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1. Aircraft Overview

1.1 General

The Eclipse 500 is a twin-turbofan aircraft powered by two Pratt & Whitney Canada PW610F-A engines. It is a five- to six-place, low-wing, T-tail aircraft using conventional aircraft semi-monocoque structural elements joined together using both friction stir welding and mechanical fasteners. The primary aircraft structure is aluminum with limited use of composite materials in secondary structural areas such as fairing and floor panels.

The Eclipse 500 is an 'all electric' aircraft and uses conventional mechanical flight controls that do not require hydraulics, except for the master brake cylinders.

In general the management of the Eclipse 500 is divided into four functional areas:

1. Avio Integration (ACS and PFD)
2. Thrust Control (Throttles and Engine Control Systems)
3. Emergency Controls (Left Switch Panel Hard Switches)
4. Flight Controls (Mechanical Flight Control System)

The avionics system on the Eclipse 500 provides total aircraft integration through redundant computer systems that provide the pilot centralized control of most aircraft systems and functions. The Electronic Flight Instrument System (EFIS) consists of two 10.4 inch Primary Flight Displays (PFDs) and a 15.3 inch Multi Function Display (MFD). Referred to as Avio™, the Eclipse 500's avionics increase safety and reduce pilot workload.

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Figure 1. Eclipse 500

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1.2 Aircraft Dimensions

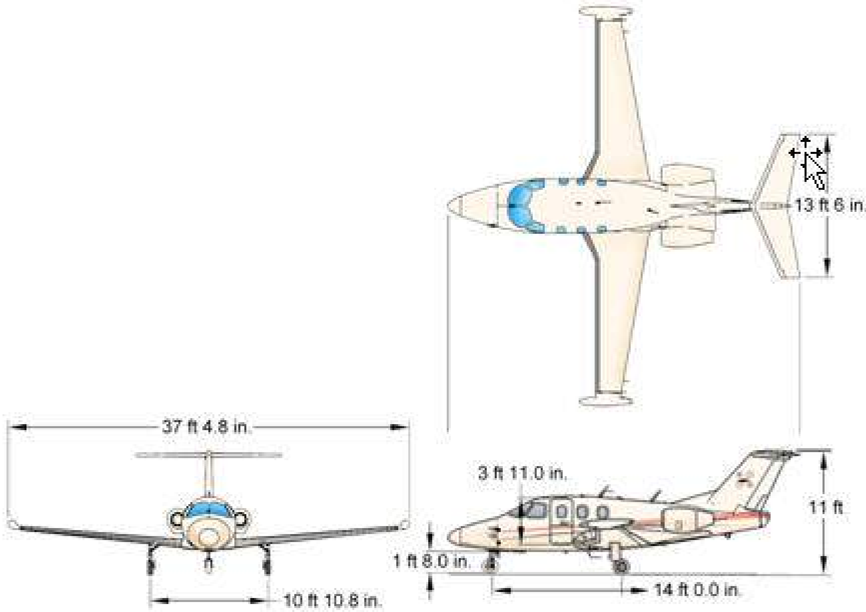

Figure 2. Aircraft Dimensions

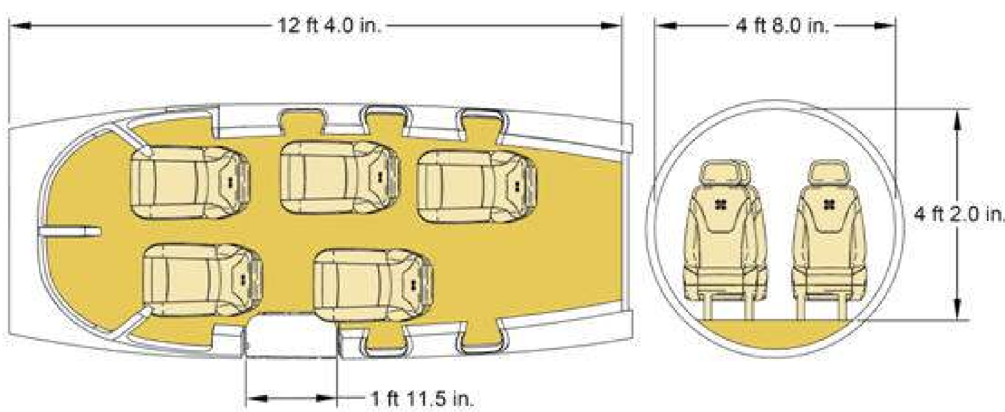

Figure 3. Cabin Dimensions

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1.3 Seating Arrangements

Standard seating is a five place configuration; however an optional six seat is available. Seats may be removed from the aircraft to provide additional space. Removal of seats is accomplished by pulling four release wires at the base of each seat. Doing so releases the seat base from the tracks; it can then be slid forward and removed.

For ease of entry and stowing baggage passenger seats have a lever on the aisle facing side that allows the seats to fold forward. To return the seats to the upright position, push the seatback up and aft until it locks in position.

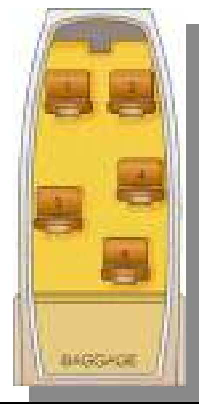

Figure 4. Standard Five Seat Configuration

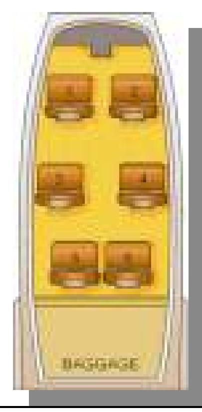

Figure 5. Six Seat Configuration

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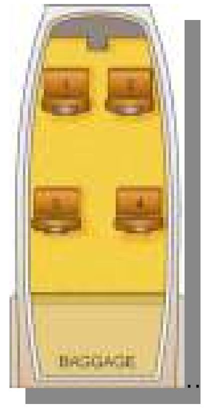

Figure 6. Four Seat Configuration

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1.4 Performance and Capabilities

1.4.1 Performance

Below is a table of key performance data of interest to the pilot.

Table 1. Performance Data

Performance		Design Speeds	
Max Cruise Speed (at 4,950 lbs, ISA conditions, 35,000 ft)	370 KTAS	V_s (Stall speed clean configuration)	90
NBAA IFR Range, 4 Occupants (at high speed, 200 lb Pilot + 3 170 lb Passengers)	1,155 nm	V_{SO} (Stall Speed landing configuration)	70
Time to Climb, 35,000 ft	19 min.	V_o (Operating maneuvering speed)	180
Max Climb rate (Both Engines, Takeoff Power)	3,314 fpm	V_{MO} (Max Operating Limit Speed)	275
Single engine climb rate	888 fpm	M_{MO} (Max Operating Mach Number)	0.64 M
		V_{FE} (Flaps TO)	200
		V_{FE} (Flaps LDG)	120
		V_{LE}	275
		V_{LO}	200
Limit Load Factors		**Operational Limitations**	
Flaps UP	+3.62/-1.45 g's	Max operating altitude	41,000 ft
		Max Cabin Pressure Differential	8.7 PSI
		Single engine service ceiling	25,000 ft

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1.4.2 Aircraft Parameters and Capabilities

Below is a table detailing key aircraft parameters and capabilities of interest to the pilot.

Table 2. Aircraft Parameters and Capabilities

Cabin		**Weights**	
Cabin Length (Pressure Vessel)	148 in	Max Ramp Weight	5,800 lbs
Height	50 in	Max Landing Weight	5,415 lbs
Width	56 in	Max Takeoff Weight	5,760 lbs
Aisle Width	9 in	Max Zero fuel Weight	4,860 lbs
Luggage Area	16 ft^3 / 260 lbs	Useful Load	2,266 lbs
Operating Pressure (8,000 ft cabin @ 41,000 ft)	8.33 psi	Total Fuel Capacity	1,540 lbs
Pressurized Volume	240 ft^3	Total Useable Fuel	1,516 lbs
Wing		**Power Plant**	
Wing Span	37.4 ft	Two Pratt & Whitney 610F turbofan engines	900 lbs Thrust
Wing Sweep	0^o leading edge	**Design Life**	
Wing Area	144.4 ft^2	Hours	20,000 hours
Aspect Ratio	8.88	Cycles	20,000 cycles

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1.5 Eclipse 500 Aircraft Systems

The Eclipse 500 Aircraft systems are divided into four major functional areas

1. Avio Avionics Suite
2. Thrust Control
3. Essential Systems
4. Mechanical Flight Controls

1.5.1 Avio Avionics Suite

The Eclipse 500 integrated avionics system provides may of the required controls and displays, sensor data processing and aircraft subsystem monitoring and control. Details on this functional area of Avio are contained within chapter 2, “Avio Avionics Suite.”

1.5.2 Thrust Control

The Eclipse 500 is a twin turbofan jet powered by two Pratt & Whitney Canada PW610F-A high-bypass turbofan engines. These engines produce high fuel efficiency and lower noise output in comparison to an average turbojet engine. The control of thrust in the Eclipse 500 does not require Avio in order to continue to operate. The engine thrust control has three basic elements:

1. Throttles
2. Full Authority Digital Engine Control (FADEC) units
3. Fuel Metering Units (FMUs)

The use of dual FADEC channels, increases redundancy and heath monitoring capability. Thrust is manually set using two throttles or automatically set using the autothrottle system.

1.5.1 Essential Systems

The essential systems in the Eclipse 500 are designed to operate autonomously in the event failure occur and by design, do not require Avio in order to operate. These systems are:

1. Battery power, and control of electrical contactors
2. Electrical Circuit Protection
3. Oxygen & Passenger Masks
4. Emergency Gear Extension
5. Cabin Pressurization Dump
6. Emergency Locator Beacon

1.5.2 Mechanical Flight Controls

The elevators, ailerons and rudders are all actuated by the pilot through the side sticks and rudder pedals by mans of pushrods, cables, bell cranks and pulleys.

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1.6 Audio

1.6.1 Cabin Speakers

There are two cabin speakers for an additional source of audio in the event of an inoperative headset or other pilot requirement. The Cabin Speakers are turned off during normal operations. However, by pressing the “SPKR” button on the Pilot’s (the left side) keyboard, the COM1/COM2 audio is sent to the Pilot’s speaker. By pressing the “SPKR” button again, the Pilot’s cabin speaker is turned off. An LED positioned just above the SPKR button on the Keyboard is illuminated to indicate that the speaker is selected. The volume control on the Pilot’s keyboard can be used to adjust the speaker volume.

The Copilot’s keyboard (if installed) controls the audio sent to the Copilot’s speaker in the same manner as the Pilots controls.

Speaker functionality is outlined in Section 15.9 “Keyboard”

1.6.2 Handheld Microphones

There are two hand held microphones (Pilot’s and Copilot’s). Each handheld microphone has a built-in Push-To-Talk switch. There is a separate handheld microphone jack on each of the flight crew ’s armrests so that the handheld microphones (used primarily as backup for the headset microphones) can remain plugged in along with the headset or boom microphones.

The left handheld microphone is permanently wired to the Left PFD, and the right handheld microphone is permanently wired to the Right PFD. The COM SOURCE switch located on the left switch panel does not affect these microphones; they always remain connected to the on-side PFD.

When a member of the flight crew pushes the handheld Push-To-Talk button, the microphone audio is transmitted over COM1 or COM2, depending on the flight crew/member’s radio selection.

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1.7 Emergency Equipment

1.7.1 Fire Extinguisher

In the event of a cabin or cockpit fire a "BC" rated halon fire extinguisher is located below the throttle quadrant. The safety pin should be checked prior to flight and may be retained with a plastic band to prevent inadvertent fire extinguisher activation. The halon extinguishing agent may make breathing difficult and use of the fire extinguisher should be accompanied with the use of an oxygen mask and smoke goggles (if available).

Figure 7. Fire Extinguisher

1.7.2 Emergency Exits

The aircraft has a designated emergency exit located on the right side of the aircraft to be used in the event that the primary (left-side) exit is rendered unavailable. This door weighs approximately 12 lbs. To open the door:

- Remove the cover
- Pull the red handle to release the door
- Pull the door in to rotate approximately 90°
- Place door through exit hatch and discard on aircraft wing.

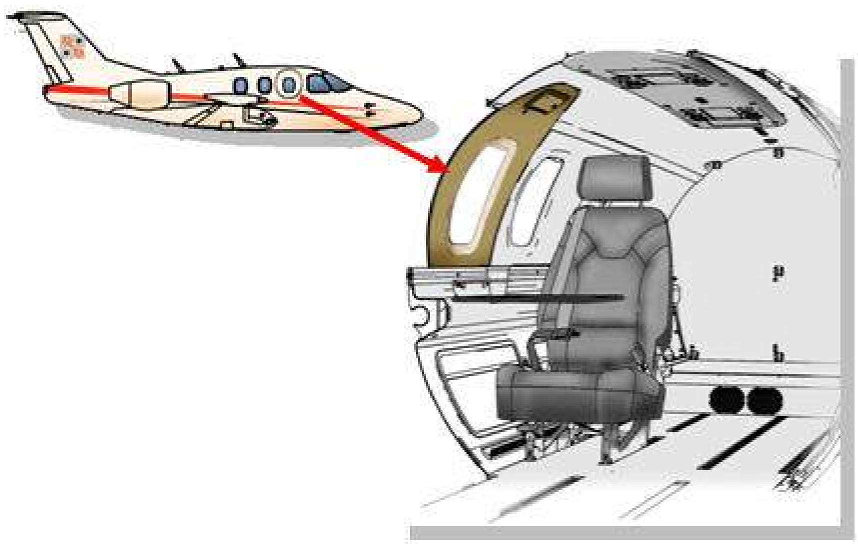

Figure 8. Emergency Exit

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1.7.3 Oxygen

The airplane is equipped with an oxygen system for use by the pilots and passengers in the event of a loss of cabin pressurization or presence of smoke or fumes in the cockpit. The Eclipse 500 is equipped with either a 22 cubic foot oxygen bottle or an optional 40 cubic foot oxygen bottle. The 40 cubic foot bottle option also includes a right pilot seat quick donning mask. There are four constant flow oxygen masks for the rear passenger seats as well as a constant flow oxygen mask for the right front passenger/pilot seat.

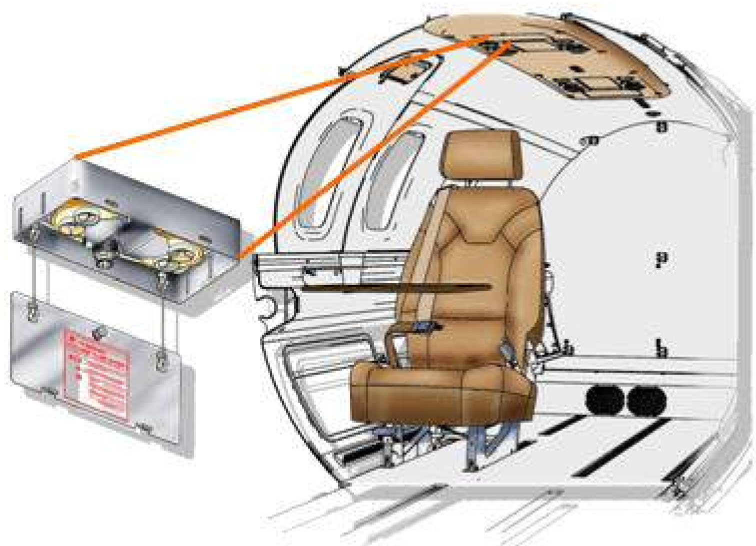

Figure 9. Passenger Oxygen

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1.8 Aircraft Overview Review Questions

1. **The only hydraulic system on the Eclipse 500 is:**
   a. The flight control system
   b. The wheel braking system
   c. The landing gear actuators
   d. All of the above are hydraulically operated

2. **What material is the primary aircraft structure composed of?**
   a. Plastic
   b. Fiberglass
   c. Titanium
   d. Aluminum

3. **Describe how to remove seats from the Eclipse 500:**

4. **The useful load of the Eclipse 500 is:**
   a. 2,250 lbs
   b. 2,500 lbs
   c. 2,266 lbs
   d. None of the above

5. **Maximum Zero Fuel Weight is:**
   a. 5,000 lbs
   b. 4,000 lbs
   c. 4,860 lbs
   d. None of the above

6. **The maximum operating altitude for the Eclipse 500 is:**
   a. FL 250
   b. FL 500
   c. FL 250
   d. FL 410

7. **The design life of the Eclipse 500 is 20,000 hours or:**
   a. 18,183 cycles
   b. 35 years
   c. 40 years
   d. 20,000 cycles

8. **The single engine service ceiling is:**
   a. 25,000 feet
   b. 35,000 feet
   c. 41,000 feet
   d. None of the above

9. **What are the four major functional areas that comprise the Eclipse 500?**
   a.
   b.

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c.

d.

10. In the optional configuration, what is the maximum seating capacity of the Eclipse 500 (including both front pilot seats)?

a. Five
b. Six
c. Seven
d. Four

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2. Avio Avionics Suite

2.1 General

The Avio Avionics Suite is a highly integrated avionics system that serves as the basic systems architecture and interfaces with almost every aircraft function. Avio is divided further into five functional areas.

1. Aircraft Computer Systems
2. Pilot Displays
3. Pilot Controls/Interfaces
4. Primary Sensors
5. Aircraft Subsystems (Electrical Power Generation/Distribution)

While there are five functional areas, the two Primary Flight Displays (PFDs) and two Aircraft Computer Systems (ACS') are considered the pillars of the avionics system. Through a series of 30 data busses that interconnect all components of the avionics, many of the operations of the aircraft are routed through a combination of these four components. Data busses are electrical paths used to transfer data and instructions back and forth between two computers and can be thought of as the pipes through which information flows. It is along these data busses that commands are sent to the aircraft and systems status information is then returned to the pilot.

Figure 10.   Cockpit Layout

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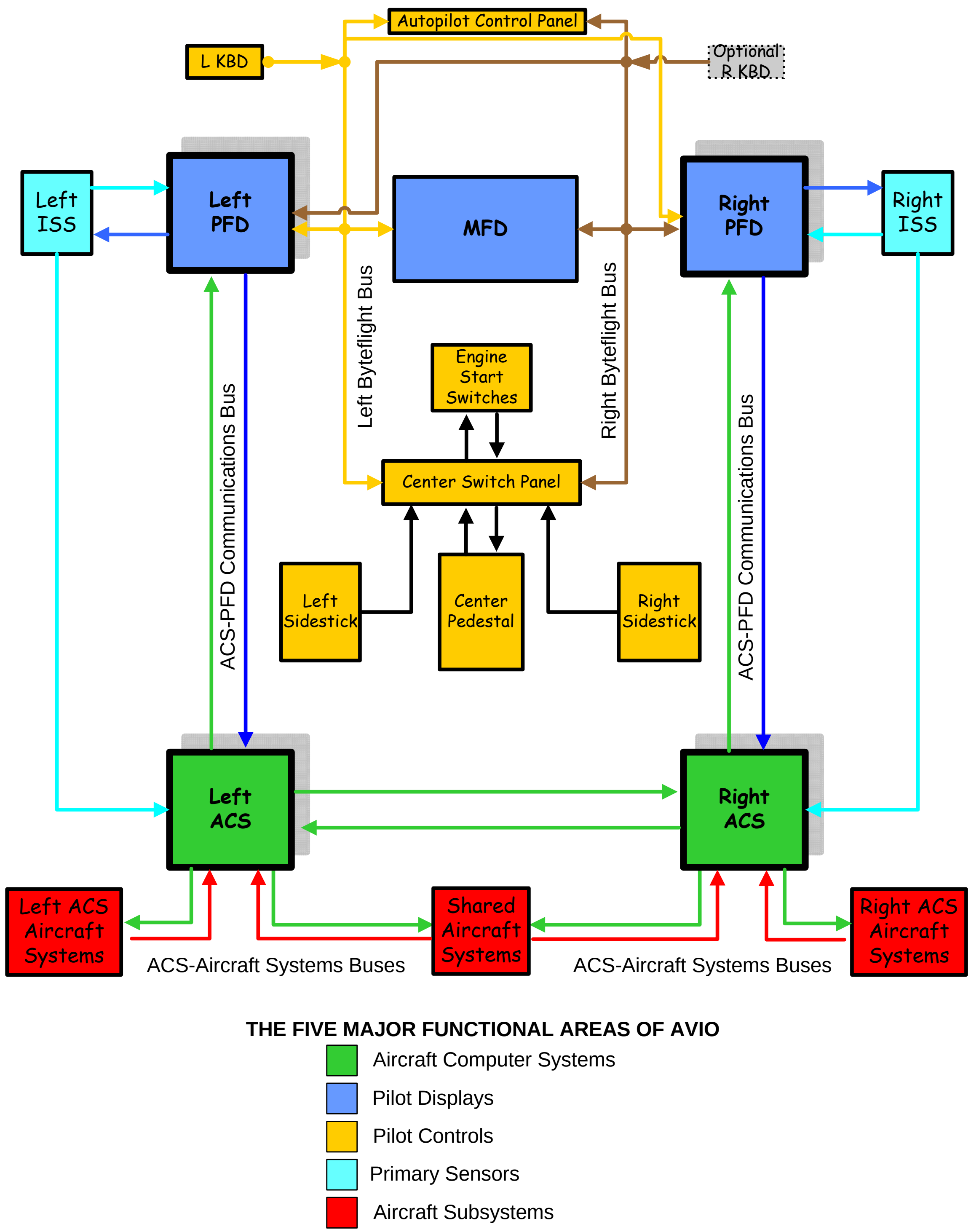

Figure 11. Avionics Architecture

2.2 Aircraft Computer Systems

The Aircraft Computer System (ACS) consists of two identical ACS computers. Each ACS unit is co-located with one of the aircrafts two Full Authority Digital Engine Controller (FADEC) units in a Line Replaceable Unit known as an Avio Processing Center (APC). The left Avio Processing Center is located along the left aft fuselage wall, while the right Avio Processing Center is located underneath the baggage compartment floor.

While these units are physically the same, each individual (left or right) ACS will perform slightly different operations. The ACS has three primary functions

- Command and Control of Systems- activation, deactivation, load shedding
- Performs Pilot Commands
- Monitors and Reports- Fault Sensing

2.2.1 Command and Control of systems

The command and control of systems capability of the ACS allows the pilot the primary means of systems control on the Eclipse 500. Unlike aircraft cockpits of the past, the Eclipse 500 is devoid of many of the various switches, levers and other manual controls for aircraft systems. In its place, the pilot's interface takes place primarily through the use of line select key controls on various aircraft systems synoptic pages normally located on the MFD.

There are two types of automation that the Eclipse 500 utilizes. One type of automation involves decisions that require speed that is faster than a pilot can make. This type of automation is exemplified by the engine control system (FADEC- Fully Automated Digital Engine Control). The engine demands that fuel control decision to the engine must be made many times per second, each time taking into account a range of aircraft parameters such as outside air temperature, air speed, and altitude. In cases like this, the pilot is informed of overall performance (Indicated Turbine Temperature (ITT), N1 and N2 turbine speeds and oil pressure) to verify that the engine is performing within its design limits

The other kind of automation is aimed at reducing pilot workload. In many cases functions that are routine or unnecessarily burdensome have been automated. An example of this is the command of the electric fuel pumps. For most normal operations, the electric fuel pumps are in the automatic (AUTO) mode of operation. This means the ACS automatically activate for start, fuel crossfeed, and low fuel pressure. Notification of the pilot that this is occurring takes place through a STATUS level CAS message; this assures that the pilot is always kept aware of the current state of systems components.

Automatic electrical load shedding is also provided by the ACS. When the ACS detects a loss of electrical power, i.e. the loss of a single or the loss of both generators; it has the capability of automatically load shedding the necessary electrical equipment to maintain sufficient power and systems functionality for the pilot to safely manage the aircraft.

2.2.2 Performs Pilot Commands

While several systems have automatic controls, the pilot has the capability to override or manually control systems components from the synoptic pages. Commands from these synoptic pages are sent to the ACS upon which the individual components are activated.

Examples of control and command of systems include:

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- Engine System Control- Ignition control Engine dry motoring
- Fire Suppression
- Fuel system control- electric fuel pumps, fuel crossfeed
- Flight Controls- primary flap and trim control, secondary trim control
- Electrical- control of electronic circuit breakers
- Environmental- fan activation and speed, temperature control
- Pressurization- aircraft pressurization settings
- Ice Protection- anti-ice and de-ice controls
- Primary landing gear control
- Exterior Lighting- command of ECB's to activate and deactivate lighting

2.2.3 Systems Monitoring and reporting

The systems monitoring and reporting capability of the ACS' allow reporting of various systems status to the pilot through the Primary and Multi-Function Displays (PFD & MFD). Examples of system monitoring and fault sensing include:

- Electrical system monitoring
- Fuel System monitoring- (fuel gauging probes, fuel pumps, valves)
- Secondary engine parameter monitoring- (fuel flow, oil temperature, oil pressure)
- Engine fire detection
- Pressurization and climate control system monitoring (temperature sensors, valves)
- Trim monitoring- (trim motor the current state and position of primary and secondary flight controls: flaps, trims, control surfaces)
- Landing gear monitoring- (gear position, actuator operation)
- Ice Protection monitoring- (operation of anti-ice and deice system components)
- Door indication monitoring- (state of main cabin door)
- Brake system monitoring- (brake fluid level)
- Oxygen system monitioring- (oxygen pressure)

Control monitoring is often attached to various Crew Alerting System Messages (CAS), (ex. PARKING BRAKE status message indicates that the PARKING BRAKE handle is pulled out).

As a compliment to monitoring of systems, the ACS also provides fault sensing capability for the various systems components and their associated sensors. Failure monitoring is provided for various systems, some examples include the failure of: flap actuators; control valves, such as the fuel shutoff valve; sensors, such as the climate control temperature sensors. Should a component or sensor fail a CAS message is displayed to the pilot to indicate that a failure has occurred. Due to the built in redundancy of aircraft systems, many of these failures do not result in a complete loss in system functionality, but only a loss in a redundant component.

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2.3 Pilot Displays

The Electronic Flight Instrument System (EFIS) is the primary component of the integrated avionics suite contained on the Eclipse Model 500. The primary components of the EFIS are two 10.4 inch active matrix liquid crystal Primary Flight Displays (PFD) and one 15.3 inch active matrix liquid crystal Multi Function Display (MFD). The EFIS displays all primary flight information including aircraft system synoptic pages that allow control of most aircraft functions.

2.3.1 Primary Flight Displays (PFD)

The PFDs are two of the primary components of the integrated avionics. They are an information center in that they route pilot commands to the ACS, as well as receive aircraft status information and route it to the MFD for display. In addition the PFDs provide the following display and control functionality. The PFDs are outlined in detail in the PFD chapter of this manual:

1. Airspeed/Mach Display
2. Altitude and Vertical Speed Display
3. Autopilot/Yaw Damper Mode Display
4. Baro-Correction Display
5. Autopilot Targets Display
    a. Airspeed
    b. Attitude-Flight Director Command Bars
    c. Altitude
    d. Vertical speed
    e. Heading
6. Localizer and Glideslope Deviation
7. Attitude Direction Indicator (ADI)
    a. Pitch Attitude
    b. Roll Attitude
    c. Slip/Skid Indication
8. Airspeed & Altitude Indications
9. Magnetic Heading
10. VOR & ILS
11. Communications and Navigation Radio Tuning
12. Transponder Control (Mode S)
13. Composite Mode (used during MFD failure)

2.3.2 Multi-Function Display (MFD)

The MFD is the primary interface for the pilot to the aircraft systems and their status. While this display is the center of the displays and a focal point for the pilot, it is considered to be a ‘dumb’ display in the context of avionics system architecture. All

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information to and pilot commands from the MFD is routed through both of the PFDs to the ACS'.

The MFD is divided into upper and lower portions. The upper portion of the MFD is continuously displayed, while the lower portion is considered configurable. Primary control of most system functionality is provided through several systems synoptic pages presented on the MFD. Each system synoptic page contains a schematic of the selected system displaying the status of primary system components. A synoptic page contains only information that the pilot needs to be aware of or that he/she has control over. Less significant information such as vent lines, and other data not required to diagnose system state or performance is excluded to prevent clutter. System synoptic layouts are designed around operational control of the system and while similar are not representative of actual system layout.

The MFD provides the following display and control functionality and is outlined in detail in the MFD chapter of this manual:

UPPER PORTION

1. MFD ADI
2. Aircraft Systems Information
    a. Engine
    b. Landing Gear
    c. Flight Controls
        - Flaps
        - Trim
    d. Cabin Pressurization
    e. Fuel
3. Crew Alerting System (CAS)

LOWER PORTION

1. Aircraft Systems Synoptics
    a. Engine
    b. Fuel
    c. Electrical
    d. Electronic Circuit Breakers
    e. Environmental
    f. Pressurization
    g. Ice Protection
    h. Flight Controls
    i. Aircraft Operations
    j. Sensor Status
    k. Setup
2. Audio Pages

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2.4 Pilot Controls

In addition to the PFD and MFD, there are several switch/control panels that allow direct pilot inputs to the aircraft.

a. Center Switch Panel

The Center Switch Panel serves as both a pilot control interface to aircraft systems and as a means of routing commands from other pilot control interfaces to the ACS'.

Direct pilot controls include:

- Landing Light
- Taxi/Recognition Lights
- Landing Gear
- Strobe/Beacon Lights
- Ice Protection- (Engine Anti-Ice & Wing Deice)
- Ice Inspection Light
- Cabin Lights
- Dome Light
- Footwell Lights (Optional)
- Cockpit Dimming
- Night/Day Switch

Command Routing

- Autopilot Control Panel
- Engine Start Switch Panel
- Left and Right Sidesticks
- Center Pedestal (Rudder Trim Switch and Flap Selector Inputs)

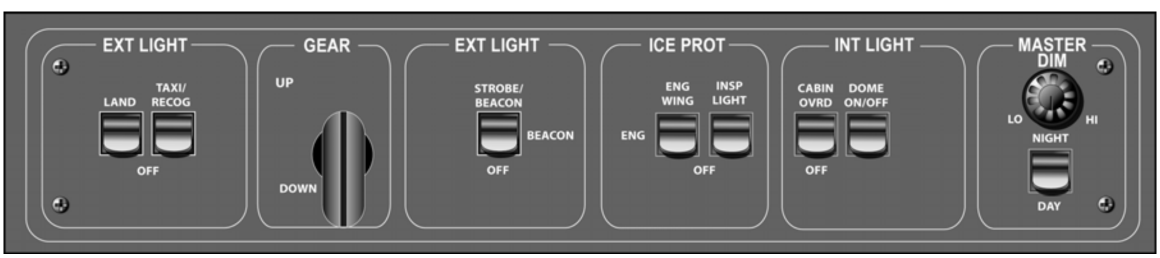

Figure 12. Center Switch Panel

b. Engine Start Switch Panel

Commands from the engine start switch panel are routed through the center switch panel to the PFD, then on to the ACS. The Engine Start Switch panel has three positions:

- OFF- Commands engine to off
- ON/START- Initiates Start Sequence, position for normal operations
- CONT IGN- Manually activates igniters

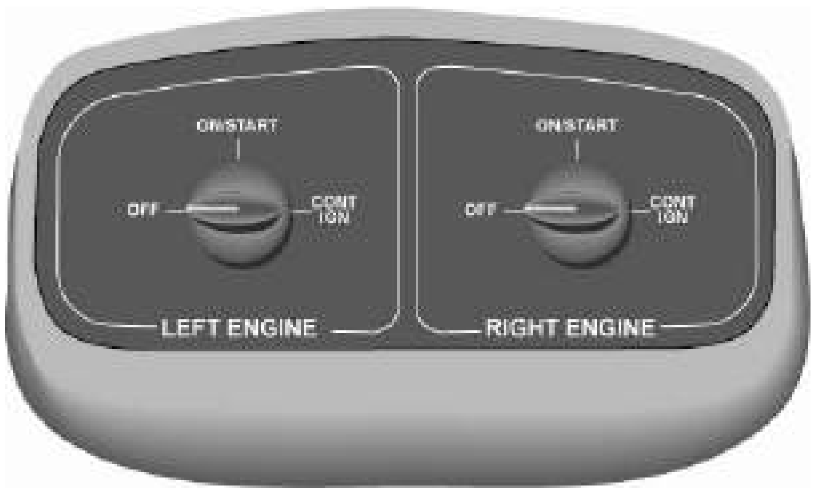

Figure 13. Engine Start Switch Panel

c. Autopilot Control Panel

Autopilot Control Panel inputs are routed through the center switch panel to the PFD and on to the ACS. The Autopilot Control Panel allows control of the following functions:

- Autoflight mode and pre-select bug control
- Barometer Setting (BARO Set)
- Map Lights (Left and Right)
- Caution/Warning Flights (Left and Right)
- Fire Warning and Suppression (Left and Right)

Figure 14. Autopilot Control Panel

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d. Sidestick (Left and Right)

With the exception of the push-to-talk switch that is directly wired its respective PFD, switch inputs from each sidestick are routed through the center switch panel to the PFD and on to the ACS. The left and right sidesticks allow for the following functionality:

- All Interrupt Switch
- Autopilot Disconnect
- Transponder IDENT
- Microphone push-to-talk
- Pitch and Roll Trim
- Landing Gear Warning Mute

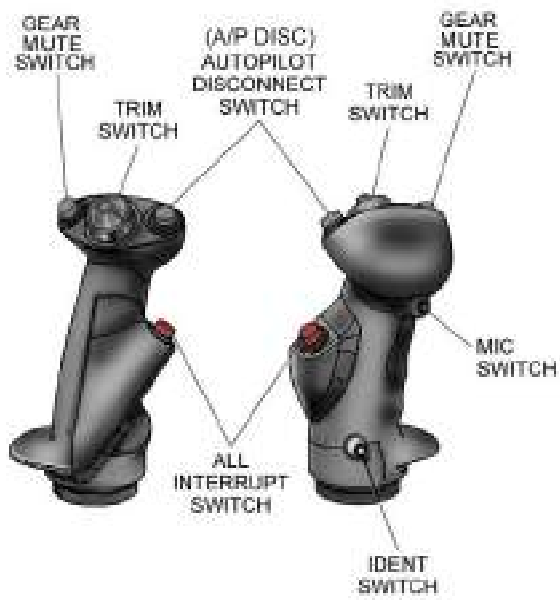

Figure 15. Sidestick

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e. Left Switch Panel (Essential Switch Panel)

The left switch panel is also considered the essential switch panel, as many of the switches and controls on this panel have direct connections to the associated component and do NOT require ACS control to function. The item that requires ACS functionality to operate is the CABIN AIR SOURCE switch that controls the position of the flow control valves. Left switch panel functionality includes:

- Communications selections (headset/mask, Left or Right PFD)
- Mechanical Circuit Breakers (Left PFD, Left ACS)
- ELT Switch and Annunciation
- Five Electrical Contactor Switches (Generators x2, Batteries x2, Bus Tie)
- Oxygen Control and Pressure Display
- Cabin Air Control (Air Source and Cabin Dump)

Figure 16. Left (Essential) Switch Panel

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f. Right Switch Panel (Optional)

The right switch panel contains the same communications selections available on the left switch panel.

- Communications selections (headset/mask, Left or Right PFD)

Figure 17. Right Switch Panel

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g. Keyboards

The keyboards are an alternate means from inputting data, entering and controlling functions. Keyboard inputs are routed directly to the PFDs. All control functions, with the exception of some PFD composite mode functionality can be accessed elsewhere on the flight deck. The keyboard supports the following:

- Audio Selection and Control
- Communication Radio Selection and Control
- Flight Management System (FMS) Functions- (Future Functionality)
- Alphanumeric Entry of waypoints and Radio Frequencies
- Synoptic Page Selection on the MFD

Figure 18.   Keyboard

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h. Throttle Quadrant Switches (Flaps & Rudder Trim)

The throttle quadrant contains the two throttles, a flap position selector and a rudder trim switch. In addition there are two switches located on the left throttle, an Autothrottle Disconnect (A/T DISC) and Takeoff/Go-around (TOGA) switches.

The throttles have no direct connection to the ACS; information sensed by two position sensors for each throttle is sent directly to the FADEC Units.

Rudder trim, flap selector, autothrottle disconnect and TOGA switch position information is sent through the center switch panel to the PFDs then on to the ACS.

Figure 19. Throttle Quadrant

i. Line Select Keys

Line select keys on the PFD and MFD allow control of various aircraft inputs, including frequency entry and system control. Each display has 10 line select keys that correspond to different functions depending on what PFD or MFD function is enabled. Line select keys are often associated with the PFD or MFD pages within which they are used to activate or deactivate specific systems components (Ex. Fuel Pumps).

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Figure 20. Line Select Key

j. Rocker Keys

The left and right rocker keys allow the pilot to select several pages at the bottom of the lower right and lower left tiles of the PFD and MFD. These keys can be pressed once to move the selected page left or right. Holding down the key allows slow, steady scrolling through the available pages. Scrolling is not a looping function and once the end of a particular set of pages is reached, the pilot must scroll back to return to the first page in the sequence.

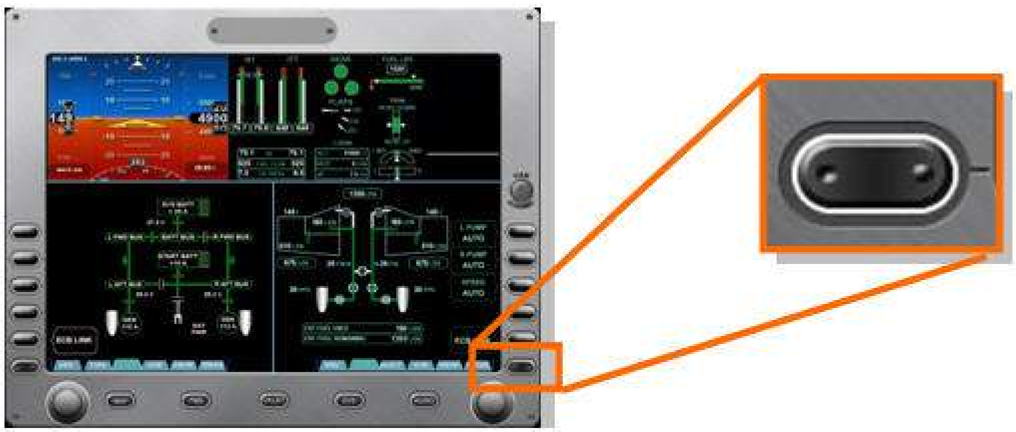

Figure 21. Rocker Key

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k. Primary Function Keys

There are five primary function keys located at the bottom of the MFD. These keys control what appears on the lower two tiles of the MFD. The pilot has five options, Map (MAP), Flight Management System (FMS), Checklist (CKLST), Systems (SYS), and Audio (AUDIO). Pressing each of these keys will configure the lower two tiles of the MFD as follows:

- MAP
  Lower left set to MAP, lower right is set to page previously on lower left.
- FMS
  Lower left tile set to FMS, lower right tile set to MAP
- CKLST
  Lower left tile set to Checklists, lower right tile set to the associated system/synoptic page.
- SYS
  Lower left set to last used systems synoptic page or if last page not known, to the first page in the tabbed list (ENG)
- AUDIO
  - Single Press
    Lower left set to PILOT AUDIO page, lower right set to page previously shown on lower left.
  - Double Press
    Lower left set to PILOT AUDIO page, lower right set to COPILOT AUDIO page

Figure 22. Primary Function Keys

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I. Concentric Knobs

Two concentric knobs are located on the bottom portion of the PFD and MFD. The MFD knobs are shaped for pilot feel and recognition, while the PFD knobs are smooth.

Each knob corresponds specifically to the information presented on the adjacent side of the display (left knob corresponds to the left portion of the PFD or lower left tile of the MFD; right knob corresponds to the right portion of the PFD or lower right tile of MFD). Rotating the knobs clockwise moves cursor or highlight from top to bottom, left to right, or numerical values to increase. Rotating the knobs counterclockwise moves cursor or highlight from bottom to top, right to left, or numerical values to decrease.

Drop Down Menu Selection

Some display pages contain additional drop down menus for control. Within a drop down menu, rotating the outer knob moves the curser from field to field. Rotating the inner knob will scroll through drop down menu choices when shown, and selections are made by pressing the inner knob. Rotating the outer knob with the drop down menu choices displayed will cancel the drop down menu.

Sequential Choice Selection

When a display allows sequential choices in a field, such as environmental fan speed settings, rotating the associated outer knob moves the cursor from field to field. Rotating the inner knob cycles through the choices for that field and pushing the inner knob will have no effect.

Text Editing

If text editing is available on a page, rotating or pushing the inner knob activates the cursor for editing. Rotating the outer knob allows movement of the cursor location within the text field. Once the cursor is placed over the desired text, rotating the inner knob will change the text. When editing is complete, pressing the inner knob sets the text. While editing text, rotating the outer knob counterclockwise with the cursor on the first character will deactivate text editing.

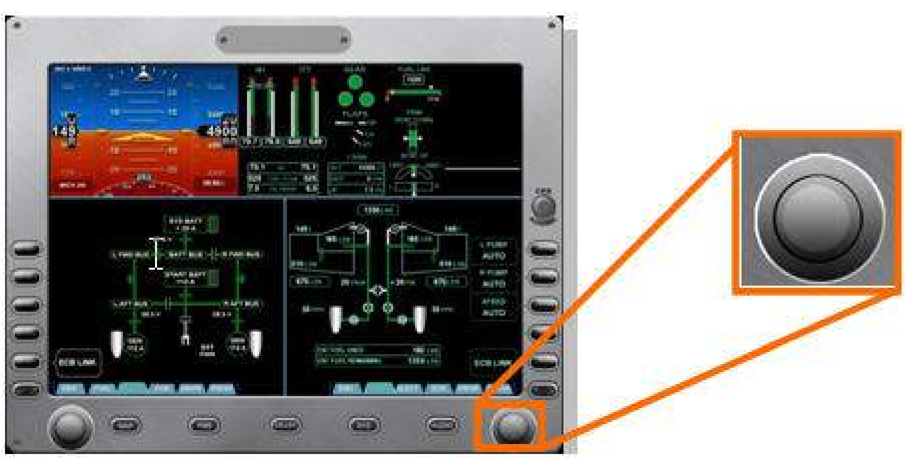

Figure 23. Concentric Knobs

m. Single Rotary Knobs

Single rotary knobs on the PFD and MFD provide control of pilot and copilot volume and squelch on the PFD and selection and acknowledgment of CAS messages on the MFD.

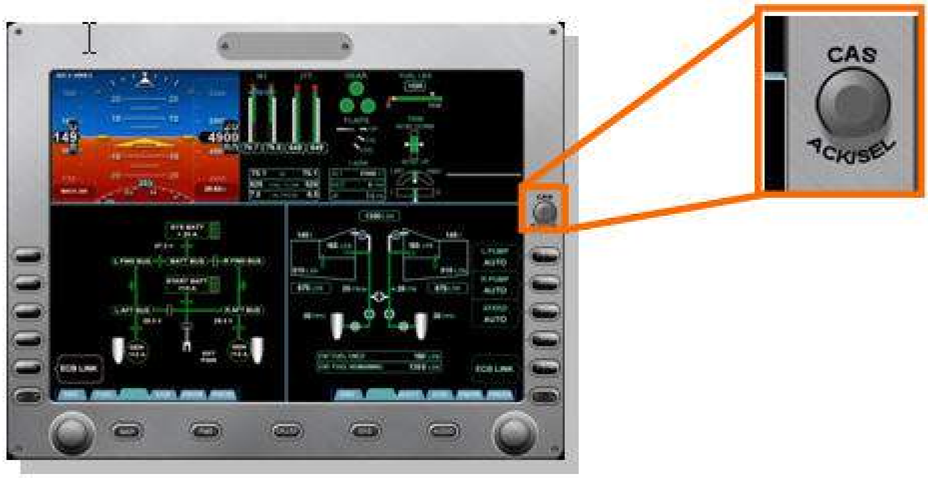

Figure 24. Single Rotary Knob

2.5 Primary Sensors

Air data, attitude and navigation information are provided to the ACS by two Integrated Sensor Suites (ISS). An ISS is comprised of three independent units working together.

1. Three Air Data Computers (ADC)
2. Two Attitude Heading and Reference Systems (AHRS)
   a. Two Magnetometers (MAGs)
3. Two Global Positioning Systems (GPS)

Information from all three of these systems is sent to the ACS for comparison and failure monitoring, to FADECs for engine control and to the PFD and MFD for display.

2.6 Aircraft Subsystems

The Eclipse 500 aircraft Subsystems include:

- Engines & Fire Protection
- Fuel
- Electrical
  — Electronic Circuit Breakers
- Climate Control
  — Environmental
  — Pressurization

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- Ice Protection
- Landing Gear
- Flight Controls
- Oxygen
- Autoflight
  - Autopilot
  - Autothrottle (Future Functionality)

All aircraft subsystems have Aircraft Computer System interfaces that are outlined in the various systems chapters. For most of the aircraft systems direct pilot control is provided through MFD synoptic pages. Exceptions to this are Oxygen (controlled on the left switch panel), Landing Gear (controlled through the center switch panel), and Autoflight (controlled through the autopilot control panel).

While most aircraft systems functions are shared between the ACS units, there are some that are routed through a specific on-side ACS. Flap and landing gear actuators are controlled by the onside ACS (i.e. left ACS controls left flap actuators). Trim also functions in this manner; the left ACS controls the left pitch trim actuator as well as the roll trim actuator, while the right ACS controls the right pitch trim actuator, as well as the yaw trim.

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2.7 Avionics Overview Review Questions

1. **What are the five functional areas of Avio?**

   a.

   b.

   c.

   d.

2. **List and briefly describe the three functions of the Aircraft Computer Systems (ACS')**

   a.

   b.

   c.

3. **The ACS controls what function of the two aircraft engines?**

4. **What information is NOT displayed on the upper portion of the MFD?**

   a. Landing Gear Position

   b. Oil Temperature

   c. Oil Pressure

   d. Fuel Level

5. **How do signals from the center switch panel get to the Aircraft Computer System?**

   a. Through the autopilot control panel

   b. Directly

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c. Through the MFD

d. Through the PFDs

6. **List the eight instrument/switch panel inputs the pilot has:**

a.

b.

c.

d.

e.

f.

g.

h.

7. **Where are line-select keys found?**

a. On both PFDs
b. On the MFD
c. Both A & B
d. None of the above

8. **What action is accomplished by rocker keys?**

a. They allow for volume control of the cockpit speakers
b. They allow the pilot to move from page to page on both the PFD and MFD
c. Rocker keys allow the pilot to dim the PFD and MFD display
d. None of the above

9. **What is the purpose of the primary function keys located below the MFD?**

a. They allow the pilot to quickly access frequently used MFD functions
b. They are used as a backup to the rocker keys
c. Both A & B
d. None of the above

10. **What is a concentric knob?**

a. A knob that can be turned both ways
b. A knob with an inner and outer portion
c. A knob used on the PFD and MFD to make graduated selections
d. All of the above

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3. Flight Controls

3.1 General

The flight control system consists of primary flight controls (ailerons, rudder, and elevator) and secondary flight controls (wing flaps and trim).

The primary flight controls are operated with a sidestick and rudder pedals at each pilot station. The primary flight control system is a mechanical system which uses bellcranks, pushrods, cables, and pulleys to actuate the control surfaces. Rudder pedals are individually adjustable. Static wicks are attached to the elevator (two per elevator) and wing tip tanks(one per tip tank) to discharge static electricity.

Trim for the three primary flight controls is electrically powered. Elevator and aileron trim is controlled by a four-position switch on the top of each sidestick. Rudder trim is controlled by a rotary switch mounted on the aft portion of the center pedestal. Trim position for all three axes is displayed on the MFD. If a normal trim control fails, all three trim systems can be controlled using the flight controls synoptic page on the MFD. All trim motors can be inhibited in the event of a trim runaway.

To protect against high wind conditions, a gust lock is placed over the left sidestick to secure the ailerons and elevator in place, while the rudder is locked by mechanical resistance from the nose wheel steering system.

The wing flaps are electrically powered fowler flaps, controlled by a three-position flap selector lever located on the throttle quadrant. Flap position is displayed on the upper portion of the MFD.

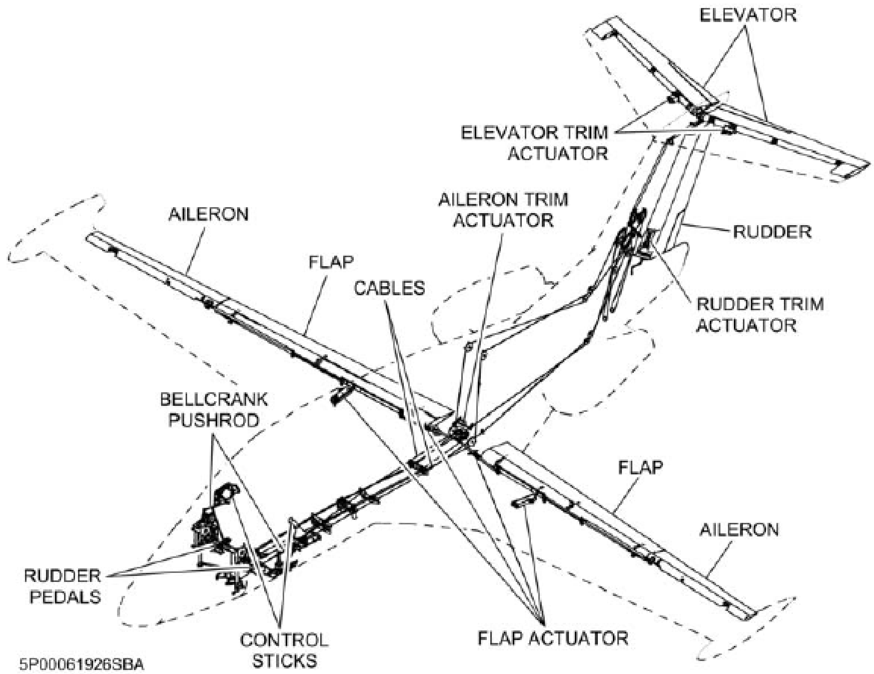

Figure 25. Flight Controls Schematic

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3.2 Aircraft Computer System (ACS) Interfaces

3.2.1 Flaps

There are four electromechanical flap actuators on the Eclipse 500, two per flap. The ACS is responsible for commanding the flaps to the position selected by the pilot using the flap selector switch on the throttle quadrant. The ACS also monitors each actuator for actual position versus the pilot selected position, as well as monitoring the status of each actuator for failure.

The left flap actuators receive their commands and report their status to the right ACS, while the right flap actuators receive their commands and report their status to the left ACS.

All actuators communicate with each other to assure flap position agreement

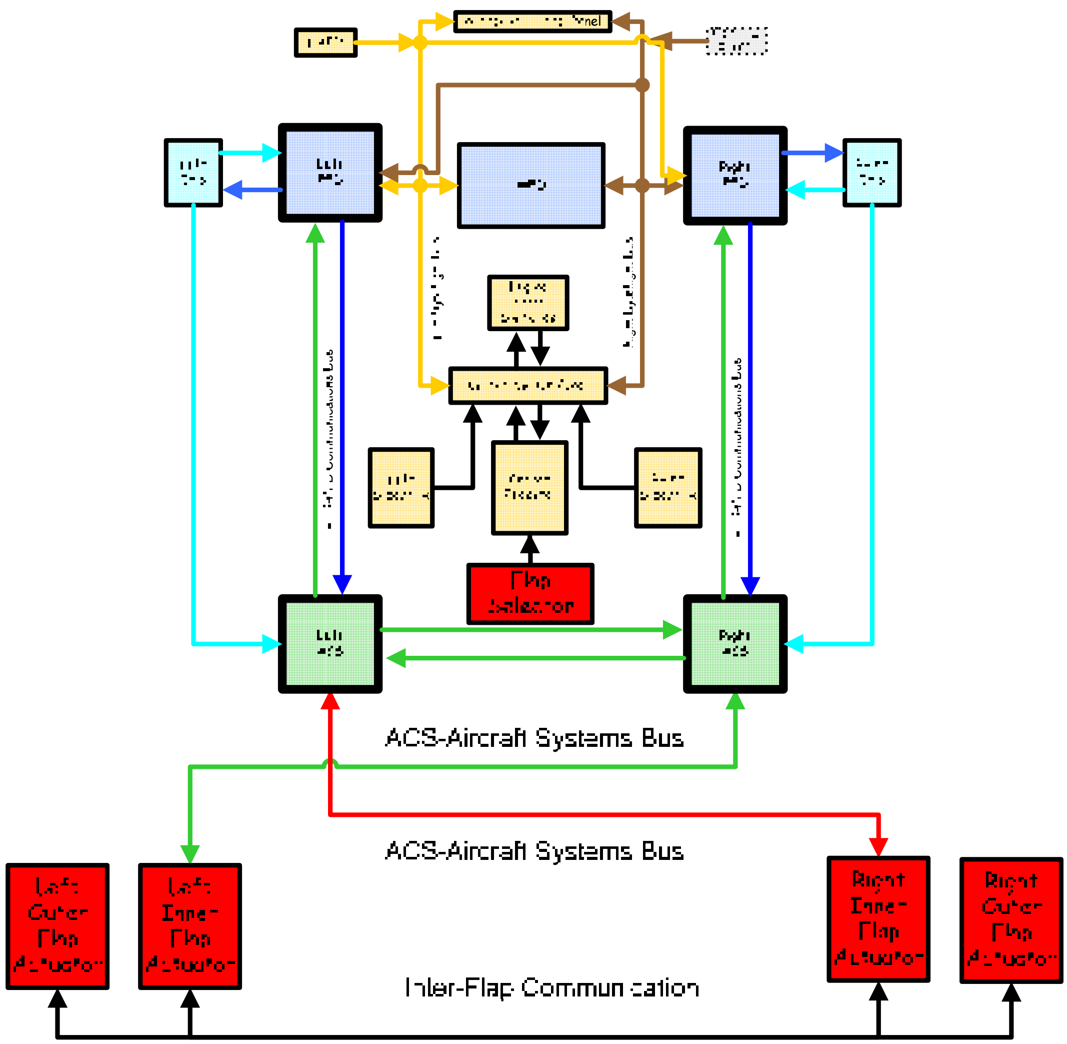

Figure 26. ACS-Flap Interface

3.2.2 Trim

The Eclipse 500 has four trim motors; two are used for pitch trim, one for roll (aileron) trim and one for yaw (rudder trim). Pilot control for pitch and roll trim is through the trim switch on each sidestick, while rudder trim inputs are made through the rudder trim switch on the throttle quadrant.

The ACS commands the actuators based on these pilot inputs. The left ACS is responsible for commanding and monitoring the left pitch trim and roll trim motors, while the right ACS is responsible for commanding and monitoring the right pitch trim and yaw trim motors.

In addition to commanding the trim motors the ACS also receives position information from each actuator and monitors for unexpected movement, actuator position errors, as well as pitch trim disagreement.

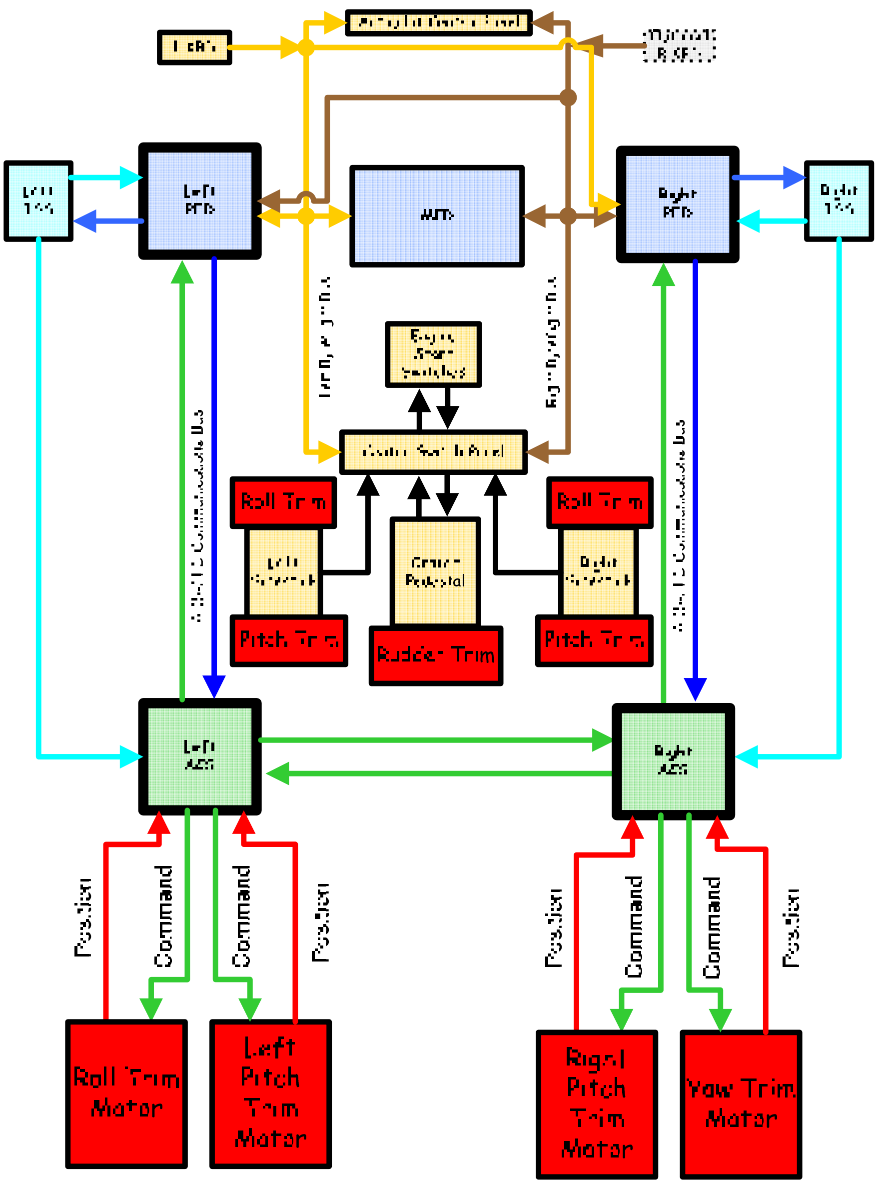

Figure 27. ACS-Trim Interface

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3.3 Limitations and Specifications

3.3.1 Wing Flaps

Maximum altitude for flap extension .... 20,000 ft MSL

VFE:
T/O .... 200 KEAS
LDG .... 120 KEAS

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3.4 Controls and Indicators

3.4.1 Sidestick

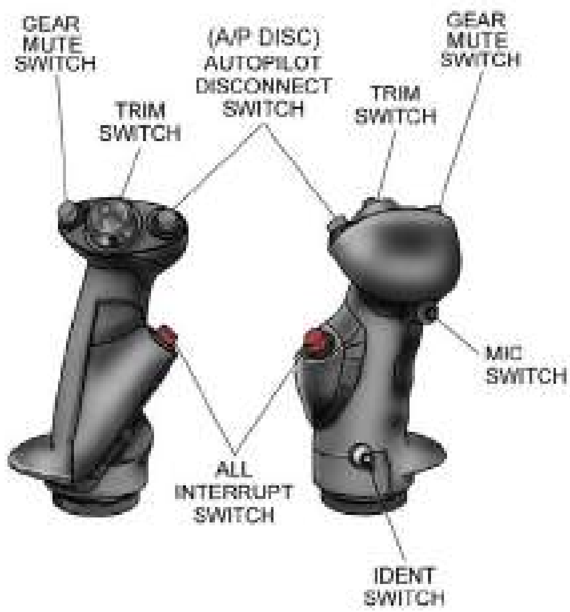

Figure 28. Sidestick

A/P DISC .... Disconnects the autopilot.

ALL INTERRUPT .... Disconnects the autopilot, autothrottle, flight director, yaw damper, over/underspeed protection, and interrupts the stick pusher and all trim while the ALL INTERRUPT switch is pressed. Holding this switch down for two seconds will prompt the Flight Controls(FLCS) synoptic to appear on the MFD.

MIC .... Keys the headset or oxygen mask microphone.

GEAR MUTE .... Silences the landing gear warning horn for conditions when the warning horn is mutable.

IDENT .... Activates transponder IDENT function.

TRIM SWITCH .... Activates Aileron and Elevator trim.

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3.4.2 Throttle Quadrant

Figure 29. Throttle Quadrant

3.4.3 Flight Controls Synoptic

Figure 30. FLCS Synoptic Flight Controls

The flight control synoptic (FLCS) provides a display of position, alternate trim control inputs, and control over the stall protection system.

Trim position is shown graphically, and as a percentage of control surface movement, with a white trim pointer indicating its exact position.

Elevator .... % NOSE UP or NOSE DOWN

Ailerons .... % Left Wing Down (LWD) or Right Wing Down (RWD)

Rudder ....% Left or Right

Each trim position display has a green band which is the trim position range for takeoff. Should trim indications become unavailable, a TRIM POSITION FAULT advisory message appears and the trim pointer is removed.

Four line select keys provide additional control of the flight control system.

TRIM

All trim switches (aileron, elevator, and rudder) can be disabled by the line select key labeled TRIM. The two selections are:

- NORMAL
- ALTERNATE

In NORMAL, all trim inputs are controlled through the sidestick and rudder trim switches. In the event of an emergency or if the pilot chooses to use the MFD as the primary means of trim control, selecting ALTERNATE will allow the pilot to use the

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concentric knobs on the lower portion of the MFD to control trim in each individual axis. Rotating the outer knob moves a cursor box to the desired axis, while rotating the inner knob changes the trim setting.

NOTE:

Pressing the ALL INTERRUPT switch on the sidestick for two seconds will cause the flight controls synoptic to appear to allow switching from NORMAL to ALTERNATE

ALL INTRP

The ALL INTERRUPT line select key disables all interrupt switch on both sidesticks in the event that the switch fails in the all interrupt position

The ALL INTRP line select key has two selections

- NORMAL
- DISABLE

STALL PROT

The stall protection line select key allows enabling and disabling of the stall protection system and has two selections

- ON
- OFF

Pressing the stall protection line select key prompts a CONFIRM and CANCEL line select key to appear. If CONFIRM is pressed, stall protection is turned OFF and a STALL PROTECTION OFF status message appears.

ECB LINK

The ECB LINK line select key selects the Flight Control Electronic Circuit Breaker synoptic.

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3.4.4 Flap Position Display

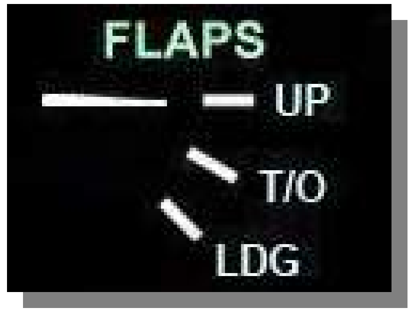

Figure 31.   Flap Position (Normal)

When the flap selector is moved, a white box is displayed around the selected position. The flap position tick mark turns magenta until the flap position agrees with the flap selector position, at which point the tick turns white and the white box disappears.

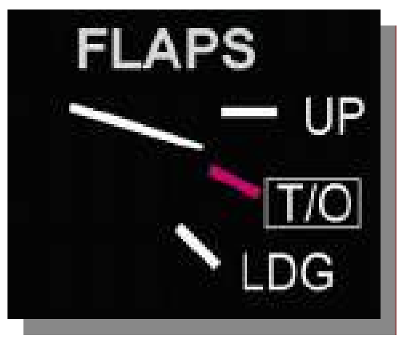

Figure 32.   In Transit to T/O Position

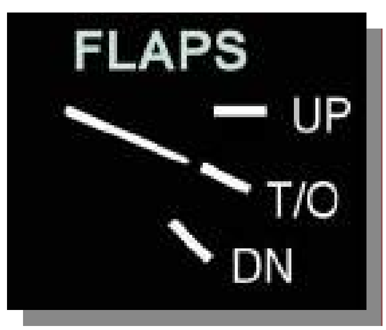

Figure 33.   Flap Position Display (T/O Position)

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If a flap failure occurs due to an actuator failure or asymmetry sensed by any flap actuator, all flap movement stops, the pointer remains displayed in the last position and a FLAP FAIL caution message appears.

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3.5 System Description

3.5.1 Ailerons

The ailerons are located outboard of the flaps, with deflection accomplished by lateral movement of either sidestick. Control inputs pass through a series of pushrods, cables and pulleys to the control surfaces.

3.5.2 Rudder

Rudder deflection is accomplished through the left and right rudder pedals. Pedal travel is four inches fore and aft of neutral. Control inputs pass from the rudder pedals to the rudder control surface through a series of cables, pushrods and other associated components.

Figure 34. Rudder Pedals

Rudder pedals are individually adjustable fore and aft (1.75 inch travel) by depressing a lever located above each pedal and pulling or pushing the pedals to adjust.

Figure 35. Rudder Pedal Adjustment

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3.5.3 Elevator

The two elevators on the horizontal stabilizer are mechanically connected. Elevator deflection is accomplished by fore and aft movement of either sidestick. Control inputs pass through a series of cables, pushrods and other associated components to move the elevators.

3.5.4 Sidestick

The ailerons and elevator are controlled with one of two sidesticks located on the left and right cockpit sidewall. The sidesticks are angled inward to allow for natural wrist position. The control surfaces are unpowered and move together through a mechanical interconnect.

Aileron and elevator trim is controlled by a four position switch on the top of each sidestick. Each sidestick has the additional switches:

A/P DISC.................................. Disconnects the autopilot, yaw damper still engaged.

ALL INTERRUPT .... Disconnects the autopilot, autothrottle, flight director, yaw damper, over/underspeed protection, and interrupts the stick pusher and all trim while the ALL INTERRUPT switch is pressed. Holding this switch down for two seconds will prompt the Flight Controls(FLCS) synoptic to appear on the MFD.

MIC.. Keys the headset or oxygen mask microphone

GEAR MUTE... Silences the landing gear warning horn for conditions when the warning horn may be muted.

IDENT .... Activates the transponder IDENT feature

TRIM .... Activates Aileron and Elevator trim

3.5.5 Trim

The aileron, elevator, and rudder trim are electrically operated. Aileron and elevator trim are controlled by switches on each sidestick, while rudder trim is controlled by a rotary switch on the throttle quadrant.

Inputs from the trim control switches are sent to several trim actuators. Aileron trim actuators move the aileron centering spring, resetting the neutral position of the ailerons. A rudder trim actuator moves trim tab on the rudder. Pitch trim is provided through two pitch trim actuators, one on each elevator. The trim actuators send trim position back to the ACS, where it is sent to the MFD for continuous display.

A “drum roll” aural tone is heard if manual or autopilot elevator trim movement is continued for more than two seconds. If uncommanded trim motion is sensed a TRIM UNCOMMANDED warning message appears, requiring trim to be deactivated with the ALL INTERRUPT switch on the sidestick.

Trim is also adjustable on the flight control synoptic using the concentric knobs on the lower portion of the MFD. This feature is designed to provide trim control in the event of a failure of the normal trim controls, but it is available for selection at all times.

A failure of trim in any axis will cause a PITCH TRIM FAIL, AILERON TRIM FAIL, or RUDDER TRIM FAIL caution message to appear. Trim for Aileron and Rudder will be

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unavailable in the event of a failure; however should a pitch trim failure occur, limited trim capability will be available through the second elevator trim actuator.

3.5.6 Flaps

Each wing trailing edge has a single fowler flap. The flaps are controlled through the three-position flap selector located on the throttle quadrant. Flap selector position is sent to both ACSs, which then control the flaps in parallel. The flaps can be set to three positions:

- UP
- T/O (Takeoff)
- LDG (Landing)

Flaps are moved by four electro-mechanical actuators, two on each flap, one inboard and one outboard. Flap position is sent to the ACS by the actuators, then to the MFD for continuous display.

To prevent asymmetrical deployment, flaps only operate if all four actuators are synchronized. Electronics in each flap actuator monitor its position relative to the other actuators. If any actuator senses or causes a flap position mismatch greater than two degrees, all flap motion ceases and a FLAP FAIL caution message appears.

If flap asymmetry is sensed on the ground, the ACS automatically attempts to synchronize the flaps. If flap synchronize is unsuccessful, a FLAP FAIL caution message appears, and the flaps do not operate.

In the event that a flap actuator fails to stop at the position selected by the flap selector position, that actuator will continue to run to maintain the requested setting against the airflow. This condition triggers a FLAP POSITION HOLD FAIL caution message to appear.

3.5.7 Gust Lock

The gust lock for the ailerons and elevator is a fabric strap which is installed over the left sidestick to hold it full right. The gust lock is held in position by adjustable straps that clip into a ring to the left of the sidestick and to the pilot seat track.

The rudder is held in position by mechanical resistance in the nose wheel steering system.

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3.6 Normal Operations

3.6.1 Sidestick

CONTROL MOVEMENT

The sidestick is angled inboard in a “natural” wrist position. Pitch control is accomplished with forward and aft movement of the sidestick. The wrist angle must stay neutral when adjusting pitch to avoid introducing unwanted roll.

Moving the sidestick toward the left commands a left bank; while moving the sidestick toward the right commands a right bank.

On the ground, the sidestick is full forward as the static position of the elevators is full down. As airspeed increases during the takeoff roll, the elevators and sidestick assume a neutral pitch position before rotation.

TRIM

Aileron and pitch trim are accomplished by moving the four-way trim switch on either sidestick. Rudder trim is activated by moving the rotary rudder trim switch on the pedestal.

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3.7 Abnormal Procedures

3.7.1 All Interrupt

There is a red ALL INTERRUPT switch on the inboard side of each sidestick. The button has the following functions:

- Disconnects the autopilot.
- Disconnects the flight director.
- Disconnects the autothrottle.
- Disconnects the yaw damper.
- Disconnects the over/under speed protection.
- Interrupts the stick pusher as long as the switch is held down. When the switch is released, the stick pusher is restored.
- Interrupts all trim movement, as long as the switch is held down. When the switch is released, trim movement is restored.

When pressed, an ALL INTERRUPT ACTIVE status message appears. Should the ALL INTERRUPT switch fail, a L (R) ALL INTERRUPT FAULT advisory appears.

3.7.2 Elevator Trim Tab Split

In the event that the left and right elevator tabs differ in position, a ELEVATOR TRIM TAB SPLIT advisory message appears. Re-synchronizing the tabs is accomplished by making small trim inputs.

3.7.3 Alternate Trim

In the event of a failure of a normal sidestick or rudder switch trim control a L (R) SIDESTICK TRIM FAULT, or RUDDER TRIM FAULT advisory message appears and alternate trim must be selected. This is accomplished using the flight controls synoptic on the MFD and the concentric knobs located on the left lower corners of the MFD.

- Hold ALL INTERRUPT button for two seconds or Select the flight controls synoptic
- Select ALTERNATE with the TRIM line select key
- When the ALTERNATE is enabled, a white selector box appears around the elevator trim display.
- Rotating the outer knob located on the bottom of the MFD moves the selector box between the rudder trim, aileron trim, and elevator trim displays.
- Trim is accomplished using the inner knob. Each “click” of the knob provides a 0.25 second trim command. The inner knob must be continuously rotated to keep the trim moving.

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3.8 Crew Alerting System Messages

Table 3. Flight Control CAS Messages

Message	Condition	Category
TRIM UNCOMMANDED	Uncommanded trim movement detected	Warning
AILERON TRIM FAIL	Aileron trim actuator not responding normally to input or has failed	Caution
PITCH TRIM FAIL	One or both pitch trim actuators are not responding normally to input or has failed. Trim authority may be limited	Caution
FLAP FAIL	Flaps have failed	Caution
FLAP POSITION HOLD FAIL	Backdrive clutch failed; actuator motor will actively try to keep flaps in position	Caution
RUDDER TRIM FAIL	Rudder trim actuator not responding normally to input or has failed	Caution
L (R) ALL INTERRUPT FAULT	Left or right all-interrupt switch has failed (ground only)	Advisory
ELEVATOR TRIM TAB SPLIT	Left and right elevator trim tabs differ in position.	Advisory
RUDDER TRIM FAULT	Rudder trim switch inoperative (ground only)	Advisory
L (R) SIDESTICK TRIM FAULT	Left or Right trim switch inoperative (ground only)	Advisory
TRIM POSITION FAULT	Trim position indicators failed. Trim pointer is removed	Advisory
ALL INTERRUPT ACTIVE	ALL INTERRUPT switch active	Status
STALL PROTECTION OFF	Stall protection selected OFF	Status

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3.9 Flight Controls Review Questions

1. **The flight control system on the Eclipse 500 is:**
   a. A fly-by-wire system which uses an on-board flight computer and flight control servo motors for each individual primary flight controls.
   b. A mechanical system that uses cables, pulleys, bell cranks, and pushrods.
   c. Hydraulically controlled.
   d. None of the above.
2. **What are two components of the Flight Control System that have Aircraft Computer System interfaces?**
   a.
   b.
3. **The trim system on the Eclipse 500 is best described as:**
   a. Electrically powered and operated.
   b. Manually powered via a mechanically operated trim wheel.
   c. Pitch trim is electronically powered; aileron and rudder trim are both powered manually via a mechanically operated trim wheel.
   d. None of the above.
4. **The flaps on the Eclipse 500 are best described as:**
   a. Hydraulically powered fowler flaps.
   b. Electrically powered fowler flaps.
   c. Pneumatically powered fowler flaps.
   d. Manually powered fowler flaps.
5. **Vfe for flaps in the T/O (takeoff) position is:**
   a. 150 KEAS
   b. 175 KEAS
   c. 120 KEAS
   d. 200 KEAS
6. **Vfe for flaps in the LDG (landing) position is:**
   a. 120 KEAS
   b. 150 KEAS
   c. 200 KEAS
   d. 175 KEAS
7. **List the functions of the All Interrupt switch:**
   a.
   b.
   c.
   d.
   e.
   f.

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g.

8. **Describe a shortcut to activating the alternate trim feature:**

9. **Trim can be adjusted via the sidestick as well as:**

   a. On the FLCS (Flight Controls Synoptic) page on the MFD.
   b. By using the mechanical trim wheels for each respective trim axis.
   c. The trim can ONLY be adjusted on the sidestick.
   d. None of the above

10. **The FLAP FAIL caution message is displayed when:**

   a. A flap position mismatch of more than two degrees has occurred.
   b. If flaps cannot be extended electrically.
   c. If the pilot selects the LDG flap position during the before takeoff checklist.
   d. None of the above.

11. **What MFD synoptic page will be displayed when the ALL Interrupt button on the sidestick control is pressed for two seconds?**

   a. Ice protection.
   b. Fuel
   c. Pressurization
   d. Flight Controls

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4. Landing Gear and Brakes

4.1 General

The landing gear is a conventional tricycle configuration, with nose wheel steering being accomplished mechanically through individually adjustable rudder pedals. Extension and retraction is accomplished by three electrically powered actuators. Mechanical brakes on the gear actuator motors hold the gear in the retracted position. These mechanical brakes also hold the gear in the extended position with the aid of over-center braces. These actuator brakes are capable of supporting the gear throughout the flight envelope. Normal extension takes approximately ten seconds and retraction takes approximately seven seconds.

Abbreviation	Full Context
LH	Left Hand
MLG	Main Landing Gear
NLG	Nose Landing Gear
PBV	Parking Brake Valve
RH	Right Hand

	Description
(solid red line)	Supply to Brake Cylinders
(red dashed line)	Emergency Release Cable
(blue dash-dot line)	Electrical Extend/Retract
(green dotted line)	LH Brake Line
(purple dotted line)	RH Brake Line

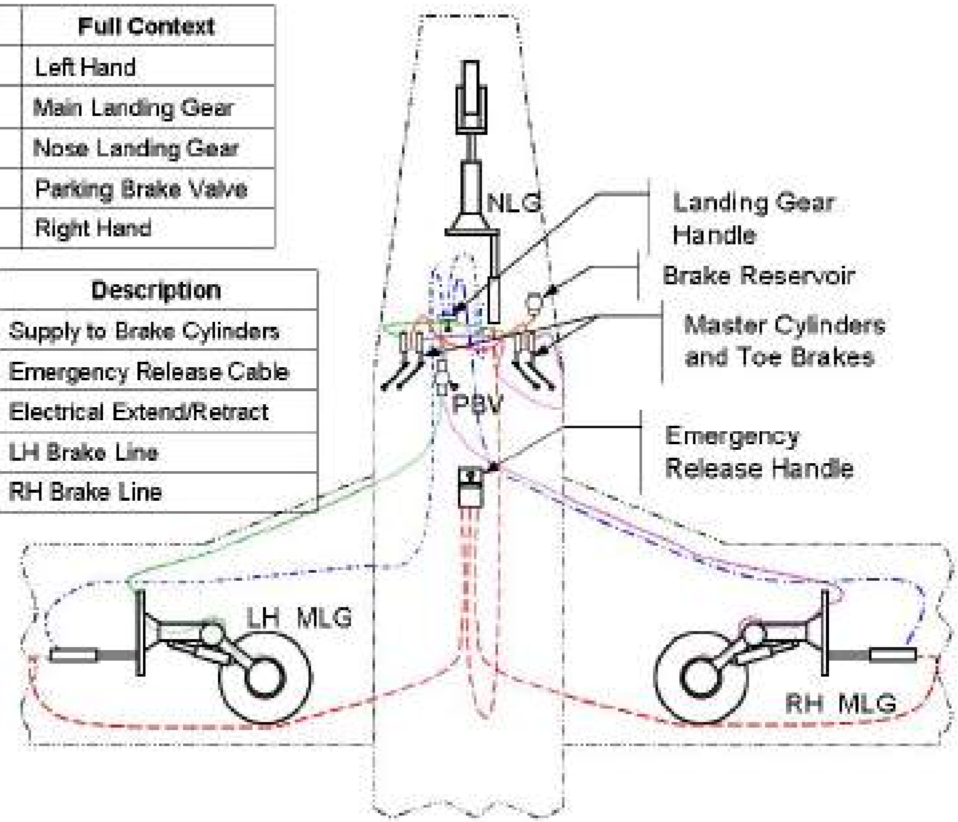

Figure 36. Landing Gear Schematic

4.2 Aircraft Computer Systems (ACS) Interfaces

The flight crew can retract or extend the landing gear using the landing gear switch on the center switch panel. Pilot commands from the landing gear switch are sent through the PFD to both ACS' which in turn command the three independent landing gear actuators. Commands for gear position go directly to the actuator motor and individual actuator status is sent back to the ACS. There are also several independent position indications from several proximity sensors that are also sent to the ACS for status display on the MFD.

Emergency extension of the landing gear is a direct mechanical release and does not require ACS control to accomplish. There is a emergency landing gear handle proximity switch that is monitored by the ACS that reports if the emergency gear handle remains extended following an emergency gear extension.

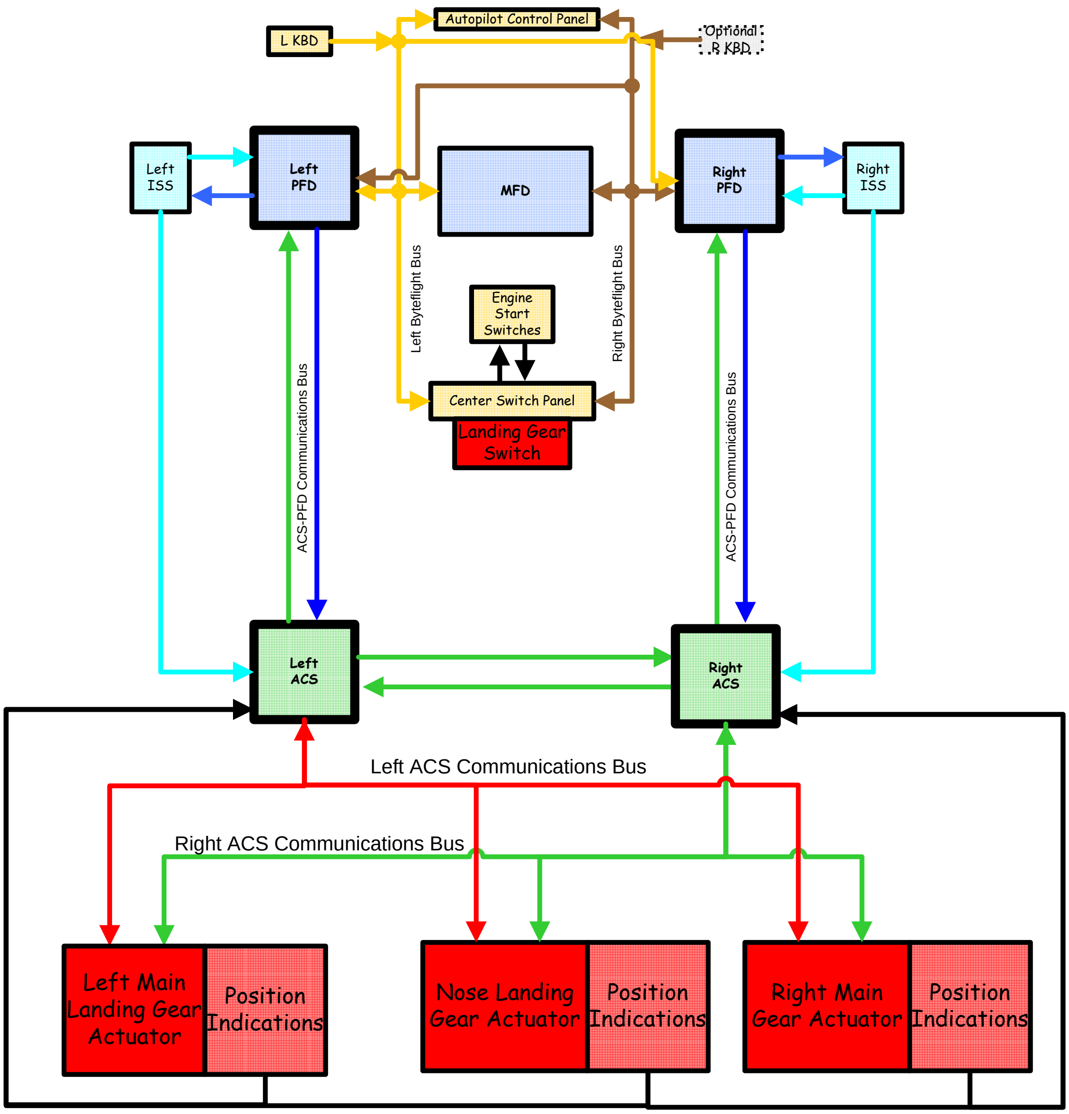

Figure 37. Landing Gear-ACS Interface

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4.3 Limitations and Specifications

4.3.1 Airspeed, Mach and Altitude Limitations

Maximum Gear Speed
V_{LO} .... 200 KEAS
V_{LE} .... 275 KEAS

4.3.2 Tire Speed Limitation

Maximum Speed .... 139 Knots Ground Speed

4.3.3 Tire Pressure

Main Gear .... 103 +/- 2 PSI
Nose Gear .... 70 +/- 2 PSI

4.3.4 Hard Landing Indicators

A maintenance inspection of the landing gear is required before takeoff if any hard landing indicator shows evidence of a hard landing.

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4.4 Controls and Indicators

4.4.1 Gear Handle

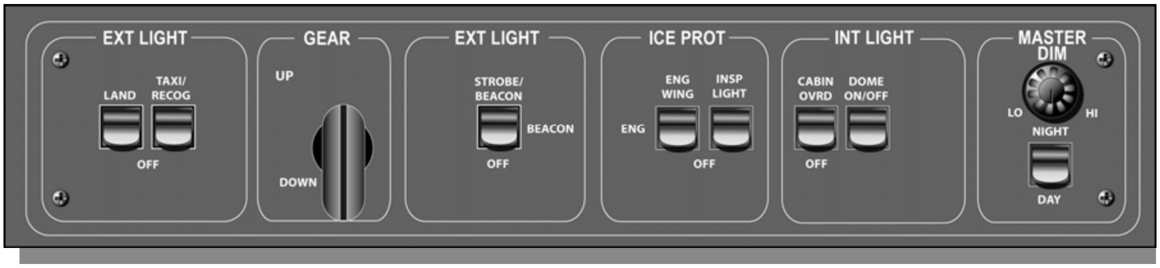

Figure 38. Gear Handle Location

4.4.2 Emergency Gear Release Handle

Figure 39. Emergency Gear Release Handle Location

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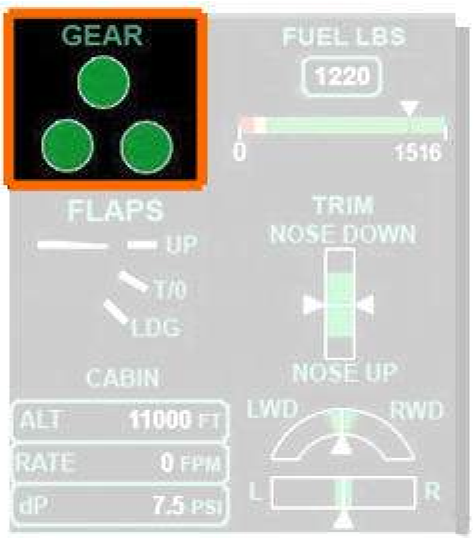
4.4.3 Landing Gear Position Annunciation

A position annunciation for each gear is displayed on the upper portion of the MFD.

Figure 40. Landing Gear Position Annunciation

- A green circle with white border indicates the gear is Down and Locked.



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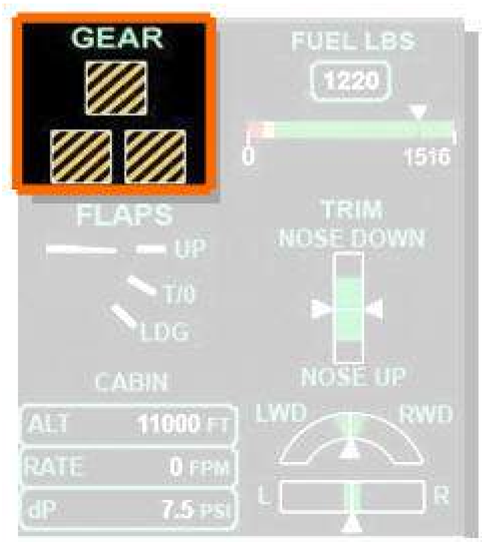
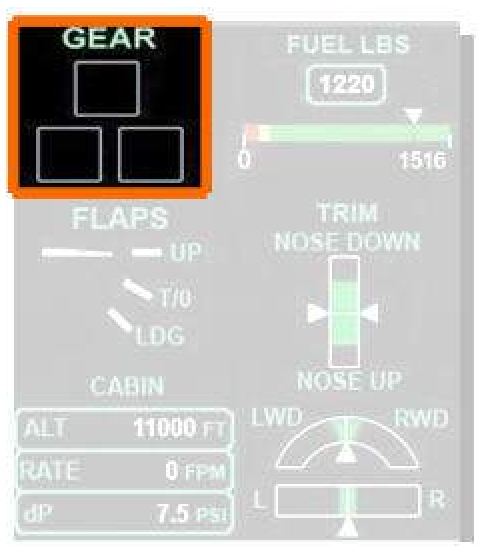
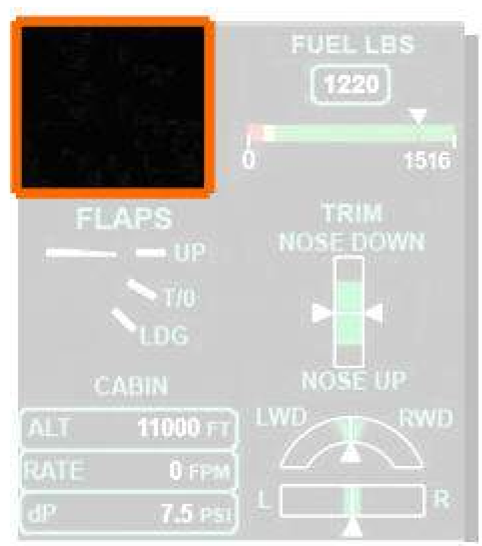
- A amber hatched square indicates the gear is in transit



- A hollow white square indicates the gear is Up and Stowed.

  When all three landing gear are Up and Stowed for ten seconds, the white squares will disappear.





NOTE:

During composite mode operation on the PFD, when gear is displayed on the upper right hand portion of the PFD, gear Up and Stowed position annunciation does not disappear after ten seconds.

- If any indicator is not Up and Stowed or Down and Locked, the entire display stays in view and the failed gear is indicated with amber hatched squares. If any gear is in transit for more than 15 seconds, a LANDING GEAR FAIL caution message appears and the in-transit symbol remains displayed.

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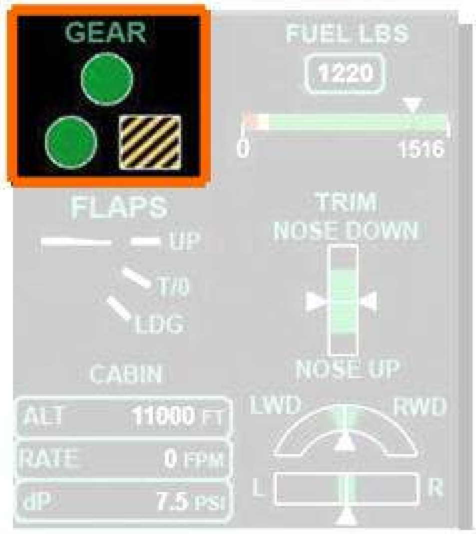

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4.5 System Description

4.5.1 Main Gear

The main landing gear consists of single wheels supported by trailing link strut assemblies. Each assembly includes a shock absorber filled with hydraulic fluid and nitrogen. When the gear is retracted, the wheel and tire assemblies are not enclosed and protrude from the wheel well approximately 1/2 inch. Fairings on the outer hubs make the wheels aerodynamically clean.

The main gear is held in the retracted position by mechanical brakes on the actuator motors and in the extended position by the actuator brakes and over-center folding braces.

Each main gear assembly has three proximity sensors—Down and Locked, Up and Stowed, and Weight On Wheels (WOW). The WOW sensor prevents gear retraction when there is weight on the landing gear.

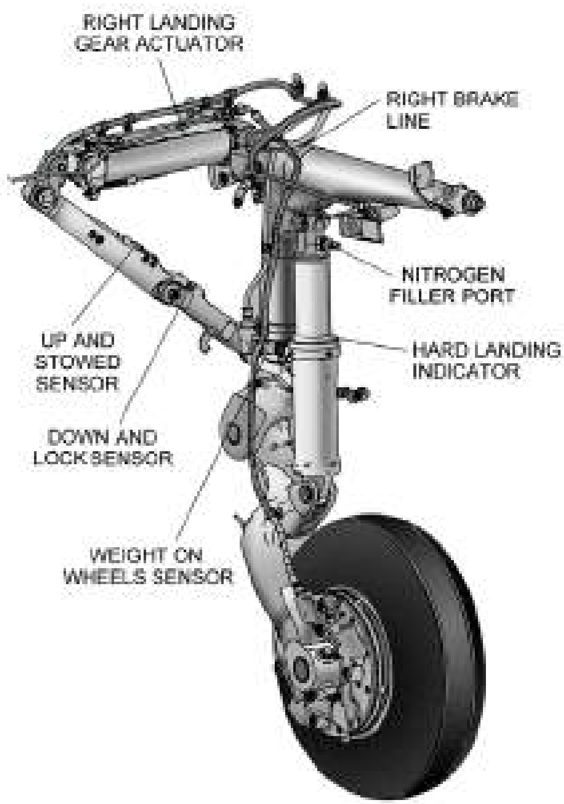

Figure 41.   Main Landing Gear

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4.5.2 Nose Gear

The nose gear assembly incorporates a shock absorbing strut filled with hydraulic fluid and nitrogen, as well as a shimmy dampener. The nose gear is held in the retracted position by mechanical brakes on the actuator motor, and in the extended position by the actuator brake and an over-center folding drag brace. When the nose gear is retracted, it is completely enclosed by the gear doors. There are two proximity sensors on the nose gear—Down and Locked and Up and Stowed.

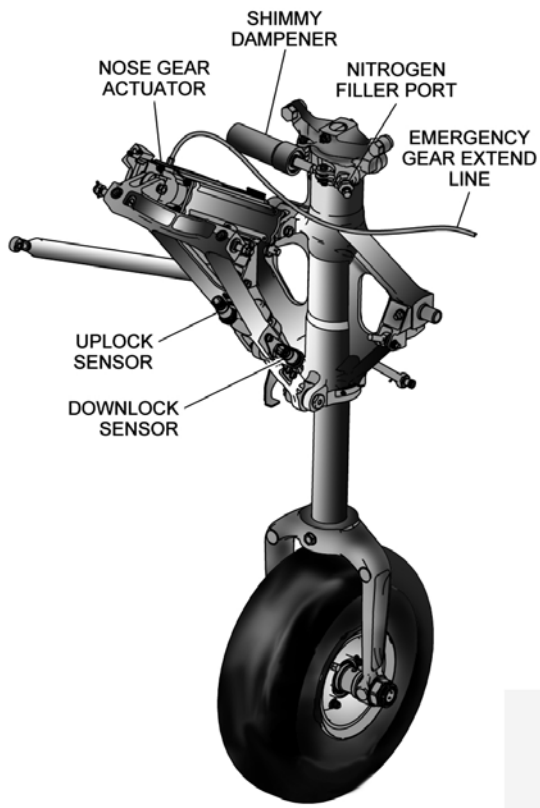

Figure 42. Nose Landing Gear

4.5.3 Landing Gear Actuators

The main gear and nose gear have electromechanical actuators that retract to extend the gear and extend to retract the gear. This design provides minimum exposure of the extended portion of the actuator to the elements for increased reliability.

Each actuator assembly consists of a ball-screw actuator, an electric motor, and a mechanical actuator brake.

4.5.4 Landing Gear Actuator Brakes

The main gear and nose gear actuator assemblies contain a spring-driven mechanical brake that prevents the motor from turning when electrical power is removed. The actuator brakes hold the gear in the retracted or extended position and require power to unlock.

In the event of electrical failure, the actuator brakes lock in place and prevent any movement of the actuators. Manual gear extension is accomplished with an

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emergency gear release handle that mechanically releases the actuator brakes, allowing the gear to freefall.

The actuator brakes are capable of supporting the gear in the retracted position without sagging with g-loads up to 2.0 g. The gear may sag at loads above 2.0 g, but automatically retract when the g-load is reduced. When the actuator sag tolerance is exceeded, the ACS applies power to the actuator motors, unlocking the brakes. The motors drive in the retract direction until the gear is re-stowed, at which point the actuator brakes are re-engaged.

NOTE:

When this occurs, the pilot can expect to see a gear unsafe indication for the gear or gears that are being re-stowed.

4.5.5 Landing Gear Warning Horn

The landing gear warning horn sounds under 12,500 feet MSL, if any gear is not Down and Locked under three conditions:

1. Flaps extended beyond T/O setting
2. Airspeed less than 120 knots with one or both throttles below mid-range (30 degrees TLA)
3. Airspeed less than 140 knots with one or both throttles below mid-range (30 degrees TLA

NOTE:

The warning horn is NOT silenceable for conditions 1 and 2.

The warning can be silenced for condition 3 with the GEAR MUTE button on either sidestick.

4.5.6 Nose Wheel Steering

Nose wheel steering operates through mechanical linkage. With weight on the nose gear, a steering lever at the top of the nose gear engages a mating lever attached to the rudder pedals. When the gear is retracted and weight is off the nose wheel, the steering lever disengages, and the gear self-centers with a pair of internal cams. The cams will not reengage until weight is back on the nose wheel; this prevents landing with the nose wheel turned.

The rudder pedals provide +/- 15 degrees of steering angle. Turns beyond 15 degrees are accomplished with differential braking. When the steering angle exceeds 15 degrees, the steering cams disengage and allow free castering up to 360 degrees. The cams also disengage to allow 360 degrees of turning when the airplane is towed. When the nose wheel returns within the +/- 15 degree angle, the cams reengage, returning steering control to the rudder pedals.

NOTE:

Should the nosewheel caster beyond 60 degrees left or right, it may be necessary to have ground crew reduce the angle of the nosewheel to allow it to reengage to the 15 degree steering band

4.5.7 Brakes

The braking system is mechanically actuated and hydraulically operated. Braking is provided by hydraulically operated single disc brakes on each main gear. When

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pressure is applied to the toe brakes, hydraulic pressure is applied to the corresponding main gear brake.

There is a brake fluid reservoir outside the forward pressure bulkhead. An optical sensor triggers a BRAKE FLUID LOW advisory message when the brake fluid is low.

Each main gear brake assembly incorporates two brake wear indicator pins. As brake pads wear, the pins are pulled into the housing. When the pins are flush with the hex head of the pin retainer housing, the brakes require servicing.

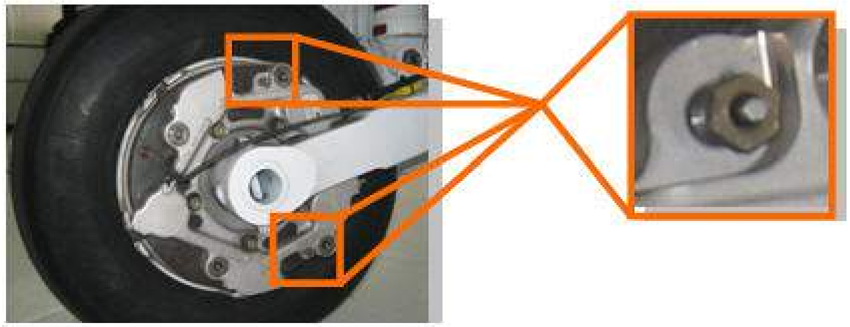

Figure 43. Brake Wear Indicators

4.5.8 Parking Brake

The parking brake is set from either pilot seat by depressing both brake pedals and simultaneously pulling the parking brake handle on the center pedestal. This moves a mechanical lever on the parking brake cylinder which traps pressure between the parking brake cylinder and the wheel brakes. When the parking brake is set, the valve handle position is sensed by a proximity switch that triggers a PARKING BRAKE status message.

The parking brake is released by pushing in the parking brake handle. If the parking brake is engaged when takeoff power is applied a CONFIG PARKING BRAKE warning message appears

4.5.9 Hard Landing Indicators

The main landing gear shock absorbers have mechanical hard landing indicators consisting of red painted grooves at the upper end of the shock absorbers. The grooves are normally covered by a silver split-ring. A hard landing compresses the shock absorber to the point that the split-ring is forced out of the groove, revealing the red paint.

For the nose gear, a hard landing will bend a tab near the top of the nose gear strut on the aft side.

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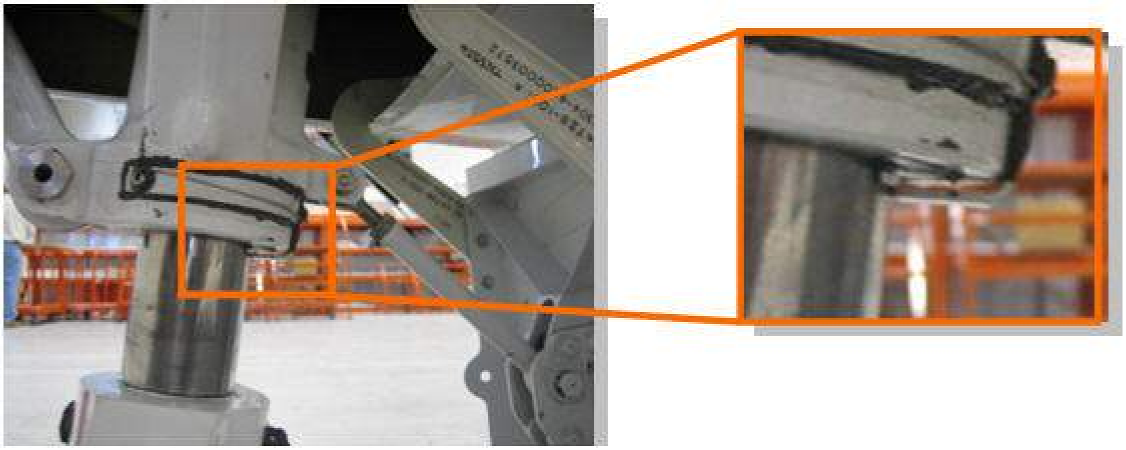

Figure 44. Nose Gear Hard Landing Indicator

Figure 45. Main Gear Hard Landing Indicator

NOTE:

If a hard landing is indicated by either the split-ring or tab, a maintenance inspection of the landing gear is required before flight.

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4.6 Normal Operations

4.6.1 Gear Retraction

When the gear handle is placed in the UP position, the ACS releases the three actuator brakes and applies power to the gear motors in the retract direction. When each gear folding brace moves away from the gear-down proximity sensor, the gear position annunciation changes from green (Down and Locked) to amber/hatched (In Transit).

The nose gear retracts forward into the nose wheel well. Each main gear retracts inboard into the main gear wheel well.

When each gear reaches the up position, power is removed from the actuator motor and the actuator brake is automatically set.

All gear doors are mechanically linked to the respective gear assembly. Movement of the main gear causes the strut mounted main gear doors to close with the gear. Movement of the nose gear opens two aircraft mounted forward nose gear doors, allowing the gear to pass between them. As the nose gear retracts into the wheel well, the two nose gear doors close along with an aft strut mounted door.

When each gear moves to the gear-up proximity sensor, the gear position annunciation changes from amber/hatched (In Transit) to white bordered (Up and Stowed). If all gear indicate Up and Stowed for ten seconds, the white borders and the word “Gear” disappear.

4.6.2 Gear Extension

When the gear handle is placed in the DOWN position, the ACS releases the three mechanical actuator brakes and applies power to the gear motors in the extend direction. When each gear moves away from the gear-up proximity sensor, the gear position annunciation reappears as amber/hatched (In Transit).

When each gear reaches the down position, power is removed from the actuator motor and the actuator brake is automatically set.

The landing gear is mechanically held in the down position by the over-center mechanism and the actuator brakes.

Movement of the nose gear opens and closes the forward nose gear doors for passage of the gear. When the nose gear is extended, the forward nose gear doors are closed while the aft door remains open.

When each gear moves to the gear-down proximity sensor, the gear position annunciation changes from amber/hatched (In Transit) to green (Down and Locked).

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4.7 Abnormal Procedures

4.7.1 Emergency Gear Extension

In the event of a failure of the normal gear extension system a LANDING GEAR FAIL caution message appears and the gear can be mechanically extended using the emergency gear release handle on the cockpit floor aft of the pedestal between the pilots. Emergency extension of the landing gear is accomplished by gravity, with air load assisted freefall of the nose gear. The momentum of the freefalling gear and the back-driving of the gear motors ensure the drag/side braces go into the over-center locked position.

When the emergency gear cable is fully extended, the gear actuator brakes are mechanically released. When the emergency gear handle is re-stowed, the actuator brakes are reapplied. If the emergency gear handle is not stowed following an emergency gear extension an EMER GEAR HANDLE caution message appears reminding the pilot to stow the handle.

The Emergency Gear Extension procedure is:

1. Put the gear handle in the DOWN position.
2. Reduce airspeed to between 195 and 200 knots
3. Open the emergency release handle door, and pull the emergency release handle up and aft. This causes two things to happen:
   - A proximity switch sends a signal to the ACS to remove electrical power from the three gear actuator motors.
   - At full throw, the emergency gear handle cable mechanically releases the actuator brakes, allowing the gear to freefall.

   NOTE:
   Pulling the emergency gear handle requires approximately 18 lbs of force to pull and should be pulled to full extension in one smooth motion.
4. When three green Down and Locked indications are displayed, return the emergency gear release handle to the stowed position to apply the mechanical actuator brakes.

   NOTE:
   Actuator brakes will NOT engage unless the emergency gear release handle is returned to the fully stowed position

4.7.2 Weight On Wheels Sensor Fault

In the event that there is a disagreement between the two weight on wheels sensors, a WOW SENSOR FAULT advisory message appears.

CAUTION:
This will cause the aircraft to depressurize when the speed goes below 60 KEAS and the autopilot, including yaw damper and stick pusher, to be lost.

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4.8 Crew Alerting System Messages

Table 4. Landing Gear CAS Messages

Message	Condition	Category
EMER GEAR HANDLE	Emergency gear handle is not stowed	Caution
LANDING GEAR FAIL	Landing gear system failure	Caution
BRAKE FLUID LOW	Low brake fluid	Advisory
WOW SENSOR FAULT	Weight on wheels sensors disagree	Advisory
PARKING BRAKE	Parking brake is set	Status

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4.9 Landing Gear Review Questions

1. **Which ACS has primary control over the landing gear actuators?**
   a. Left ACS
   b. Right ACS
   c. Landing gear actuators have independent controllers
   d. Both ACS have control
2. **The Eclipse 500 landing gear system is powered by:**
   a. A hydraulic pump.
   b. An electrically powered worm gear drive.
   c. Compressed nitrogen.
   d. Electrically powered landing gear actuators.
3. **What landing gear system component holds the landing gear in the up (retracted) position?**
   a. Up-lock hooks.
   b. Mechanical brakes on the gear actuator motors.
   c. Gear doors locking closed.
   d. Aerodynamic forces generated within the landing gear wells.
4. **Nose wheel steering is accomplished by:**
   a. A nose wheel steering motor which is controlled by the ACS when the pilot engages the nose wheel steering switch.
   b. Mechanical linkages between the nose wheel and the rudder pedals.
   c. Mechanical linkages between a tiller and the nose wheel.
   d. Differential braking with a free castering nose wheel.
5. **Describe the landing gear extension process:**
6. **What indication should the pilot expect to see 10 seconds after a normal gear retraction?**
   a. Nothing, the gear indicator disappears
   b. A landing gear safe status message and landing gear indicator disappears
   c. Three white boxes indicating gear is up and stowed
   d. Three white indicators disappear and the word “GEAR” remains
7. **During an emergency landing gear extension, what will cause the landing gear to fall?**

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a. The emergency landing gear handle releases the actuator brakes allowing the landing gear to fall to the extended position via gravity.

b. A high-pressure nitrogen charge will force the landing gear into the extended position.

c. Emergency landing gear extension is automated through the ACS.

8. **The maximum gear extension (Vlo) speed is:**

   a. 200 KEAS
   b. 250 KEAS
   c. 275 KEAS
   d. 185 KEAS

9. **The maximum landing gear extended (Vle) speed is:**

   a. 185 KEAS
   b. 200 KEAS
   c. 275 KEAS
   d. 250 KEAS

10. **What must a pilot/operator do in the event of a hard landing indication?**

    a. Visually inspect the tires on the next preflight.
    b. Have a maintenance inspection completed prior to the next takeoff.
    c. Check the strut compression on the subsequent preflight inspection.
    d. Check the tire pressure before the next flight.

11. **What holds the landing gear in the down (extended) position:**

    a. The landing gear actuator brakes.
    b. Over-center folding braces.
    c. Continuous mechanical pressure from the landing gear actuator motors.
    d. Both A and B are correct.

12. **What will happen if the landing gear is in transit for longer than 15 seconds?**

    a. A LANDING GEAR FAIL caution message is displayed.

    b. The landing gear brakes will automatically engage regardless of gear position.

    c. The pilot must recycle the landing gear lever immediately.

    d. A LANDING GEAR FAULT advisory message is displayed

13. **Which is the only condition where the landing gear warning horn may be silenced?**

    a. Airspeed less than 140 knots below 12,500 feet MSL and either or both throttles at idle.

    b. Airspeed less than 120 knots and either or both throttles at idle.

    c. Flaps extended beyond T/O setting.

14. **The brakes on the Eclipse 500 are:**

    a. Electrically operated and actuated.
    b. Mechanically actuated and hydraulically operated.
    c. Electronically operated and mechanically actuated (Brake by wire).

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15. **What indicates that the brake pads are worn?**

16. **What does the PARKING BRAKE status message indicate?**

17. **What might I expect to see on the MFD landing gear indicator in high G maneuvers- Ex- steep turns.**

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5. Oxygen

5.1 General

The airplane is equipped with an oxygen system for use by the pilots and passengers in the event of a loss of cabin pressurization or presence of smoke or fumes in the cockpit.

The pilot position is fitted with a quick-donning diluter-demand mask, located on the top left portion of the pilot seat and connected to an outlet in the left armrest. The right pilot seat is fitted with a constant flow mask, contained behind a door on the lower right side of the instrument panel. In addition, the right pilot seat is optionally fitted with a quick-donning diluter-demand mask, located on the top right portion of the right pilot seat.

Two constant flow mask containers are located in the ceiling of the cabin. Each container contains two masks. The passenger masks automatically deploy in the event of depressurization, or the masks can be manually deployed by the pilot. Passengers must pull down on the mask to activate the flow of oxygen.

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5.2 Aircraft Computer System (ACS) Interfaces

The ACS receives input from a low pressure oxygen switch. This switch monitors oxygen pressure from the regulator to assure that there is sufficient pressure to properly operate a crew mask and supply sufficient oxygen to the passenger masks. When oxygen pressure decreases below 46 +/- 4 PSI the switch triggers an OXYGEN PRESSURE warning message. This message will disappear once the oxygen pressure increases to 60 PSI.

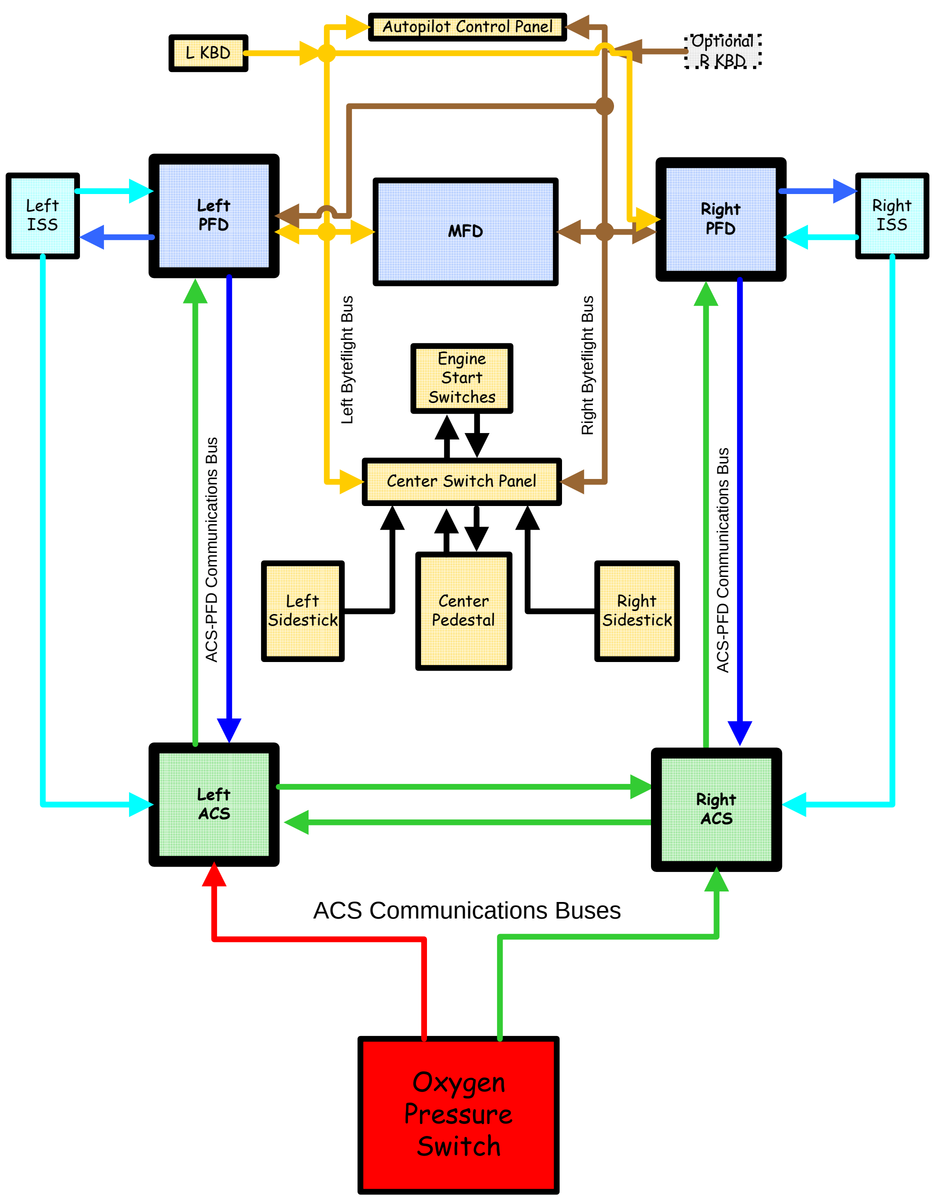

Figure 46. Oxygen-ACS Interface

5.3 Limitations and Specifications

5.3.1 Oxygen Bottle Pressure

Normal Oxygen Bottle Pressure .... 1850 psi

Minimum Oxygen Bottle Pressure .... 200 psi

NOTE:

The minimum pressure for oxygen regulator operation is 200 psi. Refer to the Aircraft Flight Manual oxygen duration chart for the oxygen requirement for a particular flight.

5.3.2 Oxygen Type

The oxygen system must be serviced with aviation grade oxygen to avoid freezing and/or malfunction of the oxygen system.

5.3.3 Oxygen System Activation (AUTO)

Oxygen System Activation ....14,000 +000/-500 feet cabin altitude

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5.4 Controls and Indicators

5.4.1 Oxygen Controls

Figure 47. Oxygen Panel Location

OXYGEN CONTROL KNOB

ON .... Oxygen system is on; pressure-regulated oxygen is available.
OFF... Oxygen system is off.

PASSENGER MASK SELECTOR

OFF... Oxygen system is off.
AUTO.......... Passenger masks automatically deploy at 14,000 foot cabin altitude.
DROP .... Passenger masks deploy immediately.

OXYGEN BOTTLE PRESSURE GAUGE

Oxygen bottle pressure

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5.5 System Description

5.5.1 Standard Configuration

- 22 cubic foot oxygen bottle and regulator assembly
- Quick-don diluter-demand oxygen mask on the left pilot seat
- Five constant flow oxygen masks
  - One passenger mask at the right pilot seat
  - Four passenger masks

5.5.2 Optional Configuration

- 40 cubic foot oxygen bottle and regulator assembly
- Quick-don diluter-demand oxygen mask on the left pilot seat
- Quick-don diluter-demand oxygen mask on the right pilot seat
- Five constant flow oxygen masks
  - One passenger mask at the right pilot seat
  - Four passenger masks

5.5.3 Oxygen Bottle

The airplane is equipped with either a 22 cubic foot or 40 cubic foot oxygen bottle, located in the left side of the nose compartment.

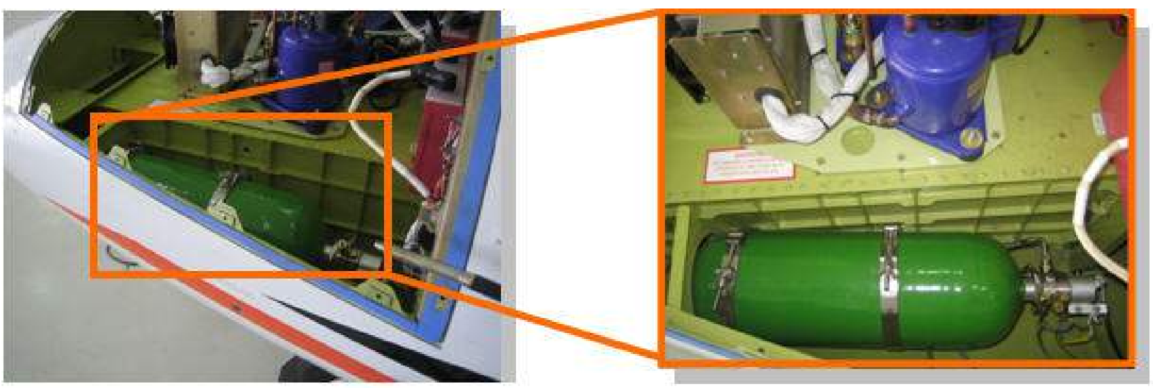

Figure 48. Oxygen Bottle Location (40 Cubic Foot)

5.5.4 Oxygen Service Panel

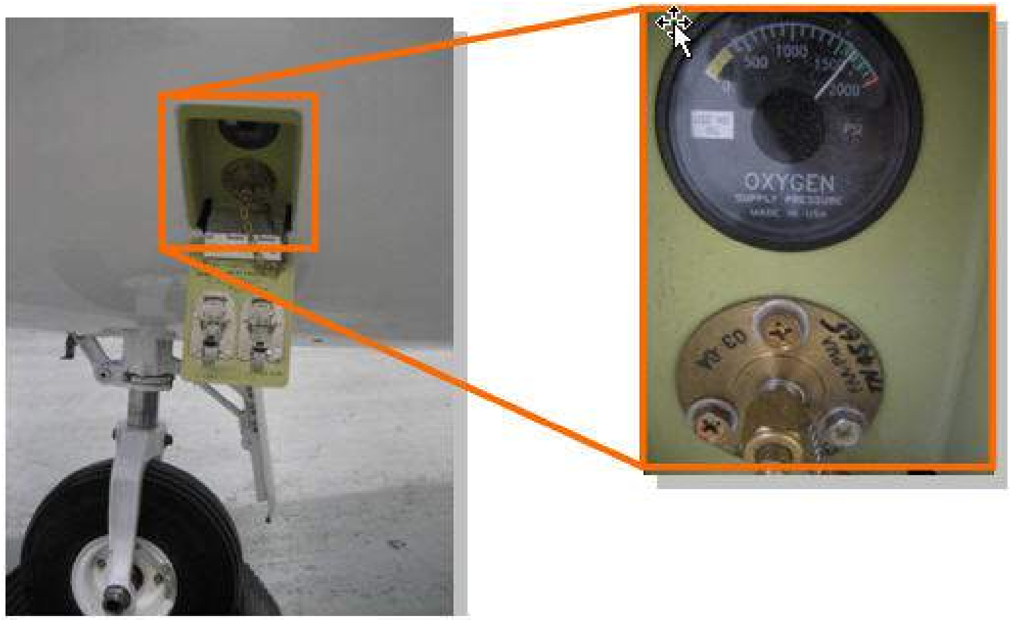

Figure 49. Oxygen Service Panel

An oxygen service panel is located on the left side of the nose. The service panel contains an analog pressure gauge. The normal servicing range of 1550 to 1850 psi is indicated by a green band. Low pressure (0 to 300 psi) is indicated by an amber band. Overpressure (above 1850 psi) is indicated by a red band.

Instrument	Caution Range (Yellow)	Normal Range (Green)	Max. Limit (Red)
Oxygen Pressure (psi)	0-300 psi	1,550-1,850 psi	1,850 psi – Full Scale

5.5.5 Cockpit Oxygen Gauge

Oxygen bottle pressure can also be read on a gauge on the left switch panel. The caution range and maximum limit pressures are indicated differently than the exterior service panel gauge. A low oxygen pressure of 0-200 psi is indicated in RED, while overpressure, >1850 psi is indicated in amber. Normal operating range, 200-1850 psi is green.

Instrument	Caution Range (Red)	Normal Range (Green)	Max. Limit (Yellow)
Oxygen Pressure (psi)	0-200 psi	200-1,850 psi	1,850 psi – Full Scale

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Figure 50. Cockpit Oxygen Pressure Gauge

5.5.6 Armrest Oxygen Panel

The pilot quick don mask oxygen hose and oxygen mask microphone are connected via the left and right armrest panels.

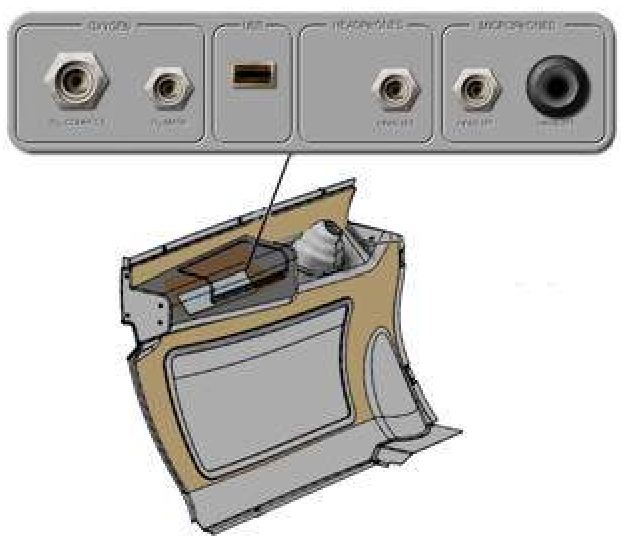

Figure 51. Armrest Oxygen Panel

5.5.7 Blowout Disc

A green blowout disc is located forward of the oxygen service panel. The disc is designed to blow out at approximately 2700 psi. Blow out of the disc indicates an overpressure has occurred or that the oxygen system has been improperly serviced. A ruptured disc requires maintenance action before flight.

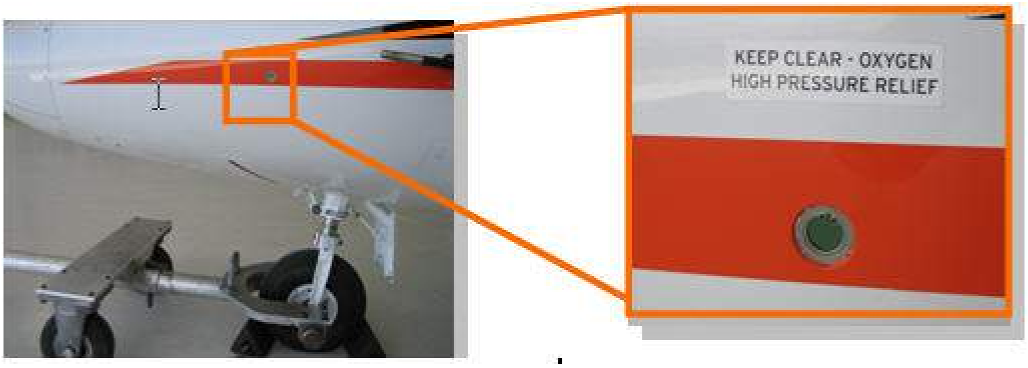

Figure 52.   Blowout Disc Location

CAUTION:

Always provide 24 inches of free space perpendicular to disk during aircraft preflight.

5.5.8 Oxygen Regulator

An oxygen regulator is connected to the oxygen cylinder to reduce oxygen pressure to the pilot and passenger masks. The regulator is activated by the oxygen control knob on the left switch panel.

5.5.9 Pilot Oxygen

When the oxygen control knob is in the ON position, low pressure oxygen from the regulator flows to the pilot oxygen mask(s). To use the system, the pilot need only don the oxygen mask and breathe. Oxygen pressure is confirmed by a green flag on the crew mask hose.

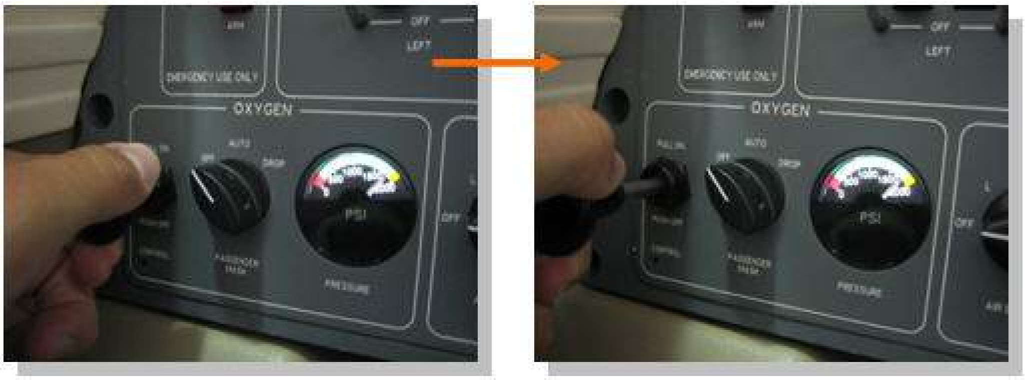

Figure 53. Oxygen Control Knob Activation

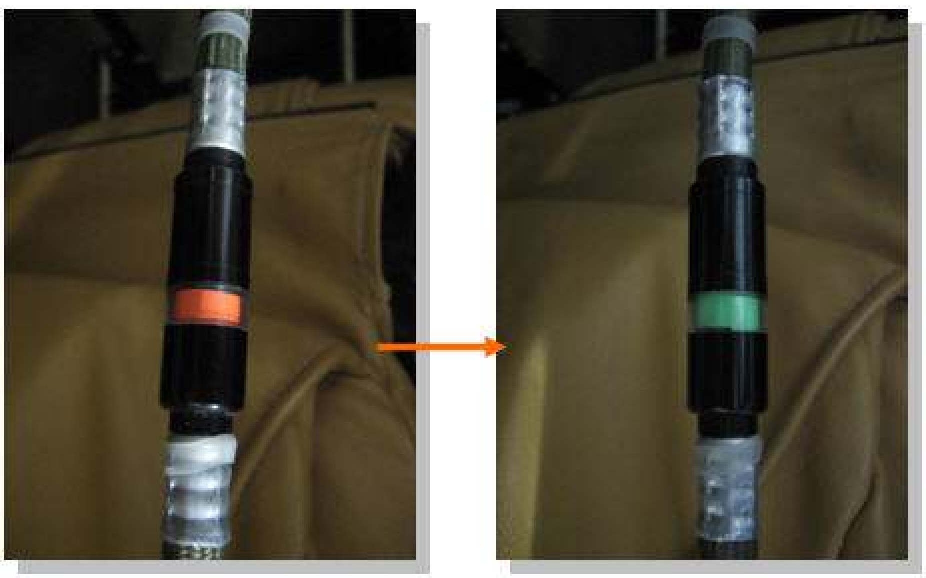

Figure 54. Crew Mask Hose Flow Indicator

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5.5.10 Cabin/Passenger Oxygen

When the oxygen control knob is in the ON position, low pressure oxygen from the regulator flows to the three-position PASSENGER MASK selector valve labeled OFF, AUTO, DROP, on the left switch panel. The cabin oxygen valve is opened one of two ways:

- Electrically, by a solenoid triggered by the 14,000 foot cabin altitude switch
- Mechanically, by selecting DROP with the PASSENGER MASK selector

NOTE:

The pilot can deploy the mask at any time without electrical power using this mode.

When cabin altitude decreases to 10,000 feet the altitude switch resets the solenoid valve and oxygen flow ceases to the passenger masks. However if the masks are manually deployed using the DROP selection on the passenger mask selector, oxygen flow will continue below 10,000 feet.

Figure 55. Passenger Mask Selector Activation

5.5.11 Pilot Oxygen Masks

The left seat pilot (and optionally the right seat pilot) position is provided with a quick donning, pneumatic harness crew mask with a diluter-demand regulator. The mask is designed to be donned with one hand. Oxygen is available for use when the oxygen control knob is in the ON position. Oxygen flow to the mask can be verified by a green flow indicator in the oxygen line to the mask. With no oxygen supply, a red indicator will be displayed. When stowed, the mask should be set in 100%, with the harness packed in accordance with the packing instructions located within the mask stowage cup.

Figure 56.   Pilot Quick-Don Mask Location

Donning the mask is accomplished by removing the mask from the seat mounted compartment and squeezing a red lever on the side of the regulator. This inflates the pneumatic harness, allowing the pilot to place the harness around his /her head. Once the harness and mask are in place, releasing the red lever deflates the pneumatic harness for a snug fit. Comfort adjustors located on the harness hose attach points allow for repositioning on the mask on the pilot’s face.

Figure 57. Red Lever and Oxygen Mask Adjustment

The mask regulator on the front of the mask allows selection of NORMAL, 100%, and EMERGENCY settings by rotating the selector to the desired position.

NORMAL......................Regulator supplies a mixture of oxygen and ambient cabin air. Oxygen flow is on demand.

100%................................Regulator supplies 100% oxygen with no ambient cabin air. Oxygen flow is on demand.

NOTE:

It is recommended that the mask be stored set on this mode.

EMERGENCY ....100% oxygen is delivered under pressure. This mode is automatically active at 34,000 feet cabin altitude regardless of the setting on the mask. Mask pressure is proportional to the cabin altitude up to 45,000 feet.

Figure 58. Quick Don Mask Regulator

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5.5.12 Passenger Oxygen Masks

Four continuous flow passenger oxygen masks are contained within two oxygen mask containers in the cabin with (each container housing two masks.) There is also an identical oxygen mask container for the right pilot seat located on the right switch panel. Each unit is equipped with a pneumatically-operated door latch which opens the door and allows the oxygen mask to drop. The latch is opened by low pressure oxygen flowing into the system, either because low cabin pressure (cabin altitude 14,000 feet and above) triggers the cabin oxygen valve solenoid or because the pilot selects DROP on the PASSENGER MASK selector.

A pin-release mechanism is attached to the mask by a lanyard. When the mask is pulled, the lanyard pin is released and oxygen flows to the mask. A green flow indicator appears in a clear section of the hose to indicate oxygen flow.

If passenger oxygen masks are automatically dropped and the cabin altitude decreases below 10,000 feet oxygen flow will cease to the passenger masks. If the passenger oxygen masks are manually dropped using the passenger mask selector oxygen flow will continue all the way to the ground.

Figure 59. Passenger Mask Location and Deployment (Right Switch Panel)

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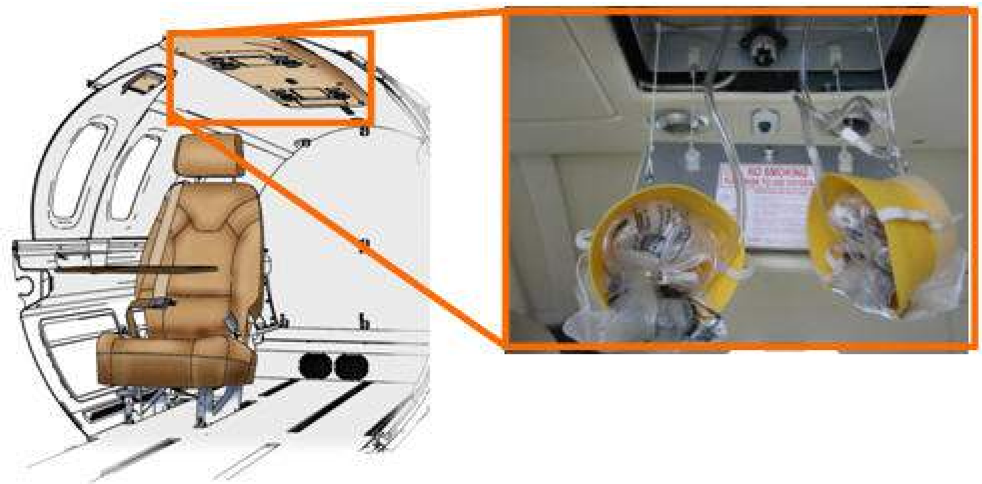

Figure 60. Passenger Oxygen Mask Location and Deployment (Cabin)

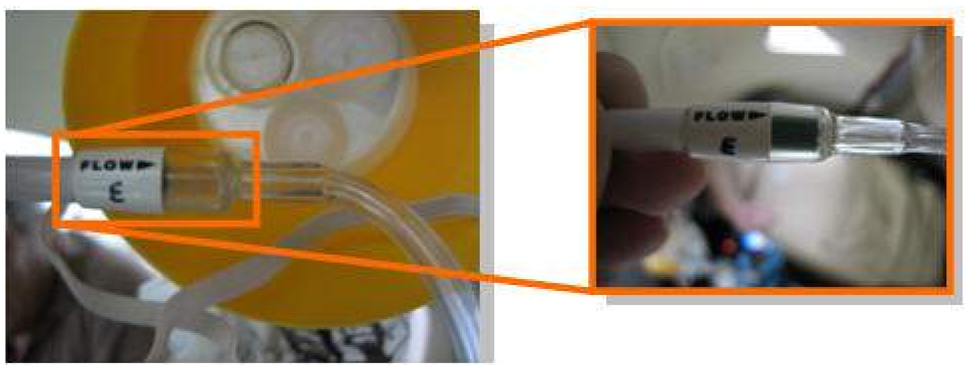

Figure 61. Passenger Oxygen Mask Flow Indicator

5.5.13 Emergency Operation

As long as the oxygen control knob is in the ON position, oxygen is available to the pilot and right pilot seat masks.

If the cabin altitude exceeds 12,750 feet MSL an aural alert; 'Mask On, Descend!, will sound every 30 seconds until the cabin altitude descends below 12,500 feet or if the cabin altitude is descending at 1,800 fpm or greater.

If cabin altitude exceeds 14,000 feet MSL with the oxygen control knob in the ON position and the passenger oxygen selector in AUTO, the cabin pressure altitude switch will open the passenger oxygen solenoid valve. When the solenoid valve is opened, the passenger oxygen manifold is pressurized, causing the pneumatic door switches to open the doors and deploy the masks.

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NOTE:

If the masks do not deploy automatically, the pilot can activate the passenger oxygen by moving the PASSENGER MASK selector to the DROP position. This bypasses the solenoid valve and mechanically opens the oxygen valve. The PASSENGER MASK selector does not require electrical power to operate. To assure oxygen flow to masks, check the green flow indicator located in the mask lines and verify the pin is pulled to initiate the flow of oxygen to the masks.

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5.6 Normal Operations

5.6.1 Oxygen System Preflight

Prior to engine start, pull the oxygen control knob to activate the oxygen system and verify system pressure on the BOTTLE PRESSURE gauge.

The PASSENGER MASK selector should be in the AUTO position to allow for automatic mask deployment.

Verify oxygen flow to quick don mask (s) by viewing the flow indicator in the oxygen line. Set the regulator to the 100% and test mask operation by removing the mask and depressing the red lever on the side of the regulator to inflate the harness. Also breathe from the mask to assure oxygen flow.

5.6.2 Oxygen Duration

Federal aviation regulations require that one pilot wear an oxygen mask and use oxygen above FL350.

- Operations under 14 CFR Part 91 require a 10 minute supply of oxygen for all passengers in the event of a cabin depressurization. The 22 cubic foot bottle meets this requirement.
- Operations under 14 CFR Part 135 require a two hour supply of oxygen for each crew-member and a 10 minute supply for all passengers. The 40 cubic foot bottle meets these requirements.

Table 5. Table Oxygen Duration 22 cu ft Cylinder – Part 91

# Pass	# Pilots	Total Useable Cylinder Capacity (LITERS)	Oxygen Used in Preflight (LITERS)	Emergency Oxygen Consumed in 10 min Descent (Pilot+Pass) (LITERS)	Pilot Cruise Consumption Above 35K ft. (Mask in "NORM") (LITERS)	Maximum Oxygen Consumption Time Above 35K ft for Pilot (Mask in "NORM") (MINUTES)
0	1	580	2.32	32.84	544.84	249.93
1	1	580	2.32	78.84	498.84	228.83
2	1	580	2.32	124.84	452.84	207.72
3	1	580	2.32	170.84	406.84	186.62
4	1	580	2.32	216.84	360.84	165.52
5	1	580	2.32	262.84	314.84	144.42

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Table 6. Oxygen Duration 40 cu ft Cylinder – Part 91

# Pass	# Pilots	Total Useable Cylinder Capacity (LITERS)	Oxygen Used in Preflight (LITERS)	Emergency Oxygen Consumed in 10 min Descent (Pilot+Pass) (LITERS)	Pilot Cruise Consumption Above 35K ft. (Mask in "NORM") (LITERS)	Maximum Oxygen Consumption Time Above 35K ft for Pilot (Mask in "NORM") (MINUTES)
0	1	1005	2.32	32.84	969.84	444.88
1	1	1005	2.32	78.84	923.84	423.78
2	1	1005	2.32	124.84	877.84	402.68
3	1	1005	2.32	170.84	831.84	381.58
4	1	1005	2.32	216.84	785.84	360.48
5	1	1005	2.32	262.84	739.84	339.38

Table 7. Oxygen Duration 40 cu ft Cylinder – Part 135

# Pass	# Pilots	Total Useable Cylinder Capacity (LITERS)	Oxygen Used in Preflight (LITERS)	Crew Emergency Descent Requirement 10 min (LITERS)	30-Minute Rule for Passenger Oxygen Reserve Above 15K ft (LITERS)	Single Pilot Cruise Consumption Above 25K ft. (Mask in "NORM") (LITERS)	Maximum Oxygen Consumption Time Above 25K ft for Pilot (Mask in "NORM") (MINUTES)
0	1	1005	2.32	32.84	0.00	969.84	444.88
1	1	1005	2.32	32.84	139.88	829.965	380.72
2	1	1005	2.32	32.84	279.75	690.09	316.56
3	1	1005	2.32	32.84	419.63	550.215	252.39
4	1	1005	2.32	32.84	559.50	410.34	188.23
5	1	1005	2.32	32.84	699.38	270.465	124.07
0	2	1005	4.64	65.68	0.00	934.68	428.75
1	2	1005	4.64	65.68	139.88	794.805	364.59
2	2	1005	4.64	65.68	279.75	654.93	300.43
3	2	1005	4.64	65.68	419.63	515.055	236.26
4	2	1005	4.64	65.68	559.50	375.18	172.10
0	2	1005	4.64	65.68	0.00	934.68	428.75

NOTE:

Refer to the onboard oxygen duration chart for oxygen requirements for a particular flight

5.6.3 Oxygen System Post-Flight

When the engines are shut down, push in the oxygen control knob to shut off the oxygen system and prevent inadvertent oxygen depletion.

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5.7 Abnormal Procedures

5.7.1 Low Oxygen Pressure

The OXYGEN PRESSURE warning message appears with low pressure downstream of the oxygen regulator. Thus, when the oxygen system is off (oxygen control knob in the OFF position with at least one engine operating or in flight), the OXYGEN PRESSURE warning message is displayed.

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5.8 Crew Alerting System Messages

Table 8. Oxygen CAS Messages

Message	Condition	Category
OXYGEN PRESSURE	Oxygen line pressure below 46 psi.	Warning

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5.9 Oxygen Review Questions

1. **What triggers passenger mask deployment during normal oxygen system operation on the Eclipse 500?**
   a. The pilot manually deploys the masks.
   b. The masks will automatically deploy with a cabin pressure altitude of 14,000 ft +0/-500 feet
   c. The masks will automatically deploy with a cabin pressure altitude of 12,500 ft. +500/-500
   d. The masks will automatically deploy with a cabin pressure altitude of 14,000 ft +500/-500 feet

2. **Label the RED, GREEN and AMBER range maximum and minimum values using the diagram below:**

3. **The purpose of the blowout disk is:**
   a. To adjust cabin pressure.
   b. Indicates that an over pressurization has occurred and indicated that the bottle requires service.
   c. To prevent ice from forming in the oxygen bottle when the pressurized oxygen is released.
   d. To keep the oxygen bottle sealed until it is ready for use.

4. **On preflight what action shall the pilot accomplish in order to ensure the OXYGEN PRESSURE warning will not be displayed?**
   a. Pull the oxygen control knob prior to engine start.
   b. Make sure the oxygen bottles have been properly filled.
   c. Both A and B are correct
   d. None of the above

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5. **The GREEN PSI range on the external oxygen bottle gauge range is _______PSI to _________PSI.**

6. **According to 14 CFR Part 91.211 at which altitude shall a SINGLE pilot always use their quick don mask?**
   a. FL350
   b. FL250
   c. FL410
   d. According to 14 CFR Part 91 BOTH A and C are correct.

7. **Maximum allowed oxygen bottle pressure limit is:**
   a. 200 PSI
   b. 1850 PSI
   c. 185 PSI
   d. 400 PSI

8. **Minimum allowed oxygen bottle pressure is:**
   a. 1800 PSI
   b. 250 PSI
   c. 400 PSI
   d. 200 PSI

9. **At which cabin altitude will the passenger oxygen system automatically activate?**
   a. 12,750 ft
   b. 14,000 ft
   c. 15,000 ft
   d. 12,500 ft

10. **If selected, which oxygen regulator mode will ALWAYS deliver 100% oxygen under pressure?**
    a. Normal
    b. 100%
    c. Emergency
    d. Oxygen is never delivered under pressure with the quick don mask.

11. **On the three position passenger mask selector, which position would be selected for a manual release of the passenger oxygen masks?**
    a. OFF
    b. AUTO
    c. DROP

12. **At what cabin pressure altitude does the ‘Mask On, Descend!” aural alert activate?**

13. **What are two ways to deactivate/silence the ‘Mask On, Descend!” aural alert?**

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a.

b.

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6. Ice Protection

6.1 General

The ice protection system is comprised of the following:

- Pneumatic de-ice boots on the leading edges of the wing and horizontal stabilizer
- Left and right heated windshields
- Heated pitot / Angle Of Attack (AOA) probes
- Heated pitot / static probe
- Heated static ports
- Engine anti-ice

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6.2 Aircraft Computer System (ACS) Interfaces

The ACS has control and monitoring functionality over both the Anti-ice and Deice components of the ice protection system.

The deice system includes a bleed air deice manifold that is responsible for routing engine bleed air through various valves and pressure switches to the wing and horizontal stabilizer boots.

The anti-ice system consists of automatically heated air data probes (discussed in the Air Data Chapter) and heated engine inlets.

Air is routed to both deice manifold and the engine inlets by a pressure regulating shut-off valve on each engine.

The pilot selections using the ENG/WING switch on the center switch panel are sent through the PFD to the ACS, which in turn controls inflation and deflation of the boots and routing of air to the engine inlets by turning on and off applicable Electronic Circuit Breakers (ECBs). The ECBs for the ice protection system are located within the Aft Power Distribution Center in Electronic Circuit Breaker Units (ECBUs) four and five.

Six sensors allow the ACS to monitor the ice protection system components for low bleed air pressure from the engine or low pressure within the deice boots. The pressures switches also provide feedback to the ACS for failure monitoring.

ICE PROTECTION SYSTEM SENSORS

1. Left Engine
   a. Inlet Temperature
   b. Regulated Pressure Switch
2. Right Engine
   a. Inlet Temperature
   b. Regulated Pressure Switch
3. Deice Boots
   a. Outer Wing Boot Pressure Switch
   b. Inner Wing/Stabilizer Boot Pressure Switch

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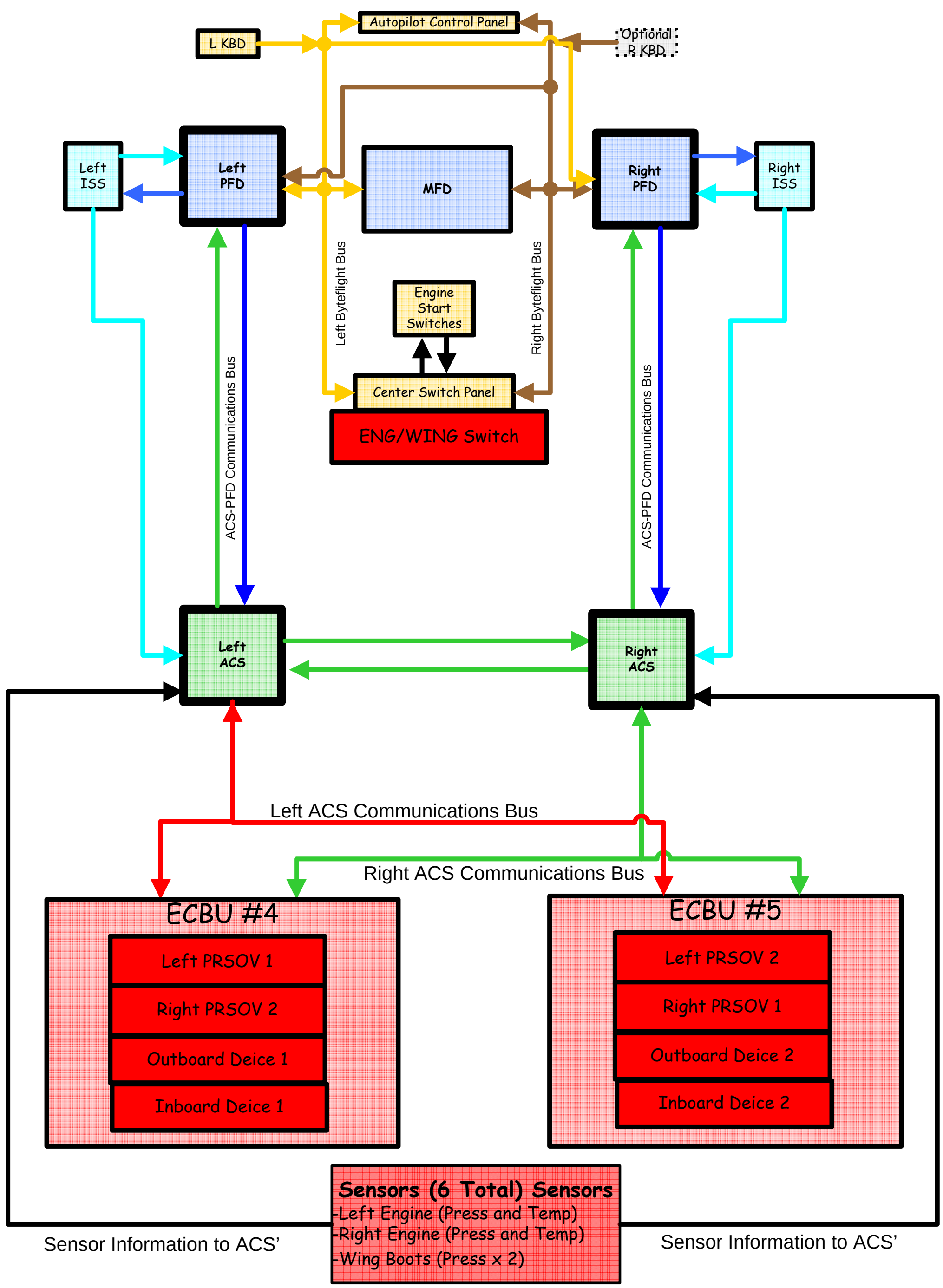

Figure 62. Ice Protection-ACS Interface

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6.3 Limitations and Specifications

6.3.1 Icing Conditions

Flight into known icing conditions is prohibited.

When outside air temperature is 10°C (50°F) or below and visible moisture is present, engine anti-ice must be selected ON for all ground and flight operations,.

When operating the engines at idle speed on the ground in freezing fog and visible moisture, the engine speed must be increased once every five minutes to 65% N1 to avoid ice accumulation on the spinner.

6.3.2 Pneumatic De-ice

The use of wing deice (boots) is prohibited.

The following wing deice Electronic Circuit Breakers (ECBs) must be collared:

- INBOARD WING DEICE L,
- INBOARD WING DEICE R,
- OUTBOARD WING DEICE L and
- OUTBOARD WING DEICE R.

6.3.3 Windshield Heat

The use of windshield heat is prohibited.

The following windshield heat ECB must be collared:

- L/R WINDSHIELD HEAT.

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6.4 Controls and Indicators

6.4.1 Center Switch Panel-Ice Protection

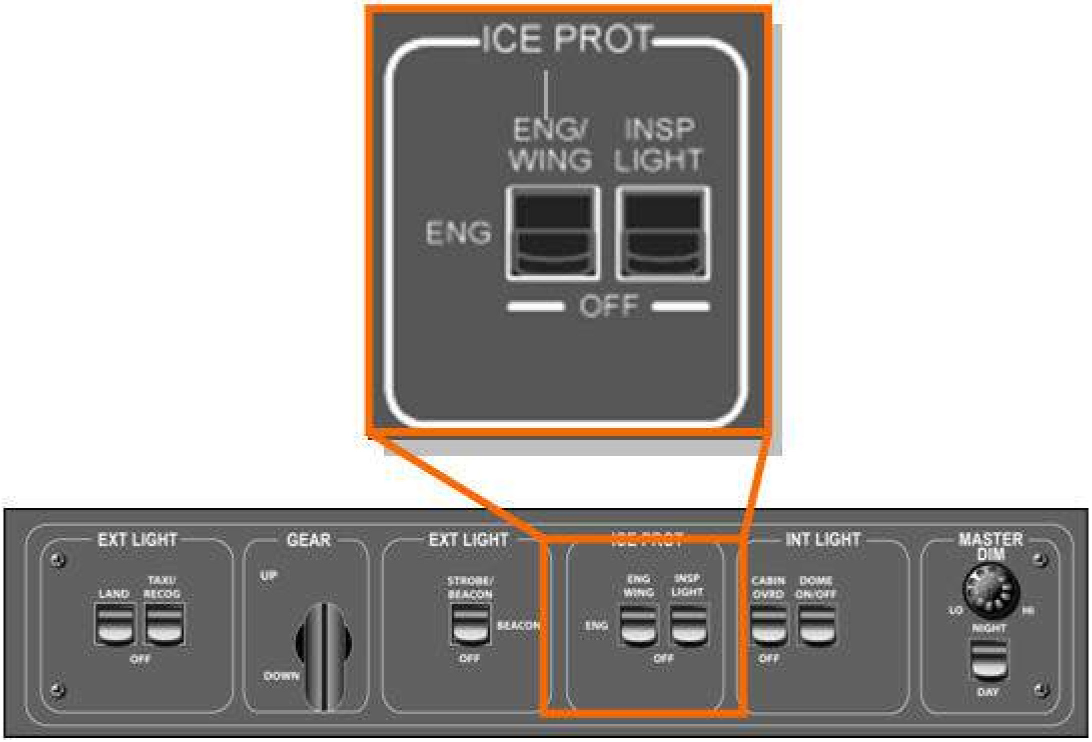

Figure 63. Center Switch Panel- Ice Protection

ENG / WING Switch

ENG/WING .... Engine anti-ice and boot de-ice systems on
ENG .... Engine anti-ice system only on
OFF.. Engine anti-ice and boot de-ice systems off

INSP LIGHT Switch

INSP LIGHT .... Wing inspection light on
OFF.. Wing inspection light off

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6.4.2 Ice Protection Synoptic

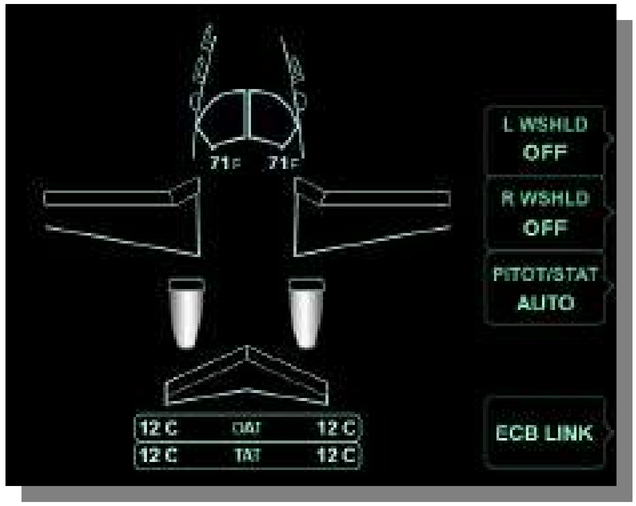

Figure 64. Ice Protection Synoptic

L and R WSHLD LINE SELECT KEY
- ON .... Windshield heat on
- OFF............ Windshield heat off

WINDSHIELD DISPLAY
- Green outline .... Windshield heat on
- White outline .... Windshield heat off
- Amber outline .... Windshield overheat or failure
- White temperature .... Normal temperature range
- Red temperature............ Overheat (with red OVHT)

PITOT/STAT LINE SELECT KEY
- ON .... Pitot/static heat on
- AUTO............ Automatic

PROBE DISPLAY
- Green............ Probe/Static heat on
- Amber .... Probe/Static heat failed

DE-ICE BOOT DISPLAY
- Green............ De-ice system on
- White............ De-ice system off
- Amber .... De-ice system failed

Engine Display
- Green............ Engine anti-ice on
- White............ Engine anti-ice off
- Amber .... Engine anti-ice failed

OAT .... Outside Air Temperature
TAT .... Total Air Temperature

NOTE:

Amber and red display colors are consistent with CAS message colors.

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6.5 System Description

6.5.1 Windshield Heat

The left and right windshields each contain a mat with electrical heater wire embedded into the acrylic plies in the center portion of the windshield. Windshield temperature is automatically controlled so that the outer windshield panels maintain a temperature above freezing. Any super-cooled water droplets remain in a liquid state while on the windshield. Water droplets that impact the windshield either evaporate or run to the top or side edges of the windshields where they either freeze or are shed into the slipstream.

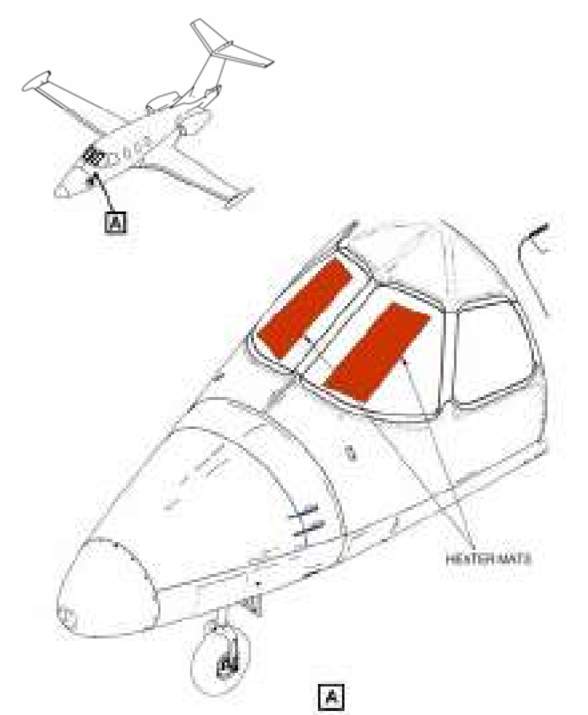

Figure 65.   Windshield Heater Mat

The ACS maintains the windshield temperature between 127°F and 140°F (53°C and 60°C) by cycling windshield heat on and off. The left and right windshield heat is powered by separate Electronic Circuit Breakers (ECBs) so that an electrical problem will not impact both windshields.

Windshield heat is controlled by two line select keys labeled L WSHLD AND R WSHLD on the ICE protection synoptic. These keys allow the windshield heat to be selected to ON or OFF. The default state for windshield heat is OFF. When activated a WINDSHIELD HEAT MANUAL status message appears.

Operation of windshield heat is displayed on the ICE protection synoptic by windshield outlines on plan view of the aircraft. A white windshield outline indicates that the windshield heat is off. A green windshield outline indicates that windshield heat is on and functioning normally.

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6.5.2 Defog

In the event of a failure of the windshield heat system, a defog system is available. It is controlled from the ENVIR synoptic.

6.5.3 Pneumatic De-ice

The airplane is equipped with pneumatically operated neoprene de-ice boots mounted on the leading edges of the wings and horizontal stabilizer. There is one boot on each wing, separated into an inboard and outboard section; And also one boot on each horizontal stabilizer.

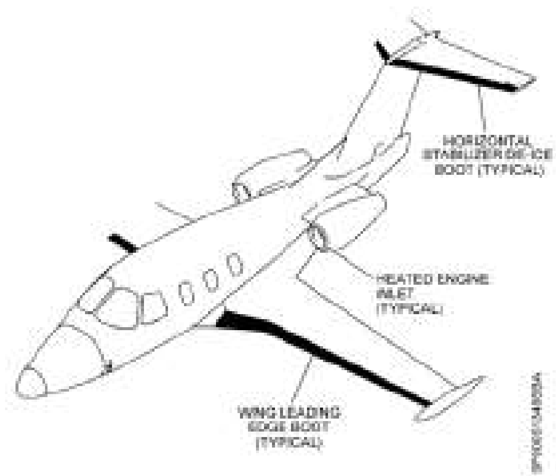

Figure 66. Leading Edge De-Ice Boot Location

De-ice boot inflation is activated by selecting ENG/WING on center switch panel. At least one engine must be running for the system to operate since engine bleed air inflates the boots.

An ENG/WING ICE PROT ON status message indicates both engine anti-ice and wing de-ice are activated. Normal operation of the boot de-ice system is indicated on the ICE protection synoptic by green leading edges on the wings and horizontal stabilizer on the airplane graphic display. When the de-ice system is off, the leading edges are black with a white outline.

The ACS controls the inflation/deflation cycle and monitors system pressure. Pneumatic air is first routed to the inboard wing and horizontal stabilizer boots, then to the outboard wing boots. Each cycle takes approximately one minute. When the system is switched off, the current cycle is completed and the system turns off.

Bleed air from the engines is fed to a common de-ice manifold through pressure regulating shut-off valves on each engine. A dual distribution valve in the de-ice manifold directs pressurized bleed air into the boots, resulting in boot inflation that breaks any ice accretion. After the boots are inflated, the dual distribution valve then directs the pressurized air through an ejector nozzle within the manifold that creates suction to deflate the boots and maintain the aerodynamic profile of the leading edges.

6.5.4 Engine Anti-Ice

Engine anti-ice protection is provided by pressurized bleed air directed into a perforated tube on the inside of each engine inlet cowl. Bleed air entering the tube heats the cowl, preventing ice formation. This air is then exhausted overboard.

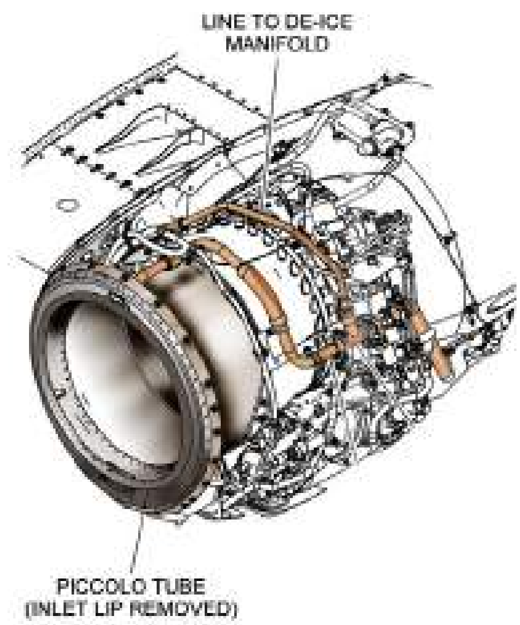

Figure 67. Engine Inlet Anti-Ice

Engine anti-ice is activated by selecting engine anti-ice only (ENG) or both engine anti-ice and wing de-ice (ENG/WING) on the center switch panel.

An ENG A/ICE ON status message indicates only engine anti-ice is activated. An ENG/WING ICE PROT ON status message indicates both engine anti-ice and wing de-ice are activated. Normal operation of the engine anti-ice system is indicated on the ICE protection synoptic by green engine inlets on the airplane graphic display. When the system is off, the engines are displayed in black with a white outline.

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6.5.5 Pitot/AOA Probes, Pitot-Static Probe and Static Ports

All air data system probes and ports are heated automatically for all ground and flight operations by self-regulating heaters. The probes receive their power from separate ECBs and are monitored by the ACS.

The self-regulating heater in each probe monitors and regulates the probe temperature within a specified range. This temperature is high enough to prevent buildup of ice but not hot enough to cause damage.

Probe and static port heat is selectable to AUTO or ON by a line select key labeled PITOT/STAT on the ICE protection synoptic. The default state for PITOT/STAT heat is the AUTO position. Probe and port heat begins automatically cycling on when at least one engine is running. On the ground probe heat can be manually activated without engines running using the PITOT/STAT line select key.

Normal operation of the probe and static port heat is indicated on the ICE protection synoptic by a green display on the airplane graphic. When a probe or static port is unheated (off), it appears black with a white outline.

6.5.6 Wing Inspection Light

A wing inspection light is located in the left-hand wing root fairing to illuminate the left wing leading edge for visual ice detection at night.

The wing inspection light is controlled by a two position INSP LIGHT switch on the center switch panel.

Figure 68. Wing Inspection Light Location

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6.6 Normal Operations

6.6.1 Ground Operations

Ice protection configuration on the ground is dependant on the pilot's need for windshield defogging. On the ground, the pilot may activate windshield heat or use the DEFOG feature on the environmental (ENVIR) synoptic. DEFOG mode allows the pilot to use conditioned bleed air to warm the interior surfaces of the windshield, instead of windshield heat. Additionally, all air data probes will be heated automatically during ground operations.

6.6.2 Flight Operations

In flight, the pilot can activate windshield heat using the ICE protection synoptic. In the event of a windshield heat failure, the DEFOG feature should be used.

In actual and/or anticipated icing conditions, windshield heat and engine anti-ice should be activated. Constant use of engine cowl heat will prevent ice from being ingested into the engines. Air data probes will be automatically heated during flight operations and their status may be monitored on the ICE protection synoptic.

Wing leading edge and horizontal stabilizer boots should also be used as necessary to remove accumulated ice from leading edge surfaces. To monitor accumulation of ice at night, activate the ice inspection light switch to illuminate the leading edge of the left wing.

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6.7 Abnormal Procedures

6.7.1 Windshield Overheat

The appearance of a L (R) WSHLD OVHT warning message should be considered a false indication as windshield heat is inoperative.

Overheat is also indicated on the ICE protection synoptic. The outline of the windshield turns amber, a red OVHT message appears inside the windshield outline and the temperature display changes to red.

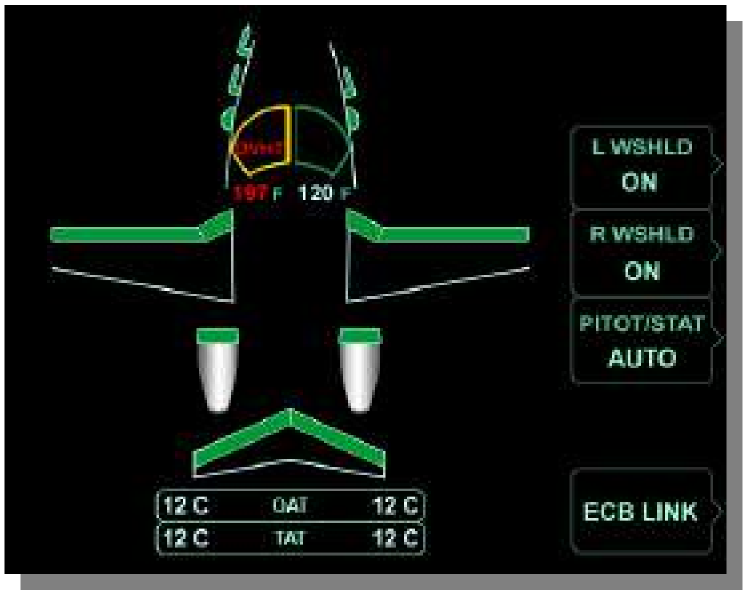

Figure 69. Windshield Overheat

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6.7.2 Windshield Heat Failure

If either windshield fails for a reason other than an overheat, L (R) WSHLD HEAT FAIL caution message appears. Failure is also indicated on the ICE protection synoptic by the windshield outline turning amber.

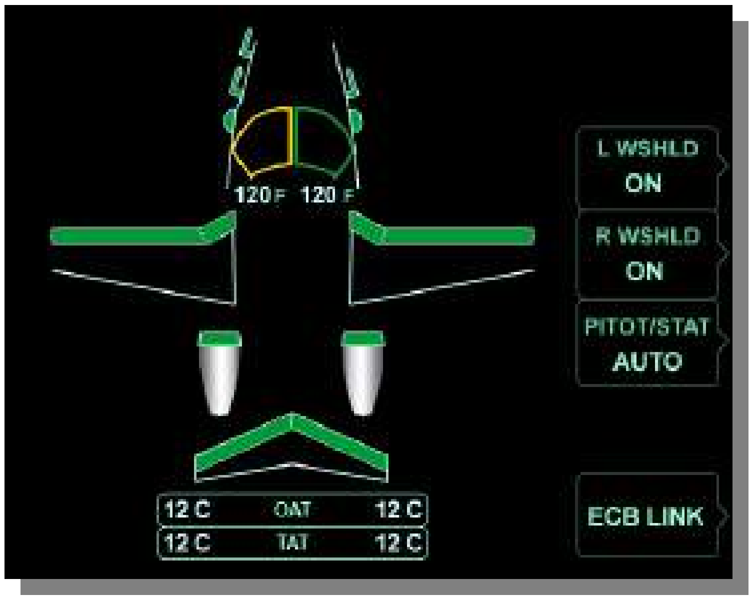

Figure 70. Windshield Heat Failure

6.7.3 Pneumatic De-ice System Failure

A malfunction of the pneumatic de-ice boots causes a WING DEICE FAIL caution message to appear. Malfunctions include inadequate pressure for inflation, boot not deflating, inadequate vacuum to retain the boots against the wing when the system is off, and failure of de-ice manifold heat. The failure is also indicated on the ICE protection synoptic by the affected wing or horizontal boot section turning amber.

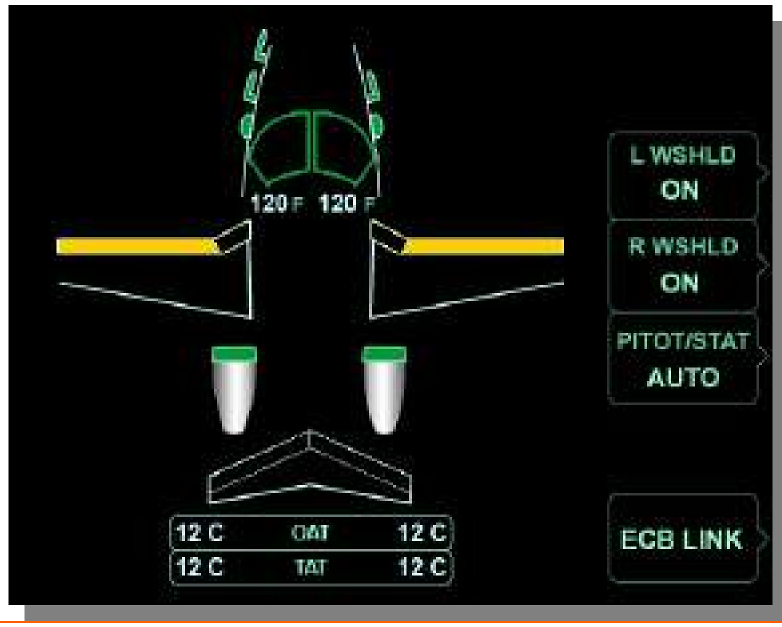

Figure 71. Wing De-Ice Failure

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6.7.4 Engine Anti-Ice System Failure

A malfunction of engine inlet anti-ice during flight causes a L (R) ENG A/ICE FAIL caution message to appear, along with the associated caution alert tone. The failure is also indicated on the ICE protection synoptic by the engines cowls on the airplane graphic turning amber.

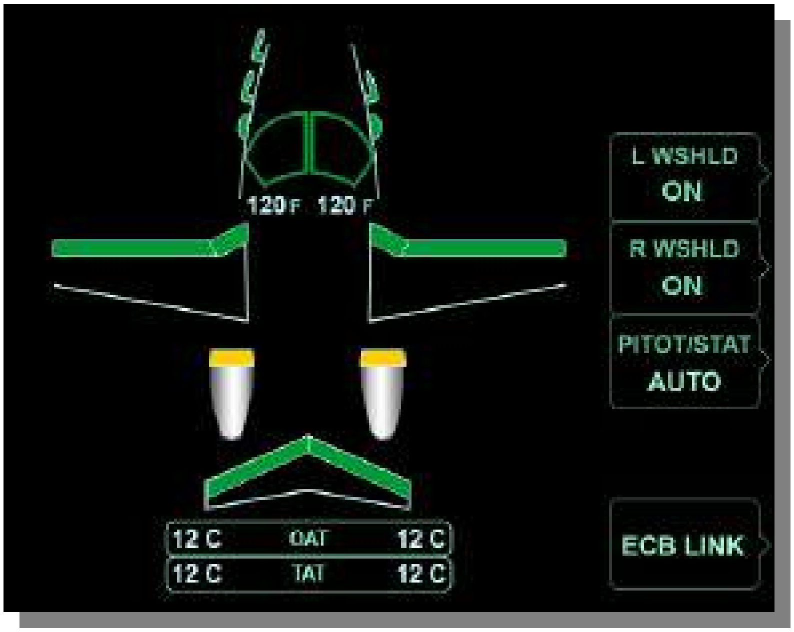

Figure 72. Engine Anti-Ice Failure

NOTE:

This CAS message also appears if the system is switched on and the inlet temperature sensor remains cold, indicating no airflow.

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6.7.5 Probe and/or Port Heat Failure

A complete failure of a probe or static port heat causes a L (R) PITOT HEAT FAIL, L (R) STATIC HEAT FAIL, or STBY PITOT HEAT FAIL caution message to appear, along with the associated caution alert tone. The failure is also indicated on the ICE protection synoptic by the probe or port turning amber. Since static ports have two heating elements, it is possible that only one may fail. Should this occur a L (R) STATIC HEAT FAIL advisory message appears to alert the loss of redundancy.

Figure 73.   Pitot/AOA Probe Failure

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6.7.6 Windshield Heat Sensor Fault

A malfunction of the imbedded temperature sensors causes a L (R) WSHLD HEAT FAULT advisory message to appear. The associated temperature display on the ICE protection synoptic appears as three red dashes.

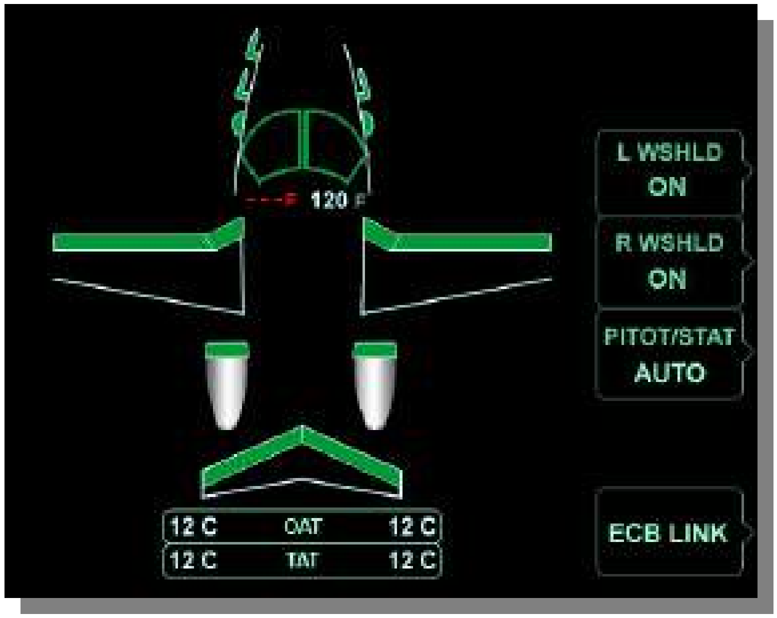

Figure 74.   Windshield Heat Sensor Fault

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6.7.7 Pressure Regulating Shut-Off Valve Fault

A failure of a pressure regulating shut off valve causes a L (R) ENG A/ICE VLV FAULT to appear. This valve fails open allowing pneumatic de-ice to remain available.

6.7.8 De-ice Pressure Sensor Fault

Should a wing de-ice pressure sensor malfunction be detected on the ground, a WING DEICE MON FAULT advisory message appears and flight into icing conditions is prohibited. Should this fault occur in flight, wing de-ice is unavailable and a WING DEICE FAIL caution appears.

6.7.9 Engine Anti-Ice Sensor Fault

Should an engine anti-ice sensor malfunction be detected on the ground, an ENG ANTI-ICE MON FAULT advisory message appears and flight into icing conditions is prohibited. Should this fault occur in flight, engine anti-ice is unavailable and a WING DEICE FAIL caution appears.

6.7.10 Static Heater Monitor Fault

Should the ACS be unable to monitor the function of the static heaters, a STATIC HTR MON FLT advisory message appears. The heaters will still operate.

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6.8 Crew Alerting System Messages

Table 9. Ice Protection CAS Messages

Message	Condition	Category
L WSHLD OVHT	False indication. Windshield heat is inoperative. No pilot action required.	Warning
R WSHLD OVHT	False indication. Windshield heat is inoperative. No pilot action required.	Warning
L (R) ENG A/ICE FAIL	Engine anti-ice failed	Caution
L (R) PITOT HEAT FAIL	No pitot heat detected	Caution
STBY PITOT HEAT FAIL	Pitot/static probe heat failure	Caution
L (R) STATIC HEAT FAIL	Static port heaters are inoperative	Caution
L (R) WSHLD HEAT FAIL	Windshield heat is inoperative	Caution
WING DEICE FAIL	Wing deice malfunction detected	Caution
L (R) ENG A/ICE VLV FAULT	Engine anti-ice valve is stuck open	Advisory
ENG ANTI-ICE MON FAULT	Engine anti-ice sensors failed (Ground Only)	Advisory
L (R) STATIC HEAT FAIL	Static port A or B heater is inoperative (Ground Only)	Advisory
L (R) WSHLD HEAT FAULT	L (R) windshield heat sensor fault. Loss of redundancy (Ground Only)	Advisory
STATIC HTR MON FLT	Unable to monitor function of heaters. Heaters will still operate	Advisory
WING DEICE MON FAULT	Wing de-ice pressure sensor malfunction (On Ground Only)	Advisory
ENG A/ICE ON	Engine anti-ice only on	Status
ENG/WING ICE PROT ON	Engine anti-ice and wing de-ice on	Status
WINDSHIELD HEAT MANUAL	Windshield heat manually activated	Status

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6.9 Ice Protection Review Questions

1. **What electronic circuit breaker units contain the Ice Protection system Electronic Circuit Breakers?**

   a.

   b.

2. **When the temperature is below 10° C, when may icing occur on the ground?**

   a. When visible moisture in any form is present.
   b. When ramps, taxiways, and runways are covered in water.
   c. When ramps, taxiways, and runways are covered in slush and snow.
   d. All of the above are correct.

3. **When should pneumatic de-ice be used?**

   a. All the time as a preventative measure.
   b. Only when ice is visibly present on the airframe.
   c. Only below temperatures of -40° C.
   d. None of the above

4. **When should engine anti-ice be used?**

   a. Anytime icing conditions exist or are anticipated.
   b. Only after significant airframe ice accretion has occurred.
   c. Anti-ice should only be used in the air to prevent cowl overheating.
   d. Both A and B are correct.

5. **On the Ice Protection Synoptic, what does an amber outline/fill indicate?**

6. **What has happened when the CAS displays: "WSHLD HEAT FAULT"?**

   a. The ACS was unable to disable windshield heat.

   b. The CAS is alerting the pilot to a windshield heat sensor failure.

   c. The windshield heating element has malfunctioned and can no longer provide windshield heat.

   d. None of the above.

7. **How is automatic probe and port heat is activated?**

8. **How is probe and port heat manually activated?**

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9. **How are the engine inlets heated?**
   a. Electrically
   b. Engine bleed air from the inboard bleed air port on each engine
   c. Conditioned bleed air from the deice manifold
   d. Engine bleed air from the outboard bleed air port on each engine

10. **What is the air source for the pneumatic boots?**
    a. A compressor in the nose section inflates the boots as needed.
    b. Engine bleed air is used for boot inflation
    c. The boots are mechanical in nature and are inflated via servo motors.
    d. None of the above.

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7. Fuel

7.1 General

The fuel system is a supply pressurized wet-wing design. Normally each engine receives fuel from the corresponding wing tank, but fuel from either wing can supply both engines through a crossfeed valve. Fuel Management and balancing is automatically controlled by the ACS, but can be overridden by the pilot.

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7.2 Aircraft Computer System (ACS) Interfaces

The ACS is responsible for the following fuel system functions:

1. Calculating and Monitoring Fuel Quantities
2. Monitoring and Controlling Fuel Balancing through Fuel Crossfeed
3. Monitoring Fuel Temperature and Pressure
4. Controlling Fuel Shutoff Valves and Electric Fuel Pumps

The ACS monitors inputs from various sensors throughout the fuel system and based on these inputs determines the fuel system status and activates the electric fuel pumps and fuel system valves automatically as necessary for normal operation. Sensors and components on the right side of the fuel system reports directly to the Right ACS, while sensors and components on the left side reports directly to the Left ACS

The pilot has direct fuel system control inputs through the FUEL synoptic on the MFD and can view system status as reported by the ACS from systems sensors, activate the electric fuel pumps, or initiate manual fuel balancing.

Pilot inputs through the MFD are routed through the PFD to the ACSs which use these commands to turn on and off applicable Electronic Circuit Breakers (ECBs). The ECBs for the fuel system are located within the Aft Power Distribution Center in Electronic Circuit Breaker Units (ECBUs) four and five.

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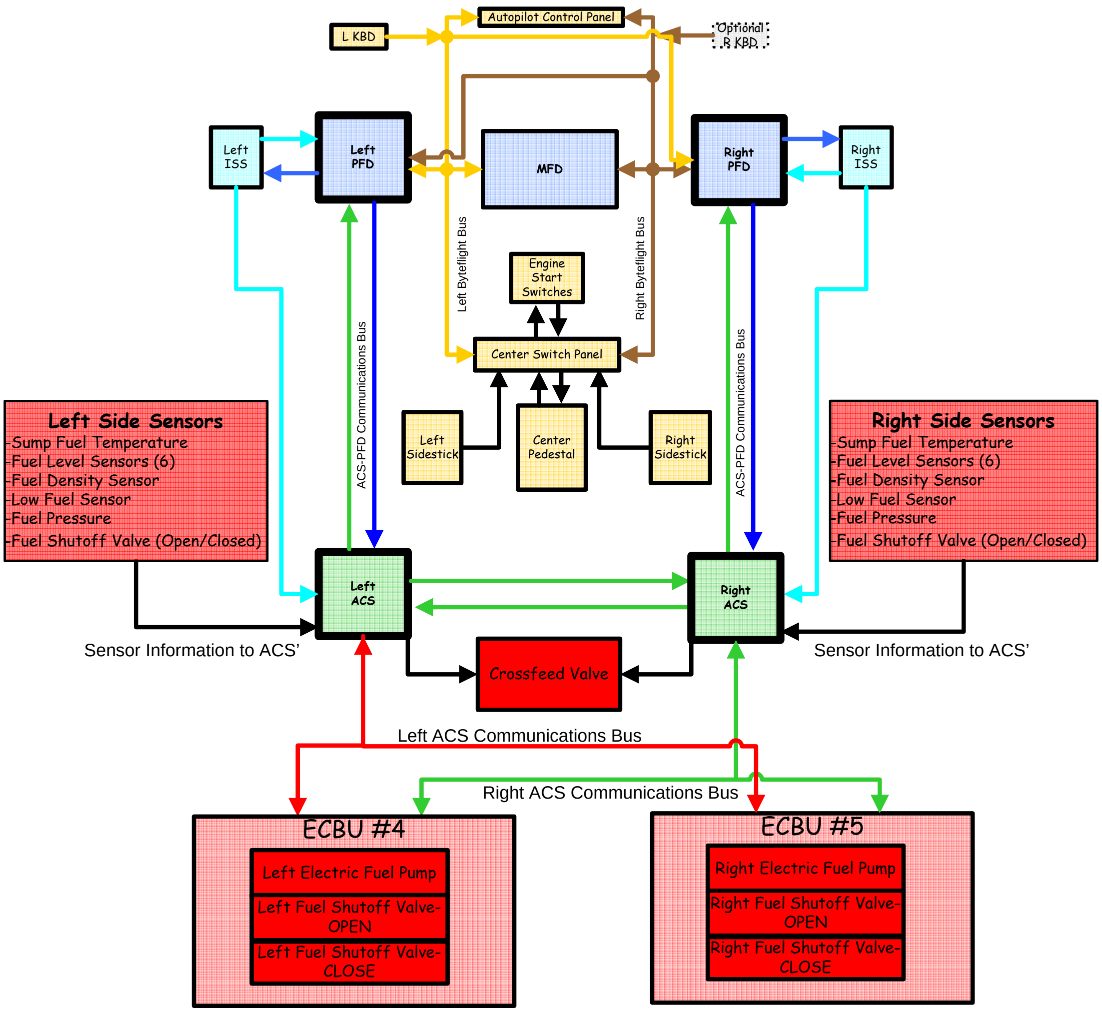

Figure 75. Fuel-ACS Interface

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7.3 Limitations and Specifications

7.3.1 Approved Fuel Grades

Jet A/A1, JP-8

7.3.2 Fuel Capacities

Total Fuel Capacity.. 1,540 lbs, 227.5 US Gal

Total Usable Fuel .... 1,516 lbs, 224 US Gal

Total Unusable Fuel .... 24 lbs, 3.5 US Gal

Maximum Fuel Imbalance.. 65 lbs, 9.6 US Gal

Low Level Fuel Indication .... 105 lbs, 15.5 US Gal (per side)

NOTE 1:
Usable Fuel can be safely used during all Normal Category maneuvers.

NOTE 2:
Fuel weights are calculated at 15°C; 1 US Gal = 6.77 lbs.

NOTE 3:
Un-coordinated maneuvers including sideslips / skids are limited to 45 seconds in duration.

7.3.3 Fuel Additives

Anti-Icing additives meeting the following specifications are required for all operations. Example: Prist

- MIL-I-27686
- MIL-I-85470
- Phillips PFA-55MB

7.3.4 Fuel Temperature

Maximum fuel sump temperature, continuous... 66°C (150°F)
Maximum fuel sump temperature, transient (30 minute maximum) .... 77°C (170°F)
Maximum fuel sump temperature, takeoff.. 51°C (124°F)

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7.4 Controls and Indicators

7.4.1 MFD Fuel Display

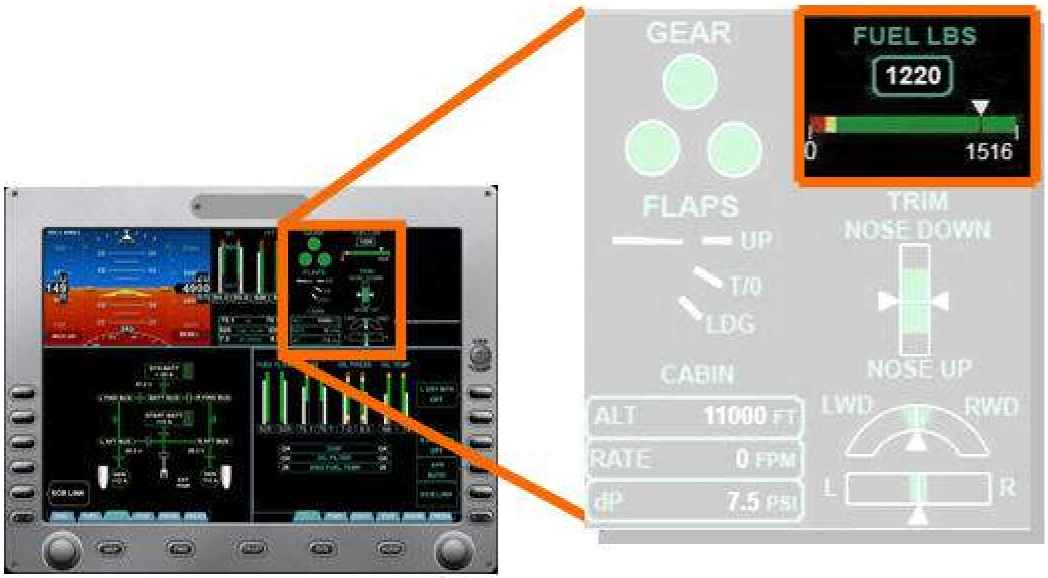

Figure 76. MFD Fuel Display

Fuel quantity is continuously displayed on the upper portion of the MFD. Fuel capacity is displayed as a horizontal green scale, with caution (amber, indicating 280 pounds of total fuel remaining) and warning (red, indicating 210 pounds of total fuel remaining) areas on the left side.

Fuel quantity is indicated by a white pointer above the scale. Total fuel quantity remaining in pounds is displayed above the scale. The total quantity display turns amber when fuel remaining is less than 280 pounds, and red when fuel remaining is less than 210 pounds.

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An individual sump quantity display appears below the total fuel quantity scale with the quantity digits in amber if least one sump tank quantity decreases to the caution level of 140 pounds or less, and red when the corresponding sump quantity decreases to less than 105 pounds.

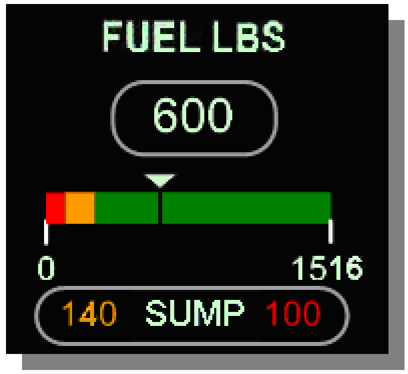

Figure 77. Sump Tank Quantity Display

Sump tank fuel quantities of 140 lbs and 105 lbs that turn the sump quantity display amber and red equate to the fuel quantities that trigger the FUEL QTY LOW caution and L (R) FUEL QTY LOW warning messages.

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7.4.2 Fuel Synoptic

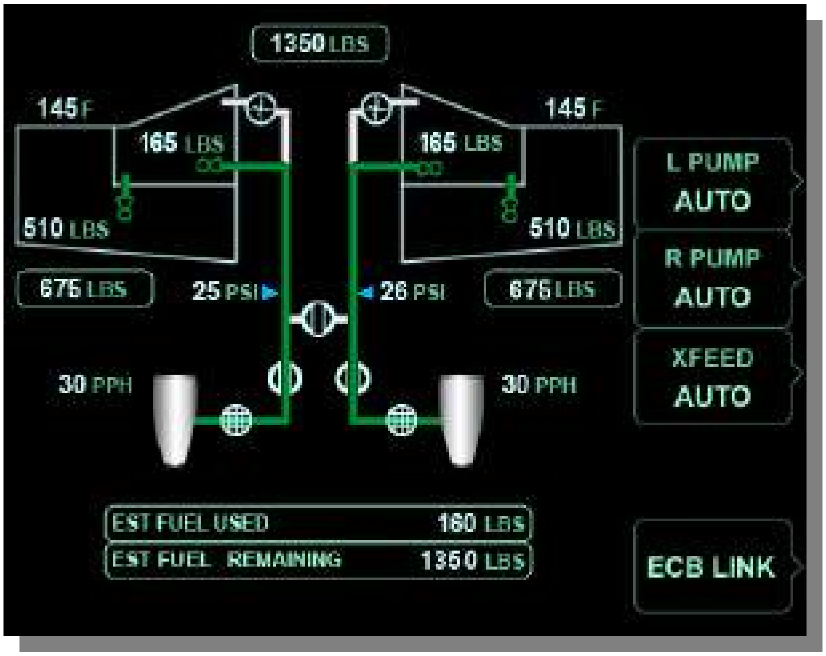

Figure 78. Fuel Synoptic- Normal

The fuel synoptic displays fuel system information and the status of fuel system components. The following information is displayed:

- Status of the electric fuel pumps
- Commanded position of the crossfeed valve
- Actual position of the fuel shutoff valves
- Total fuel quantity (also always displayed on the MFD)
- Total wing fuel quantity
- Fuel quantity in the wing tanks and sump tanks
- Fuel temperature in each sump tank
- Fuel pressure in the left and right fuel supply lines
- Fuel flow for each engine
- Estimated fuel used and estimated fuel remaining
- Status of the fuel filter

MEASURED FUEL QUANTITY

Total fuel quantity from the gauging system is displayed at the top of the fuel synoptic, along with tank quantities in both wing tanks and both sump tanks.

The total fuel quantity digits turn amber when total fuel quantity is below 280 lbs and red when total fuel quantity is less than 210 lbs.

Wing and sump tank quantity digits turn amber when a sump tank quantity is 140 lbs or less. When sump quantity is below 105 lbs, the interior of the sump and wing tanks turns red and sump tank quantity digits appear in white.

Line select keys on the fuel synoptic provide manual control of the two electric fuel pumps and the crossfeed valve.

L PUMP .... AUTO / ON

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R PUMP .... AUTO / ON
XFEED .... AUTO / L→R / L←R / OFF

The ECB LINK line select key opens the Electronic Circuit Breaker (ECB) page to access fuel ECBs.

ESTIMATED FUEL QUANTITIES

Estimated fuel used and estimated fuel remaining are displayed at the bottom of the fuel synoptic. A snapshot of the total fuel is taken at engine start, and then fuel used and fuel remaining are calculated using fuel flow.

Estimated fuel quantity is independent of the gauging system, and serves as a backup in the event of a gauging system failure. A significant difference in the estimated and gauged fuel quantity might also be an indication of a fuel leak.

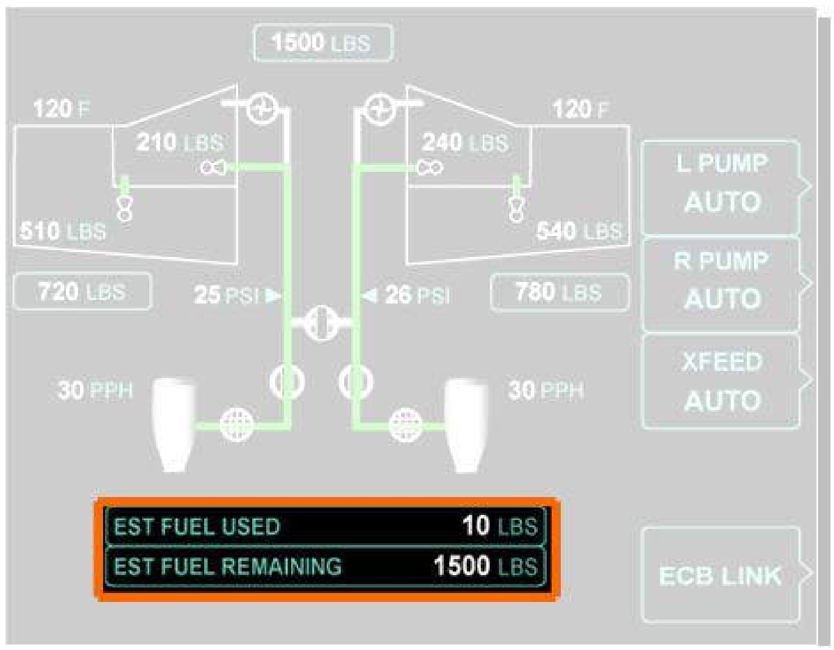

Figure 79. Estimated Fuel Used & Estimated Fuel Remaining Display

7.5 System Description

7.5.1 Fuel Tanks

Fuel is contained within each wing in a “wet wing” design. Each wing is separated into two tanks, a wing tank (outer portion of the wing) and a sump tank (inner portion of the wing). Fuel flows from the wing tanks to the sump tanks by gravity, aided by ejector transfer pumps.

7.5.2 Fuel Pumps

There are ten fuel pumps on the airplane.

- Two ejector boost fuel pumps (one per wing)
- Two ejector transfer fuel pumps (one per wing)
- Two electric fuel pumps (one per wing)
- Four engine driven fuel pumps (two per engine)

7.5.3 Ejector Boost Pumps

An ejector boost pump is located in each sump tank to pump fuel from the sump tank to the Fuel Metering Unit (FMU).

The ejector boost pumps are venturi type that have no moving parts and do not require electrical power to operate. Pressurized return fuel from the engines flows through the ejector boost pump venturi, pulling fuel from the sump tank. Return fuel is also called “motive fuel” since it causes the pumping action.

7.5.4 Ejector Transfer Pumps

An ejector transfer pump is located in each sump tank to aid gravity flow by pumping fuel from the wing tank to the sump tank to keep the sump tank full whenever the associated engine is running. The ejector transfer pumps are also a venturi design, and are operated with motive fuel discharged from the ejector boost pumps.

If an ejector transfer pump fails, gravity transfer from the outboard wing tank to the inboard sump tank is adequate to keep fuel supplied to the engine.

If there is a failure of internal wing transfer or fuel becomes trapped outboard a L (R) FUEL UNUSABLE caution message appears and the total amount of unusable fuel for flight should be increased to 50 lbs.

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7.5.5 Electric Fuel Pumps

An electric fuel pump is located in each wing root. The electric pumps function in parallel with the ejector boost pumps to pump fuel from the sump tanks to the engines and are capable of supplying adequate fuel to both engines throughout the flight envelope. The electric fuel pumps operate at a higher pressure and will effectively override the ejector boost pumps. The electric fuel pumps are off during most normal flight operations. The pumps start automatically in the following situations:

1. Engine start
2. Automatic fuel balancing
3. Low fuel pressure/ Ejector boost pump failure

> **NOTE:**
> If low fuel pressure is detected (below 15 PSI), it is a likely indicator that an ejector boost pump has failed. The corresponding electric fuel pump starts and remains on for the duration of the flight.

4. Sump quantity 50 lbs or less

Manual control of the electric fuel pumps is available via two line selected keys on the fuel synoptic. The electric fuel pump line select keys, labeled L PUMP and R PUMP, are selectable between AUTO and ON. When an electric fuel pump is operating a L(R) FUEL PUMP ON status message appears. The pump on status message will not appear during automatic fuel balancing.

If low pressure is detected from an electric fuel pump, a L (R) FUEL PUMP FAIL caution message appears and fuel crossfeed from the affected side is no longer available.

7.5.6 Engine Fuel Pumps

Two engine-driven fuel pumps for each engine are located in the FMU (Fuel Metering Unit). Fuel from the sump tank flows to the low pressure fuel pump and then through the fuel/oil heat exchanger and fuel filter, located outside the FMU. Fuel flows from the fuel filter to the high pressure fuel pump. This ensures that fuel is available to the engine through all flight regimes. Excess fuel not needed by the engine is routed under pressure to the sump tank as return fuel.

7.5.7 Fuel Filter

Before fuel flows to the high pressure fuel pump it passes through a fuel filter that contains an impending bypass switch. This bypass switch allows fuel to bypass the filter in the event of a restriction. Should this occur a L (R) FUEL FILTER advisory message appears on the ground only, alerting the pilot of possible fuel contamination. Should this bypass switch fail a L (R) FUEL BYPASS FAULT advisory appears on the ground only. Flight with a failed bypass switch is prohibited.

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7.5.8 Fuel Valves

CROSSFEED VALVE

The left and right sides of the fuel system are connected by a crossfeed valve, which operates automatically to maintain fuel balance between the wings within 50 pounds. The crossfeed valve requires electrical power to operate and is normally controlled by the ACS, but can be overridden by initiating manual fuel crossfeed using the fuel synoptic. A loss of electrical power will cause the crossfeed valve to close. Commanded crossfeed valve position is displayed on the fuel synoptic. Should the crossfeed valve fail or not reach its commanded position, a XFEED VLV FAIL advisory message appears and fuel crossfeed may not be available.

FUEL SHUTOFF VALVES

An electric fuel shutoff valve for each engine is located in the wing root downstream of the ejector boost pumps and electric fuel pumps. The valves open and close automatically during normal engine start and shutdown sequence. They also close when the associated FIRE-ARMED button is pressed. With a loss of electrical power a fuel shutoff valve will not operate, a L (R) FUEL SOV FAIL advisory message appears and the fuel shutoff valve will remain in its last commanded position.

7.5.9 Fuel Heat

A fuel/oil heat exchanger in each engine keeps fuel within normal operating temperature limits.

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7.5.10 Fuel Temperature Sensor

A temperature sensor located within each sump tank measures sump tank fuel temperature. If the fuel temperature in a sump tank reaches 150°F, a HOT FUEL caution message appears. The sump temperature information turns amber. If the fuel temperature in a sump tank reaches 170°F, a HOT FUEL warning message appears. The sump temperature information turns red.

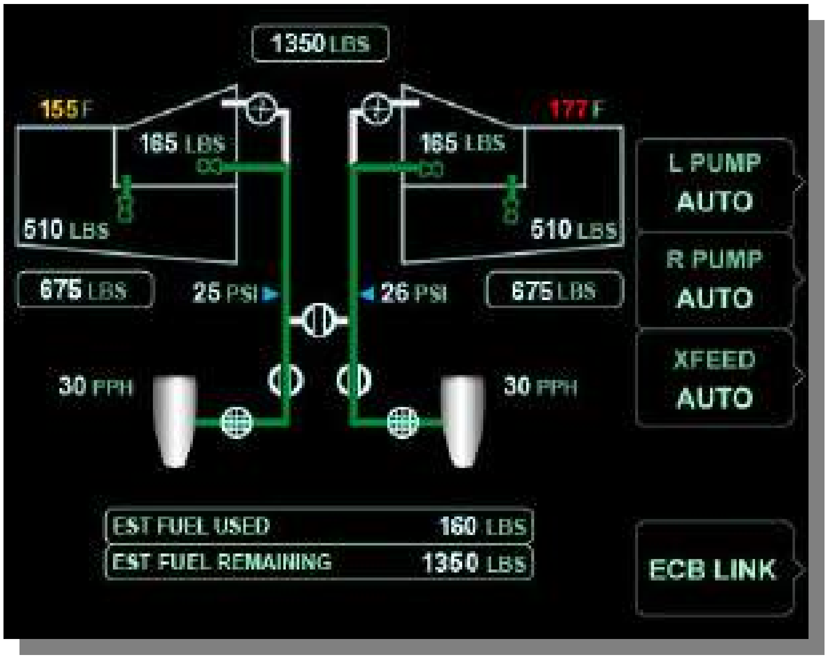

Figure 80. Fuel Synoptic- Fuel Hot Caution and Warning

Should fuel temperature become unavailable red triple dashes will be displayed.

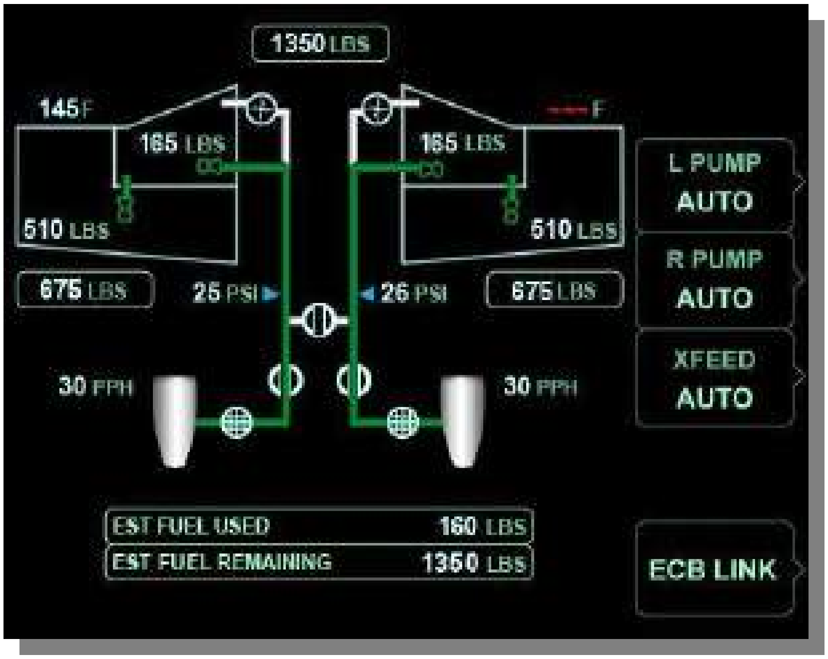

Figure 81. Fuel Synoptic: Temperature Sensor Failure

7.5.11 Return Fuel

The engine fuel pumps supply more fuel than is needed by the FMUs. The excess fuel is returned to the wings under pressure where it provides motive force to operate the ejector pumps. Return fuel first enters the ejector boost pumps, which pump fuel from the sump tanks to the engines. Discharge fuel from the ejector boost pumps then operates the ejector transfer pumps, which pump fuel from the wing tanks into the sump tanks.

Since the return fuel has been heated by the fuel/oil heat exchanger in the engine, the return fuel serves to keep the fuel tank temperature above the fuel freeze point.

7.5.12 Fuel Quantity Gauging System

The fuel gauging system consists of seven capacitance-gauging probes per wing. Quantity and density information is sent to the ACS where the fuel quantity in pounds is calculated. The information is then sent to the MFD fuel display and the fuel synoptic.

A temperature sensor in each sump tank sends sump tank temperature to the ACS for fuel density calculation. The temperature of both sump tanks is displayed on the fuel synoptic in Fahrenheit degrees.

The gauging system adjusts fuel quantity based on aircraft pitch and indicates zero with zero usable fuel (the gauging accurate within +/- 2% with zero pitch).

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On the ground the inboard gauging probes also determine the presence of AVGAS. The ACS detects the presence of AVGAS by comparing the fuel di-electric property with standard di-electric curves for Jet-A and AVGAS. An AVGAS DETECTED warning message appears at an AVGAS concentration of approximately 80%. Amber AVGAS text also is displayed below the total fuel quantity display on the fuel synoptic.

NOTE:

Operation with AVGAS is prohibited.

A FUEL QTY LOW caution message appears when the gauging system determines fuel in either sump tank is 140 pounds or less. In this case, the respective sump tank quantity on the fuel synoptic turns amber.

Optical sensors in both sump tanks serve as a backup for the fuel gauging system. If either sump tank fuel quantity decreases to 105 pounds useable fuel, the optical sensor in that tank triggers a L (R) FUEL QTY LOW warning message. In this case, the respective sump tank quantity on the fuel synoptic turns red. The low level sensors are independent of the fuel gauging system and monitored by the opposite ACS for further independence.

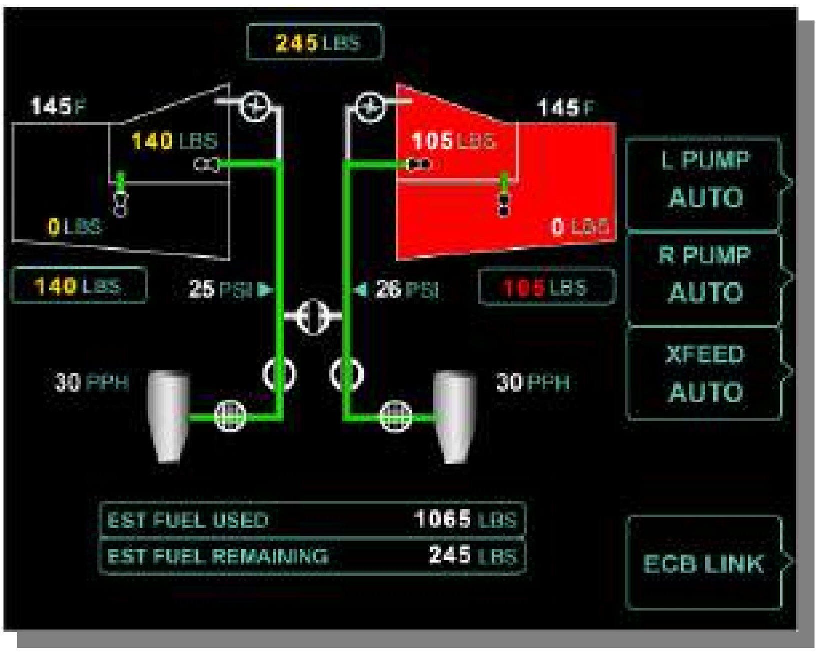

Figure 82. Fuel Synoptic- Low Fuel Caution and Warning

In the event the most inboard sump probe is not completely submerged in fuel the electric fuel pump automatically turns on. If this probe fails, the electric fuel pump will turn on when the low level sensor is activated and remains on for the duration of the flight. Activating the electric fuel pump in these situations assures that adequate fuel flow will be available with low fuel quantities.

Should a capacitance probe fail a FUEL GAUGING FAULT advisory message appears and white FUEL GAUGING FAULT text appearing above the affected white wing outline on the fuel synoptic.

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NOTE:
Automatic fuel balancing is unavailable

7.5.13 Vent System

Each wing has an independent vent system that has dual paths for venting in and out. Two overboard vents exits on the bottom of each wing near the tip tank serve to maintain normal fuel tank pressure relative to atmospheric pressure to prevent fuel tank collapse or wing structural failure. The vent system also prevents the fuel tanks from being vented through the fill ports to reduce the amount of splash-back during fueling. There is a vent space in the aft section of each tip tank to prevent fuel spillage in high roll attitudes or during thermal expansion of the fuel while the aircraft is parked with full fuel.

A climb vent line internal to the aircraft wing vents into the aft vent bay on each wing to allow equalization of tank pressure during climb.

Two vent lines that connect to the vent bay vent out of the aircraft on the underside of each wing allowing the vent bay proper ventilation and facilitating the equalization of pressure within the wings.

A third vent line is connected to a float valve that allows overflow fuel that may have drained into the vent bay due to thermal expansion to flow back into the wing tanks through a one way check valve in the vent bay.

7.5.14 Fuel Pressure Measurement

A pressure sensor downstream of the ejector boost and electrical fuel pumps measures fuel pressure in the feed line to the engine. If fuel pressure below 15 PSI, a L (R) FUEL PRESS LOW warning message appears, the fuel pressure digits to turn red, and the corresponding electric fuel pump automatically activates. Should fuel pressure information become unavailable a L (R) FUEL PRESS FAULT advisory appears on the ground only and white triple dashes will be displayed.

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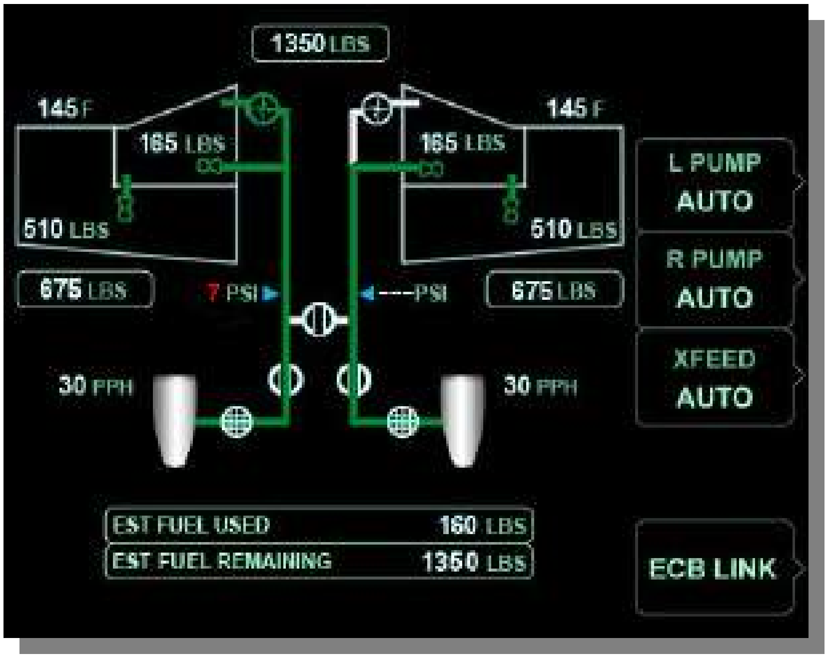

Figure 83. Fuel Synoptic- Low Fuel Pressure & Pressure Sensor Fault

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7.5.15 Fuel Balancing

Fuel can be fed from either wing to the opposite engine via the crossfeed valve. When a fuel imbalance of 50 pounds between the wings is detected, the crossfeed valve automatically opens, the electric fuel pump on the heavy side automatically starts, and a FUEL AUTO XFEED L←R or FUEL AUTO XFEED L→R status message appears.

Since the electric fuel pumps operate at a higher pressure than the ejector boost pumps, fuel from the heavy wing will flow to both engines. When the quantity difference is within 10 pounds, the crossfeed valve closes and the electric fuel pump is switched off. The rate at which an imbalance is corrected depends on engine fuel burn. Normally a lateral imbalance will be corrected within 10 minutes.

In the event of an engine failure, the automatic balance system keeps the fuel load balanced while ensuring that the remaining usable fuel is available to the operating engine.

If the auto crossfeed system is not automatically activated, fuel can be manually balanced using the XFEED line select key on the fuel synoptic. Activating manual fuel XFEED causes a FUEL MAN XFEED L→R or FUEL MAN XFEED L←R status message to appear.

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7.6 Normal Operations

7.6.1 Fueling

Fueling is accomplished through over wing fuel ports at each tip tank. When the fuel level approaches the top of the tank, fuel is visible in time to shut off the refueling nozzle. There is no automatic shutoff. If the tank is over-filled, fuel will overflow onto the top of the wing.

Figure 84. Over wing Fuel Port-Right Wing

The sump tanks fill first due to the positive wing dihedral. However, if fueling is stopped before the sump tanks are full, gravity feed may not fill the tanks. In this situation, the transfer ejector pumps will fill the sump tanks once the engines are started. A L (R) FUEL QTY LOW warning message may be displayed briefly until the sump tanks are full. The fuel gauging system is accurate during this time.

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7.7 Abnormal Procedures

7.7.1 Automatic Fuel Balance Failure

If a fuel imbalance is not corrected automatically and a fuel imbalance exceeds 65 lbs a FUEL IMBALANCE caution message is displayed, prompting the pilot to initiate manual crossfeed.

In the event of a gauging system failure (capacitance probe failure) or electric fuel pump failure, the automatic balance system is inhibited and a FUEL BALANCE MON FAULT advisory message appears.

Should automatic balancing continue for 15 minutes without the imbalance being corrected an AUTO BALANCE FAIL caution appears. This message may be an indication of a fuel leak and EST FUEL REMAINING should be compared to total fuel quantity from the gauging systems to confirm if a leak is present.

If automatic balancing is inoperative, the pilot can manually control fuel crossfeed using the fuel synoptic. The XFEED line select key allows the pilot to select one of four operations:

- OFF
- AUTO
- L←R
- L→R

Selecting L←R or L→R opens the crossfeed valve, turns on the appropriate electric fuel pump, and prompts a FUEL MAN XFEED L←R or FUEL MAN XFEED L→R status message to appear.

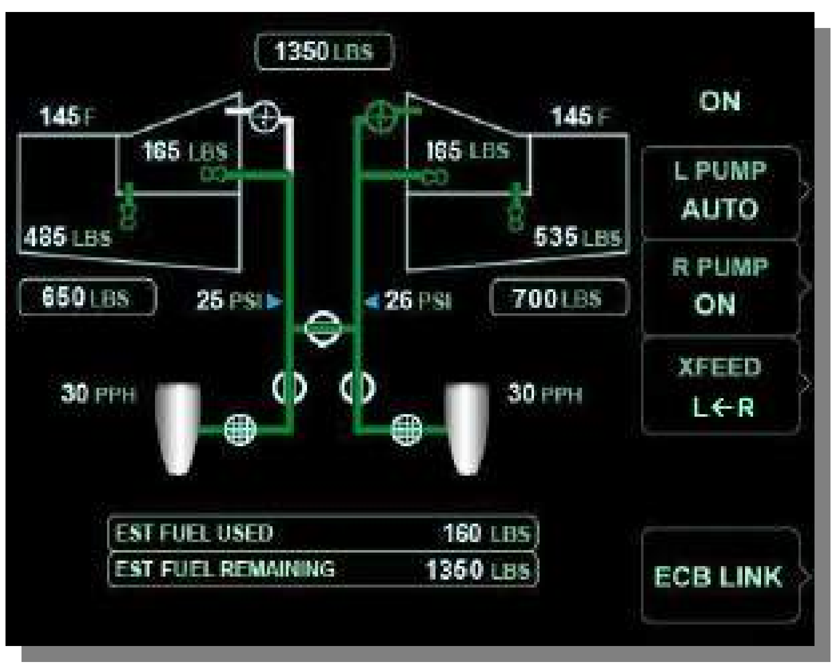

Figure 85. Fuel Synoptic- Manual Fuel Crossfeed

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7.8 Crew Alerting System Messages

Table 10. Fuel CAS Messages

Message	Condition	Category
AVGAS DETECTED	AVGAS mixture is 80% or greater. (Ground Only)	Warning
L (R) FUEL PRESS LOW	Fuel pressure below 15 PSI in feed line	Warning
L (R) FUEL QTY LOW	Sump tank quantity is less than 105 pounds	Warning
HOT FUEL	Temperature of fuel in sump tank is greater than 170° F.	Warning
AUTO BALANCE FAIL	Auto fuel balance continuous operation for more than 15 minutes	Caution
FUEL IMBALANCE	Fuel imbalance greater than 65 pounds	Caution
L (R) FUEL PUMP FAIL	Left or right electric fuel pump inoperative	Caution
FUEL QTY LOW	Fuel quantity in either sump tank is 140 pounds or less	Caution
HOT FUEL	Fuel temperature in either sump tank between 150° F and 170° F.	Caution
L (R) FUEL UNUSABLE	Failure of internal wing fuel transfer and/or trapped fuel outboard	Caution
FUEL BALANCE MON FAULT	Later fuel balance detection is inoperative. Automatic fuel balance disabled	Advisory
L (R) FUEL BYPASS FAULT	Fuel filter bypass switch has malfunctioned (Ground Only)	Advisory
L (R) FUEL FILTER	Impending fuel filter bypass detected- engine running (Ground Only)	Advisory
FUEL GAUGING FAULT	Gauging system failure. Auto balance is disabled.	Advisory
L (R) FUEL PRESS FAULT	Pressure sensor failure detected (Ground Only)	Advisory
L (R) FUEL SOV FAIL	Valve has failed in last commanded position	Advisory
XFEED VLV FAIL	Valve is not in commanded position. Fuel crossfeed may not be available	Advisory
FUEL AUTO XFEED L →R	Automatic fuel balance in progress	Status
FUEL AUTO XFEED L ← R	Automatic fuel balance in progress	Status
FUEL MAN XFEED L → R	Manual fuel crossfeed selected	Status
FUEL MAN XFEED L ← R	Manual fuel crossfeed selected	Status
L (R) FUEL PUMP ON	Respective electric fuel pump on for other than fuel crossfeed	Status

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7.9 Fuel Review Questions

1. **What are the approved fuel grades for the Eclipse 500?**
   a. JET A/A1
   b. JP-8
   c. Any kind of Avgas
   d. Both A & B
2. **What is the maximum allowable fuel imbalance on the Eclipse 500?**
   a. 12 US Gallons
   b. 50 lbs
   c. 50 US Gallons
   d. 65 lbs
3. **Describe how fuel balanced on the Eclipse 500?**
4. **What is the purpose of 'motive' flow fuel in the EA500 Fuel System and where does the motive flow fuel originate?**
5. **List 4 conditions that will cause the Electric Fuel Pump to AUTOMATICALLY activate**
   a. 1:____
   b. 2:____
   c. 3:____
   d. 4:____
6. **Fuel shutoff valves (SOVs) are used to cut fuel to the engines and will remain in what position during an electrical failure?**
   a. Shut
   b. Open
   c. The last position they were in during the time of the electrical failure.
7. **A "FUEL QTY LOW," caution message will be displayed when fuel quantity in the sump tank drops below.**

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a. 140 lbs
b. 155 US Gallons
c. 150 lbs
d. 105 lbs

8. **A “L or R FUEL QTY LOW” warning message is triggered at ______lbs in the sump tank.**

9. **How can a pilot verify that there is a potential fuel leak?**
   a. The FUEL LEAK DETECT caution message appears
   b. Comparing EST FUEL REMAINING vs. total fuel quantity on the fuel synoptic.
   c. An AUTO BALANCE FAIL caution message appears
   d. Both B & C

10. **What failure (s) will render the automatic fuel balancing capability inoperative?**
    a. Electric fuel pump failure
    b. Ejector boost pump failure
    c. Capacitance probe failure (one or more)
    d. Both A & C
    e. All of the above

11. **What is the total fuel quantity and useable fuel quantity for the Eclipse 500?**

12. **List and describe the function of the 10 fuel pumps on the Eclipse.**

13. **How is fuel balanced on the Eclipse 500?**
    a. The pilot manually switches a fuel selector valve.
    b. The ACS will automatically balance fuel via the crossfeed valve and turning on an electric fuel pump on the heavy side.
    c. Both A and B

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d. The FADEC system will reduce engine power on the heavy side to compensate for fuel imbalance issues.

14. **How does an ejector type fuel pump operate?**

a. They are electrically powered fuel pumps.

b. Ejector type fuel pumps contain no moving parts and are considered a venturi-type fuel pump.

c. They are mechanical pumps, using internal gears to pump the fuel to the engine.

d. None of the above

15. **How is the fuel kept from freezing on the Eclipse 500?**

a. Engine oil-fuel heat exchangers are used to keep fuel temperatures above freezing limits.

b. Anti-icing additives must be used at all times

c. Both A and B

16. **A "FUEL QTY LOW," caution message will be displayed when fuel quantity drops below.**

a. 140 lbs
b. 155 US Gallons
c. 150 lbs
d. 105 lbs

17. **A "FUEL QTY LOW," warning message will be displayed when fuel quantity drops below.**

a. 140 lbs
b. 155 US Gallons
c. 150 lbs
d. 105 lbs

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8. Engines & Fire Protection

8.1 General

Two Pratt & Whitney PW-610F-A engines, each producing 900 pounds of takeoff thrust, are aft-mounted on the airplane. The engine is a two-spool (N1 and N2), high-bypass turbofan. The N_1 rotor consists of a single fan driven by a single stage axial turbine. The N_2 rotor consists of a single mixed flow axial rotor, and a centrifugal compressor, driven by a single stage high pressure axial turbine. The N_1 and N_2 rotors are mechanically independent and counter rotate to reduce the effects of torque. An accessory gearbox connected to the N_2 rotor drives the Starter/Generator, fuel pumps, and oil pumps. The PW 610F-A engines do not use thrust reversers.

The engines are controlled by two dual-channel Full Authority Digital Engine Control (FADEC) units through the dual Aircraft Computer Systems (ACS).

All engine parameters are displayed on the MFD. Primary parameters are continuously displayed, while secondary parameters are displayed on the Engine (ENG) synoptic page.

Each engine has individual flight deck controls. Thrust is set by positioning the throttles, either automatically by the autothrottle system or manually by the pilot. The engine start sequence is automatic when an engine start switch is placed to the ON/START position.

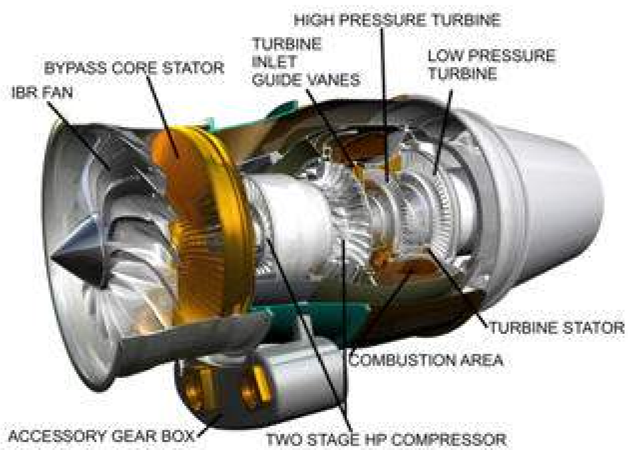

Figure 86. PW 610F-A Engine

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8.2 Aircraft Computer Systems (ACS) Interfaces

The ACS interface with the engine and fire protection system is divided into four areas

1. Thrust Control
2. Engine Starting
3. Secondary Engine Parameter Monitoring
4. Fire Detection and Suppression

8.2.1 Thrust Control

The primary thrust control interface for the pilot is through the two throttles located on the throttle quadrant. Inputs from each throttle go directly to both FADEC units. The FADEC combines these inputs with air data information received from the Integrated Sensor Suites and sets thrust by regulating fuel output from the Fuel Metering Unit (FMU). The FADECs monitor the primary engine sensors (N1, N2 and ITT) and report this information to the ACS which is then routed through the PFD to the MFD for display.

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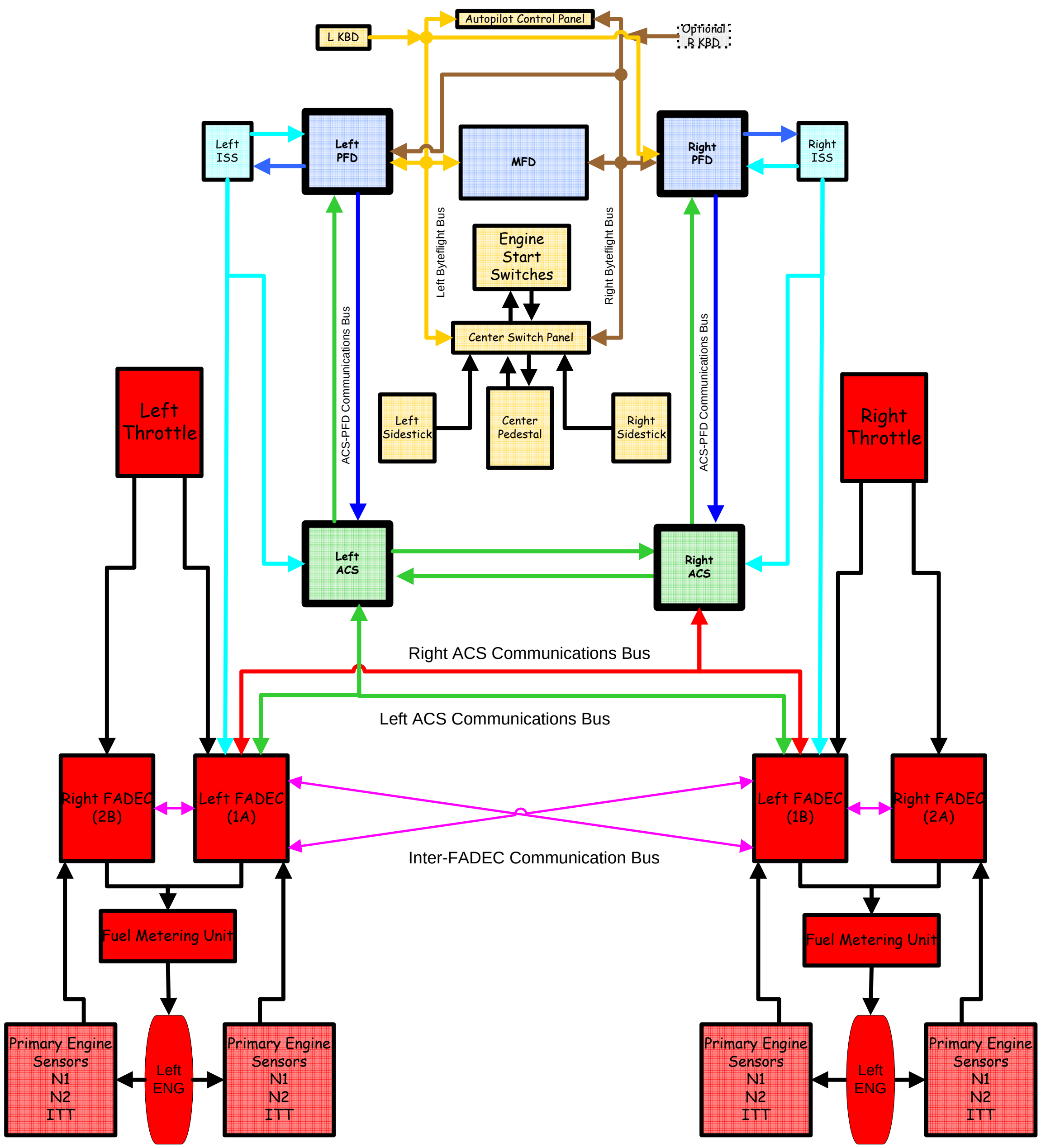

Figure 87. Thrust Control-ACS Interface

8.2.2 Engine Starting

The ACS provides control of the engine stop and start sequences based on pilot commands using the engine start switch panel. Pilot commands are transmitted from the engine start switch panel to the center switch panel. From the center switch panel these commands are sent through the PFD to the ACS'. An engine start command is sent from the ACS to the FADECs and to other aircraft systems involved in or reconfigured during the engine start process (Electrical, Fuel, Climate Control and Ice Protection).

During on-ground engine starts, the ACS also provides an automatic start abort feature. If an engine start is aborted, the ACS reconfigures the aircraft systems back to a power off configuration and prompts a ENG START ABORT caution message appears.

NOTE:

The ACS will not automatically abort in-flight restarts to allow an engine restart regardless of aircraft system state.

Once and engine start is complete, the FADECs run the engine independently and report primary engine parameters (N1, N2 and ITT) to the ACS for display to the pilot.

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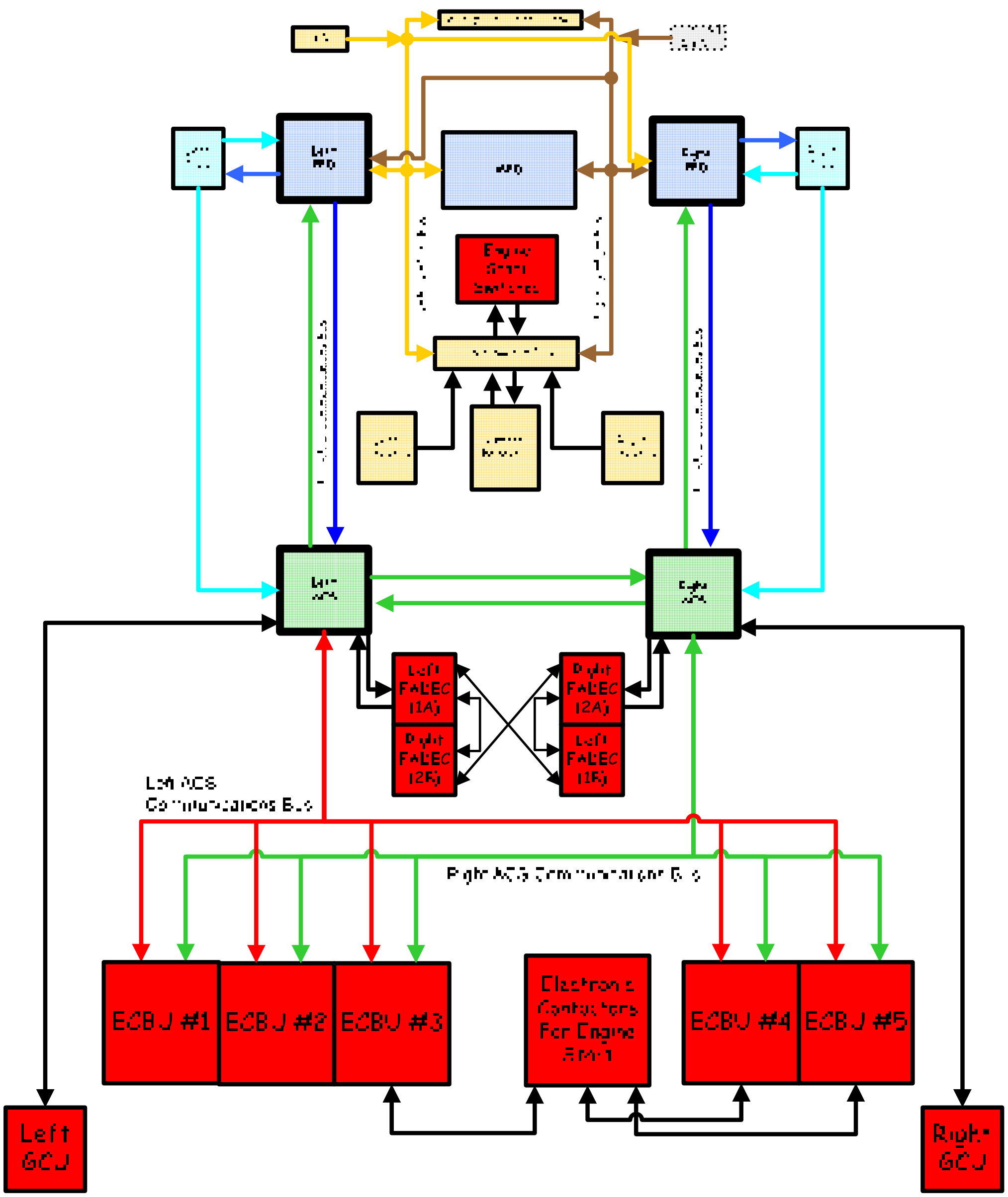

Figure 88. Engine Starting-ACS Interface

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8.2.3 Secondary Engine Parameter Monitoring

The ACS monitors secondary engine parameters and reports system status through the PFDs to the MFD for display. Sensors from the left engine send their information to the left ACS, while sensors for the right engine send their information to the right ACS. The engine sensors that send information to the ACS are:

- Chip Detector
- Fuel Filter Impending Bypass Switch
- Oil Filter Impending Bypass Switch
- Oil Temperature
- Oil Pressure
- Fire Detection

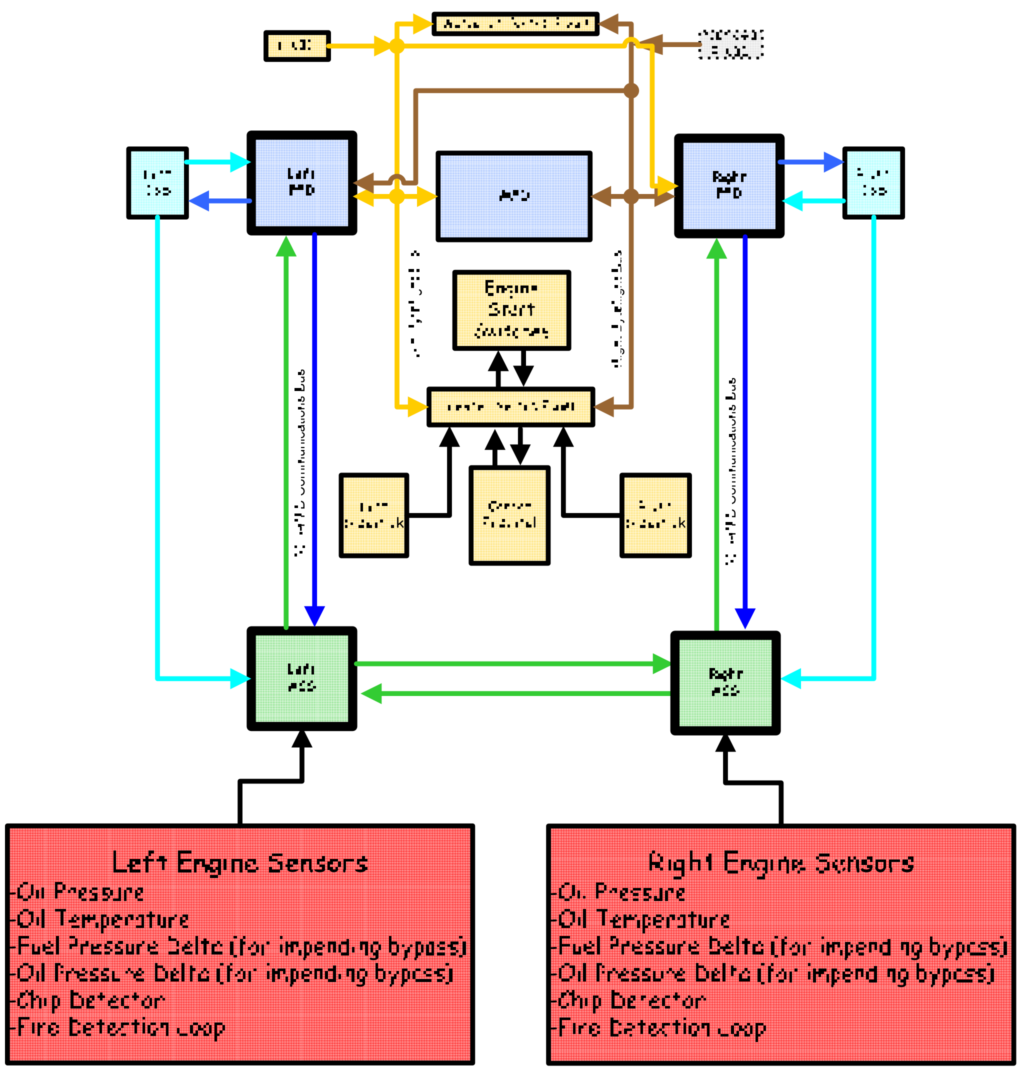

Figure 89. Secondary Engine Parameter-ACS Interface

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8.2.4 Fire Detection and Suppression

Fire Detection is accomplished using a resistive wire wrapped around each engine. Changes in resistance occur when the wire is heated, signaling a potential fire. The ACS' monitor the fire detection loop for each engine. When a potential fire is detected, a signal will be sent through the PFD to the Autopilot Control Panel where it is annunciated by the illumination of the FIRE portion of the left or right FIRE/ARMED button.

Fire suppression is provided by a single fire suppression canister in each engine pylon. This canister is controllable by and reports its status to the ACS. Pressing the FIRE/ARMED button once sends a signal to the ACS to remove fuel and electrical power from the engine, arms the fire canister and illuminates the green ARMED portion of the FIRE/ARMED button. A second push of the FIRE/ARMED button sends a signal to the ACS to activate the ECB associated with the fire canister; this will discharge the fire canister. Once discharged the fire canister reports its status to the ACS which in extinguishes the green ARMED indication from the FIRE/ARMED button

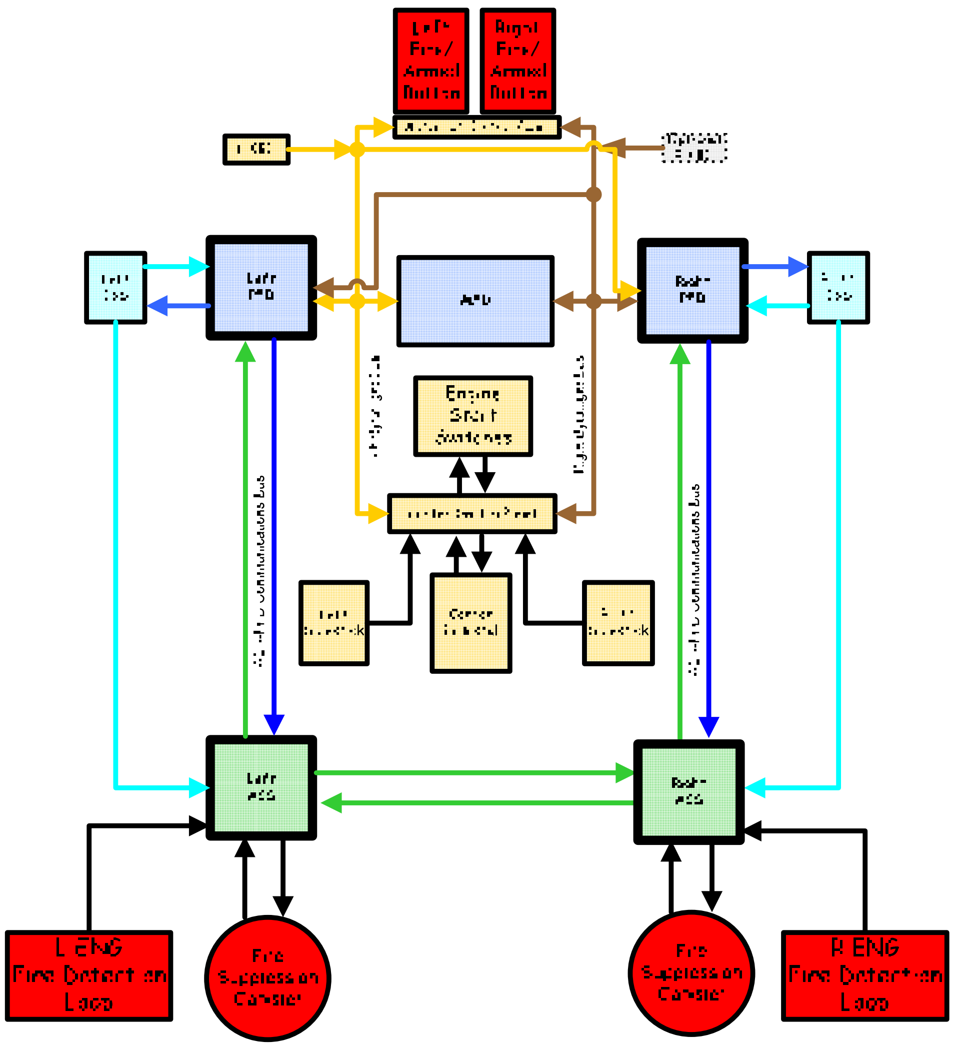

Figure 90. Fire Detection and Suppression-ACS Interface

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8.3 Limitations and Specifications

8.3.1 Engine Operating Limitations

Table 11. Engine Operating Limitations

Operating Condition	Time Limit (Minutes)	Max ITT (ºC)	N2(%)	N1 (%)
START	N/A	850	--	--
GROUND IDLE	Continuous	-	46.7 min	--
FLIGHT IDLE	Continuous	-	52.1 min[(b)]	--
TAKEOFF	5 minutes[(a)]	795	100	102
APR	10 minutes[(a)]	795	100	102
MAXIMUM CONTINUOUS	Continuous	795	100	102
TRANSIENT	20 sec	810	102	103

(a) The total time during which take-off thrust may be used is limited to 5 minutes. The 5 minute limit commences when the throttle is first advanced to the take-off position.

(b) Flight idle speeds are a function of ambient pressure and temperature. The engine control will keep the engine within its mechanical limits.

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8.3.2 Oil

Table 12. Oil Pressure

Operating Condition	Time Limit (Min)	Oil Press (b)	Oil Temp (°C)	
			Min	Max
START	N/A	0-9.0[b][c]	-40	135
GROUND IDLE	Continuous	See [b]	-40	135
FLIGHT IDLE	Continuous		20	135
TAKEOFF	5 minutes[a]		20	135
APR	10 minutes		20	135
MAXIMUM CONTINUOUS	Continuous		20	135
TRANSIENT	90 sec		-	140

(a) The total time during which take-off thrust may be used is limited to 5 minutes. The 5 minute limit commences when the throttle is first advanced to the take-off position.

(b) Oil pressure – See Oil Pressure Minimum and Maximum chart.

(c) During engine start or motoring cycles, oil pressure of 0.0 (0 PSIG) is only allowable below 15% N2. Positive oil pressure is required above 15% N2.

8.3.3 Oil Pressure Minimum and Maximum

Table 13. Normalized Indicated Oil Pressure

	Green Band	Yellow Band		Red Band	
N2 [%]	ALL	High	Low	High	Low
15% – 100%	2.0 – 8.0	8.1 – 9.0	1.0 – 1.9	9.1 – 10	0.0 – 0.9

NOTE 1:

If the transient time period is exceeded when oil pressure is in the amber band, the oil pressure display changes from amber to red and an exceedance CAS message appears.

NOTE 2:

If the 90-second caution time period is exceeded, the oil temperature display changes from amber to red and an exceedance CAS message appears.

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8.3.4 Oil Quantity

Total Oil Capacity .... 1.62 US GAL (6.48 qts)

Minimum Before Engine Start .... MIN

NOTE:

An oil quantity check of the sight gauge on each engine is required before engine start. Oil level must be between MIN and MAX.

8.3.5 Oil Temperature For Engine Start

Minimum oil temperature for engine start .... -40°C

8.3.6 Fuel

Table 14. Fuel Temperature

Operating Condition	Time Limit (Min)	Fuel Temp °C [a]	
		Min	Max
START	N/A	-40 [a]	121
GROUND IDLE	Continuous	-40 [a]	121
FLIGHT IDLE	Continuous	18 [a]	121
TAKEOFF	5 minutes [a]	18	121
APR	10 minutes	18	121
MAXIMUM CONTINUOUS	Continuous	18 [a]	121

(a) Minimum fuel temperature limit is not applicable to ground operation.

8.3.7 Fuel Temperature Limits for Engine Start

Maximum engine fuel temperature for engine start .... 121°C

8.3.8 Engine Start

Maximum Crosswind Limit .... 30 knots

Maximum Tailwind Limit .... 25 knots

Maximum Tailwind Limit N1>75% .... 15 knots

8.3.9 Cold Day Operation Temperature Limits (Ground)

Engine starting at temperatures between -20°C (-4°F) and 5°C (41°F) must be accomplished with an external Ground Power Unit (GPU) connected and supplying electrical power.

Engine starts are not permitted at a temperature less than -20°C/-4°F.

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8.3.10 In-Flight Restart

25,000 Feet and Below
Airspeed....................139-234 KEAS

15,000 Feet and Below
Airspeed....................<237 KEAS

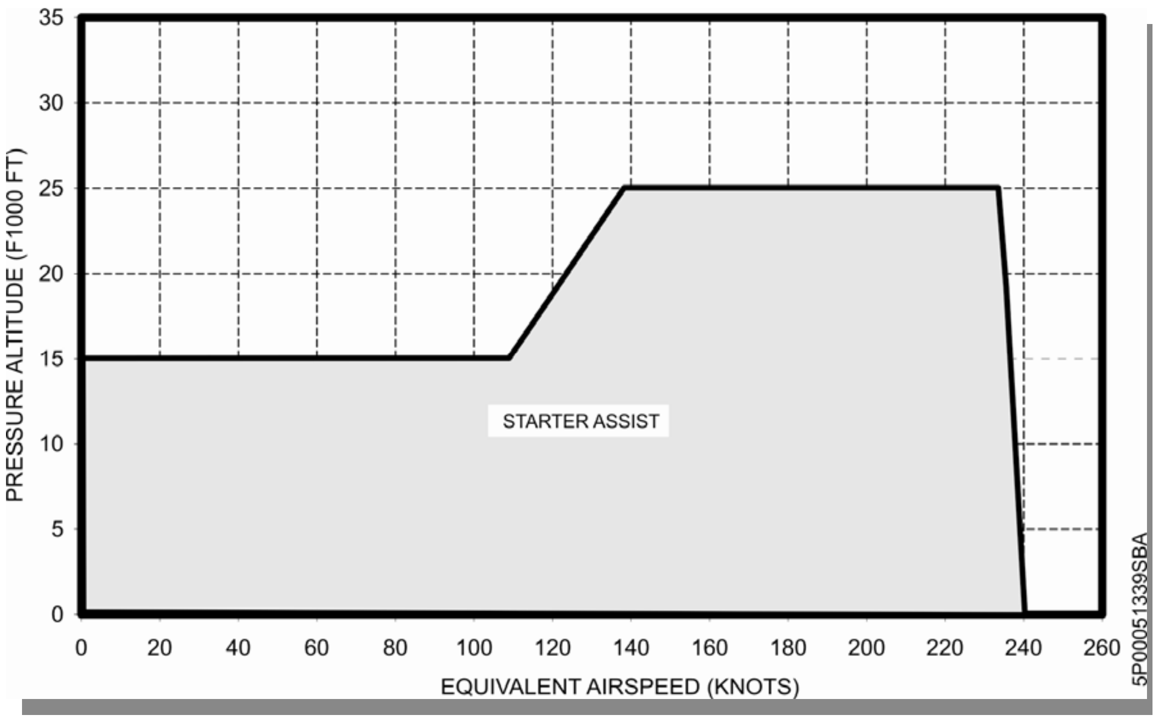

Figure 91. Starter Assisted Air Start Envelope

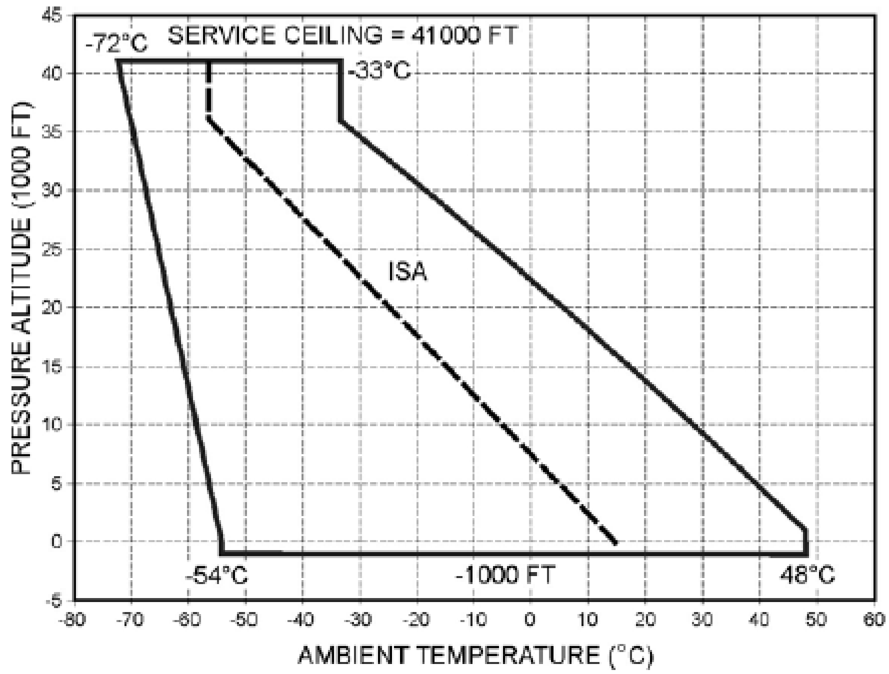

Figure 92. Engine Temperature Operating Envelope

CAUTION:

In order to minimize start ITT, allow engine to windmill until ITT is less than 100°C before initiating in flight engine restart.

8.3.11 Start Cycle

Engine starters are limited to the following operating/cool-down intervals, both for engine start and motoring:

	Operating	Cool-Down
Cycle #1	30 sec	1 min
Cycle #2	30 sec	1 min
Cycle #3	30 sec	30 min

NOTE:

The cycles may be repeated as required.

8.3.12 Battery Start

Minimum Temperature
Battery only engine start .... 5°C / 41°F

Minimum start battery voltage
Battery only engine start .... 23 VDC

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8.4 Controls and Indicators

8.4.1 Engine Start Switch Panel

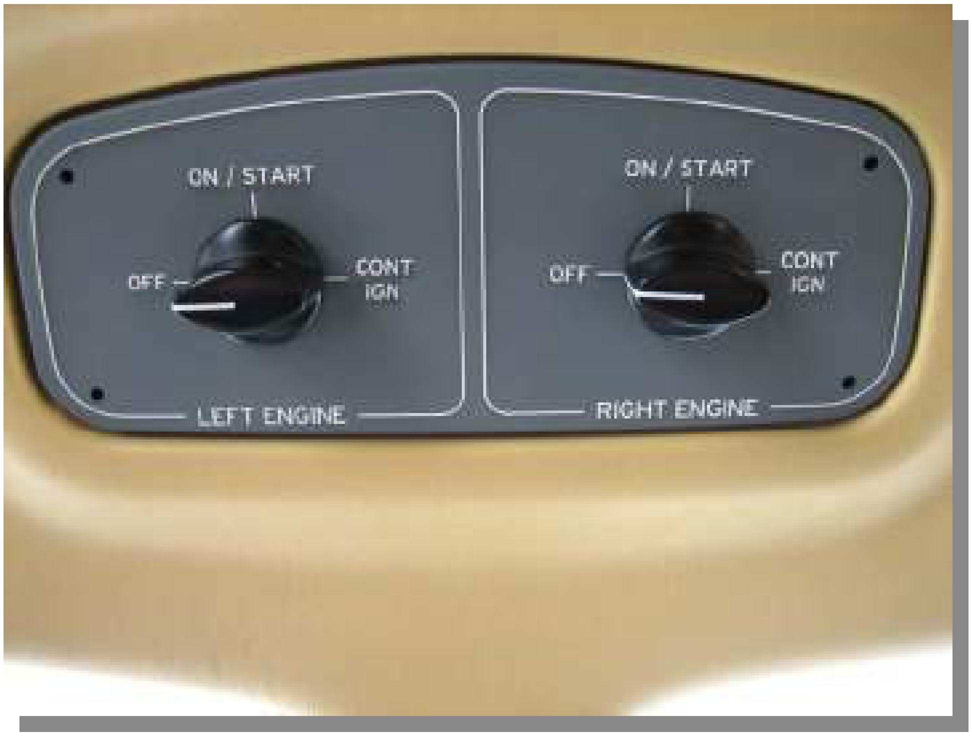

Figure 93. Engine Start Switch Panel

OFF .... Initiates engine shutdown sequence

ON/START ....Initiates engine start sequence
Normal position when engine is operating

CONT IGN...Provides continuous ignition

8.4.2 Throttle Quadrant

Figure 94. Throttle Quadrant

8.4.3 Engine Controls

Two throttles are located on the throttle quadrant. Start, shutdown, and ignition are controlled from the engine start switch panel located on the ceiling directly above the throttle quadrant. Other engine functions are controlled from line select keys on the ENG synoptic page.

Engine Start Switch Panel

- Start (ON/START)
- Stop (OFF)
- Continuous ignition (CONT IGN)

NOTE:

The switch must be pushed in to move between OFF and ON/START.

8.4.4 Continuous Ignition

Continuous ignition is turned on by moving the rotary switch on the engine start switch panel to the CONT IGN position. It is recommended that continuous ignition is activated while operating in heavy rain, severe turbulence, or volcanic dust

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8.4.5 Engine Instrument Display (on MFD)

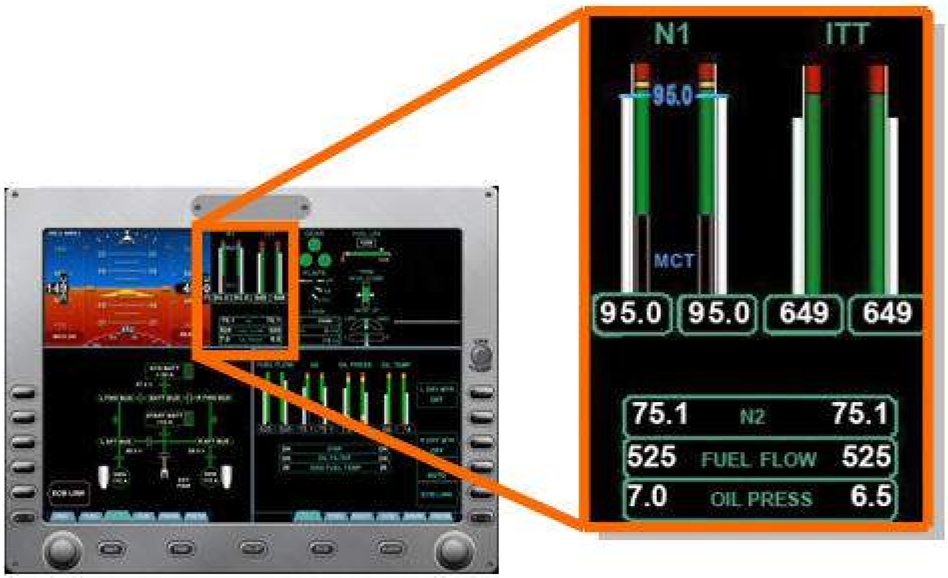

Figure 95. MFD Primary Engine Parameter Display

Primary engine parameters are continuously displayed on the upper portion of the MFD. Primary engine parameters include N1 speed and ITT tapes, as well as digital readouts of N2, Fuel Flow and Oil Pressure.

8.4.6 Engine (ENG) Synoptic

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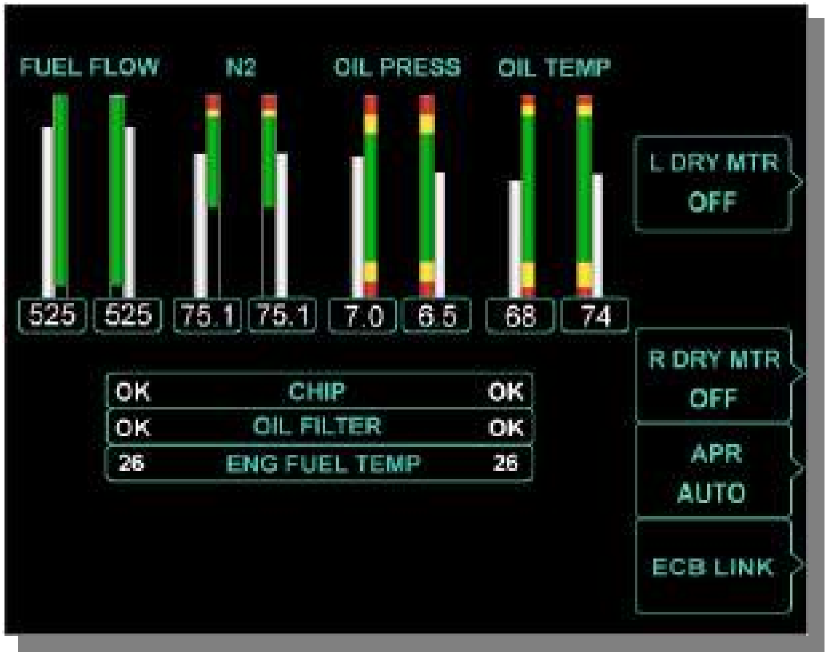

Figure 96. Engine Synoptic

LINE SELECT KEYS ON ENG SYNOPTIC

L DRY MTR
- ON .... Left dry motoring
- OFF........ Left dry motoring off

R DRY MTR
- ON .... Right dry motoring
- OFF........ Right dry motoring off

NOTE:

The L and R DRY MTR line select key selections disappear when the aircraft is in flight (weight off wheels).

APR
- AUTO........ Automatic Power Reserve is automatically controlled
- OFF........ Automatic Power Reserve deactivated

ECB LINK
- Selects engine circuit breakers on Electronic Circuit Breaker (ECB) synoptic

ENGINE INSTRUMENTS

Primary engine indications are continuously displayed on the upper portion of the MFD. Secondary engine indications are also continuously displayed on the upper portion of the MFD during engine start and normal steady state engine operation. The secondary engine indications are also displayed on the engine synoptic page.

Primary Instruments

- Indicated Turbine Temperature (ITT) .... tape and digital value
- N_1 rotor RPM .... tape and digital value
- N_2 rotor RPM .... digital value
- Oil pressure .... digital value
- Fuel flow .... digital value

Secondary Instruments

- N_2 rotor RPM .... tape and digital value
- Oil pressure .... tape and digital value
- Oil temperature .... tape and digital value
- Fuel flow .... tape and digital value
- Fuel Metering Unit (FMU) temperature .... digital value
- Oil filter bypass .... OK / IMP BYP
- Chip detector .... OK / DETECT

The current level is indicated by a digital readout or by a moving tape gauge and a digital readout.

Each tape gauge display has an adjacent tape showing operating limits in green (normal), amber (caution), and red (limit exceeded).

The digital display and the moving tape change color as the value increases—white (normal), amber (caution), or red (limit exceeded). If a limit is exceeded, a CAS message appears.

All primary engine instruments are fully redundant. The circuits that control and monitor primary engine parameters are duplicated to reduce the possibility of a hardware failure causing the pilot to receive misleading or no information about engine status.

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8.4.7 N1 RPM

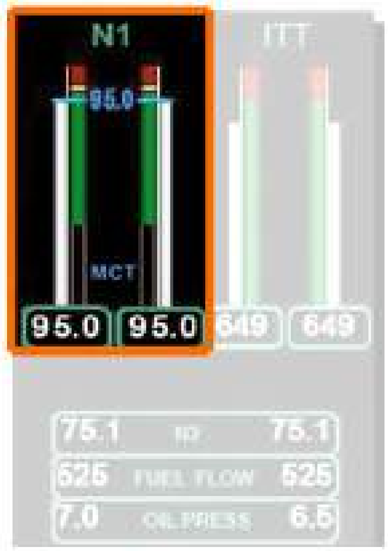

Figure 97. N1 Tape

N_1 is continuously displayed on the MFD with a moving tape and digital readout in percent of maximum RPM. The scale of the tape is 0 to 105%. An adjacent tape displays N_1 limits. A green band on the limit tape extends from approximately 21% to 100%. An amber band extends from 100% to 101%. A red band begins at the maximum continuous limit of 101%.

The digital value and moving tape are white for N_1 values in the green band, in amber for N_1 values in the amber band, and in red for N_1 values above the RPM limit. If the RPM exceeds the limit for 20 seconds, a L (R) ENG EXCEEDANCE warning message appears.

A blue bug and blue digital readout between the left and right N_1 tapes display the N_1 target calculated by the ACS for the mode of flight.

With the throttles advanced to the takeoff setting the state of the APR is displayed above the N_1 tapes as either APR ARMED (white) or APR ON (green).

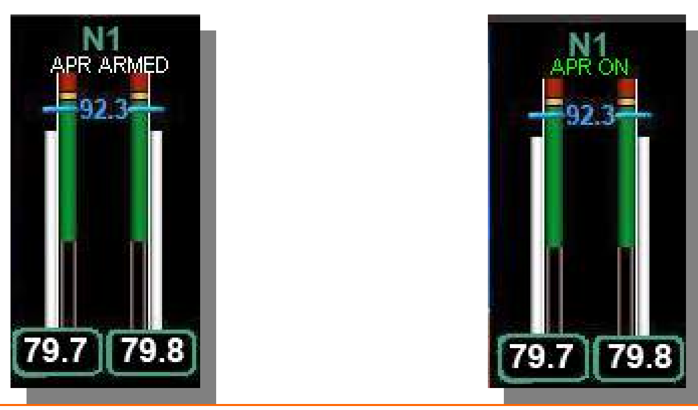

Figure 98. APR Indications

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When the throttles are reduced on climb to maximum continuous thrust as calculated by the ACS, blue MCT text appears at the lower portion of the tape that is associated with the blue N1 bug.

8.4.8 Indicated Turbine Temperature (ITT)

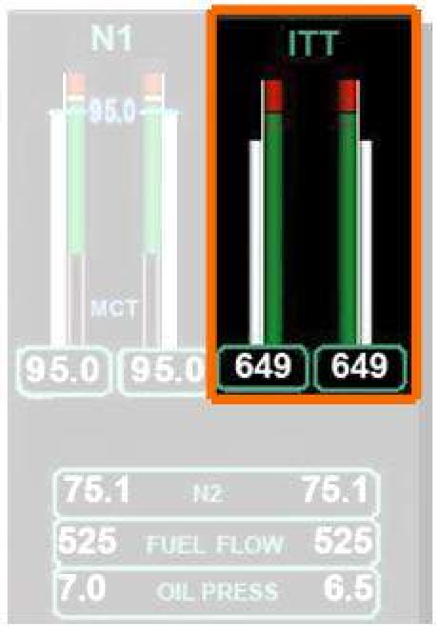

Figure 99. ITT Tape

ITT is continuously displayed on the MFD with a moving tape and digital readout. The ITT tape range is 0-850°C. An adjacent tape displays ITT limits. A green band on the limit tape extends from 300°C to the maximum continuous ITT limit. The FADEC determines the maximum ITT limit, and a red band is displayed beginning at that value.

The digital ITT value and moving tape are displayed in white for values under the ITT limit and in red for values above the limit. An L (R) ENG EXCEEDANCE warning message appears:

- If ITT exceeds the limit (but not above 810°C) for 20 seconds
- If the ITT reaches 810°C

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8.4.9 N2 RPM

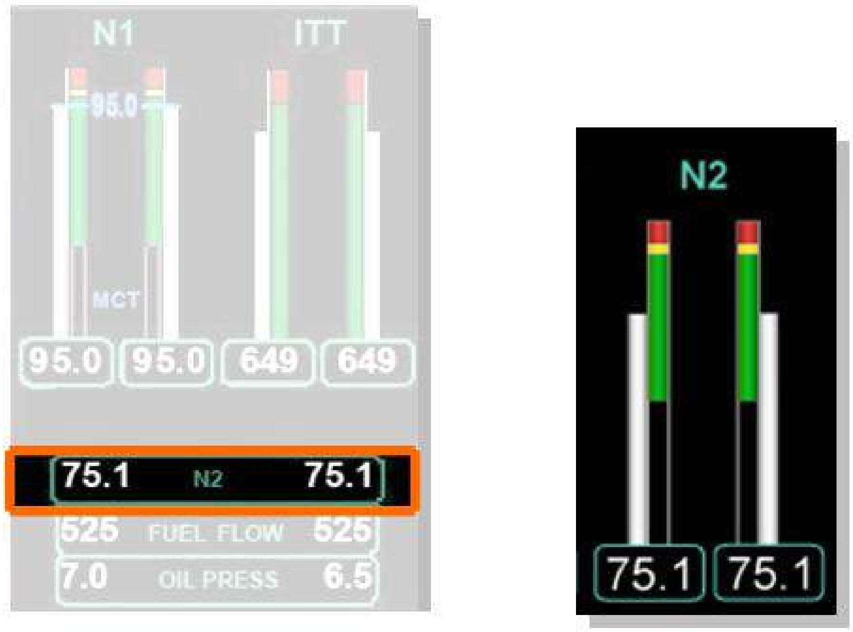

Figure 100. N2 Displays- Digital and Tape

N_2 is continuously displayed on the MFD with a digital readout in percent of maximum RPM and with a moving tape and digital readout on the engine synoptic page. The scale of the tape is 0 to 105%. An adjacent tape displays N_2 limits. A green band on the limit tape extends from 45% to 100%. An amber band extends from 100% to 102%. A red band begins at the maximum continuous limit of 102%.

The digital value and moving tape are white for N_2 values in the green band, in amber for N_2 values in the amber band, and in red for N_2 values above the RPM limit. If the RPM exceeds the limit for 20 seconds, a L (R) ENG EXCEEDANCE warning message appears

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8.4.10 Fuel Flow

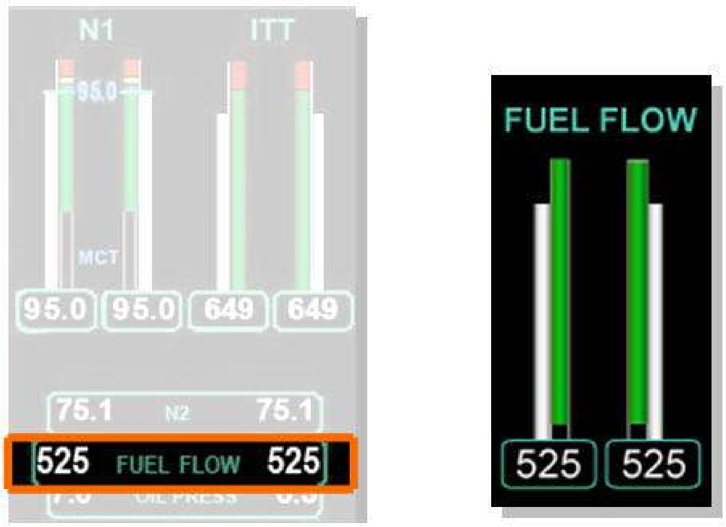

Figure 101. Fuel Flow Displays- Digital and Tape

Fuel flow is continuously displayed on the MFD with a digital readout in pounds per hour (PPH) and with a white moving tape and digital readout on the engine synoptic page. The scale of the tape is 0-800 PPH. An adjacent tape displays fuel flow range, with a green band extending from 60 PPH to the top of the tape. There are no amber or red bands.

8.4.11 Oil Pressure

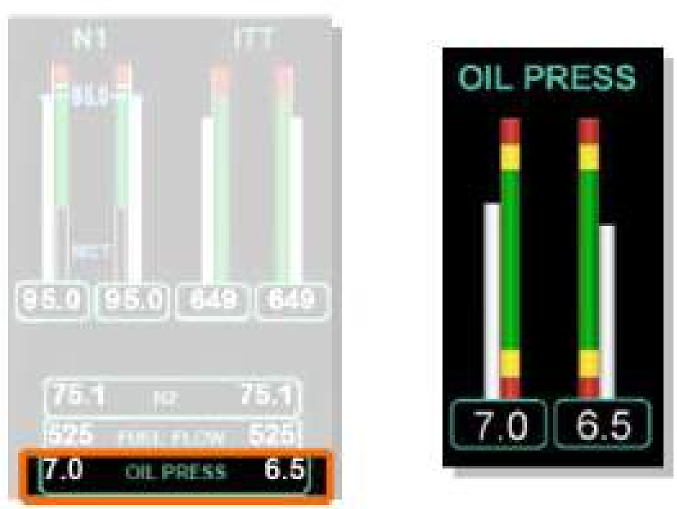

Figure 102. Oil Pressure Displays- Digital and Tape

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Oil pressure is continuously displayed on the MFD with a digital readout and with a moving tape and digital readout on the engine synoptic page. Oil pressure is displayed on a normalized scale from 0 to 10 rather than in PSI.

An adjacent tape displays oil pressure limits. Operating limits in PSI change with N_2 RPM. However, this is transparent to the pilot. The color bands display constant limits regardless of the engine RPM.

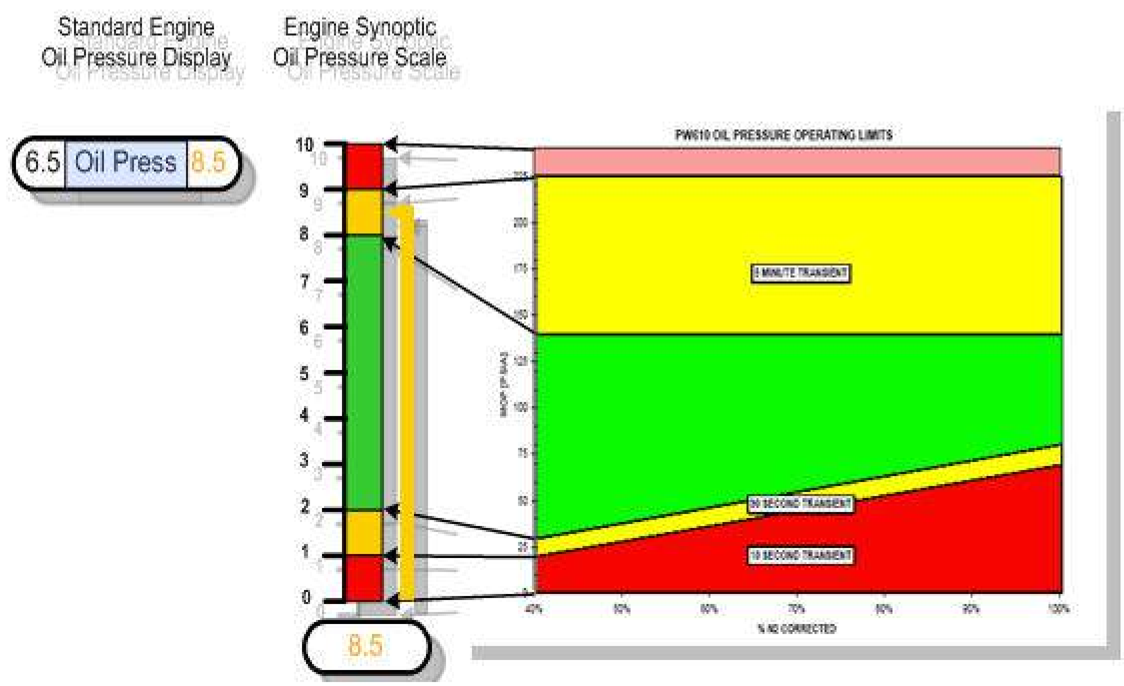

Figure 103. Oil Pressure Normalization Chart

When oil pressure is in the normal (green band) range the moving tape and digital value are white. If the oil pressure is in the caution (amber band) range (either high or low), the tape and digital value are amber.

The amber bands and the lower red band incorporate a time delay for transient conditions.

If the oil pressure is in the high caution range of 8.1-9.0 for greater than 5 minutes, the digital value and tape turn amber and a L(R) OIL PRESSURE HIGH warning message appears. This message also appears instantaneously if the oil pressure enters the high warning range, above 9.0.

If the oil pressure is in the low caution range of 1.0-1.9 for more than 90 seconds, the digital value and tape turn red and a L (R) OIL PRESSURE LOW warning message appears. This message also appears if the oil pressure enters the low warning range for more than 15 seconds.

Table 15. Oil Pressure Amber and Red Indications

Oil Pressure	Time Delay for Amber Display
9.1 – 10	None
8.1 – 9	5 minutes

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Table 15. Oil Pressure Amber and Red Indications

Oil Pressure	Time Delay for Amber Display
1 – 1.9	90 seconds
0 – 0.9	15 seconds

8.4.12 Oil Temperature

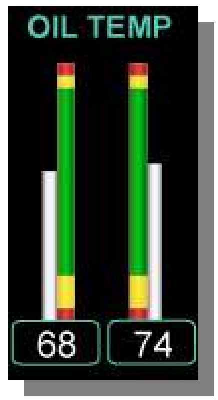

Figure 104. Oil Temperature Tape

Temperature indications from the engine oil sensor are displayed with a digital readout and a moving tape on the engine synoptic page. The scale of the tape is -50°C to 150°C. An adjacent tape displays oil temperature limits. The green band extends from 20°C to 135°C. There are two amber bands, one from 20°C to -40°C and the other from 135°C to 140°C. There are two red bands, one from -40°C and below and another beginning at 140°C.

When oil temperature is in the normal (green band) range, the digital oil temperature value and indicator tape are white. If the oil pressure is in the caution (amber band) range (either high or low), the tape and digital value are amber.

The amber bands incorporate a time delay for transient conditions.

If the oil temperature enters the high caution range of 135°C-140°C or the low caution range of less than 20°C, the digital value and tape turn amber and a L (R) ENG OIL TEMP LOW or L (R) ENG OIL TEMP HIGH caution message appears instantaneously.

If a high oil temperature remains in the caution range for more than 90 seconds, the digital value and tape turn red and a L (R) OIL TEMP HIGH warning message appears.

If the engine oil temperature enters the high warning range of 140°C or drops below the low warning range of -40°C, the digital value and tape turn red and a L (R) ENG OIL TEMP HIGH warning message appears instantaneously.

Should the engine oil temperature sensor fail, a L (R) OIL TEMP FAULT advisory message appears and oil temperature indications for that engine will be unavailable and a red X appears in place of the oil temperature tape.

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Table 16. Oil Temperature CAS Delay Time

Oil Temperature	Time Delay for CAS
Above 140°C	None, immediately red
135°C to 140°C	Amber for 90 seconds, then red
Less than 20°C	None, immediately amber
Below -40°C	None, immediately red

8.4.13 Engine Chip Indication

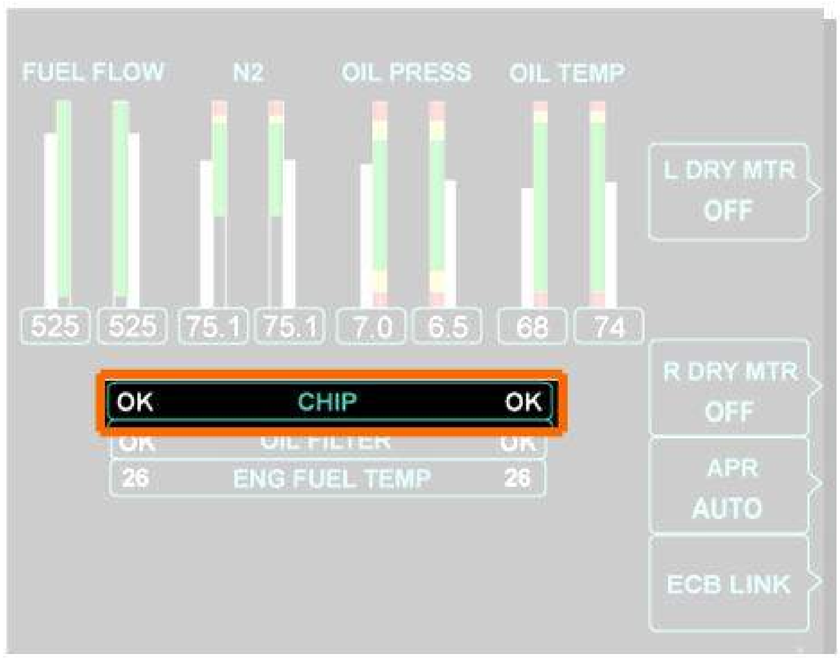

Figure 105. Engine Chip Display

If the ACS detects metal contamination in the oil, it is displayed on the CHIP display at the bottom of the engine synoptic page. The display has three states:

Table 17. Engine Chip Color Indications

Situation	Display
Normal	OK (white)
Chip Detector Failed	--- (White)
Contamination Detected	DETECT (White)

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8.4.14 Oil Filter Status (Impending Oil Filter Bypass)

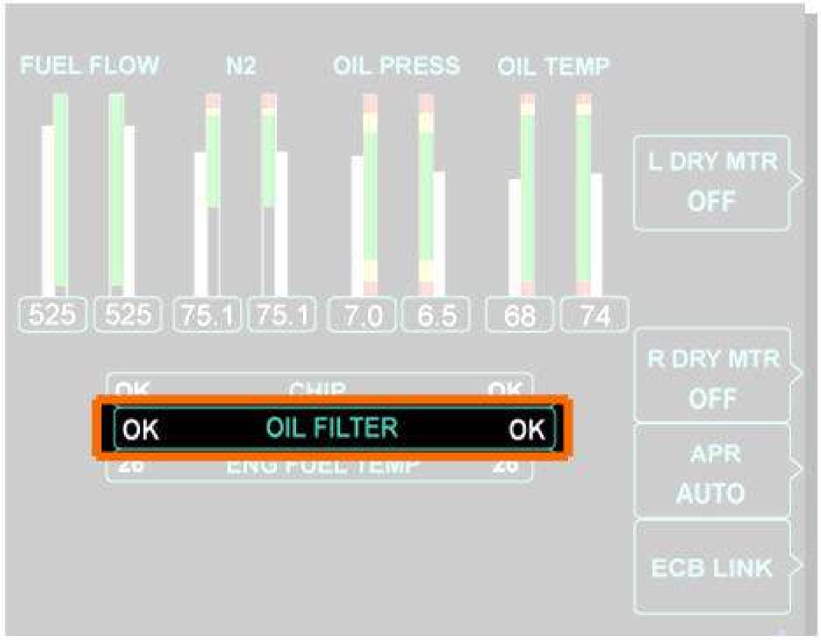

Figure 106. Oil Filter Display

If the ACS detects an impending oil filter bypass, a L (R) ENG OIL FILTER advisory message appears and an indication is displayed on the OIL FILTER display at the bottom of the engine synoptic page. The display has three states:

Table 18. Impending Bypass Color Indications

Situation	Display
Normal	OK (white)
Bypass Switch Failed	--- (White)
Oil Filter Impending Bypassed	IMP BYP (White)

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8.4.15 Engine Fuel Temperature

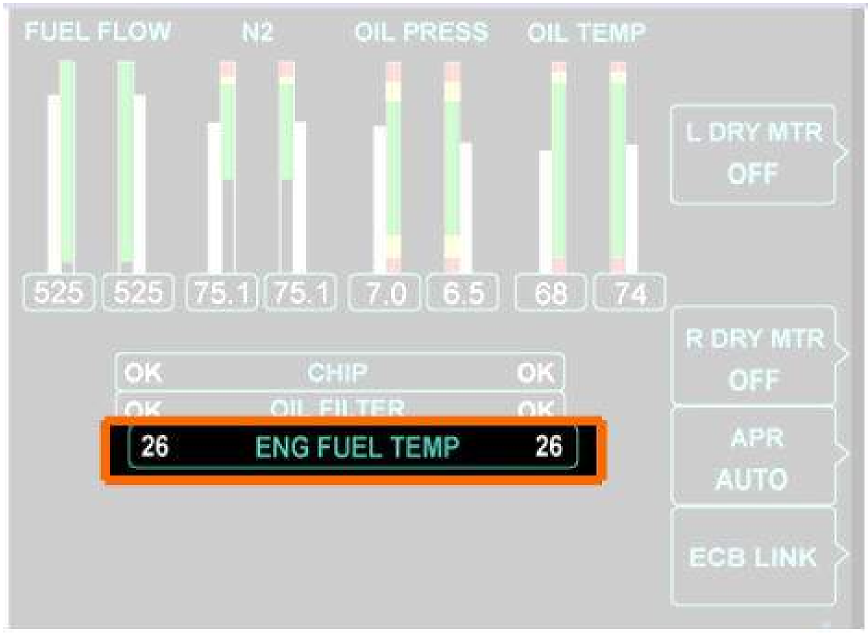

Figure 107. Engine Fuel Temperature Display

Engine fuel temperature in the FMU is displayed on the engine synoptic with a white digital readout in °C.

8.5 System Description

8.5.1 Full Authority Digital Engine Controller (FADEC)

The engines are controlled through two FADEC units. The FADEC has full authority over the operation of the engine. The FADEC sets thrust by controlling fuel flow based on throttle position. Throttle position measured by potentiometers correlates to the desired engine power. There are three primary operating ranges for the throttles, Idle, Maximum Continuous Thrust (MCT) and Takeoff.

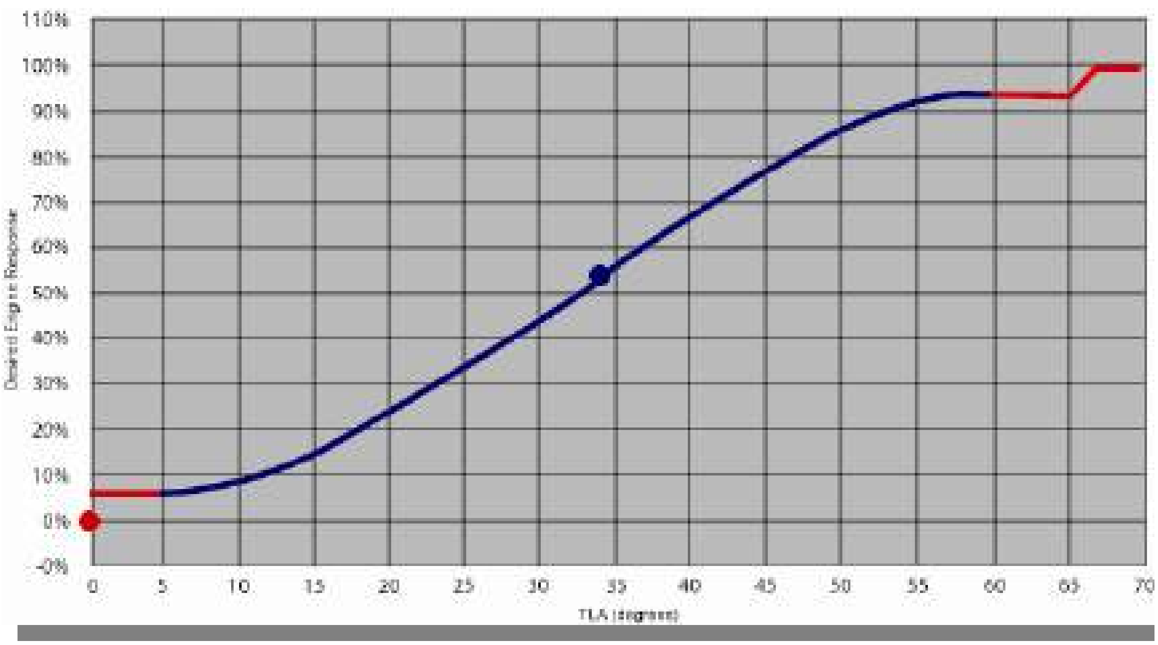

Figure 108. Throttle Position vs. Engine Power

Thrust level	Throttle Position (Degrees)
Idle	0 – 4
Maximum Continuous	59 – 65
Takeoff / APR	67 – 70

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The FADEC receives information from the following sensors:

- Engine status
  - N_1
  - N_2
  - ITT
  - Fuel temperature
- Air data information
  - TAT
  - Airspeed
  - Pressure altitude
- Airplane status
  - Weight On Wheels
  - Electrical system configuration
- Pilot commands
  - Mode (start, stop, motor, continuous ignition)
- Throttle position

The FADEC system is considered part of the engine, however, for reliability reasons the FADEC units are located in the compartment inside the pressure vessel.

Each engine has two FADEC cards, either of which can control the engine. Each set of two FADEC cards is co-located with an ACS in one of the aircraft's two Avio Processing Centers (APC). The FADEC cards are physically separated. The left Avio Processing Center houses one FADEC card from each of the left and right engines. The right Avio Processing Center also houses one FADEC card from each of the left and right engines.

FADEC POWER SOURCES

Each FADEC unit has three power sources:

- Left generator
- Right generator
- System battery

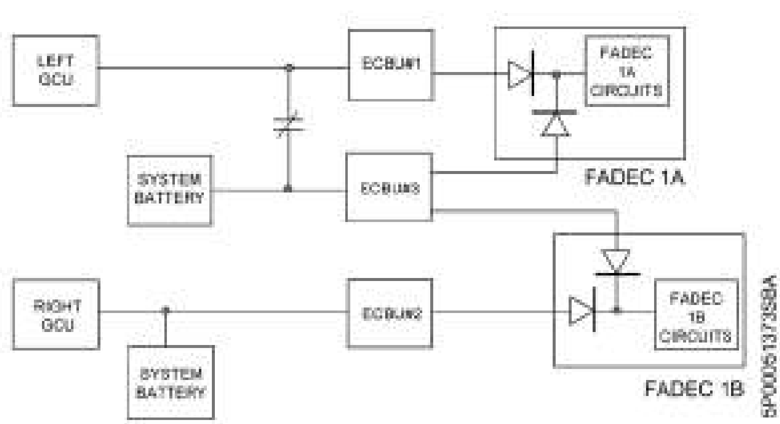

Figure 109. FADEC Power Sources

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8.5.2 Throttles

Thrust is set through manual pilot control of the throttles or automatically by the autothrottle system.

Takeoff thrust is set automatically by the FADEC when the pilot positions the throttles to the full-forward position.

8.5.3 Autothrottle

When engaged, the autothrottle will control the position of the throttles to regulate engine thrust consistent with autopilot directed flight attitude and conditions.

8.5.4 Automatic Power Reserve

The PW610F engines incorporate an Automatic Power Reserve (APR) feature that automatically increases thrust on one engine when the other engine experiences a loss of power when both throttles are at the takeoff power setting.

APR ARMING

APR arms automatically when both throttles are advanced to takeoff power with both engines running. Arming of APR is indicated by white APR ARMED text that appears above the N_1 tape on the MFD. Operation with APR ARMED at takeoff thrust is allowed for five minutes. Should this five minute time be exceeded a L (R) ENG EXCEEDANCE warning message appears prompting the pilot to reduce thrust to the maximum continuous thrust (MCT) setting.

APR DISARMING

Once armed the APR system will remain armed until the throttles are reduced from the takeoff power setting. APR is also disarmed manually using the 'Manual APR Disarming/Deactivating' procedure.

MANUAL APR DISARMING/DEACTIVATING

The APR system can be disarmed on ground or in flight with a line select key on the ENG synoptic page.

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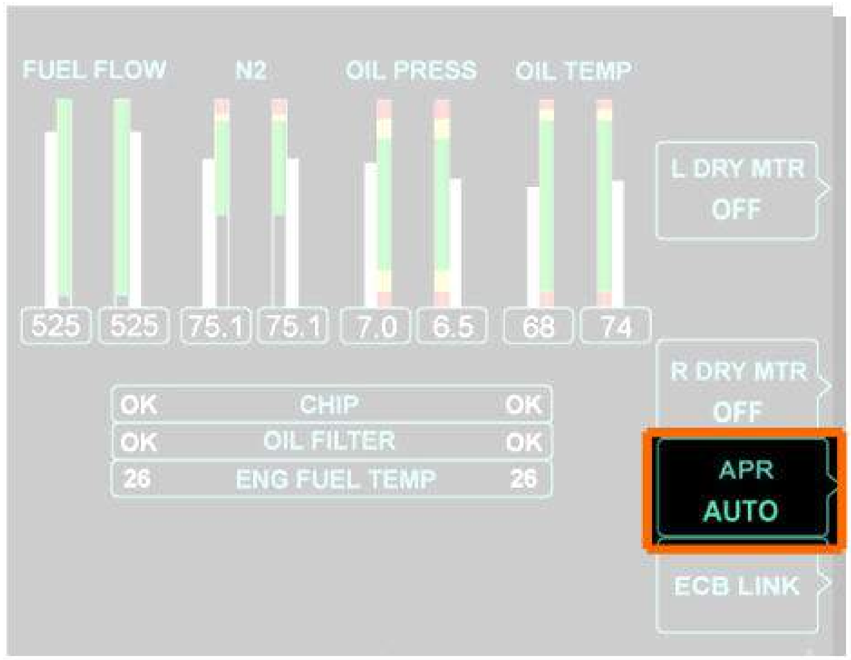

Figure 110. APR Line Select Key

Disarming the system is a two-step operation requiring pilot confirmation. This prompts an APR DISARMED status message to appear while on the ground. Rearming APR does not require confirmation and is a one-step operation.

Disarm:

AUTO→CONFIRM→OFF
AUTO→CANCEL→AUTO

Re-arm

OFF→AUTO

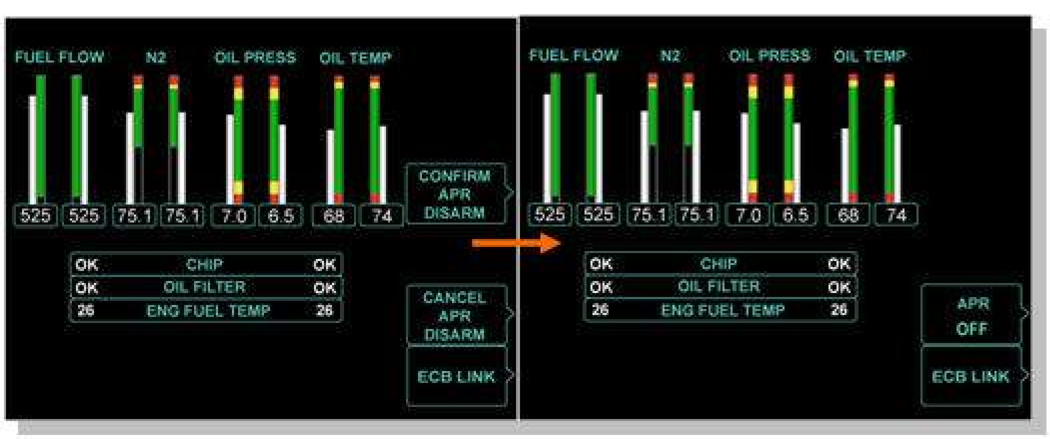

Figure 111. APR Disarm Sequence

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AUTO ACTIVATION

Once armed, the APR system will automatically activate if there is a difference detected between engine speeds.

- Left or Right N1 fan speed differ by 20% or more
- Left or Right N2 compressor speed differ by 10% or more

When an engine fails — green APR ON text is displayed above the N_1 tape on the MFD. APR increases thrust on the operating engine by increasing fuel flow, allowing the engine to operate up to the ITT limit of 795°C. The increased thrust is limited by any of the following parameters:

- 900 pounds absolute thrust
- 110% of normal takeoff thrust with both engines operating
- ITT limit for APR (795°C)
- N1 or N2 speed limit

If an engine fails during a low altitude/low temperature takeoff, where engines are producing full rated thrust, APR does not increase thrust on the operating engine.

Operation with APR active is allowed for 10 minutes. The red band on the ITT limit tape changes to the new limit for this 10 minute period. When the throttles have been at the takeoff position for more than 10 minutes, the ITT digital value and moving tape turn red and a L (R) ENG EXCEEDANCE warning message appears to prompt the pilot to reduce thrust to the maximum continuous thrust (MCT) setting.

TEST APR ACTIVATION

With APR armed, reduce one engines throttle below the mid range while leaving the other engine at takeoff.

DEACTIVATION

Once APR is activated, either automatically or via a test activation, it will remain active until the engines are shutdown, or the pilot uses the 'Manual Disarm/Deactivation' procedure.

8.5.5 Starter/Generators

A starter/generator is mechanically coupled to each engine. During engine start, the starter/generator functions as a motor. Power from the start battery drives the starter via a Generator Control Unit (GCU) connected to each starter/generator. After the engine is running, the starter/generator functions as a generator and supplies power to the airplane via the GCU.

8.5.6 Engine Fuel System

Fuel is supplied to the engines by a Fuel Metering Unit (FMU) that receives fuel under pressure from fuel pumps located in the sump tanks. Fuel for each engine is further pressurized by an engine-driven low pressure fuel pump within the engine. From the low pressure pump fuel flows from the FMU through a fuel/oil heat exchanger to cool engine oil. Fuel then flows through the main fuel filter, which incorporates a bypass in the event of filter blockage and a differential pressure switch to indicate impending fuel filter bypass. Fuel returns to the FMU and passes through a high pressure pump and fuel metering valve controlled by the FADEC. The fuel metering valve then distributes fuel to the fuel nozzles. Excess fuel is routed back

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to the fuel tank under pressure as “motive” fuel to operate the ejector pumps in each fuel tank.

FMU drains on the bottom portion of the engine are subject to very small leakage on a constant basis and may have minor fuel drips; however drain holes on the engines are normally dry.

Fuel temperature in the FMU is monitored by the ACS and FADEC. Should the fuel temperature exceed 121°C/250°F a L (R) ENG FUEL HOT warning message appears.

8.5.7 Bleed Air

Two ports on each engine provide bleed air used for ice protection and cabin pressurization. Bleed air from the outboard port on each engine is routed to the engine nacelle for engine inlet anti-ice and to the de-ice manifold for leading edge de-ice boots. Bleed air from the inboard port on each engine is routed to the flow control valve for heating and pressurization controlled by the climate control system.

8.5.8 Oil System

The engine oil system is completely contained within the engine. Oil is drawn from the oil tank by an engine-driven oil pump. The pump incorporates a pressure relief valve to avoid damage during engine starts in cold temperatures. From the oil pump, the oil passes though a full-flow filter that incorporates a bypass valve and a differential pressure switch to indicate impending oil filter bypass. Should the pressure switch indicate an impending bypass a L (R) ENG OIL BYPASS advisory appears. From the oil filter, oil passes though an air- cooled oil cooler and fuel-oil heat exchanger, each designed to cool the oil. The air-cooled oil cooler uses bypass air from the fan section of the engine, while the fuel-oil heat exchanger uses fuel flow from the sump tanks. Oil then passes through an oil temperature sensor and pressure sensor, then to the main bearing cavities and the engine accessory gearbox. Oil returns to the reservoir by gravity and scavenge pumps.

A separate line from the accessory gearbox to the oil tank incorporates a magnetic chip detector. Metal contamination triggers a L (R) ENG CHIP DETECTED advisory message to appear. If this detector fails, a L (R) ENG CHIP FAULT advisory appears and chip detection is unavailable.

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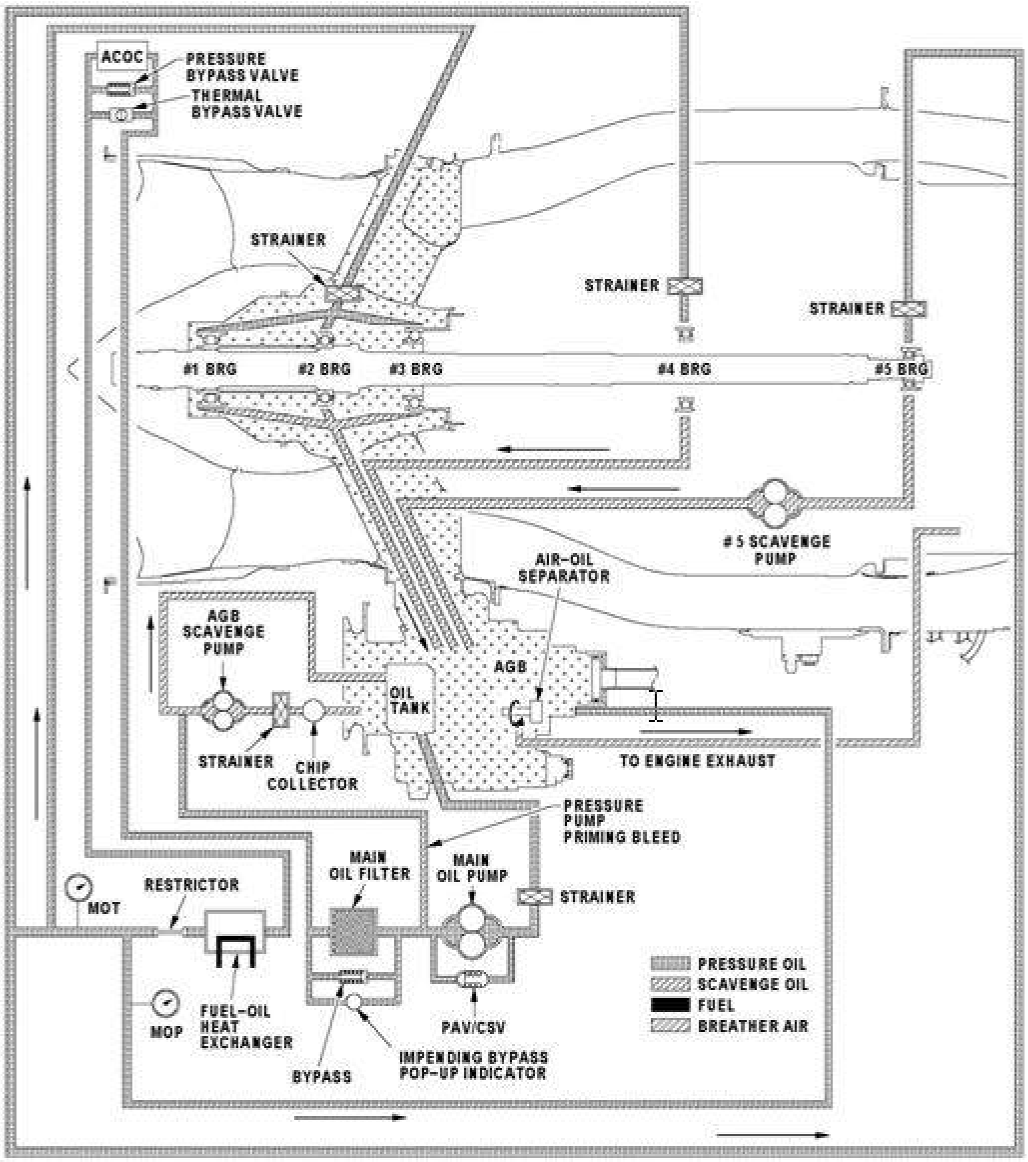

Figure 112. Engine Oil Schematic

There is an oil level sight glass and oil filler port on the side of the integral oil tank. The filler port is protected by a feature to prevent oil loss in case the oil cap is not properly installed.

Figure 113. Engine Oil Sight Glass

8.5.9 Fire Protection

The fire detection system monitors the aircraft engines for signs of overheating and fire.

Engine fire protection consists of:

- firewalls
- ventilation of all zones within the engines
- drainage in those areas subject to leakage of flammable fluids
- fire detection
- fire suppression

The fire detection system gives multiple indications of an engine overheat or fire condition to the air crew. These include:

- L (R) ENG FIRE warning messages
- dual guarded indicator/control buttons that turn on when a fire (red) condition occurs
- “Left Engine or Right Engine Fire” audible alarm

Figure 114. FIRE/ARMED Button

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FIRE DETECTION

Each engine contains a single temperature detector loop to detect an engine fire. The left engine temperature sensor cable is monitored by the left ACS. The right ACS monitors the right engine temperature sensor cable.

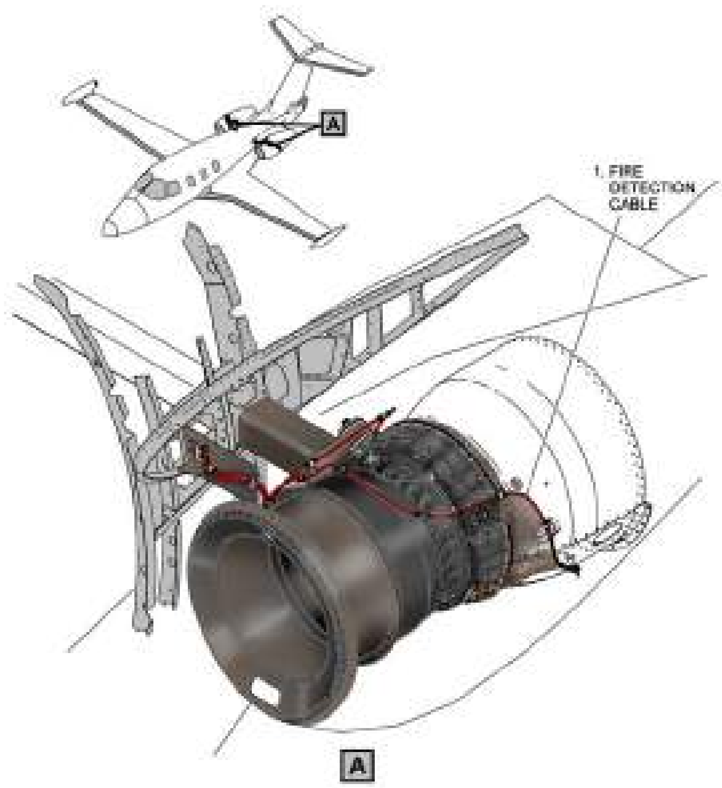

Figure 115. Fire Detection Loop

The ACS has two main fire detection functions. It gives an alert to the flight crew within 5 seconds of overheat, by sensing changes in the electrical resistance on the loop. It also monitors the fire detection system and gives an indication of the failure of system integrity to the air crew. Should a fire loop experience a fault a L (R) FIRE DETECTOR FAULT advisory message appears.

When the sensor cable is exposed to a temperature of 400°F (204°C) the instrument panel red fire indicator will illuminate, an audible alarm will sound and a L (R) ENG FIRE warning message appears.

The audible alarm is silenced by pressing the WARN/CAUTION button on the Autopilot Control Panel. If the red fire indicator goes out after reducing thrust, it is likely a bleed air leak has occurred and a fire condition is not present. If the red fire indicator remains illuminated, a fire condition exists and the fire extinguishing system should be activated

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FIRE SUPPRESSION

The fire extinguishing system is made up of a fire extinguishing cartridge and associated delivery tubing and wiring. A pressurized fire canister with a pyrotechnic discharge cartridge is installed in each engine pylon.

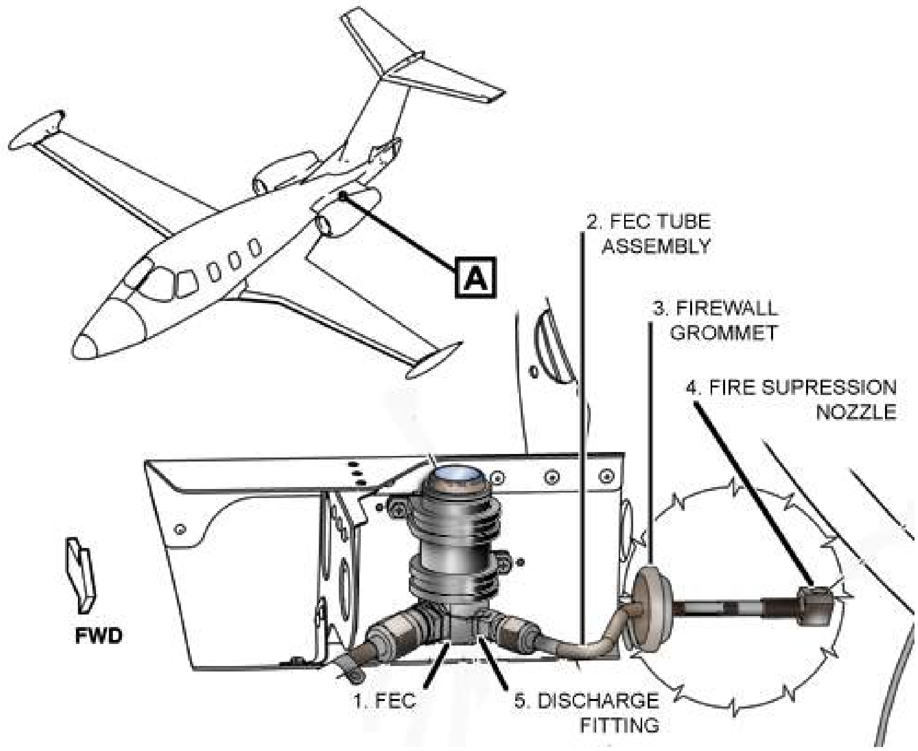

Figure 116.   Fire Extinguisher Canister Location

The fire extinguishing system delivers the PhostrEx™ extinguishing agent to the engine by a tube and nozzle located inside the nacelle and aimed to provide maximum dispersion.

The fire extinguisher is a single shot system, dispersed by an electrical charge that activates an explosive squib in the fire extinguisher canister releasing the agent under pressure. Rigid tubes convey the suppression agent to the nacelles, where it is injected via nozzles located on the firewalls. The agent eliminates oxygen in the nacelle and extinguishes the fire. Each fire canister is controlled independently from the other and has a dedicated switch/indicator.

The fill level should be in the green band indicated on the canisters which can be seen through clear windows in the top of each pylon.

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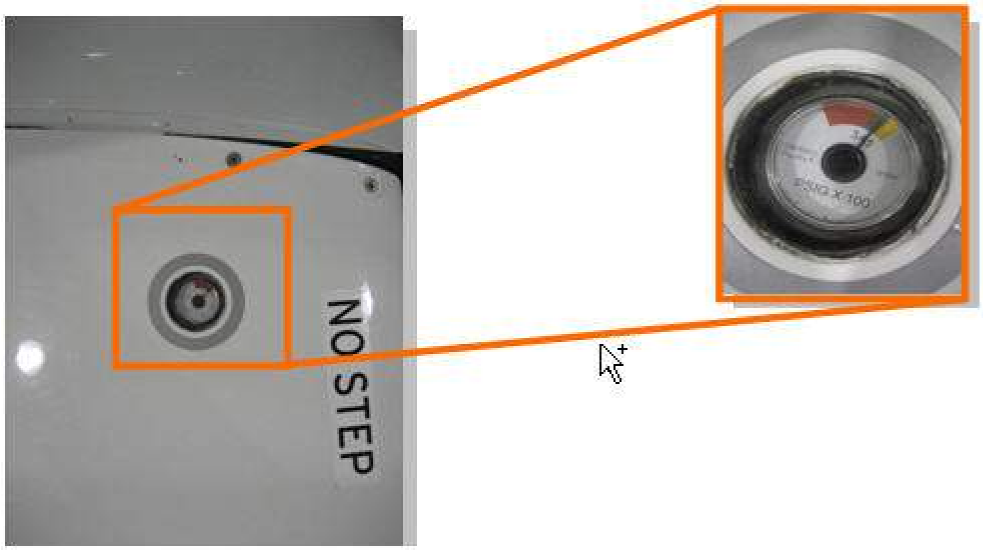

Figure 117. Fire Canister Pressure Indicator- Engine Pylon

COCKPIT CONTROLS

Two buttons labeled FIRE/ARMED are on the left and right sides of the autopilot control panel. The left button is for the left engine and vice versa. An engine fire is indicated by a red light in the respective button and by an audible fire warning which will continue until the fire is extinguished.

The first press of the FIRE/ARMED button does the following:

1. Closes the fuel shutoff valve
2. Closes the bleed air valve (PRSOV)
3. Turns off the igniters
4. Closes Flow Control Valve
5. Closes Fan Air Control Valve
6. Arms the fire canister
7. Green ARMED text on the FIRE/ARMED button is illuminated when the fire extinguisher is armed for discharge.

NOTE:

In the event that the engine was shut down inadvertently using the FIRE/ARMED button, the engine may be restarted by turning the engine start switch to the OFF position, then placing it to the ON/START position. This will also reset the fire canister to the OFF position.

The second press of the FIRE/ARMED button discharges the fire canister to the respective engine. Once the extinguishing agent is discharged the green ARMED text extinguishes and a L (R) EXTNGR DSCHG advisory message appears indicating that the fire extinguisher capability has been depleted.

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8.6 Normal Operations

8.6.1 Engine Start

Engine start is automatically controlled by the ACS and FADEC. The start sequence is initiated by pushing in the engine start switch on the engine start switch panel and turning it to ON/START. The automatic engine start sequence is as follows:

START/MOTORING MODES

Table 19. Start/Motoring Modes

Starting		Motoring	
On-Ground Assisted	In-Flight Assisted	Wet	Dry

AUTOMATIC START ABORT

The FADEC provides automatic start abort functionality for failed ground starts based on:

1. ITT Exceedance
2. No light-off
3. Hung start
4. N2 Below ‘Fuel on” Threshold
5. Loss of required inputs/outputs for FADEC during engine start

ON GROUND START SEQUENCE

1. Engine Start Switch-- ON/START
2. Electrical system is configured for start.
    a. Bus Tie contactor- CLOSE
    b. Right Battery Bus contactor- CLOSE
    c. L and R Forward Circuit Breakers/Contactors- OPEN
3. N2- 3 to 10%
    a. Starter ON
    b. Fuel Shutoff valve- OPEN
    c. Electric Fuel Pump- ON
    d. Igniters ON
    e. ITT Redline- INCREASES TO 850°C
4. N2- 15%
    a. Oil Pressure rise

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NOTE:
FADEC does not abort engine start for abnormal oil pressure

b. ITT Rise

5. N2- 20%

a. N1 Rise

NOTE:
FADEC will not abort for lack of N1 rotation until N2 reaches 45%

b. ITT continues to rise

6. N2- 30 to 35%

a. Electric Fuel Pump- OFF

b. Starter-OFF

c. Left and Right Forward Circuit Breakers/Contactors- CLOSE

d. Right Battery Bus Contactor- OPEN

e. Generator Contactor- OPEN

f. Bus Tie Contactor- OPEN

NOTE:
Bus Tie Contactor opens after 2nd engine start

7. N2- Ground Idle (Approx 47% N2)

a. ITT Stabilizes

b. ITT Redline returns to 795°C

If the aircraft systems do not automatically configure properly for engine start an ENG START FAIL advisory message appears. Check the state of the BUS TIE contactor switch and verify that it is in AUTO; once completed engine restart may be attempted. Should engine parameters exceed limits during engine start on the ground, the FADEC automatically aborts the start and an ENG START ABORT caution message appears. If this message appears, determine the cause of the abort and if a mechanical failure is suspected do not attempt to restart the engine.

IMPORTANT:
The FADEC does not automatically abort engine air starts. The pilot is responsible for monitoring engine parameters.

8.6.2 Engine Shutdown

Engine shutdown is accomplished by turning the engine start switch to OFF.

NOTE:
The engine start switch must be pushed in to move it from ON/START to OFF to prevent inadvertent shutdown of the engine.

8.6.3 Engine Dry Motoring

If an engine start is aborted, fuel can puddle in the engine combustion chambers. This fuel can be pumped out (without adding more fuel and without ignition) by dry motoring the engine using the line select keys labeled L DRY MTR and R DRY MTR

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on the engine synoptic. This feature is available on ground only; the line select key control of dry motoring is removed in flight.

8.6.4 Takeoff

Takeoff thrust is set by advancing both throttles to the takeoff position (full-forward). The FADEC controls fuel flow such that the engines produce takeoff thrust for the ambient conditions. The engines are rated to produce 900 pounds of thrust at sea level at or below International Standard Atmosphere (ISA) temperature + 10°C.

8.6.5 Continuous Ignition

To avoid engine flameout in turbulence, heavy rain, or icing conditions, continuous ignition is selected by placing the engine start switch to the CONT IGN position.

8.6.6 Flight and Ground Idle RPM

Engine idle speed is higher in-flight (approx. 52% N2) than on the ground (approx. 47% N2), as determined by the WOW sensor. This feature is incorporated to provide a higher margin in-flight and avoid the possibility of engine flameout due to anomalies in engine inlet airflow.

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8.7 Abnormal Procedures

8.7.1 Automatic Power Reserve

In the event of engine failure during takeoff, the Automatic Power Reserve (APR) system increases thrust on the operating engine by up to 10%.

8.7.2 Aircraft Computer System Failure

The fuel flow and fuel temperature are supplied by the FADEC to the opposite ACS and will continue to be displayed.

8.7.3 Manual Engine Shutdown

If the engine fails to shut down with the engine start switch selected OFF, control automatically transfers to the other FADEC unit. If both FADEC units fail, the pilot can shut down the engine by manually closing the Fuel Shutoff Valve by pressing the FIRE/ARMED button once.

8.7.4 Engine Failure

In the event that an engine failure a L (R) ENG FAIL warning message appears.

8.7.5 Engine Control Failures (FADEC Channel Failures)

SINGLE CHANNEL

A failure of one of the FADEC channels causes a loss of redundancy in the engine control system and prompts a L (R) ENG CONTROL advisory message to appear on ground. This message indicates that one of the left or right side FADEC channels has experienced a fault and will not affect engine operation; however flight with an inoperative FADEC channel is not recommended.

DUAL CHANNEL

A failure of both FADEC channels on one side is a more serious condition that prompts a L (R) ENG CONTROL FAIL caution message to appear. This failure may degrade engine control to a point where the engine may fail to a fixed fuel flow or throttle setting and may require that the engine be manually shut down using the FIRE/ARMED button.

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8.8 Crew Alerting System Messages

Table 20. Engine CAS Messages

Message	Condition	Category
L (R) ENG FAIL	Left or Right Engine failure	Warning
L (R) ENG FIRE	Engine fire detected	Warning
L (R) ENG EXCEEDANCE	Engine has exceeded limits (N1, N2, ITT, expiration of 5 minute T/O thrust or 10 minute APR ON timer.)	Warning
L (R) ENG OIL TEMP HIGH	Oil temperature exceeds allowable limits	Warning
L (R) ENG OIL PRESS HIGH	Oil pressure exceeds allowable limits	Warning
L (R) ENG OIL PRESS LOW	Oil pressure below allowable limit	Warning
L (R) ENG FUEL HOT	Fuel temperature at engine Fuel Metering Unit (FMU) exceeds limits	Warning
ENG START ABORT	Engine start aborted by FADEC (ground only)	Caution
L (R) ENG CONTROL FAIL	A failure has occurred in the engine control system that may degrade engine control. The engine may fail to a fixed fuel flow or throttle setting	Caution
L (R) ENG OIL TEMP HIGH	Oil temperature is between 135°C and 140°C	Caution
L (R) ENG OIL TEMP LOW	Oil temperature below 20°C (ground only)	Caution
L (R) ENG CHIP DETECTED	Metal particles detected in engine oil (ground only)	Advisory
L (R) ENG CHIP FAULT	Engine oil chip detector has failed and may not be ale to detect metal in the engine oil (ground only)	Advisory
L (R) ENG CONTROL	A loss of redundancy in the engine control system has occurred. Engine operation is not affected. (ground only)	Advisory
L (R) ENG OIL BYPASS FAULT	The engine oil filter bypass pressure switch failure (ground only)	Advisory
L (R) ENG OIL FILTER	The engine oil filter pressure switch has tripped, the oil filter may be bypassed (ground only)	Advisory
L (R) ENG OIL TEMP FAULT	Engine oil temperature sensor failure. (ground only)	Advisory
ENG START FAIL	Aircraft systems did not automatically configure for start	Advisory
L (R) EXTNGR DSCHG	Left or right fire extinguisher has discharged. Once discharged, the fire extinguisher capability has been depleted	Advisory
L (R) FIRE DETECTOR FAULT	Fire detection circuit is shorted or open. Fire detection is unavailable.	Advisory
APR DISARMED	APR disarmed (ground only)	Status

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8.9 Engine and Fire Protection Review Questions

1. **What are the four areas that the Aircraft Computer System interfaces with the Engines & Fire Protection Systems?**

   a.

   b.

   c.

   d.

2. **Where do inputs from the throttles go to?**

   a. Through the ACS to the FADECs

   b. Directly to the FADECs

   c. Through the PFD to the ACS to the FADECs

   d. Directly to the FMUs

3. **During preflight how is the engine oil checked?**

   a. By using a dipstick on the side of each engine nacelle.
   b. By viewing the oil level in the sight gauge.
   c. Oil level is displayed on the Engine (ENG) synoptic page.
   d. None of the above

4. **The minimum battery voltage for a battery only engine start is:**

   a. 48V
   b. 28V
   c. 20V
   d. 23V

5. **FADEC stands for which of the following?**

   a. Full Authority Digital Engine Controller.
   b. Fixed Axis Digital Engine Coupler.
   c. Fuel Air Data Engine Controller.
   d. None of the above.

6. **What are the primary engine sensors?**

   a.

   b.

   c.

7. **List the two items that the FADEC uses to activate the Automatic Power Reserve system to automatically activate?**

   a.

   b.

8. **APR will increase thrust up to how much on the operating engine in the event of an engine failure?**

   a. 25% of takeoff thrust (N1)
   b. 110% of takeoff thrust (N1)

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c. 110 RPMs
d. 30% N_1

9. **The PW-610F-A engine has how many rotors (spools)?**
    a. One
    b. Two
    c. Three
    d. None of the above
10. **How many channels does EACH FADEC have?**
    a. 4
    b. 1
    c. 2
    d. 3
11. **CONT IGN does which of the following?**
    a. Provides continuous ignition to prevent engine flameout.
    b. Enables automatic control of continuous ignition as required by the FADEC.
    c. Turns off the FADEC
    d. None of the above
12. **The purpose of engine dry motoring is to:**
    a. Start the engine quietly.
    b. Pump excess fuel out of the engine by running it without adding fuel.
    c. Provide engine cooling following long periods of operation.
    d. None of the above.
13. **How can the engines be turned off?**
    a. By pressing the FIRE/ARMED button once
    b. By selecting CONT IGN for both engines using the engine rotary switch.
    c. By selecting OFF for both engines on the engine rotary switch.
    d. Both A & C
14. **Fire suppression for each engine is provided by:**
    a. A fire extinguisher located in the cockpit.
    b. PhostrEx canisters installed in each pylon
    c. Four Halon bottles placed outside of the pressure vessel
    d. There is no specific fire suppression system for the engines.
15. **The minimum temperature for engine start is:**
    a. 0° F
    b. -15° C
    c. -25° F
    d. -20° C or -4° F
16. **List the three sources of power for the FADEC units:**
    a.
    b.
    c.
17. **What is engine bleed air from the inboard P3 bleed port on the engine used for?**

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9. Climate Control

9.1 General

The climate control system is comprised of four mutually dependent sub-systems:

- Bleed Air Supply Sub-System
- Cabin Air Distribution Sub-System
- Air Conditioning Sub-System
- Cabin Pressurization Control Sub-System

The Bleed Air Supply Sub-System provides aircraft pressurization, ventilation, and cabin conditioned bleed air. Bleed airflow is controlled automatically by the ACS or manually through line select keys on the pressurization (PRESS) synoptic as well as hard switches on the left switch panel.

The Cabin Air Distribution Sub-System distributes conditioned bleed air and air conditioned air throughout the pressurized cabin through two evaporator units according to the temperature and operational mode demands of two control zones within the cabin. Cockpit and cabin air flow rate is automatically controlled by the ACS or manually controlled though the environmental (ENVIR) synoptic.

The Air Conditioning Sub-System provides cooling for the pressurized cabin bleed air. The air conditioning system is automatically controlled by the ACS or manually controlled through the environmental (ENVIR) synoptic.

The Cabin Pressurization Control Sub-System works in conjunction with the ACS to automatically regulate the cabin pressure. The system can also be controlled manually by the pilot through the pressurization (PRESS) synoptic.

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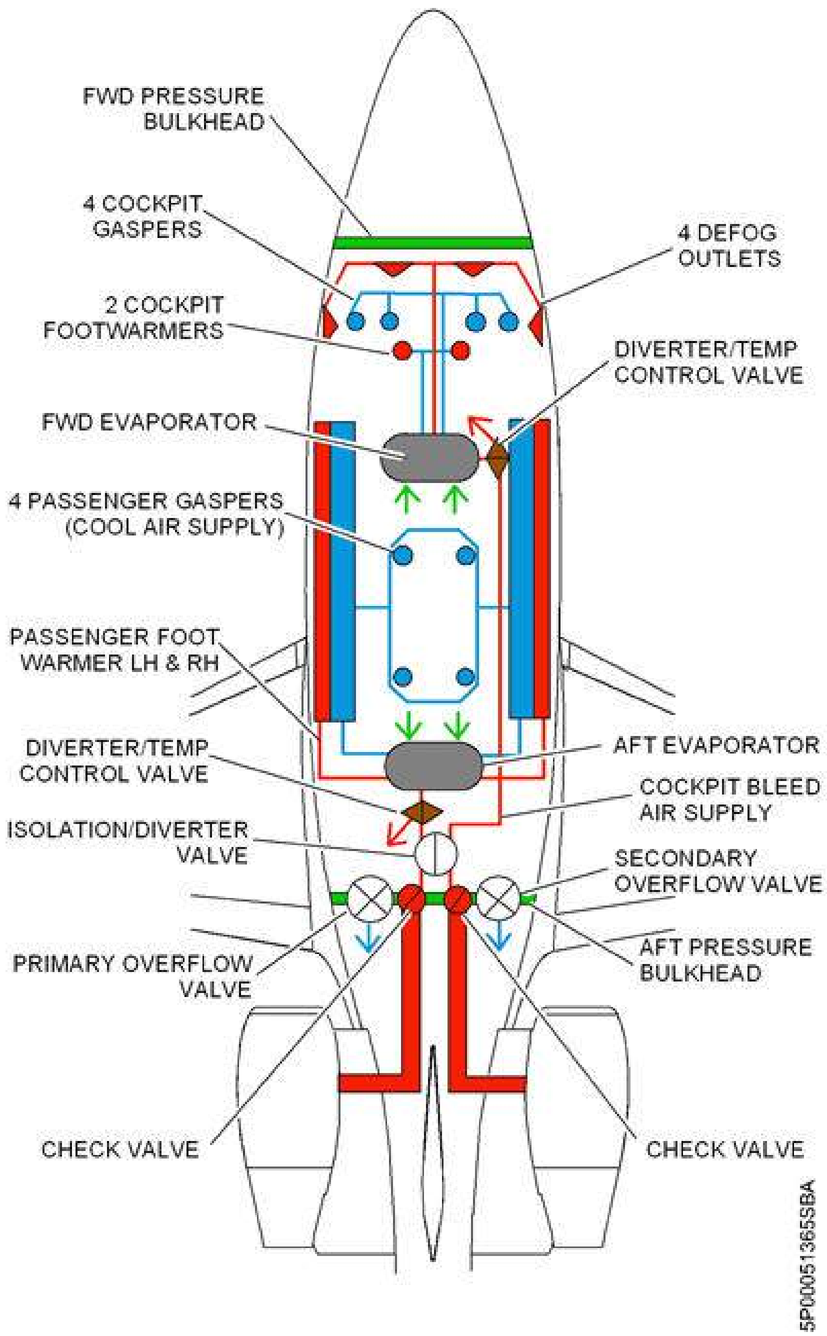

Figure 118. Climate Control System Overview

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9.2 Aircraft Computer System (ACS) Interfaces

The ACS has control and monitoring functionality the four major subsystems of the Climate Control System and provides the following functions:

1. Cabin and Cockpit Temperature Control
2. Bleed Air, Fan Air and Ram Air Control and Monitoring
3. Bleed Air Temperature Control
4. Air Conditioning Control and Monitoring
5. Windshield Defog
6. Cabin Dehumidification
7. Manual and Automatic Pressurization Control and Monitoring
8. Over-Temperature Protection

Pilot inputs to the climate control system are made through the environmental (ENVIR) and pressurization (PRESS) synoptic pages as well as the Cabin Air Source selector on the left switch panel. Synoptic inputs are sent through the PFD, while the Cabin Air Source switch position is first sent through the center switch panel, then to the PFD. From the PFD, inputs are sent to the ACS which then configures the climate control system components by turning on and off applicable Electronic Circuit Breakers (ECBs). The ECBs for the climate control system are located within the Aft Power Distribution Center in Electronic Circuit Breaker Units (ECBUs) four and five.

Cabin pressure regulation is accomplished through the primary outflow valve and controlled directly by the left ACS. Normal operation of the pressurization system is automatic, however direct pilot inputs are accomplished through the pressurization (PRESS) synoptic page.

Several sensors send status information on the climate control system to the ACS' for display on the MFD. Sensor information related to the left engine is sent to the left ACS while information related to the right engine is sent to the right ACS.

CLIMATE CONTROL SYSTEM SENSORS

1. Left Engine
   a. Cabin Zone Temperature Sensor
   b. Aft Evaporator Temperatures
   c. Bleed Air Over Temperature Sensor
   d. Pylon Over Temperature Sensor
2. Right Engine
   a. Cockpit Zone Temperature Sensor
   b. Forward Evaporator Temperatures
   c. Bleed Air Over Temperature Sensor
   d. Pylon Over Temperature Sensor

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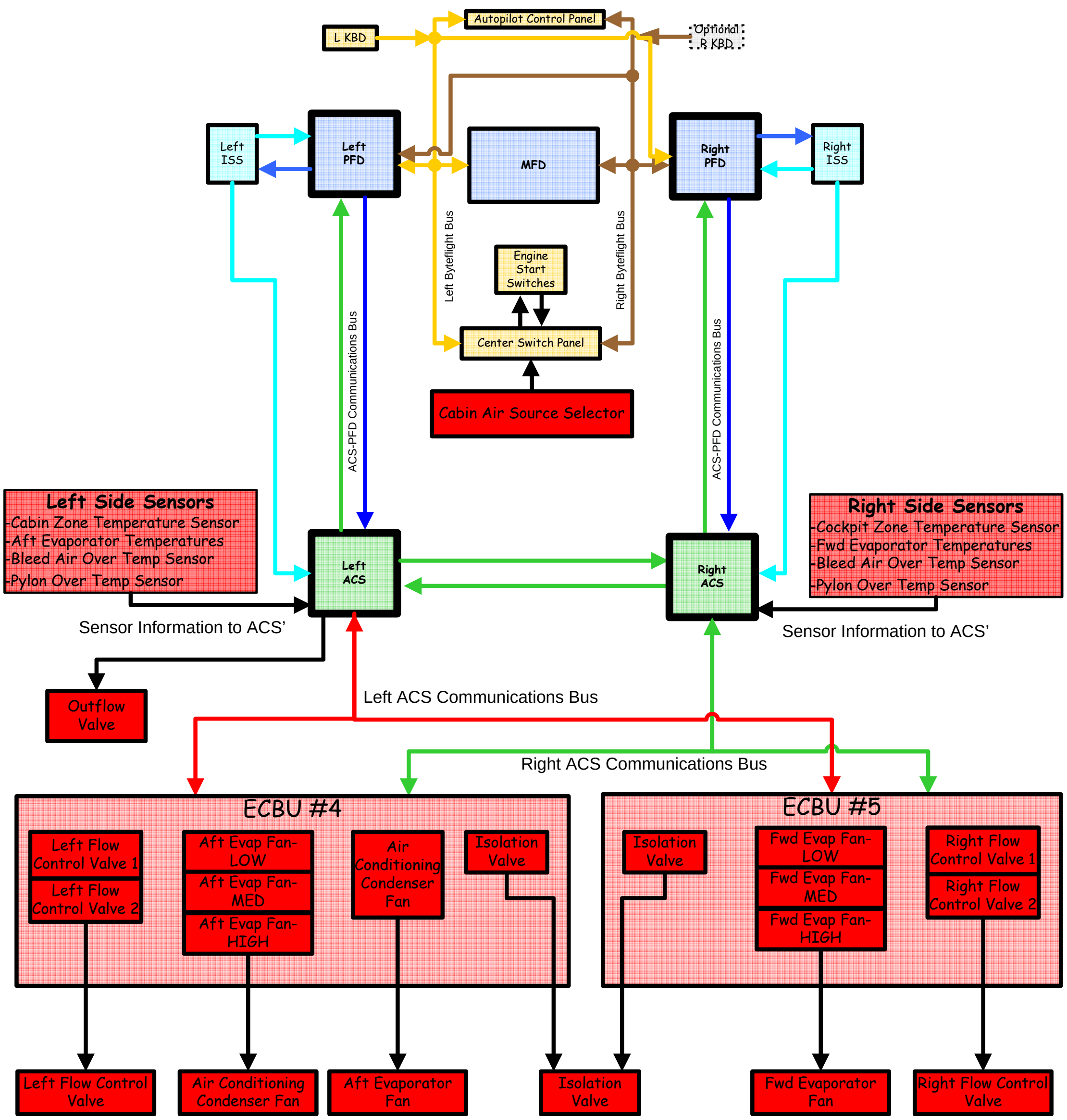

Figure 119. Climate Control System-ACS Interface

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9.3 Limitations and Specifications

9.3.1 Cabin Pressurization Limitations

Maximum Regulated Cabin Pressure Differential (ΔP) ....8.33 PSI
Maximum Regulated Negative Cabin Pressure Differential (ΔP) ....-0.5 PSI
Positive Pressure Relief, Primary Outflow Valve ....8.6 PSI
Positive Pressure Relief, Secondary Outflow Valve..8.7 PSI

Maximum Bleed Air Muffler Duct Temperature. .... 185°F (85° C)
Maximum Evaporator Temperature.. 176°F (80° C)
Maximum Pylon Temperature .... 350°F(177°C)

- Landing with cabin pressurized is not approved
- When operating in the Manual mode, negative entries of Selected Cabin Altitude are not approved.

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9.4 Controls and Indicators

9.4.1 Cabin Air Controls

Figure 120. Cabin Air Sub Panel

AIR SOURCE SWITCH

Table 21.   Air Source Switch Selections

OFF	No bleed air flow. Left and right flow control valve closed.
NORM	Bleed air provided from the right and left engines at the low flow setting. Air from the left engine flows to the cabin, while air from the right engine flows to the cockpit.
L	Bleed air provided from left engine only. Right flow control valve closed. Left flow control valve set to high flow.
R	Bleed air provided from right engine only. Left flow control valve closed. Right flow control valve set to high flow. (Based on AIR DISTR selection.)

NOTE:

Should AIR SOURCE switch fail an AIR SOURCE SW FAULT advisory message appears.

CABIN DUMP SWITCH

Table 22.   Cabin Dump Switch Selections

OFF	Normal operation
ON	■ Both outflow valves fully open ■ Both flow control valves switch to high flow ■ All bleed air routed to cockpit

9.4.2 Pressurization Display

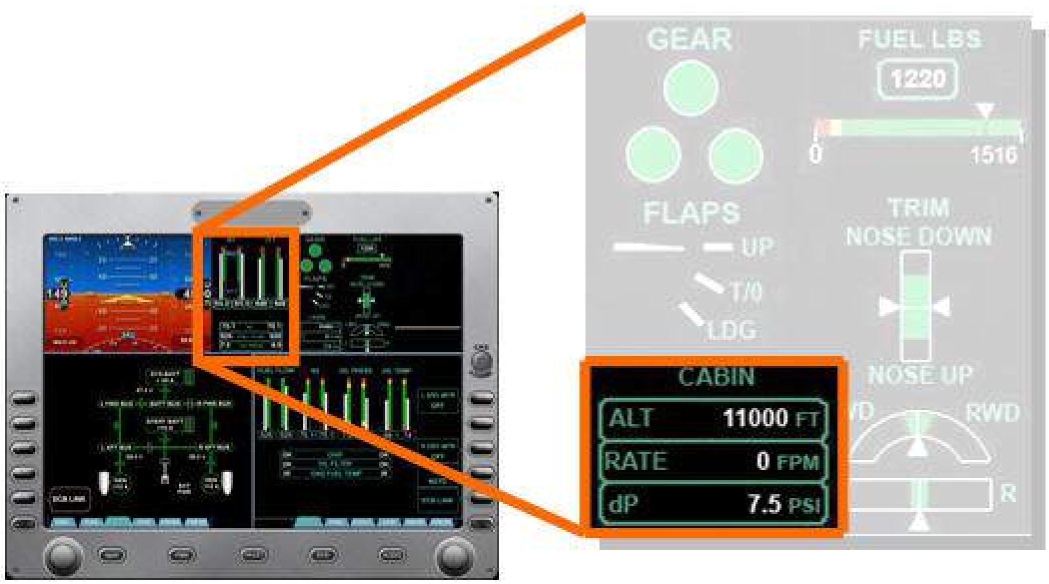

Figure 121.   MFD Pressurization Display

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9.4.3 ALT (FT)

Cabin altitude rounded to the nearest 50 feet is presented. If the cabin altitude exceeds 8,750 ft, a CABIN ALTITUDE caution message appears and the numeric digits turn amber. If the cabin altitude exceeds 10,000 ft, a CABIN ALTITUDE warning message appears and the numeric digits turn red. At a cabin altitude of 12,750 ft an aural warning sounds every 15 seconds. To silence the aural warning, one of the following conditions must be met:

- A rate of descent of 1,800 feet per minute or greater.
- A descent below 12,500 ft cabin altitude

NOTE:

A CABIN ALTITUDE warning message may indicate cabin depressurization.

RATE (FPM)

Cabin altitude rate of change rounded to the nearest 100 FPM (Feet Per Minute) is presented. Should the cabin altitude rate be too high, the numeric digits turn amber. The crew can select the cabin rate of climb or descent between 0 and 2,500 feet per minute.

DP (PSI)

Differential pressure between cabin altitude and airplane altitude, rounded to the nearest 0.1 PSI. If the differential pressure exceeds 8.7 PSI, a CABIN dP HIGH warning message appears and the numeric digits turn red.

ENVIRONMENTAL SYNOPTIC

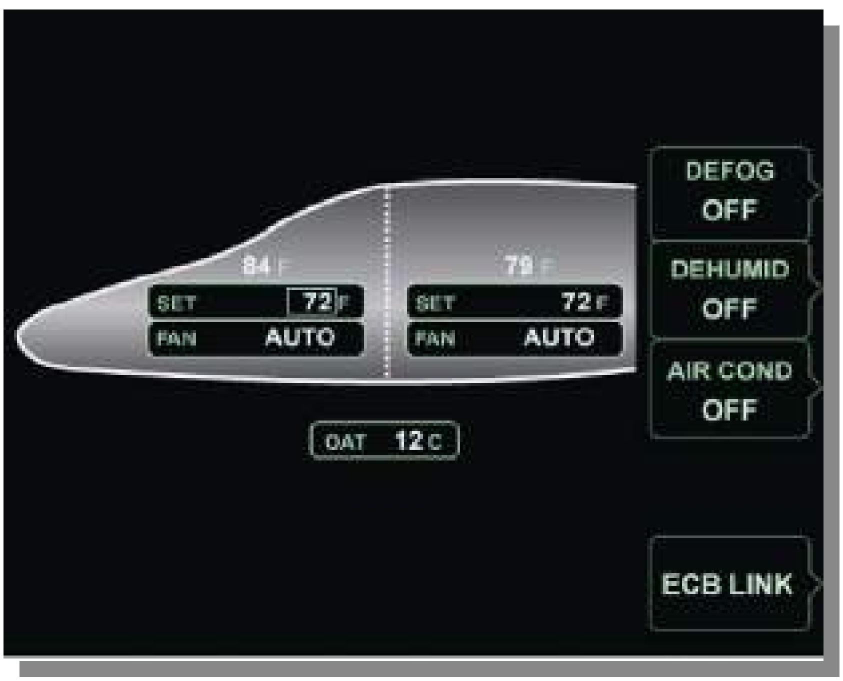

Figure 122. Environmental Synoptic

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The environmental (ENVIR) synoptic provides control of cockpit and cabin temperatures, as well as desired evaporator fan speeds through the concentric MFD knobs. Control of DEFOG, DEHUMID and AIR COND is provided on this synoptic through three line select keys. To set desired temperature, rotate the outer portion of the concentric MFD knob to select the function to be controlled. (The blue box steps through the four parameters.) Rotate the inner MFD knob to the desired setting.

Table 23. Environmental Synoptic Selections

Function	Settings
84 F / 78 F	Current cockpit and cabin temperature in degrees F
SET	Desired cockpit and cabin temperature in 2 degree increments from 64° F to 84° F plus MAX HEAT and MAX COOL. Default setting at power-up is 72° F
FAN	Cockpit and cabin evaporator fan—OFF / AUTO / LOW / MEDIUM / HIGH. Default setting at power-up is AUTO
DEFOG	OFF / ON. Default setting at power-up is OFF
DEHUMID	OFF / ON. Default setting at power-up is OFF
AIR COND	OFF / AUTO. Default setting at power-up is OFF
OAT	Outside Air Temperature in degrees °C
ECB LINK	Selects Climate Control ECB synoptic page

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9.4.4 Pressurization Synoptic

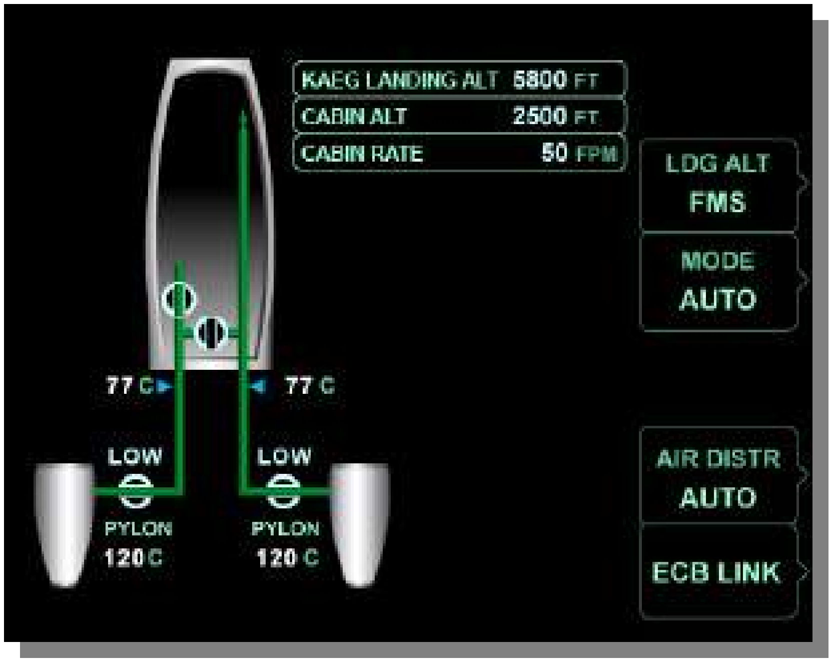

Figure 123. Pressurization Synoptic

Pressurization system control, including modes of operation and selection of air distribution is provided on the pressurization (PRESS) synoptic. The LDG ALT, CABIN ALT, and CABIN RATE functions are controlled by the concentric MFD knobs. While in MANUAL mode of operation, rotate the outer portion of the concentric MFD knob to select the function to be controlled.
(The blue box steps through the three boxes.) Rotate the inner portion of the MFD knob to desired setting.

Table 24. Pressurization Synoptic Indications

Pylon Temperature	Temperature in pylon
Flow Control Valve Setting	HIGH or LOW flow
Duct Temperature	Bleed air temperature downstream of heat exchanger
Isolation/Cabin Shutoff Valves	Position of isolation and cabin air shutoff valve

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Table 25. Pressurization Synoptic Selections

LDG ALT FT	LDG ALT key set to FMS:	FMS destination airport identifier and landing altitude displayed.
	LDG ALT key set to MANUAL:	Landing altitude can be manually set between 0 and 11,500 feet.
SEL CABIN ALT FT	Set cabin altitude in MANUAL pressurization mode. Range is -1,000 feet to 11,500 feet.	
SEL CABIN RATE FT	Set cabin rate in MANUAL pressurization mode. Range is 0 to 2,500 fpm.	
MODE	AUTO	Pressurization controlled automatically.
	MANUAL	Pressurization controlled manually using CABIN ALT FT and CABIN RATE FT windows.
	CABIN ALT HOLD	Pressurization maintained at present cabin pressure altitude.
AIR DISTR	AUTO	Air distribution controlled by ACS.
	COCKPIT ONLY	Air routed to cockpit.
	CABIN/COCKPIT	Air routed to cabin and cockpit.
ECB LINK	Selects pressurization ECB synoptic page.	

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9.5 System Description

9.5.1 Bleed Air Supply System (BASS)

GENERAL

High pressure engine bleed air from a P3 bleed port is used by the climate control and pressurization system. High pressure bleed air from the P3 bleed air port is the source of fresh air for the aircraft.

Before the bleed air can be used for pressurization and climate control it must be cooled. Bleed air from both sources is routed through a bleed air heat exchanger and bi-level flow control valve located in each engine pylon and then through bleed air muffler ducts to the Cabin Air Distribution Sub-System.

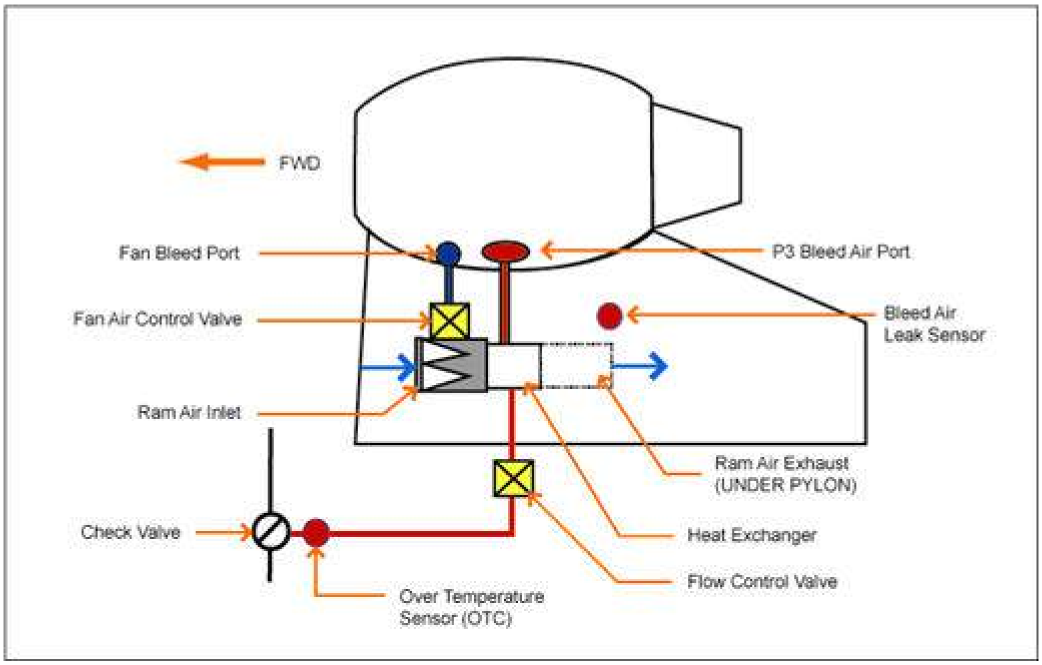

Figure 124. Pylon Bleed Air Schematic

- Bleed Air Heat Exchangers

  A bleed air heat exchanger located in each pylon regulates bleed air temperature based on the demand for cockpit and cabin heating or cooling. There are two sources of airflow through the bleed air heat exchanger used for cooling the high pressure bleed air from the engine, ram air and fan air.

  During ground operations there is not enough ram air pressure for cooling, so low pressure fan bleed air is used. The low pressure fan bleed air is routed through a fan air control valve to the heat exchanger. A variable ram exhaust outlet modulates the amount of fan air over the heat exchanger to condition the bleed air as required by the climate control system.

  During flight operations the fan air control valve is closed and ram air flows over the heat exchanger through an inlet duct on the top of each engine pylon. The variable ram exhaust outlet modulates the amount of ram air over the heat exchanger to condition the bleed air as required by the climate control system.

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If the ram air exhaust valve or fan air control valve fails a CLIMATE CTRL FAIL advisory message appears and degraded bleed air temperature regulation can be expected.

- **Bleed air overheat protection**

  Two bleed air temperature sensors for each side provide bleed air overheat detection:

  — A temperature sensor in each pylon near the heat exchangers monitors for bleed air leaks. The pylon temperature is displayed on the pressurization synoptic. If the pylon temperature exceeds 177°C (350°F), the temperature display turns red and an L (R) PYLON OVERHEAT warning message appears.

  — A temperature sensor in each bleed air muffler duct downstream of the heat exchanger monitors bleed air temperature. Bleed air temperature is displayed on the pressurization (PRESS) synoptic. If the bleed air temperature exceeds 85°C (185 °F), the temperature display remains white, a L (R) BLEED AIR TEMP HIGH advisory message appears and the associated flow control valve closes. Should the bleed air temperature exceed 100°C (212°F), the temperature display turns red, an L (R) BLEED AIR OVERHEAT warning message appears, and if not already closed, the associated flow control valve automatically closes.

TEMPERATURE SENSOR FAILURE

- Bleed Air

  If the bleed air temperature sensor in the muffler duct fails, a L (R) BLEED AIR TEMP FAULT advisory message appears and the temperature display on the pressurization synoptic page reverts to red dashes. Bleed air temperature is then monitored by a temperature sensor in each evaporator assembly. The bleed air temperature limit in this case is 176° F. If this temperature is exceeded, the variable exhaust door on the pylon automatically goes to the full open position for maximum cooling by the bleed air heat exchanger.

- Pylon

  If the pylon temperature sensor fails, a L (R) PYLON TEMP FAULT advisory message appears and the temperature display on the pressurization synoptic page reverts to red dashes.

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FLOW CONTROL VALVES

Bleed air downstream of each heat exchanger is routed to an electrically-actuated flow control valves located in the pylon. The flow control valves have two functions: two-step flow control and shutoff.

The High or Low setting is automatically controlled by the ACS. In the event of a loss of electrical power, the flow control valve fails to the LOW setting.

Table 26. Flow Control Valve Functions — High/Low

Low Flow	■ Normal Position ■ Ground Idle ■ No Power
High Flow	■ Cabin altitude exceeds 10,000 feet ■ Cabin rate of climb exceeds 2,500 fpm ■ L or R selected on the AIR SOURCE switch ■ Bleed air is available from only one engine ■ Cabin temperature control falls approximately 7 °F below the selected temperature ■ DUMP is selected ON

The shutoff function is automatically controlled by the ACS, with manual shutoff override from the cockpit AIR SOURCE switch.

Table 27. Flow Control Valve Automatic Shutoff Operation *

Airplane Status	Flow Control Valve Position
On ground Engine shut down	Closed
Engine start	Closed
On ground Engine running	Open
On ground or in-flight Engine running No power to Flow Control Valve	Open
In-flight Engine running	Open
In-flight Engine shut down	Closed
On ground during engine shutdown	Closed for 10 seconds to stop potentially contaminated air from entering cabin

* NORM selected on AIR SOURCE Switch

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Table 28. Flow Control Valve Manual Shutoff Operation *

AIR SOURCE Switch Position	Flow Control Valve Position
NORM	Both flow control valves are in automatic control mode.
L	Left flow control valves is in automatic control mode. Right flow control valve closed.
R	Left flow control valve closed. Right flow control valve is in automatic control mode.
OFF	Both flow control valves closed.

* Using AIR SOURCE switch.

When the AIR SOURCE switch is set to an “on” position (NORM, L, or R), the flow control valves will not open if any of the following conditions exist:

- Bleed air temperature is too high
- Engine is starting

When the AIR SOURCE selector is placed in the OFF, L or R position, a L (R) AIR SOURCE SELECTOR status message appears, indicating that one or both of the bleed air sources is off.

If a flow control valve fails, a L (R) BLEED VALVE FAIL advisory message appears.

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9.5.2 Cabin Air Distribution

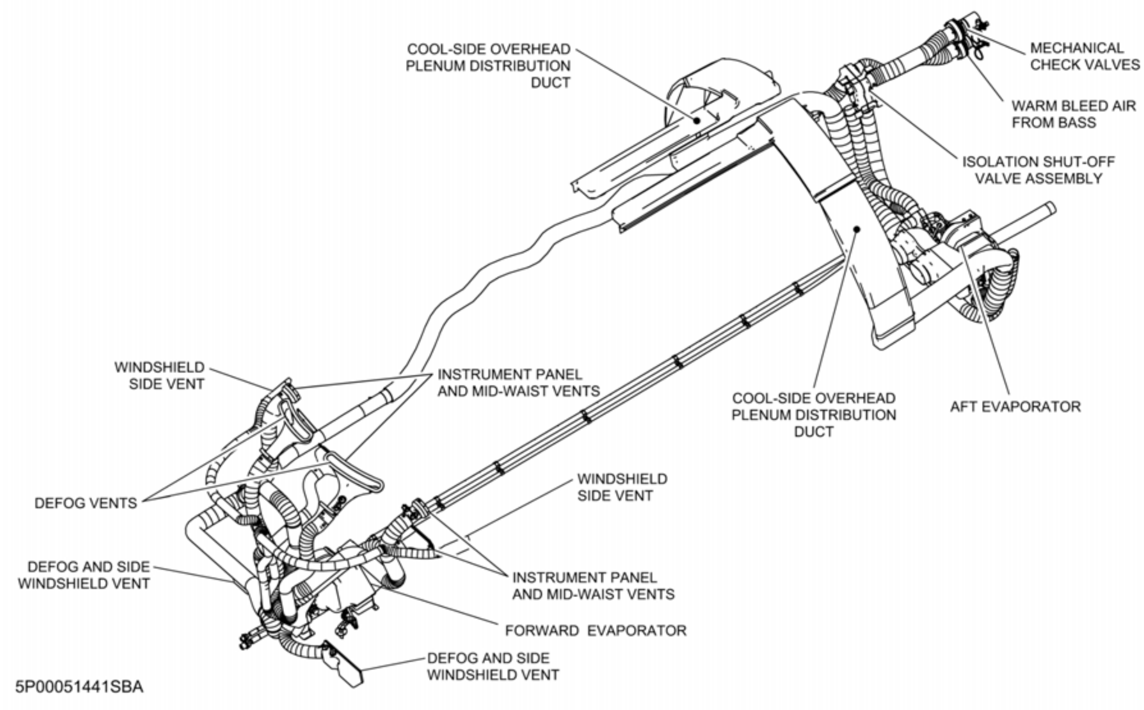

Figure 125. Cabin Air Distribution Components

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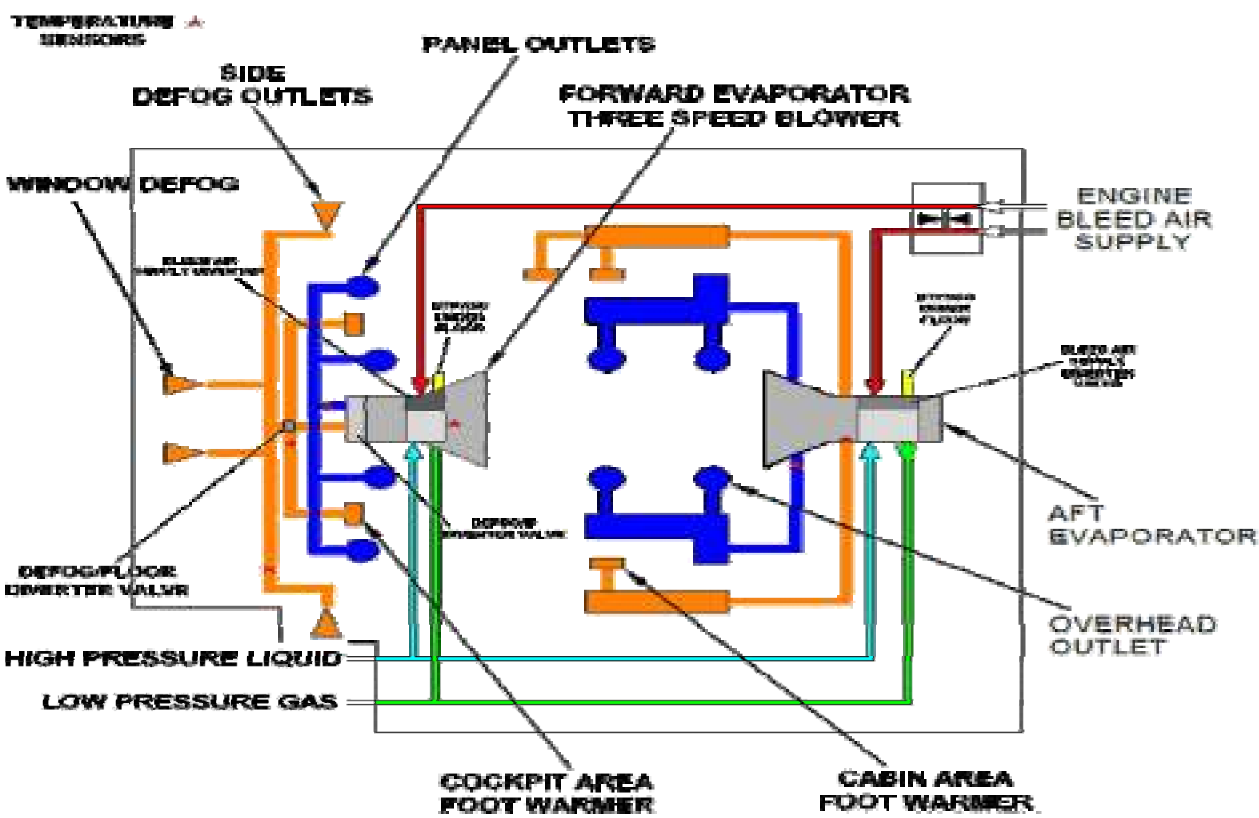

Figure 126. Cabin Air Distribution Schematic

GENERAL

The Cabin Air Distribution System receives cooling air from the air conditioning and condition bleed air from the bleed air system and distributes it to the cockpit and cabin zones through two evaporator assemblies and associated distribution ducts. Cooled air from the evaporators is routed through an upper distribution duct system, while conditioned bleed air from the evaporators is routed through a lower distribution duct system. Used cabin air is directed under floor and exits through the primary and secondary outflow valves.

FORWARD EVAPORATOR

The forward evaporator, located behind the throttle quadrant, supplies conditioned bleed air and air conditioned cooled air to the switch panel gaspers, foot warmer outlets, cockpit mid-waist outlets, side window and windshield defog outlets using a 3-speed, 28 volt DC fan.

Conditioned bleed air, normally supplied by the right engine enters the forward evaporator and passes through a bleed air diverter valve. This valve is responsible for regulating the use of conditioned bleed air for cockpit air. Should cockpit temperature demand require very little conditioned bleed air, this door allows this air to be diverted under floor. Air conditioned air is provided separately within the forward evaporator unit by air flowing through the evaporator coil, that is then routed

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through the three speed blower. The three-speed blower is responsible for pushing both air conditioned air and conditioned bleed air through the airflow ducting to the various vents. The primary flow of conditioned bleed air is to the floor and window defog vents, while air conditioned air generally flows through the instrument panel and mid waist vents.

There are two additional diverter valves within the forward evaporator that are responsible for mixing air conditioning air with conditioned bleed air and further routing this air for defogging and dehumidification.

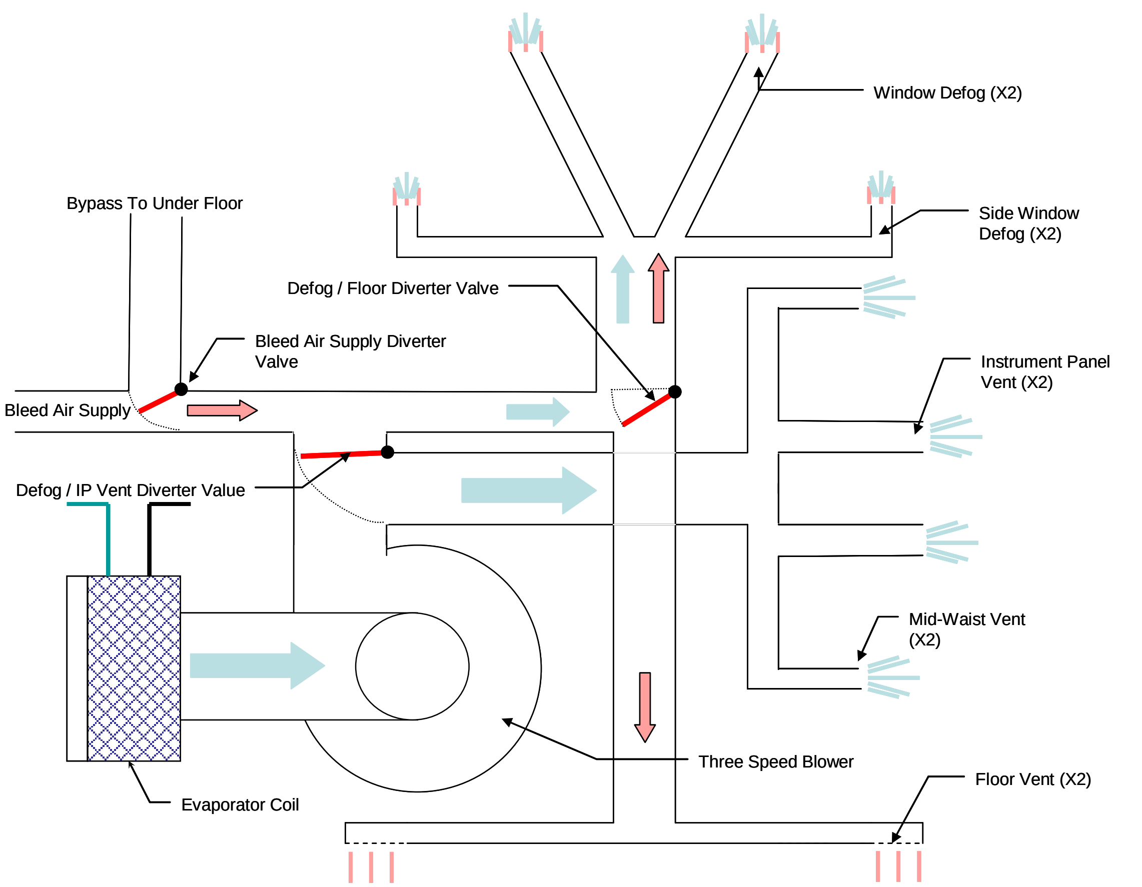

Figure 127. Forward Evaporator Schematic

AFT EVAPORATOR

The aft evaporator, located under the baggage compartment floor, supplies conditioned bleed air and air conditioned cooled air to the cabin foot warmer outlets and overhead gaspers using a 3-speed, 28 volt DC fan.

Conditioned bleed air is normally routed to the aft evaporator from the left engine through the Cabin Shutoff Valve. Once within the aft evaporator, the conditioned bleed air passes through a bypass valve that diverts the air under floor as necessary to meet cabin zone temperature demand. Conditioned bleed air that was not diverted underfloor is then routed directly to the floor vents in the cabin temperature zone.

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NOTE:

Conditioned bleed air does not mix with air conditioned air within the aft evaporator

Air conditioned air is provided separately within the aft evaporator unit. Two intake vents in the aft portion of the cabin provide air flow through the aft evaporator coils, which is cooled and blown through the overhead cabin vents by a three-speed blower. Air conditioned air is mixed with the conditioned bleed air within the cabin to achieve the desired temperature.

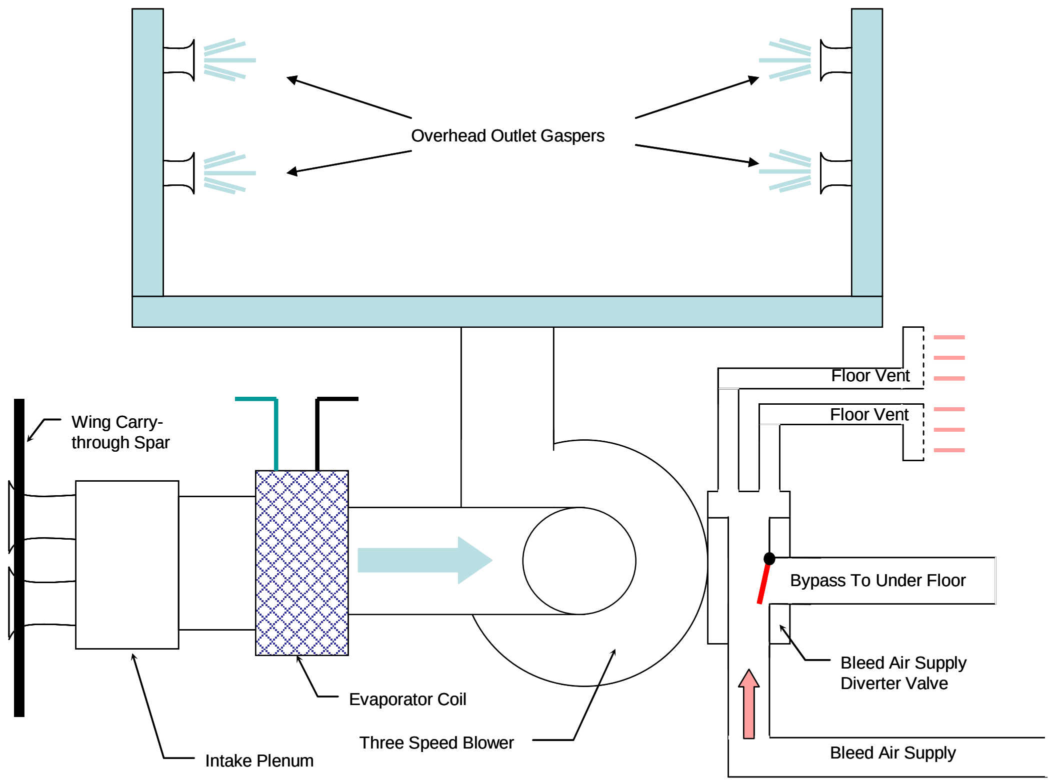

Figure 128. Aft Evaporator Schematic

TEMPERATURE REGULATING DIVERTER DOORS

The forward and aft evaporators incorporate a temperature regulating diverter door. Conditioned bleed air introduced to the cabin air distribution system is regulated to meet the desired zone temperatures by ACS control of the diverter doors. For example, if MAX COOL is selected the conditioned bleed air will be diverted under floor until the desired temperature is achieved.

TEMPERATURE SENSORS

Two temperature sensors, one in the cockpit and one in the cabin, are used for temperature regulation. The cockpit sensor is located on the right-hand side of the aircraft underneath the right seat armrest panel. The cabin sensor is on the center of the aft cabin ceiling. In the event a cabin or cockpit temperature sensor fail, white dashes replace the zone temperature on the ENVIR synoptic page.

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ISOLATION AND CABIN SHUTOFF VALVES

Bleed air from each flow control valve is routed to one of two zones, cockpit or cabin. Routing of bleed air is controlled by two valves, an isolation valve and a cabin shutoff valve. Valve position is indicated on the pressurization synoptic. During normal operation, the right engine's conditioned bleed air will be routed to the cockpit (forward evaporator) and prevented from flowing to the cabin through the isolation valve. Respectively, the left engine's conditioned bleed air will be routed to the cabin (aft evaporator) through the cabin shutoff valve and prevented from flowing to the cockpit by the isolation valve.

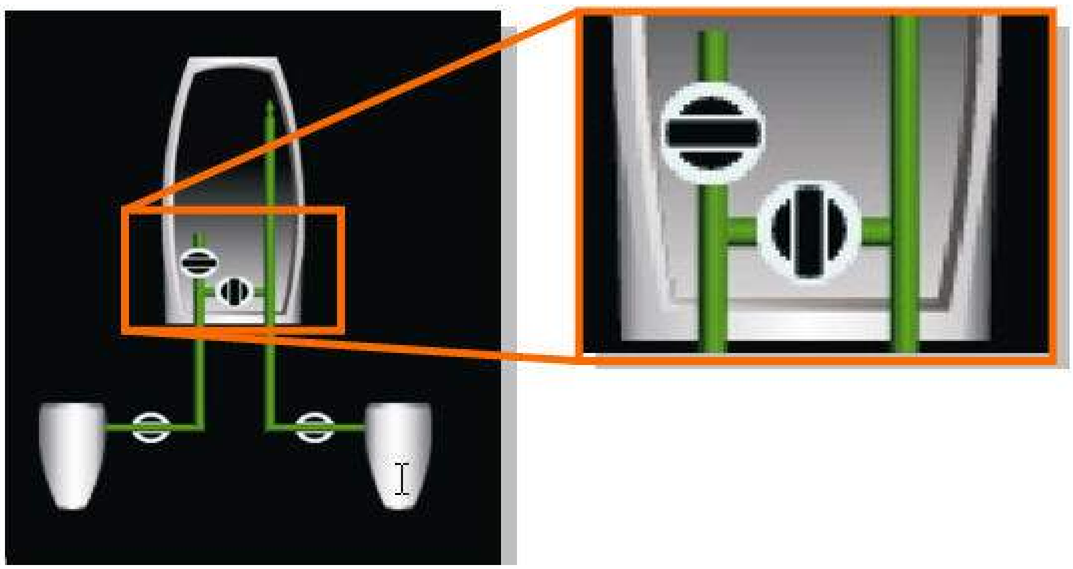

Figure 129. Cabin Isolation and Shutoff Valves

Isolation Valve .... Isolates the left bleed air source from the right bleed air source.

Cabin Shutoff Valve ....Regulates bleed air going to the cabin

The isolation and cabin shutoff valves are automatically controlled by the ACS, with manual override available through the use of the air distribution (AIR DISTR) line select key on the pressurization synoptic. Changing air source selections with the AIR SOURCE switch or activating cabin dump will always override the pilot's previous selection from the AIR DISTR line-select key on the MFD. In the event that the pilot selects the AIR SOURCE switch to OFF, L or R an AIR SOURCE SELECTOR status message appears.

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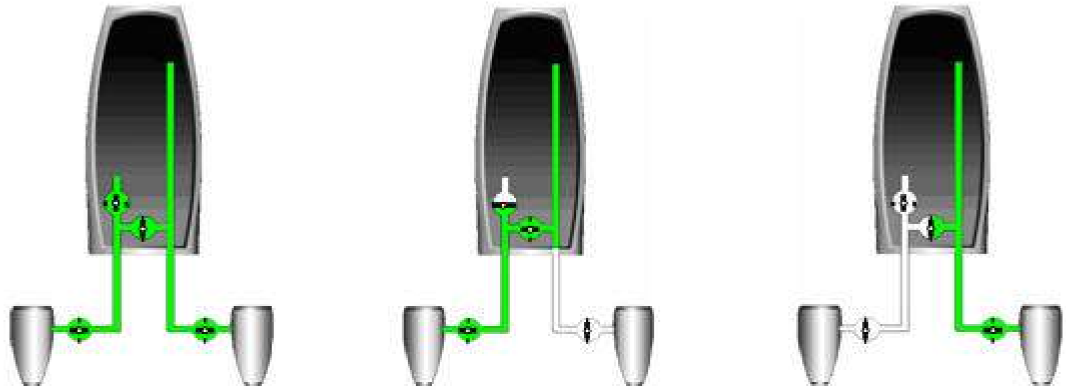
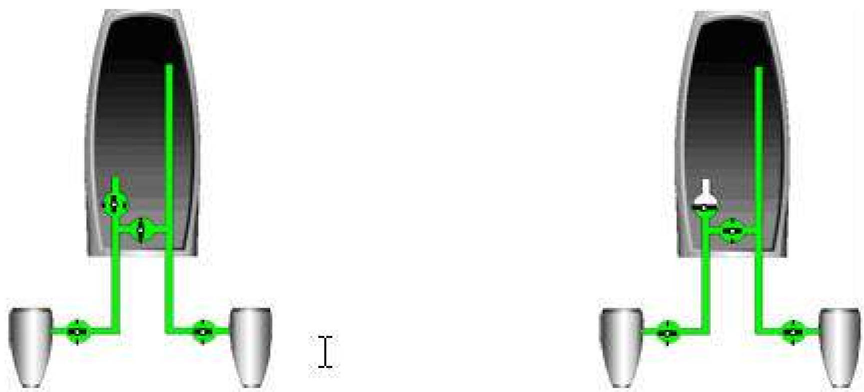


Left and right bleed air available.   Left bleed air available.   Right bleed air available.

Figure 130.   Automatic Isolation/Cabin Shutoff Valve Operation



Cabin/Cockpit   Cockpit Only

Figure 131.   Manual Isolation Valve/Cabin Shutoff Valve Operation (AIR DISTR Line Select Key)

NOTE:

In the third Line Select key position (AUTO), air distribution is controlled by the ACS or the Air Source Switch.

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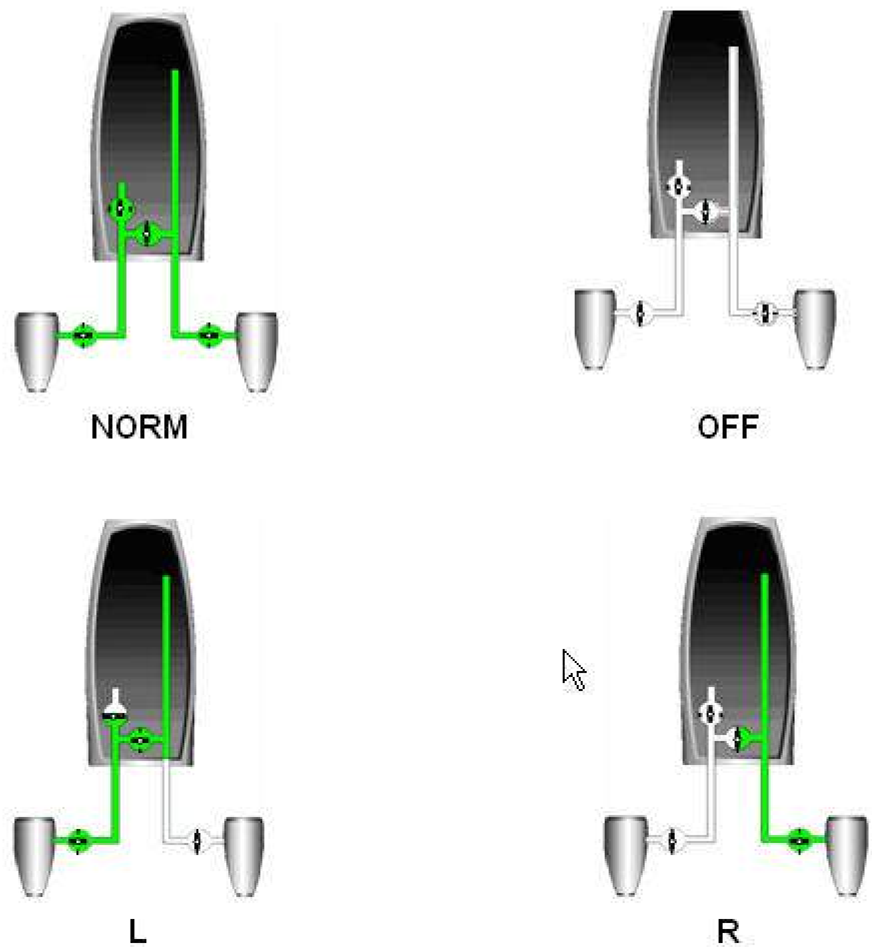

Figure 132. Manual Isolation Valve/Cabin Shutoff Valve Operation (AIR SOURCE Switch)

NOTE:

When the AIR SOURCE switch is in any position other than AUTO, the AIR DISTR Line Select key reverts to the AUTO position.

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9.5.3 Air Conditioning

GENERAL

Cockpit and cabin cooling and humidity control is provided by the air conditioning sub system. There are two evaporators in the aircraft. The forward evaporator is located under the throttle quadrant for cockpit cooling. The aft evaporator is located under the baggage compartment floor for cabin cooling.

Other air conditioning components, including the compressor and condenser assembly, are located in the forward equipment bay outside the pressure vessel. Two air conditioning doors are located on the right hand side of the aircraft nose. An inward opening condenser inlet door allows intake of ambient air used for cooling during ground operations. After the ambient air is routed through the condenser it is exhausted through an outward opening outlet door.

Figure 133. Condenser Inlet and Exhaust Doors

Each evaporator incorporates a three-speed (LOW, MED, HIGH), 28 volt DC fan that is automatically controlled by the ACS, or manually controlled by the pilot through the ENVIR synoptic.

Air conditioning operation is inhibited at high altitude. As the aircraft climbs through 29,000 ft, the air conditioning automatically shuts down and automatically restarts when the airplane descends through 28,000 ft.

In the event that a component of the air conditioning system fails, an AIR CONDITIONING FAIL advisory message appears.

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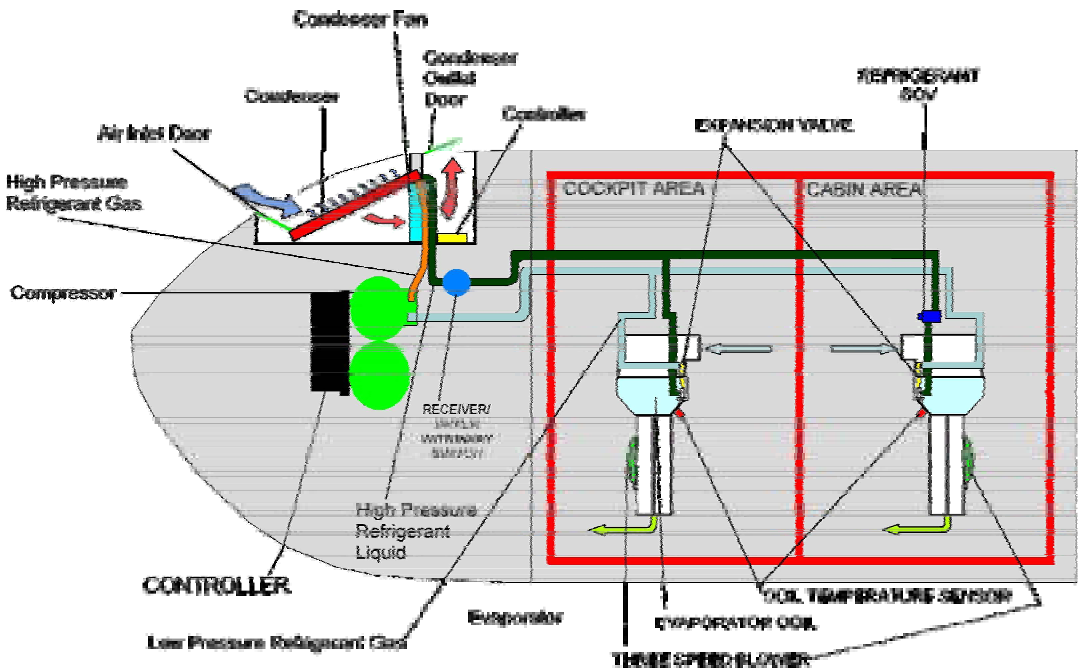

Figure 134. Air Conditioning System Schematic

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AIR CONDITIONING SYSTEM CONTROL

The air conditioning system can be selected AUTO or OFF using a line select key on the environmental (ENVIR) synoptic on the MFD. The default setting at power-up is OFF. In the AUTO position, the following functions can be controlled on the ENVIR synoptic:

- Separate cockpit and cabin temperature control
- Separate cockpit and cabin evaporator fan control
- Windshield defog
- Dehumidification

COCKPIT AND CABIN TEMPERATURE CONTROL

Cockpit and cabin temperatures can be separately set in two-degree increments from 64°F to 84°F. In addition there are MAX HEAT and MAX COOL settings for rapid heating or cooling of the cabin. The default value at power-up of is 72°F.

MAXIMUM HEATING

The MAX HEAT setting is designed for rapid heating of the cabin when required. Selecting MAX HEAT for the cabin and/or cockpit routes bleed air at the maximum permissible temperature to that zone until the maximum allowed temperature (115° F) is reached. Once the zone temperature reaches 115° F, the temperature is modulated to maintain 115° F.

MAXIMUM COOLING

The MAX COOL setting is designed for rapid cooling of the cabin when required. Selecting MAX COOL for the cabin and/or cockpit routes bleed air to the evaporators at the minimum temperature available from the heat exchanger and provides maximum cooling from the air conditioning. Cold air is supplied to that zone until the minimum allowed temperature (50° F) is reached. Once the zone temperature reaches 50° F, the evaporator fan automatically steps to MED or LOW speed to maintain that temperature.

COCKPIT AND CABIN EVAPORATOR FAN CONTROL

The cockpit and cabin evaporator fans can be separately adjusted to OFF, AUTO, LOW, MED, or HIGH. The default setting at power-up of the evaporator fan is AUTO.

In the AUTO position and a cooling mode, the evaporator fan speed is set as follows:

Cabin/cockpit temp. within approx. 2°F of selected temp .... LOW

Cabin/cockpit temp. within approx. 7°F of selected temp ....MED

Cabin/cockpit temp. more than approx 7°F above selected temp. ....HIGH

WINDSHIELD DEFOG

The DEFOG selection allows the crew to route conditioned bleed air to the windshield to evaporate condensation on the cockpit windshield and side windows in conjunction with the use of the FWD Evaporator fan. In this mode approximately 90% of the airflow is routed to the defog ducts, and approximately 10% of the airflow is routed to the cockpit foot warmers. The default setting at power-up is OFF. Optimal DEFOG performance is obtained when the cockpit temperature is set to MAX HEAT, the forward evaporator FAN is set to HIGH and the dehumidification (DEHUMID) feature is ON.

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DEHUMIDIFICATION

When DEHUMID is set to ON, humidity is removed from the cabin using the air conditioning system. The default setting at power-up is OFF. When set to ON the air conditioning continually cycles as follows: On for one minute and then off for three minutes.

9.5.4 Pressurization

GENERAL

In conjunction with the flow control valves and the cabin altitude pressure sensor, the Cabin Pressure Control Sub-System regulates and maintains the cabin pressurization to a scheduled pressure level.

Bleed air flows into the cabin at a constant rate as determined by the position of the flow control valves. Aircraft pressurization is controlled by regulating the rate at which air escapes from the cabin via outflow valves.

The pressurization system consists of the following components:

- Pressurization control
- Primary outflow valve
- Secondary outflow valve
- Cabin dump switch
- Cabin pressure sensor (integral to primary outflow valve)

OUTFLOW VALVES

The primary and secondary outflow valves control pressurization and over and under pressure protection by regulating the exhaust flow of air from the cabin into the aft fuselage compartment and then overboard. Both outflow valves are located on the aft pressure bulkhead under the cabin baggage compartment floor and equally divide exhaust airflow. The outflow valves do not require electrical power to operate.

Figure 135. Secondary and Primary Outflow Valves

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The outflow valves provide three pressure limit functions:

Cabin altitude ....13,000 feet +/- 1500 feet

Positive differential pressure...Primary OFV – 8.6 PSI
Secondary OFV – 8.7 PSI

Negative differential pressure ....-.04 PSI

PRESSURIZATION CONTROL

Three pressurization modes can be selected on the pressurization synoptic:

- AUTO
- MANUAL
- CABIN ALT HOLD

In AUTO mode, the landing altitude can be set automatically using the destination airport programmed in the FMS, or set manually. Cabin rate of climb or descent is normally controlled between 400 and 700 fpm. Cabin pressure is controlled automatically based on a schedule to meet the following parameters:

Airplane Altitude	Cabin Altitude
41,000 feet	8,000 feet
20,000 feet	2,500 feet
1,500 feet	Sea Level

In the MANUAL mode, cabin altitude and cabin rate of climb are selected on the pressurization synoptic. The pressurization system regulates to the selected cabin altitude and cabin rate of climb.

The CABIN ALT HOLD mode maintains the present cabin pressure altitude in the event of a pressurization controller failure or electrical signal loss. When manually selected by the pilot, a CABIN ALT HOLD MODE status message appears.

If primary pressurization control fails the backup controller automatically holds the current cabin altitude and a CABIN ALT HOLD MODE advisory message appears.

Should the cabin remain pressurized on the ground a CABIN PRESS ON GROUND caution message appears and the cabin must be depressurized through the activation of the cabin DUMP switch.

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CABIN DUMP SWITCH

The pilot can release the cabin pressure to ambient pressure in the event of over-pressurization, smoke in the cabin, or in the event of ground pressurization. With the DUMP switch ON, both outflow valves open fully and all bleed air is routed to the cockpit at high flow. A red CABIN DUMP text also appears on the left side of the pressurization synoptic.

Figure 136. Cabin Dump Switch

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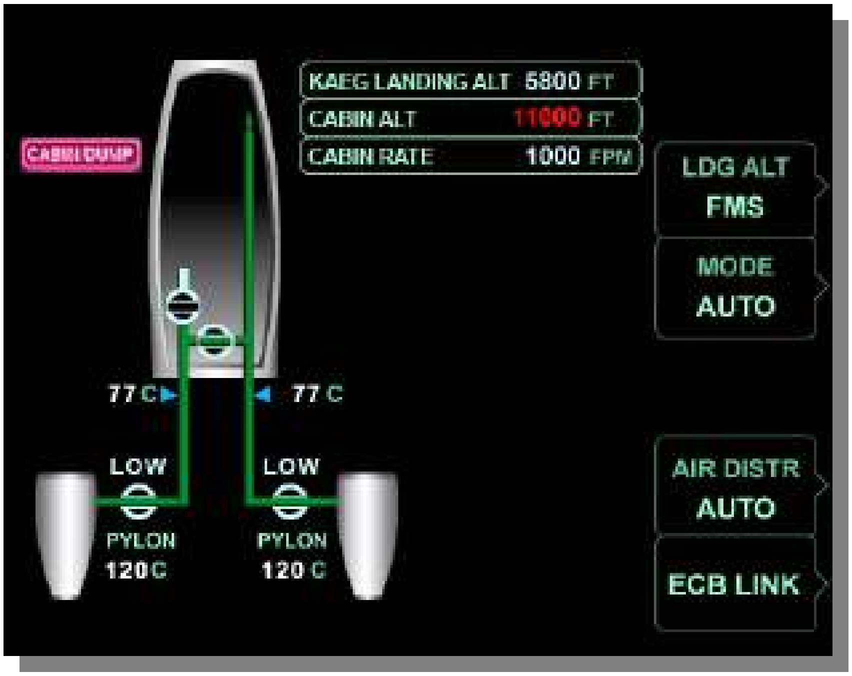

Figure 137. Cabin Dump- PRESS Synoptic

NOTE:

The cabin dump switch dumps the cabin to 13,500 ft +/- 1500 feet.

SMOKE CLEARING

In the event of smoke in the cabin, the smoke and fumes evacuation checklist requires the cabin DUMP switch to be activated . This opens both outflow valves, routes all air forward to facilitate forward-to-aft airflow; and sets the forward evaporator speed to high to vent the smoke overboard.

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9.6 Normal Operations

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9.7 Abnormal Procedures

9.8 Cold Weather Operations (Temperature Sensor Indications)

In the event that the aircraft cabin has become cold soaked to -13°F or less the pilot may initially see ACS indications of failed temperature sensors. These indications should be considered false due to the extreme cold. The temperature regulation control will also default to a special mode of operation for cold temperatures. Once the engines are started and warm bleed air warms the system, the ACS will stop displaying senor failures and temperature regulation will resume to normal.

9.8.1 Single Engine Operations

In the event of an engine shutdown or failure, bleed air from the operating engine is routed to the cockpit. This automatic function can be overridden by the pilot with the AIR DISTR line select key on the pressurization synoptic.

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9.9 Crew Alerting System Messages

Table 29. Climate Control System CAS Messages

Message	Condition	Category
CABIN ALTITUDE	Cabin altitude environment has exceeded 10,000 ft.	Warning
CABIN dP HIGH	Cabin differential pressure exceeded.	Warning
L (R)BLEED AIR OVERHEAT	Bleed air supply temperature limiting has failed	Warning
L (R) PYLON OVERHEAT	Left or right pylon overheat detected	Warning
CABIN ALTITUDE	Cabin altitude has exceeded 8,750 ft.	Caution
CABIN PRESS ON GROUND	Cabin is pressurized on the ground.	Caution
L (R) BLEED VALVE FAIL	Bleed air valve stuck in low flow position or failed open when commanded closed.	Advisory
CABIN ALT HOLD MODE	Primary pressurization failed. Backup controller attempting to hold cabin altitude constant.	Advisory
AIR CONDITIONING FAIL	Air conditioning has failed	Advisory
L (R) BLEED AIR TEMP HIGH	Bleed air supply temperature is too high. Normal bleed air temperature control has failed. L or R bleed air temperature is being limited by the flow control valves	Advisory
CLIMATE CTRL FAIL	Indicates failure of either left or right ram air exhaust valve or the left or right fan air control valve. Expect degraded bleed air temperature regulation	Advisory
L (R) PYLON TEMP FAULT	The pylon temperature sensor has failed	Advisory
L (R) BLEED AIR TEMP FAULT	The bleed air temperature sensor has failed	Advisory
AIR SOURCE SW FAULT	The air source selector switch has failed	Advisory
AIR SOURCE SELECTOR	The air source selector is in another position than NORM.	Status
CABIN ALT HOLD MODE	Cabin altitude hold mode active as selected by the pilot.	Status

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9.10 Climate Control Review Questions

1. **List and briefly describe the primary function the 4 sub-systems of the climate control system:**

2. **What does a CABIN ALTITUDE warning message indicate?**
   a. A loss of cabin pressure resulting in a cabin altitude greater than 10,000 ft.
   b. Cabin over pressurization.
   c. Failure of the bleed air supply system.
   d. None of the above is correct.

3. **What are the three levels of cabin altitude alerting?**
   a.
   b.
   c.

4. **What does sounding the "Mask On Descend" aural alert indicate?**

5. **What are three items occur when the DUMP switch is activated?**
   a.
   b.
   c.

6. **Why may a pilot elect to use the cabin dump switch?**
   a. To clear smoke from a smoke-filled cabin.
   b. To depressurize aircraft that is pressurized on the ground.
   c. In the event of an over pressurization.
   d. All of the above are correct.

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7. **How does the Bleed Air Supply System (BASS) cool the engine bleed air prior to use in the cabin?**
   a. Through a pylon mounted heat exchanger unit that uses ram or fan air to cool bleed air.
   b. The bleed air is cooled with air/fuel heat exchangers.
   c. The bleed air is run to the front of the aircraft and by traveling that distance it is cooled enough for interior use.
   d. None of the above is correct.
8. **What is the purpose of the Flow Control Valves?**
   a. Two Step flow control.
   b. To assure the thrust available for a go-around by restricting bleed control authority during high power settings.
   c. To provide conditioned bleed air to the cabin for use by the pressurization and cabin air distribution systems.
   d. Both A & C are correct.
9. **In the event of an engine failure where will bleed air be routed?**
   a. To the cabin.
   b. To the cockpit.
   c. It depends on what engine has failed.
   d. None of the above are correct
10. **How does the climate control system heat the cockpit and cabin?**
   a. Four electric heating elements are strategically placed throughout the cabin for uniform heating and air circulation.
   b. Conditioned engine bleed air is allowed to enter the cabin for heating and pressurization needs.
   c. Fresh air inlet on the top of the engine pylons provides ram air that is heated by the engines and used for cabin heating.
   d. None of the above is correct.
11. **Air conditioning in the Eclipse 500 is achieved by:**
   a. Running compressor bleed air through air conditioning “packs,” which are next two each engine pylon.
   b. Running air to a cabin (rear) and cockpit (forward) evaporator where it is cooled and mixed with conditioned bleed air.
   c. Running ram air into the air conditioning system through a series of NACA ram air inlets on the nose of the aircraft.
   d. Air conditioning is provided by ram air from a fresh air inlet on the top of the engine pylons.
12. **During NORMAL operation which engine’s bleed air will be sent towards the cockpit?**
   a. Left engine

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b. Both engines equally will send air towards the cockpit during normal operations.

c. Air is only sent towards the cabin, not the cockpit.

d. Right engine

13. **What system is responsible for humidity control?**

a. Bleed Air Supply System
b. Pressurization System
c. Air Conditioning System
d. Cabin Air distribution System

14. **How many evaporators are installed in the aircraft?**

a. 1
b. 2
c. 3
d. 5
e. None of the above is correct.

15. **What is the purpose of the outflow valves?**

a. The outflow valves are an integral part of the air conditioning system, in that they control the amount of refrigerant in the system.

b. The outflow valves shut off the bleed air supply system allowing the cabin to depressurize.

c. The outflow valves prevent engine power loss on takeoff due to overloading of the bleed air supply system.

d. The outflow valves determine cabin pressure by regulating how much pressurized air can escape from the cabin.

16. **Which electronic circuit breaker units provide power to climate control system components?**

a.

b.

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10. Electrical

10.1 General

The Eclipse 500 electrical power distribution system is a split bus, DC system, powered by two 200 amp, 30 VDC regulated starter/generators driven by the engine's accessory gearbox.

Circuit protection is provided by 127 Electronic Circuit Breakers (ECBs) in conjunction with two mechanical circuit breakers on the left switch panel. Critical electric functions are powered through redundant circuit breakers connected to different power buses. This permits continued operation of all critical avionics components even if a bus fault occurs or a circuit breaker fails. The reduction in mechanical circuit breakers significantly reduces cockpit switch panel clutter. In addition, the use of the more reliable, ACS controlled ECBs reduces pilot workload.

There are also two 22 amp hour, 24 VDC sealed, maintenance-free lead acid batteries located in the nose compartment of the aircraft. A start battery and systems battery provide aircraft power when generators are not running and float on electrical buses when engines are running to reduce voltage transients when electrical equipment is switched on or off. A 28 volt DC external power receptacle is located on the lower right aft fuselage. The pilot can monitor and configure the electric system using the electrical synoptic page on the MFD.

Entry, overhead, and baggage compartment lights are powered directly from the Hot Battery Bus allowing them to be turned on without powering the avionics. These lights are on a timer to avoid depleting the batteries.

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10.2 Aircraft Computer System (ACS) Interfaces

The electrical system is automatically controlled by the Aircraft Computer System (ACS) during normal operation. The two aircraft batteries (Start and Systems) have no direct interface with the ACS and are directly controlled by the pilot through two switches on the left switch panel.

Based on pilot commands (engine start, stop), or generator status (both operational, one inoperative, both inoperative), the ACS automatically configures the electrical system, as well as activating and deactivating Electronic Circuit Breakers for various systems components. While the ACS has can command ECBs, the current protection feature of each ECB is independent of the ACS.

In return the ACS monitors the status of electrical system components including: contactor position, bus voltages, generator output, battery state and rate of charge or discharge, as well as ECB status.

The ACS provides control commands and receives status information for the following electrical system components:

1. Battery Bus Contactor
2. Start Battery Contactor/ Lighting Controller
3. Start Battery Heater
4. Systems Battery Heater
5. External Power Contactor
6. Electronic Circuit Breaker Unit #1
7. Electronic Circuit Breaker Unit #2
8. Left Generator Control Unit and Contactor
9. Right Generator Control Unit and Contactor
10. Forward Power Distribution Center
    a. Electronic Circuit Breaker Unit #3
    b. Left Battery Bus Contactor
    c. Right Battery Bus Contactor
    d. Battery Bus
    e. Left Forward Bus
    f. Right Forward Bus
11. Aft Power Distribution Center
    a. Electronic Circuit Breaker Unit #4
    b. Electronic Circuit Breaker Unit #5
    c. Bus Tie Contactor (BTC)
    d. Left Forward Circuit Breaker/Contactor
    e. Right Forward Circuit Breaker/Contactor
    f. Left Aft Bus
    g. Right Aft Bus

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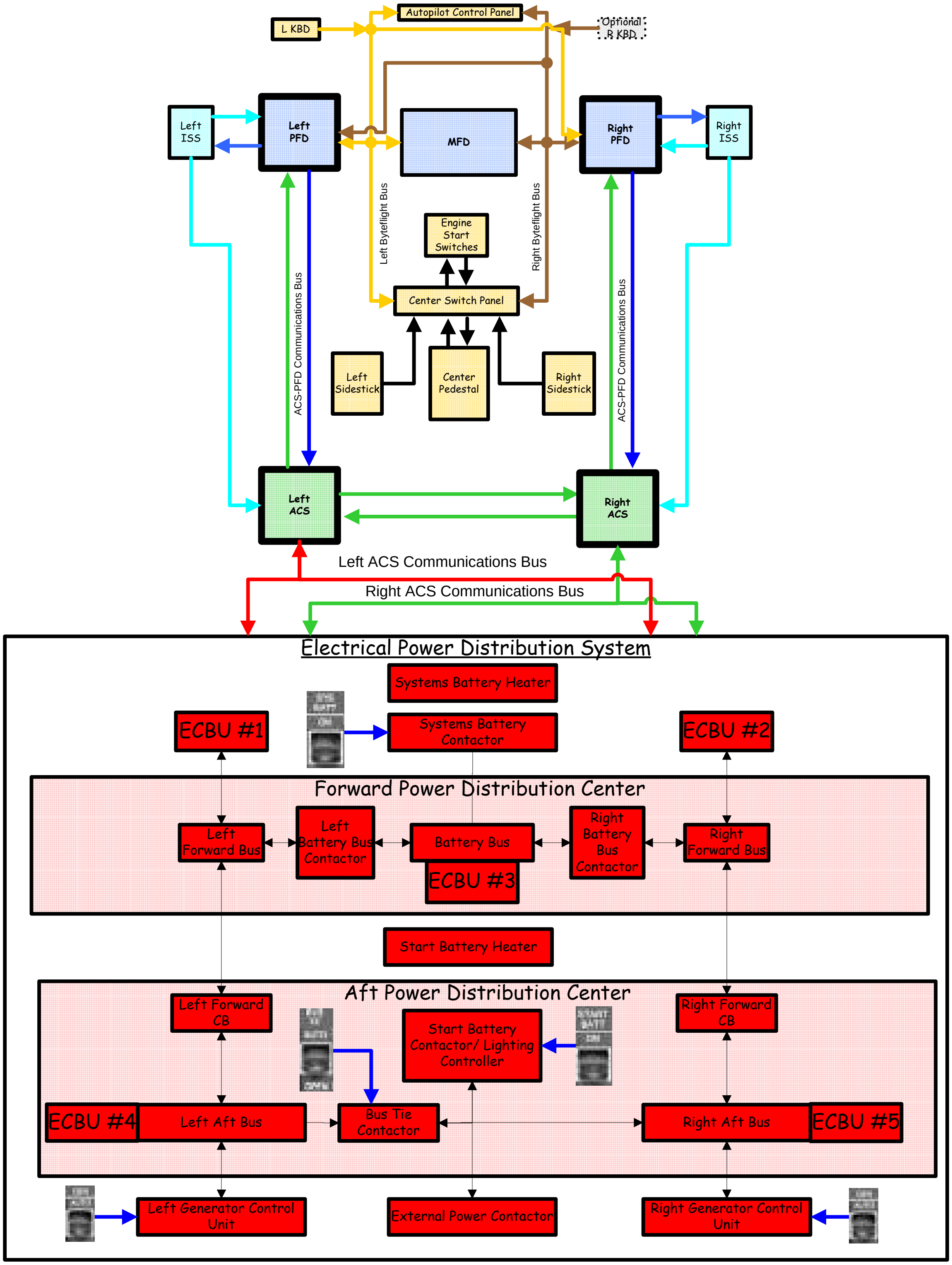

Figure 138. Electrical Power Distribution-ACS Interfaces

10.3 Limitations and Specifications

Batteries	
Nominal voltage (each battery)	24 VDC
Battery capacity (each battery)	22 amp-hours
Minimum voltage for battery start	23 VDC

Starter/Generators	
Regulated Output voltage (each generator)	28.5 VDC
Maximum continuous output current (each generator)	200 amps

External Power	
Maximum voltage	29 VDC
Minimum voltage (45 seconds)	24 VDC
Minimum voltage (any duration)	10 VDC

The External Power Contactor automatically opens if the polarity is wrong or if the voltage is out of limits:

- Greater than 29 volts at any time
- Aircraft current draw greater than 400A
- External Power current draw from aircraft greater than 5 A
- Less than 24 volts for longer than 45 seconds, or
- Less than 10 volts at any time.

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10.4 Controls and Indicators

10.4.1 Electrical Switches

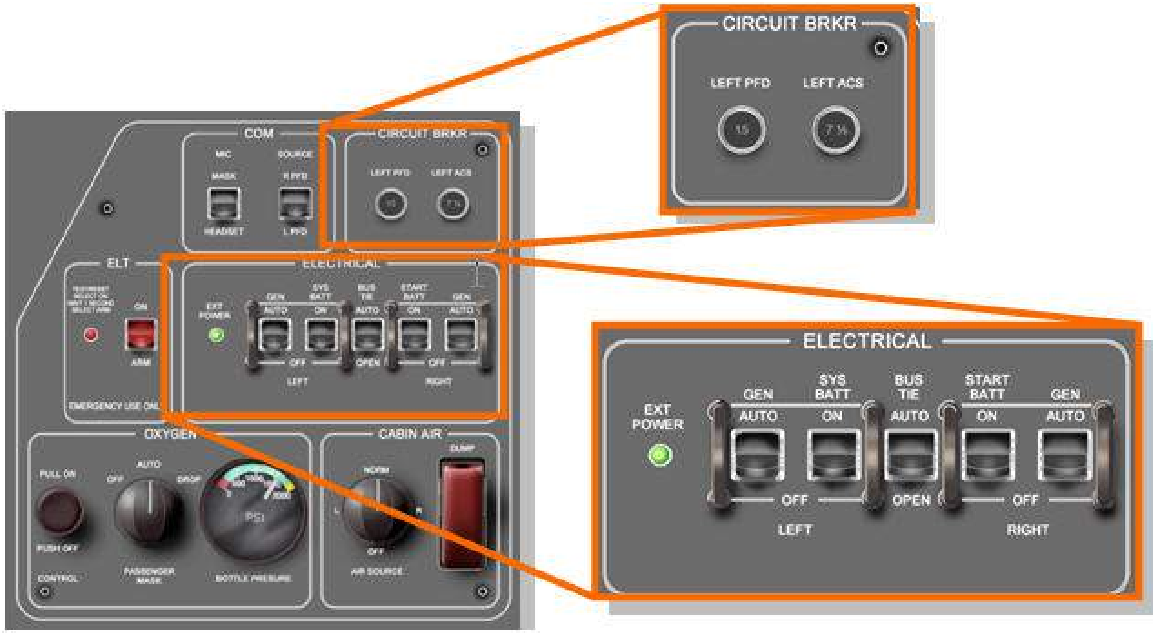

Figure 139. Electrical Switches

LEFT GEN
- AUTO .... Left generator contactor ACS controlled
- OFF .... Left generator contactor open

RIGHT GEN
- AUTO .... Right generator contactor ACS controlled
- OFF .... Right generator contactor open

SYS BATT
- ON .... Systems battery contactor closed
- OFF .... Systems battery contactor open

START BATT
- ON .... Start battery contactor closed
- OFF .... Start battery contactor open

BUS TIE
- AUTO .... Bus tie contactor under ACS control
- OPEN .... Bus tie contactor open

EXT POWER .... Green LED indicates external power is connected and voltage is the correct polarity and within limits.

LEFT PFD .... Mechanical circuit breaker for left PFD

LEFT ACS .... Mechanical circuit breaker for left ACS

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10.4.2 Electrical Synoptic

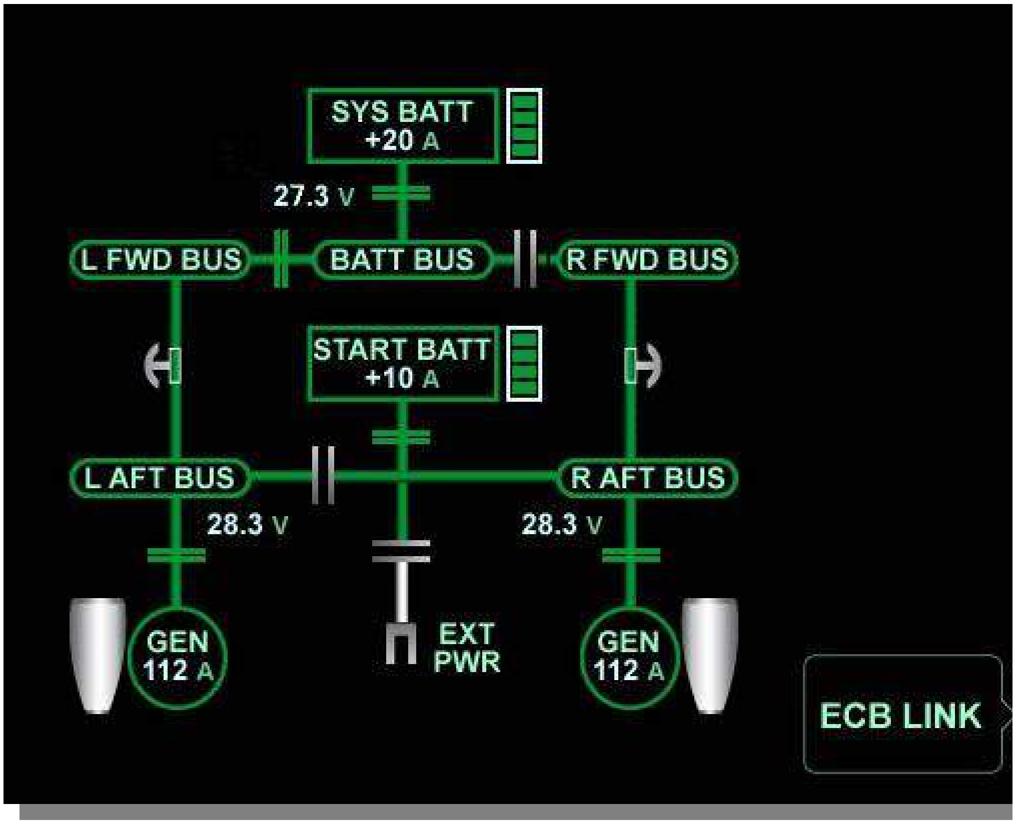

Figure 140. Electrical Synoptic

The electrical synoptic displays the following:

- Position of all electrical contactors
- Battery charge or discharge
- Current flow
- Voltage on certain buses
- Generator current output

GENERATOR OUTLINE
- Green .... Generator operating
- White .... Generator off
- Amber .... Generator failed/inoperative

BATTERY OUTLINE
- Green .... Battery Charging
- Amber .... Battery Discharging
- White .... Battery Contactor Open (no power to or from)

- Bus bar segments are green if voltage is greater than 20 volts.
- Bus bar segments are white if voltage is 20 volts or less.
- Vertical ribbon to right of batteries indicates state of battery charge in volts.

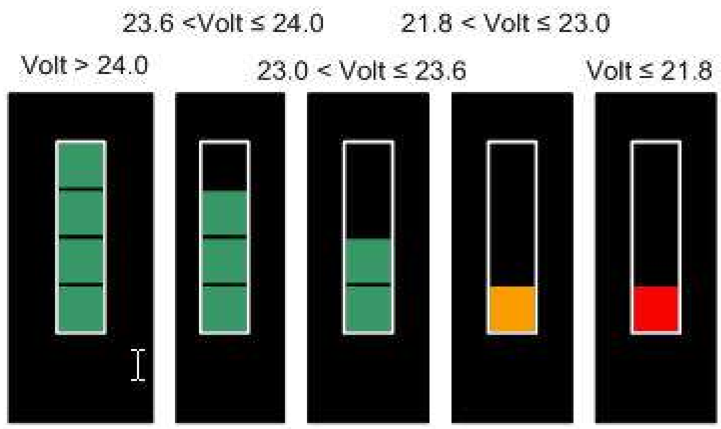

Figure 141. Battery State Display

10.4.3 Electronic Circuit Breaker (ECB) Synoptic

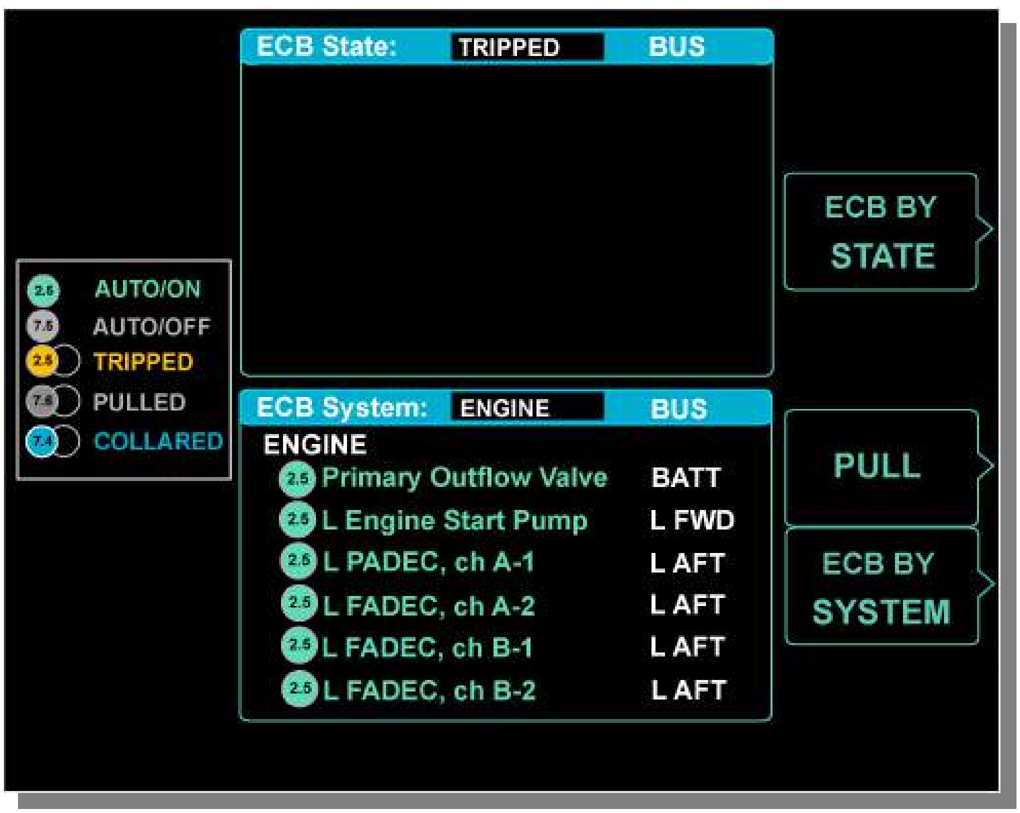

Figure 142. Electronic Circuit Breaker Synoptic

The upper display allows the pilot to select the ECBs by state, out, tripped, pulled or collared. The lower display allows the pilot to select the ECBs by system.

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ECB STATES

Table 30. Electronic Circuit Breaker States

STATE	CONDITION	INDICATION
AUTO/ON	Normal state	White outline/green interior
AUTO/OFF	ECB turned off by the ACS	White outline/gray interior
TRIPPED	ECB off due to circuit fault	Amber
PULLED	ECB opened by the pilot	Gray
COLLARED	ECB locked out by a maintenance technician	White outline/cyan interior

10.5 SYSTEM DESCRIPTION

10.5.1 Starter/Generator Units

A starter/generator is mechanically driven by each engine through the accessory gearbox. Power from the starter/generators is fed to the left and right Generator Control Units (GCUs).

The starter/generators serve as electric starter motors for the engines. During engine start, the left or right GCU use Direct Current (DC) power from the start battery to drive the starter/generator as a motor. The resulting mechanical torque is applied through the engine's accessory gearbox to start the engine.

Either starter/generator can supply power for the entire airplane, with the exception of the air conditioning system. (The air conditioning compressor is load shed during single generator operation)

10.5.2 Generator Control Units (GCUs)

The left and right Generator Control Units are located in the aft compartment outside the pressure vessel and control the starter/generators during engine start. The GCUs automatically switch from the start mode to generator mode at a specific engine cut-off speed and regulate starter/generator power from 30 volts to 28.5 volts DC depending on engine speed and electrical load.

The GCUs also provide detection and protection for the following electrical faults:

- Ground fault
- Over- and under-voltage from the S/Gs
- Reverse Current
- Overspeed
- Open ground

10.5.3 Batteries

Two identical 24 volt DC, 22 amp sealed, maintenance-free lead acid batteries are located in the nose compartment outside the pressure vessel. Both batteries are charged when the generators are operating. When external power is connected, battery charging requires both BATT switches to be ON.

In the event of a loss of both starter/generators and/or GCUs, the two batteries provide a minimum of 30 minutes power to essential systems.

During normal operation the batteries “float” on the buses to minimize voltage transients that may be caused by electrical loads being switched on or off.

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SYSTEMS BATTERY

During normal operation, the systems battery is connected to the left side of the electrical system through the battery bus and battery bus contactor. During engine start, the forward buses are automatically disconnected from the aft buses so that the systems battery powers the avionics and avoids exposing the battery to the voltage drop caused by high starting currents.

START BATTERY

During normal operation, the start battery is connected to the right electrical buses through the start battery contactor. The start battery is also connected to the hot battery bus, which supplies power for equipment that must be operated before either battery switch is turned ON.

The start battery supplies power for engine starting either by itself, or in parallel with external power if it is connected. With one engine running, the start battery supplies power in parallel with the generator to start the second engine.

BATTERY HEATER PAD

To assure a 30 minute minimum life, a heated battery pad is installed under each battery. Each battery heating pad contains a 300-Watt heater element, an embedded thermistor, and a 100°C cut-off. The operational point of each thermal switch is 104 degrees C (rising) and 93 degrees C (falling). The Left ACS is responsible for monitoring temperatures in the heater pads and forwarding it to the Right ACS. Both ACSs turn on power to the battery heater when the Outside Air Temperature falls below 10 degrees C and the aircraft is powered by generator or GPU power. The ACSs turn the heaters off when the temperature as sensed by the temperature sensor rises to 80 degrees C, and on, when it falls to 70 degrees C.

Failure of a battery heater pad could shorten battery-only operation time to less than 30 min. If a battery heater pad fails, it is indicated on the ground only with the appearance of a BATT HEATER FAIL advisory message.

10.5.4 External Power

A 28 volt DC external power receptacle is located on the lower right aft fuselage. External power automatically powers the airplane when both battery switches are turned on and the power is the correct polarity and the voltage.

EXTERNAL POWER CONTACTOR

The External Power Contactor automatically closes if the following conditions are met:

- Neither starter/generator is online.
- External power is the correct polarity and voltage is between 24 and 29 volts.
- Both battery switches are on.

Having both batteries online with external power minimizes the possibility of electrical noise from the external power source affecting airplane equipment.

The external power contactor automatically opens if the polarity is wrong or if any of the following occur:

- Greater than 29 volts at any time
- Aircraft current draw greater than 400A
- External Power current draw from aircraft greater than 5 A
- Less than 24 volts for longer than 45 seconds

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- Less than 10 volts at any time
- When generator power is available after engine start

EXTERNAL POWER LIGHT

The green external power light on the electrical panel is on if the following conditions are met:

- External power is plugged in.
- Power is the correct polarity and the voltage is between 24 and 29 volts.

NOTE:

Illumination of the green external power light does not indicate that external power is being used; both battery switches must be in the ON position.

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10.5.5 Electrical Buses

There are two battery buses and four equipment buses.

BATTERY BUSES

- Hot Battery Bus
  The hot battery bus is connected to the start battery and is powered at all times. Its purpose is to provide power for overhead cabin and baggage compartment, when the battery switches are off. These lights are on timers and depending on the light, will automatically deactivate within five or fifteen minutes to prevent battery depletion.
- Battery Bus
  The systems battery is connected to the battery bus and is powered when the SYS BATT switch is on. The battery bus provides power to all four FADEC channels, the left PFD and the left ACS through two mechanical circuit breakers on the left switch panel, labeled LEFT PFD and LEFT ACS. The battery bus voltage is indicated on the upper portion of the electrical synoptic, adjacent to the battery bus contactor.

In the event that low voltage is detected on the battery bus, a BATT BUS VOLTAGE LOW advisory message appears.

EQUIPMENT BUSES

Four equipment buses, left and right forward and left and right aft, supply power for all aircraft systems. During normal operation the ACS divides the buses into a left/right configuration, with the left forward and left aft buses receiving power from the left generator, and the right forward and right aft buses receiving power from the right generator.

The left and right aft bus voltages are indicated on the lower portion of the electrical synoptic, adjacent to the left and right aft bus segments.

In the event that low voltage is detected on any of the equipment buses, one of the following caution messages will appear.

- L AFT BUS VOLTAGE LOW
- R AFT BUS VOLTAGE LOW
- L FWD BUS VOLTAGE LOW
- R FWD BUS VOLTAGE LOW

BUS TIE CONTACTOR

The bus tie contactor electrically ties together or isolates the left and right aft buses. The bus tie contactor is controlled by the BUS TIE switch on the left switch panel. During normal operation with the BUS TIE switch in the AUTO position, the ACS controls the position of the bus tie contactor; however it can be manually opened by placing the BUS TIE switch in the OPEN position. Should the bus tie contactor become stuck closed, a BUS TIE FAIL caution message appears.

In AUTO, the bus tie contactor is open during normal operations, and will automatically close if any of the following are powering the airplane:

- Single generator
- Battery
- External power

All aircraft buses are powered in the above situations and when operating on a single generator or external power, both batteries are being charged.

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10.5.6 Circuit Protection

Electrical components and wiring are protected by load shedding, contactors, mechanical circuit breakers, and Electronic Circuit Breakers (ECBs). The ACS monitors currents on the various buses so that any faults are detected. Faults on buses cause contactors or ECBs to open, thereby isolating the faulty bus or buses. This triggers CAS messages to indicate which buses are not powered. Over and under-voltage protection is also provided for the starter/generators and external power contactor.

LOAD SHEDDING

Under normal operation, the aircraft has two batteries and two generators to power all of the avionics and electronic systems. If a situation arises where both generators on the aircraft malfunction or become unusable the aircraft will continue to operate on battery power. When this occurs, the ACS automatically will shed electrical equipment to provide at least 30 minutes of electrical power to those loads that are essential to continued safe flight and landing. This state is called "Battery-Only Load-Shed". When Battery-Only Load-Shed occurs, the ACS automatically sheds or "Locks" non-essential ECB's.

SMART LOAD SHED

Smart Load Shed functionality is specifically related to the Air Data System and Integrated Sensor Suites. Should a failure of a redundant system component occur and both generators become inoperative/malfunction, it is possible that a load shed could deactivate the ISS providing the best information to the pilot.

Should both generators become inoperative with both of the ISS' fully operative, the ACS will continue to power the ISS and components that it determines to be the most accurate at the time.

- Left and Right AHRS (2)
- Left and Right Air Data Computers (ADC) (2)
- Left and Right Angle of Attack Processors (2)
- Left and Right GPS (2)
- Left and Right Pitot/AOA Heat (2)
- Left and Right Integrated Sensor Suite (ISS) (2)

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CONTACTORS

Ten contactors connect various components of the electrical system. All contactors are normally operated by the ACS.

- System Battery
- Left Battery Bus
- Right Battery Bus
- Start Battery Contactor
- Bus Tie Contactor
- Left Generator Contactor
- Right Generator Contactor
- External Power Contactor
- Left Forward Circuit Breaker/Contactor
- Right Forward Circuit Breaker/Contactor

Operation of the left and right generator, battery, and bus tie contactors is controlled with corresponding switches on the left switch panel.

If the battery bus contactor trips due to an over-current condition, the system battery is isolated from the battery bus and a SYS BATT CONTACT TRIP caution message appears.

If the start battery contactor trips due to an over-current condition, the start battery is isolated from the electrical system and a START BATT CONTACT TRIP advisory appears.

NOTE:

Engine start is not possible with the start battery isolated.

START BATTERY CONTACTOR AND LIGHTING CONTROLLER

The start battery contactor and lighting controller is a self-contained unit that houses the following electrical components.

1. Start Battery Contactor
2. Hot Battery Bus
3. Interior Lighting Controller
4. 125 A Fuse for the Air Conditioning System

In addition to housing the start battery contactor and the 125 amp fuse for the air conditioning, the Start Battery Contactor and Lighting Controller also houses the hot battery bus which is responsible for providing power to interior lighting with the battery switches off. A lighting controller function internal to this unit allows for control and regulation of internal lighting along with the internal timer to deactivate those lights after five minutes.

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MECHANICAL CIRCUIT BREAKERS

There are two mechanical circuit breakers on the left switch panel that supply power to the left PFD and left ACS. This ensures that electrical power can be restored to the critical flight instruments and ACS if an event causes all the ECBs to turn off.

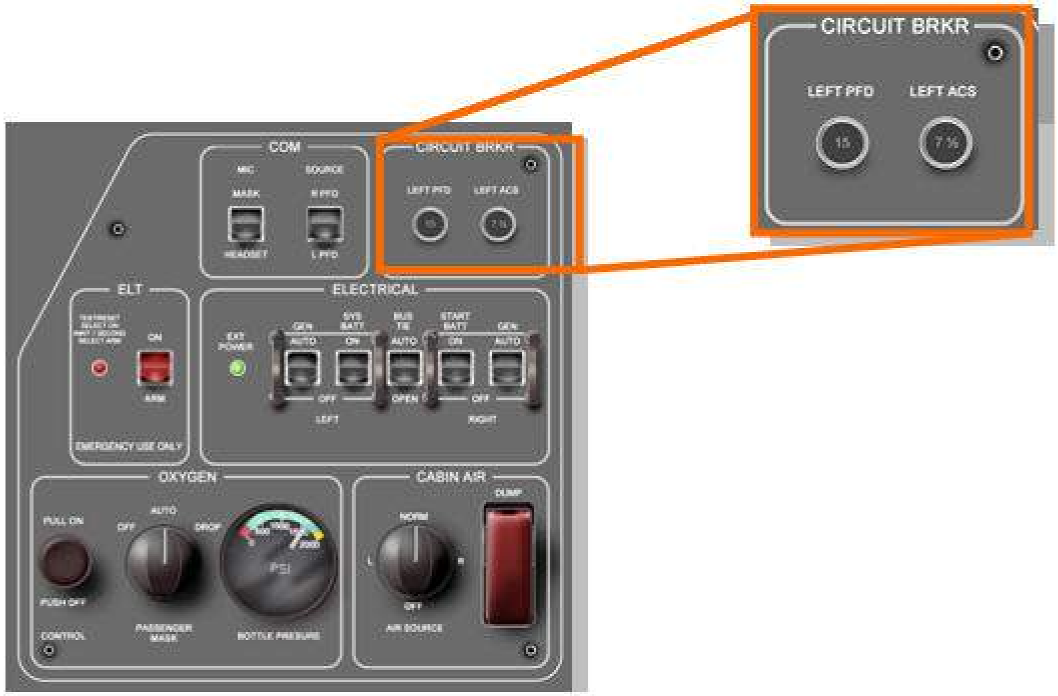

Figure 143. Mechanical Circuit Breaker Location

ELECTRONIC CIRCUIT BREAKERS

Power is distributed to the various electrical components through ECBs rather than mechanical circuit breakers. Each ECB detects over-current conditions to trip the ECB to protect the aircraft wiring.

127 ECBs are contained in five Electronic Circuit Breaker Units (ECBUs), each associated with one electrical bus:

- ECBU #1 Left Forward Bus
- ECBU #2 Right Forward Bus
- ECBU #3 Battery Bus
- ECBU #4 Left Aft Bus
- ECBU #5 Right Aft Bus

The ECBs can be monitored and controlled and on the ECB Synoptic page on the MFD. Each ECB has five possible states:

- AUTO/ON Normal state
- AUTO/OFF ECB turned off by the ACS
- TRIPPED ECB off due to circuit fault
- PULLED ECB opened by the pilot
- COLLAREDECB locked out by a maintenance technician

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The ACS will open an ECB (AUTO/OFF) as necessary for system operation or load shedding. An ECB in the AUTO/OFF state will not automatically reset when a circuit fault is cleared, but can be reset by the pilot if appropriate. If an ECB is pulled by the pilot, the ACS cannot close it. An ECB labeled "collared" was locked out by maintenance and may be reset by the pilot on-ground only. Once an engine is started or the aircraft is in flight, ECBs cannot be collared or uncollared.

The status of each ECB is maintained in non-volatile memory when the aircraft is powered down. When the aircraft is powered up, the prior state of each ECB is restored. However, all ECB's that are "pulled" reset upon power-up. All critical functions are powered through redundant circuit breakers connected to different power buses. This strategy permits continued operation of all critical avionic functions even if a bus fault occurs or an ECB fails. If ACS communication with an ECB is lost, or if it is unable to be switched off, an ECB CTRL FAULT advisory message appears.

POWER DISTRIBUTION CENTERS

There are two Power Distribution Centers on the aircraft. They are considered Line Replaceable Units (LRUs) for the electrical system.

The Forward Power Distribution Center is located aft of the forward pressure bulkhead and contains the power distribution components for the left and right forward busses with the exception of ECBU #s 1 and 2 which are separate LRUs.

Forward Power Distribution Center

- ECBU #3
- Left Battery Bus Contactor
- Right Battery Bus Contactor
- Systems Battery Bus
- Left Forward Bus
- Right Forward Bus

The Aft Power Distribution Center is located along the upper left fuselage wall adjacent to the Left Avio Processing Center and contains the power distribution components for the left and right aft power buses. The left and right bus components are physically separated within the Aft Power Distribution Center and are electrically independent with the exception of the Bus Tie Contactor which is used to connect the left and right aft buses.

- Aft Power Distribution Center
    - Left Side
        - Left Forward Circuit Breaker
        - Left Aft Bus
        - ECBU #4
        - Bus Tie Contactor (BTC)
    - Right Side
        - Right Forward Circuit Breaker
        - Right Aft Bus

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- ECBU #5

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10.6 Normal Operations

10.6.1 Ground Operation

BATTERY POWER

With both battery switches OFF, the hot battery bus provides power to the cabin overhead and entry lights and to the baggage compartment lights. With battery power only, these lights are on timers to prevent battery depletion.

Dome light .... 5 minutes
Baggage compartment light .... 5 minutes

If the START BATT switch is placed to ON with no external power, the bus tie contactor automatically closes, allowing the start battery to power all buses. If the SYS BATT switch is then placed to ON, the systems battery is paralleled with the start battery. Ground operation on battery power should be of limited duration to prevent battery depletion.

When the start or system battery is discharging, a START or SYS BATT DISCHARGE caution message appears.

EXTERNAL POWER

All buses may be powered by external power. Both battery switches must be in the ON position for the external power contactor to close. With external power and both battery switches ON, external power also charges both batteries.

The green EXT POWER light on the left switch panel indicates that good external power (correct polarity and voltage) is available for use. The states of the external power contactor or battery switches have no effect on the external power light.

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10.6.2 Engine Start

FIRST ENGINE START

Starting the first engine is accomplished using start battery power or if external power is available, external power in parallel with the start battery. Engine start is automatically controlled by the ACS and FADEC. When the start sequence is initiated, the ACS separates the electrical system into a forward/aft configuration by opening both left and right forward circuit breaker contactors and closing the right battery bus contactor and bus tie contactor. In this configuration, the systems battery powers the avionics components on the forward buses to protect them from voltage drop due to high starter current. Power from the start battery and external power is routed through the GCU to drive the starter/generator as a motor. The resulting mechanical torque is applied through the engine's accessory gearbox to start the engine.

After the first engine is started and generator power is available, the electrical system reconfigures to a left/right configuration. Both left and right forward circuit breaker/contactors close, the right battery bus contactor opens, disconnecting the systems battery from the right forward bus and the bus tie contactor remains closed to power both aft buses through the operating generator. If external power is being used, the external power contactor also opens to prevent reverse current flow.

ONE ENGINE RUNNING

With one engine running and the generator delivering electrical power, the second engine may be started using start battery power in parallel with the operating generator. The left and right forward circuit breaker/contactors open, disconnecting the forward buses from the aft buses during engine start as they were during the first engine start.

If desired, the second engine can be started with external power paralleled with the start battery. To do this, the pilot turns off the GEN switch for the operating engine to allow the external power contactor to close.

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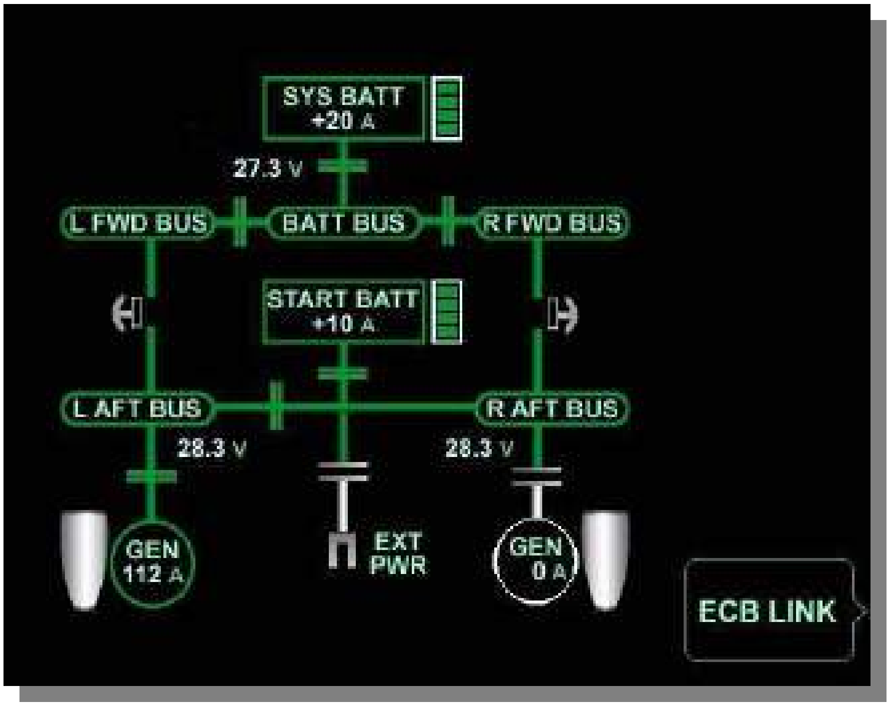

Figure 144. Electrical Synoptic With One Engine Running

TWO ENGINES RUNNING/ IN-FLIGHT

With both engines running and during normal flight operation with power output from both generators, the left and right electrical systems are split (bus tie contactor is open). The left system is powered by the left generator, and is connected to and charges the systems battery. The right system is powered by the right generator and is connected to and charges the start battery.

AIR-GROUND LOGIC

The ACS uses the current status of the aircraft (on-ground or in-flight, as determined through the Weight-On-Wheels sensor) to determine the appropriate control functions for normal operation and failure conditions.

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10.7 Abnormal Procedures

10.7.1 One Generator Inoperative

A loss of a generator prompts a load shed of the air conditioning system and the bus tie contactor to automatically close so the opposite generator powers the entire airplane and charges both batteries. When engines are running, an inoperative generator causes a L (R) GEN OFFLINE caution message to appear.

NOTE:

The BUS TIE switch must be in the AUTO position for this to occur.

If an in-flight engine restart is required, it is accomplished using the operating generator and the start battery. A process similar to ground start takes place in which the aft buses are isolated from the forward buses, with the forward buses being powered by the system battery.

10.7.2 Both Generators Inoperative

With both generators inoperative in flight, the aircraft is operating on battery power only and a BATTERY POWER ONLY warning message appears. The ACS will shed all electrical loads that are not required for continued safe flight and landing. The systems battery and start battery have sufficient capacity to power the remaining (emergency) loads for at least 30 minutes.

For engine start when both generators inoperative, the start battery powers the starter/generator for the engine being started. The systems battery powers those loads on the forward busses required for continued safe flight and landing. A fully charged start battery allows at least three start attempts.

10.7.3 Load Shedding

The ACS automatically sheds non-essential loads that cause overload of the remaining operating generator.

ONE STARTER/GENERATOR OFFLINE

- In Air or On Ground
  - — The air conditioning system is only system load shed
  - — If air conditioning load shed capability is lost on the ground a LOAD SHED SYS FAULT caution message appears and manual load shed may be required

BATTERY ONLY (START OR DUAL GENERATOR OFFLINE IN FLIGHT)

- On Ground
  - 80 non-essential ECB’s Load Shed
  - MFD NOT shed
- In Flight
  - — 82 non-essential ECB’s Load Shed
  - — Including MFD

10.7.4 Electrical Smoke Clearing

In the event of electrical smoke in the cabin, the pilot initiates the Smoke Clearing Procedure to isolate the source of the smoke. The Smoke Clearing procedure turns

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off electrical power to most of the devices and busses on the left (or right) side of the aircraft and powers down any dual-supplied avionics that have redundant power coming from the alternate side power bus. The exceptions are the FADEC and ISSs which remain powered.

LEFT BUS ISOLATION

The left bus isolation requires the pilot to remove power from all left side equipment and calls for the pilot to turn off the left generator (GEN), systems battery (SYS BATT) and open the bus tie contactor (BTC). This will remove power from all equipment associated with the Battery Bus, Left Forward Bus and Left Aft Bus including any redundant ECB's.

RIGHT BUS ISOLATION

The right bus isolation procedure requires the pilot to remove power from all right side equipment and calls for the pilot to turn off the right generator (GEN), start battery (START BATT) and open the bus tie contactor (BTC). This will remove power from all equipment associated with the Right Forward Bus and Right Aft Bus including any redundant ECB's.

After the smoke-causing component is isolated and the appropriate ECB pulled, the electrical switches are restored to the normal position. All ECBs maintain their state before the smoke clearing procedure because the state of each ECB is stored in its internal memory.

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10.8 Crew Alerting System Messages

Table 31. Electrical CAS Messages

Message	Condition	Category
BATTERY POWER ONLY	Aircraft is operating on battery power only	Warning
L AFT BUS VOLTAGE LOW	Left aft bus voltage is low	Caution
R AFT BUS VOLTAGE LOW	Right aft bus voltage is low	Caution
L FWD BUS VOLTAGE LOW	Left forward bus voltage is low	Caution
R FWD BUS VOLTAGE LOW	Right forward bus voltage is low	Caution
L (R) GEN OFFLINE	Engine running, generator switched ON but no current flow, or Generator switch off	Caution
BUS TIE FAIL	The bus tie contactor is stuck closed	Caution
LOAD SHED SYS FAULT	Air conditioning load shed capability is lost (ground only)	Caution
START BATT DISCHARGE	Start Battery is discharging	Caution
SYS BATT CONTACT TRIP	Battery Bus Contactor has tripped due to over current. System Battery is off and isolated from Battery Bus	Caution
SYS BATT DISCHARGE	System Battery is discharging	Caution
BATT BUS VOLTAGE LOW	Voltage on Battery Bus is low	Advisory
ECB CTRL FAULT	Control of one or more ECBs has been lost or cannot be switched off (On ground only)	Advisory
START BATT CONTACT TRIP	Start battery contactor has tripped due to over current. Start Battery is isolated from electrical power system	Advisory
BATT HEATER FAIL	Battery heater blanket has failed (ground only)	Advisory

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10.9 Electrical Review Questions

1. **During normal operation the electrical system is:**
   a. Completely controlled by the pilot
   b. Automatically controlled by the ACS
   c. Controlled by the engine's FADEC units
   d. None of the above
2. **The starter generators serve as:**
   a. Starter motors to start the jet engines
   b. Power generators to power the aircraft's electrical system
   c. Small electric motors that turn larger generators to produce electrical power.
   d. Both A and B are correct
3. **The Voltage output of a starter/generator is:**
   a. 12.5 VDC
   b. 24 VDC
   c. 28.5 VDC
   d. 30 VDC
4. **The regulated Voltage output of to the aircraft electrical system is:**
   a. 12.5 VDC
   b. 24 VDC
   c. 28.5 VDC
   d. 30 VDC
5. **A SINGLE Starter Generator can provide power for the entire airplane with the exception of what system?**
   a. Passenger lighting.
   b. Fire suppression.
   c. Air conditioning.
   d. Pressurization.

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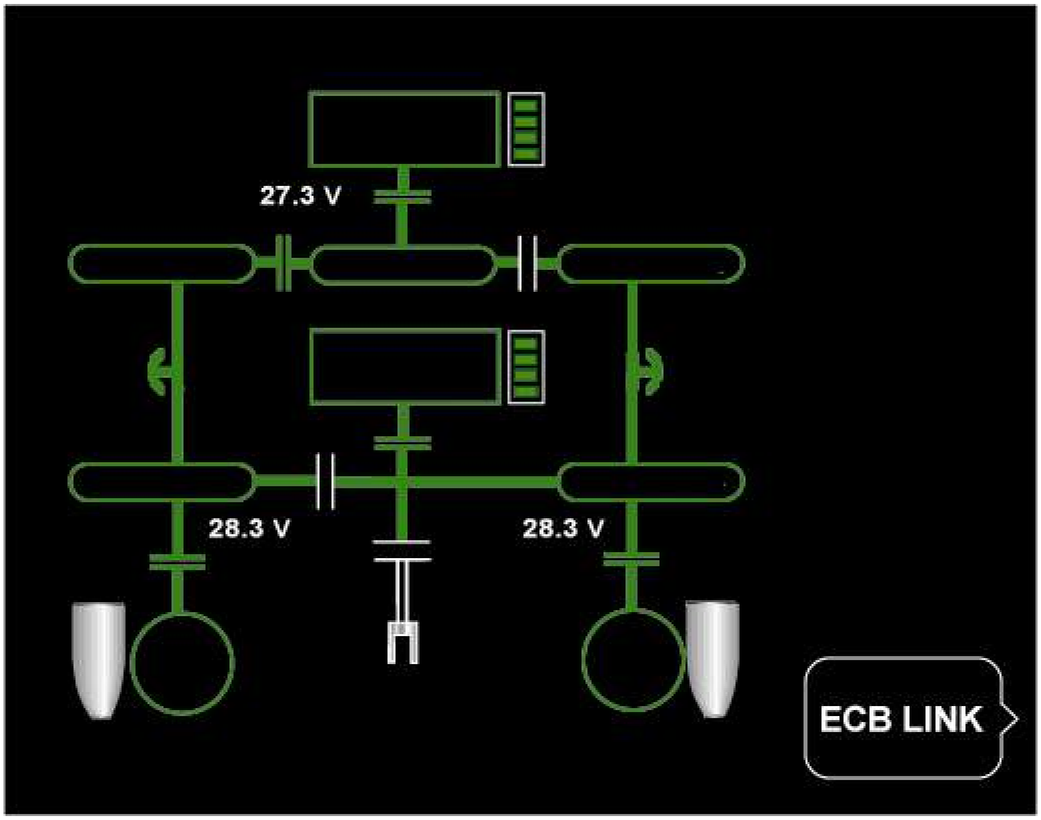
6. **Label the components of the electrical system on the synoptic below: 5 electrical busses, two batteries, generators, and 10 contactors.**



7. **List four conditions that are required to allow use of external power(IE green light on)**
   a. 1: ____
   b. 2:____
   c. 3:____
   d. 4:____

8. **What items are powered by the HOT BATTERY BUS?**

9. **When the External Power Light (Green) is illuminated what is happening?**
   a. External power is plugged in.
   b. External power is of the correct voltage.
   c. The batteries are being charged if the battery switches are ON.
   d. All of the above are correct.

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10. **Describe in general terms the difference between a mechanical circuit breaker and an electronic circuit breaker?**

11. **Electronic circuit breaker status may be viewed where?**
    a. They are displayed on every system's synoptic page for respective system components.
    b. On the ECB SYNOPTIC page.
    c. On the electric system synoptic page
    d. None of the above are correct

12. **What is one examples of protection and/or detection that the Generator control units provide?**

13. **ACS load shedding should automatically remove power to what system (s) during single generator operation?**

14. **What type of batteries are installed on the Eclipse 500?**
    a. NiMh (Nickel Metal Hydride)
    b. Maintenance-free lead acid
    c. NiCad
    d. Sealed gel batteries

15. **Which battery is connected to the Hot Battery Bus?**
    a. Start Battery
    b. Systems Battery
    c. Aft Battery
    d. No battery is attached to the Hot Battery Bus; External Power is used to power this bus

16. **What is the purpose of the BUS TIE CONTACTOR?**
    a. To isolate buses
    b. To tie buses
    c. To turn off the starter/generators
    d. Both A and B are correct
    e. None of the above are correct

17. **Circuit protection is accomplished by:**
    a. Mechanical circuit breakers
    b. Electronic circuit breakers
    c. Contactors
    d. Load shedding
    e. All of the above are correct

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18. **If both starter/generators fail in flight what is the minimum battery time available?**
    a. 60 min
    b. 30 min
    c. 45 min
    d. 35 min
19. **Which two electrical system components are independent of the Aircraft Computer Systems?**
    a.
    b.
20. **List the five conditions that will cause external power to automatically disconnect:**
    a.
    b.
    c.
    d.
    e.

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11. Interior Lighting

11.1 General

Interior Lighting is divided into two lighting areas that include both standard and optional lighting:

- Cockpit
  - Cockpit Dome Lighting
  - Cockpit Foot Well Lighting (Optional)
  - Map Lights
- Cabin
  - Upper Cabin Wash Lighting
  - Lower Cabin Wash Lighting (Optional)
  - Cabin Reading Lights
  - Baggage Compartment Light

Most of the interior lights are controlled by a lighting controller within the electrical system. With both battery switches OFF, the hot battery bus provides power to the cabin overhead and baggage compartment lights. With battery power only, these lights are on timers to prevent battery depletion.

Dome light .... 5 minutes

Baggage compartment light .... 5 minutes

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11.2 Aircraft Computer System (ACS) Interfaces

A dedicated lighting controller is located in the Start Battery Contactor/Lighting Controller unit and is considered part of the electrical system and has no direct link to the ACS. This controller provides the following functions:

1. Switching
2. Current limiting
3. Lighting Timer

Pilot inputs for interior lighting are through several switches throughout the cockpit as well as an interface on the center switch panel.

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11.3 Limitations and Specifications

No content.

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11.4 Controls and Indicators

Interior lighting is controlled with several switches on the center switch panel. A MASTER DIM control is also located on the center switch panel and provides the ability to dim all lights to a higher or lower level according to time of operation, such as DAY or NIGHT. A control knob on the MASTER DIM panel may be rotated to gradually increase or decrease interior light intensity.

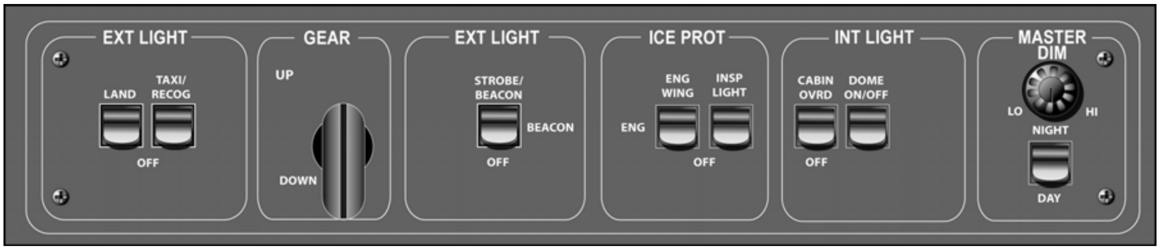

Figure 145. Center Switch Panel - Standard

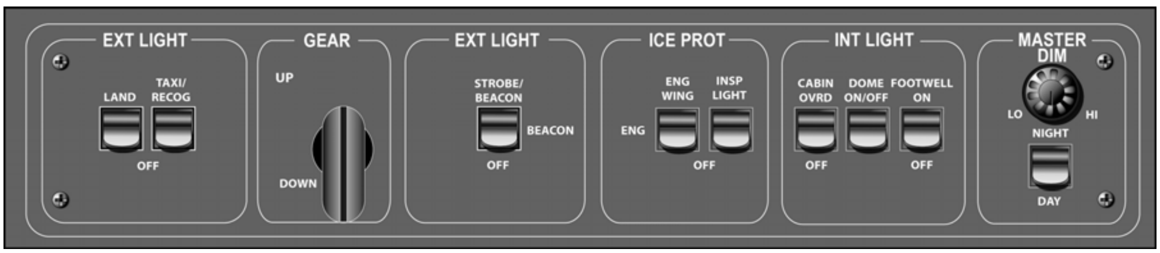

Figure 146. Center Switch Panel - FOOT WELL Light Option

Table 32. Interior Light Center Switch Panel Controls

Sub Panel	Switch Nomenclature	Control
INT LIGHT	CABIN OVRD	Override Upper Cabin Wash Lighting
	DOME	Cockpit Dome Lighting
	FOOTWELL	Foot Well Lighting
MASTER DIM	DIM	Interior lights dimming, low to high
	NIGHT/DAY	Interior Lights NIGHT (Low), DAY (Bright)

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11.5 System Description

11.5.1 Start Battery Contactor / Lighting Controller

The Start Battery Contactor and Lighting Controller Unit is a component of the electrical system that is responsible for the control of all interior lighting. All control and over-current protection for the interior lights are provided through the lighting controller. Although the interior lights do not have specific Electronic Circuit Breakers associated with them, the lighting controller will act in this capacity, deactivating any light that experiences an overcurrent situation.

11.5.2 Cockpit Dome Lighting

The cockpit dome lighting consists of a string of LED's on the front end of the overhead console. Two light switches control the cockpit dome lighting. One switch is located on the Armrest Light Switch Panel mounted on the front of the left armrest of the left front passenger seat located closest to the entrance to the aircraft. The other switch is located on the center switch panel.

Figure 147. Cockpit Dome Lighting Armrest Switch

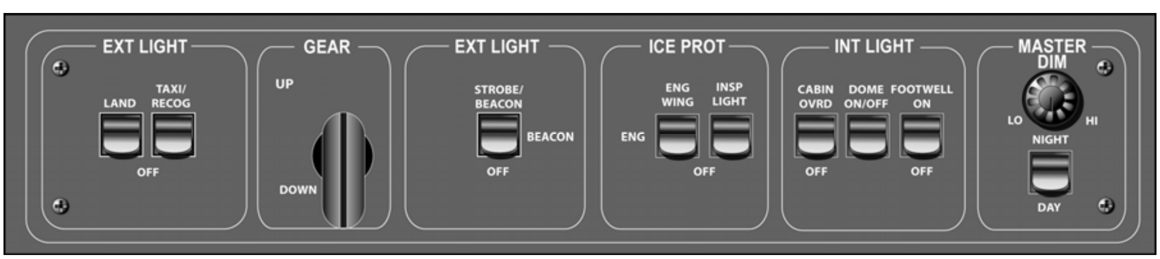

Figure 148. Cockpit Dome Lighting Center Switch Panel Switch

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11.5.3 Cockpit Foot Well Lighting (Optional)

The foot well lighting system consists of a series of LED lights located underneath the instrument panel. The FOOTWELL switch located on the center switch panel activates this lighting.

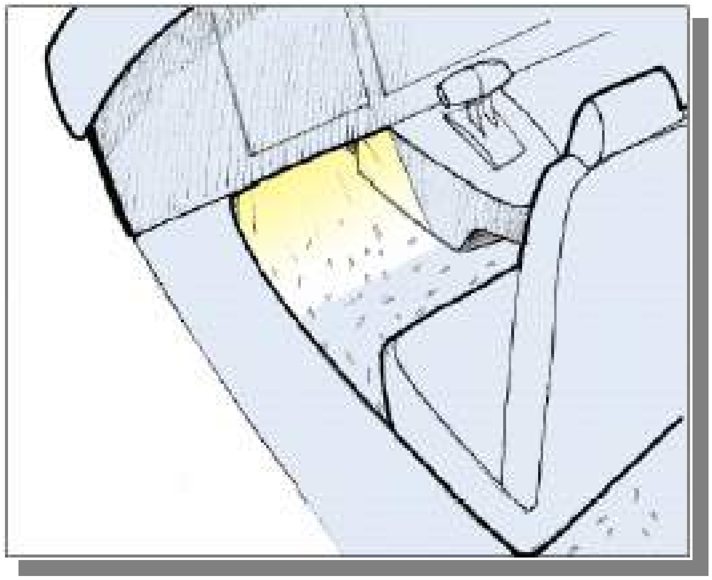

Figure 149. Cockpit Foot Well Lighting

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11.5.4 Map Lights

The map lights consist of two groups of focused LED located under the glare shield for map reading in the cockpit, with one group on either side of the cockpit. A switch on the autopilot control panel is used to activate each light. The co-pilot light is operated by an identical knob on the right side of the autopilot control panel.

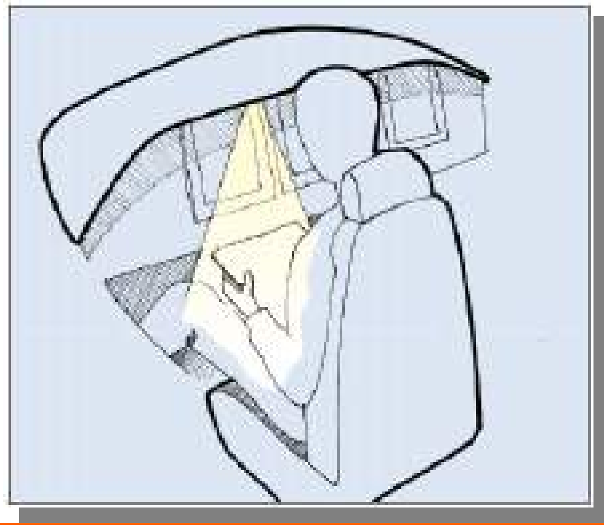

Figure 150. Map Lighting

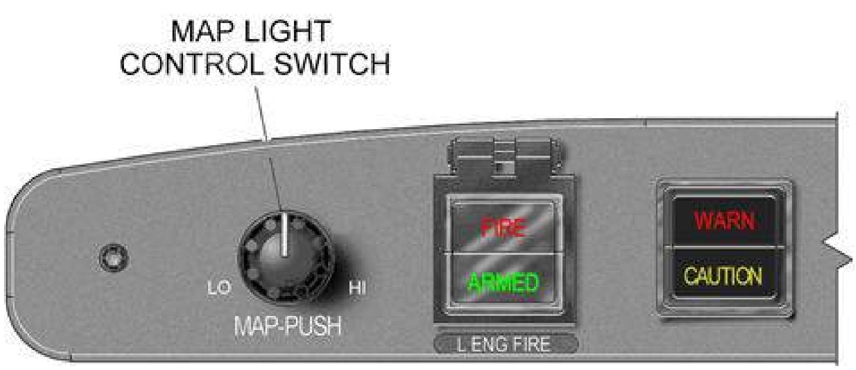

Figure 151. Map Light Control

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11.5.5 Upper Cabin Wash Lighting

The upper cabin wash lighting consists of LED's running the perimeter of the overhead console in the cabin. The cabin lighting control panel located on the overhead console allows control of this lighting. Pushing the upper cabin wash lighting switch once turns lights on dim, pushing it a second time turns them on bright and a third time turns them back off.

Figure 152. Overhead Cabin Wash Lighting

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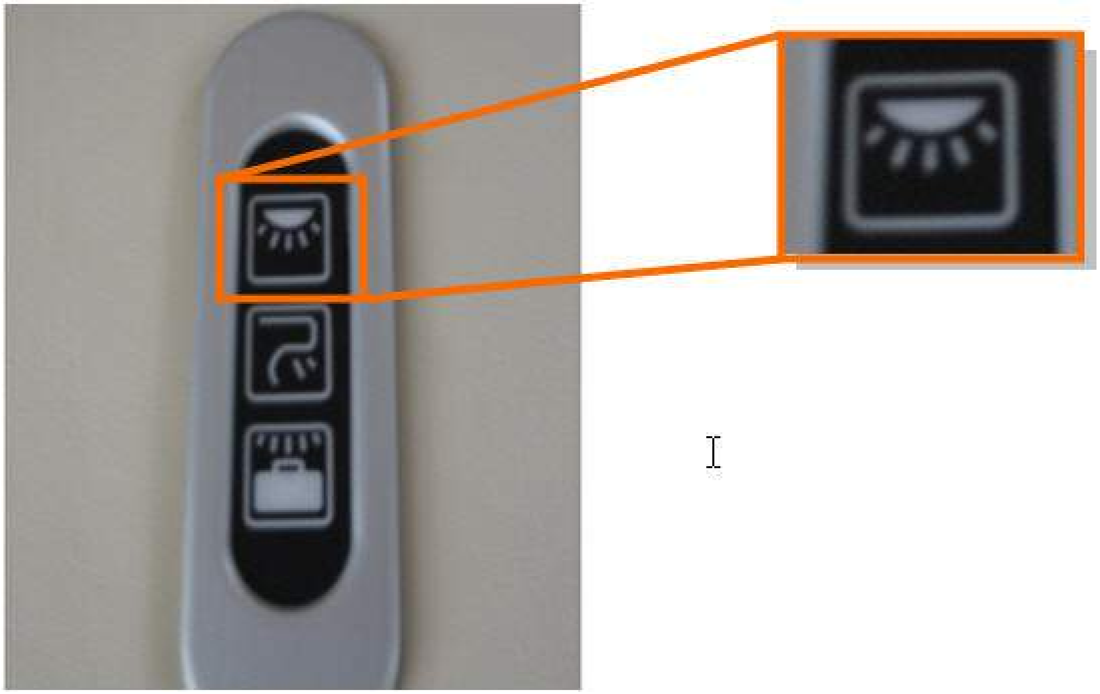

Figure 153. Overhead Cabin Wash Lighting Control

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11.5.6 Lower Cabin Wash Lighting (Optional)

The lower cabin wash lighting system consists of LED's running underneath the armrests from the back of the co-pilot's seat to the beginning of the cargo compartment on the right side of the aircraft, and from the edge of the door to the beginning of the cargo compartment on the left side of the aircraft. These lights are controlled by a switch on the overhead console lighting control panel. Pushing the lower cabin wash lighting switch once turns lights on dim, pushing it a second time turns them on bright and a third time turns them back off.

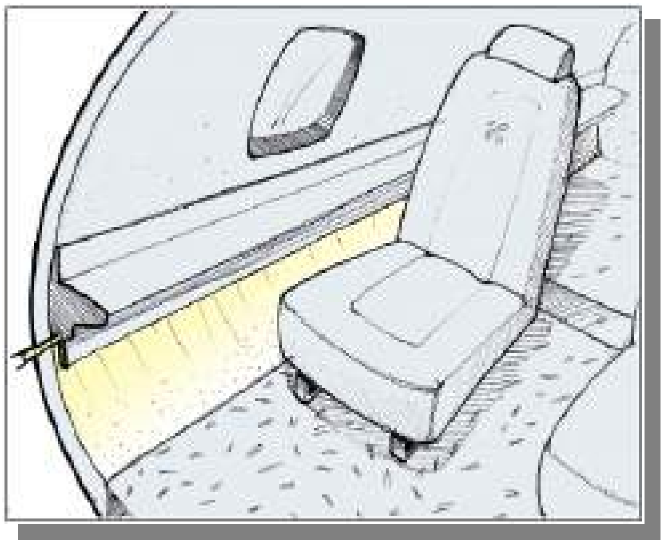

Figure 154.   Lower Cabin Wash Lighting

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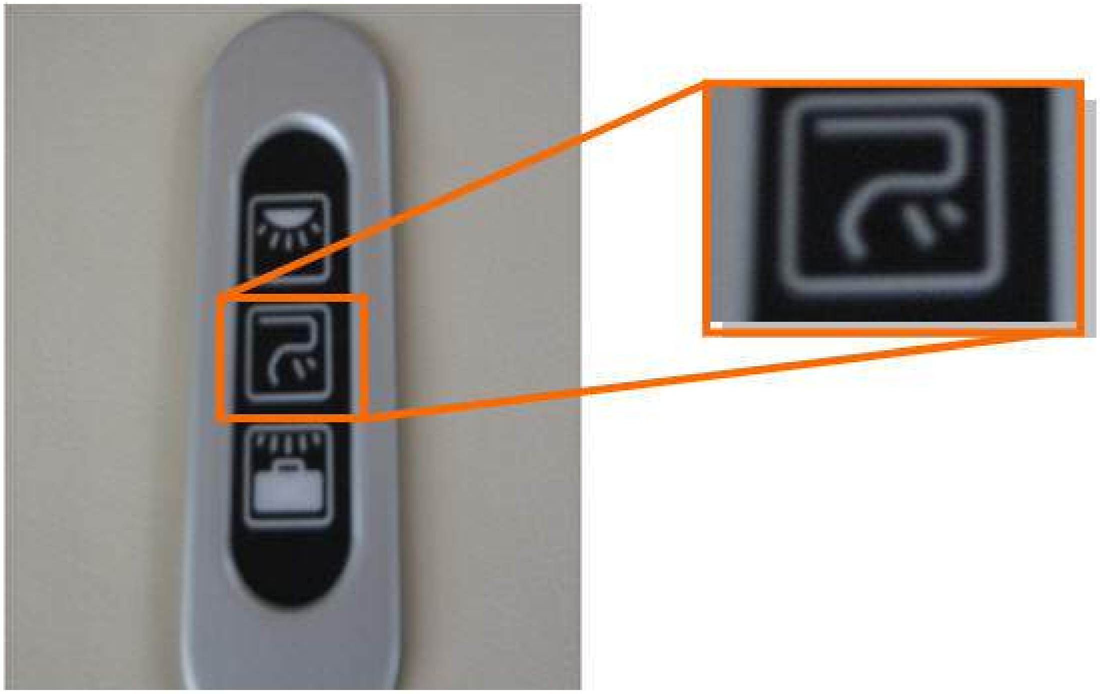

Figure 155.   Lower Cabin Wash Lighting Control

11.5.7 Cabin Reading Lights

The cabin reading lights provide the individual light for each passenger seat. The bezel on each light allows it to swivel and it has its own control located near each LED light on the overhead console.

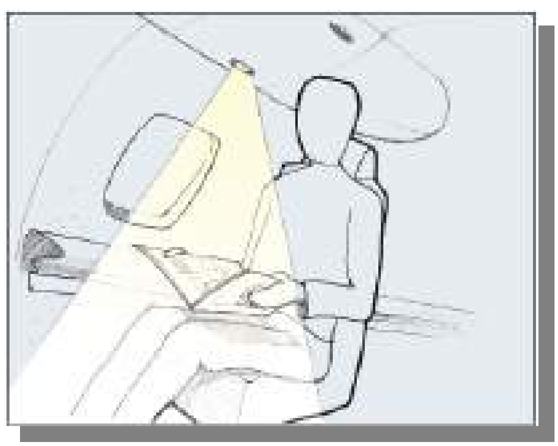

Figure 156.   Cabin Reading Lights

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11.5.8 Baggage Compartment Lights

The LED baggage lights provide lighting to the baggage area in the aft cabin. The control switch for this light is located on the overhead console lighting control panel.

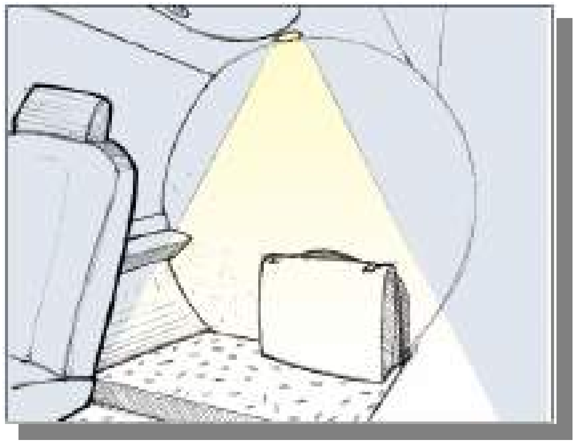

Figure 157. Baggage Compartment Light

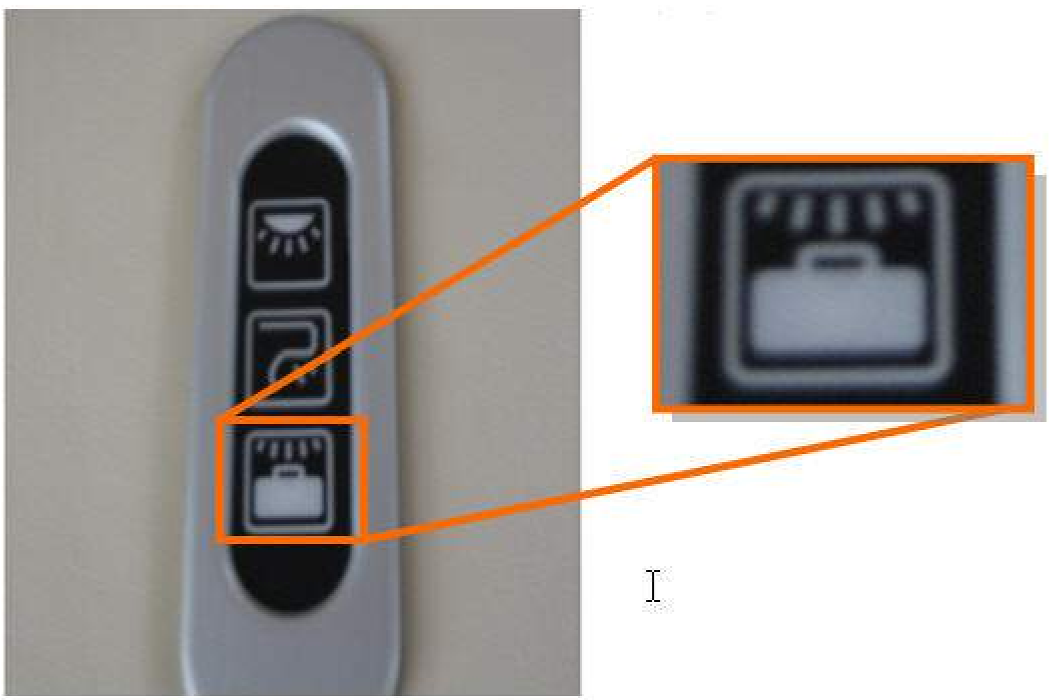

Figure 158. Baggage Compartment Light Control

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11.6 Normal Operations

11.6.1 Cabin Override Switch

A CABIN OVRD switch on the center switch panel allows pilot override of passenger control of all cabin lighting. Selecting the OVRD position extinguishes all cabin lighting. If it is returned to the off position only reading lights will come back on, all other cabin will have to be turned back on using cabin lighting control panel.

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11.7 Abnormal Procedures

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11.8 Crew Alerting System Messages

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11.9 Interior Lighting Review Questions

1. **LED lights are used on the Eclipse 500 to:**
   a. Provide extended lighting system component life & redundancy by using multiple strings of LEDs
   b. Reduce drag
   c. Save weight
   d. Answers A & B are correct
2. **What is the purpose of the Start Battery Contactor/ Lighting Controller?**

3. **Why are come interior lights on timers?**
   a. LEDs burn out very quickly and the timer is installed to prevent overuse of LED lighting
   b. To prevent excessive battery depletion while lights are being used on battery power only.
   c. For cosmetic purposes only
   d. None of the above
4. **The interior lighting system is divided into which two categories?**
   a. Forward & Aft
   b. Upper & Lower
   c. Right & Left
   d. Cockpit & Cabin
5. **Where is the switch for the foot well lighting located?**
   a. Under the left-pilot's armrest
   b. On the center switch panel
   c. There is no switch these lights are always on but and can only be dimmed
   d. None of the above
6. **Where is the map lighting control switch?**
   a. A rotary switch on the autopilot control panel
   b. On the center switch panel
   c. On the sidestick
   d. None of the above
7. **Where is the upper cabin wash lighting switch located?**
   a. On the overhead console
   b. On the center switch panel
   c. This lighting comes on automatically and there is no switch
   d. Both A & B are correct
8. **How is the baggage compartment lit?**

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a. With a baggage compartment light operated by a switch on the overhead console
b. It is not lit because the wash lighting and the passenger reading lamps provide ample lighting inside the aircraft
c. The lower wash lighting continues into the baggage compartment
d. None of the above

9. **Where is the switch for the passenger reading lights located?**

a. On the center switch panel
b. Under each passenger’s arm rest
c. On the overhead panel next to each passenger reading light
d. None of the above

10. **What is the function of the CABIN OVRD switch?**

a. Activation and deactivation of the upper cabin wash lighting
b. Overrides the cabin switch for the reading lights prevents passenger activation and turns lights off if on
c. Deactivates the lower cabin wash lighting
d. Overrides the cabin switch for the upper cabin wash lighting-prevents passenger activation and turns lights off if on
e. None of the above

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12. Exterior Lighting

12.1 General

The exterior lighting system provides four operating modes:

- Runway/Taxiway Illumination
  — Landing and/or taxi lights (if installed)
- Recognition Lighting
  — Steady state and intermittent flashing of the taxi/recognition lights (if installed)
- Position Lighting
  — Red and green position lights located on the left and right wingtips and a white aft facing tail light located on the trailing edge of the horizontal stabilizer fairing
- Anti-Collision Lighting
  — Strobes on each wingtip and in the tail cone

Several of the aircraft lights utilize Light Emitting Diodes (LEDs). Each of these lights contains several strings of individual LEDs. This ensures that should one light or string of lights fail, the rest remain illuminated.

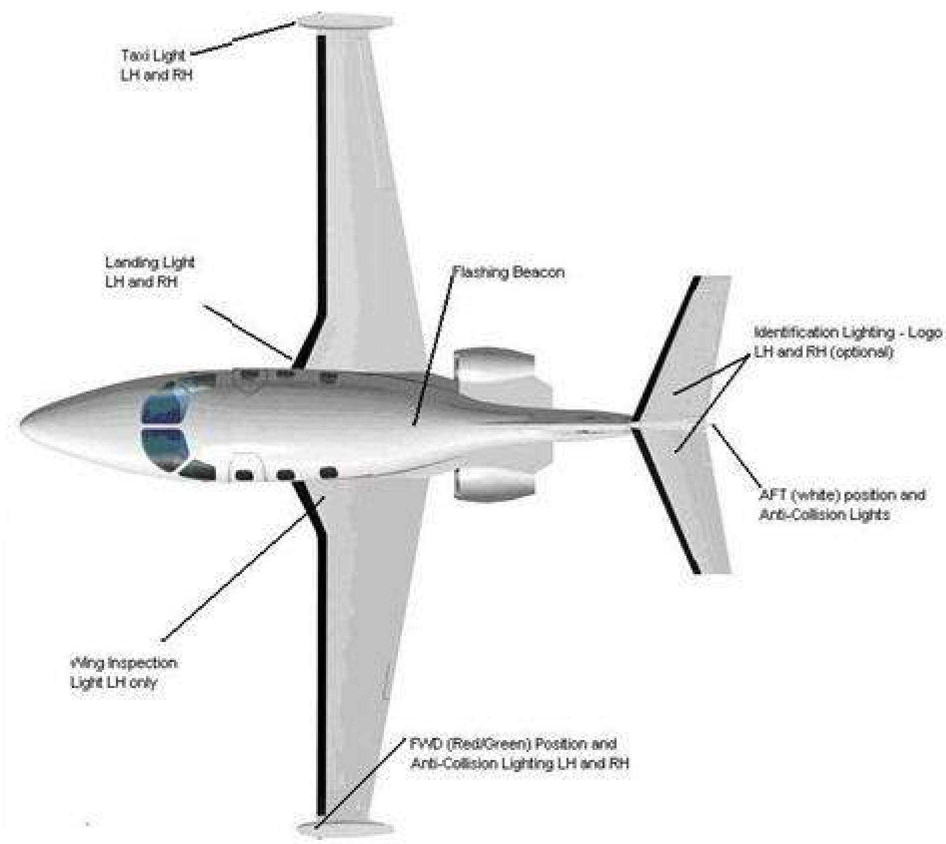

Figure 159. Exterior Lighting – Top View

Figure 160. Exterior Lighting- Left Side View

12.2 Aircraft Computer System (ACS) Interfaces

The Aircraft Computer System controls all exterior lights by activating and deactivating appropriate exterior lighting ECBs based on pilot commands. The ten exterior lighting ECBs reside on Electronic Circuit Breaker Units, one, four and five.

All exterior lighting is controlled by the pilot through hard switches on the center switch panel. Commands from the center switch panel are routed through the PFD to the ACS' which in turn command the ECBs. The following lights are part of the exterior lighting system:

1. Left and Right Landing Lights
2. Left and Right Taxi/Recognition Lights (Optional)
3. Left, Right, Aft Anti-Collision (Strobe) Lights
4. Beacon Light
5. Left, Right, Aft Position Lights
6. Wing (Ice) Inspection Light

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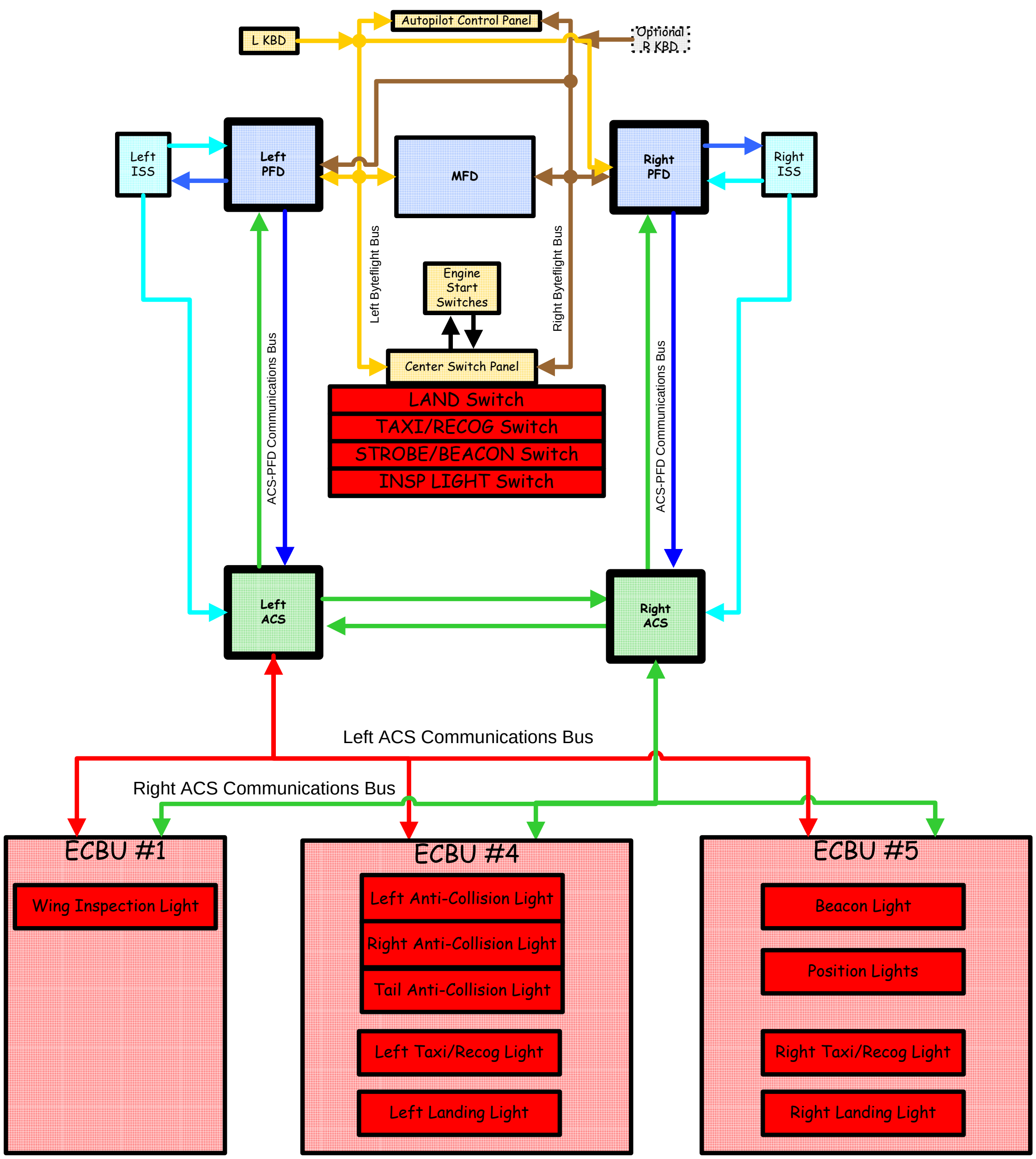

Figure 161. Exterior Lighting-ACS Interfaces

12.3 Limitations and Specifications

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12.4 Controls and Indicators

All exterior lighting is controlled with switches located on the center switch panel under two EXT LIGHT sub panels.

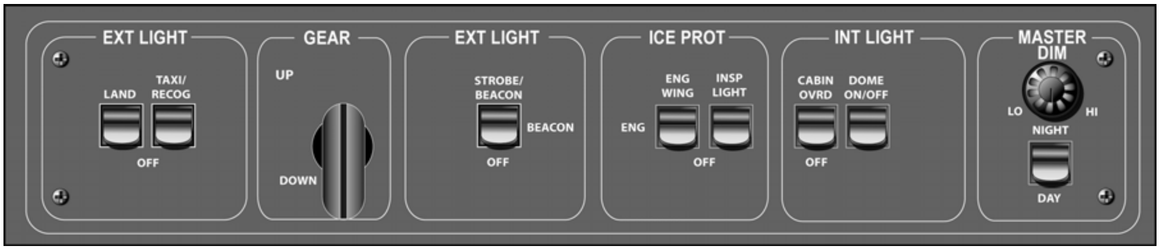

Figure 162. Center SWITCH Panel- Standard

12.4.1 Center SWITCH Panel- Standard

Table 33. Exterior Lighting Switch Functions

Sub Panel	Switch Nomenclature	Control
EXT LIGHT	LAND	Left and Right Landing Lights
	TAXI / RECOG	Left and Right Taxi Lights (Steady on ground and alternating flashing in air)
EXT LIGHT	STROBE/BEACON	Left, Right Wing and Tail Strobes & Flashing Beacon
	BEACON	Flashing Beacon only
ICE PROT	INSP LIGHT	Ice Inspection Light

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12.5 System Description

12.5.1 Landing Lights

The landing light consists of two 50W High-Intensity Discharge (HID) landing lights, one located in each of the forward wing root fairings. During ground operation with the landing light off and the taxi lights activated, the landing light will operate at a lower intensity to provide additional lighting for taxi. In flight, the landing light will operate at full intensity.

The landing lights are controlled with a single two-position switch located on the center switch panel.

A failure of a landing light causes a LANDING LIGHT FAIL advisory message to appear.

12.5.2 Position /Anti-Collision Lights

Position and anti-collision lights are collocated on a single assembly within the tip tanks and separately on the horizontal stabilizer fairing and tail cone.

POSITION LIGHTS

Position indication is provided by red and green LED position lights mounted within the forward dry bay of the wing tip tanks. A white aft facing position light is located on the horizontal stabilizer fairing. Each light consists of a string of four red, green or white LEDs.

Position lights are automatic and are illuminated anytime the avionics system is powered up.

A failure of any of the position lights causes a POSITION LIGHT FAIL advisory message to appear.

ANTI-COLLISION LIGHTS

Two white LED strobe lights are also located within the forward dry bays on the wings and one is located within the tail cone. Each anti-collision light fixture is composed of several strings of six white LEDs.

Anti-collision lighting is controlled with a three-position STROBE/BEACON switch located on the center switch panel.

A failure of an anti-collision light will cause a STROBE FAIL advisory message to appear.

12.5.3 Wing Inspection Light

A single 50W halogen wing inspection light located in the left hand wing root fairing is used to illuminate the left hand wing when operating in suspected icing conditions at night.

The wing inspection light is controlled with a two-position INSP LIGHT switch located on the center switch panel.

A failure of the wing inspection light causes an INSPECTION LIGHT FAIL advisory message to appear.

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12.5.4 Flashing Beacon

The flashing beacon is composed of a single string of eight red LEDs and is located on the upper aft fuselage just forward of where the dorsal fairing intersects the top of the aft fuselage.

This beacon is activated by use of the same switch used to operate the Anti-Collision lights. By placing the switch labeled STROBE/BEACON in the BEACON position only the beacon will be activated. If the switch is raised to the STROBE/BEACON position, all strobes and the beacon will be in operation.

12.5.5 Taxi/Recognition Lights

There are two 35W taxi lights located in each of the wing tips, to provide for additional lighting when taxiing and during night operations. The operation of the Taxi/Recognition lights is dependant on the status of the Weight On Wheels (WOW) sensor. During ground operation the Taxi/Recognition lights will illuminate in a steady state fashion. When the WOW sensor indicates and in-flight condition, these lights will transition to pulsating operation for better recognition.

Taxi lights are activated by a two position TAXI/RECOG switch located on the center switch panel.

A failure of one of the Taxi/Recognition lights causes a TAXI LIGHT FAIL advisory message to appear.

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12.6 Normal Operations

No content.

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12.7 Abnormal Procedures

12.7.1 Battery Only Load Shed

In the event the electrical system is powered by battery power only, the ACS load sheds the following lights:

- Beacon
- Anti-Collision
- Left and Right Taxi
- Right Landing
- All Optional Lighting

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12.8 Crew Alerting System Messages

Table 34. Exterior Lighting CAS Messages

Message	Condition	Category
LANDING LIGHT FAIL	Landing light failure detected	Advisory
POSITION LIGHT FAIL	Position light failure detected	Advisory
STROBE FAIL	Strobe light failure detected	Advisory
TAXI LIGHT FAIL	Taxi light failure detected	Advisory
INSPECTION LIGHT FAIL	Wing ice inspection light failure detected	Advisory
BEACON LIGHT FAIL	Beacon light failure detected	Advisory

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12.9 Exterior Lighting Review Questions

1. **What electronic circuit breaker units provide power to the external lighting system?**

   a.

   b.

   c.

2. **What type of lighting is used for position lighting purposes?**

   a. Red and green position lights located on the wingtips and a white light located on the trailing edge of the horizontal stabilizer fairing.

   b. White lights located in the wing roots

   c. Blue lights located in the landing gear wheel wells

   d. None of the above

3. **How are position lights activated?**

   a. By the POS LIGHT switch on the center switch panel

   b. By the POS LIGHT switch on the left switch panel

   c. Position lights are activated anytime power is applied to the aircraft wing roots

   d. None of the above

4. **What type of lighting is used for anti-collision purposes?**

   a. The Eclipse 500 does not use anti-collision lights
   b. Strobe lights located on each wingtip and the tail
   c. Red and green lights located on the wingtips
   d. White lights located in the wingtips

5. **Where are the landing lights located on the Eclipse 500**

   a. In the wing roots
   b. On the wing tips
   c. Attached to the nose gear
   d. None of the above

6. **What type of light is used in the landing light system?**

   a. Tightly grouped LEDs
   b. Combination halogen projector/LED lights
   c. Florescent bulbs
   d. HID (High Intensity Discharge)

7. **Where are the taxi lights located?**

   a. They are the same lights as the landing lights but are dimmed when the taxi light switch is turned on

   b. They are located in the aircraft's nose and can be serviced in the forward equipment bay

   c. They are located in conjunction with the landing lights installed on the main landing gear

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d. None of the above

8. **Which lights automatically light up when the avionics system powers up?**

   a. Strobe lights
   b. Recognition lights
   c. Landing lights
   d. Position lights

9. **If a position light fails how will the pilot know from inside the cockpit?**

   a. By seeing a reduced load on the electrical synoptic page on the MFD.
   b. A POSITION LIGHT FAIL CAS advisory message will appear
   c. The pilot will not know if a light fails with the exception of the exterior pre-flight inspection
   d. None of the above

10. **What is the purpose of the wing inspection light?**

    a. To make the aircraft's wing more conspicuous when flying in dense traffic
    b. To make preflight of the aircraft's boots easier when it is dark
    c. To inspect the wing for ice accretion while flying in conditions probable to icing
    d. None of the above

11. **What type of light is used for the wing inspection lighting system?**

    a. A halogen bulb
    b. A tightly packed group of LEDs
    c. A HID (High Intensity Discharge) lamp
    d. None of the above

12. **How can the aircraft's beacon be operated independently?**

    a. By moving the STROBE/BEACON switch to the BEACON position
    b. By pulling the ECBs for the strobes
    c. If the strobes are operating the beacon will also be operating and each lighting system cannot be operated independently
    d. The beacon is always operating whenever power is applied to the airplane

13. **How will the Taxi/Recognition lights appear in the air?**

    a. They will pulsate to provide a greater level of recognition in comparison to their steady-state operation on the ground
    b. While in the air they operate the same as they do on the ground
    c. The Taxi/Recognition lights do not function without weight on wheels (WOW)
    d. None of the above

14. **Which lighting systems will be load shed during battery only operation?**

    a. Beacon, anti-collision, left & right taxi, right landing, all optional lighting
    b. Ice inspection light & right landing light
    c. Only decorative interior lighting will be load shed
    d. None of the above

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13. Air Data

13.1 General

The Air Data System consists of four sub-systems: pitot/AOA, static, Outside Air Temperature (OAT) and Air Data Computer (ADC). The pitot/AOA system contains two heated pitot/AOA probes, with one installed on either side of the nose. Each probe has three openings into the free stream airflow: a central opening for pitot measurements, and two openings that provide AOA data.

The static system contains heated dual static ports, one installed on either side of the forward fuselage below the windshield and cross-connected (upper right cross-connected to the lower left static port) to compensate for the effects of aircraft yaw or sideslip. There is a third pitot/static probe that provides air data information to the MFD ADI and can be used by the pilot for comparison in the event of air data disagreement.

The air temperature system consists of two OAT probes, one mounted to the either side of the vertical stabilizer fairing. Each of the OAT probes contains two independent temperature sensors with connections to the Air Data Computer and the ACS.

Information from these probes is transmitted to an Air Data Computer where it is processed and made available to other systems as needed.

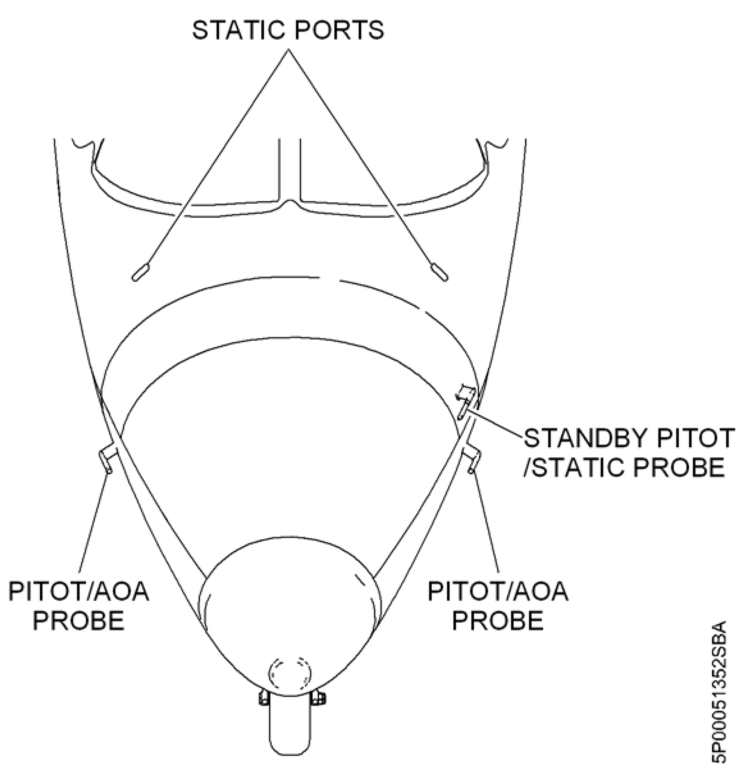

Figure 163. Pitot/AOA, Pitot/Static, and Static Ports

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13.2 Aircraft Computer System (ACS) Interfaces

The air data system is comprised of two Integrated Sensor Suites (left and right) that serve as the fourth of five major components of the integrated avionics. An Integrated Sensor Suite is further divided into three major components:

- Air Data Computers (ADC)
- Attitude Heading and Reference System (AHRS)
- Global Positioning System (GPS)

Information collected by the Integrated Sensor Suites is sent to three places within the airplane: both Aircraft Computer Systems (ACS') for comparison and failure monitoring, the Full-Authority Digital Engine Control Units (FADECs) for engine control and to the PFD's and MFD for display to the pilot.

A left and right Air Data computer, serve as the primary air data sources for the left and right PFDs. They are responsible for collecting inputs from the two dual static ports, two pitot/angle of attack probes, and two outside air temperature probes. The air data computers process this information and send it to the AHRS for distribution to the aircraft systems.

GPS information is collected by two GPS units and sent to the AHRS for distribution to the aircraft systems.

Two Attitude Heading and Reference Systems serve as the primary attitude and heading sources for the left and right PFD's as well as the MFD Attitude Indicator (ADI). The AHRS units use two magnetometers located in the horizontal stabilizer to collect, then provide attitude and magnetic heading information to the aircraft systems. A separate information processor within the AHRS unit serves to collect, combine if necessary and distribute information from the ADC, AHRS and GPS to the ACS', FADEC's and Pilot Displays for use.

A third, independent pitot/static probe is considered Air Data Computer three and provides pitot/static information directly to the ACS'. Air data information from ADC three is the solo air data source for the MFD Attitude Indicator (ADI).

There are two pieces of information that are returned to the Integrated Sensor Suites for correction purposes, these are:

1. RAIM (Radio Autonomous Integrity Monitoring) information to the GPS units
2. BARO (Altimeter Setting) correction to the Air Data Computers

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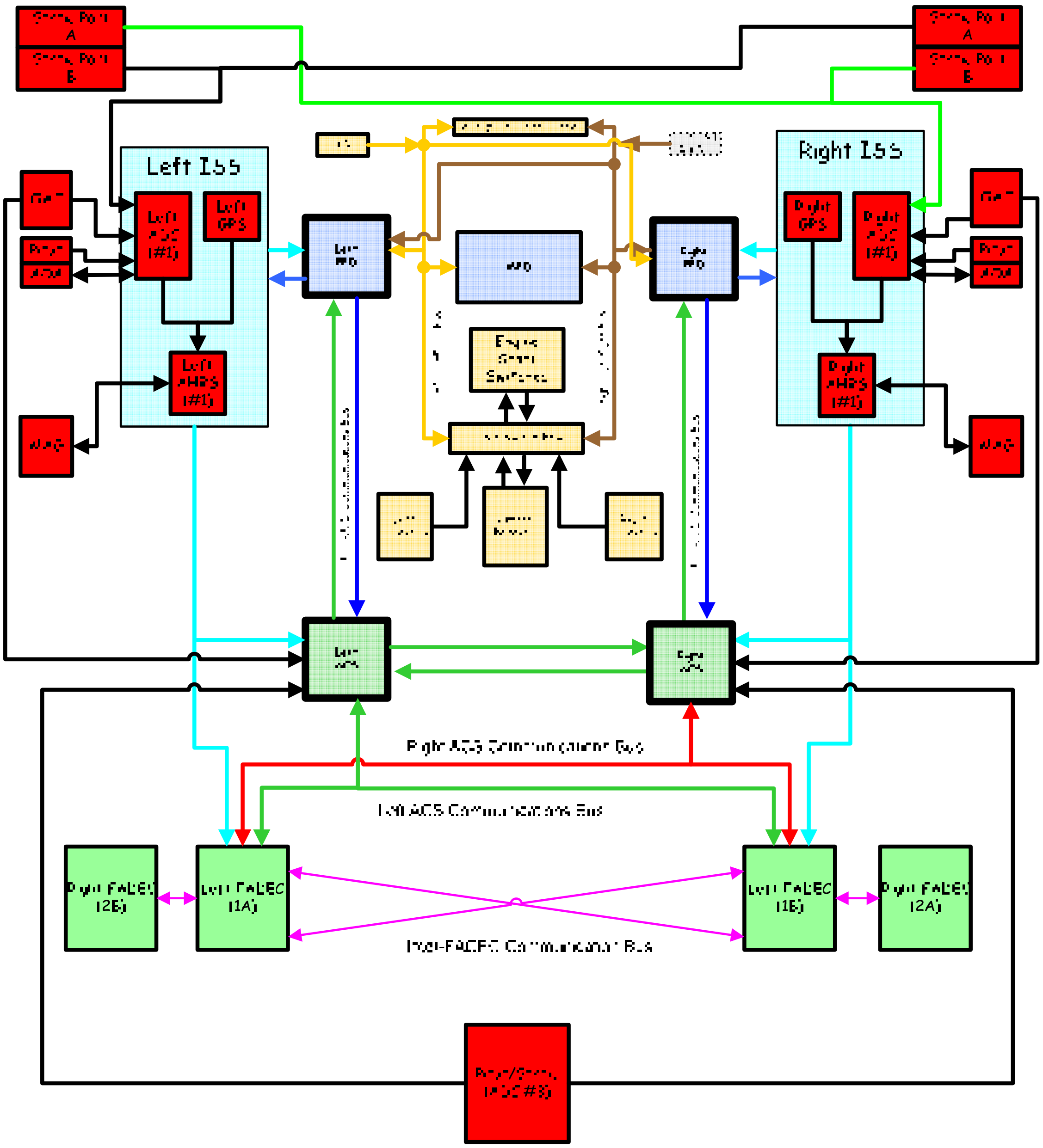

Figure 164. Air Data-ACS Interface

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13.3 Limitations and Specifications

13.3.1 Attitude and Heading Reference System (AHRS)

Operation at latitudes requiring direction indication referenced to true North are prohibited.

13.3.2 Air Data Computer 3 (ADC 3)

Following the loss of both ADCs 1 and 2, the use of ADC 3 is limited to airspeeds of 160 KEAS and below..

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13.4 System Description

13.4.1 Pitot/ AOA

Pitot pressure is transmitted through the pitot inlet of the pitot/AOA probe to the Air Data Computers located inside the forward pressure bulkhead. The Air Data Computers interpret the data provided, along with error corrections to present airspeed for display on the PFDs as well as total pressure for use by the FADEC and ACS.

Angle-of-attack is sensed by differential pressure transducers contained in the base of each pitot/AOA probe and transmitted to the Air Data Computer, where the data is processed and provided to the PFD, ACS, and FADECS.

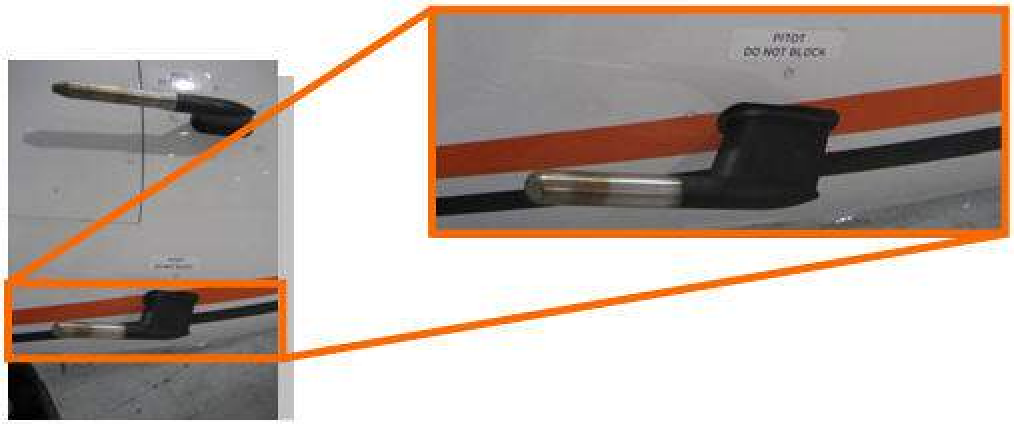

Figure 165. Pitot/AOA Probe- Left Side

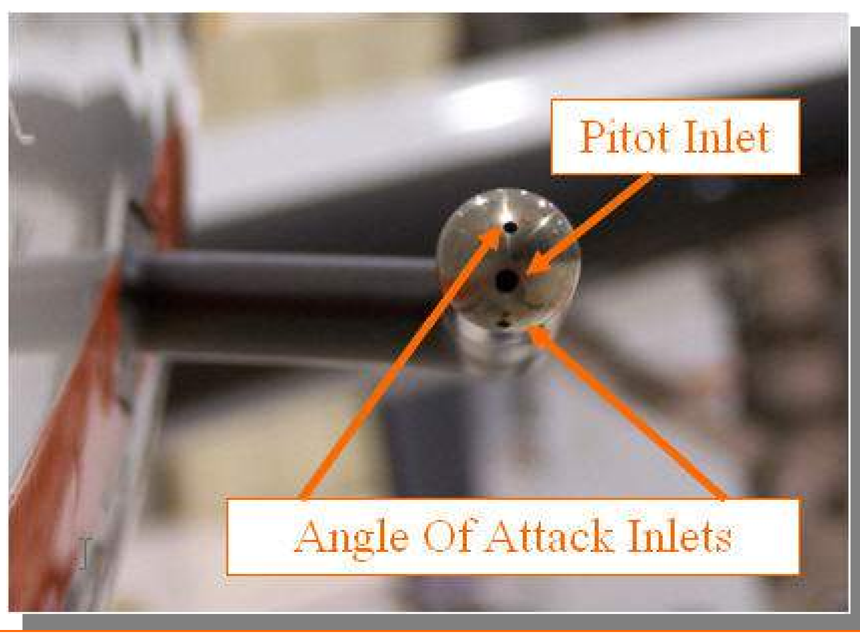

Figure 166. Pitot/AOA Inlet Locations

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13.4.2 Static Ports

A dual static port is mounted on either side of the forward fuselage. Static air pressure is transmitted to the Air Data Computers, where it is processed and provided to the PFDs for display. This information is also used by the FADECs, and processed by the ACS. The static ports are heated by dual internal heating elements that provide anti-ice protection.

Figure 167.   Dual Static Port- Left Side

13.4.3 Pitot / Static

An independent pitot/static probe provides information directly to the ACS for display on the MFD ADI. Information provided by this probe may also be used by the pilot in the event of a system abnormality or a disagreement between the primary probes.

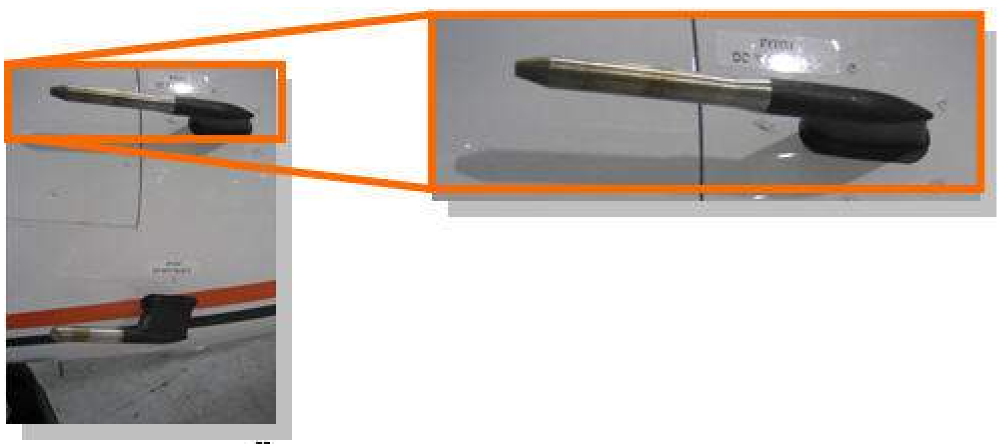

Figure 168.   Pitot Static Probe

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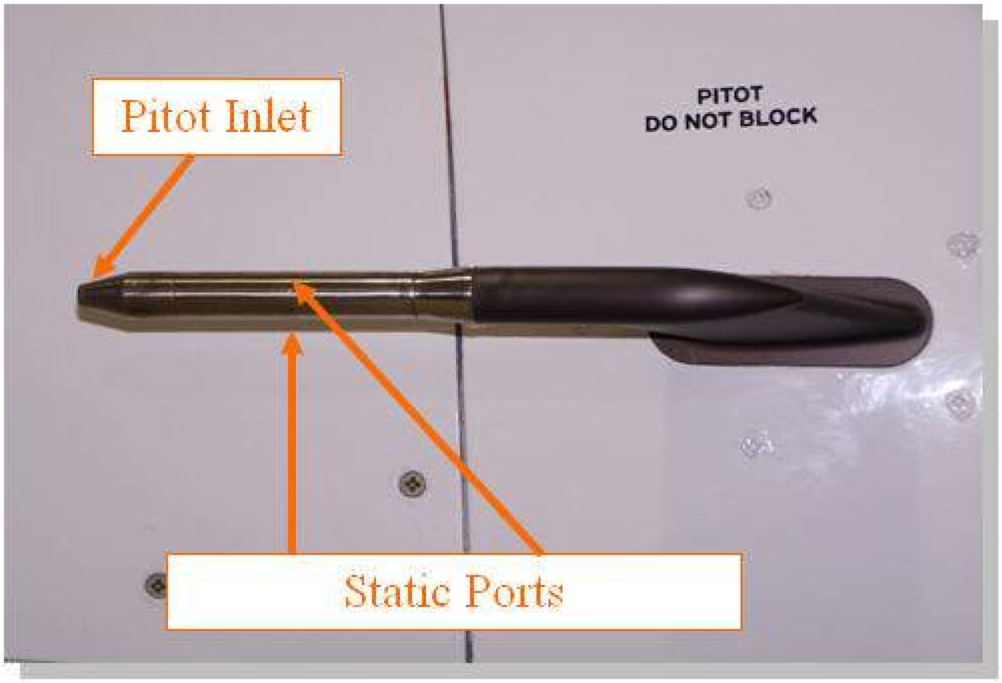

Figure 169. Pitot/Static Inlets

13.4.4 Probe and Port Heat

All pilot-static and AOA probes and ports are heated through self-regulating internal heating elements controlled by the ACS that provide anti-ice protection during cold weather or icing conditions. Pitot-Static system heat is manually controllable through the PITOT STAT line select key on the ICE protection synoptic page and is in AUTO for normal operations.

13.4.5 Outside Air Temperature (OAT)

Each OAT probe contains two independent sensors that provide information to the Air Data Computers and both ACSs. Both computer systems process the data provided and present OAT for display on the PFDs and Total Air Temperature (TAT) for use by the FADECs. The OAT sensors measure a temperature that requires a correction based on aircraft Mach number.

The OAT probes are located on the vertical stabilizer fairing and are outside of ice accretion areas and do not require heating for anti-icing protection.

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Figure 170. Left OAT Probe

13.4.6 Air Data Computers (ADC)

The Air Data Computers (ADC) are responsible for the intake and processing of all air data inputs. Pitot-Static, AOA, and OAT. Information is measured and calculated in the Air Data Computer. Information from the ADC's is transmitted to the Attitude and Heading Reference System (AHRS) where it is combined with other navigation data and sent to the ACS.

13.4.7 Integrated Sensor Suite (ISS)

There are two Suites on the aircraft. The ISS can be considered a grouping of three separate system components that work together to provide air data information to the ACS. An ISS is composed of the ADC, AHRS and GPS unit. Data from the ADC and GPS is sent to the AHRS where it is combined with the attitude and heading data which is then sent to the ACS. Information from the ISS is sent directly to the PFD for display, to the ACS for comparison and failure monitoring, and to the FADEC for engine control.

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13.5 Controls and Indicators

13.5.1 Sensor Selection

In the event that sensors disagree or on pilot preference, air data source selection is possible through the SENSOR synoptic on the MFD. Two line select keys allow selection of the AHRS and ADC information that is used by the PFDs. A BARO-SET line select key is also available for a secondary means of altimeter entry (primary source is the BARO SET knob on the Autopilot Control Panel).

LINE SELECT KEYS:

AHRS SRC
- AUTO .... AHRS automatically selected by ACS.
- 1 .... Left and Right PFD using Left (#1) AHRS.
- 2 .... Left and Right PFD using Right (#2) AHRS.

ADC SRC
- AUTO .... ADC automatically selected by ACS.
- 1 .... Left and Right PFD using Left (#1) ADC.
- 2 .... Left and Right PFD using Right (#2) ADC.

BARO-SET
Altimeter setting between 22.50 through 34.50 inches Hg entered using concentric knob on MFD. Pressing inner knob sets standard 29.92 in Hg

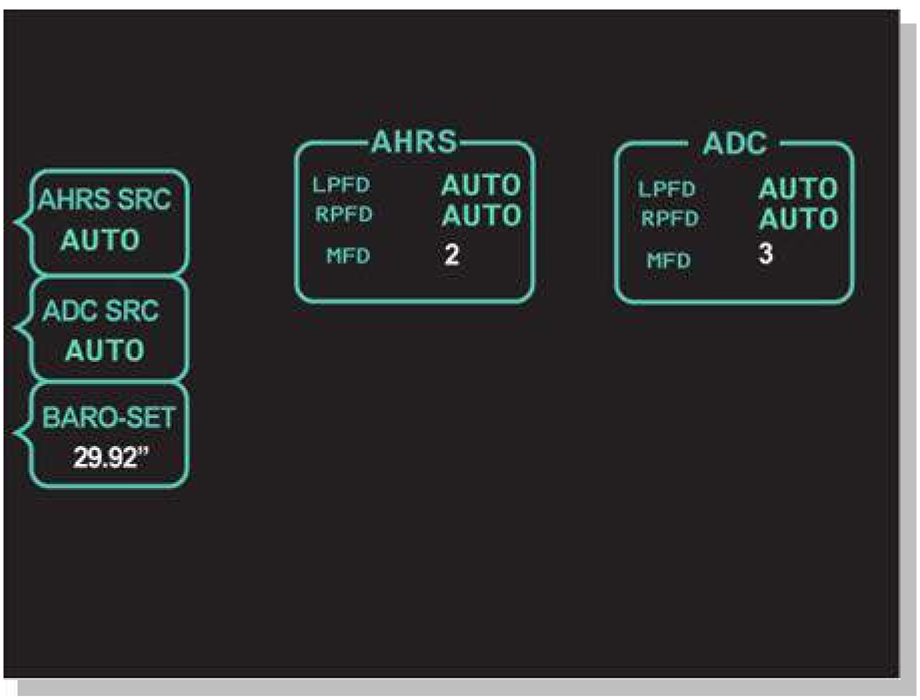

Figure 171. SENSOR Synoptic Page

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13.6 Normal Operations

The Air Data System requires no pilot action during normal operation. All pitot/static probes/ports are automatically heated. The ACS provides power to the probe and static port heaters when either of the engines is running or there is no weight on wheels.

Electrical control of the Air Data System is accomplished through the ACS. Power for each probe is provided by an Electronic Circuit Breakers (ECBs). Power for the pitot/AOA probe and static port heat are also provided by ECB's. In the event of failure of one ADC, the pilot is able to switch to the other air data source using the SENSOR synoptic page.

The pitot/AOA probes provide pressure to the ADC. The computers use pressure data from the pitot/AOA probes and static air pressure from the static ports to determine airspeed, Mach, and total pressure. The ADC uses air temperature from the OATs to determine airspeed, Mach, and air temperature, and present the data on the PFD. This information is also used by the ACS for comparison and failure monitoring and by the FADEC for engine control.

Angle-Of-Attack data is derived from the pitot/AOA probes and transmitted to the ADC where differential air pressure data is converted to angle-of-attack data. It is combined with other air data information and sent to the PFD and ACS for use by the stall protection system.

To determine aircraft altitude the ADC uses static air pressure data from the dual static ports to determine altitude and vertical speed. The ADC relays this information to the PFDs, ACS and FADECs.

OAT information is also transmitted to the ADC and ACS by two OAT probes located on the vertical stabilizer fairing. The air data computers interpret the data provided, and present temperature for display on the PFDs and MFDs. OAT information is also used by the ACS to provide the FADEC with Total Air Temperature (TAT) for engine control.

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13.7 Abnormal Procedures

13.7.1 Air Data Disagreement

If abnormal indications are generated by the ADC (i.e. airspeed, altitude, attitude, heading, and temperature) the incorrect source is flagged to the pilot via one of several DISAGREE caution and advisory messages and requires

DISAGREE CAS MESSAGES:

- ADC
  - AIRSPEED DISAGREE (Caution)
  - ALTITUDE DISAGREE (Caution)
- AHRS
  - ATTITUDE DISAGREE (Caution)
  - HEADING DISAGREE (Caution)
- Temperature
  - TAT DISAGREE (Advisory)

These messages require pilot action to compare air data in question with the other source(s) of information. Once a valid source is determined, the pilot selects the new source via the SENSOR page on the MFD. A TAT DISAGREE advisory message requires that the pilot view the ICE protection synoptic to compare temperature indications.

13.7.2 Sensor Failure

The air data system is a redundant design, preventing complete loss of air data in the event of a component failure. Should any component, ADC, AHRS, or GPS fail, one of the following messages will appear:

- AHRS 1 FAIL (CAUTION)
- AHRS 2 FAIL (CAUTION)
- ADC 1 FAIL (ADVISORY)
- ADC 2 FAIL (ADVISORY)
- ADC 3 FAIL (ADVISORY)
- GPS 1 FAIL (ADVISORY)
- GPS 2 FAIL (ADVISORY)

With ADC and AHRS SRC on the SENSOR page selected to AUTO, the ACS will automatically revert to using the operating source for air data information. Since all air data information is sent through the on-side AHRS to the ACS, should an AHRS fail with AUTO selected, the affected PFD will use the AHRS and ADC from the opposite side. Example: AHRS 1 fails; the Left PFD will use AHRS 2 and ADC 2.

CAUTION:

A failure of ADC 1, 2 or AHRS 1, 2 will reduce functionality such that flight in RVSM airspace may NOT be continued. The autopilot will also disengage and NOT be able to be reengaged.

There is no pilot control over GPS selection. In the event of a GPS failure, the ACS will automatically revert to the operating GPS.

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13.8 Crew Alerting System Messages

Table 35. Air Data CAS Messages

Message	Condition	Category
AHRS 1 (2) FAIL	AHRS 1 or 2 Failure- System will automatically revert to operating AHRS (unless equipped with optional third AHRS) in AUTO mode	Caution
AIRSPEED DISAGREE	Left and right airspeed disagree	Caution
ALTITUDE DISAGREE	Left and right altitude disagree	Caution
ATTITUDE DISAGREE	Left and right attitude disagree	Caution
HEADING DISAGREE	Left and right heading disagree	Caution
ADC 1 FAIL	ADC 1 Failure or AHRS 1 to ADC 1 communication is lost- System will automatically revert to operating ADC in AUTO mode	Advisory
ADC 2 FAIL	ADC 2 Failure or AHRS 2 to ADC 2 communication is lost- System will automatically revert to operating ADC in AUTO mode	Advisory
ADC 3 FAIL	Airspeed and altitude on the MFD ADI has been lost	Advisory
GPS 1 FAIL	GPS 1 Failure- System will automatically revert to operating GPS	Advisory
GPS 2 FAIL	GPS 2 Failure- System will automatically revert to operating GPS	Advisory
TAT DISAGREE	Left and right total air temperature disagree in flight	Advisory

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13.9 Air Data Review Questions

1. **List the three locations/aircraft components that receives air data information from the ISS', as well as what each destination component uses it for:**

   a.

   b.

   c.

2. **What data is sent BACK to the ISS' from the aircraft systems?**

3. **Where are the static ports located on the aircraft?**

   a. Dual static ports are located on either side of the aircraft nose.
   b. Dual static ports are located on each side of the empennage.
   c. A single static port is located behind each pitot/AOA probe.
   d. None of the above

4. **Where does the ADC get its angle of attack information?**

   a. From pitot/AOA probes located on the aircraft nose
   b. From the pitot/static probe only
   c. From the static ports
   d. No angle of attack information is used by the ADC

5. **What is the purpose of thepitot/static probe?**

   a. It is the only heated probe and thus provides pertinent data when ice is encountered

   b. Provides information to the ACS for use on the MFD ADI

   c. Can be used in the event of a system abnormality or disagreement between primary probes.

   d. Answers B & C are correct

6. **How are the probes and ports protected from ice?**

   a. Only the probe/static is electrically heated for ice protection.
   b. All probes and ports are heated by self-regulating internal heating elements
   c. Pneumatic bleed air is routed to the base of each port for ice protection
   d. None of the above

7. **Where are the OAT probes located?**

   a. Under the right-hand wing
   b. One is located on the nose and the other is located on the tail
   c. Along the top of the aft fuselage at the base of the vertical stabilizer fairing.

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d. None of the above

8. **What information is collected by the Air Data Computers?**

9. **What are the three primary items comprise an Integrated Sensor Suite?**

   a.

   b.

   c.

10. **In the event of a sensor disagreement, what can the pilot do to restore valid data to their PFD?**

    a. They can look at the cross-side PFD
    b. They can use the standby instruments on the MFD
    c. They can change the air data source on the SENSOR synoptic page
    d. All of the above

11. **With the air data sources set in the AUTO position what will happen in the event of a failure?**

    a. The pilot will be prompted by a CAS message that indicates the failed component

    b. The ACS will automatically select the operative source of air data

    c. None of the above

    d. A & B are correct

12. **Which air data components are load shed during single generator operation?**

    a. Left & Right Pitot/AOA heat, and Left & Right Static port heat
    b. Left side Pitot/AOA heat only
    c. Right side heat Pitot/AOA heat only
    d. None of the above

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14. Primary Flight Display (PFD)

14.1 General

The Primary Flight Display (PFD) operates in either a Normal Mode or Composite Mode. In Normal Mode, the PFD provides a traditional electronic flight instrument representation including Flight Mode Annunciations (FMAs), an Attitude Direction Indicator (ADI), Airspeed Indicator, Altimeter, Vertical Speed Indicator and Horizontal Situation Indicator including a moving map. The PFD also provides a Composite Mode in which, the PFD provides a reversionary capability showing additional aircraft systems information which can be used in the event of a Multi Function Display (MFD) failure.

Figure 172. Primary Flight Display (PFD)

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14.2 Limitations and Specifications

No content.

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14.3 System Description

14.3.1 Initialization

Figure 173. PFD Initialization

On initial power-up of the PFD, an initialization page displaying the version of Avio is presented. This information should be verified prior to flight.

14.3.2 Normal Mode

The PFD Normal Mode is organized into five tiled areas that are capable of displaying all necessary flight information. Several of these tiles are configurable and display the following information:

TILE 1
- Flight Mode Annunciation (FMA)

TILE 2
- Airspeed Indicator
- Attitude Direction Indicator (ADI)
- Slip Skid Indicator
- Flight Director
- Altimeter
- Approach Minimums Display
- Vertical Speed Indicator
- Marker Beacon Receiver

TILE 3 (CONFIGURABLE)
- Primary Navigation (NAV) selection
- Secondary Navigation (NAV) selection
- Range and view selection

TILE 4
- True Airspeed
- Outside Air Temperature (OAT)
- Time
- Horizontal Situation Indicator (HSI)
- Rate of Turn Indicator
- Wind Indicator
- Projected Track Indicator

TILE 5 (CONFIGURABLE)
- Active communication (COM) Frequency
- Communication frequency being monitored (MON)
- Heading pre-select display
- Communication (COM) radio tuning and selection
- Navigation (NAV) radio tuning and selection
- Transponder (XPDR) tuning and selection

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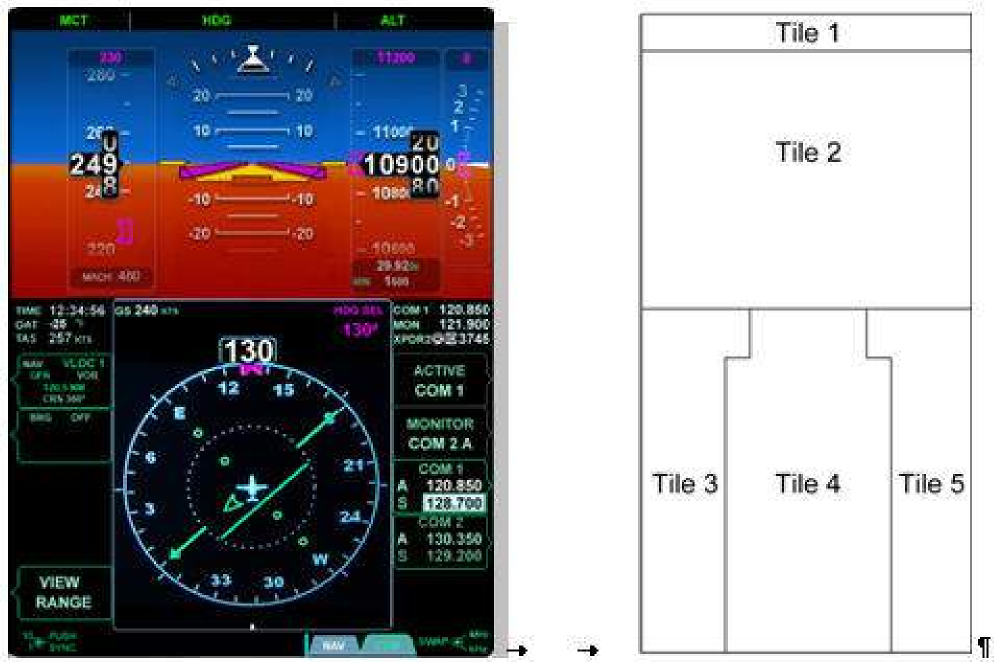

Figure 174. PFD Tile Layout

14.3.3 Tile 1 – Flight Mode Annunciation (FMA)

The FMA field displays active and armed Autothrottle, Lateral Navigation and Vertical Navigation mode annunciations received from the Autoflight system.

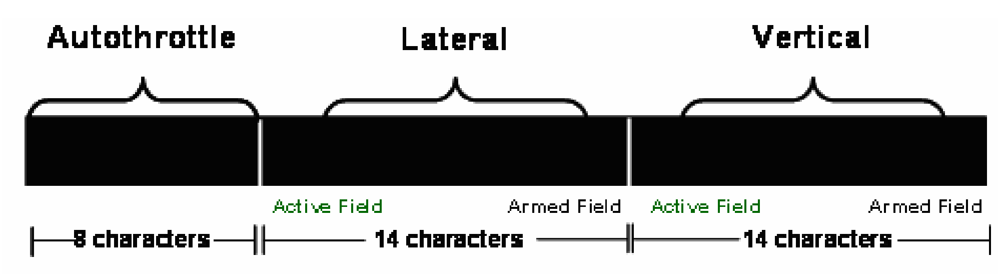

Figure 175. Flight Mode Annunciation Window

The lateral and vertical navigation mode sections of the FMA field are further subdivided into subfields for the Active (engaged) and Armed modes. The Autoflight displays only one active and one armed mode at a time for lateral and vertical control. If the system is reporting both an active and armed mode as valid for display the active mode appears to the left in green and the armed mode appears to the right in white.

Figure 176. Flight Mode Annunciation Example

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When an Autoflight system mode becomes the active engaged mode, the green text of the active mode pulses with variable intensity for three seconds and then becomes steady. The autothrottle system, if engaged by pilot, will manipulate the throttles automatically to hold the airspeed target during descents and cruise flight.

A complete list of flight mode annunciations is located in Appendix A of this document.

14.3.4 Tile 2 – Attitude Direction Indicator & Primary Flight Information

In Tile-2 the PFD continuously displays primary flight instruments of attitude, airspeed, altitude, and vertical speed. Tile 2 also displays flight director cues, autopilot targets, air data instrument trends, slip/skid, precision approach path deviations, mach, radar altitude, and barometric (BARO) correction. Air data instruments and other alphanumeric fields are overlaid on top of the attitude indicator Autoflight System Mode Depictions. The engagement state of the autopilot and yaw damper are presented outside of the FMA window in tile 2.

Figure 177.   PFD Tile 2- Attitude Direction Indicator & Primary Flight Information

NOTE:

A specific annunciation of autothrottle engagement state is not required since if engaged, by pilot action or automatically, text appears in the autothrottle portion of the Flight Mode Annunciation window.

AUTOPILOT ENGAGEMENT & DISENGAGEMENT

The control of the autopilot and display of its modes and status is contained within the system composed of the EFIS, autopilot servos, and control panels. If the autopilot is engaged, a green text AP appears in the upper left corner of tile 2, adjacent to the airspeed tape. When the yaw damper is engaged, green YD text is also displayed below the autopilot indication adjacent to the airspeed tape.

Figure 178. Autopilot & Yaw Damper Display - PFD

When the autopilot is disconnected, whether by the pilot, autopilot failure, or automatic disconnect, an amber AP DISC text appears on the PFD and an aural alert tone will sound to notify the flight crew of autopilot disengagement. This occurs during any phase of flight.

Figure 179. Autopilot Disconnect Annunciation

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AIRSPEED INDICATOR

The airspeed indicator consists of a scale, numerical labels, trend vector, reference markings, airspeed bugs, and Mach number display.

Figure 180.   Airspeed Indicator- PFD

- **Airspeed Tape**

  The airspeed indicator tape is displayed on the left portion of tile 2. The airspeed scale is displayed in Knots Equivalent Airspeed (KEAS), labeled every 20 knots, with a 60 knot rage continuously visible.   There are larger unlabeled tick marks every 10 knots. The current airspeed is a rolling digit presentation in the center of the scale displayed as a black filled airspeed window with white digits.

- **Mach Number**

The Mach number is displayed below the airspeed tape as a digital readout with up to three decimal places, no leading zeros. Mach is displayed with the Mach number is .450 or above and remains displayed until the Mach decreases to .400. If Mach number is not displayed, the graphical display disappears.

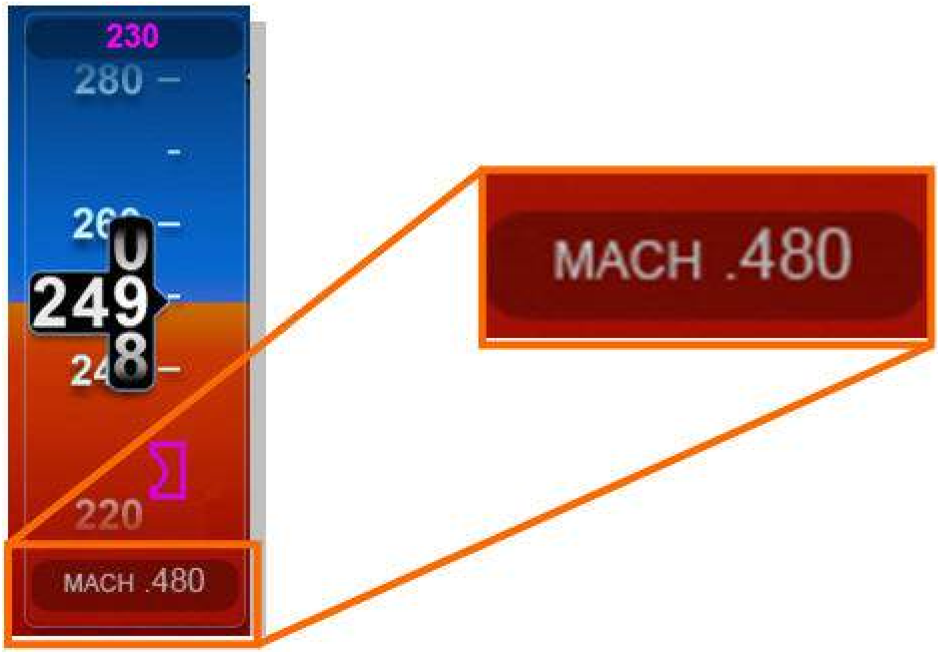

Figure 181.   Mach Indication

- **Trend Vector**

A blue airspeed trend vector is displayed slightly to the right of the current airspeed, such that it is not hidden behind the current airspeed window. This airspeed trend vector points at the airspeed scale at the predicted airspeed 6 seconds in the future based upon the airspeed change in the last 2 seconds.

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- **Airspeed Bug**

  A magenta target airspeed bug is displayed to the right side of the airspeed tape. The bug initializes at 10 knots and will initially appear as hollow. When the autopilot is engaged and in altitude change (ALT CHG) (Climb) mode, the bug is solid and indicates that a speed target is captured. When the SPD-SEL knob on the autopilot control panel is pressed, the target bug synchronizes to the current airspeed. The airspeed bug is solid only if being used by the flight director/autopilot to capture a preset speed. Once a speed is captured the bug becomes hollow.

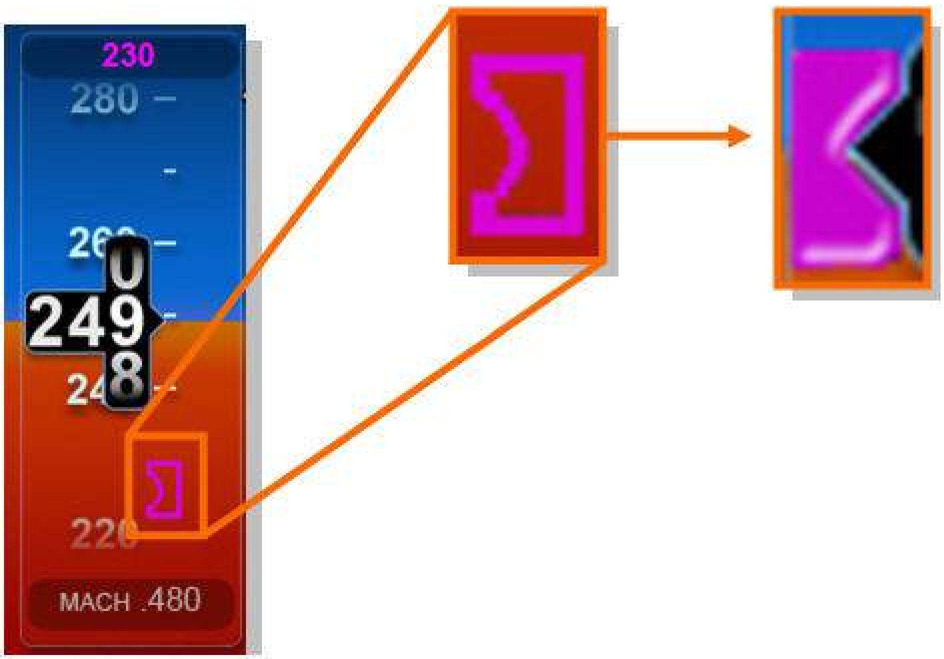

Figure 182. Airspeed Bug

- **V Speeds**

  Several V-speeds are displayed on the airspeed tape.

  — Rotation Speed- ROT
  Rotation speed is bugged with ROT text next to a single black tick mark on the airspeed tape when the appropriate speed is set in the OPS page on the MFD. ROT XX KTS is also displayed below in an outline window where the Mach display appears.

  — Takeoff Flap Extension Speed- T/O
  The maximum takeoff flap operation speed is bugged with T/O text next to a single black tick mark on the airspeed tape.

  — Landing Flap Extension Speed- LDG
  The maximum landing flap operation speed is bugged with LDG text and a single black tick mark on the airspeed tape.

  — Final Approach Reference Speed- REF
  The final approach reference speed is bugged with REF text next to a single black tick mark on the airspeed tape when the appropriate speed is set in the OPS page on the MFD.

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— Best Single Engine Climb Rate Speed- YSE
The best single engine climb rate speed, Vyse, is bugged with white YSE text next to a single cyan tick mark.

- **Airspeed Exceedance**

  The airspeed tape is displayed as a dashed line above V_{MO} or M_{MO} as long as there is no speed exceedance. If V_{MO} is exceeded, the airspeed tape is solid red and the airspeed display is red. If M_{MO} is exceeded, the airspeed tape is solid red and the Mach display is red.

Figure 183. Airspeed and Mach Exceedance

- Stall

  The airspeed tape is displayed as a red dashed line below the stall speed for the current configuration as long as the airspeed is above that speed. If the airspeed reaches the stall speed for the current configuration, the airspeed tape is solid red and the airspeed display is red.

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ATTITUDE DIRECTION INDICATOR (ADI)

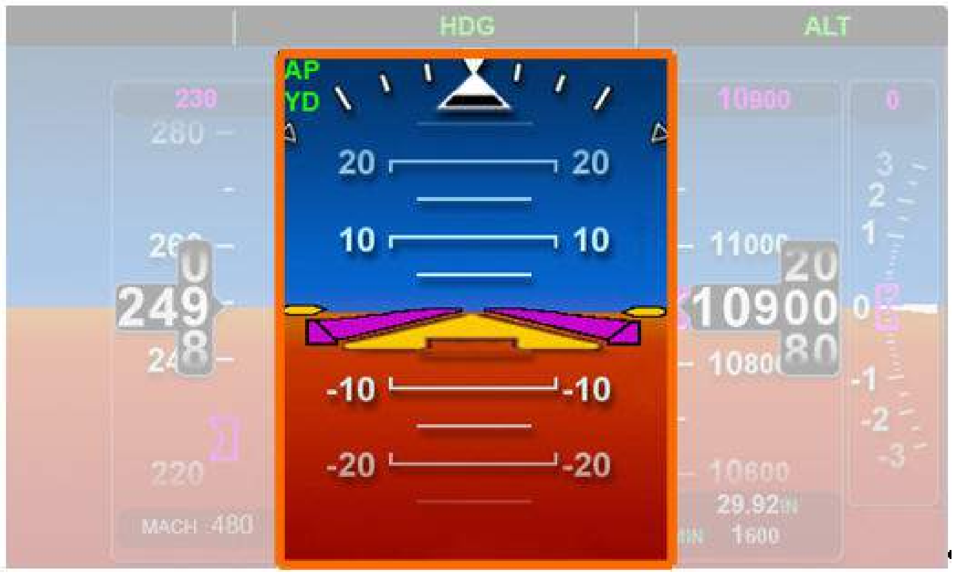

Figure 184.   Attitude Direction Indicator

The Attitude Direction Indicator (ADI) is located in the center portion of tile 2. It uses a traditional blue sky brown ground with a horizon line extending the width of Tile 2. The ADI also contains a pitch ladder, roll angle pointer/scale, and an amber wedge style attitude reference symbol. Flanking the attitude reference symbol are two amber horizon reference pointers, referred to as outriggers.

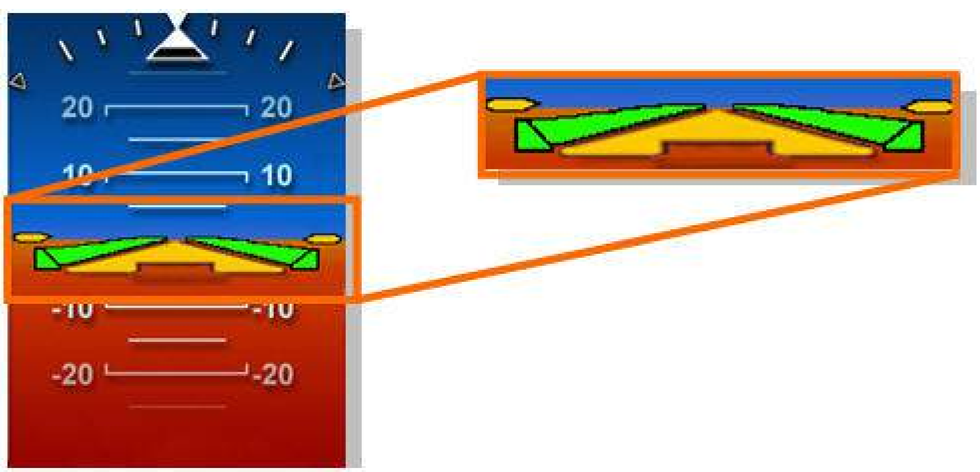

Figure 185.   Horizon Reference Pointers

- **Pitch**

The ADI is accurate for +/- 90˚ of pitch. The pitch display remains static over the range of 23˚ nose up to 23˚ nose down. Beyond +/- 23˚ a portion of the sky or a portion of the ground are always visible. At extreme pitch angles, angles greater than 50˚ pitch up and 30˚ nose down, a series of white chevrons point towards the horizon.

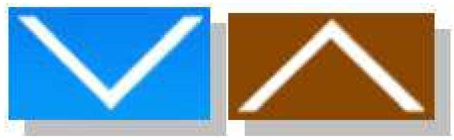

Figure 186. Pitch Chevrons

The pitch scale is displayed has horizontal labeled lines at 10˚, 20˚, 30˚, 40˚, 50˚, and 70˚, with unlabeled lines every 5˚. The right and left side of the larger increments have tick marks pointing either up or down towards the horizon. At 90˚ of pitch there is a small circular ring.

- **Roll**

Figure 187. Roll Indications

The ADI is accurate for +/- 180˚ of roll. The roll scale is displayed with black triangles at black triangles at 0˚, 45˚ left, and 45˚ right; large tick marks at 30˚ and 60˚ right and left and smaller tick marks at 10˚ and 20˚ right and left. Roll angle is displayed by a white triangular roll pointer that remains parallel with the airplane symbol (fixed at the top of the ADI).

NOTE:

The roll scale remains fixed at the top of the ADI while the roll pointer and the airplane symbol roll in parallel with the airplane.

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- **Slip/Skid Indicator**

Figure 188. Slip/Skid Indicator

The PFD displays a sailboat type slip/skid indicator. The trapezoid shape of the slip indicator moves horizontally in relation to the base of the roll pointer triangle to indicate uncoordinated flight (slip or skid). When the slip or skid of the aircraft is zero (coordinated flight), the trapezoid shape of the Slip indicator is centered horizontally in relation to the bottom of the roll pointer triangle.

- **Flight Director (FD)**

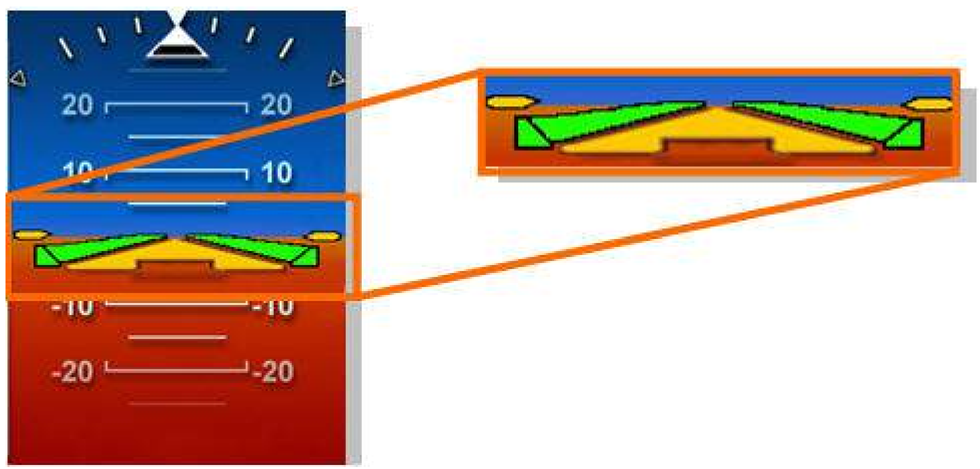

Figure 189. Flight Director

When active, the Flight Director (FD) is displayed in the center of the ADI on top of the pitch wedge. The FD provides simultaneous roll and pitch guidance. The FD moves vertically in line with the airplane reference symbol for pitch guidance, and rotates about its center for roll guidance. Pitch guidance is provided for +/- 15˚ and roll guidance is provided for +/- 30˚.

The FD automatically turns on when any autopilot mode is selected from the Autopilot Control Panel. The FD steering bars are displayed in green when the FD is engaged and the autopilot off. When the autopilot is activated the FD command bars turn magenta. Invalid flight director data will cause the flight director to be removed.

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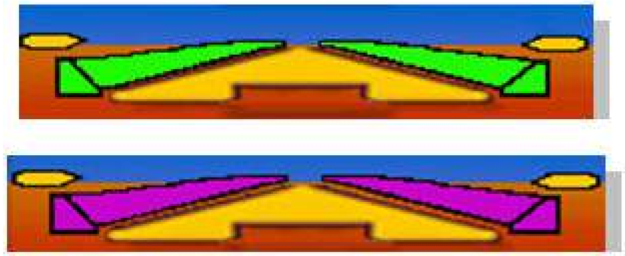

Figure 190. Flight Director Indications

- **Horizontal Deviation Indicator (HDI)**

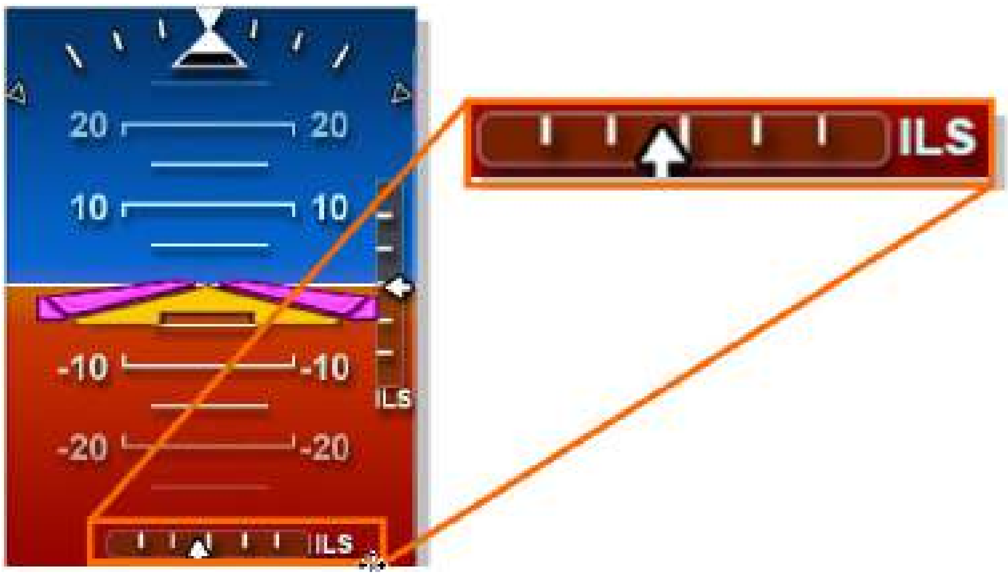

Figure 191. Horizontal Deviation Indicator (HDI)

The PFD displays a horizontal deviation indicator when VLOC1 or VLOC2 is tuned to and receiving a localizer frequency.

The HDI scale provides tick marks for zero deviation, half and full scale (left, right). The navigation source is displayed to the right of the HDI and will indicate ILS, LOC, BCRS (back course) or FMS. A white HDI pointer indicates course deviation; if the pointer exceeds full scale deviation, it turns amber.

Figure 192. Horizontal Deviation Indicator- Full Scale

If navigation signal is lost or invalid, the HDI pointer is removed, the associated text turns red and a red X covers the HDI.

Figure 193. Horizontal Deviation Indicator- Signal Loss

- **Vertical Deviation Indicator (VDI)**

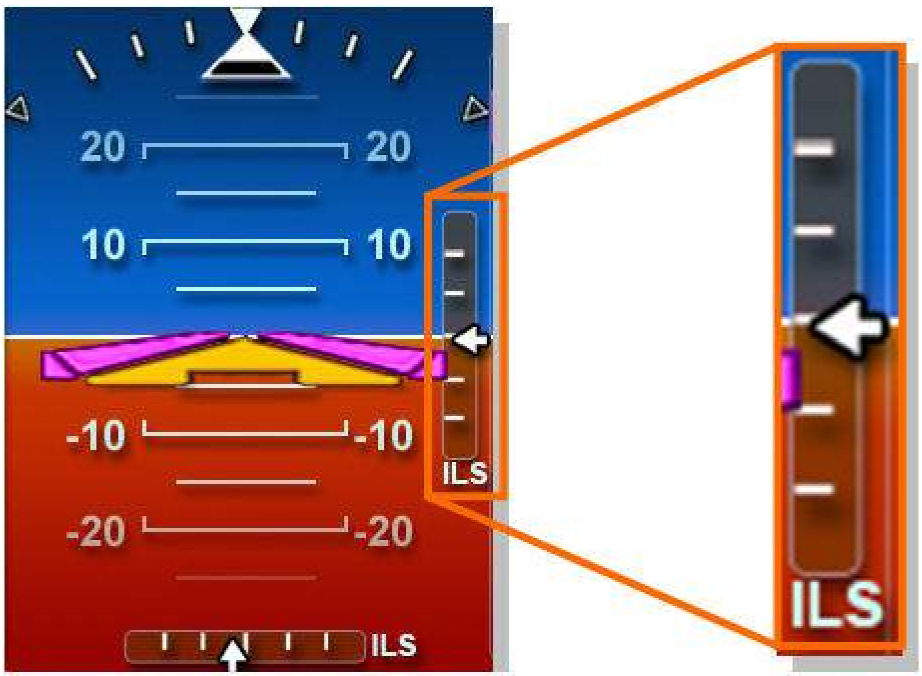

Figure 194. Vertical Deviation Indicator (VDI)

The PFD displays a vertical deviation (glide slope) indicator when VLOC1 or VLOC2 is tuned to and receiving a localizer frequency.

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The VDI scale provides tick marks for zero deviation, half and full scale (up, down). The navigation source is displayed to the below the VDI and will indicate either ILS or FMS. A white VDI pointer indicates course deviation; if the pointer exceeds full scale deviation, it turns amber.

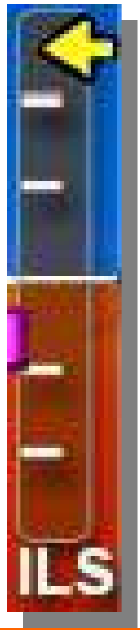

Figure 195. Vertical Deviation Indicator- Full Scale

If the PFD detects vertical deviation data as invalid or failed due to lost communications, without a change in VLOC frequency or a change in Primary Navigation source, the VDI pointer is removed, the associated text turns red and a red X that covers the VDI.

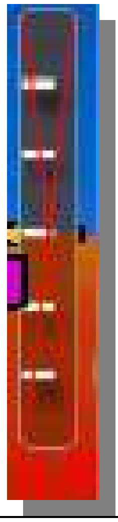

Figure 196. Vertical Deviation Indicator- Signal Loss

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- Marker Beacon Receiver

  A marker beacon display appears below the ADI, if an ILS or localizer is selected as the primary navigation source and/or if an ILS or localizer approach is loaded in the FMS. When activated, the marker beacon receiver sensitivity is automatically set to LO, the marker beacon audio is automatically turned on, and the following signals are detected and displayed:

  Outer Marker .... Blue display labeled "OM."

Figure 197. Outer Marker Display on PFD

  Middle Marker ....Amber display labeled "MM."

Figure 198. Middle Marker Display on PFD

  Inner Marker.. White display labeled "IM."

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Figure 199.   Inner Marker Display on PFD

If an ILS or localizer is not selected or an ILS or localizer approach is not loaded in the FMS, the marker beacon receiver sensitivity is automatically set to HI and the following signal is detected and displayed:

Airway Marker ....White display labeled “AM.”

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ALTIMETER

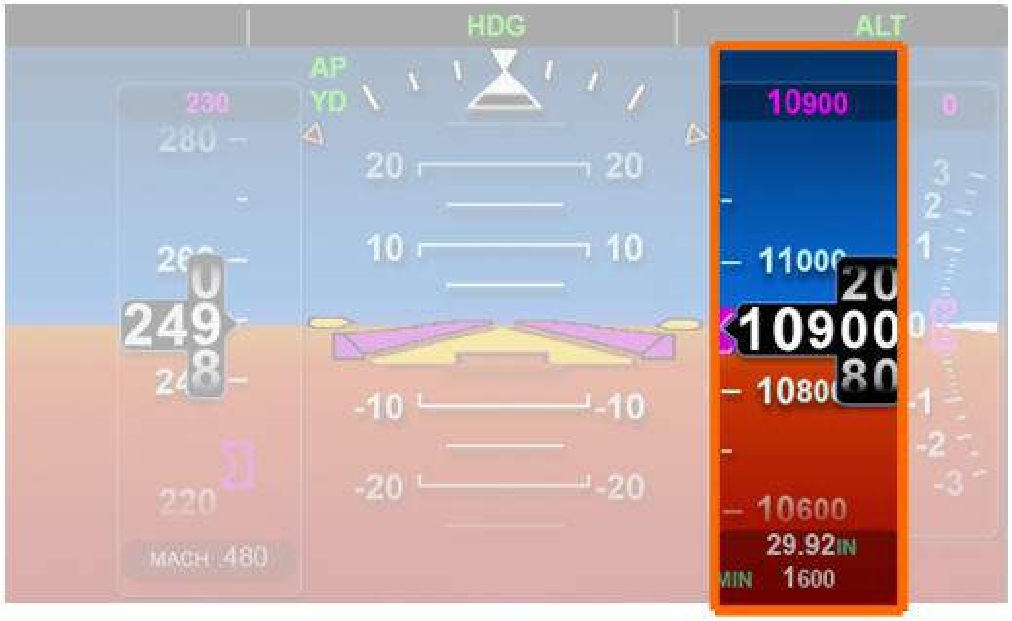

Figure 200.   Altimeter

- **Altitude Tape**

  The altimeter consists of an altitude tape, an altitude window, an altitude pre-select (bug), an altitude pre-select digital readout, an altitude trend vector, and a baro setting readout.

  The altitude in feet is displayed with labels every 200 feet and smaller unlabeled tick marks every 100 feet, with at least 600 feet of altitude visible at one time. The altitude scale moves relative to the fixed window to indicate baro corrected altitude. Relative motion of the altitude window with respect to the altimeter scale is up for increasing altitudes.   The altitude window contains the numeric value of the baro corrected altitude in 20 foot increments. The movement of the altitude scale lower limit is at -1,000' MSL and the upper limit is at 50,000' MSL.

- **Trend Vector**

  The altimeter also displays a trend vector when altitude is changing at rates above 300 fpm. The altitude trend vector is drawn under the altitude pointer such that it is completely hidden at low rates of altitude change.

Figure 201.   Altimeter Trend Vector

- **Altitude Bug**

  A magenta target altitude bug is displayed to the left side of the tape.   When the flight director/autopilot is engaged the target indicates what altitude has been selected for capture. When the ALT-SEL knob on the autopilot control panel is

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pressed, the target bug synchronizes to the current altitude. The altitude bug is solid only if being used by the flight director/autopilot to capture a preset altitude. Once an altitude is captured the bug becomes hollow.

- **Approaching Minimums Message**

  Within 1000 feet of the pre-selected altitude, white APPROACHING SEL ALT text appears inside the altitude pre-select window. In addition, there is also an approaching minimums aural alert that occurs within to 50 feet of the selected altitude..

- **Altitude Deviation Message**

  For RVSM protection a deviation indicator is provided at the top of the altitude tape. Should current altitude deviate more than +/- 200 feet from the pre-selected altitude amber ALTITUDE DEVIATION text appears inside the altitude pre-select window and an altitude alert aural sounds.

- **Invalid Data**

  The PFD can detect invalid altitude data reported from the Air Data Computer. When pressure altitude is determined to be invalid, the PFD removes the altitude window (with value), the altitude trend vector; the altitude scale, the altitude bug/numeric value, and displays a red "X" covering the area where the altitude scale was.

- **Baro Set (Altimeter Setting)**

  The upper portion of a data block located below the altitude tape displays barometric pressure setting. Setting the barometric altimeter setting is accomplished using the BARO SET knob on the autopilot control panel or through the BARO-SET line select key on the SENSOR synoptic page. Pushing the BARO SET knob on the autopilot control panel resets the altimeter setting to 29.92. The BARO set value is restricted to a minimum value of 28.00 in Hg and a maximum value of 31.00 in Hg.

- **Approach Minimums Display**

  An approach minimums display is located in the lower portion of the data block below the altitude tape. The minimum value entered under the NAV frequency page on the PFD is displayed in the data block and an amber tick mark will appear on the altitude tape. Within 100 feet for the set minimums an aural alert, “APPROACHING MINIMUMS” is sounded.

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VERTICAL SPEED INDICATOR

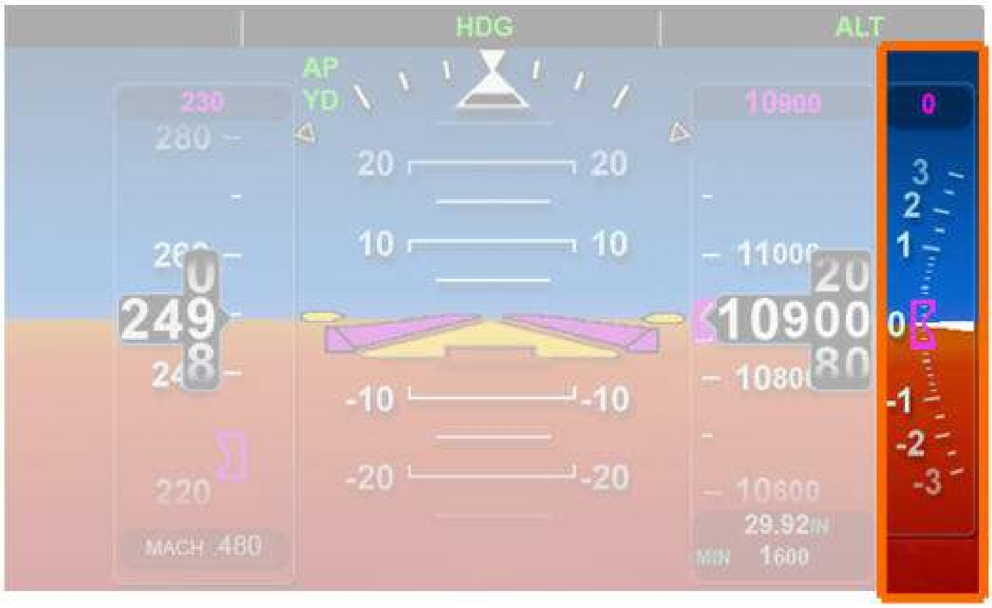

Figure 202.   Vertical Speed Indicator

- **Vertical Speed Tape**

  The Vertical Speed Indicator (VSI) is located to the right of the altimeter and displays vertical speed between -3000 fpm to +3000 fpm. The vertical speed scale has major tick marks labeled at +/- 1000, 2000 and 3000 fpm and small unlabeled tick marks every 100 feet up to +/- 1000 fpm. After +/- 1000 fpm intermediate tick marks are located at 500 fpm (ex. 2500 fpm)

- **High Vertical Speeds**

  The digital value of vertical speed is displayed when the vertical speed exceeds +/- 3000 fpm and is rounded to the nearest 100 fpm for values greater than or equal to ±3000 fpm. When the autopilot is in altitude change (ALT CHG) mode a green diamond indicates the vertical speed target used when this mode is engaged.

- **Vertical Speed Bug**

  A magenta target vertical speed bug is displayed in the middle of the tape. When the autopilot is selected to ALT CHG mode in a descent, the vertical speed bug turns solid magenta until the target vertical speed is reached, the bug then becomes hollow. Vertical speed is selected with a roller wheel on the autopilot control panel.

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- **Radar Altimeter**

  An optional radar altimeter provides information on the aircraft's absolute aircraft altitude. The absolute altitude value is displayed below the vertical speed tape.

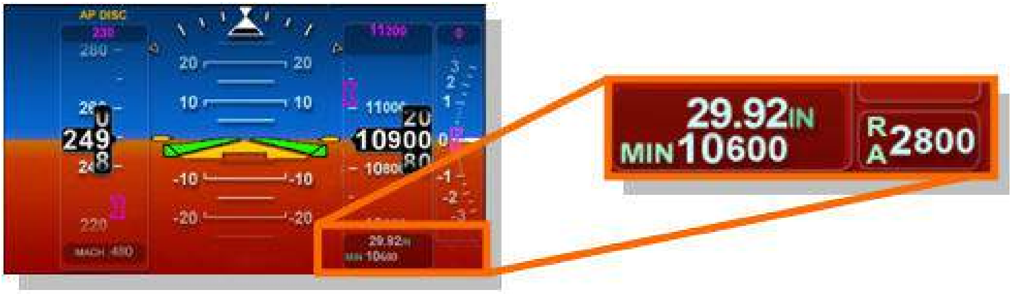

Figure 203.   Radar Altimeter

14.3.5 Tile 3 – Primary, Secondary NAV Source Selection, Data block and Left Line Select Keys

Figure 204. PFD Tile 3- Line Select Key Options

TILE 3 DATA BLOCK

Figure 205. Tile 3 Data Block

- **Time**

  Time is displayed on the upper portion of the data block in HH:MM:SS. The clock is automatically set by the GPS; however it is capable of being selected to 12 or 24 hour format, as well as to local or UTC (Zulu) time on the SETUP synoptic page.

- **Outside Air Temperature (OAT)**

  The OAT is displayed as an integer of up to three digits with no leading zeros. The units for temperature are in degrees C or degrees F based upon pilot preference selection on the SETUP synoptic page.

- **True Airspeed (TAS)**

  The true airspeed is displayed as a whole number of up to three digits.

- **Ground Speed (GS)**

  The ground speed between 0 and 999 kts is displayed as a whole number of up to three digits and includes a label "GS" to the left of the ground speed value and a label "KTS" to the right.

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■ Line Select Keys and Concentric Knob (LEFT)

Left-side line select keys provide selection of navigational sources for the HSI course pointer / D-bar and RMI pointers. Line select key five provides various view and range options for Tile 4 data overlay using the left concentric knob.

Line Select Key 1,
NAV

Primary NAV source select .... VLOC 1
VLOC 2
FMS
OFF

Line Select Key 2,
BRG

Secondary NAV source select .... VLOC 1
VLOC 2
FMS
OFF

Line Select Key 3
NO FUNCTION

Line Select Key 4
NO FUNCTION

Line Select Key 5
View/Range .... Pressing View Range allows use of left concentric knob to select range and view.

Concentric Knob (LEFT)
Inner Knob .... When VIEW/RANGE is selected, pressing the inner knob changes HSI view from full to 120° arc.

Outer Knob .... When VIEW/RANGE is selected, rotating the outer knob changes the NM value of the inner and outer range rings on the HSI.

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14.3.6 Tile 4 – Horizontal Situation Indicator (HSI) and Overlays

Figure 206. PFD Tile 4- HSI

The HSI is located in PFD Tile 4 and it displays a standard HSI format with aircraft heading, selected heading, selected course, bearing to waypoint (or station), course deviation, flight plan, to/from, distance to waypoint and wind magnitude/direction.

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COMPASS ROSE

The 360° compass rose consists of a selectable compass rose scale and aircraft symbol and is selectable to a full or forward looking display. Compass headings are displayed with two digits, having no leading zeros (ex. 03 for 30 degrees) through the use of the VIEW/RANGE line select key and left concentric knob.

Figure 207. View/Range Selection

- **View**

  With the full compass view, 360° with N, S, E, W cardinal headings displayed, the aircraft symbol is located at the center of the full compass rose scale. Major graduation marks are located every 10 degrees, beginning at North. It displays numeric labels for non-cardinal headings every 30 degrees starting from North and displays N, E, S, or W for the appropriate cardinal headings.

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Figure 208. 360 Degree Compass View

The forward-looking arc compass rose scale depicts 120 degrees and maintains the same graduation scale as the full view. The wing/fuselage intersection of the aircraft symbol is at the radial center of the forward-looking arc compass rose scale and points towards the top of the screen.

Figure 209. 120 Degree Arc View

- **HSI Map Range (NM)**

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While using the GPS moving map, two range rings are located on the HSI and are selectable to several ranges. Range selection for both the inner and outer ring is controlled by pressing the VIEW/RANGE line select key and rotating the inner portion of the left concentric knob. Rotating the knob left decreases range, while rotating the knob right increases range. The current range selection in NM is displayed on the upper right portion of the rings. Range is selectable to the following distances:

		Distance (nm)						
Inner Ring	1	2.5	5	10	20	40	80	120
Outer Ring	2	5	10	20	40	80	160	240

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- **Heading Window**

  The current aircraft magnetic heading is displayed in a window at the top of the HSI. When the EFIS is powered up current aircraft is displayed.

Figure 210. Heading Window

- **Heading Bug**

  A magenta target heading bug is displayed along the outer edge of the compass rose. At start-up, the heading bug synchs to current aircraft heading. Heading bug position is controlled by the HDG SEL knob on the Autopilot Control Panel and associated pre-select information is displayed in the heading pre-select window, located in the upper right portion of the HSI display. One knob click is equal to +/-1 degree, however scrolling the HDG SEL knob quickly will cause an accelerate function to rapidly rotate the heading bug. Pressing the HDG-SEL knob synchs the heading bug to the current aircraft heading. The heading bug is solid only if being used by the flight director/autopilot to capture a preset heading. The heading bug remains solid while in heading mode.

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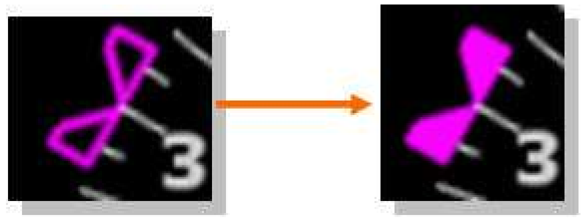

Figure 211. Heading Bug

- **Projected Track Indicator**

  The projected track indicator based off of ground track information from the GPS is located on the upper portion of the HSI. The indicator consists of a track pointer and track line and moves relative to the compass rose scale to indicate the magnetic track angle. It starts at the center of the compass rose scale and ends at the tip of the track pointer.

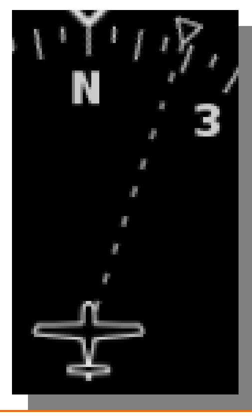

Figure 212. Projected Track Indicator

- **Course Deviation Indicator (CDI)**

  The CDI consists of a CDI needle, a TO/FROM indicator, and a deviation scale and corresponds with the NAV line select key on the PFD. The CDI arrowhead points to the current selected course on the HSI compass rose to the current selected course of the primary navigation source.

- **Course Selection**

  Course is selected with the left concentric knob and is displayed as course, (CRS) in the NAV line select key window. Rotating the outer portion of the knob changes the selected course in 10 degree increments, while rotating the inner knob changes the selected course in 1 degree increments. With a navigation frequency tuned and identified, pressing the left concentric knob centers the course with a TO indication. Pressing the knob without a navigation frequency tuned and identified, synchs the course selection arrow with current aircraft heading.

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Figure 213. Course Selection

- **Indications & Loss of Signal**

  The CDI moves relative to the course selection arrow to indicate course deviation. When the course deviation is zero, the CDI is green and aligned with the rest of the course selection arrow, centered on the horizontal scale. When the intended course is to the left or right of the current aircraft position, the CDI displaces accordingly. If the deviation is greater than full scale, the deviation bar turns amber. If navigation signal is interrupted or intermittent, the TO/FROM flag and the needle disappear.

- **Scale**

  VOR — When a VOR station is selected as primary navigation source, the CDI indicates the course deviation in degrees with a full scale of range of 10 degrees left or right.

  Localizer — When a localizer is the primary navigation source, the CDI indicates localizer deviation in degrees with a full scale range of 2.5 degrees left or right.

  FMS — When the FMS is the primary navigation reference full scale deflection is dependent upon the current navigation mode.

Navigation Mode	Full Scale Deflection
Enroute	5.0 nm
Terminal	1.0 nm
Approach	0.3 nm

  The “TO/FROM” indicator for VOR navigation is a single arrowhead located in the center of the HSI. The arrowhead points TO the station if the bearing to the station differs from the selected course by less than 90 degrees, and points FROM the station when the bearing to the station differs from the selected course by more than 90 degrees.

- Radio Magnetic Indicator (RMI)

  The blue dual-line bearing pointer corresponds to the BRG line select key on the PFD. When selected to an FMS or VLOC frequency, the RMI arrowhead points to the current selected course of the primary navigation source. The bearing pointer is not displayed if the VLOC source is tuned to an ILS or LOC station.

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14.3.7 Tile 5 –Communication, Navigation, Surveillance Display, Data Block and Right Line Select Keys

Figure 214. Tile 5- Communication, Navigation, Surveillance

TILE 5 DATA BLOCK

Figure 215. Tile 5 Data Block

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HEADING PRE-SELECT WINDOW (HDG SEL)

- **COM (Communication)**

  The COM field displays the active radio frequency and source. This can either be COM 1 or COM 2. When the microphone key on the sidestick is pressed a TX symbol appears next to the COM field to indicate that the radio is transmitting.

- **MON (Monitor)**

  The MON field displays the radio frequency that is selected for monitoring. This field will only be displayed if a frequency is selected by the MONITOR line select key under the COM page on the PFD.

- **XPDR (Transponder)**

  The transponder field displays the active transponder, code, and status information. Status information includes an ID text when the transponder is selected to IDENT, as well as an R indicating that the transponder is being interrogated by ground-based radar.

- **Line Select Keys and Concentric Knob (RIGHT)**

  Five line select keys provide selection of communication and navigation and transponder sources, frequency and transponder code entry, as well as a monitoring feature. Pilot control of these inputs is provided through three PFD pages (COM, NAV, XPDR) that are selectable through a rocker key below line select key five. The COM page is the default page on the PFD. If another page is selected, it will automatically revert to the COM page in approximately 10 seconds.

- **COM Page Line Select Key Options**

Line Select Key 1 (R1),
ACTIVE
Active Communication Source .... COM 1
COM 2

Line Select Key 2 (R2),
MONITOR (Active - A, Standby - S)
Communication frequency monitor selection .... COM 1 A
COM 1 S
COM 2 A
COM 2 S

NOTE:
It is not possible to monitor ACTIVE COM frequency

Line Select Key 3 (R3),
COM 1 (Active- A, Standby- S)
Communication 1 Radio Selection .... Active Frequency
Standby Frequency

Line Select Key 4 (R4),
COM 2 (Active- A, Standby- S)
Communication 2 Radio Selection .... Active Frequency
Standby Frequency

Line Select Key 5 (R5)
NO FUNCTION

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Concentric Knob (RIGHT)

Inner Knob....................kHz/SWAP

With a COM frequency highlighted, rotating the inner knob changes the kHz (three digits right of the decimal point) portion of the communication frequency. Pressing the inner knob with COM 1 or COM 2 line select keys active, swaps standby and active frequencies.

Outer Knob....................MHz

With a COM frequency highlighted, rotating the outer knob changes the MHz portion (three digits left of the decimal point) of the communication frequency.

- **NAV Page Line Select Key Options**

Line Select Key 1 (R1),
MINIMUMS

Entry of altitude minimums in FT MSL............Set using right concentric knob

Line Select Key 2 (R2),
MONITOR (Active- A, Standby- S)

Navigation frequency monitor selection....................NAV 1 A
NAV 1 S
NAV 2 A
NAV 2 S

Line Select Key 3 (R3)
NAV 1 (Active- A, Standby- S)

Navigation 1 Radio Selection....................Active Frequency
Standby Frequency

Line Select Key 4 (R4),
NAV 2 (Active- A, Standby- S)

Navigation 2 Radio Selection....................Active Frequency
Standby Frequency

Line Select Key 5 (R5)

NO FUNCTION

Concentric Knob (RIGHT)

Inner Knob....................kHz/SWAP

With a NAV frequency highlighted, rotating the inner knob changes the kHz portion (two digits right of the decimal point) of the communication frequency. Pressing the inner knob with NAV 1 or NAV 2 line select keys active, swaps standby and active frequencies.

Outer Knob....................MHz

With a NAV frequency highlighted, rotating the outer knob changes the MHz portion (three digits left of the decimal point) of the communication frequency

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- **XPDR Page Line Select Key Options**

Line Select Key 1 (R1),
ACTIVE
Active Transponder (XPDR) Source ....XPDR 1
XPDR 2

Line Select Key 2 (R2),
CODE
Transponder Code Entry Field .... Set using right concentric knob

Line Select` Key 3 (R3),
MODE

Transponder mode selection.. GND (Ground)
SBY (Standby)

NOTE:
In both GND and SBY, the transponder will transition to altitude reporting with weight-off-wheels, following takeoff and automatically transition back to GND following touchdown

Line Select Key 4 (R4), VFR
VFR Transponder Code Selection .. Pressing this line select key automatically changes transponder CODE to 1200

Line Select Key 5 (R5)
NO FUNCTION

Concentric Knob (RIGHT)
Inner Knob... CODE entry
When the CODE line select field is highlighted, rotating the inner knob changes the individual digits within the transponder code.

Outer Knob.. CODE entry
When the CODE line select field is highlighted, rotating the outer knob moves the cursor between digits within the transponder code.

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14.4 Normal Operations

14.4.1 Communication, Navigation and Surveillance (CNS)

GENERAL

The Communication, Navigation, Surveillance system is generally referred to as the Radio System and individual equipment is referred to as radios. The Radio System is controlled primarily through the PFD and keyboard inputs as well as the MFD. The PFD and keyboard are used to control common functions such as source selection and frequency entry, while the MFD is used primarily for audio control. Master volume control for a crewmember is located on the PFD as a knob above right line select key 1, as well as a volume knob on the keyboard. Volume control for each individual audio source is located on the MFD AUDIO synoptic page.   All CNSand Audio control and display capabilities are available on the PFD and MFD. Some alternative input methods are available via the keyboard.

Three radio pages are available, selected with the right rocker key below right line select key 5. The rocker key is used to select the desired tab at the bottom right of the PFD.

- COM
- NAV
- XPDR

When COM is selected, two communication (COM) radios are controlled with the right side line select keys and the right concentric knob at the bottom of the PFD. Two frequencies—Active (A) and Standby (S)—are displayed for each COM radio.

When NAV is selected, two navigation (NAV) radios are controlled with the right side line select keys and the right concentric knob at the bottom of the PFD. Two frequencies—Active (A) and Standby (S)—are displayed for each NAV radio.

The navigation course on the HSI is selected with the left concentric knob on the bottom of the PFD.

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COM RADIOS

- **COM Radio Selection**

  The active COM radio is selected with the ACTIVE line select key; pressing the line select key swaps between COM 1 and COM 2. Only one COM radio can be used for transmission at one time and the selected radio is automatically monitored. If the audio output volume for the selected radio is below 25%, the volume is automatically set to the 25% level.

Figure 216. COM Radio Tuning

- **COM Radio Tuning**

1. Select COM page using the rocker key.
2. Only a standby (S) frequency can be tuned.
3. Press right line select key 3 to tune the standby frequency for COM 1, or right line select key 4 to tune the standby frequency for COM 2.
4. Tune the standby frequency by using the right concentric knob. Rotating the outer portion of the concentric knob bi-directionally scrolls through the range 118 to 136 MHz in 1 MHz increments. Rotating the inner portion of the concentric knob bi-directionally scrolls through the range 0 to 975 KHz in 25 KHz increments.
5. Pressing the inner portion of the knob swaps the active and standby frequencies.

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The COM radios can also be tuned and selected using the keyboard.

1. Press COM 1 or COM 2 on the keyboard.
2. Enter the desired frequency in the form xxx.yyy.

NOTE:

For cardinal frequencies, the decimal point and digits after the decimal point are optional.

Optional digits not entered by the pilots are automatically entered. For example, for 25 KHz spacing, if the 2nd digit after the decimal point is 2, the 3rd digit (5) is automatically entered.

3. Press ENTER. This tunes the standby frequency. To make it active, press the SWAP key on the keyboard or do so by pressing the inner portion of the right concentric knob on the PFD with the appropriate COM window selected.

- **Com Radio Monitor**

In addition to the transmit radio, one additional COM radio can be monitored with right line select key 2. Pressing the MONITOR line select key allows monitoring of:

— COM 1 Standby (S)
— COM 1 Active (A)
— COM 2 Standby (S)
— COM 2 Active (A)
— OFF

NOTE:

The ACTIVE COM radio cannot be monitored.

The monitor feature is independent of the other PFD; this allows a multi-pilot crew to monitor different frequencies simultaneously.

Frequency monitoring is also available on the keyboard by pressing the MONITOR key to swap through frequencies in the MONITOR line select window.

- **Volume and Squelch**

Pilot volume and squelch control is available through a single rotary knob located on the upper right portion of the PFD. Rotating the knob left or right decreases or increases pilot audio volume. Pressing the knob activates squelch control and rotating the knob left or right decreases or increases pilot squelch.

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NAV RADIOS

- **Primary Navigation Source Selection**

  The primary navigation reference is continuously displayed under the left side line select key 1 and drives the green CDI pointer. Available selections are: OFF, VLOC1, VLOC2 or FMS.

- **VLOC Selections**

  When a navigation source is selected to VLOC 1 or VLOC 2 for use in the primary line select key window, VLOC 1, VLOC 2 text appears to the right of the NAV text. The appropriate frequency and type of navaid (VOR, ILS) are displayed below the NAV source. The ACS automatically identifies the frequency by listening to the Morse code identifier comparing it to the navaid database. When the frequency is positively identified the navaid identifier replaces the numeric frequency. Selected course ("CRS xxx") is displayed on the bottom line of the window. Also displayed within the primary NAV line select window is GPS calculated distance (DME) from the selected navaid in NM.

Figure 217. Primary NAV Source Selection- VLOC

When a navigation source is selected to FMS for use in the primary line select key window, the text FMS appears to the right of the NAV text. The FMS course (DTK) and distance to the next waypoint is displayed on the bottom line of the window.

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Figure 218. Primary NAV Source Selection- FMS

- Secondary Navigation Source

  The secondary navigation reference is continuously displayed under the left side line select key 1 and drives the dual-line blue RMI pointer. Available selections are: OFF, VLOC1, VLOC2 or FMS.

- VLOC Selections

  When a navigation source is selected to VLOC 1 or VLOC 2 for use in the secondary line select key window, a VLOC 1, VLOC 2 appears to the right of the BRG text.   The appropriate frequency and type of navaid (VOR, ILS) are displayed below the NAV source. The ACS automatically identifies the frequency by listening to the Morse code identifier comparing it to the navaid database. When the frequency is positively identified the navaid identifier replaces the numeric frequency. Selected current bearing (BRG) is displayed on the bottom line of the window. DME is not displayed in the BRG window.

Figure 219. Secondary NAV Source Selection- VLOC

When a navigation source is selected to FMS for use in the primary line select key window, the text FMS appears to the right of the BRG text. The FMS bearing to the next waypoint is displayed on the bottom line of the window. .

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Figure 220.   Secondary NAV Source Selection- FMS

■ Nav Radio Tuning

Figure 221.   NAV Radio Tuning

1. Select NAV page using the rocker key.
2. Only a standby (S) frequency can be tuned.
3. Press right line select key 3 to tune the standby frequency for NAV 1, or right line select key 4 to tune the standby frequency for NAV 2.
4. Tune the standby frequency by using the right concentric knob. Rotating the outer portion of the concentric knob bi-directionally scrolls through the range 108 to 117 MHz in 1 MHz increments. Rotating the inner portion of the concentric knob bi-directionally scrolls through the range 0 to 950 KHz in 50 KHz increments.

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5. Press the right knob to swap the Active (A) and Standby (S) frequencies.

- **Nav Radio Monitor**

In addition to the navigation radio, one additional NAV radio can be monitored with right line select key 2. Pressing the MONITOR line select key allows monitoring of:

— NAV 1 Active (A)
— NAV 1 Standby (S)
— NAV 2 Active (A)
— NAV 2 Standby (S)
— OFF

- **Approach Minimums Setting**

With NAV page selected on the PFD, right line select key 1 is used to enter a 4-digit MSL altitude for an approach minimums reminder. Minimums are displayed in the MINIMUMS line select window, as the MIN window below the altimeter on the PFD, and as an amber horizontal line on both altimeters. An entry on one PFD automatically enters it on the other PFD.

- **Entering Minimums**

1. Select NAV page using the rocker key.
2. Press right line select key 1 to activate a cursor in the MINIMUMS line select window.
3. Rotating the outer portion of the concentric knob moves the cursor between digits, while rotating the inner portion of the concentric knob changes individual digits.
4. When an altitude is entered it will appear in the MIN window below the altimeter.

Approach minimums can also be set using the keyboard.

1. Press the MIN SET key on the keyboard
2. NAV page is automatically selected, a cursor is placed in MINIMUMS window
3. Enter the minimum altitude using the number keys on the keyboard
4. Press ENTER to set the minimums

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TRANSPONDER

- Active Transponder Selection

  The active transponder (XPDR) is selected with the ACTIVE line select key; pressing the line select key swaps between XPDR 1 and XPDR 2. This is also accomplished using the keyboard by pressing the XPDR 1 or XPDR 2 keys.

Figure 222.   Transponder Control

- **Transponder Code Entry**

  1. Select XPDR page using the rocker key.
  2. Press right line select key 2 to activate a cursor in the CODE window.
  3. Rotating the outer portion of the concentric knob moves the cursor between digits, while rotating the inner portion of the concentric knob changes individual digits.

  Transponder codes can also be set using the keyboard.

  1. Press the XPDR 1 or XPDR 2 key, verify associated green light illuminates indicating transponder is selected
  2. Press XPDR SQWK key.
  3. Enter the transponder code using the number keys on the keyboard

- **Mode Selection**

  1. Press right line select key 3 to change mode between SBY, GND

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2. Weight off wheels automatically transitions the transponder to the altitude reporting setting (ALT)

Mode can also be set using the keyboard

1. Press SBY, GND keys to set transponder as necessary

- **VFR**

Pressing the right line select key 4 automatically sets the VFR transponder code (1200) in the selected transponder

- **IDENT Feature (AVAILABLE ON KEYBOARD and SIDESTICK)**

A transponder IDENT feature is available through a dedicated key on the keyboard. There is also a pinky controlled switch on each sidestick dedicated to IDENT.

NOTE:

If the selected transponder is not in ON or ALT, there is no affect

Figure 223. Keyboard Transponder Group

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14.5 Abnormal Procedures

14.5.1 PFD Failure

In the event that a PFD fails, all flight information will be available through the standby indications on the MFD or on the cross-side PFD. To assure that radio communication will still be available, the pilot must select the opposite PFD using the COM SOURCE switch on the left switch panel.

14.5.2 PFD Composite Mode

Composite Mode allows the pilot to use pages that are normally available only on the MFD in the event of an MFD failure. When selected for composite mode the PFD remains similar in appearance to the normal mode of operation; however, there are two additional tiles displayed. These tiles contain necessary aircraft and engine systems information.

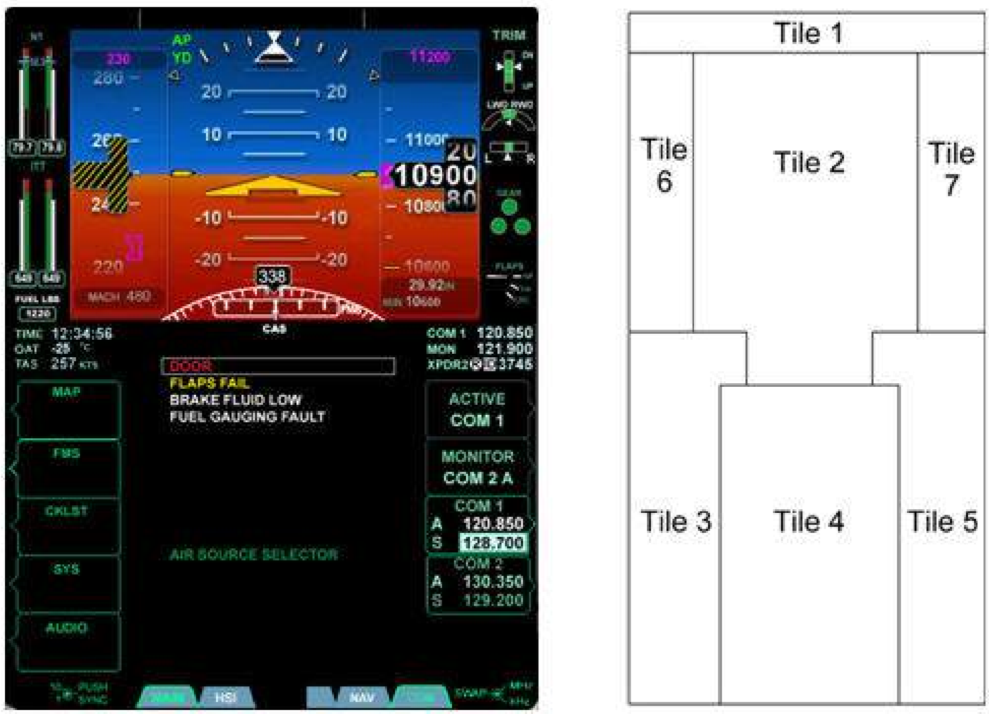

Figure 224. PFD Composite Mode

COMPOSITE MODE SELECTION

The Composite Mode must be manually selected in one of two ways. At any time, composite mode can be selected using the keyboard, or in the event of an MFD failure it can be selected using the left rocker key on the PFD.

- **Keyboard Selection**

  1. Press the left or right PFD key.
  2. Press the PFD COMPOSITE key.

Figure 225. Keyboard Composite Group

- **MFD Failure**

  In the event of an MFD failure, two page tabs labeled NORMAL and COMPOSITE automatically appear at the left bottom corner of the left PFD.

Figure 226. Composite Mode- PFD Selection

Select the COMPOSITE page with the rocker key

NOTE:

Once COMPOSITE is selected, the page tabs change from NORMAL and COMPOSITE to MAIN and HSI. When this occurs, the keyboard is the only means of exiting the composite mode.

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NOTE:

If only one keyboard (standard left) is installed, the NORMAL and COMPOSITE page tabs will continuously appear on the right PFD if/until that PFD is selected into composite mode.

COMPOSITE MODE FLIGHT INSTRUMENTS

When a PFD is in the Composite Mode, the flight instruments are always displayed and the pilot always has control of the communication and navigation radios.

All instruments with the exception of the VSI (it is removed) remain displayed on the ADI portion of the PFD (top half) .

A 120° arc magnetic compass rose is displayed at the bottom of the ADI.

The right line select keys all perform their normal functions, as selected with the COM, NAV, and XPDR keys at the bottom of the PFD.

- **Tile 6: Engine Instruments**

  Engine information is permanently displayed on the left side of the PFD to the left of the airspeed indicator. The following engine information is displayed:

  — N1 Tapes
  — ITT Tapes
  — Fuel Quantity Digital Display

- **Tile 7: Aircraft Systems**

  Pertinent aircraft system information is permanently displayed on the right side of the PFD, to the right of the altimeter. The following system information is displayed:

  1. Trim Indicators (aileron, rudder, and elevator trim)
  2. Landing Gear Position

     NOTE:

     Landing gear indications are permanently displayed. Up and stowed gear indicators will not disappear after 10 seconds.

  3. Flap Position (as done on MFD)

- **Composite Mode Pages**

  There are two composite mode page options that become available along the lower left portion of the PFD. These pages are MAIN and HSI and are selectable using the left rocker key on the PFD.

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Figure 227. Composite Mode Pages-MAIN-HSI

— **MAIN**

The MAIN page is the default page displayed when composite mode is selected. This page displays the CAS message window in tile 4 and provides line select key options for all of the primary function keys on the MFD (MAP, FMS, CKLST, SYS, and AUDIO). Acknowledgement of CAS messages is accomplished using the right line select key number five.

— **Primary Function Selection**

Selecting the primary function options is available using left line select keys 1 through 5 or by using the keyboard.

- **Composite Mode Page Selection from PFD**

Select the Composite Mode:

1. Press left line select keys 1 through 5 for the desired Composite Mode page.

   a. L1 CKLST
   b. L2 FMS
   c. L3 MAP
   d. L4 SYS
   e. L5 AUDIO

- **Composite Mode Page Selection from Keyboard**

Select the Composite Mode:

1. Press L PFD or R PFD

2. Press PFD COMPOSITE

3. Press the key for the desired option.
   a. MAP
   b. FMS
   c. CKLST
   d. SYS
   e. AUDIO

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Figure 228. Keyboard **Primary Function Group**

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COMPOSITE MODE PAGES

— Systems Page (SYS)

The aircraft system synoptic and the operational pages can be selected with the left rocker key.

1. Engine (ENG)
2. Fuel (FUEL)
3. Electrical (ELECT)
4. Electronic Circuit Breaker (ECB)
5. Environmental (ENVIR)
6. Pressurization (PRESS)
7. Ice Protection (ICE)
8. Operation (OPS)
9. Sensor (SENSOR)
10. Setup (SETUP)

Figure 229. Composite Mode- Systems-PRESS

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— **Audio Page (AUDIO)**

The AUDIO page provides control and setting for all communication and navigation systems with an audio output. Each pilot can tune and change each audio source volume level via this page.

- **Exiting the Composite Mode**

The only way to exit the Composite Mode is with the keyboard

1. Press L PFD or R PFD
2. Press PFD COMPOSITE

NOTE:

If both keyboards are inoperative, any PFD in the Composite Mode remains in the Composite Mode for the duration of the flight.

- **Composite Mode Lockout**

To avoid conflicting commands, only one user interface is active at one time. If the left PFD is in composite mode with the MFD working, system functions normally controlled through the MFD are locked out. If only the right PFD is in composite mode with the MFD working, functions are locked out on the MFD. If both PFDs are in composite mode, system functions can be controlled only through the left PFD.

- **Crew Alerting System (CAS) Message Display**

To provide similar functionality for CAS message acknowledgement on a PFD operating in composite mode, an alert prompt appears in the R5 line select key, any time a new caution or warning level message appears.

Figure 230. PFD Composite Mode - Caution CAS

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Figure 231. PFD Composite Mode- Warning CAS

14.6 Crew Alerting System Messages

Table 36. PFD CAS Messages

Message	Condition	Category
AVIONICS COOLING FAN	Left or Right PFD fans have failed	Advisory
XPDR 1 FAIL	Transponder 1 or 2 has failed	Advisory

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14.7 PFD Review Questions

1. **What are the two modes of operation for the Primary Flight Display (PFD)?**

   a.

   b.

2. **What portion of the PFD contains flight mode annunciation?**

   a. Tile 5
   b. Tile 1
   c. Tile 3
   d. Flight mode annunciation does not take place on the PFD, it takes place on the ACP only

3. **Where can autopilot engagement status be visually confirmed?**

   a. On the ADI with the word AP appearing in green
   b. On the HSI with a green light
   c. Autopilot engagement is not displayed on the PFD
   d. None of the above

4. **What type of airspeed is displayed on the airspeed tape?**

   a. Indicated airspeed
   b. True airspeed
   c. Calibrated airspeed
   d. Equivalent airspeed

5. **When is Mach number displayed and when does it disappear?**

6. **What does the airspeed trend vector display?**

   a. Where airspeed will be in the next 10 seconds
   b. Where airspeed will be in the next 6 seconds
   c. The direction of change only
   d. None of the above

7. **What does the YSE bug that appears on the airspeed tape indicate?**

   a. This is the blue-line (V_{yse}) speed which indicates single-engine best rate of climb.

   b. It is the speed that should be bugged for final approach

   c. It is the highest speed at which the aircraft can be flown with flaps LDG selected

   d. None of the above

8. **At extreme pitch angles (above 70°) what is indicated on the ADI?**

   a. Nothing but blank space
   b. Chevrons are located beyond the pitch ladder
   c. The ADI will not pitch beyond 70°
   d. None of the above

9. **How are slips and skids indicated on the PFD?**

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a. With a graphical representation of an inclinometer below the HSI

b. A trapezoid shape moves horizontally in relation to the roll indicator on the ADI

c. A mechanical inclinometer is embedded into the bottom of the PFD

d. None of the above

10. **What color will the flight director be when the autopilot is disengaged?**

a. Blue

b. Yellow

c. Green

d. The flight director will not be present when the autopilot is disengaged.

11. **What will be displayed over the ADI when a localizer frequency is the primary navigation source?**

a. A small HSI

b. A small glide slope indicator will be displayed to the right of the ADI and a HDI will be displayed centered below the ADI.

c. Both A & B

d. None of the above

12. **When does the altitude trend vector appear?**

13. **When ALT CHG mode is active and the autopilot is engaged, how will the altitude bug appear?**

a. Solid magenta
b. Solid green
c. Hollow magenta
d. Hollow green

14. **What has happened when a red "X" is displayed over an area of the PFD?**

15. **How is the autoflight system's recommended vertical speed displayed on the VSI?**

a. A solid magenta VSI bug
b. A green diamond
c. A black square
d. None of the above

16. **Describe how the pilot can change the view from the 120 arc view to the 360 degree compass view on the PFD:**

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17. **The VIEW/RANGE line-select key changes:**
    a. The size of the text on the PFD
    b. The scale of the map overlay on the HSI
    c. The HSI presentation (Full or 120° arc)
    d. B & C are correct
18. **How is Rate of turn is indicated?**
    a. With a white rate of turn indicator below the HSI
    b. With a blue curved bar which appears above the compass rose
    c. With a vertical hourglass shape that appears next to the HSI
    d. None of the above
19. **What are the two ways to enter the composite mode on the PFD?**
    a.
    b.
20. **What information is lost from the PFD when composite mode is entered?**
21. **What is the default page on the PFD during composite mode?**

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15. Multi Function Display (MFD)

15.1 General

The Multi Function Display (MFD) consists of a 15.3 LCD display located between the PFDs. The top half of the MFD permanently displays important aircraft systems information including the MFD ADI, engine instruments, as well as the status of the landing gear, flight control, pressurization and fuel systems information. Also included on the upper portion of the MFD is the Crew Alerting System (CAS) message window. The lower portion of the MFD allows pilot control of the Flight Management System, moving map, electronic checklists and all system synoptic pages.

Figure 232.   Multi-Function Display (MFD)

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15.2 Limitations and Specifications

No content.

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15.3 System Description

15.3.1 Initialization

Figure 233. MFD Initialization

On initial power-up of the MFD, an initialization page displaying the version of Avio is presented. Also presented are the version and effective dates of the Navigation Data. This information should be verified prior to flight.

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15.3.2 Multi Function Display (MFD) Layout

The MFD is organized into eight tiled areas that display all pertinent standby indications and systems information. The upper portion of the MFD is permanently displayed, while the lower tiles are configurable.

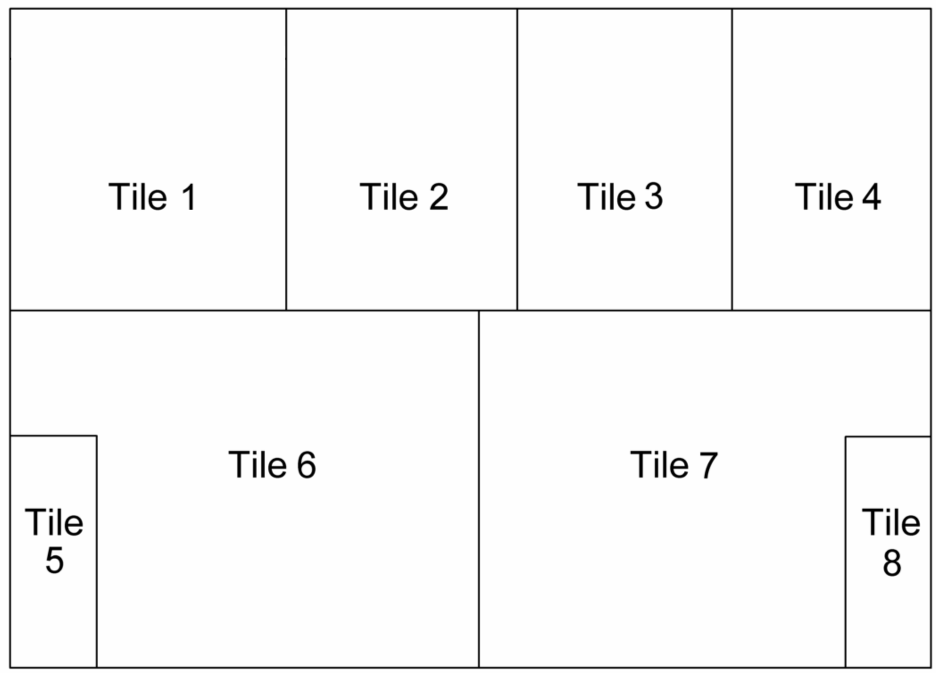

Figure 234. MFD Tile Layout

Tile 1
- MFD Attitude Direction Indicator (ADI)

Tile 2
- Engine Instruments
  - N1 Tape
  - ITT Tape
  - N2 Digital Display
  - Fuel Flow Digital Display
  - Oil Pressure Digital Display

Tile 3
- Landing Gear Status
- Flap Position
- Cabin Pressurization
  - Current cabin altitude
  - Current cabin altitude rate of climb
  - Cabin differential pressure (dP)
- Fuel Quantity Indicator
- Trim Position
  - Pitch
  - Roll
  - Yaw

Tile 4
- CAS Message Window

Tile 5
- Tile 6 line select key options

Tile 6
- Configurable

Tile 7
- Configurable

Tile 8
- Tile 8 line select key options

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15.4 Tile 1 – MFD Attitude Direction Indicator (ADI)

Figure 235. MFD ADI

The MFD ADI is available as a third source of flight information during normal and abnormal operations, such as flight information disagreement or PFD failure. The MFD ADI is configured similar to Tile 2 of the PFD, and displays the following information.

- Air Data Source Selection (ADC and AHRS)
- Airspeed tape and digital airspeed readout (KEAS)
- Mach digital display
- Attitude Indicator
- Slip/Skid Indicator
- Altimeter tape and digital altitude readout (MSL)
- Barometric altimeter setting
- 120˚ compass rose (magnetic heading)

The following information is NOT displayed on the MFD ADI

- Flight Mode Annunciations (FMAs)
- Airspeed upper or lower redlines
- Airspeed and Altitude Trend Vectors
- All Autopilot pre-select windows and bugs
- Flight director command bars.
- Localizer or Glide slope deviation indicators (HDI) and (VDI)
- Vertical speed
- V-speed bugs
- Radar Altimeter
- AOA indication

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15.4.1 Air Data Source Selection (ADC & AHRS)

The ADC source and the AHRS source are displayed in the top left corner of the MFD ADI. ADC 3 and AHRS 2 are the default air data and attitude information sources on initial start up. The primary sources of air data and attitude information for the MFD ADI are selectable using the SENSOR synoptic page.

15.4.2 Attitude Heading Reference System (AHRS) Sources

- AHRS 1
- AHRS 2
- AHRS 3 (If Installed)

15.4.3 Air Data Computer Sources

- ADC 1
- ADC 2
- ADC 3

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15.5 Tile 2 – Engine Instruments

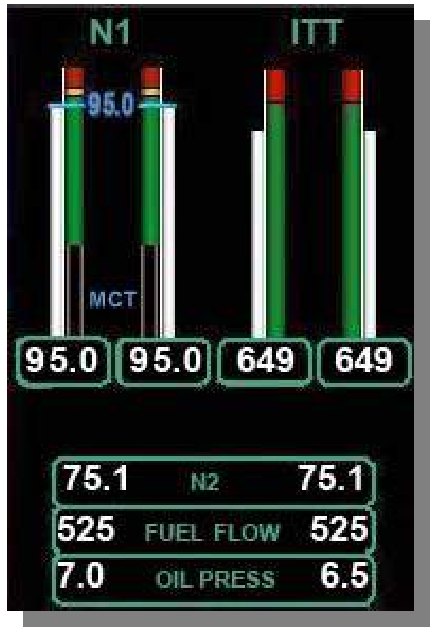

Figure 236. Engine Instruments

Tile 2 displays N1 and ITT tapes, as well as N2, Fuel Flow, and Oil Pressure in digital format.

15.5.1 N1 RPM

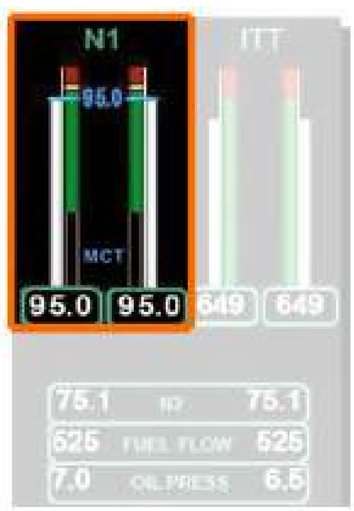

Figure 237. N1 RPM

N1 is continuously displayed on the MFD with a moving tape and digital readout in percent of maximum RPM. The scale of the tape is 0 to 105%. An adjacent tape displays N1 limits. A green band on the limit tape extends from approximately 21% to

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100%. An amber band extends from 100% to 101%. A red band begins at the maximum continuous limit of 101%.

The digital value and moving tape are white for N_1 values in the green band, in amber for N1 values in the amber band, and in red for N1 values above the RPM limit. If the RPM exceeds the limit for 20 seconds, an ENG EXCEEDANCE warning message appears.

A blue bug and blue digital readout between the left and right N1 tapes display the N1 target calculated by the ACS for the mode of flight.

With the throttles advanced to the takeoff setting the state of the Automatic Power Reserve (APR) is displayed above the N1 tapes as either APR ARMED (white) or APR ON (green).

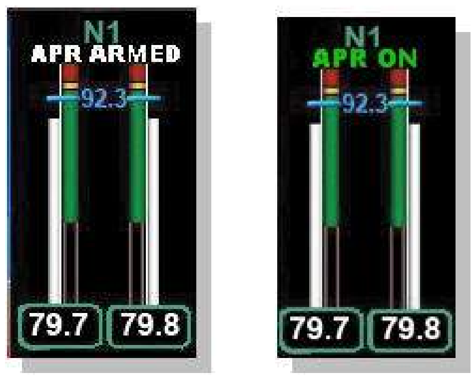

Figure 238. APR Indications

When the throttles are reduced on climb to maximum continuous thrust as calculated by the ACS, blue MCT text appears at the lower portion of the tape that is associated with the blue N1 bug.

15.5.2 Indicated Turbine Temperature (ITT)

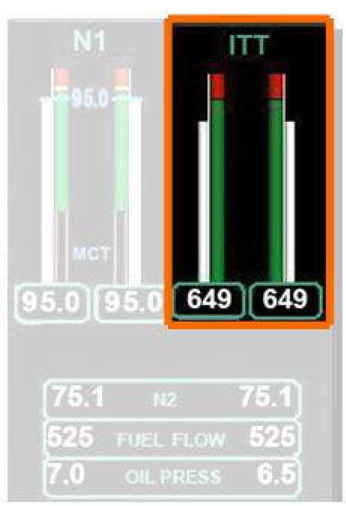

Figure 239. ITT Display

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ITT is continuously displayed on the MFD with a moving tape and digital readout. The ITT tape range is 0-850°C. An adjacent tape displays ITT limits. A green band on the limit tape extends from 300°C to the maximum continuous ITT limit. The FADEC determines the maximum ITT limit, and a red band is displayed beginning at that value.

The digital ITT value and moving tape are displayed in white for values under the ITT limit, and in red for values above the limit. An ENG EXCEEDANCE warning message appears:

- If ITT exceeds the limit (but not above 810°C) for 20 seconds
- If the ITT reaches 810°C

15.5.3 N2 RPM

Figure 240. N2 RPM Display

N2 is continuously displayed on the MFD with a digital readout in percent of maximum RPM, and with a moving tape and digital readout on the ENG synoptic page. The scale of the tape is 0 to 105%. An adjacent tape displays N2 limits. A green band on the limit tape extends from 45% to 100%. An amber band extends from 100% to 102%. A red band begins at the maximum continuous limit of 102%.

The digital value and moving tape are white for N2 values in the green band, in amber for N2 values in the amber band, and in red for N2 values above the RPM limit. If the RPM exceeds the limit for 20 seconds, an ENG EXCEEDANCE warning message appears.

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15.5.4 Fuel Flow

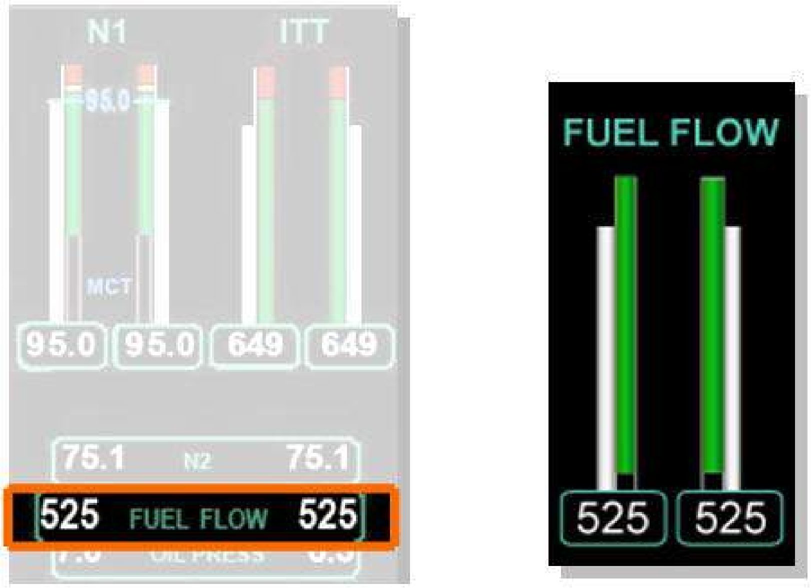

Figure 241. Fuel Flow Display

Fuel flow is continuously displayed on the MFD with a digital readout in pounds per hour (PPH) and with a white moving tape and digital readout on the ENG synoptic page. The scale of the tape is 0-800 PPH. An adjacent tape displays fuel flow range with a green band extending from 60 PPH to the top of the tape. There are no amber or red bands.

15.5.5 Oil Pressure

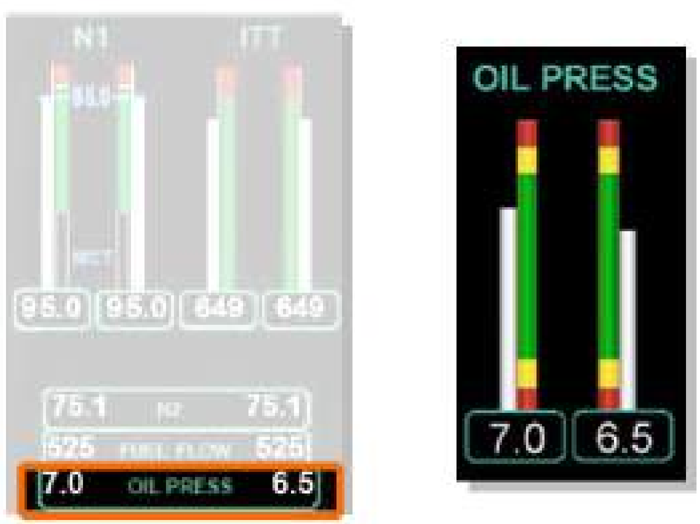

Figure 242. Oil Pressure Display

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Oil pressure is continuously displayed on the MFD with a digital readout and with a moving tape and digital readout on the ENG synoptic page. Oil pressure is displayed on a normalized scale from 0 to 10 rather than in PSI.

An adjacent tape displays oil pressure limits. Operating limits in PSI change with N2 RPM. However, this is transparent to the pilot. The color bands display constant limits regardless of the engine RPM.

When oil pressure is in the normal (green band) range the moving tape and digital value are white. If the oil pressure is in the caution (amber bands) range (either high or low), the tape and digital value are amber. If the oil pressure is above 9 or below 1, the tape and digital value are red, and a L(R) OIL PRESSURE HIGH or L (R) OIL PRESSURE LOW caution appears.

The amber bands and the lower red band incorporate a time delay for transient conditions. For oil pressures outside the green range, the oil pressure value and tape are amber for a period of time. If the exceedance continues, the oil pressure value and tape turn red.

Oil Pressure	Time Delay for Amber Display
9.1-10	None
8.1-9	5 minutes
1-1.9	90 seconds
0-0.9	10 seconds

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15.6 Tile 3 – Aircraft Systems

Tile 3 displays systems status information for the landing gear, flaps, cabin pressurization, fuel and trim.

Figure 243. Aircraft Systems Display

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15.6.1 Landing Gear

The Landing Gear position displays the status of the gear by both the color and shape of the indicator.

- A green circle with white border indicates the gear is Down and Locked.

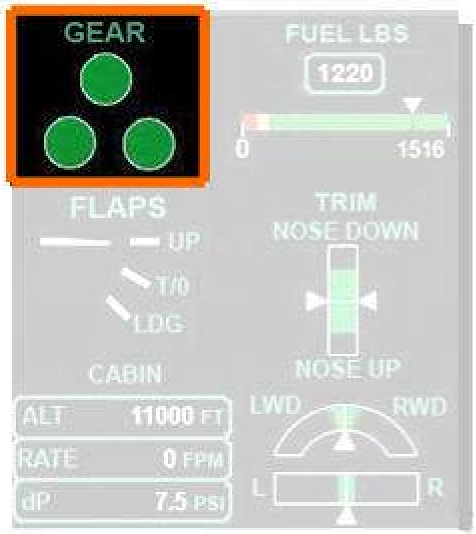

Figure 244. Landing Gear Down Locked Indication

- An amber hatched square indicates the gear is in transit

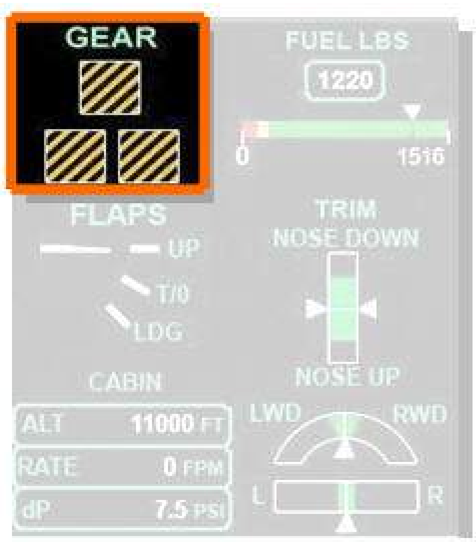

Figure 245. Landing Gear In Transit Indication

- A hollow white square indicates the gear is Up and Stowed.

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When all three landing gear are Up and Stowed for ten seconds, the white squares will disappear.

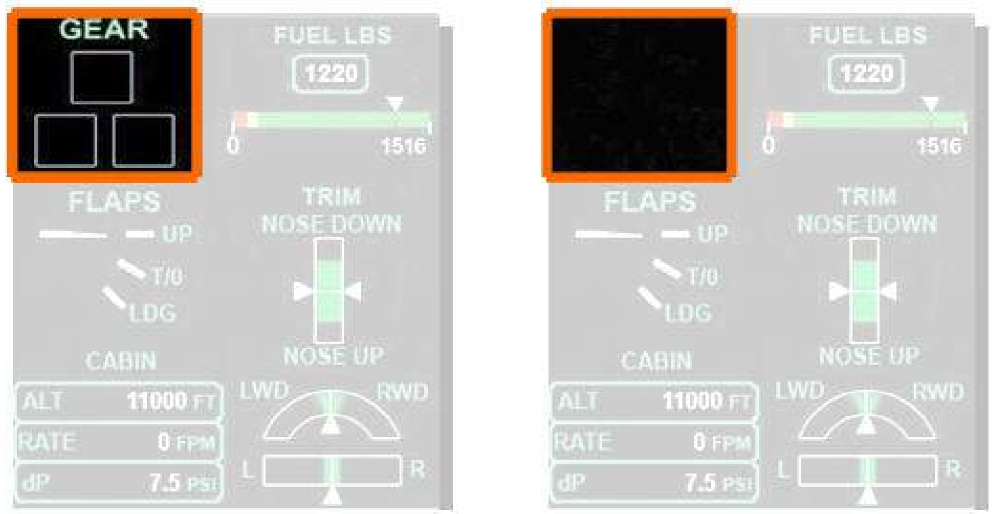

Figure 246. Landing Gear Up and Stowed Indication

NOTE:

During composite mode operation on the PFD, when gear is displayed on the upper right hand portion of the PFD, gear Up and Stowed position annunciation does not disappear after ten seconds.

If any indicator is not up and stowed or down and locked, the entire display stays in view and the failed gear is indicated with amber hatched squares. If any gear is in transit for more than 15 seconds, a LANDING GEAR FAIL caution message appears and the in-transit symbol remains displayed.

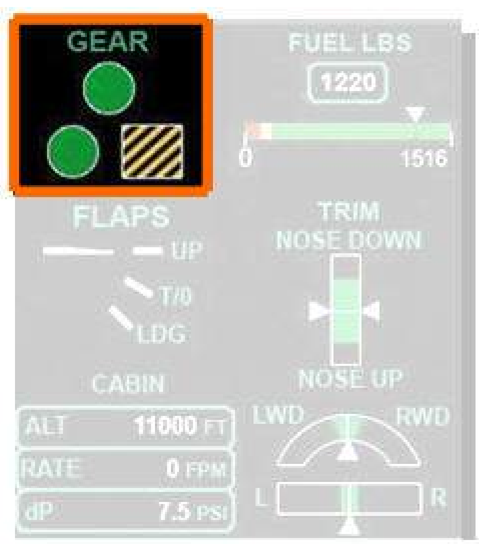

Figure 247. Landing Gear Fail in Transit Indication

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15.6.2 Flap Position

The flap position indicator informs the pilot of the position of the flaps and is capable of pointing to intermediate positions between the three commanded states.

Figure 248.   Flap Position (Normal)

When the flap lever is moved, a white box is displayed around the selected position. The flap tick mark turns magenta until the flap position agrees with the flap lever position, at which point the tick turns white and the white box disappears.

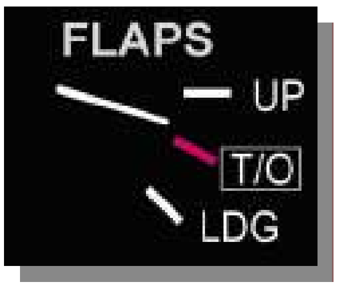

Figure 249.   In Transit to T/O Position

When the flap position matches the flap lever position, the display is white.

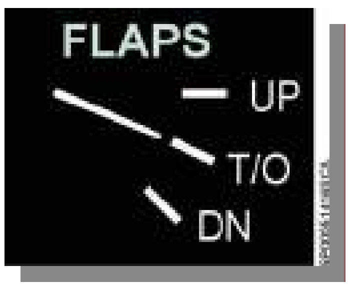

Figure 250.   Flap Position Display (T/O Position)

Flap asymmetry sensed by any flap actuator stops all flap movement, an CAS caution message FLAP FAIL also appears and the flap pointer remains in the last known position.

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15.6.3 Cabin Pressurization

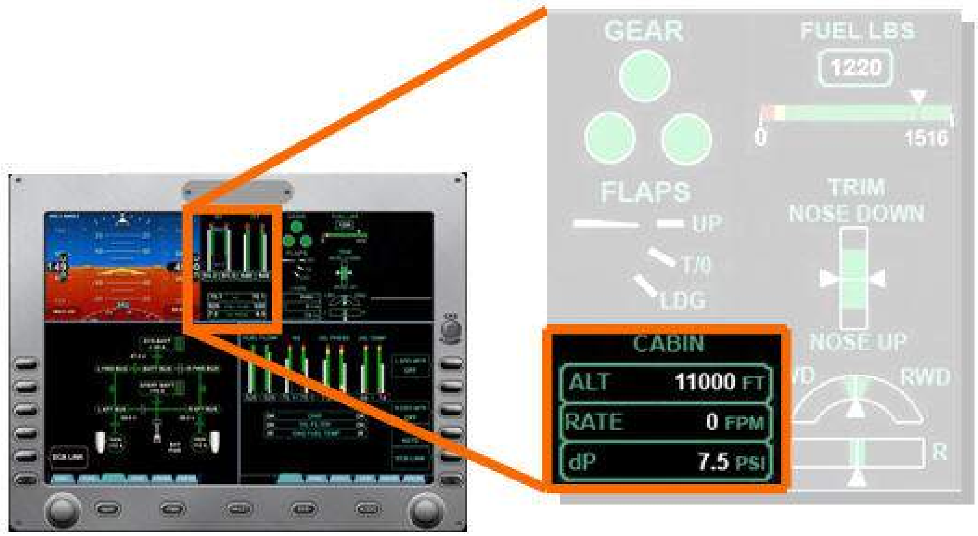

Figure 251. Cabin Pressurization Display

ALT (FT)

Cabin altitude rounded to the nearest 50 feet is presented. If the cabin altitude exceeds 8,750 ft, a CABIN ALTITUDE caution message appears and the numeric digits turn amber. If the cabin altitude exceeds 10,000 ft, a CABIN ALTITUDE warning message appears and the numeric digits turn red. At a cabin altitude of 12,750 ft an aural warning sounds. To silence the aural warning, of the following conditions must be met:

- A rate of descent of 1800 fpm or greater.
- A descent below 12,500 ft.

NOTE:

A CABIN ALTITUDE warning message indicates a cabin altitude of 10,000 ft and which may indicate a rapid cabin depressurization.

RATE (FPM)

Cabin altitude rate of change rounded to the nearest 100 fpm is presented. Should the cabin altitude rate be too high, the numeric digits turn amber. The crew can select the cabin rate of climb or descent between 0 and 2,500 feet per minute.

dP (PSI)

Differential pressure between cabin altitude and airplane altitude, rounded to the nearest 0.1 PSI. If the differential pressure exceeds 8.7 PSI, a CABIN dP HIGH warning message appears and the numeric digits turn red.

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15.6.4 Fuel Quantity

Figure 252. Fuel Quantity Display

Fuel quantity is continuously displayed on the upper portion of the MFD. Fuel capacity is displayed as a horizontal green scale, with caution (amber, indicating 280 pounds of total fuel remaining) and warning (red, indicating 210 pounds of total fuel remaining) areas on the left side.

Fuel quantity is indicated by a white pointer above the scale. Total fuel quantity remaining in pounds is displayed above the scale. The total quantity display turns amber when fuel remaining is less than 280 pounds, and red when fuel remaining is less than 210 pounds.

An individual sump quantity display appears below the total fuel quantity scale with the quantity digits in amber if least one sump tank quantity decreases to the caution level of 140 pounds or less, and red when the corresponding sump quantity decreases to less than 105 pounds.

Figure 253. Sump Tank Quantity Display

Sump tank fuel quantities of 140 lbs and 105 lbs that turn the sump quantity display amber and red equate to the fuel quantities that trigger the FUEL QTY LOW caution and L (R) FUEL QTY LOW warning messages.

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15.6.5 Trim

Figure 254. Trim Display

Trim indications for Pitch, Roll, and Yaw are displayed below the fuel quantity information. Trim is indicated by a white pointer and a green band indicates the allowable trim range for takeoff. If throttles are advanced to takeoff power with the trim pointer is outside of the green band on any of the three indicators a CONFIG PITCH TRIM, CONFIG AILERON TRIM, or CONFIG RUDDER TRIM warning message appears. If this occurs, re-trim until the indicator is within the green band and the message will disappear.

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15.7 Tile 4 – Crew Alerting System (CAS)

The Crew Alerting System (CAS) provides the pilot with information related to abnormal aircraft conditions and aircraft system status. Messages are normally displayed on Tile 4 on the MFD; however, in the event of an MFD failure CAS messages are displayed on the PFD in composite mode. Visual alerts are provided on the master warning and master caution light button on the autopilot control panel. Aural alerts are also provided. CAS messages are categorized according to the severity of the condition, and are displayed in the message window with the most recent messages (within a categorization) presented at the top of the list. The aural components of CAS are voice messages and alert tones that are transmitted to the crew headphones and speakers. A single concentric knob located on the upper right side of the MFD is used to select and acknowledge CAS messages.

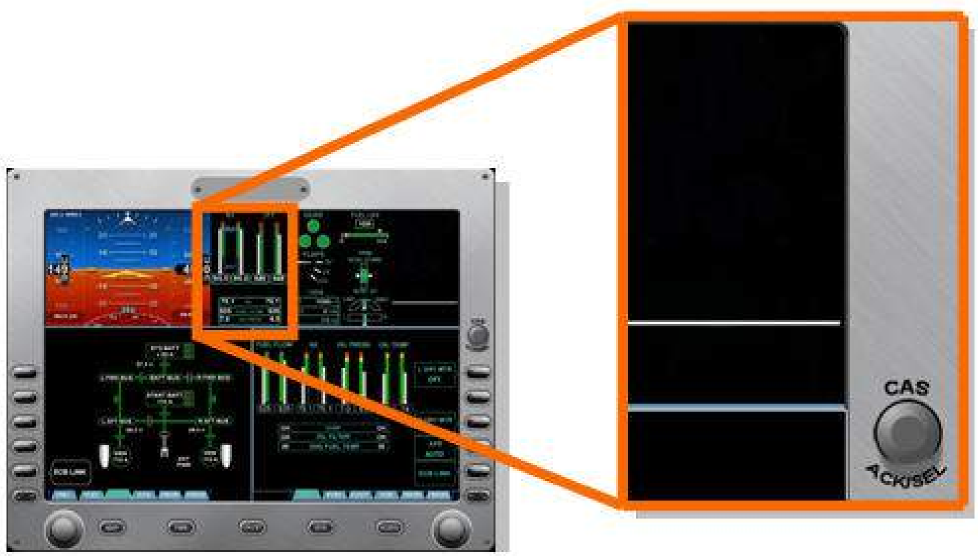

Figure 255.   CAS Message Display

15.7.1 CAS Message Classifications & Hierarchy

CLASSIFICATION

There are four classifications of CAS messages: warning, caution, advisory, and status.

Warning Messages. A red warning message alerts conditions that require immediate flight crew awareness and response. Examples include aircraft or systems in a hazardous configuration and serious system failures.

Caution Messages. An amber caution message alerts conditions that require immediate flight crew awareness and subsequent flight crew response. Examples include malfunctions or failures which could result in a hazardous airplane condition.

Advisory Messages. A white advisory message alerts conditions that require flight crew awareness and may require subsequent flight crew response. Examples include a system malfunction or failure leading to a loss of redundancy or degradation of a system.

Status Messages. A green status message indicates a specific aircraft system condition that is recognized using a visual indication, but does not require an alert and does not require flight crew response. Status messages keep the pilot informed, without burdening him/her with nuisance or unnecessary information.

HIERARCHY

Warning messages have priority over cautions, and cautions have priority over advisories. On the CAS message window, warnings are always displayed above cautions and cautions are always displayed above advisories. Status messages are located at the bottom of the CAS message window below a white dividing line. Within each group of messages, i.e. warnings, cautions, etc., a new message will displayed above existing messages.

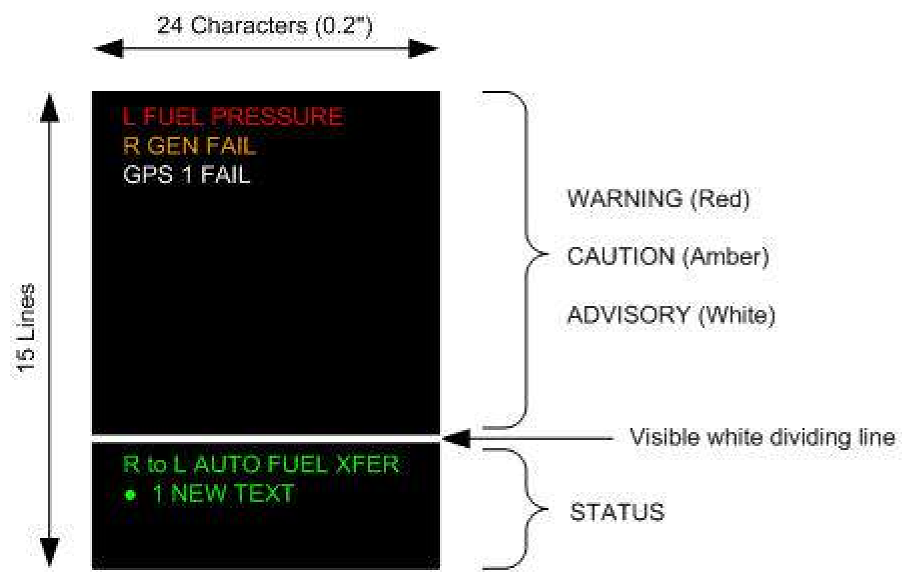

Figure 256. CAS Message Hierarchy

15.7.2 CAS & Aural Alerts

ANNUNCIATION

A CAS Message is presented with accompanying aural alert and flashing master warning/caution button lights for warning and caution conditions.

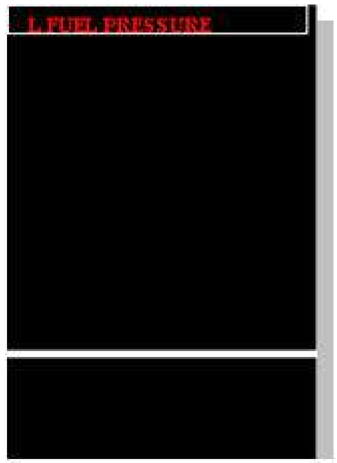

Figure 257. CAS Message Annunciation

Figure 258. Warning-Caution Button

Advisory messages are not accompanied by aural alerts or master warning/caution button lights. A selection box is automatically presented around the message.

NOTE:

Status level messages cannot be highlighted using the selection box

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ACKNOWLEDGMENT & RECALL

■ Acknowledgement

1. Pilot silences aural alert by depressing master warning button on ACP (light extinguishes).
2. Pilot acknowledges the CAS message by depressing the CAS control knob. (Advisory messages that do not contain a checklist OR synoptic assist will move into RECALL bin when acknowledged – see below for description of recall function).
3. Corrective action checklist is displayed in MFD tile 6, and accompanying synoptic is placed in MFD tile 7 (if available). Checklist and synoptic displace previous tile displays.
4. Upon checklist completion (if available) and if the event has been corrected, the CAS message shall disappear. Checklist and synoptic remain on the MFD tiles until the pilot selects a different view.
5. Upon checklist completion (if available) and if the event has not been corrected, the CAS message shall move to the recall bin.

■ Recall

The recall function provides the ability to recall previous warning, caution and advisory CAS messages where the condition still exists (those that have not been "corrected," but where the pilot action has been completed). "RECALL" appears in uppercase white letters in a fixed position directly above the white dividing line in the CAS message window. "RECALL" will remain visible until power is removed from the aircraft. CAS Messages placed in the recall bin are only stored for the current power cycle. When "RECALL" is selected via the control knob and acknowledged, recall messages appear above the "RECALL" label. Messages in the recall bin are grouped chronologically within their categorizations.

Figure 259. CAS Message Recall

AURAL ALERTING

Aural alerting is provided through on-side headset audio and cockpit speakers for various aircraft conditions and are listed in priority based on action required by flight crew.

NOTE:

Aural alerting is routed through the PFD audio system. Should one PFD fail, the pilot must select the cross-side PFD using the COM SOURCE select to retain aural alerting though the headset.

- **Stall Warning Alert**
  - CONDITION — Aircraft approaching stall.
  - AUDIO — Voice message, “Stall, Stall!”
  - VISUAL — “STALL” text appears in red on ADI and Master Warning Light illuminates.
- **Master Warning**
  - CONDITION — Alert associated with red warning level CAS messages
  - AUDIO — Master warning alert tone
  - VISUAL — Warning light on autopilot control panel illuminates and CAS message appears on MFD. The warning light stays on until the condition goes away or the master warning button is pressed by the pilot. The CAS message remains until the condition goes away or the checklist has been completed and the corrective action accomplished.
- **Cabin Altitude**
  - CONDITION — Cabin altitude exceeds 12,750 feet
  - AUDIO — Voice message, “Mask on Descend!”
  - VISUAL — NONE

  NOTE:

  At 8,750 ft cabin altitude a CABIN ALTITUDE caution message appears along with the caution alert tone and at 10,000 ft cabin altitude a CABIN ALTITUDE warning message appears along with the caution alert tone.
- **Autopilot Disconnect**
  - CONDITION — Autopilot disconnected
  - AUDIO — Calvary charge alert tone
  - VISUAL — Pulsing amber text “**AP DISC**” appears on the PFD below the FMA line. A second press of the autopilot disconnect pushbutton on the sidestick causes the aural tone and “**AP DISC**” message to disappear simultaneously.

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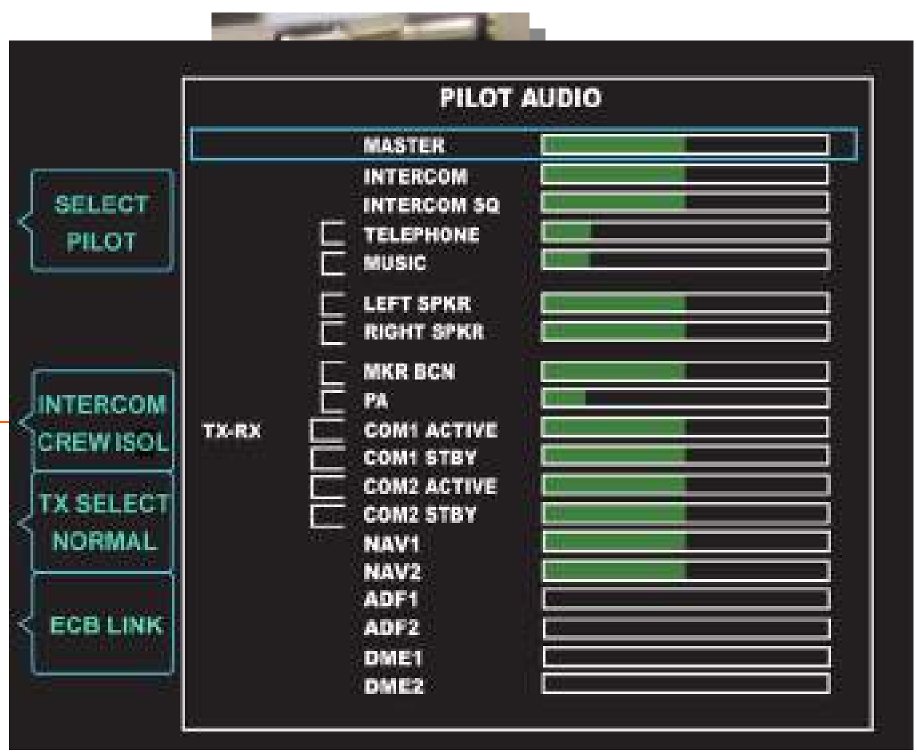
Figure 260. Autopilot Disconnect Display

- **Fire Warning Alert**
  - — CONDITION — Left or right engine fire detected
  - — AUDIO — Voice message, "Left Engine Fire!" or "Right Engine Fire!"
  - — Visual



ceases fuel flow and automatically closes several engine related control valves and illuminates the green ARMED portion of the FIRE/ARMED button.

- A second press of the FIRE/ARMED button discharges extinguishing agent and prompts a L (R) EXTNGR DSCHG advisory message to appear.

- L or R ENG FIRE warning messages remain displayed until the fire is no longer detected or the checklist and corrective action has been completed.

- **Overspeed Alert**
  - — CONDITION — Aircraft speed exceeds Vne.
  - — AUDIO — Overspeed cricket alert tone
  - — VISUAL — "OVERSPEED" in white on ADI, airspeed is in the red band on airspeed tape and airspeed digits appear red.

    The visuals remain until the airspeed is out of the overspeed range.

- **Approaching Minimums**
  - — CONDITION — 50 feet above preset minimum altitude
  - — AUDIO — Voice Message, "Approaching Minimums!"
  - — VISUAL — NONE

- **Minimums**
  - — CONDITION — Descending through preset minimum altitude
  - — AUDIO — Voice message, "Minimums!"
  - — VISUAL — NONE

- **Master Caution**
  - — CONDITION — Alert associated with amber caution level CAS messages
  - — AUDIO — Master caution alert tone
  - — VISUAL — Caution Light on autopilot control panel illuminates and CAS message appears on MFD. The caution light stays on until the condition goes away or the Master caution button is pressed by the pilot. The CAS message remains until the condition goes away or the checklist has been completed and the corrective action accomplished.

- **Radar Altitude Callout**
  - — CONDITION — Callouts of radar altitudes of 500, 100, 50, 20 and 10 feet.
  - — AUDIO — Voice messages:

    – "Five hundred feet"
    – "One hundred feet"
    – "Fifty feet"
    – "Twenty feet"
    – "Ten feet"
  - — VISUAL — NONE

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- **Altitude Alert (approach and deviation alerts)**
  - — CONDITION

    Approach Alert
    Aircraft approaching 1000 feet of altitude pre-select target

    Deviation Alert
    Aircraft deviates + or - 200 feet from selected altitude
  - — AUDIO — C-Cord alert tone
  - — VISUAL

    Approach Alert
    Within 1000-200 feet of selected altitude, blue APPROACHING SEL ALT text appears below the pre-selected altitude. Within 200 feet of selected altitude, blue text disappears

    Deviation Alert (greater than 200 feet from selected altitude)
    Amber ALTITUDE DEVIATION text appears below the altitude set in the pre-select window.
- **Landing Gear Warning**
  - — CONDITION

    Landing gear is up when aircraft is in landing configuration below 12,500 feet:

    - Flaps extended beyond T/O setting
    - Airspeed less than 120 knots and either or both throttles below mid range
    - Airspeed less than 140 knots and either or both throttles below mid range
  - — AUDIO — Voice message, “Landing Gear, Landing Gear!”
  - — VISUAL — White “CONFIG GEAR” text appears on ADI and Master Warning Light illuminates.
- **Trim In Motion**
  - — CONDITION — Trim in motion for more than 2 seconds
  - — AUDIO — Trim Clacker alert tone
  - — VISUAL — NONE

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TAKEOFF CONFIGURATION OK AND WARNING MESSAGES

T/O Config OK Status Message

The Takeoff Configuration OK (T/O CONFIG OK) Status message will be annunciated to the flight crew after the following conditions have been satisfied.

1. Both engines running at idle RPM or above.
2. Flaps are properly set either in the UP or TO position.
3. All 3 trims are set in the green band.
4. OAT is properly entered on the OPS page with “MAN” depicted.
5. Parking brake released.
6. Door is properly latched.

CAUTION:

If the message is not annunciated to the flight crew prior to departure proceeding with the takeoff is not approved.

The T/O CONFIG OK Status Message is automatically removed when the throttles are advanced for takeoff.

T/O Config Warning Messages

If the throttle is advanced for takeoff when the airplane is not correctly configured, the takeoff warning horn sounds and a red warning message is displayed showing the configuration problem:

CONFIG ELEV TRIM..Elevator trim not in green band

CONFIG RUDDER TRIM .... Rudder trim not in green band

CONFIG AILERON TRIM .... Aileron trim not in green band

CONFIG PARKING BRAKE ....Parking brake is set

CONFIG FLAP...Flaps extended beyond takeoff range

CONFIG ENG TEMP.............. Ambient temperature not entered on OPS synoptic

NOTE:

CONFIG FLAP warning will not appear for attempting takeoff with the flaps in the UP position

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15.8 Tiles 5, 6, 7, 8 – Configurable Displays

Figure 262. MFD Configurable Displays

The lower tiles are configurable using five primary function keys located along the lower portion of the MFD. These keys control what appears on the lower two tiles; tile 6 and tile 7 of the MFD. The pilot has five options, Map (MAP), Flight Management System (FMS), Checklist (CKLST), Systems (SYS), and Audio (AUDIO). Pressing each of these keys will configure the lower two tiles of the MFD as follows:

- MAP — Lower left set to MAP, lower right is set to page previously on lower left
- FMS — Lower left tile set to FMS, lower right tile set to MAP
- CKLST — Lower left tile set to Checklists, lower right tile set to the associated system/synoptic page
- SYS — Lower left set to last used systems synoptic page or if last page not known, to the first page in the tabbed list (ENG).

  Available Synoptics and features are listed below. A more detailed description of each synoptic is found in each aircraft systems chapter.

Table 37. Synoptic Pages and Features

System/Synoptic Page	Features
Engine (ENG)	■ Secondary engine parameters ■ Left and right engine motoring control ■ Ignition test control ■ APR disable control
Fuel (FUEL)	■ Measured fuel quantity in each tank ■ Low sump fuel state ■ State of fuel pumps and valves ■ Engine fuel flow ■ Fuel temperature at sump tanks

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Table 37. Synoptic Pages and Features

System/Synoptic Page	Features
Electrical (ELECT)	■ Battery and generator voltage/current ■ Contactor state ■ State of power buses
Electronic Circuit Breaker (ECB)	■ View ECBs by system ■ View ECBs by state (AUTO-ON/OFF, Locked, Collared, Tripped)
Environmental (ENVIR)	■ Heating and cooling control for the cabin and cockpit
Pressurization (PRESS)	■ View status of relevant bleed air valves ■ Pressurization (allows manual entry of cabin altitude, rate, landing altitude)
Ice Protection (ICE)	■ Status of engine anti-ice system ■ Status of wing/stabilizer deice boot function ■ Status of pitot/static/AOA heater ■ Status and temperature of windshield heater
Flight Controls (FLCS)	■ Status of trim ■ Manual trim ■ Disabling of ALL INTERRUPT sidestick switch.
Operations (OPS)	■ Weight and balance entry ■ Rotation and reference speed entry ■ Systems tests (Autopilot, Stick Pusher, Cockpit Lighting)
Sensor (SENSOR)	■ Air data source selection for the PFD and MFD
Setup (SETUP)	■ Display dimming ■ View PFD and MFD versions

- AUDIO — Lower left set to AUDIO page, lower right set to page previously shown on lower left. OR if pressed twice, PILOT audio page appears on the lower left tile and COPILOT audio page appears on the lower right tile.

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15.8.1 Additional Synoptics

There are several additional synoptic pages, AUDIO OPS, SENSOR, SETUP available for pilot use.

AUDIO SYNOPTIC

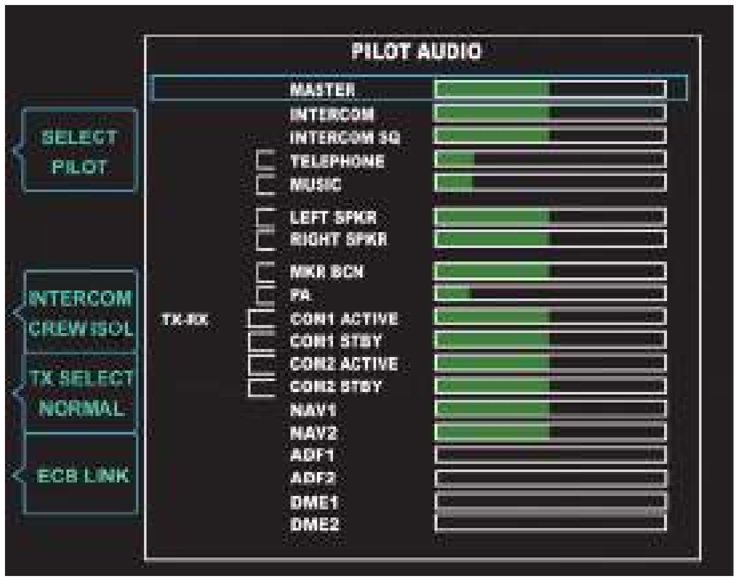

Figure 263. Pilot Audio Synoptic Page

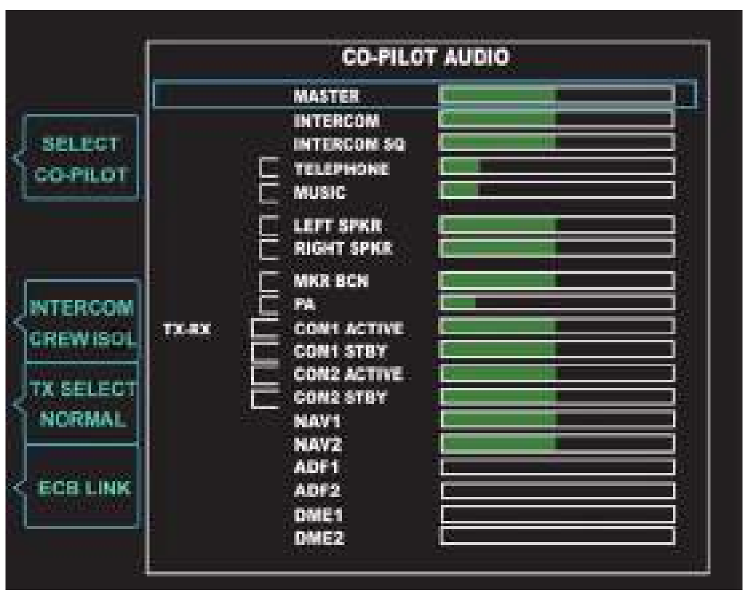

Figure 264. Co-Pilot Audio Synoptic Page

The AUDIO synoptic page is selected with a single or double press of the AUDIO primary function key on the MFD. A single press of the primary function key displays the pilots audio page on tile 6 (lower left) of the MFD, while a double press displays the pilots audio page on tile 6 (lower left) and the co-pilots audio page on tile 7 (lower right) tile. This synoptic allows selection of Pilot and Co-Pilot audio setup, intercom and cockpit radio split.

Line select keys on the audio synoptic:

- SELECT PILOT / COPILOT
- INTERCOM PILOT ISOL / CREW ISOL
- TX SELECT NORMAL / SPLIT
- ECB LINK Links to Avionics ECB synoptic page

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- **Audio Control Selection**

  The SELECT line select key provides for pilot / copilot audio control selection. When only one audio page is displayed on the lower tiles of the MFD, this line select key option is available. If both the Pilot and Co-pilot pages are available, this line select key option disappears.

  With the audio page selected, a cursor appears at the top of the synoptic. Rotating the outer portion of the left or right concentric knob will move the cursor between the various audio selections. Once highlighted, rotating the inner portion of the left or right concentric knob clockwise will increase selected volume, while rotating counterclockwise decreases selected volume. Volume changes and current volume are reflected through a horizontal tape to the right of each audio selection. There are also several hollow outlined boxes on the left side of each audio selection. With an audio setting selected, pressing the inner portion of the right knob fills this box, allowing the audio for this selection to be heard over an activated speaker.

  The Transmit Radio shall be identified by a “TX/RX” next to it in the Audio Page source list.

  The Monitor Radio shall be identified by a “RX ONLY” next to it in the Audio Page source list.

  SQ- When cursor selected, pressing the inner knob turns the Squelch (SQ) box green, and allows the squelch for that individual frequency to be adjusted.

- **Intercom Mode Control**

  The INTERCOM line select key provides intercom control for the mode choices of pilot isolate, crew isolate, or all.

- **Transmit Radio Selection**

  The TX SELECT line select key provides for transmit radio selection, Normal or Split.

  If NORMAL is selected, the ACTIVE COM selected by one pilot at is automatically selected for the other pilot.

  If SPLIT is selected, the pilot and copilot can select different radios as their own transmit radio.

- **Keyboard Control**

Figure 265. Keyboard Audio Control

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— **Volume / Squelch**
  The keyboard upper right Vol/Sq knob functions identically to its PFD Vol/Sq knob. Rotating the knob left or right decreases or increases pilot audio volume. Pressing the knob activates squelch control and rotating the knob left or right decreases or increases pilot squelch.

— **Speaker (SPKR)**
  Pressing the SPKR key toggles that crewmember's cockpit overhead speaker on/off. When the speaker is on, the keyboard light above the SPKR key is illuminated.

— **Public Address (PA)**
  Pressing the PA key toggles the cabin speaker on/off. When the cabin speaker is on, the light above the PA key is illuminated. The MFD Audio Page does not have to be displayed.

— **Pilot Isolate (PILOT ISOL)**
  Pressing the PILOT ISOL key toggles the intercom mode between its current mode and pilot isolate mode. If the intercom was already in pilot isolate mode pressing this key has no effect. When the pilot isolate is active, the light above the PILOT ISOL key is illuminated.

OPS

The Operations (OPS) synoptic page provides pilot interface with:

— Aircraft Operations-Flight and Engine Times
— Weight & Balance
— V-Speed
— System Tests

■ **Aircraft Operations-Flight and Engine Times**

When the OPS page is selected a display of a detailed breakdown of aircraft operations information appears, including flight and block hours for the current flight as well as the number of engine cycles. Also displayed are aircraft totals for:

— Flight Hours
— Left Engine Hours
— Right Engine Hours
— Left Engine Starts
— Right Engine Starts
— Cycles

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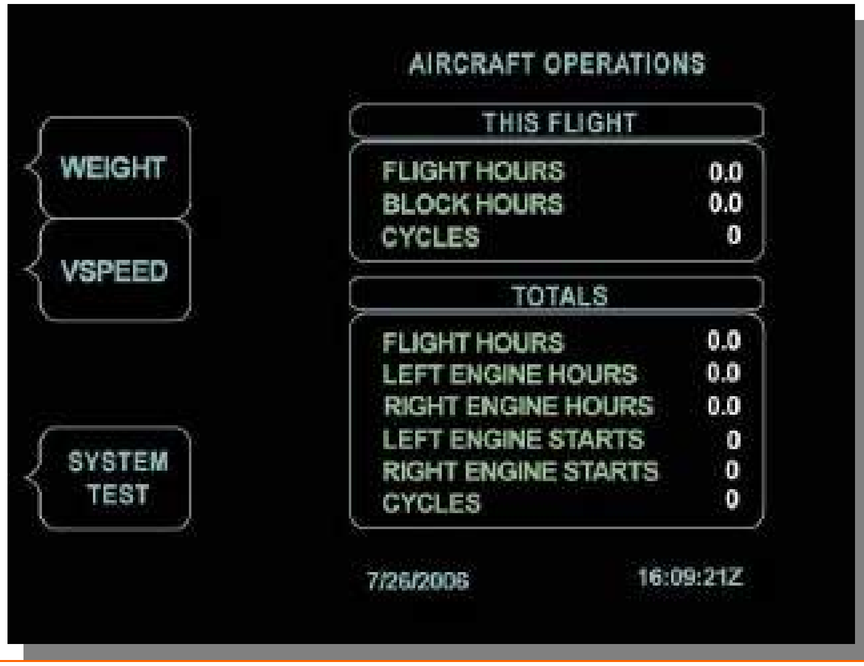

Figure 266. OPS Synoptic Page

- **WEIGHT-Weight & Balance**

The weight & balance page is selected with the WEIGHT line select key on the OPS page. Pressing this key prompts the weights page to appear allowing entry of weights for all positions on the aircraft. The pilot weight will initialize to 170 lbs, while other seat and baggage positions are initialized to zero pounds. Rotating the outer portion of the concentric knob selects the desired position. Once selected, rotating the inner portion of the concentric knob clockwise or counterclockwise increases or decreases the weight value incrementally by five pounds per click.

Entered weights for pilot (PILOT), copilot (COPILOT), passenger one (PAX 1), passenger two (PAX 2), passenger three (PAX 3), passenger four (PAX 4) and baggage (BAGGAGE) are automatically summed and indicated on the PAYLOAD line.

NOTE:

If a value of >260 lbs is entered into the BAGGAGE field, the value turns red indicating that compartment capacity is over design limits.

Aircraft empty weight is automatically displayed and is non selectable.

Available fuel load as calculated by the ACS is automatically displayed. If the FUEL line is selected, it is editable in five pound increments by rotating the inner portion of the concentric knob. Should the fuel weight be modified manually amber MAN text appears. Should a capacitance probe failure prevent total fuel load calculation, three red dashes appear in the FUEL line.

The gross weight is the automatic sum of EMPTY, FUEL and PAYLOAD weights and the field is non selectable. If the GROSS weight exceeds the maximum ramp weight the numeric value turns red. Should the calculated fuel load be unavailable the GROSS weight is displayed in amber, as the maximum takeoff weight.

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— **RESET**

Pressing the RESET line select key with the cursor over a value in a weight field resets the value to the default setting. Pressing the RESET line select key with the FUEL line selected will remove the amber MAN text and reset the fuel value to the weight calculated by the ACS.

— **RETURN TO OPS**

Pressing the RETURN TO OPS line select key displays the AIRCRAFT OPERATIONS portion of the OPS page.

Figure 267. OPS Weights Synoptic Page

- **V-Speed**

The V-Speed page is selected with the VSPEED line select key on the OPS page. Pressing this key prompts left line select key options to change, while the AIRCRAFT OPERATIONS information remains displayed.

— **T/O TEMP**

The T/O Temp line select key displays the temperature information from the left and right OAT probes within 1°C, that is used by the FADEC to calculate the takeoff power settings.

This line select key also provides for manual pilot override of the temperature. Pressing the T/O Temp line select key places a cursor in the bottom portion of the line select window. Rotating the inner portion of the concentric knob clockwise or counterclockwise increases or decreases the temperature in 1°C increments between -40°C and 50°C. When a manual temperature is entered white MAN text appears next to the temperature.

Pressing the T/O Temp line select key a second time resets the temperature to the ACS calculated values.

— **VR**

The VR line select key window appears on ground only and displays the ACS calculated rotation speed setting or allows for manual entry of rotation speed by the pilot. When the VR line select key is pressed a cursor appears and the ACS calculated value for rotation based on the current aircraft weight and flap settings appears in the window. This speed is also automatically bugged on the airspeed tape on the PFDs.

Rotating inner portion of the concentric knob clockwise or counterclockwise manually increases the rotation speed value in one knot increments and automatically changes the bugged airspeed to the selected value.

When a rotation speed is manually selected, amber MAN text appears in the VR line select window and a REMOVE TARGET line select key option appears. Pressing the REMOVE TARGET line select key removes the VR bug on the PFDs and replaces the VR value with three white dashes in the line select key window.

— **VREF**

The VREF line select key window appears in flight only and displays the ACS calculated reference speed setting or allows for manual entry of reference speed by the pilot. When the VREF line select key is pressed a cursor appears and the ACS calculated value for rotation based on the current aircraft weight and flap settings appears in the window. This speed is also automatically bugged on the airspeed tape on the PFDs.

Rotating inner portion of the concentric knob clockwise or counterclockwise manually increases the reference speed value in one knot increments and automatically changes the bugged airspeed to the selected value.

When a reference speed is manually selected, amber MAN text appears in the VR line select window and a REMOVE TARGET line select key option appears. Pressing the REMOVE TARGET line select key removes the VREF bug on the PFDs and replaces the VREF value with three white dashes in the line select key window.

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— **RETURN TO OPS**

Pressing the RETURN TO OPS line select key displays the AIRCRAFT OPERATIONS portion of the OPS page.

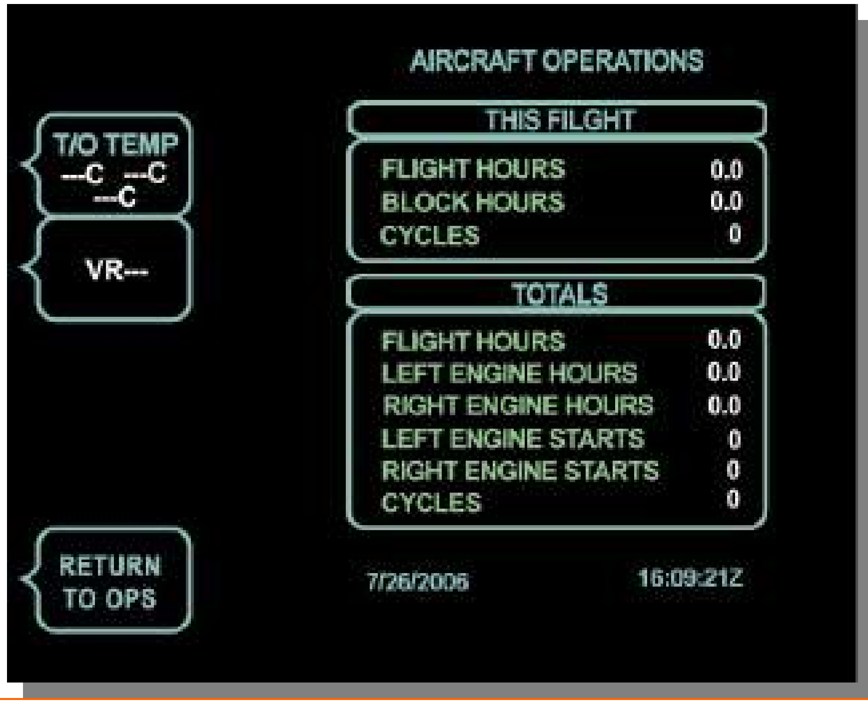

Figure 268. OPS VSPEED Synoptic Page

Figure 269. OPS VSPEED Manual VR Entry

- **SYSTEM TEST**

The system test page is selected with the SYSTEM TEST line select key on the OPS page. Pressing this key prompts the SYSTEM TEST page to be displayed. The system test page provides access to the aircraft maintenance mode on the ground only, as well as the ability to conduct a system test for the cockpit lamps, autopilot and stall protection.

— **A/C MAINT MODE**

The aircraft maintenance mode line select key provides a means for maintenance personnel to conduct certain systems tests, update system software, as well as collaring ECB's when required as part of a maintenance action. This mode is also accessible to the pilot on ground only and is selected to ON or OFF using the A/C MAINT MODE line select key.

— **START TEST**

To be a systems test, use the outer portion of the concentric knob to move the cursor to the desired system test and press the START TEST line select key. This will activate the selected system test; displays a "Test in progress" message below the TESTS window, as well as brings up a STOP TEST line select key option. Pressing the STOP TEST line select key will abort the test.

— **COCKPIT LAMPS TEST**

Activating this test will automatically command the autopilot control panel, center switch panel and keyboard lights to illuminate. This test is available in flight and on ground.

— **AUTOFLIGHT**

Activating the autoflight test is only allowed on ground and allows two minutes to engage the autopilot to conduct the required autopilot and autothrottle checks. After two minutes have transpired, on-ground autopilot engagement is prevented. The AUTOFLIGHT systems test is detailed in the autoflight chapter.

— **STALL PROTECTION**

Activating the stall protection test is only allowed on ground and provides an automatic test of the stall protection system by simulating high angles of attack and sending this data to the ACS. This will automatically trigger the stall warning sequence including the "STALL, STALL" aural warning and activation of the stick pusher. Once the stick pusher has been engaged, indicating normal operation, the test is discontinued by pressing the STOP TEST line select key.

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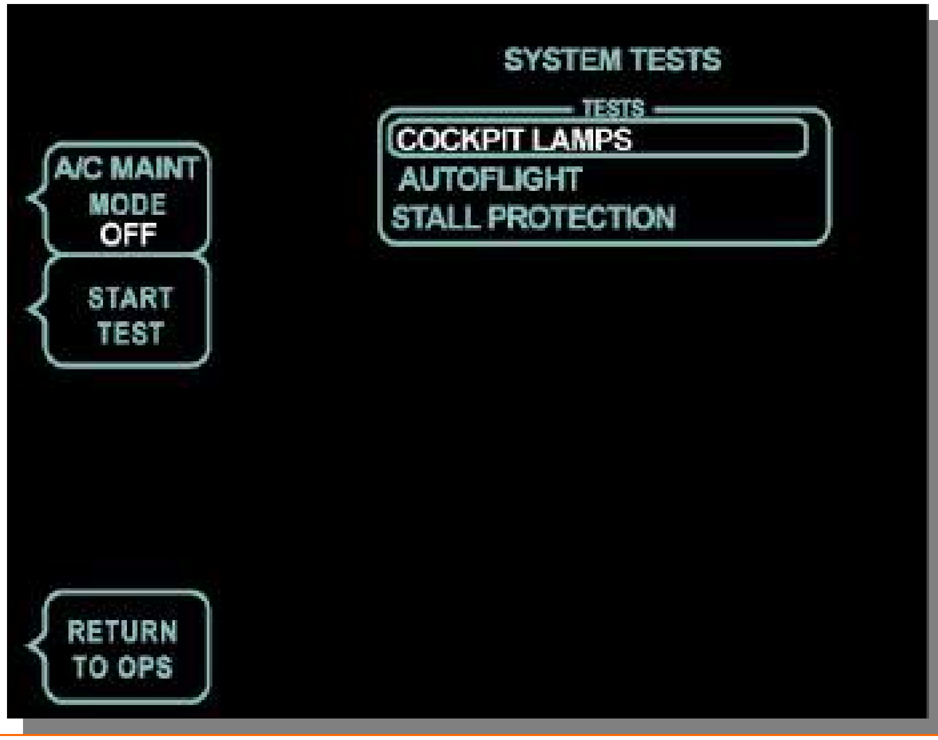

Figure 270. OPS Systems Test

— **RETURN TO OPS**

Pressing the RETURN TO OPS line select key displays the AIRCRAFT OPERATIONS portion of the OPS page.

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SENSOR

The Sensor (SENSOR) synoptic page provides pilot selection of Air Data system sources for the left and right PFDs as well as the standby ADI. This page also provides a secondary input for the altimeter setting. The main display on the SENSOR synoptic is two windows containing the source selection for the AHRS and ADC for all three displays.

— PFD AHRS SRC

The Attitude Heading Reference System source (AHRS SRC) line select key allows selection of the AHRS source for the PFDs to AUTO, 1, or 2.

- **AUTO**
  In the AUTO mode, the ACS automatically uses AHRS 1 for the left PFD, AHRS 2 for the right PFD, as well as the MFD ADI. In the event a third AHRS is available, it is used as the primary source for the MFD ADI. Should a failure of either primary AHRS source (1 or 2) occur, the off-side PFD will automatically use the remaining operating AHRS.
- **1**
  Selection of 1 for the AHRS SRC manually sets both the left and right PFD to uses AHRS 1.
- **2**
  Selection of 2 for the AHRS SRC manually sets both the left and right PFD to uses AHRS 2.

— PFD ADC SRC

The Air Data Computer Source (ADC SRC) line select key allows selection of the ADC source for the PFDs to AUTO, 1, or 2.

- **AUTO**
  In the AUTO mode, the ACS automatically uses ADC 1 for the left PFD, ADC 2 for the right PFD, and ADC 3 for the MFD ADI. Should a failure of either primary ADC source (1 or 2) occur, the off-side PFD will automatically use the remaining operating ADC.
- **1**
  Selection of 1 for the ADC SRC manually sets both the left and right PFD to uses ADC 1.
- **2**
  Selection of 2 for the ADC SRC manually sets both the left and right PFD to uses ADC 2.

— MFD AHRS/ADC SRC

Selection of the AHRS and ADC Source for the MFD ADI is not available. On start-up, the AHRS source defaults to AHRS 2, and if installed AHRS 3, while the ADC defaults to ADC 3.

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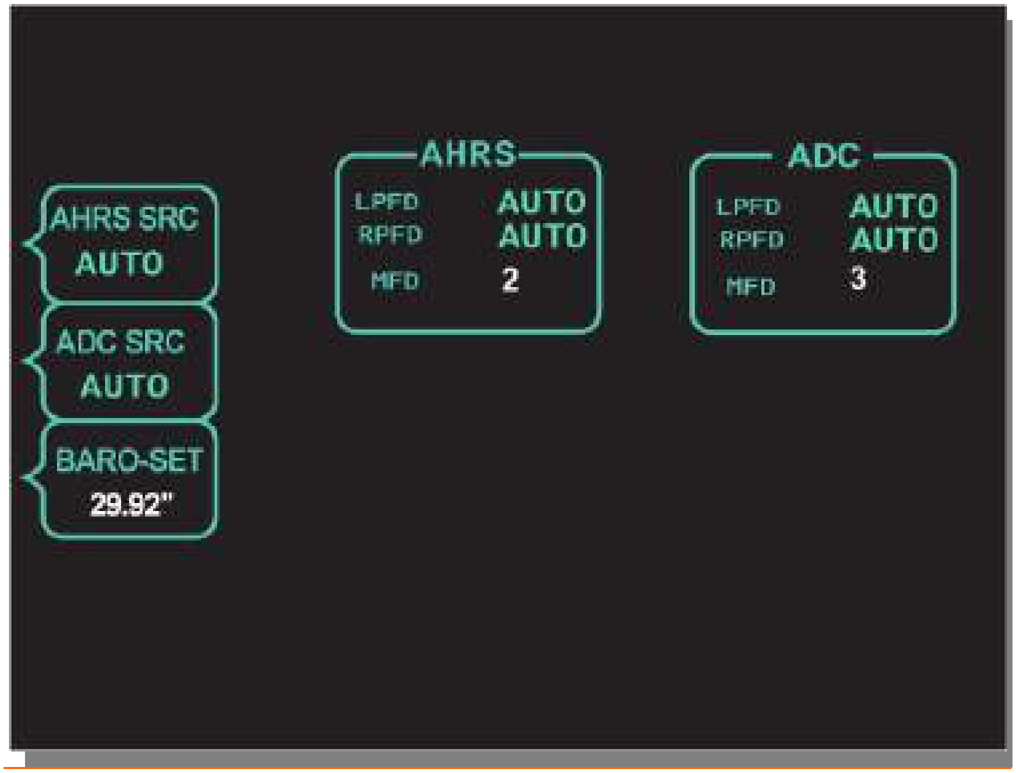

Figure 271. SENSOR Synoptic Page

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- **SETUP**

  The Setup (SETUP) synoptic page provides pilot information on the current display dimming setting, as well as the ability to see the software versions for the left and right PFDs as well as the MFD.

  — **SHOW VERSIONS**

  Pressing the SHOW VERSIONS line select key will display the current software versions for the left PFD as well as provide a SYSTEM line select key option. Pressing the SYSTEM line select key will change the synoptic page display between left PFD, right PFD and MFD.

Figure 272.   SETUP Synoptic Page

15.9 Keyboard

15.9.1 General

A left side and optionally right side keyboards are available to provide an additional interface between the pilot or copilot and the PFD, MFD. The keyboard is located behind the switch panel below the PFD and is accessed by pushing a door cover that will fold under the keyboard when it is deployed. The keyboards do not replace any functionality on the PFD and MFD and are designed to provide a secondary and in some cases easier means of selection and programming on the displays by providing one button push functions that might require several steps on the PFD or MFD. The keyboard is divided into several key groups: Composite, Transponder, Primary Function, Alpha, Numerical, and COM/NAV.

Figure 273. Keyboard

15.9.2 Composite Group

Figure 274.   Keyboard Composite Group

Control of PFD composite mode is accomplished using three keys labeled L PFD, R PFD, and PFD COMPOSITE. When the L PFD or R PFD are selected, a light above the key illuminates, indicating that it is active. If pressed again, the selected PFD key becomes inactive and the light on the button turns off. If the L PFD key is active, pressing PFD COMPOSITE one time changes the left PFD into Composite Mode. Pressing PFD COMPOSITE again toggles the left PFD back to Normal Mode. If the R PFD key is active, pressing PFD COMPOSITE one time changes the right PFD into Composite Mode. Pressing PFD COMPOSITE again toggles the right PFD back to Normal Mode. Only one of the L PFD or R PFD keys can be active at any time.

15.9.3 Transponder Group

Figure 275.   Keyboard Transponder Group

XPDR 1 & XPDR 2

Selecting a transponder (XPDR) for control is accomplished using two keys labeled XPDR1 and XPDR2. When either XPDR1 or XPDR2 key is pressed, a green light above the XPDR1 or XPDR2 key illuminates and the selected transponder becomes active. This also automatically selects the XPDR page on the PFD. One

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transponder is selected at all times; this means that pressing the same key twice will have no effect.

IDNT

Sets the selected transponder to . If the selected transponder is not in ON or ALT mode, there is no effect.

XPDR SQWK

Allows the pilot to edit the Mode A code displayed in the CODE line select window on the PFD. To change a code, press the XPDR SQWK and enter four digits using the keyboard, then press ENTER. This will set the code in the CODE line select window.

SBY

Sets the selected transponder to Standby Mode

ALT

Sets the selected transponder to reply to ATC interrogations with both Mode A and Mode C replies using whatever Mode A code is currently set.

ON

Sets the selected transponder to reply to ATC interrogations with the Mode A replies using whatever Mode A code is currently set.

VFR

Sets the Mode A code of both transponders to 1200,

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15.9.4 Function Group

Figure 276. Keyboard Function Group

The top row of function group keys allow selection of the same functions selectable using the five primary function keys on the MFD.

- MAP
- FMS
- CKLST
- SYS
- AUDIO

The second row function group buttons provide various functions

- D -> (Direct To)
  Pressing the direct to key brings up the FMS page on tile 6 of the MFD with the Direct To data entry block ready to receive a waypoint identifier and MFD tile 7 set to Moving Map.
- AFM
  Pressing the AFM key brings up the AFM portion of the OPS page on tile 6 of the MFD and shifts previously shown information on tile 6 to tile 7.
- PREV (Previous)
  Pressing PREV, selects the previous (to the left) tabbed page on tile 6 of the MFD.
- NEXT
  Pressing NEXT selects the next (to the right) tabbed page on tile 6 of the MFD.
- W/B (Weight and Balance)
  Pressing the W/B key brings up the Weight & Balance portion of the OPS page and shifts previously shown information on tile 6 to tile 7.
- PERF
  Pressing the W/B key brings up the performance portion of the OPS page and shifts previously shown information on tile 6 to tile 7.

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15.9.5 Alpha Group

Figure 277. Keyboard Alpha Group

The alpha group consists of the keyboard's alphabetic character keys plus SP (space) and CLR (clear) keys in the middle area of the keyboard. Key presses in this group only affect the MFD tile 6 and 7 only when alphabetic character input is appropriate. The four alphanumeric keys associated with the cardinal headings, N, S, E and W are highlighted with a white square.

15.9.6 Numerical Group

Figure 278. Keyboard Numerical Group

The numerical group consists of the keyboard's numerical character keys plus the "+/-", ".", "/" and ENTER keys located in the middle area of the keyboard. Key presses in this group may affect the PFD Tile 5 for communication and navigation frequency/code entries and MFD tiles 6 and 7 when numerical character input is appropriate.

15.9.7 COM/NAV Group

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Figure 279.   Keyboard COM/NAV Group

— **COM 1 & COM2**

Selecting a communication radio (COM) for control is accomplished using two keys labeled COM1 and COM2. When either COM 1 or COM 2 key is pressed, a green light above the COM 1 or COM 2 key illuminates and the selected communication radio becomes active. One communication radio is selected at all times; this means that pressing the same key twice will have no effect.

— **COM SEL**

Pressing this key changes the highlighted cursor in the communication line select key window between the COM1 standby frequency and the COM2 standby frequency The user may enter a new frequency at the cursor position.

— **SWAP**

Pressing this key exchanges the active frequency and standby frequency for the communication radio, whose line select key window contains the highlighted cursor.

— **MIN SET**

Allows the pilot to edit the minimum altitude displayed in the MIN pre-select window below the altimeter. To change altitude, press the MIN SET and enter four digits using the keyboard, then press ENTER. This will set the code in the CODE line select window.

— **SPARE/BLANK**

This key is not currently assigned and pressing it has no effect.

— **MONITOR**

Pressing this key sequentially steps through the available frequency monitor sources including OFF.

— **SPKR**

Pressing this key toggles the selected crew member's overhead speaker on and off. The left keyboard controls the left Overhead Cockpit Speaker and the right keyboard controls the right Overhead Cockpit Speaker.

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The light on the keyboard above the SPKR button is illuminated when the speaker is on.

— **PA**

Pressing this key toggles the Passenger Cabin Overhead Speaker on and off. The light on the keyboard above the PA key illuminates when the speaker is on.

— **PILOT ISOL**

Pressing this key toggles the Intercom Pilot Isolate Mode on and off. The light on the keyboard above the PILOT ISOL key illuminates when the pilot isolate mode is on. Both the Left and Right Keyboards can control this function.

— **MB**

Pressing this key toggles the Marker Beacon received audio on and off for the associated crew member. The Left Keyboard controls Pilot MB audio and the Right Keyboard (if installed) controls Copilot MB audio. The light above the MB key illuminates when the MB audio is on.

15.9.8 Cursor Control Device/Joystick

Figure 280.   Cursor Control Device/Joystick

The cursor control device/joystick is used for input on the MAP display.

15.10 Normal Operations

No Content

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15.11 Abnormal Procedures

15.11.1 MFD Failure

In the event that a MFD fails, all flight information will be available through the primary standby indications on the PFDs

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15.12 Crew Alerting System Messages

Table 38. MFD CAS Messages

Message	Condition	Categories
DUAL DATA BUS FAIL	Both data busses between the Autopilot, Autopilot Control Panel, Center Switch Panel, Keyboard, Left and Right PFDs and MFD have failed.	Caution
ACP FAIL	Autopilot Control Panel not communicating with PFDs	Advisory
AVIONICS DATABUS FAIL	One or more data busses have been lost	Advisory
L KEYBOARD FAIL	L or R Keyboard has failed	Advisory

15.13 Takeoff Configuration Warnings

Table 39. Takeoff Configuration Warnings

Message	Condition	Categories
CONFIG AILERON TRIM	Aileron trim is not within takeoff limits and TLA past 40°	Warning
CONFIG ELEV TRIM	Elevator trim is not within takeoff limits and TLA past 40°	Warning
CONFIG FLAP	Flaps extended beyond T/O position and TLA past 40°	Warning
CONFIG ENG TEMP	OAT not entered on OPS page and TLA past 40°	Warning
CONFIG PARKING BRAKE	Parking brake handle is set and TLA past 40°	Warning
CONFIG RUDDER TRIM	Rudder trim is not within takeoff limits and TLA past 40°	Warning

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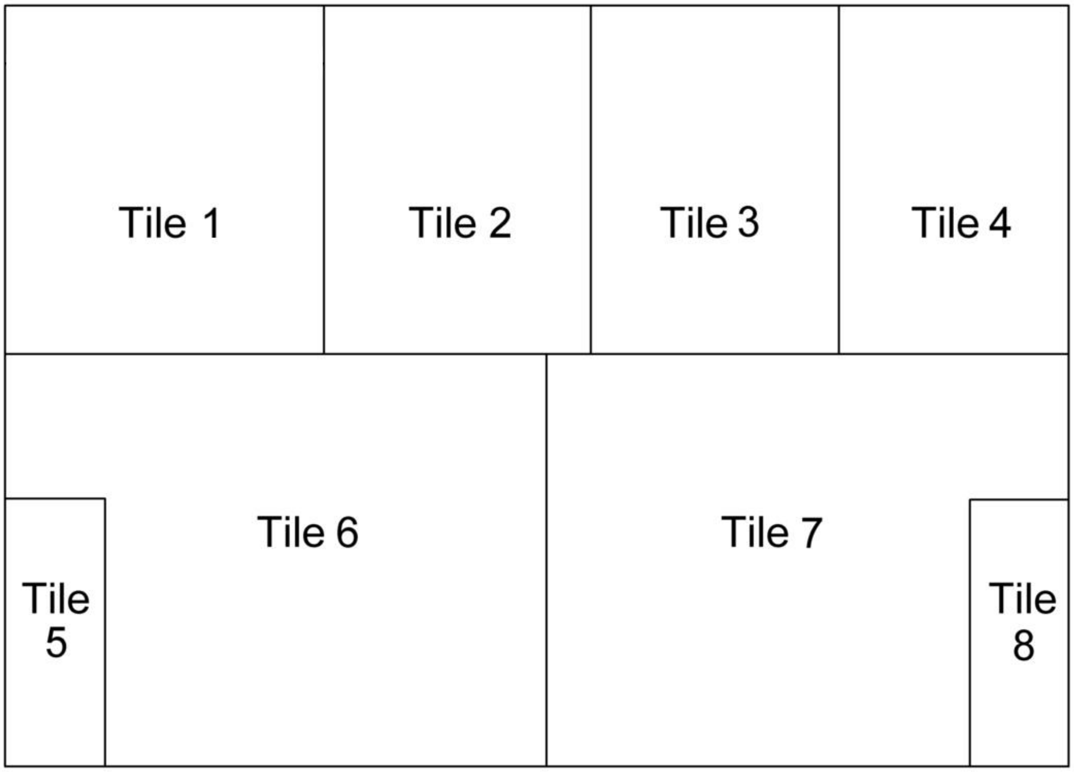
15.14 MFD Review Questions

1. **List the information contained within each of the tiles below**



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2. **Which portion/tile of the MFD continuously displays the same information?**
   a. Tile 6
   b. Tile 7
   c. The top portion (Tiles 1,2,3,&4)
   d. None of the above

3. **What are the default sources for air data and attitude information on the MFD ADI?**
   a.
   b.

4. **When the throttles are advanced to takeoff power, what is displayed above the N1 Tape?**
   a. TAKEOFF POWER in green text
   b. T/O in white text
   c. APR ARMED in white text with both engines operating
   d. APR ON in green text when a single engine is operating
   e. Both C & D are correct

5. **List the visual indications of a flap failure on the MFD?**

6. **How is cabin altitude displayed?**
   a. With an analog cabin altimeter mounted below the MFD
   b. It is displayed continuously as a digital readout on the top portion of the MFD
   c. Cabin altitude is only displayed when the pressurization synoptic page is selected
   d. None of the above

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7. **When will the total fuel quantity value turn amber on the fuel display?**
   a. When total fuel remaining is less than 500 pounds
   b. When total fuel remaining is less than 100 pounds
   c. When total fuel remaining is less than 310 pounds
   d. None of the above

8. **List the proper order (from top to bottom) of CAS message hierarchy as well as their associated colors.**

9. **How can a pilot silence an aural alert accompanied with a CAS message?**

10. **The pilot sets the desired cockpit and cabin temperatures on the _________ synoptic page.**

11. **What is the purpose of 'maintenance mode?' Can the pilot access this mode and if so, how?**

12. **Describe the functionality of the AUDIO primary function key.**

13. **Holding the ALL INTERRUPT for 2 seconds will cause what to occur on the MFD? Why does the display do this?**

14. **The N2 engine value is:**
   a. Constantly displayed as a digital value
   b. Only displayed on the MFD engine synoptic page

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c. Constantly displayed as a digital value during takeoff only
d. None of the above

15. **What are the indications that the landing gear is down and locked?**

a. Three solid green circles
b. Three open white squares
c. Three solid green circles followed which go blank after 5 seconds
d. None of the above

16. **What must the pilot do to maintain aural alerting capability if their respective PFD fails?**

a. Turn up the volume
b. Use the audio on the cross side PFD by selecting COM SOURCE
c. Turn on the cabin speakers
d. None of the above

17. **What is the function of tiles 6 & 7?**

a. They are configurable using five primary function keys
b. They are for CAS message display
c. They are for weather radar only
d. None of the above

18. **What PFD/MFD functionality does the keyboard replace?**

a. The keyboard is the ONLY way to tune NAV 1 & NAV 2
b. The keyboard is the ONLY way to set the transponder
c. The keyboard is the ONLY way to switch the PFD to composite mode.
d. The keyboard does NOT replace any functionality. It is designed as a secondary interface with the PFD and MFD.

19. **In the event of a MFD failure what shall the pilot do?**

a. Land immediately and except a sudden loss of electrical power
b. Switch their PFD to composite mode
c. Both A and B
d. None of the above

16. Autoflight

16.1 General

The Autoflight System is comprised of a two axis flight director and a three axis autopilot. The Yaw damper can be engaged independently of the autopilot coupling in roll and pitch. The Autoflight system is capable of heading tracking, altitude hold and capture, and course tracking.

All autopilot modes are commanded through the Autopilot Control Panel (ACP) which is located just below the glare shield. Autoflight system mode annunciation is displayed on the PFD. The Autopilot, Yaw Damper and Autothrottle buttons on the autopilot control panel are also lighted to indicate a selected status.

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16.2 Aircraft Computer System (ACS) Interfaces

The autoflight system is comprised of the following components:

1. Autopilot Control Panel
2. Pitch, Roll and Yaw Servos
3. Autopilot Computers

NOTE:

The autopilot computers are actually part of the actuators

Commands for the autopilot are made through the autopilot control panel and are sent directly to the three autopilot servos through redundant byte flight buses. These commands are also sent to the PFD's for display of the autopilot targets and flight mode annunciation. Each autopilot servo contains a motor control as well as an autopilot computer that receives and process autopilot commands from the pilot.

The autoflight system also sends automatic trim commands for pitch trim through the PFDs to the left and right ACS. Additional inputs from the all interrupt, autopilot disconnect, gear mute and pitch trim switches are sent through the center switch panel to the autopilot servos.

The ACS provides air data and attitude information as well as providing control of the stall warning function and provides the autoflight system with a command to activate the stick pusher as part of the stall protection system.

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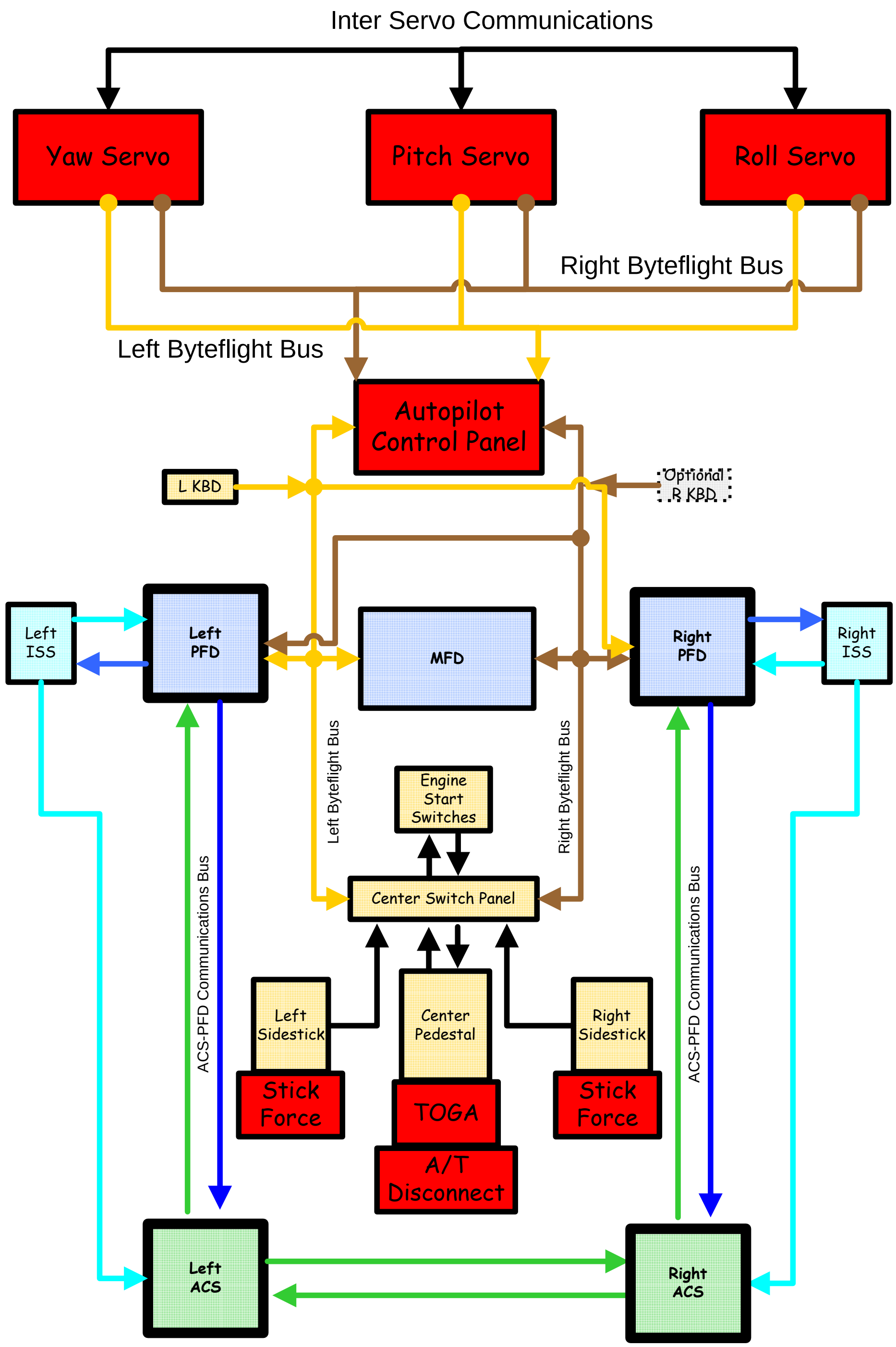

Figure 281. Autoflight-ACS Interface

16.3 Limitations and Specifications

Maximum Altitude Yaw Damper Off ....20,000 ft

Maximum Airspeed with Yaw Damper Inoperative...250 KEAS

NOTE:

For operations with the yaw damper inoperative and flaps extended, the normal flap speed and altitude restrictions apply.

Do not intentionally overpower the autopilot.

Autopilot and Yaw Damper must be selected OFF for takeoff and landing.

Autopilot minimum use height
Climb, Enroute, or Descent ....1,000 feet AGL

Approach
Precision ....400 feet AGL
Visual and non-precision.. 400 feet AGL

Autopilot must be operational for RVSM operations.

Stall Protection System and Stick Pusher must be successfully tested prior to flight.

The use of the autothrottle system is prohibited. The following Autothrottle ECB must be collared: AUTOTHROTTLE SERVOS.

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16.4 Controls and Indicators

16.4.1 Autopilot Control Panel

Figure 282. Autopilot Control Panel

BARO SET/PUSH STD (BAROMETRIC SETTING/PUSH STANDARD)

The BARO SET knob provides the primary means of entry for the barometric altimeter setting that is displayed on the upper portion of the PFD. Rotating the knob clockwise or counterclockwise increases and decreases the barometric altimeter setting respectively in .01 increments. Pressing the BARO SET knob sets 29.92" Hg.

YD OFF/ON (YAW DAMPER OFF/ON)

The YD OFF/ON button engages and disengages the yaw damper. The first press of the yaw damper button engages the yaw damper if not already engaged by autopilot engagement. When engaged green YD text appears on the upper left portion of the PFD, as well as illumination of a green light on the yaw damper button.

NOTE:

The yaw damper is automatically engaged with autopilot engagement.

Figure 283. Autopilot and Yaw Damper Engaged Indications-PFD

AP OFF/ON (AUTOPILOT OFF/ON)

The AP OFF/ON button engages and disengages the autopilot. The first press of the autopilot button engages the autopilot and the yaw damper if not already engaged. If no autopilot modes were previously selected, engaging the autopilot defaults to PITCH and ROLL hold and green PITCH and ROLL text will appear in the flight mode annunciation window on the top of each PFD. When activated green AP text appears on the upper left portion of the PFD just above the green YD text on the upper left portion of the PFD. The green light on the AP OFF/ON button will also illuminate with autopilot engagement. Pressing the button a second time disengages the autopilot, reverting to the flight director only mode.

NOTE:

Disengaging the autopilot using the AP OFF/ON button does not disengage the yaw damper.

ATS OFF/ON (AUTOTHROTTLE OFF/ON)

The ATS OFF/ON button engages and disengages the autothrottle system. The first press of the autothrottle button engages the autothrottle. When engaged, the autothrottle defaults to the SPD HOLD mode of operation, a green light on the ATS OFF/ON button illuminates and the autothrottle modes appear as green text in the flight mode annunciation window on the top of each PFD.

NOTE:

The autothrottle system may only be engaged with the autopilot engaged.

SPD-SEL (SPEED SELECT)

The SPD-SEL knob allows selection of airspeed targets for use by the autopilot and autothrottle. This knob controls the magenta airspeed bug on the airspeed tape. A speed pre-select window appears directly above the airspeed tape that displays the digital value in addition to the magenta bug. Rotating the SPD-SEL knob clockwise or counterclockwise respectively increases and decreases the value of the airspeed bug. Pressing the SPD-SEL knob synchronizes the airspeed bug and pre-select value to the current airspeed.

NAV (NAVIGATION)

The NAV button allows lateral autopilot navigation based on the selection of the primary navigation source on the PFD. The three sources of information for this mode are, VLOC1, VLOC2, or FMS. Pressing the NAV button with the autopilot OFF will activate this mode as part of flight director only navigation.

APPR (APPROACH)

The APPR button allows lateral and vertical autopilot navigation based on the selection of the primary navigation source on the PFD. The lateral approach modes are LOC (localizer), LOC BC (localizer back course), VOR, FMS, while the only vertical approach mode is GS (glide slope) for ILS approaches. Pressing this button will ARM the appropriate approach mode and show following white text on the flight mode annunciation window:

1. Lateral Modes
    a. LOC BC APPR
    b. LOC APPR
    c. VOR APPR
    d. FMS APPR

NOTE:

LOC APPR appears for both localizer and ILS approaches

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HDG (HEADING)

The HDG button allows lateral navigation using the HDG only mode. Pressing the HDG button with the autopilot OFF activates this mode as part of flight director only navigation. This mode is also activated when Go-Around is selected using the button on the left throttle.

HDG-SEL (HEADING SELECT)

The HDG-SEL knob allows selection of heading targets for use by the autopilot. This knob controls the magenta heading bug on the HSI display on the PFD. A heading pre-select display appears in the upper right corner of the HSI window on the PFD that displays the digital value in addition to the magenta bug. Rotating the HDG-SEL knob clockwise or counterclockwise moves the heading bug clockwise or counterclockwise. Pressing the HDG-SEL knob synchronizes the heading bug with the current aircraft heading.

ALT CHG (ALTITUDE CHANGE)

The ALT CHG button allows vertical navigation control for climbs and descents. There are two altitude change modes, climb, and descent. The altitude change mode is engaged by pressing the ALT CHG button and subsequently setting a higher altitude using the ALT SEL knob. This initiates a climb using airspeed as the target. The altitude change descent mode is engaged by pressing the ALT CHG button and subsequently setting a lower altitude using the ALT SEL knob. This initiates a descent using vertical speed as the target. When ALT CHG is selected green ALT CHG text appears in the flight mode annunciation window on the PFD.

THUMB WHEEL (UP/DOWN)

The thumb wheel provides selection of both vertical speed and pitch targets for climbs and descents. When the autopilot is operating in PITCH only mode, rotating the thumb wheel up or down adjusts the flight director command bars. When the autopilot is operating in ALT CHG descent mode, rotating the thumb wheel increase or decreases the vertical speed target.

ALT (ALTITUDE)

The ALT button allows vertical navigation using the ALT hold mode. Pressing the ALT button with the autopilot OFF will activate this mode as part of flight director only navigation and cause the flight director to capture the current altitude. This mode is also activated as an ARMED mode when ALT CHG is selected.

ALT-SEL (ALTITUDE SELECT)

The ALT-SEL knob allows selection of altitude targets for use by the autopilot. This knob controls the magenta altitude bug on the altitude tape display on the PFD. An altitude pre-select display appears at the top of the altitude tape on the PFD that displays the digital value in addition to the magenta bug. Rotating the ALT-SEL knob clockwise or counterclockwise increases or decreases the value of the altitude bug. Pressing the ALT-SEL knob synchronizes the altitude bug, pre-select value and flight director command bars to the current aircraft altitude.

16.4.2 Flight Mode Annunciation

The Flight Mode Annunciator (FMA) consists of several display fields at the top of the PFD. These modes appear in green when active and in white when armed. A white arrow appears in the lateral and vertical portions of the flight mode annunciation

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window that points to the armed mode that will replace the current active mode. The PFD breaks down the flight director operation into three categories: Autothrottle, Lateral (roll), and Vertical (pitch).

Figure 284. Flight Mode Annunciation Location

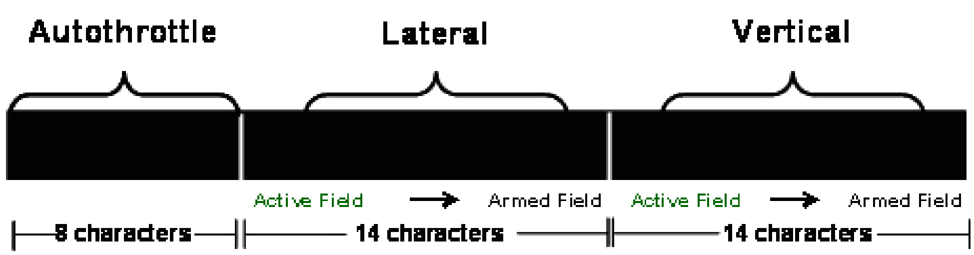

Figure 285. Flight Mode Annunciation Window

MODES OF OPERATION

Within the three categories of autopilot mode annunciation there are a number of flight mode annunciations that are divided into lateral, vertical, approach and speed modes. With the exception of the takeoff (T/O) mode -- a flight director only mode -- all the autopilot modes are the same as flight director modes. When a previously armed mode becomes the active/engaged mode; the green text of the new active mode pulses for three seconds before becoming solid. The mode transitions which use pulsing are:

- **ALT** to **ALT CAP** (pulses)
- **VOR** to **VOR** (pulses)
- **LOC** to **LOC** (pulses) including back course
- **GS** to **GS** (pulses)
- **FMS** to **FMS** (pulses)
- **GA PITCH** associated with entering Go Around mode

Below are lists of the lateral, vertical, approach and speed mode annunciations that may appear:

Table 40. Lateral Flight Mode Annunciations

Category	Sub-Mode	ACTIVE Text	ARMED Text
Roll Hold		ROLL	
Heading Hold		HDG	
Navigation (FMS)	FMS Armed		FMS
	FMS Capture/Track	FMS	
Navigation (VOR)	VOR Armed		VOR
	VOR Capture/Track	VOR	
Navigation (LOC)	LOC Armed		LOC
	LOC Capture/Track	LOC	
Go-Around (G-A)		HDG HOLD	
Takeoff (FD Only)			TO ROLL

Table 41. Vertical Flight Mode Annunciations

Category	Sub-Mode	ACTIVE Text	ARMED Text
Pitch Hold		PITCH	
Altitude	Altitude Capture	ALT CAP	ALT
	Altitude Track	ALT	ALT
Altitude Change (ALT CHG)	Climb/Descent	ALT CHG	
Go-Around (G-A)		GA PITCH	
Takeoff (FD Only)			TO PITCH

Table 42. Approach Flight Mode Annunciations

Approach Category	Sub-Mode	ACTIVE Lateral Text	ARMED Lateral Text	ACTIVE Vertical Text	ARMED Vertical Lateral Text
LOC BC		LOC BC APPR	LOC BC APPR		
LOC ONLY	Armed		LOC APPR		

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Table 42. Approach Flight Mode Annunciations

Approach Category	Sub-Mode	ACTIVE Lateral Text	ARMED Lateral Text	ACTIVE Vertical Text	ARMED Vertical Lateral Text
	Capture/Track	LOC APPR			
VOR	Armed		VOR APPR		
	Capture/Track	VOR APPR			
ILS	LOC/GS Armed		LOC APPR		GS
	LOC/GS Capture/Track	LOC APPR		GS	
FMS	Armed		FMS APPR		
	Capture/Track	FMS APPR			

Table 43. Autothrottle/Speed Flight Mode Annunciations

Category	Sub-Mode	ACTIVE Text
Autothrottle	Speed Hold	SPD HOLD
	Thrust Reference/Max Continuous Thrust (MCT)	MCT
	Underspeed Protection	SPD PROT
	Overspeed Protection	SPD PROT

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16.5 System Description

16.5.1 Autopilot Servos

There are three servos in the aircraft, each controlling one axis of rotation. The roll control servo is located near the wing root outside of the pressure vessel and the pitch and yaw servos are located in the tail cone. Control of the servos is accomplished through central processing modules located within each servo; making a dedicated autoflight computer unnecessary.

The pitch and yaw servos have additional functionality in that the pitch servo also provides stick pusher capability and the yaw servo can independently provide the yaw damper feature. Each of the servos receives power from an individual Electronic Circuit Breaker (ECB) located within Electronic Circuit Breaker Unit three (ECBU3), which is connected to the right forward electrical bus.

16.5.2 Autopilot

GENERAL

When engaged, the autopilot controls the ailerons, elevators, and rudder to meet the targets set by the flight director depicted on the PFD. Green AP text appears in the upper left-hand portion of the ADI to indicate that the autopilot is engaged. The yaw damper can be independently engaged in the roll (ailerons) and pitch (elevator) axis. Should the autopilot be engaged without any previous flight director modes selected, the autopilot will enter pitch and roll hold modes. Although the yaw damper can be engaged independently, it is automatically engaged when the autopilot is engaged.

ENGAGEMENT ENVELOPE

The following conditions must be met for the autopilot to engage:

1. Pitch Attitude .... Within -50° and +50°
2. Pitch Rate.......... Within ± 5° per second
3. Roll Angle..........Within 75° Left or Right Wing Down
4. Roll Rate .... Within ± 10° per second
5. Time after Takeoff (Weight Off Wheels) .... 15 seconds
6. Normal Acceleration-Flaps UP.......... Within 0g-2G
7. Normal Acceleration-Flaps Extended.......... Within 0.5g-1.5g
8. Lateral Acceleration ....Within ± 0.5g

NOTE:

Once engaged the autopilot will maintain the following limits:

- Pitch attitude within -15° and +25°
- Pitch rate within ± 3.5° per second
- Roll angle within 30° Left or Right Wing Down
- Roll rate within ± 2° per second

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AUTOMATIC DISENGAGEMENT

The autopilot will automatically disengage. The autopilot disconnect tone will be heard and amber AP DISC text appears above the ADI on the PFD when one of the following occurs:

1. Autopilot Failure (Includes servo failure, power loss)
2. ADC #1/#2 or AHRS #1/#2 Disagree
3. ADC #1/#2 or AHRS #1/#2 Failure
4. Pitch Trim Failure
5. Stick Pusher Activation
6. Left or Right byte flight data bus failure
7. Pilot overpowers the pitch or roll servo that causes either slip clutch to slip

MANUAL DISENGAGEMENT

The autopilot will manually disengage. The autopilot disconnect tone will be heard and amber AP DISC text appears above the ADI on the PFD when one of the following occurs:

1. A/P OFF/ON button on autopilot control panel pressed
2. A/P DISC switch on either sidestick pressed
3. ALL INTERRUPT switch on either sidestick pressed
4. Manual Pitch Trim activated by pilot

16.5.3 Flight Director

The single cue flight director is presented on each PFD over imposed onto the ADI. The autopilot function is inclusive of the flight director function as it is not possible to have autopilot engaged without the flight director on. Should the autopilot be engaged while flight director modes are active, the autopilot will engage with those modes active.

ENGAGEMENT

The engagement envelope of the flight director is the same as the autopilot with the exception of the flight director takeoff mode that can be enabled on the ground. Engagement of the flight director is represented by the flight director command bar coming into view. If the autopilot is engaged the flight director will be displayed in magenta. If the flight director is engaged and the autopilot is disengaged, the flight director will be green.

DISENGAGEMENT-AUTOMATIC AND MANUAL

Conditions that cause automatic disengagement and removal of the flight director are the same as those that will disconnect the autopilot. In addition, the flight director will disappear automatically on the ground with airspeeds less than 45 knots. Manual removal of the flight director is accomplished by pressing the ALL INTERRUPT button on either sidestick.

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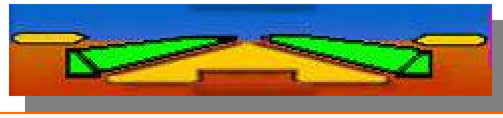

Figure 286. Flight Director-Flight Director Only

Figure 287. Flight Director- Autopilot Engaged

16.5.4 Pitch Auto Trim

Pitch Auto Trim is enabled whenever the autopilot is engaged. If a high level of mistrim is reached, an autopilot disconnect could immediately be followed by a dangerous pitch excursion. The Pitch Auto Trim system ensures that a significant buildup of mistrim force is prevented by transferring aerodynamic loading from the elevator to the pitch trim tabs. In the event that Auto Pitch Trim fails, the autopilot will remain engaged and a PITCH TRIM FAIL caution message will be posted notifying the pilot of the failure.

16.5.5 Yaw Damper

The Yaw Damper (YD) function is to reduce the natural tendency of the aircraft to exhibit Dutch Roll at certain airspeed and altitude combinations. The yaw damper servo will move the rudder to counteract the aircraft movements leading to Dutch Roll. The servo has as much authority as the rudder can travel.

ENGAGEMENT

The yaw damper engagement envelope is the same as the autopilot. The yaw damper is engaged manually by pressing the YAW DAMP button on the autopilot control panel, but will always automatically engage when the autopilot is selected and the yaw damper wasn't already engaged. Once engaged green YD text appears on the upper left-hand portion of the ADI on each PFD.

DISENGAGEMENT-AUTOMATIC AND MANUAL

When the autopilot is disconnected the yaw damper will remain engaged. Automatic disengagement occurs for the same conditions that trigger automatic autopilot disengagement. Manual yaw damper engagement is accomplished by pressing the YD OFF/ON button on the autopilot control panel with the autopilot already disengaged, or by pressing the ALL INTERRUPT switch on the sidestick.

16.5.6 Autothrottle

When engaged, the autothrottle controls the position of the throttles, which in turn controls engine thrust. When coupled with the rest of the autopilot modes, the autoflight system is able to track airspeed, or if necessary automatically activate as part of the over and underspeed protection.

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ENGAGEMENT

The Autothrottle (ATS) engagement envelope is the same as the autopilot. Autothrottle engagement is accomplished by pressing the ATS button on the autopilot control panel.

AUTOMATIC DISENGAGEMENT

The autothrottle will automatically disconnect if one of the following occurs:

1. Both engines OFF
2. Weight-On-Wheels (on ground) and airspeed less than 45 knots
3. Stick pusher is activated
4. Stall Warning issued
5. Autothrottle failure

MANUAL DISENGAGEMENT

The autothrottle will manually disconnect if:

1. ATS OFF/ON button on autopilot control panel is pressed
2. A/T DISC button on left throttle is pressed
3. Autopilot disengaged
4. ALL INTERRUPT switch on either sidestick is pressed
5. Pilot manually pushes throttles- actual position and autothrottle position vary by >10° for three seconds

16.5.7 Flight Envelope Protection

The autoflight system continuously monitors airspeed trends and uses the autothrottles to prevent an aircraft overspeed or stall as the aircraft nears overspeed (V_{MO}, M_{MO}) or underspeed (stall). In addition to speed protection the autoflight systems also uses the autothrottles to aid the stall protection system in preventing a deep stall.

OVERSPEED PROTECTION

If the aircraft will exceed maximum speeds by 6 knots (.02 mach) or another maximum speed based on aircraft configuration (i.e. V_{FE}), the autothrottle system will automatically reduce the position of the throttles. A red SPD PROT appears in the speed portion of the flight mode annunciation window. Overspeed protection (OPS) function is based on whether or not the autopilot is engaged; outlined below.

Table 44. Overspeed Protection Based on Autopilot Engagement

Autopilot ENGAGED	Autopilot DISENGAGED
Autothrottle- -Automatically engages to control and limit airspeed	**Autothrottle-** -Automatically engages to control and limit airspeed
Autopilot- -Used to reduce and control airspeed using pitch (elevator)	**-Autopilot-** Will NOT automatically engage, pilot must manually control airspeed using pitch

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Table 44. Overspeed Protection Based on Autopilot Engagement

Autopilot ENGAGED	Autopilot DISENGAGED
-If necessary will engaged SPD HOLD to increase pitch and reduce speed	(elevator)

UNDERSPEED PROTECTION

If the aircraft nears a minimum speed of $1.15V_S$ based on current aircraft configuration (based on weight and CG), Underspeed protection (UPS) is activated. The throttles are auto engaged and advanced such that airspeed is controlled at $1.15V_S$. A red SPD PROT appears in the speed portion of the flight mode annunciation window. UPS is automatically disabled during approach and landing and is manually disabled by pressing the ALL INTERRUPT switch on either sidestick. It can be momentarily disabled for 30 seconds by pressing the A/T DISC button on the left throttle. UPS function is based on whether or not the autopilot is engaged; outlined below:

Table 45. Underspeed Protection Based on Autopilot Engagement

Autopilot ENGAGED	Autopilot DISENGAGED
Autothrottle- -Automatically engages to control and limit airspeed	**Autothrottle-** -Automatically engages to control and limit airspeed
Autopilot- -Controls roll attitude to its state prior to the Underspeed protection engagement (limited to ±15°) -Holds the altitude prior to the Underspeed engagement	**Autopilot-** -Will NOT automatically engage, pilot must manually control airspeed using pitch (elevator)

Figure 288. Over and Underspeed Protection Flight Mode Annunciation

16.5.8 Stick Pusher

The ACS and the Autoflight System coordinate to provide stall protection. The ACS analyzes the aircraft's configuration, speed, and angle of attack to determine the angle at which stall protection will become necessary. The autopilot pitch servo is capable of providing the necessary elevator force to counter a nose-high pitch attitude. Upon receiving the command to push, the Autoflight System disconnects the autopilot and applies the equivalent 45 lbs of pitch-down force on the sidestick. The pilot may override the pusher by pressing the All-Interrupt sidestick button or by applying a force of about 40 lbs on the sidestick to allow the pitch trim clutch to slip.

16.5.9 Modes of Operation

TAKEOFF

Takeoff mode is a flight director only mode that is activated when the aircraft is on the ground in a takeoff configuration with the TOGA switch pressed. Both flight director

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pitch and lateral targets are set in this mode. When the TOGA switch on the left throttle is pressed, the flight director will command a wings level attitude (TO ROLL) for the lateral mode and based on current aircraft configuration (number of operating engines and flap setting), weight and CG will set the flight director to a pitch up target (TO PITCH).

NOTE:

Engine failure will cause an automatic reduction in the pitch target

Both TO ROLL and TO PITCH modes are exited by selecting another lateral or vertical mode or by engaging the autopilot.

NOTE:

For the autopilot to capture a pre-selected altitude following takeoff, ALT CHG must be selected.

GO-AROUND

When the TOGA button is pressed in the air the flight director will fix on a go-around pitch attitude and heading. This mode will not disengage the autopilot. If the autopilot was not previously engaged prior to this mode it can still be engaged if desired. When the TOGA button on the left throttle is pressed, the autopilot will capture and hold the current heading and HDG HOLD appears as the active lateral mode in the flight mode annunciation window. In addition the autopilot will set a fixed pitch target based on the number of operating engines, and display GA PITCH as the active pitch mode in the flight mode annunciation window. As with takeoff mode, go-around mode will not capture a pre-selected altitude. To capture a pre-selected altitude ALT CHG must first be pressed.

Figure 289. TOGA Flight Mode Annunciations

ROLL HOLD

Roll hold is one of the primary functions of the autopilot and is activated as a default mode if no previous mode is selected, or when a higher mode (HDG, NAV) becomes unavailable without a subsequent flight director mode present. To utilize roll hold, press the A/P OFF/ON button to turn on the autopilot, if no other lateral mode is pre-selected, ROLL appears as the active lateral mode in the flight mode annunciation window.

Roll hold will hold the aircraft in a wings level attitude if activated within 5° of a wings level attitude. If roll hold is selected when the current angle of bank is between 5° and 30° the flight director will command an attitude to hold the current bank angle. If roll hold is selected at bank angles greater than 30°, the flight director will command an attitude to reduce and hold a 30° bank angle. In the event of an engine failure, the wings level logic will default to a 2° angle of bank into the operative engine to compensate for yaw due to asymmetric thrust.

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Figure 290. PITCH and ROLL Hold Flight Mode Annunciations

HEADING SELECT/HOLD

Heading mode is selected by pressing HDG on the autopilot control panel. When heading mode is engaged the flight director will turn towards the magenta heading bug on the compass rose and HDG appears as the active mode in the flight mode annunciation window. The flight director will follow the direction of the turn as indicated by the twisting of the heading knob on the autopilot control panel. Therefore, if commanded, the flight director will turn past 180° if the HDG-SEL knob is turned in that direction. The heading bug is available for use when the flight director is disengaged or engaged. It is adjusted by rotating the HDG-SEL knob on the autopilot control panel. Pushing the HDG-SEL knob will synchronize the heading with the aircraft's current heading.

The heading bug is displayed in one of two ways, hollow, or solid. A solid heading bug display indicates the autopilot/flight director is using the heading bug as a target.

NAV

Nav mode allows the autopilot/flight director to follow the navigational guidance provided by the primary navigation source selected on the left PFD. These NAV sources can be VOR, LOC, or FMS.

If a VOR frequency is the selected navigation source on the PFD, the flight director will use the deviation of the green Course Deviation Indicator (CDI) to compute guidance in order to center it. The course is set by using the lower left concentric knob on the PFD. When arming the navigation mode using a VOR frequency, VOR text appears as the armed mode in the flight mode annunciation window. When the autopilot captures the VOR course, VOR appears, pulses for three seconds, and then becomes steady as the active mode. If the autoflight system detects that the aircraft is flying over the station, the flight director will hold the current heading until the VOR signal becomes usable again. The FMA indication will not change.

If a localizer frequency is selected as the navigation source on the PFD, the flight director will use the deviation from the CDI in order to compute guidance in order to center it. When arming the navigation mode using a LOC frequency, LOC appears as armed in flight mode annunciation window. When the autopilot captures the LOC course, LOC appears, pulses for three seconds, and then becomes steady as the active mode.

If the Flight Management System is selected as the primary navigation source on the PFD, the flight director will use a roll steering command directly from the FMS to provide lateral guidance. When arming the navigation mode using a FMS frequency, FMS appears as the armed mode in the flight mode annunciation window. When the autopilot captures the FMS course, FMS appears, pulses for three seconds, and then becomes steady as the active mode.

PITCH HOLD

Pitch hold is the other primary function of the autopilot and is activated as a default mode for vertical navigation if no previous mode is selected, or when a higher mode (ALT, ALT CHG, GS) becomes unavailable without a subsequent flight director mode present. To utilize pitch hold, press the A/P OFF/ON button to turn on the autopilot, if

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no other lateral mode is pre-selected, PITCH appears as the active mode in the flight mode annunciation window.

When pitch hold is engaged, the autopilot will hold the aircraft's current pitch attitude. If pitch hold is selected when the current pitch is greater than -15° or 25° the flight director will adjust the pitch to within -15° and 25°. If desired, the current pitch attitude may be adjusted by using the thumbwheel on the autopilot control panel. This will adjust the position of the flight director, which in turn adjusts the aircraft's pitch.

ALT HOLD

Altitude hold mode can be activated directly by pressing ALT on the autopilot control panel, or by the capture of a pre-selected altitude from another vertical mode (PITCH, ALT CHG, GS). When a flight director mode is currently active (i.e. ALT CHG) or when there's no flight director mode, pressing ALT will cause the flight director to capture and hold the altitude at the time when ALT button was pressed.

When capturing an altitude ALT as the armed mode and ALT CAP pulses for three seconds during altitude capture. Once captured, ALT appears as the active mode. If altitude capture is occurring during a climb, the aircraft will arrest the climb and track the current altitude. If the aircraft overshoots the target altitude due to the energy in the climb, a slight descent might be required to track the altitude, and vice versa when ALT is activated while descending.

The altitude bug is displayed in one of two ways, hollow, or solid. A solid altitude bug display indicates the autopilot/flight director is using the altitude bug as a target. The target bug will not synchronize itself to the altitude being tracked and will remain a hollowed outline associated with the altitude the pilot had previously selected. To select a new altitude with the altitude bug, the pilot must use the ALT SEL knob on the autopilot control panel.

ALT CHG

Alt change mode behaves differently based on whether it is commanded to descend or climb.

- **Climb**

  Climb is associated with speed hold mode only. To climb, the ALT SEL knob must first be rotated to a target altitude above the aircraft's current altitude. The ALT CHG button should then be pressed on the autopilot control panel. Upon engagement, this mode will track the target airspeed bug (solid) using elevator authority; ALT CHG appears as the active mode and ALT appears as the armed mode in the flight mode annunciation window.

  The pilot can then adjust either the airspeed bug or engine thrust, or both, to modify the climb. The capture of the altitude will occur in the same manner as ALT hold mode. As the aircraft approaches the desired altitude, ALT remains the armed mode, while active mode of ALT CHG is replaced by ALT CAP as the active vertical mode that pulses for three seconds until the altitude is captured.

- **Descent**

  Descent is a vertical speed hold mode only. To descend, the ALT SEL knob must first be turned to select an altitude lower than the aircraft's current altitude. The ALT CHG button should then be pressed on the Autopilot Control panel. Upon engagement, this mode uses elevator authority to track the Vertical Speed bug. The vertical speed target is automatically set on the VSI based on a computed 3° glide-path. The vertical speed bug will be solid, indicating that the flight director is tracking the vertical speed bug as a target. ALT CHG appears as the active

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mode and ALT appears as the armed mode in the flight mode annunciation window.

The pilot can then adjust either the vertical speed target using the thumb wheel or engine thrust to control airspeed during an ALT CHG descent. The capture of the altitude will occur in the same manner as ALT hold mode. As the aircraft approaches the desired altitude, ALT remains the armed mode, while active mode of ALT CHG is replaced by ALT CAP that pulses for three seconds until the altitude is captured.

Figure 291. Altitude Change Flight Mode Annunciations

APPROACH MODES

- **LOC APPR and LOC APPR/GS (ILS)**
  To activate approach mode the APPR button is pressed on the autopilot control panel. When LOC is selected as the primary navigation source on the PFD, the flight director will track the course deviation as displayed by the CDI and correct accordingly. The ACS can make the distinction between a VOR and LOC based on frequency and will track a localizer frequency with tighter tolerances than it would normally track a localizer course. When the localizer approach mode is selected, LOC APPR or LOC BC APPR appears as the standby mode in the flight mode annunciation window. Once captured, LOC APPR or LOC BC APPR appears as the active mode in the flight mode annunciation window.

  The APPR LOC will enable the GS capture if signal is present for use on ILS approaches. The flight director will use vertical deviation indication to compute guidance in order to center it. If the ACS detects a back course signal, it will automatically reverse the polarity of the CDI. In addition to the appearance of the LOC APPR armed and active indication, when a glide slope signal is received, GS appears as the armed indication in the flight mode annunciation window. When captured, GS appears as the active mode in the flight mode annunciation window.

- **VOR APPR**
  To activate approach mode the APPR button is pressed on the autopilot control panel. If VOR is the selected as the primary navigation source on the PFD, the flight director will use the deviation of the Course Deviation Indicator (CDI) to compute guidance in order to center it. The course is set by using the lower left concentric knob on the PFD. When selected, VOR APPR appears as the armed mode in the flight mode annunciation window. Once captured VOR APPR appears as the active mode in the flight mode annunciation window.

  When the autoflight system detects that the aircraft is flying over the station, the flight director will hold current heading until the VOR signal becomes usable again (this is commonly referred to at the cone of confusion). When using the VOR approach mode the lateral tracking tolerance is lowered for better accuracy during the approach.

- **FMS APPR**

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If FMS is selected as the primary navigation source on the PFD, the flight director will use a roll steering command directly from the FMS to provide roll guidance. FMS APPR appears as armed in the flight mode annunciation. If the required navigation precision for a particular active approach in the FMS is met by the GPS, the FMS will allow transition to the FMS approach mode and FMS APPR appears as active in the flight mode annunciation window. This is accompanied by a scale change on the CDI that should occur within 2 nm of the FAF.

NOTE:

An independent APPR annunciation will replace TERM on the PFD near the HSI and is not related to the Autoflight Annunciation.

SPEED MODES

- **Speed Hold**
  Speed hold is the default speed mode when the autothrottle system is activated using the ATS OFF/ON button on the autopilot control panel. When activated SPD HOLD appears in the speed portion of the flight mode annunciation window. This mode tracks the target airspeed as set on the airspeed bug using the SPD SEL knob on the autopilot control panel. Pushing the SPD SEL knob synchronizes the target airspeed to the current aircraft speed.
- **Thrust Reference (MCT)**
  The maximum continuous thrust mode is activated when the ALT CHG mode is active and the autothrottle is on. When ALT CHG is activated, the thrust automatically increase to MCT, MCT appears as the active speed mode and the autopilot will track the airspeed using elevator authority.

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16.6 Normal Operations

16.6.1 Before Taxi

AUTOPILOT SYSTEM PRE-FLIGHT TEST

1. Select the OPS Systems Test Page on MFD.
2. Center the Control Sticks and the rudder pedals (approximately).

   NOTE:

   Selecting AUTOFLIGHT test will initiate self-test for the Autopilot System (A/P) and Yaw Damper System (YD). The AUTOFLIGHT test takes approximately **1 to 2 minutes** to complete, depending on pilot's pace.

3. On the OPS Systems Test Page, select "AUTOFLIGHT" and "START TEST."

   NOTE:

   During the following steps, always check if any autoflight system CAS messages appear on MFD and follow the AFM instructions for each message.

4. Verify that "IN PROGRESS" is indicated on the OPS Systems Test page.
5. Press the AP OFF/ON button and verify that:
   a. YD OFF/ON and AP OFF/ON button lights are on;
   b. The FMA tile on PFD displays "PITCH" and "ROLL" in green text, ALT in white text;
   c. Symbols "AP" and "YD" appear at the top of the ADI;
   d. Stick and rudder pedals cannot be moved with small forces.
6. Verify that the stick can be overpowered without causing AP to disconnect. While overpowering in PITCH (forward-aft) direction the following will occur:
   a. The pitch trim tab will be commanded to move;
   b. The "Trim-In-Motion" aural alert will sound after trim servo moving for 2 seconds;
   c. The "PITCH MISTRIM" CAS will appear after about 4 seconds indicating pitch clutch slippage
7. Verify that the rudder pedals can be overpowered, without causing YD to disconnect.
8. Dial vertical wheel on autopilot and control panel and verify stick moves in pitch
9. Press the HDG-SEL knob to sync the heading bug to its current heading. Press the HDG mode button on ACP
10. Verify that the FMA tile on PFD displays "**PITCH**_ALT" and "**HDG**"
11. Dialing the HDG-SEL knob on ACP and verify stick moves in roll
12. Press AP DISC on the stick and VERIFY that:
    a. YD OFF/ON button light remains on and AP OFF/ON button light is off
    b. The FMA displays **PITCH**_ALT" and "**HDG**"
    c. **AP DISC** appears at the top of the ADI and blinks for at least 3 seconds
    d. AP disconnect aural alert is on and can be silenced by pressing "AP DISC" button again
    e. Stick can be moved freely.
13. Press YD OFF/ON button and VERIFY that
    a. YD OFF/ON button light is off
    b. Symbol "YD" disappears from the top of the ADI
    c. Rudder pedals can be moved in either direction with normal resistance

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14. De-select the "AUTOFLIGHT" test on OPS Systems Test page.
15. Verify that the "IN PROGRESS" indication on the OPS page extinguishes.

NOTE:

The AUTOFLIGHT test function includes a 2-minute timer. If the 2-minute period expires, the autopilot will no longer be engaged and further testing will not work. In this case, push the START TEST button again and continue with the test. The AUTOFLIGHT test can be terminated at any time by any of the following action or conditions:

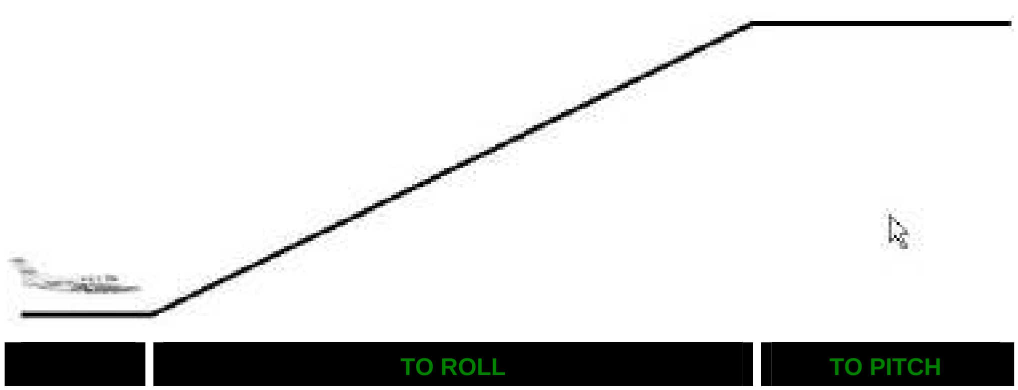
- Pressing the MFD knob to un-select the AUTOFLIGHT test on OPS Systems Test page.
- Either WOW indicates in-air
- Either Equivalent airspeed is greater than 45 knots
- 2 minutes have elapsed since the AP initiated the AP preflight test mode.

During the AP preflight test, the following buttons behave as if aircraft were in-air:

- ALL INTERRUPT button on either Control Stick
- AP DISC button on either Control Stick
- YD OFF/ON button on the Autopilot Control Panel
- AP OFF/ON button on the Autopilot Control Panel
- AP mode buttons on the Autopilot Control Panel

16.6.2 Before Takeoff

After positioning the aircraft on the runway centerline, the pilot will configure the aircraft for takeoff by pressing the TOGA button. In the takeoff mode, the flight director will not be coupled to the autopilot until the autopilot is turned on during initial climb. The pre-selected airspeed should also be set prior to takeoff with the airspeed bug. The heading bug should be set to the appropriate heading to be flown when the autopilot is engaged.



INITIAL CLIMB

The pilot should first select a new heading if necessary and then select HDG mode. The autopilot can then be engaged which will activate pitch mode and heading mode. The pilot should activate the ALT CHG mode only when the bugged airspeed is at or above the aircraft's current airspeed. This will prevent the aircraft from descending to its airspeed target when ALT CHG is activated. After the pilot verifies speed bug position, the ALT CHG mode should be activated. ALT will appear as the armed pitch mode, with ALT CHG appears as the active pitch mode.

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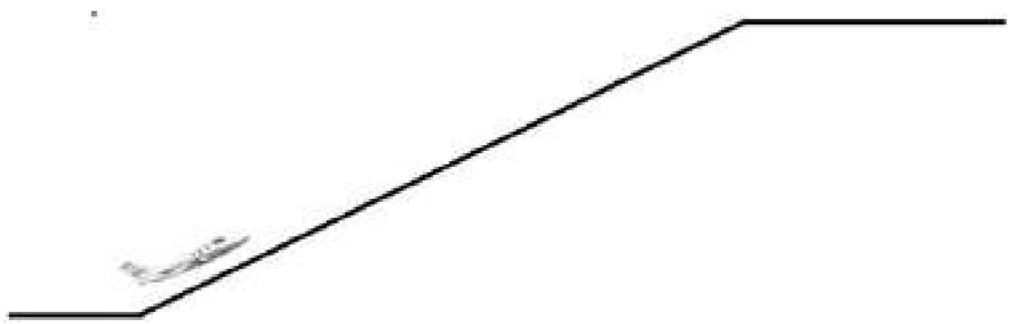


	HDG	ALT CHG → ALT

- **NAV Mode Activation During Initial Climb**

  To use the navigation (NAV) lateral autopilot mode, the pilot must first select the desired navigation source on the PFD. When the NAV button is pressed on the autopilot control panel the selected source will become armed and will become active when selected navigation mode is captured. To ensure that the NAV mode becomes active, the pilot must ensure that the aircraft's current heading will allow the navigation source to be captured otherwise the heading should be adjusted so an appropriate intercept can be made.

VOR Navigation Selected on PFD and ARMED

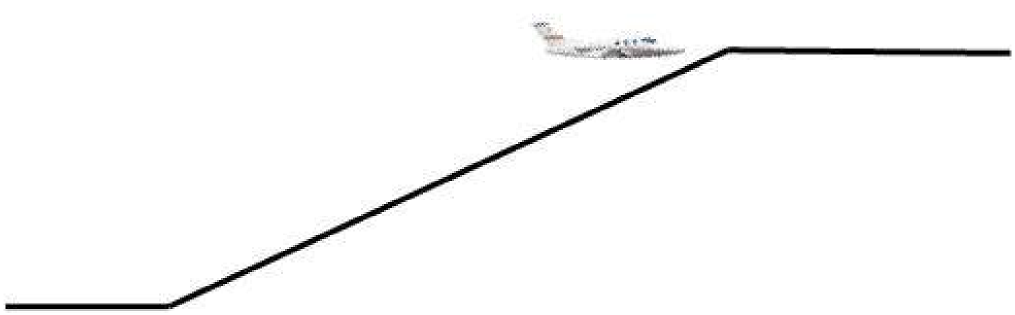
	HDG → VOR	ALT CHG → ALT

VOR Navigation Selected on PFD and Active

	VOR	ALT CHG → ALT

- **Aircraft Asked to Hold Current Altitude During Climb**

  While climbing in ALT CHG Mode, the pilot may press the ALT button to cancel active climb and hold the current aircraft altitude. When ALT is pressed, ALT CAP appears as the active pitch mode, with ALT as the armed mode. The aircraft will then progressively capture the newly assigned altitude and then track that altitude until another mode is selected or resumed.



ALT Button Pressed and Altitude Capture In-Progress

	VOR	ALT CAP → ALT

ALT Button Pressed and Altitude Has Been Captured

	VOR	ALT

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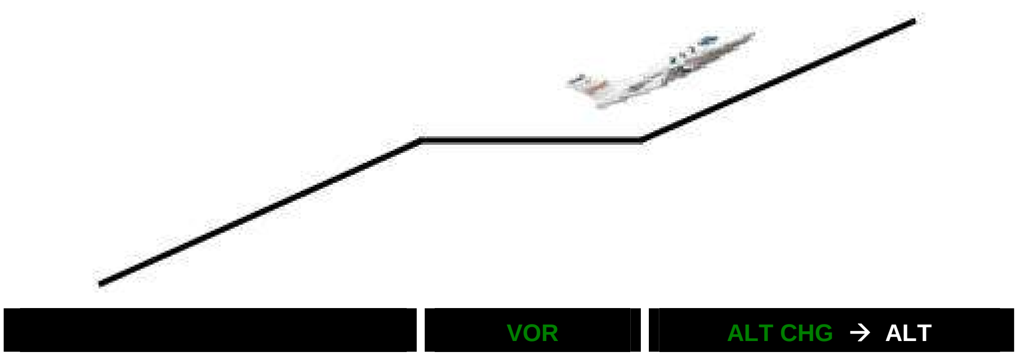
- **Climb Resumed**

Prior to receiving a level off instruction, the pilot was climbing to an assigned altitude. Even though the aircraft was leveled off prior to reaching this altitude the pre-selected altitude will remain as a selectable (bugged) target if the climb is to be continued. In this case the pilot need only press the ALT CHG button to continue the climb.

If the pilot is assigned a new altitude after level off, they must select the new altitude by rotating the ALT SEL knob on the autopilot control panel to set the desired altitude using the altitude bug. This newly selected altitude will appear on the PFD and pressing ALT CHG to capture the new altitude.

After reaching and capturing the pre-selected altitude, the pilot need not take further action unless a further climb or descent is required.



- **Descent**

To descend, the pilot must select the desired altitude with the ALT-SEL knob. This selected altitude must be lower than the aircraft's current altitude. To begin the descent, the pilot must press the ALT CHG button to begin the descent to the pre-selected altitude. The aircraft will then pitch for the solid vertical speed bug on the VSI. This vertical speed will provide a 3° glide-path during the descent. To adjust the airspeed during the descent the pilot will have to adjust the power setting.

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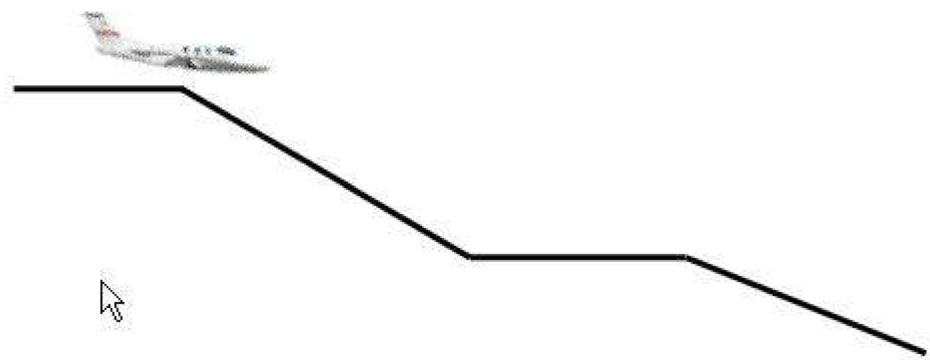
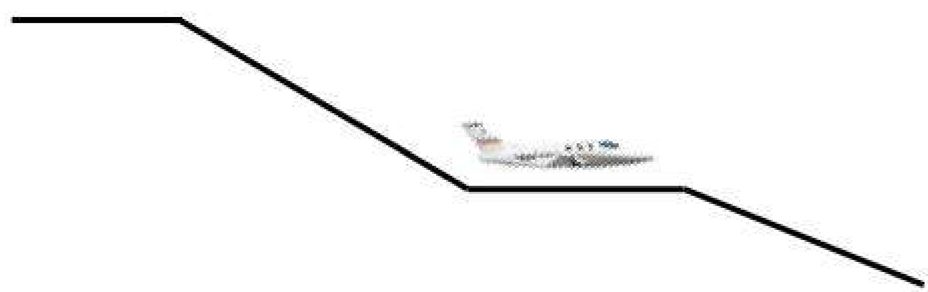


ALT CHG Activated as in a Descent

	VOR	ALT CHG → ALT

- **Leveling Off Mid-Descent**

  To level off during descent press the ALT button to capture and hold the aircraft's current altitude.



Level off Altitude Capture In-Progress

	VOR	ALT CAP → ALT

Level Off Altitude Captured

	VOR	ALT

- **Descent Continued From Level-off**

  To continue the descent from an intermediate level off the pilot need only press the ALT CHG button. This will resume the descent to the previously selected altitude. If this altitude needs to be changed the ALT-SEL knob can be used to select the new altitude target.

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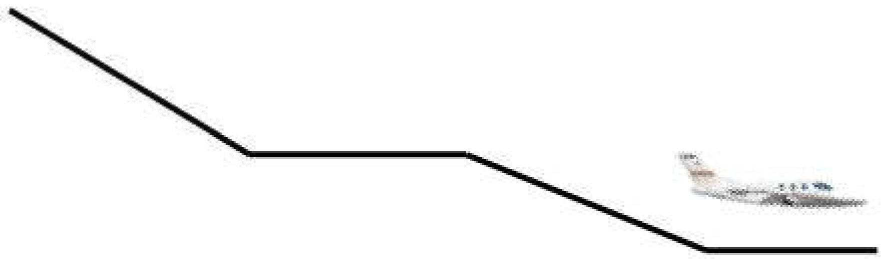


Level Off Altitude Capture In-Progress

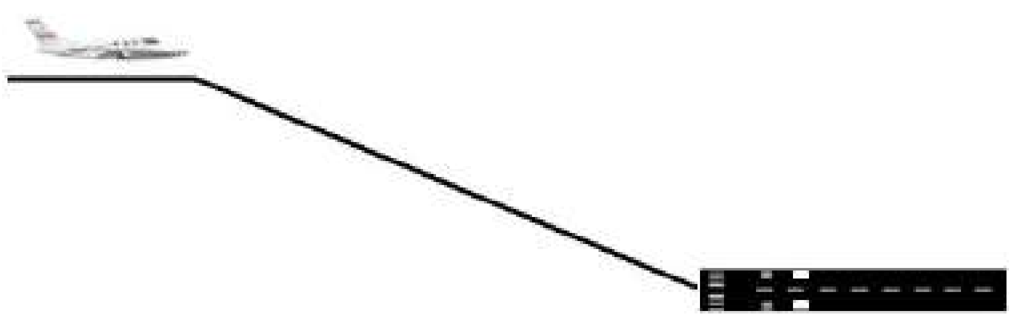
	VOR	ALT CAP → ALT

Level Off Altitude Captured

	VOR	ALT

- **ILS Approach – Prior To Course Capture**

  An ILS can be initiated from HDG mode (vectors). The pilot will need to have the appropriate navigation source VLOC1 or VLOC2 using a localizer/ILS frequency selected on the PFD so that the autopilot can capture that course from the assigned heading/VOR radial. Once selected LOC APPR appears as the armed lateral mode and GS appears as the armed vertical mode. When the localizer and glideslope courses are captured they become the active modes for the autopilot.



ILS Intercept from HDG Mode

SPD	HDG → LOC APPR	ALT → GS

- **ILS Approach – After Course Capture**

  In order for the glideslope to be captured, the autopilot must first be able to capture and track the localizer. When the localizer course has been captured the autopilot will follow the flight director indications associated with the CDI displacement on the PFD.

  NOTE:
  Approach mode must be selected for the autoflight system to utilize the glideslope. Approach mode is also necessary to navigate with the precision required for an instrument approach procedure.

- **Missed Approach**

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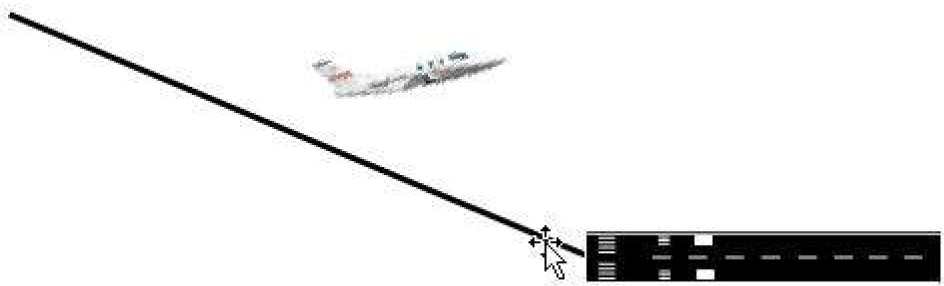
When a missed approach is necessary using the autopilot, pressing the TOGA button activates the HDG HOLD and GA PITCH as active lateral and pitch modes, and the throttles should be advanced to maintain airspeed. The aircraft will fly with roll-hold and pitch-hold during TOGA operations. Following the go-around ALT CHG mode can be selected and it may necessary to change the pre-selected altitude for the missed approach procedure.



Missed Approach With VOR Mode Armed

	HDG HOLD → VOR	GA-PITCH

Missed Approach After VOR Mode and ALT CHG Have Activated

	VOR	ALT CHG → ALT

Missed Approach With Heading Hold Only

	HDG-HOLD	GA-PITCH

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16.7 Abnormal Procedures

16.7.1 Uncommanded Autopilot Mode Change

When the autopilot is engaged in a higher mode of operation than the default modes of PITCH and ROLL hold, it is possible that due to a loss of navigational signal that the current mode cannot be maintained. If this occurs the autopilot automatically reverts to PITCH and ROLL hold, and an AP/FD MODE CHANGE caution appears to alert the pilot.

16.7.2 Pitch Mistrim

Should the pitch autotrim system become unable to reduce the amount of force on the elevator, and it exceeds approximately 20 lbs, a PITCH MISTRIM caution message appears. This requires the autopilot be disengaged and manually trimmed for pitch to reduce the resultant forces on the sidestick.

CAUTION:

Prepare for high stick forces when disengaging the autopilot. Stick forces may exceed 20 pounds.

16.7.3 Stall Protection or Stick Pusher Failure

In the event that both the stall warning system and stick pusher become unavailable a STALL PROTECTION FAIL caution message appears. A similar message appears in the event of only a stick pusher failure; in this case it is a STICK PUSHER FAIL caution message. If either message appears in flight, it requires the pilot to increase the final approach speed, possibly increase landing distance based on the flap setting and limit bank angles to less than 30° to protect against potential stalls in the landing environment.

16.7.4 Autopilot and Yaw Damper Failure

The appearance of an AUTOPILOT FAIL caution message likely indicates the failure or loss of power to the aileron or elevator autopilot servos. A reset of the electronic circuit breakers associated with each servo is recommended before attempting to reengage the autopilot.

NOTE:

If the autopilot remains deactivated RVSM requirements are no longer met and if operating in RVSM airspace, the pilot must notify Air Traffic Control.

A YAW DAMPER FAIL caution likely indicates the failure or loss of power to the rudder servo. A reset of the electronic circuit breaker associated with this servo is recommended before attempting to reengage the autopilot. If a reset is unsuccessful the aircraft must descend below 20,000 ft and maintain airspeed below 250 knots per aircraft limitations.

NOTE:

See Airplane Flight Manual, Section 2- Limitations

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16.8 Crew Alerting System Messages

Table 46. Autoflight CAS Messages

Message	Condition	Categories
AUTOPILOT FAIL	Autopilot system component has failed	Caution
AP/FD MODE CHANGE	Uncommanded mode transition	Caution
PITCH MISTRIM	Autopilot is maintaining constant forces on elevator	Caution
STALL PROTECTION FAIL	Stall warning and stick pusher have failed	Caution
STICK PUSHER FAIL	Stick pusher has failed	Caution
YAW DAMPER FAIL	Yaw damper has failed	Caution

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16.9 Autoflight Review Questions

1. **The flight director on the Eclipse 500 is a:**
   a. Single-cue flight director
   b. Dual-cue flight director
   c. Both A & B
   d. None of the above
2. **After takeoff, what is the minimum altitude (AGL) that the autopilot can be engaged?**
   a. 1000 ft AGL
   b. 400 ft AGL
   c. 500 ft MSL
   d. 1000 ft MSL
3. **What color will the flight director be when the autopilot is engaged?**
   a. Magenta
   b. Blue
   c. Green
   d. Yellow
4. **What are the default modes for lateral and vertical modes if the autopilot is engaged with no other modes pre-selected?**
   a.
   b.
5. **When climbing in ALT CHG mode, how will the speed bug appear?**
   a. Hollow
   b. Solid
   c. Hollow and will change color to magenta
   d. Solid and will change color to green
6. **What will happen when the HDG-SEL knob is pressed on the autopilot control panel?**
   a. The heading bug will become solid
   b. The heading bug will sync with the aircraft's current heading
   c. Nothing, the HDG-SEL knob cannot be pressed
   d. None of the above
7. **Where is the autopilot computer located on the Eclipse 500?**
   a. In the back of the plane against the pressure bulkhead
   b. There is no autopilot computer; all of the servos have central processing modules that work together.
   c. The ACS is the autopilot computer
   d. None of the above
8. **What is the purpose of the yaw damper?**
   a. To prevent the need for the pilot to use rudder to counter the asymmetrical thrust during an engine failure.

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b. To delay the effects of Mach Tuck.

c. To combat the effects of adverse yaw

d. To combat the effects of Dutch roll

9. **How can the pilot override the stick pusher?**

   a. The pilot can never override the stick pusher
   b. By pressing and holding the ALL-INTERRUPT button on the side-stick
   c. By overpowering the stick pusher causing the servo clutches to slip
   d. Both B & C

10. **Describe how the autopilot test is activated:**

11. **What does the appearance of a AP/FD MODE CHANGE caution message indicate?**

12. **What are the two primary modes of operation for the Eclipse 500 autopilot system?**

    a. Yaw and roll
    b. Climb and descend
    c. Pitch hold and roll hold
    d. Nav and steering

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