Eclipse 550® Systems Manual

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Published by
Eclipse Aerospace Incorporated
2503 Clark Carr Loop SE
Albuquerque, New Mexico 87106
U.S.A.

Part Number: 06-124561
Revision 00, May 2015

Eclipse 550® Systems Manual

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Avio Avionics Suite

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Avio Avionics Suite

1

1.1 General

The Avio Avionics Suite is a highly integrated avionics system that serves as the basic systems architecture for and interfaces with most aircraft functions. See Figure 1-1. Avio is further divided into five functional areas:

1. Aircraft Computer Systems (ACSs)
2. Pilot displays
3. Pilot controls/interfaces
4. Primary sensors
5. Aircraft subsystems (e.g., electrical power generation/distribution)

See Figure 1-2. While there are five functional areas, the two Primary Flight Displays (PFDs) and two Aircraft Computer Systems (ACSs) are the core of the avionics system. Through a series of 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 components. Commands are sent along these data buses to the aircraft, and systems status information is then returned to the pilot.

Figure 1-1. Cockpit Layout

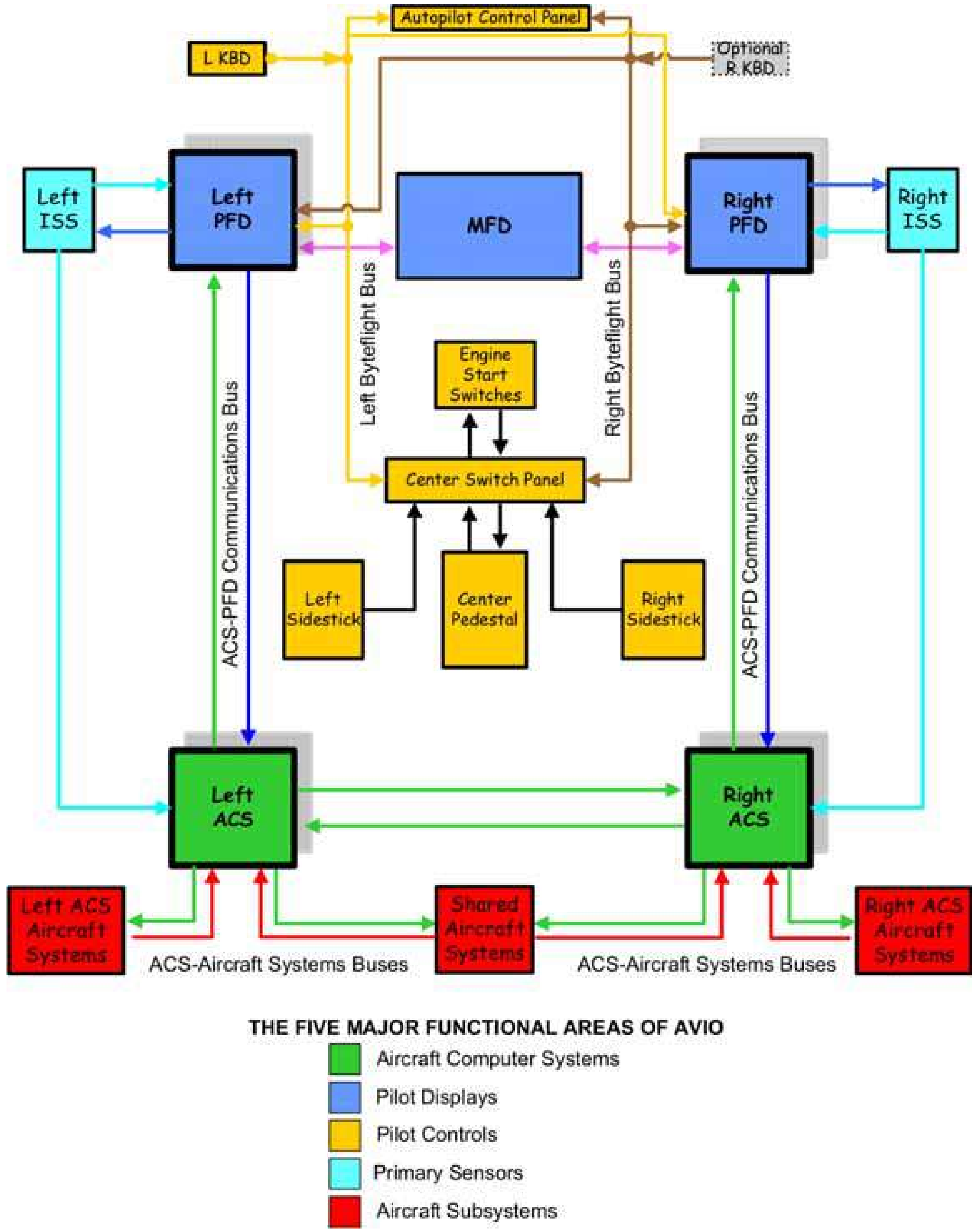

Figure 1-2. Avionics Architecture

1.2 Aircraft Computer Systems

The Aircraft Computer System (ACS) consists of two identical ACS computers. Each ACS unit is co-located with one of the aircraft's two Full Authority Digital Engine Control (FADEC) units in a Line Replaceable Unit (LRU) 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:

- Automatic command and control of systems
- Performs pilot commands
- Systems monitoring and fault reporting

1.2.1 Automatic Command and Control of Systems

The command and control of systems capability of the ACS is the pilot's primary means of systems control on the Eclipse 550. Unlike aircraft cockpits of the past, the Eclipse 550 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.

The Eclipse 550 utilizes multiple types of automation. One type of automation involves split-second decisions that are faster than the pilot can make. This type of automation is exemplified by the FADEC. Fuel control decisions for 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.

Another type of automation reduces pilot workload. In many cases, functions that are routine or unnecessarily burdensome tasks 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 will activate the fuel pumps automatically for engine start, fuel crossfeed, and low fuel quantity or pressure. Notification of the pilot that this is occurring takes place through a STATUS level CAS (Crew Alerting System) message; this assures that the pilot is always kept aware of the current state of systems components.

Another example of the ACS providing workload reducing automation is automatic electrical load shedding. When the ACS detects a loss of electrical power, i.e., the loss of one or both generators, it automatically load sheds the necessary electrical equipment to maintain sufficient power and systems functionality for the pilot to safely manage the aircraft.

1.2.2 Performs Pilot Commands

While several systems have automatic controls, the pilot has the capability to override or manually control systems components through hard switches in the cockpit and Line Select Keys (LSKs) on aircraft systems control pages, also known as “synoptic” pages. Commands from these hard switches and synoptic page LSKs are sent to the ACS, which activates the individual components.

Examples of control and command of systems include:

- Engine system control – ignition control, engine dry motoring
- Fire suppression
- Fuel system control – electric fuel pumps, fuel crossfeed
- Flight controls – flap and trim control
- Electrical – control of Electronic Circuit Breakers (ECBs)
- 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 ECBs to activate and deactivate lighting

1.2.3 Systems Monitoring and Fault Reporting

The system’s monitoring and reporting capability of the ACS allows reporting of various systems status to the pilot through the Primary Flight and Multi Function Displays (PFD and MFD). Examples of system monitoring and fault sensing include:

- Electrical system monitoring (voltage amperage, contactor status, ECB status)
- Fuel system monitoring (fuel gauging probes, fuel pumps, valves)
- Secondary engine parameter monitoring (fuel flow, oil temperature, oil pressure)
- Engine fire detection (fire detection thermistor loop)
- Pressurization and climate control system monitoring (temperature sensors, valves)
- Electro-Mechanical Actuator/Servo position monitoring (pitch, roll, and yaw trim servos, Vapor Cycle System (VCS) doors, Variable Outlet Ram-air Exhaust (VORE) doors)
- Landing gear monitoring (proximity weight on wheel (WOW) and gear position)
- Ice protection monitoring (temperature and pressure sensors in the de-ice/anti-ice system)
- Door indication monitoring
  (proximity sensor on the locking bayonet of the main cabin door)
- Brake system monitoring (optical brake fluid level sensor)
- Oxygen system monitioring (oxygen pressure)

Control monitoring is often attached to various Crew Alerting System (CAS) messages. For example, a PARKING BRAKE status message indicates that the PARKING BRAKE handle is extended.

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, including 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.

1.3 Pilot Displays

The Electronic Flight Instrument System (EFIS) is the primary component of the integrated avionics suite contained on the Eclipse 550. The primary components of the EFIS are two 10.4 inch active matrix liquid crystal Primary Flight Displays (PFDs) and one 15.3 inch active matrix liquid crystal Multi Function Display (MFD).

Figure 1-3. Cockpit Layout

1.3.1 Primary Flight Displays (PFD)

The PFDs have an important role in the AVIO avionics system. The PFDs function as information distribution centers. The PFDs route pilot commands to the ACS, which then sends the command to the appropriate aircraft subsystem. The aircraft subsystems send information to the ACS which then sends the information to the PFDs for display and further distribution to the MFD. Additionally, the PFDs provide the following display and control functionality (the PFDs are outlined in detail in Chapter 13, “Primary Flight Display (PFD)”:

1. Airspeed/mach
2. Altitude and vertical speed
3. Autopilot/yaw damper mode
4. Baro Setting
5. Autopilot/Flight Director targets
    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. Magnetic heading
9. VOR, ILS, and FMS information.
10. Communications and navigation radio tuning
11. Transponder control
12. Composite mode (used during MFD failure)
    a. FMS (all except VNAV available)
    b. SYS (all except OPS: WEIGHT & PERF)
    c. AUDIO

NOTE:
MAP, CHKLST are unavailable on the PFD

1.3.2 Multi Function Display (MFD)

The MFD is the primary interface for the pilot to the aircraft systems and their status. This display is the center of the displays and a focal point for the pilot. All information to and pilot commands from the MFD is routed through both of the PFDs to the ACSs.

The MFD is divided into upper and lower portions. The upper-right portion of the MFD is continuously displayed; the lower- and upper-left portions are configurable. Several systems synoptic pages presented on the MFD provide primary control of most system functionality. Each system synoptic page contains a schematic of the selected system which displays 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, although similar, do not represent actual system layout.

The MFD provides the following display and control functionality and is outlined in detail in Chapter 14, "Multi-Function Display (MFD)."

UPPER PORTION

1. Mini Tile
   a. MAP
   b. PROGRESS
   c. ACTIVE
2. Aircraft systems information
   a. Engine
   b. Landing Gear
   c. Flight Controls
      1. Flaps
      2. Trim
   d. Cabin pressurization
   e. Fuel
3. Crew Alerting System (CAS)

LOWER PORTION

1. MAP
   a. Nav Display (ND)
   b. MAP
      1. MAP INFO PAGE
      2. MAP SETTINGS
         (a) XM SETTINGS
            (1) XM AGES

c. CHART
  1. AIRPORT MENU
    (a) AIRPORT INFO
    (b) XM DATA
      (1) METAR
      (2) TAF
      (3) CITY FORECAST
    (c) CHART MENU
      (1) Chart View
        — Tall chart

2. FMS

   a. Active flightplan (ACTV)
   b. Progress (PROG)
   c. Route (ROUTE)
   d. Nearest (NREST)
   e. User waypoints (USER)
   f. Vertical navigation (VNAV)

3. Normal Checklist (CKLST)

4. Aircraft systems synoptics (SYS)

   a. Engine (ENG)
   b. Fuel (FUEL)
   c. Electrical (ELECT)
   d. Electronic Circuit Breakers (ECB)
   e. Environmental (ENVIR)
   f. Flight Controls (FLCS)
   g. Pressurization (PRESS)
   h. Ice Protection (ICE)
   i. Aircraft Operations (OPS)
     1. Weight and Balance (WEIGHT)
     2. V-speeds and Engine Temperatures entry (VSPEED ENG TEMP)
     3. Performance (PERF)
     4. System Test
       (a) EFIS SERVICE MODE
       (b) MAINTENANCE MODE
   j. Setup (SETUP)
     1. SENSORS
       (a) GPS
         (1) SATELLITE STATUS
     2. SETTINGS
       (a) INSTALLED EQUIPMENT

3. Audio Mixer(AUDIO)

1.4 Pilot Controls

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

1.4.1 Center Switch Panel (CSP)

See Figure 1-4. 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 ACSs. The CSP is dual-channeled for redundancy. Pilot commands travel via the Left and/or Right Byteflight busses to the PFDs for distribution.

Direct pilot controls include:

- Landing light
- Taxi/recognition lights
- Normal landing gear handle
- Strobe/beacon lights
- Ice protection (engine anti-ice and wing de-ice)
- Ice inspection light
- Cabin lights
- Dome light
- Footwell lights (optional)
- Cockpit dimming
- Night/day switch

Command Routing:

- Engine start switch panel
- Left and right sidesticks
- Center pedestal (rudder trim switch and flap selector inputs)

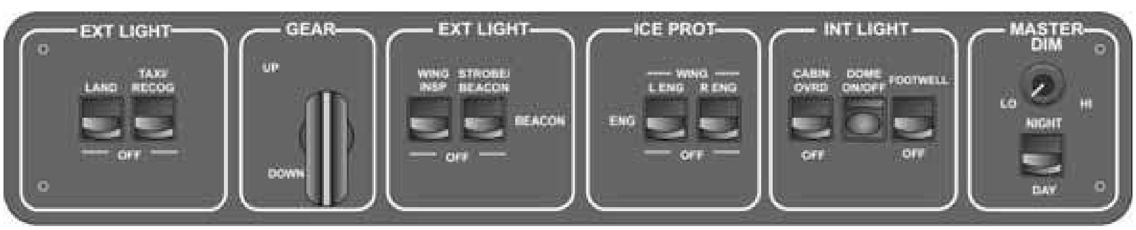

Figure 1-4. Center Switch Panel

1.4.2 Engine Start Switch Panel

See Figure 1-5. 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

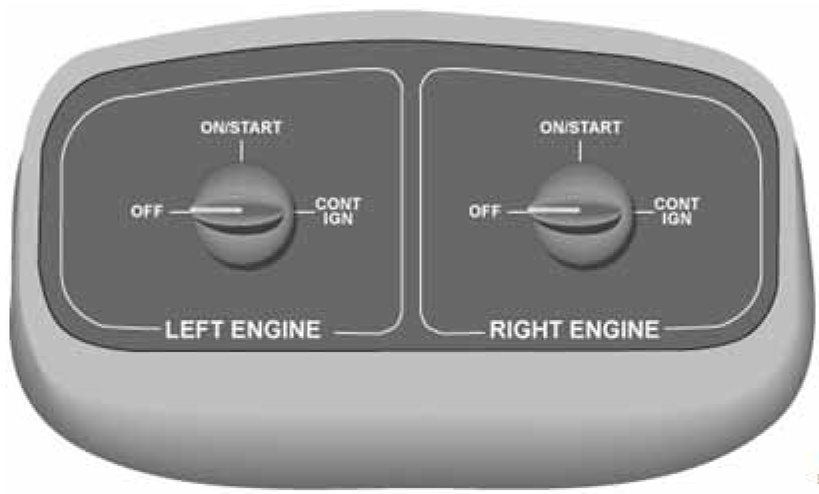

Figure 1-5. Engine Start Switch Panel

1.4.3 Autopilot Control Panel

See Figure 1-6. 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)
- Map lights (left and right)
- Caution/warning lights (left and right)
- Fire warning and suppression (left and right)

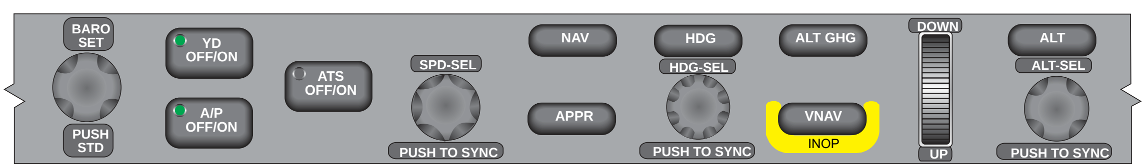

Figure 1-6. Autopilot Control Panel

1.4.4 Sidestick (Left and Right)

Switch inputs from each sidestick are routed through the center switch panel to the PFD and on to the ACS. See Figure 1-7. In addition to flight control of the aircraft, 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

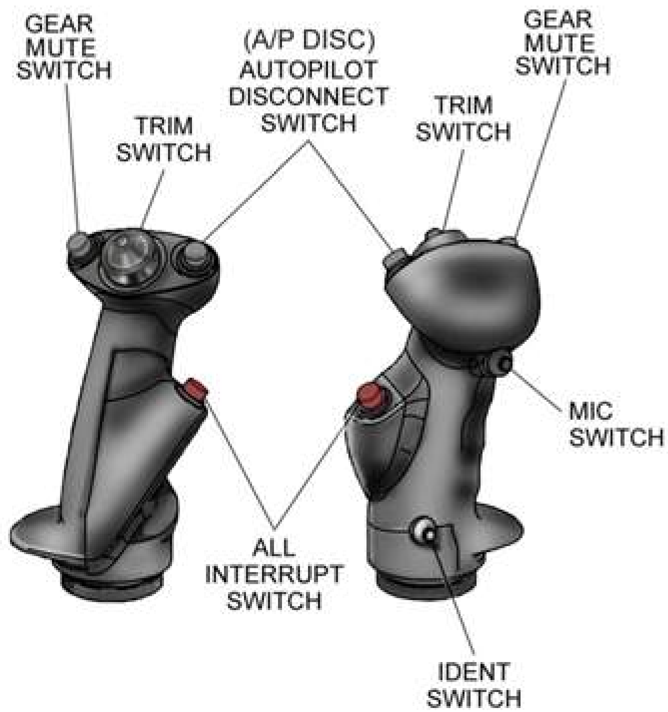

Figure 1-7. Sidestick

1.4.5 Instrument Panel - Left (IPL)

See Figure 1-8. The IPL is also called the essential switch panel since 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 microphone selections (MIC MASK/HEADSET)
- Mechanical circuit breakers (LEFT PFD & CNS (Communication, Navigation, Surveillance) 1, LEFT ACS)
- Emergency Locator Transmitter (ELT) switch and annunciation
- Five electrical contactor switches (Right Generator, Left Generator, System Battery, Bus Tie Contactor, Start Battery)
- Oxygen PULL-ON Knob, PASSENGER MASK mode selector, and oxygen pressure display.
- Cabin air control (AIR SOURCE and cabin DUMP)

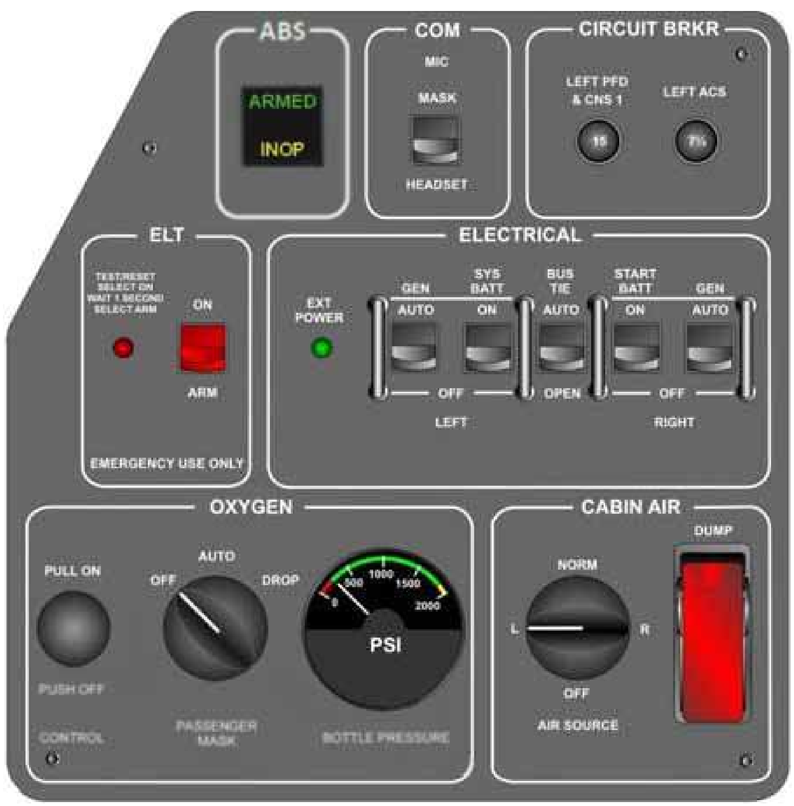

Figure 1-8. Instrument Panel - Left

1.4.6 Instrument Panel - Right (IPR)

See Figure 1-9. The IPR contains the fifth continuous flow passenger oxygen mask. Aircraft with the optional second quick-don oxygen mask will have a Communications Microphone Selection switch for the copilot quick-don oxygen mask.

Figure 1-9. Instrument Panel - Right

1.4.7 Armrest Panel

See Figure 1-10. The armrest panels, while not considered a switch panel, are an important pilot interface. A panel beneath both the left and right side pilot armrests provides the following:

- Oxygen line connection (quick don mask)
- Oxygen mask microphone jack (quick don mask)
- Pilot headset jacks (headphone and microphone)
- Handheld microphone jack
- USB Port
- Mechanical Circuit Breakers
- Left Armrest
  - COM1/NAV1
  - ACP1
  - PFD1
  - XPDR1/KYBD1
- Right Armrest
  - XPDR2/KYBD2
  - PFD2
  - ACP2
  - COM2/NAV2

The USB port located under the left (pilot's) armrest allows for uploading of important software and database updates (e.g., Jeppesen E-Chart and Navigation Databases). The USB port located under the right (co-pilot's) armrest is used for maintenance purposes only.

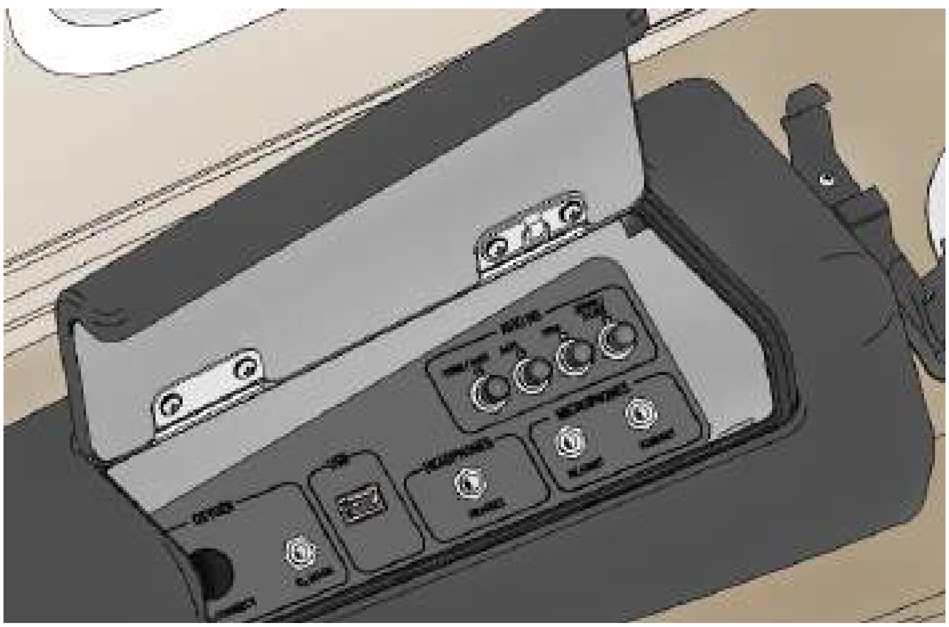

Figure 1-10. Pilot's Side Armrest Panel

☞ **IMPORTANT:**
The pilot should not attempt to use the right (co-pilot's) USB port for other than maintenance purposes.

1.4.8 Keyboards

See Figure 1-11. The keyboards are an alternate means for inputting data 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:

- MFD Primary function selection
- Audio selection and control
- Communication radio selection and control
- Flight Management System (FMS) functions
- Alphanumeric entry of waypoints and radio frequencies
- Tab control for the MFD (PREV/NEXT)
- Cursor Control Device (CCD)
- Data Entry Path (LPFD/RPFD or MFD)
- PFD Composite control
- OPS: PERF page selection
- Transponder (XPDR) selection and control

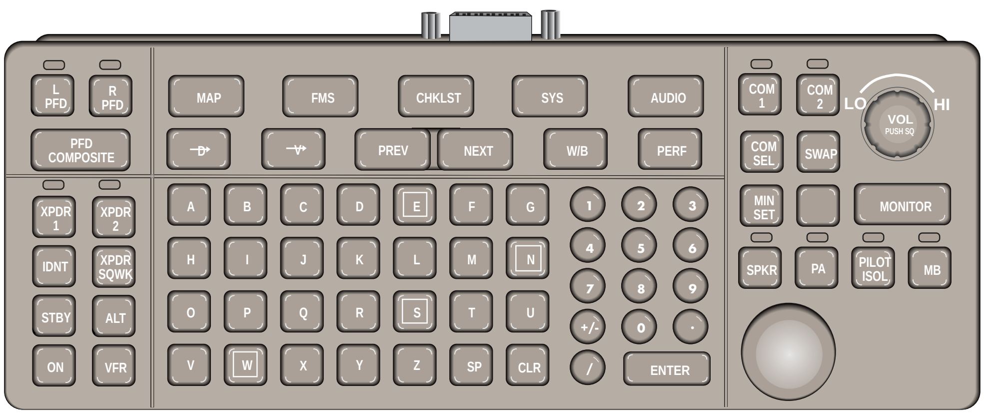

Figure 1-11. Keyboard

1.4.9 Throttle Quadrant Switches (Flaps and Rudder Trim)

See Figure 1-12. The throttle quandrant contains the following switches:

- Left and Right Engine Control Thrust Lever Angle (TLA) Rheostats - Throttles
- Take-Off / Go-Around (TOGA)
- Autothrottle Disconnect (A/T DISC)
- Flap Position Selector
- Rudder Trim Switch

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, A/T DISC and TOGA switch position information is sent through the center switch panel to the PFDs, then on to the ACS.

Figure 1-12. Throttle Quadrant

1.4.10 Line Select Keys

See Figure 1-13. Line select keys on the PFD and MFD allow control of various aircraft inputs, including frequency entry and system control. Each display has ten Line Select Keys (LSKs), five on each side. The Top Left LSK is referred to as Left LSK 1. Bottom Right LSK is referred to as Right LSK 5. Depending on what PFD or MFD functions are enabled, the screen label next to the LSK will annunciate what pressing the LSK will command.

Line select keys are often associated with the PFD or MFD pages within which they are used to activate or deactivate specific systems components, such as the fuel pumps.

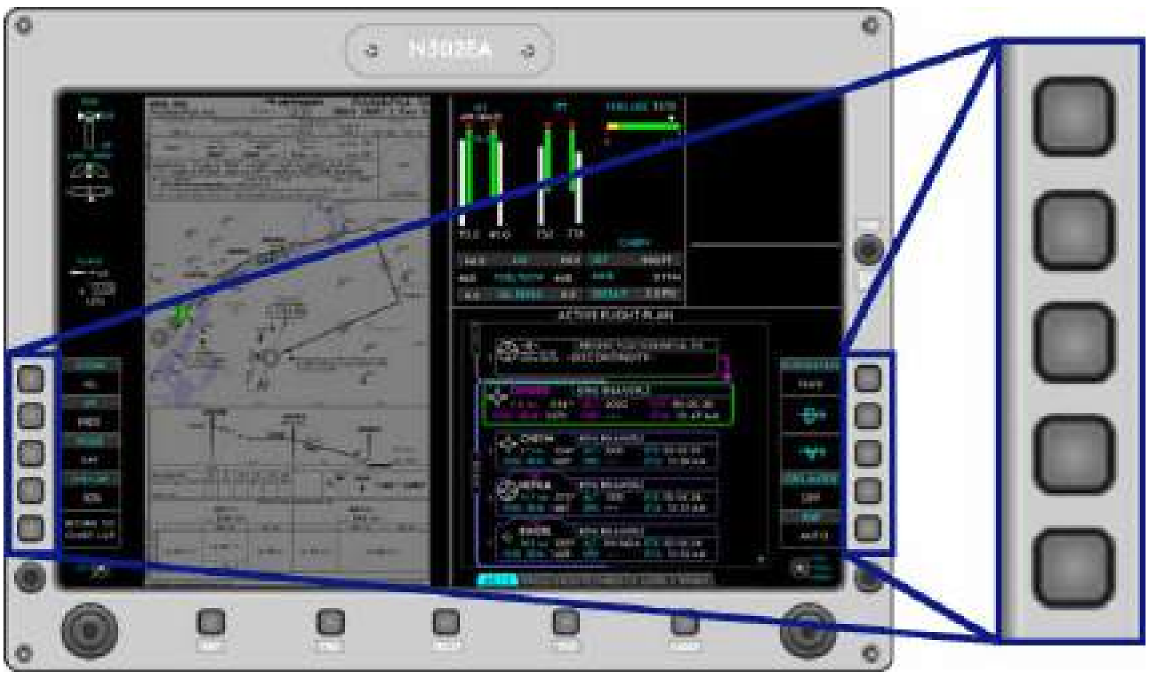

Figure 1-13. Line Select Keys

1.4.11 Tab Select Knobs

See Figure 1-14. The left and right Tab Select Knobs allow the pilot to select the desired tab at the bottom of the lower right and lower left tiles of the PFD and MFD. These knobs can be rotated to scroll through the available tabs. Scrolling is not a looping function; 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 1-14. Tab Select Knob

1.4.12 Primary Function Keys

See Figure 1-15. 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 tile set to the last used MAP tab; lower right tile set to page previously on the lower left.
- FMS
  Lower left tile set to the FMS ACTV tab; lower right tile set to page previously on the lower left.
- CKLST
  Lower left tile set to the electronic checklist page; lower right tile set to page previously on the lower left.
- SYS
  Lower left set to last used systems synoptic tab or, if last page unknown, to the first tab in the list (ENG); right tile set to page previously on the lower left.
- AUDIO
  Lower left set to the AUDIO page; lower right set to page previously shown on lower left.

Figure 1-15.   Primary Function Keys

1.4.13 Concentric Knobs

See Figure 1-16. Two concentric knobs are located on the bottom portion of the PFD and MFD. 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). The Dual Concentric Knob (DCK) consists of an outer knob, an inner knob, and a center push button. Generally the outer knob is used to move a selector or to set the larger value (such as the MHz portion of a COM frequency). The inner knob is used to change the selected value or set the smaller value (such as the KHz portion of a COM frequency). The push button is used to activate a function in the selected LSK window (such as toggling standby and active COM frequency). If a LSK window in the column above the Dual Concentric Knob (DCK) is in focus (as indicated by a green outline) the knob will change the value in that window.

Drop Down Menu Selection

Some display pages contain additional drop down menus for control. Rotating the outer knob moves the cursor from field to field. Rotating the inner knob scrolls through drop down menu choices, and selections are made by pressing the inner knob.

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

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.

Figure 1-16. Concentric Knobs

1.4.14 Single Rotary Knob

See Figure 1-17. Single rotary knobs on the PFD provide control of master volume and squelch. The single rotary knob on the MFD provides the selection and acknowledgment of CAS messages on the MFD.

Figure 1-17. Single Rotary Knob

1.5 Primary Sensors

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

1. Air Data Computer (ADC)
   - Pitot
   - Angle of Attack (AOA)
   - Static
   - Outside Air Temperature (OAT)
2. Attitude Heading and Reference Systems (AHRS)
   - Magnetometers

Information from both Integrated Sensor Suites is sent to the ACS for comparison and failure monitoring, to FADECs for engine control, and to the PFD and MFD for display.

1.6 Aircraft Subsystems

The Eclipse 550 aircraft subsystems include:

- Engines and Fire Protection
- Fuel
- Electrical
  - Electronic Circuit Breakers (ECBs)
- Climate control
  - Environmental
  - Pressurization
- Ice protection
- Landing gear
  - Anti-Skid Brakes
- Flight controls
- Oxygen
- Autoflight
  - Autopilot
  - Autothrottle

While most aircraft system functions are shared between the ACS units, there are some that are routed through a specific on-side ACS. For instance, engine starting is controlled by the on-side ACS (i.e., the left ACS controls the left engine starting). Trim also functions in this manner. The left ACS operates the roll trim and the left pitch trim, while the right ACS operates the yaw trim and the right pitch trim. The Flap System uses a slightly different arrangement: the left ACS controls the flaps via the left inboard actuator, and the right ACS controls the flaps via the right inboard actuator.

All aircraft subsystems have ACS interfaces that are outlined in the various systems chapters.

1.7 Avionics Overview Review Questions

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

   a.

   b.

   c.

   d.

   e.

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

   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 ACS?**

   a. Through the autopilot control panel
   b. Directly
   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 and B
d. None of the above

8. What action is accomplished by tab select knobs?

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. They 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 tab select knobs
c. Both A and 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

Flight Controls

2

Contents

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Flight Controls

2

2.1 General

See Figure 2-1. 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.

Trim for the three primary flight controls is electro-mechanically actuated. 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 upper portion of the MFD, and in detail on the Flight Controls (FLCS) Synoptic. 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 by use of the ALL INTERUPT button on the sidesticks.

To protect against high wind conditions, a gust lock is placed over the left sidestick and locked into the pilot seat rail to secure the ailerons and elevator in place. Rudder movement is inhibited by mechanical resistance from the nose wheel steering system.

The wing flaps are electro-mechanically actuated 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.

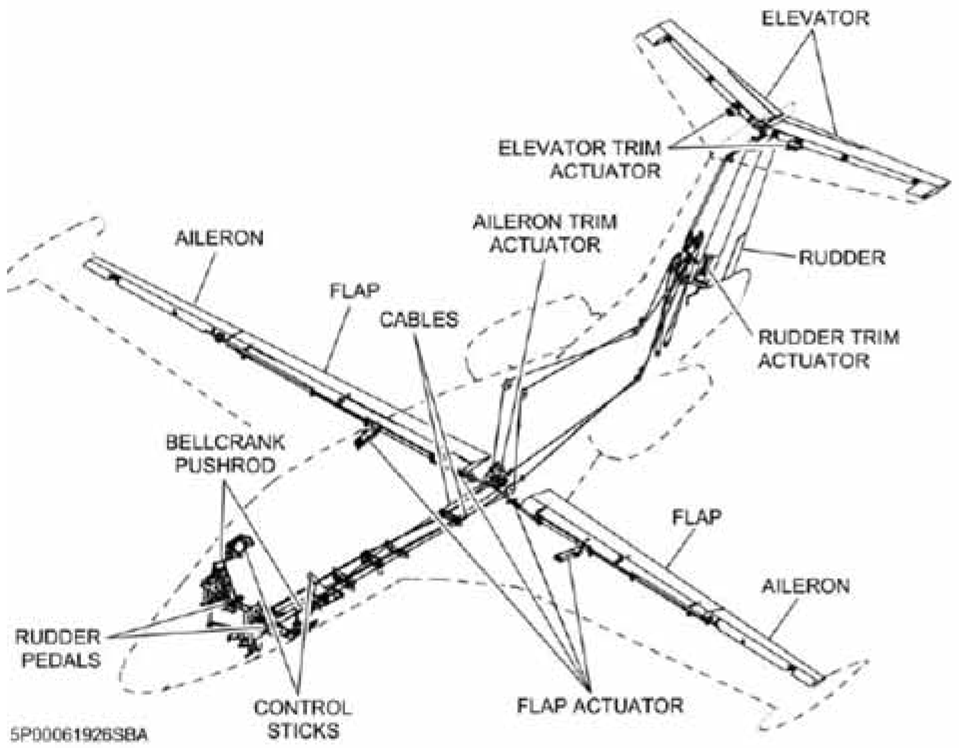

Figure 2-1. Flight Controls Schematic

2.2 Aircraft Computer System (ACS) Interfaces

2.2.1 Flaps

See Figure 2-2. There are four electromechanical flap actuators on the Eclipse 550, 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 monitors the actuators, and potentiometers to determine flap position.

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

2.2.2 Trim

See Figure 2-3. The Eclipse 550 has four trim motors; two are used to move the elevator trim tabs (pitch), one to change the centering spring position (roll), and one to move the rudder trim tab (yaw). Pilot control for pitch and roll trim is through the trim switch on each sidestick, and 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, and pitch trim disagreement.

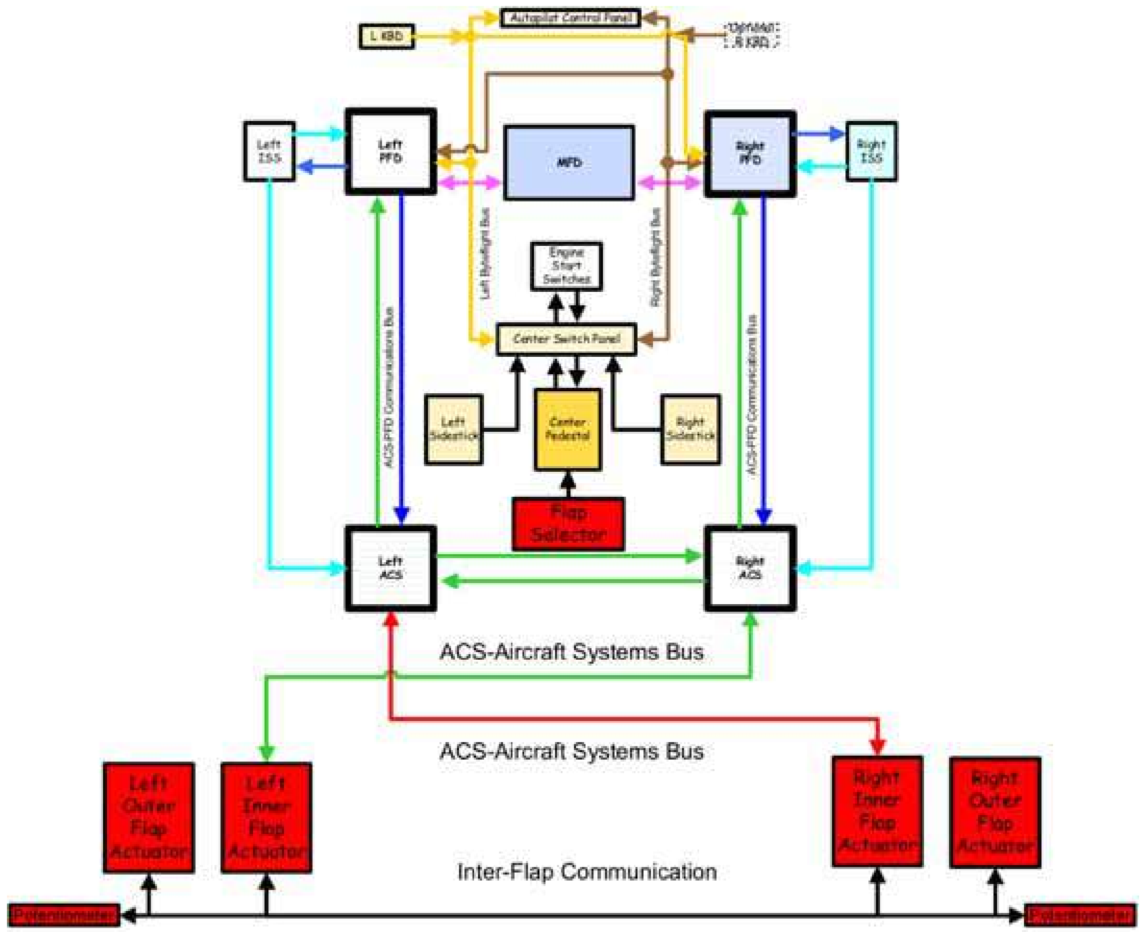

Figure 2-2. ACS – Flap Interface

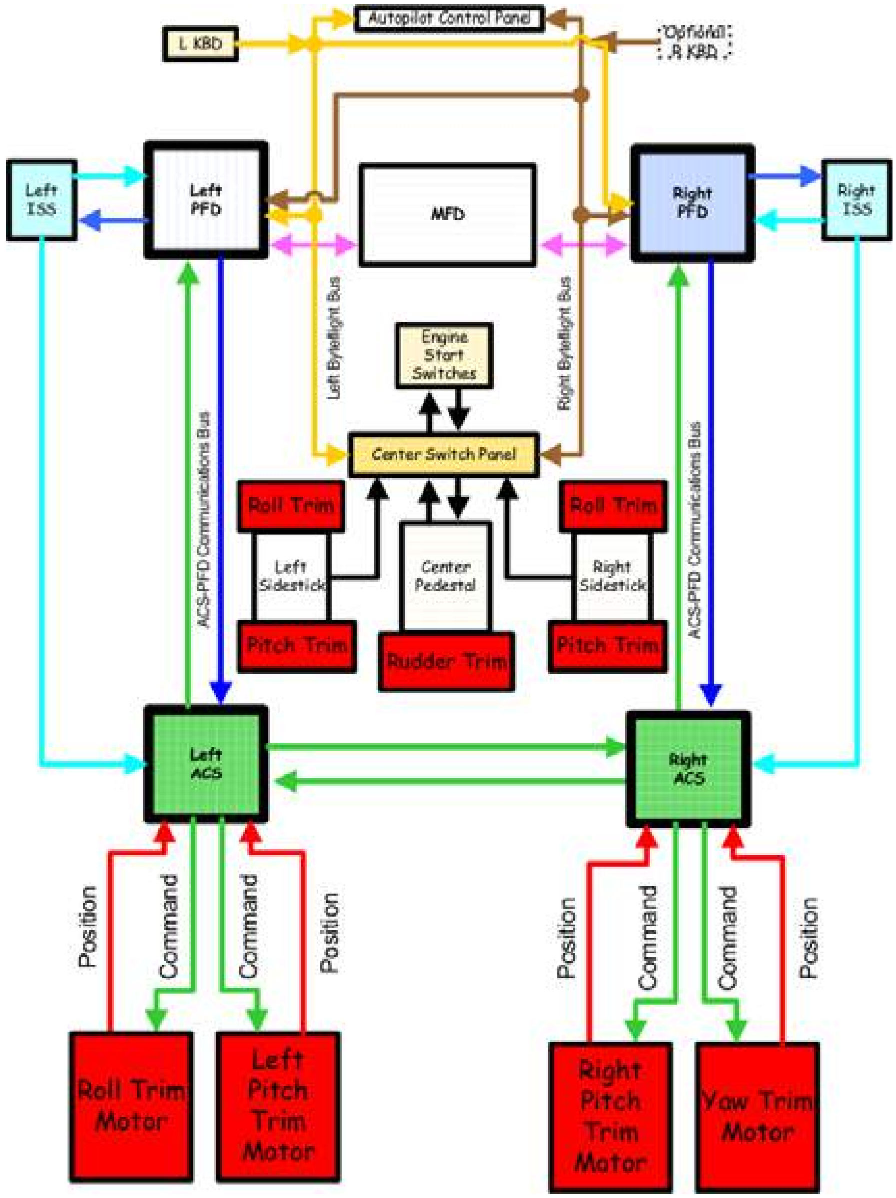

Figure 2-3. ACS – Trim Interface

2.3 Limitations and Specifications

2.3.1 Wing Flaps

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

VFE:
- T/O .... 200 KEAS
- LDG .... 140 KEAS

2.4 Controls and Indicators

2.4.1 Sidestick

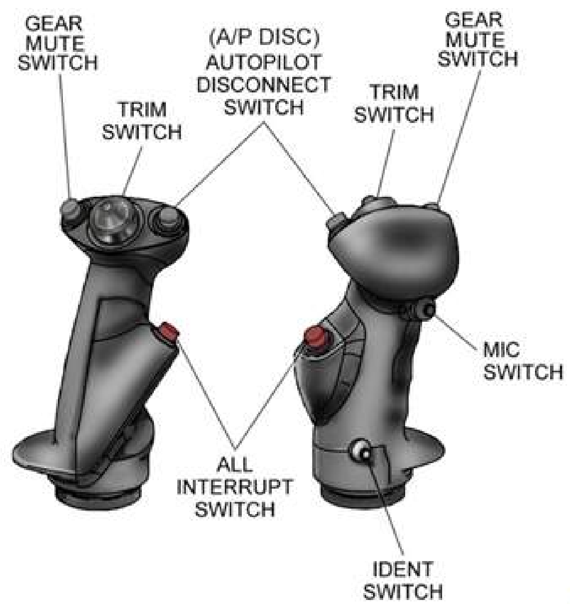

Figure 2-4. Sidestick

A/P DISC..................................	Disconnects the Autopilot and Autothrottle (SPD PROT mode still available). Second press will silence the Autopilot disconnect aural tone, and extinguish the A/P DISC annunciation below the sky pointer. Yaw Damper and Flight Director remain engaged.
ALL INTERRUPT......................	Disconnects the autopilot, autothrottle (SPD HOLD, MCT), flight director, yaw damper, and inhibits the autothrottle under/over speed protection (SPD PROT), INOPs the ABS, 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. Also prompts an ALL INTERRUPT ACTIVE status message to appear.
MIC...	Keys the headset or oxygen mask microphone.
GEAR MUTE............................	Silences the landing gear configuration aural warning for conditions when the warning is mutable.
IDENT.......................................	Activates the transponder IDENT function.
TRIM SWITCH.........................	Activates the aileron and elevator trim.

2.4.2 Throttle Quadrant

See Figure 2-5. The throttle quadrant contains the two throttles, a flap position selector, and a rudder trim switch. Additionally, there are two switches located on the left throttle: the Autothrottle Disconnect (A/T DISC) on the left side of the left throttle, and the Takeoff/Go-around (TOGA) underneath the left throttle.

FLAP SELECTOR ....UP (0°), TO (17°), LDG (34°)

RUDDER TRIM ....NOSE LEFT, NOSE RIGHT

Figure 2-5. Throttle Quadrant

2.4.3 Flight Controls Synoptic

Figure 2-6. FLCS Synoptic Flight Controls

The flight control synoptic (FLCS) provides a display of position, alternate trim control, and the ability to disable the ALL INTERUPPT button.

Trim position is shown graphically and as a percentage of control surface movement. A white, or green (ground only) trim pointer indicates the trim 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 to show the trim position range for takeoff. On the ground the trim pointers will turn green if they are indicating within the green band. In flight or any time outside of the green band the trim pointers will be white. Should trim indications become unavailable, a TRIM POSITION FAULT advisory message appears and the trim pointer is removed.

Three line-select keys provide additional control of the flight control system.

2.4.3.1 TRIM

All trim switches (aileron, elevator, and rudder) can be disabled by the line-select key labeled TRIM. See Figure 2-6. 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 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. Each "click" of the inner knob equates to 0.25 seconds of trim movement.

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.

Figure 2-7. FLCS Synoptic Flight Controls

2.4.3.2 ALL INTRP

See Figure 2-6. The ALL INTRP line-select key disables the 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

2.4.3.3 ECB LINK

See Figure 2-6. LSK 5 - ECB LINK is a shortcut to the ECB (Electronic Circuit Breaker) page with ECB by system selected to FLCS (Flight Controls).

2.4.4 Flap Position Display

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 green and the white box disappears.

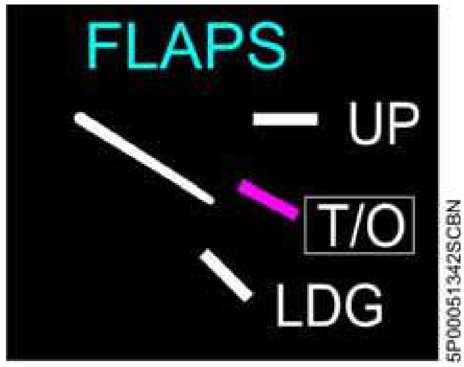

Figure 2-8. In Transit to T/O Position

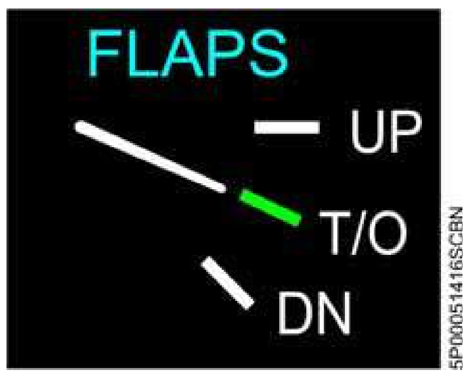

Figure 2-9. Flap Position Display (T/O Position)

If a flap failure occurs due to an actuator failure or an asymmetry sensed by any flap actuator, then:

1. Flap Actuator movement stops.
2. Flap position pointer remains displayed in the last position.
3. FLAP FAIL Caution message appears.

2.5 System Description

2.5.1 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.

2.5.2 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.

See Figure 2-10. 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 2-10. Rudder Pedal Adjustment

2.5.3 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.

2.5.4 Sidestick

The ailerons and elevator are controlled with the 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.

2.5.5 Trim

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

The aileron trim actuator moves the aileron centering spring, resetting the neutral position of the ailerons. A rudder trim actuator moves the trim tab on the rudder. Pitch trim is provided through two pitch trim actuators, one on each side of the 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 sounds if manual or autopilot elevator trim movement is continued for more than five seconds. If uncommanded trim motion is sensed, a TRIM UNCOMMANDED warning message appears.

Trim is also adjustable on the flight control synoptic via 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.

2.5.6 Speed Controlled Pitch Trim

The Pitch trim speed of deflection is dependent on airspeed. The faster the aircraft is traveling, the slower the elevator trim tabs will move when commanded. Large airspeed accelerations with delayed trim actuations may result in longer than normal trim movement and possibly a PITCH MISTRIM caution message.

2.5.7 Pitch Auto Trim

The Autopilot when engaged will command changes to the pitch trim depending on force sensed by the Autopilot Pitch servo. If the trim switch for pitch on the sidestick is pressed, the autopilot will disengage. Roll and Yaw trim inputs will have no effect on Autopilot engagement status, and will not be trimmed automatically.

If the AP is unable to trim out the forces, an AP PITCH MISTRIM caution CAS message is displayed to alert the pilot of possible high pitch forces if the AP is disconnected.

2.5.8 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 simultaneously. The flaps can be set to the following three positions:

- UP – 0°
- T/O (Takeoff) – 17°
- LDG (Landing) – 34°

NOTE:
Even though the angular travel of the flap is equal (0 to 17 and 17 to 34), the linear travel of the flap is not. Full travel of the Flaps from UP to LDG requires 22 seconds, and 16 of those seconds are from UP to T/O.

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

To prevent asymmetrical deployment, flaps operate only if all four actuators are synchronized. Potentiometers monitor actual 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 synchronization is unsuccessful, a FLAP FAIL caution message appears and the flaps do not operate.

In the event 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.

2.5.9 Gust Lock

See Figure 2-11. The gust lock for the ailerons and elevator is a fabric strap installed over the left sidestick to hold the sidestick full down and 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.

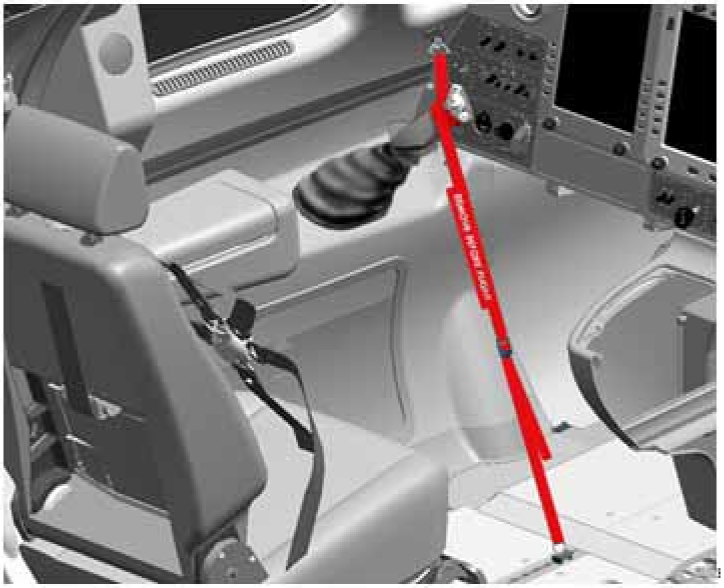

Figure 2-11. Gust Lock

2.6 Normal Operations

2.6.1 Sidestick

2.6.1.1 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, and moving the sidestick toward the right commands a right bank.

On the ground, the sidestick is full forward when 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.

2.6.1.2 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.

2.7 Abnormal Procedures

2.7.1 Elevator Trim Tab Split

In the event that the left and right elevator tabs differ in position, an ELEVATOR TRIM TAB SPLIT advisory message appears. Re-synchronizing the tabs can be attempted by making small trim inputs, reference the QRH for this procedure.

2.7.2 Alternate Trim

In the event of a failure of a normal sidestick or rudder switch trim control, an 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.

1. Hold the ALL INTERRUPT button for two seconds, or select the flight controls synoptic.
2. Select ALTERNATE with the TRIM line-select key.
3. When the ALTERNATE is enabled, a green selector box appears around the elevator trim display.
4. 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.
5. Trim is accomplished using the inner knob. Each “click” of the knob provides a 0.25 second trim command.

2.8 Crew Alerting System Messages

Table 2-1. Flight Control CAS Messages

Message	Condition	Category
TRIM UNCOMMANDED	Uncommanded trim movement detected.	WARNING
AILERON TRIM FAIL	Aileron Trim not responding to pilot input or has failed.	Caution
FLAP FAIL	Flaps have failed	Caution
FLAP POSITION HOLD FAIL	Backdrive Clutch failed; actuator motor will try to keep flaps in position.	Caution
PITCH MISTRIM	Autopilot is holding an excessive pitch force on the elevator.	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
ROLL MISTRIM	Autopilot is holding an excessive force on the aileron.	Caution
RUDDER TRIM FAIL	Rudder Trim not responding normally to input or has failed.	Caution
STALL PROTECTION FAIL	Stall Warning and Stick Pusher have failed.	Caution
STICK PUSHER FAIL	Stick Pusher 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

2.9 Flight Controls Review Questions

1. **The flight control system on the Eclipse 550 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 550 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 550 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. **V_{fe} for flaps in the T/O (takeoff) position is:**
   a. 140 KEAS
   b. 175 KEAS
   c. 120 KEAS
   d. 200 KEAS

6. **V_{fe} for flaps in the LDG (landing) position is:**
   a. 140 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.

   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. Flaps cannot be extended electrically.
    c. 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

Landing Gear and Brakes

3

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Landing Gear and Brakes

3

3.1 General

The landing gear is a conventional tri-cycle configuration, with nose wheel steering 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.

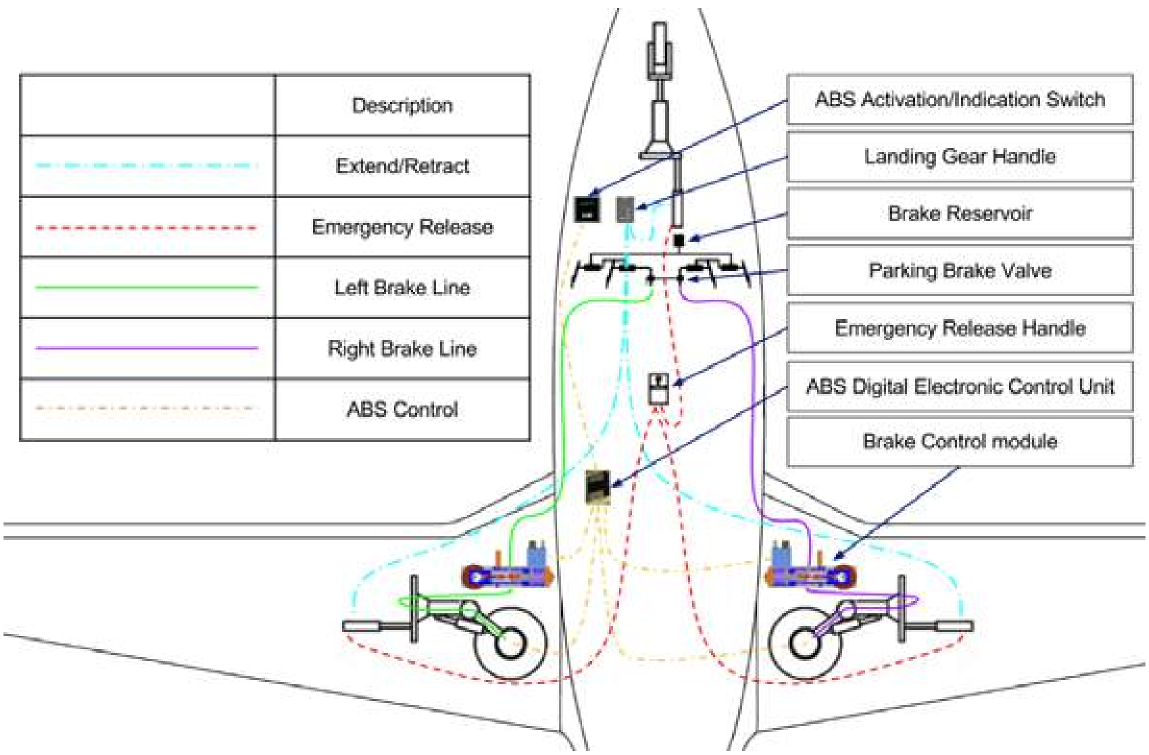


Figure 3-1. Landing Gear Schematic

3.2 Aircraft Computer Systems (ACS) Interfaces

See Figure 3-2. Extension and Retraction of the landing gear is controlled by the gear handle on the center switch panel- UP to retract the gear and DOWN to extend the gear. Position commands are sent from the Center Switch Panel (CSP) through the Primary Flight Display (PFD) to both Aircraft Computer Systems (ACS), which commands the gear position of the three independent landing gear actuators. The main and nose gear each have three proximity sensors, an up and stowed, down and locked, and a weight on wheels proximity sensor. These proximity sensors sense position through electromagnetism versus contact switches of legacy systems. When the target metal is in proximity of the electromagnetic sensor the signal is sent to the ACS to indicate the gear status on the Multi-Function Display (MFD). The ACS also uses position information to command the actuator brakes. The two main gear and nose gear are each held in the retracted position by an electro-mechanical spring-driven actuator brake on each actuator motor, and held in the extended position by the actuator brake and an over-center brace.

When the gear reaches the commanded position as sensed by the proximity sensors the ACS removes electrical power from the actuator brake, the actuator brakes mechanically hold the gear in the current retracted or extended position. Since the actuator brakes require electrical power to unlock, a loss of electrical power will prevent any actuator movement. (The emergency gear extension can also release the actuator brake.) Once the gear is extended an over center brace also holds the gear locked

If electrical power is lost or a LANDING GEAR FAIL occurs, the gear can be extended by a direct mechanical release of the actuator brakes using the emergency gear release handle located on the floor between the pilots seat under the EMERGENCY GEAR DOWN door. When the red handle is pulled to the full up and latched position, three cables mechanically release the three landing gear actuator brakes allowing the gear to free-fall to the down and locked position. When the gear indicates Down and Locked, the emergency gear release handle must be returned to the stowed position to reengage the spring-loaded mechanical actuator brakes. To assure the pilot completes this important step in the AFM/QRH procedure, the emergency gear handle position is monitored by the ACS and an EMER GEAR HANDLE caution message will display if the handle is not stowed following an emergency gear extension.

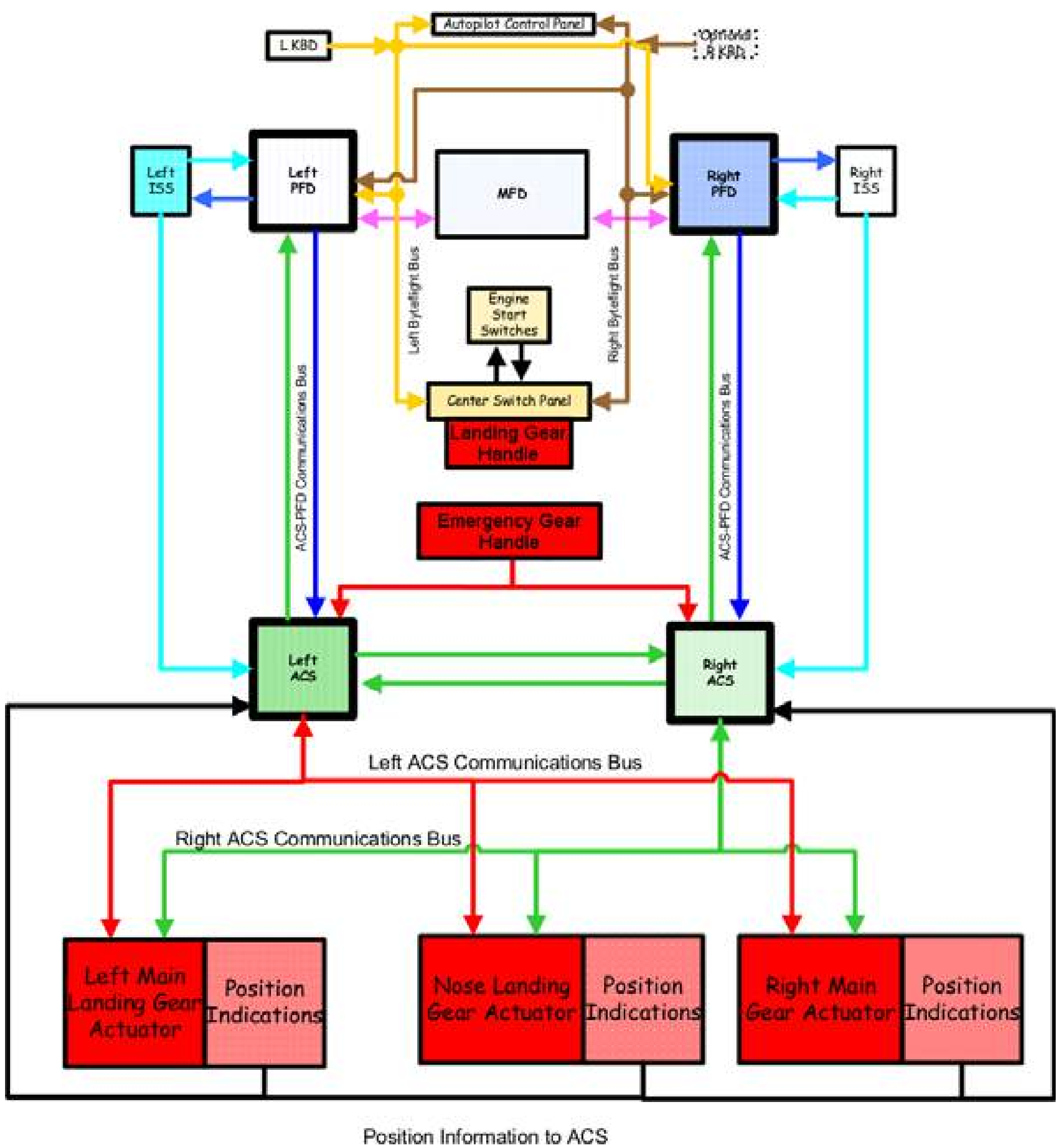


Figure 3-2. Landing Gear – ACS Interface

3.3 Limitations and Specifications

3.3.1 Airspeed, Mach, and Altitude Limitations

Maximum gear speed

V_{LO} .... 200 KEAS
V_{LE} .... 285 KEAS

Maximum Altitude for Landing Gear Operation .... 20,000ft (6096 m) PA

NOTE:
Except as defined in the Airplane Flight Manual (AFM), Section 3, “Emergency Procedures.”

3.3.2 Tire Speed Limitation

Maximum speed .... 139 knots ground speed

NOTE:
Some takeoff conditions (Flaps UP) may be limited by tire speed. Reference the takeoff weight limit tables in the Airplane Flight Manual (AFM), Section 5, “Performance.”

3.3.3 Tire Pressure

Main Gear (Bias Ply) .... 83 ± 2 psi
Nose Gear .... 70 ± 2 psi

3.3.4 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.

Main Landing Gear   Nose Landing Gear

Figure 3-3. Hard Landing Indicators

3.4 Controls and Indicators

3.4.1 Gear Handle

See Figure 3-4. The GEAR handle, located on the center switch panel, is the normal pilot control for retraction (UP) and extension (DOWN) of the landing gear.

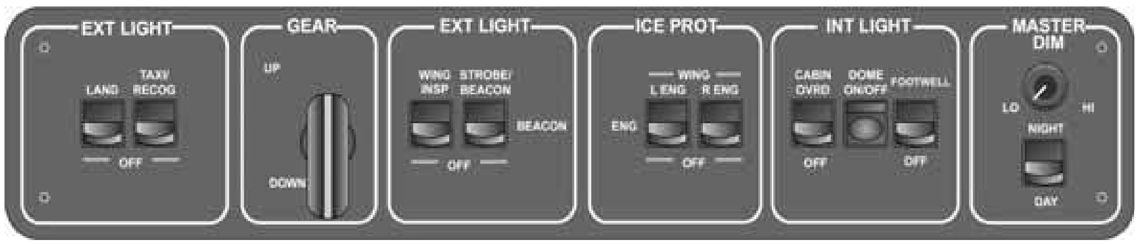


Figure 3-4. Gear Handle Location

3.4.2 Emergency Gear Release Handle

In the event of a loss of electrical power or a landing gear failure, an emergency gear release handle is located on the floor between the pilots seat. This handle is attached to three cables that are routed directly to the three landing gear actuator brakes. When the emergency gear release handle is pulled up and back to the fully latched position, the actuator brake holding the landing gear in the up position is released, allowing the gear to gravity freefall to the down and locked position. In order to reengage the spring loaded actuator brakes and hold the gear in the down position, the Emergency Gear Release Handle must be stowed. To stow the handle, press the green release (REL) lever on the back of the emergency gear release handle and return the handle to the full down position. If the handle is not stowed, the EMER GEAR HANDLE caution message will be displayed.

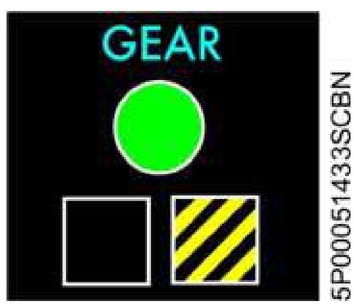
Figure 3-5. Emergency Gear Release Handle Location

3.4.3 Landing Gear Position Annunciation

Figure 3-6. Landing Gear Position Annunciations

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

- A green circle with white border indicates the gear is down and locked.



- An 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, the 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.

3.5 System Description

3.5.1 Main Gear

See Figure 3-8. 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 and the underside of the wing decrease the parasitic drag.

The landing gear are held in the retracted position by electro-mechanical spring-driven actuator brakes on each gear actuator motor. The landing gear are held in the extended position by the actuator brakes and an over center brace.

Figure 3-7. Proximity Sensor

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.

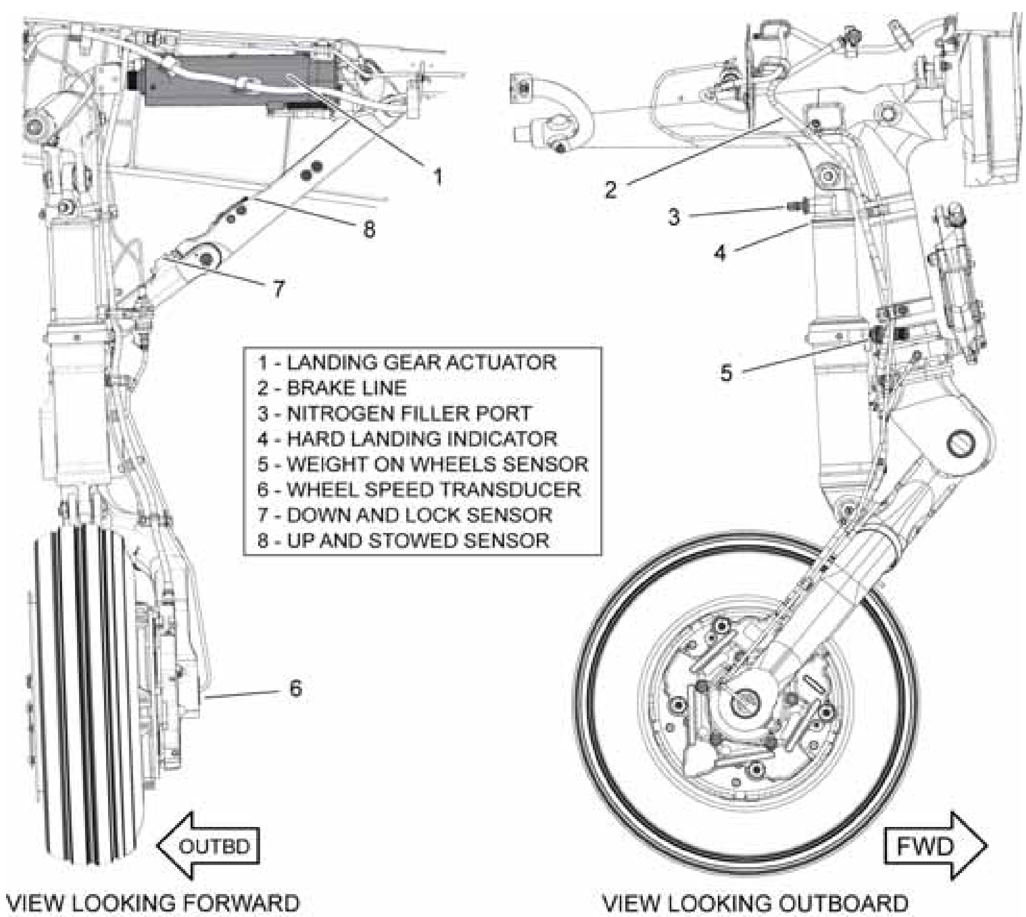


Figure 3-8. Main Landing Gear (Left Side - Weight off Wheels)

3.5.2 Nose Gear

See Figure 3-9. 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 the actuator brake and held 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, when extended the forward doors open mechanically enough to let the nose gear pass, and then close again. There are two proximity sensors on the nose gear — Down and Locked and Up and Stowed.

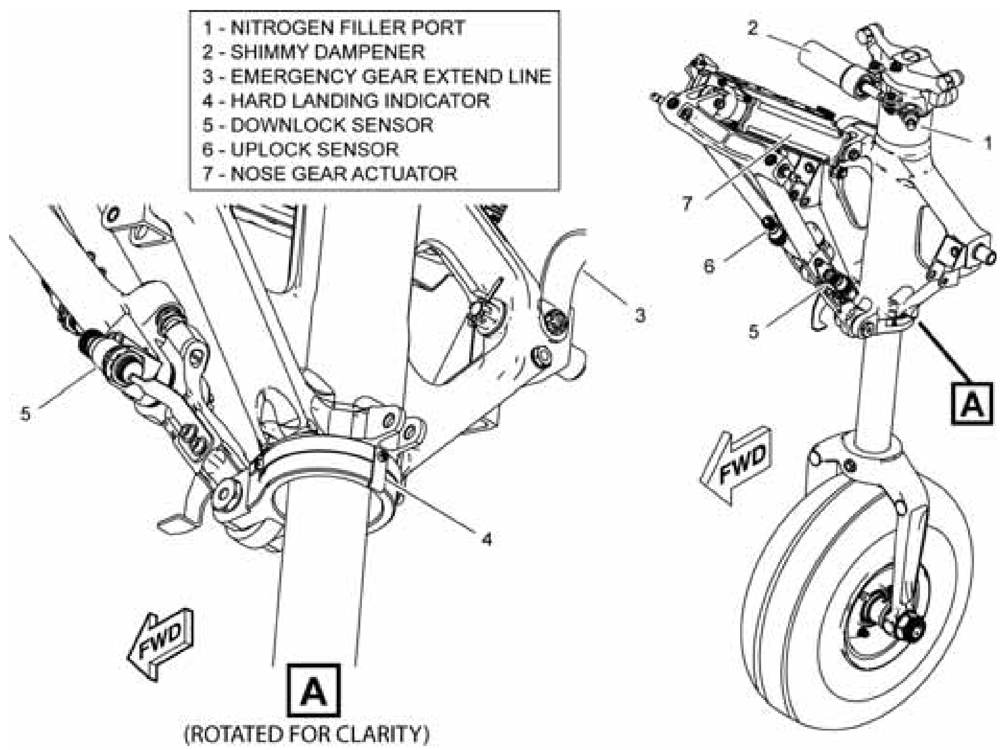


Figure 3-9. Nose Landing Gear

3.5.3 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.

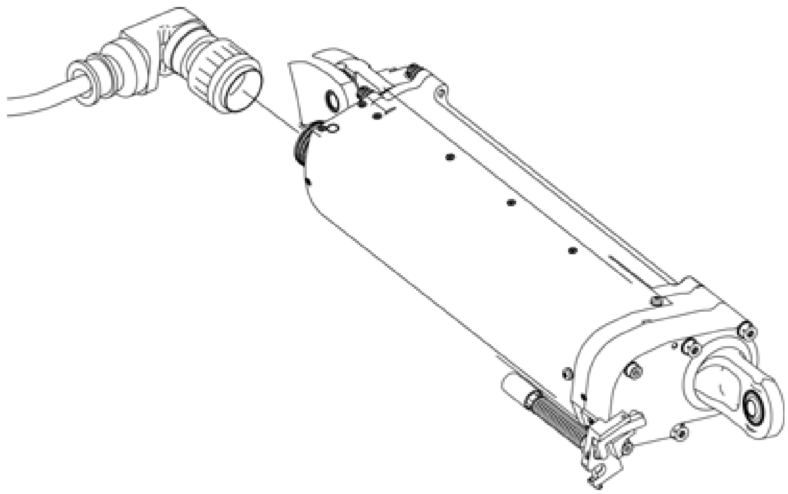


Figure 3-10.   Actuator

3.5.4 Landing Gear Actuator Brakes

The main gear and nose gear actuator assemblies contain a spring-driven electro-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 electrical power to unlock in normal operation.

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 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 that is being re-stowed.

3.5.5 Landing Gear Warning Horn

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

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

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.

3.5.6 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 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 re-engage until weight is back on the nose wheel; this prevents landing with the nose wheel turned.

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

3.5.7 Hard Landing Indicators

See Figure 3-12. 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.

Figure 3-11. Main Gear Hard Landing Indicator

Figure 3-12. Nose 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.

3.6 Normal Operations

3.6.1 Gear Retraction

When the gear handle is placed in the UP position, position commands are sent through the Primary Flight Display (PFD) to both Aircraft Computer Systems (ACS), which command the gear position of the three independent landing gear actuators. The ACS releases the three actuator brakes and applies power to the gear actuators. To retract the gear the actuator extends towards the strut. This action will provide the mechanical force in the correct direction to unlock the over center mechanism. When each gear folding brace moves away from the gear-down proximity sensor, the gear position annunciation changes from green circles (Down and Locked) to amber/hatched squares (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 a strut mounted aft 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 gears indicate Up and Stowed for ten seconds, the white borders and the word GEAR disappear.

3.6.2 Gear Extension

When the gear handle is placed in the DOWN position, commands are sent through the Primary Flight Display (PFD) to both Aircraft Computer Systems (ACS), which commands the gear position of the three independent landing gear actuators

The ACS releases the three mechanical actuator brakes and applies power to the gear actuators. To extend the gear the actuator retracts. This way while the gear is in the extended position there is minimal amount of the actuator exposed to the elements. When each gear moves away from the gear-up proximity sensor, the gear position annunciation reappears as amber/hatched squares (In Transit).

When each gear moves to the gear-down proximity sensor, the gear position annunciation changes from amber/hatched squares (In Transit) to green circles (Down and Locked). Power is removed from the actuator. The actuator brake will automatically set with a lack of power.

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.

3.7 Abnormal Procedures

3.7.1 Emergency Gear Extension

In the event of a failure of the normal gear extension system, a LANDING GEAR FAIL caution message appears. The gear can be 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 free-falling 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 to remind the pilot to stow the handle.

For the Emergency Gear Extension procedure reference the QRH or section 3 of the AFM.

1. Airspeed in Coordinated Straight Flight .... 195 to 200 KEAS
2. EMERGENCY GEAR RELEASE Handle .... PULL
   (Pull in one continuous motion until latched)

   NOTE:
   Pulling the emergency gear handle requires approximately 18 pounds of force to pull and should be pulled to full extension in one smooth motion.
3. GEAR Indication .... Verify Three Green
   (Do not retract gear after successful extension.)

   NOTE 1:
   If gear fails to fully extend, decrease airspeed to 180 KEAS (VO) and apply G force in attempt to extend gear.

   NOTE 2:
   LANDING GEAR FAIL CAS message will be displayed; no action required.

   NOTE 3:
   After Emergency Gear Extension, inspect gear according to the Aircraft Maintenance Manual prior to the next flight.
4. EMERGENCY GEAR RELEASE Handle .... PUSH Fully In

IF ALL GEAR EXTEND:

1. Gear Handle .... DOWN

3.7.2 Weight On Wheels (WOW) Sensor Fault

In the event of a disagreement between the two Weight on Wheels (WOW) 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.

3.8 Brake System

3.8.1 Brakes

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

See Figure 3-13. 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 (with the parking brake set), the brakes require servicing.

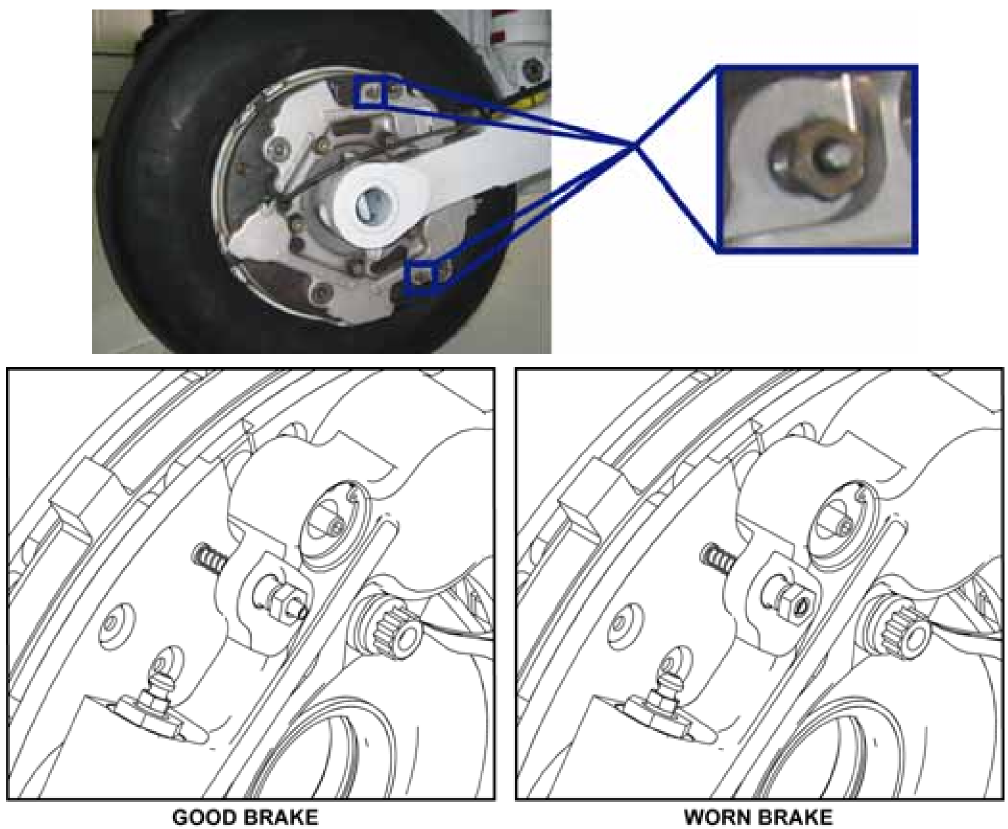


Figure 3-13. Brake Wear Indicators

3.8.2 Parking Brake

The parking brake is set from either pilot seat by depressing both brake pedals, holding the pressure, and then 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.

The Parking Brake handle position is sensed by a proximity switch that triggers a PARKING BRAKE status message. This status message only denotes the position of the PARKING BRAKE handle, and does not monitor the pressure applied to the brakes.

NOTE:
For ground operations with the cabin door open (e.g., preflight), the pilot may elect to leave the parking brake off and use chocks to secure the aircraft. During this type of operation, the pilot can expect to see a DOOR warning message, indicating that power is on the airplane and the door is open. When the parking brake handle is pulled out to set the parking brake, the DOOR warning message changes to a DOOR status message.

The parking brake is released by pushing in the parking brake handle. If the parking brake handle is pulled out when a high power setting is applied, a CONFIG PARKING BRAKE warning message appears.

3.9 Crew Alerting System Messages

Table 3-1. Landing Gear CAS Messages

Messages	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	WOW sensors disagree	Advisory
PARKING BRAKE	Parking brake is set	Status

3.10 ANTI-SKID BRAKE SYSTEM (ABS)

3.10.1 General

The purpose of this system is to prevent tire skidding that may result from braking on low-friction runway surfaces and/or the application of excessive brake pedal force. This skid prevention, in turn, helps to maintain increased braking effectiveness and reduces the incidences of tire damage. The Anti-Skid Braking System (ABS) monitors the ratio between GPS Groundspeed and main landing gear wheel speed for an indication of a wheel that is at a high risk of skidding. If a skid is detected the ABS will activate to rapidly relieve brake pressure, causing the wheel to accelerate and alleviating the skid risk. Positive feedback is provided to the pilot from the brake pedal(s) from the side(s) which is in the skid condition. When the ABS activates to prevent a skid, the brake pedal(s) for the skidding wheel(s) will push back against the pilot's foot. Once the wheel accelerates and a non-skid condition is sensed by the ABS, brake pressure is restored to the wheel. With continuous brake pressure the ABS system will modulate the brake pressure to maintain the highest brake efficiency available without damaging the wheel.

3.10.2 Aircraft Computer System (ACS) Interfaces

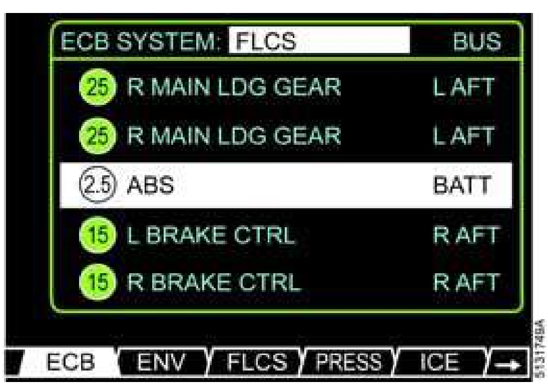


Figure 3-14. Aircraft Computer System (ACS) Interface

The ABS Digital Electronic Control Unit (DECU) receives GPS data from the PFD directly, and not through the ACS. The ABS receives 28VDC electrical power from three electronic circuit breakers, one for the digital electronic control unit (ABS), from the battery bus, and one each for the Brake Control Modules (L/R BRAKE CTRL) from the right aft bus. For the ABS system, the ACS interfaces only with the Gear Handle and the ECBUs. When the Gear handle is in the UP position the ACS removes power (AUTO/OFF) from the three ABS ECBs. The activation/indication switch will show INOP for a moment and then the lights on the activation/indication switch will extinguish. When the Gear Handle is placed in the DOWN position the ACS will reenergize (AUTO/ON) the three ABS ECBs. The activation/indication switch will annunciate INOP momentarily as the DECU conducts a self-test, and then should annunciate ARMED. If the switch continues to indicate INOP or all lights are extinguished consult your AFM/QRH for procedures. During a battery power only situation the ACS will automatically load shed (PULLED) the three ABS ECBs. The brakes function normally but with ABS functionality unavailable.

3.10.3 Limitations and Specifications

Anti-Skid Braking System (ABS) - Do not apply brakes in air with ABS ARMED. Brake checks must only be done on the ground or when ABS is NOT ARMED.

3.10.4 Controls and Indicators

ACTIVATION AND INDICATION SWITCH

The ABS activation/indication switch is the only indication of the status of the ABS.

When the ARMED light is illuminated the DECU is now providing skid protection and will activate the BCM's as necessary to prevent either wheel from skidding.

Illumination of the INOP light indicates that the ABS has been disabled by manual input or unavailable due to lack of GPS signal, or a system malfunction.

INOP and ARMED extinguished (dark switch) is a normal indication with the system in standby (on the ground with less than 15 knots of groundspeed, or in the air with the Gear Handle UP). If INOP and ARMED are extinguished in the air with the Gear Handle DOWN, then ABS functionality is unavailable and consult your AFM/QRH for procedure.

If both the ARMED and INOP light are illuminated a fault in the ABS is indicated and ABS is not available.

Pressing the activation/indication switch will cycle between the ABS being enabled or INOP. The ABS cannot manually be armed because it is a function of the DECU to check for required interfaces, and faults.

3.10.5 System Description

GLOBAL POSITIONING SYSTEM (GPS) DATA

GPS Groundspeed data is sent from the PFD to the DECU for comparison against wheelspeed.

WHEEL SPEED TRANSDUCERS (WST)

The wheel speed transducer fits inside the hollow wheel axle. A drive cap fits to the wheel. The cap has a slot which captures the drive tab of the sensor. An electrical connector allows disconnection of the sensor without the need for sensor removal.

Figure 3-15. Wheel Speed Transducers (WST)

DIGITAL ELECTRONIC CONTROL UNIT (DECU)

The DECU monitors the GPS groundspeed from the PFD, wheelspeed from the WSTs, selection of the Activation/Indication switch, status of the ALL INTERRUPT switch, and the solenoid valve in the BCM. From this data the DECU determines the state of the system and indicates this on the activation/indication switch. The DECU monitors the groundspeed and wheelspeed to determine when the ABS needs to activate.

Figure 3-16. Digital Electronic Control Unit (DECU)

ACTIVATION AND INDICATION SWITCH

The ABS activation and indication switch is located in the upper portion of the instrument panel - left (IPL). The ARMED, and INOP indications are controlled by the DECU. Pressing the switch allows for disabling of the ABS or enabling if previously disabled (indicated by an illuminated INOP light).

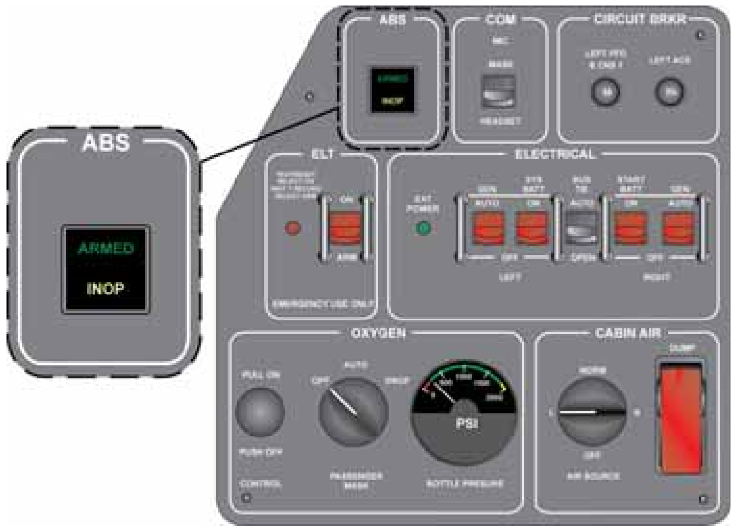


Figure 3-17. ABS Switch

In normal operation the activation/indication switch will be:

ARMED when the pilot pushes the button from a previously inop state, when the groundspeed is more than 15 knots on the ground, or in flight when the gear is extended.

INOP when the pilot pushes the button from a previously armed or standby (on the ground below 15 kts GS) state, when there is a fault, a lack of GPS signal, momentarily after gear extension and retraction, or when the pilot presses and HOLDS the ALL INTERRUPT button on either sidestick.

Dark when there is a lack of power to the system (i.e. gear selected up), or on the ground below 15 knots groundspeed.

BRAKE CONTROL MODULE (BCM)

An ABS Brake Control Module (BCM) is in the feed line from the master cylinder to the slave cylinder on each side. Each ABS Brake Control Module contains a DECU controlled solenoid valve, an electrically powered and activated hydraulic pump, and a hydraulic accumulator.

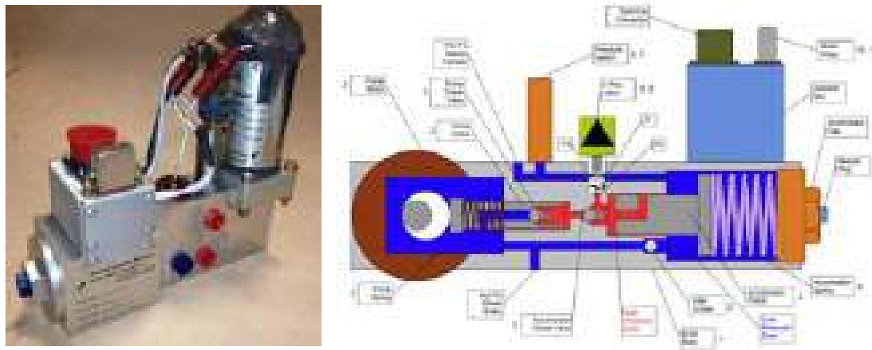


Figure 3-18. Brake Control Module (BCM)

There are two pressure switches associated with each BCM. A pressure switch in the BCM monitors the brake fluid pressure in the line coming into the BCM. When the system is in the ARMED state, and pressure reaches approximately 100psi the BCM pump is energized. The BCM pump charges the pressure in the accumulator, so that the BCM is ready should the ABS need to activate. The fluid which is pressurized by the pump is used to provide feedback through the brake pedals when the ABS activates. There is also a pressure switch in the line downstream of the BCM that will inhibit the pump in the BCM if the ABS activates (inadvertent brake application in the air with ABS ARMED) and pressure falls below approximately 25 psi. When the BCM pump is inhibited normal braking remains, but ABS is unavailable.

Solenoid Valve Pressure Switch

Figure 3-19. Pressure Switches

The ABS Brake Control Modules are installed in the forward portion of the wheel well. Shrouds are installed to protect the ABS Brake Control Modules from foreign objects which may be picked up by the tires.

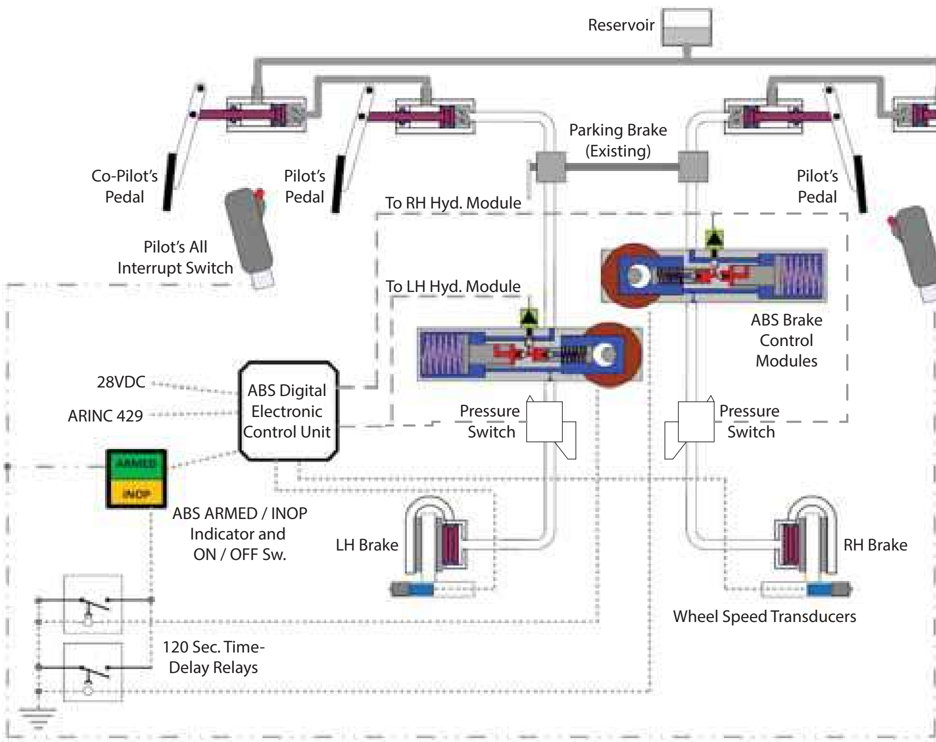


Figure 3-20. System Diagram

With the ABS system ARMED on the ground, when brakes are applied to decelerate the aircraft, the BCM pump will activate and provide pressure (charge). This pump operation may be heard in the cabin but does not indicate that the ABS has activated. The ABS DECU compares GPS groundspeed and individual wheel speed to determine when action is required from the side-specific BCM to prevent a wheel from skidding. If either or both wheel speeds fall below 85% of GPS groundspeed, the DECU will energize the side-specific BCM solenoid valve causing the valve to open a path from the accumulator to the pilot's brake pedal. The increased pressure in the line to the master cylinder will push the side-specific brake pedal back towards the pilot's foot. The rapidly decreasing pressure in the BCM will cause the fluid from the slave cylinder (brake caliper) to back fill into the BCM, reducing the fluid pressure and allowing the wheel speed to increase. As the wheel re-accelerates, the applied fluid pressure is restored, causing the brake torque to increase. This cycle repeats itself, effectively governing the wheel's speed to 85% of groundspeed, and pulsating the side-specific pilot's foot, until the surface conditions improve or the pilot reduces pedal force. When the groundspeed decreases below 15 knots the BCM pump deactivates, and the activation/indication switch will once again be dark.

3.10.6 Normal Procedures

When power is first applied to the aircraft the ABS will display a flashing INOP light which indicates that the GPS groundspeed data is not valid.

Once the GPS units are providing groundspeed data the activation/indication switch will be dark, meaning the GPS is enabled and the ABS should arm once ground speed exceeds 15 knots.

Before Taxi, the ABS Test should be completed reference the AFM "AMPLIFIED NORMAL PROCEDURES" for details. The ABS test will test the activation/indication switch including the ARMED and INOP lamps, the validity of WST data, the connection with the ALL INTERRUPT button, the connection to the BCM solenoid valve, and the DECU built in test.

During taxi if the groundspeed increases over 15 knots the activation/indication switch should annunciate ARMED. When brakes are applied to decelerate the aircraft with the system ARMED, the BCM pump will activate and provide pressure (charge). At any time the system is ARMED the ABS will activate if the wheelspeed falls below 85% of groundspeed. Once the groundspeed has decelerated below 15 knots the system will disarm, the activation/indication switch will be dark, and the BCM pump will turn off. Normal braking remains, but ABS activation below 15 knots of groundspeed is unavailable.

During the takeoff roll the activation/indication switch should annunciate ARMED as the aircraft accelerates above 15 knots groundspeed. The ABS will be armed in case of rejected takeoff braking requirements. After rotation when the landing gear is retracted, the ACS removes power (AUTO/OFF) from the three ABS ECBs. The activation/indication switch will show INOP for a moment and then the lights on the activation/indication switch will extinguish. During flight with the landing gear retracted the ABS system is not powered, and the activation/indication switch will remain dark. Pressing the activation/indication switch with the system depowered will have no effect.

NOTE:
Do not apply brakes in the air with the system ARMED. The most common situations where pilots inadvertently activate the ABS while airborne are just shortly after rotation prior to gear retraction, and after gear extension. Loss of Braking pressure will occur. Release brakes after touchdown and reapply (pump brakes) for correct activation. Several brake applications may be required to establish full braking pressure. See AFM Section 3: "Inadvertent ABS Activation While Airborne (with the system ARMED)". The recovery technique while airborne includes disarming (INOP) the system and reapplying brakes, before rearming the system.

When the landing gear is extended before landing, the ACS will reenergize (AUTO/ON) the three ABS ECBs. The activation/indication switch will annunciate INOP momentarily as the DECU conducts a self-test, and then should annunciate ARMED. If the switch continues to indicate INOP or all lights are extinguished consult your AFM/QRH for procedures. Do not apply brakes in the air with the system armed. Brakes may be applied once both main wheels are rotating on the ground. With the system ARMED, if either or both wheel speeds fall below 85% of GPS groundspeed the ABS will activate and relieve brake pressure to allow the wheel speed to increase. The ABS will activate as needed to maintain a wheelspeed at or above the 85% groundspeed threshold. For a runway with spots or strips of ice and snow-pack, or wet painted areas the brakes may occasionally release as the tires roll over these slick areas. For clear and dry pavement, the system will probably not operate unless the operator applies too much brake force in an aggressive stopping maneuver. In this case, the ABS will respond and save the tires from damage. Once the groundspeed has decelerated below 15 knots the system will disarm, the activation/indication switch will be dark, and the BCM pump will turn off. Normal braking remains, but ABS activation below 15 knots of groundspeed is unavailable.

3.10.7 Abnormal Procedures

The amber INOP indicator illuminates when any of the following faults are detected:

- GPS ground speed is out of range or unavailable
- Wheel speed is out of range or unavailable
- Controller Power is low <18VDC
- Controller Built-in-Test (BIT) has failed
- ABS Brake Control Module solenoid control line open circuit

A time delay relay will illuminate the INOP indicator if the Brake Control Module pump operates for >120 seconds continuously.

ABS operation is routed through the ALL INTERRUPT switches on the side-stick controllers. If emergency disablement of the ABS is needed, the pilot (or copilot) may press and hold the ALL INTERRUPT switch which will inhibit ABS activation and restore normal braking. If the ALL INTERRUPT switch is held during heavy braking, the ABS will be inoperative and tires may skid until brake pressure is reduced by the pilot. When the ALL INTERRUPT switch is released the previous ABS state will be restored.

NOTE:
Refer to the AFM/QRH for abnormal procedures including:

- INOP Flashing
- INOP and ARMED illuminated
- ABS INOP ON or Flashing (while in air)
- Brakes ineffective or pulling to one side
- INOP illuminates with Brake Application
- ARMED Not Illuminated with Landing Gear Down (while in air)
- Inadvertent ABS Activation (while in air)

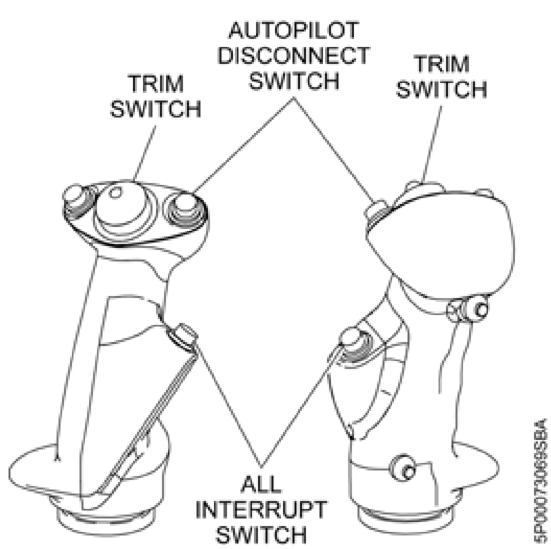


Figure 3-21. All Interrupt Switches

3.11 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 ACSs have control

2. **The Eclipse 550 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 ten 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?

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 (V_{LO}) speed is:

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

9. The maximum landing gear extended (V_{LE}) speed is:

a. 185 KEAS
b. 200 KEAS
c. 275 KEAS
d. 285 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 550 are:**
    a. Electrically operated and actuated
    b. Mechanically actuated and hydraulically operated
    c. Electronically operated and mechanically actuated (brake by wire)
15. **What indicates that the brake pads are worn?**

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

17. **What might the pilot expect to see on the MFD landing gear indicator in high G maneuvers such as steep turns?**

18. **True or False: applying brakes in air with ABS ARMED can cause loss of braking pressure.**

19. **Name the primary components of the ABS.**

20. **At what ground speed will the ABS ARM?**
    a. 20 kts
    b. 10 kts
    c. 15 kts
    d. 9 kts
21. **A loss of GPS data will:**
    a. have no effect on the ABS.
    b. cause the ABS to be INOP.
    c. arm the ABS.
    d. all of the above
22. **The ABS can be inhibited by pressing and holding the all interrupt switch.**
    a. true
    b. false

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Oxygen

4

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Oxygen

4

4.1 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 the 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. Additionally, 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. The pilot can also manually deploy the masks. Passengers must pull down on the mask to activate the flow of oxygen.

4.2 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.

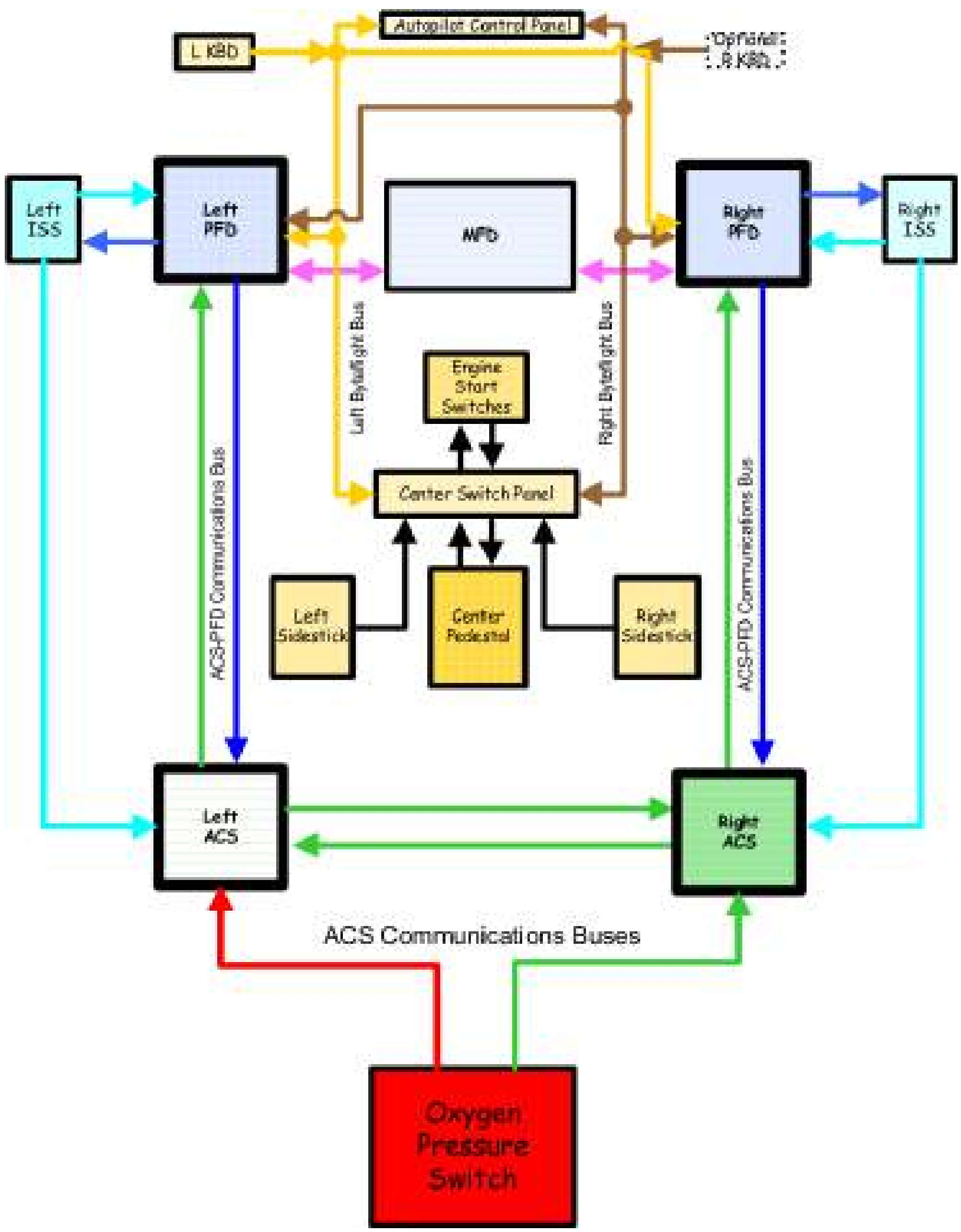


Figure 4-1. Oxygen – ACS Interface

4.3 Limitations and Specifications

4.3.1 Oxygen Bottle Pressure

Normal oxygen bottle pressure.. 1850 psi

Minimum oxygen bottle pressure.. 200 psi

NOTE:
The minimum pressure for oxygen bottle regulator operation is 200 psi. When cylinder pressure is below 200 psi, the O_2 system pressure to masks may drop below 46 psi and trigger an "OXYGEN PRESSURE" CAS message.

For flight oxygen requirements, refer to the oxygen duration tables in “Oxygen Duration” on page 4-18 or Section 7 of the Aircraft Flight Manual.

4.3.2 Oxygen Type

The oxygen system must be serviced with Aviator's Breathing Oxygen to avoid freezing and/or a malfunction of the oxygen system.

4.3.3 Oxygen System Activation (AUTO)

Oxygen system activation................................... 14,000 +000/-500 feet cabin altitude

4.4 Controls and Indicators

4.4.1 Oxygen Controls

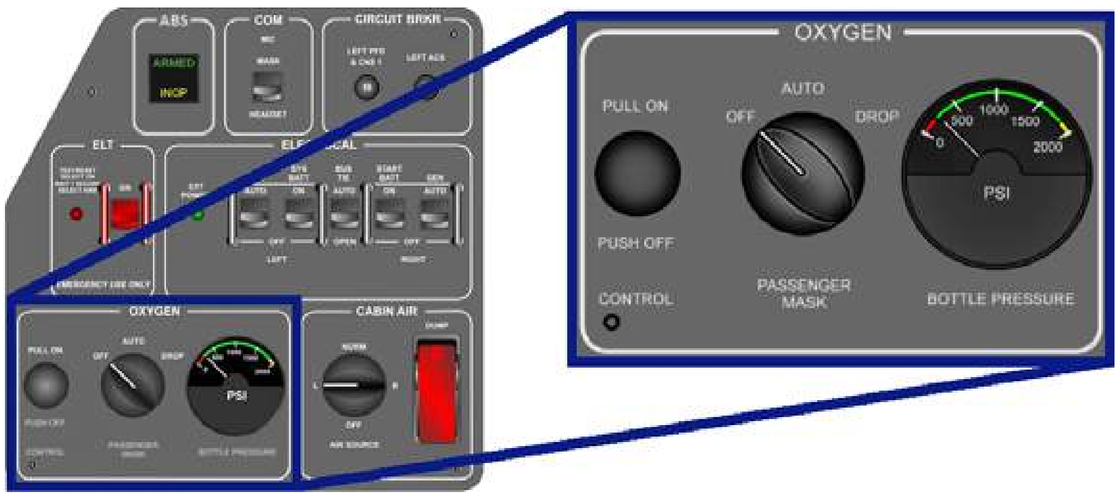


Figure 4-2. Oxygen Panel Location

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 feet cabin altitude.
- DROP...Passenger masks deploy immediately.

OXYGEN BOTTLE PRESSURE Gauge..See following table.

Table 4-1. Cockpit Oxygen Pressure Gauge

Caution Range (Red)	Normal Range (Green)	Maximum Limit (AMBER)
0-200 psi	200-1,850 psi	>1,850 psi- Full Scale

4.5 System Description

4.5.1 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

4.5.2 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

4.5.3 Oxygen Bottle

The oxygen bottle is located in the left side of the nose compartment.

Figure 4-3. Oxygen Bottle Location (40 Cubic Foot)

4.5.4 Oxygen Service Panel

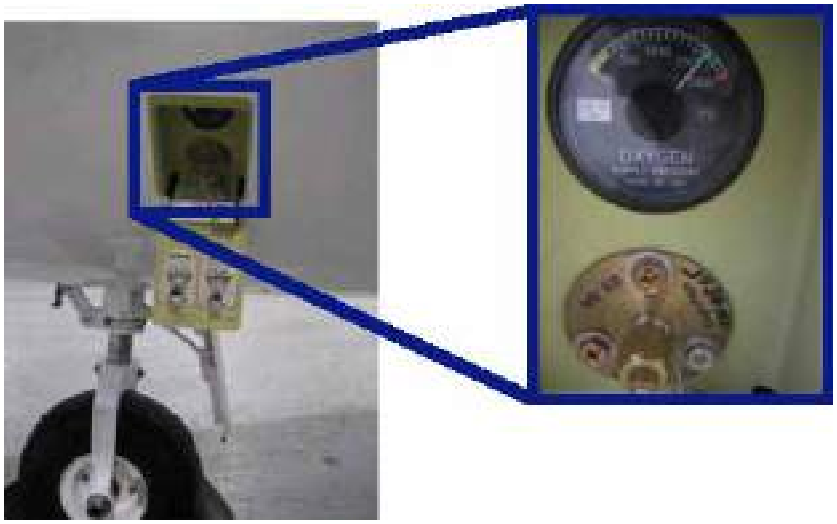


Figure 4-4. Oxygen Service Panel

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. Refer to Section 8 of the AFM for Oxygen system servicing procedures.

Table 4-2. Oxygen Service Panel Pressure Gauge

Caution Range (Yellow)	Normal Range (Green)	Maximum Limit (Red)
0-300 psi	1,550-1,850 psi	>1,850 psi- Full Scale

4.5.5 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 greater than 1850 psi is indicated in amber. Normal operating range, 200-1850 psi, is green.

Figure 4-5. Cockpit Oxygen Gauge

Table 4-3. Cockpit Oxygen Pressure Gauge

Caution Range (Red)	Normal Range (Green)	Maximum Limit (Yellow)
0-200 psi	200-1,850 psi	>1,850 psi- Full Scale

4.5.6 Armrest Oxygen Panel

See Figure 4-6. The pilot and optional copilot quick-don mask oxygen hoses and oxygen mask microphones are connected via the left and right armrest panels.

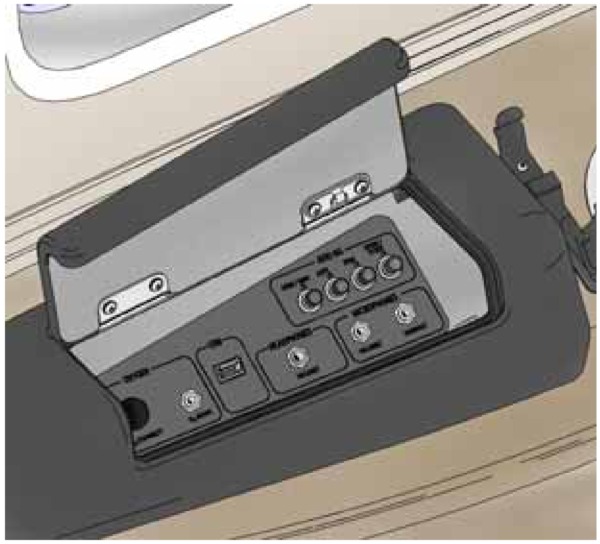


Figure 4-6. Armrest Oxygen Panel

4.5.7 Blowout Disc

See Figure 4-7. 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.

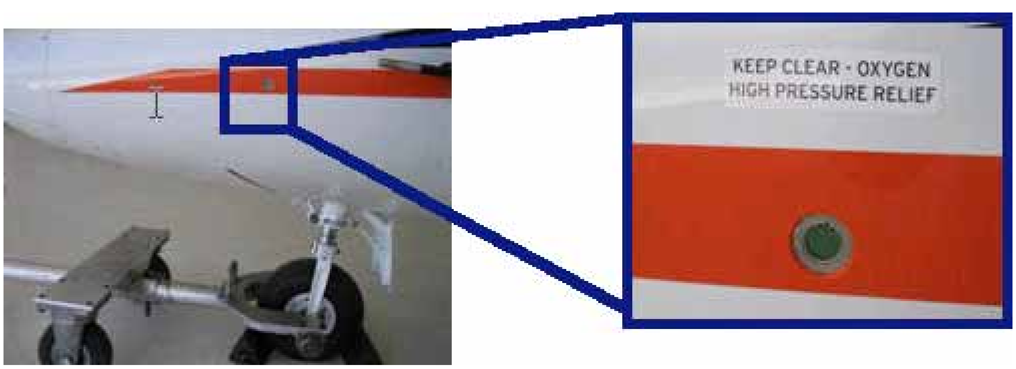


Figure 4-7. Blowout Disc Location

⚠ **CAUTION:**
Always provide 24 inches of free space perpendicular to disk during aircraft preflight.

4.5.8 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.

4.5.9 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 needs only to don the oxygen mask and breathe. Oxygen pressure is confirmed by a green flag on the crew mask hose.

Figure 4-8. Oxygen Control Knob Activation

Figure 4-9. Crew Mask Hose Flow Indicator

4.5.10 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 with either of two methods:

- Automatically – by a solenoid triggered by the 14,000 feet cabin altitude switch
- Manually – by selecting DROP with the PASSENGER MASK selector

NOTE:
The pilot can deploy the mask at any time without electrical power using the DROP selection. Regardless of whether the masks are deployed in AUTO or DROP, oxygen will only flow to masks that passengers have pulled towards their face pulling a lanyard which starts the flow of oxygen.

In the AUTO selection when the 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 with the DROP selection, oxygen flow will continue until the passenger mask selector is moved to another selection.

Figure 4-10. Passenger Mask Selector Activation

4.5.11 Pilot Oxygen Masks

See Figure 4-11. The left seat pilot position (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.

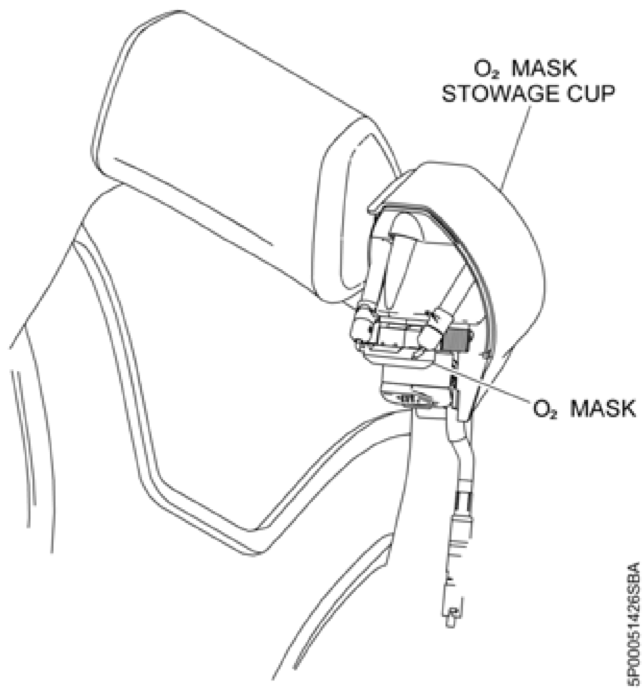


Figure 4-11. Pilot Quick-Don Mask Location

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; see Figure 4-12. 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.

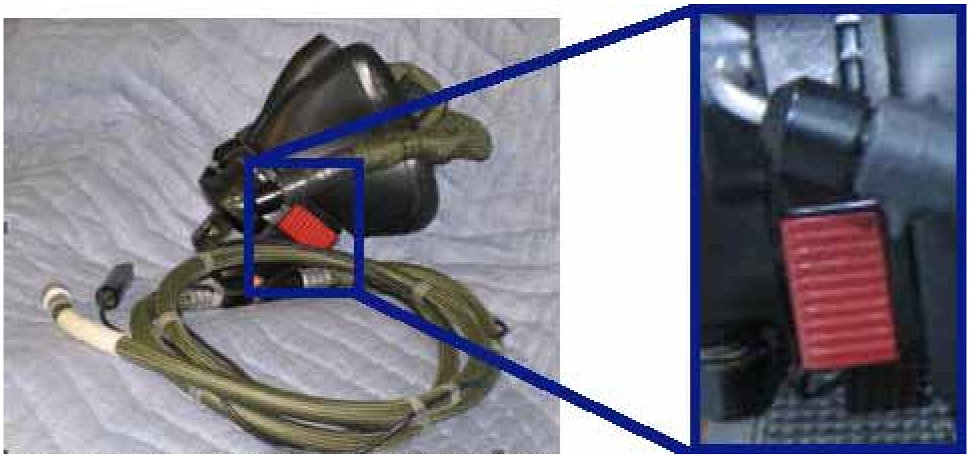


Figure 4-12. Red Lever and Oxygen Mask Adjustment

See Figure 4-13. The mask regulator on the front of the mask allows selection of NORM, 100%, and EMER settings by rotating the selector to the desired position. Table 4-4 describes the regulator settings.

Figure 4-13. Quick Don Mask Regulator

Table 4-4. Quick Don Mask Regulator Settings

Regulator Setting	Control
NORM	Regulator supplies a mixture of oxygen and ambient cabin air. Oxygen flow is on demand. With the regulator set in the NORM position, the regulator automatically provides supplemental oxygen at a predetermined rate based on cabin altitude. Ambient air is allowed to enter the regulator and mix with the system oxygen during inhalation. As cabin altitude increases, the percentage of ambient air entering the regulator is reduced until 100% oxygen is inhaled by the user. This feature conserves system oxygen while maintaining protective levels of oxygen in the event of an emergency decompression.
100%	Regulator supplies 100% oxygen with no ambient cabin air, regardless of altitude. Oxygen flow is on demand. **NOTE:** It is recommended that the mask be stored set on this mode.
EMER	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. The EMER control setting, like the 100% setting, provides 100% oxygen regardless of altitude. In addition, a positive pressure is provided within the mask face cone. The emergency safety pressure feature prevents entrance of ambient gas contaminants by providing a pressure seal. This feature protects the respiratory system against lethal or toxic fumes that might be present within the aircraft.

4.5.12 Quick-Don Mask Stowage Procedures

See Figure 4-14. Execution of the following steps provides a positive attachment of the mask to the storage cup and ensures the quick-don capability in case of emergency.

1. Pinch harness behind the nose portion of mask.

2. Fold main cord down to regulator body.

3. Fold top harness down over main cord.

Make sure most of the gathered harness rests toward the top of the mask instead of hanging below the bottom toward regulator. Excess harness low in the cup may cause pressure build up to push the hose out of the clip.

4. Insert top end of mask into the cup so that the purge valve fits under the lip.

5. Push the mask toward the top of the cup so that the rubber portion of the lower hose fits securely into the clip at the bottom of the cup. When mask is properly stowed, most of the rubber collar at the top of the oxygen hose is securely held by the clip.

CAUTION:
Do not tuck harness inside mask. Doing so eliminates the quick-don feature of the mask. Stow mask in 100% setting.

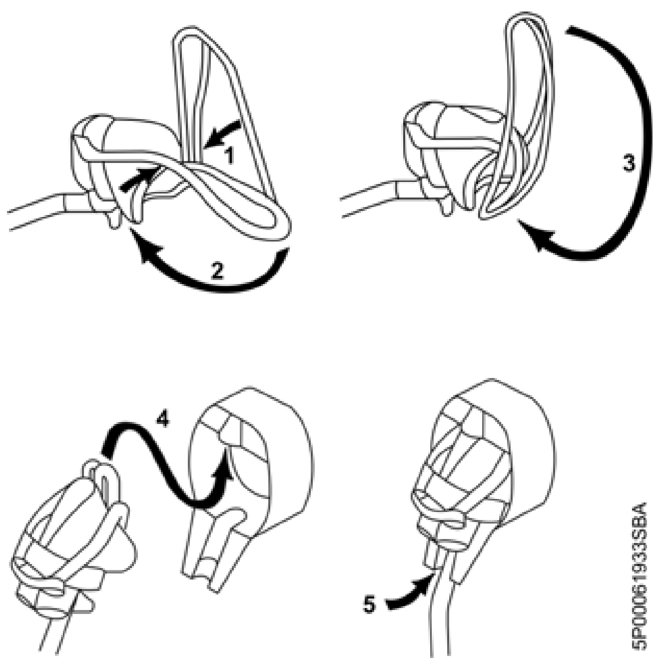


Figure 4-14. Quick-Don Mask Stowage Procedures

4.5.13 Passenger Oxygen Masks

See Figure 4-15 and Figure 4-16. 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 instrument panel - right. 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. See Figure 4-17.

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 mask selector is set to DROP, for manual deployment, oxygen flow will continue until a different selection is made.

Figure 4-15. Passenger Mask Location and Deployment (Instrument Panel - Right)

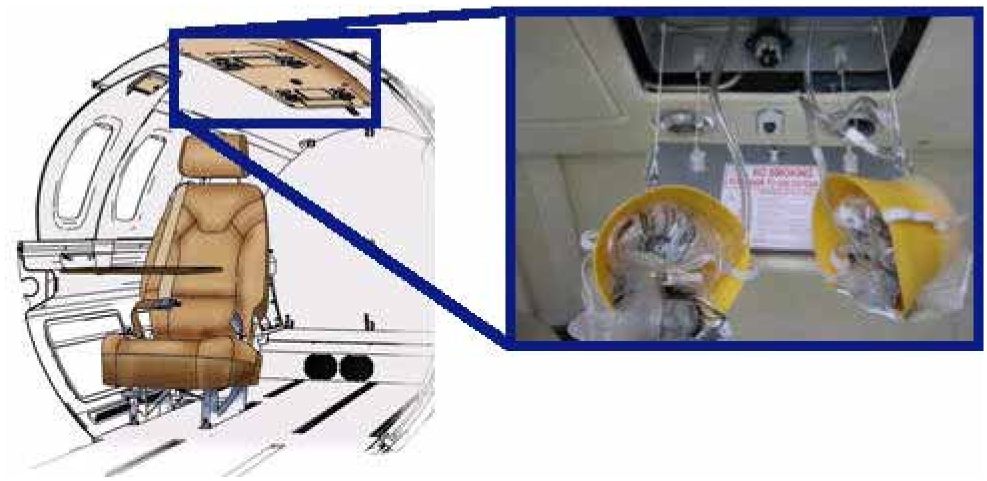


Figure 4-16. Passenger Oxygen Mask Location and Deployment (Cabin)

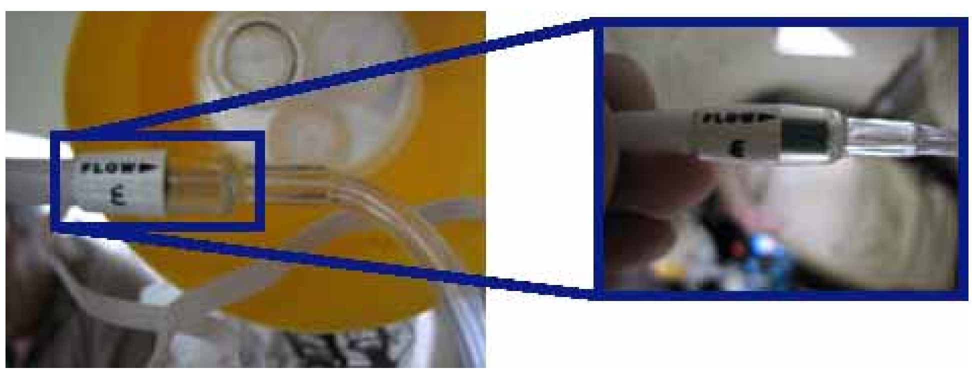


Figure 4-17. Passenger Oxygen Mask Flow Indicator

4.5.14 Emergency Operation

As long as the oxygen control knob is in the ON position, oxygen is available to the pilot and right-pilot seat quick donning masks. The continuous flow mask in the instrument panel - right is for emergency use only and will deplete the oxygen cylinder when used.

If the cabin altitude exceeds 12,750 feet MSL, an aural alert, "Mask On, Descend!" sounds 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 opens 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.

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.

4.6 Normal Operations

4.6.1 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.

There are two ways to preflight the crew masks. The Mask removal procedure should be used on the first flight of each day. The non-removal procedure may be used on subsequent flights.

MASK REMOVAL

NOTE:
Conduct this mask removal inspection on the first preflight of the day, or after a change of crew.

1. Remove the mask from the stowage cup.
2. Press the red harness inflation button to inflate the harness.
3. Listen and feel the harness for leaks that may prevent the harness from fully inflating.

4. Don the mask and release the red harness inflation button, allowing the harness to deflate smoothly. Breathe normally; check for breathing quality in each of the three control modes: NORM, 100% & EMER; (aviators breathing oxygen is odorless, colorless, and tasteless). The mask shall not vibrate, chatter, or flutter excessively. Set mode to 100%.
5. Select the MASK HEADSET switch to MASK. Speak normally into the mask. The microphone shall operate without excessive noise or static at normal volume. Reset the MASK HEADSET switch to HEADSET.
6. Remove the mask and stow per instruction decal on stowage cup.
7. Set the seat headrest to a height that will allow the pilot to access the oxygen mask.

MASK NON-REMOVAL

1. Verify that the communications connector is securely connected to the mating jack.
2. Verify that the oxygen hose is securely attached to the aircraft oxygen outlet.
3. Momentarily switch the control knob to the EMER position and allow oxygen to flow through the regulator to verify function. The regulator pressurization should be momentarily audible in the headset, confirming the communications system is functional (MIC switch in the MASK position).
4. Set the seat headrest to a height that will allow the pilot to access the oxygen mask.

⚠ CAUTION:
Maintaining the regulator in the EMER position can deplete the oxygen system. Return the regulator to the 100% position upon verification of proper function.

4.6.2 Oxygen Duration

See Figure 4-18. For single pilot flight, FAR 91.211 requires that the pilot wear and use an oxygen mask when at or above FL350. It is permissible to wear and use the oxygen mask with the regulator in the NORM setting. Remember to stow the mask with the regulator set to 100%.

For flights with two pilots, FAR 91.211 does not require the use of the oxygen masks, provided the aircraft is equipped with two quick donning masks and both pilots remain at the controls. If either pilot leaves their seat, the other must wear and use their oxygen mask. It is recommended the Masks be stowed in the 100% setting.

NOTE:
Operations under 14 CFR Part 91 require a ten 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 ten minute supply for all passengers. The 40 cubic foot bottle meets these requirements.

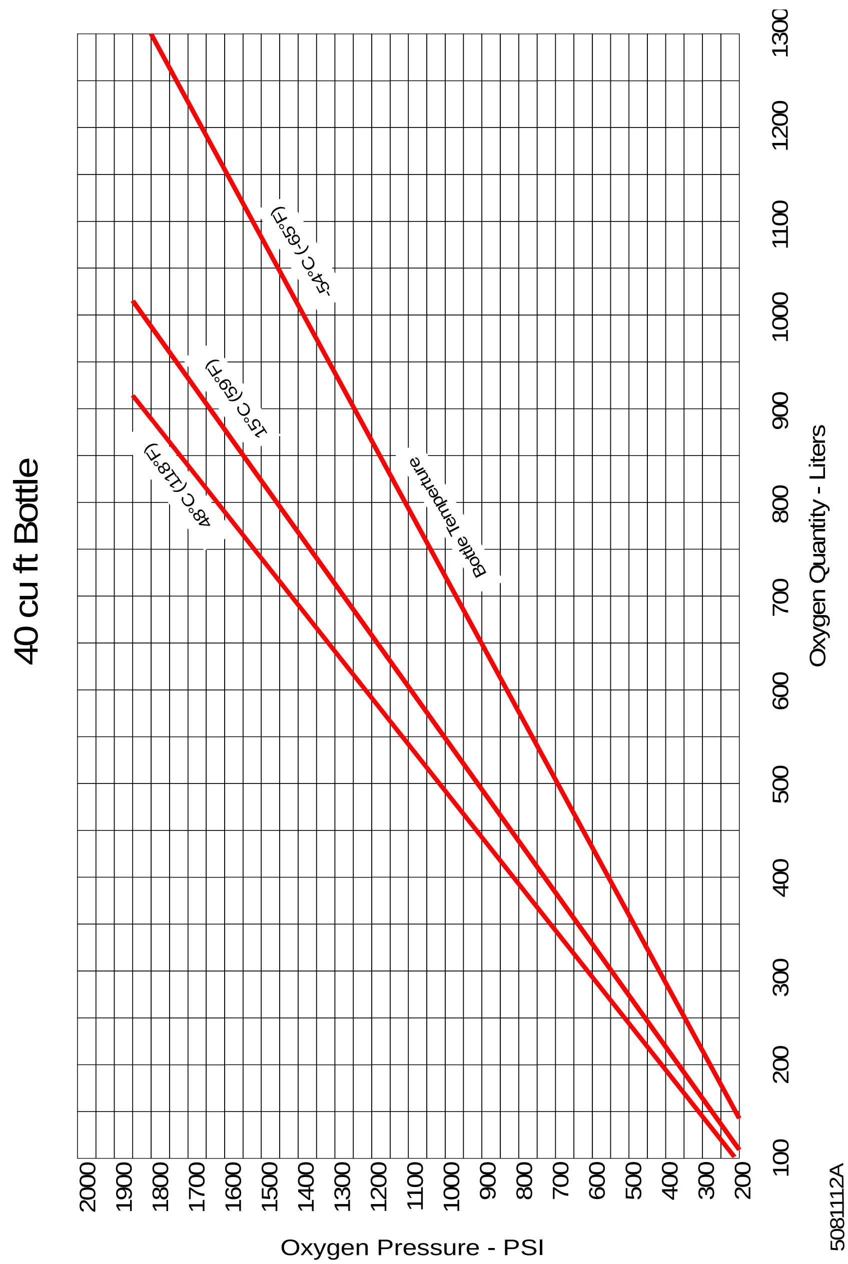


Figure 4-18. 40 Cubic Foot Bottle, Oxygen Quantity

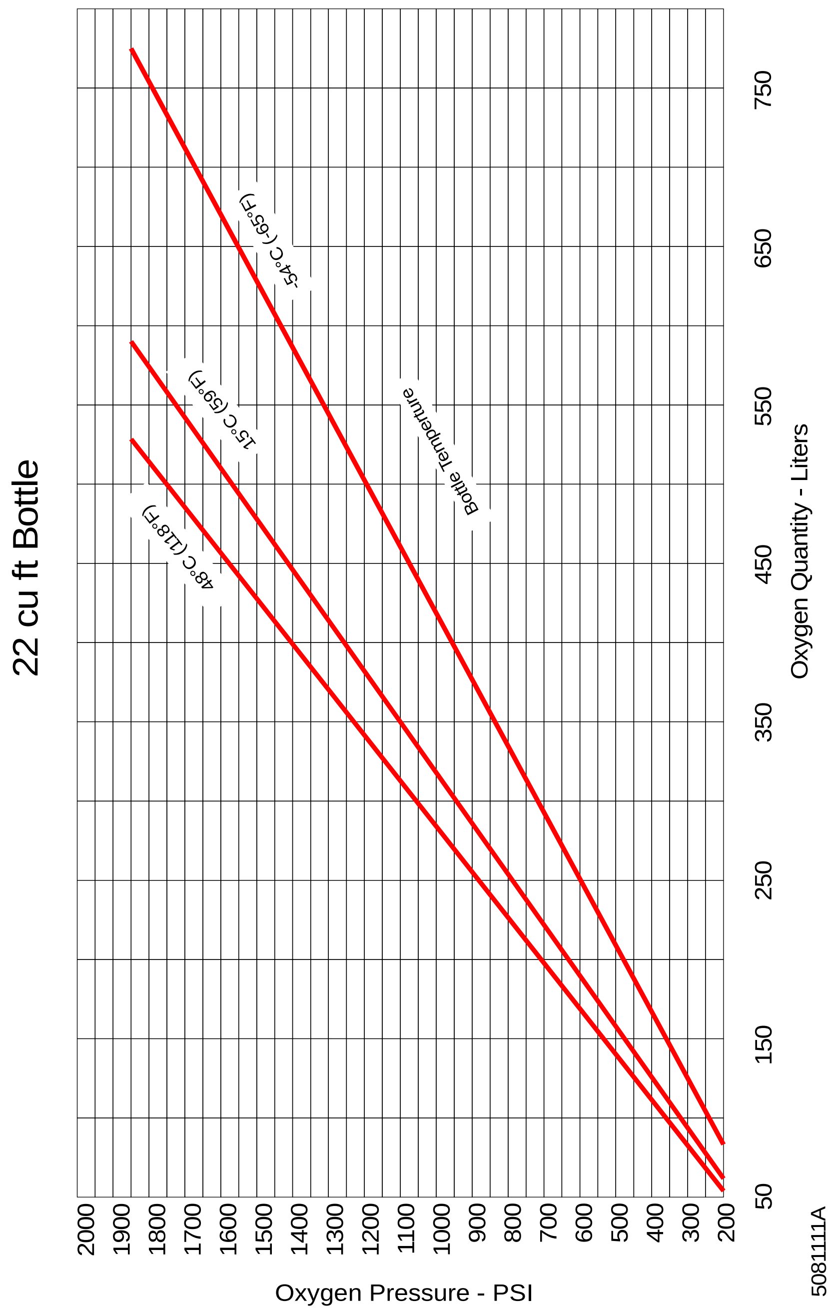


Figure 4-19. 22 Cubic Foot Bottle, Oxygen Quantity

Table 4-5. Pilot Oxygen Usage for FL350 or Above

Time on Oxygen (hr:min)	Oxygen Quantity Used (LITERS)	Time on Oxygen (hr:min)	Oxygen Quantity Used (LITERS)
:30	68	3:00	409
:45	102	3:15	443
1:00	136	3:30	477
1:15	170	3:45	511
1:30	204	4:00	545
1:45	238	4:15	579
2:00	272	4:30	613
2:15	306	4:45	647
2:30	341	5:00	681
2:45	375		

Table 4-6. 10,000 Ft Cruise Oxygen Duration – hr:min

Oxygen Quantity (Liters)	1 pilot	1 pilot+1	1 Pilot+2	1 Pilot+3	1 Pilot+4	1 Pilot+5
200	1:05	0:11	-	-	-	-
300	1:53	0:27	0:12	-	-	-
400	2:20	0:42	0:21	0:12	-	-
500	3:28	0:57	0:30	0:19	0:12	-
600	4:16	1:12	0:39	0:25	0:17	0:13
700	5:03	1:28	0:48	0:32	0:23	0:17
800	5:51	1:43	0:57	0:38	0:28	0:21
900	6:39	1:58	1:07	0:45	0:33	0:25
1000	7:26	2:13	1:16	0:51	0:38	0:29
1100	8:14	2:29	1:25	0:58	0:43	0:33
1200	9:01	2:44	1:34	1:04	0:48	0:37
1300	9:59	2:59	1:43	1:11	0:53	0:41
Assumes 10 minute descent with crew masks set to 100% Oxygen & Cruise with Masks set to NORM						

Table 4-7. 15,000 Ft Cruise Oxygen Duration – hr:min

Oxygen Quantity (Liters)	1 pilot	1 pilot+1	1 Pilot+2	1 Pilot+3	1 Pilot+4	1 Pilot+5
200	1:13	0:12	-	-	-	-
300	2:06	0:28	0:12	-	-	-
400	2:59	0:44	0:22	0:13	-	-
500	3:52	1:00	0:31	0:19	0:13	-
600	4:46	1:16	0:41	0:26	0:18	0:13
700	5:39	1:32	0:50	0:33	0:23	0:17
800	6:32	1:48	1:00	0:40	0:28	0:21
900	7:25	2:04	1:09	0:46	0:34	0:26
1000	8:18	2:20	1:19	0:53	0:39	0:30
1100	9:12	2:36	1:28	1:00	0:44	0:24
1200	10:05	2:52	1:38	1:06	0:49	0:38
1300	10:58	3:08	1:47	1:13	0:54	0:43
Assumes 10 minute descent with crew masks set to 100% Oxygen & Cruise with Masks set to NORM						

Table 4-8. 20,000 Ft Cruise Oxygen Duration – hr:min

Oxygen Quantity (Liters)	1 pilot	1 pilot+1	1 Pilot+2	1 Pilot+3	1 Pilot+4	1 Pilot+5
200	1:04	0:12	-	-	-	-
300	1:51	0:27	0:12	-	-	-
400	2:38	0:43	0:22	0:13	-	-
500	3:25	0:58	0:31	0:19	0:13	-
600	4:12	1:14	0:40	0:26	0:18	0:13
700	4:59	1:30	0:50	0:33	0:23	0:17
800	5:46	1:45	0:59	0:39	0:29	0:22
900	6:33	2:01	1:09	0:46	0:34	0:26
1000	7:20	2:17	1:18	0:53	0:39	0:30
1100	8:07	2:32	1:37	1:00	0:44	0:34
1200	8:54	2:48	1:47	1:06	0:49	0:39
1300	8:41	3:03	1:46	1:13	0:55	0:43
Assumes 10 minute descent with crew masks set to 100% Oxygen & Cruise with Masks set to NORM						

Table 4-9. 25,000 Ft Cruise Oxygen Duration – hr:min

Oxygen Quantity (Liters)	1 pilot	1 pilot+1	1 Pilot+2	1 Pilot+3	1 Pilot+4	1 Pilot+5
200	0:27	-	-	-	-	-
300	0:47	0:17	-	-	-	-
400	1:06	0:27	0:16	0:10	-	-
500	1:26	0:37	0:23	0:16	0:11	-
600	1:46	0:47	0:30	0:21	0:15	0:11
700	2:06	0:57	0:37	0:26	0:20	0:15
800	2:25	1:06	0:44	0:32	0:24	0:19
900	2:45	1:16	0:51	0:37	0:28	0:22
1000	3:05	1:26	0:58	0:43	0:33	0:26
1100	3:25	1:36	1:05	0;48	0:37	0:30
1200	3:44	1:46	1:12	0:53	0:42	0:34
1300	4:04	1:56	1:19	0:59	0:46	0:37
Assumes 10 minute descent with crew masks set to 100% Oxygen & Cruise with Masks set to NORM						

NOTE:
For flight oxygen requirements, refer to the oxygen duration tables in Section 7 of the Aircraft Flight Manual.

4.6.3 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.

4.7 Abnormal Procedures

4.7.1 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.

4.8 Crew Alerting System Messages

Table 4-10. Oxygen CAS Messages

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

4.9 Oxygen Review Questions

1. What triggers passenger mask deployment during normal oxygen system operation on the Eclipse 550?

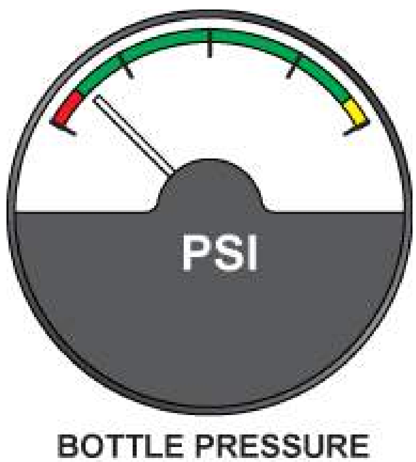
a. The pilot manually deploys the masks.

b. The masks will automatically deploy with a cabin pressure altitude of 14,000 feet +0/-500 feet.

c. The masks will automatically deploy with a cabin pressure altitude of 12,500 feet +500/-500.

d. The masks will automatically deploy with a cabin pressure altitude of 14,000 feet +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. To indicate that over pressurization has occurred and 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 should 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 bottle has been properly filled.
c. Both A and B are correct
d. None of the above

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 should 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 feet
b. 14,000 feet
c. 15,000 feet
d. 12,500 feet

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?**

    a.

    b.

Ice Protection System

5

Contents

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Ice Protection System

5

5.1 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

The pitot/AOA probes, pitot/static probe, static ports and windshield are electrically heated. Engine anti-ice uses bleed air to heat the engine inlet. The wing and horizontal stabilizer are de-iced by pneumatic boots utilizing engine bleed air. A wing ice-inspection light illuminates the left wing leading edge to identify icing at night. The Aircraft Computer System (ACS) controls and monitors both the anti-ice and de-ice components of the ice protection system after pilot activation.

When flying, the engine anti-icing system must be ON (ICE PROT - ENG) when the OAT is 10°C (50°F) or colder and visible moisture in any form is present (fog with visibility of one mile (1600 m) or less, rain, snow, sleet, or ice crystals). In flight when the OAT is 10°C (50°F) to -40°C(-40°F) and visible moisture in any form is present (such as clouds, rain, snow, sleet, or ice crystals). The wing de-icing system must be ON (ICE PROT switch WING/L(R) ENG) when in icing conditions or ice is detected on the aircraft, and remain on until the entire wing is clear of ice.

5.2 Aircraft Computer System (ACS) Interfaces

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

The de-ice system includes a bleed air de-ice 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 Chapter 12, "Air Data"), heated engine inlets, and windshield heat.

Bleed air is routed from the outboard P3 port from each engine. The bleed air then is modulated by the ACS controlled (on/off) Pressure Regulating Shutoff Valve (PRSOV). After the PRSOV, the bleed air flow is divided to the engine anti-ice and the de-ice manifold.

The pilot selections using the ENG/WING switch on the center switch panel are sent through the PFD to the ACS. The ACS controls the PRSOV for routing of the bleed air to the engines, and the de-ice manifold for inflation and deflation of the boots by turning on and off applicable Electronic Circuit Breakers (ECBs).

With the ENG/WING switch in the ENG position, the ACS will command the PRSOV open. This supplies bleed air to the engine inlets as well as the de-ice manifold. If the Switch is placed in the WING position, the PRSOV stays open, the engine inlet continues to be heated, and the de-ice manifold is commanded to operate the wing and horizontal stabilizer de-ice boots. Additionally, with the switch in the WING position, the ACS updates the predicted Stall Angle Of Attack, which increases depicted Stall Speed/Pusher, V_{REF}, and V_{YSE}.

Six sensors allow the ACS to monitor the ice protection system components for low pressure from the Engines, at the de-ice boots, and temperature at the engine inlet. The pressures switches also provide feedback to the ACS for failure monitoring.

5.2.1 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. De-ice boots
   a. Outer wing boot pressure switch
   b. Inner wing/stabilizer boot pressure switch

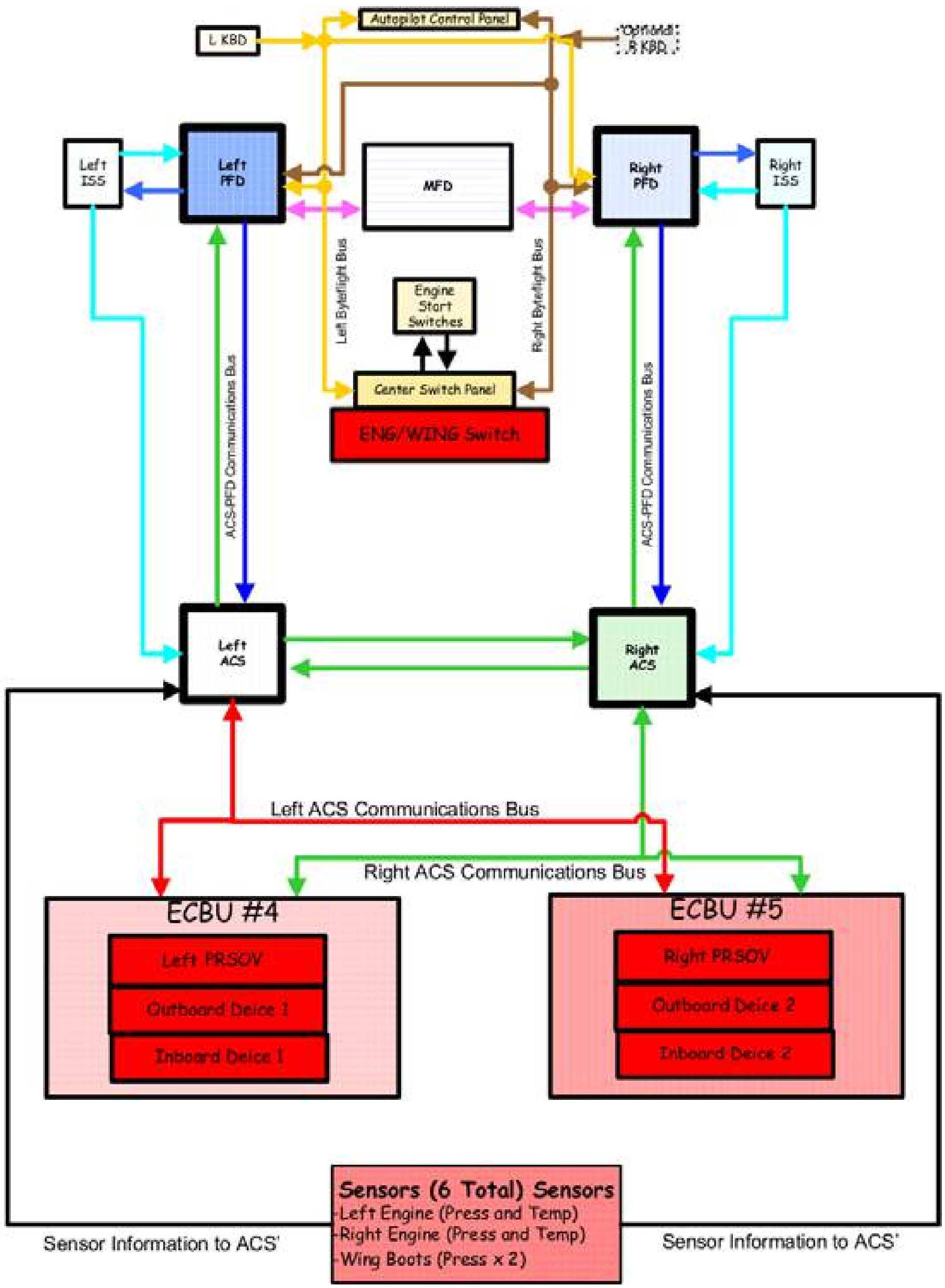

Figure 5-1. Ice Protection – ACS Interface

5.3 Limitations and Specifications

5.3.1 Icing Conditions

- Flight into known icing conditions is approved.
- Wings, vertical and horizontal stabilizers, flight control surfaces, and engine inlets must be free of any frost, snow, and ice for takeoff.
- Takeoff with polished frost is prohibited.
- A visual and tactile check of the wing upper surface and leading edge must be conducted for the formation of frost, ice, snow, or slush prior to takeoff if the OAT is 10°C (50°F) or colder and it cannot be determined if the wing fuel temperature is above 0°C (32°F), and when one or more of the following conditions apply:
  - There is visible moisture present (rain, snow, sleet, ice crystals, frost or fog).
  - Water is on the wing upper surface.
  - The difference between the OAT and dew point is 3°C (5°F) or less.
  - The aircraft was flown in icing conditions since the previous takeoff.
- The aircraft and ice protection systems must be operated in accordance with the limitations in this section, normal procedures in the AFM Section 4, emergency procedures in the AFM Section 3, and performance speeds/data in the AFM Section 5, where specified.
- Flight in icing conditions with gear or flaps extended is prohibited except for takeoff, approach and landing, or go-around (minimize the time in icing conditions with gear of flaps extended).
- Takeoff in icing conditions with the flaps up is prohibited.

5.3.2 Engine Anti-ice System

5.3.2.1 GROUND OPERATIONS

- The engine anti-icing system must be ON (ICE PROT - ENG) when the OAT is 10°C (50°F) or below when operating on ramps, taxiways, or runways where surface snow, ice, standing water, or slush is present.
- When operating the engines at idle 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.
- The engine anti-icing system must be ON (ICE PROT - ENG) when the OAT on the ground and for takeoff is 10°C (50°F) or colder, and visible moisture in any form (fog with visibility of one mile (1600 m) or less, rain, snow, sleet, or ice crystals) is present.

5.3.3 Flight Operations

The engine anti-icing system must be ON (ICE PROT - ENG) when the OAT is 10°C (50°F) or colder, and visible moisture in any form (fog with visibility of one mile or less, rain, snow, sleet, or ice crystals) is present.

5.3.4 Wing De-Ice System

Do not operate the wing/stabilizer de-ice boots at OAT colder than -40°C.

5.3.4.1 GROUND OPERATIONS

The wing de-ice system must be OFF for takeoff (ICE PROT switch – OFF or ENG only).

5.3.4.2 FLIGHT OPERATIONS

Icing conditions exist when the OAT in flight is 10°C (50°F) to -40°C (-40°F) and visible moisture in any form (clouds, rain, snow, sleet, or ice crystals) is present.

The wing de-icing system must be ON (ICE PROT switch WING/L(R) ENG) when in icing conditions or when ice is detected on the aircraft, and remain on until the entire wing is clear of ice.

5.3.5 Super-Cooled Large Droplet Icing, Freezing Rain, or Freezing Drizzle

- Flight in Super-cooled Large Droplet (SLD) icing, freezing rain, or freezing drizzle conditions is prohibited. SLD may be indicated by ice accretion on the areas of the airframe that do not normally collect ice, such as the upper surface of the wing or side windows, ridges of ice that form aft of the de-ice boot, or drops that splatter on impact and freeze.
- If these conditions are encountered, select all ice protection systems ON (ICE PROT switch WING/L(R) ENG) and exit the icing conditions as soon as possible.
- Do not connect the autopilot if these conditions are observed or when there are unusual aileron trim requirements, or if autopilot roll mistrim conditions exist. If the autopilot is connected before entering these conditions: firmly hold the sidestick, then disconnect the auto pilot.

5.4 Controls and Indicators

5.4.1 Center Switch Panel – Ice Protection

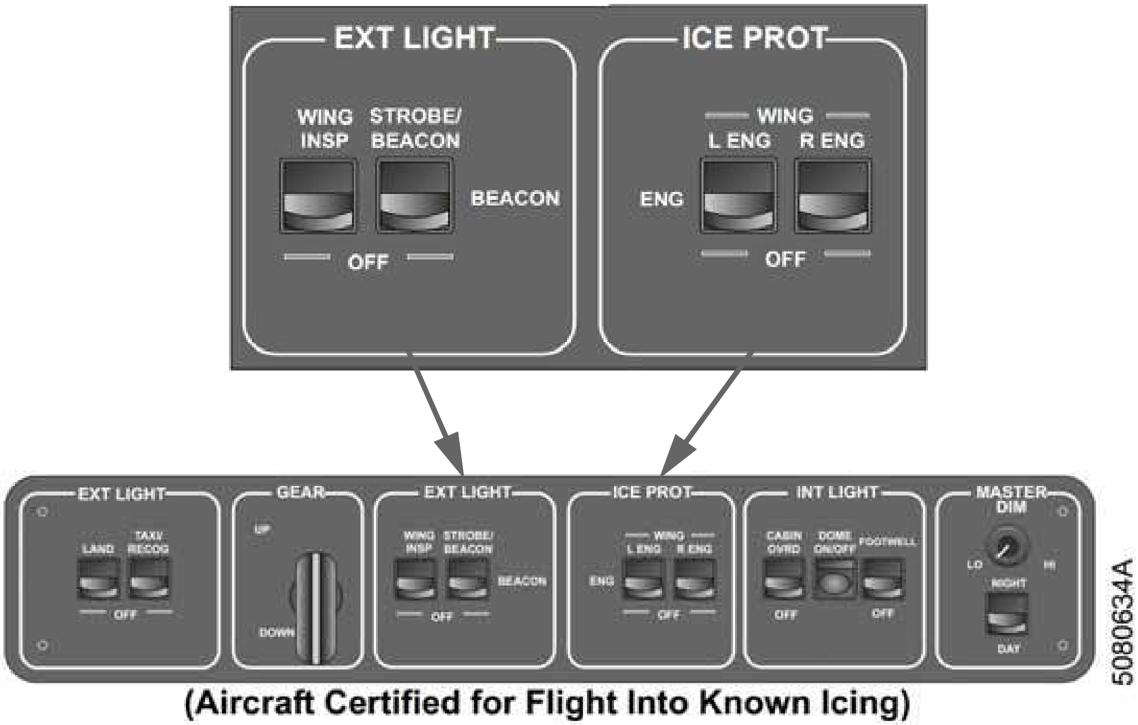

Figure 5-2. Center Switch Panel – Ice Protection

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

5.4.2 Ice Protection Synoptic

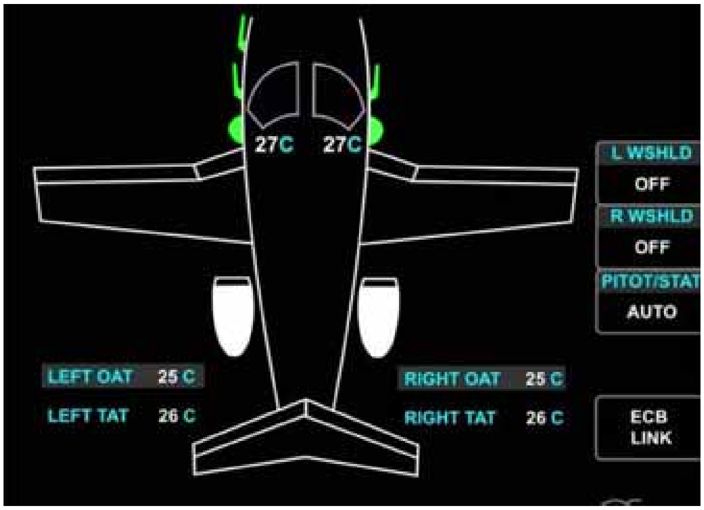

Figure 5-3. Ice Protection Synoptic

L and R WSHLD LINE SELECT KEY
- NORMAL .... Windshield heat on
- HI .... Windshield heat on high
- OFF .... Windshield heat off

WINDSHIELD Display
- Green outline .... Windshield heat on
- White outline .... Windshield heat off
- Amber outline .... Windshield heat 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 connectivity
- Amber .... Probe/static heat failure

DE-ICE BOOT Display
- Green .... De-ice system on
- Black with White Outline .... De-ice system off
- Amber .... De-ice system failed

Engine Display
- Green .... Engine anti-ice on
- Black with White Outline .... 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.

5.5 System Description

5.5.1 Windshield Heat

See Figure 5-4. Both the left and right windshields are glass faced, and contain a mat with an electrical heater wire embedded into the acrylic plies in the center portion of the windshield. Windshield temperature is automatically controlled so that the center portion of the window is heated with the desired range between 41° and 46°C. 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.

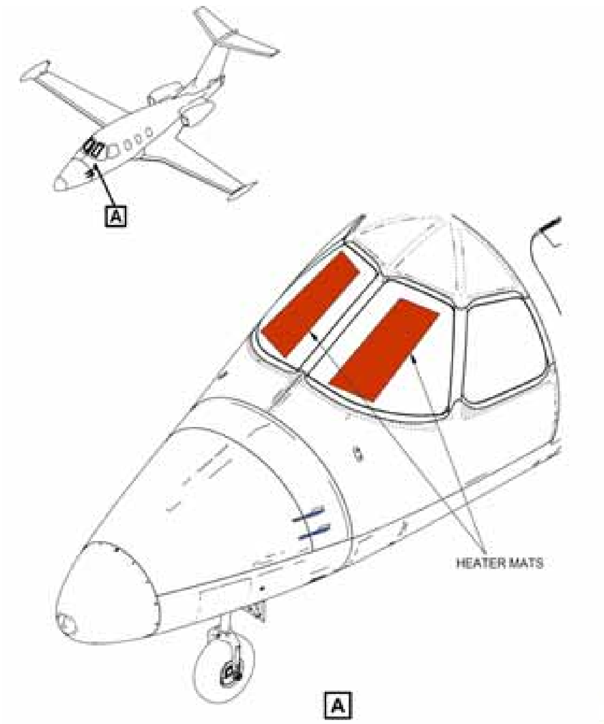

Figure 5-4. Windshield Heater Mat

The ACS maintains the windshield temperature 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 NORMAL, HI, or OFF. Upon start up of the second engine, the Windshield heat will automatically turn ON to test for connectivity and faults. After 10 seconds the Windshield will automatically switch to OFF.

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.

5.5.2 Defog

A Defog system is available for defogging of the cockpit windows and in the event of a failure of the windshield heat system. It is controlled from the ENVIR synoptic. Further information is available in Chapter 8, "Climate Control."

5.5.3 Pneumatic De-ice

See Figure 5-5. 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 one boot on each horizontal stabilizer.

With both ENG/WING switches in the OFF or ENG position the deice-boots are deflated. With a lack of pressure from the outboard P3 deflation vacuum is supplied from the inboard P3 bleed air port prior to the Flow Control Valve after the heat exchanger. This pressurized air is routed to a dual distribution valve within the Deice Manifold which redirects the air through an ejector nozzle. Moving pressurized air through the venturi in an ejector creates vacuum (suction) which is used to open the Primary Outflow Valve (Pressurization) when on the ground, and deflates the deice boots in order to maintain the aerodynamic profile of the leading edges.

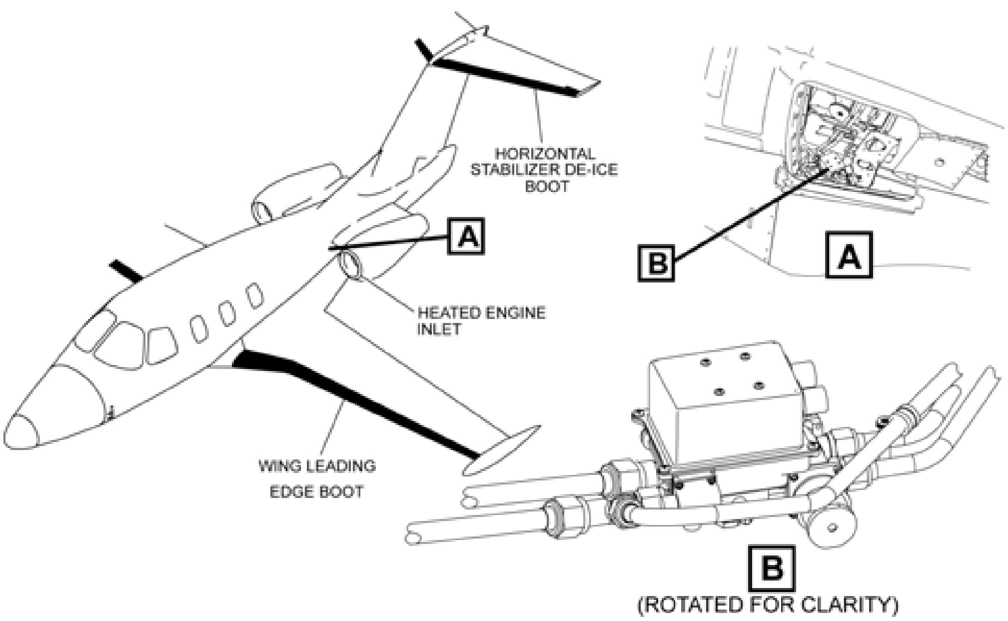

Figure 5-5. Leading Edge De-ice Boot Location

De-ice boot inflation is activated by selecting left, right, or both ENG/WING switches to WING position on the center switch panel. At least one engine must be running at 72% N2 or above for the system to operate since engine bleed air inflates the boots. The ACS controls the inflation/deflation cycle and monitors system pressure through pressure sensors located within the wing 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.

When activated, 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 deflation pressure continues.

Bleed air from the outboard P3 bleed air port on the engine is fed to a Pressure Regulating Shut-off Valve (PRSOV) on each engine. The PRSOV is closed when the ENG/WING switch is in the OFF position. When the ENG/WING switch is placed in the ENG or WING position the PRSOV opens and reduces the pressure of the bleed air from the engine from 165 PSI to 21 PSI. The air is then divided to Engine anti-ice, and Wing de-ice. For Wing De-ice, the bleed air from both engines is sent to a common (both engines send inboard and outboard P3 bleed air) deice manifold.

A dual distribution valve in the de-ice manifold reduces the bleed air pressure to 20 PSI, and 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.

With the PRSOV selected closed by placing the ENG/WING switch in the OFF position, deflation pressure is provided solely by the inboard P3 line input to the deice manifold.

A failure of a pressure regulating shut off valve causes an L(R) ENG A/ICE VLV FAULT to appear. With a lack of electrical power the PRSOV fails open, allowing bleed air for engine anti-ice and wing de-ice to remain available.

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, a WING DEICE FAIL caution appears.

5.5.4 Engine Anti-ice

See Figure 5-6. Engine anti-ice protection is provided by pressurized bleed air from the outboard P3 engine bleed air port, routed through the PRSOV, then directed into a perforated tube on the inside of each engine inlet cowl. Bleed air entering the tube heats the inlet, preventing ice formation. This air is then exhausted out of the tube onto the inlet for the Starter/Generator; this inlet will be de-iced as well.

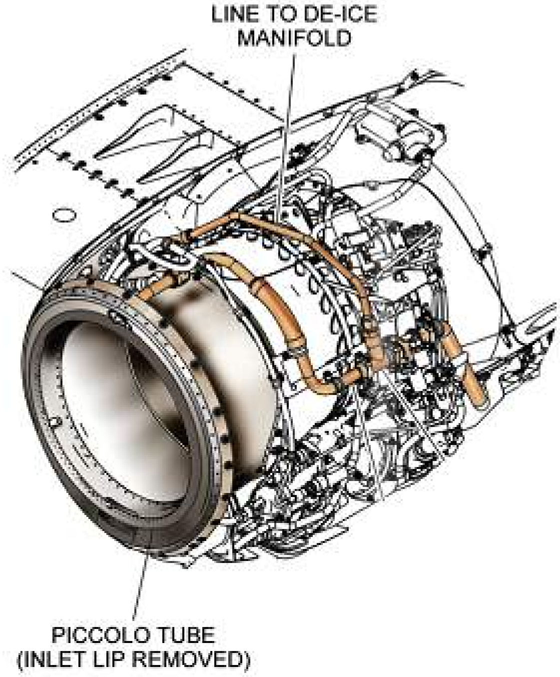

Figure 5-6. Engine Inlet Anti-ice

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. Sensors located within each engine inlet monitor bleed air temperature. 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. If an increase in temperature is not sensed, a malfunction of engine anti-ice is indicated by an L(R) ENG A/ICE FAIL caution message, and the affected engine inlet depiction on the ICE page turns amber.

The L(R) ENG A/ICE FAIL caution message will also display if only one engine anti-ice switch is selected ON and both engines are running — to remind the pilot to activate both switches.

A malfunction of the temperature sensor is indicated by an ENG ANTIICE MON FAULT advisory message (on the ground only). If the sensor fails in flight, an ENG A/ICE FAIL caution message is displayed.

A L(R) ENG A/ICE VLV FAULT advisory message will display if the PRSOV fails (fails to the open position) with the ENG/WING switch OFF. Engine anti-ice remains on and performance is affected; however, WING de-ice is still selectable.

5.5.5 Pitot/AOA Probes, Pitot/Static Probe, and Static Ports

All air data system probes (except for the Outside Air Temperature [OAT] 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.

Probe and port heat begins automatically cycling on when at least one engine is running, or any time weight off wheels.

On the ground, probe heat can be manually selected to AUTO or ON, while on a GPU, without engines running using the PITOT/STAT line-select key on the ICE synoptic. The default state for PITOT/STAT heat is the AUTO position.

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.

5.5.6 Wing Inspection Light

See Figure 5-7. 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 WING INSP switch on the center switch panel.

Figure 5-7. Wing Inspection Light Location

5.6 Normal Operations

5.6.1 Preflight

It is essential to take off with an aerodynamically clean airplane. Low temperatures and precipitation associated with cold weather operation create problems while the airplane is on the ground. Frost, ice and snow may adhere to and accumulate on the surfaces of the airplane. Accumulations of ice, snow, and frost will not blow off on the takeoff roll. All of the airplane surfaces, wing, vertical and horizontal tail, flight controls and hinges, flaps, pitot/AOA probes, pitot/static ports, and engine inlets must be free of frost, ice and snow before takeoff. The removal of frozen accumulations by chipping or scraping is not recommended. Use a soft brush, squeegee or mop to clear loose snow. When removing ice or snow, start from the empennage and work forward.

If ice, snow and frost cannot be removed by hand, have the airplane thoroughly deiced using deicing fluid (refer to AFM Section 8). Airplane deicing fluids may be used diluted or undiluted according to the manufacturer's recommendations. Deicing fluids may be applied either heated or unheated. Deicing fluids should only be applied at low pressure by trained personnel with proper equipment.

Deice Fluids

Only fluids conforming to the following specifications and applied per the manufacturer's application procedure are approved for use.

- SAE AMS 1424 Type I
- ISO 11075 Type I

NOTE:
If deicing fluids are used, special attention must be given to ensure that the pitot/AOA probes, pitot/static ports, the area forward of the cockpit windshield, and engine inlets are free of deicing fluids. De-icing must be accomplished at the last possible time prior to takeoff. Refer to the latest FAA Holdover Time Guidance. The holdover clock starts at the beginning of the last application of deice fluid.

Frozen accumulations may be removed by placing the aircraft in a warm hangar, allowing accumulations to melt from the aircraft surfaces. ***Remove loose snow from the airplane before placing into the warm hangar.*** Remove water from the airplane using a squeegee or mop to prevent refreezing when the aircraft is moved outside in freezing conditions, or in flight. Re-inspect the aircraft once outside to assure freedom of movement of the flight controls and other components.

Cold temperatures reduce the solubility of water that might be in the fuel. Drain the Fuel drains frequently and thoroughly. Observe Fuel Additive limitations. Oxygen bottle pressure may also be less than normal due to low temperatures. Oxygen quantity can be determined for the conditions using the oxygen duration calculation in “Oxygen Duration” on page 4-18 or Section 7 of the Aircraft Flight Manual.

Powering the aircraft with a Ground Power Unit (GPU) for 30 minutes or longer will allow the battery heaters to warm the batteries.

Engine Start

Cold temperatures congeal engine oil and decrease the lead-acid battery effectiveness. Engine starts are not permitted at oil temperatures colder than -20°C/-4°F. When starting engines with oil temperatures colder than 5°C/41°F, a GPU or cross-generator start is required. Observe battery storage limitations. Minimum Battery Voltage for Engine Start is 23 VDC for a Battery Start, and at least 25 VDC for a GPU-assisted start as observed on the ELEC synoptic. At all times observe Engine Fuel and Oil temperature limits, both can be viewed on the ENG synoptic.

An engine dry motor for 10-20 seconds prior to first engine start will help warm the engine lubricants and battery. Observe starter limitations.

5.6.2 Ground Operations

The engine anti-icing system must be ON (ICE PROT - ENG) when the OAT is 10°C (50°F) or below when operating on ramps, taxiways, or runways where surface snow, ice, standing water, or slush is present.

When operating the engines at idle 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. The spinner is not protected by bleed air and the inertia of the increased Fan rotation is used to shed ice accretions. The engine anti-icing system must be ON (ICE PROT - ENG) when the outside air temperature (OAT) on the ground and for takeoff is 10°C (50°F) or colder and visible moisture in any form is present (such as fog with visibility of one mile (1600m) or less, rain, snow, sleet, or ice crystals). The pilot may activate windshield heat on the ICE synoptic and/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 or in addition to windshield heat. All pitot and static probes will be heated with one or more engines running in AUTO, or when selected to ON during ground operations.

NOTE:
PITOT/STAT ON selection is available on the ground prior to engine start only if a suitable GPU is powering the aircraft.

Taxi

Avoid taxiing through deep snow or slush. If taxiing on ice snow, slush, or water, is necessary, taxi at reduced speed and allow greater distance for decreased braking efficiency. Snow and slush can be forced into the brake assemblies, which may cause the brakes to freeze during a prolonged hold on the ground or during the subsequent flight. Use the brakes to create some friction induced heating of the brake discs to minimize the possibility of the brakes freezing. Use both engines for taxi on slippery surfaces. Directional control may be difficult to maintain during one-engine taxi on a slick surface. Keep the flaps retracted during taxi to avoid throwing snow or slush into the flap mechanisms and to minimize damage to the flap surfaces.

Before Takeoff

The aircraft is only approved for takeoff on paved runways. Contaminant runway data is not provided.

Complete the normal Before Takeoff procedures. Verify that the airplane remains free of frozen contaminants. Do not take off with frost, snow, or ice on the wings or aircraft control surfaces, including the horizontal stabilizer and elevators. Even small accumulations of ice on the wing leading edge can cause an increase in stall speed and possible degradation in stall characteristics. Check the flight controls and trims for complete freedom of movement before taking the runway for takeoff.

⚠ **WARNING:**
Ice, frost or snow on top of deicing solutions must be considered as adhering to the airplane. Takeoff should not be attempted under these conditions.

5.6.3 Flight Operations

Takeoff

Takeoff in icing conditions with the flaps up is prohibited. Wing de-ice system must be off for takeoff (ICE PROT switch – OFF or ENG only).

If taxi was made on a snow or slush covered taxiway, delay gear retraction if possible until a safe altitude is reached and cycle landing gear one or two times to shed any ice accumulation.

In-flight

Flight into known icing is flight where icing conditions are known to exist from pilot report or visual observation. Icing conditions may exist when the outside air temperature (OAT) in flight is 10°C (50°F) to -40°C (-40°F) and visible moisture in any form is present (such as clouds, rain, snow, sleet, or ice crystals). Do not operate the Wing/stabilizer de-ice boots at outside air temperatures (OAT) colder than -40°C. When flying into icing or anticipated icing conditions, select engine anti-ice and the wing and horizontal stabilizer de-ice boots ON. The first indication of ice formation is usually on the wing boots. During night operations, the wing ice inspection light (WING INSP) may be used to visually inspect the left wing leading edge for ice accumulation. Keep the wing de-ice system ON until the entire wing is clear of ice, including the portion of outer wing not protected by the boot and upper wing surface. Observe the Minimum Airspeed in Icing Conditions of 165 KEAS except for takeoff, approach, landing, go-around, or as specified in AFM Section 3, "Emergency Procedures." Windshield heat, which defaults to OFF, should be selected to NORMAL on the ICE synoptic prior to entering icing or anticipated icing conditions. It can be selected to HI in heavy icing and to NORMAL just prior to landing for improved visibility. In the event of a windshield heat failure, the DEFOG feature should be used. Pitot and static probes will be automatically heated during flight operations, and their status may be monitored on the ICE protection synoptic.

Ice contamination will form on unprotected aircraft surfaces even when the anti-ice and de-ice systems are activated. Ice accumulation will affect aircraft performance and increase the drag and weight. The most notable change will be an increase in the stall speeds. Aircraft handling qualities can also be adversely affected. Minimize the duration of icing encounters as much as practical by requesting an altitude above or below icing conditions. Most icing conditions are vertically narrow. Changing altitude will usually exit the icing. With the either or both of the ENG/WING switches selected to WING the stall warning and stick pusher (stall protection ice mode) will activate at higher airspeeds than with a clean uncontaminated aircraft. The airspeed increase is phased in over a period of 30 seconds after the switch is selected to WING. An ICING STALL PROT status message will also be displayed to indicate when the increased airspeed schedule is in effect. If both ENG/WING switches are placed in either the ENG or OFF position, the stall protection resets to the normal indications in 3 seconds, and the ICING STALL PROT status message is removed. The stall protection ice mode will effect not only the stall speed, but also VREF, and VYSE.

Intermittently operating with the autopilot off will allow more readily detectable changes in flight control feel. Do not connect the autopilot if unusual ice is observed on the unprotected upper wing surface or when there are unusual aileron trim requirements or if autopilot roll mistrim conditions exist. If the autopilot is connected before entering the conditions firmly hold the sidestick then disconnect the autopilot.

Weather Radar returns may be affected by ice accumulations on the nose, causing dark spots that mask weather displays, similar to no-weather returns. Additional care should be taken when in icing conditions to properly interpret the weather display.

Super-Cooled Large Droplet Icing (SLD), Freezing Rain, or Freezing Drizzle

Flight in SLD, freezing rain, or freezing drizzle is prohibited and should be exited as soon as possible. If time permits report the conditions to air traffic control.

Freezing rain or drizzle may be identified by visible rain or drizzle with OATs colder the +5°C or ice accretion at a rapid rate on the upper surface of the wing or side windows. Ice forming on parts of the aircraft that normally do not have ice accretion is also an indicator of SLD or freezing conditions. Ice may accumulate very rapidly and on parts of the aircraft not visible to the pilot. These accumulations may result in hazardous ice that could exceed the ice protection system capabilities and severely impact the aircraft handling qualities and reduce performance. Increasing airspeed within the limitations may be required to improve handling qualities. This type of icing could also affect the pitot/static/angle of attack system resulting in possible airspeed, altitude disagrees, or loss of data and stall warning, stick pusher or autopilot failure.

Landing

The aircraft is only approved for landing on paved runways. Contaminant runway data is not provided. Landing with the ENG/WING switch in the WING position will be at increased speed. Prior to landing verify the correct chart in AFM Section 5 Performance is used to determine the increased landing distance. During a landing with the wing deice boots on, the throttles will be reduced to less than 72% N2 and a WING DEICE FAIL will be observed.

Do Not retract flaps to UP if the flaps were extended while in icing conditions.

After Clearing Runway

Avoid taxiing through deep snow or slush. However, if it was necessary to taxi through snow or slush with the flaps extended, it is recommended that the flaps be left extended to protect them in case of ice or snow accumulation.

Post Flight

To reduce the possibility of frozen brakes, chock the aircraft and avoid setting the parking brake during freezing conditions. Remove ice, snow, and dirt from landing gear actuators, struts and wheel wells. Check gear doors, down-lock and weight on wheel sensors, wheels, brakes, and tires. Remove ice, snow, and dirt from flaps and flap tracks before retracting flaps.

Install aircraft protective covers. If the aircraft is to be parked for an extended period at ambient temperatures of -5°C or colder, it is recommended that crew oxygen masks be disconnected and stowed in a heated room. If the aircraft is to remain in subfreezing temperatures for an extended period, remove water and liquid containers from the aircraft. Observe battery storage limitations.

5.7 Abnormal Procedures

5.7.1 Windshield Overheat

See Figure 5-8. If either windshield temperature sensor senses a temperature above 71°C, an L(R) WSHLD OVHT warning message appears. On the ICE Synoptic, the outline of the windshield turns amber; a red OVHT message appears inside the windshield outline; and the temperature display changes to red.

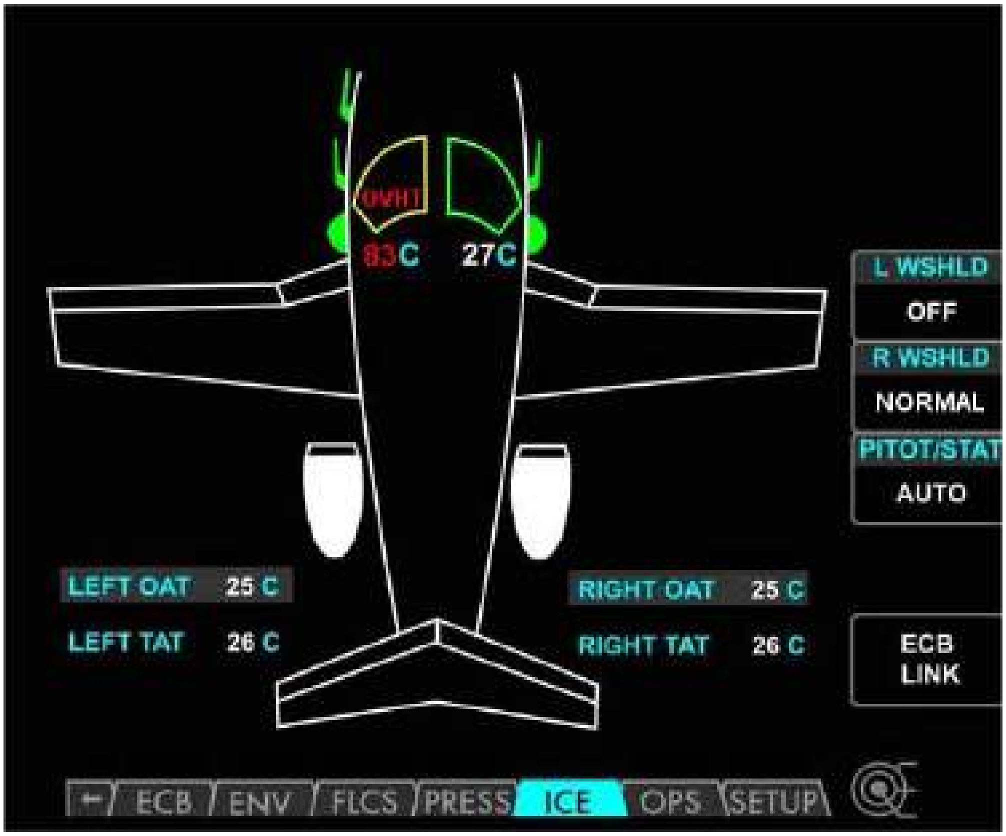

Figure 5-8. Windshield Overheat

5.7.2 Windshield Heat Failure

See Figure 5-9. If either windshield heater fails for a reason other than an overheat, an L(R) WSHLD HEAT FAIL caution message appears. Failure is indicated on the ICE synoptic by the windshield outline turning amber.

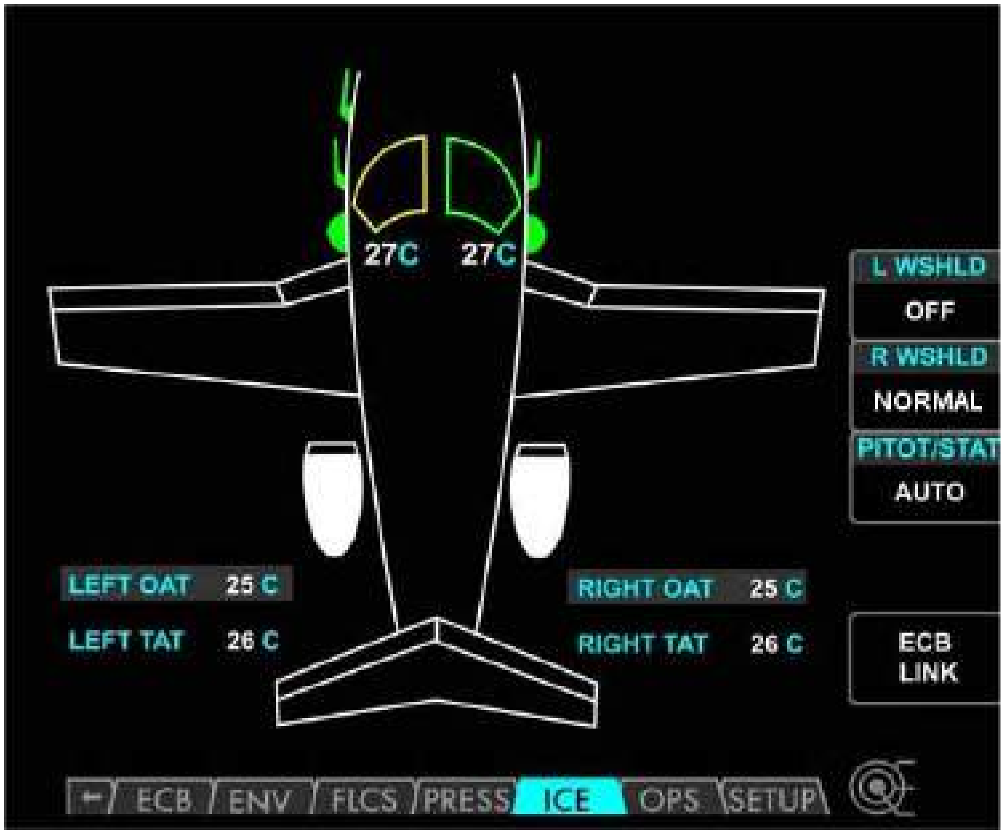

Figure 5-9. Windshield Heat Failure

5.7.3 Pneumatic De-Ice System Failure

See Figure 5-10. 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
- Failure of de-ice manifold heat

The failure is indicated on the ICE synoptic by the affected wing or horizontal boot section turning amber.

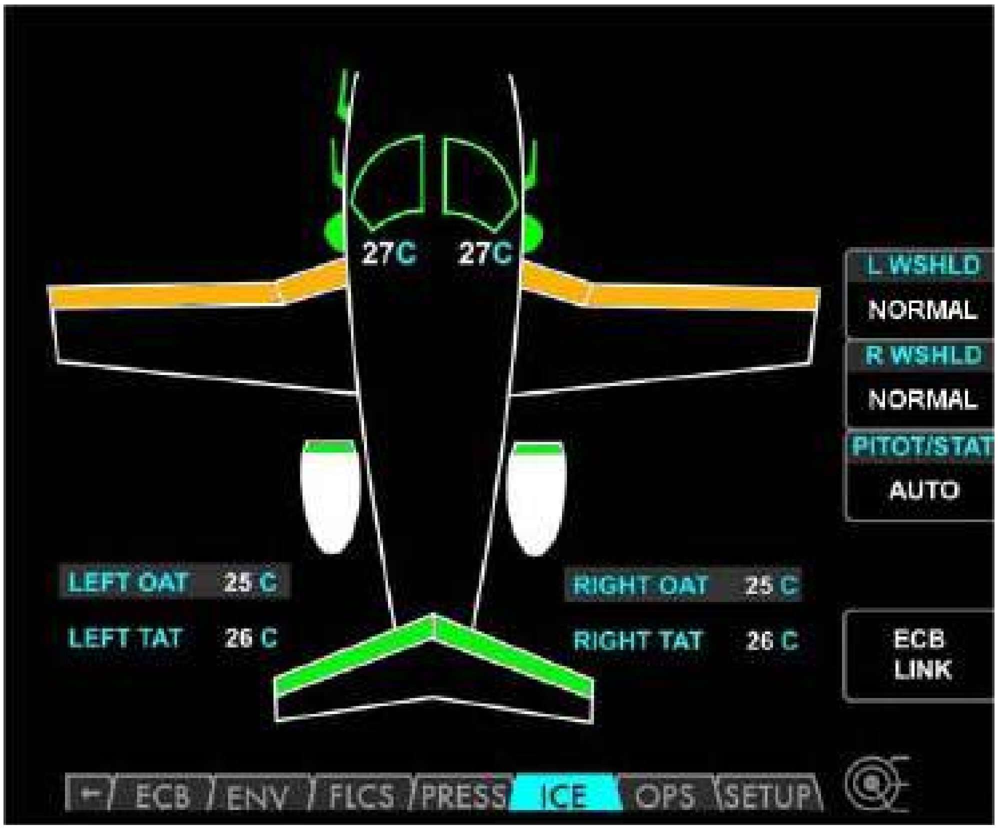

Figure 5-10. Wing De-Ice Failure

5.7.4 Engine Anti-ice System Failure

See Figure 5-11. A malfunction of engine inlet anti-ice during flight causes an L(R) ENG A/ICE FAIL caution message. The failure is indicated on the ICE synoptic by the engine inlets on the airplane graphic turning amber.

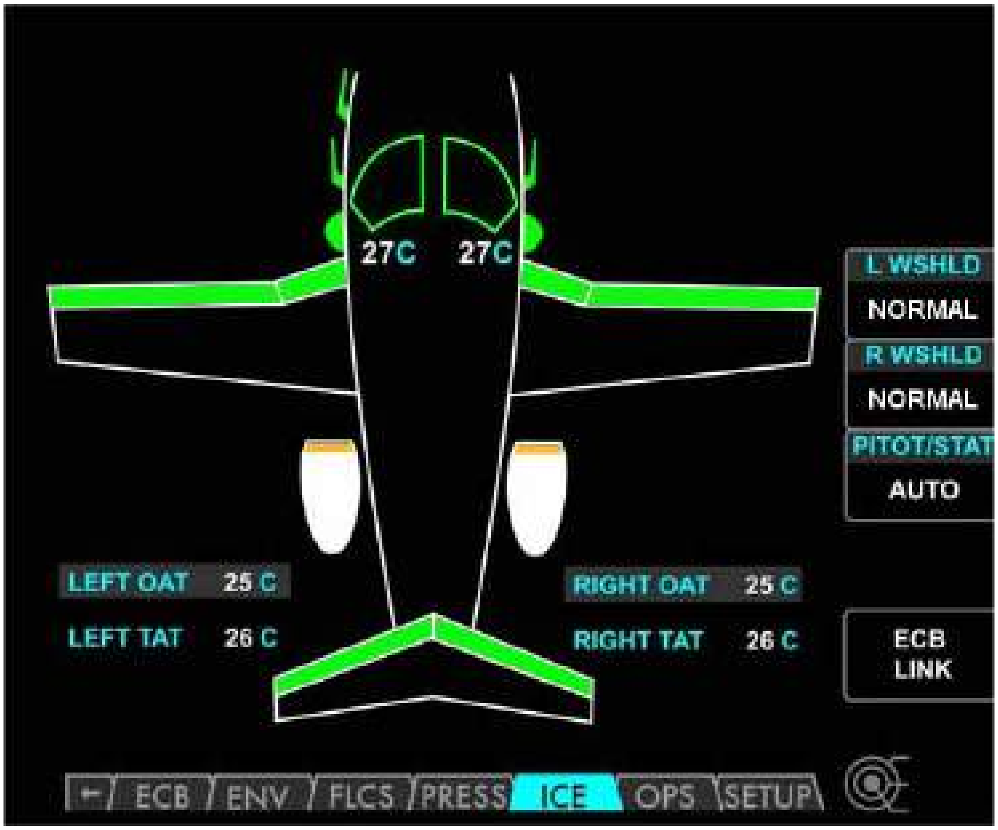

Figure 5-11. Engine Anti-ice Failure

NOTE:
This CAS message also appears if only one of the engine anti-ice switches is on and both engines are operating.

5.7.5 Probe and/or Port Heat Failure

See Figure 5-12. A failure of a probe or static port heat causes an 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 indicated on the ICE 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, an L(R) STATIC HEAT FAIL advisory message appears to alert the loss of redundancy.

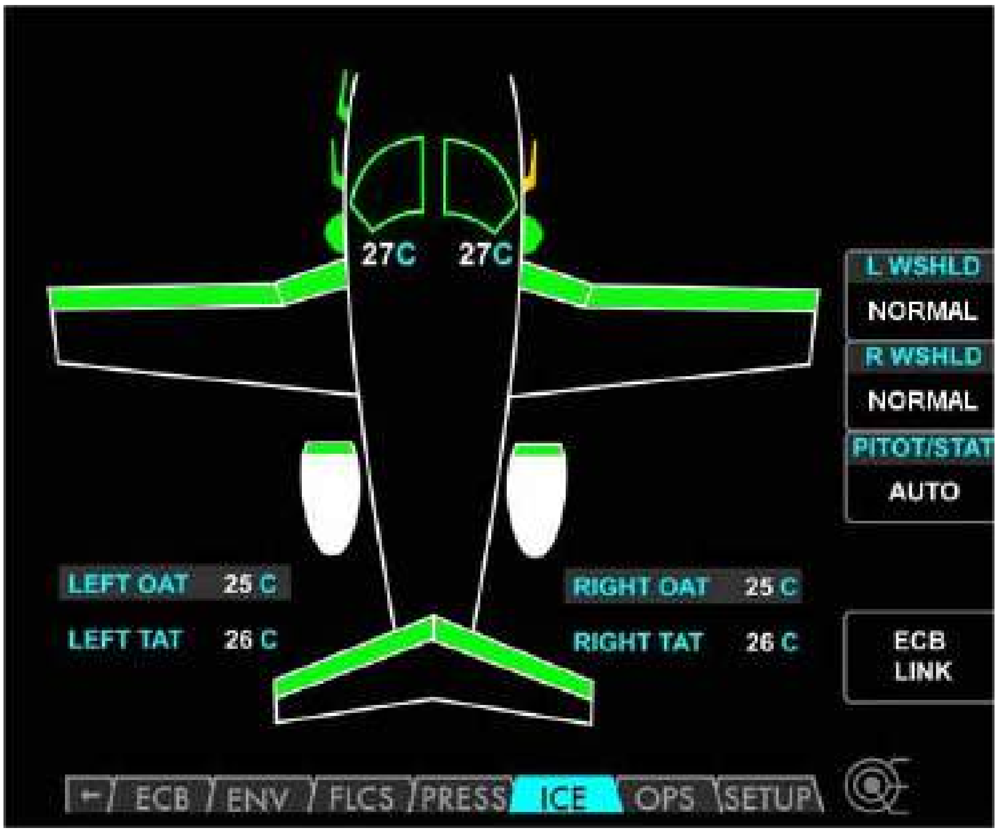

Figure 5-12. Pitot/AOA Probe Failure

5.7.6 Windshield Heat Sensor Fault

See Figure 5-13. A malfunction of the embedded temperature sensors causes an L(R) WSHLD HEAT FAULT advisory message to appear. The associated temperature display on the ICE protection synoptic appears as three dashes.

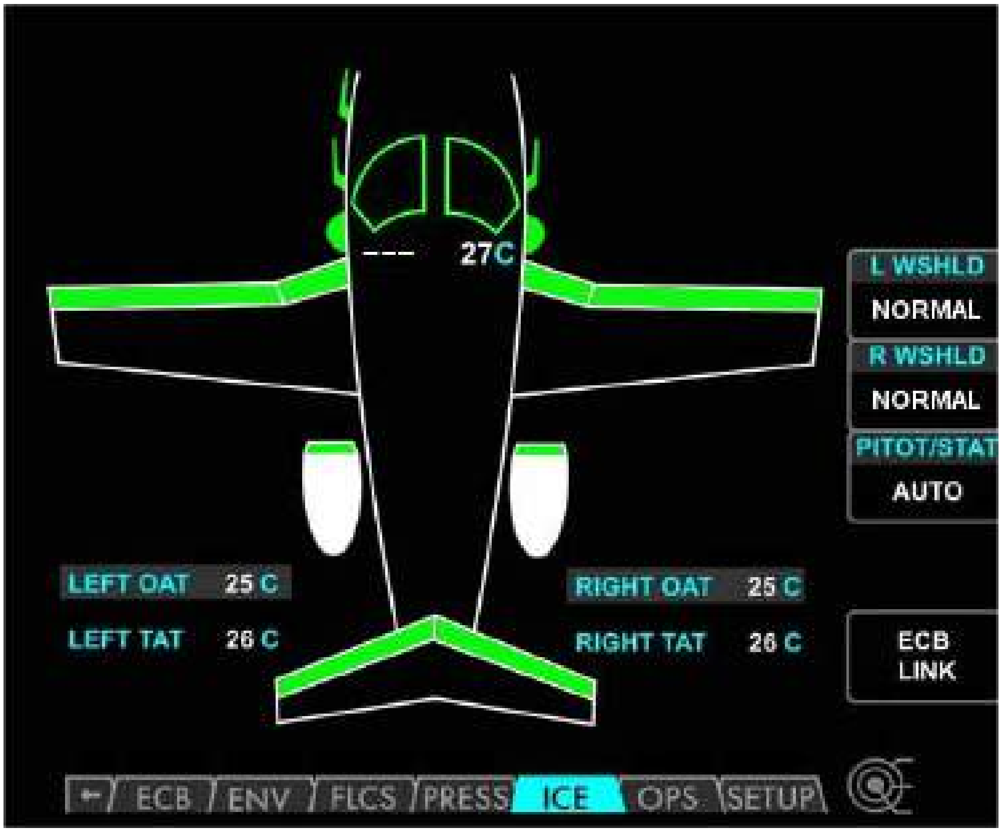

Figure 5-13. Windshield Heat Sensor Fault

5.7.7 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 (On the Ground Only). The heaters may still be operable.

5.8 Crew Alerting System Messages

Table 5-1. Ice Protection CAS Messages

Message	Condition	Category
L WSHLD OVHT	The left windshield is overheating.	Warning
R WSHLD OVHT	The right windshield is overheating.	Warning
L (R) ENG A/ICE FAIL	Engine anti-ice failed	Caution
L (R) PITOT HEAT FAIL	Pitot/AOA Probe heat failure	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 de-ice malfunction detected	Caution
L(R) ENG A/ICE VLV FAULT	Engine anti-ice valve (PRSOV) 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.	Advisory
WING DEICE MON FAULT	Wing de-ice pressure sensor malfunction (ground only)	Advisory
ENG A/ICE ON	Engine anti-ice on	Status
ENG/WING ICE PROT ON	Engine anti-ice and wing de-ice on	Status
WSHLD HEAT OFF	Windshield heat manually selected off.	Status
ICING STALL PROT	Stall speed Ice mode enabled	Status

5.9 Ice Protection Review Questions

1. 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.

2. 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

3. 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. Only in the air to prevent cowl overheating
d. Both A and B

4. On the ICE protection synoptic, what does an amber outline/fill indicate?

5. 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.

6. How is automatic probe and port heat activated?

7. How is probe and port heat manually activated?

8. 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 de-ice manifold
d. Engine bleed air from the outboard bleed air port on each engine

9. 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

Fuel

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6.1 General

Eclipse 550 wings have a "wet-wing" design to contain fuel. Each wing has two tanks:

- a wing tank that includes the outer portion of the wing and tip tank, and
- a sump tank making up the inner portion of the wing.

Fuel flows from the wing tanks to the sump tanks by gravity aided by ejector transfer pumps. Normally, each engine receives fuel from the corresponding wing tank via ejector boost pumps and/or an electrical pump, but fuel from either wing can supply both engines through a cross feed valve.

6.2 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 automatic fuel crossfeed
3. Monitoring fuel temperature and pressure
4. Controlling fuel shutoff valves and electric fuel pumps

The ACS monitors inputs from the following sensors:

- Fuel Sump Temperature
- ENG Fuel Temperature
- Fuel level (Capacitance) probes
- Low Fuel (Optical) probes
- Fuel Density Probe
- Fuel Pressure
- Fuel shutoff Valve position

Based on these inputs, the ACS 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 report directly to the right ACS, and sensors and components on the left side reports directly to the left ACS.

The pilot has direct fuel system control through the FUEL synoptic on the MFD. The pilot 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).

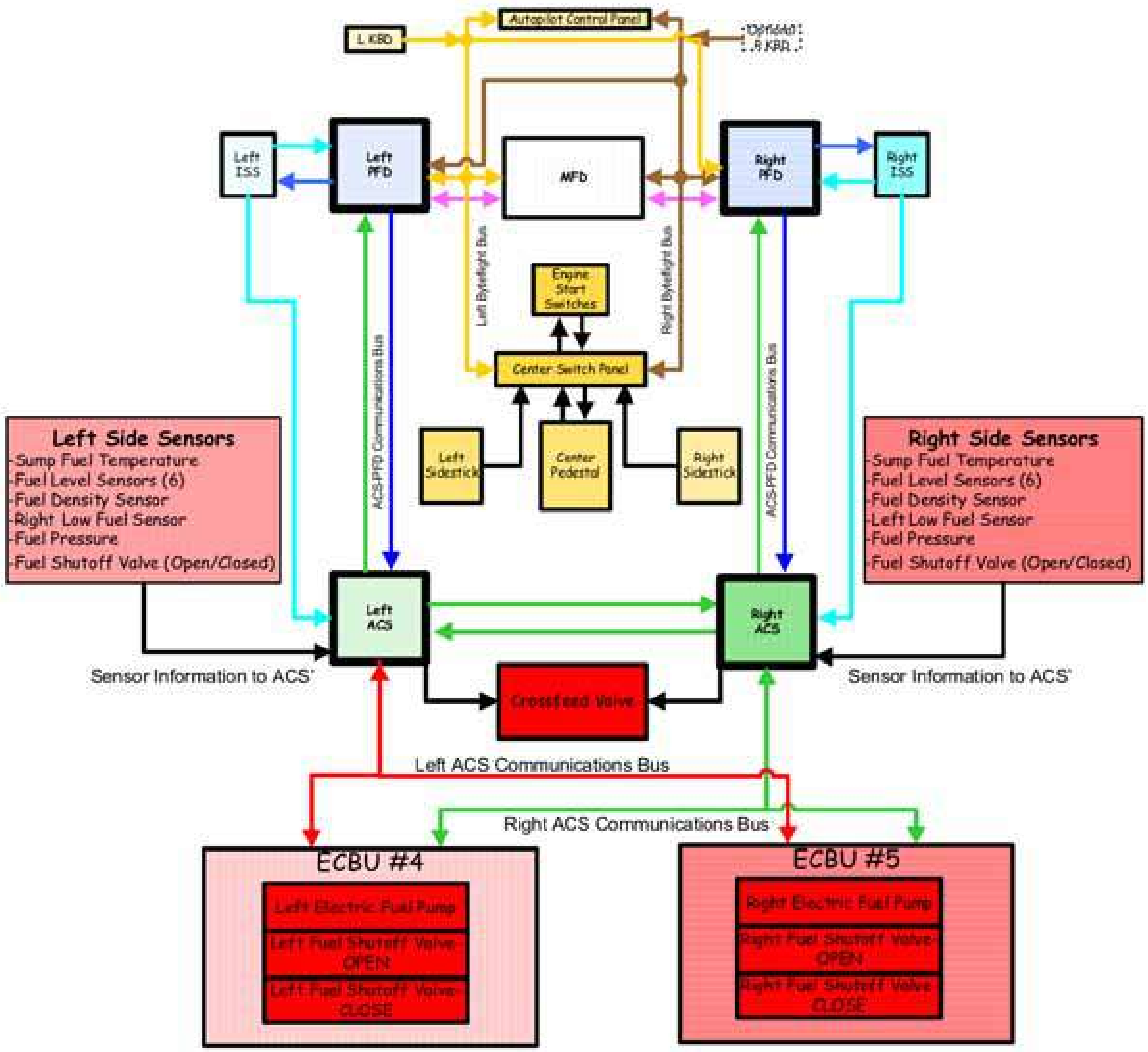

Figure 6-1. Fuel – ACS Interface

6.3 Limitations and Specifications

6.3.1 Approved Fuel Grades

Jet A/A1, JP-8.

6.3.2 Fuel Capacities

Total fuel capacity .... 1,722 lbs, 254 US gal

Total usable fuel.. 1,698 lbs, 251 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 sump)

NOTES:

- Usable fuel is available during all Normal Category maneuvers.
- Fuel weights are calculated at 15°C. 1 US gal = 6.77 lbs.
- Un-coordinated maneuvers including sideslips/skids are limited to 45 seconds in duration.
- The MFD displays the actual fuel quantity. The actual quantity may exceed the total capacity of 1698 lbs or the display mark of 1680 lbs. due to fuel temperature variations.

6.3.3 Fuel Additives

Fuel System Icing Inhibitors (FSII) (also known as Prist or additive) are required for all operations. FSII mixed in a concentration of 0.10% to 0.15% by volume per the manufacturer’s instructions, shall meet:

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

NOTE:
JP-8 already contains the required anti-icing additive so no additional additive should be used.

6.3.4 Fuel Sump Temperature

Maximum fuel sump temperature for Takeoff ....51°C (124°F)

NOTE:
This is temperature in the sump tank, as observed on the FUEL page. Fuel temperature limitations for the engines as observed on the ENG synoptic are:

Table 6-1. Engine Fuel Limitations

OPERATING CONDITION	TIME LIMIT	ENGINE FUEL TEMP ºC MIN	ENGINE FUEL TEMP ºC MAX
START	N/A	-40	121
GROUND IDLE	Continuous	-40	121
FLIGHT IDLE	Continuous	18[a]	121
TAKEOFF	5 minutes	18	121
APR	10 minutes	18	121
MAXIMUM CONTINUOUS	Continuous	18[a]	121
(a) Minimum fuel temperature limit is not applicable to ground operation.			

6.4 Controls and Indicators

6.4.1 MFD Fuel Display

Figure 6-2. 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 band indicating less than 280 pounds of total fuel remaining.

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.

NOTE:
Actual full tank indication in pounds varies with fuel temperature. Cold Fuel fills the same volume as warm fuel, but cold fuel is more dense and therefore heavier.

Figure 6-3. PFD Fuel Display

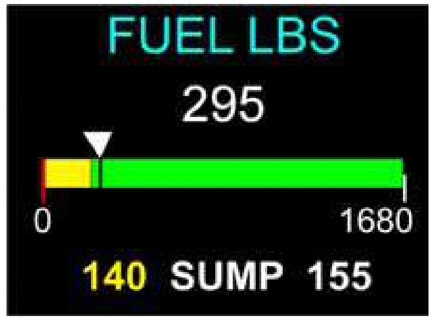

Figure 6-4. Sump Tank Quantity Display

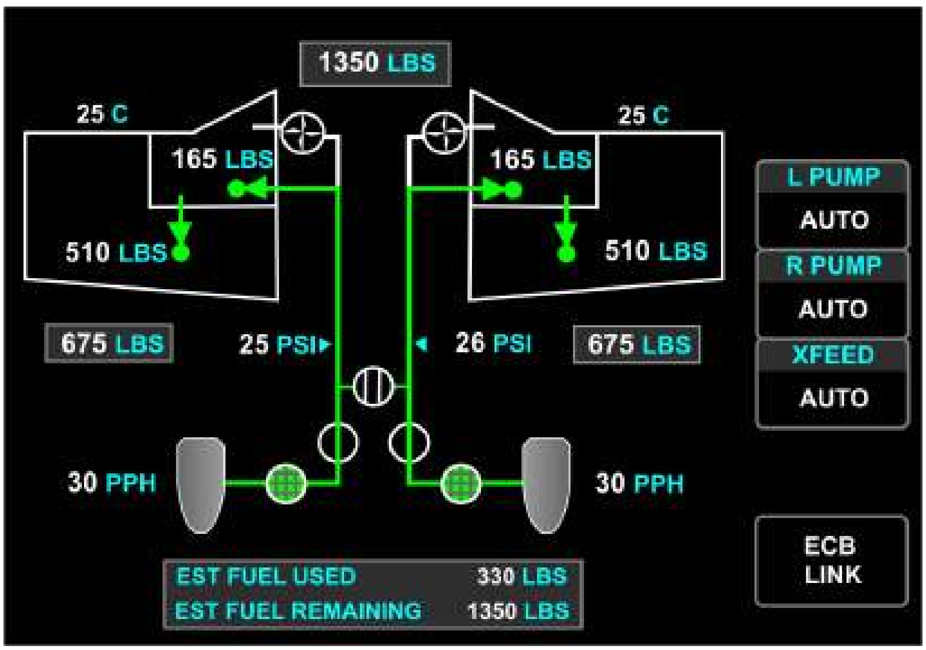

Figure 6-5. Fuel Synoptic – Normal

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 (XFEED) 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

6.4.1.1 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 pounds and red when total fuel quantity is less than 210 pounds.

Wing and sump tank quantity digits turn amber when a sump tank quantity is 140 pounds or less. When sump quantity is below 105 pounds, 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
R PUMP.. AUTO/ON
XFEED.. AUTO/ L>R / R>L/ OFF

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

6.4.1.2 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, then the estimated fuel used and estimated fuel remaining are calculated using fuel flow.

Other than the fuel snap shot taken at engine start, the 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 be an indication of an issue with capacitance probe calibration, probe failure, or an indication of a fuel leak.

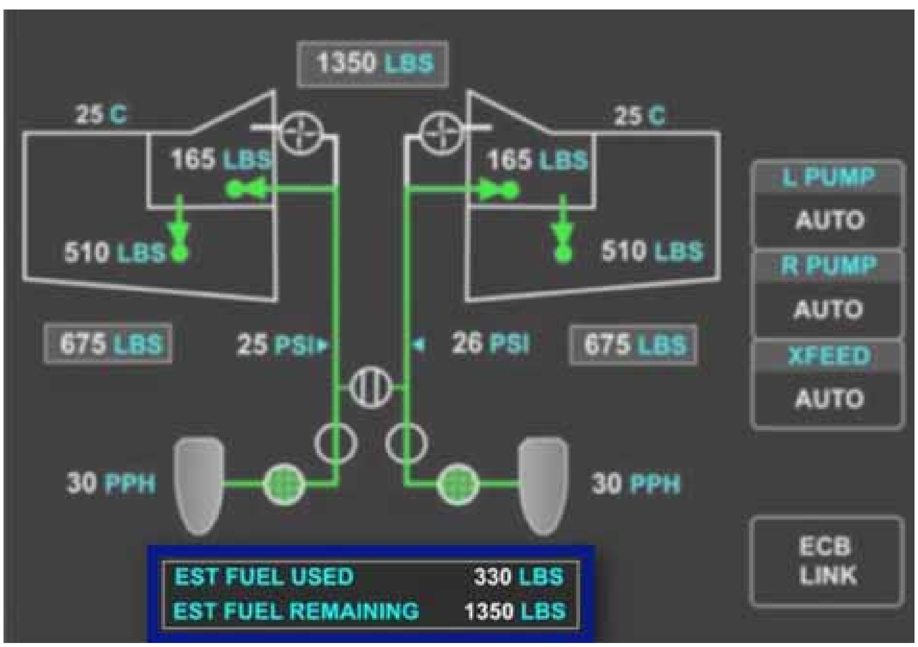

Figure 6-6. Estimated Fuel Used and Estimated Fuel Remaining Display

6.5 System Description

6.5.1 Fuel Tanks

Fuel is contained within each wing in a "wet wing" design. Each wing has 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 through flapper (check) valves, aided by ejector (motive flow) transfer pumps.

Figure 6-7. Flapper Valves

6.5.2 Fuel Pumps

There are ten fuel pumps on the airplane as follows:

- 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)

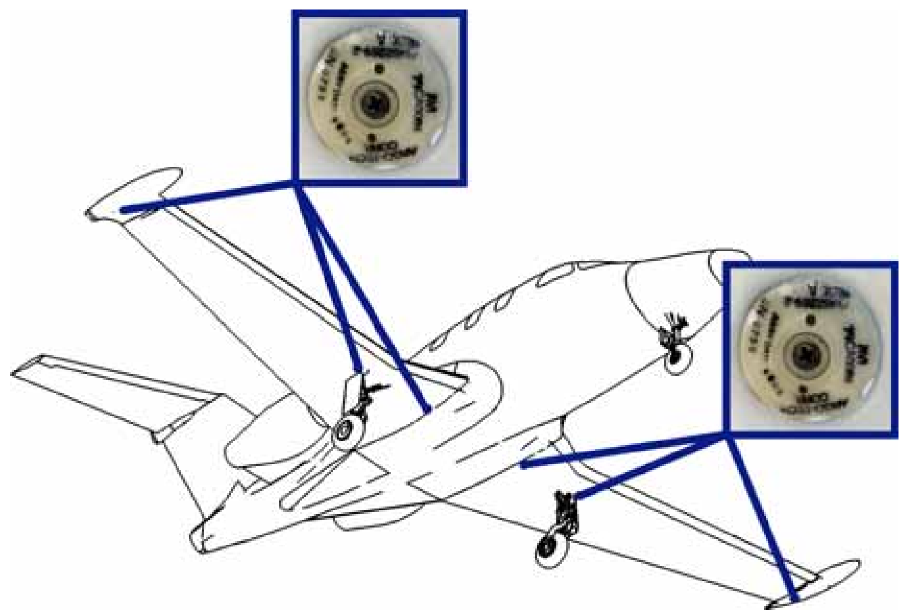

Figure 6-8. Fuel Sump Locations

6.5.3 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 motive flow type which 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.

6.5.4 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 in order to keep the sump tank full whenever the associated engine is running. The ejector transfer pumps are a motive flow 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 pounds.

6.5.5 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:
Detection of low fuel pressure (below 15 psi) 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 pounds or less
5. Low Fuel Level sensor failure

Manual control of the electric fuel pumps is available via two line-select 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.

6.5.6 Engine Fuel Pumps

Two engine-driven fuel pumps for each engine are located in the FMU. 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 on-side sump tank as return fuel. Return fuel does not cross feed.

6.5.7 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. If this occurs, a L(R) FUEL FILTER advisory message appears, alerting the pilot of possible fuel contamination. If this bypass switch fails, a L(R) FUEL BYPASS FAULT advisory appears on the ground only. Flight with a failed bypass switch is prohibited.

6.5.8 Fuel Valves

6.5.8.1 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. The pilot can override the crossfeed valve 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. The ACS monitors the crossfeed valve by monitoring the fuel pressure on both sides of the fuel system. If the crossfeed valve fails or does not reach its commanded position, the left and right side pressures will not equalize during crossfeed operations. The FUEL Synoptic will show the commanded position of the valve with an amber outline, and a XFEED VLV FAIL advisory message appears. Fuel crossfeed may not be available.

6.5.8.2 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. If electrical power is lost, a fuel shutoff valve will stay in the last commanded position, and a L(R) FUEL SOV FAIL advisory message appears.

6.5.8.3 FUEL HEAT

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

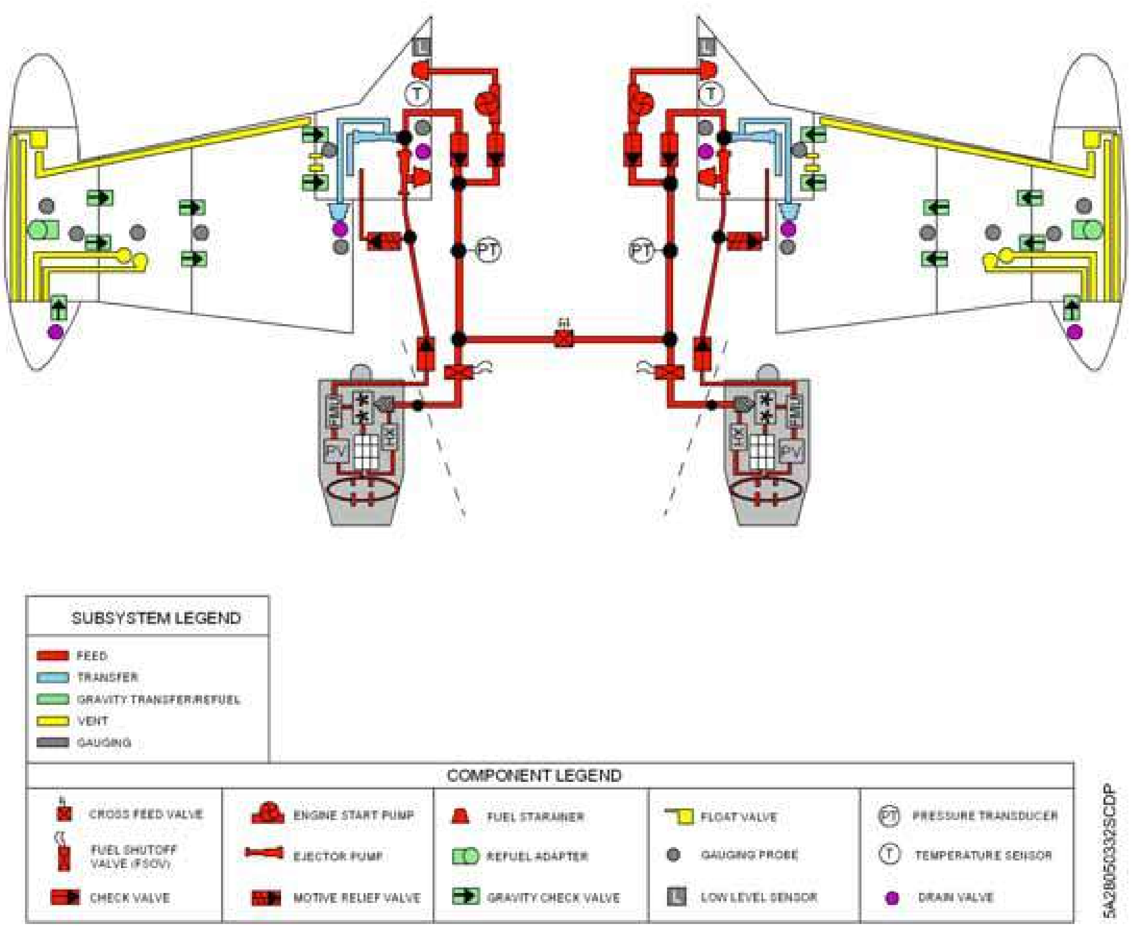

Figure 6-9. Fuel System Schematic

6.5.9 Fuel Temperature Sensor

A temperature sensor located within each sump tank measures sump tank fuel temperature. See Figure 6-10. If the fuel temperature in a sump tank reaches 66°C (150°F), a HOT FUEL caution message appears, and the sump temperature information turns amber. If the fuel temperature in a sump tank reaches 77°C (170°F), a HOT FUEL warning message appears, and the sump temperature information turns red.

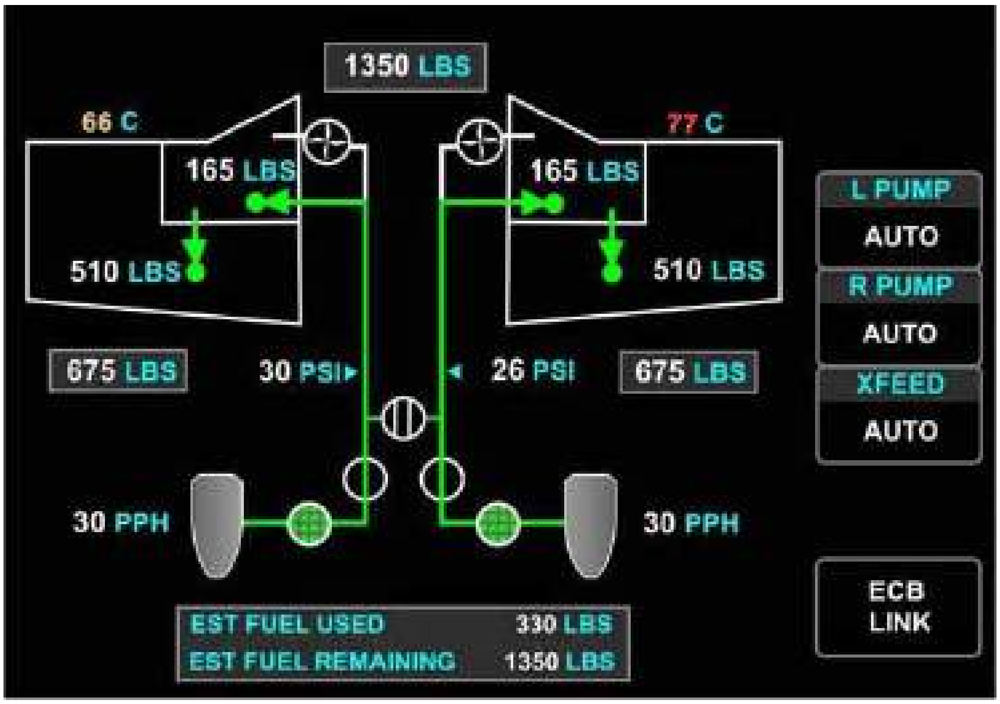

Figure 6-10. FUEL Synoptic – Fuel Hot Caution and Warning

Should fuel temperature become unavailable, red triple dashes (see Figure 6-11) will be displayed.

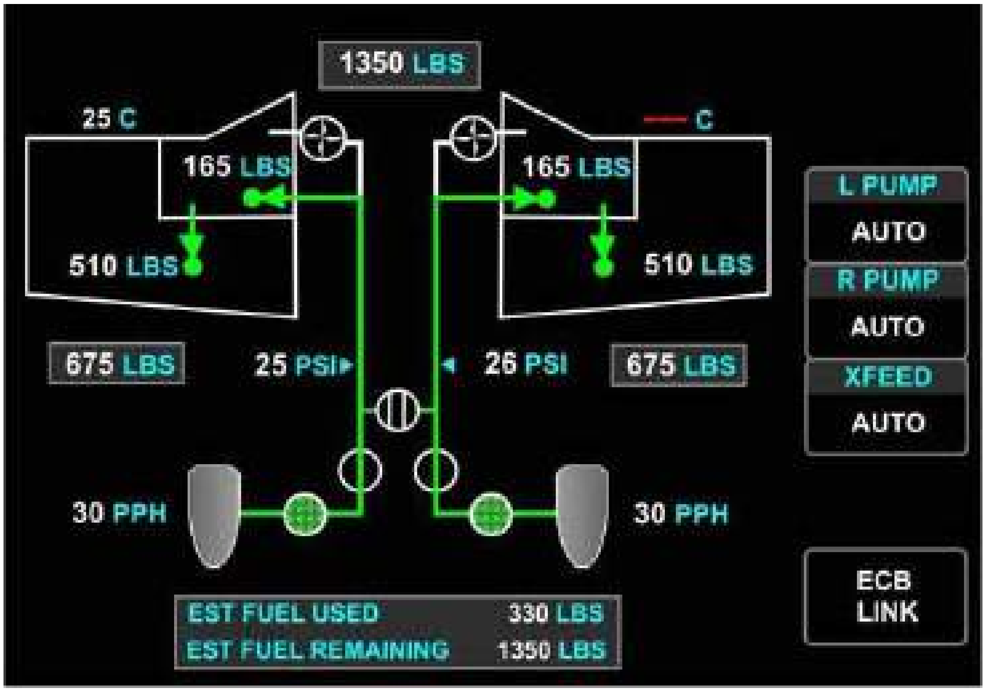

Figure 6-11. FUEL Synoptic – Temperature Sensor Failure

6.5.10 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.

Because the return fuel has been heated by the fuel/oil heat exchanger in the engine, the return fuel warms the fuel tank temperature.

6.5.11 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, which calculates the fuel quantity in pounds. 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 degrees Fahrenheit.

The gauging system adjusts fuel quantity based on aircraft pitch and indicates zero with zero usable fuel. The gauging is accurate within ± 2% with zero pitch.

On the ground, the inboard gauging probes also determine the presence of aviation gasoline (AVGAS). The ACS detects the presence of AVGAS by comparing the fuel dielectric property with standard dielectric 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 usable fuel, the optical sensor in that tank triggers an 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 are monitored by the opposite side ACS.

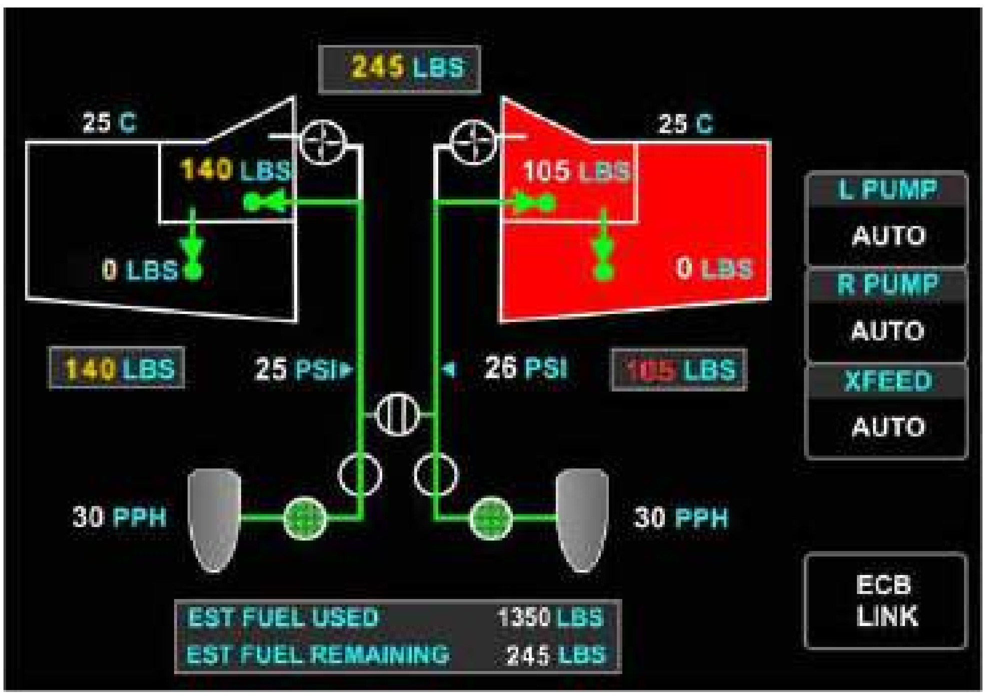

Figure 6-12. FUEL Synoptic – Low Fuel Caution and Warning

In the event the most inboard (Low Fuel Optical Sensor) sump probe is not completely submerged in fuel, the electric fuel pump automatically turns on. If this probe fails, the electric fuel pump turns on 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.

If a capacitance probe fails, a FUEL GAUGING FAULT advisory message appears and white FUEL GAUGING FAULT text appears above the affected white wing outline on the fuel synoptic.

NOTE:
Automatic fuel balancing is unavailable.

6.5.12 Vent System

Each wing has an independent vent system with dual paths for venting in and out. Two overboard vent exits on the bottom of each wing near the tip tank 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 in order to reduce the amount of splash-back during fueling.

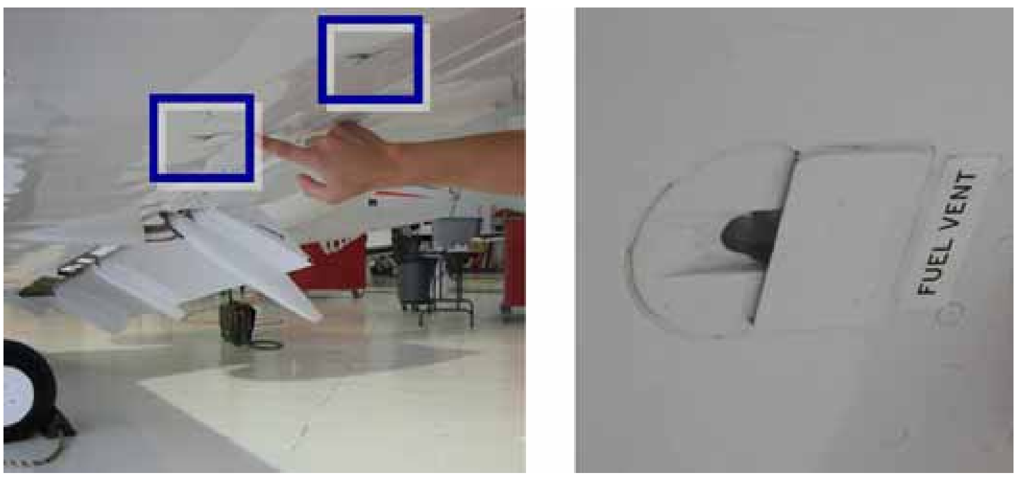

Figure 6-13. Vents

There is a vent space in the aft section of each tip tank that prevents 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 tip tank in order to allow equalization of tank pressure during climb.

Two vent lines connect the tip tank vent bay to overboard vents on the underside of each wing, allowing proper ventilation of the vent bay 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.

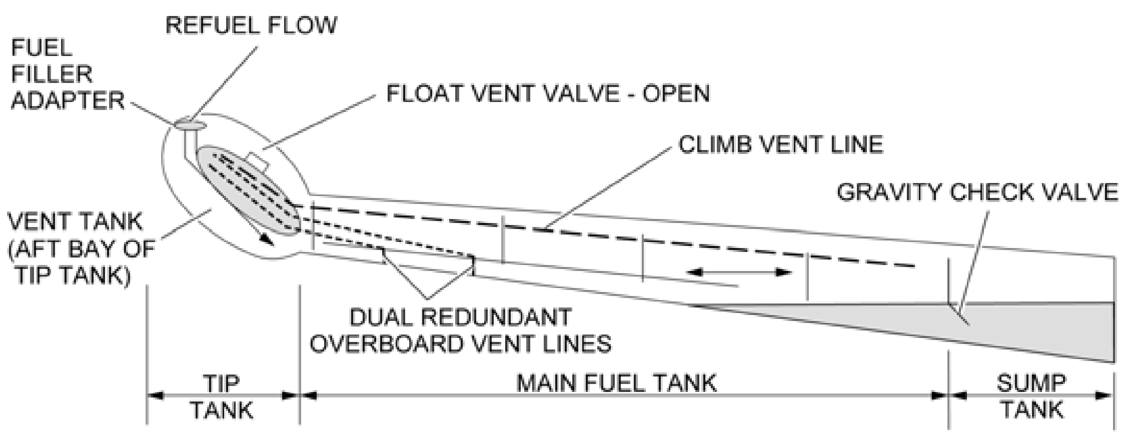

Figure 6-14. Fuel Venting System

6.5.13 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 falls below 15 psi, an L(R) FUEL PRESS LOW warning message appears; the fuel pressure digits turn red; and the corresponding electric fuel pump automatically activates. If fuel pressure information becomes unavailable, an L(R) FUEL PRESS FAULT advisory appears on the ground only, and white triple dashes will be displayed.

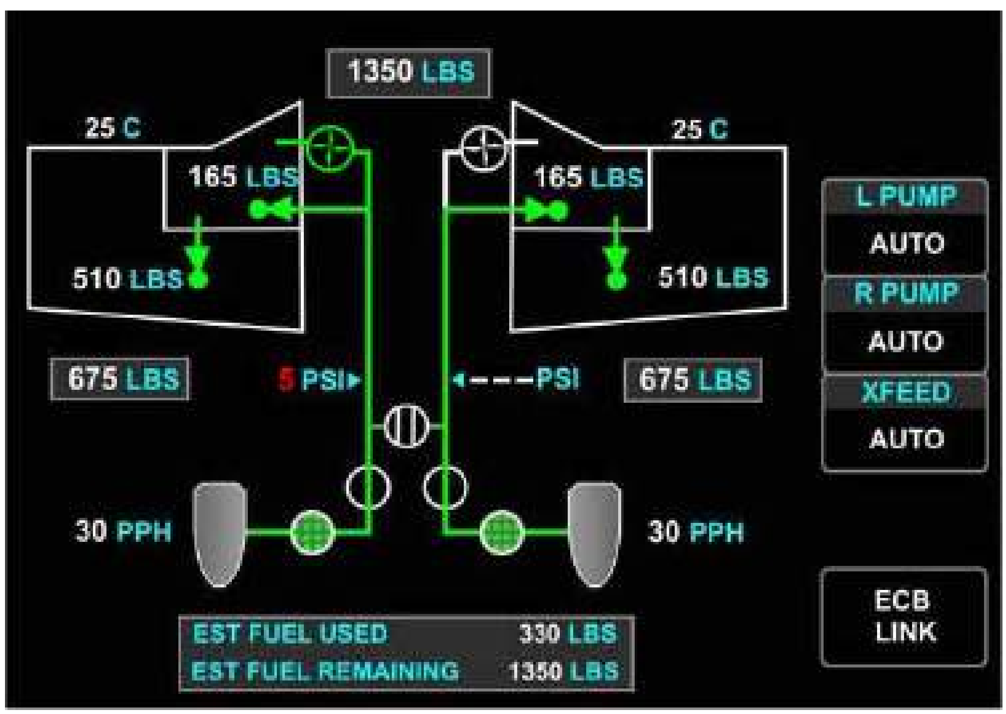

Figure 6-15. Fuel Synoptic – Low Fuel Pressure and Pressure Sensor Fault

6.5.14 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 ten 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.

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. Manual fuel crossfeed will not shut off automatically, and must be managed by the pilot.

6.6 Normal Operations

6.6.1 Fueling

Fueling is accomplished through over-wing fuel ports at each tip tank shown in Figure 6-16. 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 6-16. 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.

6.7 Abnormal Procedures

6.7.1 Automatic Fuel Balance Failure

If a fuel imbalance is not corrected automatically when a fuel imbalance exceeds 65 pounds, 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.

If automatic balancing continues 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. See Figure 6-17. 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.

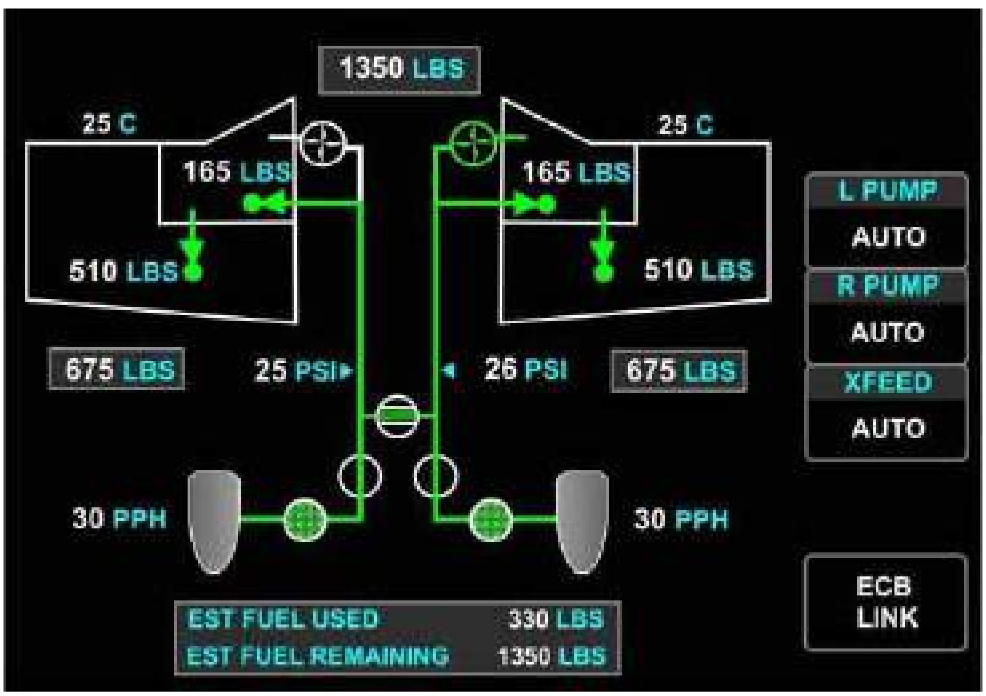

Figure 6-17. Fuel Synoptic – Fuel Crossfeed

6.8 Crew Alerting System Messages

Table 6-2. Fuel CAS Messages

Message	Condition	Category
AVGAS DETECTED	AVGAS mixture is 80% or greater (ground only).	Warning
L(R) FUEL PRESS LOW	Fuel pressure is 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 is 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 is between 66°C (150°F) and 77°C (170°F).	Caution
L(R) FUEL UNUSABLE	Failure of internal wing fuel transfer and/or trapped fuel outboard.	Caution
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.	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 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

6.9 Fuel Review Question

1. **What are the approved fuel grades for the Eclipse 550?**
   a. JET A/A1
   b. JP-8
   c. Any kind of AVGAS
   d. Both A and B

2. **What is the maximum allowable fuel imbalance on the Eclipse 550?**
   a. 12 US gallons
   b. 50 pounds
   c. 50 US gallons
   d. 65 pounds

3. **Describe how fuel is balanced on the Eclipse 550.**

4. **What is the purpose of "motive" flow fuel in the Eclipse 550 fuel system, and where does the motive flow fuel originate?**

5. **List four conditions that will cause the electric fuel pump to automatically activate:**
   a.
   b.
   c.
   d.

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 is displayed when fuel quantity in the sump tank drops below:**
   a. 140 pounds
   b. 155 US gallons
   c. 150 pounds
   d. 105 pounds

8. A "L or R FUEL QTY LOW" warning message is triggered at _____ pounds 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. By comparing EST FUEL REMAINING vs. total fuel quantity on the fuel synoptic
c. An AUTO BALANCE FAIL caution message appears
d. Both B and 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 and C
e. All of the above

11. What is the total fuel quantity and usable fuel quantity for the Eclipse 550?

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

13. How is fuel balanced on the Eclipse 550?

a. The pilot manually switches a fuel selector valve.

b. The ACS automatically balances fuel via the crossfeed valve and by turning on an electric fuel pump on the heavy side.

c. Both A and B

d. The FADEC system reduces 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. They contain no moving parts and are a venturi-type fuel pump.
c. They are mechanical pumps that 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 550?

a. Engine oil-fuel heat exchangers 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 pounds
b. 155 US gallons
c. 150 pounds
d. 105 pounds

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Engines and Fire Protection

7

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Engines and Fire Protection

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7.1 General

Two Pratt & Whitney PW-610F-A engines, each producing 900 pounds of takeoff thrust, are aft-mounted on the airplane. See Figure 7-1. The engine is a two-spool (N1 and N2), turbofan engine, with a full length annular bypass duct.

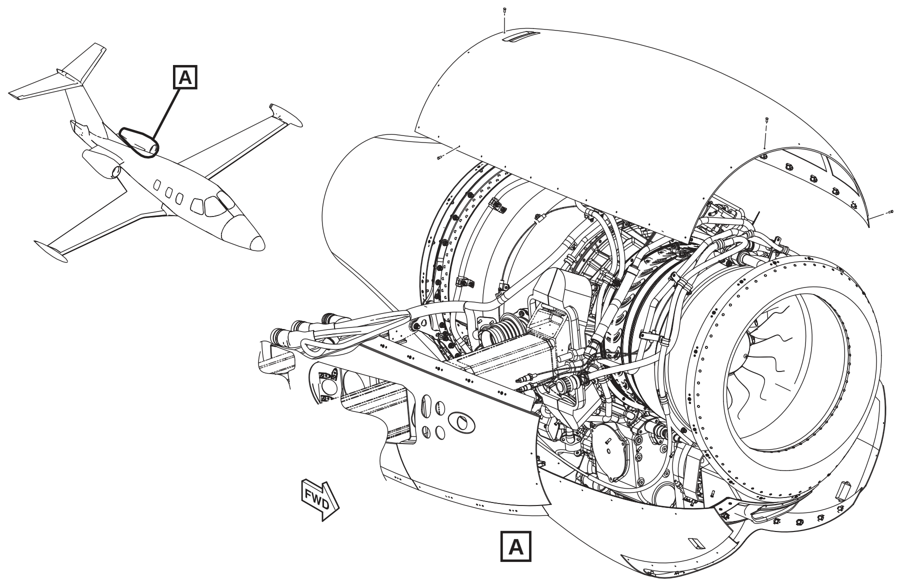

Figure 7-1. PW 610F – A Engine

The blades and guide vanes are air foils within a jet engine, they are classified as either a compressor or a turbine. Compressors are using rotational energy to create air pressure (e.g. a hair dryer), and Turbines use air pressure to create rotational energy (e.g. windmill). Compressors and Turbines are also categorized according to the type of flow. When the flow is parallel to the axis of rotation, they are called axial flow, and when flow is perpendicular to the axis of rotation, they are referred to as centrifugal flow. There is also a third category, called mixed flow, where both centrifugal and axial flow velocity components are present. Compressors are found in the cold section of the engine upstream of the combustion liner, and turbines are found in the hot section of the engine downstream of the combustion liner. Each Compressor or Turbine stage each contains a rotor (rotating blades) and a stator (stationary blades or guide vanes). Rotors rotate to either create pressure and air velocity (Compressors) or extract energy in order to create rotational velocity (Turbine). Stators act as guides in order to smooth and direct the airflow to the next stage.

In the PW 610F a concentric shaft system supports the low pressure (N1) and high pressure (N2) rotors. The inner (N1) shaft supports the Low Pressure compressor (fan), which is driven by a single-stage Low Pressure turbine. The outer (N2) shaft system is mechanically independent of the N1 shaft, and counter rotates to reduce the effects of torque. The N2 shaft supports a single mixed flow stage and one centrifugal stage High Pressure compressor driven by a single-stage High Pressure turbine. Air enters the engine through the fan case and is accelerated rearwards by the fan. The fan itself is machined out of a single piece of titanium, and is referred to as an Integrally-Bladed Rotor (IBR) Fan. Concentric dividing ducts split the air into bypass and core flow streams.

Fan bypass air flows into the bypass duct before exiting with the core air flow, through a common exhaust mixer. Bypass air does not enter the combustion section of the engine and is used as thrust much like air from a propeller. The Fan Air Control Valve extracts the bypass ducts relatively cool pressurized air in order to cool the pylon air to air heat exchanger during ground operations. Additionally, bypass air in the exhaust section assists in centering the hot gases in order to keep the composite tail cone cool.

The core air flows into the High Pressure (N2) compressor. A bleed valve is provided to prevent surge in between the mixed flow compressor and the centrifugal compressor due to incongruent airflow at low engine speeds. At low engine speeds the bleed valves discharges core air into the bypass duct. At high engine speeds the bleed valve is closed creating more efficient thrust. A supply of core air is taken from the centrifugal impeller for engine cooling and sealing purposes, as well as P3 inboard and outboard Bleed Valves for anti/de-ice, cabin pressurization, and heating.

Core air flow exits the centrifugal compressor through diffuser pipes that convert velocity to static pressure. The diffused air then passes to the reverse flow annular combustion liner. The combustion liner has varying sized perforations, which allow entry of the compressed air at the evenly and at the correct angle to mix with the fuel and form a combustible air/fuel mixture.

Fuel is injected into the combustion chamber through a fuel manifold and floating nozzle assembly with 7 primary and 6 secondary fuel nozzles.

During starting, and when CONT IGN (Continuous Ignition) is selected the air/fuel mixture is ignited by two spark igniters which protrude into the combustion chamber liner at the 4 and 8 o'clock positions. These igniters are powered by the aircraft's 28VDC which has been passed through the ignition exciter box in order to transform the electricity into a low amp 17,000 volt spark. Once the engine is started and when CONT IGN is not selected the igniters are not powered, the temperature of the combustion liner is sufficient to ignite the air/fuel mixture.

The resultant gases expand in the combustion chamber, reverse direction and pass through a single-stage High Pressure Turbine (N2). The blades of the turbine extract the pressure from the airflow and turn it into rotational velocity of the N2 shaft, which in turn drives the high pressure compressor. At 100% the N2 shaft is rotating at 48,000 revolutions per minute. The gases then pass through a single-stage Low Pressure Turbine (N1). The blades of the low pressure turbine extract the pressure from the airflow and turn it into rotational velocity of the N1 shaft, which in turn drives the low pressure compressor (fan). At 102% the N1 shaft is rotating at 22,542 revolutions per minute.

The remainder of the hot gases exits the low pressure turbine through the exhaust case and exhaust mixer to mix with the bypass air flow, and produce thrust.

An Accessory Gear Box (AGB) on the bottom of the engine is connected to the N2 shaft through a tower shaft. The tower shaft rotates gears to drive the starter/generator, oil pumps, fuel pumps and the fuel metering unit. The AGB also incorporates an air/oil separator which exits the engine rearward through an adapter at the 6 o'clock position in the bypass duct. Oil jets, supplied with pressurized oil, provide lubrication, cooling, cleaning, and protection for the gears and bearings. Oil returns to the AGB and integral oil tank for use in circulation.

During engine start, the Starter/Generator functions as a motor turning the gears in the Accessory Gear Box, including fuel and oil pumps, and the tower shaft which is connected to the N2 Shaft. The N2 shaft is spun in order for the high pressure compressor to increase the pressure of the air coming into the combustion liner. Once a minimum amount of air flow enters the combustion liner fuel from the primary fuel nozzles are added. The spark igniters then ignite the fuel/air mixture. The resultant expanding gases spin the high pressure turbine causing the N2 shaft and high pressure compressor to speed up. The low pressure turbine further extracts the energy from the expanding gases to spin the N1 shaft and low pressure compressor (Fan). Once more air enters the combustion liner the secondary fuel nozzles disperse more fuel, and the engine further increases in ITT, N2, and N1. After the engine is running, the Starter/Generator is driven by the N2 shaft and functions as a generator to supply power to the aircraft.

The engines are controlled by two dual-channel Full Authority Digital Engine Control (FADEC) units. The FADECs using fuel flow from the fuel metering unit control the engine N1 speed and thereby the engine thrust in accordance with the position of the thrust lever angle (TLA) and the prevailing ambient conditions. The engine indicating system consists of the N1 speed sensor, the N2 speed sensor and T6 Exhaust Gas Temperature sensors. Exhaust gas temperature (T6), together with fuel temperature Total Air Temperature (TAT) and fan speed (N1) are used to calculate a value corresponding to Inter-Turbine temperature (ITT). 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 an individual thrust lever. Thrust is set by positioning the throttles either automatically by the Autothrottle System (ATS), or manually by the pilot. The engine start sequence is automatic when an engine start switch is placed to the ON/START position.

7.2 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

7.2.1 Thrust Control

The pilot controls primary thrust 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.

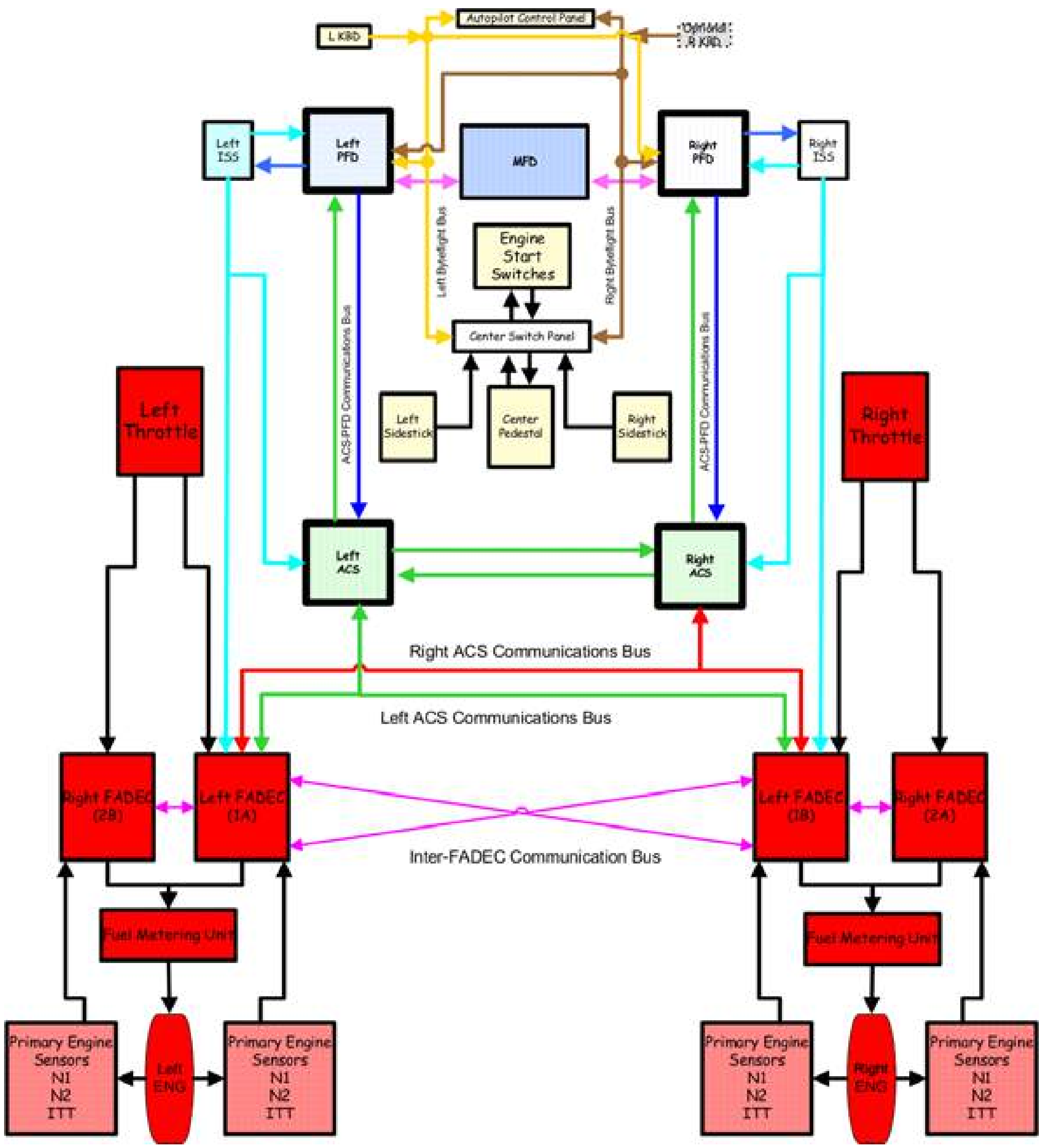

Figure 7-2. Thrust Control – ACS Interface

7.2.2 Engine Starting

The ACS provides control of the engine start and shutdown sequences based on pilot commands using the engine control panel. Pilot commands are transmitted from the engine control panel to the center switch panel. From the center switch panel, these commands are sent through the PFD to the ACSs. 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).

The ACS verifies that the system configuration is correct. If a part of the system does not reconfigure, the ACS will abort the start, and an ENG START FAIL advisory message appears.

On the ground, the FADEC will abort for:

- ITT Exceedance (Hot Start)
- No light off
- Hung Start
- N2 below Fuel On Threshold
- Loss of required input/output for the FADEC.

If the FADEC aborts a start, an ENG START ABORT caution message appears.

FADEC will not abort for:

- Lack of Oil Pressure above 15% N2
- Lack of N1 Rotation

If an engine start is aborted, either manually or automatically, the ACS reconfigures the aircraft systems back to pre-start configuration.

NOTE:
FADEC start protection is not available in-flight. Monitor engine instruments for Hot or Hung Start.

Once an 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.

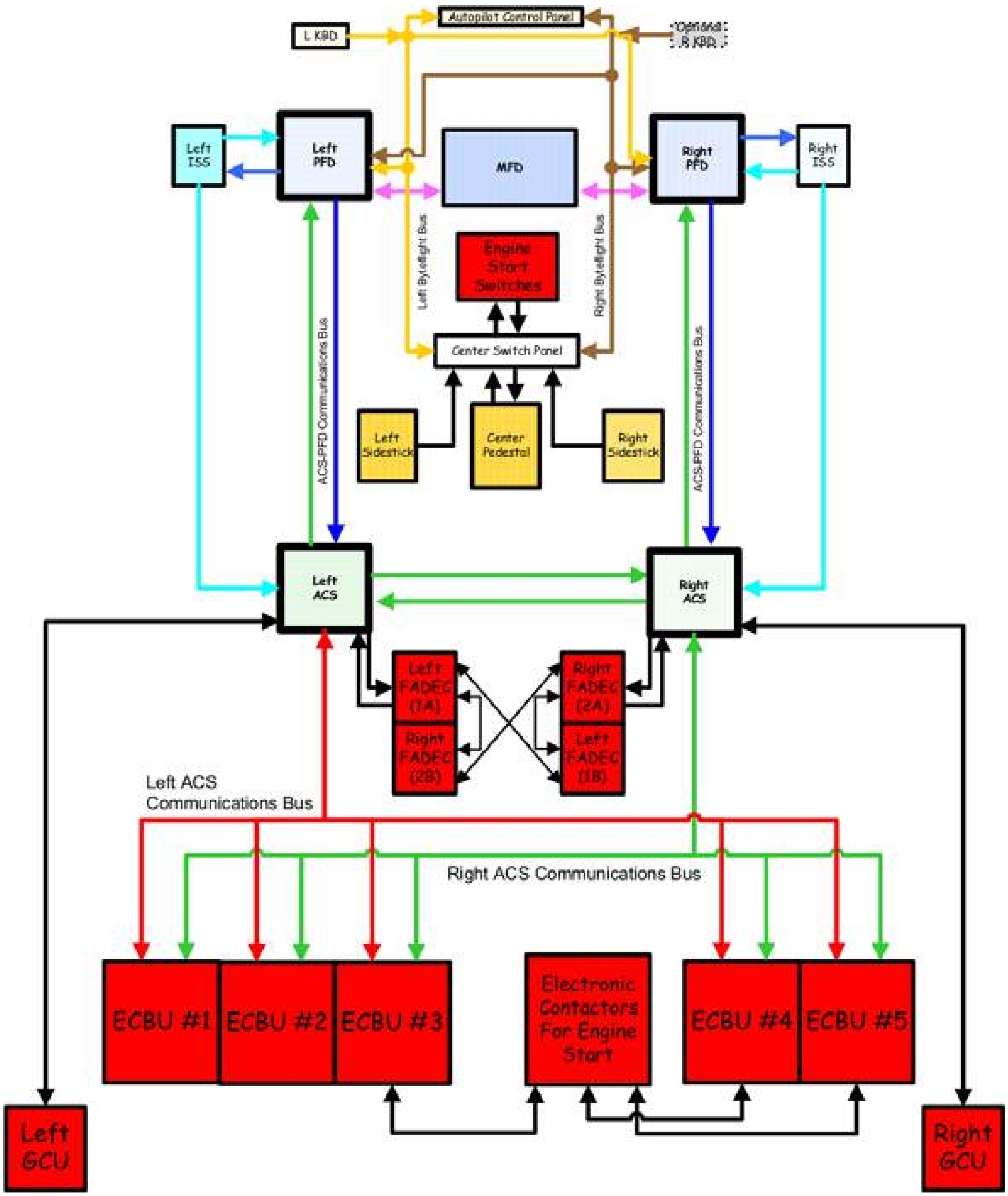

Figure 7-3. Engine Starting – ACS Interface

7.2.3 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, and 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 (IMP BYP)
- Oil filter impending bypass switch
- Oil temperature
- Oil pressure
- Fire detection

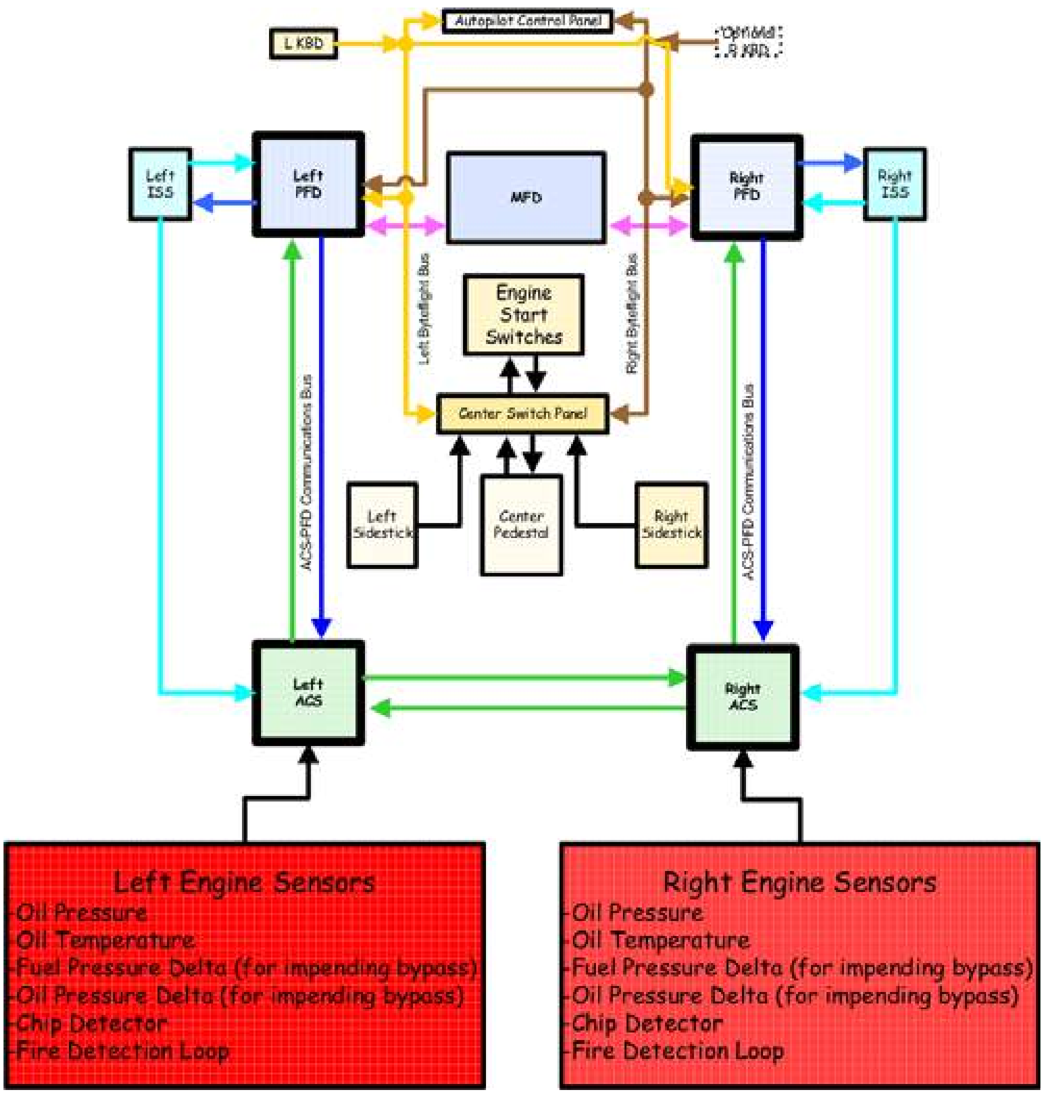

Figure 7-4. Secondary Engine Parameter – ACS Interface

7.2.4 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 ACSs 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 as well as a L(R) ENG FIRE warning and a "Left Engine Fire" or "Right Engine Fire" aural alert.

Fire suppression is provided by a single fire suppression canister in each engine pylon. The ACS controls the canister and monitors its status.

Pressing the FIRE/ARMED button once sends a signal from the Autopilot Control Panel to the Center Switch Panel, to the PFDs, and then on to the ACS to command:

1. Fuel Shutoff Valve (FSOV) Close
2. Igniters Off
3. Pressure Regulating Shut Off Valve (PRSOV) Close
4. Flow Control Valve (FCV) Close
5. Fan Air Control Valve (FACV) Close
6. Arms the Fire Extinguisher Canister (FEC)
7. 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 Extinguisher Canister (FEC); this will discharge the extinguishing agent. Once discharged, the FEC reports its status to the ACS which extinguishes the green ARMED indication from the FIRE/ARMED button, and annunciates a L(R) EXTNGR DSCHG advisory message.

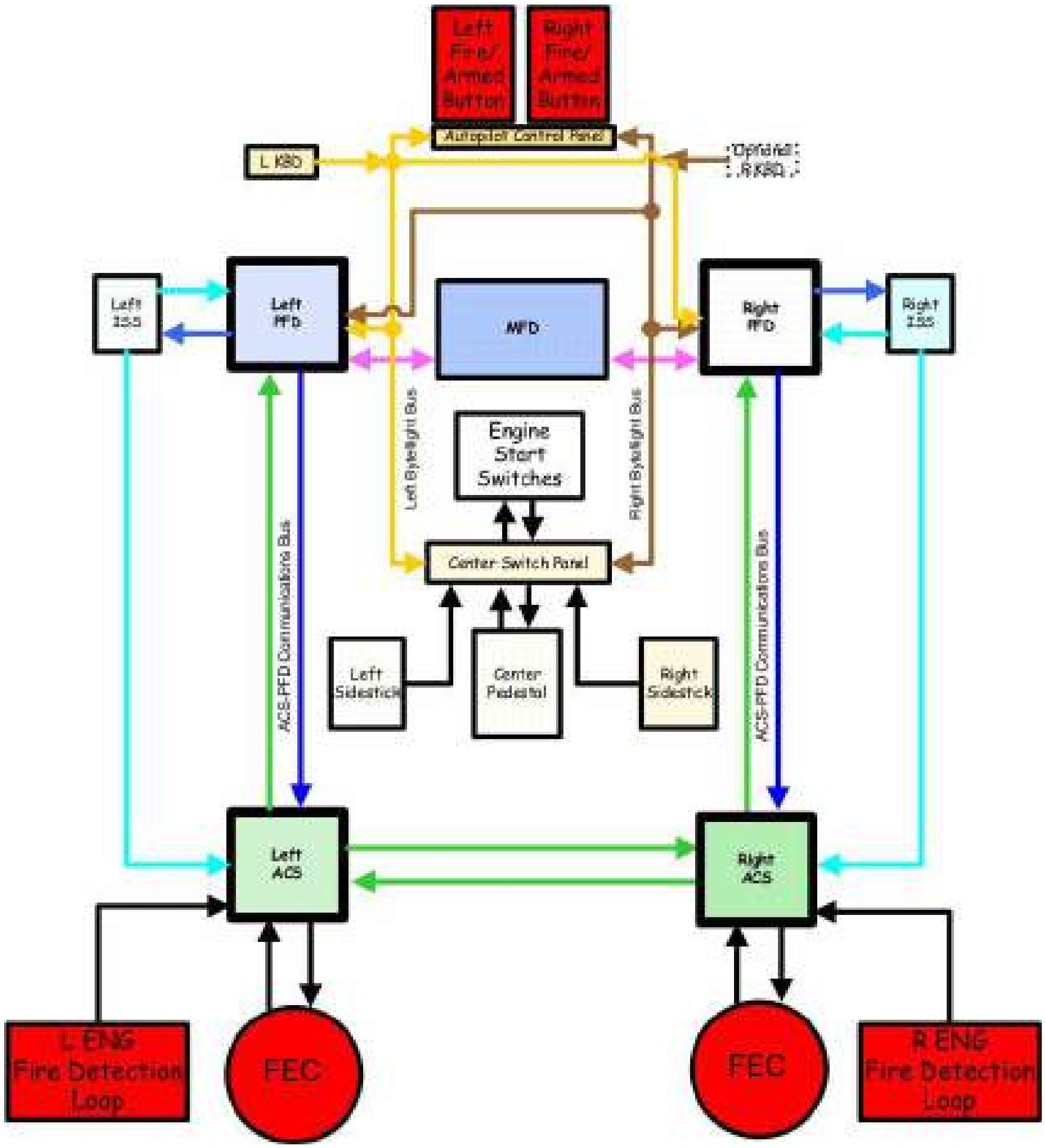

Figure 7-5. Fire Detection and Suppression – ACS Interface

7.3 Limitations and Specifications

7.3.1 Engine Operating Limitations

Table 7-1. Engine Operating Limitations

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

(a) The time limit commences when the throttle is first advanced to 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.

7.3.2 Engine Fuel Limitations

Table 7-2. Engine Fuel Limitations

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

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

NOTE:
Engine starts are not permitted at an oil temperature colder than -20 °C.

APPROVED FUEL GRADES

Jet A/A1, JP-8 (All other fuels are prohibited.)

FUEL ADDITIVES

Fuel System Icing Inhibitors (FSII) are required for all operations. FSII shall meet MIL-I-85470, MIL-I-27686, or Phillips PFA-55MB specifications and be mixed in a concentration of 0.10% to 0.15% by volume per the manufacturer’s instructions. JP-8 already contains the required anti-icing additive so no additional additive should be used.

7.3.3 Oil

Table 7-3. Engine Oil Limitations

OPERATING CONDITION	TIME LIMIT	OIL PRESS (b)	OIL TEMP -ºC	
			MIN	MAX
START	N/A	0 to 9.0[b]	-40[e]	135
GROUND IDLE	Continuous	2 to 8	-40[d][e]	135
FLIGHT IDLE	Continuous	2 to 8	20	135
TAKEOFF	5 minutes[a]	2 to 8	20	135
APR	10 minutes[a]	2 to 8	20	135
MAXIMUM CONTINUOUS	Continuous	2 to 8	20	135
TRANSIENT	90 seconds	1 to 1.9[c]	-	140
	5 minutes	8.1 to 9.0[c]	-	-

(a) The time limit commences when the throttle is first advanced to the take-off position.

(b) During engine start or motoring, oil pressure of 0.0 is only allowable below 15% N2. A positive oil pressure is required above 15% N2. Transient to 9.0 is allowed during start.

(c) Oil pressure transients are allowed to these limits at all operating conditions.

(d) Engine thrust may be increased above ground idle to warm engine oil provided oil pressure is maintained between 2 and 8.

(e) Refer to “Engine Starting Limitations” on page 7-13.

7.3.4 Oil Pressure

Negative “G” is limited to 5 seconds maximum.

NOTE:
Zero oil pressure may occur for a maximum of 15 seconds during negative "G" maneuvers.

7.3.5 Oil Grade or Specification

Only oils conforming to the specifications of MIL-L-23699 Type II Aviation Turbine Engine Oil are approved for use. The following oils conform to this specification:

- Aero Shell Turbine Oil 500 (Type II Standard)
- Aero Shell Turbine Oil 560 (Type II HTS)
- BP Turbo Oil 2380 (Type II Standard)
- BP Turbo Oil 2197 (Type II HTS)
- Castrol 5000
- Mobil Jet Oil Type II (Type II Standard)
- Mobil Jet Oil 254 (Type II HTS)
- Royco Turbine Oil 500 (Type II Standard)
- Royco Turbine Oil 560 (Type II HTS)
- TurboNycoil TN 600

7.3.6 Oil Quantity

Total oil capacity ....6 qts (5.68L)

Oil Tank Capacity (Fill, per engine)..3.60 qts (3.41L)

NOTES:

- An oil quantity check is required prior to engine start. Do not start engine with oil below minimum level on the sight glass.
- Engine Oil level is most accurate 10 minutes after shutdown.

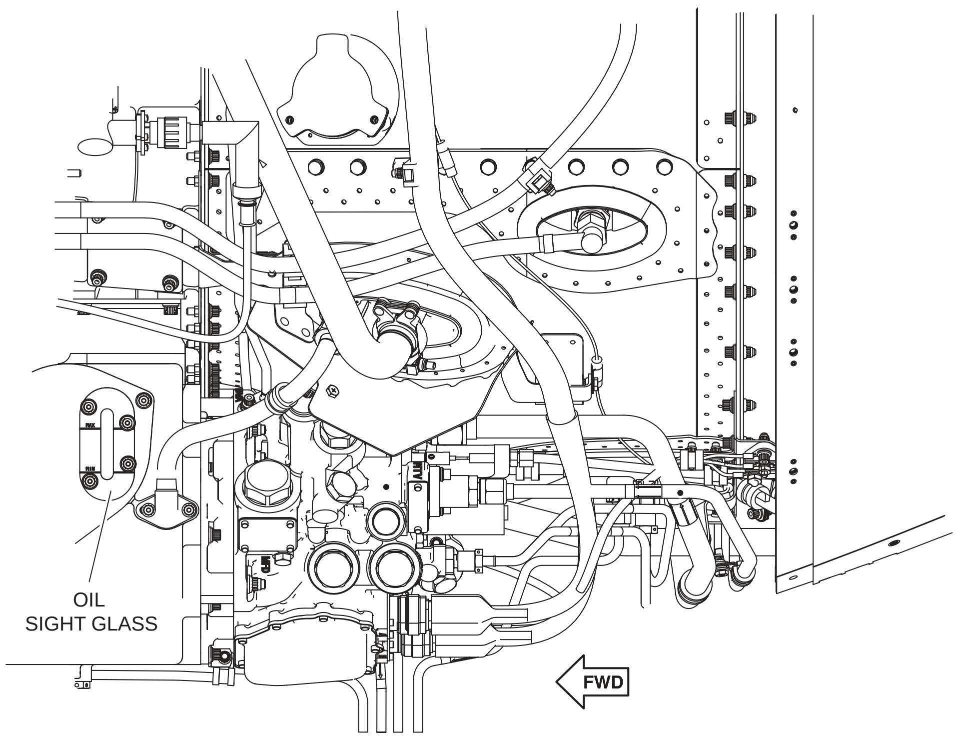

Figure 7-6. Oil Sight Glass Location

7.3.7 Engine Starting Limitations

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

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.

Minimum Battery Voltage for Engine Start .... 23 VDC

Minimum System Voltage for GPU-assisted Engine Start .... 25 VDC

7.3.8 Starter Limitations

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

Table 7-4. Starter Limitations

	Operating	Cool-Down
Cycle #1	30 seconds	1 minute
Cycle #2	30 seconds	1 minute
Cycle #3	30 seconds	30 minutes

NOTE:
Dry motoring an engine is a cycle of the starter.

7.3.9 Engine Ground Operations Wind Limitations

Maximum crosswind limit.......... 30 knots

Maximum tailwind limit.......... 25 knots

Maximum tailwind limit (N1 greater than 75%) .... 15 knots

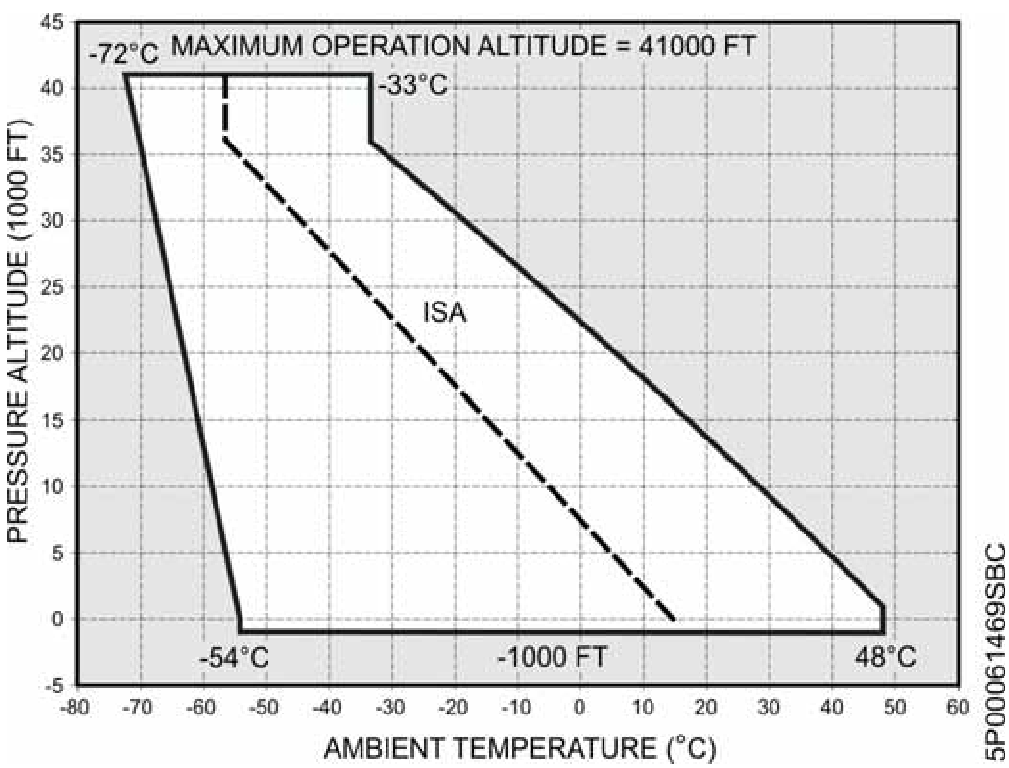

Figure 7-7. Operating Temperatures Limitations Envelope

7.3.10 Engine Operations in Icing Conditions

GROUND OPERATIONS

The engine anti-icing system must be ON (ICE PROT - ENG) when the OAT is 10°C (50°F) or below when operating on ramps, taxiways, or runways where surface snow, ice, standing water, or slush is present.

When operating the engines at idle 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.

The engine anti-icing system must be ON (ICE PROT - ENG) when the outside air temperature (OAT) on the ground and for takeoff is 10°C (50°F) or colder and visible moisture in any form is present (such as fog with visibility of one mile (1600 m) or less, rain, snow, sleet, or ice crystals).

FLIGHT OPERATIONS

The engine anti-icing system must be ON (ICE PROT - ENG) when the OAT is 10°C (50°F) or colder and visible moisture in any form is present (fog with visibility of one mile (1600 m) or less, rain, snow, sleet, or ice crystals).

7.4 Controls and Indicators

7.4.1 Engine Control Panel

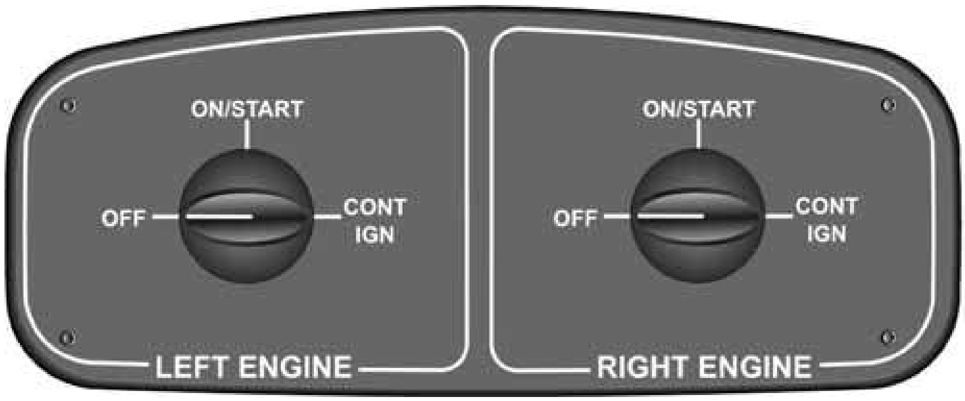

Figure 7-8. Engine Control Panel

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

OFF .... Initiates engine shutdown sequence

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

CONT IGN .... Provides continuous ignition

7.4.2 Throttle Quadrant

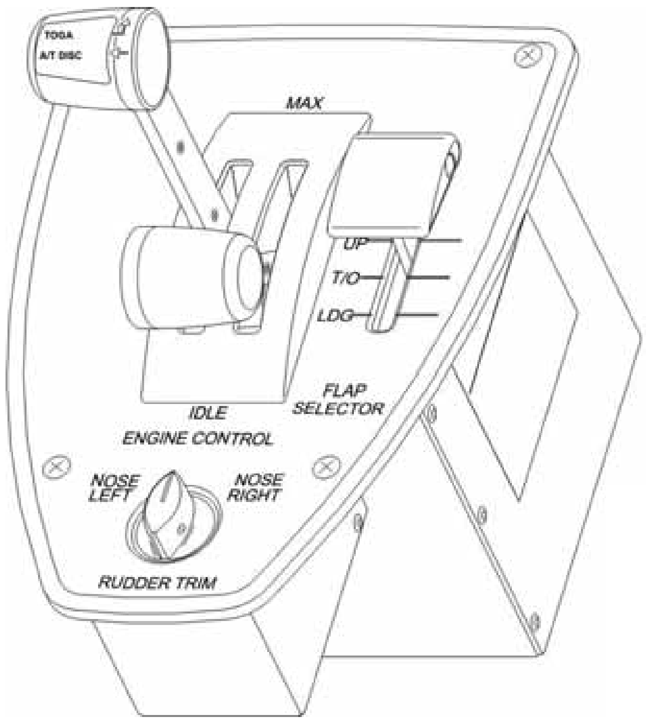

Figure 7-9. Throttle Quadrant

7.4.3 Engine Controls

Two throttles are located on the throttle quadrant. Engine Start, normal shutdown, and ignition are controlled from the engine control panel located on the ceiling directly above the throttle quadrant. Other engine functions (such as Automatic Power Reserve disarming, dry motoring and wet motoring) are controlled from line-select keys on the ENG synoptic page.

7.4.4 Continuous Ignition

Continuous ignition is turned on by moving the rotary switch on the engine control panel to the CONT IGN position. Continuous Ignition should be activated while operating in heavy rain, severe turbulence or volcanic dust.

7.4.5 Engine Instrument Display (on MFD)

Figure 7-10. 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 PRESS.

7.4.6 Engine (ENG) Synoptic

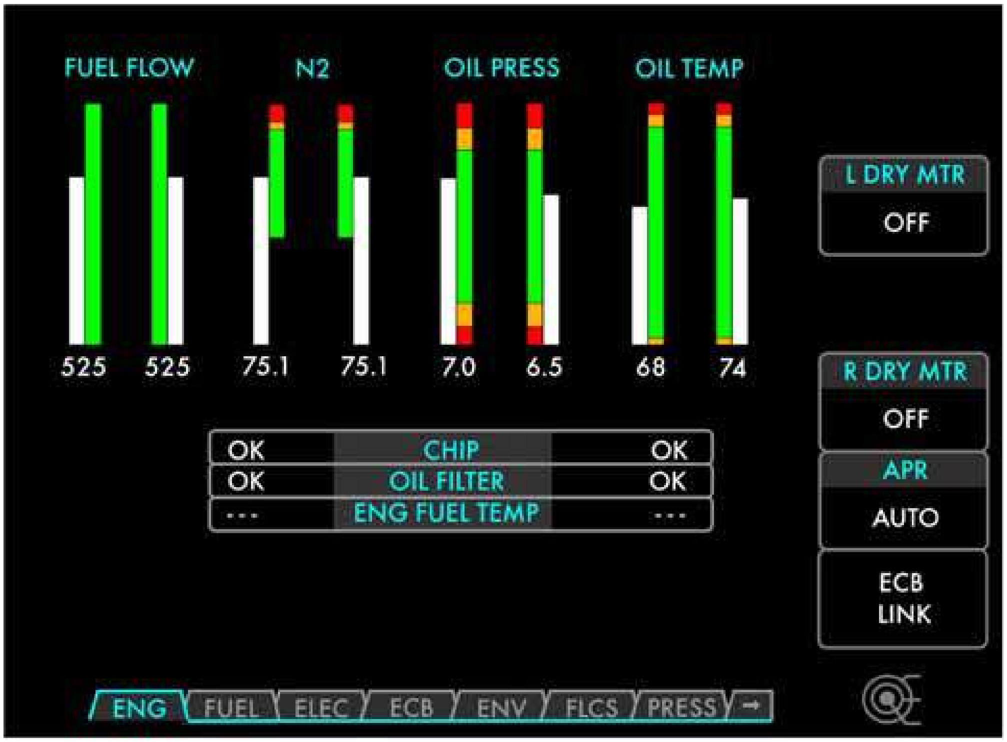

Figure 7-11. Engine (ENG) Synoptic

7.4.6.1 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)
- Engine Start Panel switch is left in ON/START following an Aborted Start

APR

- AUTO .... Automatic Power Reserve is automatically controlled
- Disarm .... Automatic Power Reserve deactivated

NOTE:
Disarming requires a confirmation line-select key selection.

ECB LINK

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

7.4.6.2 ENGINE INSTRUMENTS

Primary engine indications are continuously displayed on the upper portion of the MFD. The secondary engine indications are also displayed on the engine synoptic page.

Primary Instruments

- Indicated Turbine Temperature (ITT)....................................tape and digital value
- N1 rotor RPM ....tape and digital value
- N2 rotor RPM ....digital value
- Oil pressure..digital value
- Fuel flow..digital value

Secondary Instruments

- N2 rotor RPM ....tape and digital value
- Oil pressure..tape and digital value
- Oil temperature ....tape and digital value
- Fuel flow..tape and digital value
- ENG FUEL (Fuel Metering Unit) 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.

7.4.7 N1 RPM

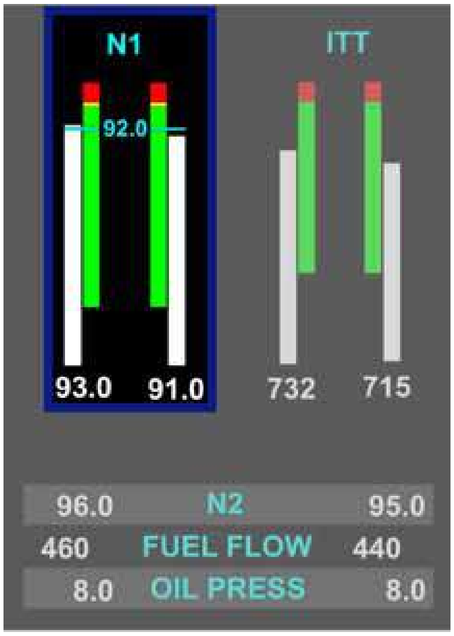

Figure 7-12. N1 Tape

See Figure 7-12. 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 21% to 102%. An amber band extends from 102% to 103%. A red band begins at the transient limit of 103%.

The digital value and moving tape are white for N1 values in the green band, in amber for N_1 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 L(R) ENG EXCEEDANCE warning message appears.

A blue bug and blue digital readout between the left and right N1 tapes displays the N1 target calculated by the ACS for the mode of flight. If the current thrust is set below Maximum Continuous Thrust (MCT), the blue bug will be set for MCT. Once Throttle Lever Angle (TLA) exceeds the MCT range, the blue bug is reset for a Takeoff (T/O) Power setting.

With the throttles advanced to the takeoff setting, the state of the APR is displayed above the N1 tapes as either APR ARMED (white) or APR ON (green). Blue T/O text also appears between the tapes near the bottom, indicating that takeoff thrust is set.

Blue MCT text appears at the lower portion of the N1 tapes when the selected N1 is equal to MCT as determined by the FADECs.

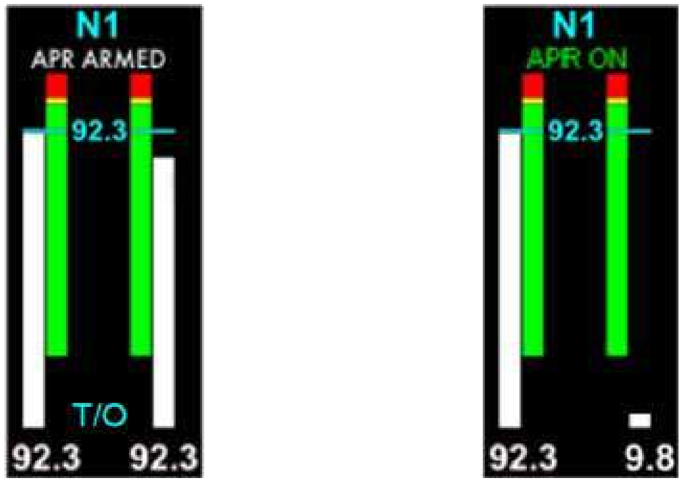

Figure 7-13. APR Indications

7.4.8 Inter Turbine Temperature (ITT)

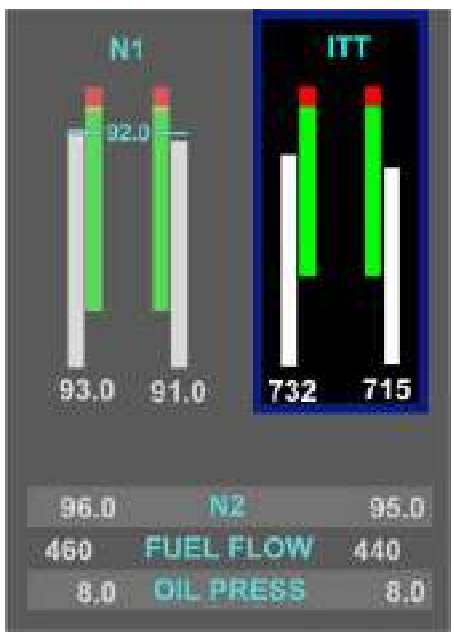

Figure 7-14. ITT Tape

See Figure 7-14. ITT is continuously displayed on the MFD with a moving tape and digital readout. The ITT tape range is 0-900°C. An adjacent tape displays ITT limits. A green band on the limit tape extends from 300°C to the maximum continuous ITT limit of either 795° or 850°C (Engine Start). In other than an Engine Start situation, an amber band will be displayed from the 795 to 850 denoting the transient ITT Limits.

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

- ITT exceeds 795°C (but not above 850°C) for 20 seconds
- ITT reaches 850°C

7.4.9 N2 RPM

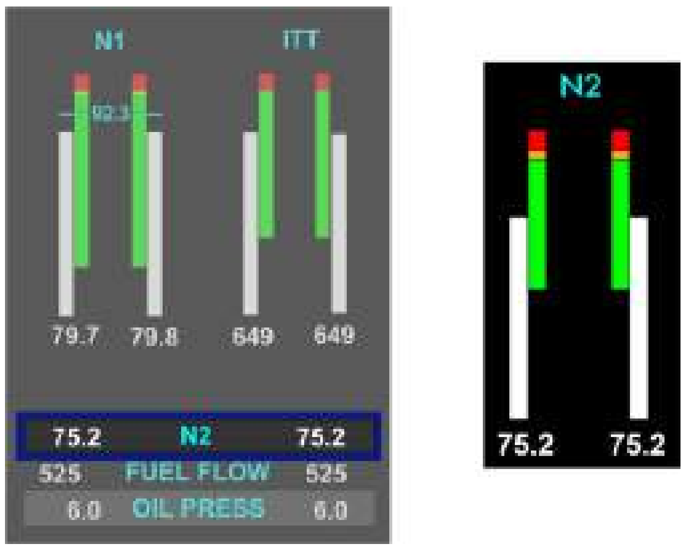

Figure 7-15. N2 Displays – Digital and Tape

See Figure 7-15. 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 engine 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 transient 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 N2 RPM remains in the transient amber band for 20 seconds, the tape and digital display changes to red, and an L(R) ENG EXCEEDANCE warning message appears.

7.4.10 Fuel Flow

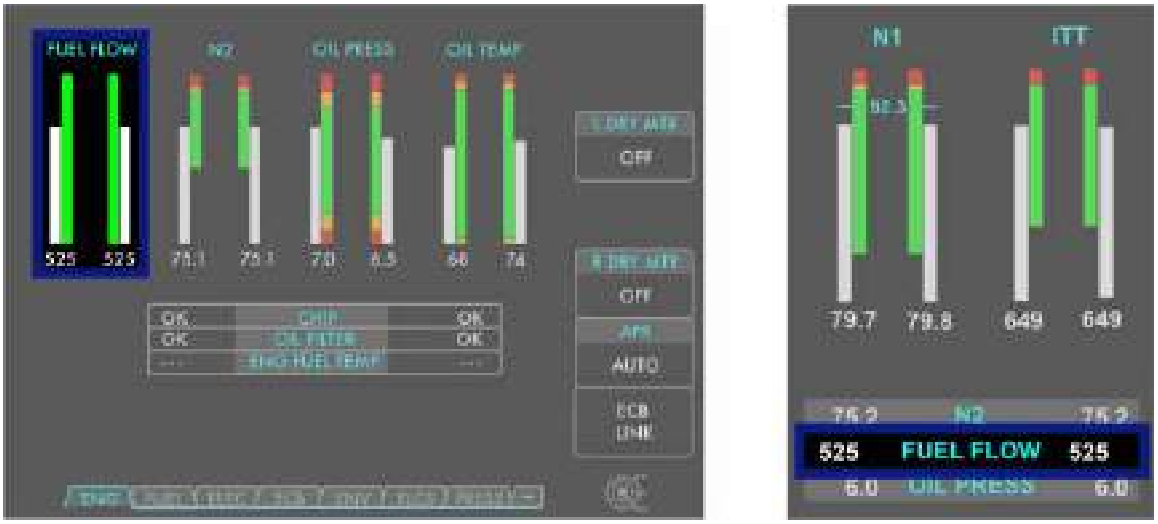

Figure 7-16. Fuel Flow Displays – Digital and Tape

See Figure 7-16. 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 both the FUEL and ENG synoptic pages. 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.

7.4.11 Oil Pressure

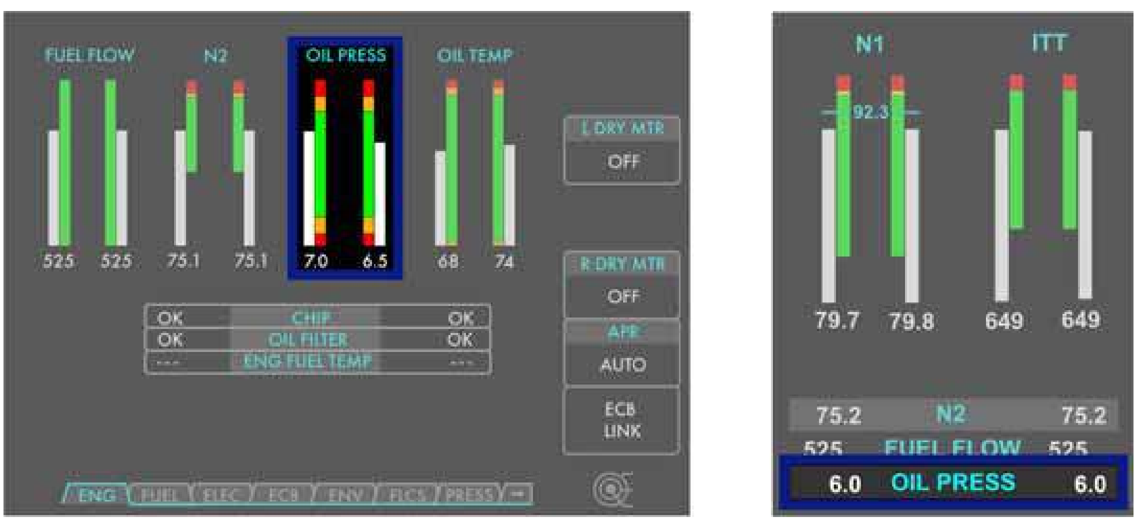

Figure 7-17. Oil Pressure Displays – Digital and Tape

See Figure 7-17. 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.

See Figure 7-18. 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.

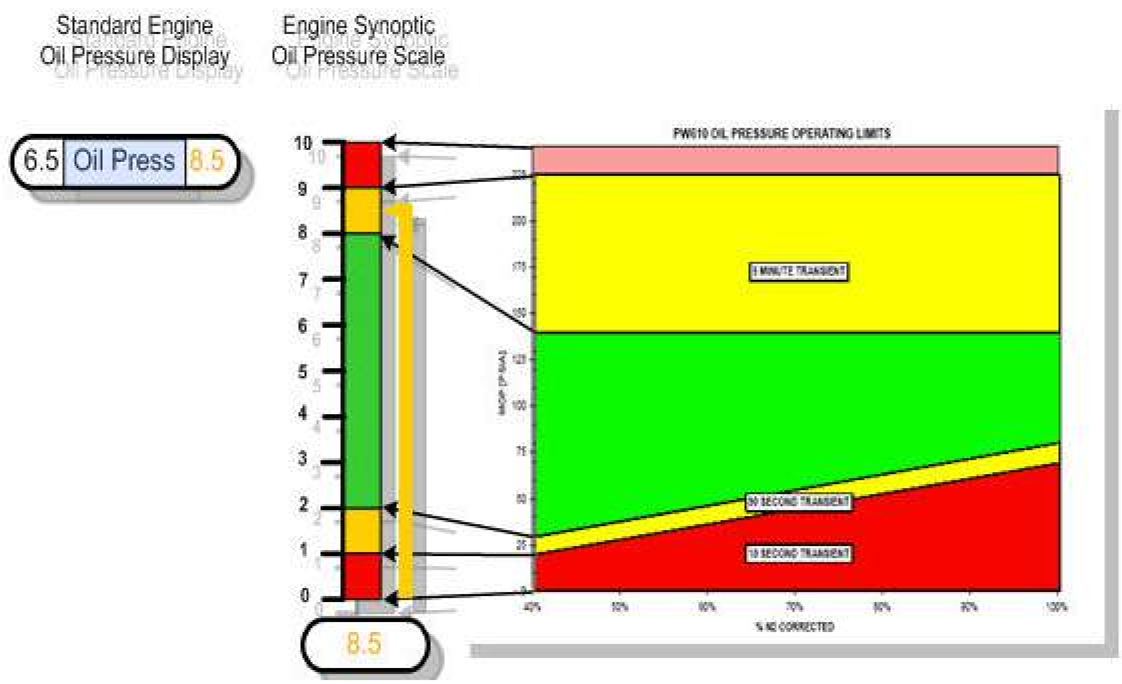

Figure 7-18. Oil Pressure Normalization Chart

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

See Table 7-5**.** The amber transient bands incorporate a time delay for transient conditions.

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

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

Table 7-5. Oil Pressure Amber and Red Indications

Oil Pressure	Time Delay for Red Display
9.1 – 10	None
8.1 – 9	5 minutes
1 – 1.9	90 seconds

7.4.12 Oil Temperature

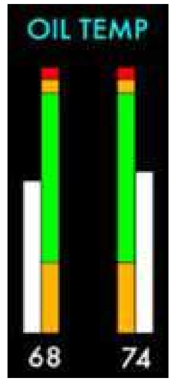

Figure 7-19. Oil Temperature Tape

See Figure 7-19. 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 -40°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. A red band extends from 140°C and up.

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

If the oil temperature enters the high transient range of 135°C to 140°C, the digital value and tape turn amber, and an L(R) ENG OIL TEMP HIGH caution message appears instantaneously. If the oil temperature enters the low transient range, the digital value and tape turn amber. If power is increased towards takeoff while the oil temperature is below 20°C, an L(R) ENG OIL TEMP LOW caution message appears. If a high oil temperature remains in the caution range for more than 90 seconds, the digital value and tape turn red and an L(R) OIL TEMP HIGH warning message appears.

If the engine oil temperature enters the high warning range of 140°C the digital value and tape turn red and an L(R) ENG OIL TEMP HIGH warning message appears instantaneously.

Should the engine oil temperature sensor fail, an L(R) OIL TEMP FAULT advisory message appears. Oil temperature indications for that engine will be unavailable; the oil temperature tape will be removed; and the digital value will be dashed.

7.4.13 Engine Chip Indication

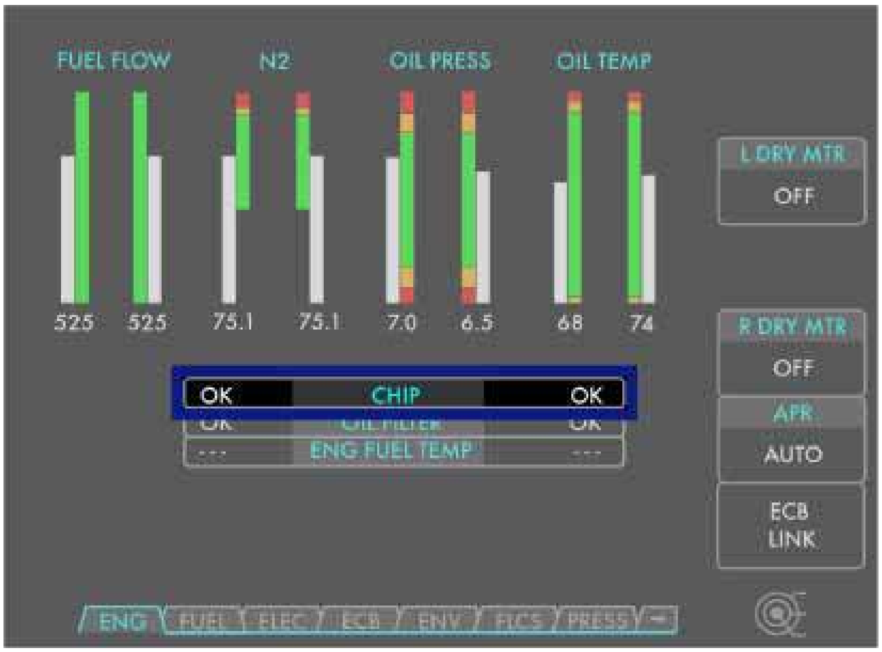

Figure 7-20. Engine Chip Display

See Figure 7-20. If the magnetic chip detector senses metal contamination in the oil, the ACS will inform the pilot on the CHIP display at the bottom of the engine synoptic page. The display has three states, shown in Table 7-6.

Table 7-6. Engine Chip Color Indications

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

7.4.14 Oil Filter Status (Impending Oil Filter Bypass)

Figure 7-21. Oil Filter Display

Figure 7-21. If the impending bypass pressure switch senses a blockage of the oil filter, an 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, shown in Table 7-7.

Table 7-7. Impending Bypass Color Indications

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

7.4.15 Engine Fuel Temperature

Figure 7-22. Engine Fuel Temperature Display

Engine fuel temperature in the Fuel Metering Unit (FMU) is displayed on the engine synoptic with a white digital readout in degrees Celsius. This temperature is taken just prior to fuel leaving the FMU for the fuel nozzles.

7.5 System Description

7.5.1 Full Authority Digital Engine Control (FADEC)

The engines are controlled through two dual-channeled Full Authority Digital Engine Control (FADEC) units. The FADEC sets thrust by controlling fuel flow based on Throttle Lever Angle (TLA). TLA is measured by potentiometers in the throttle quadrant. Shown in Table 7-8, there are three primary operating ranges for the throttles — Idle, Maximum Continuous Thrust (MCT) and Takeoff.

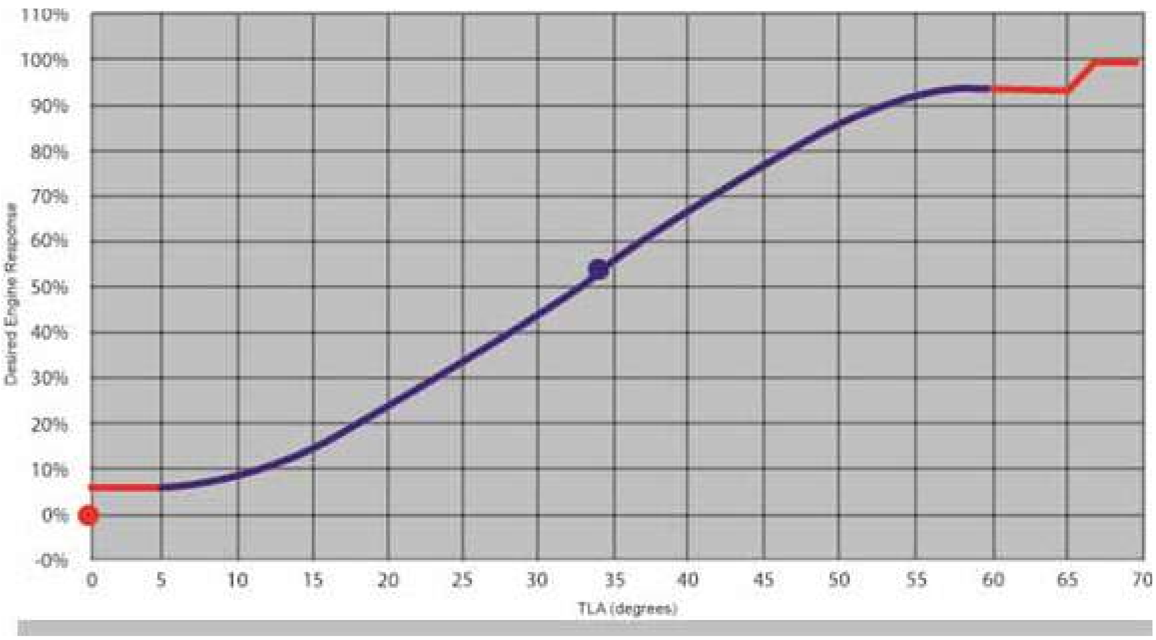

Figure 7-23. Throttle Position vs. Engine Power

Table 7-8. Throttle Position vs. Thrust Level

Thrust Level	Throttle Lever Angle (Degrees)
Idle	0 – 4
Maximum Continuous	59 – 65
TO/APR	67 – 70

The FADEC receives information from the following sensors:

- Engine status
  - N1
  - N2
  - ITT
  - Fuel temperature
- Air data information
  - TAT
  - Airspeed
  - Pressure altitude
- Airplane status
  - Weight on Wheels (WOW)
  - 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 inside the pressure vessel.

Each engine has two FADEC cards, either of which can control the engine. The FADEC cards are physically separated from each other. One Card from each engine is collocated with one of the Aircraft Computer Systems in a unit called the Avio Processing center (APC). The left APC, located on the aircraft sidewall in the baggage compartment, houses one FADEC card from each of the left and right engines. The right APC, located underneath the right side of the baggage compartment floor, also houses one FADEC card from each of the left and right engines.

7.5.1.1 FADEC POWER SOURCES

Each FADEC unit has three power sources:

- Left generator
  - Left FWD bus
- Right generator
  - Right FWD bus
- System battery
  - Battery bus

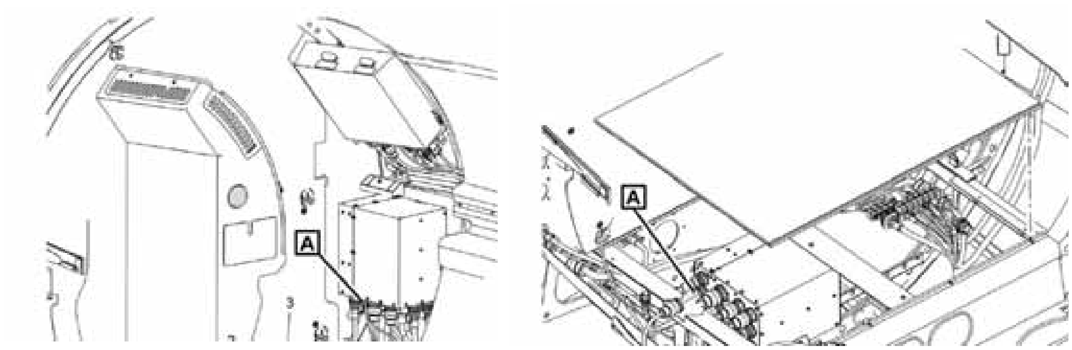

Figure 7-24. FADEC Power Sources

7.5.2 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.

Engine sync is automatic as long as the throttles are set within the normal operating range (12- to 65-degree Throttle Lever Angle) and within five degrees of each other. To make small power changes (e.g., a few percent N1), the pilot can move one throttle slightly forward or aft. This will set a new power setting for one engine to which the other will automatically sync.

7.5.3 Autothrottle

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

7.5.4 Starter/Generators

A starter/generator (S/G) is mechanically coupled to each engine by the Accessory Gear Box (AGB). The AGB is connected to the N2 shaft via gearing and a tower shaft.

During engine start, the S/G functions as a motor driving the N2 Shaft. 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 S/G is driven by the N2 shaft and functions as a generator to supply power to the airplane via the GCU

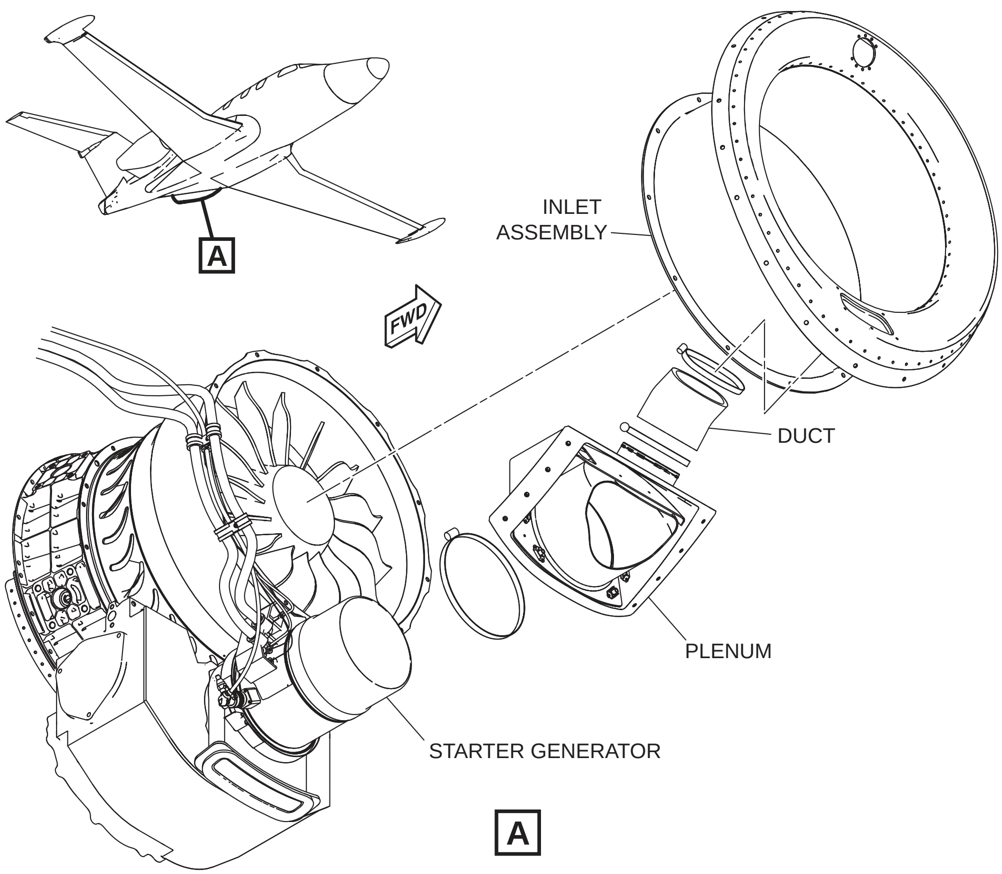

Figure 7-25. Starter/Generator

7.5.5 Engine Fuel System

After the Fuel Shutoff Valves in the wings, the fuel travels in lines through the aft equipment bay, and out to the engines in the pylon trailing edge. The fuel is routed to the Fuel Metering Unit (FMU) under pressure from fuel pumps located in the sump tanks. The FMU is connected to the Accessory Gear Box on the engine in order to run two fuel pumps. Fuel for each engine is pressurized by an engine-driven low-pressure fuel pump within the FMU.

From the low-pressure pump, fuel flows away from the FMU through the fuel to oil heat exchanger in order 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 7 Primary and 6 Secondary for a total of 13 simplex fuel nozzles in the combustion section of the engine. Excess fuel is routed back to the fuel tank under pressure as warm “motive” fuel to operate the ejector pumps in each fuel tank and warm the fuel in the tank.

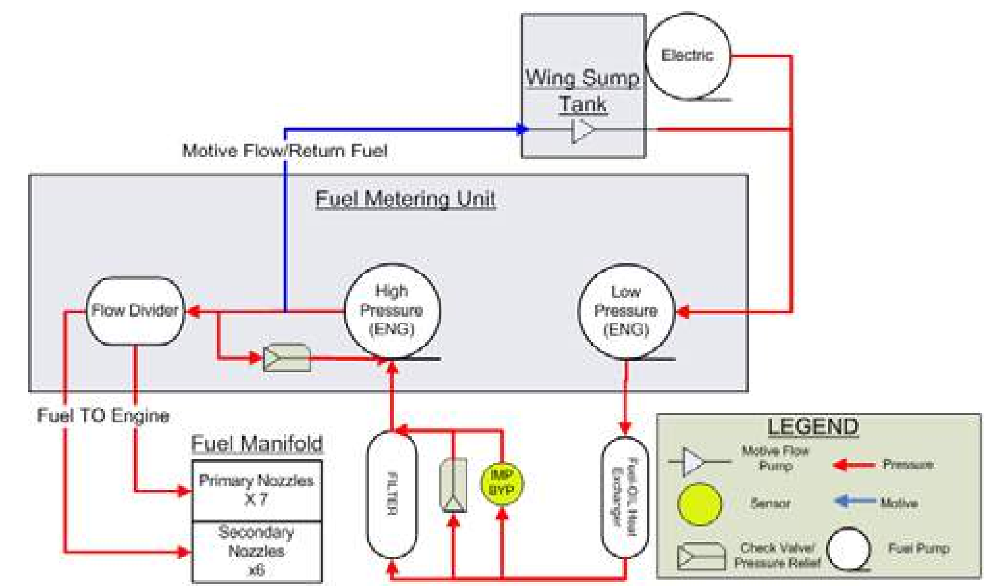

Figure 7-26. Fuel System Schematic

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, an L(R) ENG FUEL HOT warning message appears.

NOTE:

ENG FUEL HOT is the triggered by the engine fuel temp as depicted on the ENG Synoptic. HOT FUEL cautions and warnings are triggered by high sump tank temperature as depicted on the FUEL Synoptic.

7.5.6 Bleed Air

Bleed air is compressed air taken from the engine for use in other than creating thrust.

A bleed valve is used to optimize air flow between the mixed flow and centrifugal stages of the engine. The bleed valve is positioned upstream of the centrifugal impeller to prevent surge, and to optimize starting and handling operability. The bleed valve actuator, which is operated hydraulically using fuel flow from the Fuel Metering Unit, varies it's position based on engine speed. At low engine speeds the bleed valve actuator opens a path for high pressure core air to be released into the bypass section of the engine. At high engine speeds when the mixed flow compressor, and centrifugal compressor airflow is more efficient the bleed valve actuator modulates closed to produce more thrust.

Two ports on each engine extract air from the centrifugal compressor impeller. This is the last stage of compression before entering the combustion chamber and yields airflow of approximately 165PSI and 350F based on engine speed. These bleed air ports are named the P3 ports. The P3 ports provide bleed air used for ice protection and climate control. P3 Bleed air from the outboard port on each engine is routed through the Pressure Regulating Shutoff Valve (PRSOV) to the engine nacelle for engine inlet anti-ice and to the de-ice manifold for inflating the leading edge de-ice boots.

P3 Bleed air from the inboard port on each engine is routed through an air to air heat exchanger in the pylon and then sent to the de-ice manifold, and to the Flow Control Valve (FCV). Inboard P3 air sent to the de-ice manifold is sent over through an ejector in order to produce vacuum pressure. This vacuum pressure is used to open the outflow valves on the ground and deflate the de-ice boots. Inboard P3 air sent to the FCV is used for heating and pressurization controlled by the climate control system.

Bypass air while cooler and lower pressure than P3 air is also bled off the engine by the Fan Air Control Valve (FACV). The FACV opens when the aircraft is on the ground by an ACS controlled electric motor. The FACV opens a path for bypass air from the Fan to be routed over the air to air heat exchanger in the pylon to cool the inboard P3 (core) air.

7.5.7 Oil System

See Figure 7-27. The engine oil system is completely contained within the engine. The capacity of the oil system is 6 quarts, with 3.6 of those quarts being contained in the oil tank. Oil is drawn from the oil tank by an engine-driven oil pump. The pump incorporates a combination Cold Start Valve (CSV) and Pressure Adjusting Valve (PAV) which allows for pressure relief to avoid damage during cold oil temperature starts, as well as overall adjustment of the oil pressure. From the oil pump, the oil passes though a 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, an L(R) ENG OIL FILTER advisory appears. From the oil filter, oil passes though an air-cooled oil cooler (ACOC). The ACOC passes relatively cool bypass air from the fan section of the engine over a heat exchanger in order to cool the oil. The ACOC incorporates a thermal and pressure bypass valve so that if the oil temperature is cold the oil bypasses the ACOC. After leaving the ACOC the oil travels to the fuel to oil heat exchanger (FOHE). The FOHE uses fuel flow from the sump tanks in order to cool the oil. As a by-product of cooling the oil, the warmed fuel helps to keep ice crystals from forming in the fuel filter, and excess fuel is returned to the sump tank and warms the sump fuel.

Oil then passes through the main oil temperature and pressure sensors (MOP and MOT Sensors) and then to the five main bearing cavities in the shaft. Bearing cavities 1 through 4 return the oil to the Accessory Gear Box with gravity, and the oil returning from bearing cavity 5 is aided with an engine driven scavenge pump. The Accessory Gear Box contains an air-oil separator, and the air is vented at the oil breather in the engine exhaust. The oil continues back to the oil tank, to continue the cycle again. 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 an L(R) ENG CHIP DETECTED advisory message to appear. If this detector fails, an L(R) ENG CHIP FAULT advisory appears and chip detection is unavailable.

See Figure 7-27. 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.

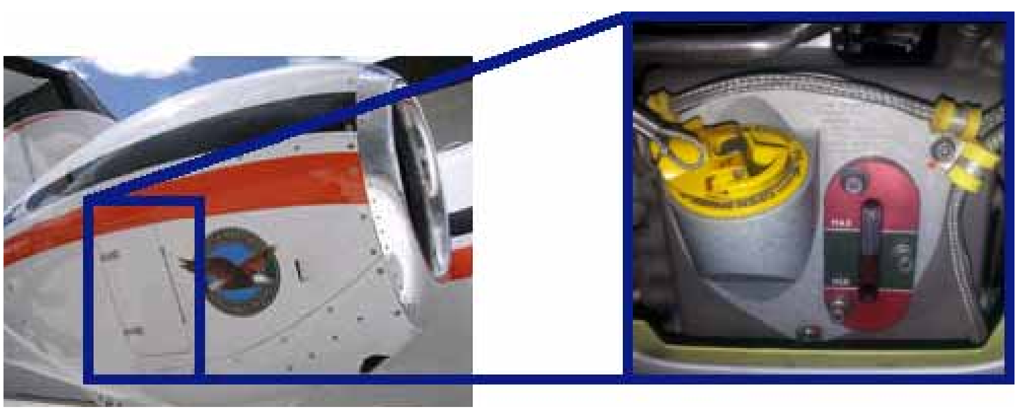

Figure 7-27. Engine Oil Sight Glass

7.5.8 Automatic Power Reserve

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

7.5.8.1 APR ON ACTIVATION

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

- Left and right N1 fan speeds differ by 20% or more
- Left and right N2 compressor speeds differ by 10% or more

When an engine fails, a green APR ON text is displayed above the N1 tape on the MFD. The FADEC operating in APR mode increases thrust on the operating engine by increasing fuel flow, allowing the engine to operate up to the following parameters:

- 900 pounds absolute thrust
- ITT limit for APR (795°C)
- N1 Speed Limit (102%)
- N2 Speed Limit (100%)

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 of a throttle at takeoff power with APR active is allowed for ten minutes. When the throttles have been at the takeoff position for more than ten minutes, the L(R) ENG EXCEEDANCE warning message appears to prompt the pilot to reduce thrust to the MCT setting.

7.5.8.2 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 N1 tape on the MFD. Operation with APR ARMED at takeoff thrust is allowed for five minutes. Should this five-minute time be exceeded, an L(R) ENG EXCEEDANCE warning message appears, prompting the pilot to reduce thrust to the maximum continuous thrust (MCT) setting.

7.5.8.3 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.

7.5.8.4 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. See Figure 7-28.

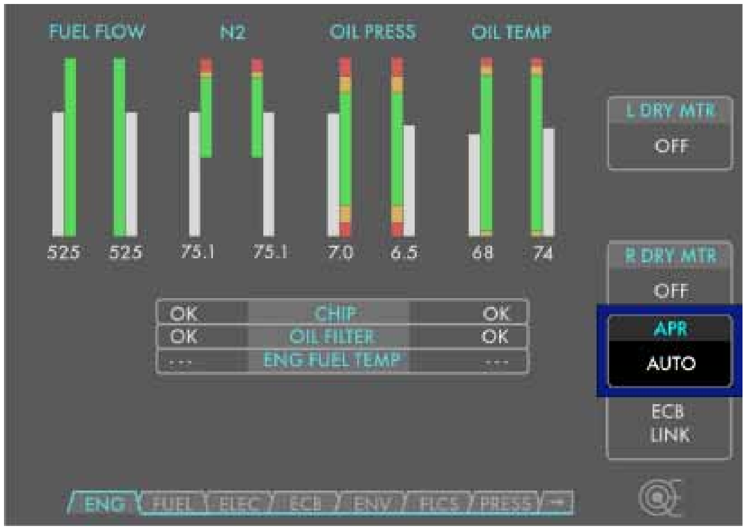

Figure 7-28. APR Line Select Key

See Figure 7-28. 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/DISARM/CONFIRM (or CANCEL)
  - APR DISARM
- Re-arm
  - DISARM/AUTO

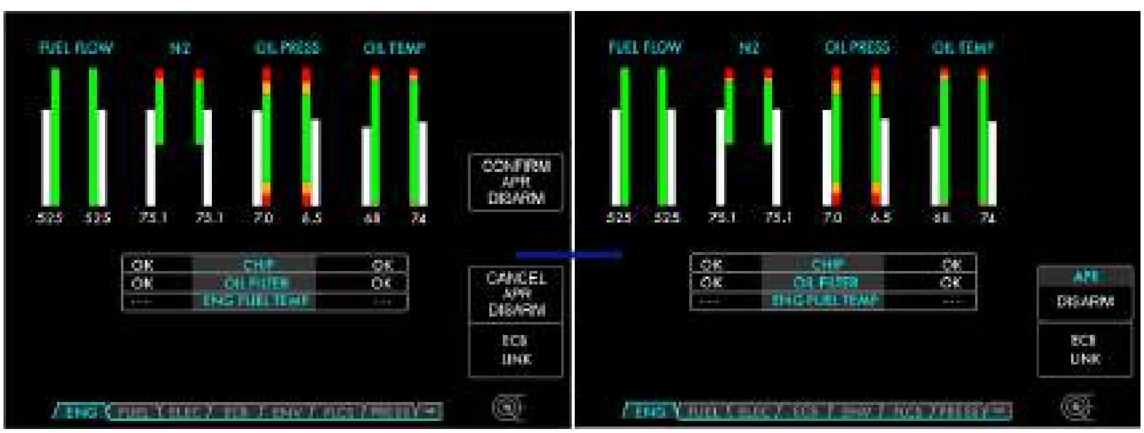

Figure 7-29. APR Disarm Sequence

7.5.8.5 DEACTIVATION

Once APR is activated, either automatically or via a test activation, it remains active until the engines are shutdown or the pilot uses the "Manual APR Disarming/Deactivating" procedure in section 7.5.8.4.

7.5.9 Fire Protection

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

Engine fire protection consists of the following:

- Firewalls
- Ventilation of all zones within the engines
- Drainage in those areas subject to leakage of flammable fluids
- Fire detection
- Fire suppression

See Figure 7-30. 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 Fire" or "Right Engine Fire” audible alarm.

Figure 7-30. FIRE/ARMED Button

7.5.9.1 FIRE DETECTION

See Figure 7-31. Each engine contains a single temperature detector (thermistor) loop to detect an engine fire. The left ACS monitors the left engine temperature sensor cable. The right ACS monitors the right engine temperature sensor cable.

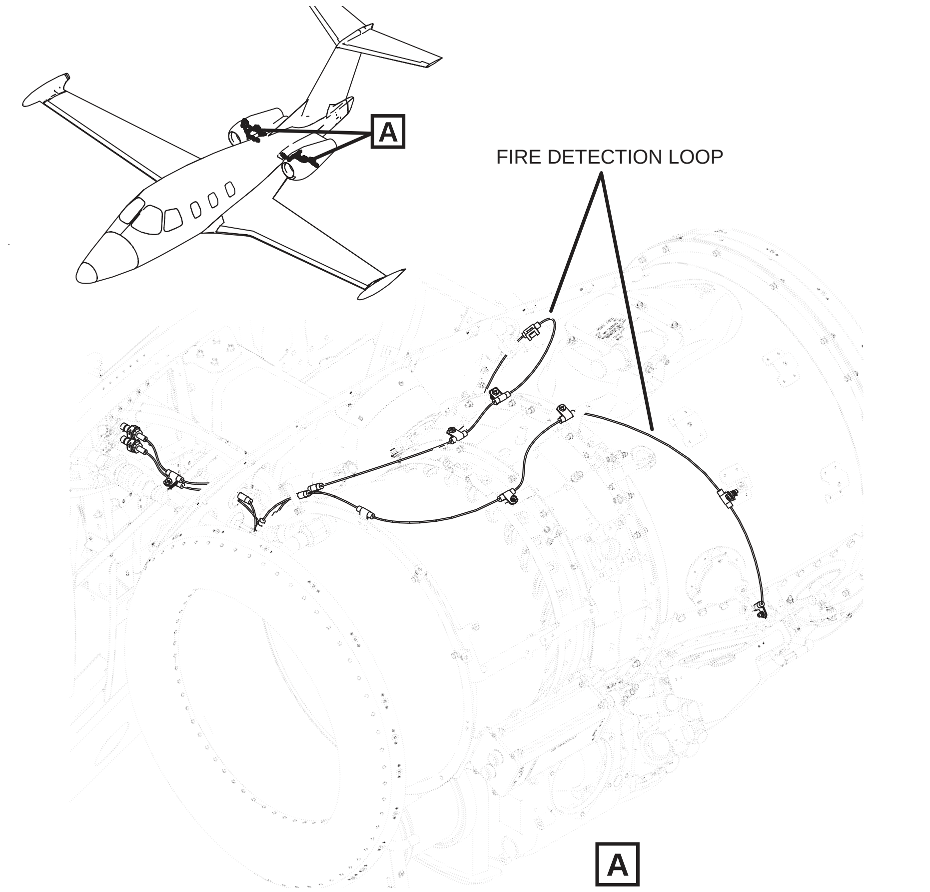

Figure 7-31. Fire Detection Loop

The ACS has two main fire detection functions. It gives an alert to the flight crew within five 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, an 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 an L(R) ENG FIRE warning message appears.

The audible alarm is silenced by pressing the WARN/CAUTION button on the autopilot control panel; consult the QRH procedure for ENG FIRE. 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 may exist.

7.5.9.2 FIRE SUPPRESSION

The fire extinguishing system is made up of a Fire Extinguisher Canister (FEC), also known as a Phostrex Canister, and the associated tubing and wiring. A pressurized FEC with a pyrotechnic discharge cartridge is installed in each engine pylon.

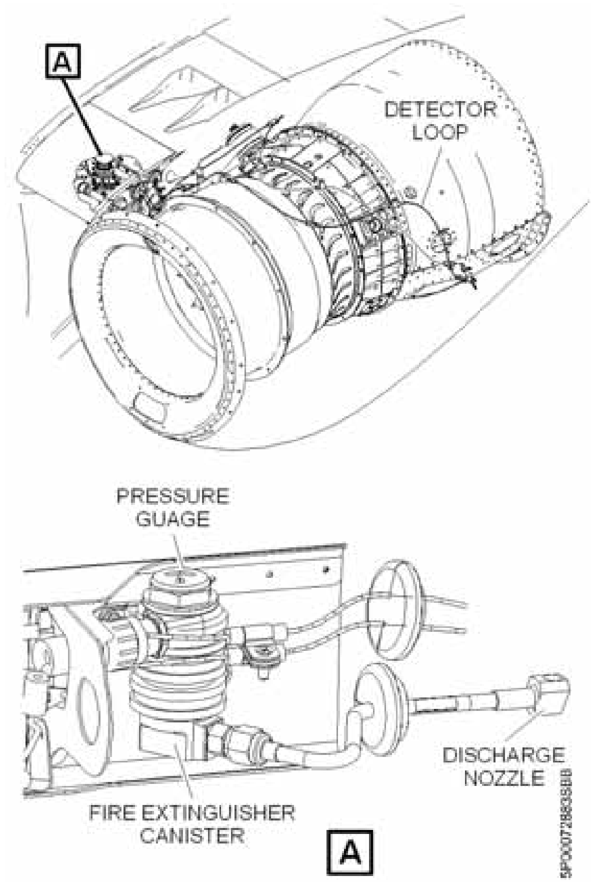

Figure 7-32. Fire Extinguisher Canister Location

The fire extinguishing system delivers the PhostrEx™ extinguishing agent to the area between the engine and the engine cowlings by a tube and nozzle.

The FEC is a single-shot system, dispersed by an electrical charge that activates a small pyrotechnic charge in the FEC to release the agent under pressure. Rigid tubes convey the suppression agent to the nacelles, where it is injected via nozzles. 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 pressure gauge of the FEC should be in the green band indicated on the canisters which can be seen through clear windows in the top of each pylon.

NOTE:
If the outside air temperature is below 10°C, refer to the Fire Extinguisher Canister Temperature Correction Charts in the AFM for the minimum pressure range with the FEC.

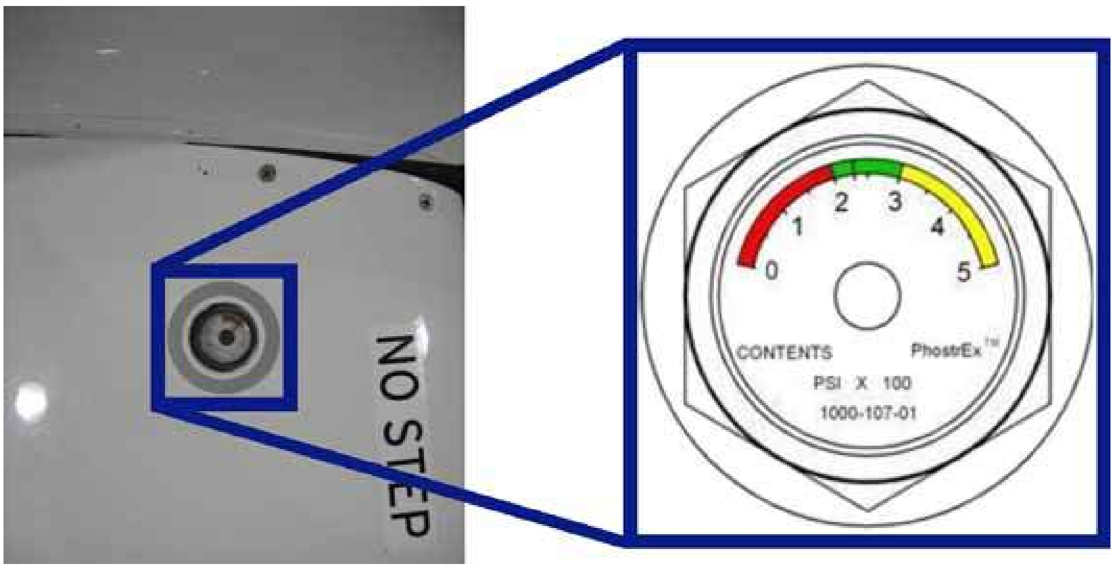

Figure 7-33. Fire Canister Pressure Indicator – Engine Pylon

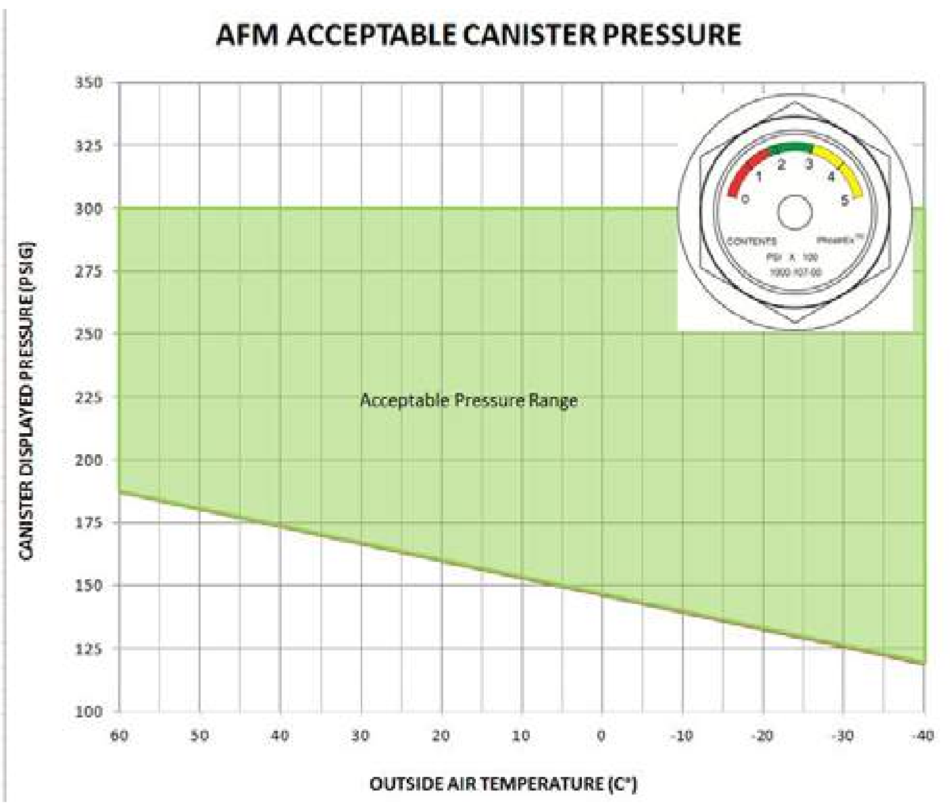

Figure 7-34. Acceptable Canister Pressure

7.5.9.3 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 the right button is for the right engine. An engine fire is indicated by a FIRE light in the respective button, a L(R) ENG FIRE warning, and a "Left Engine Fire" or "Right Engine Fire" aural alert which wil 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 outboard bleed air valve - Pressure Regulating Shutoff Valve (PRSOV).
3. Turns off the igniters.
4. Closes the inboard bleed air valve - Flow Control Valve (FCV).
5. Closes the bypass air bleed - Fan Air Control Valve (FACV).
6. Arms the Fire Extinguisher Canister (FEC).
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 disarm the Fire Extinguisher Canister.

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 an L(R) EXTNGR DSCHG advisory message appears indicating that the fire extinguisher capability has been depleted. If the fire detection loop cools due to the fire being suppressed the FIRE indication will extinguish.

7.6 Normal Operations

7.6.1 Engine Start

During engine start the ACS's automatically configure the aircraft systems and the engine start is automatically controlled by the FADEC's. 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:

7.6.1.1 START/MOTORING MODES

Table 7-9. Start/Motoring Modes

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

7.6.1.2 ON-GROUND START SEQUENCE

1. The switch must be pushed in to move between OFF and ON/START.
   a. the MFD ITT tape indicator red line rolls up to 850°C and the notification IGN appears above the tape as the spark igniters are activated.
   b. the right battery bus contactor opens
   c. the bus tie contactor closes
   d. the left and right Forward Remote ECBs (FRECBs) OPEN
   e. the generator contactor closes to allow power from the start battery, assisted by a GPU or opposite side generator to motor the starter.
   f. the respective fuel shut-off valve opens
   g. the respective electric fuel pump energizes
2. Approximately 10% N2:
   a. Fuel flow from the primary fuel nozzles starts
   b. ITT starts to increase
3. Approximately 15% N2:
   a. Oil pressure increases (FADEC does not abort for abnormal oil pressure)
   b. ITT continues to increase
4. Approximately 20% N2:
   a. N1 increases (FADEC does not abort for lack of N1 rotation)
   b. ITT continues to increase
5. Approximately 30% N2:
   a. ITT peaks and begins to stabilize
   b. Fuel Flow from the secondary fuel nozzles
   c. ITT continues to rise again
6. Approximately 40% N2:
   a. Starter/Generator should cut out

7. Ground Idle N2 (46.7 RPM minimum):
   a. the MFD ITT tape indicator red line rolls down to 795°C and the notification IGN disappears.
   b. the electric fuel pump shuts OFF
   c. ITT stabilizes
   d. the left and right Forward Remote ECBs (FRECBs) close
   e. the right battery bus contactor opens
   f. If the GEN switch was selected to AUTO the generator contactor closes automatically, if not a L(R) GEN OFFLINE caution message is annunciated.
   g. the bus tie contactor opens after the second engine starts

CAUTION:
Whenever the engine fails to light, a dry motoring cycle is required to clear out trapped fuel or vapors. The high speed rotor (N2) should be allowed to decelerate to zero RPM before attempting another start. Repeat complete starting sequence, observing starter limits. (Refer to "Engine Starting Limitations" on page 2-12 in the AFM.)

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. If 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; if a mechanical failure is suspected, do not attempt to restart the engine.

7.6.1.3 Automatic START ABORTS

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

1. Loss of required inputs/outputs for FADEC during engine Start
2. N2 below "Fuel on" threshold
3. No light off
4. Hung Start (fuel/air mixture ignites, but the engine fails to achieve self-sustaining speed)
5. Hot Start (ITT trend or actual exceedance)

7.6.2 Engine Shutdown

Normal engine shutdown is accomplished by turning the engine start switch to OFF. Electrical power to the ACS and FADECs (Forward busses) is required for engine shut down. The FADEC seizes the fuel flow from the fuel metering unit. The ACS closes the fuel shutoff valve, and reconfigures systems for the loss of bleed air and electrical power from the generator.

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

7.6.3 Engine Dry Motoring

If an engine start is aborted, fuel can puddle in the engine combustion chambers, and the composite tail cone. This fuel can be pushed out (while inhibiting fuel and ignition) by dry motoring the engine using the line-select keys labeled L DRY MTR and R DRY MTR on the engine synoptic. This feature is only available on the ground with the Engine Control Panel selector in the OFF Position. The Line Select Key control of dry motoring is removed in flight. While dry motoring the engine, the dry motor line select key will display a timer, so that the user may observe starter limitations and deselect dry motor in less than 30 seconds.

7.6.4 Takeoff (T/O)

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.

7.6.5 Ignition (IGN)

The notification of IGN above the ITT tapes denotes that the spark igniters are active. Normally the spark igniters are selected on automatically during engine start, or manually by selecting CONT IGN.

To avoid engine flameout in areas of volcanic ash, turbulence, heavy rain or icing conditions, continuous ignition is selected by placing the respective switch on the Engine Control Panel to the CONT IGN position.

7.6.6 Flight and Ground Idle RPM

Engine idle speed is higher in-flight (approximately 52% N2) than on the ground (approximately 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.

7.7 Abnormal Procedures

7.7.1 In-Flight Engine Restart

All in-flight engine restarts are considered *starter assisted*. The ACS and FADEC automatically control the engine start sequence in the same manner as on ground starts.

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

All in-flight engine restarts must be completed within the Starter Assisted Air Start Envelope shown below.

25,000 feet and below
Airspeed .... 140-234 KEAS

15,000 feet and below
Airspeed .... Less than 234 KEAS

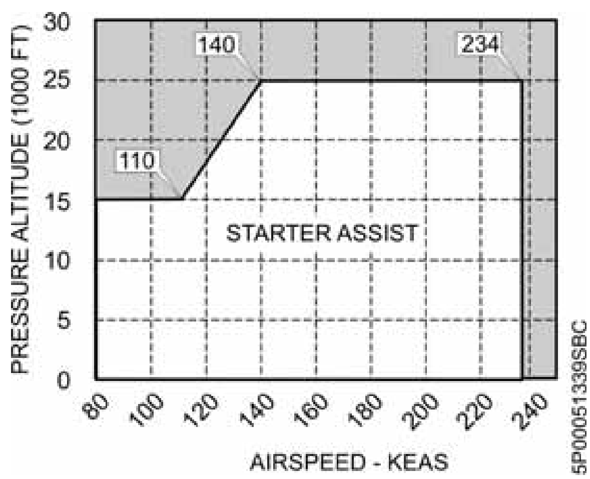

Figure 7-35. Starter Assisted Air Start Envelope

⚠ **CAUTION:**
In order to minimize start Inter Turbine Temperature (ITT), allow engine to windmill until ITT is less than 100°C before initiating in flight engine restart.

7.7.2 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 the limits for ITT, N1 and N2 Rotor speed, and 900 lbs of thrust.

7.7.3 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. Engine Start and shutdown require ACS interaction.

7.7.4 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. Electrical power and ACS control is required for engine shutdown from both the Engine Control Panel and the FIRE/ARMED button since the fuel shutoff valve is electrically operated and controlled by the ACS.

7.7.5 Engine Failure

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

7.7.6 Engine Control Failures (FADEC Channel Failures)

7.7.6.1 SINGLE CHANNEL

A failure of one of the FADEC channels causes a loss of redundancy in the engine control system and prompts an 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.

7.7.6.2 DUAL CHANNEL

A failure of both FADEC channels on one side is a serious condition that prompts an L(R) ENG CONTROL FAIL caution message to appear. This failure may diminish engine control to the point where the engine may fail to a fixed fuel flow. Consult the QRH for L(R) ENG CONTROL FAIL caution message procedures.

7.8 Crew Alerting System Messages

Table 7-10. 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 minutes 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 occurred in the engine control system which could 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 able 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

7.9 Engine and Fire Protection Review Questions

1. **What are the four areas that the Aircraft Computer System (ACS) interfaces with the engine and fire protection systems?**

   a.

   b.

   c.

   d.

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

   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. 48 volts
   b. 28 volts
   c. 20 volts
   d. 23 volts

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. **What are the two items that the FADEC uses to activate the Automatic Power Reserve (APR) 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)
   c. Up to 900 lbs absolute thrust
   d. 30% N1

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. **What is the purpose of engine dry motoring?**
    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 control panel
    d. Both A and 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 oil 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. How is engine bleed air from the inboard P3 bleed port on the engine used?

Climate Control

8

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Climate Control

8

8.1 General

See Figure 8-1. The climate control system is comprised of four mutually dependent sub-systems:

- Bleed Air Supply System (BASS)
- Cabin Air Distribution System
- Vapor Cycle System (VCS) (Air Conditioning)
- Cabin Pressurization Control System (Outflow Valves)

The bleed air supply system provides the warm air supply for aircraft pressurization, ventilation, and cabin conditioned bleed air. Bleed airflow is controlled automatically by the Aircraft Computer System (ACS) or manually through selections on the environmental (ENVIR) and pressurization (PRESS) synoptics, as well as hard switches on the instrument panel left.

The cabin air distribution 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 vapor cycle system provides cooling for the cabin air. The vapor cycle system is automatically controlled by the ACS or manually controlled through the environmental (ENVIR) synoptic.

The cabin pressurization control system controls the exhaust of pressurized cabin air through the outflow valves working 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.

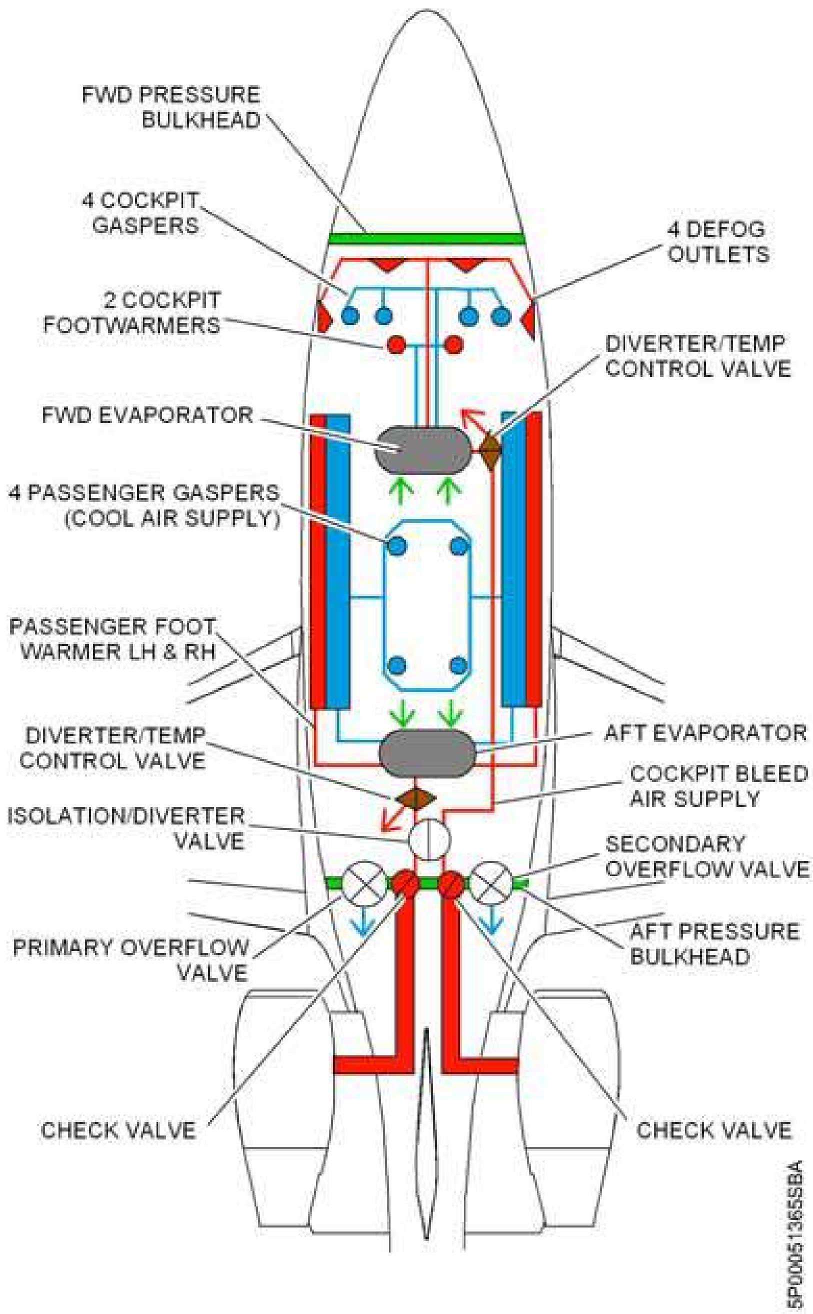

Figure 8-1. Climate Control System Overview

8.2 Aircraft Computer System (ACS) Interfaces

See Figure 8-2. The ACS has control and monitoring functionality of the four major subsystems of the climate control system and provides the following functions:

1. Cabin and cockpit temperature control
2. Variable Outlet Ram Exhaust (VORE) door position
3. Fan Air Control Valve (FACV) position
4. Flow Control Valve (FCV) position
5. Evaporator Fan speed
6. Evaporator internal valve position
7. Air conditioning control and monitoring
8. Windshield defog
9. Cabin dehumidification
10. Manual and automatic pressurization control and monitoring
11. 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 AIR SOURCE switch on the instrument panel left. Synoptic inputs are sent through the PFD, and the 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).

Cabin pressure control is accomplished through the primary outflow valve and controlled directly by the left ACS. Normal operation of the pressurization system is automatic; however, 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, and information related to the right engine is sent to the right ACS.

8.2.1 Climate Control System Sensors

1. Left ACS:

   a. Cabin zone temperature sensor
   b. Aft evaporator temperatures
   c. Left bleed air temperature sensor
   d. Left pylon over temperature sensor

2. Right ACS:

   a. Cockpit zone temperature sensor
   b. Forward evaporator temperatures
   c. Right bleed air temperature sensor
   d. Right pylon over temperature sensor

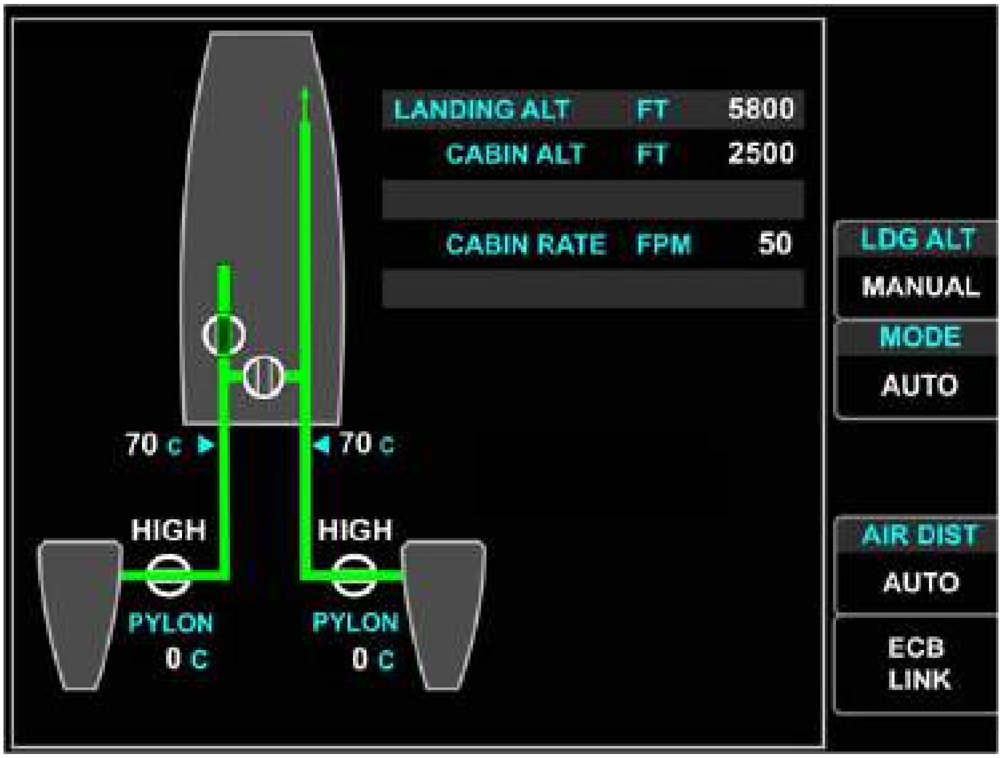

Figure 8-2. Climate Control System – ACS Interface

8.3 Limitations and Specifications

8.3.1 Cabin Pressurization Limitations

Positive pressure relief, secondary outflow valve .... 8.7 psi

Maximum regulated negative cabin pressure differential .... -0.5 psi
....Landing with cabin pressurized is not approved.

8.4 Controls and Indicators

8.4.1 Cabin Air Controls

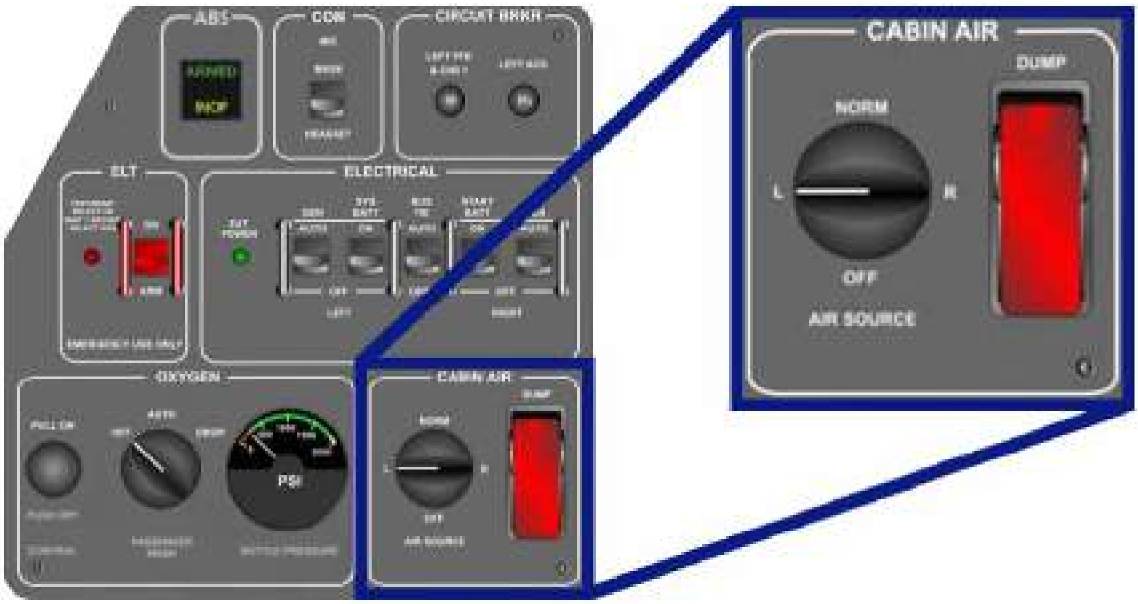

Figure 8-3. Cabin Air Sub Panel

8.4.1.1 AIR SOURCE SWITCH

Table 8-1. 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. With two engines providing bleed air and the AIR DISTR environmental line select key in AUTO, bleed air from the left engine flows to the cabin, and bleed 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.

NOTE:

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

8.4.1.2 CABIN DUMP SWITCH

Table 8-2. Cabin DUMP Switch Selections

OFF	Normal operation
ON	■ Primary and secondary outflow valves open ■ Left and Right (NORM) flow control valves switch to high flow ■ All bleed air routed to cockpit

8.4.2 Pressurization Display

Figure 8-4. MFD Pressurization Display

8.4.2.1 ALT (FT)

See Figure 8-4. Cabin altitude rounded to the nearest 50 feet is presented. If the cabin altitude exceeds 8,750 feet, a CABIN ALTITUDE caution message appears and the digits turn amber. If the cabin altitude exceeds 10,000 feet, a CABIN ALTITUDE warning message appears and the digits turn red. At a cabin altitude of 12,750 feet an aural warning "MASK ON DESCEND" 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.

8.4.2.2 RATE (FPM)

See Figure 8-4. Cabin altitude rate of change rounded to the nearest 100 fpm is presented. If the cabin altitude rate of climb is more than 2,500 feet per minute, the digits turn amber. The crew can select the cabin rate of climb or descent between 0 and 2,500 feet per minute.

8.4.3 Environmental Synoptic

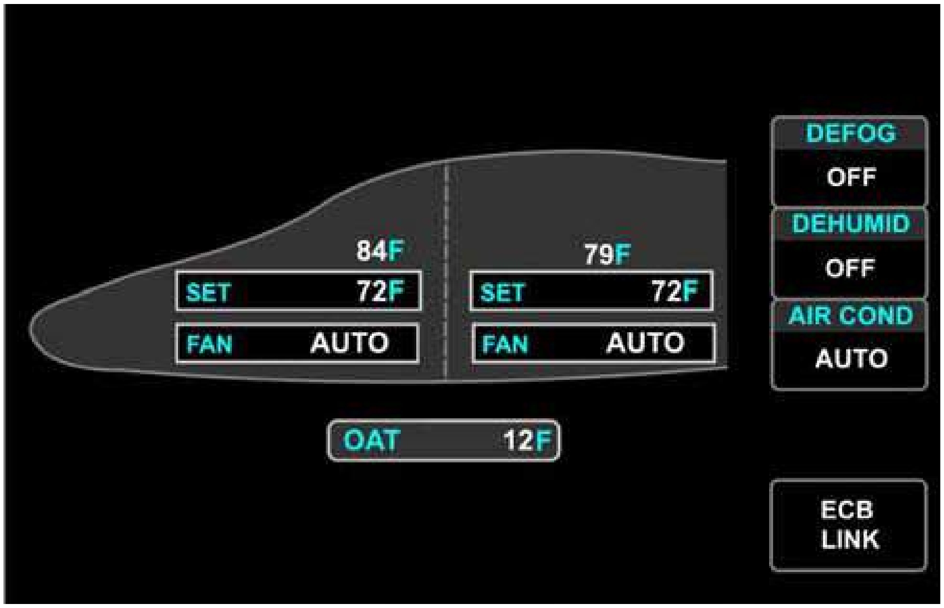

Figure 8-5. Environmental (ENVIR) Synoptic

See Figure 8-5. The environmental (ENVIR) synoptic provides control of cockpit and cabin temperatures, as well as 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. Setting the desired temperature and fan speed is accomplished through the MFD concentric knobs.

Table 8-3. Environmental Synoptic Selections

Function	Settings
XX F/ XX C	Current cockpit and cabin temperature in degrees Fahrenheit or Celsius, depending on settings page selection.
SET	Desired cockpit and cabin temperature in 2°F (1°C) increments from 64°F (19°C) to 84°F (29°C) plus MAX HEAT and MAX COOL. Default setting at power-up is 72°F (23°C).
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. (This key will ONLY appear with AIR COND selected to AUTO.)
AIR COND	OFF/AUTO. Default setting at power-up is OFF.
OAT	Outside Air Temperature in degrees Fahrenheit or Celsius, depending on setting.
ECB LINK	Selects ENVIRONMENT ECB synoptic page.

8.4.4 Pressurization Synoptic

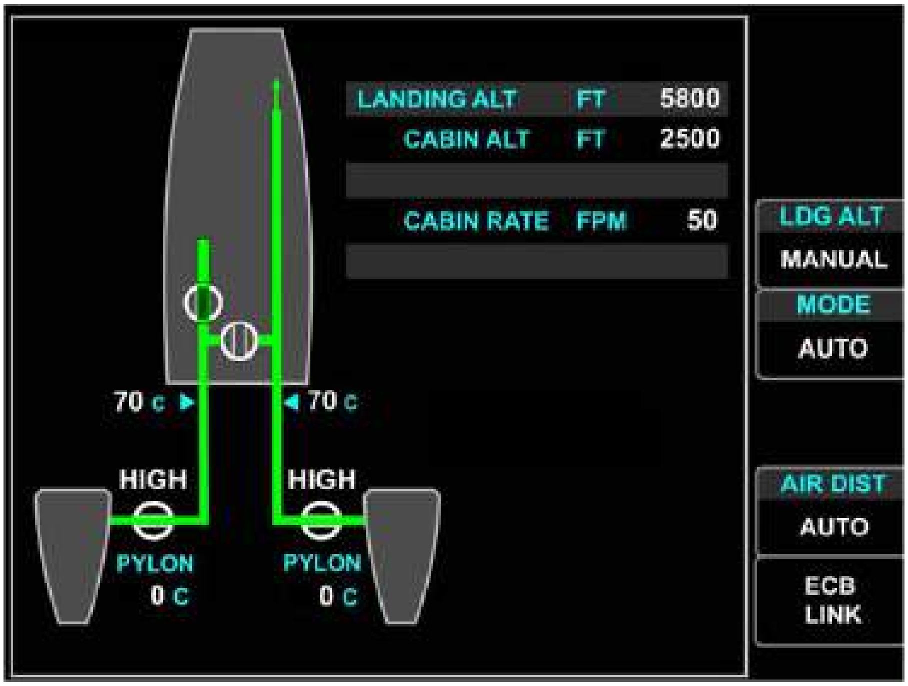

Figure 8-6. Pressurization (PRESS) Synoptic

See Figure 8-6. 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.

Table 8-4. Pressurization Synoptic Indications

Flow Control Valve Setting	Shutoff (closed), HIGH, and LOW Flow
Duct Temperature	Bleed air temperature downstream of the heat exchanger
Isolation Valve	Position of the isolation valve
Cabin Shutoff Valves	Position of the cabin shutoff valve
Pylon Temperature	Temperature in degrees Celsius of the Pylon outside of the heat exchanger

Table 8-5. 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 feet.	
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 COCKPIT ONLY CABIN/COCKPIT	Air distribution controlled by ACS. Air routed to cockpit. Air routed to cabin and cockpit.
ECB LINK	Selects pressurization ECB synoptic page.	

8.5 System Description

8.5.1 Bleed Air Supply System

8.5.1.1 GENERAL

High pressure engine bleed air from the inboard P3 bleed air port is used by the climate control and pressurization system.

Before the bleed air can be used for pressurization and climate control, it must be cooled. Bleed air from both engines are routed through a bleed air heat exchanger and Flow Control Valve (FCV) located in each engine pylon, and then through bleed air muffler ducts to the cabin air distribution system.

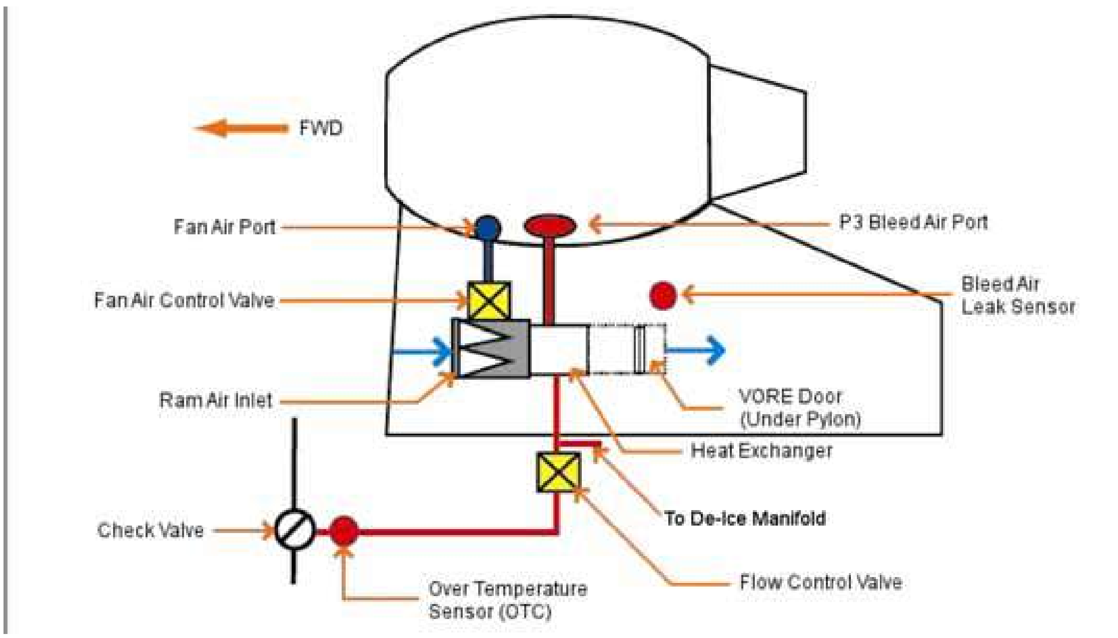

Figure 8-7. Pylon Bleed Air Schematic

- **Pylon Bleed Air Schematic**

  See Figure 8-7. A bleed air heat exchanger located in each pylon regulates bleed air temperature based on the demand for cockpit and cabin heating or cooling.

  Bleed air is hot pressurized air which is tapped off the inboard P3 port. The P3 number stands for that it is the pressure side of the engine at the 3rd station. The bleed air from the P3 port is core engine air at the last stage of compression before being sent into the combustion section. This hot bleed air is passed through an air to air heat exchanger in the pylon. The two sources of relatively cooler air that are passed over the heat exchanger in order to cool the bleed air are ram air and fan air.

  During ground operations, there is insufficient ram air pressure for cooling, so an ACS controlled Fan Air Control Valve (FACV) opens to allow relatively low-pressure, low-temperature bypass air to flow across the heat exchanger.

NOTE:
If the Outside Air Temperature is above 75F (24C) the Air Source Switch should be left to the OFF position before and during taxi to reduce air conditioning load, and alleviate BLEED AIR TEMP HIGH risk during taxi, and the subsequent takeoff and climb out.

During flight operations, the fan air control valve is closed and ram air flows over the heat exchanger through a NACA inlet duct on the top of each engine pylon. The ACS controlled Variable Outlet Ram-air Exhaust (VORE) door and actuator modulates the exhaust flow and, therefore, the amount of air flowing over the heat exchanger to cool the bleed air.

If the VORE door fails, a CLIMATE CTRL FAIL advisory message appears, and degraded bleed air temperature regulation can be expected.

NOTE:
VORE door operation may be verified on the ground with the engines OFF by setting different throttle positions. Full forward throttle should result in a full open VORE door. Care should be taken to place the throttles in the idle position prior to the next engine start.

- **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, 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, a L(R) BLEED AIR TEMP HIGH advisory message appears, and the associated flow control valve closes, and the VORE door will move to the full open position. The ACS will command the opposite side flow control valve to high flow and route the bleed air to the cockpit.

If the opposite side exceeds 85C the Flow Control Valves on both sides would modulate back and forth to retain cabin pressurization while attempting to cool the duct temperature.

If the bleed air temperature exceeds 100°C, the temperature display turns red, an L(R) BLEED AIR OVERHEAT warning message appears, and the associated flow control valve automatically closes, if not already closed.

8.5.1.2 TEMPERATURE SENSOR FAILURE

- Bleed Air

  If the bleed air temperature sensor in the muffler duct fails, an L(R) BLEED AIR TEMP FAULT advisory message appears and the temperature display on the pressurization synoptic page reverts to dashes. Bleed air temperature is then monitored by a temperature sensor in each evaporator assembly. The bleed air temperature limit in this case is 80°C. If this temperature is exceeded, the VORE 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, an L(R) PYLON TEMP FAULT advisory message appears and the temperature display on the pressurization synoptic page reverts to dashes.

8.5.1.3 FLOW CONTROL VALVES

Bleed air downstream of each heat exchanger is routed to ACS-controlled 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 8-6. Flow Control Valve Functions – HIGH/LOW

Low Flow	■ Normal Position ■ Lack of electrical power to the FCV
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 ■ DUMP is selected ON ■ Cabin temperature control falls approximately 7°F below the selected temperature when above a pressure altitude of 12,500 feet **NOTE:** If a zone is selected to 68F the Flow control valve will not go to HIGH with a temperature variance of 7F or more. If high duct temperatures are experienced in HIGH flow 68F should be selected.

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

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

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

8.5.2 Cabin Air Distribution

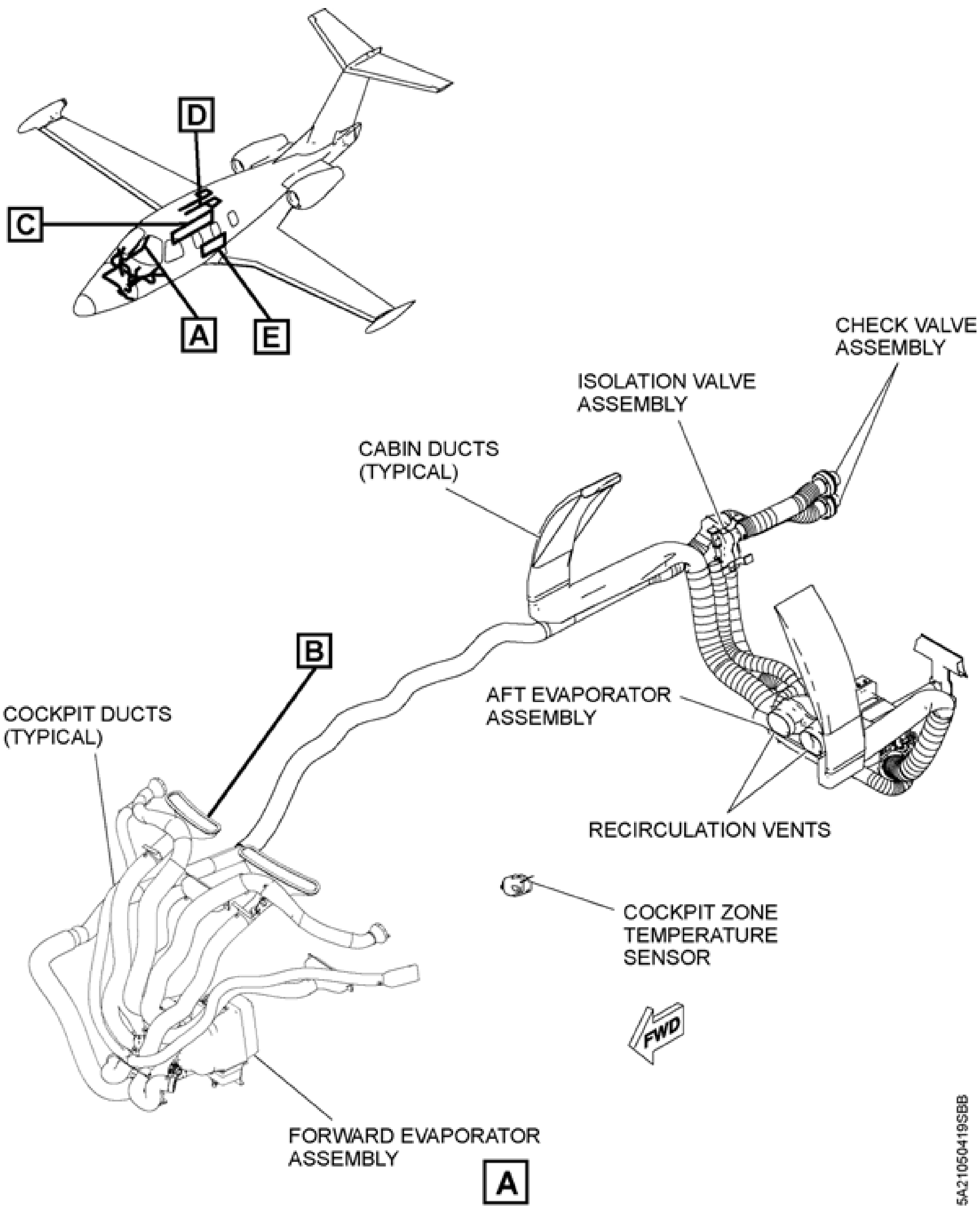

Figure 8-8. Cabin Air Distribution Components (Sheet 1 of 3)

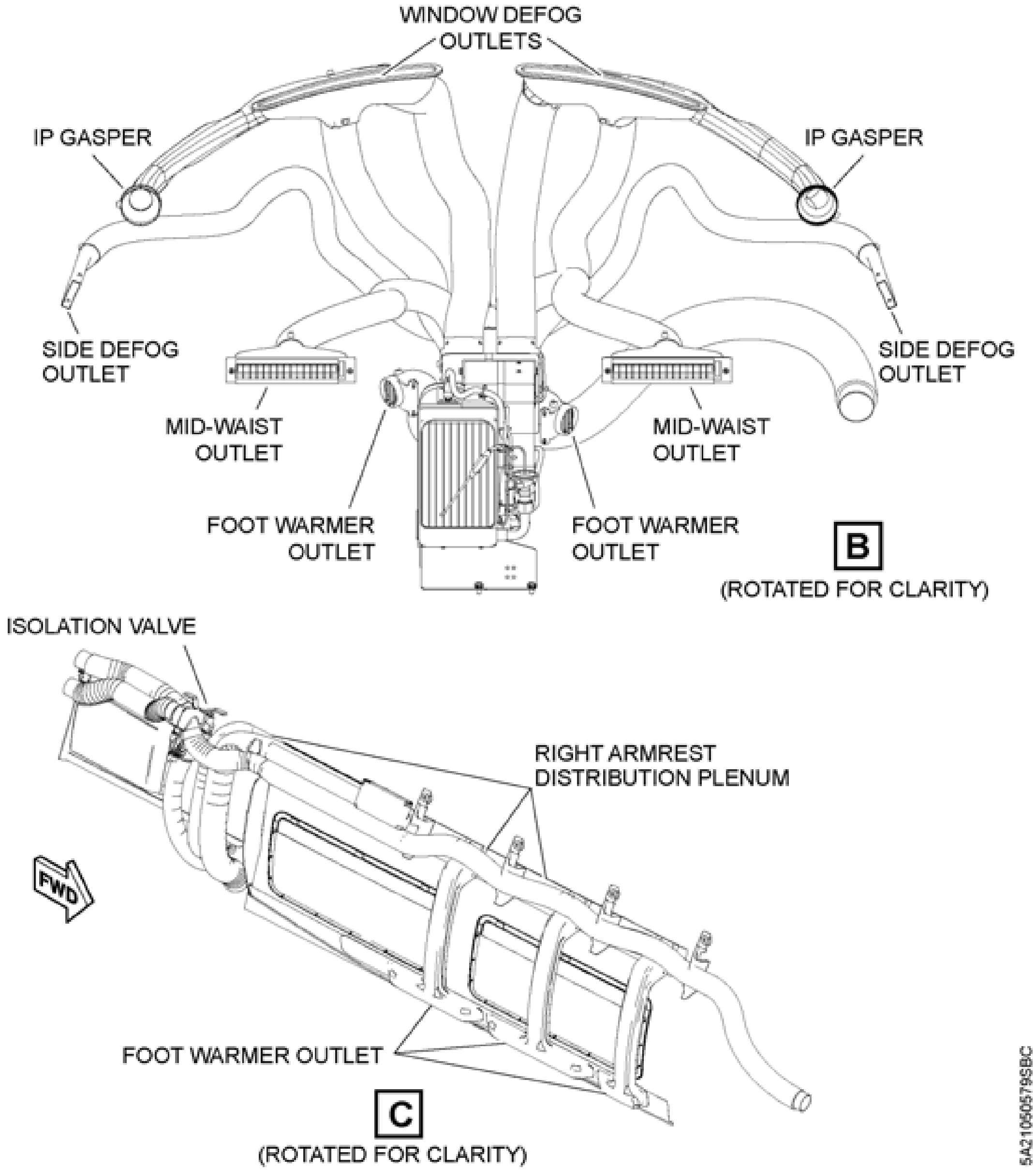

Figure 8-8. Cabin Air Distribution Components (Sheet 2 of 3)

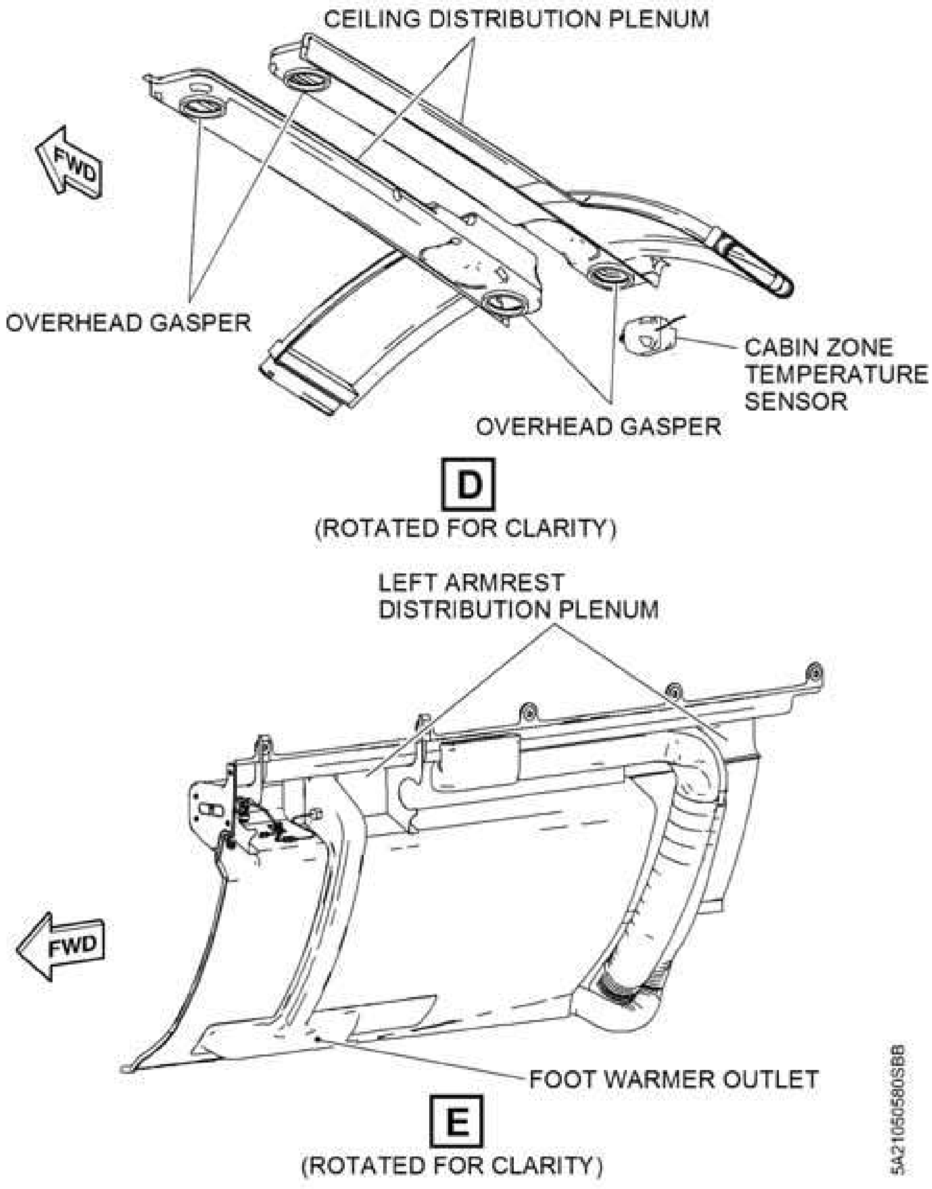

Figure 8-8. Cabin Air Distribution Components (Sheet 3 of 3)

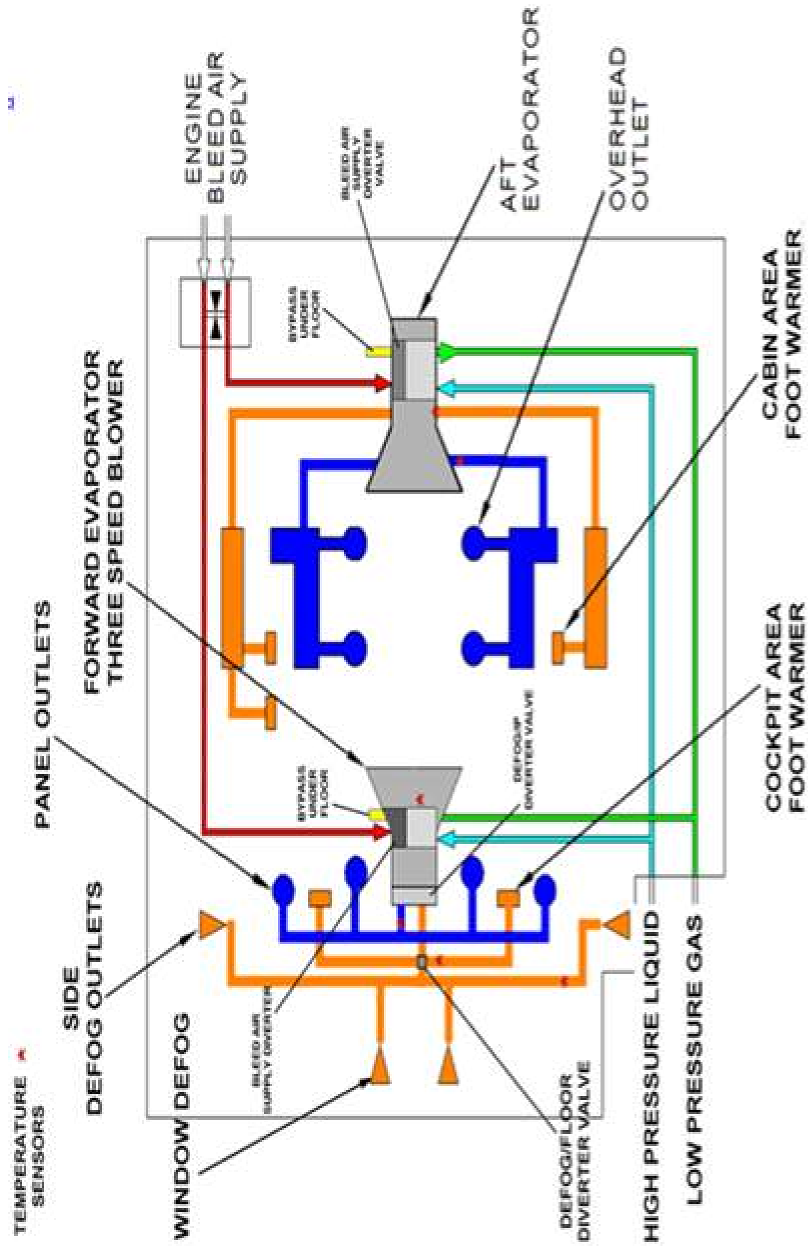

Figure 8-9. Cabin Air Distribution Schematic

8.5.2.1 GENERAL

The cabin air distribution system receives cooling air from the Vapor Cycle System and conditioned bleed air from the bleed air supply system and distributes it to the cockpit and cabin zones through two evaporator assemblies and associated distribution ducts. Cooled air is routed through an upper distribution duct system, while warm bleed air from the evaporators is routed through a lower distribution duct system. Cabin air is either recirculated through evaporator intakes or exits the pressure vessel through the outflow valves.

8.5.2.2 FORWARD EVAPORATOR

See Figure 8-10. The forward evaporator, located behind the throttle quadrant, utilizes a three-speed, 28 volt DC fan to deliver recirculated and/or cooled air from the VCS to the mid-waist vents and the cockpit gaspers, as well as the DEFOG outlets directed at the cockpit windows.

Warm bleed air is supplied to either the foot warmers, bypassed to under the floor, or to the DEFOG outlets directed at the cockpit windows.

Warm bleed air, normally supplied by the right engine enters the forward evaporator and passes through an ACS controlled bleed air diverter valve. This diverter valve is responsible for regulating the use of warm bleed air in the cockpit. If cockpit temperature demand requires very little warm bleed air, the diverter valve allows the bleed air to be diverted under the floor. Air conditioned air is provided separately within the forward evaporator unit by air flowing through the vapor cycle system evaporator coil, then routed through the three-speed blower.

There are two additional diverter valves within the forward evaporator that are responsible for mixing cool, dry VCS air, which has been sped up with the evaporator fan, with warm bleed air, and routing this air to the forward and side cockpit windows for defogging.

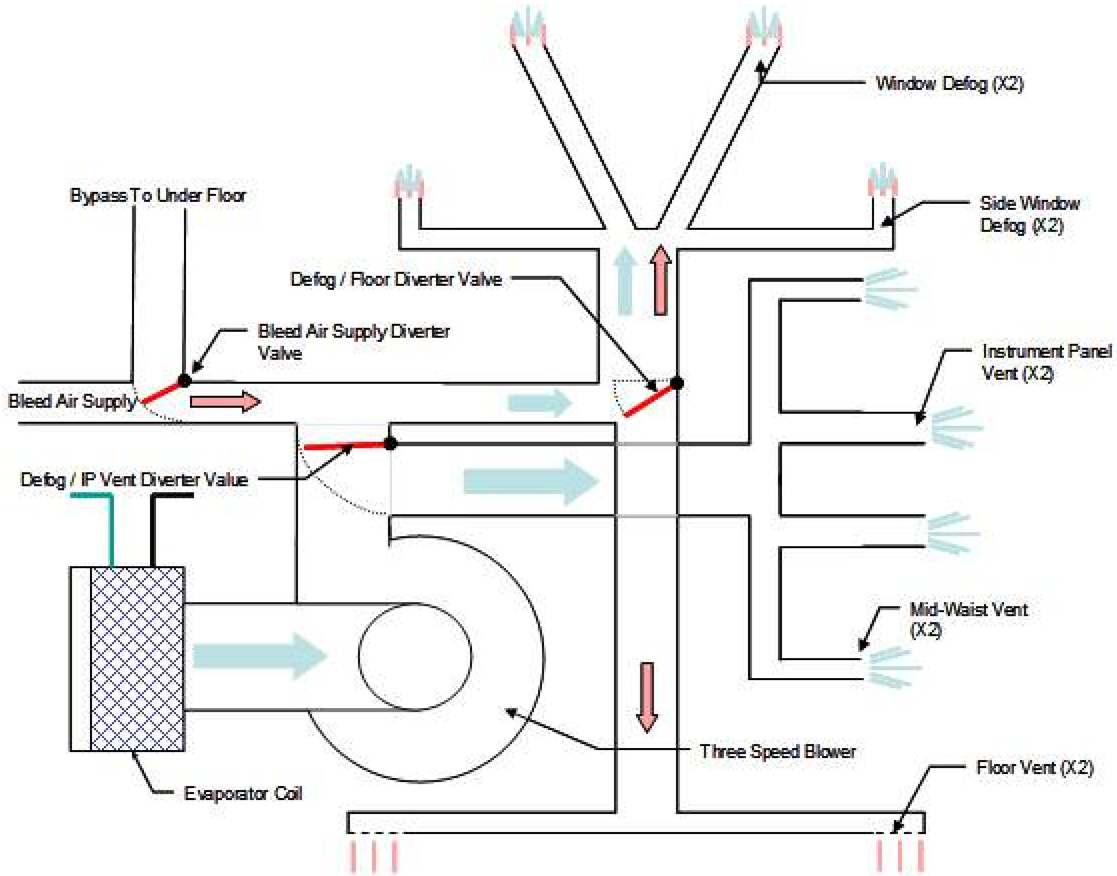

Figure 8-10. Forward Evaporator Schematic

8.5.2.3 AFT EVAPORATOR

See Figure 8-11. The aft evaporator, located under the baggage compartment floor, supplies cooled and recirculated air to overhead gaspers. Two intake vents in the baggage compartment step provide intake air for the evaporator coil. Air is cooled and blown through the overhead gaspers by an ACS controlled three-speed 28VDC fan.

Warm bleed air is normally routed to the aft evaporator from the left engine. Once within the aft evaporator, the warm 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 routed to vents on both sides of the cabin temperature zone, in the sidewall, just above the floor.

NOTE:
Warm bleed air does not mix with cooled and recirculated air in the aft evaporator.

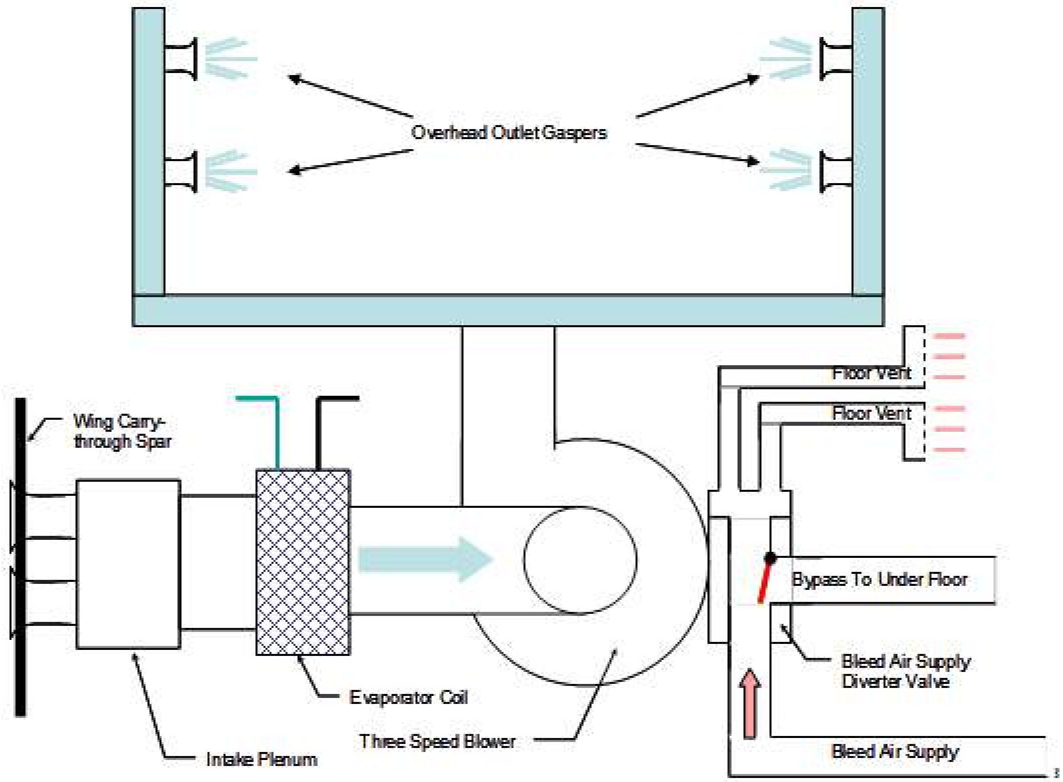

Figure 8-11. AFT Evaporator Schematic

8.5.2.4 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 side of the aircraft in the sidewall above the right seat armrest panel. The cabin sensor is in the aft portion of the overhead "surfboard" panel. In the event a cabin or cockpit temperature sensor failure, white dashes replace the zone temperature on the ENVIR synoptic page.

8.5.2.5 ISOLATION AND CABIN SHUTOFF VALVES

See Figure 8-12. 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 bleed air will be routed to the forward evaporator and prevented from flowing to the aft evaporator through the isolation valve. The left engine's conditioned bleed air will be routed to the aft evaporator through the cabin shutoff valve and prevented from flowing to the cockpit by the isolation valve.

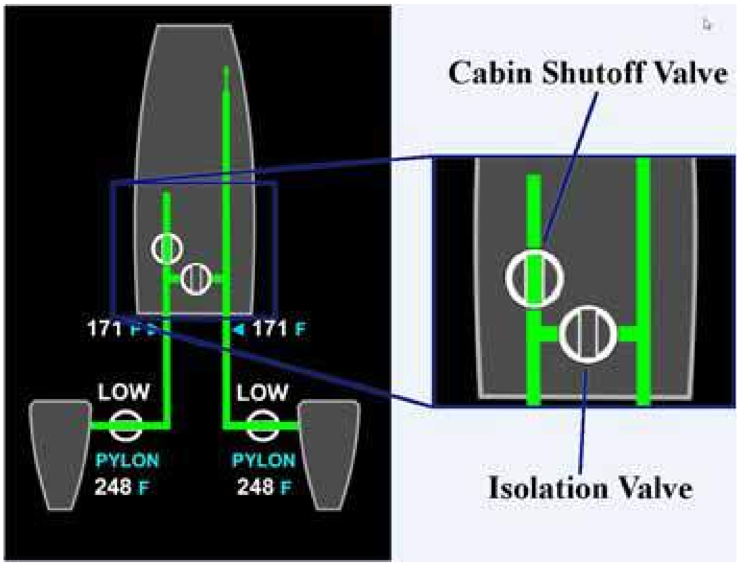

Figure 8-12. Cabin Isolation and Shutoff Valves

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 (PRESS) 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.

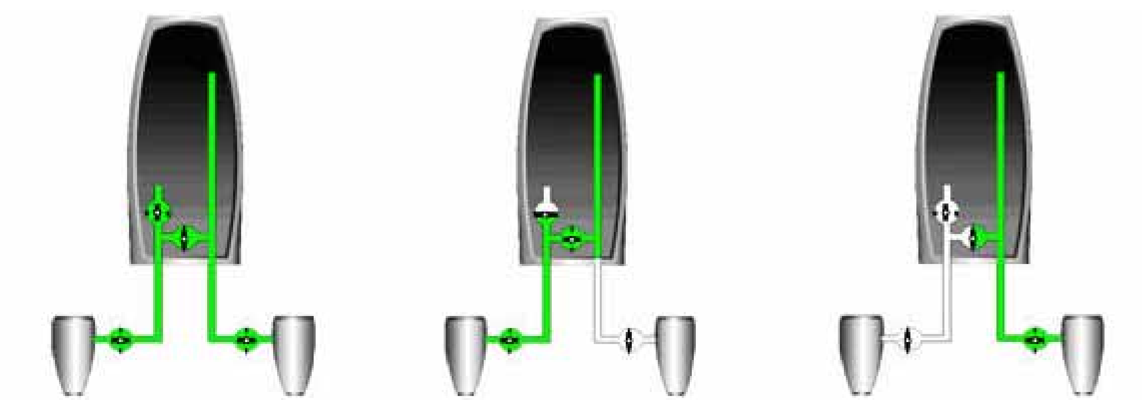

Figure 8-13. Automatic Isolation/Cabin Shutoff Valve Operation

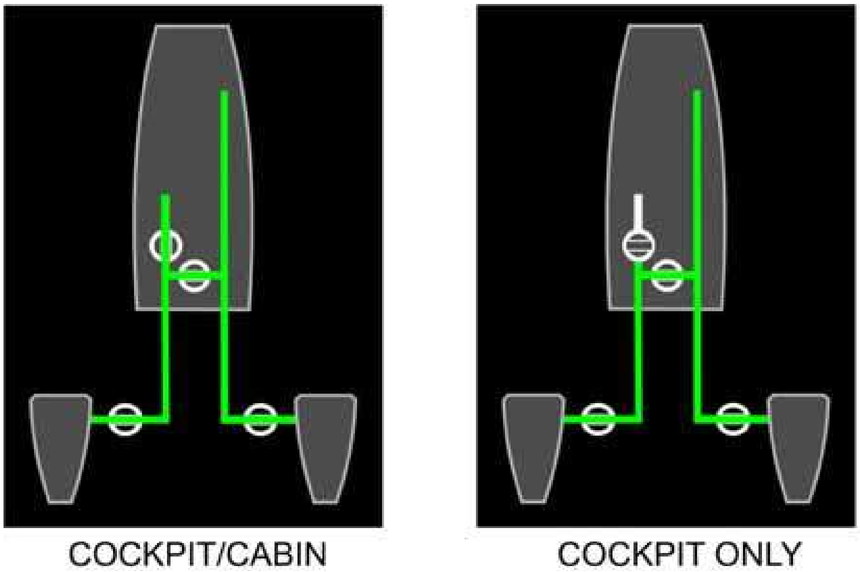

Figure 8-14. Manual Isolation Valve/Cabin Shutoff Valve Operation (AIR DISTR Line Select Key)

NOTE:
When the AIR SOURCE switch is in any position other than AUTO, the AIR DISTR line-select key reverts to the AUTO position.

8.5.3 Vapor Cycle System

8.5.3.1 GENERAL

Cooling and humidity control is provided by the Vapor Cycle System utilizing R-134A refrigerant.

See Figure 8-15. Vapor Cycle System components, which are outside the pressure vessel in the forward equipment bay, include the compressor, the condenser assembly, and associated doors and actuators. The electrically operated compressor pressurizes the refrigerant which, in turn, heats the refrigerant. The condenser is a heat exchanger that cools the pressurized refrigerant using ambient air. Two ACS controlled VCS doors are located on the right side of the aircraft nose. An inward opening condenser inlet door allows intake of the ambient air used for cooling of the pressurized refrigerant in the condenser. After the ambient air is routed over the condenser heat exchanger the warmed ambient air is exhausted through an outward opening outlet door.

Figure 8-15. Condenser Inlet and Exhaust Doors

The pressurized, cooled refrigerant fluid is sent into the pressure vessel and through a receiver-drier which acts as a check valve and accumulator. Then the refrigerant flows through an expansion valve. Depressurizing a cooled fluid leads to a further temperature drop. The cool depressurized refrigerant is passed through the evaporator coil, which is another heat exchanger. Recirculated air from the pressure vessel is routed over the evaporator coil by the evaporator 3-speed 28VDC fan. The air that is passed over the evaporator coil is dehumidified by the cooling action. Accumulated water from the dehumidification process is exhausted below the aircraft in two ports below the evaporators. Cooled air from the evaporators is exhausted out of the gaspers, mid-waist vents, and defog vents in the Cockpit, and the overhead gaspers in the cabin.

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 feet.

In the event that a malfunction of the air conditioning system is detected, an AIR CONDITIONING FAIL advisory message appears.

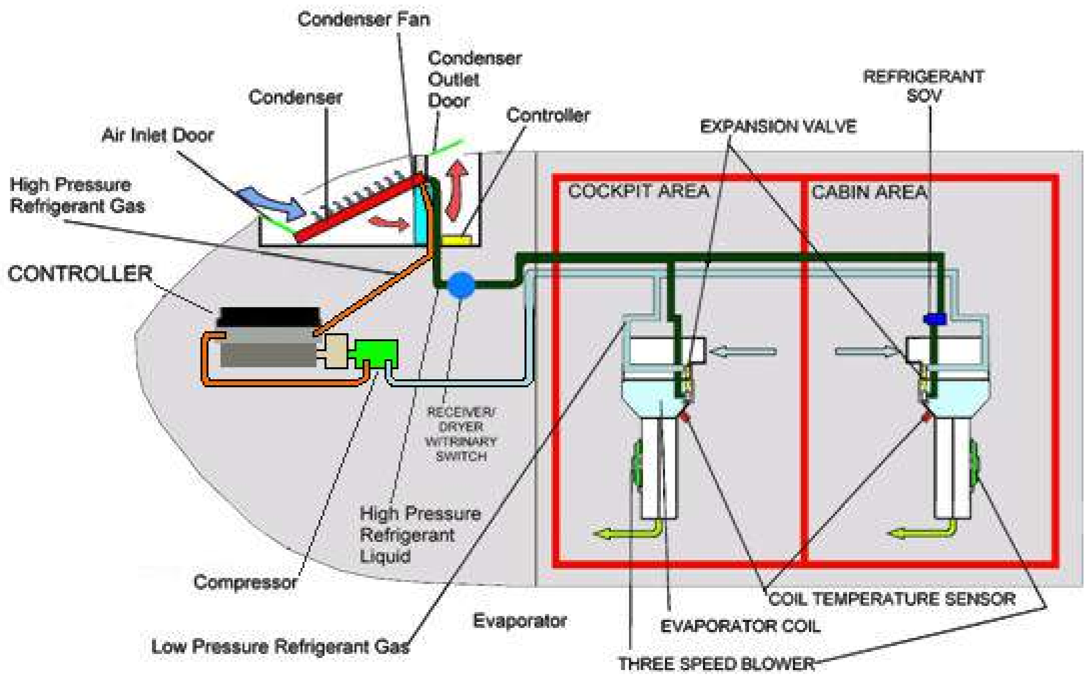

Figure 8-16. Air Conditioning System Schematic

8.5.3.2 AIR CONDITIONING SYSTEM CONTROL

See Figure 8-16. 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

NOTE:
On the environmental synoptic page, the DEHUMID key will only appear with the air conditioning system selected to AUTO.

8.5.3.3 COCKPIT AND CABIN TEMPERATURE CONTROL

Cockpit and cabin temperatures can be separately set in two-degree increments from 18°C/64°F to 29°C/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 is 23°C/72°F.

8.5.3.4 MAXIMUM HEATING

The MAX HEAT setting is designed for rapid heating of the cabin and/or cockpit when required. Selecting MAX HEAT by setting the desired temperature above 29C/84F for the cabin and/or cockpit routes bleed air at the maximum permissible temperature to that zone until the zone temperature reaches the maximum allowed temperature. Once the zone temperature reaches 46°C/115°F, the temperature is modulated to maintain 46°C/115°F.

8.5.3.5 MAXIMUM COOLING

The MAX COOL setting is designed for rapid cooling of the cabin and/or cockpit when required. Selecting MAX COOL by selecting the desired temperature to below 18°C/64°F for the cabin and/or cockpit routes bleed air to the evaporators at the minimum temperature available from the pylon heat exchanger, routes the warm air below the floor, and provides maximum cooling from the VCS. Cold air is supplied to that zone until the zone temperature reaches the minimum allowed temperature. Once the zone temperature reaches 10°C/50°F, the evaporator fan automatically steps to MED or LOW speed to maintain that temperature.

8.5.3.6 COCKPIT AND CABIN EVAPORATOR FAN CONTROL

The cockpit and cabin evaporator fans can be separately adjusted to OFF, AUTO, LOW, MED, or HIGH. With more than battery power, the evaporator fans will turn on in the AUTO state at power up.

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

Cabin/cockpit temperature within 4°C/2°F of selected temperature.................... LOW

Cabin/cockpit temperature within 2°C/4°F of selected temperature ....MED

Cabin/cockpit temperature more than 4°C/7°F above selected temperature.......HIGH

8.5.3.7 WINDSHIELD DEFOG

The DEFOG selection allows the crew to route warm bleed air to the windshield to evaporate condensation on the cockpit windshield and side windows in conjunction with the use of the forward 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, and the dehumidification (DEHUMID) feature is ON.

8.5.3.8 DEHUMIDIFICATION

When DEHUMID is set to ON, humidity is removed from the cabin using the VCS. The default setting at power-up is OFF. When set to ON, the VCS cycles on for one minute, then off for three minutes.

8.5.4 Cabin Pressurization Control System

8.5.4.1 GENERAL

In conjunction with the Bleed Air Supply System (BASS) and the cabin altitude pressure sensor, the cabin pressure control 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 and the amount of bleed air available (engine speed dependent). 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)
- Pressurization static ports

8.5.4.2 OUTFLOW VALVES

See Figure 8-17. The primary and secondary Outflow Valves (OFVs) control pressurization and over- and under-pressure protection by regulating the exhaust flow of air from the cabin into the non-pressurized aft equipment bay. Both outflow valves are located on the aft pressure bulkhead under the cabin baggage compartment floor and equally divide exhaust airflow. The over/under pressurization protection function of the outflow valves does not require electrical power and operates independent of the ACS.

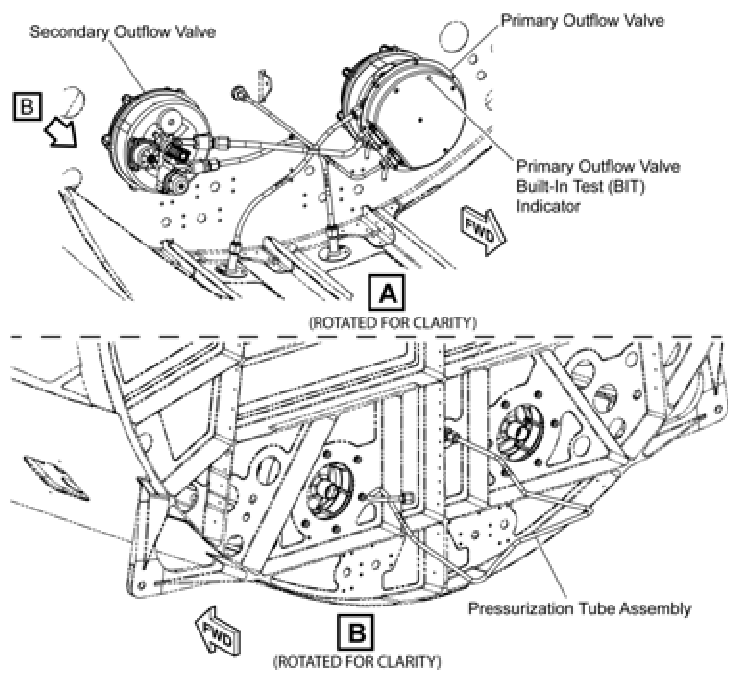

Figure 8-17. Secondary and Primary Outflow Valves

The outflow valves provide three pressure limit functions:

Cabin altitude...13,500 feet ±1,500 feet
Maximum automatically commanded differential pressure.............................8.33 psi
Positive differential pressure.. Primary OFV – 8.6 psi
....Secondary OFV – 8.7 psi
Negative differential pressure..-.05 psi

8.5.4.3 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 parameters included in the chart below:

Table 8-7. Automatic Control of Cabin Pressure

Airplane Altitude	Cabin Altitude	Differential Pressure
41,000 feet	8,000 feet	8.33
20,000 feet	2,500 feet	6.8
3,000 feet	Sea Level	1.3

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

☞ **IMPORTANT:**
When MANUAL mode is selected, the window and selection of the landing altitude (LDG ALT) are removed. The pilot is responsible for continuous update of the cabin altitude and rate of climb or descent.

The CABIN ALT HOLD mode maintains the present cabin pressure altitude. When manually selected by the pilot, a CABIN ALT HOLD MODE status message appears and white text, CABIN ALT HOLD, appears on the Pressurization synoptic page.

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

If the cabin differential pressure is exceeded, a CABIN dP HIGH warning message appears. The air source switch will need to be manipulated to manually control the input of bleed air since the outflow valves are not allowing the air to escape effectively.

If the cabin remains 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.

8.5.4.4 DUMP SWITCH

See Figure 8-18. The pilot can release the cabin pressure to ambient pressure in the event of over-pressurization (CABIN dP HIGH), cabin smoke or fumes, or in the event of ground pressurization (CABIN PRESS ON GROUND). With the DUMP switch ON, both outflow valves open fully and all bleed air is routed to the cockpit at high flow. A CABIN DUMP text also appears on the left side of the pressurization synoptic; see Figure 8-19.

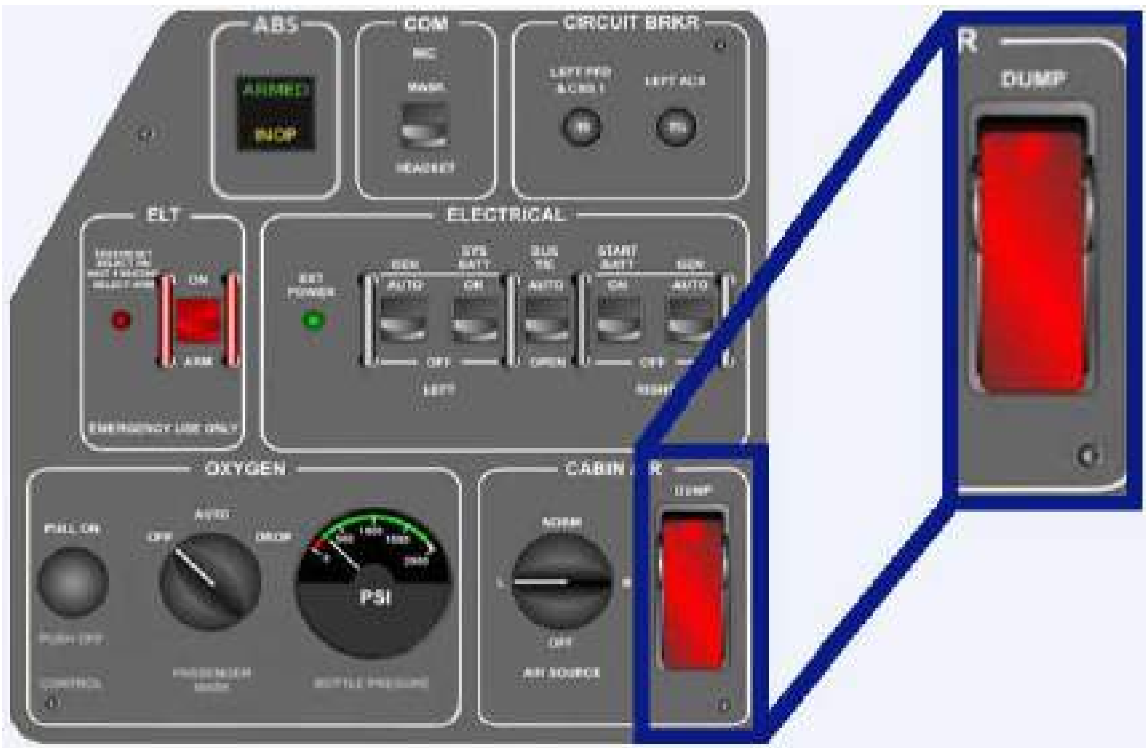

Figure 8-18. Cabin DUMP Switch

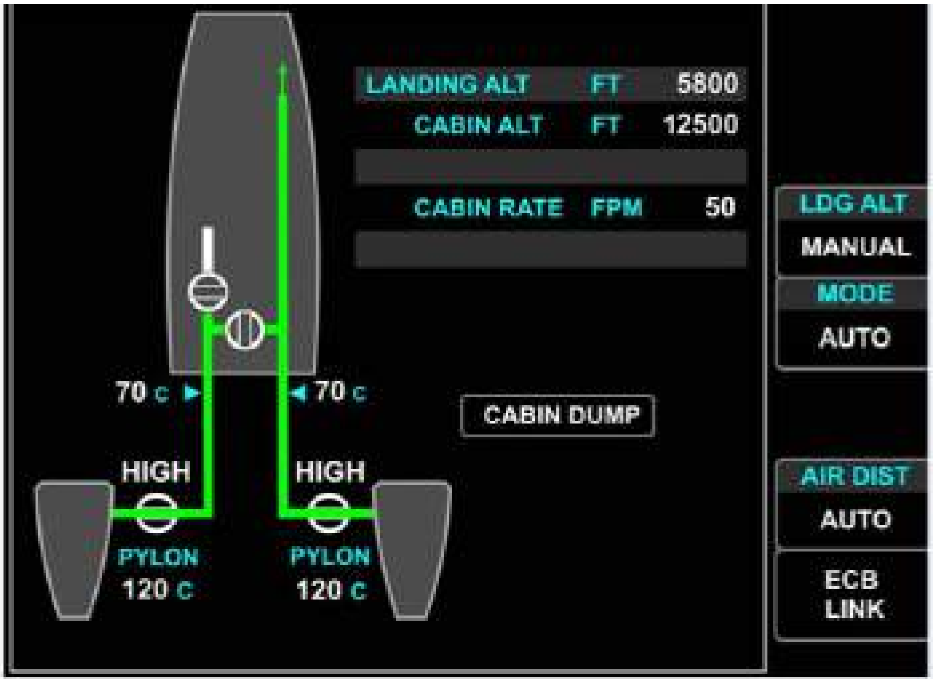

Figure 8-19.   Cabin Dump – PRESS Synoptic

NOTE:
The cabin DUMP switch dumps the cabin to 13,500 ft ±1,500 feet.

8.5.4.5 SMOKE CLEARING

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

8.6 Abnormal Procedures

8.6.1 Cold Weather Operations (Temperature Sensor Indications)

In the event that the aircraft cabin has become cold soaked to -25°C/-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 an alternate mode of operation for cold temperatures. Once the engines are started and warm bleed air warms the system, the ACS will stop displaying sensor failures and temperature regulation will resume to normal.

8.6.2 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.

8.7 Crew Alerting System Messages

Table 8-8. Climate Control System CAS Messages

Message	Condition	Category
CABIN ALTITUDE	Cabin altitude environment has exceeded 10,000 feet.	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 feet.	Caution
CABIN PRESS ON GROUND	Cabin is pressurized on the ground.	Caution
L(R) BLEED VALVE FAIL	Bleed air valve has not reached commanded position.	Advisory
CABIN ALT HOLD MODE	Primary pressurization failed. Backup controller attempting to hold cabin altitude constant.	Advisory
AIR CONDITIONING FAIL	Vapor Cycle System has failed.	Advisory
L(R) BLEED AIR TEMP HIGH	Bleed air supply temperature is above 85°C. 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 Variable Outlet Ram-air Exhaust door. 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

8.8 Climate Control Review Questions

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

   a.

   b.

   c.

   d.

2. **What does a CABIN ALTITUDE warning message indicate?**

   a. A loss of cabin pressure resulting in a cabin altitude greater than 10,000 feet
   b. Cabin over-pressurization
   c. Failure of the bleed air supply system
   d. None of the above

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 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

7. **How does the Bleed Air Supply System (BASS) cool the engine bleed air prior to use in the cabin?**

    a. Pylon-mounted heat exchanger unit uses ram or fan air to the cool bleed air.

    b. Air/fuel heat exchangers cool the bleed air.

    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 ensure 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 and 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

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 550 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
b. Both engines will send air equally 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 (BASS)
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

15. What is the purpose of the outflow valves?

a. The outflow valves are an integral part of the air conditioning system because 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.

Electrical Distribution

9

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Electrical Distribution

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9.1 General

The Eclipse 550 electrical power distribution system is a split-bus DC system, powered by two starter/generators driven by the engine's accessory gearbox, which produce up to 200 amps at 30VDC, regulated to 28.5VDC.

Circuit protection is provided by 127 Electronic Circuit Breakers (ECBs) in conjunction with two mechanical circuit breakers on the instrument panel left and the four mechanical circuit breakers in each of the pilot arm rest panels. 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. Additionally, the use of the more reliable ACS-controlled ECBs reduces pilot workload.

There are two 22 amp hour, 24 VDC, sealed lead-acid batteries located in the nose compartment of the aircraft. A start battery and systems battery provide aircraft power when the generators are not supplying the electrical power. When the generators (or external power) are supplying electrical power the batteries float on electrical buses to reduce voltage transients.

A 28 volt DC external power receptacle is located on the lower right aft fuselage. The pilot can monitor the electrical system using the electrical synoptic page, and configure the system using the switches on the instrument panel left.

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 5-minute timer to avoid depleting the batteries.

9.2 Aircraft Computer System (ACS) Interfaces

See Figure 9-1. The electrical system is automatically controlled by the Aircraft Computer System (ACS) during normal operation. The start and system battery contactors have no direct interface with the ACS, but are directly controlled by the pilot through two switches on the instrument panel left.

Based on pilot commands (engine ON/START, OFF, generators OFF, AUTO) or generator status (both operational, one inoperative, both inoperative), the ACS automatically configures the electrical system as well as activates and deactivates Electronic Circuit Breakers (ECBs) for various systems components. Although the ACS commands the auto-on and auto-off functions of the 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, and ECB status.

The ACS commands and receives status information for the following electrical system components:

- Battery bus contactor (systems battery)
- Start battery contactor
- Start battery heater
- Systems battery heater
- External power contactor
- Left Generator Control Unit (GCU) and contactor
- Right GCU and contactor
- Forward power distribution center:
  - Electronic Circuit Breaker Units (ECBUs) 1, 2, and 3
  - Left battery bus contactor
  - Right battery bus contactor
  - Battery bus
  - Left forward bus
  - Right forward bus
- Aft power distribution center:
  - Electronic Circuit Breaker Units (ECBUs) 4 and 5
  - Bus Tie Contactor (BTC)
  - Left forward circuit breaker/contactor
  - Right forward circuit breaker/contactor
  - Left aft bus
  - Right aft bus

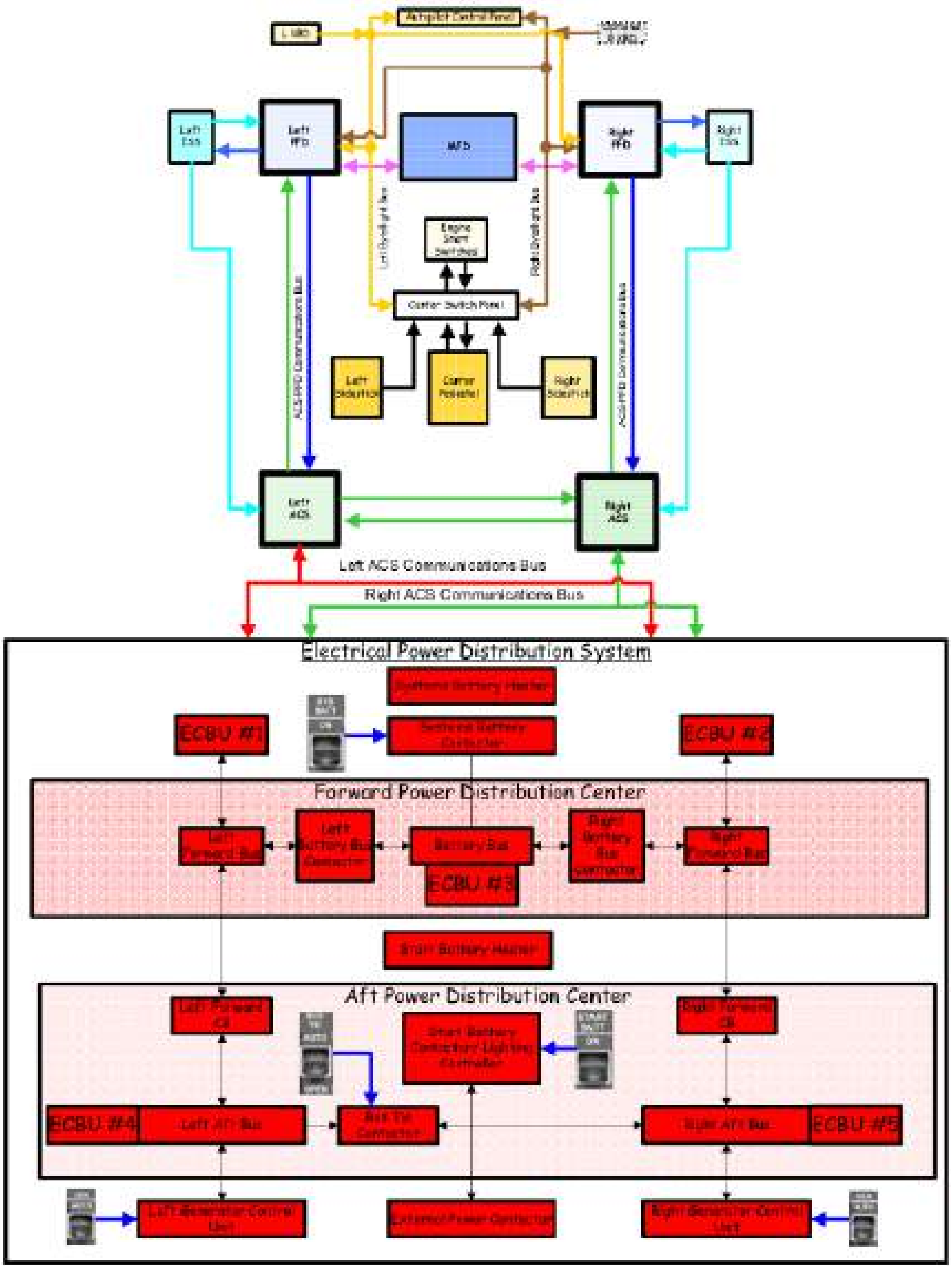


Figure 9-1. Electrical Power Distribution – ACS Interfaces

9.3 Limitations and Specifications

9.3.1 Battery Limitations

Flight is not permitted if the aircraft batteries are stored at temperatures colder than -15°C (5°F).

During Ground-Idle operations with the air conditioning system operating, the Start Battery may discharge (yellow Start Battery outline on synoptic page). If this occurs, the right engine speed (N2%) must be set between 52-54% to ensure reserve battery power.

NOTE:
If the Start Battery is still discharging at this setting, this must be reported to maintenance personnel.

9.3.2 Generator Limitations

VCS operation is not allowed until start battery charging current is less than 25 Amps as seen on Elect. synoptic page (START BATT +25A).

Ground .... 100 Amps at Sea Level with a straight line taper to 185 Amps at 3000 ft Pressure Altitude.

Flight up to 35,000 ft: ....185 Amps

Flight above 35,000 ft:..150 Amps.

Short duration transients above these limits are allowed for engine starting and battery charging after engine start.

NOTE:
185 Amps Generator Draw is possible whenever Engine N2 is 52% or above.

9.3.3 Electronic Circuit Breakers (ECB)

ECBs for equipment options not installed must be collared for flight if the ECBs are displayed on the ECB page. Installed equipment is listed on the SETUP, SETTINGS, INSTALLED EQUIPMENT page.

9.4 Controls and Indicators

9.4.1 Electrical Switches

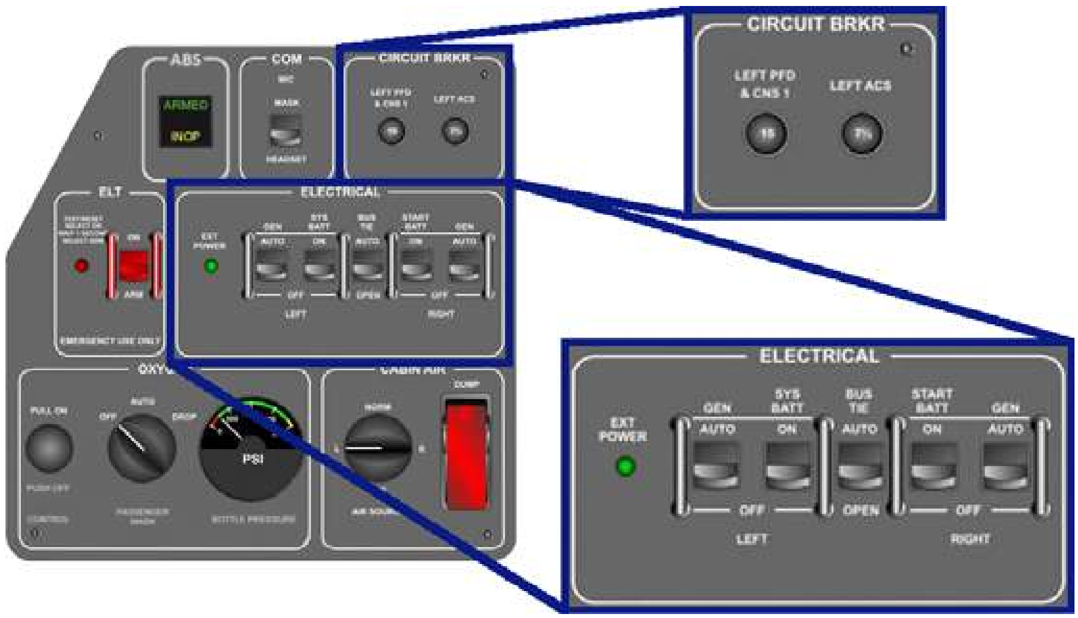


Figure 9-2. Electrical Switches

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 (BTC) under ACS control
- OPEN .... Bus tie contactor open

EXT POWER .... Green LED indicates external power is connected .... and the correct polarity and voltage is within limits

LEFT PFD & CNS 1 .... Mechanical circuit breaker for left PFD as well as .... Comm, NAV, and Surveillance 1.

LEFT ACS .... Mechanical circuit breaker for left ACS

9.4.2 Electrical Synoptic

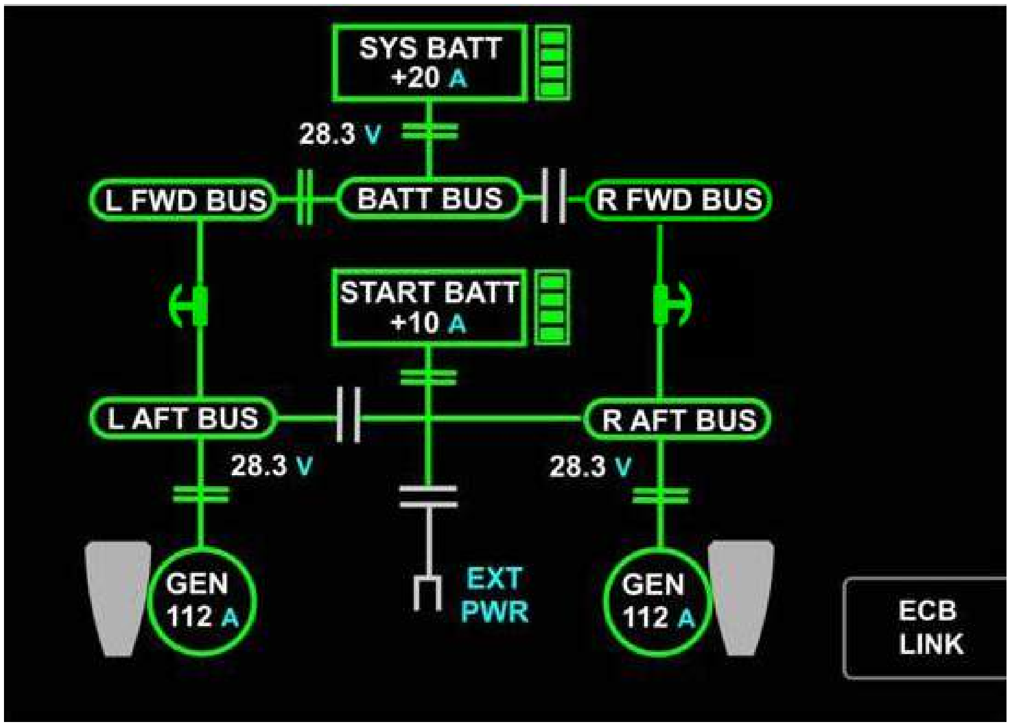


Figure 9-3. Electrical Synoptic

The above 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 offline

BUS BAR

- Bus bar segments are green if voltage is greater than 20 volts.
- Bus bar segments are white if voltage is 20 volts or less.

BATTERY OUTLINE

Green .... Battery charging
Amber .... Battery discharging
White .... Battery contactor open (no power to or from offline)

BATTERY VERTICAL RIBBON

Vertical ribbon to right of batteries indicates state of battery charge in volts as shown in Figure 9-4.

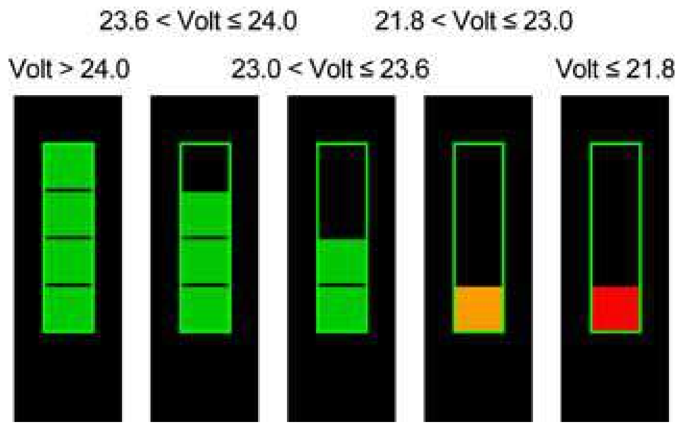


Figure 9-4. Battery State Display

9.4.3 Electronic Circuit Breaker (ECB) Synoptic

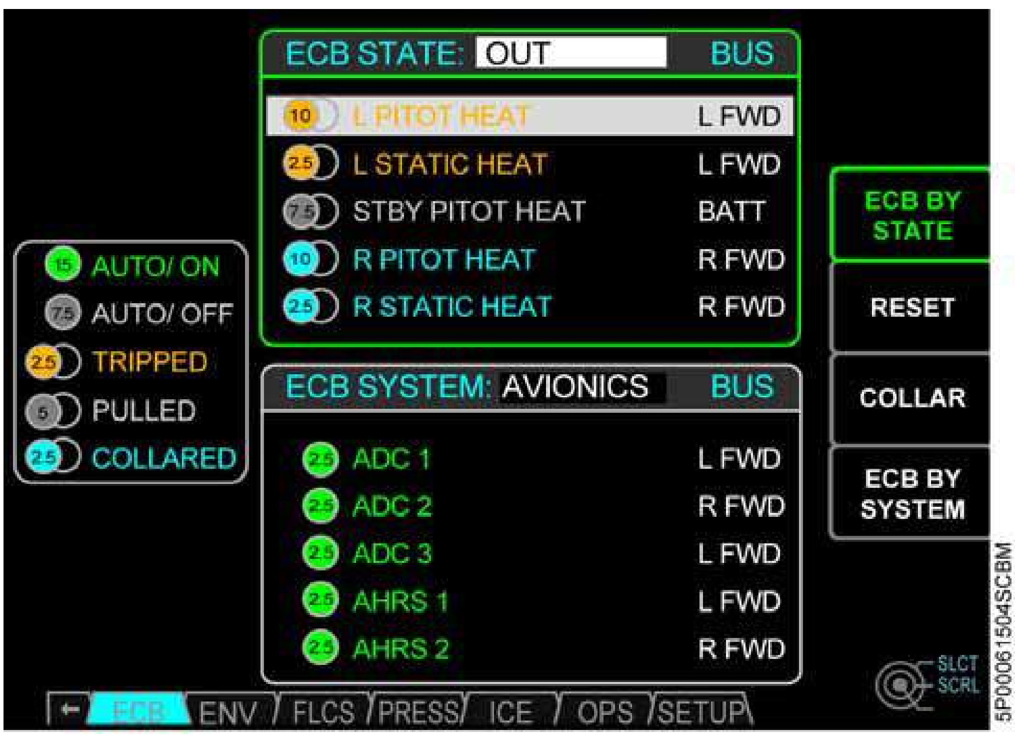


Figure 9-5. Electronic Circuit Breaker (ECB) Synoptic

See Figure 9-5. 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.

Table 9-1. 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 tripped due to circuit fault	Amber
PULLED	ECB pulled by the pilot	Gray
COLLARED	ECB pulled and locked out	White outline/cyan interior
– – –	Loss of communication with ECB. ECB cannot be controlled.	Red dashes (– – –)

9.5 System Description

9.5.1 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 Generator Control Units (GCUs).

The starter/generators serve as electric starter motors for the engines. During engine start, the GCU uses Direct Current (DC) power from the start battery alone, or the start battery power is paralleled with an operating generator or external power. This power is used to drive the starter/generator as a motor. The resulting mechanical torque is applied through the engine's accessory gearbox and a towershaft connected to the N2 shaft to start the engine. Once the engine is started N2 rotation, through the gearbox rotates the Starter/Generator to produce electrical power.

Either starter/generator can supply power for the entire airplane, with the exception of the vapor cycle system (the air conditioning compressor is load shed during single generator operation).

9.5.2 Generator Control Units (GCUs)

The left and right Generator Control Units (GCUs) are located behind the aft pressure bulkhead; they control the starter/generators. With the generator electrical switches configured in the AUTO position, the GCUs automatically switch from the start mode to generator mode. The starter is disengaged when engine N2 reaches 40% and is reengaged as a generator when N2 reaches ground idle. The GCUs then 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-voltage and under-voltage from the Starter Generators
- Reverse current
- Overspeed
- Open ground

9.5.3 Batteries

Two identical 24 volt DC, 22 amp-hour, sealed lead-acid batteries are located in the nose compartment outside the pressure vessel. Both batteries are charged when the generators are operating. In order to charge both batteries when external power is connected, the SYS BATT and START BATT switches must be set to ON, and the BUS TIE switch set to AUTO.

In the event of a loss of both starter/generators and/or GCUs, the two batteries provide a minimum of 60 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.

9.5.3.1 SYSTEMS BATTERY

During normal operation, the systems battery is connected to the left side of the electrical system (Battery Bus, Left Forward Bus, and Left Aft Bus). During engine start, the forward buses are automatically isolated from the aft buses by the forward/rear electronic circuit breaker (FRECB). The right battery bus contactor closes, so that the systems battery powers the forward buses, which contain equipment like the FADEC and avionics. Isolating the forward buses avoids exposing these systems to the voltage spikes caused by high starting currents.

9.5.3.2 START BATTERY

During normal operation, the start battery is connected to the right electrical buses (Right Aft Bus and the Right Forward Bus) through the start battery contactor.
The start battery is also connected to the hot battery bus, which supplies power for equipment that may be operated without either of the battery switches turned ON.

The start battery supplies power for engine starting either by itself or in parallel with external power if connected. With one engine running, the start battery supplies power in parallel with the generator to start the second engine.

9.5.3.3 BATTERY HEATER PAD

To assure a 60-minute BATTERY POWER ONLY electrical supply, 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 left ACS monitors temperatures in the heater pads and forwards it to the right ACS. Both ACSs turn on power to the battery heater when the Outside Air Temperature (OAT) falls below 10°C, and the aircraft is powered by a generator or Ground Power Unit (GPU). The ACSs cycle the battery heaters to regulate the battery temperature between 70° and 80°.

Failure of a battery heater pad could shorten battery-only operation time to less than 60 minutes. If a battery heater pad fails, it is indicated with the appearance of a BATT HEATER FAIL advisory message.

9.5.4 External Power

A 28-volt DC external power receptacle is located on the lower right aft fuselage. External power automatically powers the airplane when the SYSTEM and START BATT switches are set to ON, the BUS TIE switch is set to AUTO, and the power is the correct polarity and voltage.

9.5.4.1 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.

9.5.4.2 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.
- The Bus Tie switch is in the AUTO position.

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 400 amps.
- External power current draw from aircraft greater than 5 amps .
- Less than 24 volts for longer than 45 seconds.
- Less than 10 volts at any time.
- When generator power is available after engine start.

9.5.5 Electrical Buses

There are two battery buses and four equipment buses.

9.5.5.1 BATTERY BUSES

- **Hot Battery Bus**
  The hot battery bus is connected to the start battery and is powered at all times. It provides power for the cockpit dome light and the baggage compartment light when the battery switches are OFF. These lights are on timers and, depending on the light, automatically deactivate five minutes after activation 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 & Communication, Navigation, Surveillance (CNS1), and the LEFT ACS through two mechanical circuit breakers on the instrument panel left. 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.

9.5.5.2 EQUIPMENT BUSES

Four equipment buses, left and right forward and left and right aft, supply power for the aircraft systems. During normal operation, the ACS divides the buses into a left/ right configuration. The left forward and left aft buses receive power from the left generator and the systems battery. The right forward and right aft buses receive power from the right generator and start battery.

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 appears:

- L AFT BUS VOLTAGE LOW
- R AFT BUS VOLTAGE LOW
- L FWD BUS VOLTAGE LOW
- R FWD BUS VOLTAGE LOW

9.5.5.3 BUS TIE CONTACTOR (BTC)

The Bus Tie Contactor (BTC) electrically ties together or isolates the left and right aft buses. The BTC 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 BTC; however, it can be manually opened by placing the BUS TIE switch in the OPEN position. If the BTC becomes 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:

- Left or Right GENERATOR OFFLINE
- BATTERY POWER ONLY
- External Power contactor closed
- Engine Start

All aircraft buses are powered in the above situations. When operating on a single generator or external power, both batteries are charging.

The status of the BUS TIE contactor is displayed on the electrical synoptic.

9.5.6 Circuit Protection

Electrical components and wiring are protected by load shedding, contactors, mechanical circuit breakers, and ECBs. The ACS monitors currents on the various buses so that any faults are detected. Faults 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-voltage and under-voltage protection is also provided for the starter/generators and external power contactor.

9.5.6.1 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 continues to operate on battery power. When this occurs, the ACS sheds electrical equipment to provide 60 minutes of electrical power to those loads that are essential to continued safe flight and landing. This state is called BATTERY POWER ONLY load shed. When BATTERY POWER ONLY load shed occurs, the ACS automatically sheds non-essential ECBs. Load shed ECBs appear as PULLED on the ECB synoptic page.

9.5.6.2 SMART LOAD SHED

A sub-function of BATTERY POWER ONLY load shed is smart load shed. Smart load shed functionality is specifically related to the air data system and Integrated Sensor Suites (ISS).

If both generators become inoperative with both of the ISS fully operative, the ACS pulls the ECBs for the ISS and components that it determines to be the least accurate at the time. Such components include the following:

- Left and right Attitude Heading and Reference Systems (AHRS)
- Left and right Air Data Computers (ADC)
- Left and Right Angle of Attack (AOA) processors
- Left and right GPS
- Left and right Pitot/AOA heat

9.5.6.3 CONTACTORS

Ten contactors connect various components of the electrical system. The contactors are as follows:

- System battery contactor
- Left battery bus contactor
- Right battery bus contactor
- Start battery contactor and lighting controller
- Bus Tie Contactor
- Left generator contactor
- Right generator contactor
- External power contactor
- Left Forward/Rear ECB (FRECB) contactor
- Right Forward/Rear ECB (FRECB) contactor

Operation of the left and right generator, system battery, start battery, and bus tie contactors is controlled with corresponding switches on the instrument panel left.

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.

9.5.6.4 START BATTERY CONTACTOR AND LIGHTING CONTROLLER

The start battery contactor and lighting controller is a unit that houses the following electrical components:

- Start battery contactor
- Hot battery bus
- Interior lighting controller
- 125-amp fuse for the vapor cycle system

In addition to housing the start battery contactor and the 125 amp fuse for the vapor cycle system, the start battery contactor and lighting controller also house the hot battery bus which is responsible for providing power to the cockpit dome and baggage lights with the battery switches off. The lighting controller regulates the power to the cockpit dome and baggage light with an internal timer. These lights will be deactivated 5 minutes after activation. Once the START BATT switch is placed in the ON position, the light controller also controls lighting to interior lights including the upper and lower cabin wash, etc.

9.5.6.5 MECHANICAL CIRCUIT BREAKERS

See Figure 9-6. Power is provided through mechanical circuit breakers on the left switch panel to the LEFT PFD & CNS1 and LEFT ACS. Mechanical circuit breakers in each of the pilot's armrest panels protect the PFDs and the Communications, Navigation and Surveillance system.

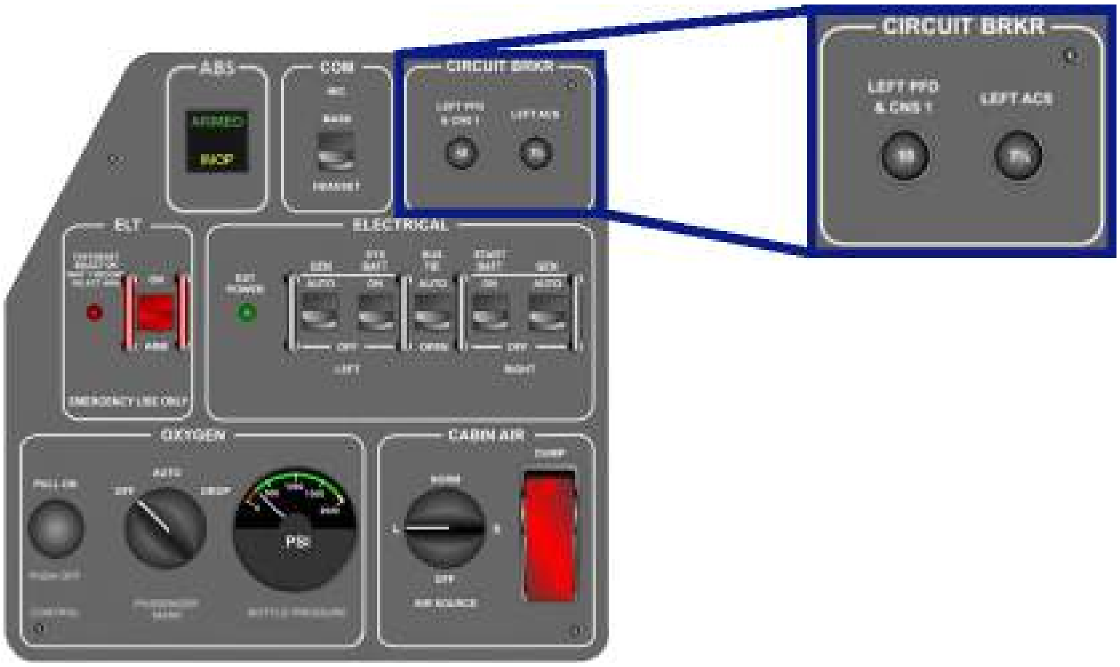


Figure 9-6. Mechanical Circuit Breaker Location

9.5.6.6 ELECTRONIC CIRCUIT BREAKERS (ECBs)

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 electrical components.

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 with 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
- COLLARED - ECB locked out by a maintenance technician
- "– – –" - Loss of communication with ECB. ECB cannot be controlled.

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 it can be reset by the pilot if appropriate. If an ECB is pulled by the pilot, the ACS cannot close it. If an ECB labeled COLLARED is locked out by maintenance, it 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. If the prior state of an ECB was TRIPPED, PULLED, or COLLARED, the prior state of each ECB is restored once the aircraft is powered 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 unable to be switched off, an ECB CTRL FAULT advisory message appears.

9.5.6.7 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 buses.

The forward power distribution center is comprised of the following:

- ECBU 1, 2, and 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 APC 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.

The aft power distribution center is comprised of the following:

- Left side
  - Left Forward/Rear ECB (FRECB) contactor
  - Left aft bus
  - ECBU #4
  - Bus Tie Contactor
- Right side
  - Forward/Rear ECB (FRECB) contactor
  - Right aft bus
  - ECBU 5

9.6 Normal Operation

9.6.1 Ground Operation

9.6.1.1 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.

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 limited to prevent battery depletion.

When the start or system battery is discharging, a START or SYS BATT DISCHARGE caution message appears.

9.6.1.2 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. In order to charge the System and Start Battery, both battery switches must be in the ON position and the BUS TIE switch must be in the AUTO position.

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.

NOTES:

- The state of the EXT POWER light does not indicate battery charging. Battery charging information can be obtained from the ELEC synoptic and CAS messages.
- Before Starting with external power, the status of the batteries without external power should be ascertained. Starting with an insufficient START battery may cause a ENG START ABORT. Starting with an insufficient SYSTEMS battery may result in an ACS and or FADEC failure.

9.6.2 Engine Start

9.6.2.1 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/Rear Electronic Circuit Breaker (FRECB) contactors and closing the right battery bus contactor and bus tie contactor. In this configuration, the systems battery powers the avionics components on the left forward, right forward, and battery bus to protect them from voltage spikes on the aft buses due to high starter current. Power from the start battery and external power is supplied to the left and right aft buses as well as the hot battery bus. The power is routed form the left or right aft bus through the Generator Control Unit (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 FRECBs close, the right battery bus contactor opens, disconnecting the systems battery from the right forward bus. The Bus Tie Contactor (BTC) remains closed to power both aft buses through the operating generator. If external power is being used, the External Power Contactor (EPC) also opens to prevent reverse current flow.

9.6.2.2 ONE ENGINE RUNNING

See Figure 9-7. With one engine running and the generator delivering electrical power, the second engine may be started using the start battery power in parallel with the operating generator. The ACS separates the electrical system into a forward/aft configuration again by opening both left and right FRECBs and closing the right battery bus contactor and bus tie contactor. The system battery powers the forward buses, and the Start battery in conjunction with the operating generator powers the aft buses.

If desired, the second engine start can be made using the start battery paralleled with external power. To do this, the pilot turns off the GEN switch for the operating engine to allow the external power contactor to close.

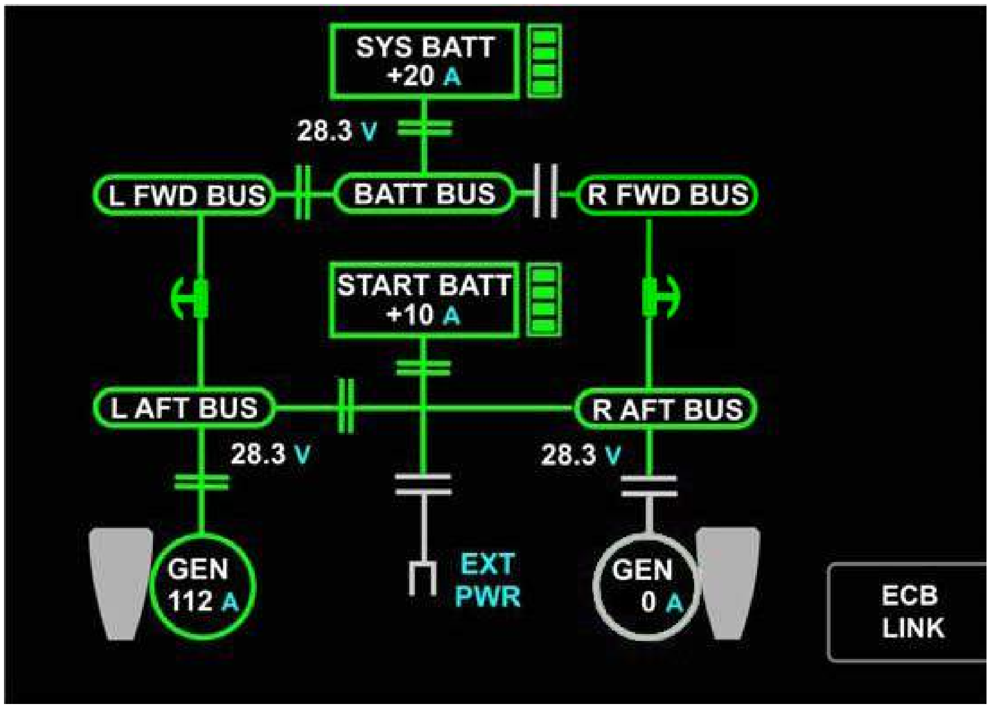


Figure 9-7. Electrical Synoptic with One Engine Running

9.6.2.3 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 side of the system (L AFT, L FWD, BATT BUS) is powered by the left generator and the systems battery. The right side of the system (R AFT, R FWD, hot battery bus) is powered by the right generator and the start battery.

9.6.2.4 AIR-GROUND LOGIC

The ACS uses the current status of the aircraft (on-ground or in-flight, as determined through the Weight on Wheels (WOW) sensor) to determine the appropriate control functions for normal operation and failure conditions.

9.7 Abnormal Procedures

9.7.1 L(R) GEN OFFLINE

A loss of a generator prompts a load shed of the air conditioning system. The bus tie contactor automatically closes to allow the opposite generator to power all electrical buses, and charge both batteries. When an engine is running, an inoperative generator causes an L(R) GEN OFFLINE caution message to appear.

If an in-flight engine restart is required, it is accomplished using the operating generator and the start battery. The electrical system will reconfigure to a forward/aft system as it does for ground starts.

9.7.2 BATTERY POWER ONLY

With both generators inoperative in flight, the aircraft operates 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 60 minutes.

For engine start when both generators are inoperative, the electrical system will reconfigure to a forward/aft system as it does for ground starts. A fully charged start battery allows at least three start attempts.

9.7.3 Load Shedding

The ACS automatically sheds non-essential loads that cause overload of the remaining operating generator.

9.7.3.1 ONE STARTER/GENERATOR OFFLINE

In Flight 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.

9.7.3.2 BATTERY POWER ONLY (DUAL GENERATOR OFFLINE IN FLIGHT)

In Flight:

- 82 non-essential ECBs load shed (ACS pulls the ECB for these items)
- Smart Load Shed is accomplished by the ACS. The least effective Integrated Sensor Suite is pulled offline.

9.7.4 Electrical Smoke Clearing

In the event of electrical smoke in the cabin, the pilot initiates the Smoke or Fumes AFM/QRH procedure to isolate the source of the smoke. The smoke clearing procedure removes power from the left side (L AFT, L FWD, BATT BUS) or right side (R AFT, R FWD, Hot Battery Bus) of the aircraft by placing the Bus tie to OPEN and the desired side battery and generator to OFF. The ACS within 7 seconds will pull the ECBs for the devices that have a redundant power source from the alternate side.

9.7.4.1 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) and systems battery (SYS BATT) and to 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 ECBs.

9.7.4.2 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) and start battery (START BATT) and to open the BTC. This will remove power from all equipment associated with the Right Forward Bus and Right Aft Bus, including any redundant ECBs.

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.

9.8 Electronic Circuit Breakers Bus Allocation

Table 9-2. Battery Bus Allocation List

Battery Bus	
System	**ECB Name**
ANTI-SKID BRAKE SYSTEM	ABS
AVIONICS	ADC 3
AVIONICS	INTEGRATED SENSOR 1
ELECTRIC	START-BATTERY HEAT
ENGINE	L ENG FADEC CH A
ENGINE	L ENG FADEC CH B
ENGINE	R ENG FADEC CH A
ENGINE	R ENG FADEC CH B
ICE PROT	L STATIC HEAT
ICE PROT	STBY PITOT HEAT

Table 9-3. Forward Bus Allocation Lists

Left Forward Bus		Right Forward Bus	
System	**ECB Name**	**System**	**ECB Name**
AVIONICS	ADC 1	AVIONICS	ADC 2
AVIONICS	AUDIO MIXER	AVIONICS	AHRS 1
AVIONICS	CENTER SWITCH PANEL	AVIONICS	AHRS 2
AVIONICS	DIAG STRG UNIT	AVIONICS	AUDIO MIXER
AVIONICS	**(O)** ELECTRONIC FLIGHTBAG	AVIONICS	CENTER SWITCH PANEL
AVIONICS	GPS 2	AVIONICS	GPS 1
AVIONICS	L AOA	AVIONICS	L AIRCRAFT COMPUTER
AVIONICS	MFD	AVIONICS	L PFD, COM/NAV1, ACP
AVIONICS	R AIRCRAFT COMPUTER	AVIONICS	MFD
AVIONICS	R PFD, COM/ NAV2, ACP	AVIONICS	R AIRCRAFT COMPUTER

Table 9-3. Forward Bus Allocation Lists (Cont'd)

Left Forward Bus		Right Forward Bus	
System	**ECB Name**	**System**	**ECB Name**
AVIONICS	SPARE PWR L2	AVIONICS	R AOA
AVIONICS	**(O)** TRAFFIC ALERT SYS	AVIONICS	R PFD, CNS2, ACP
AVIONICS	**(O)** WEATHER RADAR	AVIONICS	**(O)** R STANDBY DISPLAY
AVIONICS	L STANDBY DISPLAY	AVIONICS	L STANDBY DISPLAY
AVIONICS	**(O)** R STANDBY DISPLAY	AVIONICS	SPARE PWR L3
ELECTRIC	SYSTEMS-BATTERY HEAT	ENGINE	L ENG FADEC CH B
ENGINE	L ENG FADEC CH A	ENGINE	R ENG FADEC CH B
ENGINE	L ENG FIRE EXTNGR	ENGINE	R ENG FIRE EXTNGR
ENGINE	L ENG START	ENGINE	R ENG START
ENGINE	R ENG FADEC CH A	FLCS	AP AILERON SERVO
ENVIRONMENT	PAX OXYGEN CTRL	FLCS	AP ELEVATOR SERVO
ICE PROT	L PITOT HEAT	FLCS	AP RUDDER SERVO
ICE PROT	R STATIC HEAT	ICE PROT	L STATIC HEAT
ICE PROT	WING INSPECTION LGT	ICE PROT	R PITOT HEAT
		ICE PROT	R STATIC HEAT

(O) Denotes optional equipment; may not display if equip. not installed.

Table 9-4. Aft Bus Allocation Lists

Left Aft Bus		Right Aft Bus	
System	**ECB Name**	**System**	**ECB Name**
AVIONICS	**(O)** DATALINK WEATHER	AVIONICS	**(O)** ADS B
AVIONICS	INTEGRATED SENSOR 2	AVIONICS	AUDIO CTRL UNIT
AVIONICS	**(O)** RADAR ALTIMETER	AVIONICS	DIAG STRG UNIT
AVIONICS	SPARE PWR L 1	AVIONICS	**(O)** DME
AVIONICS	**(O)** TERRAIN ALERT SYS	AVIONICS	**(O)** LIGHTNING DETECT
ELECTRIC	**(MX)** L BUS CB	AVIONICS	SPARE PWR R1
ELECTRIC	L GEN CTRL UNIT	AVIONICS	SPARE PWR R2
ENGINE	L ENG IGNITION	AUTOTHROTTLE	AUTOTHROTTLE SERVOS
ENVIRONMENT	AFT EVAP FAN - HIGH	ANTI-SKID BRAKE SYSTEM	L BRAKE CTRL
ENVIRONMENT	AFT EVAP FAN - LOW	ANTI-SKID BRAKE SYSTEM	R BRAKE CTRL
ENVIRONMENT	AFT EVAP FAN - MED	ELECTRIC	**(O)** CABIN 115 VAC
ENVIRONMENT	CONDENSER FAN	ELECTRIC	**(MX)** R BUS CB
FLCS	L MAIN LDG GEAR	ELECTRIC	R GEN CTRL UNIT
FLCS	NOSE LDG GEAR	ENGINE	R ENG IGNITION
FLCS	R MAIN LDG GEAR	ENVIRONMENT	FWD EVAP FAN - HIGH
FUEL	L FIREWALL VLV - CLOSE	ENVIRONMENT	FWD EVAP FAN - LOW
FUEL	L FIREWALL VLV - OPEN	ENVIRONMENT	FWD EVAP FAN - MED
FUEL	L FUEL PUMP	FLCS	AUTOTHROTTLE SERVOS
ICE PROT	INBOARD WING DEICE	FLCS	FLAPS
ICE PROT	L ENG ANTI-ICE VLV	FUEL	R FIREWALL VLV - CLOSE

Table 9-4. Aft Bus Allocation Lists (Cont'd)

Left Aft Bus		Right Aft Bus	
System	**ECB Name**	**System**	**ECB Name**
ICE PROT	L WINDSHIELD HEAT	FUEL	R FIREWALL VLV - OPEN
ICE PROT	OUTBOARD WING DEICE	FUEL	R FUEL PUMP
LIGHTING	L LANDING LGT	ICE PROT	DEICE MANIFOLD HTR
LIGHTING	L STROBE LGT	ICE PROT	INBOARD WING DEICE
LIGHTING	L TAXI LGT	ICE PROT	OUTBOARD WING DEICE
LIGHTING	R STROBE LGT	ICE PROT	R ENG ANTI-ICE VLV
LIGHTING	TAIL STROBE LGT	ICE PROT	R WINDSHIELD HEAT
PRESSURE	CABIN ALT DUMP	LIGHTING	BEACON
PRESSURE	L ENG BLEED FLOW HI/LO	LIGHTING	POSITION LGTS
PRESSURE	L ENG BLEED VLV	LIGHTING	R LANDING LGT
PRESSURE	L/R AIR SEGREG VLV	LIGHTING	R TAXI LGT
		PRESSURE	AFT CABIN AIR VLV
		PRESSURE	PRI OUTFLOW VLV
		PRESSURE	R ENG BLEED FLOW HI/LO
		PRESSURE	R ENG BLEED VLV

(O) Denotes optional equipment; may not display if equip. not installed.
(MX) Reset in maintenance mode only.

9.9 Crew Alerting System Messages

Table 9-5. 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 switch 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 bus contactors have been lost (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.	Advisory

9.10 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. Vapor Cycle System
    d. Pressurization

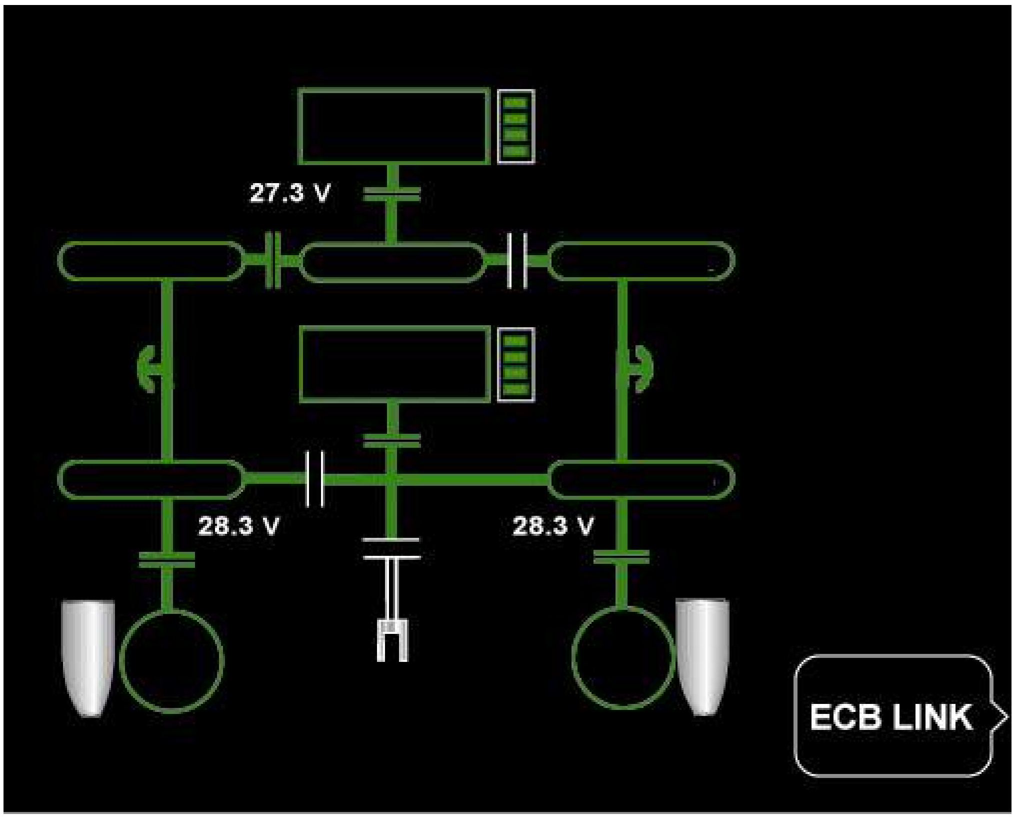
6. **List four conditions that are required to allow use of external power (i.e. green light on):**
    a.
    b.
    c.
    d.

7. **What items are powered by the hot battery bus?**
    a.
    b.

8. 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 charging.
d. All of the above are correct.

9. Label the following components of the electrical system on the synoptic below: five electrical buses, two batteries, two generators and ten contactors.



10. Describe in general terms the difference between a mechanical circuit breaker and an Electronic Circuit Breaker (ECB)?

11. Where can Electronic Circuit Breaker (ECB) status be viewed?

a. 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.

12. What are examples of protection and/or detection that the Generator Control Units (GCUs) provide?

13. What type of batteries is installed on the Eclipse 550?

a. NiMh (Nickel Metal Hydride)
b. Sealed lead acid
c. NiCad
d. Sealed gel batteries

14. 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 powers this bus

15. What is the purpose of the bus tie contactor?

a. To isolate the aft buses
b. To tie the aft buses
c. To turn off the starter/generators
d. Both A and B
e. None of the above

16. Circuit protection is accomplished by:

a. Mechanical circuit breakers
b. Electronic Circuit Breakers (ECB)
c. Contactors
d. Fuse
e. All of the above

17. If both starter/generators fail in flight, what is the minimum battery time available?

a. 60 minutes
b. 30 minutes
c. 45 minutes
d. 35 minutes

18. Which two electrical system components are independent of the Aircraft Computer Systems (ACSs)?

a.
b.

19. List the five conditions that will cause external power to automatically disconnect:

a.
b.
c.
d.
e.

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Interior Lighting

10

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Interior Lighting

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10.1 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)
  - Display and instrument panel back lighting
  - Map lights
- Cabin
  - Upper cabin wash lighting
  - Lower cabin wash lighting (optional)
  - Cabin reading lights
  - Baggage compartment light

With both battery switches OFF, the hot battery bus provides power to the cockpit dome and baggage compartment lights. With battery power only, these lights are on a 5-minute timer to prevent battery depletion.

10.2 Aircraft Computer System (ACS) Interfaces

A dedicated lighting controller, located in the Start Battery Contactor and Lighting Controller Unit, is considered part of the electrical system and has no direct link to the Aircraft Computer System (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 on the center switch panel.

10.3 Controls and Indicators

A MASTER DIM control is located on the center switch panel. It provides the ability to dim the PFDs, MFD, and instrument panel lights to a higher or lower range according to the switch position of DAY or NIGHT. The Master Dim selection has no effect on the Standby Display Unit (SDU).

A knob on the MASTER DIM panel may be rotated to gradually increase or decrease instrument panel light intensity within the DAY or NIGHT range. The INT LIGHT subpanel of the Center Switch Panel (CSP) allows for selection of Cabin Override, Cockpit Dome, and footwell lighting (optional). Additional interior lighting options can be selected on the armrest panel and the cabin overhead panel.

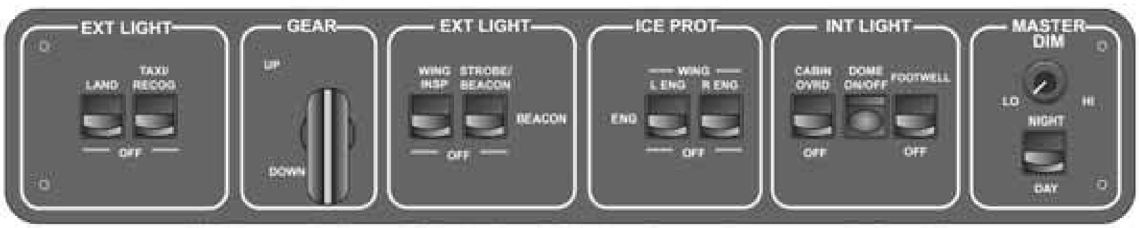

Figure 10-1. Center Switch Panel

Table 10-1. Interior Lighting Controls

Subpanel	Switch	Control
INT LIGHT	CABIN OVRD	ON – Turns Cabin Lights OFF (overrides cabin control of lights). OFF – Allows cabin control of lights.
	DOME ON/OFF	ON – Turns Cockpit Dome Light ON. OFF – Turns Cockpit Dome Light OFF.
	FOOTWELL (option)	ON – Turns Footwell Lighting ON. OFF – Turns Footwell Lighting OFF.
MASTER DIM	DIM	Low to High – Dims displays, cockpit backlighting, and keyboard.
	NIGHT/DAY	NIGHT – Low DAY – Bright (Displays, cockpit backlighting, and keyboard.)

10.4 System Description

10.4.1 Start Battery Contactor and Lighting Controller

The start battery contactor and lighting controller provides control and over-current protection for the following internal lights:

- Upper Cabin Wash
- Lower Cabin Wash
- Reading Lights
- Baggage Light (Hot Battery Bus)
- Cockpit Dome (Hot Battery Bus)

Although the interior lights do not have specific Electronic Circuit Breakers (ECB) associated with them, the lighting controller will act in this capacity, deactivating a light that experiences an over-current situation.

10.4.2 Cockpit Dome Lighting

The cockpit dome lighting consists of a string of LEDs in the forward section of the overhead console. Two light switches control the cockpit dome lighting. One switch is located on the armrest switch panel mounted on the front of the left armrest. The other switch is located on the center switch panel.

Figure 10-2.   Cockpit Dome Lighting – Armrest Switch

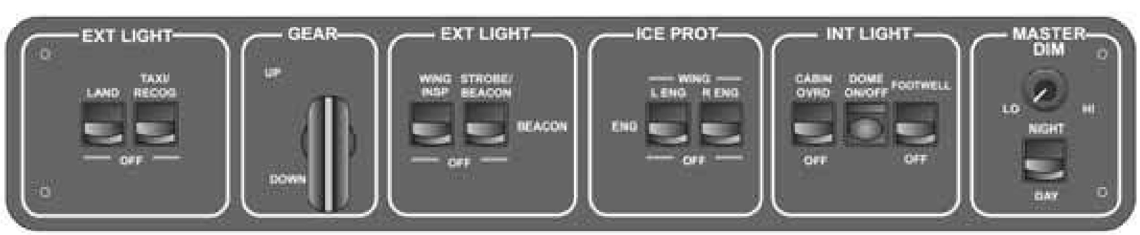

Figure 10-3.   Cockpit Dome Lighting – Center Switch Panel Switch

10.4.3 MASTER DIM Panel

The master dim subpanel on the right side of the center switch panel allows dimming of the MFD, the PFDs, and the instrument panel backlighting. The DAY/NIGHT switch allows the user to change to a different range of light levels available for cockpit lighting. A rheostat-type knob then allows the pilot to vary the light intensity (HI/LO) within the selected range (DAY/NIGHT).

10.4.4 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.

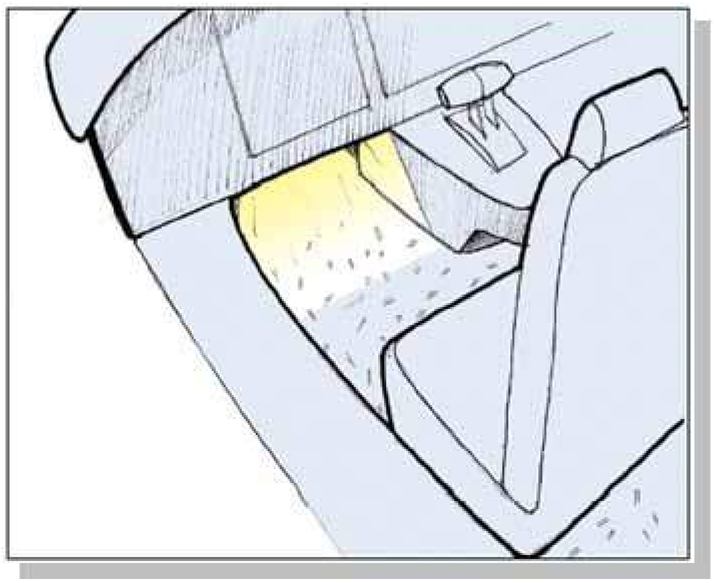

Figure 10-4. Cockpit Foot Well Lighting

10.4.5 Map Lights

The map lights consist of two groups of focused LEDs located under the glare shield for map reading in the cockpit, with one group on either side of the Autopilot Control Panel (ACP). Identical switches on the left and right of the ACP are used to activate and control each light. MAP-PUSH for on/off, rotate for LO/HI brightness.

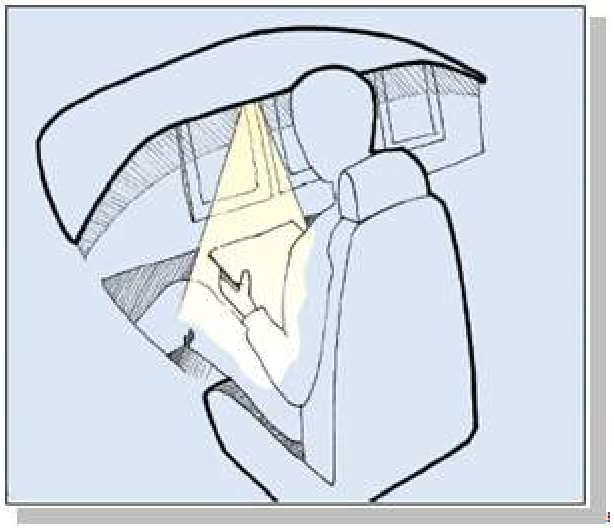

Figure 10-5. Map Lighting

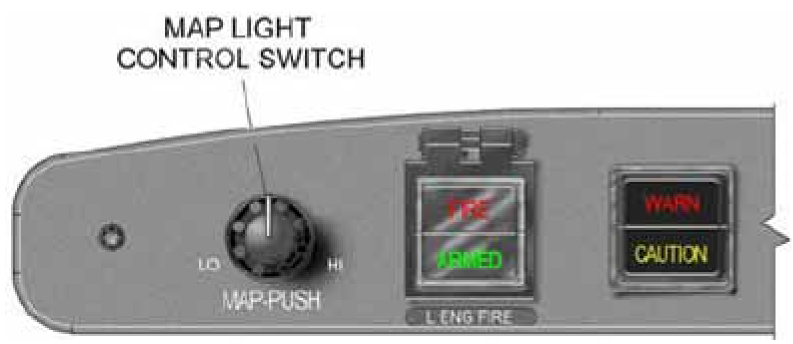

Figure 10-6. Map Light Control

10.4.6 Upper Cabin Wash Lighting

The upper cabin wash lighting consists of LEDs running the length 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 pushing it a third time turns the upper cabin wash lights off.

Figure 10-7. Overhead Cabin Wash Lighting

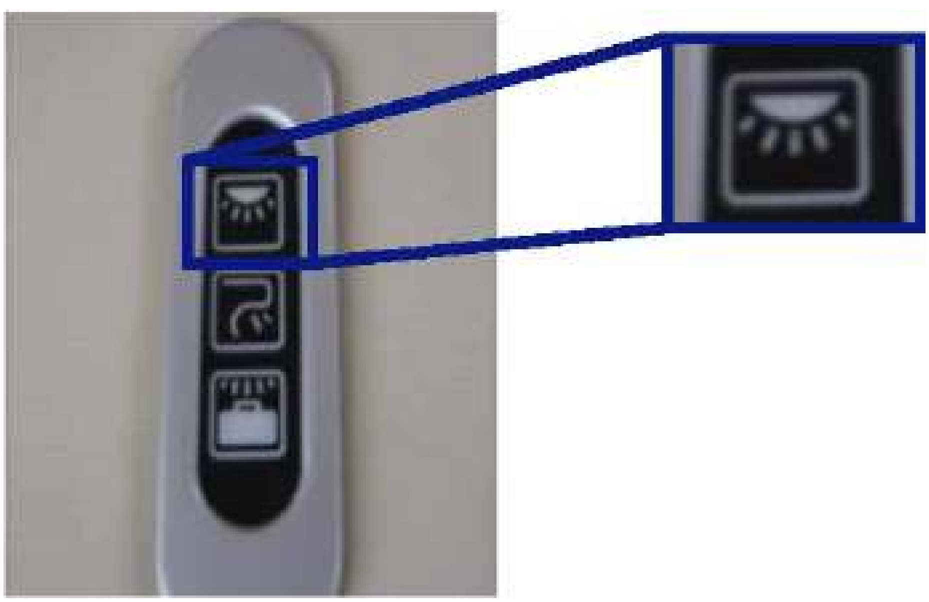

Figure 10-8. Cabin Lighting Control Panel – Upper Cabin Wash

10.4.7 Lower Cabin Wash Lighting (Optional)

The lower cabin wash lighting system consists of LEDs running underneath the armrests from the back of the copilot'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 cabin 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 pushing it a third time turns the lower cabin wash lights off.

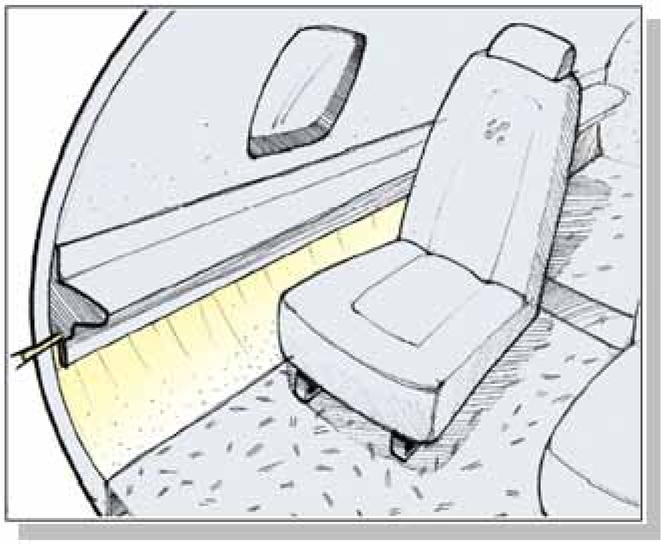

Figure 10-9. Lower Cabin Wash Lighting

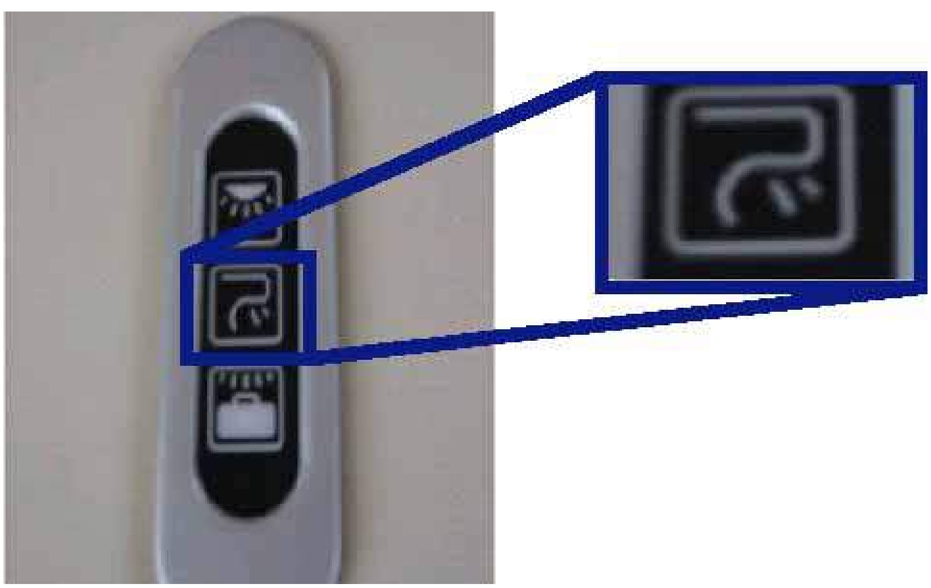

Figure 10-10. Cabin Lighting Control Panel – Lower Cabin Wash

10.4.8 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 rocker switch located near each LED light on the overhead console.

Figure 10-11. Cabin Reading Lights

10.4.9 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 cabin lighting control panel.

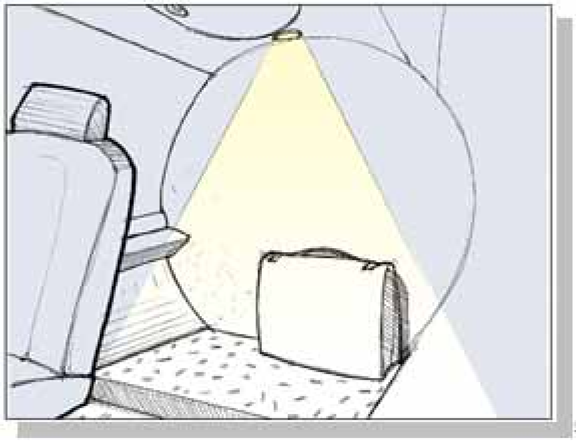

Figure 10-12. Baggage Compartment Light

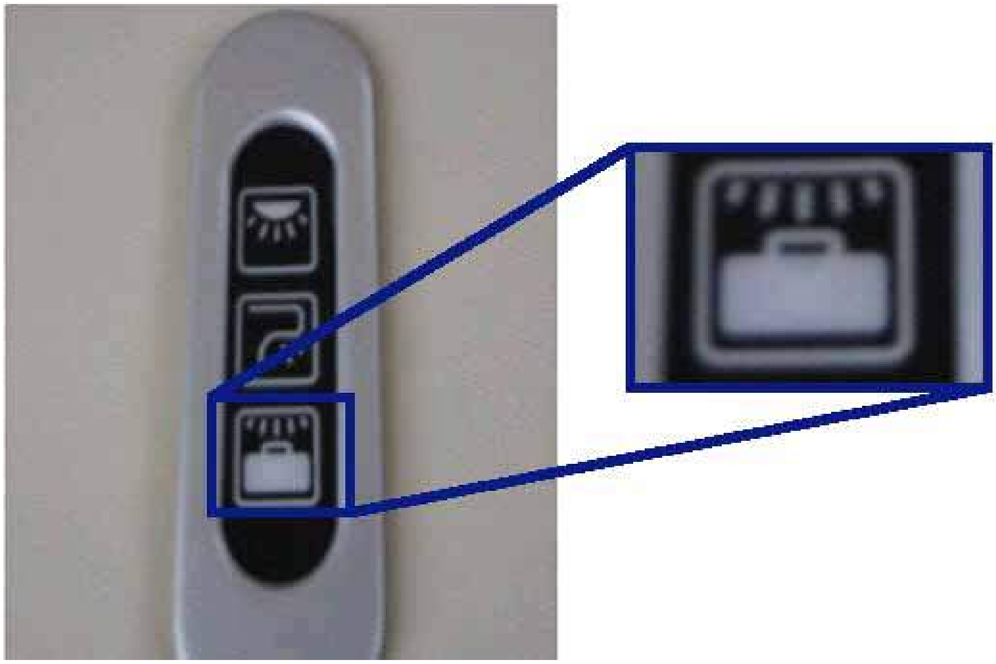

Figure 10-13. Cabin Lighting Control Panel – Baggage Compartment Light

10.5 Normal Operations

10.5.1 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 the upper cabin wash, lower cabin wash and the baggage light. It also inhibits the reading lights. If it is returned to the OFF position, reading lights that were previously on will return. The upper cabin wash, lower cabin wash, and baggage light will need to be reselected using the cabin light control panel.

10.6 Interior Lighting Review Questions

1. **LED lights are used on the Eclipse 550 to:**

   a. Provide extended lighting system component life and redundancy by using multiple strings of LEDs

   b. Reduce drag

   c. Save weight

   d. A and C

2. **What is the purpose of the Start Battery Contactor and Lighting Controller?**

3. **Why are some interior lights on timers?**

   a. LEDs burn out very quickly, and the timer prevents overuse of LED lighting.

   b. Timers prevent excessive battery depletion while the lights are powered by the hot battery bus.

   c. Timers are for cosmetic purposes only.

   d. None of the above

4. **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 and can only be dimmed
   d. None of the above

5. **Where is the map light 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

6. **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 and B

7. **How is the baggage compartment lit?**
    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
8. **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
9. **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 and prevents passenger activation and turns lights off if on
    c. Deactivates the lower cabin wash lighting
    d. Overrides the cabin light control panel and the reading light control
    e. None of the above

Exterior Lighting

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Exterior Lighting

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11.1 General

See Figure 11-1 and Figure 11-2. The following lights are part of the exterior lighting system:

- Left and right landing lights
- Left and right taxi/recognition lights
- Left, right, and aft anti-collision (white strobe) lights
- Beacon (red flashing) light
- Left (red), right (green), and aft (white) position lights
- Wing inspection light

The position, beacon, and anti-collision light systems utilize Light Emitting Diodes (LEDs). Each of these lights contains several strings of individual LEDs. This ensures that if one light or string of lights fails, the rest remain illuminated. The taxi/recognition, and wing inspection lights are halogen lamps, while the landing lights are high intensity discharge lamps.

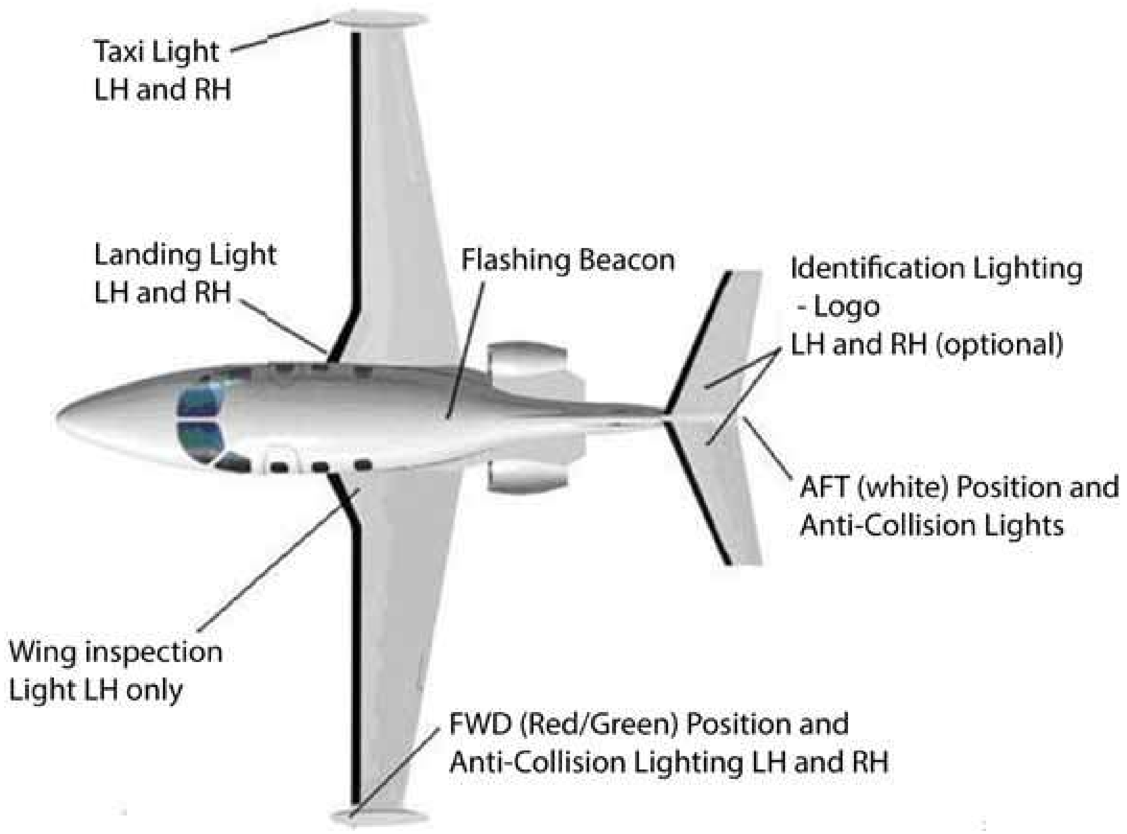

Figure 11-1. Exterior Lighting – Top View

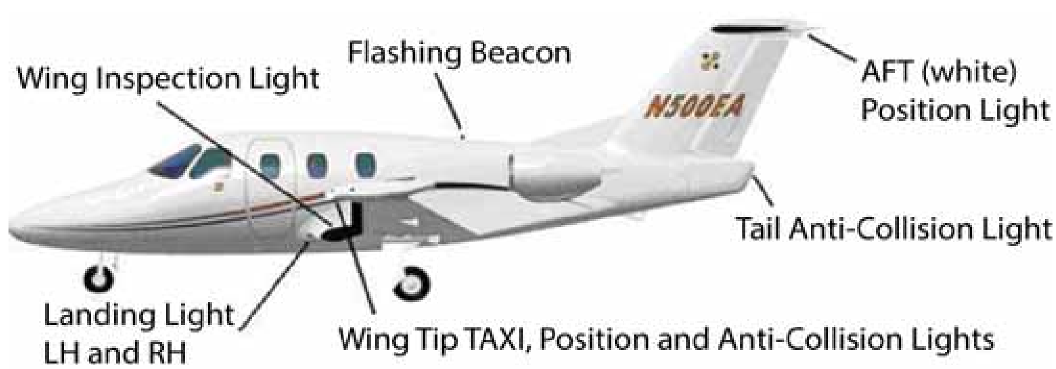

Figure 11-2. Exterior Lighting - Left Side View

11.2 Aircraft Computer System (ACS) Interfaces

See Figure 11-3. The Aircraft Computer System (ACS) controls all exterior lights by activating and deactivating appropriate exterior lighting Electronic Circuit Breakers (ECBs) based on pilot commands. The ten exterior lighting ECBs reside on Electronic Circuit Breaker Units (ECBUs) 1,4, and 5.

The pilot controls all exterior lighting through hard switches on the center switch panel. Commands from the center switch panel are routed through the PFD to the ACSs, 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
3. Left, right and aft anti-collision (strobe) lights
4. Beacon light
5. Left, right and aft position lights
6. Wing (ice) inspection light

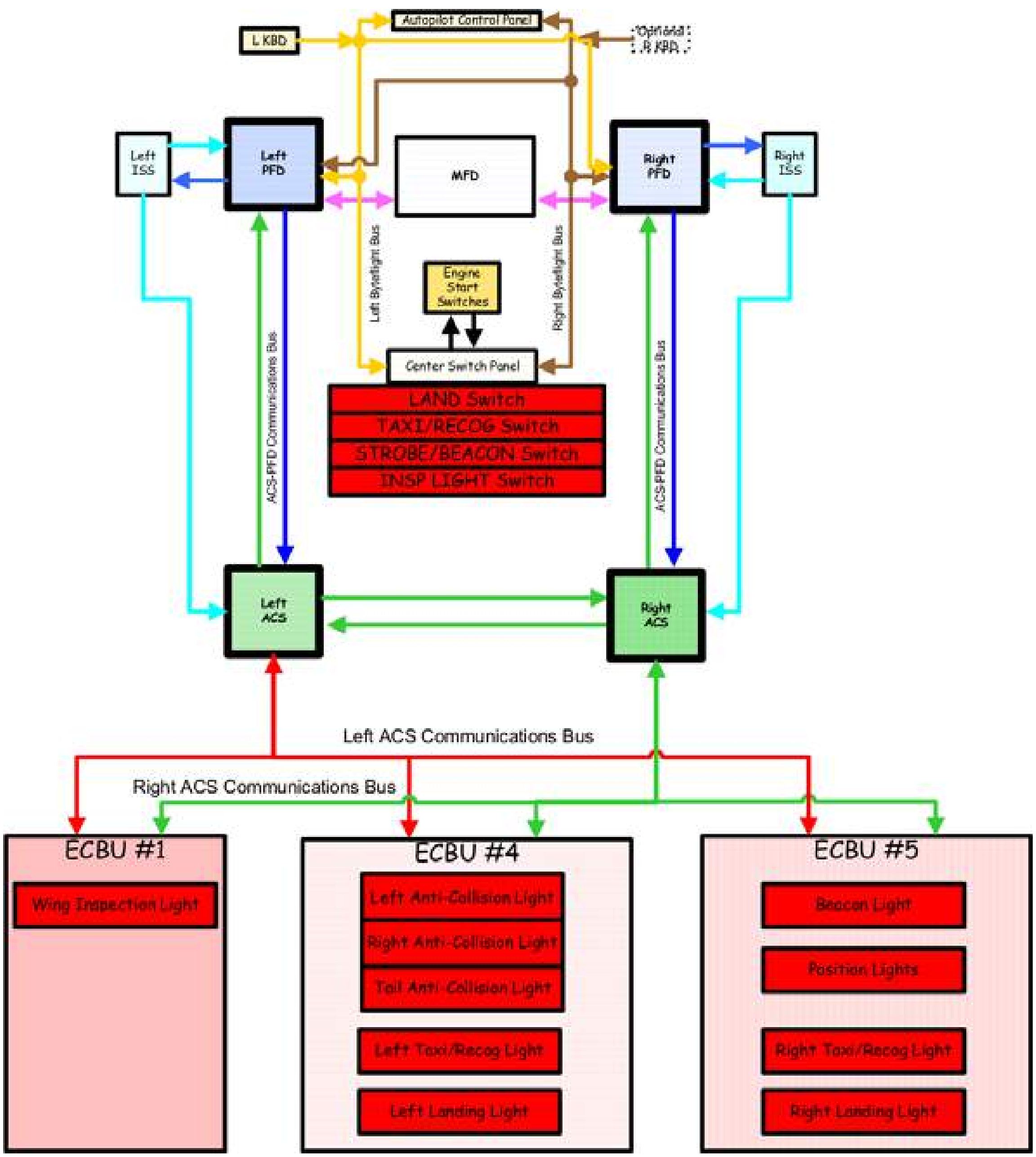

Figure 11-3. Exterior Lighting – ACS Interfaces

11.3 Controls and Indicators

See Figure 11-4. All exterior lighting is controlled with switches located on the center switch panel under two EXT LIGHT sub panels.

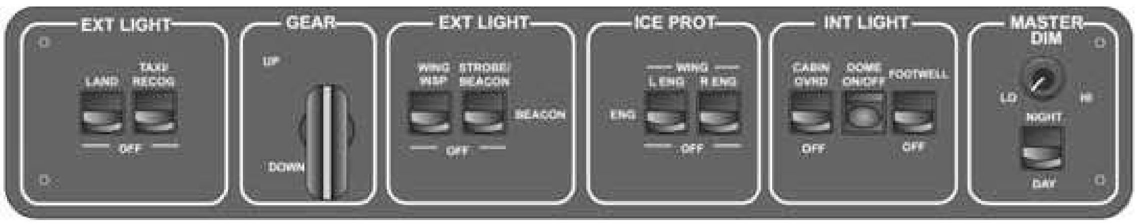

Figure 11-4. Center Switch Panel

Table 11-1. 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 and flashing beacon
	BEACON	Flashing beacon only
ICE PROT	WING INSP LIGHT	Wing inspection light

11.4 System Description

11.4.1 Landing Lights

The landing light consists of two 50 watt 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. With the landing lights selected on, 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.

11.4.2 Taxi/Recognition Lights

There are two 50 watt 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 depends on the status of the Weight On Wheels (WOW) sensor. During ground operation, the Taxi/Recognition lights illuminate in a steady-state fashion. When the WOW sensor indicates an in-flight condition, these lights 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.

11.4.3 Wing Inspection Light

A single 50 watt 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 WING INSP switch located on the center switch panel.

A failure of the wing inspection light causes an INSPECTION LIGHT FAIL advisory message to appear.

11.4.4 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.

11.4.4.1 POSITION LIGHTS

Position indication is provided by red and green LED position light fixtures mounted within the forward portion of the wing tip tanks. A white aft facing position light is located on the horizontal stabilizer fairing.

Position lights are automatic and are illuminated anytime the aircraft is powered up.

A failure of any of the position lights causes a POSITION LIGHT FAIL advisory message to appear.

11.4.4.2 ANTI-COLLISION LIGHTS

Two white LED strobe light fixtures are located within the forward portion of the wing tip tanks, and one is also located within the tail cone. Each anti-collision light fixture is composed of several strings of white LEDs.

Anti-collision lighting is controlled with a three-position STROBE/BEACON switch located on the center switch panel. The switch must be in the full up position for the anti-collision lights to activate.

A failure of an anti-collision light will cause a STROBE FAIL advisory message to appear.

11.4.5 Flashing Beacon

The flashing beacon is composed of a single string of red LEDs and is located on the upper aft fuselage just forward of the tail.

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 (middle) position, only the beacon will be activated. If the switch is raised to the STROBE/ BEACON (up) position, the strobes and beacon will operate.

11.5 Abnormal Procedures

11.5.1 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

11.6 Crew Alerting System Messages

Table 11-2. 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

11.7 Exterior Lighting Review Questions

1. **What Electronic Circuit Breaker Units (ECBUs) 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
    d. None of the above

4. **What type of lighting is used for anti-collision purposes?**

    a. The Eclipse 550 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 550?**

    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.

    d. None of the above

8. **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. The 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
9. **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 icy conditions
    d. None of the above
10. **What type of light is used for the wing inspection lighting system?**
    a. Halogen bulb
    b. Tightly packed group of LEDs
    c. HID (High Intensity Discharge) lamp
    d. None of the above
11. **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
12. **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
13. **Which lighting systems will be load shed during battery-only operation?**
    a. Beacon, anti-collision, left and right taxi, right landing and all optional lighting
    b. Ice inspection light and right landing light
    c. Only decorative interior lighting
    d. None of the above

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Air Data

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Air Data

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12.1 General

See Figure 12-1. The Air Data System consists of:

- two Pitot/Angle of Attack (AOA) probes,
- two Static Ports,
- two Outside Air Temperature (OAT) probes,
- one Pitot/Static (standby) Probe, and
- three Air Data Computers (ADCs).

A Pitot/AOA probe is 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 dual heated static ports, one installed on either side of the forward fuselage below the windshield, and cross-connected to compensate for the effects of aircraft yaw or sideslip.

An Outside Air Temperature probe is installed on either side of the vertical stabilizer fairing. Each of the OAT probes contains two independent temperature sensors with connections to the ADC and the ACS.

Information from the Left Pitot/AOA probe as well as a cross-connected static source is transmitted to ADC #1. Information from the Right Pitot/AOA probe as well as a cross-connected Static source is transmitted to ADC #2. ADC #1 and #2 process the information and send it to the ACSs and FADECs. The standby pitot/static probe, the top probe on the left side of the nose, and ADC #3 at the base of the probe provide air data information to the Standby Display Unit (SDU). Information from ADC #3 can be used by the pilot for comparison in the event of a disagreement between ADC #1 and #2.

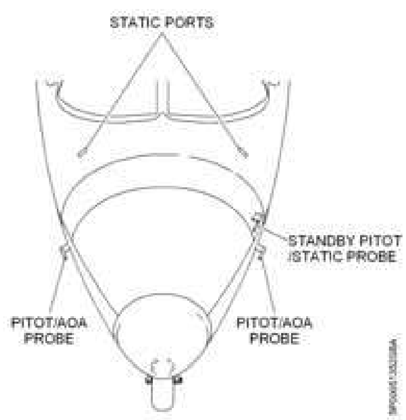

Figure 12-1. Pitot/AOA, Pitot/Static, and Static Ports

12.2 Aircraft Computer System (ACS) Interfaces

The air data system is comprised of two (#1 Left and #2 Right) Integrated Sensor Suites (ISSs). An ISS is comprised of these major components:

- Air Data Computers (ADC)
- Attitude Heading and Reference System (AHRS)
- Global Positioning System (GPS)
- Magnetometer
- Outside Air Temperature (OAT)

Information collected by the ISSs is sent to three places within the airplane: both Aircraft Computer Systems (ACSs) for monitoring and fault reporting, the Full-Authority Digital Engine Control Units (FADECs) for engine control, and the Pilot Displays.

ADC # 1 (Left) is the primary air data source for the Left PFD. ADC #2 (Right) is the primary air data source for the Right PFD. The ADCs collect pitot/AOA and Air Temperature inputs from the on side probes, and are supplied with cross-connected static information. The ADCs process for distribution to the aircraft systems.

Attitude Heading and Reference System (AHRS) #1 serves as the primary source of attitude and heading information for the left PFD. AHRS #2 is the primary source for the right PFD. Magnetometers located in the horizontal stabilizers sense the magnetic field and send magnetic heading information to the AHRS units. The AHRS calculates aircraft attitude and combines this with data from the on-side magnetometer and, ADC unit to display attitude and heading data on the PFDs and provide this data to the ACS and FADEC.

At the base of the standby pitot/static probe is the third ADC. It provides pitot/static information directly to the ACSs. Air data information from ADC 3 is the sole air data source for the Standby Display Unit.

12.3 Limitations and Specifications

12.3.1 Air Data Computer 3 (ADC 3)

Following the loss of ADC 1 and 2, the use of ADC 3 is limited to airspeeds of below 160 KEAS and above 80 KEAS.

12.3.2 Attitude and Heading Reference System (AHRS)

Operation at latitudes requiring direction indication referenced to true North is prohibited.

12.3.3 SDU Limitations

The SDU uses air data from ADC3 thus the limits of ADC3 apply to the use of the SDU.

Operating the SDU in magnetic mode near the Earth’s magnetic poles can lead to erroneous readings. DG mode should be used in locations with high magnetic inclination.

The HSI displays Magnetic heading not True heading. Caution should be used while navigating in areas of high magnetic declination.

In the event the SDU becomes the only airspeed indicator to the Pilot / Co-Pilot, do not exceed 160 KEAS above FL 200.

Do not reference SDU Vmo/Mmo Maximum Operating Speed indicator above FL 200.

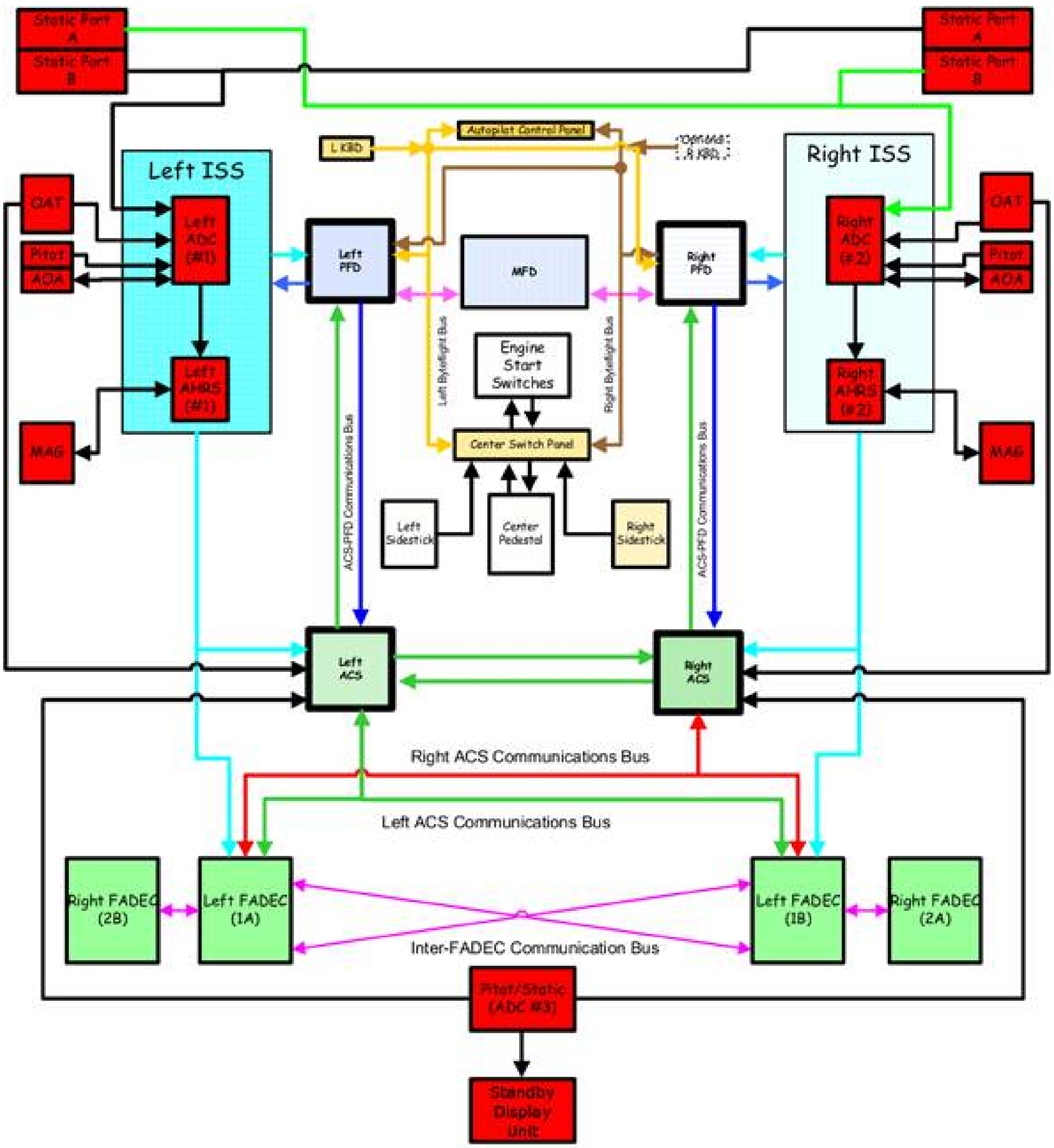

Figure 12-2. Air Data – ACS Interface

12.4 Controls and Indicators

12.4.1 Sensor Selection

See Figure 12-3. In the event that sensors disagree, air data source selection is possible through the SETUP synoptic on the MFD by selecting the SENSORS line select key (LSK). The Dual Concentric Knob (DCK) allows source selection of the AHRS or ADC to the respective PFDs. A BARO SET line-select key is also available for a secondary means of altimeter entry; the primary source is the BARO SET knob on the autopilot control panel.

12.4.1.1 SOURCE SELECTION

AHRS SOURCE SELECTION

AUTO .... AHRS automatically selected by the ACS.
In the AUTO mode, the ACS automatically uses AHRS 1 for the left PFD and AHRS 2 for the right PFD. If either primary AHRS source (1 or 2) fails, both PFDs automatically use the remaining operative AHRS.

1 ....Left and right PFD use the left (#1) AHRS.

2 .... Left and right PFD use the right (#2) AHRS.

ADC SOURCE SELECTION

AUTO ....ADC automatically selected by the ACS.
In the AUTO mode, the ACS automatically uses ADC 1 for the left PFD and ADC 2 for the right PFD. If either primary ADC source (1 or 2) fails, both PFDs automatically use the remaining operative ADC.

1 ....Left and right PFD use the left (#1) ADC.

2 ....Left and right PFD use the right (#2) ADC.

BARO SET

Altimeter settings between 22.50 (948 hPa) through 34.50 (1,050 hPa) inches Hg are entered using the concentric knob on the MFD. Pressing the inner knob sets standard 29.92 (1,013 hPa) inches Hg.

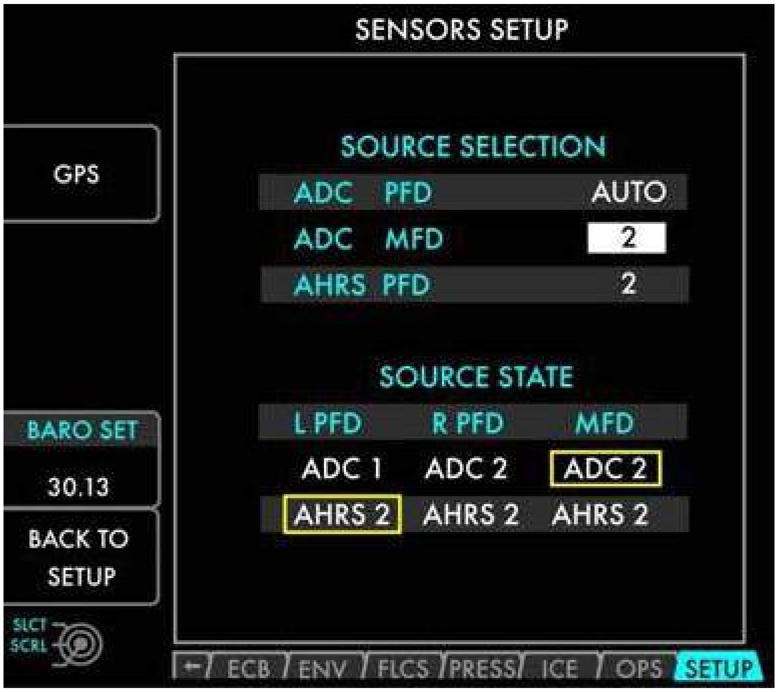

Figure 12-3. SENSOR Synoptic Page

12.5 System Description

12.5.1 Pitot/AOA

See Figure 12-4 and Figure 12-5. Pitot pressure is transmitted through the pitot inlet of the pitot/AOA probe to the Air Data Computers (ADCs) located inside the forward pressure bulkhead. The ADCs interpret the data and output equivalent airspeed, true airspeed, and total pressure for the PFDs, ACSs, and FADECs.

AOA is sensed by differential pressure transducers contained in the base of each pitot/AOA probe and transmitted to the ADC, where the data is processed and provided to the PFD, ACS, and FADECs.

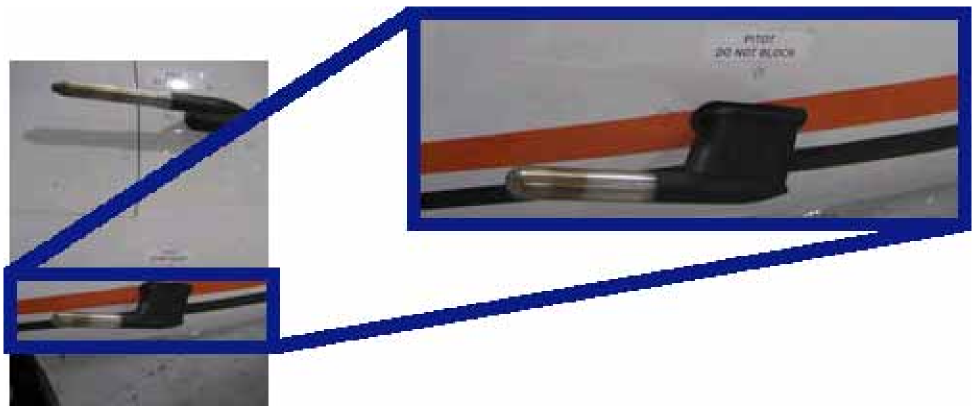

Figure 12-4. Pitot/AOA Probe – Left Side

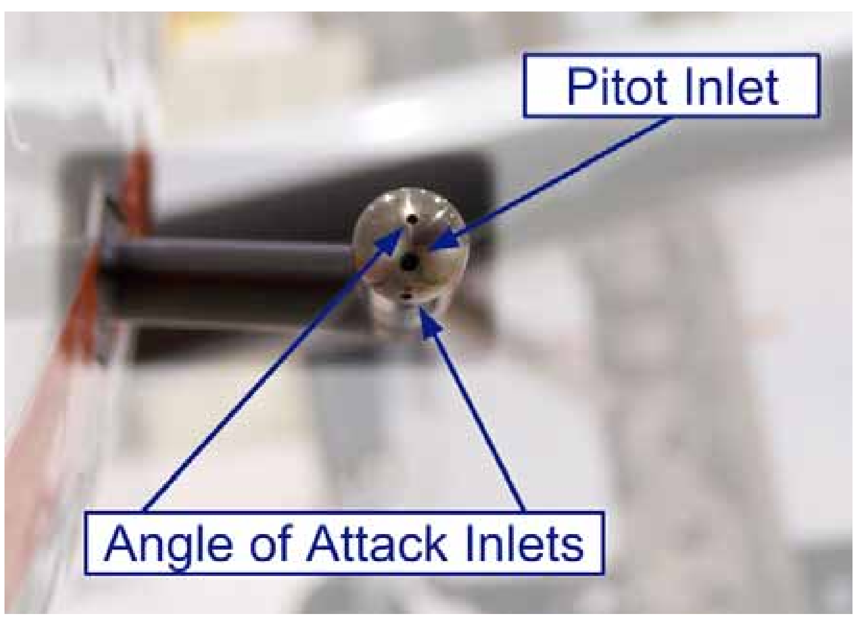

Figure 12-5. Pitot/AOA Inlet Locations

12.5.2 Static Ports

See Figure 12-6. Static air pressure is cross-connected between Left and Right sides and sent to the ADCs. The ADCs output the data to the PFDs, ACSs, and FADECs. The static ports are heated by dual internal self regulating heating elements that provide anti-ice protection. The static source may be drained of water by two static drain valves in the cockpit.

NOTE:
Do not operate the static drains in flight.

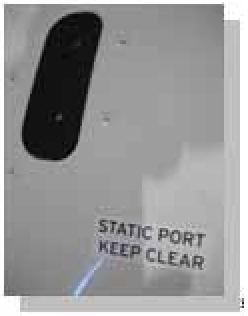

Figure 12-6. Dual Static Port – Left Side

12.5.3 Pitot/Static Probe

See Figure 12-7 and Figure 12-8. An independent pitot/static probe provides information directly to the ACS and the Standby Display Unit (SDU). The pilot may use information provided by this probe in the event of a system abnormality or a disagreement between the primary probes.

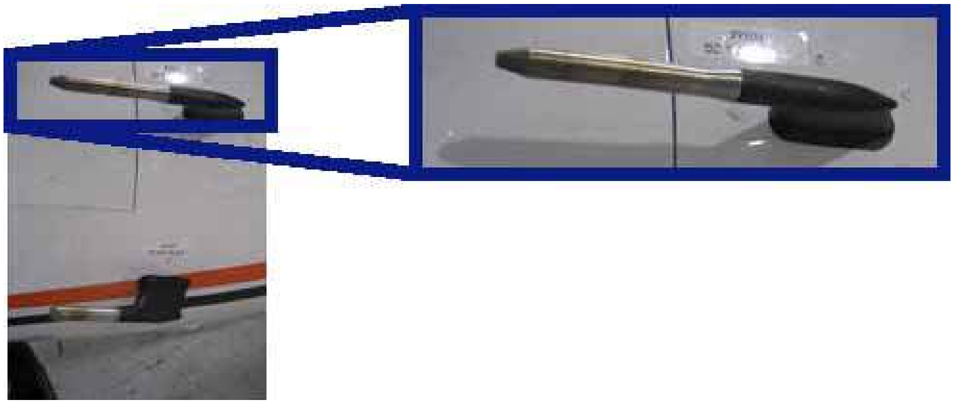

Figure 12-7. Pitot/Static Probe

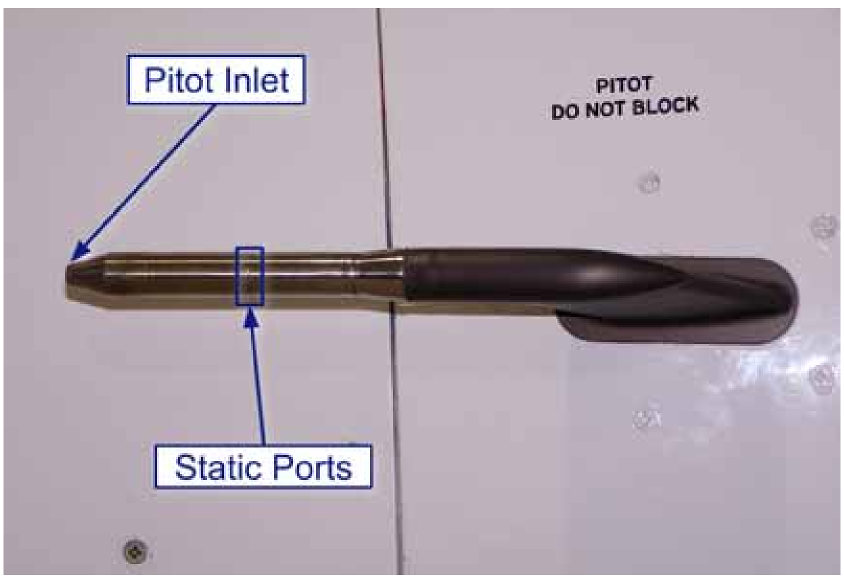

Figure 12-8. Pitot/Static Inlets

12.5.4 Probe and Port Heat

Static Ports, Pitot/AOA probes, and the Pitot/Static Probe are heated through self-regulating internal heating elements that provide anti-ice protection. Probe and Port heat is activated by the ACS anytime a generator is running, or weight is off wheels. On the ground with a GPU connected, the Probe and Port heat can be activated through the PITOT/STAT line select key on the ICE protection synoptic page. AUTO is normal operation and is selectable to ON.

12.5.5 Outside Air Temperature (OAT)

See Figure 12-9. Each Outside Air Temperature (OAT) probe contains two independent sensors. One temperature sensor information is sent to the on-side ACS and the other to the on-side Air Data Computer. 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 probes, located on the vertical stabilizer fairing, are outside of ice accretion areas and do not require heating for anti-ice protection.

Figure 12-9. Left OAT Probe

12.5.6 Air Data Computers (ADCs)

Air Data Computers (ADCs) 1 and 2 are located inside the pressure vessel on the forward pressure bulkhead. ADC 1 and 2 collect and process data from the Pitot/AOA Probes, OAT probes, and Static Ports. Probe and Port information is measured and calculated in the ADCs. Data from the ADC 1 and 2 is transmitted to the on-side Attitude and Heading Reference System (AHRS) unit where it is combined with other navigation data. The AHRS units use ADC information to correct for acceleration errors.

ADC 3 is located at the base of the Pitot/Static (Standby) Probe. ADC 3 information is sent directly to the ACS and the SDU. ADC 3 information can not be displayed on the PFDs.

12.5.7 Integrated Sensor Suite (ISS)

There are two Integrated Sensor Suites (ISSs) on the aircraft. The ISS is not a physical box, but an electronic grouping of separate system components that work together to provide primary sensor data to the ACS and FADEC units. An ISS is composed of the on-side Air Data Computer (ADC), Attitude and Heading Reference System (AHRS), Outside Air Temperature (OAT), Global Positioning System (GPS), and Magnetometer. Data from the ADC and Magnetometer is sent to the AHRS where it is combined with the attitude and heading data. The ACS sends the ISS Baro-correction and Receiver Autonomous Integrity Monitoring (RAIM) information. The combined data is then sent from the ISS directly to the PFDs, the ACS, and the FADECs.

12.6 Normal Operations

The air data system requires no pilot action during normal operation. All pitot/static probes and ports are automatically heated. The Aircraft Computer System (ACS) provides power to the probes and static port heaters when either of the engines is running or with weight off wheels.

Electrical control of the Air Data System is accomplished through the ACS. Power for each probe is provided by an Electronic Circuit Breaker (ECB). Power for the pitot/ Angle of Attack (AOA) probe and static port heat are also provided by ECBs. In the event of an ADC or AHRS failure, the remaining source is automatically selected by the ACS.

NOTE:
AHRS and/or ADC source selection on the SENSORS synoptic must be in the AUTO mode for this to occur.

The center orifice on the Pitot/AOA probe provides ram air pressure to the on-side ADC.

The top and bottom orifices on the Pitot/AOA probe send air pressure to an Angle of Attack transducer within the probe. The differential pressure between the top and bottom orifice is expressed in an electrical signal which is sent to the on-side ADC.

Static (ambient) air enters through the cross-connected (one source from aircraft left and one from the right) static ports and is plumbed to the ADC.

Outside Air Temperature information is sensed by the OAT Probes and sent to the on-side ACS and ADC.

The ADC processes the data and outputs to the PFD and ACS:

- Equivalent Airspeed (KEAS) –Calibrated airspeed in nautical miles per hour corrected for compressibility
- True Airspeed (KTAS) – Equivalent Airspeed in nautical miles per hour corrected for Air Density
- Mach number – Ratio of the True Airspeed to the local speed of sound
- Outside Air Temperature (OAT) – Static air temperature in °C
- Total Air Temperature (TAT) – Static air temperature corrected for Ram Rise from aircraft speed.
- Altitude
- Vertical Speed
- Angle Of Attack

The OAT Probe also sends Total Air Temperature information directly to the ACS for use in the FADECs.

NOTE:
The Cabin Pressurization Control Subsystem (Outflow Valves) have their own static ports, located under the tail near the aft pressure bulkhead. These static ports are not a part of the Air Data System.

12.7 Abnormal Procedures

12.7.1 Air Data Disagreement

If abnormal indications are generated by the Air Data Computers (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:

12.7.1.1 DISAGREE CAS MESSAGES

- ADC
  - AIRSPEED DISAGREE (Caution)
  - ALTITUDE DISAGREE (Caution)
- AHRS
  - ATTITUDE DISAGREE (Caution)
  - HEADING DISAGREE (Caution)
- TAT
  - 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 SENSORS page on the MFD. The TAT DISAGREE advisory message requires the pilot to view the ICE protection synoptic to compare temperature indications.

12.7.2 ADC 3 FAIL

Air Data Computer 3 for the SDU display has failed.

1. Do not refer to SDU Airspeed, Altitude, and ROC.

NOTE:

L (R) ENG CONTROL FAULT advisory message will be displayed; no action required.

12.7.3 Sensor Failure

The air data system has a redundant design to prevent complete loss of air data in the event of a component failure. If any component, ADC, AHRS, or GPS fail, one of the following messages appears:

- 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 Source Selection on the SENSORS page selected to AUTO, the ACS automatically reverts to using the operating source for air data information. Since all air data information is sent through the on-side Attitude Heading and Reference System (AHRS) to the Aircraft Computer System (ACS), if an AHRS fails with AUTO selected, the affected PFD uses the AHRS and ADC from the opposite side. For example, if AHRS 1 fails, the left PFD will use AHRS 2 and ADC 2.

⚠ **CAUTION:**
The autopilot will disconnect and cannot be reconnected with an ADC1/2 or AHRS1/2 failure. With the autopilot disconnected, the aircraft no longer meets the equipment requirements for RVSM operations. Advise ATC of the failure and loss of RVSM compliance. A descent below FL290 out of RVSM airspace may be required by ATC.

Should the inoperative ADC or AHRS become operative or if power is restored, the ACS will return the ADC or AHRS configuration to its normal state.

GPS selection is accessible from the GPS Sensors Page. In Auto if a GPS fails, the ACS automatically reverts to the operating GPS.

12.8 Standby Display Unit

12.8.1 General

The Standby Display Unit has been designed and incorporated to display the following information:

1. Attitude
2. Airspeed (with color bands)
3. Baro Corrected Altitude
4. Vertical Speed
5. Heading

Figure 12-10. SDU Instrument Display Configuration

12.8.2 Controls and Indicators

12.8.2.1 ADJUSTMENT MODES

When the Menu is not displayed pressing the Select (SEL) button will cause an indication to appear in the lower right corner of tile 2. Pressing SEL again will scroll to the next adjustable setting. The adjustable settings are BARO, HDG, and BRT. These adjust the Baro Correction, Heading, and Display Brightness.

BARO

Baro correction adjustment is the default selection. Using the Scroll UP or DOWN (▲ ▼) buttons will change the baro setting in Hectopascals or Inches of Mercury depending on Menu setting. Pressing and holding the menu button for two seconds will set the baro setting 29.92.

BRT

The brightness of the SDU screen is normally set automatically using an ambient light sensor. With the BRT selection the brightness can be manually adjusted. Pressing and holding the menu button for two seconds will set the brightness to full bright.

Figure 12-11. SDU Brightness Control

12.8.2.2 MENU

The Menu in tile 2 may be entered through the Menu (MEN) button. The Menu offers options for Metric display (altitude in meters), Baro Set Units (inHg inches of mercury/ HP Hectopascals), DG Mode (OFF/ON), Latitude, and Service Mode.

Selections are Highlighted with the Scroll UP or DOWN (▲ ▼) buttons. To select the currently highlighted menu option, press the select (SEL) button.

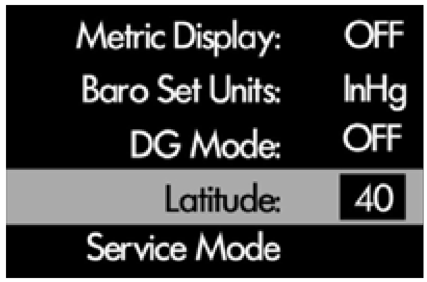

Figure 12-12. Menu

12.8.3 System Description

The SDU is powered up when power is supplied to the aircraft. Power up and initialization requires approximately 90 seconds in which the aircraft should be kept stationary. During the initialization the appropriate warning flags will be displayed.

Figure 12-13. SDU Initialization

12.8.3.1 TILE 1

ATTITUDE INDICATOR

Attitude information is derived from the SDU's internal MEMS Gyroscopes and accelerometers. The pitch ladder shows the pitch of the aircraft and provides warnings of extreme pitch. The roll indicator functions in the same fashion as the PFD indicator without a slip-skid indicator.

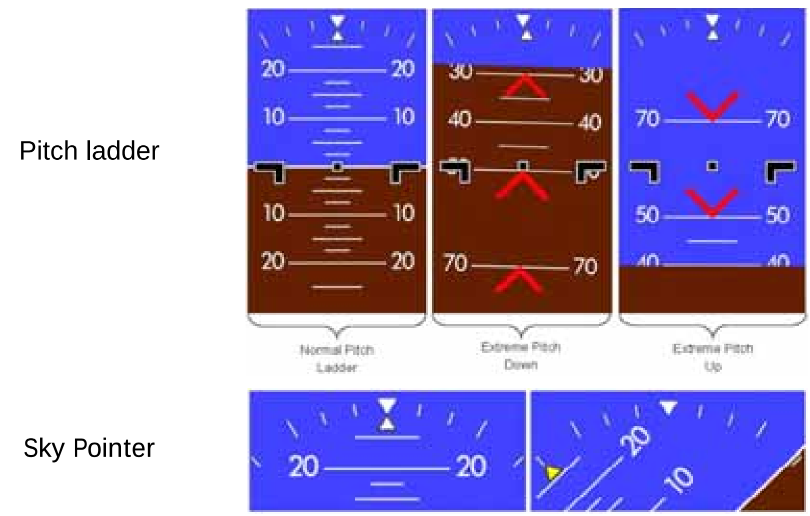

Figure 12-14. Attitude Indicator

AIRSPEED INDICATOR

The Airspeed Indicator is displayed on the left side of tile 1. The SDU utilizes the Air Data from the Standby Pitot/Static Probe and Air Data Computer #3 (ADC3). This information is subject to the limitations and correction tables contained in the Aircraft Flight Manual. As the Standby Pitot/Static probe does not contain Angle of Attack (AOA) sensing, Stall speed color bands are not AOA compensated. The SDU will not issue aural warnings for airspeed limit excursions.

Figure 12-15. Airspeed Indicator

Table 12-1. Airspeed Indicators

Airspeed Range	Color Bar	Speed Range (KEAS)
High Speed Awareness	Red	≥285/.64M
Normal Operations	Green	≤285/.64M - ≥95
Flap Operating	Green & White	≤140 - ≥95
Stall Speed	White	≤95 - ≥73
Low Speed Awareness	Red	≤73 - ≥21

ALTIMETER

The Altimeter is displayed on the right side of tile 1. It displays baro-corrected altitude above sea level. The altimeter can be set for both feet and meters by toggling the metric display on or off in the Menu (MEN). The baro correction is set using the Scroll UP and DOWN Buttons (▲ ▼) when the Menu (MEN) is not selected. Clicking the scroll up or down buttons changes the baro setting by .01 in Hg or 1 HPA. Pressing and holding the scroll buttons will advance the baro setting in the desired direction at an increased rate. Pressing and holding the Menu (MEN) button will set standard (29.92 in Hg or 1013HPA). Baro Correction is viewed just below the Altimeter tape in tile 2. When the Baro correction is changed the digits will blossom. The SDU will change the Baro correction to standard when climbing through the pressure altitude of 18,000 feet. This transition may not occur at the same time the PFD altimeters switch to standard. The SDU will not change the Baro Correction based on BARO SET on the Autopilot Control Panel (ACP).

Figure 12-16. Altimeter

12.8.3.2 TILE 2

VERTICAL SPEED INDICATOR (VSI)

The VSI is located on the right side of tile 2. Minor gradations indicate 500 feet per minute (fpm) increments; major gradations indicate 1,000 fpm increments. Zero fpm is the center of the scale. Descent is below the center, negative numbers are assumed. When rate of climb/descent exceeds 500 fpm a digital readout will appear above or below the VSI.

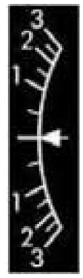

Figure 12-17. Vertical Speed Indicator (VSI)

HORIZONTAL SITUATION INDICATOR (HSI)

The HSI is displayed in the center of tile 2. The default source of heading information is the external magnetometer. If the SDU is not receiving valid magnetometer data, the SDU will switch to an internal Directional Gyro (DG).

Indication	HSI Source	Cause
M	External magnetometer	Default
M	External magnetometer (previous data)	Fault detected with external magnetometer within the first 5 minutes.
DG	Internal Gyroscope	DG mode has been selected by the pilot.
DG	Internal Gyroscope	Fault detected with the external magnetometer. SDU has switched automatically to DG mode.

Figure 12-18. Horizontal Situation Indicator (HSI)

12.8.3.3 DG MODE

Directional Gyro (DG) mode utilizes an internal gyroscope. This mode is enabled through a menu selection or external magnetometer fault. DG mode is to be selected by the pilot in areas of high magnetic inclination. Latitude must be set through the SDU Menu for correct magnetic heading indication.

12.8.4 Abnormal Procedures

12.8.4.1 SDU RESET

If the SDU detects a fault or momentary loss of power it will reset. If in flight the display will indicate a prompt of “MAINTAIN A LEVEL ATTITUDE AND A STEADY COURSE PRESS SEL TO REINITIALIZE”.

Press select and the SDU screen will return to normal but with an amber ALIGNING annunciation until the SDU has realigned.

In the event a hardware component fails the SDU will display a red box with red text to indicate what components have failed. This internal fault detection cannot detect if the Pitot/Static probe is blocked.

Figure 12-19. SDU Reset

12.9 Crew Alerting System Messages

Table 12-2. 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 lost communication between AHRS 1 and ADC 1 – system will automatically revert to operating ADC in AUTO mode.	Advisory
ADC 2 FAIL	ADC 2 failure or lost communication between AHRS 2 and ADC 2 – system automatically reverts to operating ADC in AUTO mode.	Advisory
ADC 3 FAIL	Airspeed, altitude and vertical speed information on the SDU has been lost.	Advisory
GPS 1 FAIL	GPS 1 failure – system automatically reverts 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

12.10 Air Data Review Questions

1. **List the three locations/aircraft components that receive air data information from the ISSs as well as how each destination component uses it:**

   a.

   b.

   c.

2. **What data is sent back to the ISSs 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 Air Data Computer (ADC) get its Angle of Attack (AOA) information?**

   a. From pitot/AOA probes located on the aircraft nose
   b. From the pitot/static probe only
   c. From the static ports
   d. The ADC does not use AOA information.

5. **What is the purpose of the pitot/static probe?**

   a. It is the only heated probe and thus provides pertinent data when ice is encountered

   b. It provides information to the Aircraft Computer System (ACS) for use on the Standby Display Unit (SDU)

   c. It can be used in the event of a system abnormality or disagreement between primary probes

   d. Answers B and C

6. **How are the probes and ports protected from ice?**

   a. Only the pitot/static probe 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 Outside Air Temperature (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
d. None of the above

8. What information is collected by the ADCs?

9. What are three primary items comprise an Integrated Sensor Suite (ISS)?

a.

b.

c.

10. In the event of a sensor disagreement, what can the pilot do to restore valid data to the PFD?

a. Look at the cross-side PFD
b. Use the standby instruments on the SDU
c. 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 and B are correct

12. Which air data components are load shed during single generator operation?

a. Left and right pitot/AOA heat and left and right static port heat
b. Left pitot/AOA heat only
c. Right pitot/AOA heat only
d. None of the above

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Primary Flight Display (PFD) 13

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Primary Flight Display (PFD) 13

13.1 General

See Figure 13-1. 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 (VSI), and Horizontal Situation Indicator (HSI) which includes overlays of Traffic, Weather Radar, Stormscope, and Flight Plan. The PFD also provides a Composite mode in which the PFD provides a reversionary capability in order to access flight critical information in the event of a Multi Function Display (MFD) failure.

Figure 13-1. Primary Flight Display (PFD)

13.2 Limitations and Specifications

13.2.1 Headsets

After engine start, the use of headsets by the flight crew is required

13.2.2 GPS Based Distance to Station Function

The GPS does not provide distance to a selected VHF navigation source unless it is part of the GPS flight plan.

The following limitations apply unless the optional DME is installed.

The navigation database must be verified for currency before using distance information.

Flight at or above FL240 is not approved with GPS distance unavailable (distance value dashed).

If GPS distance becomes unavailable (distance value dashed) while in flight at or above FL240, inform ATC immediately.

Valid GPS based distance to station meets the performance and integrity requirements for:

- 14 CFR Part 91, section 91.205(e) requirement for Distance Measurement Equipment at or above FL240
- Flying a published DME arc
- Establishing a distance to a station or fix

NOTES:

- GPS NOTAMS should be checked and RAIM predictions used to determine GPS availability.

13.2.3 GPS Navigation Database

IFR en route and terminal navigation is prohibited unless the flight crew verifies the currency of the database or if the database is not current the flight crew verifies each selected waypoint for accuracy by reference to current approved data.

GPS instrument approaches are prohibited, unless the approach data is verified by the flight crew to be current. GPS instrument approaches must be accomplished in accordance with an approved instrument approach procedure that is loaded from the database.

Navigation is prohibited north of 89° north latitude or south of 89° south latitude.

13.2.4 Approaches

Accomplishment of an ILS, LOC, LOC-BC, LDA, SDF, MLS, VOR approach, or any other type of approach not approved for GPS overlay is not authorized with GPS navigation guidance from the final approach fix inbound.

When conducting approaches referenced to true North, the heading selection on the AUX pages must be adjusted to TRUE.

Table 13-1. Approach Annunciations

Published Minimums	Definition	FMS Annunciations
LNAV/VNAV-B	Lateral Navigation with Vertical Navigation using Barometric Altitude	LNAV/VNAV-B
LNAV-B	Lateral Navigation with Barometric Vertical Reference	LNAV-B
LNAV	Lateral Navigation with advisory vertical guidance. RNAV non-precision LNAV approach with advisory vertical guidance. Pilot must maintain aircraft altitude within constraints on the approach.	LNAV
LNAV/VNAV	Lateral Navigation/Vertical Navigation. RNAV non-precision approach with advisory vertical guidance.	LNAV/VNAV
LP-B	Localizer Performance with Barometric Vertical Reference	LP-B
LPV	Localizer Precision with Vertical guidance approach. RNAV precision approach.	LPV
LP	Localizer precision with no vertical guidance. Fly to LP Minimums.	LP

13.2.5 Navigation Database Limitations

The ARINC 424 navigation database effectivity needs to be verified before using the Flight Management Navigator.

The operator of the aircraft is required to check RAIM availability. For flight planning purposes, operations within the U.S. National Airspace System on RNP and RNAV procedures when SBAS signals are not available, the availability of GPS integrity RAIM shall be confirmed for the intended route of flight. In the event of a predicted continuous loss of RAIM of more than five minutes for any part of the intended route of flight, the flight should be delayed, canceled, or re- routed on a track where RAIM requirements can be met.

13.2.6 Barometric VNAV- Limitations

While operating under LNAV/VNAV-B level of service, published restrictions specified for "Uncompensated Baro-VNAV systems" must be followed.

13.3 System Description

13.3.1 Normal Mode

See Figure 13-2. The PFD Normal Mode is organized into five tiled areas capable of displaying all necessary flight information. Several of these tiles are configurable and display the following information:

13.3.1.1 TILE 1

- Flight Mode Annunciator (FMA)
  - *Autothrottle Modes*
  - *Lateral Modes*
  - *Vertical Modes*

13.3.1.2 TILE 2

- Airspeed Tape
  - *SPD SEL Display*
  - *Mach Number Display*
  - *VR/VREF (REF) Display*
  - *High and low speed awareness tapes*
  - *VYSE (YSE), VR, VREF (REF), Climb (CLB), VFE takeoff (T/O), VFE landing (LDG), bugs*
- Attitude Direction Indicator (ADI)
  - Sky Pointer
  - Slip Skid Indicator
  - Pitch Ladder
  - Pitch Chevrons
  - Flight Director
  - AP/AT/YD engagement status
  - Flight Director (FD)
- Altitude Tape
  - Pre-selected Altitude
  - Altitude warnings
  - Approach Minimums
  - Barometric pressure setting (in Hg, HPA)
  - Approach minimums display
- Vertical speed indicator
- Marker beacon receiver
- Horizontal Deviation Indicator
  - Source
  - Scaling
- Vertical Deviation Indicator
  - Source

13.3.1.3 TILE 3 (CONFIGURABLE)

- Course Deviation Indicator source
  - FMS Alternate Operation Mode
  - VECTORS/SUSPEND/OFFSET/MISSED APROACH
- (FMS, VLOC 1, VLOC 2) selection
- Overlay (TRAFFIC, WX RADAR, TRAFFIC/WX RADAR) selection

- Bearing Pointer source
  - Waypoint ID and Distance
- (FMS, VLOC 1, VLOC 2, ADF) selection
- View selection
  - ARC/FLTPLAN, ARC, FULL/FLTPLAN, FULL
- True airspeed
- Outside Air Temperature (OAT)
- Time
- Horizontal Situation Indicator (HSI)
- Wind indicator
- Projected track indicator

13.3.1.4 TILE 4

- HDG SEL Bug display
- Desired Track display
- Omni Bearing Selector display
- CDI Course (CRS)
- Phase of Flight
- Approach Level of Service
- NAV Failures
- Radar Tilt/Gain
- Radar Failures
- Wind Indicator
- Distance & ETE to active waypoint
- Groundspeed
- Horizontal Situation Indicator
- Range display
- Heading display (magnetic or true)
- Projected track indicator
- Course Deviation Indicator
- Bearing Pointer

13.3.1.5 TILE 5 (CONFIGURABLE)

- Active communication (COM) frequency
- Communication frequency being monitored (MON)
- Communication (COM) radio tuning and selection
- Navigation (VOR, LOC) radio tuning and selection
- Transponder (XPDR) tuning and selection
- Active Transponder (XPDR) and Code
- Approach Minimum Selection
- Automatic Direction Finder (ADF) radio tuning, mode selection, and monitoring
- Timer
- Weather Radar
  - Mode Selection
  - Tilt
  - Gain
- Stormscope
  - Mode Selection
  - Strike Clear

Figure 13-2. PFD Tile Layout

13.3.2 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.

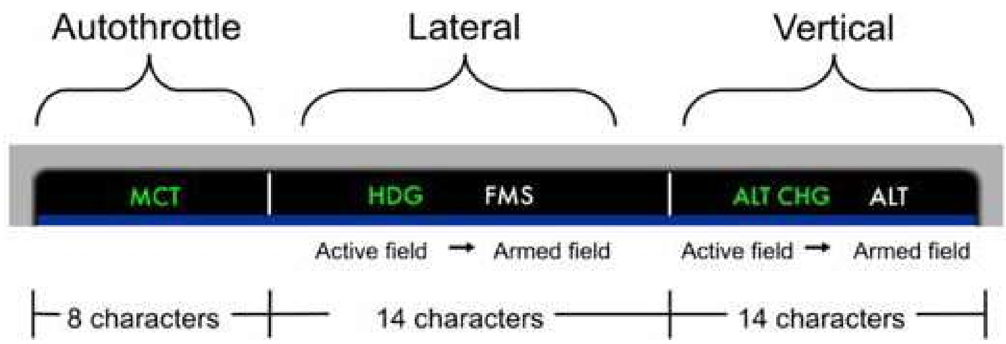


Figure 13-3. Flight Mode Annunciation (FMA) Window

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 reports 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.

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, manipulates the throttles automatically to hold the airspeed target during descent and cruise flight.

A complete list of FMAs is located in Chapter 15 of this document.

13.3.3 Tile 2 – Attitude Direction Indicator (ADI) and Primary Flight Information

In Tile2, the PFD continuously displays primary flight instruments of attitude, slip-skid, 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, and barometric (BARO) correction. The engagement state of the autopilot, autothrottle, and yaw damper are presented outside of the FMA window in Tile 2.

Figure 13-4. PFD Tile 2

13.3.3.1 AUTOPILOT ENGAGEMENT AND DISENGAGEMENT

See Figure 13-5. The Autopilot, Autothrottle, and Yaw Damper engagement status can be confirmed by green AP, AT, and YD text in tile 2 adjacent to the airspeed tape.

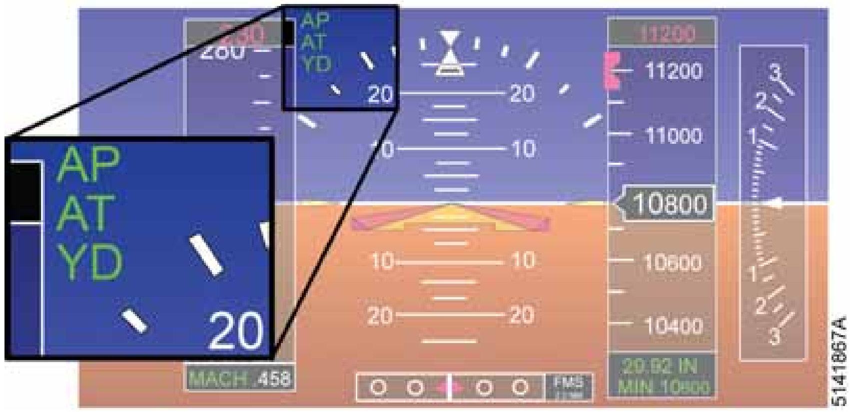


Figure 13-5. Autopilot and Yaw Damper Display – PFD

See Figure 13-6. When the Autothrottle is disconnected an amber AT DISC will be shown for three seconds on the PFD above the sky pointer, a single autoflight cavalry charge aural alert sounds. The AT DISC will disappear and the aural alert does not require silencing. When the autopilot is disconnected an amber AP DISC text appears on the PFD, and an autoflight cavalry charge aural alert tone sounds for a minimum of three iterations to notify the flight crew of autopilot disengagement. The AP DISC text and autoflight cavalry charge will persist until the pilot silences the warning using the AP DISC button on either sidestick. If the autothrottle was disengaged in addition to the autopilot an amber AP/AT DISC text appears on the PFD for three seconds and the autoflight cavalry charge aural alert will sound. After the three seconds the AP/AT DISC text will be replaced by the AP DISC text and the autoflight cavalry charge aural will persist until the pilot silences the warning using the AP DISC button on either sidestick.

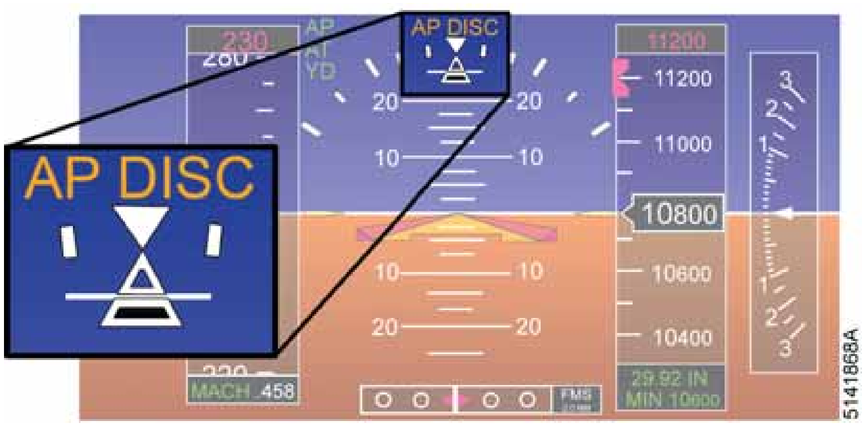


Figure 13-6. Autopilot Disconnect Annunciation

13.3.3.2 AIRSPEED INDICATOR

The airspeed indicator consists of a scale, numerical labels, trend vector, reference markings, airspeed bugs, and Mach number display.

Figure 13-7. 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 range continuously visible. There are major tick marks every 10 knots and minor tick marks every 5 knots. The current airspeed is 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, with no leading zeros. Mach is displayed when the Mach number is .400 or above, and remains displayed until the Mach decreases to .350. If V_{ref} is set using the REF button on the V-SPEEDS ENG TEMP sub-page of the OPS synoptic page, it is displayed when below .350 Mach. If V_{ref} has not been set and airspeed is below .350 Mach, then nothing is displayed below the airspeed tape.

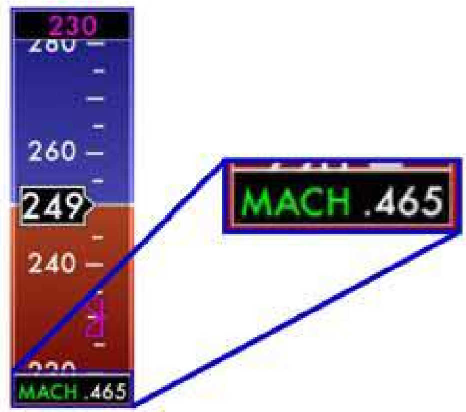


Figure 13-8. Mach Indication

- **Trend Vector**

A magenta 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 six seconds in the future based upon the airspeed change in the previous two seconds.

Figure 13-9. Trend Vector

- **Airspeed Bug**

A magenta target airspeed bug is displayed to the right side of the airspeed tape. When the autopilot is engaged and in ALT CHG - climb mode, or the Autothrottle is engaged in SPD HOLD or MCT, the bug is solid and indicates that a speed is targeted to be held. 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 or autothrottle to capture and hold a preset speed.

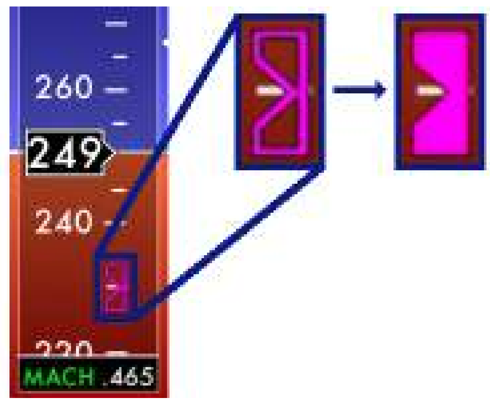


Figure 13-10. Airspeed Bug

- **V Speeds**

The airspeed tape displays several V speeds:

— 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 V-SPEEDS ENG TEMP subpage of the OPS synoptic 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 V-SPEEDS ENG TEMP subpage of the OPS synoptic page on the MFD.

— Best Single Engine Climb Rate Speed (YSE)
The best single engine climb rate speed, V_{yse} appears as a YSE text bug. This airspeed is based on APR Thrust on the operating engine and varies with flap selection, weight, altitude and temperature.

— Climb (CLB)
The best fuel for distance speed from the Time, Fuel & Distance to Climb Charts appears as a CLB text bug. It varies with weight, altitude, and temperature.

- **Airspeed Exceedance**

The high speed awareness tape is displayed as a dashed line above V_{MO} or M_{MO}, or configuration limit (V_{FE}, V_{LE}) 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. Further speed excursion will cause the airspeed box to sequence between red and amber. At 3 knots above V_{MO}, M_{MO}, or configuration limit the autothrottle will activate SPD PROT mode, and reduce the throttle to stay below the high speed awareness tape. If the speed continues to build, at 6 knots above the red tape an overspeed textual alert will appear on the ADI, and an aural "cricket" alert will sound, until the speed is reduced. The SPD-SEL bug cannot be set to a number above the high speed awareness red tape. If the red tape decreases in speed (MMO in the climb, change of configuration) and the SPD-SEL bug is no longer at a valid airspeed the bug will move to the closest valid airspeed.

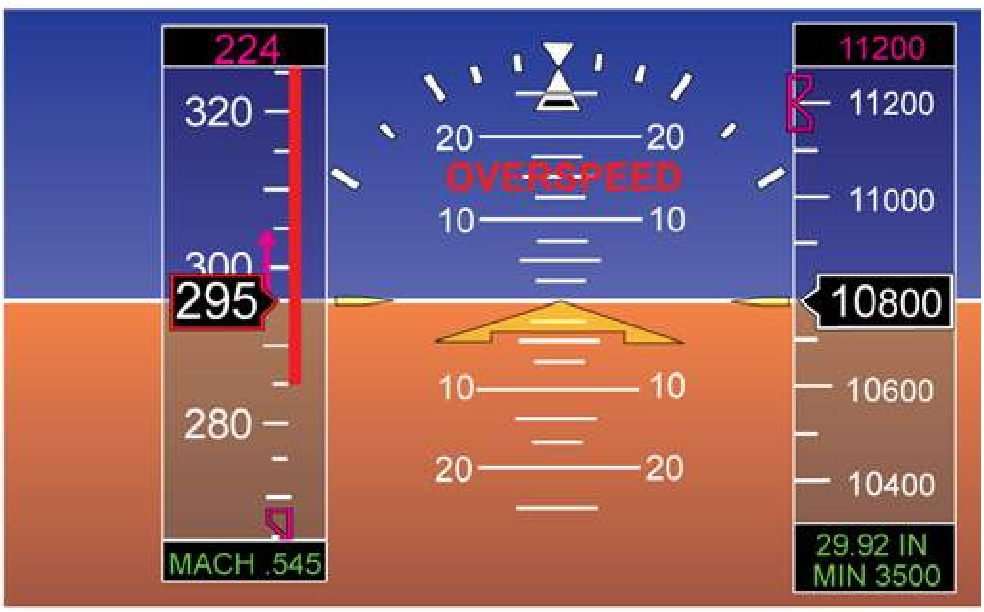


Figure 13-11. Airspeed Exceedance

The low speed awareness red tape is displayed below a speed which equates to an Angle of Attack (AOA) for stall speed in the current configuration, based on flap selection and wing de-ice status. The red tape is responsive to on-side AOA, and will change speed as AOA changes. When the ICE PROT switch is placed in the WING position, the low speed awareness tape will creep upwards over a period of 30 seconds. When the ICE PROT switch is placed in either ENG or OFF the low speed awareness tape will decrease to it's normal level in 3 seconds. If the current airspeed decreases below the low speed awareness red tape the airspeed box turns red and a textual STALL indication will appear on the ADI. An aural alert of "STALL" will sound. If speed continues to decrease the Autothrottle SPD PROT mode would activate bringing the throttles to MCT. If speed was allowed to continue to decrease and both Air Data Computers agree that the aircraft is approaching a stall the Stick Pusher would activate to lower the AOA. A PUSH textual alert would appear on the ADI and an aural alert "PUSH" would sound. The SPD-SEL bug can not be selected to a speed below the low speed awareness tape. If the bugged speed becomes in valid (change in AOA, configuration, or ICE PROT) the bug will be moved to the closest valid airspeed.

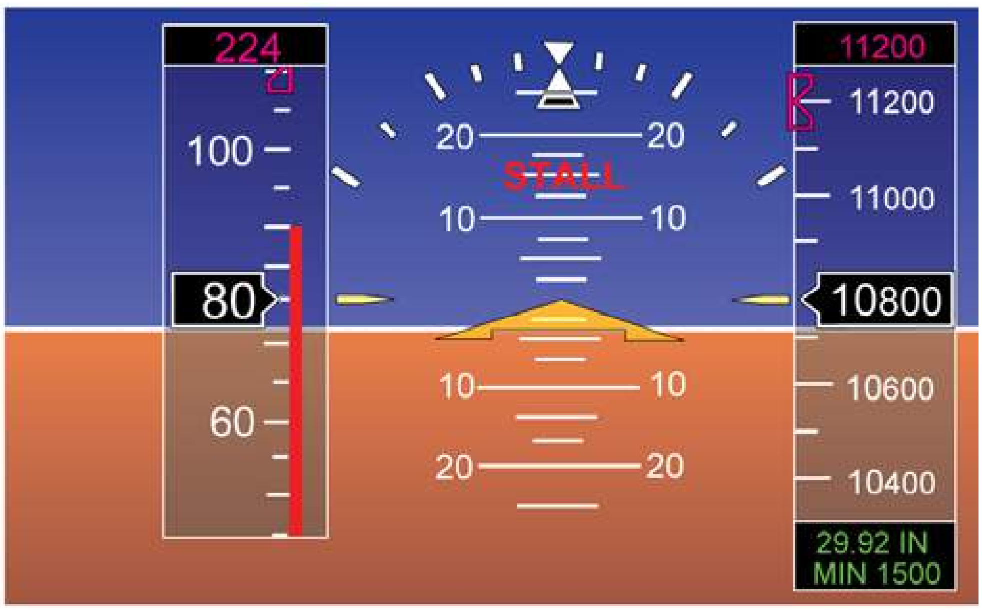


Figure 13-12. PFD, Stall Warning Display

13.3.3.3 ATTITUDE DIRECTION INDICATOR (ADI)

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, a 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 13-13. Attitude Direction Indicator (ADI)

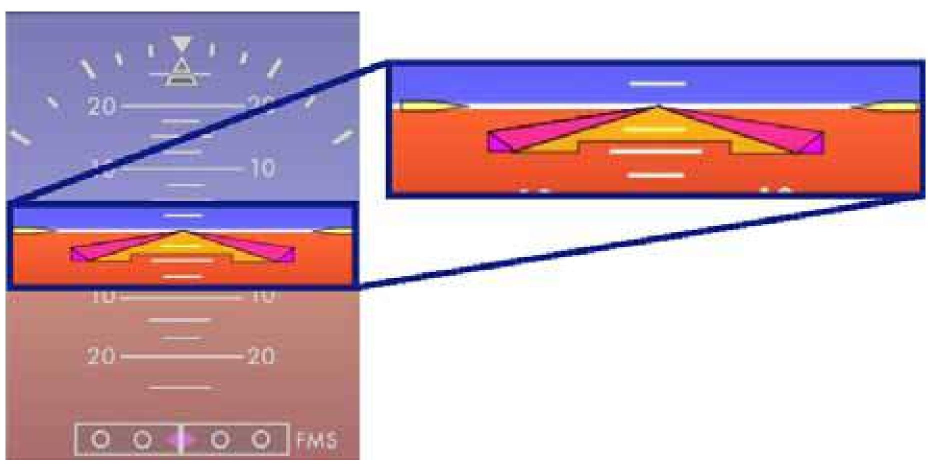


Figure 14-14. Horizon Reference Pointers

- **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 is always visible. At extreme pitch angles a series of red chevrons point towards the horizon.

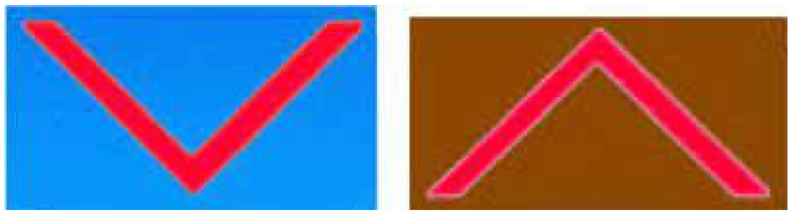


Figure 13-15. Pitch Chevrons

The pitch scale is displayed as horizontal labeled lines at 10°, 20°, 30°, 40°, 50°, and 70°, with unlabeled lines every 5° and 2.5°. The right and left side of the larger increments have tick marks pointing up or down towards the horizon. At 90° of pitch, there is a small circular ring.

- **Roll**

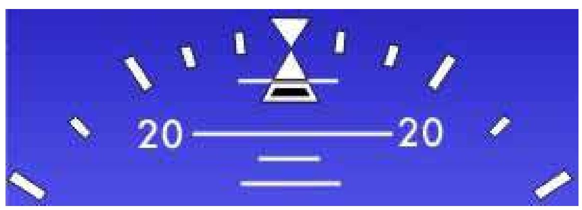


Figure 13-16. Roll Indications

The ADI is accurate for ±180° of roll. The roll scale is displayed with a white triangle at 0°, large tick marks at 30° and 60° left and right, and smaller tick marks at 10°, 20°, and 45° left and right. Roll angle is displayed by a white triangular sky 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 sky pointer and the airplane symbol roll in parallel with the airplane. A roll to the right will have the sky pointer deflect to the left and vice versa.

- **Slip/Skid Indicator**

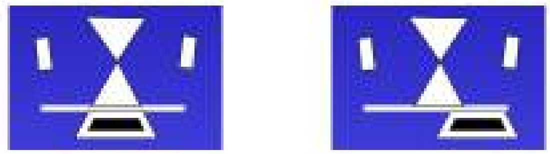


Figure 13-17. Slip/Skid Indicator

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 sky pointer triangle.

- **Flight Director (FD)**

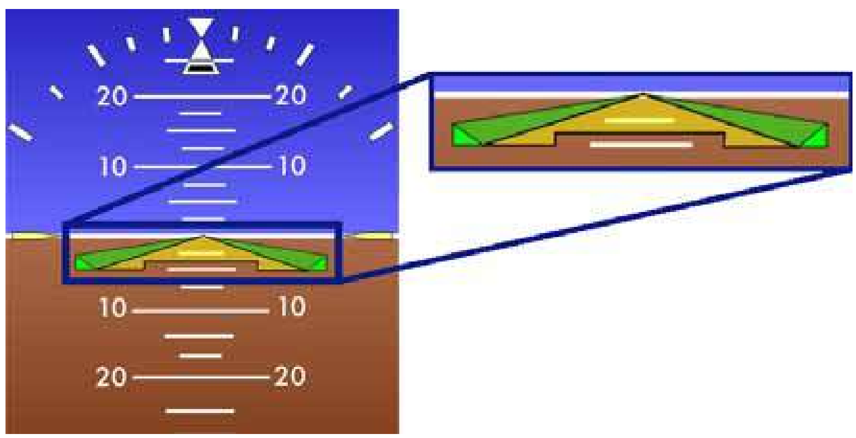


Figure 13-18. Flight Director (FD)

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 is off. When the autopilot is activated, the FD command bars turn magenta. Invalid FD data will cause the FD to be removed.

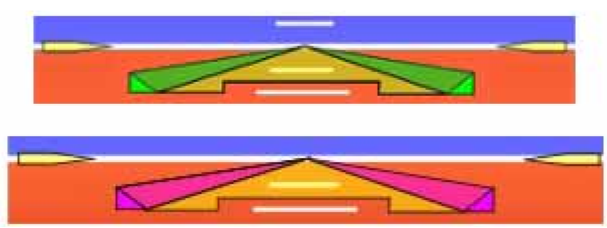


Figure 13-19. Flight Director (FD) Indications

- **Horizontal Deviation Indicator (HDI)**

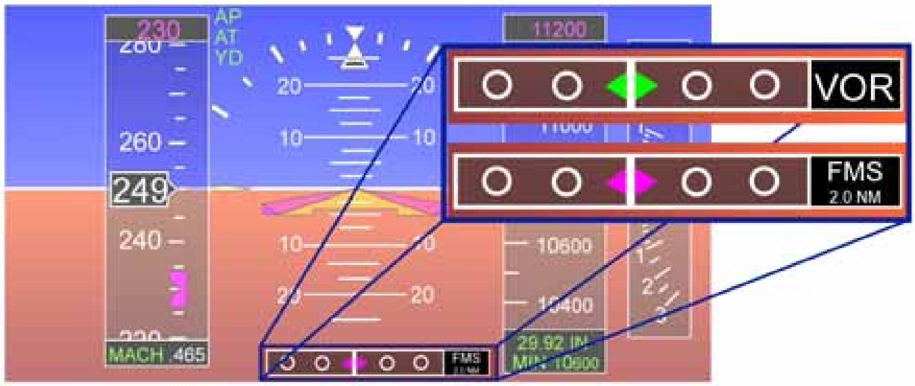


Figure 13-20. Horizontal Deviation Indicator (HDI)

The PFD also displays a Horizontal Deviation Indicator (HDI) in the lower portion of the ADI. Like the CDI needle, the HDI scale provides tick marks for zero deviation, half and full scale (left and right). The navigation source is displayed to the right of the HDI and indicates VOR, FMS, Localizer (LOC), or Localizer Back Course (LOC BC). With the FMS as the selected navigation source the deviation scaling is automatically set depending on the mode of operation: Oceanic, Enroute, Terminal, Approach. A HDI diamond indicates course deviation. If the pointer exceeds full scale deviation an amber hollow diamond is shown.

Figure 13-21. Horizontal Deviation Indicator (HDI) – Full Scale

If navigation signal is lost or invalid the HDI will be replaced by an amber LOC flag.

Figure 13-22. Horizontal Deviation Indicator – Signal Loss

- **Vertical Deviation Indicator (VDI)**

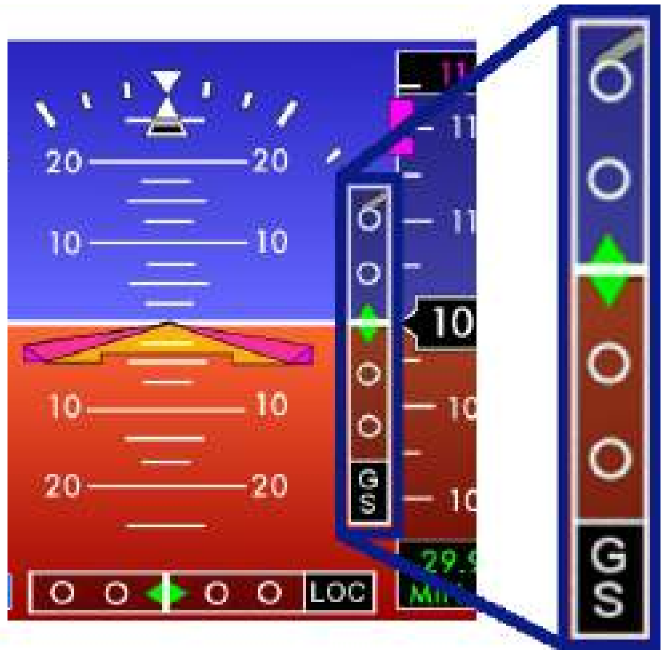


Figure 13-23. Vertical Deviation Indicator (VDI)

The PFD displays a Vertical Deviation Indicator (VDI) for glide slope (GS), when the active navigation source is tuned to and receiving a localizer frequency and the current aircraft heading is not more than 90° from the selected course (back-course area).

When the FMS is selected as the navigation source and the FMS has transitioned into the Approach mode, The PFD will display a Vertical Deviation Indicator. For a Localizer Performance with Vertical Guidance (LPV) approach, the VDI will depict the glide path (GP). For an Lateral Navigation/Vertical Navigation (LNAV/VNAV) approach the VDI will depict Vertical Path (VPATH). For Laternal Navigation (LNAV), and Localizer Performance (LP) non-precision approaches the VDI will display, yet the autopilot will not be able to couple to the deviation commands. the VDI for LNAV and LP approaches is not vertical guidance, and is advisory in nature only.

The VDI scale provides a straight line for zero deviation, with circles at 1/3 and 2/3 deviation up and down. A diamond pointer indicates course deviation; if the pointer exceeds full scale deviation an amber hollow diamond is shown. In scale indication will be a Green (ILS) or Magenta (FMS) filled diamond.

Figure 13-24. Vertical Deviation Indicator (VDI) – 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 will be replaced by an amber G/S flag.

If on a FMS approach and the GPS accuracy lacks the vertical resolution required to show guidance or vertical advisory a fail-down will occur. The approach level of service will balloon up with the white boxed text LNAV ONLY, and an amber MSG (Message). Once the message is accepted on the FMS PROG tab the LNAV only will shrink to it's normal size and turn magenta. The VDI will no longer be displayed.

- **Marker Beacon Receiver**

Marker beacons are selected ON by default, but the audio can be turned off by selecting the MARKER BEACON item on the AUDIO page and pushing the dual concentric knob or by pushing the MB button on the keyboard. If subsequently, a Localizer frequency is entered and made active the Marker Beacons will once again enable.

In addition to the aural tones, visual indications are displayed on the lower part of the ADI as follows:

1. Outer Marker ....Blue display – "OM"
2. Middle Marker.. Amber display – "MM"
3. Inner Marker..White display – "IM"
4. Airway marker .... White display – "AM"

If a localizer is selected as the primary navigation source on either PFD, the marker beacon sensitivity is automatically set to LOW. At all other times it is set to HIGH and the Airway Marker signal is detected and displayed.

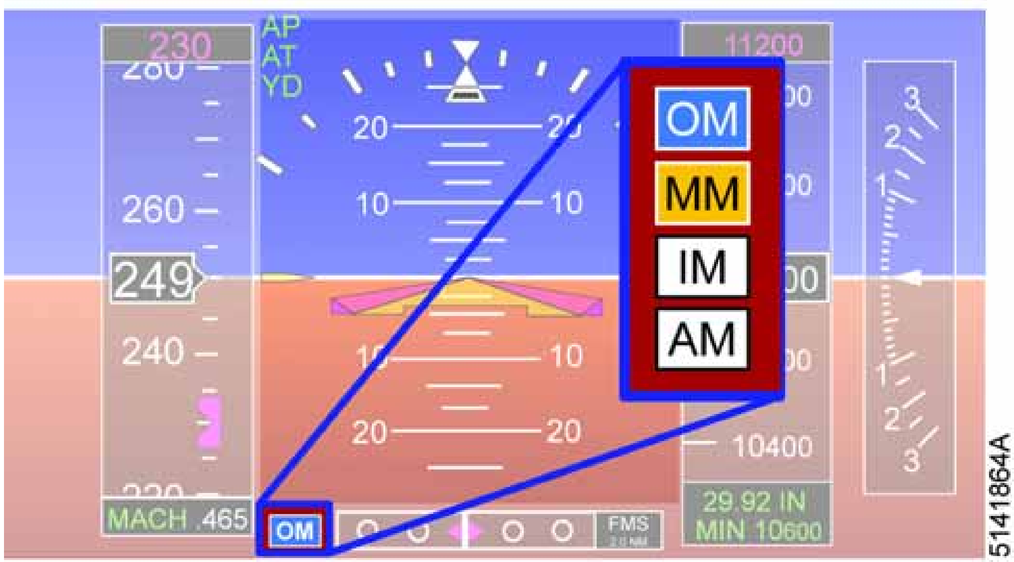


Figure 13-25. Marker Displays on PFD

13.3.3.4 ALTIMETER

Figure 13-26. 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 600 feet of altitude visible at one time. The altitude scale moves relative to the fixed window to indicate BARO corrected altitude. 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 feet MSL, and the upper limit is at 50,000 feet MSL.

- **Trend Vector**

The altimeter displays a magenta trend vector when altitude is changing at rates above 300 fpm. The altitude trend vector depicts the altitude change predicted over the next 6 seconds based upon altitude change over the last two seconds.

- **Altitude Bug**

A magenta target altitude bug is displayed to the left side of the tape. When the FD/autopilot is engaged, the target indicates what altitude has been selected for capture. When the ALT-SEL knob on the autopilot control panel is pressed, the target bug synchronizes to the current altitude. The altitude bug is solid only when the FD/autopilot is set to capture a preset altitude. Once an altitude is captured, the bug becomes hollow.

- **Approaching Minimums Aural Alert**

  An "APPROACHING MINIMUMS" aural alert sounds when 100 feet above the selected minimum altitude. On reaching the selected altitude, a "MINIMUMS" aural alert is annunciated. In addition, the minimums value and MIN label turn yellow. The aural alert can be selected OFF with the MINIMUMS ALERT selection on the SETTINGS page.

- **Altitude Alert Message**

  When approaching the selected altitude within 1,000 ft, an aural C-chord is heard. If deviating 200 ft from the selected altitude after acquiring it, the same C-chord aural is heard and an amber ALT ALERT message is annunciated above the altitude tape.

Figure 13-27. Altitude Alert Message

- **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 SETUP - SENSORS synoptic page.

  The barometer setting will automatically switch to standard 29.92 inches of Mercury (Hg) or 1013 Hectopascals (HPA) as the aircraft passes through a PRESSURE altitude of FL180. This setting may be disabled on the Settings synoptic Auto Baro Set.

  Pushing the BARO SET knob on the autopilot control panel resets the altimeter setting to 29.92 inches Hg (1013 HPA). The BARO units may be adjusted between English (inches of Hg) or Metric (HPA), on the Settings synoptic. Changing the BARO SET on the PFDs will not change the BARO on the Standby Dispaly Units (SDUs).

- **Approach Minimums Display**

An approach minimums display is located in the lower portion of the data block below the altitude tape.

The value for approach minimums is entered under the NAV tab: Right LSK1 MINS of the PFD. The value can either be entered through the dual concentric knobs or the keyboard.

The approach minimum value is displayed under the altitude tape in green if the aircraft is above the selected altitude, and amber for at or below. An amber tick mark on the altitude tape depicts the selected minimum altitude.

The approach minimums may be transported to the altitude pre-selector by Highlighting the MINS LSK and then pressing the center push button of the dual concentric knobs. this is used in order to command the autopilot to hold altitudes which are not at 100 foot increments, for example MDA 1140 MSL.

- **Invalid Data**

The PFD can detect invalid altitude data reported from the Air Data Computer (ADC). When pressure altitude is determined to be invalid, the PFD removes the altitude window (with value), the altitude trend vector, the altitude scale, and the altitude bug/numeric value, then displays a red boxed ALT indication covering the area where the altitude scale was.

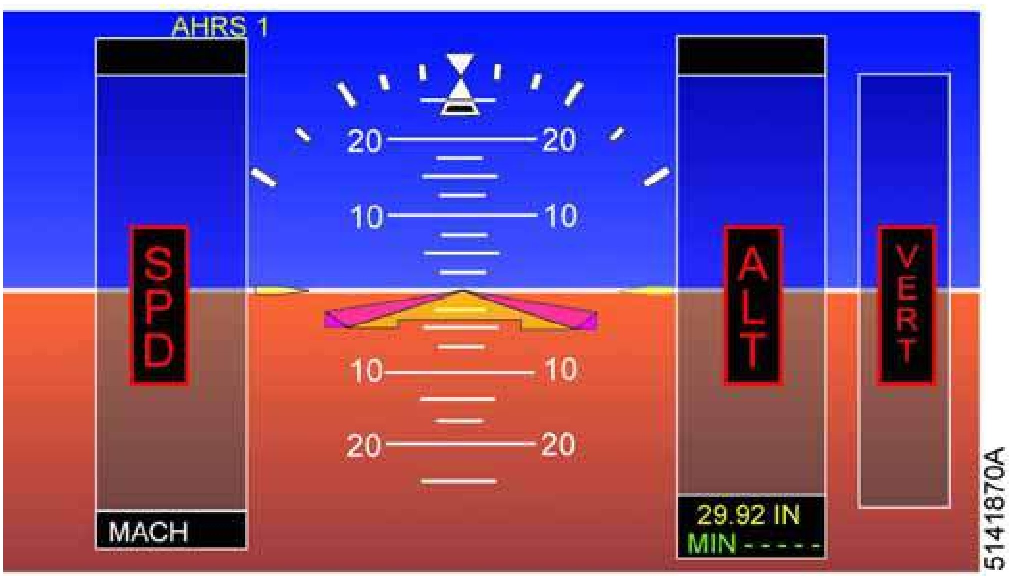


Figure 13-28. Invalid Data

13.3.3.5 VERTICAL SPEED INDICATOR (VSI)

Figure 13-29. Vertical Speed Indicator (VSI)

- **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 (e.g., 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.

- **Vertical Speed Bug**

  When the autopilot or flight director is selected to ALT CHG mode in the descent, a magenta filled vertical speed bug appears. The digital value of the selected vertical speed appears in a box above the vertical speed indicator. With the first press of the ALT CHG (descent) mode the Vertical Speed Bug is selected to a 3 degree descent based on True Air Speed (TAS). Selected Vertical Speed may be changed with the use of the thumb wheel on the Autopilot Control Panel (ACP). Each click of the thumb wheel changes the selected vertical speed by 100 fpm.

13.3.4 Tile 3 – Primary, Secondary NAV Source Selection, Data Block and Left Line Select Keys

Figure 13-30. PFD Tile 3 – Line Select Key Options

13.3.4.1 TILE 3 DATA BLOCK

Figure 13-31. Tile 3 Data Block

- **True Airspeed (TAS)**

  The True Airspeed (TAS) is displayed as a whole number of up to three digits.

- **Outside Air Temperature (OAT)**

  The Outside Air Temperature (OAT) is displayed as a whole number up to 3 digits with no leading zeros.

- **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 Universal Time Code (Zulu) or a bias from Zulu to net Local time. The clock is configurable on the Settings synoptic page.

- **Line Select Keys and Concentric Knob (LEFT)**

Line Select Keys (LSKs) on the Left side of the PFD in normal mode provide selection of Navigational sources and options on the HSI.

LSK 1 configures the Course Deviation Indicator (CDI) as well as the Horizontal Deviation Indicator (HDI) and Vertical Deviation Indicator (VDI).

LSK 2 configures the Bearing Pointer (BRG).

LSK 3 provides various Overly options on the HSI.

LSK 5 provides various Viewing options of the HSI.

— Line Select Key 1
CDI
Primary NAV source select VOR1/LOC1
VOR2/LOC2
FMS

— Line Select Key 2
BRG
Secondary NAV source select VOR1
VOR2
FMS
ADF
OFF

— Line Select Key 3
OVERLAY .... TRAFFIC
WX RADAR
TRAFFIC/WX RADAR

— Line Select Key 4
NO FUNCTION

— Line Select Key 5 .... ARC (120 degree view)
ARC/FLTPLN (with flight plan overlay)
FULL (360 degree view)
FULL/FLTPLN (with flight plan overlay)

— Concentric Knob (LEFT)
Inner Knob .... CRS, changes the course for the VHF (VOR or LOC) selected navigation source.
Pushing the inner knob will center the course for a VOR source.
The Desired Track (DTK) of the FMS source is set automatically by the FMS.
The FMS OBS course is set by the inner knob when the FMS is operated in the Omni-Bearing Selector (OBS) mode.

Outer Knob .... RNG, rotating the outer knob changes the NM value of the outer range ring on the HSI.
Options are 5,10,20,40,80,160,320, and 640 nm.

13.3.5 Tile 4 – Horizontal Situation Indicator (HSI) and Overlays

Figure 13-32. PFD Tile 4 – Horizontal Situation Indicator (HSI)

The HSI is located in PFD Tile 4. 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.

Figure 13-33. VIEW Selection

- **View**

  With FULL view 360 degrees is shown. Major graduation marks are shown every 10 degrees, minor graduations are shown every 5 degrees. Headings are labeled every 30 degrees.

Figure 13-34. 360° Compass View

See Figure 13-35. The ARC view depicts 120° 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 and points towards the top of the screen.

Figure 13-35. 120° Arc View

- **HSI Map Range (nm)**

  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 rotating the outer portion of the left concentric knob. Rotating the knob left decreases range and rotating the knob right increases range. The current range selection in nautical miles (nm) is displayed on the upper right portion of the rings.

- **Heading Window**

  The current aircraft heading is displayed in a box at the top of the HSI.

Figure 13-36. Heading Window

Heading Reference is configurable to Magnetic or True North Reference on the settings page of the Setup Synoptic. When the Heading Reference setting is MAG, a green 'M' is displayed adjacent to the HSI Current Heading Window. This is duplicated on the MFD ND tab.

Figure 13-37. Mag Reference on the HSI

When the Heading Reference setting is TRUE, a green 'T' is displayed adjacent to the Current Heading Window on the HSI and ND. In addition, the Desired Track, Selected Course, and Selected Heading will be annunciated with a 'T' to indicate True Reference on the PFD.

Figure 13-38. True Reference on the HSI

When the Heading Reference setting is TRUE, the compass rose on the HSI and the MFD ND (HEADING UP) will be rotated to align True Aircraft Heading at the 12 o'clock position, and the heading reference (triangle) will be rotated around the compass rose to indicate the Magnetic Heading.

- **Heading Bug**

A magenta target heading bug is displayed along the outer edge of the compass rose. At start-up, the heading bug is set to 360 degrees.

Heading bug position is controlled by the HDG SEL knob on the autopilot control panel. Associated pre-select information is displayed in the heading pre-select window, located in the upper left portion of the HSI display. One knob click is equal to +/-1°; however, scrolling the HDG SEL knob quickly will cause an accelerate function to rapidly rotate the heading bug.

Pressing the HDG-SEL knob synchronizes the heading bug to the current aircraft heading. The heading bug is solid only if in use by the flight director/autopilot to capture a preset heading. The heading bug remains solid while in Heading (HDG) or FMS Vectors (FMS VEC) mode.

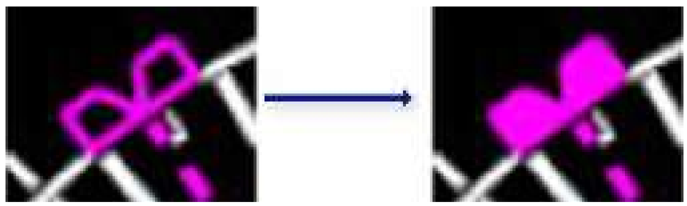


Figure 13-39. Heading Bug

- **Projected Track Indicator**

The projected track indicator, based off the ground track information from the FMS, is displayed along the compass scale as a hollow white diamond when in the FULL view, and as a grey line extending from the aircraft symbol when in the ARC view.

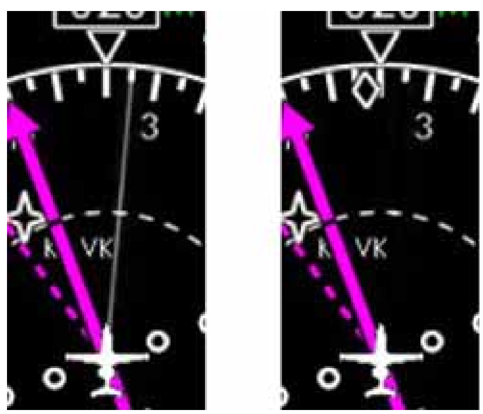


Figure 13-40. Projected Track Indicator

- **Course Deviation Indicator (CDI)**

The Course Deviation Indicator (CDI) consists of a CDI needle with an integral TO/FROM indicator, and a deviation scale. It corresponds with the CDI Left Line Select Key 1 on the PFD. The CDI arrowhead points to the current selected course (CRS, DTK, OBS) on the HSI compass rose to the current selected course of the primary navigation source. The left PFDs CDI is the only CDI connected to NAV and APPR functions of the autopilot.

Figure 13-41. Tile 3 – Left Line Select Keys

- **Course Selection**

Desired Track (DTK) is automatically set by the FMS. VHF Course (CRS) and FMS Omni-Bearing Selector (OBS) is selected using the left concentric knob and is displayed above and to the left of the HSI.

At start-up, the CRS is set to 360 degrees. Rotating the Dual Concentric Knob (DCK) inner knob changes the CRS/OBS in 1 degree increments; however, scrolling the inner knob quickly will cause an accelerate function to rapidly rotate the CRS/OBS. Pressing the inner knob will center the CRS when a VOR is selected in the CDI. CRS selection can be made from either the left PFD or the right PFD and will be synced to both PFDs.

Figure 13-42. Course Selection

- **CDI Indications**

The CDI moves relative to the course selection arrow to indicate course deviation. When the course deviation is zero, the CDI is green for a VHF source, or magenta for the FMS, and is 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 into a hollow amber box. If navigation signal is interrupted or intermittent, the CDI will disappear.

- **Scale**

VOR — When a Very High Frequency Omni-directional Range (VOR) station is selected as primary navigation source, the CDI indicates the course deviation in degrees with a full scale range of 10° left or right.

LOC — When a localizer (LOC) is the primary navigation source, the CDI indicates localizer deviation in degrees with a full scale range of 2.5° left or right.

FMS — When the FMS is the primary navigation source, full scale depends upon the current navigation mode. The FMS navigation mode is displayed in magenta text above and to the left of the HSI when the FMS is the selected CDI source.

Table 13-2. Navigation Modes

Navigation Mode	Full Scale Deflection
Enroute	2.0 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°. The arrowhead points FROM the station when the bearing to the station differs from the selected course by more than 90°.

- **Radio Magnetic Indicator (RMI)**

The blue dual-line bearing pointer corresponds to the BRG line-select key on the PFD. When selected to an ADF, FMS, or VOR source the Radio Magnetic Indicator (RMI) arrowhead points to the selected navigation source. The bearing pointer is not displayed if the BRG source is tuned to an ILS or LOC station.

13.3.6 Tile 5 – Communication, Navigation, Surveillance Display, Data Block, and Right Line Select Keys

13.3.6.1 TILE 5 DATA BLOCK

- **Ground Speed (GS)**

  The Ground Speed (GS) 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.

Figure 13-43. Tile 5 Data Block

- **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.

Figure 13-44. COM Radio Tuning

- **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.

  Optionally, if a Diversity Transponder is installed, the XPDR text will be preceded by a D-.

- **Line Select Keys and Concentric Knob (RIGHT)**

  Five line-select keys provide selection of communication/navigation/surveillance (transponder) sources, frequency/transponder code entry, and a monitoring feature. Pilot control of these inputs is provided through five PFD right side pages. (COM, NAV, XPDR, ADFDME, WXR) that are selectable through a Tab Select Knob below right line-select key 5. 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
    Communication frequency monitor selection .... COM 1
    .... COM 2
  - — 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)
    Timer
  - — Dual 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. When the timer LSK5 is selected the inner knob will select the seconds field of the countdown timer
    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. With the timer LSK 5 selected the outer knob will change the minutes field of the countdown timer.
- **NAV Page Line Select Key Options**
  - — Line select key 1 (R1)
    MINIMUMS
    Entry of altitude minimums in FT MSL........ Set using right concentric knob, or with the keyboard.
  - — Line select key 2 (R2),
    MONITOR (Active - A, Standby - S)
    Navigation frequency monitor selection........ NAV 1
    NAV 2

— 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)
Timer

— Dual Concentric Knob (RIGHT)
Inner knob...kHz/SWAP

With MINS highlighted rotating the inner knob changes the field by single digits. Pressing the inner knob with the MINS highlighted will transport the MINS to the altitude preselect.

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. With the Timer LSK 5 selected the inner knob will change the seconds field of the countdown timer.

Outer knob...MHz

With the MINS highlighted rotating the outer knob changes the field by 100's of feet.

With a NAV frequency highlighted, rotating the outer knob changes the MHz portion (three digits left of the decimal point) of the communication frequency. With the Timer LSK 5 selected the outer knob will change the minutes field of the countdown timer.

- **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 dual concentric knob
  - Line select key 3 (R3)
    MODE
    Transponder mode selection ...... STBY (Standby)-Powered but not operating
    GND (Ground)- Mode S operation on the ground
    ON - Mode A operation
    ALT - Mode A, C, and S in flight

    NOTE:
    In both GND and SBY, the transponder will transition to altitude reporting with weight off wheels, following takeoff and automatically transition back to SBY following touchdown.
  - Line select key 4 (R4)
    VFR transponder code selection ....Automatically changes transponder CODE to 1200, 1400, or 1700 depending on input on the Settings page.
  - Line select key 5 (R5)
    Timer
  - Dual 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. With the Timer LSK5 selected the inner knob will select the seconds field of the countdown timer.
    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. With the Timer LSK5 selected the Outer knob will select the minutes field of the countdown timer.

- **ADFDM Page Line Select Key Options**
  - Line select key 1 (R1)
    MONITOR ....DME 1
    DME 2
    DME OFF
  - Line select key 2 (R2)
    MONITOR ....ADF ON
    ADF OFF
  - Line Select Key 3 (R3)
    ANT MODE ....ADF
    ANT
    BFO
  - Line Select Key 4 (R4)
    ADF ....Active Frequency
  - Line Select Key 5 (R5)
    TIMER
  - Concentric Knob (RIGHT)
    Inner Knob ....ADF entry

    When the ADF line-select field is highlighted, rotating the inner knob changes the individual digits within the ADF frequency. With the Timer LSK5 selected the inner knob will select the seconds field of the countdown timer.

    Outer Knob ....ADF entry

    When the ADF line-select field is highlighted, rotating the outer knob moves the cursor between digits within the ADF frequency. With the Timer LSK5 selected the Outer knob will select the minutes field of the countdown timer.

- **WX Page Line Select Key Options**
  - Line select key 1 (R1)
    FUNCTION .... STBY
    TEST
    ON
  - Line select key 2 (R2)
    MODE .... WX
    WXA
    GND
  - Line Select Key 3 (R3)
    NONE
  - Line Select Key 4 (R4)
    STRM MODE .... STRIKE
    CELL
  - Line Select Key 5 (R5)
    STRIKE CLEAR
  - Concentric Knob (RIGHT)
    Inner Knob .... Gain/Tilt Control

    With the WX RADAR overlay on, rotating the inner knob will adjust the tilt of the radar antenna up and down in .25 degree increments.

    Outer Knob .... Gain/Tilt Control

    With the WX RADAR overlay on and the radar mode set to GND, rotating the outer knob adjusts the gain setting of the radar in .3 dB increments.

13.4 Normal Operations

13.4.1 Communication, Navigation, & Surveillance (CNS)

13.4.1.1 GENERAL

The CNS system contains:

- 2 Com Radios
- 2 Nav Radios
- 2 Transponders
  - DME
  - ADF

The CNS 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 through the audio page on the MFD.

The PFD and keyboard are used to control common functions such as source selection and frequency entry, and the MFD may be used for audio control.

Master volume and squelch control is located on both PFDs as a rotary 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. The Audio synoptic is also available on the PFDs with composite mode enabled. All CNS and audio control and display capabilities are available on the PFD and MFD. Some alternative input methods are available via the keyboard.

Four radio pages for selection with the tab select knob, below right line-select key 5. The tab select knob is used to select one of the following tabs at the bottom right of the PFD:

- COM
- NAV
- XPDR
  - DME
  - ADF

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 VHF Navigation Course (CRS) on the Horizontal Situation Indicator (HSI) is selected with the Left Dual Concentric Knob (DCK): Inner Knob on the bottom of the PFD.

13.4.1.2 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.

- **COM Radio Tuning**

  1. Select COM page using the right tab select knob.
  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 (optionally configured to 8.33 in the settings page) KHz increments.
  5. Pressing the inner portion of the right Dual Concentric Knob (DCK), or pressing the current LSK, swaps the active and standby frequencies.

The COM radios can also be tuned and selected using the keyboard.

1. Press COM SEL on the keyboard. Pressing COM SEL repeatedly will alternate the selection between COM 1 and COM 2. The green highlighted box on the PFD will indicate which radio is selected and can be tuned from the keyboard. This selection will not change which radio is selected as the active radio.
2. Enter the desired frequency.

   NOTE:
   For cardinal frequencies, the decimal point and digits after the decimal point are optional.

   Optional digits not entered by the pilot are automatically entered. For example, for 25 KHz spacing, if the second digit after the decimal point is 2, the third 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 press the inner portion of the right concentric knob on the PFD with the appropriate COM window selected.

   NOTE:
   Pressing the SWAP key on the keyboard, pressing the current LSK, or pressing the Right Dual Concentric Knob (DCK) inner knob, swaps frequencies 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
  — COM 2
  — OFF

  Active frequency monitoring is also available on the keyboard by pressing the MONITOR key to swap between COM 1, COM 2, and OFF.

- **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 or deactivates squelch.

13.4.1.3 NAV RADIOS

- **Primary Navigation Source Selection**

  The primary navigation reference is continuously displayed under the left side line-select key 1 and drives the CDI pointer. Available selections are VOR1/LOC1, VOR2/LOC2, or FMS.

- **NAV Selections**

  When a VHF navigation source is selected to the CDI window. VOR1, VOR2, LOC1, or LOC2 text will appear in green to the right of the CDI text. The frequency is displayed below the CDI source.

  When a navigation source is selected to Flight Management System (FMS) for use in the CDI line-select key window, the text FMS appears in magenta to the right of the NAV text. The active FMS waypoint identifier is displayed below the CDI text. When the FMS is operating in an alternate operation mode text of either VECTORS (white), OFFSET (white), SUSPEND (amber), or MISSED APPROACH (amber) will be displayed underneath the active waypoint identifier.

Figure 13-45. CDI Source Selection – FMS

- **Bearing Pointer Navigation Source**

The Bearing Pointer navigation source is continuously displayed adjacent to Line Select Key 2 on the left side of the PFD, and drives the dual-line Cyan Bearing Pointer (BRG) pointer. Available selections are: OFF, FMS, VOR 1, VOR 2, or ADF.

When the BRG is selected to NAV 1, NAV 2, or the ADF a VOR 1, LOC 1, VOR 2, LOC 2, or ADF appears to the right of the BRG text.

If the BRG Pointer is selected to the FMS the active waypoint and distance will be displayed. If the BRG pointer is set to NAV 1, 2, or ADF the frequency will be displayed. The bearing pointer is not displayed if the selected navigation radio is tuned to an LOC station.

GPS based distance to station with a (NM) suffix is displayed for VHF sources within 130 NM. Optionally Distance Measuring Equipment with a (DME) prefix is displayed in the BRG window.

Figure 13-46. Secondary NAV Source Selection – VLOC

When a navigation source is selected to FMS for use, the text FMS appears to the right of the BRG text. The FMS waypoint is displayed along with distance to the waypoint.

Figure 13-47. Secondary NAV Source Selection – FMS

- **NAV Radio Tuning**

Figure 13-48. NAV Radio Tuning

1. Select NAV page using the tab select knob.
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.

5. Press the right knob to swap the Active (A) and Standby (S) frequencies.The NAV radios can also be tuned and selected using the keyboard once the NAV page is selected using the tab select knob.
   a. Select NAV 1 or NAV 2 using the appropriate line-select key.
   b. Enter the desired frequency using the numeric keys on the keyboard.

      NOTE:
      For cardinal frequencies, the decimal point and digits after the decimal point are optional.

      Optional digits not entered by the pilot are automatically entered. For example, for 25 KHz spacing, if the second digit after the decimal point is 2, the third digit (5) is automatically entered.

   c. Press ENTER. This tunes the standby frequency. To make it active, press the SWAP key on the keyboard or press the inner portion of the right concentric knob on the PFD with the appropriate NAV window selected.

- **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 the following:

— NAV 1
— NAV 2
— OFF

- **Approach Minimums Setting**

With NAV page selected on the PFD, right line-select key 1 is used to enter a up to 5-digit MSL altitude for an approach minimums reminder. Minimums are displayed in the MINIMUMS line-select window, in 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 tab select knob.
2. Press right line-select key 1 to activate a cursor in the MINS line-select window.
3. Rotate the outer portion of the concentric knob to change the value in hundred foot increments, and rotate the inner portion of the concentric knob to change the value in one foot increments.
4. When an altitude is entered it will appear in the MIN window below the altimeter.

Approach minimums can also be set from the keyboard.

1. Press the MIN SET key on the keyboard.
2. NAV page is automatically selected, and 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.

13.4.1.4 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 13-49. Transponder Control

- **Transponder Code Entry**

1. Select XPDR page using the tab select knob.
2. Press right line-select key 2 to activate a cursor in the CODE window.
3. Rotate the outer portion of the concentric knob to move the cursor between digits, and rotating the inner portion of the concentric knob to change individual digits.

Transponder codes can also be set from the keyboard.

1. Press the XPDR 1 or XPDR 2 key and verify associated green light illuminates to indicate that the 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 and GND.

  2. Weight off wheels automatically transitions the transponder to the altitude reporting setting (ALT).

  Mode can also be set from the keyboard:
  Press SBY and GND keys to set transponder as necessary.

- **VFR**

  Pressing the right line-select key 4 automatically sets the VFR transponder code (1200, 1400, or 1700 as selected on the settings synoptic) 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 effect.

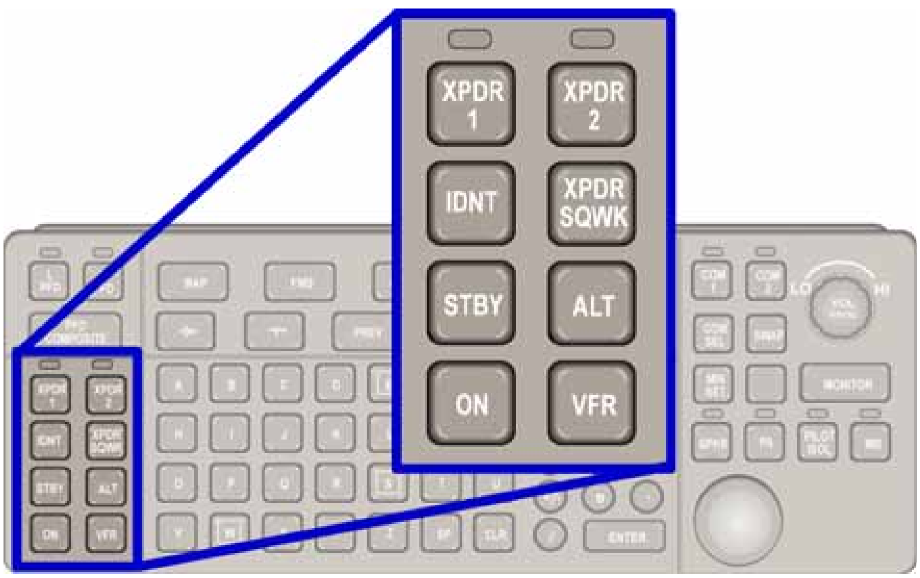


Figure 13-50. Keyboard Transponder Group Keys

13.5 Abnormal Procedures

13.5.1 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. If there is a loss of the Left PFD the autopilot NAV and APPR modes will not be able to be used. The loss of a PFD will also cause the loss of an FMS. FMS operations can be continued using the remaining PFD.

13.5.2 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 13-51. PFD Composite Mode

13.5.2.1 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. In the event of an MFD failure, it can be selected using the left tab select knob on the PFD.

- **Keyboard Selection**

  1. Light the corresponding LED by pressing the left or right PFD key.

  2. Press the PFD COMPOSITE key.

Figure 13-52. Keyboard Composite Group Keys

- **MFD Failure**

  In the event of an MFD failure, two page tabs labeled NORM and COMP automatically appear at the left bottom corner of the PFD.

  Select the COMP page with the tab select knob key.

Figure 13-53. Composite Mode – PFD Selection

- Once COMP is selected, the page tabs change from NORM and COMP to MAIN and HSI.
- If only one keyboard (standard left) is installed, the NORM and COMP page tabs will continuously appear on the right PFD until that PFD is selected into Composite mode.

13.5.2.2 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 Vertical Speed Indicator (VSI) remain displayed on the Attitude Direction Indicator (ADI) portion of the PFD (top half).

NOTE:
It is recommended to have one display in NORM, and one display in COMP following a MFD failure, so as to retain VSI display on one of the PFDs.

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, XPDR, WXR, and ADF, DME tabs (if installed) at the bottom of the PFD.

- **Tile 6 (top left) – 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 (top right) – 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:

  — Trim indicators (aileron, rudder and elevator trim)
  — Landing gear position
  — Flap position.

Figure 13-54. Composite Mode – Tiles 6 and 7

- **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 tab select knob on the PFD.

Figure 13-55. Composite Mode Pages – MAIN and HSI

— **MAIN**
The MAIN page is the default page when entering composite mode and provides a display of the Crew Alerting System (CAS) list.
The inner knob and push button on the Left dual concentric knob has the same functionality as the CAS rotary knob on the MFD.

— **Primary Function Selection**
While in the MAIN page the Left Line Select Keys allow for Primary function selection which was available on the MFD, and the availability to exit the composite mode.

- *EXIT COMPOSITE MODE:*
  Left LSK 1 - Provides an alternate means of exiting composite mode.
- *FMS*
  Left LSK 2 - Displays the same set of tabs normally found on the MFD FMS page (except VNAV) on the bottom Left of the PFD.
- *SYSTEM*
  Left LSK 4 - Displays the same set of tabs normally found on the MFD SYS page on the LH side of the PFD. Functionality and indications on these tabs are the same as displayed on the MFD (except that weight and Balance is not accessible). A MAIN tab is displayed to the left of the ENG tab allowing navigation back to the MAIN page using the left tab select knob.
- *AUDIO*
  Left LSK 5 - Displays the AUDIO page. Layout and functionality is the same as the AUDIO page on the MFD.

— **HSI**
From the MAIN tab, rotate the tab select knob to the HSI tab to display the Horizontal situation indicator and its associated controls. A 120° arc magnetic compass rose is displayed at the bottom of the ADI when a page other than the HSI page is selected. With the Left LSK 1: CDI in a valid navigation source a horizontal deviation indicator bar will appear within the arc.

13.5.2.3 COMPOSITE MODE PAGES

- **Systems Page (SYS)**

  The aircraft system (SYS) synoptic and the operational pages can be selected with the left tab-select knob:
  - Main
  - Engine (ENG)
  - Fuel (FUEL)
  - Electrical (ELEC)
  - Electronic Circuit Breaker (ECB)
  - Environmental (ENVIR)
  - Flight Controls (FLCS)
  - Pressurization (PRESS)
  - Ice Protection (ICE)
  - Operation (OPS)
  - Setup (SETUP)

Figure 13-56. Composite Mode – Systems – ENG

- **FMS**

  The FMS page provides access to the active flight plan and the various FMS pages can be selected with the left tab-select knob:

  — MAIN
  — Active Flight Plan (ACTV)
  — Progress page (PROG)
  — Stored routes page (ROUTE)
  — Nearest page (NREST)
  — User waypoints page (USER)

  NOTE:
  The VNAV tab is not available in PFD composite mode.

- **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**

  There are two ways to exit composite mode:

  1. With the keyboard:
     - Press L PFD or R PFD.
     - Press PFD COMPOSITE.
  2. With a line select key on the PFD:
     - Go to the MAIN tab on the PFD (Furthest left tab)
     - Press Left LSK1:EXIT COMPOSITE MODE.

- **Crew Alerting System (CAS) Message Display**

The MAIN page is the default page when entering composite mode and provides a display of the Crew Alerting System (CAS) list. The MAIN page can be accessed at any time by rotating the Left tab select knob to the left most tab.

When in the MAIN page the inner knob and push button on the Left dual concentric knob has the same functionality as the CAS rotary knob on the MFD.

From every tab on the PFD (except WXR), the Right LSK 5: TIMER is replaced by a flashing WARNING or CAUTION icon whenever the associated master warning or caution light is activated. Pushing Right LSK 5 acknowledges the alert in the same manner as pushing the Master Warning and Caution button on the Autopilot Control Panel.

Figure 13-57. PFD Composite Mode – Caution CAS

Figure 13-58. PFD Composite Mode – Warning CAS

13.6 Distance Measuring Equipment (DME)

13.6.1 General

An optional Rockwell Collins DME-4000 may be added to provide DME functionality. Two of the DME units' channels are paired to and co-tuned with VOR/LOC 1 and 2. The DME uses a single blade antenna located on the lower tail cone surface.

The paired DME frequency is automatically tuned when a VHF NAV frequency is tuned. The DME distance is shown above and to the right of the HSI as DME NNN.

> Estimated time enroute to the selected DME station is calculated and displayed below the distance as Time To Go to the selected DME station is calculated and displayed below the distance as TTG HH:MM:SS

In addition the distance will be shown in the BRG LSK window as DME NNN.N when a VHF NAV source with an associated DME is tuned.

DME Ident audio can be selected for monitoring on the DME tab or ADFDM if ADF is installed. Pushing the MONITOR button will cycle monitoring between OFF, DME 1 and DME2. This will be indicated by a green box next to the selected DME on the AUDIO page.

13.6.2 DME Failures

A failure of the DME is indicated by all DME indications being replaced by white dashes.

13.7 Automatic Direction Finder (ADF)

An optional Honeywell combined loop and sense ADF antenna may be installed on the aircraft. The receiver unit is housed in the number 1 Honeywell Primus Multi-Mode Digital Radio and the antenna is mounted on the RH lower wing-to-body fairing. The receiver is capable of tuning frequencies between 190 kHz to 1,799 kHz and 2180 kHz to 2189 kHz.

13.7.1 Controls and Indications

When the ADF is installed an "ADF" tab (or ADFDM if the optional DME is installed) is added to the RH side of the PFDs.

Figure 13-59. PFD, ADF Tab

The ADF Tab includes the following selections:

MONITOR: Toggles ADF audio monitoring ON and OFF. Squelch can be selected on or off and volume can be controlled on the MFD AUDIO page. Monitor status is also displayed on the AUDIO page.

ANT MODE: The ANT MODE button selects the following ADF modes:

- ADF: Bearing pointer will display relative bearing to the station. Audio can also be monitored.
- ANT: If ANT mode is selected, the loop antenna is disabled and only the sense portion of the antenna is receiving. This mode provides the clearest audio reception, but the BRG pointer will be removed.
- BFO: Beat Frequency Oscillator (BFO) creates an audible tone to identify sound from a non-modulated beacon.

ADF: Set frequency by turning the outer DCK to move the cursor and the inner DCK to change the value. The keyboard may also be used to enter the frequency.

To display relative bearing to the tuned station, the BRG LSK must be selected to ADF. The tuned frequency will then be displayed in the BRG window and an RMI-type pointer will be displayed in the compass rose/arc.

13.7.2 Failures

In case of an ADF system failure the ADF bearing pointer is removed and the tuned frequency is replaced by dashes.

13.8 Traffic Advisory System (TAS)

13.8.1 General

An optional L-3 Avionics Systems SKYWATCH HP Traffic Advisory System (TAS) may be installed. The directional antenna is located above the cockpit, and the Transmitter Receiver Computer is installed on the avionics rack in the aft equipment bay. TAS monitors the airspace around the aircraft and advises where to look for transponder-equipped aircraft that may pose a collision threat. Control and display is available on the left and right Primary Flight (PFD) Displays. The system displays range, relative bearing, relative altitude, and the rate of altitude change of monitored aircraft. The TAS system issue aural Traffic Alerts (TAs) for conflicting aircraft. The TAS system does not provide Resolution Advisories (RAs).

13.8.2 System Function

TAS is an active system that operates as an aircraft-to-aircraft interrogation device. TAS interrogates aircraft transponders in the surrounding airspace within an 35 nm horizontal radius and within its maximum vertical range of ± 10,000 feet. When TAS receives replies to its interrogations, it computes the responding aircraft's range, relative bearing, relative altitude, and closure rate.

TAS tracks up to 35 aircraft simultaneously and predicts collision threats. TAS will display 8 of the most threatening targets on the PFD.

Since the system does not provide resolution advisories, a TA ONLY is displayed on the bottom of the PFD.

Prior to engine start, the PFD will display TFC STBY to denote that the system is powered but not operating. When an engine is started and the parking brake is released, the system will automatically switch out of standby and display TAS information, TFC STBY will be replaced by TA ONLY. On the ground aural alerts will be inhibited. Once the TA ONLY is being displayed the TRAFFIC ALERT SYS test can not be conducted. The TRAFFIC ALERT SYS test should be conducted prior to releasing the parking brake.

13.8.3 Controls and Indications

Overlay

Select the OVERLAY using either PFDs Left (Tile 3) LSK 3 from OFF to TRAFFIC or TRAFFIC/WX RADAR to view the traffic overlay. The TAS is normally powered on the ground, but in standby mode. A TFC STBY message will be displayed on the lower left of the PFD. If the system is not powered, a TFC OFF is displayed.

To change the display range, rotate the Left DCK Outer knob on the PFD. TAS can continuously track up to 35 aircraft within its maximum horizontal surveillance range of 35 nm while displaying up to 8 of the most threatening targets.

Vertical Display Mode

The Vertical Display Mode can only be set from the SETUP-SETTINGS page. Select the SETTINGS LSK. Then rotate the DCK outer knob to select TAS SURVEILLANCE ALT; rotate the DCK inner knob to select one of the following modes:

- **NORMAL** displays traffic within 2700 feet above and below the current altitude of the aircraft.
- **ABOVE** displays traffic from 9,900 feet above to 2700 feet below the aircraft.
- **BELOW** displays traffic from 2700 feet above to 9,900 feet below the aircraft.
- **UNRESTRICTED** displays traffic from both 9,900 feet above and below the aircraft.

TAS continues to track up to 35 intruder aircraft within its maximum vertical surveillance range (± 10,000 ft) regardless of the vertical display mode selected.

Figure 13-60. TAS Traffic Information Display

Indicators and Symbols

Data Tag: The relative altitude of the detected aircraft in hundreds of feet. Example: +04 means the detected aircraft is 400 feet above.

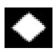
Positive data tags are displayed above the traffic symbol, and negative Data Tags are displayed below to emphasize that the traffic is above or below. If an aircraft is detected at the same altitude, 00 is displayed above the traffic symbol.

If traffic is detected beyond the selected vertical range, the Data Tag stays at the maximum or minimum relative altitude until the traffic comes within the vertical display mode range.

TAS only displays data tags for altitude-reporting aircraft. All other aircraft are considered to be at the same altitude as your aircraft.

If traffic is detected ascending or descending faster than 500 fpm, a Vertical Trend Arrow is displayed pointing up or down.


Other Traffic (OT): All other traffic within the selected display range and vertical display mode.


Proximity Advisory (PA): If traffic is detected within a horizontal range of 4 nm and a relative altitude of 1200 ft.


Traffic Advisory (TA): With the landing gear up (Sensitivity Level B), if traffic is detected within 30 seconds of a possible collision, or within a 0.55 nm horizontal radius and 800 ft relative altitude, an amber TA symbol is displayed relative to the traffic's bearing, an amber TRAFFIC is displayed on the bottom of the PFD, and a "traffic, traffic" aural voice sounds. With the landing gear down (Sensitivity Level A), the aural alerts are inhibited, and the Traffic Advisory criteria changes to 0.2 nm horizontal radius with a relative altitude of ± 600 feet, or 15-20 seconds of a possible collision.

The TA symbol remains for at least 8 seconds even if the detected aircraft no longer meets the TA criteria.

SENSITIVITY LEVELS

TAS uses two sensitivity levels to reduce the number of nuisance TA displays during takeoff and landing (sensitivity level A), and to maximize the detection of TAS during the cruise phase of flight (sensitivity level B). Sensitivity level is determined by the position of the landing gear.

Sensitivity Level A (Landing Gear Down):

Two criteria are required for displaying a TA:

1. Detected aircraft enters airspace within 0.2 nm horizontal radius and a relative altitude of ± 600 feet.
2. Detected aircraft is approaching and will intercept within 15 seconds (non-altitude reporting aircraft) or within 20 seconds (altitude-reporting aircraft).

Sensitivity Level B (Landing Gear is UP)

Two criteria are required for displaying a TA:

1. Detected aircraft enters airspace within 0.55 nm horizontal radius and a relative altitude of ± 800 feet.
2. Detected aircraft is approaching and will intercept within 20 seconds (non-altitude reporting aircraft) or within 30 seconds (altitude-reporting aircraft).

13.8.4 TAS Self-Test

To test the TAS system select the PFD OVERLAY Left (Tile 3) LSK3 to TRAFFIC or TRAFFIC/WX RADAR. Go to the OPS synoptic SYSTEM TEST page. Select the SKYWATCH system test and press the START TEST LSK. a Test pattern of 1 Traffic advisory, 1 Proximity Avisory (PA), when the test is successfully completed, an aural "Skywatch System Test Passed" is announced and the display will revert to the previous standby or traffic screen. If the self-test fails, an aural "Skywatch System Test Failed" message is announced. See "AMPLIFIED NORMAL PROCEDURES" in the AFM for more detail.

While on the ground, once the traffic is being displayed, the TRAFFIC ALERT SYS test can not be conducted. The TRAFFIC ALERT SYS test should be conducted prior to releasing the parking brake (if both engines are running).

13.8.5 Failures

If the TAS system stops functioning a amber color TRAFFIC ALERT FAIL caution message is posted and a amber TFC FAIL message is displayed on the PFD, if the TRAFFIC or TRAFFIC/WX RADAR overlay is selected.

13.9 Weather Radar System (WXR)

The Eclipse 550 is equipped with a Honeywell RDR-2000 weather radar mounted in the nose of the aircraft. Controls and indications are identical for both radars and are located on each PFD. The weather radar system is not designed for use as a pilot operable terrain or collision avoidance system, weather analysis and avoidance are the primary functions of the system.

WARNING:
When the radar is running, keep clear of the area extending 10 feet in front and 60 degrees to either side of the nose.

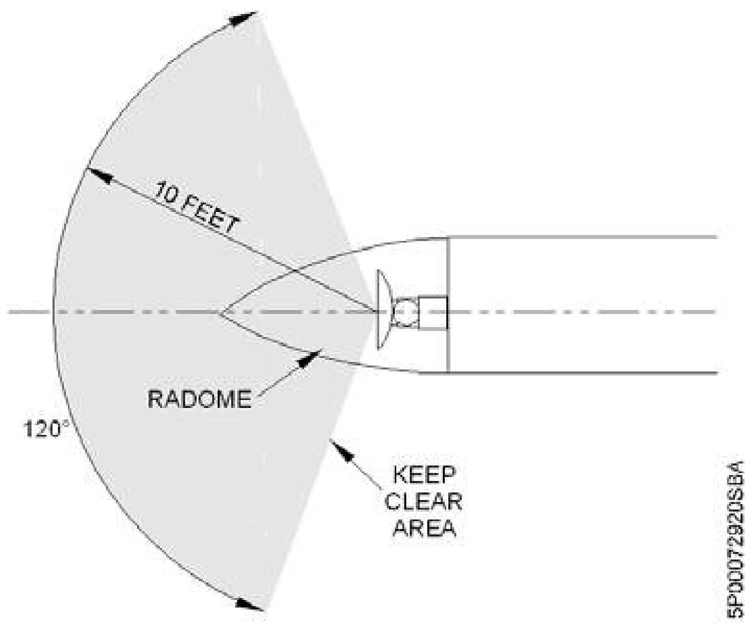


Figure 13-61. Weather Radar Safety Area

13.9.1 Control and Indications

Weather radar data is selected for display by pushing the OVERLAY LSK on either PFD. Weather radar data can be displayed separately (WX RADAR) or together with the traffic overlay (TRAFFIC/WX RADAR). Weather radar data is available in both the 360° and the arc mode. Changing the display range changes the radar operating range (up to its maximum of 240 nm).

Every second sweep of the radar antenna sends data to the other PFD enabling independent control of radar mode, tilt and gain settings. Each sweep of the radar antenna is indicated by a gray arc extending from the aircraft symbol.

The Weather Radar controls are located on the WXR tab on the RH side of the PFDs. From the WXR tab, LSKs are available to select FUNCTION and MODE, and the RH DCK sets tilt and gain.

Figure 13-62. PFD, WXR Tab, Test Mode

FUNCTION:

STBY: The weather radar is powered up, but the radar is not emitting.

TEST: The weather radar is powered up, is not emitting, and is outputting a test pattern. The pattern consists of solid color arcs. Range should be set between 20 nm and 80 nm for the Test Pattern to be properly displayed.

ON: The radar is operational. The radar is automatically set to STBY upon touchdown.

Observe the following delay times to ensure proper radar operation:

- In STBY, wait 60 seconds minimum before selecting ON.

Selected FUNCTION takes 3 seconds minimum to activate.

MODE:

Sets the following operational modes:

- WX: Normal weather detection with color-coded returns based on weather intensity as follows:
  - — Black = no return
  - — Green = weak return
  - — Yellow = moderate return
  - — Red = heavy return
  - — Magenta = intense return
- WXA: Same as WX, except Magenta-level returns are shown flashing.
- GND: Ground-mapping mode. When selected, the RH DCK outer knob adjusts the gain between 0 and -20dB. Current gain value is displayed with no decimals between 0 and -20dB. Each click of the knob changes the gain value by 0.3 dB. If gain is changed when a sweep is not active on the display, the displayed value will not update until the next sweep. A gain scale is displayed on the lower right corner of the radar overlay. Radar returns are color-coded based on weather intensity as follows:
  - — Black = no return
  - — Green = weak return
  - — Yellow = moderate return
  - — Magenta = intense return

Figure 13-63. PFD, WXR Tab, WX Mode

TILT

From the WXR tab, regardless of Mode, set the antenna tilt using the RH DCK inner knob. Each click corresponds to 0.25 degree change. The full tilt range is 15 degrees UP or DOWN. The tilt angle is displayed in degrees on the lower right corner of the radar overlay as NN.N U (up) or D (down).

TARGET ALERT

A Target Alert is issued if the radar detects a weather cell:

- With at least "red" intensity
- Within ± 10 degrees of heading
- A minimum size of 2 NM range, and 2 degrees azimuth
- Within 80 to 240 NM range.

The Target Alert display consists of two red arcs separated by a black arc at the top of the display, and centered on the aircraft heading and an amber RDR TGT message is displayed.

Target Alerts are not available in GND Mode.

STABILIZATION

The radar uses attitude data provided by the AHRS for antenna stabilization. This allows a horizontal sweep independent of normal aircraft maneuvering.

ATTENUATION COMPENSATION

The radar has two features to compensate for the effects of signal attenuation caused by weather and distance:

- In the 0 to 40 nm range, the radar automatically compensates for changing target distance to maintain a constant return intensity.
- Beyond the 40 nm range, a different feature minimizes changes in intensity and detail with varying distance. This feature is less accurate causing some changes in detail and intensity.

13.9.2 Failures

Radar failures are indicated by a message displayed on the radar overlay of the PFD rather than by a CAS message. The following messages can be displayed:

- RADAR FAIL (amber) – Radar unit has failed or the radar control is not functioning properly. Functionality is lost.
- RADAR CNTL (white) – Communication between the PFDs and the Radar has failed. Radar will switch to standby on the failed side and may still be available on the other PFD.
- RADAR NO DATA (white) – The PFDs are not receiving data from the radar. Functionality is lost.
- STAB LIMIT (white) – Radar stabilization has reached its limit. Radar performance is degraded.
- STAB OFF (white) – Radar has lost stabilization data and performance will be degraded during maneuvering.
- RANGE DISAGREE (white) – The radar operating range does not match the range selected on the PFD. Radar functionality is maintained but is not optimized for the selected range. This message may be displayed if the range is changed rapidly with the radar overlay selected ON. Operating the left and right PFDs in large range differences may cause this message. Sync PFD ranges to troubleshoot.
- MODE DISAGREE (white) – The radar operating mode does not match the mode selected on the PFD. Radar functionality is maintained but the operating mode may not be selected and is not properly indicated on the display.

13.10 Stormscope

An optional WX-500 (Stormscope®), qualified to TSO C110a for airborne passive thunderstorm detection manufactured by L3, may be installed to provide a Lightning depiction on the PFDs.

13.10.1 Aircraft Computer System (ACS) Interfaces

The Stormscope® is powered by an ECB on the Right Aft electrical bus.

13.10.2 Control and Indications

When the Stormscope is installed, associated controls (such as mode selection and strike clear) are available on both PFDs through the WXR tab.Stormscope® data is selected for display by pushing the OVERLAY LSK on either PFD. Stormscope® data is displayed with Weather radar data and can be displayed separately (WX RADAR) or together with the traffic overlay (TRAFFIC/WX RADAR). When the Stormscope unit is set to CELL or STRIKE in the WXR tab, the Stormscope overlay is displayed on the HSI. The lightning data is presented as (x) symbols if the mode is set to STRIKE, and (+) symbols if the mode is set to CELL. Strikes are presented on the display for three minutes before they are cleared.Stormscope® data is available in both the 360° and the arc mode. Changing the display range changes the Stormscope® display range (up to its maximum of 200 nm).

Lightning Strike Rate (LX RATE)

LX RATE specifies the average strikes per minute.

Figure 13-64. Stormscope Overlay

The Stormscope® controls are located on the WXR tab on the RH side of the PFDs. From the WXR tab, LSKs are available to select STRM MODE and STIKE CLEAR.

STRM MODE:

OFF: Stormscope® data is not displayed.

STRIKE: Individual lightning strikes are plotted and system sensitivity is slightly increased

CELL: The Stormscope® proccesses strike data to depict clusters of activity to depict storms.

STRIKE CLEAR: Strike Clear provides the operator with the capability for clearing the displayed strike symbols.

13.10.3 System description

The Stormscope® system has a computer mounted in the aft fueslage compartment and an antenna that is mounted at the top of the vertical stabilizer.

The sensor maps electrical discharge activity 360 degrees around the aircraft of cloud to cloud and cloud to ground lightning to a distance of 200 nautical miles for display.

A Strike mode and a Cell mode are available for display. Cell mode ranges are processed further than Strike mode data to identify weather cells, and reduce the radial spread associated with lightning strike variance.

13.10.4 Stormscope Self-Test

Stormscope Self-Test ability is available from the System Synoptic: Systems Tests Page.

Prior to starting the Stormscope test, the PFD Left LSK 3 OVERLAY should be set to either WX RADAR or TRAFFIC/WX RADAR, and PFD Right LSK 4 STRM MODE on the WXR tab (Tile 5) should be set to STRIKE. Initiate the self-test from the System Synoptic: Systems Tests Page by pressing LSK 4 START TEST. The system initiates both a Self-Test and a Strike Test on the Stormscope unit.

Initially, the system will perform a Stormscope Self-Test and the Systems Test screen will annunciate 'STORMSCOPE SELF TEST IN PROGRESS'.

Once the Stormscope unit indicates it has completed the self-test, the system will automatically command the Stormscope to initiate a Strike Test. The Systems Test page will annunciate 'STORMSCOPE STRIKE TEST IN PROGRESS'.

Strike Test Mode displays a box on the PFD HSI. Test strikes are generated by the Stormscope unit. All strike indications should be displayed inside the box. During self-test, the PFD will display any fault codes in the lower right corner of the PFD. Any Fault Codes should be recorded by the operator and reported to maintenance personnel. Press LSK4 STOP TEST on the Systems Test page to discontinue the test.

13.10.5 Stormscope Failure Indications

LX/F is displayed whenever the Stormscope unit indicates a fault or if the Stormscope unit indicates the heading is invalid. Whenever the Stormscope unit indicates a fault, the highest priority fault code is displayed to the right of the LX/F flag.

13.11 Crew Alerting Messages – CAS

Table 13-3. CAS Messages – CAS

Message	Condition	Category
TERRAIN ALERT FAIL	TAWS has failed	Caution
TERRAIN ALERT FAIL	TAS has failed	Caution
XPDR1 FAIL	Transponder 1 has failed	Advisory
XPDR2 FAIL	Transponder 2 has failed	Advisory

13.12 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 (FMA)?**

   a. Tile 5
   b. Tile 1
   c. Tile 3
   d. FMA 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 Attitude Direction Indicator (ADI) with the word AP appearing in green
   b. On the Horizontal Situation Indicator (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 (TAS)
   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, 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?**
   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. Magenta
    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 and 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 Vertical Speed Indicator (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° compass view on the PFD:**
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 and 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?**

Multi-Function Display (MFD)

14

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Multi-Function Display (MFD) 14

14.1 General

See Figure 14-1. 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 landing gear position, flap position, trim position, engine instruments, fuel quantity, and the pressurization status. 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 Moving Maps and E-charts (MAP), Flight Management Systems (FMS), Electronic Checklists (CKLST), System Synoptics (SYS) and the Audio page.

Figure 14-1. Multi-Function Display (MFD)

14.2 Limitations and Specifications

14.2.1 Navigation Systems Limitations

The use of fuel consumption performance data, as presented through the avionics system for flight planning purposes, is not approved.

14.2.2 E-Chart Limitations

Operators with Electronic Jeppesen™ Charts must have appropriate backup charts (electronic or paper) immediately available to the flight crew.

Primary navigation of the aircraft should not be performed using the map or charts on the MFD.

The E-Chart database effectivity needs to be verified before using the Jeppesen™ terminal charts.

14.3 System Description

14.3.1 Initialization

Figure 14-2. MFD Initialization

On initial power up of the MFD, an initialization page displays software versions and effective dates of the E-chart and Navigation databases. Effective dates should be verified prior to flight.

14.3.2 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, and the lower tiles are configurable.

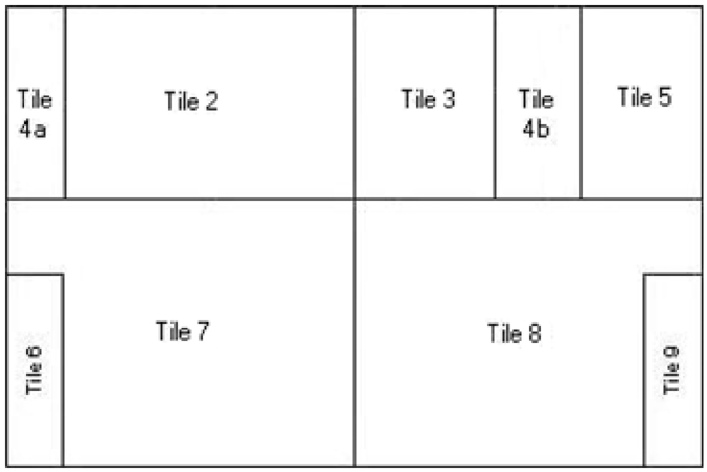


Figure 14-3. MFD Tile Layout

Tile 4a
- Landing gear status
- Flap position
- Trim position
  - Pitch
  - Roll
  - Yaw

Tile 2
Mini Tile
- Map
- FMS ACTV
- FMS PROG

Tile 3
Engine Instruments
- N1 tape
- ITT tape
- N2 digital display
- Fuel flow digital display
- Oil pressure digital display

Tile 4b
- Fuel quantity indicator
- Cabin pressurization
  - Current cabin altitude
  - Current cabin altitude rate of climb
  - Cabin differential pressure (dP)

Tile 5
CAS message window

Tile 6
Tile 7 line-select key options

Tile 7
Configurable

Tile 8
Configurable

Tile 9
Tile 8 line-select key options

14.4 Tile 5 – 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 5 on the MFD; however, CAS messages are also displayed on the PFD when operated 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 rotary knob located on the upper right side of the MFD is used to select and acknowledge CAS messages.

Figure 14-4. CAS Message Display

14.4.1 CAS Message Classifications and Hierarchy

14.4.1.1 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.

14.4.1.2 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 be displayed above existing messages.

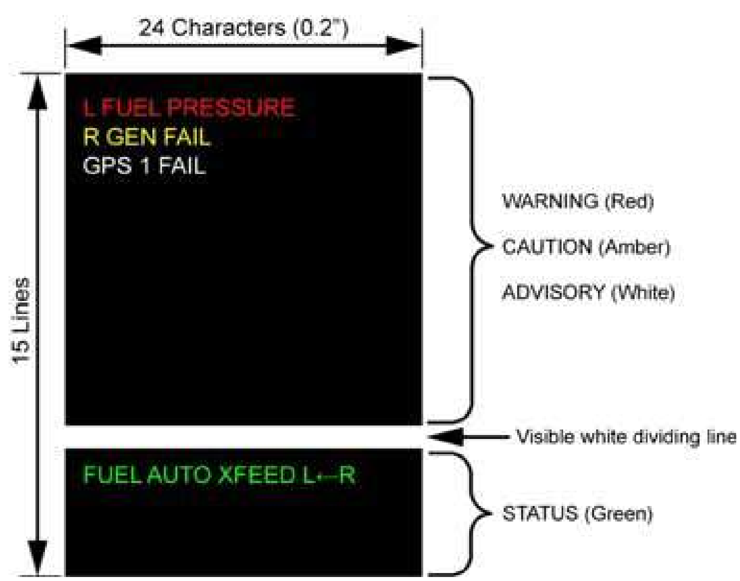


Figure 14-5. CAS Message Hierarchy

14.4.2 CAS and Aural Alerts

14.4.2.1 ANNUNCIATION

Warning and Caution CAS Messages are presented with accompanying aural alert and master warning/caution button lights for warning and caution conditions. If the PFD is operated in Composite Mode the TIMER LSK will change to an acknowledgment (ACK) LSK of a Warning or Caution.

Figure 14-6. CAS Message Annunciation

Figure 14-7. 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.

14.4.2.2 ACKNOWLEDGMENT AND RECALL

- **Acknowledgment**

1. Pilot silences aural alert by depressing the master warning button on the autopilot control panel (light extinguishes).
2. Pilot identifies the CAS message in the Quick Reference Handbook (QRH) and executes the QRH procedure to conclusion. If the condition is rectified the CAS message will disappear. If the condition continues to exist and the QRH procedure has been completed the pilot may elect to acknowledge the CAS.

   NOTE:
   If multiple CAS messages are displayed refer to the QRH procedure for the highest hierarchy level of CAS first. Observe that QRH procedures may contain a note to prioritize the QRH procedures for the CAS messages presented (e.g. L/R GEN OFFLINE and L/R AFT BUS VOLTAGE LOW).

3. Pilot acknowledges the CAS message by depressing the CAS control rotary knob. Advisory messages will move into the RECALL bin when acknowledged (see below for description of the recall function).

- **Recall**

The recall function provides the ability to recall previous warning, caution, and advisory CAS messages when 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 remains 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 rotary knob and acknowledged, the list of recall messages will overlay the current messages if any are present. After approximately 10 seconds, the CAS window defaults back to the active/current CAS messages. Messages in the recall bin are grouped chronologically within their categorizations.

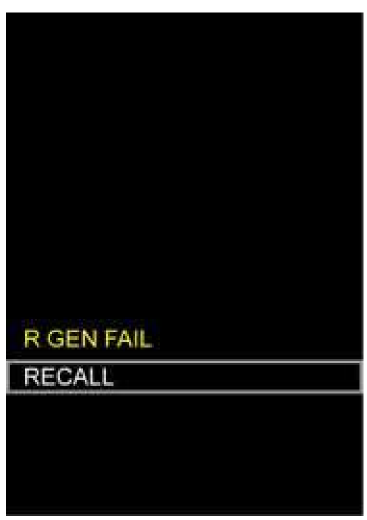


Figure 14-8. CAS Message Recall

14.4.2.3 AURAL ALERTING

Headset audio and cockpit speakers (if selected) provide aural alerts for various aircraft conditions. Aural Alerts are sounded in order of their designed priority. For Example "Minimums" may sound at the same time the "500" TAWS call out would occur. In this case "Minimums" would be heard but not "500".

- **Stall Warning Alert**
  - CONDITION – Aircraft approaching stall.
  - AUDIO – Voice message, "Stall, stall!"
  - VISUAL – STALL text appears in red on ADI
- **Stick Pusher Activation**
  - CONDITION – Aircraft approaching stall and the stick pusher has activated.
  - AUDIO – Voice message, "Push, Push!"
  - VISUAL – PUSH text appears in red on ADI
- **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, WARNING: ACK LSK appears on the PFD in Composite mode. The warning light stays on until the condition goes away or until the master warning button is pressed by the pilot. The CAS message remains until the condition goes away.
- **Cabin Altitude**
  - CONDITION – Cabin altitude exceeds 12,750 feet
  - AUDIO – Voice message, "Mask on, descend!", voice message will repeat until the cabin altitude is below 12,500 feet, or the rate of descent is maintained above 1,800 FPM.
  - VISUAL – NONE

NOTE:

At 8,750 feet cabin altitude, a CABIN ALTITUDE caution message appears along with the caution alert tone. At 10,000 feet cabin altitude, a CABIN ALTITUDE warning message appears along with the caution alert tone.

- **Autopilot Disconnect**
  - — CONDITION – Autopilot disconnected
  - — AUDIO – Autoflight Calvary charge alert tone continuing for at least 3 iterations and silenced only when the AP DISC button is pressed on either sidestick.
  - — 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.
- **Autothrottle Disconnect**
  - — CONDITION – Autothrottle disconnected
  - — AUDIO – Single cavalry charge alert tone
  - — VISUAL – Amber text AT DISC flashes on the PFD below the FMA line three times.

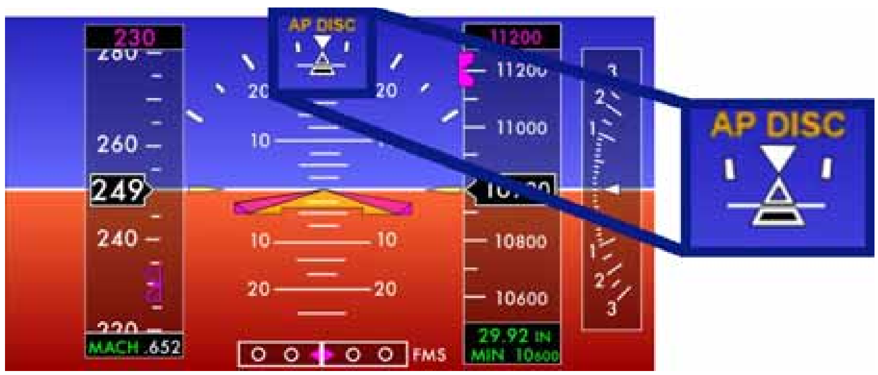


Figure 14-9. Autopilot Disconnect Display

- **Fire Warning Alert**
  - — CONDITION – Left or right engine fire detected
  - — AUDIO – Voice message, "Left engine fire!" or "Right engine fire!"
  - — VISUAL – SEE BELOW

Figure 14-10. Fire Armed Button

- Master warning light illuminates, the red FIRE portion of the FIRE/ARMED button illuminates, and an L ENG FIRE or R ENG FIRE warning message appears.
- The master warning light is extinguished when the pilot presses the master warning button.
- A single press of the FIRE/ARMED button ceases fuel flow, automatically closes several ebleed valves, inhibits the igniters, arms the pyrotechnic charge on the FEC, and illuminates the green ARMED portion of the FIRE/ARMED button.
- A second press of the FIRE/ARMED button discharges the on-side extinguishing agent and prompts an L(R) EXTNGR DSCHG advisory message to appear.
- L or R ENG FIRE warning messages remain displayed until the fire is no longer detected.

- **Overspeed Alert**
  - — CONDITION – Aircraft speed exceeds $M_{mo,}$ $V_{mo,}$ or configuration limit.
  - — AUDIO – Overspeed cricket alert tone
  - — VISUAL – OVERSPEED appears in white on ADI, airspeed is in the red band on airspeed tape, and airspeed digits and mach number if applicable appear red. The visuals remain until the airspeed is out of the overspeed range.

- **Approaching Minimums**
  - CONDITION – 100 feet above preset minimum altitude
  - AUDIO – Voice Message, "Approaching minimums!"
  - VISUAL – current altitude is approaching the minimums bug on the altitude tape.
- **Minimums**
  - CONDITION – Descending through preset minimum altitude
  - AUDIO – Voice message, "Minimums!"
  - VISUAL – MINS digits below the altitude tape turn amber.
- **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 a CAS message appears on MFD, CAUTION: ACK LSK appears on the PFD in composite mode. The caution light stays on until the condition goes away or until the Master caution button is pressed by the pilot. The CAS message remains until the condition goes away.
- **Altitude Alert (Approach and Deviation Alerts)**
  - CONDITION

    Approach Alert

    Aircraft approaching 1,000 feet of altitude pre-select target

    Deviation Alert

    Aircraft deviates ± 200 feet from selected altitude
  - AUDIO – C-Cord alert tone
  - VISUAL – Amber ALT ALERT message is annunciated above the altitude tape.
- **Landing Gear Warning**
  - CONDITION

    Landing gear is up when aircraft is below 12,500 feet and one or more of the following conditions are met:

    - 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 displayed on the center of the PFD AI.
- **Trim In Motion**
  - CONDITION – Trim in motion for more than 5 seconds
  - AUDIO – Trim Clacker alert tone
  - VISUAL – NONE

14.4.2.4 TAKEOFF CONFIGURATION OK AND WARNING MESSAGES

T/O CONFIG OK STATUS MESSAGE

The Takeoff Configuration OK (T/O CONFIG OK) status message is annunciated to the flight crew after the following conditions are satisfied:

1. Both engines running at idle RPM or above.
2. Flaps are properly set either in the UP or T/O position and matching the OPS page selection.
3. All three trims are set in the green band.
4. T/O temp 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 CONFIGURATION 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 one of the following configuration problems:

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 ......Flap position does not match the selection on the OPS page

CONFIG ENG TEMP ....Ambient temperature not entered on OPS synoptic

NOTE:
CONFIG RUDDER TRIM, CONFIG AILERON TRIM, CONFIG ENG TEMP, are inhibited for touch and goes. Elevator trim must be in the green band, and the flaps must be traveling out of LDG before the throttles are advanced following touch down.

14.5 Tiles 7 & 8 – Configurable Displays

Figure 14-11. 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 (7 and 8) 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 is set to page previously on lower left.
- CKLST – Lower left tile set to CKLST page, lower right is set to page previously on lower left.
- 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), lower right is set to page previously on lower left.
- AUDIO – Lower left set to AUDIO page, lower right set to page previously shown on lower left.

Available synoptics and features are listed below. A more detailed description of each synoptic is found in each aircraft systems chapter.

The MFD provides the following display and control functionality.

UPPER PORTION

1. Mini Tile
   a. MAP
   b. PROGRESS
   c. ACTIVE
1. Aircraft systems information
   a. Engine
   b. Landing Gear
   c. Flight Controls
      1. Flaps
      2. Trim
   d. Cabin pressurization
   e. Fuel
3. Crew Alerting System (CAS)

LOWER PORTION

1. MAP
   a. Nav Display (ND)
   b. MAP
      1. MAP INFO PAGE
      2. MAP SETTINGS
         (a) XM SETTINGS
            (1) XM AGES
   c. CHART
      1. AIRPORT MENU
         (a) AIRPORT INFO
         (b) XM DATA
            (1) METAR
            (2) TAF
            (3) CITY FORECAST
         (c) CHART MENU
            (1) Chart View
               — Tall chart

LOWER PORTION (CON'T)

2. FMS
   a. Active flightplan (ACTV)
   b. Progress (PROG)
   c. Route (ROUTE)
   d. Nearest (NREST)
   e. User waypoints (USER)
   f. Vertical navigation (VNAV)
3. Normal Checklist (CKLST)
4. Aircraft systems synoptics (SYS)
   a. Engine (ENG)
   b. Fuel (FUEL)
   c. Electrical (ELECT)
   d. Electronic Circuit Breakers (ECB)
   e. Environmental (ENVIR)
   f. Flight Controls (FLCS)
   g. Pressurization (PRESS)
   h. Ice Protection (ICE)
   i. Aircraft Operations (OPS)
      1. Weight and Balance (WEIGHT)
      2. V-speeds and Engine Temperatures entry (VSPEED ENG TEMP)
      3. Performance (PERF)
      4. System Test
         (a) EFIS SERVICE MODE
         (b) MAINTENANCE MODE
   j. Setup (SETUP)
      1. SENSORS
         (a) GPS
            (1) SATELLITE STATUS
      2. SETTINGS
         (a) INSTALLED EQUIPMENT
3. Audio Mixer(AUDIO)

Table 14-1. 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
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 automatic or 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 ■ OAT, TAT
Flight Controls (FLCS)	■ Position of trim ■ ALTERNATE TRIM ■ ALL INTERRUPT DISABLE
Operations (OPS)	■ Weight and balance entry ■ Rotation and reference speed entry ■ Systems tests (Autopilot, Stick Pusher, Cockpit Lighting) ■ Performance page
Setup (SETUP)	— View PFD and MFD versions ■ Installed Equipment ■ Sensor (SENSOR) — Air data source selection for the PFDs — GPS page — Sat status

14.5.1 Additional Synoptics

There are several additional synoptic pages (AUDIO, OPS, SENSOR, SETUP) available for pilot use.

14.5.1.1 AUDIO SYNOPTIC

Figure 14-12. AUDIO Synoptic Page

See Figure 14-12. The AUDIO synoptic page is selected with a single press of the AUDIO primary function key on the MFD. A single press of the primary function key displays the audio page on Tile 7 (lower left) of the MFD. This synoptic allows selection of audio setup, intercom, and cockpit radio split.

Line select keys on the audio synoptic:

INTERCOM .... PILOT ISOL/CREW ISOL
TX SELECT.. NORMAL/SPLIT
ECB LINK.. Links to avionics ECB synoptic page

- **Audio Control Selection**

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 moves the cursor between the various audio selections. Once an audio selection is highlighted, rotating the inner portion of the left or right concentric knob clockwise increases selected volume, and 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 either the squelch or ident features to be turned on or off.

- **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 (Transmit Selection) LSK on the AUDIO tab selects COM radio transmission synchronization ON or OFF between the pilot and the copilot.

With SYNC ON, if one pilot selects ACTIVE or MONITOR, it is automatically selected for the other pilot.

With SYNC OFF selected, the pilot and copilot can independently control their own transmit radio. When their selections differ, a SPLIT indication is shown on the ACTIVE box on the PFD COM tab. In SPLIT mode, the pilot and copilot can transmit on different COM sources. The pilot retains audio from the ACTIVE source only and the copilot can only hear his ACTIVE COM audio.

NOTE:
If in SPLIT mode when the TX SELECT is changed to SYNC ON the COM selection will sync to the left PFD.

- **Keyboard Control**

Figure 14-13. Keyboard Audio Control

— **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 or deactivates squelch.

— **Speaker (SPKR)**
Pressing the SPKR key toggles the cockpit overhead speakers on/off. When the speaker is on, the keyboard light above the SPKR key is illuminated.

— **Public Address (PA)**
N/A.

— **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.

14.5.1.2 OPS

The Operations (OPS) synoptic page provides pilot interface with:

1. Aircraft Operations – Flight, Block, Cycle, and Engine Times
   a. Weight and Balance
   b. V Speed and engine temps
      — T/O Temp
      — Flap Selection
      — VR
      — VREF
   c. Performance
      — Takeoff Performance
      — Landing Performance
   d. System Tests
      — Maintenance Mode
      — Cockpit Lamps
      — AutoFlight
      — Stick Pusher
      — Traffic
      — TAWS

- **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 the following:

— Flight hours
— Left engine hours
— Right engine hours
— Left engine starts
— Right engine starts
— Cycles

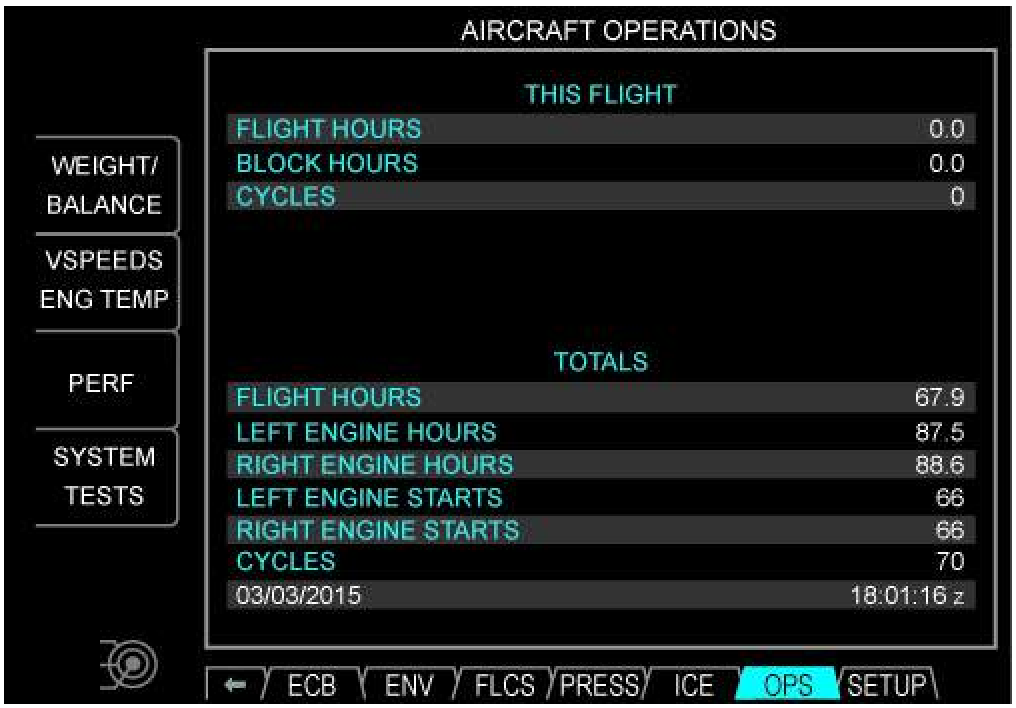


Figure 14-14. OPS Synoptic Page

- **WEIGHT (Weight and Balance)**

The weight and 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. Pressing the CONFIG LSK will cycle through the loaded options of seat configuration. Up to 10 seat configurations can be selected on the MFD, from a possible 21. Pressing CONFIG will change the presence and or position of seats 3 through 6. The EMPTY line will stay the same as the aircraft was weighed, but the EMPTY ADJ (Adjusted Empty Weight and CG) will change based on the selected configuration. ZERO FUEL, GROSS, and AVAILABLE lines are calculated using the EMPTY ADJ line. The pilot weight will initialize to 170 pounds, and 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.

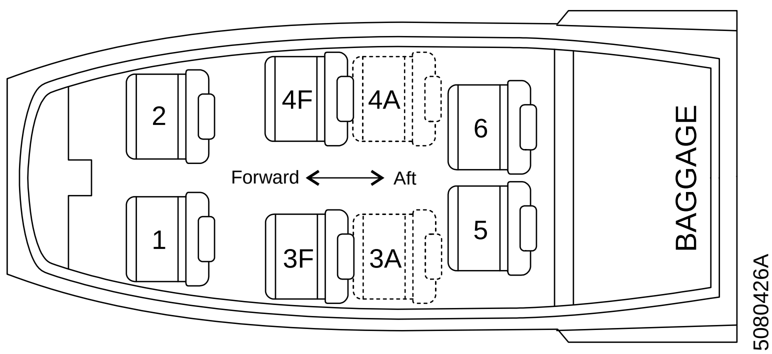


Figure 14-15. Seat Chart – All Configuration Possibilities

Selecting seat 2, 3, 4, 5, and 6 (as available) and rotating the inner portion of the knob defaults the weight in that field from 0 to 170 lbs.

Entered weights for seat 1 (pilot), seat 2 (copilot), seat 3 (left front passenger seat), seat 4 (right front passenger seat), seat 5.

NOTE:
If a value of more than 260 pounds 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 can be changed in five pound increments by rotating the inner portion of the concentric knob. If the fuel weight is modified manually, amber MAN text appears. If a capacitance probe failure prevents 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. If the calculated fuel load is unavailable, the GROSS weight is displayed in amber as the maximum takeoff weight.

— **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 removes the amber MAN text and resets 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 14-16. OPS WEIGHT 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, and 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 Outside Air Temperature (OAT) probes within 1°C, which is used by the FADEC to calculate the takeoff power settings.

  Pilot manual entry of the takeoff temperature is required prior to flight. Pressing the T/O TEMP line-select key places a cursor in the bottom portion of the line-select window. Pressing the inner portion of the concentric knob sets the current OAT into this field. 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.

  The T/O Temp should be set using the weather reporting system at the airport. OAT Probes are less effective on the ground without the air loads of flight. OAT Probes are susceptible to uneven heating due to sun and shade, as well as reading a higher than normal temperature when the aircraft is removed from a warm hangar in the winter. When the T/O Temp is manually entered a white MAN text appears to the right of the selected temperature to indicate that the FADEC has accepted the temperature.

  When a manual temperature is entered, white MAN text appears next to the temperature. This text is required for the FADEC to accept the engine temperature and for the TO CONFIG OK status message to display.

  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 and allows for manual entry of rotation speed by the pilot. If the current aircraft weight was ACCEPTED on the Weight and Balance page, when the VR line select key is pressed the ACS calculated VR will appear. This speed is automatically bugged on the airspeed tape with a digital readout below the airspeed indicator. The ACS calculated VR is based on the current aircraft weight and the selection in the FLAP SEL LSK. The FLAP SEL (Flap Position Selection) LSK is selectable to T/O or UP. If the actual flap position does not match the selection in the FLAP SEL LSK the digital values on the airspeed tape and the OPS: VSPEEDS synoptic will be amber. When the FLAP SEL LSK and the flap position agree the VR digital will be green.

Rotating the inner portion of the concentric knob clockwise or counterclockwise manually increases or decreases the rotation speed value in one knot increments. The VR bug and digital value on the airspeed indicator will change to the selected airspeed.

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. If the current aircraft weight was ACCEPTED on the Weight and Balance page, when the VREF line select key is pressed the ACS calculated VREF will appear based on a landing utilizing LDG Flaps. This speed is automatically bugged on the airspeed tape with a digital readout below the airspeed indicator (as long as the aircraft is below Mach 0.350).

Rotating the inner portion of the concentric knob clockwise or counterclockwise manually increases or decreases 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 VREF 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.

— **RETURN TO OPS**

Pressing the RETURN TO OPS line-select key displays the AIRCRAFT OPERATIONS portion of the OPS page.

Figure 14-17. OPS VSPEED Synoptic Page

Figure 14-18. OPS VSPEED Manual VR Entry

- **PERF (Take Off And Landing Data Performance) Synoptic Page**

The MFD provides a means for the pilot to determine basic takeoff and landing aircraft performance (field lengths, climb rates, weight limits) using the same data tables that are part of the Aircraft Flight Manual (AFM). These features are meant to be a standalone pilot tool for various "what-if" scenarios. The pilot enters or accepts current values for the aircraft configuration state and current or expected ambient conditions, and the MFD computes and presents the performance parameters on the PERF page of the MFD.

- **Access**

The Performance Page is available via the OPS page. The PERF page is also accessible by pressing the PERF key on the keyboard. Two pages are available: Takeoff Performance and Landing Performance.

The pilot can swap between Landing and Takeoff Performance using LSK2: LANDING/TAKEOFF PERF. The pilot can reset all pilot entered parameters on the current performance page with LSK3: RESET. The reset function affects only the currently displayed performance synoptic.

Line Select Keys – Line Performance Page

LSK1: (No Function)

LSK2: (LANDING/TAKEOFF PERF) — Switch between LANDING and TAKEOFF performance.

LSK3: (RESET) — Reset all pilot-entered parameters.

LSK4: (No Function)

LSK5: (RETURN TO OPS) — Return to the OPS top level synoptic.

- **Pilot Entry**

The Performance synoptics have the following user editable fields.

— Barometer Correction (Baro Corr)
— Field Elevation
— Field Temp
— Wind Speed
— Wind Direction
— Runway Heading (Rwy Hdg)
— Runway Gradient (Rwy Grad)
— Aircraft Weight
— Flap position (Takeoff PERF page only)

The selected field is highlighted with a white border. The selected field may be changed by rotating the DCK: Outer Knob. Rotation of the DCK: Inner Knob or pressing DCK: center push button activates the selected field. When a field is activated into the edit state, it is expanded in a white box. Upon entry completion, the pilot may exit the edit state by pressing DCK: center push button. After 5 seconds of inactivity, the edit state times out returning to an unexpanded state.

NOTE:
If pilot entry of any field would result in an out-of-range condition on the performance tables, the affected fields are removed and replaced with dashes.

- **Baro Correction**

  The BARO CORR field is initialized to the current barometric correction shown on the PFD. If the current barometric correction from the PFD is invalid, the BARO CORR will be set to STD Baro (29.92 or 1013). The MFD displays **MAN** in white text to the right of the BARO CORR if the operator has manually entered the baro correction.

  The BARO CORR value on the Performance Page has no effect on PFD altitude display.

- **Field Elevation**

  If the FIELD ELEV has not been operator-adjusted, it shall be updated to the one of the following, in order of priority:
  — If the aircraft is on ground, Baro-Corrected Altitude shown on left PFD
  — FMS Origin Runway Elevation, if available
  — '----' (blank)

  If the FIELD ELEV value is from the FMS origin airport, **FMS** is displayed to the right of the field elevation value. **MAN** is displayed to the right of the field elevation value if the pilot has manually entered field elevation.

- **Field Temperature**

  If FIELD TEMP has not been operator adjusted, its value is updated as follows:
  — Manual FADEC Temperature set on the VSPEEDS page
  — The average of the two OAT-selected temperatures in Celsius.
  — '---'

  MAN is displayed to the right of the Field Temperature if the pilot has input a temperature and the FADEC has accepted a manually set T/O TEMP on the VSPEEDS - ENG TEMP page. **MAN** is displayed to the right of the Field Temperature if the operator has manually entered Field Temperature.

- **Wind**

  The WIND speed and direction are initialized to zero. When the WIND speed equals zero, wind direction is displayed as white dashes.

  The pilot can select WIND speed between 0 and 99 knots. The pilot can select wind direction in 10 degree increments between 010 and 360.

- **Runway Heading**

  If RWY HDG has not been adjusted by the pilot, its value is either:
  — FMS Origin Airport Runway Heading, if available
  — ---

  The pilot can select the runway heading in 10 degree increments ranging from 010 to 360. **FMS** is displayed to the right of the Runway Heading if the FMS Origin Airport Runway Heading is being displayed. The MFD displays **MAN** to the right of the Runway Heading if the operator has manually entered Runway Heading.

- **Runway Gradient**

  The RWY GRAD is an enterable field, initialized to 0.0%, limited in range to ± 2.0% in 0.1% increments. **MAN** is displayed to the right of the Runway Gradient if the operator has been manually entered.

- **Weight**

  The Performance page will default the WEIGHT to the gross weight value from the Weight & Balance Synoptic Page — up to Maximum Takeoff Weight (MTOW) or Maximum Landing Weight (MLW), if the weight has been accepted on the weight/balance page. **CALC** is displayed to the right of the weight value if that value is from the Weight and Balance Page.

  On the Takeoff synoptic, if gross weight value exceeds MTOW, then the text **MTOW** is displayed to the right of the weight value. On the Landing Synoptic, if the gross weight value exceeds MLW, the text **MLW** is displayed to the right of the weight value.

  The pilot is can adjust the WEIGHT value up to MTOW/MLW lbs, in 20 lb increments. **MAN** is displayed to the right of weight value if the pilot adjusts the weight value.

- **Flap Position**

  The MFD provides the pilot the capability to adjust FLAP values to either UP or T/O. If FLAP has not been operator-adjusted, the FLAP value is updated to the value from the VSPEED entry page.

  If the selected flap position and reported flap position do not agree, the text is displayed in amber. If the selected and the reported position agree, the flap position is displayed in green text. If the pilot has manually entered the Flap Position, the text appears in white. **MAN** is displayed to the right of the Flap Position if the operator has manually edited the Flap Position.

- **Runway Data**

  If a flight plan is entered with a departure runway selected, the following data is provided from the FMS:
  - Origin ICAO
  - Runway
  - Runway Length

Figure 14-19. Runway Data

- **Informational Data**

The MFD provides the following informational data:

— Delta ISA – The difference in Celsius between FIELD TEMP and the standard day temperature.

— Density Altitude – Computed density altitude is for INFORMATIONAL PURPOSES ONLY and is not used in any takeoff performance computations. The algorithm uses an assumed relative humidity profile as a function of ambient temperature

- **Takeoff Performance Output Data**

The MFD computes the following performance parameters based on the entry fields. These parameters assume a DRY HARD runway condition and engine anti-ice is OFF, as indicated on the Takeoff page.

— T/O Weight Limit - Displayed in Amber if Aircraft weight exceeds MTOW.

— Dist to 50 ft – Displayed in amber text if the value is greater than the FMS sourced runway length.

— VR – Displayed in amber if Aircraft weight exceeds MCTOW.

— VR50 – Displayed in amber if Aircraft weight exceeds MCTOW.

— ALL ENG GRAD – Displayed in amber if Aircraft weight exceeds MCTOW.

— ALL ENG ROC – Displayed in amber if Aircraft weight exceeds MCTOW.

— ONE ENG GRAD – Displayed in amber if Aircraft weight exceeds MCTOW.

— ONE ENG ROC – Displayed in amber if Aircraft weight exceeds MCTOW.

Figure 14-20. Takeoff Performance Data

- **Landing Performance Output Data**

  (See graphic below.) The MFD computes the following performance parameters based on the entry fields. These parameters assume a DRY HARD runway condition, Flaps are LDG engine anti-ice is OFF, as indicated on the Landing synoptic.

  — D/O 50FT OBST – Displayed in amber text if the value is greater than the FMS sourced runway length.
  — VREF – Displayed in amber if Aircraft weight exceeds MCLW.
  — BALKED LDG GRAD – Displayed in amber if Aircraft weight exceeds MCLW.
  — BALKED LDG ROC – Displayed in amber if Aircraft weight exceeds MCLW.

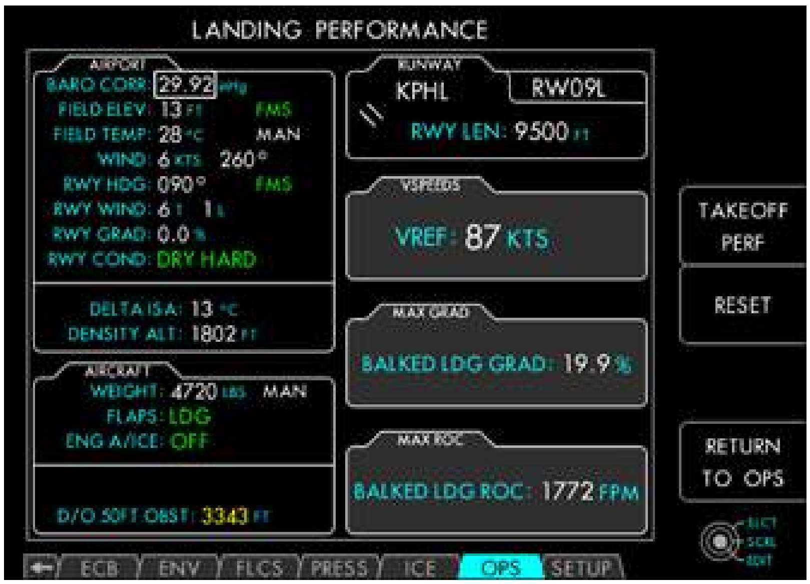


Figure 14-21. Landing Performance Data

- **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 Systems Test page provides access to the EFIS Service Mode, the Maintenance Mode, as well as providing the ability to conduct system test for the cockpit lamps, autopilot, stall protection, traffic, terrain, and Stormscope.

— **A/C MAINT MODE**

The aircraft maintenance (A/C MAINT) mode line-select key provides a means for maintenance personnel to conduct certain systems tests, update system software, as well as collaring ECBs 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 with the A/C MAINT MODE line-select key.

— **START TEST**

To start 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 activates the selected system test; displays a TEST IN PROGRESS message below the TESTS window and brings up a STOP TEST line-select key option. Pressing the STOP TEST line-select key aborts the test.

— **COCKPIT LAMPS TEST**

Activating the cockpit lamps test will automatically command the autopilot control 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 checks. After two minutes have transpired, on-ground autopilot engagement is prevented. The AUTOFLIGHT systems test is detailed in Chapter 15, “Autoflight.”

— **STALL PROTECTION**

Activating the stall protection test is allowed only on-ground and provides an automatic test of the stall protection system by simulating high Angles of Attack (AOA) and sending this data to the ACS. This automatically triggers the stall warning sequence, including the "STALL" aural and visual warnings as well as the activation of the Stick Pusher with the associated "PUSH" aural and visual warnings. Once the stick pusher engages, indicating normal operation, the test is discontinued by pressing the STOP TEST line-select key.

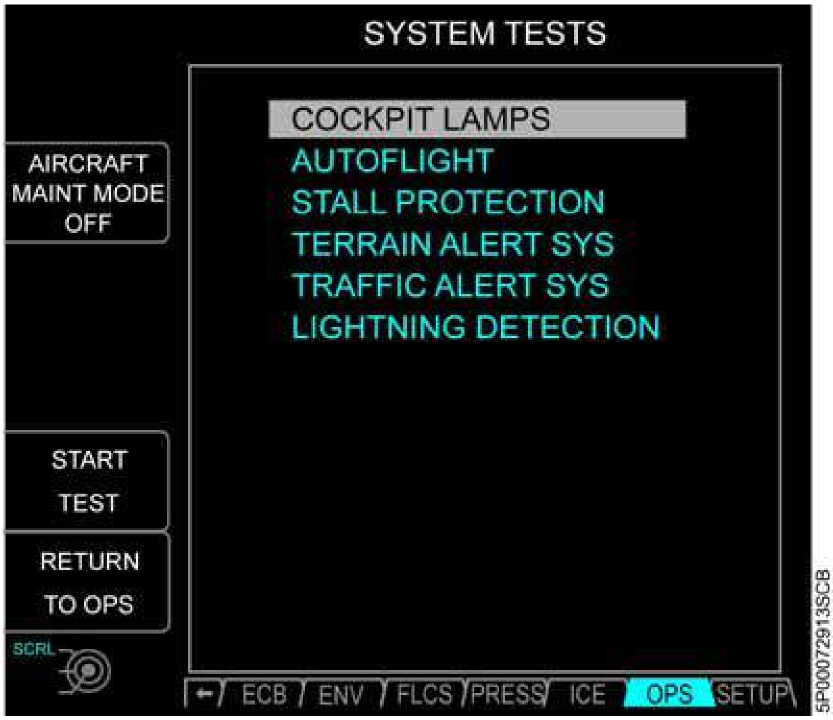


Figure 14-22. OPS SYSTEMS TEST Page

— **RETURN TO OPS**

Pressing the RETURN TO OPS line-select key displays the AIRCRAFT OPERATIONS portion of the OPS page.

14.5.1.3 SETUP

The SETUP synoptic page provides pilot information on the software versions for the left and right PFDs and the MFD, as well as NAV and chart database information.

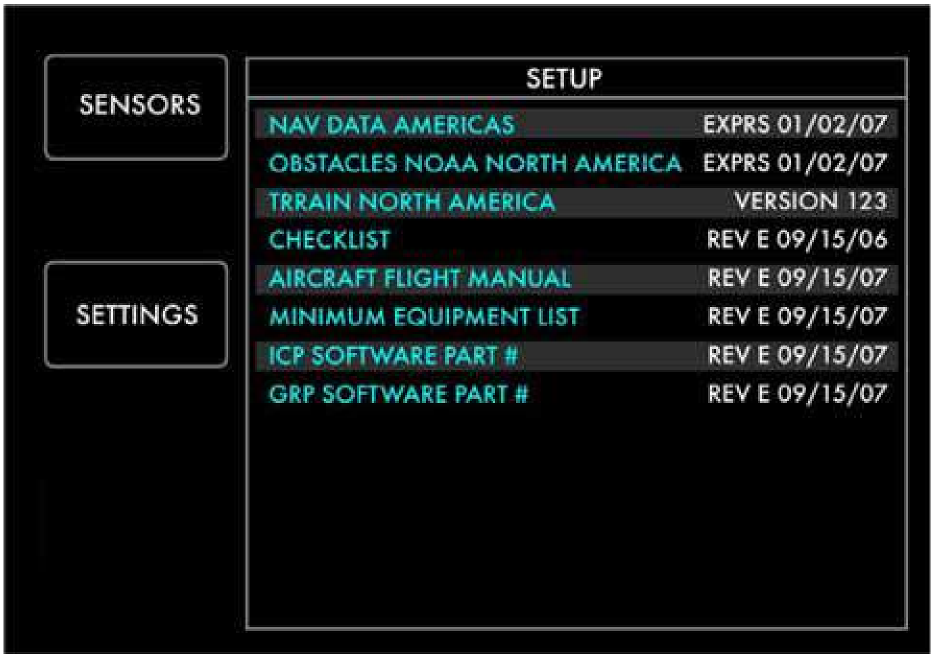


Figure 14-23. SETUP Synoptic Page

SENSORS

The lower half of the SENSORS page shows the Air and Attitude data sources. Non-standard selections are shown in an amber box. The upper half of the SENSORS page is used to select ADC and AHRS source for the PFDs and ADC source for the MFD.

A BARO SET LSK is available to set altimeter baro-setting using the inner knob (turn to change setting and push to select standard).

Pushing the GPS LSK displays the GPS tab.

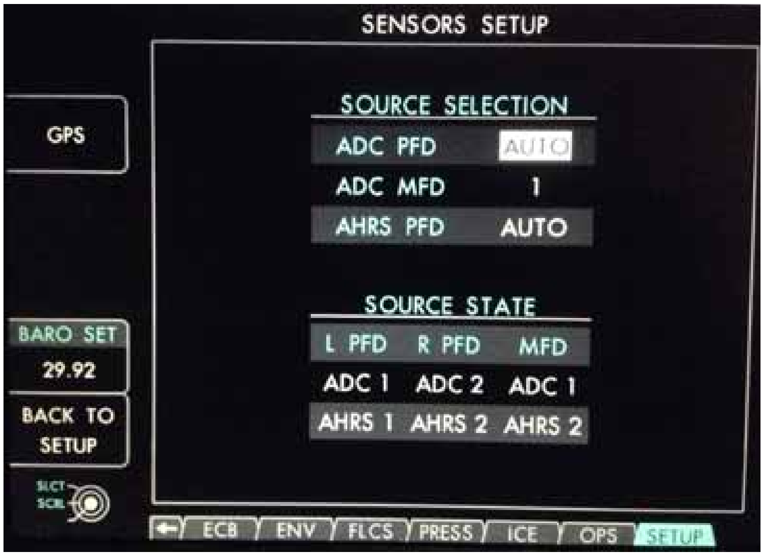


Figure 14-24. MFD, Setup Tab, Sensors Page

- **GPS Status**

The database information is contained in the Innovative Solutions & Support GPS-SBAS Receiver; therefore, DATABASE information on this display does not apply.

The SETUP page allows access to the following sub-pages via LSKs:

- SENSORS
- SETTINGS

- **GPS Status Page**

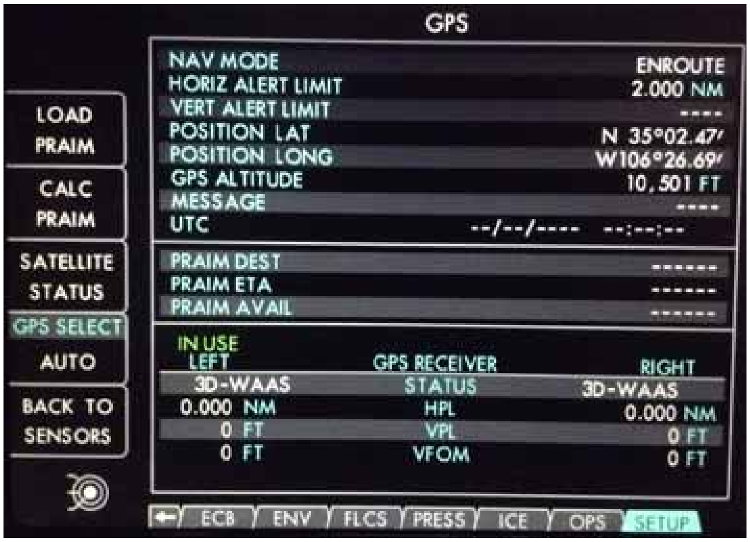


Figure 14-25. GPS Status Page

Data indicating GPS operational status is available on the GPS Status Page. This page indicates the current GPS position data, error messages, and integrity values. It is intended as a reference to aid in GPS troubleshooting and fault isolation.

To access the GPS Status page: select the SYSTEM group, scroll to the SETUP tab, press LSK1: SENSORS, then select GPS Status by pressing LSK1: GPS.

- **LSK1: LOAD PRAIM DEST**

PRAIM (Predictive Receiver Autonomous Integrity Monitoring) is designed to predict GPS availability and accuracy at a given destination and time. Pressing LSK1 will load the current FMS destination and predicted ETA. If there is no destination set for the FMS, then the PRAIM DEST, PRAIM ETA, and PRAIM AVAIL will be replaced with white dashes. LSK1: LOAD PRAIM also provides the pilot with a way to calculate the predictive RAIM of a position or time other than what is loaded. The DCK is activated and allows for manual entry of the text field of PRAIM DEST and PRAIM ETA.

Dual Concentric Knob – Text Field
DCK: Outer Knob (POS) — Move the highlighted cursor left or right.
DCK: Inner Knob (*A-9*) — Select the character at the cursor position.
DCK: Button (ADD) — Activates the selected alphanumeric Identifier.

- **LSK2: CALC PRAIM**

LSK2 will request the calculation of predictive RAIM for the destination and ETA that has been loaded (manually or automatically through the FMS).

- **LSK3: SATELLITE STATUS**

The GPS status page offers a satellite status synoptic via LSK3. The Satellite Status Synoptic page offers a graphical representation of the position and signal strength of the GPS satellites that each GPS is using for location. For GPS 1 and 2, there is a bar graph of the 15 satellites being tracked. The Satellite status page also displays the Horizontal Uncertainty Limit (HUL), Horizontal Figure of Merit (HFOM), Vertical Uncertainty Limit (VUL), and Vertical Figure of Merit (VFOM) for each GPS.

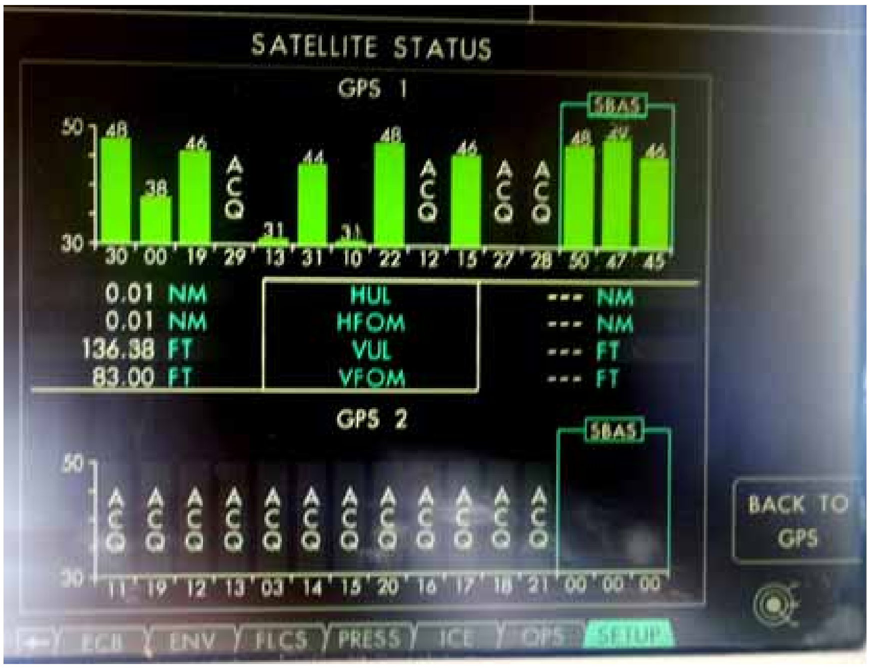


Figure 14-26. Satellite Status Page

- **LSK4: GPS SELECT (Source Selection)**

Pressing LSK4: GPS SELECT toggles the GPS source select between: GPS1 - GPS2 - AUTO. In AUTO select mode, the GPS receiver in use will automatically switch due to excessive errors. Selecting GPS1 or GPS2 uses that GPS position data explicitly. The GPS sensor being used is indicated by the **IN USE** annunciation above the LEFT or RIGHT GPS Receiver headings.

GPS ERROR MESSAGES

If the FMS detects or receives GPS faults from the active GPS, the highest priority fault will be indicated in the MESSAGE field on the GPS STATUS page. These error messages will not cause any annunciation on the PFD. If a GPS error also results in an associated FMS navigation failure, the FMS navigation failure will also be annunciated on the PFD and the FMS PROG page.

GPS Error Messages

Status Messages	Description
EQPMT FAILURE	GPS Equipment Malfunction

Status Messages	Description
WAAS MSG	No valid WAAS message received for at least 4 secs
SATELLITES	Insufficient number of WAAS “healthy” satellites available
FD ERROR	RAIM detected SV failure
ALMANAC	GPS almanacs not complete or current in Nav Database
RAM FAIL	Battery backed RAM failure or cleared
RF ERROR	GPS detected RF error
ANTENNA SHORT	GPS detected “antenna short” error
ANTENNA OPEN	GPS detected “antenna open” error
OSCILLATOR RATE	GPS computed oscillator rate exceeds 6.3 ppm
EEPROM	GPS detected fault in EEPROM
REAL TIME CLOCK	Battery powered RTC fault
PSEUDORANGE STEP	GPS detected fault
SV ERROR	RAIM predicted SV failure

GPS TROUBLESHOOTING

If the GPS source selection is set to AUTO (default setting), the FMS will automatically switch to the other GPS in the event of invalid GPS position.

NOTE:
It is recommended that the status of each GPS be checked during preflight.

SETTINGS

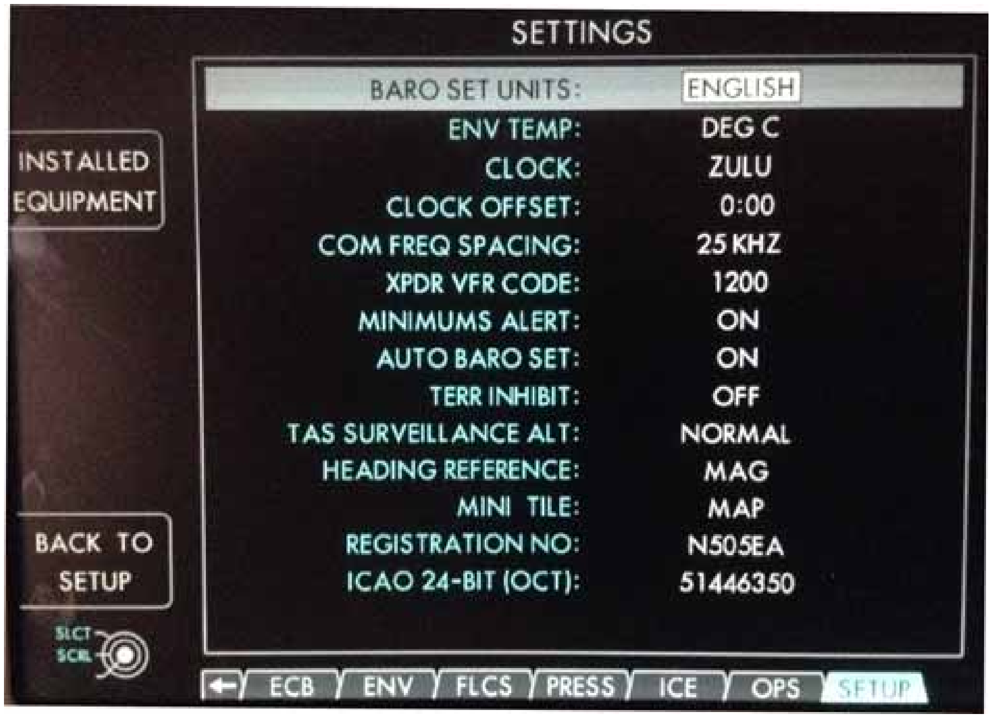


Figure 14-27. MFD, Setup Tab, Settings Page

From the SETUP tab, SETTINGS is used to select and configure pilot-selectable options. These settings persist through power cycles except where noted.

- BARO-SET UNITS: Toggles through available units. When METRIC is selected, the BARO-SET units change from ENGLISH, IN (inHg) to HPA (hPa).
- ENV TEMP: Toggles temperature units on the ENV synoptic page between DEG C and DEG F.
- CLOCK: Select between 12HR LOCAL, 24HR LOCAL and ZULU time for display on the PFDs.
- CLOCK OFFSET: Allows for setting an offset of ± 1-23 hours when local time is selected for display.
- COM FREQ SPACING: Select com radio frequency spacing between 25 kHz and 8.33 kHz.
- XPDR VFR CODE: Select the code that is transmitted when the transponder VFR mode is active. Available selections are 1200, 1400 and 1700.
- RADAR ALT VOICE: Not selectable.
- MINIMUMS ALERT: Select whether the aural "Approaching Minimums" and "Minimums" callouts are annunciated.
- AUTO BARO SET: Select whether baro-set is automatically selected to standard when climbing through FL180.

- TERR INHIBIT (if optional TAWS system installed): Switches OFF all forward-looking terrain alerts to avoid nuisance warnings at airports that are not in the system database. This item defaults to OFF following a power cycle.
- TAS SURVEILLANCE ALT (if optional TAS system installed): Selects the display of traffic to ABOVE, BELOW, NORMAL, or UNRESTRICTED modes. This item defaults to NORMAL following a power cycle.

Installed Equipment

The SETTINGS page also provides the following LSK options:

- INSTALLED EQUIPMENT: Lists all optional equipment installed on the aircraft.
- BACK TO SETUP: Returns to the Main SETUP page.

Figure 14-28. Installed Equipment

14.6 Checklists

The aircraft electronic checklists are available for selection on MFD Tiles 7/8. Pressing either the CKLST Primary Function Key on the MFD or the keyboard's CHKLST function button will enter the Electronic Checklists. Once the CHKLSTs have been loaded, lists can be selected to provide a process to confirm that desired tasks were performed. The CHKLSTs also provide additional information, such as notes, warnings, comments, cautions, tables, etc.

When selected, the MFD displays the checklist page with the checklist or item highlighted that was last in use. If checklists are activated for the first time after power up, then the MFD shall display the Checklist Main Menu.

The checklists use colors and symbols to assist the pilot in ensuring that all items are complete and none are missed, even if the pilot leaves the checklist display and comes back to it later.

Checklists are organized for display in folders. On the checklist page, the user can see the specific checklist items. The user interface is designed to provide access to any part of the checklist system at any time while optimizing the normal usage flow.

Line Select Keys
LSK1: (CHECK/UNCHECK ITEM) — Mark the task as completed.
LSK2: (GO TO LINK) — Proceed to a linked item.
LSK3: (RETURN FROM LINK) — Return from linked item.
LSK4: (ENTER LIST) — Enter the selected list.
LSK5: (RETURN TO LIST) — Exit current list and return to previous list.

14.6.1 Check/Uncheck

When the selected item is a task, LSK1: CHECK ITEM provides the pilot with the capability to select mark the task complete, if the item is unchecked. The MFD displays an empty box for checklist items which have not been completed.

Figure 14-29. Uncompleted CHECK ITEM

If the pilot checks the item, the MFD renders a green “X” in the box to indicate the task is complete. When an item is checked, the cursor (highlighted box) shall automatically move to the next checklist item. As long as Items are checked off in order, there is no need to use manually scrolling techniques because the highlight box moves down the list automatically.

If the pilot has a checked task highlighted, LSK1: UNCHECK ITEM provides the pilot with the capability to unmark the task as complete. If the user unchecks a completed task, the MFD removes the green "X" in the box.

Figure 14-30. Completed CHECK ITEM

14.6.2 Go To Link

The Checklist may provide the ability to link to other tasks or checklists. LSK 2: GO TO LINK is available when the currently highlighted item contains a link to another item. When LSK 2 key is pressed, the MFD jumps to the linked item.

Figure 14-31. Linked Item

14.6.3 Return From Link

LSK 3: RETURN FROM LINK is displayed when the pilot has jumped to an item through GO TO LINK. When the LSK 3 key is pressed, the MFD returns to the previous location.

14.6.4 Enter List

When a selected item is a list, the capability to enter a list is provided through LSK4: ENTER LIST.

14.6.5 Return to List

When the pilot has entered a list, the ability to exit that list is provided through LSK5: RETURN TO LIST. This action returns you to the previous list or the main menu. The LSK is removed at the Checklist main menu.

Figure 14-32. Checklist

Dual Concentric Knob – Checklists

DCK: Outer Knob (N/A) — No functionality.

DCK: Inner Knob (*SCRL*) — Scroll between lists / list items.

DCK: Button (SELECT) — Enter the list, or check/uncheck the selected list item.

14.6.6 Scrolling

The DCK: Inner Knob is used to scroll through the CHKLSTs. The selected checklist item will be highlighted in gray.

14.6.7 DCK: Button

The encoder pushbutton provides multiple actions dependent upon the selected item. If the selected item is a list, pressing the DCK: Button will enter the list. When a task is highlighted, pressing the DCK: Button checks/unchecks the item and advances to the next item.

14.6.8 Checklist Nomenclature

The MFD displays an indication of checklist items in the current list, and the number of items marked as completed in the upper left corner.

If all items in the current list have not been marked for completion, the indication is displayed in amber text. Once the all items in the checklist have been completed, the indication transitions to green text.

When the selected item is a list, the MFD displays an indication of checklist items inside the selected list, and the number of items marked as completed in the upper right corner. If all items inside that list have not been marked for completion, the indication is displayed in amber text. Once the all items inside the list have been completed, the indication transitions to green text.

Any list containing sublists will indicate completed sublists by displaying the list in green text. Sublists having no tasks are shown in cyan.

If more items are in a checklist below the viewable window, the MFD displays:
- More Items ... Scroll Down -

If more items are in a checklist above the viewable window, the MFD displays:
- More Items ... Scroll Up -

If no more items are in a checklist below the viewable window, the MFD displays:
- End of List -

14.7 Keyboard

14.7.1 General

Left side and optional right side keyboards are available to provide an additional interface between the pilot or copilot and the PFD and 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 of 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.

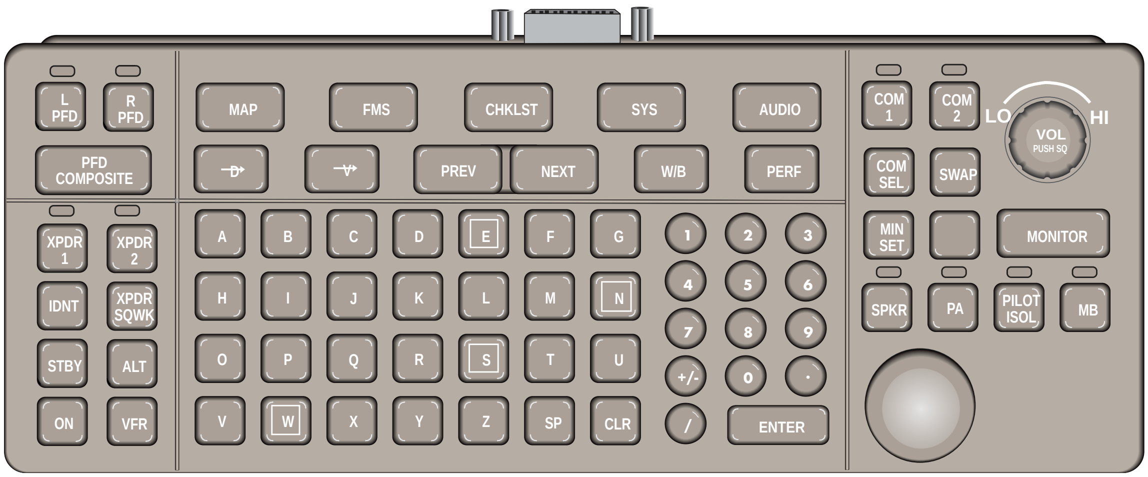


Figure 14-33. Keyboard

14.7.2 Keyboard Composite Group

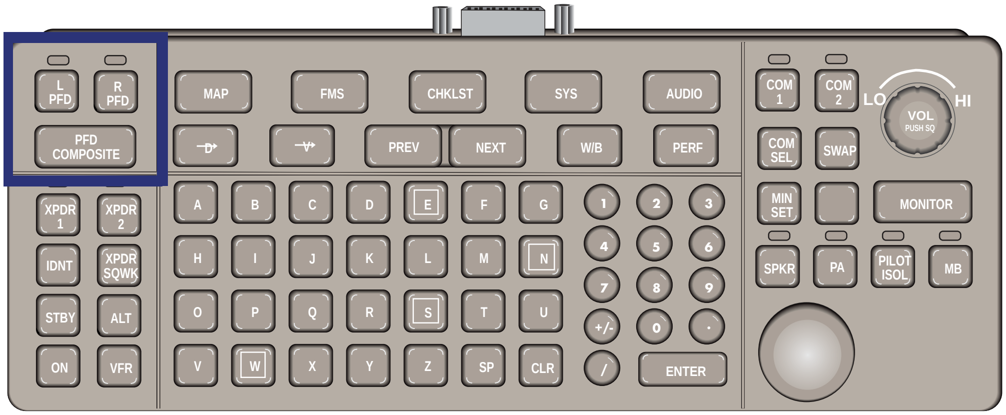


Figure 14-34. Keyboard Composite Group

Control of PFD composite mode is accomplished with three keys labeled L PFD, R PFD, and PFD COMPOSITE. When the L PFD or R PFD is selected, a light above the key illuminates, indicating 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.

14.7.3 Keyboard Transponder Group

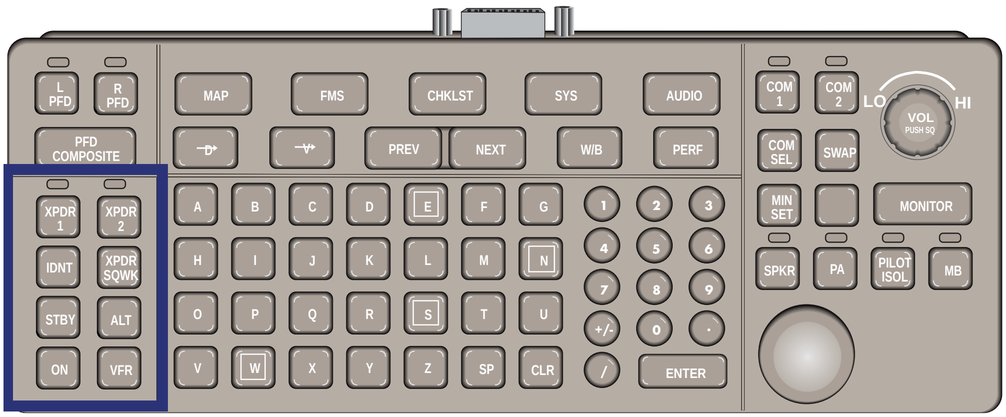


Figure 14-35. Keyboard Transponder Group

- **XPDR 1 and XPDR 2**
  Selecting a transponder (XPDR) for control is accomplished with 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 transponder is selected at all times; pressing the same key twice will have no effect.
- **IDNT**
  Pressing IDNT sets the selected transponder to Identification mode. If the selected transponder is not in ON or ALT mode, there is no effect.
- **XPDR SQWK**
  Pressing 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 sets the code in the CODE line-select window.
- **SBY**
  Pressing SBY sets the selected transponder to Standby mode.
- **ALT**
  Pressing ALT sets the selected transponder to reply to Air Traffic Control (ATC) interrogations with both Mode A and Mode C replies using whatever Mode A code is currently set.
- **ON**
  Pressing ON sets the selected transponder to reply to ATC interrogations with the Mode A replies using whatever Mode A code is currently set.
- **VFR**
  Pressing VFR sets the Mode A code of both transponders to 1200.

14.7.4 Keyboard Function Group

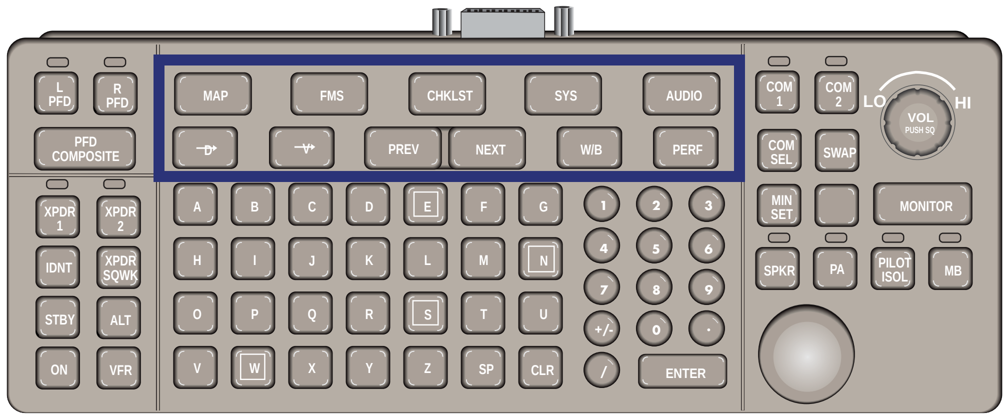


Figure 14-36. Keyboard Function Group

The top row of function group keys allow selection of the same functions selectable from the five primary function keys on the MFD.

- MAP
- FMS
- CKLST
- SYS
- AUDIO

The second row function group buttons provide the following 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. MFD Tile 7 is set to Moving Map.
- **V→**
  Activate Vectors-To-Final (VTF) (approach mode only).
- **PREV**
  Pressing PREV selects the previous (to the left) tabbed page on Tile 7 of the MFD.
- **NEXT**
  Pressing NEXT selects the next (to the right) tabbed page on Tile 7 of the MFD.
- **W/B (Weight and Balance)**
  Pressing W/B brings up the weight and balance portion of the OPS page and shifts previously shown information on Tile 7 to Tile 8.
- **PERF (Performance)**
  Pressing the PERF key brings up the performance portion of the OPS page and shifts previously shown information on Tile 7 to Tile 8.

14.7.5 Keyboard Alpha Group

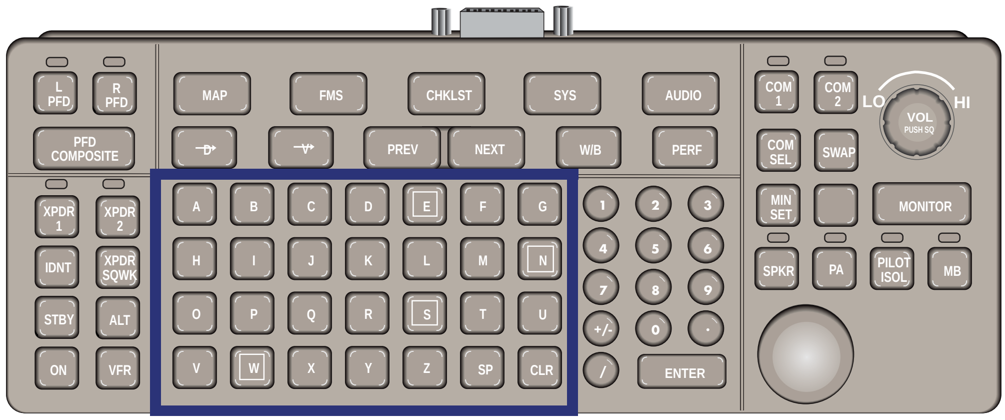


Figure 14-37.   Alpha Group

Located in the middle area of the keyboard, the alpha group consists of the keyboard's alphabetic character keys plus SP (space) and CLR (clear) keys. Key presses in this group affect only MFD Tiles 7 and 8 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.

14.7.6 Keyboard Numerical Group

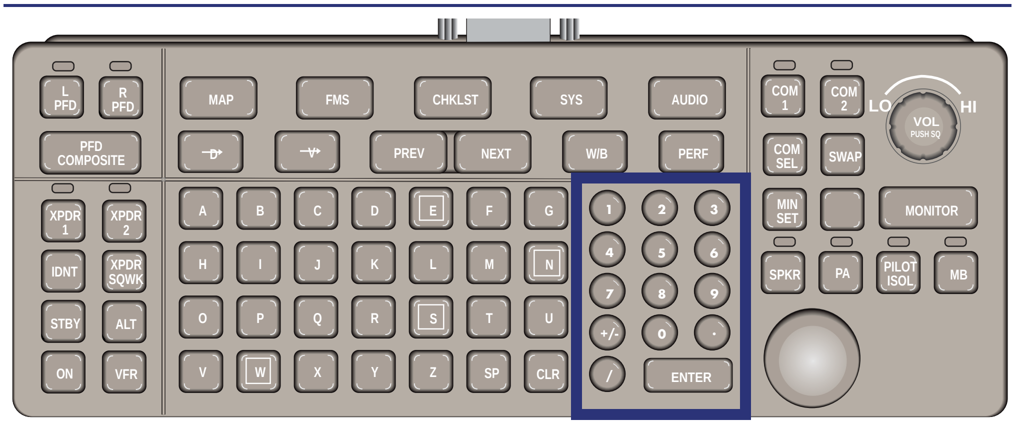


Figure 14-38.   Keyboard Numerical Group

Located in the middle area of the keyboard, the numerical group consists of the keyboard's numerical character keys plus these keys: **+/-   . /   ENTER**.

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.

14.7.7 Keyboard COM/NAV Group

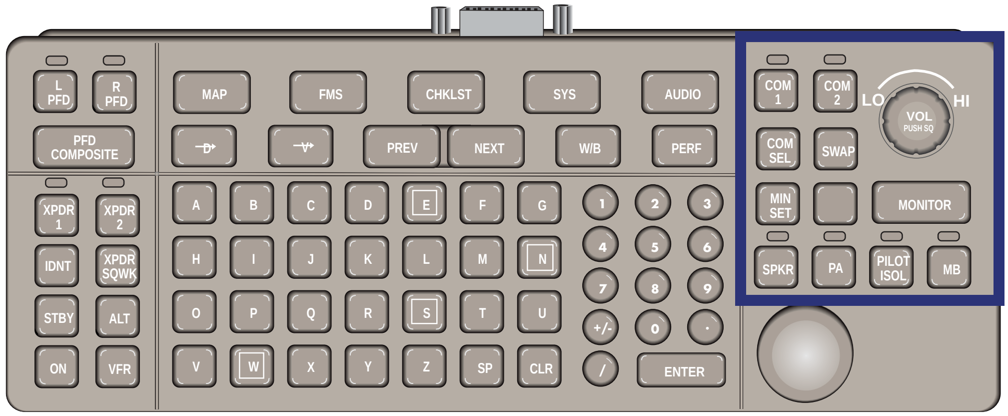


Figure 14-39. Keyboard COM/NAV Group

- **COM 1 and COM2**
  Selecting a communication radio (COM) for control is accomplished with 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; 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 pilot 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 from the keyboard, then press ENTER. This will set the minimum altitude in the MIN line-select window.
- **SPARE/BLANK**
  This key is not currently assigned. 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 overhead speaker on and off.

  The light on the keyboard above the SPKR button is illuminated when the speaker is on.

- **PA**
  Not operable.
- **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 (MB) received audio on and off. The light above the MB key illuminates when the MB audio is on.

14.7.8 Cursor Control Device/Joystick

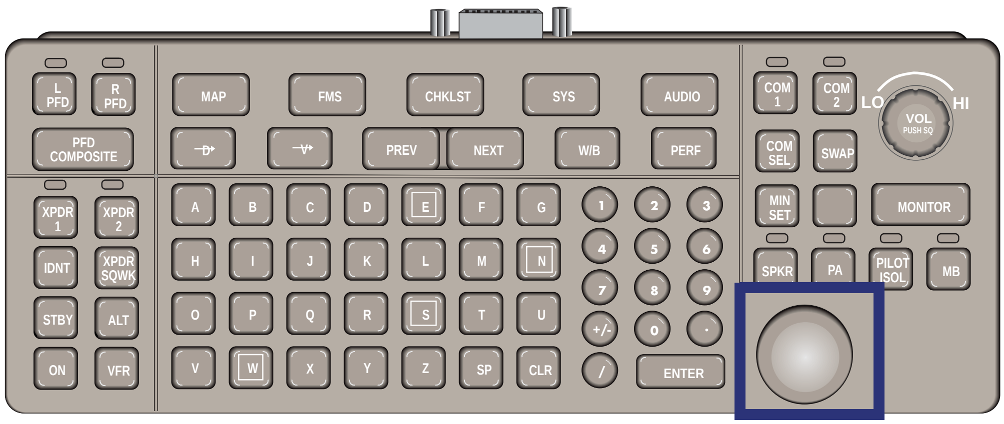


Figure 14-40. Cursor Control Device/Joystick

The Keyboard Cursor Control Device (CCD) allows the pilot to scroll the MFD map. The cursor also allows for the review of information on selected airports, NAVAIDs, or user waypoints. The information is displayed when the cursor hovers over an airport, NAVAID, or waypoint. Distance from the cursor location to the current aircraft location is also displayed.

14.8 FMS Function Group

The FMS pages provide the operator with the ability to create and execute a Flight Plan. This includes the capability to fly direct routes between waypoints, navigate via airways, or select from published departure, arrival, and approach procedures. Flight plans may also be modified, edited, and stored within the FMS pages.

When the MFD FMS Primary Function Key is pressed, the ACTV, PROG, ROUTE, NREST, USER or VNAV page is displayed in the left tile, causing the contents of the left tile to shift to the right. Two different FMS tabs may be displayed in both the left and right tiles simultaneously. The left and right tabs can still be selected independently.

The FMS functionality is presented on the following FMS tabs:

- ACTV — Provides the interface to monitor and control the Active Flight Plan.
- PROG — Displays the progress of the aircraft along the active flight path.
- ROUTE — Provides the interface to manage stored flight plans (routes).
- USER — Provides the mechanism to manage stored user defined waypoints.
- VNAV — Provides the ability to plan enroute descents to any waypoint.
- NREST — Provides access to a dynamic list of the nearest ARPTS, FIX, VOR, NDB, and ARTCC, along route.

Figure 14-41. FMS Page Tabs

14.8.1 Route Tab

The FMS has the capability to store up to 99 routes (flight plans). The controls to manage stored routes are provided on the ROUTE tab. Stored routes may be created, deleted, edited, or activated on the ROUTE tab.

The ROUTE tab provides the ability to activate a stored route, edit a stored route, create a new route, or delete stored routes.

14.8.1.1 MANAGING STORED ROUTES

The routes are listed alphabetically by route name. If all 99 routes have been entered, new routes may not be created until a route is deleted. Each route entry incorporates the Route Name (User Defined), Origin Identifier, Destination Identifier, and Waypoint Count.

The selected route is expanded and highlighted in green. The highlighted route is selected by rotating the DCK: Outer Knob to scroll through the list of routes.

Figure 14-42. Route Page

Dual Concentric Knob – Stored Route List
DCK: Outer Knob — (SCRL) Scroll to highlight the selected route in the list. DCK: Inner Knob (No Function) DCK: Button — (TOP) Select the first route in the list.

The ROUTE tab's four LSKs are used to manipulate the selected route.

Line Select Keys – Main Route Page
LSK1: (ACTIVATE FLIGHT PLAN) — Activates the selected route as the flight plan. LSK2: (EDIT FLIGHT PLAN) — Allows the selected route to be modified. LSK3: (CREATE FLIGHT PLAN) — Allows a new stored route to be created. LSK4: (DELETE FLIGHT PLAN) — Delete the selected route. LSK5: (No Function)

14.8.1.2 ACTIVATE FLIGHT PLAN

The FMS only processes the Active Flight Plan. To use one of the stored routes, it must be selected from the list and activated. Activation replaces the current active flight plan with a copy of the selected route.

14.8.1.3 EDIT FLIGHT PLAN

Editing a stored route allows a named route to be modified. The procedure for editing a stored route is identical to editing the active flight plan, which will be discussed later in this guide. Editing a stored route has no effect on the current active flight plan. Editing a route is initiated by selecting the desired route with the DCK: Outer Knob and pressing LSK2: EDIT FLIGHT PLAN. Once the flight plan is edited as desired, you can ACTIVATE FLIGHT PLAN using LSK1 or RETURN TO FLIGHT PLAN LIST using LSK5.

Figure 14-43. Route Leg/Waypoint List

Line Select Keys – Editing Stored Route
LSK1: (ACTIVATE FLIGHT PLAN) — Activates the selected route plan.
LSK2: (No Function)
LSK3: (No Function)
LSK4: (No Function)
LSK5: (RETURN TO FLTPLN LIST) — Returns to the list of stored routes.

14.8.1.4 DELETE STORED ROUTE

A stored route may be permanently deleted from the ROUTE tab to reduce the length of the Route list or to create additional room to store new routes. Select the route for deletion using the DCK: Outer Knob. Press LSK4 DELETE FLIGHT PLAN.
A confirmation is required by pressing LSK1: CONFIRM DELETE FLTPLAN.
If deletion is not desired, press LSK5: CANCEL DELETE FLTPLN.

14.8.1.5 CREATING A ROUTE/FLIGHT PLAN

The procedure for creating an active or a stored flight plan on the ACTV and ROUTE tabs are almost identical. The difference being that creating a stored flight plan requires a route name to be assigned first. A flight plan created from the ACTV tab cannot be stored later; a route created and activated from the ROUTE tab can be reused as the flight plan.

A flight plan is defined by identifying the Origin and Destination, then inserting any intermediate waypoints, airways, and procedures. The Origin and Destination are not restricted to just Airports; any type of valid waypoint may be used. Departure procedures are treated as an origin attribute. Arrivals and Approaches are treated as destination airport attributes.

When creating a flight plan from the ROUTE tab, press LSK3: CREATE ROUTE. The ENTER FLIGHT PLAN NAME attribute box is then displayed. It contains a single text field allowing the name of the new route to be entered. The name is entered using the DCK: Outer for the Cursor movement, and the DCK: Inner Knob for changing the character within the cursor. The DCK: Button will activate the name. Alternatively, the alphanumeric, ENTER, SP (space), and CL (clear) keys of the Keyboard can be used. The process of creating a new route may be canceled by pressing LSK1: CANCEL. If a Flight Plan is being created from the ACTV tab, no name is specified, and this step is skipped.

Figure 14-44. Named Route Attribute Box

NOTE:
Once a flight plan name has been specified, it cannot be changed.

14.8.1.6 SPECIFY THE ORIGIN

Next, the ORIGIN attribute box is presented with the ICAO text field active. The first letter of the ICAO identifier is preselected to 'K'. The ICAO text field is completed via the Dual Concentric Knob (DCK) or the alphanumeric keys of the keyboard.

Figure 14-45. Origin Attribute Box

Dual Concentric Knob - Text Field
DCK: Outer Knob — (POS) — Move the highlighted cursor left or right. DCK: Inner Knob — (A-9) — Select the character at the cursor position. DCK: Button — (ADD) — Activates the selected alphanumeric Identifier.

Keyboard - Editing a Text Field
Alphanumeric Keys — Enter character and advance cursor. SP Key — Enter a "space" and advance the cursor. CLR Key — Delete the character at the cursor position and back-up the cursor. ENTER Key — Activate the selected text entry.

When the Origin's identifier is selected by the DCK: Button or the ENTER Key on the keyboard, the database will be queried for matching identifiers. If none are found, an error text will be displayed. If the database contains duplicate entries with matching identifiers, the FMS will present the duplicate waypoints in a list for the pilot to select from. The list indicates the Relative Direction (arrow) and Distance to the fix. The list of duplicate waypoints is a scrolling list with only 2 waypoints shown at a time. A green arrow is displayed anytime there are more than 2 waypoints present in the list.

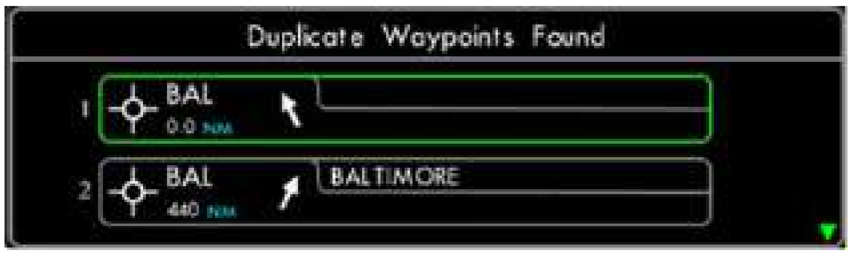


Figure 14-46. Duplicate Waypoint List

Dual Concentric Knob - Duplicate Waypoint List
DCK: Outer Knob (No Function) DCK: Inner Knob (SCRL) — Scroll through the menu. DCK: Button (SEL) — Select the highlighted menu.

After the ORIGIN field has been set, the remaining fields (RWY, SID) may be completed. The DCK: Outer Knob is used to scroll to (highlight) a field.
The DCK: Button is used to select the highlighted field. The additional fields do not have to be completed in any order (or completed at all). These fields may be completed or changed later by editing the ORIGIN.

Figure 14-47. Origin Attribute Box

Rotate the DCK: Outer Knob to select a different field (RWY or SID). Press the DCK: Button to activate the menu for the selected field.

Figure 14-48. Origin Attribute Box - SID Menu

The RWY and SID fields are all implemented as drop-down menus which list all available runways and procedures from the Nav Database.

Figure 14-49. Origin Departure Menu

The DCK: Outer Knob is used to select one of the available fields. When either the RWY or SID fields are selected, pressing the DCK: Button will activate the drop down menu which lists all available runways or procedures. Scroll through the list by rotating the DCK: Inner Knob. Select the highlighted item by pressing the DCK: Button. When a SID is selected, the SID:Transition menu field will automatically activate to allow the transition to be selected.

Dual Concentric Knob - Drop-Down Menu
DCK: Outer Knob (No Function) DCK: Inner Knob (SCRL) — Scroll through the menu. DCK: Button (SEL) — Select the highlighted menu.

When the ORIGIN options have been selected, they need to be confirmed by pressing LSK1: CONFIRM ORIGIN. Once confirmed, the Origin and any selected runway and departure procedures will be included in the flight plan.

NOTE:
Many Departure/Arrival Procedures are runway specific. When entering a SID or STAR, enter a Runway to transition From/To. Should the need arise, the Runway is easily changed by editing the ORIGIN/DESTINATION.

14.8.1.7 SPECIFY THE DESTINATION

When the Origin has been confirmed, the DESTINATION attribute box is presented with the ICAO text field active. The first letter of the ICAO identifier is preselected to 'K'. The ICAO text field is completed using the Dual Concentric Knob (DCK) or the alphanumeric keys of the Keyboard.

When the Destination's identifier is selected by the center push button or the ENTER button on the keyboard, the database will be queried for matching identifiers. If none are found, an error text will be displayed. If multiple matching identifiers are found, a drop-down list will be presented with relative bearing, waypoint type, and distance — allowing the user to select the desired waypoint.

Figure 14-50. Destination Attribute Box

After the DESTINATION field has been set, the remaining fields (RWY, STAR, APPR) may be completed. The additional fields do not have to be completed in any order (or completed at all). These fields may be completed or changed later by the EDIT or PROC menu for the DESTINATION. If you wish to add a runway, arrival, or approach at this time, Rotate the DCK: Outer Knob to select a different field (RWY, STAR, or APPR). Press the DCK: Button to activate the menu for the selected field.

Use the DCK: Outer Knob to select the RWY field, then press the DCK: Button to activate the drop-down menu listing all available runways. Scroll through the list by rotating the DCK: Inner Knob. Select the highlighted item by pressing the DCK: Button.

Use the DCK: Outer Knob to select the STAR field, then press the DCK: Button to activate the drop down menu listing all available procedures. Scroll through the list by rotating the DCK: Inner Knob. Select the highlighted item by pressing the DCK: Button.

Figure 14-51. STAR.Transition Menu

Use the DCK: Outer Knob to select the APPR field, then press the DCK: Button to activate the drop-down menu which lists all available procedures. Scroll through the list by rotating the DCK: Inner Knob. Select the highlighted item by pressing the DCK: Button.

Figure 14-52.   Approach Menu

When an APPR is selected, the APPR.IAF menu field will automatically activate to allow the Initial Approach Fix (or Feeder) to be selected. By default, Vectors-To-Final (VTF) is selected in lieu of an IAF. Changing the selected runway will not affect the selected approach.

Figure 14-53.   Approach.IAF Menu

Dual Concentric Knob - Drop-Down Menu
DCK: Outer Knob (No Function) DCK: Inner Knob (SCRL) — Scroll through the menu. DCK: Button (SEL) — Select the highlighted menu option.

NOTES:

- Special attention should be paid when selecting an IAF for an approach. If an IAF is selected which has the "NoPT" attribute, any procedure turns (or holding pattern) will be excluded from the flight plan.
- Intermediate Fixes (IF) cannot be selected directly from the Destination Approach.IAF Menu unless the fix is also an initial approach fix (IF/IAF). In order to comply with an ATC request of direct an Intermediate select the Initial that originates the approach, and then perform a Direct-To the Intermediate fix.

14.8.1.8 SPECIFY THE ROUTE

After a minimal flight plan, consisting of an origin and destination, is created, the route may be specified by inserting intermediate legs. Legs are inserted immediately after the currently selected (green highlighted) waypoint. See the inserts below.

To insert a leg into the flight plan, Scroll through the flight plan waypoints to select the ORIGIN (or last waypoint in the departure procedure). Press the DCK: Button or rotate the DCK: Inner Knob to activate the (drop-down) Leg Menu which lists the actions available to modify the highlighted leg. The actions available for a given leg are dependent on the type of leg and whether it is associated with a procedure or airway. The actions available for each type of waypoints are summarized the following table.

Menu Option	ORIGIN	Departure	General WPT	Airway	Arrival	Approach	HOLD	DEST
EXIT MENU	X	X	X	X	X	X	X	X
INTERCEPT[(a)]		X	X	X	X	X		
INSERT	X[(b)]	X[(c)]	X	X				
DELETE			X	X	X		X[(d)]	
DELETE ALL				X				
EDIT	X						X	X
HOLD		X	X	X	X	X		
PROC	X							X

(a) Intercept is only available on the ACTV tab.

(b) Insert is not available for the Origin Airport if a departure procedure is selected.

(c) Insert is only available for the last waypoint in a departure procedure.

(d) A published hold included in a procedure cannot be deleted or edited.

EXIT MENU

The first (default) action for any Leg Menu is EXIT MENU. This action allows the user to immediately exit the menu without taking any action.

Since the Leg Menu is normally activated by pressing the DCK: Button and EXIT MENU is the default menu action, simply pressing the DCK: Button a second time will escape from the menu.

Figure 14-54. Leg Menu - EXIT MENU

INSERT ACTION

The INSERT action allows a leg to be inserted after the selected leg/waypoint. The INSERT action is not available for the DESTINATION, or a HOLD, and within a published procedure.

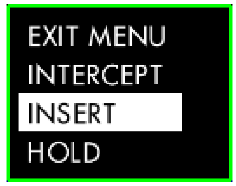


Figure 14-55. Leg Menu - INSERT

When INSERT is selected, an Insert Waypoint/Leg Attribute Box is displayed with the VIA field highlighted and DIRECT preselected. The VIA field determines if the new leg will be a direct course to the waypoint, or follow the selected airway to the end point.

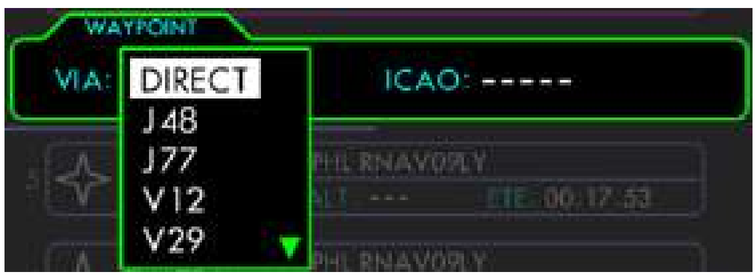


Figure 14-56. Insert Waypoint Attribute Box

NOTE:
Selecting an airway is not an option when inserting a leg after a non-airway waypoint. In this case, the VIA field will populate with DIRECT, requiring no user action.

- **Select the VIA Type**

The VIA field is implemented as a drop-down list populated with all of the airways (Victor, Jet, Q, T, etc.) which pass through the selected waypoint (in addition to the DIRECT option). Since the VIA field is preselected by default, pressing the DCK: Button will activate the drop-down menu, which lists all of the airway options in alphanumerical order. Scroll through the list by rotating the DCK: Inner Knob. Select the highlighted item by pressing the DCK: Button.

Dual Concentric Knob - Drop-Down Menu
DCK: Outer Knob (No Function) DCK: Inner Knob (SCRL) — Scroll through the menu. DCK: Button (SEL) — Select the highlighted menu option.

— VIA DIRECT

If DIRECT was selected, the ICAO field will be handled as a text field.

Figure 14-57. Insert Via Direct Waypoint

The text field is completed using the Dual Concentric Knob (DCK) or the alphanumeric keys of the Keyboard. After the ICAO identifier has been set, pressing the DCK: Button or KBD: "ENTER" Key queries the Nav Database to find the selected identifier.

Dual Concentric Knob - Text Field
DCK: Outer Knob (POS) — Move the highlighted cursor left or right. DCK: Inner Knob (A-9) — Select the character at the cursor position. DCK: Button (ADD) — Activates the selected alphanumeric Identifier.

Keyboard - Editing a Text Field
Alphanumeric Keys — Enter character and advance cursor. SP Key — Enter a "space" and advance the cursor. CLR Key — Delete the character at the cursor position and back-up the cursor. ENTER Key — Activate the selected text entry.

- **Select the End Point**

If an airway was selected for the VIA field, the ICAO field will be handled as a drop-down list populated with all of the fixes along that airway, with the entry point preselected. The list of fixes is ordered in the same sequence that the fixes occur along the airway, such that scrolling up (CCW) from the entry point will sequence through the fixes in East or South direction, and scrolling down (CW) will sequence through the fixes in the West or North direction.

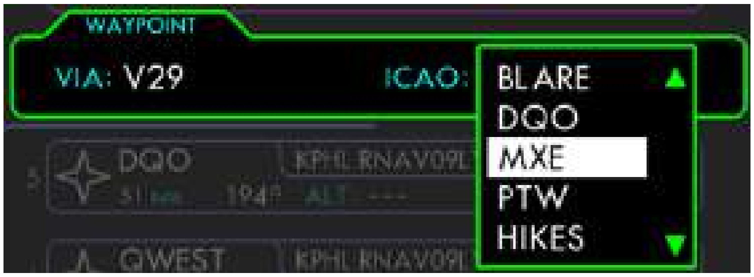


Figure 14-58. Insert Via Airway to Waypoint

Scroll through the list by rotating the DCK: Inner Knob. Select the highlighted fix by pressing the DCK: Button. When the end point is selected, all of the constituent legs of the selected airway will be added to the modified flight plan listing. These legs will be grouped together within an AIRWAY group.

Until the VIA and ICAO fields have been selected, the user may back out of the INSERT action by pressing LSK1: CANCEL-INSERT.

DELETE

The DELETE action is available from the Leg Menu for most intermediate waypoints except SID or Approach procedures. This action modifies the flight plan by removing the selected waypoint and modifying the following leg to go directly from the previous leg's (terminating) waypoint to the following waypoint.

Figure 14-59. Leg Menu – Delete

If the deleted waypoint is within an airway group, that group will be split at the removed point.

Deleting a waypoint requires user confirmation by pressing LSK1: CONFIRM DELETE before the flight plan is modified.

DELETE ALL

The DELETE ALL action is available from the Leg Menu ONLY for waypoints that are part of an airway group. This action deletes the entire bracket of waypoints at once. This action is offered in addition to the (singular) DELETE action.

Figure 14-60. Leg Menu – Delete All

Deleting the waypoints requires user confirmation by pressing LSK1: CONFIRM DELETE before the flight plan is modified.

HOLD

Holding Patterns may be created at any waypoint within the flight plan. Holding Patterns that are defined within published procedures are automatically included in the flight plan.

Figure 14-61. Leg Menu – HOLD

Holding Patterns are added to the selected waypoint by activating the Leg Menu and selecting the HOLD action. A Hold Attribute Box will be displayed with the default values preset. The holding pattern will be inserted into the flight plan after the holding fix as a separate "leg".

Holding Patterns are defined by the following attributes:

— Holding Fix
— Inbound Course (default = Course-to-Fix)
— Direction of Turns (default = Right)
— Units (default = Miles)
— Leg Length (default = 4.0 NM)

Figure 14-62. HOLD Leg Data Box

NOTE:
Holds are supported only for waypoints that exist in the flight plan. In order to hold at an off-route fix, the fix must first be inserted into the flight plan (via either Direct-To or INSERT) then configured for holding.

■ Configuring a Hold

Any of the Hold attributes may be modified while creating the hold, or later by editing the hold leg. To be modified, the attribute must be highlighted. The highlighted field may be selected by rotating the DCK: Outer Knob. The attribute menu is activated by pressing the DCK: Button, or the value may simply be adjusted by rotating the DCK: Inner Knob.

Figure 14-63. HOLD Attribute Box – Course Field Selected

Dual Concentric Knob – Edit Attribute Box
DCK: Outer Knob (SCRL) — Scroll through available fields. DCK: Inner Knob (No Function) DCK: Button (SEL) — Activate highlighted attribute field.

The Course is adjusted between 1-360° by rotating the DCK: Inner Knob. The DCK: Outer Knob changes the value by 10°. Press the DCK: Button to accept the selected value.

Line Select Keys – Confirm Direct To
LSK1: (ACCEPT) — Accept the selected hold attributes. LSK2: (No Function) LSK3: (No Function) LSK4: (No Function) LSK5: (CANCEL) — Returns to the (unchanged) original flight plan.

The EDIT Action is available in the Leg Menu when selected from an ORIGIN, a DESTINATION, or a HOLD. Using the EDIT action will open the attribute box for these types of legs so that they may be edited. In an ORIGIN, you can edit the ICAO, RWY, or SID fields. For the DESTINATION, editable fields include ICAO, RWY, STAR, and APPR.

Table 14-2. Edit Action

	ORIGIN	HOLD	DESTINATION
Editable Fields	ICAO	COURSE (Inbound)	ICAO
	RWY	TURN (Direction)	RWY
	SID	UNITS (NM/MIN)	STAR
		LEG LENGTH	APPR

Figure 14-64. DESTINATION Leg Menu – EDIT

INTERCEPT

The INTERCEPT action is available only from a Leg Menu on the ACTV flight plan tab. On the ACTV tab, the intercept action is available from the Leg Menu for most legs except the ORIGIN, DESTINATION, inside a Final Approach Fix, or a HOLD.

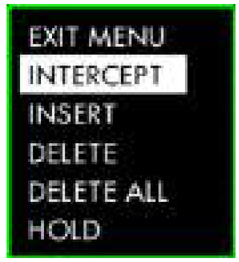


Figure 14-65. Leg Menu – INTERCEPT

14.8.1.9 LEGS

A flight plan is defined and processed by the FMS as a series of legs. Each leg consists of a path leading to a terminating fix or waypoint. The identifier of the leg's terminating fix is used to identify that leg.

The FMS will determine the appropriate path to navigate along the flight plan. Course changes in the flight path are accommodated by incorporating curved turning segments into the legs as necessary. Since the FMS navigates along both the straight and curved segments of the flight path, the CDI will ideally display on-course throughout the flight including turns.

LEG GROUPS

Flight plan legs are grouped together by a bracket (located left of the legs). The grouping delineates the legs belonging to a common procedure, airway, or history (already sequenced). The name of the group is indicated in a bracket vertical label to the left of the leg. The grouping band is color coded to indicate the type of grouping applied. The supported groups include the following:

Active flight plan leg	(magenta)	
HISTORY	(gray)	
DEPARTURE	(cyan)	
AIRWAY	(white)	
ARRIVAL	(blue)	
APPROACH	(light blue)	
MISSED APPROACH	(brown)	

If a fix is added along an airway or if a waypoint is deleted, the airway group will become divided at the modified fix. Some menu actions, such as "DELETE ALL", apply to all of the legs within a bracket.

Figure 14-66. Route Leg Listing

14.8.1.10 FLIGHT PLAN MAP SYMBOLOGY

Once a flight plan is activated, the active flight plan is available for display on the PFD HSI and MFD ND tab as well as presented on the Moving Map. The flight plan legs which are calculated by the FMS are color coded in the same ways as the grouping on the ACTV and ROUTE tabs.

Figure 14-67. Flight Plan Depiction on Map

14.8.1.11 SUPPORTED LEG TYPES

The leg type is defined by the type of path leading to the leg's terminating fix. The FMS supports the following ARINC 424 defined leg types based on: Direct, Course, Track, Distance, Radial, Intercept, Radius, Arc, and Vectors.

Supported Leg Types

Initial Fix	(IF)	Initial Fix (no path defined)
Track to Fix	(TF)	Great Circle Track to Fix
Course to Fix	(CF)	Specific Course to Fix
Direct to Fix	(DF)	Direct Track from present position to Fix
Fix to Altitude	(FA)	Specific Track to an Altitude (dynamic fix)
Fix to Course	(FC)	Specific Course/Distance from Fix
Fix to Distance	(FD)	Specific Course to a Distance from another Fix
Fix to Manual	(FM)	Specific Track to Manual Termination (dynamic fix)
Course to Altitude	(CA)	Specific Course to an Altitude (dynamic fix)
Course to Distance	(CD)	Specific Course to a Distance from another Fix
Course to Intercept	(CI)	Specific Course to Intercept the following leg
Course to Radial	(CR)	Specific Course to a Radial from another Fix
Radius to Fix	(RF)	Specific Radius Arc to Fix
Arc to Fix	(AF)	Arc with Constant Radius around a waypoint to Fix
Vectors to Altitude	(VA)	Specific Heading to an Altitude (dynamic fix)
Vectors to Distance	(VD)	Specific Heading to a Distance from another Fix
Vectors to Intercept	(VI)	Specific Heading to Intercept the following leg
Vectors to Manual	(VM)	Specific Heading to Manual Termination (dynamic fix)
Vectors to Radial	(VR)	Specific Heading to a Radial from another Fix
Procedure Turn	(PI)	Course Reversal at specific Fix
Hold to Altitude	(HA)	Mandatory Holding Pattern with Altitude Termination
Hold to Fix	(HF)	Holding Pattern in lieu of Procedure Turn to Fix
Hold to Manual	(HM)	Holding Pattern until Manual Termination

14.8.2 ACTV TAB

The ACTV Page displays the status of the Active Flight Plan and provides the control interfaces to manage and modify the Flight Plan. By default, after power-up, there will be no active flight plan. A new flight plan may be created directly from the ACTV tab, created on the ROUTE tab, or a pre-existing stored flight plan may be activated from the ROUTE tab. If the flight plan was activated from a named flight plan in the ROUTE tab, the name will appear in parenthesis at the top of the ACTV Page.

NOTES:

- A flight plan created directly from the ACTV tab will not be retained after the FMS has been shut down.
- A flight plan created or modified in the ACTV tab cannot be stored into the ROUTE tab.

If an active flight plan already exists, the ACTV tab is the default tab to appear when the FMS Mode Select Key is pressed. Otherwise, the ROUTE tab is opened by default when no active flight plan exists.

Figure 14-68. Active Flight Plan

Each leg is displayed in a separate Leg Attribute Box. The following data is provided for each leg:

- LEG INDEX NUMBER
- WAYPOINT IDENTIFIER
- WAYPOINT SYMBOL
- LEG DESCRIPTION
- LEG COURSE
- CUMULATIVE DISTANCE TO WAYPOINT
- ALTITUDE CONSTRAINT
- FUEL REMAINING
- SPEED LIMIT
- ESTIMATED TIME OF ARRIVAL
- ESTIMATED TIME ENROUTE TO WAYPOINT

Figure 14-69. Leg Attribute Box

NOTES:

- The Leg Attribute Box on the ACTIVE page includes bearing information relative to each leg, while the distance shown is cumulative. The exception to this is the active leg whose distance is line-of-sight from present position.
- If the name of the Selected Leg/Waypoint is too long to fit in the window provided, the text will scroll across the window.
- The fuel remaining is an estimated value calculated from the current burn rate. The estimated fuel remaining may be lower than planned during climb and higher during descent. The aircraft fuel quantity gauge on the upper portion of the MFD is the primary means of determining fuel status, and must be referenced against the planned fuel usage during cruise and descent.

14.8.2.1 SELECTED LEG

One of the legs in the flight plan is always selected. The selected leg is expanded and highlighted in green. A leg may be selected by rotating the DCK: Outer Knob to scroll through the list of legs. The legs of the ACTV flight plan can be manipulated in two ways: through the use of the Leg Menu activated with the DCK: Button or DCK: Inner Knob, or utilizing the ACTV tab's five LSKs.

Line Select Keys – Active Flight Plan (APPROACH MODE)
LSK1: (FLTPLAN STATE) — Toggles the HISTORY legs in the flight plan listing. LSK2: (D→) — Proceed DIRECT-TO the selected waypoint, bypassing defined route. LSK3: (V→) — Tactical Key. LSK4: (OBS MODE) — Activates OBS Mode on the selected waypoint. LSK5: (RNP) — Controls the Required Navigation Performance level mode.

NOTE:
LSK3 functions as a Tactical Key, whose functionality depends on the phase of flight.

Other flight plan changes are initiated by activating the selected leg's Leg Menu. Pressing the DCK: Button activates the Leg Menu (a Drop-Down menu listing the actions available to modify the highlighted leg). The Leg Menu may also be activated by rotating the DCK: Inner Knob. When a flight plan is not being modified, the selected leg will revert back to the active leg after 30 seconds of inactivity.

Dual Concentric Knob – Flight Plan Leg List
DCK: Outer Knob (SCRL) — Scroll to highlight the selected leg in the route. DCK: Inner Knob (MENU) — Activate the menu for the highlighted leg. DCK: Button (MENU) — Activate the menu for the highlighted leg.

14.8.2.2 ACTIVE LEG

The Active Leg indicates the leg / waypoint which is currently being navigated TO by the FMS. The Active Leg is highlighted with a magenta border and a magenta arrow (on right) extending from the preceding leg.

Figure 14-70. Active Flight Plan Leg

SEQUENCING

As the aircraft progresses along a flight plan and waypoints are passed, the active leg is "sequenced" to the next leg. Sequencing usually occurs over or abeam the terminating fix. When the active leg is sequenced, the:

- Active Waypoint,
- Desired Track (DTK), and
- Estimated Time Enroute

will immediately change to reflect the next leg. If the sequencing occurs on the curved turning path of a "fly-by" waypoint, the legs will sequence at the turn bisector (mid-point). This will be indicated where the active (magenta) leg meets the next (white) leg on the flight plan.

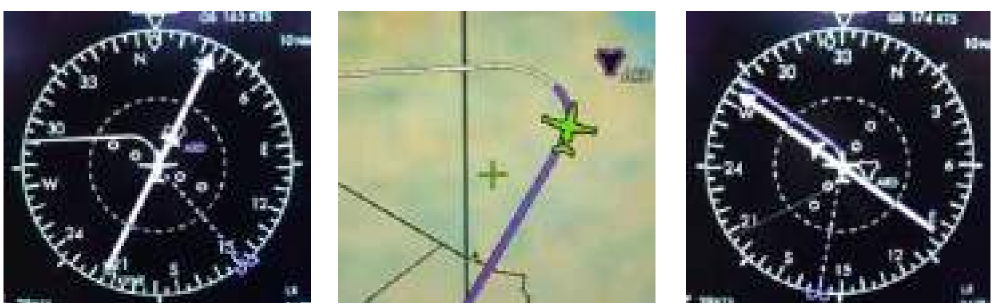


Figure 14-71. Waypoint Sequencing through a Turn

When certain conditions are encountered, automatic waypoint sequencing will be suspended. When this occurs the active leg will not be changed regardless of aircraft position. The conditions which will cause this to happen include:

- OBS Mode is selected
- aircraft enters a HOLD
- aircraft encounters a route discontinuity
- aircraft passes the last waypoint in the flight plan
- aircraft sequences the MAP on an approach,
  and the Missed Approach has not been activated

When automatic sequencing is suspended, **SUSPEND** will be annunciated on the FMS: ACTV page and on the PFD in Left-LSK1: CDI.

DISCONTINUES

A discontinuity is a gap in the flight plan path where the FMS is unable to determine the appropriate path between waypoints. Discontinuities will be caused by any procedures that are dependent on aircraft performance or by pilot actions based on present position. A discontinuity represents a leg in the flight plan not connected to another waypoint.

Any of the following conditions will cause a discontinuity to be created:

- Performing a Direct-To function (discontinuity is behind the current flight path)
- Executing a Vectors-to-Final approach
- Procedure containing a manually terminated leg (vector leg)
- Procedure that containing an altitude terminated leg
- Selecting a published departure from the origin
- Unreasonable flight path geometry (turning path requiring a steep bank angle)

A discontinuity will be indicated with "DISCONTINUITY" annunciated within the Leg Attribute Box on the ACTV page.

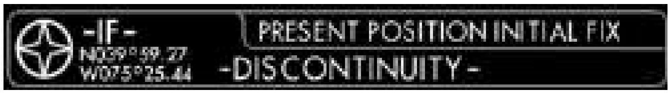


Figure 14-72. Path Discontinuity

Manually terminated legs will be indicated by "FLY XXX° - EXPECT VECTORS" within the Leg Attribute Box on the ACTV page, where XXX is the defined heading. When the aircraft reaches this discontinuity, the FMS will activate VECTORS mode, and the heading bug will automatically synchronize to the defined heading if the autopilot is in NAV mode coupled to the FMS. FMS lateral Flight Mode Annunciator will transition to FMS-VEC.

Figure 14-73. Manual Terminated Leg

When the aircraft reaches a discontinuity in the flight path, navigation and automatic waypoint sequencing will be suspended. The FMS will maintain the previous leg's track until commanded otherwise.

It is left to the pilot to "bridge the gap" and navigate the aircraft through a discontinuity. Performing a Direct-To or intercepting any of the legs following a discontinuity will resume navigation along the flight path.

CREATING A FLIGHT PLAN IN THE ACTV TAB

There are three ways to create a new flight plan from the ACTV tab.

1. If no flight plan has been created or activated, the ACTV tab will automatically display the Origin Attribute Box to allow a new flight plan to be created. Functionally the same process detailed above, except the flight plan is not named or saved, and does not require activation.
2. If an active flight plan exists, editing the ORIGIN and selecting a different ICAO identifier will cause the existing flight plan to be replaced.
3. Selecting Direct-To any of the airports listed on the NREST tab, or selecting Direct-To the Origin, will replace the existing flight plan. The new flight plan consists of a START present position fix and the new Destination airport. If on the ground at the desired Direct-To NREST airport, a flight plan will be created with an ORIGIN and DESTINATION of the same airport.

EDITING A FLIGHT PLAN

EDIT the Origin

If a flight plan already exists, scroll to highlight the ORIGIN leg, and select "EDIT" from the Leg Menu. The Origin Attribute Box will be displayed with the current origin's identifier selected. Pressing the DCK: Button, activates the ICAO text field, allowing a different origin's identifier to be selected. Changing the ORIGIN will cause the existing flight plan to be replaced. The RWY and SID fields are also editable at this time.

Figure 14-74. Origin Attribute Box

Adding/Editing a Runway or Departure Procedure

A departure procedure may be selected when the ORIGIN is being selected or later by selecting PROC from the ORIGIN Leg Menu. Scroll to highlight the ORIGIN leg, and select PROC from the Leg Menu. The selected field will be RWY. Set the RWY as desired, and then set the SID, and transition.

Figure 14-75. Origin Departure Menu

Dual Concentric Knob – Drop-Down Menu
DCK: Outer Knob (No Function) DCK: Inner Knob (SCRL) — Scroll through the menu. DCK: Button (SEL) — Select the highlighted menu.

NOTES:

- The difference between selecting EDIT or PROC from the ORIGIN/DESTINATION Leg Menu is the field (ICAO or RWY) that is activated as default. All fields are editable through EDIT or PROC.
- If a SID is selected without selecting a departure runway, the departure procedures included in the flight plan may be incomplete — omitting any procedures specific to departures from the runway in use. It is recommended to select the departure runway as soon as it is known.
- "DELETE ALL" is not an option for departure procedure brackets. To delete a departure procedure bracket, select PROC from the ORIGIN Leg Menu, replace the named procedure with - - - - - - - (dashes).

EDIT the Destination

Use The DCK: Outer knob to scroll to the DESTINATION box. Pressing the DCK: Button will activate the Leg Menu. Selecting EDIT will bring up the Destination Attribute Box with the ICAO text field selected and active with the first letter of the ICAO identifier preselected to 'K'. The ICAO text field can be edited as desired. The RWY, STAR, and APPR fields are editable at this time as well.

Figure 14-76. Destination Attribute Box

Adding/Editing an Arrival Procedure

An arrival procedure may be selected when the DESTINATION is being selected or later by editing the DESTINATION procedures. Scroll to highlight the DESTINATION leg, then select PROC from the Leg Menu.

Dual Concentric Knob - Drop-Down Menu
DCK: Outer Knob (No Function) DCK: Inner Knob (SCRL) — Scroll through the menu. DCK: Button (SEL) — Select the highlighted menu option.

NOTES:

- If a STAR is selected without selecting an arrival runway, the arrival procedures included in the flight plan may be incomplete — omitting any procedures specific to the arrivals for the runway in use. It is recommended to select the arrival runway as soon as it is known.
- "DELETE ALL" is not an option for arrival or approach procedure brackets. To delete a procedure bracket, select PROC from the DESTINATION Leg Menu and replace the named procedure with
  - - - - - - - (dashes).

Adding/Editing an Approach Procedure

An approach procedure may be selected when the DESTINATION is being selected or later by editing the DESTINATION procedures. Scroll to highlight the DESTINATION leg, then select PROC from the Leg Menu.

Figure 14-77. Destination Attribute Box

When an APPR is selected, the APPR.IAF menu field will automatically activate to allow the Initial Approach Fix (or Feeder) to be selected. By default, Vectors-To-Final (VTF) is selected in lieu of an IAF. Changing the selected runway will not affect the selected approach.

Figure 14-78. Destination Approach – IAF Menu

Dual Concentric Knob - Drop-Down Menu
DCK: Outer Knob (No Function) DCK: Inner Knob (SCRL) — Scroll through the menu. DCK: Button (SEL) — Select the highlighted menu option.

NOTES:

- "DELETE ALL" is not an option for approach procedure brackets. To delete a procedure bracket, select PROC from the DESTINATION Leg Menu and replace the named procedure with - - - - - - - (dashes).

- Special attention should be paid when selecting an IAF for an approach. If an IAF with the "NoPT" attribute is selected, any procedure turns (or holding pattern) will be excluded from the flight plan.
- Intermediate Fixes (IF) cannot be selected directly from the Destination Approach.IAF Menu unless the fix is also an initial approach fix (IF/IAF). In order to comply with an ATC request of Direct To an intermediate fix: First load and execute the approach with an IAF; then select the specified fix from the flight plan and execute a Direct To that fix.

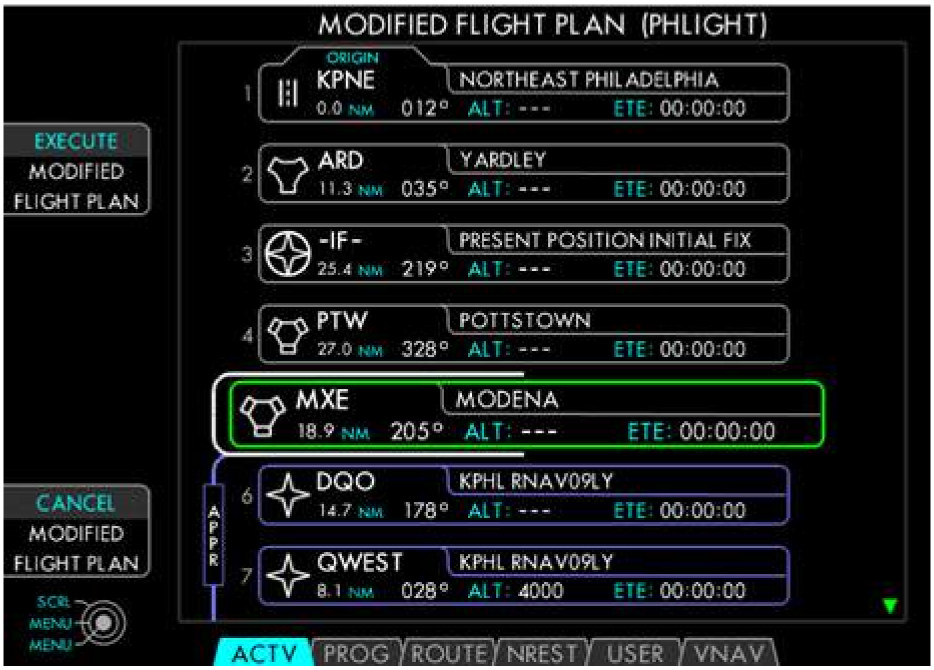


Figure 14-79. Modified Flight Plan

Line Select Keys – Modified Flight Plan

LSK1: (EXECUTE) — Activate the Modified Flight Plan.
LSK2: (No Function)
LSK3: (No Function)
LSK4: (No Function)
LSK5: (CANCEL) — Cancel the Modified Flight Plan.

14.8.2.3 FLIGHT PLAN STATE VIEW MODE

In the ACTV tab, LSK1: FLTPLN STATE is used to control how the Flight Plan legs are displayed. The two states, NAV and HISTORY, determine the visibility of the HISTORY leg group. As the flight plan progresses, waypoints are sequenced as they are passed. When the active waypoint is sequenced, the next leg becomes active, and the sequenced waypoint is added to the HISTORY group.

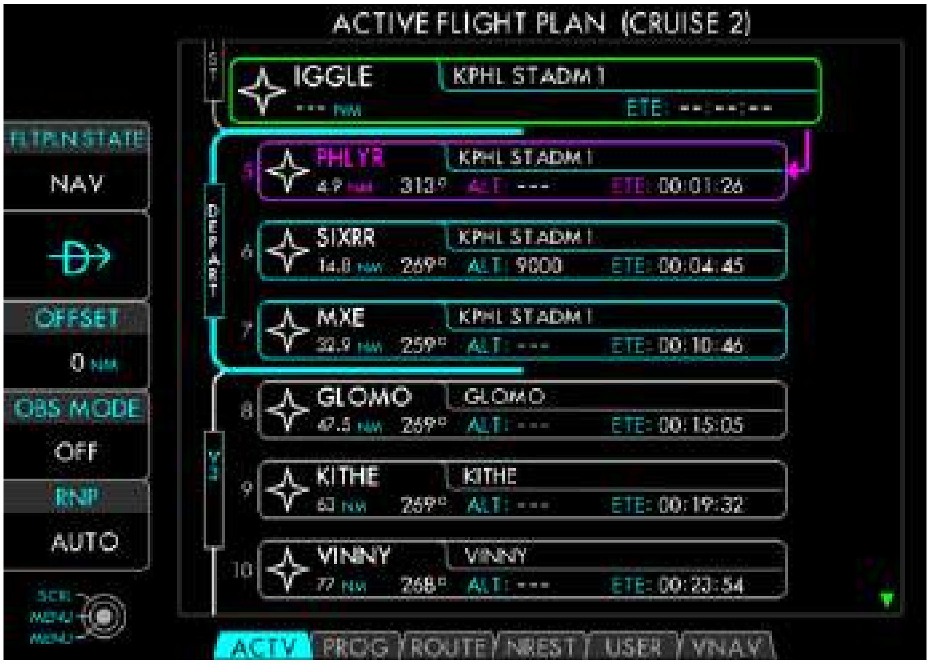


Figure 14-80. Flight Plan NAV View

In NAV State, the previous waypoint is the only member of the HISTORY group displayed in the flight plan leg list. Waypoints previous to this cannot be viewed or interacted with in the NAV State. In order to interact with waypoints in HISTORY, the user must press LSK1: FLTPLN STATE.

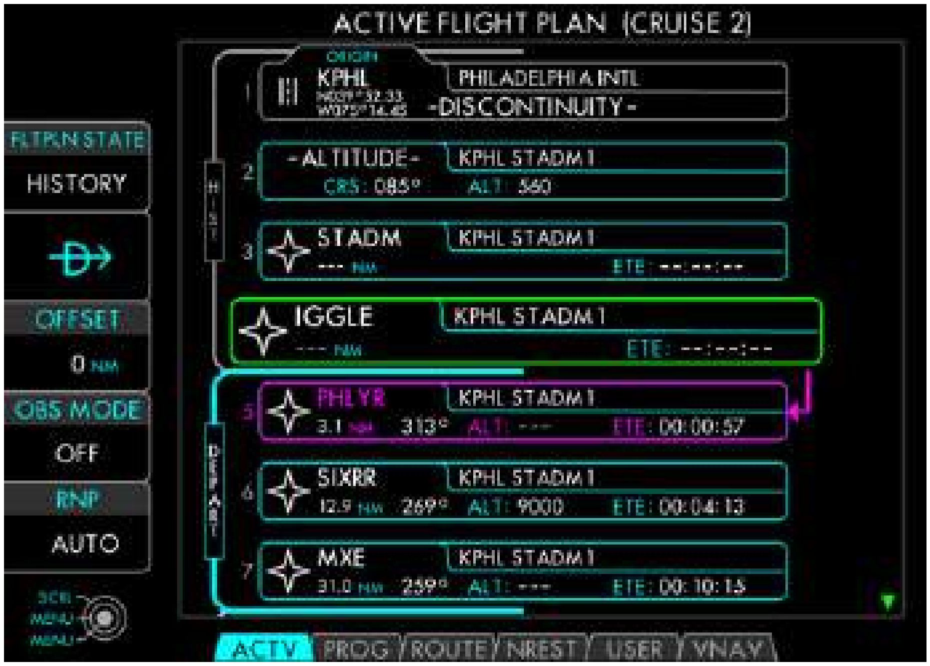


Figure 14-81. Flight Plan HISTORY View

In HISTORY State, the entire HISTORY group is displayed, available for editing or reactivation. The text within LSK1 identifies the current viewing mode. The HISTORY group is displayed in a gray bracket in the flight plan leg list and with a gray line on the moving map.

14.8.2.4 DIRECT-TO

The target of the Direct-To function is to provide a direct course to the selected leg's terminating waypoint from the active flight plan. The Direct-To function modifies the active flight plan by creating a Present Position Initial Fix (IF) waypoint with a discontinuity from the previous legs. A new leg is created from the IF waypoint directly to the selected waypoint.

Pressing LSK2: D→ displays the Direct-To Attribute Box indicating the ICAO identifier and name of the selected waypoint.

Figure 14-82. Direct-To Attribute Box

Pressing LSK1: ACTIVATE-DIRECT TO will insert the new leg from the present position to the selected waypoint into the active flight plan. Pressing LSK5: CANCEL-DIRECT TO returns to the (unchanged) original flight plan.

Line Select Keys – Confirm Direct To
LSK1: (ACTIVATE) — Activate a Direct-To leg from PPOS to the selected waypoint. LSK2: (No Function) LSK3: (No Function) LSK4: (No Function) LSK5: (CANCEL) — Returns to the (unchanged) original flight plan.

NOTE:
The track of the Direct-To leg may be offset from the linear course-to-fix to accommodate any heading change required to turn on course.

Figure 14-83. Direct-To Legs

DIRECT-TO AN ON-ROUTE WAYPOINT

If the selected waypoint exists forward within the active flight plan (not sequenced yet), the previous waypoints will be instantly sequenced into history. If the selected waypoints exist in HISTORY (already sequenced), the flight plan forward of that point will be reactivated. The original leg (connecting the preceding waypoint with the selected waypoint) will be replaced by the Direct-To leg.

DIRECT-TO AN OFF-ROUTE WAYPOINT

In order to execute Direct-To an off-route waypoint, press LSK2: D→ to any waypoint. Edit the ICAO field to the desired fix before executing the Direct-To function. In this case, the new waypoint will be inserted into the active flight plan as the active Direct-To leg.

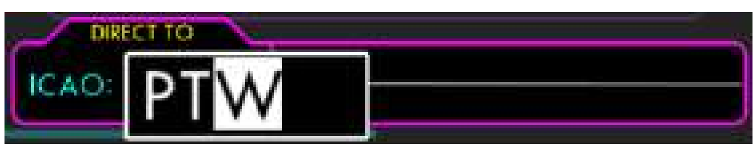


Figure 14-84. Direct-To Off-Route WPT

If the active leg is part of a published procedure, the new waypoint will be inserted after a SID, or before a STAR or IAP.

Figure 14-85. Direct-To in Procedure

DIRECT-TO THE ORIGIN/NREST

Selecting Direct-To the ORIGIN airport or one of the nearest airports from the NREST tab will cause the active flight plan to be replaced with a new, minimal flight plan consisting of a "START" present position fix as the ORIGIN and the (origin) airport as the new destination. This allows the user to quickly change the destination with approach procedures available.

Figure 14-86. Direct-To Attribute Box

Before the Direct-To Origin is activated, a warning will be displayed within the Direct-To Attribute Box stating: FLIGHT PLAN WILL BE RELPLACED.

Figure 14-87. Direct-To Flight Plan

After this minimal flight plan is created, it may be expanded by inserting intermediate waypoints and editing the destination to select approach and/or arrival procedures.

DIRECT-TO THE DESTINATION

Selecting Direct-To the DESTINATION airport will create a new leg from the present position directly to the Destination. Approach procedures will be removed from the active flight plan in the process. The rest of the flight plan will be retained in the History group.

Figure 14-88. Approach Removal

NOTE:
In order to keep the approach in the active flight plan, yet still proceed Direct-To, select the missed approach point of the Approach as the Direct-To Waypoint. Approach will be retained in HISTORY for manipulation.

14.8.2.5 TACTICAL FUNCTION KEY

LSK3 functions as a Tactical Function Key, whose functionality depends on the phase of flight.

Flight Phase		LSK3: Label	Function
ENROUTE	Outside 31NM from ORIGIN/DESTINATION	**OFFSET**	Allows the pilot to select a parallel offset from the path.
TERMINAL	Within 31NM of Destination	**V→**	Allows the pilot to select Vectors to Final.
VECTORS	FMS is in Vectors Mode	**ARM INTERCEPT**	Allows the FMS to lock into a track to intercept and sequence waypoints.
TERMINAL	To Fix is an IAF with a HOLD	**HOLD/PT BYPASS**	Allows the user to bypass a procedure turn.
APPROACH	Inside the FAF	**ACTIVATE MISSED**	Alternate means to activate the missed approach (Primary is the TOGA button).
PT ONLY	Past the IAF before the IF	**HOLD CONTINUE**	Allows the user to remain in the hold in lieu of procedure turn until another user action is made.
HOLD	After selecting hold continue on a PT, prior to passing the fix again.	**CANCEL**	Allows the user to return from HOLDING to a PT ONLY state.
HOLD	Past the Hold waypoint	**ARM EXIT**	Exit the hold after reaching the Holding Fix.

PARALLEL OFFSET

During Enroute operations, LSK3 allows the pilot to select a parallel offset from the original flight path. When the parallel offset function is available, LSK3 will be labeled as OFFSET.

The Offset function allows an offset of up to 20 NM, either right or left of the original course to be set. An offset is initiated from the present position and extends through the flight plan until the Offset is adjusted to 0 NM or until one of the following conditions is encountered:

IAF of an Approach	Route Discontinuity
STAR	Flight Path Turn > 120°
Holding Pattern	Direct-To is activated

The offset path begins with a PARALLEL OFFSET ENTRY (PTK+) fix, and terminates with a PARALLEL OFFSET EXIT (PTK-) fix. These fixes may be omitted due to insufficient distance or a discontinuity. An offset may be manually removed by adjusting the offset distance back to zero, or selecting Direct-To any waypoint.

LSK3 must be pressed first to activate the OFFSET control. The offset distance is controlled by the DCK: Inner Knob; rotate Clockwise to increment the Offset to the Right by 1 NM, and rotate Counter-Clockwise to increment the Offset to the Left by 1 NM. The DCK: Outer Knob will change the direction of the offset. The adjusted offset must be "set" by pressing the DCK: Button, else it will revert to its prior value after 5 seconds.

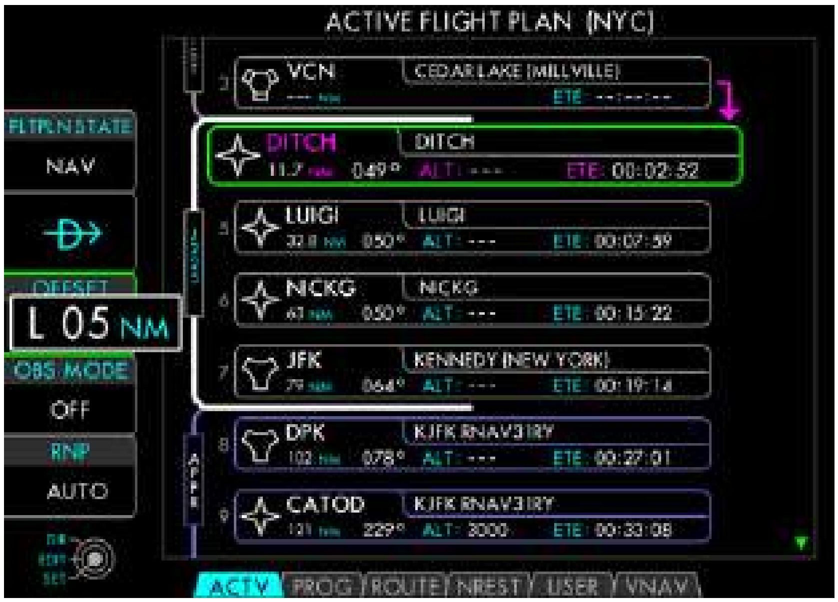


Figure 14-89. Parallel Offset

When an offset is active, the offset path will replace the original path on the map display. The enroute waypoints will remain, but their identifiers will be prefixed with a "p" (to identify them as parallel fixes). The PTK+ and PTK- fixes are also shown in the flight plan and on the map. The FMS will provide navigation guidance along the offset path.

Figure 14-90. Flight Plan with Parallel Offset

When the offset is no longer required, it must be canceled by selecting Direct-To or adjusting the offset amount to 0 NM. LSK3 must be pressed first to activate the OFFSET LSK. Then rotate the DCK: Inner Knob to adjust the offset to 0 NM.

VECTORS-TO-FINAL (VTF)

During TERMINAL or APPROACH operations, LSK3 allows the pilot to select a Vectors-to-Final (VTF) approach procedure. When the VTF function is available, LSK3 will be labeled V→.

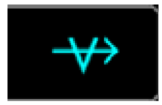


Figure 14-91. LSK3: Vectors-To-Final

When LSK3: V→ is pressed, the Destination Attribute Box is displayed with the VTF approach transition preselected. The same procedure could also be selected by selecting the destination, selecting PROC from the drop down box, selecting an approach procedure, and selecting a VTF transition. Either way, the VTF transition must be accepted by pressing LSK1: CONTINUE.

Figure 14-92. VTF Approach Transition

Figure 14-93. Vectors-To-Final Flight Plan

Alternatively a pilot could elect to INTERCEPT a leg. Loading the full approach and subsequently activating the leg from the Intermediate Fix to the Final Approach Fix allows the remainder of the approach to be stored in HISTORY for quick access. Either activating the leg or selecting Vectors-to-Final allows the pilot to bypass the Initial and Intermediate segments of the selected approach, and instead intercept the extended final approach path.

When VTF is selected, the FMS creates an initial point "IP" waypoint to extend the final approach course 10NM beyond the Final Approach Fix (FAF). This path will provide guidance to intercept and track the final approach course. When INTERCEPT is selected, the leg that is active (magenta) is from the FAF back to the previous fix. Depending on the design of the approach, the active leg could vary in distance. The actual intercept leg will go on infinitely in the inbound direction. If the aircraft path will intercept the course outside of the magenta line, the FMS will still command the turn on course.

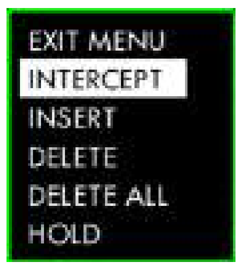


Figure 14-94. Leg Menu – INTERCEPT

When the Vector to final/Intercept leg becomes active, all waypoints prior to the FAF will be sequenced into the HISTORY group. The extended Final Approach leg will be displayed on the map in Magenta.

- **Vectors Mode**

When an intercept/vector leg is active, the FMS will enter VECTORS mode. This mode allows the pilot to steer the aircraft using the heading bug while maintaining the FMS as the active navigation source. In order for the autopilot to follow steering commands from the FMS, the left PFD CDI must be selected to FMS, and the Autopilot placed into NAV mode.

The desired lateral flight mode annunciator is **FMS VEC (active) FMS (armed)**. While the FMS is in VECTORS mode, the flight plan sequencing will be suspended. This will be indicated by the **SUSPEND** text in the ACTV FMS tile. The CDI (in FMS) will indicate VECTORS in the box by LSK1 and have the desired track of the inbound course set. The moving map and the ND tab will display a dashed magenta line to indicate the heading bug direction. The heading bug will be "filled in" magenta. The pilot should fly the aircraft according to ATC clearances so as to set up an appropriate intercept to the desired course.

NOTE:
If VECTORS mode is activated while the autopilot is coupled to the FMS, the heading bug will automatically synchronize to the current heading.

Figure 14-95. Map Depiction of Vectors-To-Final

After the aircraft is established on the desired intercept heading, the intercept should be armed by pressing LSK3: VECTORS-ARM INTERCEPT to allow the FMS to execute the turn to intercept the final leg.

NOTE:
The FMS will remain in VECTORS mode indefinitely — until the intercept is armed, another leg is activated, or a Direct-To another leg is selected. It is the pilot's responsibility to follow ATC instructions until cleared to intercept the active leg.

Figure 14-96. LSK3 – ARM INTERCEPT Button

With the autopilot in NAV mode and LSK3: VECTORS-ARM INTERCEPT pressed, the autopilot is locked on a heading to intercept. If the aircraft was in a turn at the time when LSK3 was pressed, then the aircraft will continue the turn to the previously selected heading. After pressing LSK3, the lateral Flight mode annunciator will change from **FMS VEC (active) FMS (armed)** to **FMS (active)**. Other indications that the FMS is now out of VECTORS mode are:

- PFD LSK1:CDI: VECTORS is not displayed.

- CTV FMS tab: SUSPEND (amber) is not displayed.
- Moving Map: No longer displays a dashed magenta line.
- Heading Bug on the PFD will be "hollow".

NOTES:

- With the Autopilot in NAV (FMS) mode the autopilot is locked into a heading after pressing ARM INTERCEPT. If a new heading is required, select the desired leg terminating waypoint from the ACTV tab and select intercept. The FMS will revert to VECTORS mode. Once the desired intercept heading has been re-selected, the intercept should be armed by pressing LSK3: VECTORS-ARM INTERCEPT.
- The ideal intercept is within 45 degrees of the activated leg, but the FMS will allow an intercept to proceed at any angle up to 135 degrees. However, excessive intercept angles may result in overshooting the course and require subsequent corrections.

The INTERCEPT action is available from the Leg Menu for almost any leg except ORIGIN, DESTINATION, inside the Final Approach Fix, Procedure Turn, or a HOLD. This action allows the user to immediately activate the selected leg, forcing all prior legs to be sequenced into HISTORY. This action will be utilized to bridge the gap in discontinuities, manual terminated legs, or vectors to a route.

Figure 14-97. Map Depiction of Vectors Mode

MISSED APPROACH

When the flight plan includes an approach procedure, the Missed Approach segment will not be incorporated into the active flight path until the Missed Approach has been activated. The Missed Approach cannot be activated until the aircraft is established inside the Final Approach Fix. The Missed Approach segment may be activated by pressing LSK3: ACTIVATE MISSED APPROACH on the ACTV tab, or pressing the Take Off Go Around (TOGA) button on the Left Throttle.

The LSK3: ACTIVATE MISSED APPROACH button will not be presented until the aircraft has sequenced past the FAF. The TOGA button will operate in other functions, but will not activate the missed approach in the FMS if it was pressed prior to passing the FAF.

NOTE:
It is recommended to select the FMS ACTV tab on the MFD, then review the depicted flight path on the MFD or PFD prior to beginning an approach.

Figure 14-98. Missed Approach Legs

Activating the Missed Approach segment allows the Missed Approach leg to become active when the Missed Approach Point (MAP) is sequenced. If the MAP is passed without activating the Missed Approach, the FMS will suspend waypoint sequencing and follow the Final Approach track. If the Missed Approach is activated after the aircraft is past the Missed Approach Point, the FMS will attempt to navigate the missed approach procedure from the current position

NOTE:
In some cases where the missed approach procedure begins with a turn to a fix and the lowest published minimums are less than 400' AGL, the FMS will insert an altitude fix (-ALT-) at the lowest published minimums as the first leg of the missed approach. This ensures that the turn is not initiated early.

- **Missed Approach Symbology**

The Missed Approach segment is displayed in both the active flight plan listing and on the map, regardless of whether it was activated. The Missed Approach legs are displayed in brown. Prior to activation, the Missed Approach legs are displayed partially translucent on the map. After activation these legs become fully opaque.

Figure 14-99. Missed Approach Segment

The PFD provides a expanded MISSED APPR annunciation in the PFD LSK1:CDI:FMS to indicate to the pilot that the missed approach has been activated. The annunciation remains expanded for 2 seconds.

A **MISSED APPR** message remains displayed in LSK1 while sequencing the remainder of the missed approach procedure.

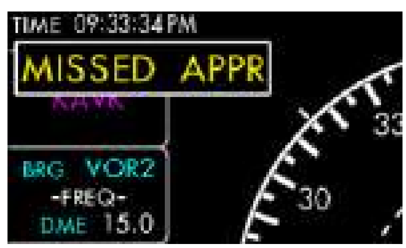


Figure 14-100. PFD MISSED APPR Annunciation

HOLD IN LIEU OF PROCEDURE TURN

When an Initial Approach Fix is selected, which contains a hold in lieu of a procedure turn, the FMS provides for the following options: bypassing a procedure turn, executing only the procedure turn, or continuing to hold and then exiting the hold.

- **Bypassing a Hold in Lieu of Procedure Turn**

  When the active waypoint is an Initial Approach Fix with a HOLD in lieu of a procedure turn, and the track change to the next leg is less than 120 degrees, the FMS ACTV tab provides the ability to bypass the Procedure Turn. The Procedure can be bypassed by pressing LSK3: HOLD/PT: BYPASS on the ACTV tab. Once pressed, the FMS requires a confirmation of the change. Once confirmed, the FMS removes the hold from the flight plan.

- **Holding**

  Holding is the option to continue holding or to exit after the entry leg is made available with LSK3: HOLD button. The functionality of LSK3 depends on the state of the hold. The HOLD leg incorporates a tab to indicate the current state of the hold (in flashing green). The possible hold states are:

  PT ONLY
  The FMS will fly the procedure turn only, and then continue to the next fix.

  HOLDING
  The FMS will hold indefinitely until commanded to exit the hold.

  EXITING
  The FMS will exit the hold after the completion of the racetrack or entry.

- **Procedure Turn (PT) Only**

  When an IAF with a hold is selected, the FMS automatically treats the hold as a Procedure Turn only and will only fly the entry leg into the hold. When the aircraft arrives at the IAF, the HOLD waypoint box will indicate PT ONLY state, and the ACTV tab will NOT display SUSPEND.

Figure 14-101. PT ONLY Leg Data Block

- **Continuing the Holding Pattern**

  While an IAF procedure turn in lieu of procedure turn is being executed, LSK3 will display HOLD: CONTINUE. Pressing this LSK will disable the PT ONLY function, and command the FMS to stay in the hold indefinitely. The waypoint box will indicate HOLDING state. The ACTV tab and PFD LSK1:CDI will display SUSPEND.

Figure 14-102. Exiting a Hold

The function of LSK3 is summarized in the following table:

HOLD STATE	LSK3: HOLD Label	NEXT STATE	Function
PT ONLY (IAF)	CONTINUE	HOLDING	Continue Holding until Commanded to Exit.
HOLDING (IAF)	CANCEL	PT ONLY	Exit immediately after the Procedure Turn.
HOLDING	ARM EXIT	EXITING	Exit the hold after reaching the Holding Fix.
EXITING	CONTINUE	HOLDING	Cancel the exit and continue holding.

■ Entering a Holding Pattern

Holding Pattern entries are calculated based on the planned course to the holding fix. Direct, Parallel, and Teardrop entries are supported. Flight Path Arrows on the moving map, ND tab, or the PFD flight plan indicate the entry type.

NOTE:
If vectoring or other circumstances place the aircraft in a position where the planned entry is no longer appropriate, executing Direct-To the holding fix will force the FMS to re-plan the hold entry.

Figure 14-103. Holding Pattern on Map

■ Inserting a Non-Published HOLD

A non-published hold can be manually entered into the flight plan at any flight plan waypoint except an Origin, Destination, or a Hold. Insert a Hold by selecting the desired Hold Waypoint in the flight plan via the DCK: Outer Knob. Select the leg menu by pressing the DCK: Button. Highlight HOLD with the DCK: Inner Knob and Select using the DCK: Button. The HOLD Attribute box will be displayed. Using the DCK, Set the COURSE (Inbound course NOT Radial), Direction of turn Left or right, UNITS Minutes or NM, and Leg Length.

Figure 14-104. HOLD Attribute Box – Direction

- **Editing a HOLD**

Editing a manually entered HOLD brings up the Hold Attribute Box with the CRS field selected. Editing a procedural hold is not permitted.

Figure 14-105. HOLD Menu — Edit

Modifying any of the available fields (COURSE, TURN, UNITS, or LEG LENGTH) is permitted. Rotate the DCK: Outer Knob to select a field. Press the DCK: Button to activate the menu for the selected field.

The Course may be adjusted between 1-360° by rotating the DCK: Inner Knob. The DCK: Outer Knob changes the value by 10°. While being adjusted, the numeric course will expand. Press the DCK: Button to accept the selected value.

The other fields are implemented as drop-down menus.

When the HOLD attributes have been set, they need to be confirmed by pressing LSK1: CONTINUE. The modifications will be shown in the flight plan leg listing. The modified flight plan may be activated by pressing LSK1: EXECUTE MODIFIED FLIGHT PLAN.

NOTE:
Editing a hold will only redefine the holding pattern. The planned entry will not be affected, and may become inappropriate depending on the changes made. Selecting Direct-To the holding fix will force the FMS to re-plan the hold entry.

OBS MODE

The MFD provides the ability to toggle the FMS between the normal (leg navigation) and Omni Bearing Select (OBS) modes. In OBS mode, the FMS will navigate along a specific bearing relative to the *active* waypoint. OBS Mode is activated and deactivated by pressing LSK4: OBS MODE. LSK4 will indicate the current state of OBS mode (ON or OFF). While OBS mode is selected, **OBS Mode** is annunciated in the active Leg Attribute Box.

Figure 14-106. OBS Mode on ACTV Page

The OBS bearing may be set on either PFD using the Left DCK: Inner Knob. The "OBS" bearing is displayed in place of CRS or DTK to the left of aircraft heading. The FMS will navigate to intercept and track along the selected bearing. After reaching the active waypoint, the aircraft will continue to navigate along the same bearing away from the waypoint.

Figure 14-107. OBS Mode on the PFD

While OBS Mode is active, the FMS will suspend automatic leg sequencing along the flight plan. This will be indicated by a **SUSPEND** annunciation on the MFD as well as the PFD LSK1:CDI. Sequencing will resume immediately once OBS mode is deactivated.

Figure 14-108. OBS Mode on the MFD

In OBS mode, the flight plan legs are removed from the MAP display — replaced with the extended bearing (magenta line) bisecting the active reference waypoint.

Deviation from the Selected Bearing is depicted on the HSI as a split bar CDI. White arrows indicate whether the aircraft is navigating TO or FROM the active waypoint.

Line Select Keys – OBS Mode
LSK1: (FLTPLAN STATE) — No Function waypoint
LSK2: (No Function)
LSK3: (No Function)
LSK4: (OBS MODE) - Deactivate OBS Mode
LSK5: (No Function)

MANUAL RNP MODE

The FMS provides the capability to override the default RNP value by entering a manual RNP value. The RNP value determines the required position accuracy and establishes the sensitivity of the CDI.

There are two RNP modes supported: AUTO and MANUAL. AUTO mode uses the published RNP values where available, or the default values otherwise. MANUAL mode allows the pilot to override the FMS established RNP during any Phase of Flight.

The CDI sensitivity is adjusted to one of the supported scales based on the current RNP value. The CDI scale equates to the cross-track error corresponding to full scale (2 dots) deflection. The supported CDI scales are indicated in the following table.

RNP & ANP Values on PROG Page

Current RNP	Full Scale Deflection
0.1 to 0.99	0.3
1.0 to 1.99	1.0
2.0 to 3.99	2.0
4.0 and greater	4.0

Figure 14-109. Manual RNP Setting

To change the RNP setting, LSK5 must first be activated (highlighted with a green border) by pressing the LSK button. When active, rotating the DCK: Outer Knob changes the RNP mode between AUTO and MANUAL. Rotating the DCK: Inner Knob modifies the manual RNP setting within the range of RNP: 0.1 to 15.0. The RNP setting expands up in size while it is being adjusted. The decimal portion is only adjustable below RNP 2.0. Changes to the manual RNP setting must be accepted by pressing the DCK: Button.

When RNP values have been manually adjusted, the manual RNP values are displayed along with the current ANP value on the FMS Progress Page.

CAUTION:
Caution should be taken when over-riding the default RNP value. In AUTO mode, the FMS changes the required RNP based on the phase of the flight. When a manual RNP is activated, it is the pilot's responsibility to ensure that the RNP selected is appropriate for the operation being conducted.

14.8.3 Progress Page

The Progress Page provides the current flight plan information, FMS dynamic data, and messages which are updated based on current flight conditions.

Figure 14-110. Flight Plan Progress

The following flight plan information is provided on the Progress Page:

- FROM (Previous) Waypoint Data
- ACTV (Active) Waypoint Data
- NEXT Waypoint Data
- MAWPT (Missed Approach Waypoint) Data
- DEST (Destination) Airport Data
- Aircraft Position (Latitude/Longitude)
- Flight Phase: (Enroute, Terminal, or Approach)
- RNP (Required Navigational Performance)
- ANP (Actual Navigation Performance)
- XTRK ERROR (Cross Track error)
- OFFSET (Parallel Offset in nautical miles)
- WIND (Headwind & Crosswind components)
- MAG VAR (Magnetic Variation in degrees)
- FMS MESSAGES

NOTE:
The Progress Waypoint Data consists of the: Identifier, Description, representative Map Symbol, Magnetic Bearing to the waypoint, and line-of-sight Distance to the waypoint.

14.8.3.1 FMS MESSAGES

Messages indicating FMS status are displayed in the FMS Message Window. Messages are displayed as long they are valid. Due to their urgent nature, three FMS failure messages are displayed directly on the PFD as well as on the MFD: PROG tab. These messages are displayed in amber to indicate a significant loss of functionality. The failures (in order of descending priority) are indicated in the following table.

Failure Messages	Description
LOSS OF NAVIGATION	The FMS is unable to determine aircraft position due to one of the following reasons: ■ No data received from the GPS ■ Equipment malfunction ■ A position failure exceeds the time-to-alert limit ■ Receiving an inadequate number of satellites to compute a position solution This will be accompanied by the NAV FAIL annunciation on the PFD.
LOSS OF VNAV	The FMS is unable to determine aircraft altitude. This will be accompanied by the VNAV FAIL annunciation on the PFD.
LOSS OF INTEGRITY – CROSS CHECK NAV	The calculated FMS position uncertainty (HPL) exceeds the allowable limits (HAL). This will be accompanied by the LOI annunciation on the PFD.

FMS CAUTION MESSAGES

Certain FMS caution messages are displayed on the MFD: PROG tab, accompanied by a general MSG annunciation on the PFD. When any of these conditions are detected, they will be displayed within the FMS Message Window on the PROG tab. When the caution message first appears, the MSG annunciation will flash until it has been acknowledged.

Pressing MFD: PROG TAB: LSK5: MESSAGE ACK acknowledges the occurrence of a caution message and stops the MSG annunciation on the PFD from flashing. The MSG annunciation will remain on the PFD until the message is no longer valid. A new Message will make the MSG annunciation blink again, even if the other messages have been acknowledged.

Failure Messages	Description
LOW ALTITUDE	The aircraft altitude is lower than the minimum altitudes specified for this approach.
STEEP TURN AHEAD	The FMS cannot navigate along the planned flight path because of the required bank angle would exceed 30 degrees.
LPV/LP NOT AVAILABLE – USE XXX MINIMUMS	The GPS is unable to achieve the required integrity of the aircraft position for the selected approach, causing the FMS to down-grade the approach (to higher minima)
APPR NOT APPROVED FOR GPS	The government agency has not authorized the overlay of a conventional ground-based approach to be flown with the GPS and/or FMS.

FMS STATUS MESSAGES

Other FMS messages are displayed only on the MFD: PROG tab. These messages are displayed in green to indicate pilot selected actions. When any of these conditions are selected, they will be displayed within the FMS Message Window on the PROG tab. A FMS status message will NOT trigger a MSG annunciation on the PFD.

Status Messages	Description
MANUAL OBS ACTIVE	OBS Mode has been activated.
HOLDING	The aircraft is established in a holding leg. This will be accompanied by the HOLD annunciation on the PFD.
FLIGHT PATH OFFSET ACTIVE	The aircraft is operating on a parallel offset path. This will be accompanied by the OFFSET annunciation within LSK1 on the PFD.
VECTORS TO FINAL	A VTF approach has been initiated. This will be accompanied by a VTF annunciation on the PFD.
VECTORS MODE ACTIVE	Vectors Mode has been activated. This will be accompanied by the VECTORS annunciation within LSK1 on the PFD.

14.8.4 NREST Tab

The Nearest Page displays a dynamic list of information for the twenty closest ARPTS, NAVAID, NDB, FIX, or ARTCC based on the current aircraft position. The items are listed sequentially, with the nearest at the top of the list.

Dual Concentric Knob – Nearest Page

DCK: Outer Knob (SCRL) — Scroll through the list of nearest items

DCK: Inner Knob (Standby Select) — Select standby auto-tuning channel COM1/COM2, NAV1/NAV2

DCK: Button (No Function)

Line Select Keys – Nearest Page
LSK1: (NEAREST) — Select type of nearest item.
LSK2: (Direct-To) — Fly directly to the selected nearest airport.
LSK3: (STANDBY) — Frequency Auto-tuning.
LSK4: (No Function)
LSK5: (RUNWAY) — Filter airports by runway length.

14.8.4.1 NEAREST AIRPORTS

The following information is provided for each airport within the list:

- Symbol
- ICAO Identifier
- Distance to the Airport
- Arrow indicating Relative Direction to the Airport
- Airport Name
- Common Traffic Advisory (CTAF) / Tower Frequency
- Longest available runway Length (feet)

Figure 14-111. Nearest Airport page

DIRECT-TO NEAREST AIRPORT

Activating the Direct-To function on the Nearest Airport Page replaces the current flight plan with a new (minimal) flight plan consisting of the PPOS (ORIGIN) direct to the selected airport. This differs from the Direct-To functionality on the ACTV tab which inserts the waypoint into the existing flight plan. This feature makes the selected airport the destination of the flight plan to allow any available approach procedures to be selected.

Direct-To Nearest Airport

Figure 14-112. Active Flight Plan

RUNWAY LENGTH FILTER

LSK5 offers the ability to filter the nearest airports by runway length. Pressing LSK5 will limit the airports displayed on the nearest tab to those with runways that are longer than the filter runway length. The selectable filters are 2500ft, 3000ft, 3500ft, 4000ft, 4500ft, and 5000ft.

The **Nearest Navaid** display below shows the following data:

- Symbol
- Identifier
- Distance
- Arrow indicating Relative Direction to the NAVAID
- Name
- Frequency

Figure 14-113. Nearest Navaid

The **Nearest NDB** display below shows the following data:

- Symbol
- Identifier
- Distance
- Arrow indicating Relative Direction to the NDB
- Name
- Frequency

Figure 14-114. Nearest NDB

The **Nearest Fix** display below shows the following data:

- Symbol
- Identifier
- Distance
- Arrow indicating Relative Direction to the FIX
- Name

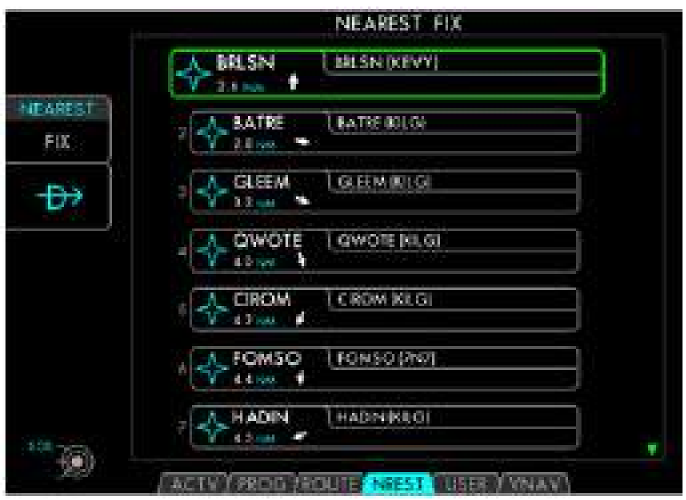


Figure 14-115. Nearest Fix

The **Nearest ARTCC** display below shows the following data:

- Transmit (TX), Receive (RX), or both (TX/RX)
- Distance
- Arrow indicating Relative Direction to the station/center
- Name

- Frequency

Figure 14-116. Nearest ARTCC

STANDBY FREQUENCY AUTO-TUNING

Standby frequency auto-tuning is an easy way to tune the COM to the frequency of nearby airports. When the desired airport is highlighted, pressing LSK3 auto-tunes the standby frequency to the desired channel. To change the primary COM frequency to the standby frequency, press LSK3 on the PFD. Use the DCK: Inner knob to select COM1/COM2 or NAV1/NAV2.

Figure 14-117. Standby Frequency Auto-Tuning

14.8.5 User Tab

The User Waypoint Page provides the ability to create and delete user-defined waypoints. User waypoints are treated the same as waypoints from the Nav Database, and may be used in the flight plan. A maximum of 20 user waypoints can be stored. The User Waypoint Page displays all user waypoints in a scrollable list. The user waypoints are ordered alphabetically by identifier.

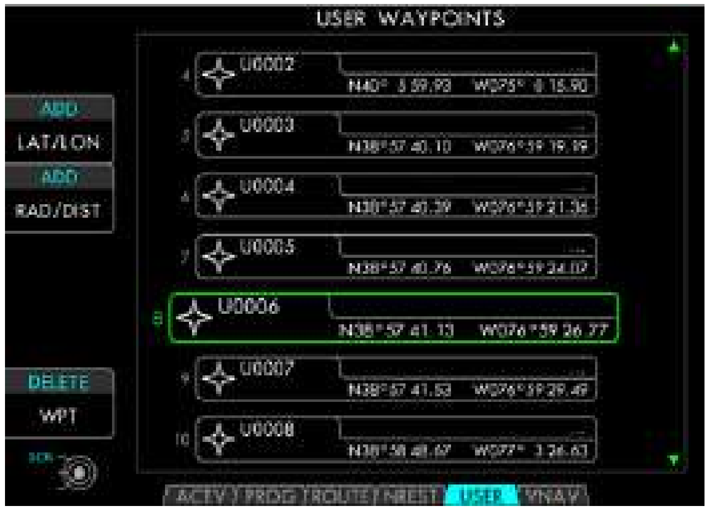


Figure 14-118. User Waypoint Page

14.8.5.1 CREATING A USER WAYPOINT

User waypoints can be created either by specifying the Lat/Lon coordinates (LSK1: ADD-LAT/LON), or by specifying a relative position from another waypoint (LSK2: ADD-RAD/DIST). When creating a waypoint by Lat/Lon, the coordinates will be preset to the aircraft's present position. In the latter case, the location is specified as a distance and bearing from a reference waypoint, but the location is stored simply as Lat/Lon coordinates.

A new user waypoint cannot be created if twenty user waypoints already exist. At least one entry must be deleted first, before a new waypoint may be created.

Line Select Keys – User Waypoints Page
LSK1: (ADD-LAT/LON) — Create a waypoint at a specific Latitude /Longitude.
LSK2: (ADD-RAD/DIST) — Create a waypoint relative to another waypoint.
LSK3: (No Function)
LSK4: (No Function)
LSK5: (DELETE WPT) — Delete the selected user waypoint.

Figure 14-119. User Waypoint Attribute Box

When a waypoint is created, the User Waypoint Attribute Box is displayed with the location field selected. The User Waypoint Attribute Box contains the following text fields:

- Identifier (5 characters) Automatically designated by the FMS. U0001- U0020
- Descriptor (32 characters)
- Location: (Latitude/Longitude or Waypoint/Radial/Distance)

The text fields may be completed with the Dual Concentric Knob (DCK) or the alphanumeric keys of the Keyboard. Use the DCK: Outer Knob to select the field, and the DCK: Button to activate the selected field.

Dual Concentric Knob – Attribute Box

DCK: Outer Knob (SCRL) — Scroll to highlight the desired attribute field.
DCK: Inner Knob (MENU) — Activate the highlighted attribute field.
DCK: Button (MENU) — Activate the highlighted attribute field.

A unique identifier is automatically assigned (U000#), but may be changed to any alphanumeric name up to 5 characters long. Duplicate user waypoint identifiers are not permitted.

Dual Concentric Knob – Text Field

DCK: Outer Knob (POS) — Move the highlighted cursor left or right.
DCK: Inner Knob (A-9) — Select the character at the cursor position.
DCK: Button (ADD) — Activates the selected alphanumeric Identifier.

Keyboard – Editing a Text Field

Alpha-Numeric Keys — Enter character and advance cursor.
SP Key — Enter a “space” and advance the cursor.
CLR Key —Delete the character at the cursor position and back-up the cursor.
ENTER Key — Activates the selected text entry.

14.8.5.2 DELETING A USER WAYPOINT

The selected waypoint is highlighted with a green border. To select a specific waypoint, scroll through the list by rotating the DCK: Outer Knob. The selected waypoint can be deleted by pressing LSK5: DELETE WPT. The deletion must be confirmed by pressing LSK1: CONFIRM before the waypoint is removed.

Dual Concentric Knob – User Page

DCK: Outer Knob (SCRL) — Scroll through the list of user waypoints.
DCK: Inner Knob (No Function)
DCK: Button (No Function)

14.8.6 VNAV Tab

The VNAV Page provides the ability to plan enroute descents to any waypoint along the ACTV flight plan. The vertical profile is defined by selecting the TARGETs for three variables.

- POSITION — Drop down list of ACTV Flight plan waypoints and distance before (-99NM) or after (+99NM).
- ALTITUDE — Target Altitude in feet to cross POSITION
- V/S REF (reference) — Desired feet per minute descent for VNAV calculations.

The FMS uses these values to determine where to indicate the T/D (Top of Descent), E/D (End of Descent which is at the POSITION coordinates), and the dynamic REQUIRED V/S (required descent in feet per minute) to arrive at the position at the target altitude.

After the TARGET fields are entered, press LSK2: VNAV STATE: EDIT. This action changes the state from EDIT to ACTIVE. The FMS will calculate the Time and Distance to get to the T/D (dynamic position), E/D points (static position), and Required V/S (dynamic vertical speed).

Figure 14-120. VNAV STATE: EDIT

14.8.6.1 REQUIRED V/S (DYNAMIC VERTICAL SPEED)

When the FMS cannot compute a VNAV profile, a CANNOT CREATE VERTICAL PATH, followed by an appropriate error indication, is displayed:

- TOD – The Active Flight plan does not have enough distance prior to the selected EOD to create a top of decent point.
- DISCON – A discontinuity exists between the EOD and calculated TOD points.
- HOLD – A hold exists between the EOD and calculated TOD.
- CLIMB – A climb is selected by the pilot.

NOTES:

- When the ACTV flight plan sequencing is in SUSPEND, the MFD will inhibit activation by graying out LSK2.
- When flying Off FMS Flight Path, i.e., when the ATC vectors VNAV tab is not accurate, use the Range to Altitude Arc in conjunction with the pre-selected ACP altitude (a MAP display).
- If the POSITION has a published Altitude Constraint, the ALTITUDE field will automatically populate with the published altitude.

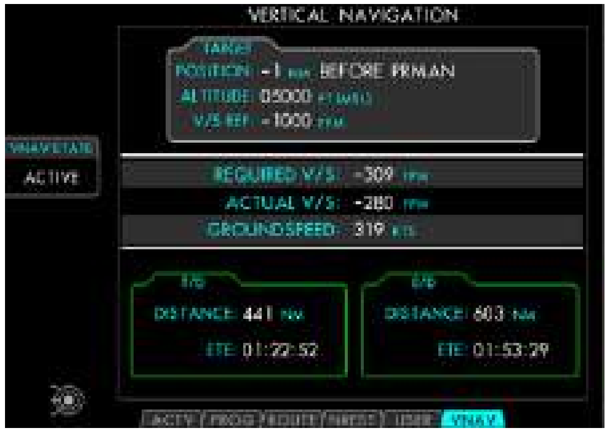


Figure 14-121. VNAV Page

Dual Concentric Knob – VNAV Page
DCK: Outer Knob (SCRL) — Scroll to highlight the desired field. DCK: Inner Knob (MENU) — Modify the value of the highlighted field. DCK: Button (MENU) — Activate the highlighted field.

VNAV Position Field

Dual Concentric Knob – Variable Distance Field
DCK: Outer Knob (x10) — Increment or Decrement the distance value by 10. DCK: Inner Knob (ADJ) — Increment (CW) or Decrement (CCW) distance value. DCK: Button (SET) — Set the distance to the highlighted value.

14.8.6.2 VNAV MAP SYMBOLOGY

When VNAV is active, symbology will be displayed on the map and ND to depict the Top-of-Descent and End-of-Descent points. After the descent is established, the Dynamic Bottom-of-Descent point will also be displayed to depict the predicted point where the target altitude will be reached, based on the current performance.

 Top-of-Descent (green)

 End-of-Descent (green)

 Dynamic Bottom-of-Descent (green)

The VNAV symbology will be removed from the map if any of the following occur:

- VNAV is deactivated (VNAV STATE: EDIT is selected).
- Waypoint sequencing becomes suspended.
- A discontinuity is encountered.
- A HOLD exists within the VNAV profile.

- Vectors mode is activated.
- OBS Mode is activated.

14.9 MAP Function Group

14.9.1 Common Features

The MAP group functionality (ND, MAP, or CHART) is normally displayed in either the lower left or lower right MFD tile, allowing the simultaneous display of map and chart pages. These tiles have a limited amount of space for the depiction of maps and charts. To help alleviate this display space limitation, the MAP and CHART tabs support a (single) merged tile with twice as much display area.

When the MFD MAP Primary Function Key is pressed, the ND, MAP, or CHART page is displayed in the left tile (Tile 7), forcing the contents of the left tile to shift to the right (Tile 8). If the MAP button is pressed twice sequentially, a MAP (ND, MAP, or CHART) page will be displayed in both the left and right tiles simultaneously. The left and right Tabs can still be selected independently.

Figure 14-122. MFD — Separate MAP Tiles

When both the left and right tiles have the MAP or CHART Tabs selected, the tiles merge into one large tile. In the merged tile, the MAP or CHART image will automatically be expanded to take advantage of the larger window size. In this mode, the associated LSKs are duplicated on the right and left sides of the bezel. All of the same functionality is available in the larger format.

Figure 14-123. MFD — Merged MAP Tiles

14.9.1.1 AIRCRAFT POSITION

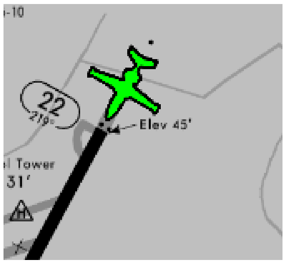
The aircraft's present position is depicted on the chart and map images as a green aircraft icon on all geo-referenced charts.

NOTE:
Only Chart or Chart Sections drawn to scale can be geo-referenced.

AIRCRAFT ICON ON CHART

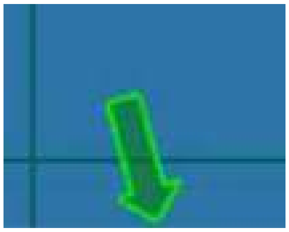
The aircraft symbol is slightly enlarged during chart zooming operations.

When the aircraft position is beyond the visible chart borders, an arrow is displayed, pointing toward the out-of-view aircraft position.



AIRCRAFT OUT-OF-VIEW

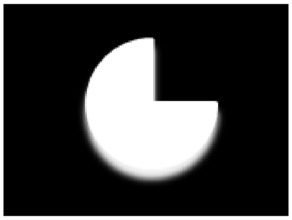
When the aircraft position is not available, the aircraft icon is depicted in the upper right corner of the tile as a circle with a slash through it. This can occur when the GPS position or aircraft heading data is lost.



AIRCRAFT POSITION NOT AVAILABLE

EFB BUSY SYMBOL

Processing requests by the pilot may take the system several seconds. A rotating clock icon is displayed above the LSKs whenever the system is processing requested data from the EFB.



14.9.2 CHART Tab

There are four levels within the E-CHARTS menu. Each menu level narrows the selection process from desired airport to the desired chart. The normal selection progression is:

E-CHARTS (STATUS) ⇨ AIRPORT MENU ⇨ CHART MENU ⇨ VIEW CHART

It is not always required or desirable to navigate through every menu level to select the desired chart. Additional menu pages are provided to access airport information and weather.

14.9.2.1 E-CHARTS STATUS PAGE

The E-CHARTS Status Page is the default page within the CHART tab. This is the initial page displayed when the CHART tab is first selected. Subsequent selection of the CHART tab returns to the last viewed page.

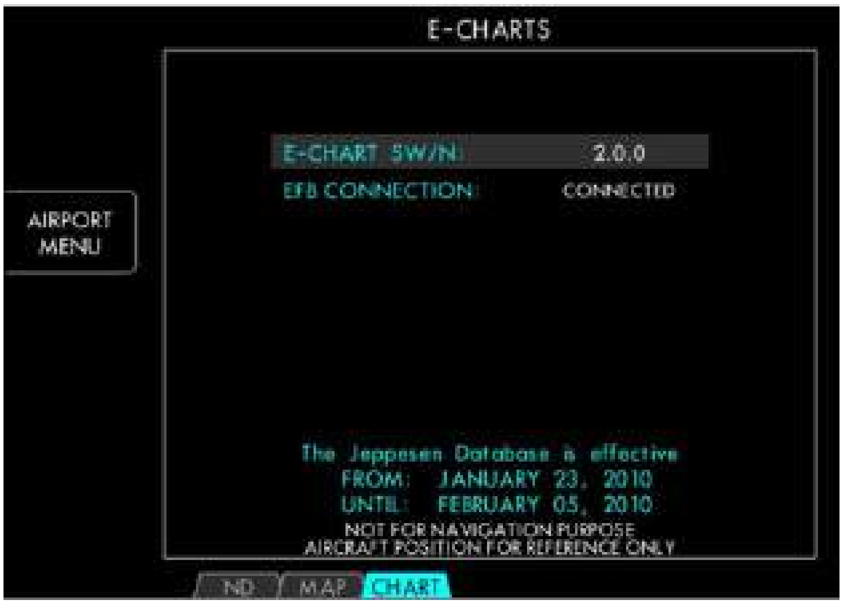


Figure 14-124. E-CHARTS Status Page

The E-Charts Status Page displays the following data related to the E-Charts:

- Jeppesen Software Version
- EFB Connection Status
- Effectivity date of the Jeppesen E-Chart database
  (The Nav Database is on an independent cycle.)

NOTE:
It is the pilot's responsibility to determine the validity of the chart database, which is depicted on the MFD startup page and the SETUP System Synoptic.

LINE SELECT KEYS

- LSK1: No Function
- LSK2: AIRPORT MENU Pressing LSK2 advances to the AIRPORT MENU page.
- LSK3: No Function

- LSK4: No Function
- LSK5: No Function

14.9.2.2 AIRPORT MENU PAGE

The Airport Menu Page allows the user to select the airport of interest and view the available charts. The airports may be selected by an ICAO identifier or selected from a list. The airport list is organized into 3 separate groups:

(1) on-route airports
(2) off-route airports
(3) airport history

The on-route airport list is automatically generated based on the on-route airports within the active flight plan. The off-route airport list is automatically populated with ten airports in close proximity to the current aircraft position. These airport ICAOs are sorted by distance from the current location. The airport history list is automatically generated based on operator history with the 10 most recently entered ICAOs included in the menu. The ICAOs are listed sequentially with the most recently entered ICAO at the top of the list. The Airport List includes the airport identifier, distance, and an arrow representing relative bearing from the aircraft. Any airport in the list may be highlighted and selected using the dual concentric knob.

DUAL CONCENTRIC KNOB

Dual Concentric Knob
DCK: Outer Knob (GROUP) — Scroll through the different groups of lists. (on-route airport list, off-route airport list, and airport history list)
DCK: Inner Knob (SCRL) — Scroll through the airport list a single line at a time.
DCK: Button (SLCT) — Select the highlighted airport from the list.

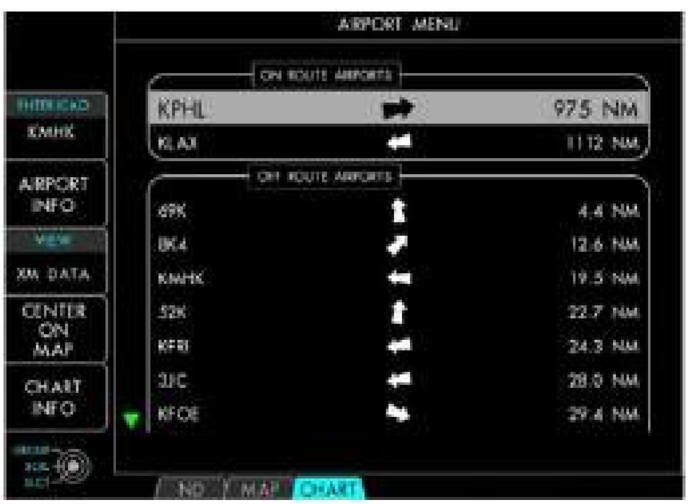


Figure 14-125. Airport Menu Page

Line Select Keys

LSK1: (ENTER ICAO) — Activates the Enter ICAO dialog.
LSK2: (AIRPORT INFO) — Advances to the AIRPORT INFO page for the selected airport.
LSK3: (VIEW:XM DATA) — Advances to the XM DATA page for the selected airport.
LSK4: (CENTER ON MAP) — Pressing LSK4 selects the map tab centered on the selected airport.
LSK5: (CHART INFO) — Pressing LSK5 brings up the E-CHART Info page.

14.9.2.3 AIRPORT INFO PAGE

The Airport Info Page lists airport features and services available at the selected airport:

Airport Name and Location	Latitude and Longitude	Elevation	Runway Length
Airport Lighting	Fuel, Oxygen, and Repair Services	Customs	Local Time Zone

Figure 14-126. Airport Info Page

Dual Concentric Knob
DCK: Outer Knob (GROUP) — Scroll through the different groups of lists. (on-route airport list, off-route airport list, and airport history list)
DCK: Inner Knob (SCRL) — Scroll through the airport list a single line at a time.
DCK: Button (SLCT) — Select the highlighted airport from the list.

Line Select Keys
LSK1: (ENTER ICAO) — Activates the Enter ICAO dialog.
LSK2: (AIRPORT INFO) — No Function
LSK3: (VIEW:XM DATA) — Advances to the XM DATA page.
LSK4: (CENTER ON MAP) — Pressing LSK4 centers the MAP tab on the selected airport. The MAP tab replaces the AIRPORT INFO page, unless both configurable MFD windows are in map mode; in which case, the opposite window opens to the MAP tab.
LSK5: (RETURN TO CHARTS/AIRPORTS) — Pressing LSK5 returns to the previous page (CHART MENU or AIRPORT MENU)

14.9.2.4 XM DATA PAGE

XM Data Page

The XM Data Page displays textual weather reports for the selected airport. The weather products are selected via the assigned LSKs. The textual weather reports, if available for the selected airport, include Meteorological Aviation Report (METAR), Terminal Aerodrome Forecast (TAF), and CITY FORCAST.

Dual Concentric Knob
DCK: Outer Knob (SCRx5) c Sc—roll through the weather data 5 lines at a time.
DCK: Inner Knob (SCRL) — Scroll through the weather data.
DCK: Button (BACK) — Returns to the previous page (LSK5).

Line Select Keys
LSK1: (No Function)
LSK2: (VIEW) — METAR
LSK3: (VIEW) — TAF
LSK4: (VIEW) — CITY FORECAST
LSK5: (RETURN TO CHARTS/AIRPORTS)

METAR report contains data for the temperature, dew point, wind speed and direction, precipitation, cloud cover and heights, visibility, and barometric pressure. METARs are displayed in both plain English and unformatted.

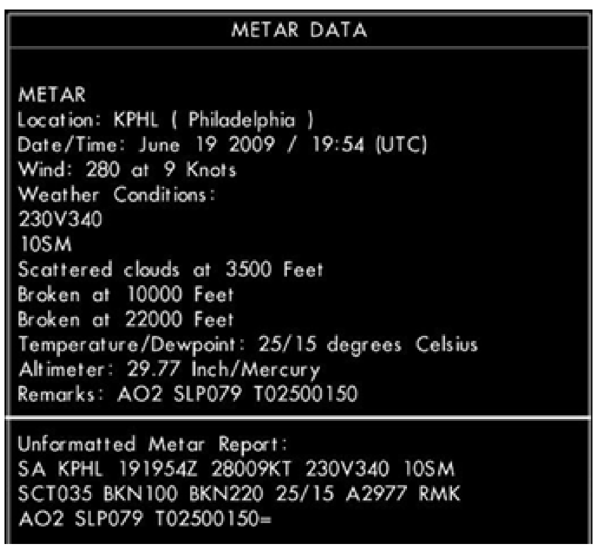
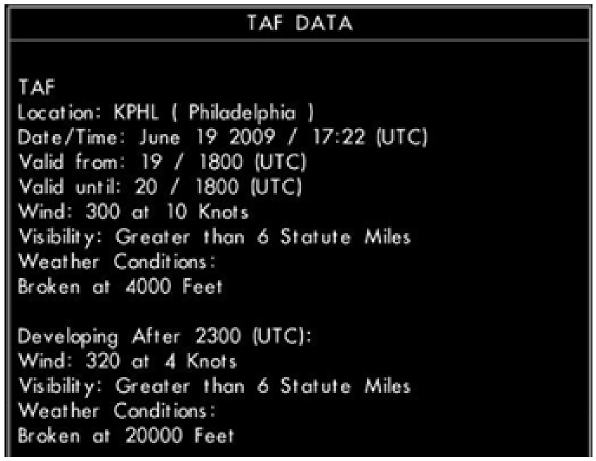


Figure 14-127. XM Data — METAR

Terminal Aerodrome Forecasts apply to a five statute mile radius from the center of the airport. TAFs complement the METAR report and use encoding similar to the METAR report. The TAF reports are generated by human forecasters. TAFs are displayed in both plain English and unformatted.

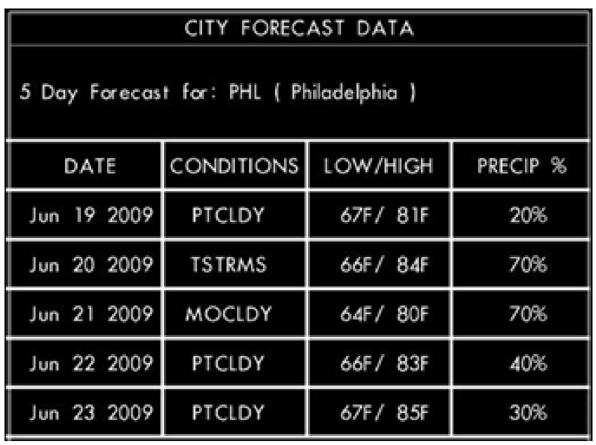

TAF DATA

TAF
Location: KPHL (Philadelphia)
Date/Time: June 19 2009 / 17:22 (UTC)
Valid from: 19 / 1800 (UTC)
Valid until: 20 / 1800 (UTC)
Wind: 300 at 10 Knots
Visibility: Greater than 6 Statute Miles
Weather Conditions:
Broken at 4000 Feet

Developing After 2300 (UTC):
Wind: 320 at 4 Knots
Visibility: Greater than 6 Statute Miles
Weather Conditions:
Broken at 20000 Feet

Figure 14-128. XM Data — TAF

CITY FORECASTs are displayed as a table with one-row-per-day, providing a five day forecast. The forecast consists of general weather conditions, the forecast low and high temperatures, and probability of precipitation in percent for each individual day.


CITY FORECAST DATA

5 Day Forecast for: PHL (Philadelphia)

DATE	CONDITIONS	LOW/HIGH	PRECIP %
Jun 19 2009	PTCLDY	67F/ 81F	20%
Jun 20 2009	TSTRMS	66F/ 84F	70%
Jun 21 2009	MOCLDY	64F/ 80F	70%
Jun 22 2009	PTCLDY	66F/ 83F	40%
Jun 23 2009	PTCLDY	67F/ 85F	30%

Figure 14-129. XM Data — City Forecast

14.9.2.5 CHARTS MENU PAGE

The Charts Menu Page displays the list of available Jeppesen charts for the selected airport. Each chart is listed on a separate line to indicate the Chart Index Number and the Chart Name.

Charts are grouped by type: AIRPORT, AIRSPACE, APPROACH, ARRIVAL, DEPARTURE, NOISE, and TEXT. The chart list is organized sequentially by the chart index number. The first available chart is highlighted by default. The highlighted chart may be selected using the dual concentric knob.

Dual Concentric Knob
DCK: Outer Knob (GROUP) — Scroll through the chart groups.
DCK: Inner Knob (SCRL) — Scroll through the chart list.
DCK: Button (SLCT) — Select the highlighted chart from the list.

Figure 14-130. Charts Menu Page

Line Select Keys
LSK1: (DISPLAY/Chart Type) — Allows the chart list to be filtered to one type of chart. The Chart Type filters are: ALL, AIRPORT, AIRSPACE, APPROACH, ARRIVAL, DEPARTURE, NOISE, and TEXT. The Chart Type filter may be selected by rotating the DCK: Outer Knob.
LSK2: (AIRPORT INFO) — Advances to the AIRPORT INFO page.
LSK3: (VIEW: XM DATA) — Advances to the XM DATA page.
LSK4: (CENTER ON MAP) — Selects the MAP tab centered on the selected airport. The MAP page replaces the CHART MENU page, unless both configurable MFD windows are in MAP; in which case, the opposite window opens to the MAP tab.
LSK5: (RETURN TO AIRPORTS) — Returns to the AIRPORT MENU.

14.9.2.6 CHART VIEW PAGES

The Chart View Pages display the selected Jeppesen chart. The chart is automatically rotated for Landscape or Portrait orientation. The chart view provides three different zoom levels, panning (up/down and left/right), present position overlay, and specific section views. The Airport (ICAO) Identifier and the Chart Name are always depicted in the chart information block located adjacent to the CHART tab.

DEFAULT CHART VIEW

In the default chart view, the chart is scaled to maximize the width to fit the visible window. The chart may be scrolled up/down and zoomed via the dual concentric knob.

Dual Concentric Knob

DCK: Outer Knob (PART) — Selects a section of the chart (header, plan view, profile view).

DCK: Inner Knob (U/D) — Scroll the chart Down (Counterclockwise) and Up (Clockwise).

DCK: Button (CTR) — Center the chart on the current aircraft position.

Figure 14-131.   Default Chart View

Line Select Keys

LSK1: (ZOOM ALL) — Zooms in on the visible chart section.

LSK2: (PAGE UP/DOWN/TALL) — Toggles the default chart view between the top and bottom half of the chart. If the selected is a Portrait Chart, holding LSK2 for 1 second enables Tall Charts across tiles 2 and 7.

LSK3: (MODE: DAY/NIGHT) — Toggles the chart view between DAY and NIGHT modes. In night mode, the chart is displayed with inverted coloration to reduce overall luminance.

LSK4: (OVERLAY BRT) — Allows Overlay Brightness to be adjusted. The brightness (intensity) can be adjusted (50%-100%) by rotating the DCK: Inner Knob.

LSK5: (RETURN TO CHART) — Returns to the default chart view.

ZOOMED CHART VIEW

In the zoomed chart view, the chart image (or section) is zoomed up in size within the visible window. The zoomed chart may be scrolled up/down and left/right with the dual concentric knob.

Dual Concentric Knob

DCK: Outer Knob (L/R) — Scroll the chart Left (Counterclockwise) and Right (Clockwise).

DCK: Inner Knob (U/D) — Scroll the chart Down (Counterclockwise) and Up (Clockwise).

DCK: Button (CTR) — Center the chart on the current aircraft position.

Figure 14-132. Zoomed Chart View

Line Select Keys

LSK1: (ZOOM IN) — Zooms in on the visible chart section.

LSK2: (ZOOM OUT) — Zooms out on the visible chart section. Zooming out to the lowest zoom level returns to the default chart view. Once you have returned to the default chart view, holding LSK2 for 1 second enables full portrait size charts (Tall Charts) across tiles 2 and 7.

LSK3: (MODE: DAY/NIGHT) — Toggles the chart view between DAY and NIGHT modes. In night mode, the chart is displayed with inverted coloration to reduce overall luminance.

LSK4: (OVERLAY BRT) — Allows Overlay Brightness to be adjusted. The brightness (intensity) can be adjusted (50%-100%) by rotating the DCK: Inner Knob.

LSK5: (RETURN TO CHART) — Returns to the default chart view.

TALL CHART MODE

Tall Chart Mode allows a chart to be displayed in multiple tiles. While in a chart with portrait orientation, holding LSK2 for 1 second will cause the chart to be displayed over tiles 2 and 7. This provides a larger viewing area requiring less pilot interaction to acquire chart information.

Dual Concentric Knob
DCK: Outer Knob (Scroll) — Scroll sections of chart. Selected sections will be highlighted in blue.
DCK: Inner Knob (No Function)
DCK: Button (center push button) — Zoom in on highlighted section.

Line Select Keys
LSK1: (ZOOM ALL) — Zooms to fit the visible chart section.
LSK2: (VP: SHOW/HIDE) — Show/Hide the Vertical Situation Display (VSD).
LSK3: (MODE: DAY/NIGHT) — Toggles the chart view between DAY and NIGHT modes. In night mode, the chart is displayed with inverted coloration to reduce overall luminance.
LSK4: (OVERLAY BRT) — Allows Overlay Brightness to be adjusted. The brightness (intensity) can be adjusted (50%-100%) by rotating the dual concentric knob: Inner Knob.
LSK5: (RETURN TO CHART) — Returns to the default chart view.

VERTICAL SITUATION DISPLAY

The Vertical Situation Display (VSD) offers a cross sectional view of an approach. The VSD allows the pilot to view their altitude versus the desired altitude based off of the waypoint information.

NOTES:

- The VSD is intended for pilot situational awareness only. The VSD is not to be used for Navigation of the aircraft.
- The selection of VSD is restricted to LPV and LNAV/VNAV Approaches only.
- The Missed Approach pictorial directions will be hidden, with the VSD overlaid. Use missed approach text in the header section. Once a missed approach is activated, the VSD will not be displayed.

The VSD will only be available while on a final approach segment if the displayed geo referenced tall chart matches the FMS selected approach, and the following conditions are met:

- Aircraft is within 10 miles of the Final Approach Fix.
- Aircraft is inside the Initial Approach Fix.
- Course Deviation is less than full scale deflection.

- Missed Approach has not been activated.
- Tall Chart is selected.
- Tall Chart is not zoomed into any section.
- The difference between the current track and the final approach course is less than 120 degrees.

If the above conditions are met, then LSK2 will display a status of VP (Vertical Profile): HIDDEN and be selectable to SHOW. The VSD is overlaid on top of the Vertical Profile of the selected Chart. If any of the above conditions are no longer valid, the VSD will not be displayed or selectable until the conditions are valid once again. Displayed information on the VSD includes:

- Final Approach Fix label, distance from runway, and crossing altitude
- Intermediate Fix label, distance from runway, and crossing altitude
- Runway label and Elevation
- Aircraft relative pitch, GPS altitude, and distance from runway

The Aircraft icon on the VSD will have a coloration of White or Amber. A White depiction occurs if the aircraft is at or above the correct altitude for glide path and/or approach ingress to the Final Approach Fix. The Aircraft is depicted in amber if the GPS altitude drifts 100 feet below glide path and/or 100 feet below ingress altitude. Once the aircraft has been depicted in amber, it will not turn white until at or above the correct GPS altitude.

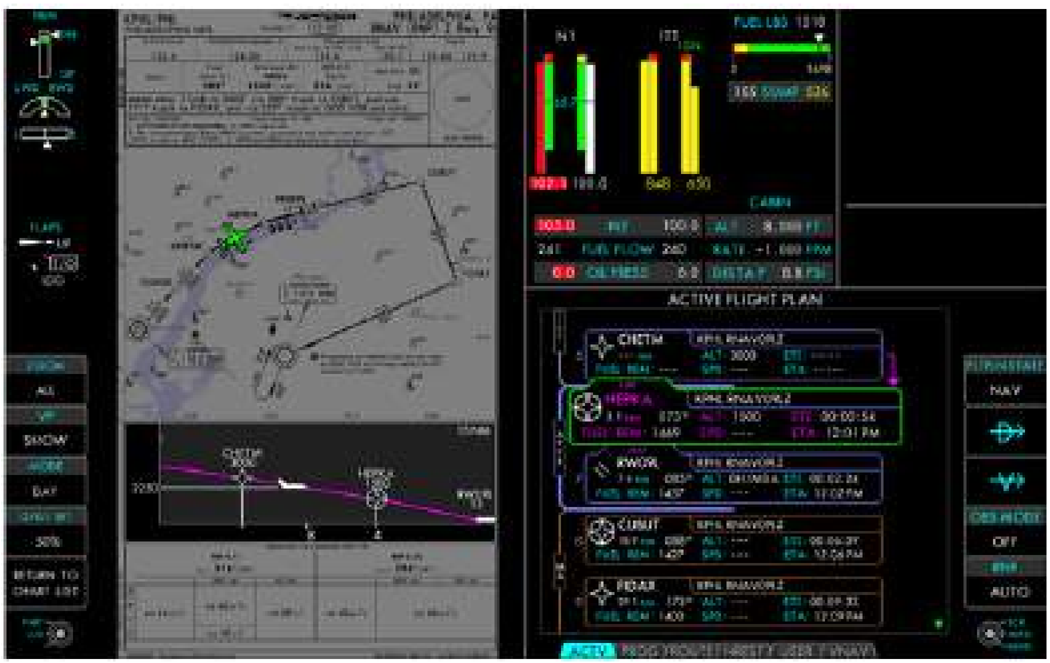


Figure 14-133. Vertical Situation Display

14.9.2.7 MISCELLANEOUS CHART ANNUNCIATIONS

The following warning messages are displayed to indicate internal failure states.

E-Chart Warning Messages

Message	Description
LOST COMMUNICATION WITH EFB	Message is displayed when there is an internal communication problem within the EFB.
AIRPORT NOT IN DATABASE	Message is displayed if the entered airport ICAO is not found in the Jeppesen E-chart database.
DATABASE MEMORY FAILED	Error message is displayed if an internal mass storage device cannot be accessed.
DATABASE INITIALIZATION FAILED	Error message will be displayed if the Jeppesen E-Chart database cannot be initialized.
CHART NOT IN DATABASE	Error displayed if operator requests a chart to be displayed that does not exist in the database.
NO CHARTS AVAILABLE	Error displayed if chart menu is requested for an ICAO with no charts in the database.
DATABASE FAILED TO LOAD CHART	Error displayed if MFD encounters a rendering error when attempting to display a chart.

14.9.3 MAP Tab

The MAP functionality renders a geo-referenced moving map which can overlay Map options and XM Weather data.

14.9.3.1 MAP INFO PAGE

The Map Info Page is the default page within the MAP tab. This is the initial page displayed when the MAP tab is first selected after a power cycle. Subsequent selection of the MAP INFO tab returns to the last viewed page.

Figure 14-134. Map Info Page

Line Select Keys – XM Receiver Identification (Radio ID)
LSK1: (No Function)
LSK2: (MAP)
LSK3: (No Function)
LSK4: (No Function)
LSK5: (No Function)

NOTE:
The XM receiver identification number is required for activation or refreshing of the XM service. The identification number consists of eight characters and numerals; however, the letters I, O, S, and F are never used.

The XM subscription level indicates the applied XM service. The available indications are:

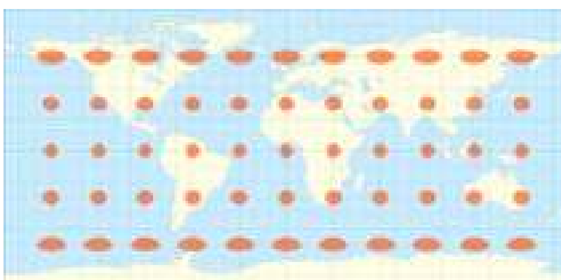
- Activation Required — XM unit has not been activated.
- Hardware Failure — Error indicates that a hardware problem occurred within the XM unit. The manufacturer suggests to power cycle the unit up to three times and, if the error persists, to return the XM module for service.
- Aviator Light/Aviator/Aviator Pro

The XM Satellite Receiver Connection Status indicates the following states:

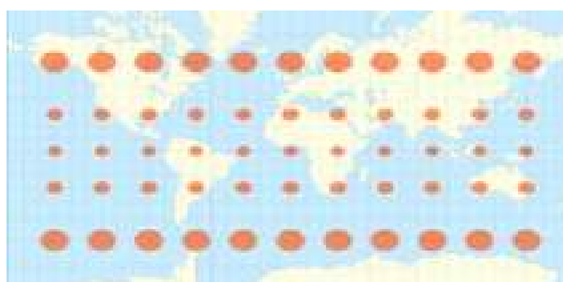
- No Connection — XM unit did not acquire satellites or unit physically not connected to antenna.
- Weak Signal — XM unit locked to satellites, but low signal strength.
- Marginal Signal — XM unit locked to satellites with medium signal strength.
- Good Signal — XM unit locked to satellites with good signal strength.

The Map tab displays the moving map with the selected map features overlaid. The Map is presented in True North format, available in Equi-Rectangular and Mercator projections. The map is not meant to be a navigation tool, but to provide the aircraft operator with a planning tool and enhance the situational awareness. The images below illustrate the distortions due to each map projection.

The Equi-Rectangular projection of the map uses equally spaced vertical straight lines and circles of latitude to evenly spread horizontal lines. The Mercator projection of the map uses equally spaced vertical straight lines. Lines of latitude are scaled to provide a constant linear scale around any point on the map.



Equi-Rectangular Map Projection



Mercator Map Projection

Figure 14-135. Map Projections

The map view provides Aircraft Position, Map overlays, XM Weather overlays, panning (up/down and left/right), and different zoom levels at 1nm increments. Pushing and holding Zoom LSKs allow for progressive zooming. A selectable legend is displayed at the bottom of the page to provide the latitude and longitude coordinates of the airplane (PL), as well as the depicted map cursor (CR).

Dual Concentric Knob
DCK: Outer Knob (LR) — Scroll the map Left and Right.
DCK: Inner Knob (U/D) — Scroll the map Up and Down.
DCK: Button (CTR) — Center the map on the current aircraft position.

Figure 14-136. MFD DCK and LSK

Line Select Keys
LSK1: (ZOOM IN) — Zooms-in to the map.
LSK2: (ZOOM OUT) — Zooms-out from the map.
LSK3: (No Function)
LSK4: (MAP SETTINGS)
LSK5: (MAP INFO)

Keyboard
CCD — Scroll map in any direction.

When the map cursor is in proximity of an airport or navaid, an information box is displayed on the moving map to indicate the type, ICAO, distance, bearing, elevation, frequency (if applicable), longest runway (Airports), and name.

14.9.3.2 MAP SETTINGS PAGE

The Map Settings Page displays a menu list of the configuration options applicable to the map display. The settings page shows the current configuration settings and allows adjustment of each of the following parameters with the DCK.

MAP PROPERTIES

- MAP PROJECTION: — RECTANGULAR / MERCATOR
- ZOOM LEVEL:
  - If UNITS is set to NM: 1 / 2.5 / 5 / 10 / 20 / 40 / 80 / 160 / 320 nm/In
  - If UNITS is set to SM: 1.2 / 2.9 / 6 / 12 / 23 / 46 / 92 / 184 / 368 / 736 sm/In
  - If UNITS is set to km: 1.9 / 4.6 / 9 / 19 / 37 / 74 / 148 / 296 / 593 / 1185 km/In
    - TOPOGRAPHY: Show / Hide
    - OVERLAY BRIGHTNESS: 50-100%
    - CENTER ON AIRCRAFT: ON / OFF

MAP OVERLAYS

- AIRWAY: Hide/Low/High/Low/High
- AIRSPACE: Show/Hide
- AIRPORT: Show/Hide
- VOR: Show/Hide
- NDB: Show/Hide
- INTERSECTION: Show/Hide
- GRID LINES: Show/Hide
- POLITICAL BORDERS: Show / Hide

FLIGHT PLAN SETTINGS

- FLIGHT PLAN: Show/Hide
- OFF ROUTE AIRPORTS: Show/Hide

NOTE:
The Show/Hide option for On-route and Off-route airports is available only if the Flight Plan is set to Show.

E-CHART OVERLAY

- LOADED E-CHART: (ICAO) Chart Name
- OVERLAY E-CHART: Show/Hide
- TRANSPARENCY: 0-75%

NOTES:

- The Loaded E-Chart and Overlay E-Chart options are available only when an E Chart has been selected in the CHART tab.
- The Transparency option is available only if the Overlay E-Chart is set to Show.

MAP LEGENDS

- SCALE BAR: Show/Hide
- RANGE RINGS: Enabled/Disabled
- RANGE TO ALTITUDE: Enabled/Disabled
- LAT/LON INFO: Show/Hide
- UNITS: NM/SM/km
- TEXT SIZE: SM/LG

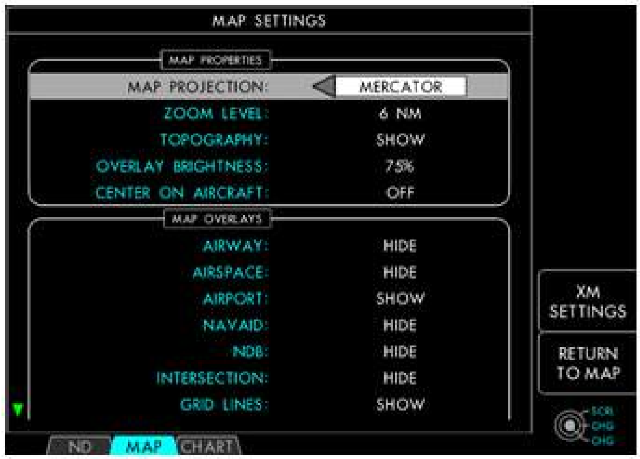


Figure 14-137. Map Settings Page

RANGE RING

The Range Ring provides a graphical representation equivalent to the selected display range on the ND tab.

Figure 14-138. Range Ring on the Map

Line Select Keys
LSK1: (No Function)
LSK2: (No Function)
LSK3: (No Function)
LSK4: (XM SETTINGS) — (Wx Data Type) Pressing LSK4 brings up the XM Settings Page.
LSK5: (RETURN TO MAP) — Pressing LSK5 returns to the Map View Page.

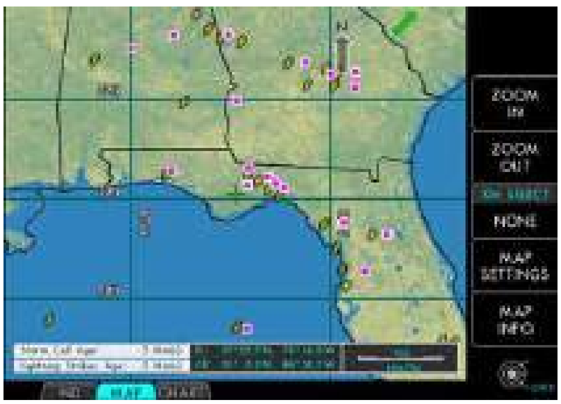
Dual Concentric Knob
DCK: Outer Knob (SCRL) — Scroll through the menu list.
DCK: Inner Knob (CHG) — Change the menu item setting. Arrows to the left/right of the settings window indicate more available settings.
DCK: Button (No Function)

14.9.3.3 XM BULLETIN VIEW

The XM Weather supports the dissemination of Meteorological and Flight Bulletins, including:

- SIGMETS
- AIRMETS
- Temporary Flight Restrictions (TFR)
- Storm Cell Identification Tracking (CELL MVMT)

The airspace bounding any active bulletin region will be displayed on the map (if selected in the XM settings). When any bulletin region is displayed, a legend will also be displayed (if selected in the XM settings), detailing the color coding used to identify bulletin regions.



XM SELECT – CELL MVMT

XM SELECT - AIRMET / SIGMET

 Storm Cell Symbol

Figure 14-139. XM Bulletin Views

DISPLAY FUNCTIONALITY

Activating the XM SELECT LSK allows the textual details of any bulletin to be selected and displayed. Only bulletin types that are active (and enabled) may be selected. The supported types are: NONE, SIGMET, AIRMET, TFR, and CELL MVMT.

The bulletin types are selected by rotating the DCK: Outer Knob to cycle through the available types or by pressing the LSK sequentially. When a type (other than NONE) is selected, LSK3 will be active. The LSK will be deactivated after 5 seconds of inactivity. To remove a selected type, the user should cycle the selections back to NONE.

When a bulletin type is selected, rotating the DCK: Inner Knob steps through each active bulletin region on the display. Selecting a bulletin causes its region to be highlighted on the map, and a tethered window is displayed containing the textual details.

Figure 14-140. Map with TFR Selected

Dual Concentric Knob
DCK: Outer Knob (CHG) — Change the active bulletin type (LSK3).
DCK: Inner Knob (SCRL) — Scroll through (select) the Wx bulletins on the map.
DCK: Button (SET) — Set the current settings and deactivate the LSK.

14.9.3.4 XM WEATHER

The XM Weather products are displayed either as overlays on the MAP tab or as textual pages associated with a specific airport on the CHART tab.

XM weather products are a subscription-based service, and are not available in all areas. To obtain an XM subscription, have your Receiver ID ready and visit *http://www.xmwxweather.com/aviation/* or call (800) 985-9200. Not all XM Weather products are currently supported. Sirius XM customer service will be able to discuss user options. The table below summarizes the currently supported XM products based on the XM subscription package.

XM Subscription Supported Product Coverages

Product	Aviator LT	Aviator	Aviator Pro
NEXRAD Radar	x	x	x
High Resolution Radar	x	x	x
Precipitation Type	x	x	x
City Forecasts	x	x	x
TFRs	x	x	x
METARs	x	x	x
TAFs	x	x	x
Lightning		x	x
AIRMETs		x	x
SIGMETs		x	x
Echo Tops		x	x
Severe Weather Storm Tracks		x	x
Winds Aloft		x	x
Freezing Levels		x	x

XM SETTINGS PAGE

The XM Settings Page displays a menu list of the configuration options applicable to the XM Weather products. The settings page shows the current setting configuration and allows adjustment of each of the following parameters using the DCK:

- XM MAP SETTINGS
  - XM OVERLAY: Show/Hide
  - OVRLY TRANSPARENCY: 0–50%
  - XM LEGENDS: Show/Hide
  - LGNDS TRANSPARENCY: 0–50%
- XM IMAGERY
  - NEXRAD: Enabled/Disabled
  - NEXRAD COVERAGE: Enabled/Disabled
  - CLOUD-TOP: Enabled/Disabled
  - ECHO-TOP: Enabled/Disabled
  - ECHO-TOP ALTITUDE: 0k – 41k feet
  - FREEZING LEVELS: Enabled/Disabled
  - PRECIP TYPE: Enabled/Disabled
- XM OVERLAYS
  - LIGHTNING STRIKES: Enabled/Disabled
  - STORM CELL TRACK: Enabled/Disabled
  - SIGMETS: Enabled/Disabled
  - AIRMETS: Enabled/Disabled
  - TFRS: Enabled/Disabled
  - WINDS ALOFT: Enabled/Disabled
  - WINDS ALTITUDE: Surface/Altitude in increments of 3,000 ft
  - WINDS LEGEND: Enabled/Disabled

The XM LEGENDS option selects or deselects the display of legend annunciations on the map display for the selected services. The XM ages legend will always be displayed independent of this setting. OVRLY TRANSPARENCY and XM LEGENDS are available only when XM OVRLY is set to show. LGNDS TRANSPARENCY is available only when XM LGNDS is set to show.

The OVRLY TRANSPARENCY and LGNDS TRANSPARENCY setting allows the XM overlays and/or legends to be blended into the map through a transparency attribute. The maximum setting is 50%, which makes the information still discernible when displayed on the map. The options for NEXRAD, CLOUD-TOP, FREEZING LEVELS and ECHO-TOP can be enabled at a time. ECHO-TOP ALTITUDE is available only when ECHO TOP is enabled. PRECIP TYPE is available only when NEXRAD or CLOUD-TOP is enabled.

Figure 14-141. XM Setting Page

Dual Concentric Knob
DCK: Outer Knob (SCRL) — Scroll through the menu list.
DCK: Inner Knob (CHG) — Change the menu item setting. Arrows to the left/right of the settings window indicate more available settings.
DCK: Button — Change the menu item setting.

Figure 14-142. XM Ages Page

Line Select Keys
LSK1: (No Function)
LSK2: (MAP SETTINGS) — Pressing LSK 2 returns to the MAP SETTINGS Page.
LSK3: (No Function)
LSK4: (XM AGES) — Pressing LSK 4 toggles the display of XM SETTINGS or XM AGES. When the XM AGES are being displayed, an automatic time out is incorporated to return to XM Settings in 10 seconds.
LSK5: (RETURN TO MAP) — Pressing LSK 5 returns to the Moving Map.

- **Winds Aloft**

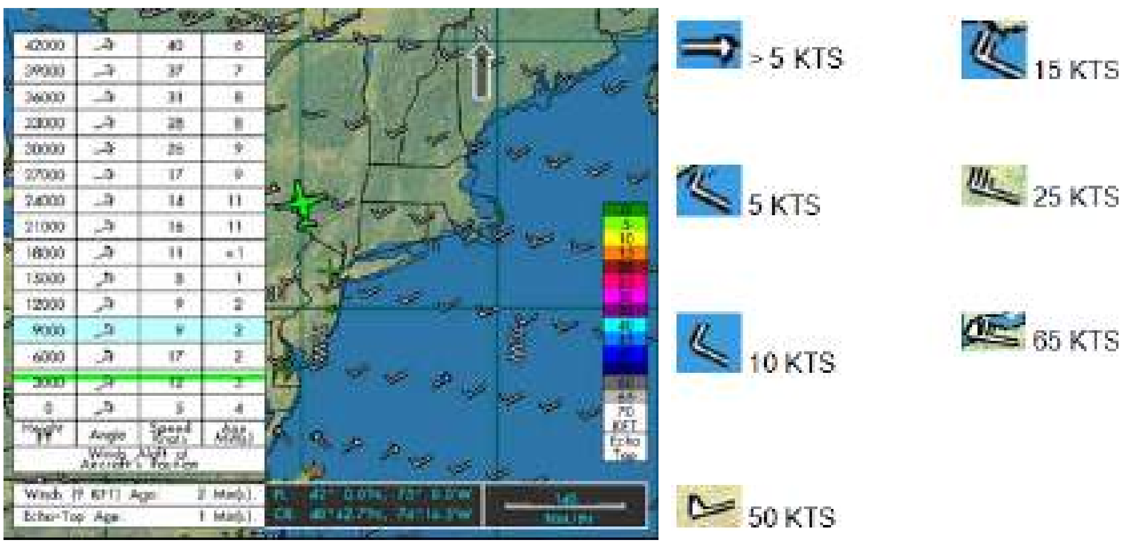


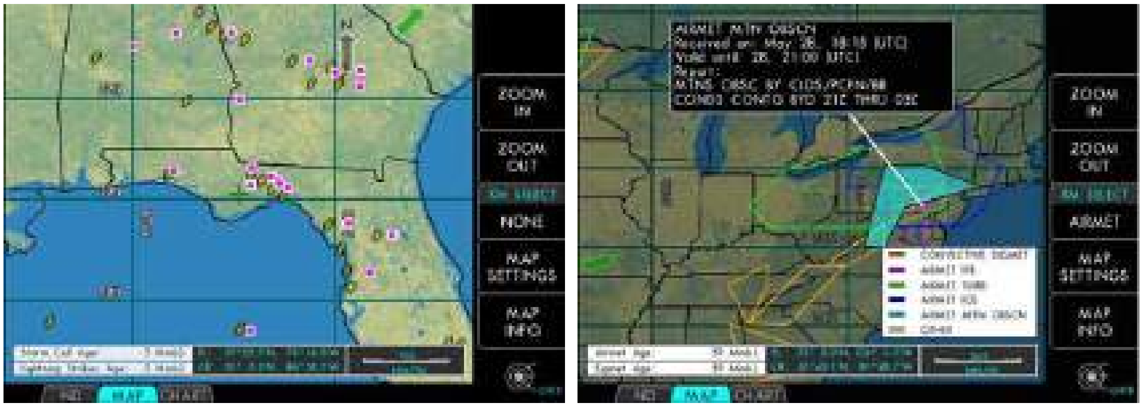
Figure 14-143. XM Weather – Winds Aloft

The Winds Aloft selection allows setting of the altitude level for which the winds aloft information should be displayed. The wind aloft information is available for heights from 0 to 42 kft in 3 kft (thousand feet) increments. A wind barb can have multiple triangles and bars. To determine the wind speed of a wind barb with multiple appendages, simply add the bars and triangles attached to the barb.

- **Winds Legend**

  The Winds Legend selection provides winds aloft at the aircraft position in increments of 3000 ft. A Green line is displayed to indicate the current aircraft altitude. The current Winds Aloft selection is highlighted in light blue.

- **Lightning Strikes / Storm Cell Track**



XM SELECT – CELL MVMT **XM SELECT – AIRMET/SIGMET**

 Storm Cell Symbol

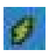
 Lightning Symbol

Figure 14-144. XM Select – Lightning Strikes / Storm Cell Track

The lightning symbol indicates whether one or more lightning strikes have been detected within the last 7 minutes. The storm cell symbol is shown at locations where potentially dangerous storm or shear conditions exist.

Press LSK3 XM SELECT: CELL MVMT in order to view the text associated with the storm cell symbol.

14.9.4 MAP OVERLAYS

14.9.4.1 AIRWAYS

The high altitude and low altitude airway lines appear on the Moving Map, without associated labeling, when the map is at a zoom level between 160 NM/IN and 40 NM/IN. The different airways are differentiated by the following color scheme: high altitude (green), low altitude (blue).

The airway labels display the airway ID when the map is zoomed into 40 NM/IN or closer.

Airway Overlay (160 NM Zoom Level)

Airway Overlay (40 NM Zoom Level)

Figure 14-145. Airway Overlay

14.9.4.2 AIRSPACE

The following airspaces appear on the Moving Map, without associated labeling, when the map is at a zoom level of 160 NM/IN to 11 NM/IN:

- Class B, Class C, Class D, Control Area and Terminal Control Area (blue)
- Alert, Caution, Danger, MOA, Prohibited, Restricted, Training, Warning and Unknown (red)

Airspace labels are displayed when the map is zoomed into 10 NM/IN or closer. Information depicted includes the class of airspace and altitudes in 100's of feet for the top and bottom of the airspace. If the map is zoomed into 1 NM/IN, the name of the airspace is provided additionally.

NOTE:
Darker shading of colors indicates overlying airspace. Always look at where the tip of the pointer is versus the label box to indicate which airspace is being labeled.

Airspace Overlay (160 NM Zoom Level)

Special Use Airspace (10 NM Zoom Level)

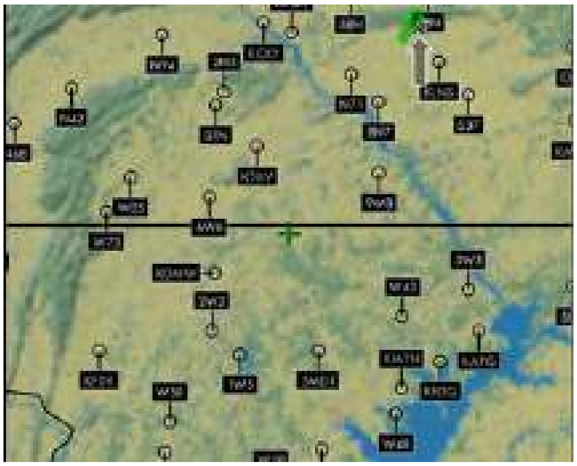
Airspace Overlay (10 NM Zoom Level)

Airspace Overlay (1 NM Zoom Level)

Figure 14-146. Airspace Overlay

14.9.4.3 AIRPORT

Airports without associated labeling appear on the moving map between 40 NM/IN and 20 NM/IN. When the map is zoomed into 20 NM/IN or closer, the airports appear on the Moving Map with associated labeling. The airports are displayed with the runway drawn to scale when the map is zoomed into 5 NM/IN or closer. The airport labels display the runway IDs when the map is zoomed into 1 NM/IN



Airport Overlay (20 NM ZOOM LEVEL)

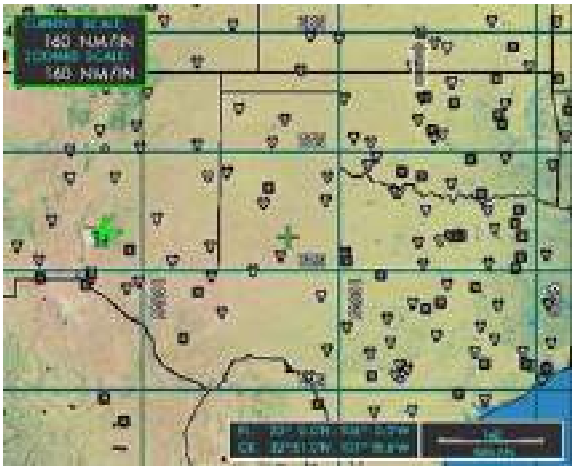
Airport Overlay (5 NM ZOOM LEVEL)

Airport Overlay (1 NM ZOOM LEVEL)

Figure 14-147. Airport Overlay

14.9.4.4 NAVAID SYMBOLS

The VHF Omni-directional Range (VOR), Distance Measuring Equipment (DME), Tactical Air Navigation system (TACAN), VOR/DME & VORTACs appear on the Moving Map, without associated labeling, when the map is at a zoom level of between 160 NM/IN and 40 NM/IN. The symbols are displayed with associated labels, which provide both ID and frequency, when the map is zoomed into 40 NM/IN or closer.



VOR Overlay (160 NM ZOOM LEVEL) **VOR Overlay (40 NM ZOOM LEVEL)**

Figure 14-148. NAVAID Symbols

14.9.4.5 NON DIRECTIONAL BEACONS (NDB)

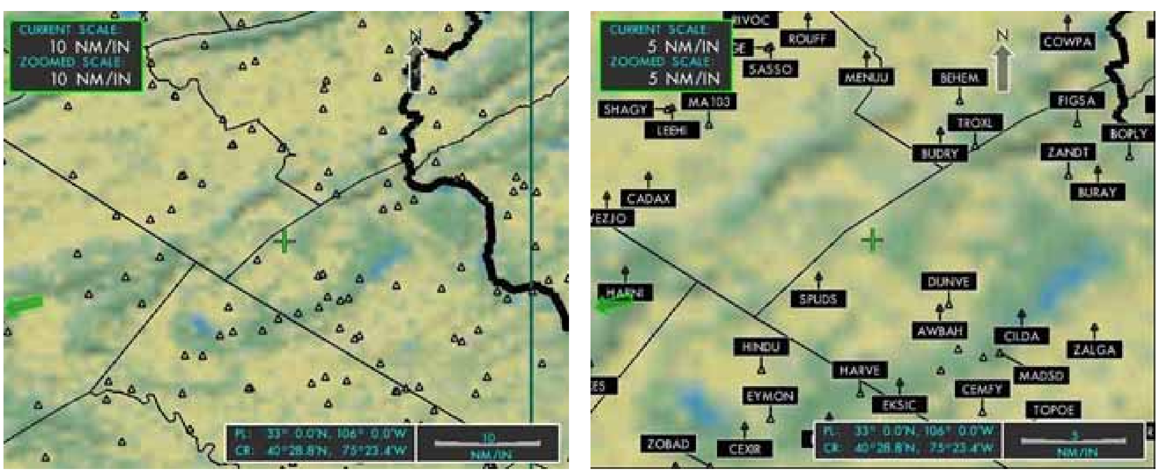
NDBs appear on the Moving Map, without associated labeling, when the map is zoomed into 40 NM/IN or closer. The NDB symbols are displayed with associated ID labels and frequency when the map is zoomed into 20 NM/IN or closer.

NDB Overlay (20 NM ZOOM LEVEL) **NDB Overlay (40 NM ZOOM LEVEL)**

Figure 14-149. NDB Overlay

14.9.4.6 INTERSECTION

The intersections and waypoints appear on the Moving Map, without associated labeling, when the map is zoomed into 10 NM/IN or closer. The Intersection labels are displayed when the map is zoomed into 5 NM/IN or closer.



Intersection Overlay (10 NM ZOOM LEVEL) **Intersection Overlay (5 NM ZOOM LEVEL)**

Figure 14-150. Intersection Overlay

14.9.4.7 FLIGHT PLAN OVERLAY

An active flight plan can be presented on the Moving Map when the FLIGHT PLAN option is set to SHOW on the Map Settings page. The flight plan is comprised of a series of waypoints, navaids and airports connected by flight plan legs which are calculated by the FMS to indicate the flight path.

14.9.4.8 E-CHART OVERLAYS

Figure 14-151.   E-Chart Overlays

14.9.4.9 RANGE TO ALTITUDE OVERLAYS

When the autopilot is engaged vertically in ALT CHG, a green arc is displayed on the Navigational Display and the Moving Map to show the Range to Altitude. The altitude is the Pre Select altitude that is adjustable on the Autopilot Control Panel (ACP). The Range to Altitude option can be enabled or disabled via the map settings page.

ND Range to Altitude

Mini Map Range to Altitude

Figure 14-152.   Range to Altitude Overlays

14.10 Abnormal Procedures

14.10.1 MFD Failure

If the MFD fails, all flight information will be available through the composite mode on the PFDs.

14.11 Crew Alerting System Messages

Table 14-3. 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

14.12 Takeoff Configuration Warnings

Table 14-4. Takeoff Configuration Warnings

Message	Condition	Categories
CONFIG AILERON TRIM	Aileron trim is not within takeoff limits and Throttle Lever Angle (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

14.13 Terrain Awareness and Warning System (TAWS)

The aircraft may be equipped with an optional Honeywell KGP 560 Ground Proximity Warning System providing increased situational awareness and terrain alerts. Control and display is available on the MFD MAP: ND (Navigation Data) tab, textual terrain alerts will be displayed on the PFD, as well as aural alerts for terrain. The TAWS computer housed on the avionics rack in the aft equipment bay uses an, obstacle and runway database, GPS position, OAT and barometric pressure to calculate when a terrain threat is present. The TAWS system is also responsible for the "500" foot call-out.

14.13.1 Controls and Indications

Overlay

Select the OVERLAY LSK to TAWS on the ND tab to bring up a TAWS System Terrain Map. Terrain is depicted in various intensities of green, yellow and red. Water is depicted in cyan. The color and fill rate depends on the aircraft altitude.

Figure 14-153. MFD, TAWS System Terrain Map

Push the VIEW/RNG LSK to change the display between FULL (360 Degree), FULL/FLTPLN (Full with flight plan overlay), ARC (120 Degree), ARC/FLTPLN (ARC with flight plan overlay) views. The terrain map is only shown ± 90° from the nose in the 360° mode. The map orientation can be set to HDG UP (heading up), TRK UP (track up), or NORTH UP. using the outer DCK. The selection is displayed in the top right of the ND tab next to the boxed display orientation heading. The boxed display orientation heading will depict the 3 digit direction for HDG, or TRK, and will display 360 in NORTH UP orientation. The inverted triangle on the compass rose, and the aircraft icon will always be set to the aircraft heading. The aircraft track is shown as a gray line extending from the aircraft to the outer range ring. The outer knob is used to change the range.

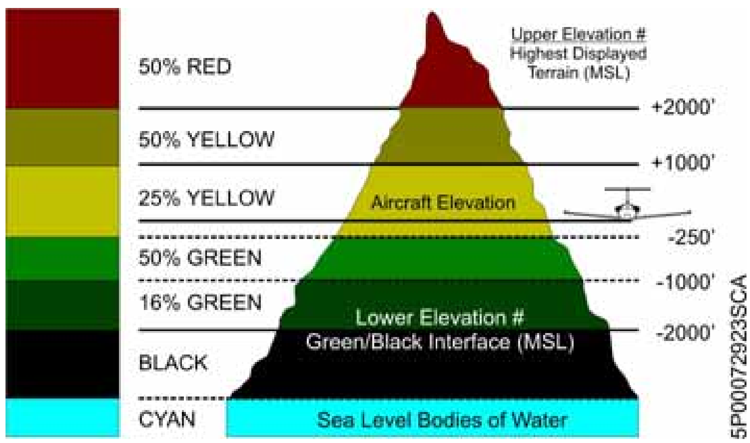


Figure 14-154. TAWS System, Lower Altitudes

The TAWS display uses two slightly different color combinations to display terrain. When there is terrain on the display that is less than 250 feet below the aircraft altitude or higher, the colors represent terrain as indicated in Figure 14-154. When the aircraft is more than 250 feet higher than the highest terrain elevation on the display the colors represent terrain as shown in Figure 14-155.

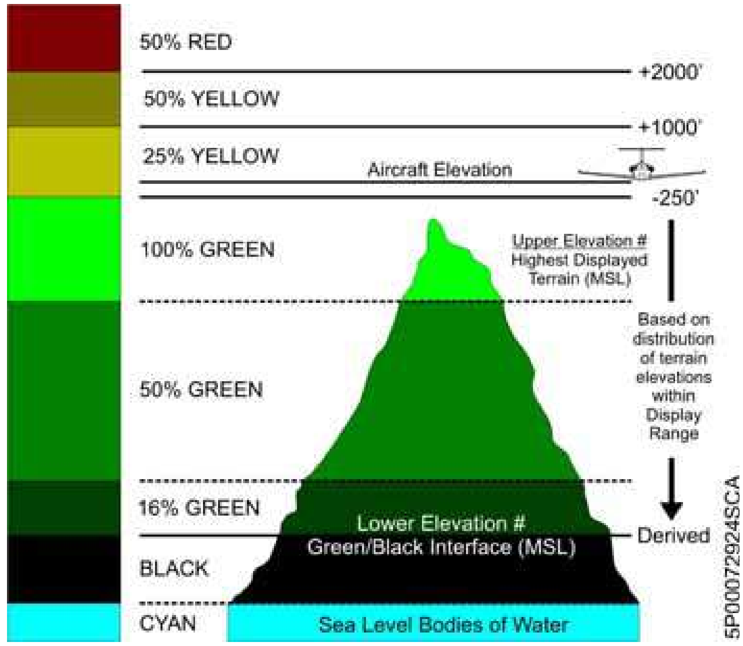


Figure 14-155. TAWS System, Higher Altitudes

Green colors are not shown when the aircraft is on the ground or during climb-out until the aircraft has reached approximately 500-800 ft AGL.

All indications are based on a calculated true height above mean sea level called GSL (Geodetic Sea Level). GSL is the calculated true height above MSL and is primarily based on GPS altitude with barometric altitude factored in. GSL is displayed in the lower left corner of the overlay as "GSL NNn" where "NN" is thousands and "n" is hundreds of feet. The highest and the lowest terrain or obstacle in the displayed area is shown in the lower right corner in the same format.

Look-Ahead

The TAWS system compares the current aircraft path with the Terrain/Obstacle Database. If impact is predicted within approximately one minute a "Caution Terrain, Caution Terrain" (or "Caution Obstacle, Caution Obstacle") aural voice is announced and a bright, solid yellow threat area is shown on the Terrain Display. In addition, a yellow TERRAIN is displayed on the ADI. The alert message will repeat approximately every 7 seconds if the aircraft continues toward the threat area.

Within approximately 30 seconds of impact, a “Terrain Terrain, Pull Up” (or “Obstacle-Obstacle, Pull Up”) aural voice sounds and a threat area on the Terrain Display is shown by a bright solid red area. In addition, a red PULL UP is displayed on the ADI. The “PULL UP” aural voice will continue until the aircraft leaves the warning area.

Figure 14-156. AI, Terrain Warning

Runway Field Clearance Floor (RFCF)

The RFCF function is only available when the aircraft is within 5 nm of an airport listed in the database with a 2,000 ft or longer runway. If the aircraft descends within the RFCF Envelope in Figure 14-157, a "Too Low Terrain, Too Low Terrain" aural voice is announced and a yellow TERRAIN is displayed on the ADI. If the aircraft continues to descend, the voice alert repeats with increasing frequency.

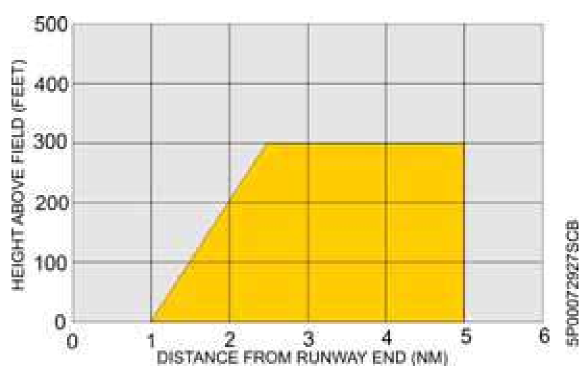


Figure 14-157. Runway Field Clearance Warning Envelope

Excessive Rate of Descent

If the aircraft descends within the Sink Rate Area of Figure 14-158 at too high a rate, a "Sink Rate, Sink-Rate" aural voice sounds and a yellow TERRAIN is displayed on the ADI. If the aircraft continues its high descent rate, the voice alert repeats with increasing frequency.

If the descent penetrates the Pull-Up Area of Figure 14-158 a "Pull-Up" aural voice sounds continuously and a red PULL UP is displayed on the ADI.

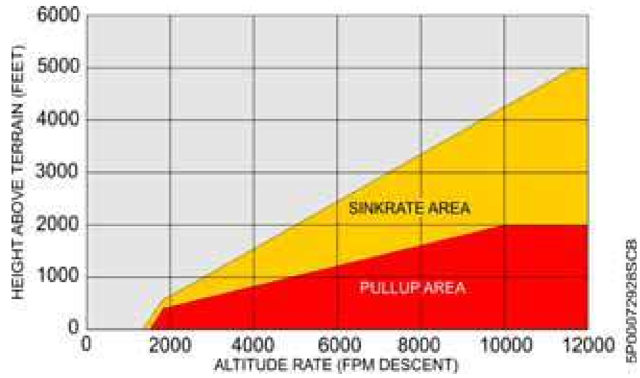


Figure 14-158. Excessive Rate of Descent Warning Envelope

Inadvertent Descent/Loss of Altitude After Takeoff

This function uses known runway position and elevation information to monitor altitude during take-off and initial climb until the aircraft reaches approximately 700 feet above the runway. If the aircraft loses altitude within the Don't Sink Envelope (Figure 14-159), a "Don't Sink-Don't Sink" aural voice sounds and a yellow TERRAIN is displayed on the ADI. The voice alert will repeat with increasing frequency until the condition is corrected.

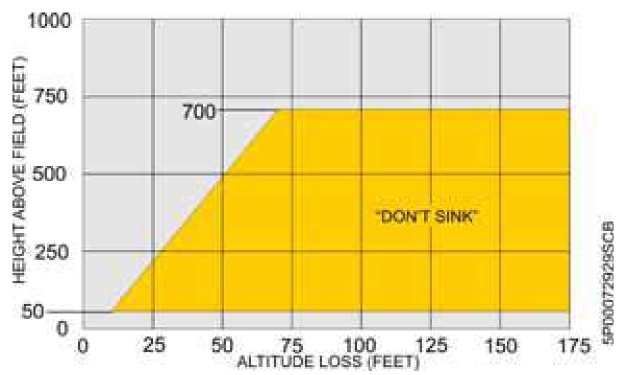


Figure 14-159. Altitude Loss After Takeoff Warning Envelope

Altitude Monitoring

The TAWS system uses the computed GSL altitude to monitor the aircraft altimetry. If a large discrepancy is detected a "Check Altitude" aural voice is annunciated and a yellow "Chk Alt" message is displayed above the GSL altitude on the TAWS overlay.

Altitude Call-out

When the aircraft descends below 500 feet above a runway within 5 nm a "Five Hundred" aural voice is annunciated.

Self-test

The TAWS system can be tested using the OPS: SYSTEM TEST page. Select the ND page OVERLAY LSK to TAWS if desired. Select TERRAIN ALERT on the SYSTEM TEST page. Press the START TEST LSK. If the system is functioning properly a test pattern is shown on the ND page. When the test is complete and the system is functioning properly, an "EGPWS SYSTEM OK" voice is annunciated. See "AMPLIFIED NORMAL PROCEDURES" in the AFM for system test detail.

Terrain Inhibit

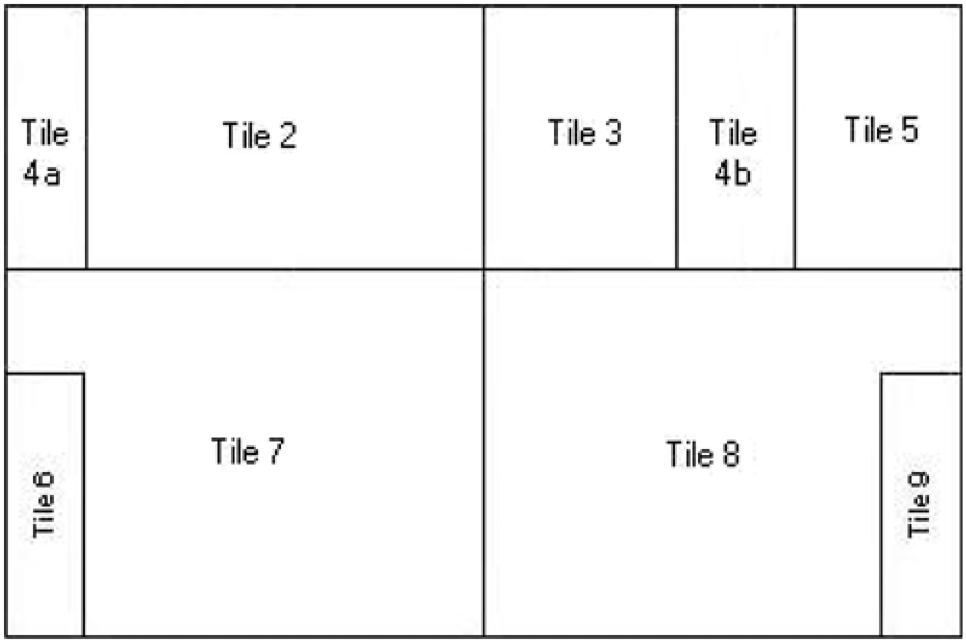
The TERR INHIBIT selection on the MFD settings page inhibits TAWS aural and ADI textual alerts when in the ON setting. An amber TERR INHIB is displayed on the ADI when in this selection.

14.13.2 Failures

If the TAWS system stops functioning, an amber TERRAIN ALERT FAIL caution message is displayed. Additionally, if the TAWS overlay is selected, an amber TERRAIN UNAVAIL message will appear on the ND page.

14.14 MFD Review Questions

1. **List the information contained within each of the tiles below:**



2. **Which portion/tile of the MFD continuously displays the same information?**
   a. Tile 3
   b. Tile 5
   c. Tile 4a & 4b
   d. All of the above

3. **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 and D are correct

4. **What are the visual indications of a flap failure on the MFD?**

5. **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

6. 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

7. List the proper order (from top to bottom) of CAS message hierarchy as well as their associated colors.

8. 9.How can a pilot silence an aural alert accompanied with a CAS message?

9. The pilot sets the desired cockpit and cabin temperatures on the _________ synoptic page.

10. Describe the functionality of the AUDIO primary function key.

11. Holding the ALL INTERRUPT for two seconds cause what to occur on the MFD? Why does the display do this?

12. The N2 engine value is:

a. Constantly displayed as a digital value
b. Only displayed on the MFD engine synoptic page
c. Constantly displayed as a digital value during takeoff only
d. None of the above

13. 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 which go blank after 5 seconds
d. None of the above

14. What is the function of Tiles 7 and 8?

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

15. What PFD/MFD functionality does the keyboard replace?

a. The keyboard is the only way to tune NAV 1 and 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.

16. 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

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Autoflight

15

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Autoflight 15

15.1 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 roll hold, heading hold, course tracking, pitch hold, airspeed climb hold, vertical speed descent hold, altitude hold, glide path tracking, and autothrottle speed hold, and MCT.

All autoflight 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.

15.2 Aircraft Computer System (ACS) Interfaces

The autoflight system is comprised of these components:

1. Autopilot Control Panel (ACP)
2. Pitch, roll and yaw servos
3. Autopilot servos
4. Autothrottle servos

NOTE:
The autopilot computers are actually part of the servos.

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 PFDs for display of the autopilot targets and flight mode annunciation. Each autopilot servo contains a motor control along with an autopilot computer that receives and processes 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, 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 control of the stall warning function. The ACS also provides the autoflight system with a command to activate the stick pusher as part of the stall protection system.

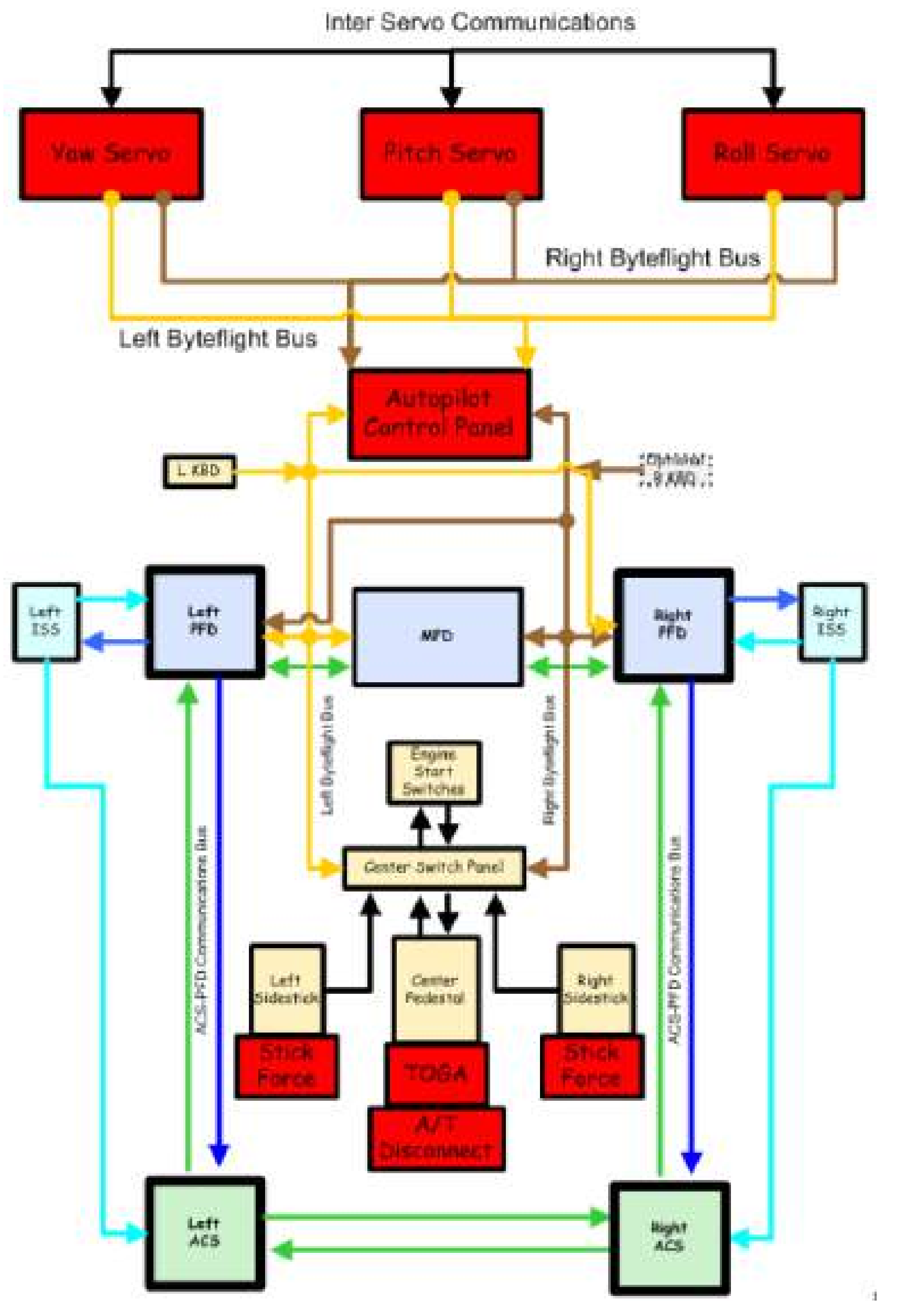

Figure 15-1. Autoflight – ACS Interface

15.3 Limitations and Specifications

Maximum altitude yaw damper OFF..20,000 feet

Maximum airspeed with yaw damper inoperative....................................... 200 KEAS

NOTE:
For operations with the yaw damper inoperative and flaps extended, the normal flap speed and altitude restrictions apply.

Table 15-1. Yaw Damper OFF Limitations

	Flap Position		
	UP	TO	LDG
Maximum Airspeed KEAS	200	200	120
Maximum Altitude Ft. (meters)	20,000 (6,096)	10,000 (3,048)	10,000 (3,048)

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 .... 400 feet AGL

Approach
Precision .... 150 feet AGL
Visual and non-precision .... 250 feet AGL

NOTES:

- Autopilot must be operational for Reduced Vertical Separation Minimums (RVSM) operations.
- Stall protection system and stick pusher must be successfully tested prior to flight.

AUTOPILOT IN ICING CONDITIONS

Intermittently operate with the autopilot OFF to detect changes in flight control feel.

Do not connect the autopilot if unusual ice is observed on the unprotected upper wing surface or when there are unusual aileron trim requirements or if autopilot roll mistrim conditions exist. If the autopilot is connected before entering the conditions firmly hold the sidestick then disconnect the autopilot.

15.4 Controls and Indicators

15.4.1 Autopilot Control Panel

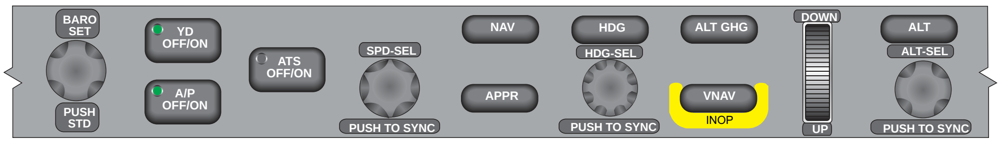

Figure 15-2. Autopilot Control Panel

15.4.1.1 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 in Hg or 1 HPA increments.

Depending on the selection on the SETUP-SETTINGS Synoptic the BARO setting will automatically change to 29.92 in Hg/1013 HPA at FL180. Pressing the BARO SET knob sets standard selection of 29.92 in HG or 1013 HPA.

NOTE:
Always verify the BARO Setting changes to standard prior to leveling off or passing through the transition altitude.

15.4.1.2 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, and a green light is illuminated on the yaw damper button.

NOTE:
The yaw damper is automatically engaged with autopilot engagement.

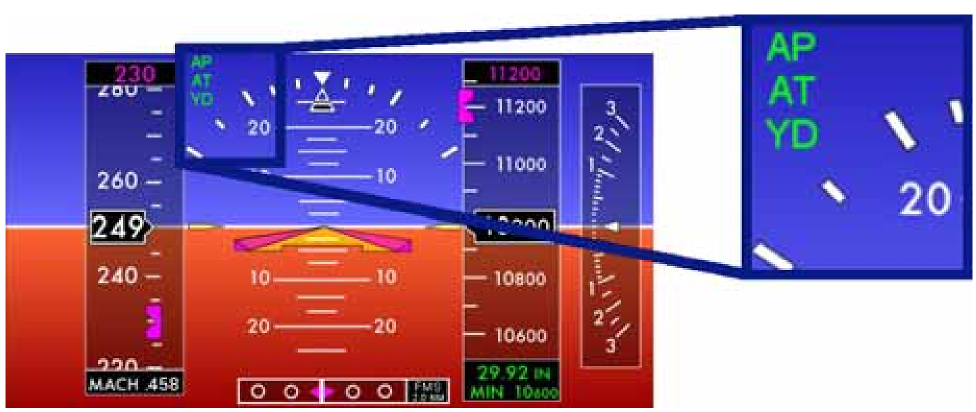

Figure 15-3. Autopilot and Yaw Damper Engaged Indications – PFD