core left section
- Core right section
- Combustor burn-thru (CBT).

The fire detection control unit (FDCU) in the EE compartment monitors data from the detection loops.

Signals from the fire detection control unit give these indications and alarms to the flight crew:

- Engine overheat
- Engine fire
- System faults.

Overheat alarms come before fire alarms. Pilot response to these alarms can prevent premature engine shutdowns. Overheat conditions unlock the engine fire handles and give these indications:

- MASTER CAUTION lights
- Engine OVERHEAT light.

Higher engine temperatures will give an engine fire alarm. The fire alarm includes the OVERHEAT and MASTER CAUTION lights and these other indications:

- Fire warning lights
- Fire handle lights
- Fuel control switch indication light
- Aural warning bell sound.

FEATURES

The engine and APU fire detection module normally uses logic that requires agreement of both detector loops for an alarm output. If one loop becomes inoperative, however, the module will use only the operative loop for detection and alarm output.

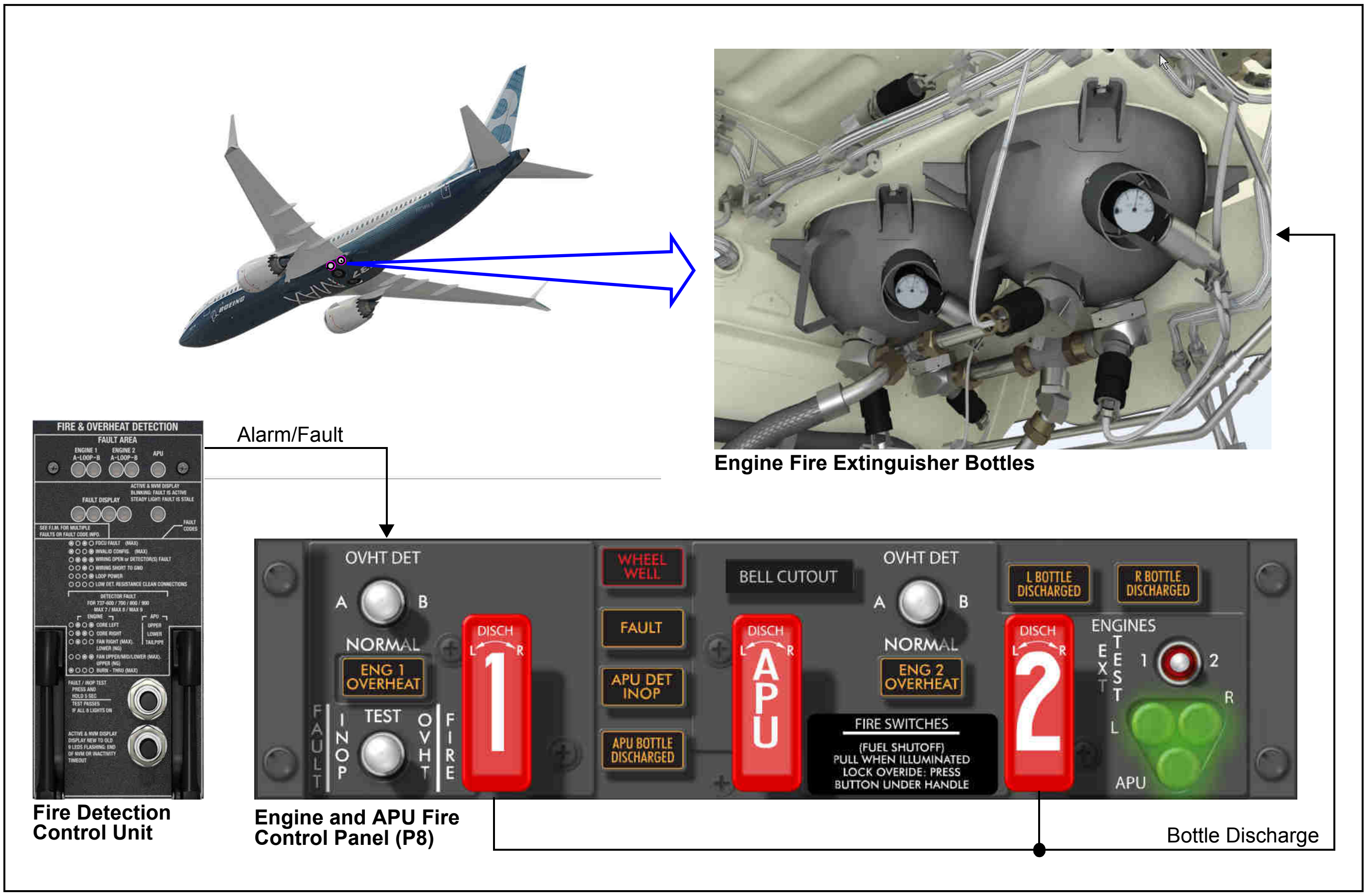
The FDCU also gives a signal to the Network File Server (NFS). The

BOEING PROPRIETARY

NFS stores engine and APU fire detection data in the Onboard Maintenance Function (OMF). When there is an overheat or fire signal from the FDCU, a maintenance message is generated and stored in the OMF.

The fire detection control unit has BITE.

Fire Protection



Engine Fire Protection

ENGINE FIRE EXTINGUISHING

You lift and turn the fire handle on the engine and APU fire control panel to operate the engine fire extinguishing system.

When you lift the fire handle, these engine systems isolate or shut down:

- Engine fuel system
- Engine hydraulic system
- Engine electric power system
- Engine pneumatic system
- Engine thrust reverser system.

When you turn the fire handle, one of two fire bottles discharges to the engine extinguisher manifold. If you turn the handle left, the left bottle discharges. If you turn the handle right, the right bottle discharges.

There are two fire extinguisher bottles in the main wheel well. Each bottle can discharge to either engine. The bottles use halon extinguishing agent and have these features:

- Pressure gages
- Dual element discharge cartridges (squibs)
- Discharge indication switches
- Overpressure relief disks.

You replace the fire bottle for servicing.

CONTROLS AND INDICATION

The engine and APU fire control panel is between the two pilots. This gives access by either pilot.

Switches on the engine and APU fire control panel control these functions:

- System tests
- Engine detection loop selection
- Fire warning bell cutout
- Engine systems shutdown
- Fire bottle discharge.

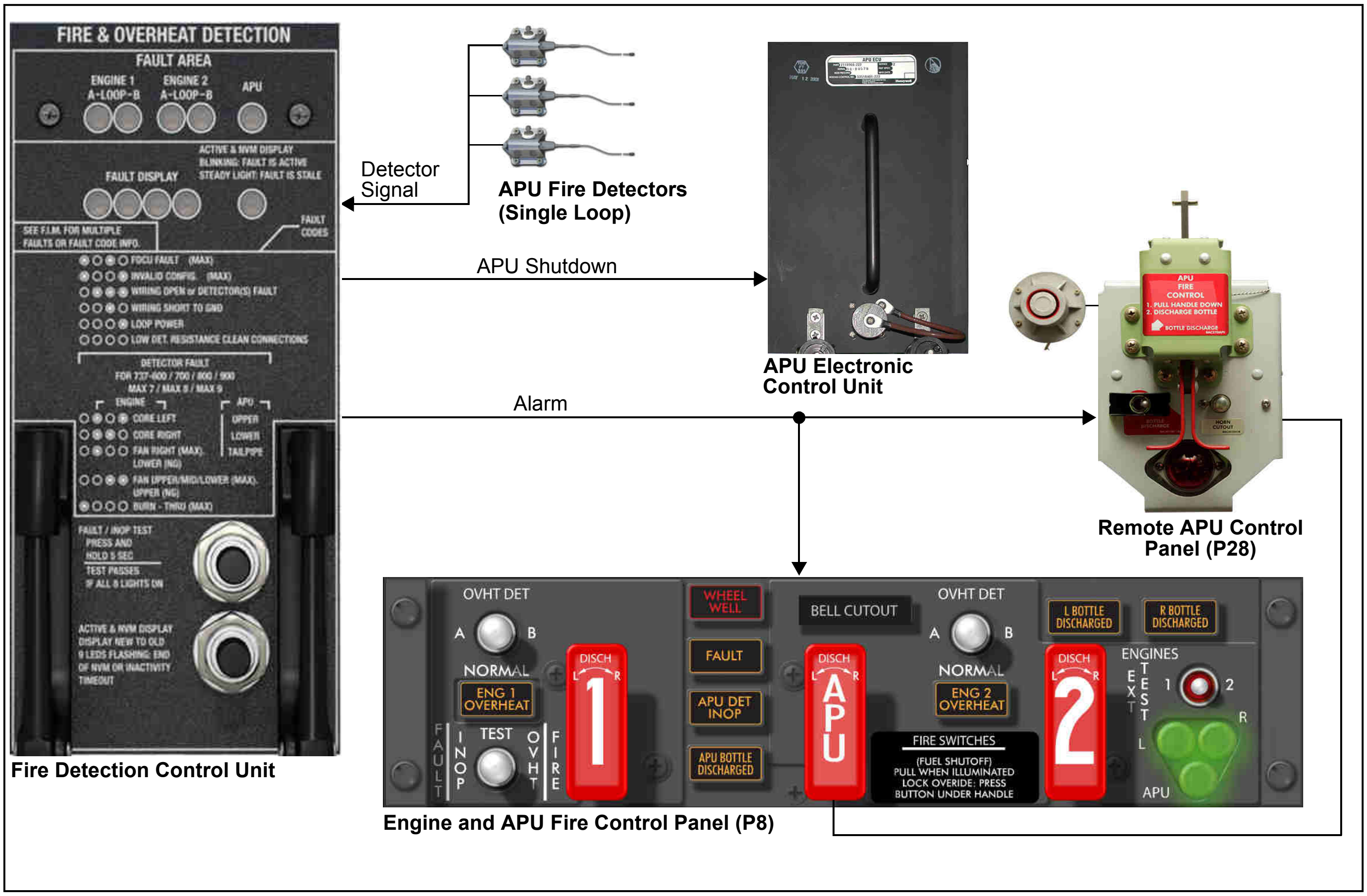
Lights on the engine and APU fire control panel and glareshield (P7) show these indications:

- Fire detection system tests
- Fire extinguisher system tests
- Engine overheat conditions
- Engine fire conditions
- Fire bottle discharge
- Fire protection system faults.

A placard on this panel gives fire switch instructions.

A pressure gage on the fire bottles show bottle condition.

A relief valve on the fire bottles protect the bottle from overpressure and overtemperature conditions.



APU Fire Protection

STRUCTURE AND MATERIALS

These structural features protect the empennage from fire:

- A titanium APU torque box firewall
- Drains to remove flammable fluids
- Fireproof fire zone hoses and hardware.

APU FIRE DETECTION

The APU fire detection system is a single loop system. The loop has two frie detectors on the APU torque box firewall (one detector on the APU door) and one fire detector above the tailpipe.

The fire detection control unit monitors the detection loop. The module is in the EE compartment. It can tell the difference between these conditions:

- APU fire
- System faults.

The APU fire detection system does not detect overheat conditions.

Signals from the fire detection control unit give these indications and alarms to the flight crew:

- APU fire
- System faults.

High temperatures in the APU compartment produce an APU fire alarm. Fire alarms show in these two places:

- The flight compartment engine and APU fire control panel (P8)
- The wheel well remote APU fire control panel (P28).

APU fire alarms cause these functions:

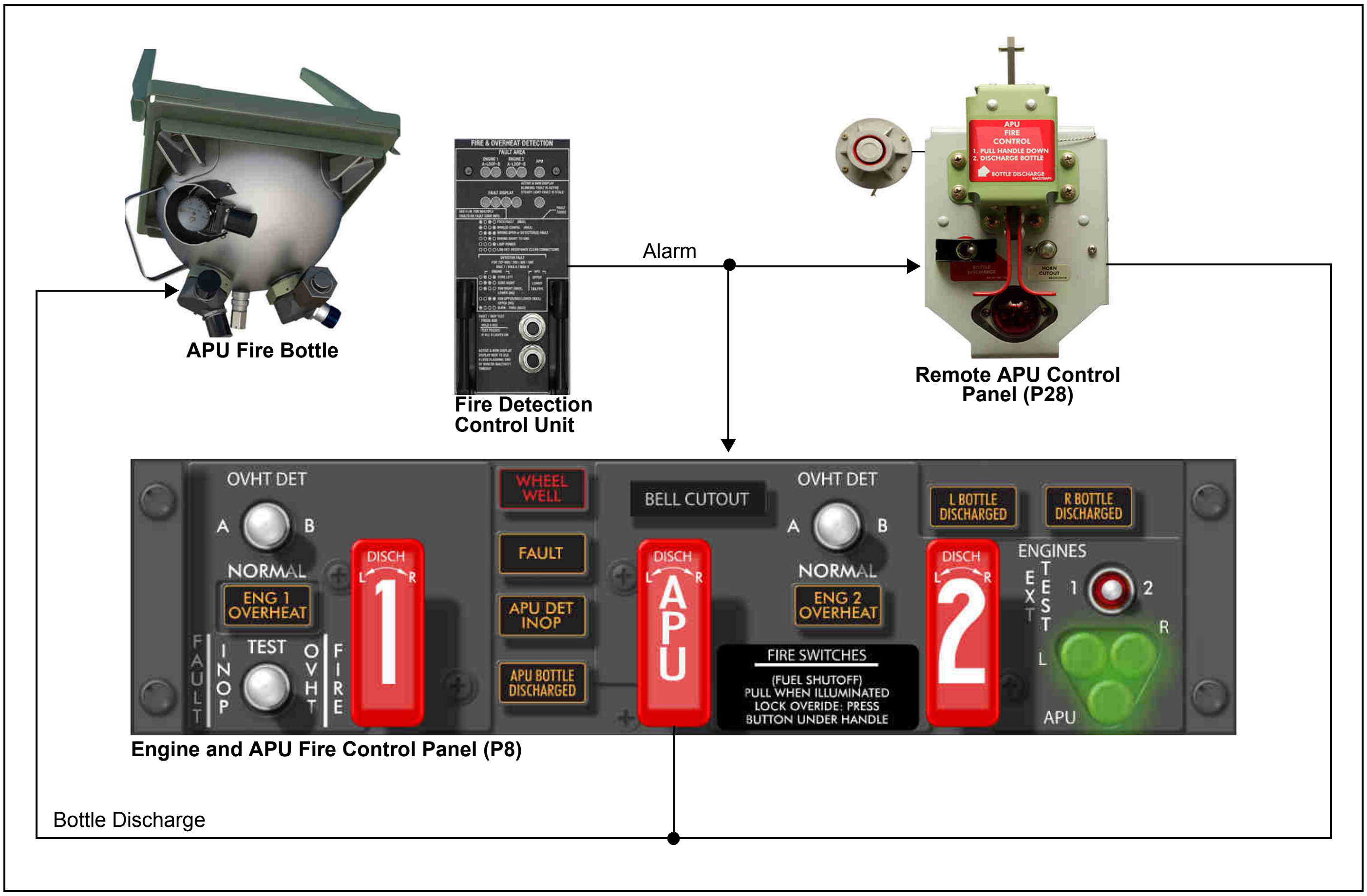
- Automatic APU shutdown
- The fire warning lights come on
- The APU fire light on P8 comes on
- The APU fire handle on P8 unlocks
- The aural warning unit gives bell sound
- The APU fire warning light on P28 flashes
- The APU fire warning horn on P28 sounds intermittantly with warning light (ground only).

FEATURES

Fire alarms automatically shutdown the APU.

The fire detection control unit has BITE.

Fire Protection



APU Fire Protection

APU FIRE EXTINGUISHING

APU fire extinguishing can be done from the flight compartment or from the wheel well.

In the flight compartment, when you lift the fire switch, these systems shutdown:

- APU
- APU fuel system
- APU air systems
- APU electric power system.

When you turn the fire switch to the left or right, the APU fire bottle discharges. There is only one fire bottle available for the APU.

The remote APU control panel (P28) has controls to extinguish an APU fire. Pull down on the handle to shutdown the APU systems and arm the fire bottle discharge switch.

Push the toggle switch to discharge the APU fire bottle.

The APU fire bottle is behind the aft pressure bulkhead in section 48. The bottle is filled with halon and has these features:

- Discharge cartridge
- Discharge indication switch
- Overpressure relief.

You replace the APU fire bottle for servicing.

CONTROLS AND INDICATION

APU fire protection controls and indications are in the flight compartment and the wheel well. In the flight compartment, they are between the pilots on the engine and APU fire control panel (P8) and the glareshield (P7). In the wheel well, they are on the remote APU control panel (P28). These locations give access to flight crew and ground personnel.

Switches on the engine and APU fire control panel control these functions:

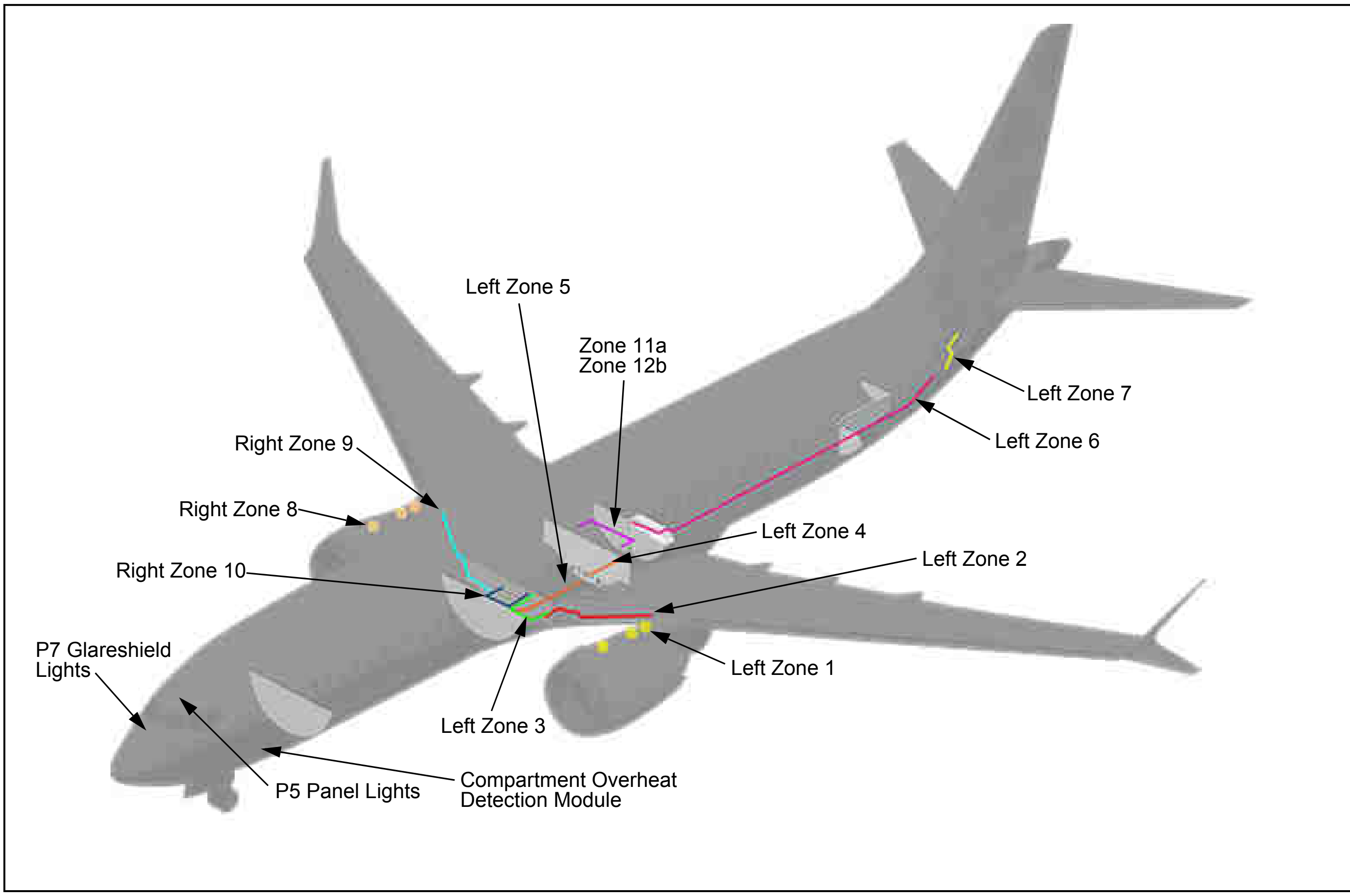
- System tests
- Fire warning bell cutout
- APU systems shutdown
- APU fire bottle discharge.

Lights on the engine and APU fire control panel are for these indications and functions:

- Fire detection system tests
- Fire extinguisher system tests
- APU fire conditions
- APU bottle discharge
- Fire protection system faults.

A placard on the P8 panel gives fire switch instructions.

BOEING PROPRIETARY



DLODS and Wheel Well Fire Detection

GENERAL

The sensing elements (single and double loop) sense these conditions:

- Wheel well fire (double loop)
- Overheats caused by a pneumatic duct leak (single loop).

The elements are in these areas:

- Left wing strut (left zone 1)
- Left wing inbd-outbd (left zone 2)
- Left AC pack (left zone 3)
- Nitrogen Generation (left zone 4)
- Keel beam (left zone 5)
- Aft body cargo (left zone 6)
- Aft body APU (left zone 7)
- Right wing strut (right zone 8)
- Right wing inbd-outbd (right zone 9)
- Right AC pack (right zone 10)
- Wheel well loop A (zone 11a)
- Wheel well loop B (zone 12b).

The compartment overheat detection module monitors the element loops. It is in the EE compartment. The module can tell the difference between these conditions:

- Overheat conditions
- System faults.

Wheel well fire conditions cause these indications:

- Fire warning lights on P7
- WHEEL WELL light on P8
- Bell sound.

Duct leak overheat conditions cause these indications:

- WING-BODY OVERHEAT lights on P5.

CONTROLS AND INDICATIONS

These are the wheel well fire controls and indications:

- Toggle switch for system test on P8
- Fire warning lights on P7
- WHEEL WELL fire light on P8
- Bell sound (P9 aural warning module).

These are the duct overheat controls and indications:

- Push-button switch for system test on P5
- WING-BODY OVERHEAT lights on P5.

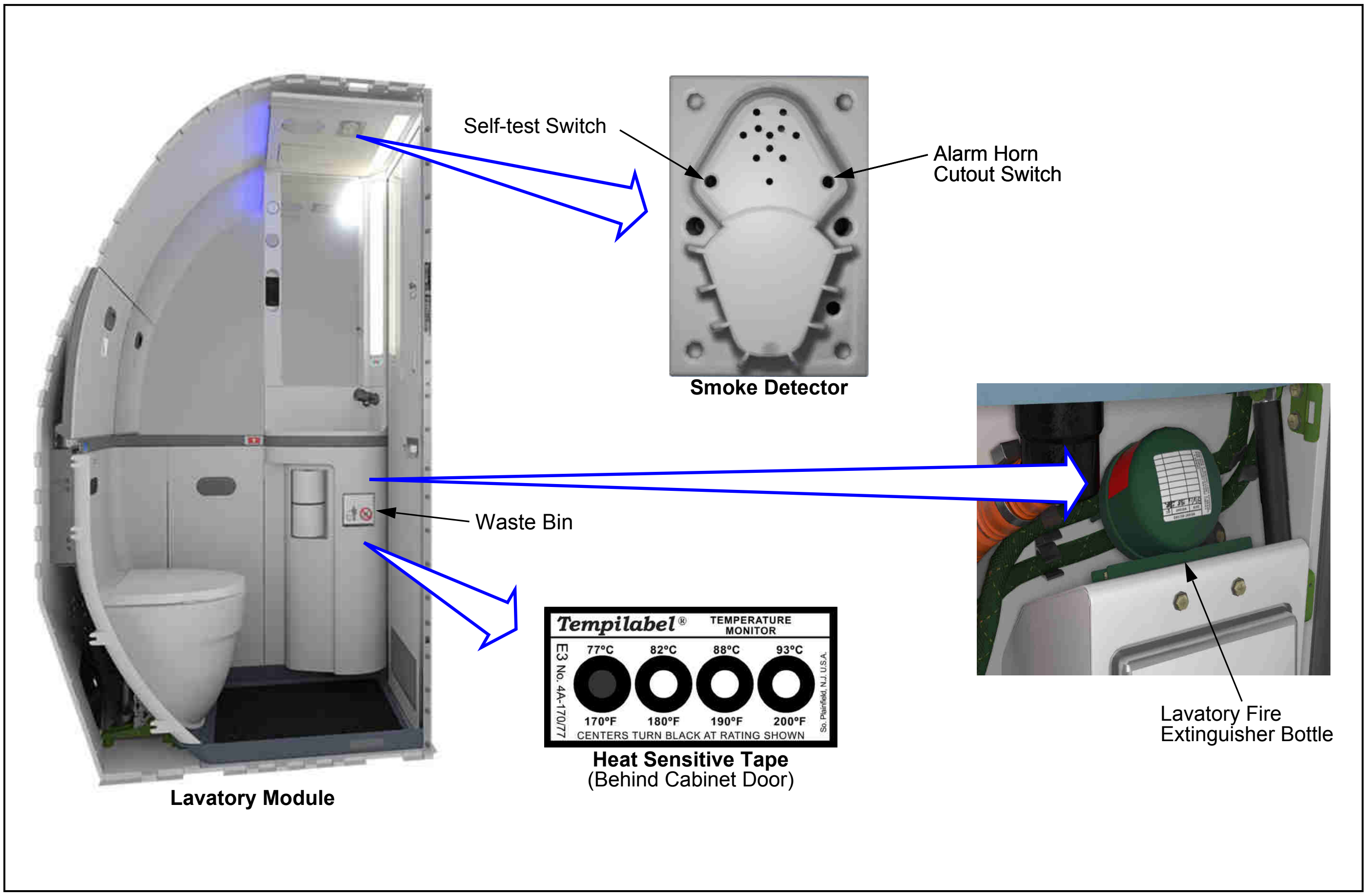
FEATURES

The compartment overheat detection module has these features:

- BITE
- Nonvolatile fault memory.

The overheat sensing loop configuration makes troubleshooting easy.

Fire Protection



Lavatory Fire Protection

LAVATORY SMOKE DETECTION

Smoke detectors are in the ceilings of all lavatories. The detectors operate a warning horn that is heard in the passenger cabin.

The smoke detectors are modular, simple, and reliable.

LAVATORY FIRE EXTINGUISHER

A fire extinguisher bottle is in the lower lavatory cabinet above the waste bin of each lavatory.

The extinguisher has these features:

- Automatic discharge operation
- FM200 extinguishing agent.

Heat sensitive tape near the bottle is used for these reasons:

- Show bottle discharge
- Record event temperature.

You replace the lavatory fire bottle for servicing.

Portable Fire Protection

These are the two types of portable fire extinguishers:

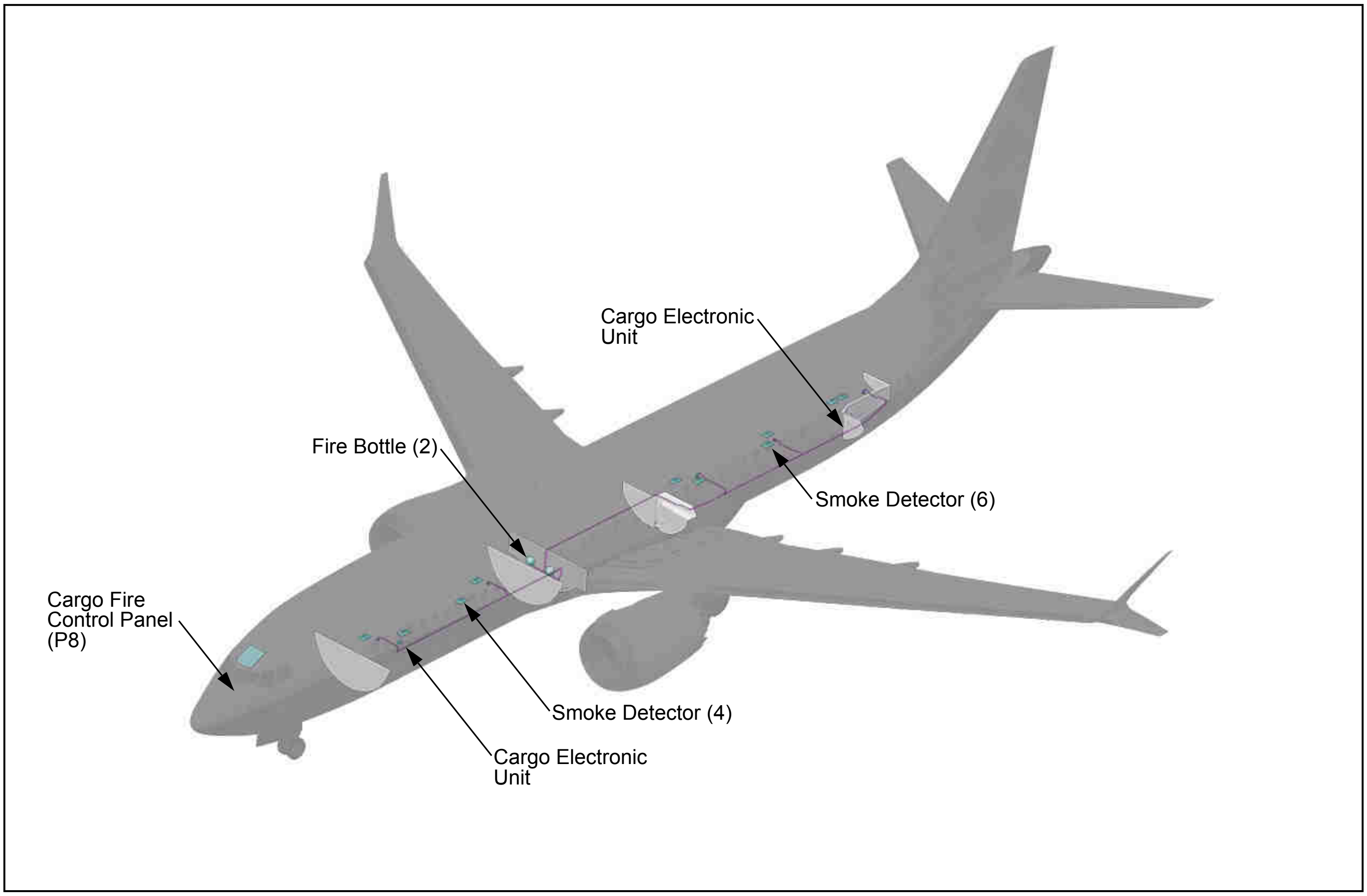
- Halon
- Water.

Halon fire extinguishers are in the flight compartment.

Halon and water fire extinguishers are in the galley areas.

These are the advantages of halon:

- The best fire extinguishing properties
- Extinguishes solid and liquid combustibles or electrical fires.
- Chemically stable, long life properties
- Noncorrosive properties
- Nontoxic properties
- Leaves no residue for reduced clean-up requirements.



Cargo Fire Protection

CARGO SMOKE DETECTION

The forward and aft cargo compartments have smoke detectors in a dual loop configuration. The smoke detectors monitor the cargo compartment air for smoke and heat.

A cargo electronic unit monitors the smoke detectors.

If there is smoke in the cargo compartment, the cargo electronic unit causes a cargo fire warning alarm. The FWD or AFT cargo fire warning light on the cargo fire control panel comes on in the flight compartment. The aural warning unit also gives a bell sound. To discharge the fire bottle, push the forward or aft cargo fire arm switch, then push the guarded discharge switch.

SMOKE DETECTORS

The forward cargo compartment has four smoke detectors and the aft cargo compartment has six smoke detectors. The forward and aft smoke detectors are identical.

The smoke detectors use photoelectric cells to detect smoke.

NOTE: The number of smoke detectors will change with the installation of auxiliary fuel tanks in the forward and aft cargo compartments.

CARGO ELECTRONIC UNITS

There is one cargo electronic unit in the ceiling of each cargo compartment inboard of the cargo door. The forward and aft cargo electronic units are identical.

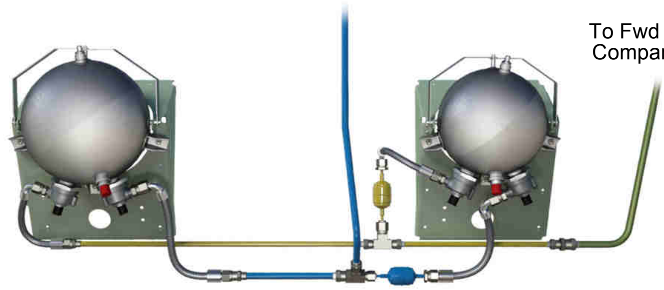
The cargo electronic unit has built-in test equipment (BITE). The BITE does power-up and periodic tests of the system. You can also use the system test switch to do a test of the system.

Fire Protection

Cargo Fire Control Panel (P8)


Cargo Smoke Detector

Cargo Electronic Unit



Cargo Fire Extinguishing Bottle

Cargo Fire Protection

CARGO FIRE CONTROL PANEL

The cargo fire control panel provides controls and indications for the cargo fire protection system. The panel is on the P8 panel and provides easy access for both pilots.

The cargo fire control panel has these functions:

- DETECTOR FAULT amber light is on if one or more of the detectors have a failure
- Three-position (A, NORM, B) DET SELECT switch, one for each cargo compartment. The NORM position lets both loops give a fire alarm. A or B lets the selected loop sense smoke and give a fire alarm
- TEST push button switch does a test of the cargo smoke detectors and the extinguisher system
- FWD, AFT red cargo fire warning switch lights are on if there is smoke in the corresponding cargo compartment
- Guarded DISCH switch light is pushed to discharge fire bottles
- FWD, AFT EXT lights show if fire bottle squibs are good.

CARGO FIRE BOTTLE

There are two cargo fire bottles. A high rate discharge (HRD) and a low rate discharge (LRD). The cargo fire bottles contains halon fire extinguishing agent. The HRD bottle weighs 25 lbs (15 kg) and the LRD weighs 13 lbs. The bottles are in the air conditioning distribution compartment. They are on the left and right side of the mix manifold mounted to the aft bulkhead.

The bottles have two discharge assemblies (squibs) connected to the discharge tubes. The discharge tubes send halon to the forward and aft cargo compartments.

The bottles have these components:

- Safety relief and fill port
- Two handles
- Pressure switch with test button
- Two discharge assemblies with squibs.

The HRD bottle provides 60 minutes of fire suppression. The LRD bottle will discharge after a 15 minute delay.

The LRD bottle has discharge flow restrictors. When discharged, the LRD bottle supplies a metered flow of halon. This supplies a total of 195 minutes of fire suppression.

Features

GENERAL

The airplane has ice protection which allows safe flight through icing conditions.

The system controls, indications, and automatic overheat protection reduce crew work load.

WING ANTI-ICE

Thermal anti-icing of the wing leading edge uses engine bleed air.

The wing anti-icing system operates in flight and on the ground.

It is not necessary to have ice protection for the empennage surfaces.

ENGINE ANTI-ICING

The inlet cowl of each engine uses its own bleed air for anti-icing.

AIR DATA SENSOR HEAT

These air data sensors use electrical heat:

- Pitot probes
- Alpha vane sensors
- Total air temperature probes.

WINDOW HEAT

The windshields and sliding flight compartment windows use electrical heat.

WINDSHIELD RAIN REMOVAL

A coating on the windshields repels water.

Windshield wipers improve visibility for takeoff, approach and landing.

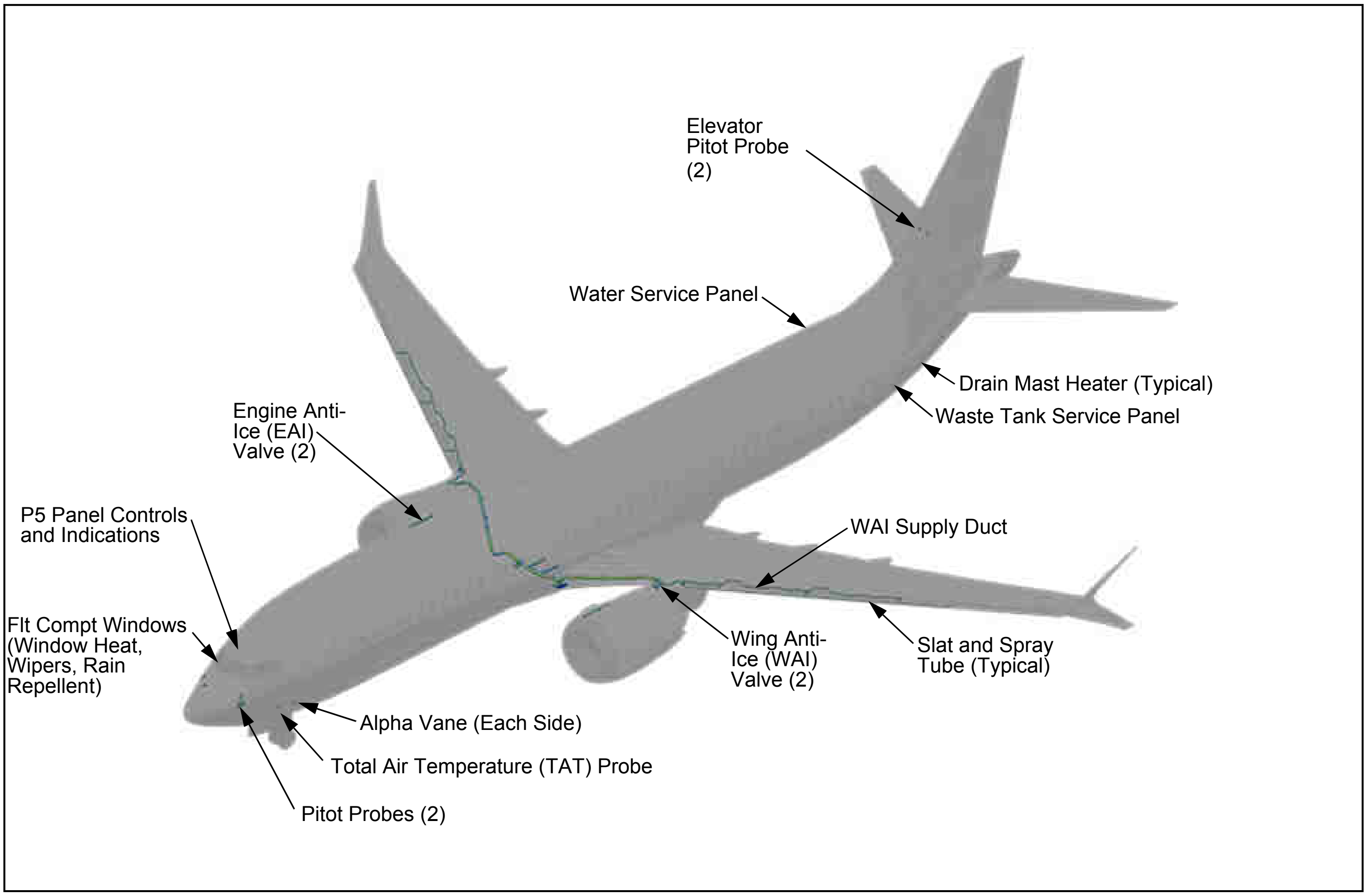
WATER SYSTEM HEAT

The water system service panel hoses and drain masts are heated electrically in flight and on the ground to prevent freezing.

WASTE SYSTEM HEAT

The waste system service panel hoses and drain fittings have heat in flight and on the ground to prevent freezing.

Ice and Rain Protection



Anti-Icing Systems

THERMAL ANTI-ICING SYSTEMS

Engine bleed air prevents ice on these surfaces:

- Outboard wing leading edges
- Engine inlet cowls.

The pneumatic manifold supplies air to the first three leading edge slats outboard of the engine strut. Anti-icing can be done in any slat position.

Engine anti-ice (EAI) air is from each engine bleed air manifold.

ELECTRIC SYSTEMS

These air data sensors use electrical heat:

- Pitot probes
- Total air temperature probes
- Alpha vanes.

The flight compartment windshields and sliding windows have electrical heat. Window heat for the fixed side windows is optional.

The drain masts use electrical heat. The drain masts have power reduction for ground operations.

The water supply lines use electric heat.

The lavatory service panel hoses and drain fittings use electrical heat.

WINDSHIELD RAIN REMOVAL SYSTEMS

The windshields have windshield wipers. The windshields also have a hydrophobic coating of water repellent compound.

MISCELLANEOUS

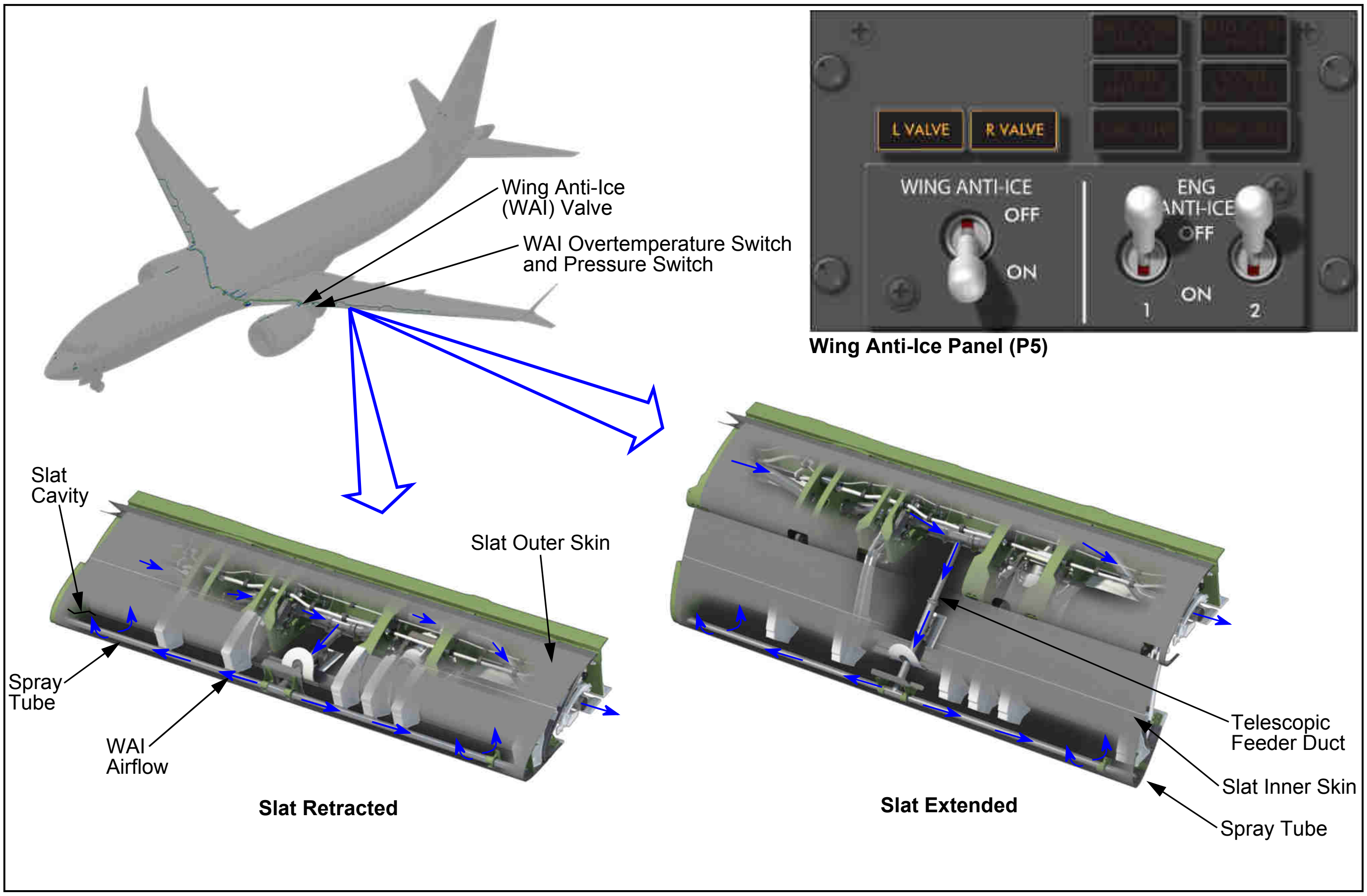
The static pressure port heat is not necessary.

There is no anti-icing for the empennage surfaces.

There is no anti-icing for the radome.

Conditioned air removes fog from the windshields.

The multiple-pane construction of the passenger windows keeps them free of fog and frost.



Wing Thermal Anti-Icing

GENERAL

The wing anti-ice (WAI) system prevents ice on the wing leading edges.

Engine bleed air warms the wing leading edges. Wing anti-icing valves are pneumatic pressure regulating valves that control the flow of air to the leading edges.

Hot air from the WAI valve flows through a leading edge supply duct to three telescopic feeder ducts. These ducts move the hot air to spray tubes inside the slat cavities. The spray tubes are perforated and supply the hot air to the slat cavities. The hot air flows overboard through holes in the lower surface of the slat.

WAI ducts, valves, overheat, and pressure switches are in the wing leading edges.

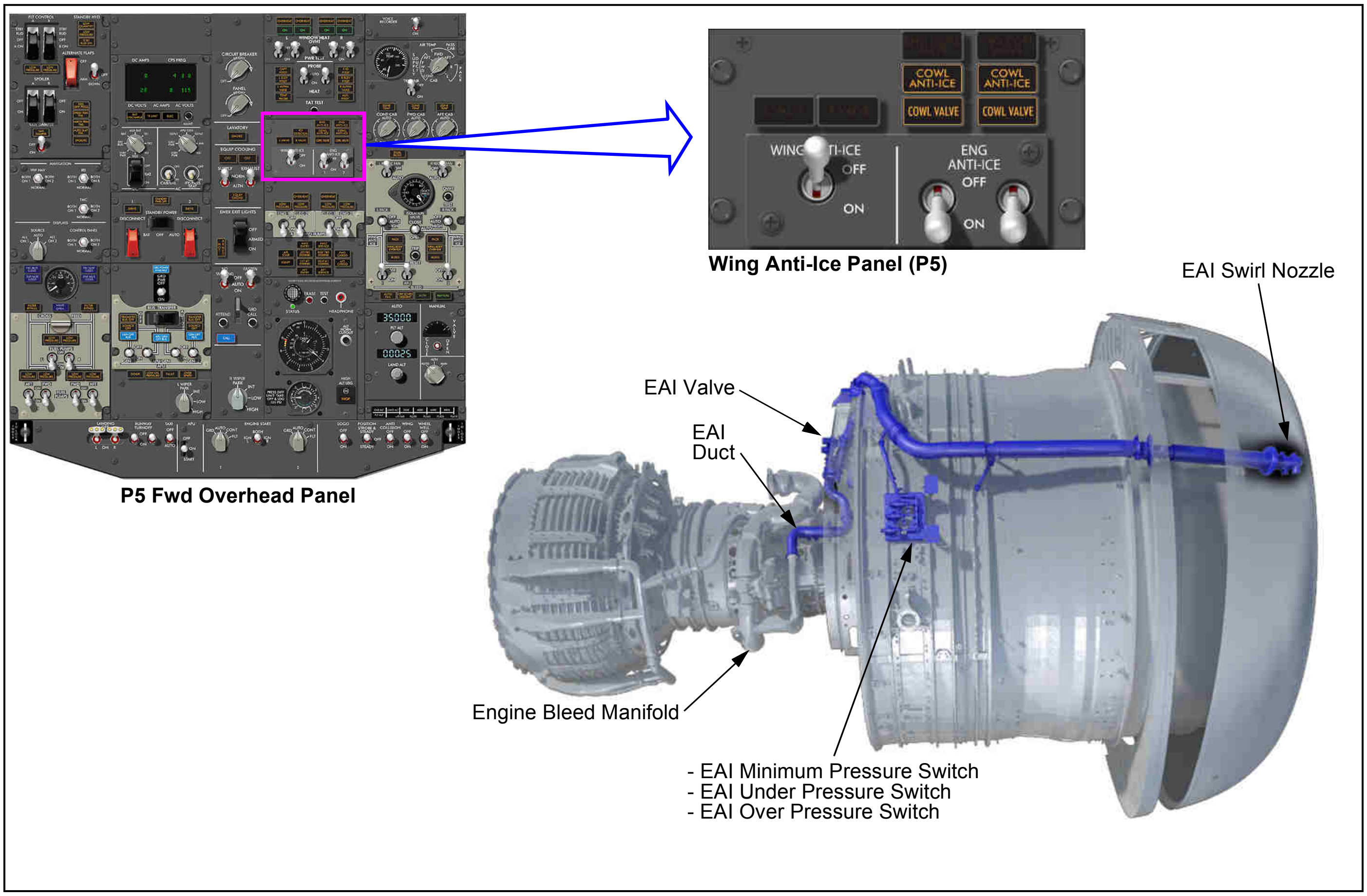
CONTROLS AND INDICATION

A single switch on the P5 forward overhead panel controls the wing anti-ice system. The switch controls both WAI valves.

WAI operates in flight or on the ground. On the ground, protective systems close the WAI valves to prevent leading edge overheat and to reduce engine bleed loads during takeoff.

The L VALVE and R VALVE lights are on when there is a switch/valve disagreement (valve failed open or closed).

The L VALVE and R VALVE lights are also tied to the MASTER CAUTION system.



Engine Anti-Icing

GENERAL

The engine anti-ice system prevents ice on the cowl surfaces during flight and ground operations.

The system uses air from the engine interstage manifold. The air flows to the engine anti-ice (EAI) valve. The EAI valve is a pressure regulating valve which controls the flow of the EAI air to the cowl. Air from the EAI valve flows through a duct to the hollow cowl inlet swirl nozzle. EAI air flows through the hollow cowl. This adds heat to the cowl inlet surface. The EAI air goes overboard through an opening in the bottom of the cowl.

CONTROL AND INDICATION

The two engine anti-ice systems operate independently.

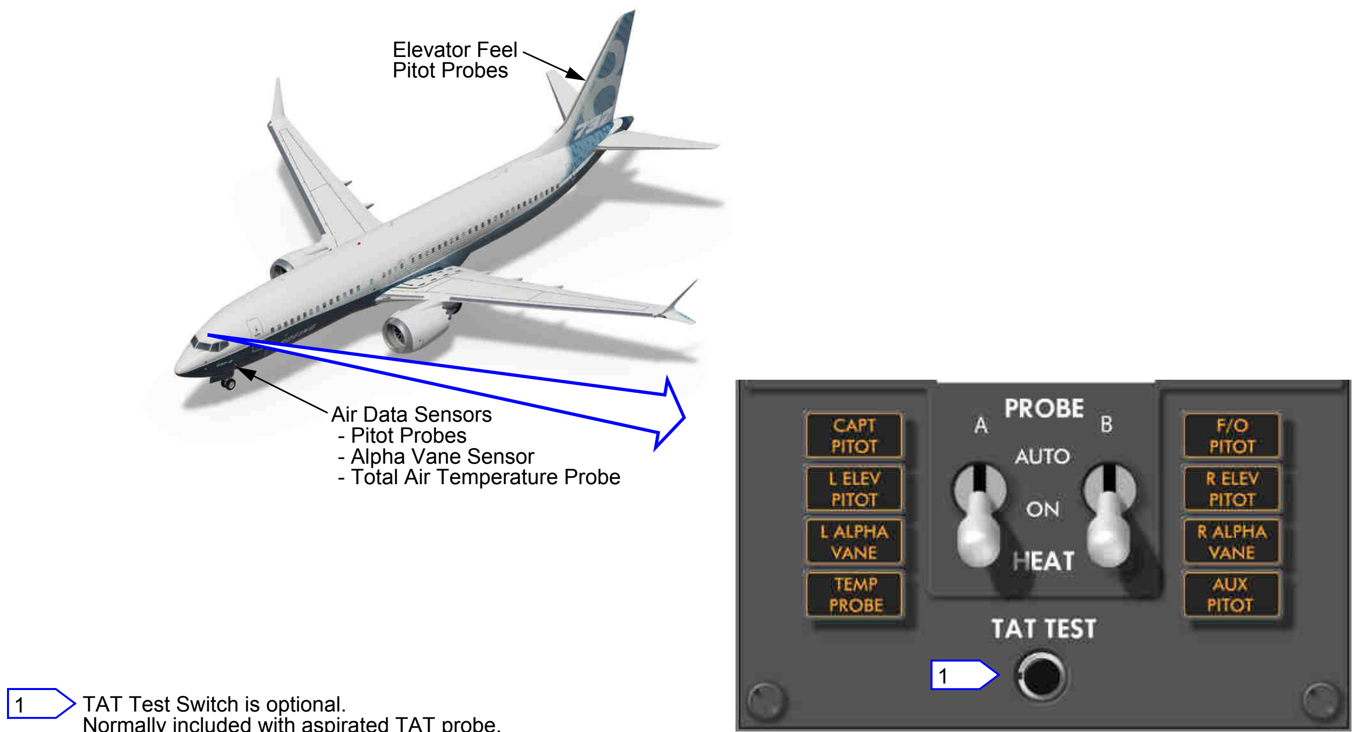
Switches on the P5 forward overhead panel control the EAI valves.

The EAI system uses 3 pressure switches for control of the EAI valve. The EAI minimum pressure switch signals the P5 panel when the EAI valve is open. The EAI under pressure switch signals when there is sufficient operating system pressure. The EAI over pressure switch signals when EAI pressure is too high.

Two COWL VALVE lights on the P5 panel are on when there is a switch/ valve disagreement (valve failed open or closed).

Two COWL ANTI-ICE lights on the P5 panel are on when there is an over pressure condition.

The COWL VALVE and COWL ANTI-ICE lights are also tied to the MASTER CAUTION system.



Probe Heat Panel (P5)

Air Data Sensor Heat

GENERAL

Air data sensors have heat to prevent ice formation. This prevents the erroneous indications of a sensor with ice.

These sensors get heat from integral electrical heaters:

- Pitot probes
- Elevator feel pitot probes
- Alpha vane sensors (angle of attack sensors)
- Total air temperature probe.

Heat for the static ports is not necessary.

The pitot probes are on both sides of the forward fuselage.

The elevator feel pitot probes are on the vertical stabilizer.

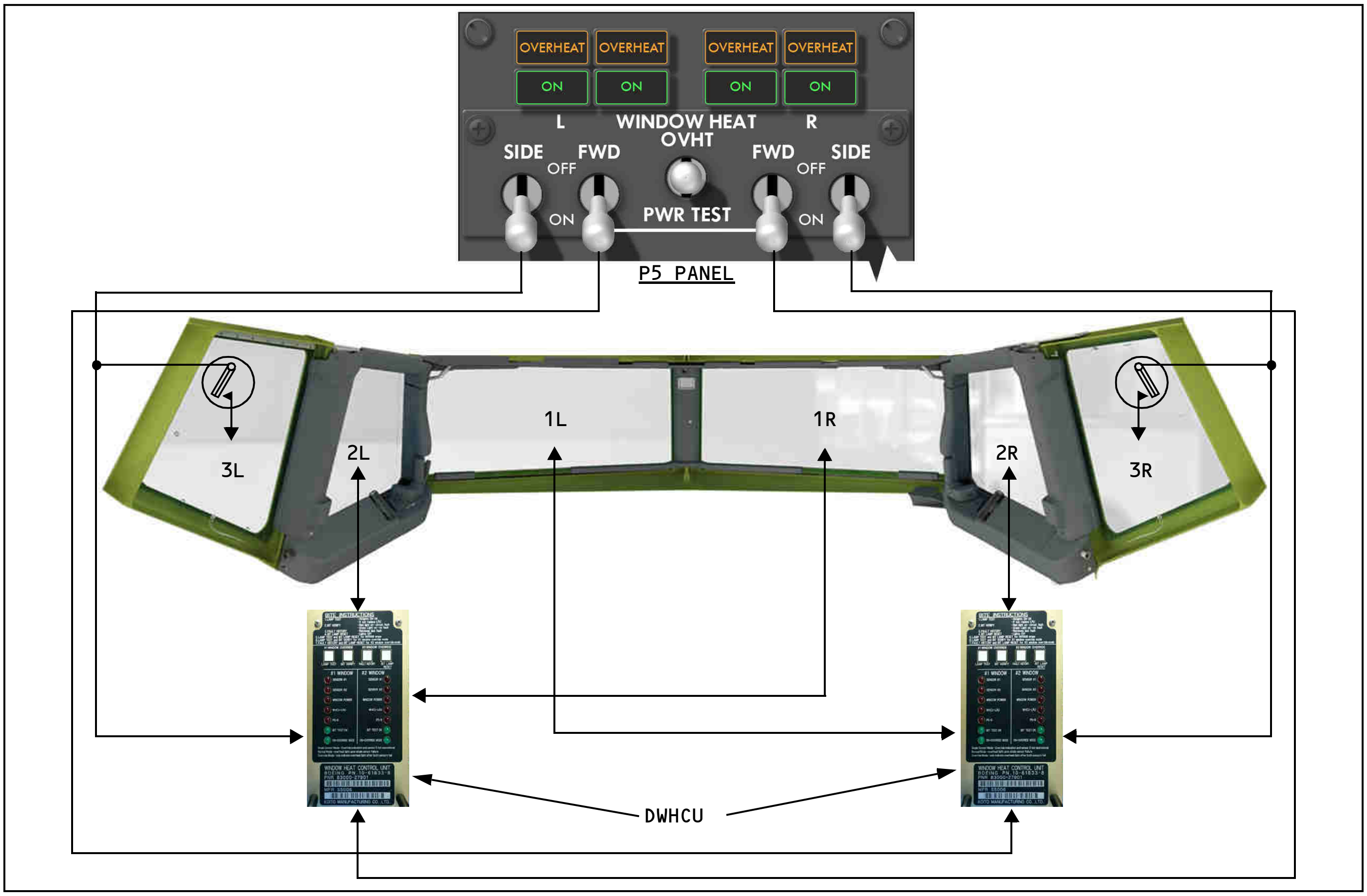
The relays and transformers that supply the voltage to the air data probes are in the EE compartment.

CONTROL AND INDICATION

Two switches on the P5 forward overhead panel control the air data probe heat. The probe heat has two systems, A and B. With the PROBE HEAT switches in the AUTO position, the probes will be heated upon engine start.

System caution lights show when a probe does not have heat.

Ice and Rain Protection



Window Heat

GENERAL

The windshields and sliding windows have heat for these reasons:

- Prevent windshield icing
- Increase windshield impact strength.

The windshields and sliding windows are made of multiple layers. One internal layer is made of a clear, electrically conductive paste.

The application of electric power to this conductive layer produces a current that warms the window.

These windows have heat:

- Windshields (1L and 1R)
- Sliding windows (2L and 2R)

Heat for side windows 3L and 3R is optional.

Two dual window heat control units (DWHCU) in the EE compartment control the heater power to the windshield and sliding windows.

DWHCU #1 controls power to windows 2L and 1R. DWHCU #2 controls power to windows 1L and 2R.

Thermal switches on the 3L and 3R windows control optional heater power to the side windows.

Conditioned air removes the fog from the windshields.

Passenger cabin windows keep free of fog by their spaced, multiple pane construction.

CONTROL AND INDICATION

These switches on the P5 forward overhead panel control the window heat system:

- FWD switches apply power to the windshields
- SIDE switches apply power to the sliding and #3 windows
- OVHT / PWR TEST switch controls overheat and power tests of the window heat system.

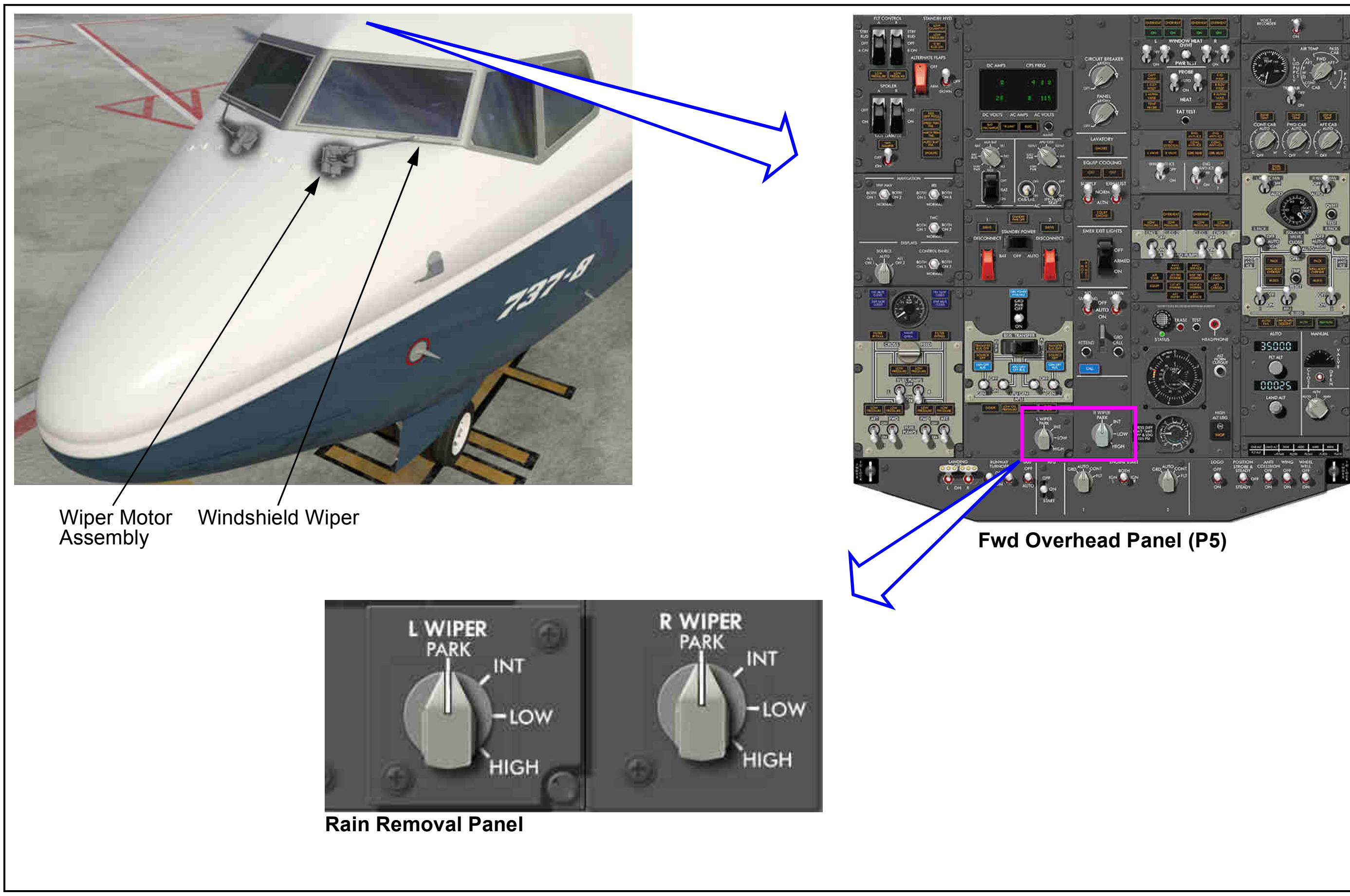
Four ON lights show when the windows are being heated.

Four OVERHEAT lights show a window overheat condition. Circuits in the control unit remove power from the overheated window.

FEATURES

The window heat control units have BITE.

BOEING PROPRIETARY



Windshield Rain Removal Systems

WINDSHIELD WIPERS

Two electric windshield wipers keep the windshields clear of rain.

The windshield wiper motors are on the lower windshield sill beam.

Two selectors or an optional single selector on the P5 forward overhead panel control the windshield wiper motors. The selectors have these positions:

- Park (Off)
- Intermittent
- Low
- High.

The wipers are self-parking.

RAIN REPELLENT WINDSHIELD COATING

A water repellent coating is on both windshields.

The coating causes liquid droplets to bead-up and roll off the windshield. In heavy rain, this makes visibility better.

Ice and Rain Protection

Water and Waste Systems Heat

POTABLE WATER SYSTEM

Electrical heating protects the potable water service panel hoses and drain fittings from freezing.

DRAIN MASTS

The water drain masts have electrical heaters. The heaters are built into the masts.

WASTE SYSTEM

Electric heating protects the waste drain valves and rinse fittings from freezing.

CONTROL AND INDICATION

The airplane electrical system supplies ac power to the water and waste system heaters.

Power to the drain masts decreases on the ground. This feature has these advantages:

- Increases the operational life of the masts
- The masts do not get hot enough to burn personnel on the ground.

System control is automatic. The system has heat when the airplane's electrical buses have power. There are no indications for these heaters.

- **Features**
- **Flight Crew Oxygen**
- **Passenger Oxygen**
- **Potable Water System**
- **Lavatory Waste Systems**
- **Vacuum Lavatory Waste System**

Features

OXYGEN SYSTEMS

Flight crew oxygen is a gaseous system.

The passenger oxygen system uses chemical generators to supply oxygen to the passenger compartment and gaseous oxygen for the lavatories.. The passenger oxygen system has automatic deployment.

WATER SYSTEMS

The potable water system has 40 or 60 gallon water tanks available.

All system components are made from corrosion resistant materials.

Super chlorinated solutions are used for sterilization of the water system.

The water system supply lines will not break or permanently distort if they freeze.

The potable water system service panel is easy to access. It uses standard service fittings.

Gray water from the galleys and lavatory wash basins drains overboard through heated drain masts.

LAVATORY WASTE SYSTEMS

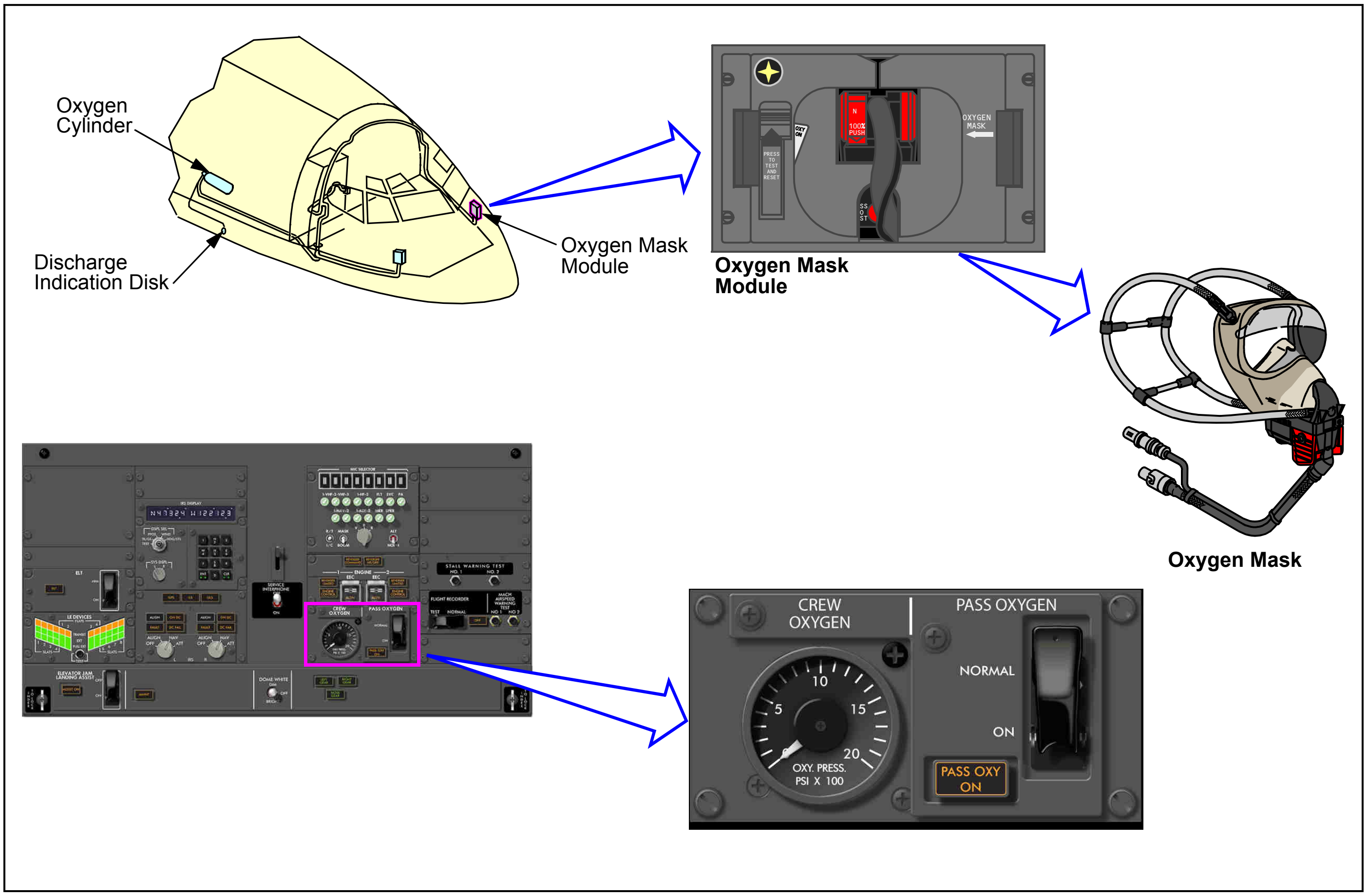
The modular lavatory units increase configuration flexibility.

Standard lavatory modules have a vacuum flush system.

The waste tank service panel is easy to access. It uses standard fittings.

BOEING PROPRIETARY

Cabin Systems



Flight Crew Oxygen

GENERAL

The flight crew oxygen system has high pressure oxygen gas.

Oxygen is stored in a cylinder in the EE compartment. The cylinder is accessed from the forward cargo compartment.

A regulator on the cylinder reduces the oxygen pressure.

The oxygen supply line and manifold is made of seamless stainless steel tubing.

Modular mask units supply the oxygen to the flight crew stations.

CONTROLS AND INDICATION

A gage on the aft P5 panel shows oxygen cylinder pressure.

A gage on the cylinder also shows cylinder pressure.

A green disk, on the airplane skin, covers the cylinder overboard pressure relief port. When the disk is broken, it shows that cylinder overpressure may have caused the cylinder to discharge overboard.

Automatic valves and flow regulators in the mask modules supply flow to the user when the mask is put on.

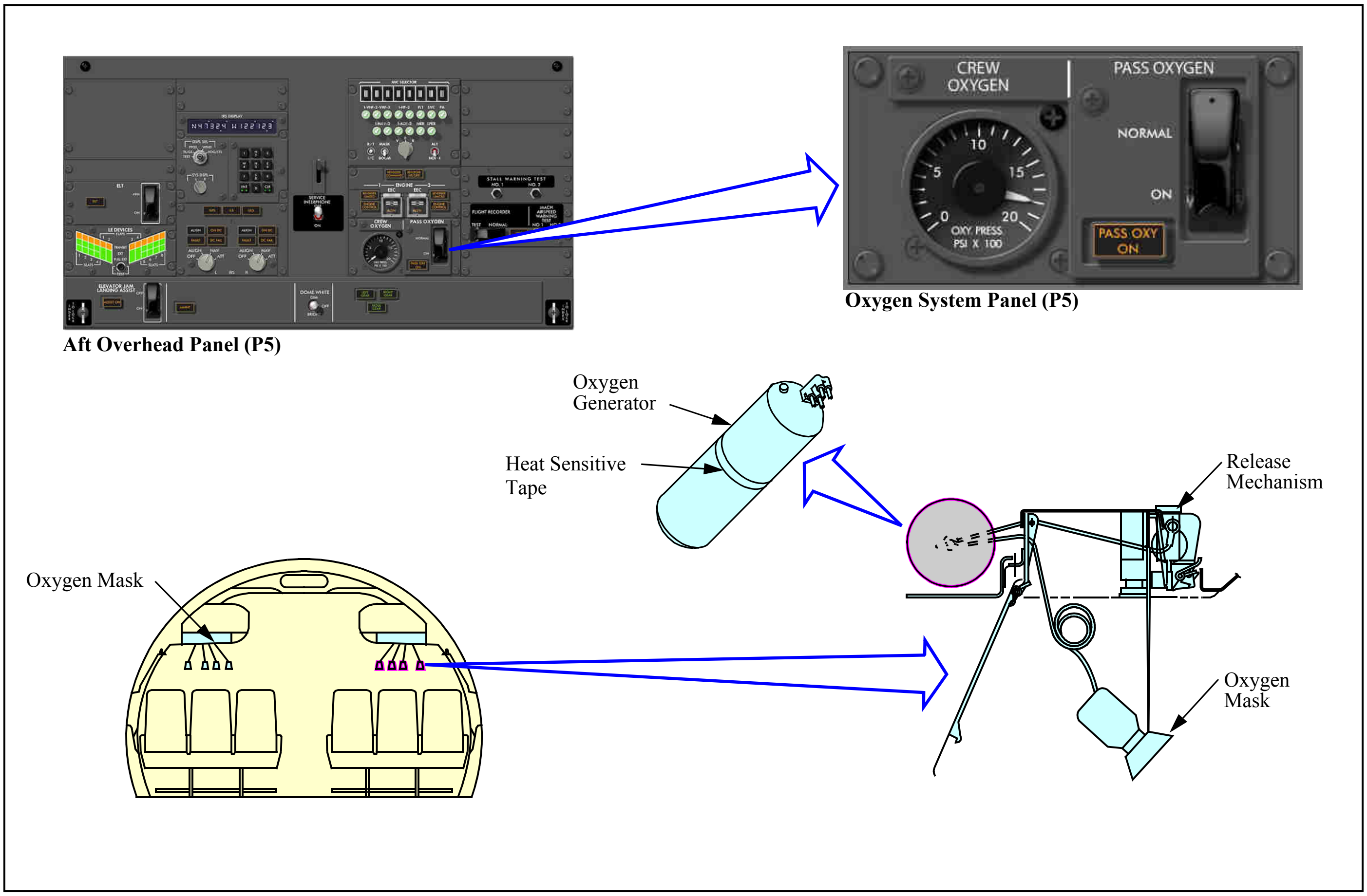
A mask module flow indicator shows oxygen flow to the user.

FEATURES

Modular masks have these features:

- Diluted or 100% oxygen flow
- Demand or continuous flow
- Goggle smoke clearance
- Integral microphones
- Quick, one-handed operation
- High reliability
- Easy serviceability
- Reduced spares inventory.

You service the oxygen cylinder by removal and replacement. An external oxygen service panel is optional.



Passenger Oxygen

Chemical oxygen generators supply emergency oxygen to the passengers and flight attendants in the passenger compartment.

The generators are in these areas:

- Passenger service units (PSU)
- Attendant service units (ASU)

Gaseous oxygen supplies the lavatories.

Oxygen masks deploy automatically or manually.

Electrical release of a spring-loaded door in the service unit deploys the masks. The open door drops the oxygen masks. A short tether connects the masks to the generator activation pin. You pull the mask to activate the oxygen generator. A flexible tube supplies oxygen to the mask.

The generators supply oxygen at a rate and for a duration, sufficient for passenger safety during descent (15 minutes).

You service the oxygen generators by removal and replacement.

The oxygen generators contain sodium chlorate and iron. When these compounds burn, the byproduct is oxygen.

Oxygen generators can reach a temperature of 450F/232C. The heat sensitive tape turns black at this temperature.

In addition to the PSU oxygen generators, portable gaseous oxygen cylinders are available for emergency first aid. These cylinders are near the flight attendant stations.

CONTROLS AND INDICATION

The oxygen masks are deployed in either of two ways:

- Automatically by an aneroid pressure switch in the EE compartment. This occurs at a cabin pressure altitude of 14,000 feet
- Manually by a guarded toggle switch on the P5 aft overhead panel.

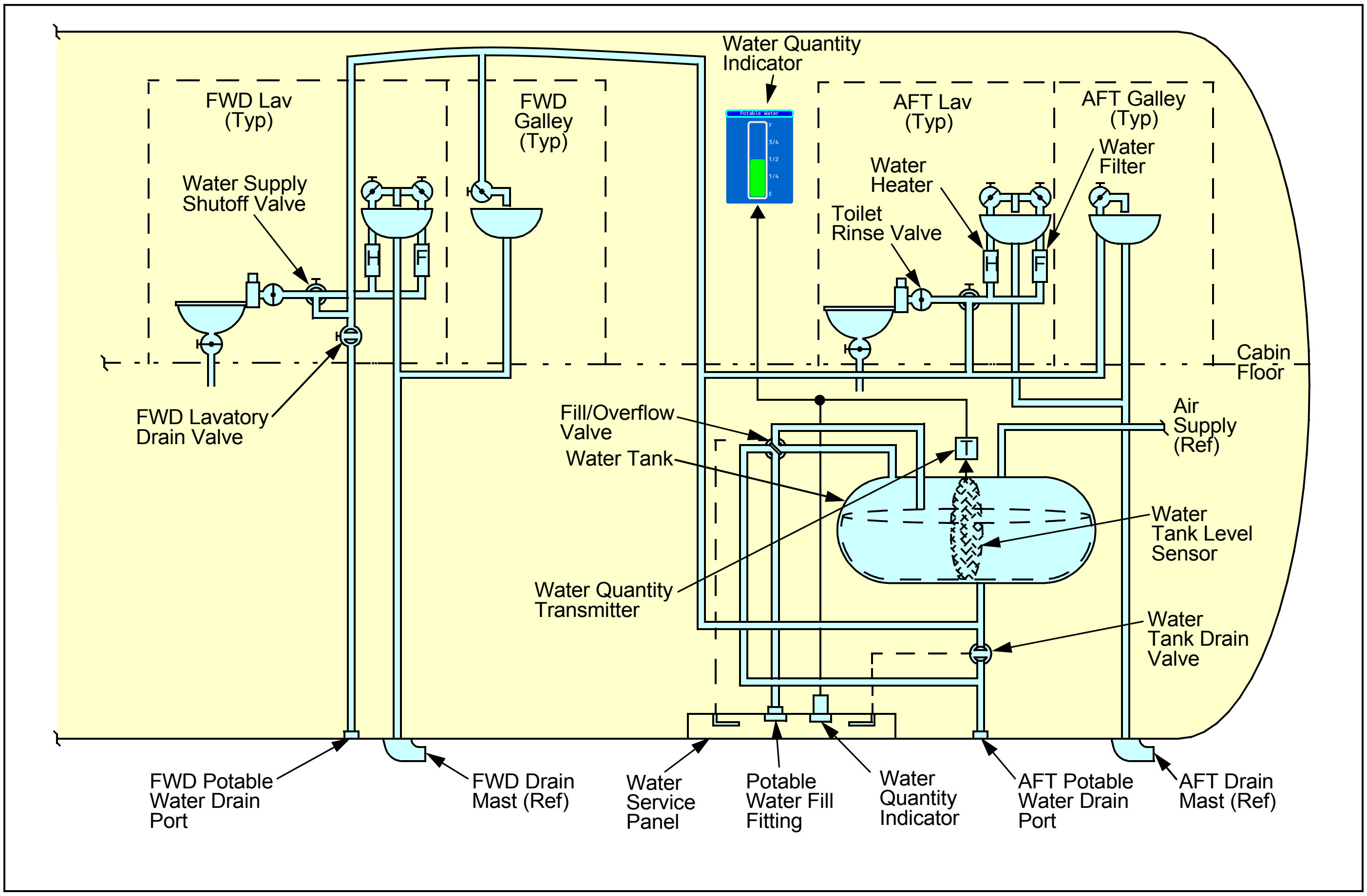
An amber light on the aft P5 panel shows when the oxygen masks deploy.

Tape on the oxygen generators show the condition of the generators.

FEATURES

There are extra oxygen masks at each PSU for infants.

Cabin Systems



Potable Water System

GENERAL

Potable (drinkable) water is stored in a single tank under the cabin floor. The tank is aft of the aft cargo compartment. The tank supplies water to these areas:

- Galleys
- Lavatory wash basins
- Vacuum lavatory toilet rinse.

Air pressure in the water tank forces water through the potable water system plumbing. Pressurized air comes from these sources:

- APU bleed air duct
- Electric compressor.

The tank is protected from collapse, contamination, and overpressurization. This is done by a pressure regulator, filter, relief valve, and venting.

A quantity transmitter on the tank transmits water tank quantity to the aft attendant panel. The water quantity shows on the environment screen.

Water system servicing is from a panel below and aft of the aft service door.

The water system plumbing is made of corrosion-resistant tubes and hoses. The components have these features:

- Sustain a freeze without rupture or permanent set
- Be compatible with super chlorinated solutions (for system sterilization)
- Increase the flexibility of galley arrangements.

The lavatory wash basins have these features:

- Electric water heaters
- Service shutoff and drain valves
- Self-venting faucets
- Charcoal filters (optional).

Gray water (waste water) drains through electrically heated drain masts.

FEATURES

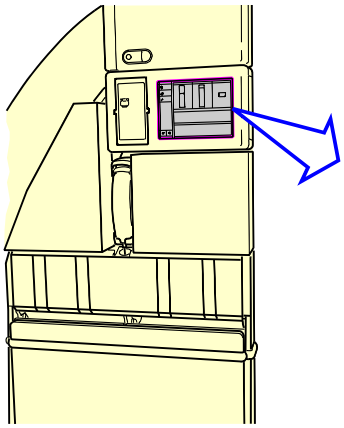
Drain valves and self venting faucets simplify system draining.

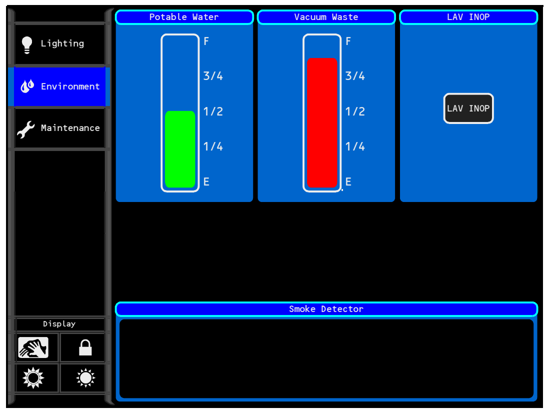
The service panel uses standard fittings.

Insulated blankets prevent the water tank from freezing.

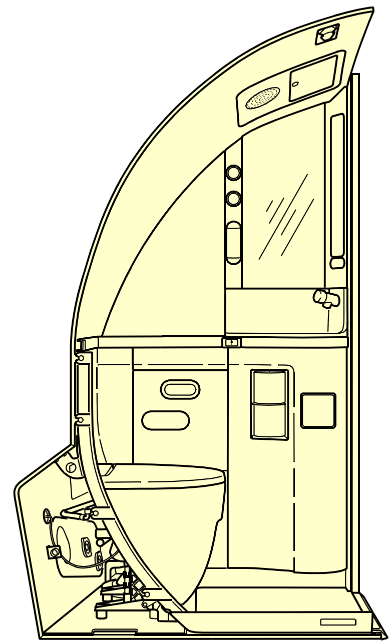
Additional ribbon, blanket, and fitting heaters are available for operation in colder climates.

The system complies with U.S. Public Health Services (USPHS) regulations.





Attendant Panel Center


Lavatory Module

Lavatory Waste Systems

GENERAL

Lavatories have these features:

- Toilet
- Wash basin with hot and cold water taps
- Mirror
- Lights
- An attendant call button
- Passenger service unit
- Smoke detector
- Trash bin with automatic fire extinguisher.

There are LED lights in the lavatories. When the lavatory door locks, the lights become brighter.

The lavatory modules can install in different positions. Customer requirements determine the position.

VACUUM TOILETS

The standard lavatories use a vacuum waste system.

The vacuum waste system uses several lavatory modules connected to one waste tank.

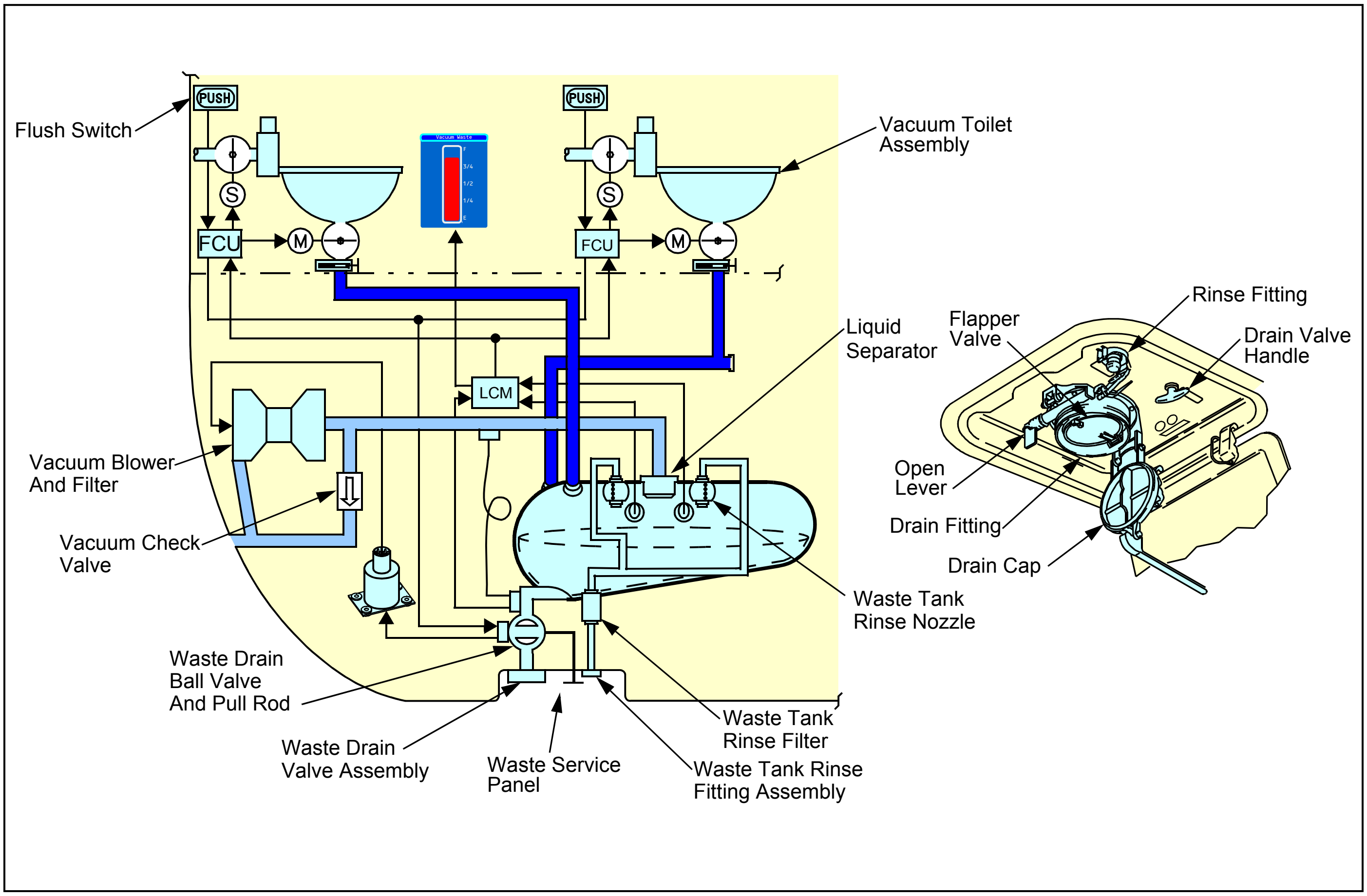
CONTROL AND INDICATION

You can monitor and test the vacuum waste system from the aft attendant panel and the exterior service panel.

The aft attendant panel Environment screen shows tank level and system faults.

Manual shutoff valves in the lavatories prevent the use of an inoperative lavatory module.

A logic control module (LCM) monitors and controls the system.



Vacuum Lavatory Waste System

GENERAL

The vacuum waste system design permits single point servicing and lavatory installation in different locations.

The system uses differential pressure (vacuum) to pull waste from the toilet to the holding tank. A vacuum blower supplies the required differential pressure when the airplane is below 16,000 ft. Ambient-to-cabin differential pressure supplies the vacuum when the airplane is above 16,000 ft.

A tank in the aft cargo compartment holds the waste.

The system includes these components:

- Lavatory toilet modules
- A waste collection and storage system.

OPERATION

A flush switch starts the flush cycle. The flush cycle has this sequence:

- Below 16,000 ft, the vacuum blower operates
- The toilet rinse valve opens momentarily to rinse the bowl
- The flush valve opens momentarily to flush the bowl
- The flush circuit resets itself.

Automatic circuits prevents a flush cycle if these conditions occur:

- The holding tank is full
- The waste collection system does not operate
- The storage tank drain valve is open.

VACUUM WASTE SERVICE

The system has single source servicing. The service panel is on the aft lower left fuselage. For toilet servicing, these procedures are necessary:

- Drain the storage tank
- Rinse the storage tank.

- **Features**
- **Flight Compartment Lights**
- **Overhead Panel Lights**
- **Exterior Lights**
- **WING ILLUMINATION LIGHTS**
- **Emergency Lights**
- **Interior Lights**
- **Sky Interior Lighting**

Features

FLIGHT COMPARTMENT LIGHTS

All instrument panels have integral lights. Background lights, floodlights, dome lights and map lights also supply light in the flight compartment.

Chart lights point light to the captain and first officer sidewalls.

EXTERIOR LIGHTS

Landing lights let the flight crew see the runway at night. Anti-collision lights and position lights show the airplane to flight crews in other airplanes. Logo lights show the airline logo to passengers in the airport terminal.

High-intensity strobe beacon lights are on the top and bottom of the fuselage, aft of the wing leading edge. Additional strobes are at each wing tip and in the tailcone.

SERVICE AND CARGO LIGHTS

There are lights in all of the service and cargo compartments for the ground crew.

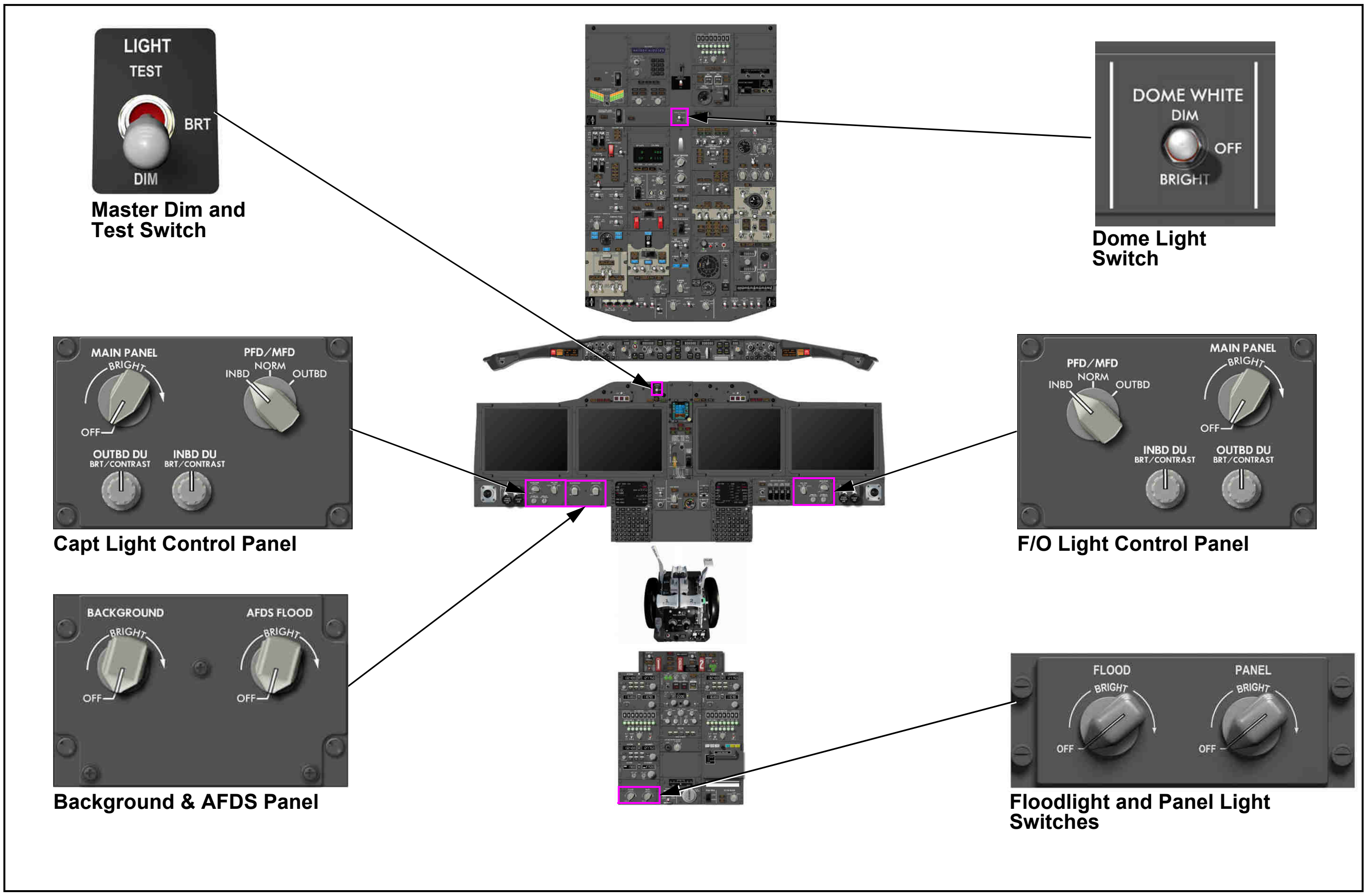
EMERGENCY LIGHTS

Emergency lights show the escape routes for passengers and crew.

PASSENGER COMPARTMENT LIGHTS

Light in the passenger compartment is supplied by LED assemblies. Assemblies are located on top of the overhead stowage bins and above the windows. Control for the lighting is from the forward and aft attendant panels.

Lights



Flight Compartment Lights

Dome lights supply light for the flight compartment. The light-shield supplies background light for the main instrument panels. Each instrument and instrument panel has its own internal light. An overhead floodlight points light on the control stand. Floodlights also point light at the circuit breaker panels in the aft section of the flight compartment.

MAIN PANEL LIGHTS

The instrument and main panel lights have adjustable controls, identified as PANEL. These controls are on the lower part of the captain and first officer main instrument panels. The captain PANEL control adjusts light intensity on the captain main panel, the center panel and the glareshield. The first officer PANEL control adjusts light intensity on the first officer panel.

White floodlights are under the glareshield to supply light to the main panels. One control adjusts the intensity of these lights. It is on the lower part of the captain main panel and is identified as BACKGROUND.

The standby electrical system supplies power for the lights under some conditions.

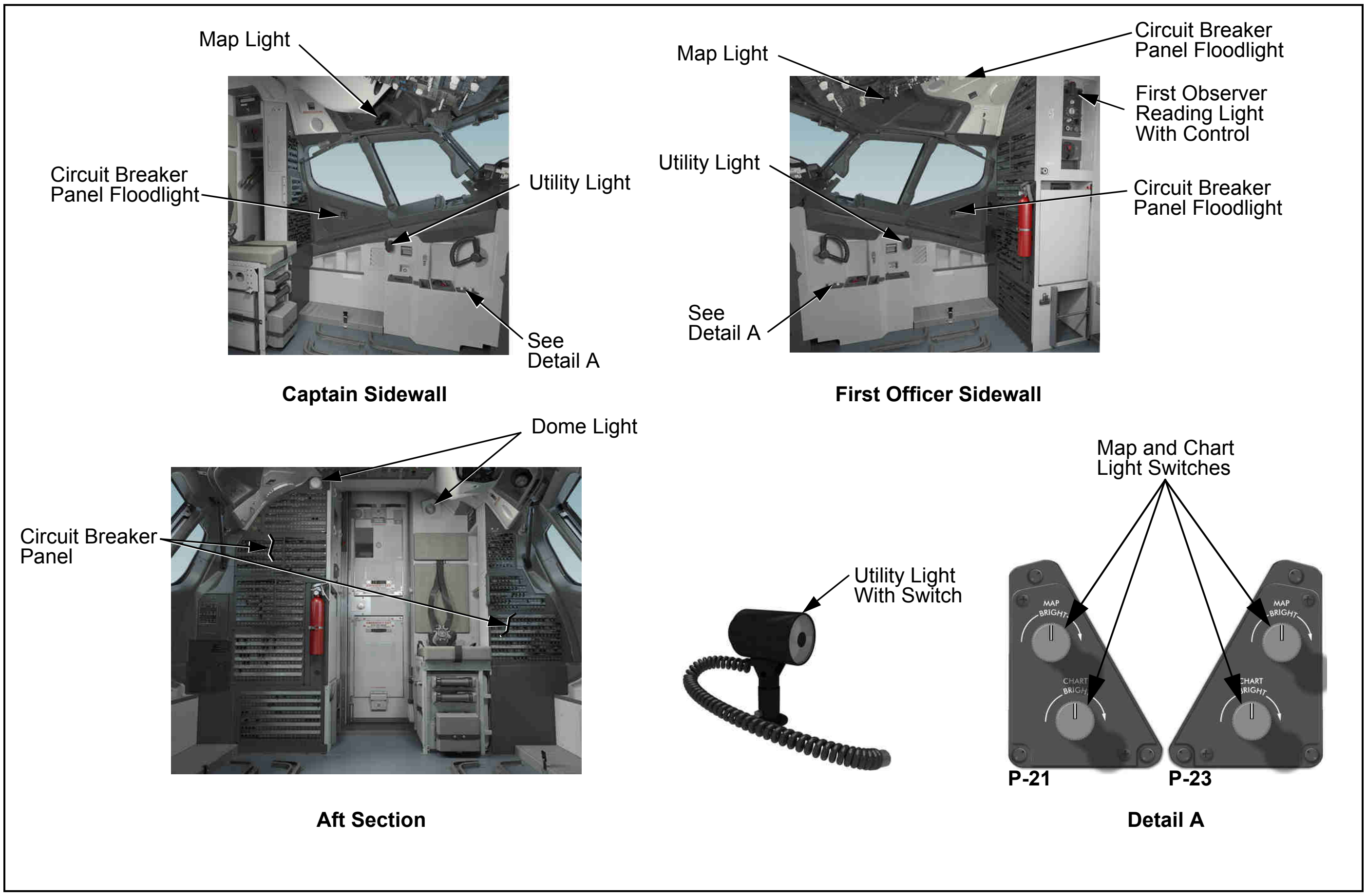
Floodlights are above the digital flight control system (DFCS) mode control panel. One control adjusts the intensity of these lights. It is on the lower part of the captain main panel and identified as AFCS FLOOD.

Use the LIGHTS switch to adjust or do a test of the flight compartment indication lights. The switch is on the center instrument panel. Put the switch in the BRT position and the indication lights come on bright. Put the switch in the DIM position and the lights will be dim. Put the switch in the TEST position and all of the indication lights come on bright.

The standby compass has an internal light and a three-position light switch. The three positions are BRIGHT, DIM, and OFF.

CONTROL STAND LIGHTS

The control stand has lights inside the instrument panel, like the units on the main instrument panels. There is also a white floodlight on the P5 forward overhead panel which supplies light to the thrust lever quadrant on the control stand. Adjustable intensity controls for these lights are on the control stand. These controls are identified as PANEL and FLOOD.



Overhead Panel Lights

An adjustable intensity control adjusts internal instrument lights and instrument panel lights on the overhead panels. It is on the forward overhead panel and identified as PANEL.

MAP LIGHTS

Map lights, which point light downward are above each pilot seat. Adjustable intensity controls for these lights are identified as MAP. They are on the sidewall by each pilot seat.

CHART LIGHTS

Chart lights, which point light on the sidewall panels are above each pilot seat.Adjustable intensity controls for these lights are identified as CHART. They are on the sidewall by each pilot seat.

UTILITY LIGHTS

Utility or flight kit lights are on the sidewalls. Each light has its own adjustable intensity control. The lights are attached to a flexible cord so that they can be pointed where necessary.

CIRCUIT BREAKER PANEL LIGHTS

White floodlights supply light to the circuit breaker panels behind the pilots. The floodlights are in the floor, sidewall, and overhead. An adjustable intensity control for these lights is identified CIRCUIT BREAKER. It is on the forward overhead panel.

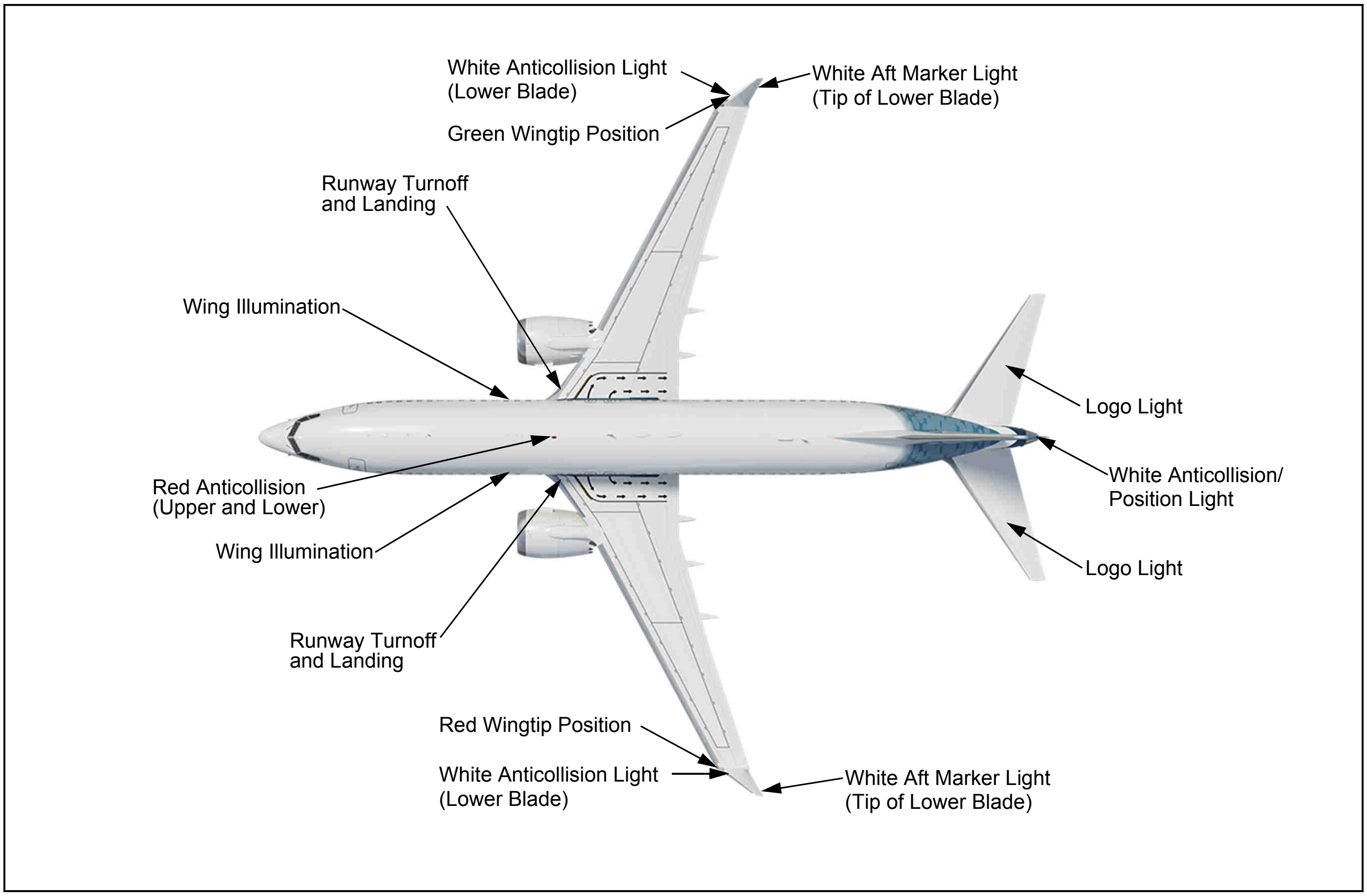
DOME LIGHTS

Two white dome lights supply light to the flight compartment. One dome light is on the panel behind each pilot. A switch on the aft overhead panel controls these lights. DOME WHITE identifies this switch. This switch has bright, dim, and off positions. A separate lamp is in the left dome light and part of the emergency light system.

OBSERVER LIGHT

Detachable observer reading lights are on the circuit breaker panels behind the crew.

Lights



Exterior Lights

Exterior light installations are reliable and easy to maintain. Double wing-tip position lights improve dispatch reliability. Exterior light switches are on the forward P5 overhead panel in the flight compartment.

LANDING LIGHTS

There are two LED fixed landing light arrays. Fixed landing lights are in the wing leading edges near the fuselage. The lights supply visibility at night and in bad weather conditions. The inboard section of each array is angled to project light to the side to show taxiway turnoffs.

POSITION LIGHTS

LED forward position light modules are on the inboard leading edge of each winglet upper blade. Two lights are in each module. The lights on the left wing are red. The lights on the right wing are green.

Dual LED aft marker lights are on each winglet lower blade end cap. The lights point aft.

ANTI-COLLISION LIGHTS

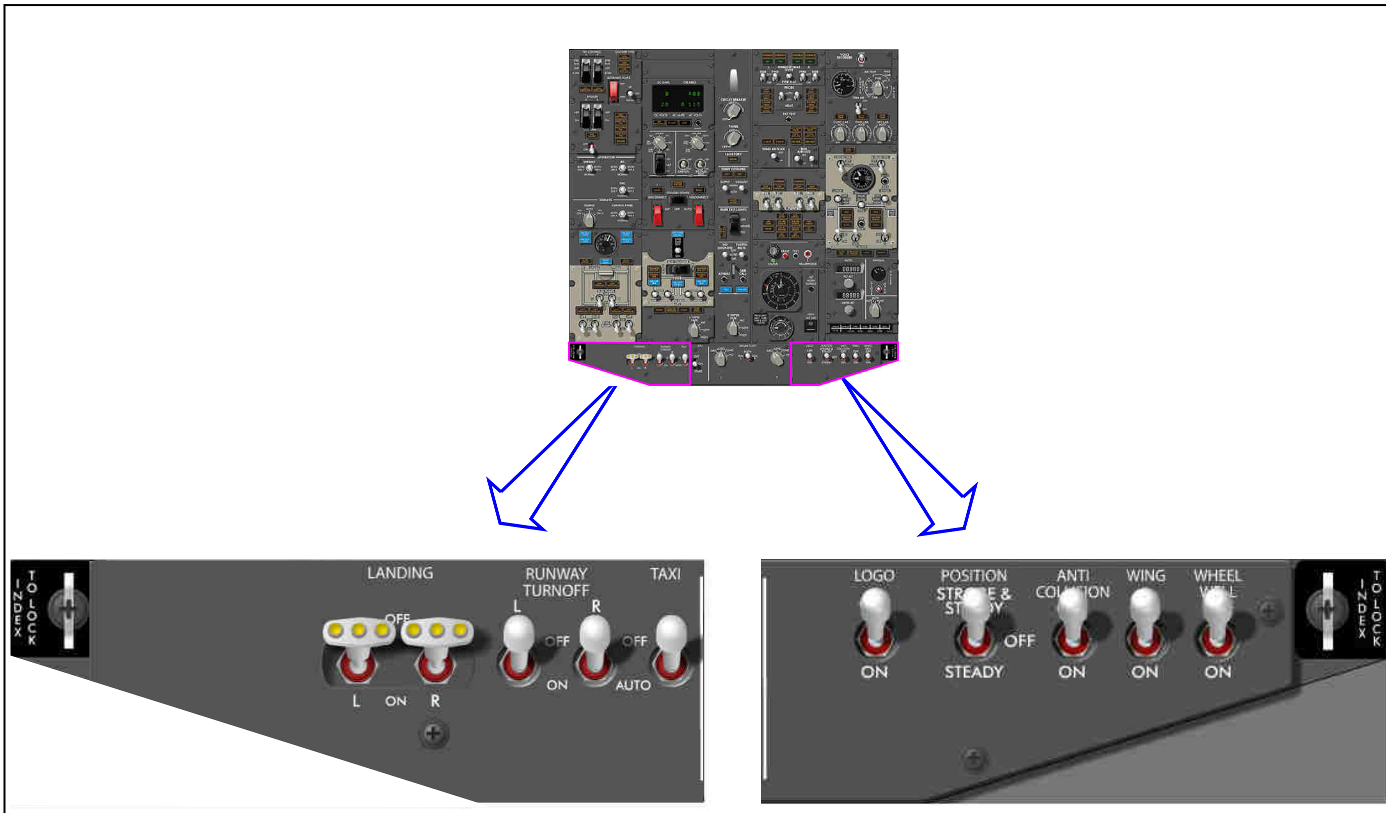
LED anti-collision lights are on the top and bottom of the fuselage, aft of the wing leading edge. Each anti-collision light is a strobe light with a red lens. Access to the upper light is through a passenger cabin ceiling panel. You reach the lower light from outside the airplane.

LOGO LIGHTS

LED logo lights are in the top of each horizontal stabilizer surface to supply light to both sides of the vertical stabilizer.

WING AND TAIL ANTI-COLLISION LIGHTS

White LED strobe lights are in each winglet on the leading edge of the lower blade. Two LED combination anti-collision and position lights are on the tailcone.



WING ILLUMINATION LIGHTS

Two LED wing lights supply light to the surface of the wings. The flight crew can select the wing lights in flight to see the wing surface. The lights are on each side of the fuselage. They are forward of the wing above floor level.

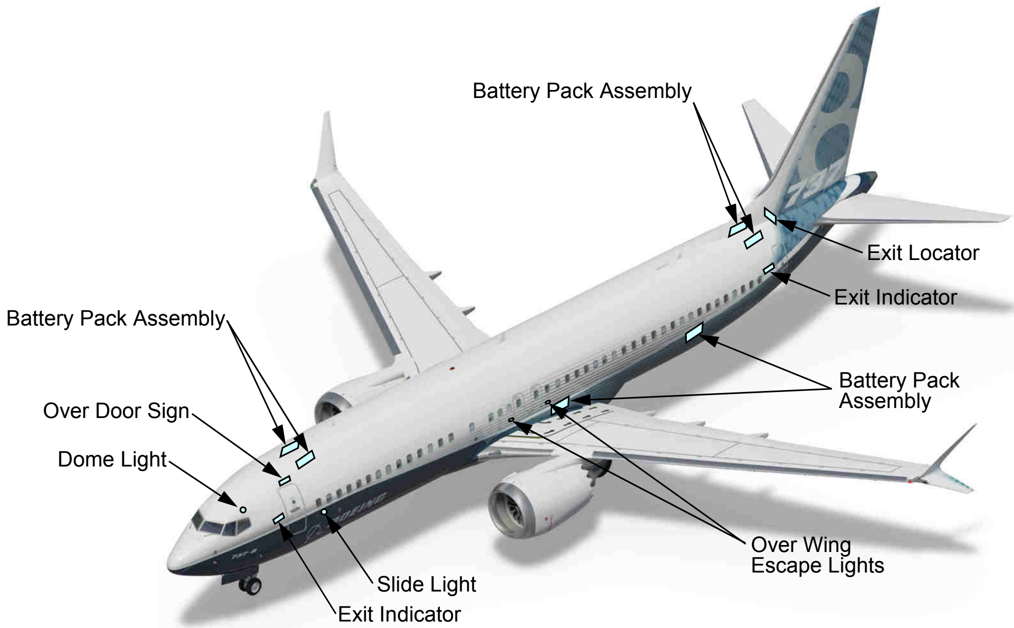
SERVICE LIGHTS

Service lights are LED's.

Service lights are in the forward equipment compartment and the electronic equipment compartment. Forward and aft cargo compartment lights go off when the cargo doors close.

Service lights are also in each wheel well. These lights supply light to the nose and main gear compartments during ground servicing. Switches for these lights are in the flight compartment, the main wheel wells, and right side of the fuselage near the nose.

Lights



Emergency Lights

INTERIOR

The emergency lighting system supplies light to the passenger compartment and flight compartment when there is a power failure.

When there is a power failure, emergency lights will automatically come on. Special batteries supply power for these lights. Emergency lights are in these areas:

- Exit locator signs
- Overwing emergency exit doors
- Flight compartment dome
- Overhead panels
- Floor track.

Many airplanes are equipped with photoluminescent floor track strips. These strips give light along the floor without using electrical power.

EXTERIOR

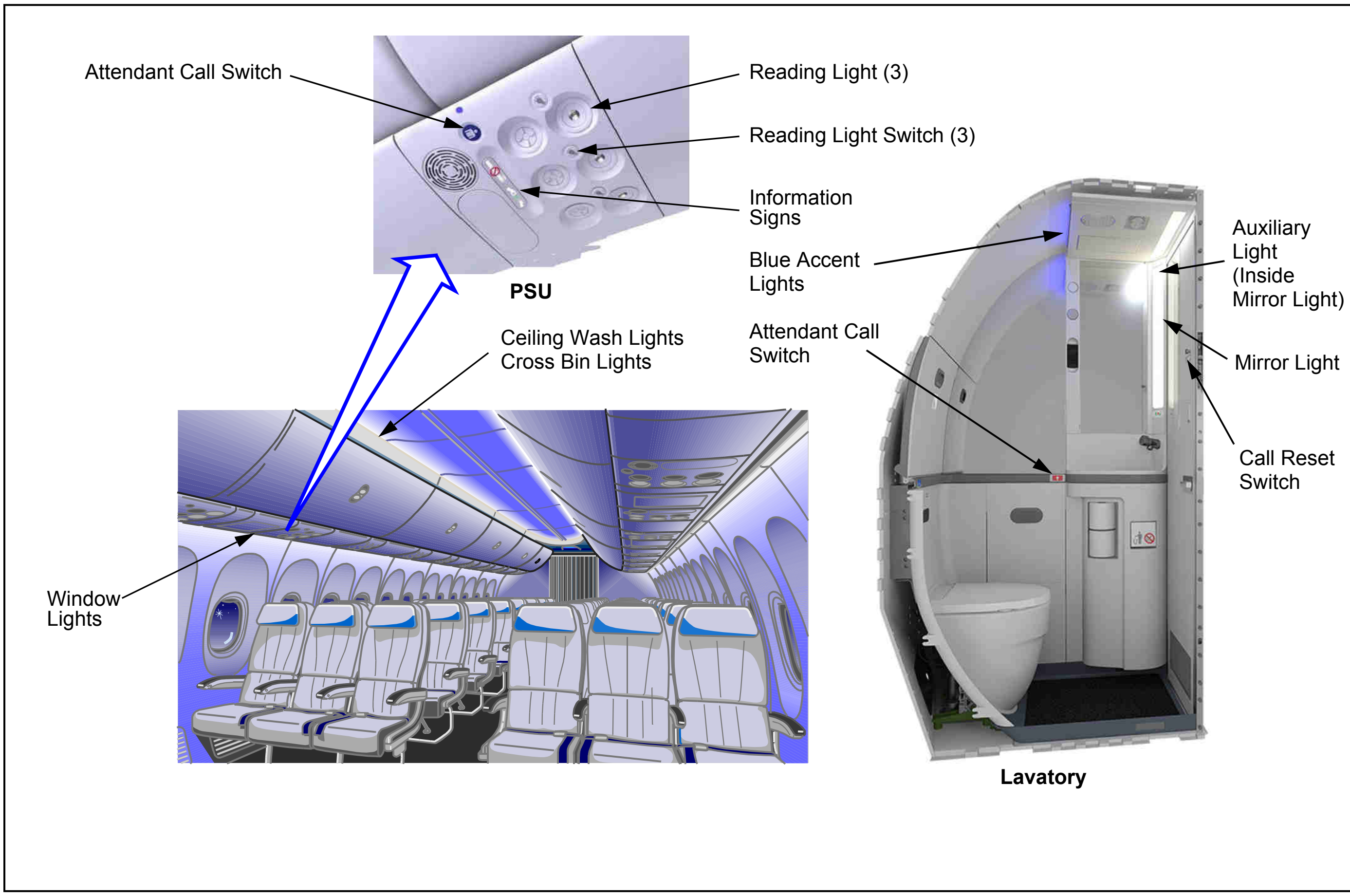
Exterior lights supply light for each emergency escape egress area. They are on the fuselage skin in these areas:

- Forward and aft entry doors
- Forward and aft service doors
- Overwing emergency exit doors.

BATTERY PACKS

The battery packs can automatically operate the emergency lights when DC Bus 1 loses power. A fully charged battery can supply power to operate emergency lights for ten minutes.

Control of these lights is usually automatic. The lights can be operated manually from the P5 overhead panel or the aft attendant panel.



Interior Lights

PASSENGER COMPARTMENT LIGHTING

Light for the passenger compartment is supplied by LED assemblies.

Ceiling lighting consists of two types of lights:

- Ceiling wash lights
- Ceiling cross-bin lights

These lights are on top of each stowage bin. The ceiling wash lights have red, green, blue and white LED's that make 32 different colors. The cross bin lights have LED's that are cool white, warm white and amber. Each assembly has a ceiling wash light and a cross bin light. The ceiling wash lights supply light to the ceiling. The cross bin lights supply light to the overhead stowage bins.

Window lights supply light to the areas below the stowage bins. The lights are below the stowage bins and above the windows. Each window light assembly has red, green, blue and white LED's that make 32 different colors.

Ceiling and window lights are controlled from the forward and aft attendant panels.

READING LIGHTS

Reading lights for each passenger are in the passenger service units (PSU) above each seat. A push-button on-off switch is adjacent to each light. Reading lights are LED's.

LAVATORY LIGHTS

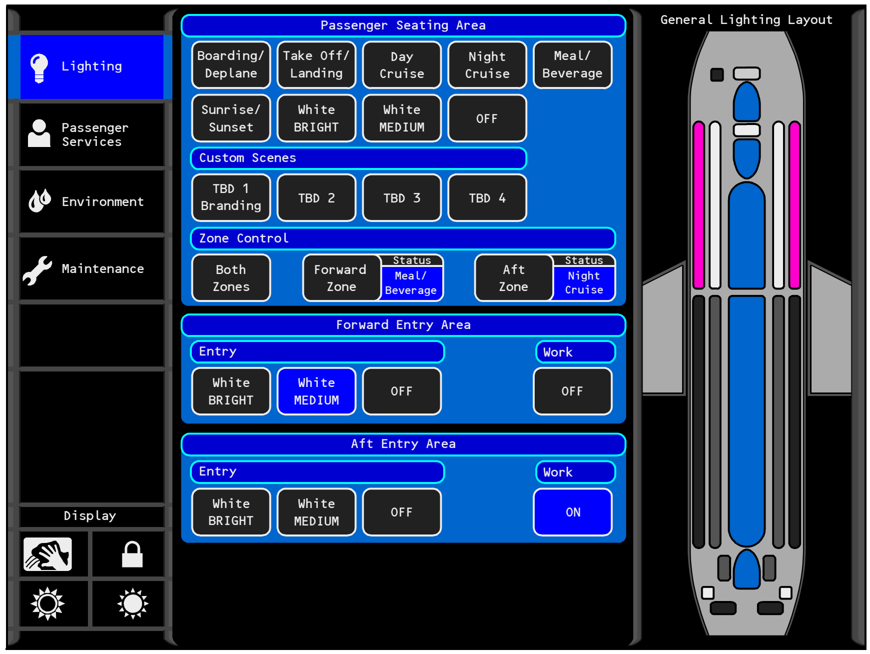
All lighting in the lavatories is LED. The lights consist of:

- Blue accent lights
- Auxiliary light
- Mirror light

The blue accent lights and the auxiliary light are on when the airplane has power. When you put the door switch to the locked position, the mirror lights come on.

BOEING PROPRIETARY

Lights



Sky Interior Lighting

The Boeing Sky Interior lighting allows the flight attendants to select both standard and custom lighting scenes in the passenger compartment.

The light screen on the attendants panels have the following windows:

- Passenger seating area
- Forward entry area
- Aft entry area.

The passenger seating area window controls the standard and custom scenes in the passenegr seating zones.

There are nine standard scene selections for the passenger seating area. There are also four optional custom scenes.

The forward and aft entry area windows control the lights in their respective areas.

BOEING PROPRIETARY

- **Features**
- **Forward Airstair**
- **Forward Airstair Operation**
- **Exterior Doors**
- **Exterior Door Operation**
- **Door Warning Lights**
- **Emergency Escape Slides**
- **Flight Compartment Door Locking System**

Features

AIRSTAIRS

A self-contained forward airstair is optional on the 737 MAX. The airstair gives airport terminal self-sufficiency. No ground support equipment is necessary for passenger boarding.

EXTERIOR DOORS

These exterior doors give access to all compartments and service areas:

- Passenger entry doors
- Service doors
- Cargo doors
- Compartment doors.

EMERGENCY EGRESS/RESCUE

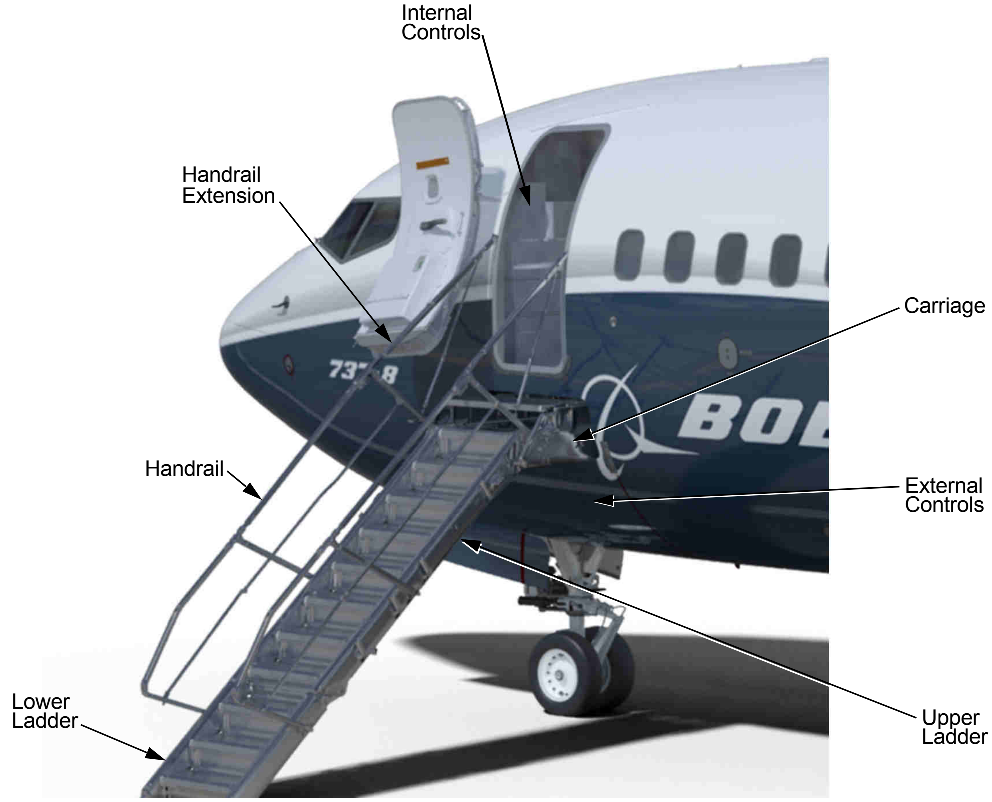
Emergency exit doors add to the emergency escape and rescue paths.

Flight compartment windows slide open to give emergency escape and rescue paths. Rescue personnel can open the first officer (F/O) window from outside.

FLIGHT COMPARTMENT DOOR

The flight compartment door divides the flight compartment from the passenger cabin. The door allows selective entry into the flight compartment.

Airplane Access



Forward Airstair

A self-contained forward airstair is optional on the 737 MAX. The airstair allows the airplane to operate at airports with no ground support equipment. The airstairs are stowed under the floor of the forward entry door.

The internal control panel is on the forward attendant panel and the external control panel is aft of the airstair door on the airplane fuselage skin.

These are the airstair major components:

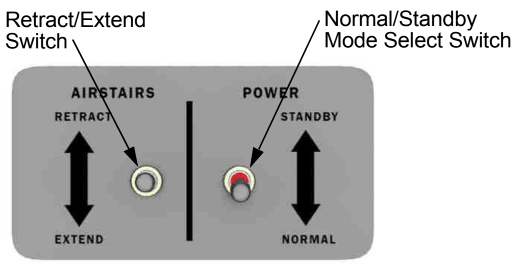
- Airstair door
- Airstair rails
- Carriage
- Upper and lower ladders
- Upper and lower handrails
- Airstair control relays
- Airstair drive motors and drive gearing
- Airstair controls.

All airstair components are in the EE compartment except the controls.

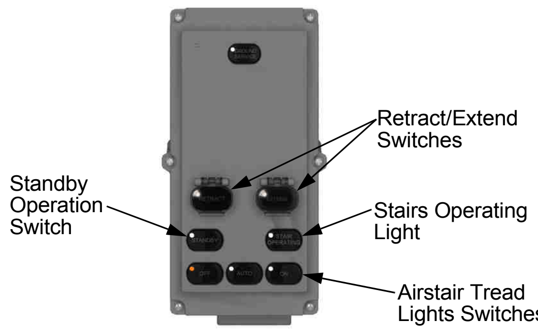

Airstair fully retracted


Airstair Partially Extended


Airstair Fully Extended



External Controls (Fuselage Skin)



FWD Attendant Panel

Forward Airstair Operation

The airstair has an electrical drive. It can extend in two different modes:

- Normal mode
- Standby mode.

The airstair extension occurs in this sequence:

- Airstair door unlocks and opens
- Airstair extends from the airplane (folded)
- Airstair ladders and handrails unfold
- Airstairs touch the ground and fully extend
- Power is automatically removed from the drive motors
- Upper handrails manually extend and attach to the inside of the forward entry door.

The retraction process is the reverse order of the extension.

These items must be done before operation of the airstair to prevent damage to equipment and injury to personnel:

- Make sure the area outside the forward entry door is clear
- Do not extend or retract the airstair in winds of more than 40 knots or in jet blast
- Stow and secure the upper handrails before operation of the airstairs
- Do not walk on the airstair until it completely extends.

CONTROLS AND INDICATION

Simple controls and indication reduce crew work load.

The airstair operation sequences are automatic. The extension and retraction sequences use power, except for the manual extension and stowage of the upper handrails.

Control circuits prevent retraction of the airstair when the upper handrails are not properly stowed.

These conditions permit the operation of the airstair from the interior control panel:

- Forward entry door must be open
- AC or DC power available.

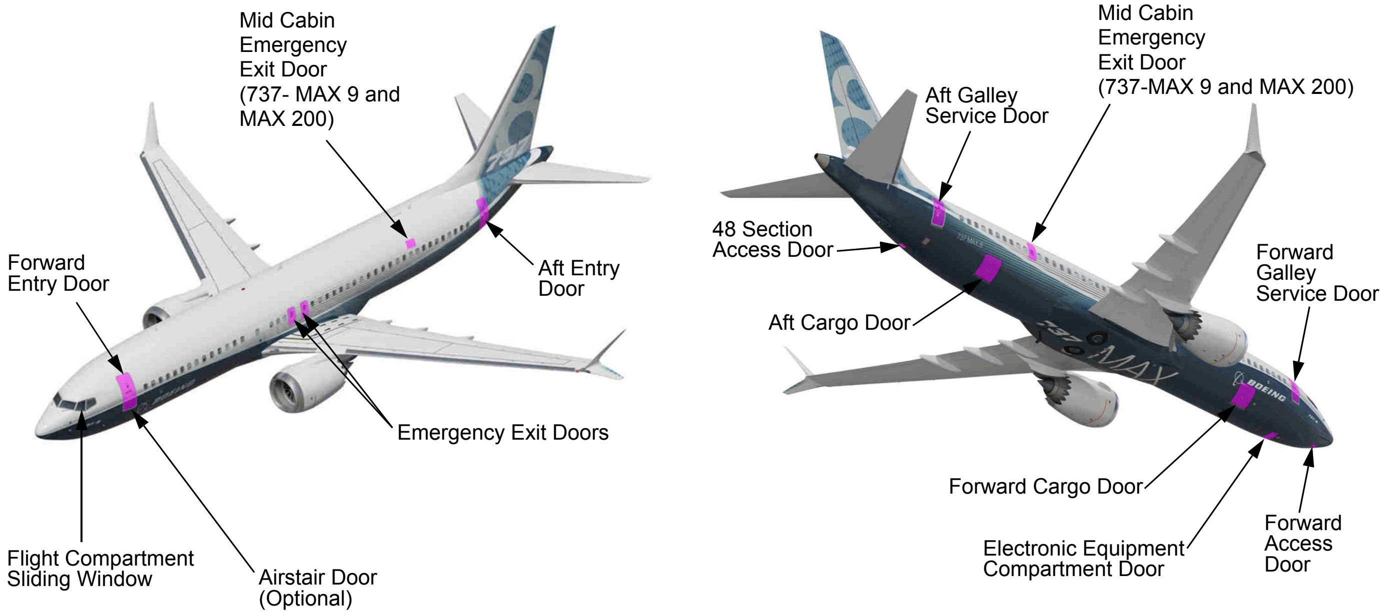
FEATURES

There are tread lights on the stair riser panels.

The airstair operates from the airplane battery during standby mode.

The airstair can extend and retract manually if the airstair drive system fails.

Airplane Access



Exterior Doors

GENERAL

The doors are part of the airplane primary structure. The plug-type doors take cabin pressure loads. Latch mechanisms hold the doors closed during unpressurized operations. Door pressure pins transmit pressure loads to pads on the door frame during pressurized operations.

Exterior handles align with the fuselage to decrease drag.

The doors operate manually. Some doors have spring-loaded counterbalance mechanisms. These decrease the force necessary to open the doors.

ENTRY AND SERVICE DOORS

The entry and service doors open outward. These are their features:

- Lock mechanism on the upper hinge holds the door open in high wind conditions
- Windows with orange escape slide warning pennants
- Escape slides for emergency exit.

Make sure the automatic slide is not armed before you open the entry or service doors. This prevents injury to personnel and damage to equipment. When the slides are armed, the orange warning pennant is put across the door window.

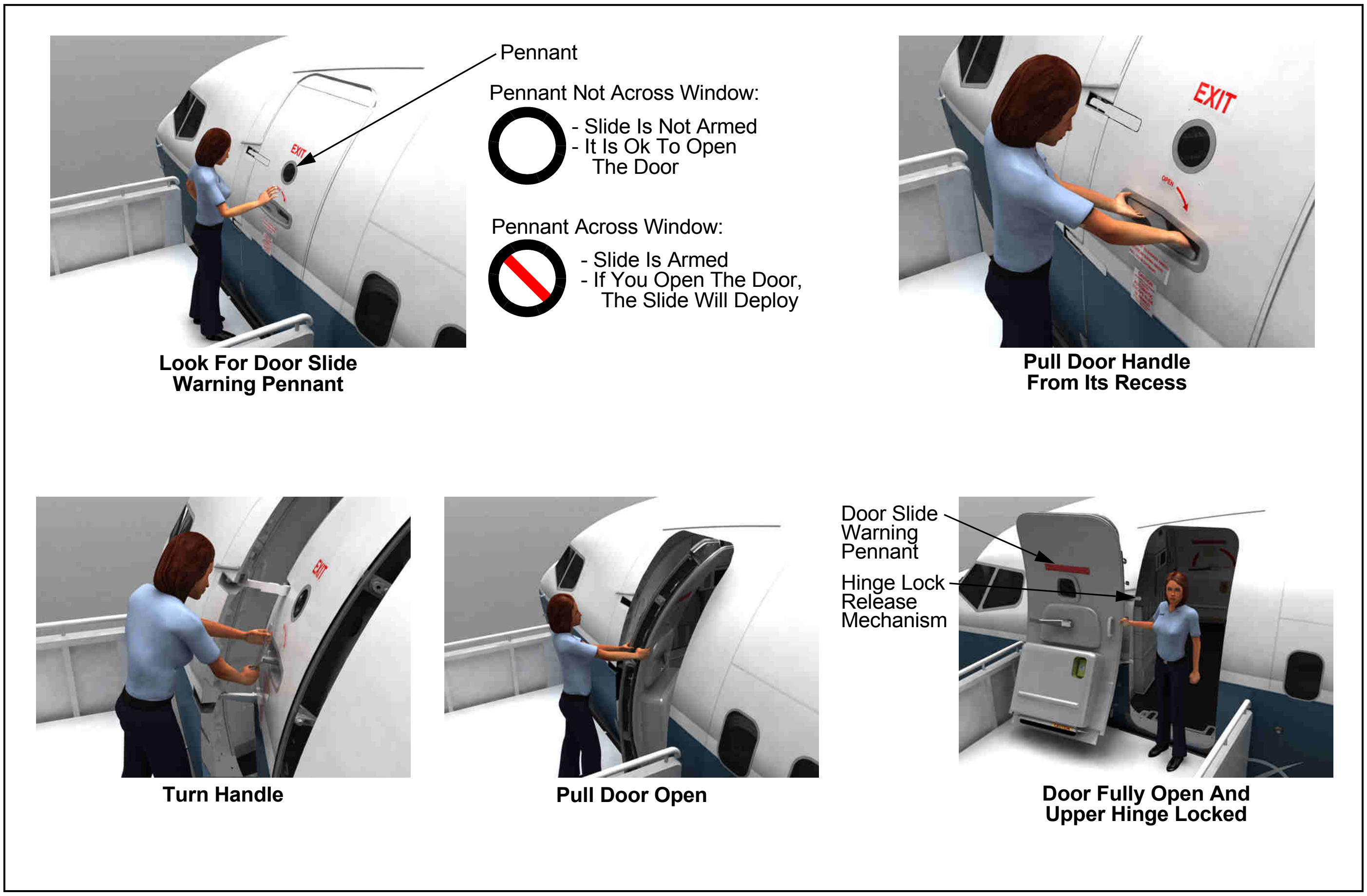
EMERGENCY ESCAPE/RESCUE

Emergency exit doors supply additional exits for the passengers if there is an emergency. The doors open outward when the interior handle or exterior vent panel are operated. Opening is by two counterbalance actuators and one hydraulic snubber.

The flight compartment sliding windows supply emergency exit paths. The first officer window has an exterior release for rescue operations.

CARGO DOORS

The forward and aft cargo doors open inward. They have spring-loaded counterbalance mechanisms and over-center uplocks for easy operation.



Look For Door Slide Warning Pennant

Pull Door Handle From Its Recess

Turn Handle

Pull Door Open

Door Fully Open And Upper Hinge Locked

Exterior Door Operation

First, the operator must ensure that the emergency escape door slide is not in the armed position before opening the door.

The exterior door control handle is pulled out from the recessed position to engage the door mechanism.

The handle is now turned 180 degrees in the clockwise direction which moves the door to the cocked position.

The door may now be pulled to the fully open position and the hinge lock engages to hold the door in the open position.

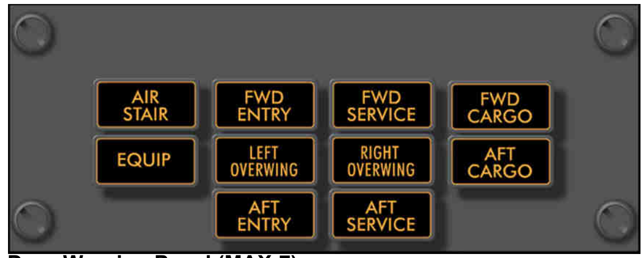
To close the door, the hinge lock is first released and then the door is swung into the closed/cocked position. The handle can now be used to fully close the door.

To drevent damage to equipment and injury to personnel, do not open or close the doors in winds of more than 40 knots or in jet blast.

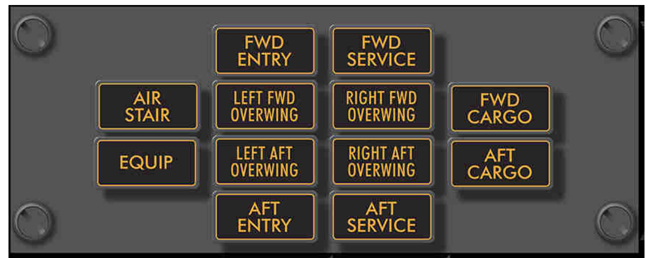
You can let the door stay latched open in winds up to 65 knots.

Airplane Access

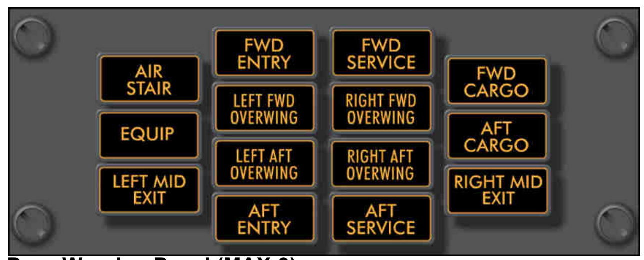
P5 Forward Overhead Panel



Door Warning Panel (MAX-7)



Door Warning Panel (MAX-8)



Door Warning Panel (MAX-9)

Door Warning Lights

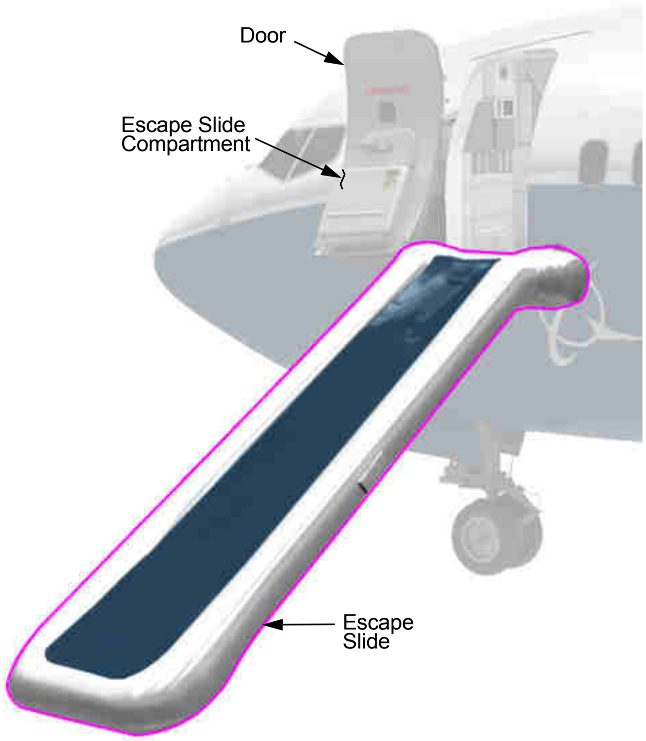
CONTROLS AND INDICATION

Amber lights on the P5 forward overhead panel show if there is an unlocked door.

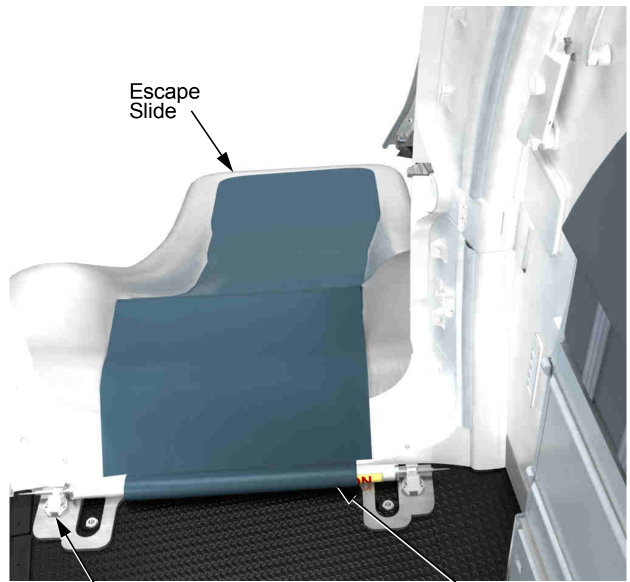
The door latch and lock mechanisms use micro-switches or proximity sensors for the door warning system.

The EQUIP light is for the EE compartment door and the forward equipment compartment door.

The pilot sliding windows are not part of the door warning system.



Escape Slide



Escape Slide Floor Brackets

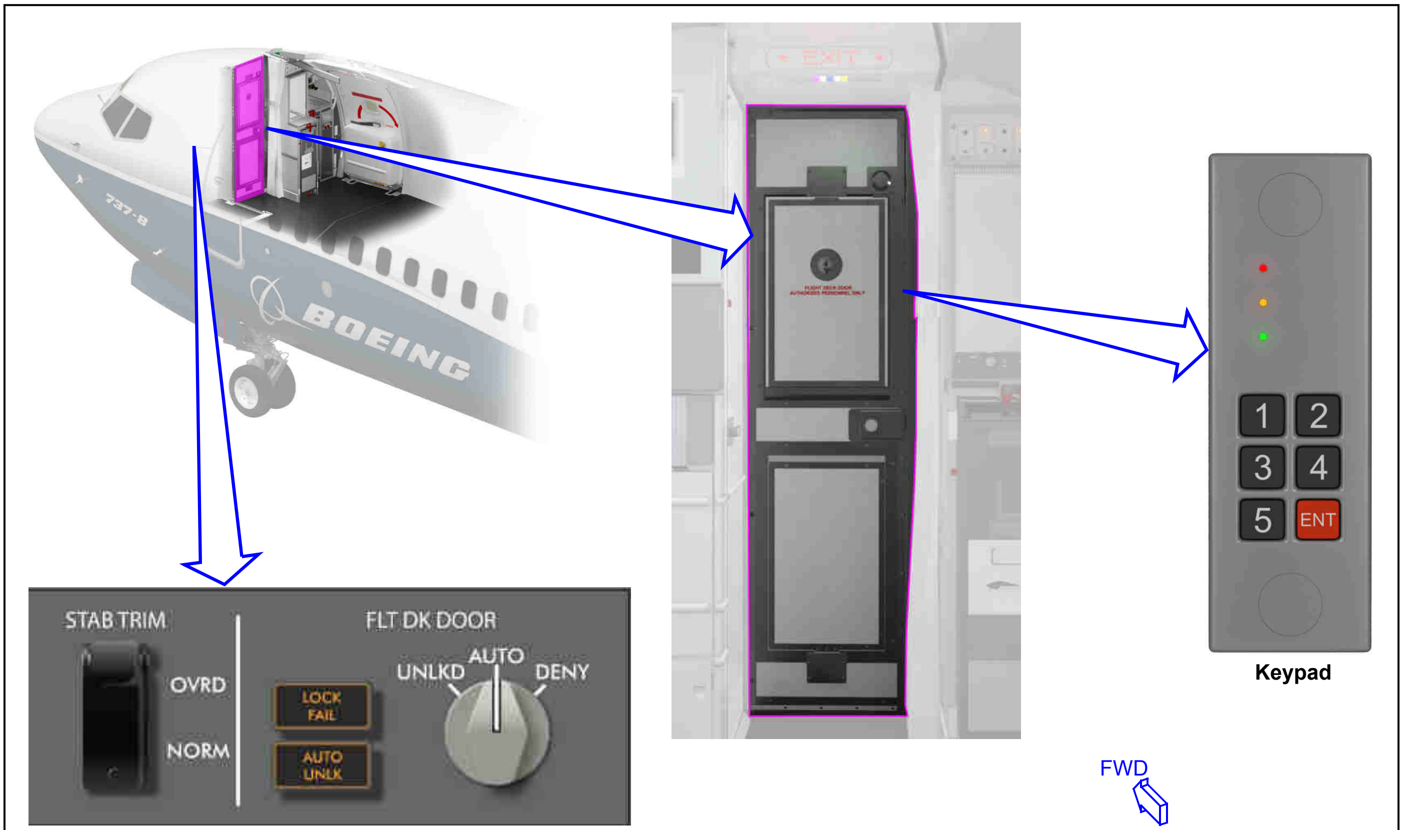
Emergency Escape Slides

The emergency escape slides help passengers and crew evacuate the airplane in an emergency. If the airplane lands in water, the escape slides can be disconnected from the airplane and used as flotation devices.

The escape slides are made of neoprene coated nylon fabric with an aluminum coating. Each slide is stowed inside a compartment on the inside of each entry and service door.

The escape slides are armed and disarmed manually from inside the airplane.

Airplane Access



Keypad

Door Control Panel (P8)

Flight Compartment Door Locking System

The flight compartment door divides the flight compartment from the passenger compartment. The door provides the flight crew with the ability to deny entry to the flight compartment. The door and and surrounding structure have ballistic properties for security.

The door may be opened from the flight compartment using the selector on the door control panel.

The keypad can be used to make a request to the flight crew to unlock the door. In emergencies, a security code can be entered to gain access to the flight compartment.

Abbreviations and Acronyms

A

AC, ac	alternating current
ACARS	aircraft communication and reporting system
ACM	air cycle machine
ACMS	airplane condition monitoring system
ACP	audio control panel
ADF	automatic direction finder
ADIRU	air data inertial reference unit
ADM	air data module
AOA	angle of attack
AOV	aft outflow valve
APB	auxiliary power unit breaker
APU	auxiliary power unit
ARINC	aeronautical radio, incorporated
A/T	autothrottle
ATC	air traffic control

B

BCF	bromochlorodifluoro-methane
BITE	built-in test equipment
BPCU	bus protection control unit
BSV	burner staging valve
BTB	bus tie breaker

C

CAPT	captain
CDU	control display unit
CIC	corrosion-inhibiting compound
CP	control panel
CRT	cathode ray tube

D

DC,dc	direct current
DFCS	digital flight control system
DFDAU	digital flight data acquisition unit
DH	decision height
DLD	dynamic load damper
DME	distance measuring equipment
DMM	data memory module
DPC	display processing computer
DU	display unit

E

EAU	engine accessory unit
ECS	environmental control system
ECU	electronic control unit
EDP	engine driven pump
EE	electronic equipment
EEC	electronic engine control
EFIS	electronic flight instrument system
EGT	exhaust gas temperature
EI	engine indication
EIS	engine instrument system
EMDP	electric motor-driven pump
EPC	external power contactor
ETA	estimated time of arrival

F

FCC	flight control computer
FFM	force fight monitor
FDR	flight data recorder
FDRS	flight data recording system
FMC	flight management computer
FMCS	flight management computer system
FMS	flight management system
FO	first officer
FQIS	fuel quantity indicating system
FSEU	flap/slat electronics unit
ft	feet
FWD	forward

G

G/S	glide slope
gal	gallon
GCB	generator control breaker
GCU	generator control unit
GPS	global positioning system
GPSSU	global positioning system sensor unit
GPWC	ground proximity warning computer
GRD	ground
GV	guide vane (may not be used)

H

HF	high frequency
HGW	high gross weight

Abbreviations and Acronyms

HMU	hydromechanical unit
HP	high pressure
HPTACC	high pressure turbine active clearance control
hrs	hours
HSI	horizontal situation indicator

I

IDG	integrated drive generator
IDU	interactive display unit
IFSAU	integrated flight systems accessory unit
ILS	instrument landing system
in	inches
Inst	instruments
INV	inverter
IRS	inertial reference system
ISDU	inertial system display unit

J

K

KCAS	knots calibrated airspeed
kg	kilogram
kVA	kilovolt-ampere

L

L	left
lbs	pounds
LCD	liquid crystal display
LE	leading edge
LNAV	lateral navigation
LPTACC	low pressure turbine active clearance control
LRU	line replaceable unit

M

m	meters
MASI	mach airspeed indicator
MCP	mode control panel
MDS	MAX display system
MG	main gear
MIC	microphone
MSU	mode select unit
MU	management unit

N

N1	fan and low pressure compressor reference
N2 high pressure compress or reference	ND navigation display
NG	nose gear
No.	number

O

OOOI	out of the gate, off the ground, on the ground, into the gate
OVHT	overheat

P

PA	passenger address
pcu	power control unit
PDP	power distribution panel
PFD	primary flight display
PRSOV	pressure regulating and shutoff valve
PSI	pounds per square inch
PSU	passenger service unit
PTT	push to talk
PTU	power transfer unit

Q

R

R	right
R/T-I/C receive/ transmit	intercomm
RA	radio altimeter
RA	resolution advisory
RCP	radio control panel
REU	remote electronics unit
RMI	radio magnetic indicator
RPM	revolutions per minute
RTO	refused takeoff

S

SATCOM	satellite communication
SCU	starter converter unit
SELCAL	selective call
Stdby	standby

T

TA	traffic advisory
TAI	thermal anti ice
TAT	total air temperature
TBV	transient bleed valve

TCAS	traffic alert and collision avoidance system
TCV	temperature control valve
TE	trailing edge
TLA	thrust lever angle
TOGA	takeoff / go-around
TR	transformer rectifier
TR	thrust reverser
typ	typical

U

V

VAC	volts alternating current
VBV	variable bleed valve
VCD	vortex control device
VDC	volts direct current
VHF	very high frequency
VHF NAV	very high frequency navigation
VNAV	vertical navigation
VOR	VHF omnidirectional range
VR	voltage regulator
VSV	variable stator vanes

W

WTAI	wing thermal anti ice
WTRIS	wheel-to-rudder interface system
WXR	weather radar

X

Y

Y/D	yaw damper

Z

Intentionally
Blank