# INSTRUMENTATION

The Citation Sovereign is equipped with the Honeywell Primus EPIC advanced Digital Automatic Flight Control System (AFCS). Four Honeywell DU-1080 Active Matrix Liquid Crystal Display (AMLCD) panels provide the flight crew with critical flight and system operations information. The Primus EPIC system is a fully integrated electronic flight information system. Integrated within the system are COMM functions, Electronic Flight Instrument System (EFIS), GPS and VHF Navigation information, the airplane Intercom System, Weather Radar, Engine Instrument and Crew Alerting System (EICAS), Aural warning, Enhanced Ground Proximity Warning Module, and the AHS-3000 Altitude Heading and Reference System. Additional integrated systems and associated descriptions of all integrated systems are discussed later in this section.

Four Modular Avionics Units (MAUs) are the heart of the Primus EPIC system. Two are installed in the nose avionics bay and two in the aft bay. The MAUs process information from the Air Data Modules (ADMs), Attitude Heading and Reference System (AHRS) Modular Radio Cabinets (MRCs), Traffic Collision and Avoidance System (TCAS II), and the Primus WX-880 Weather Radar System.

## PITOT-STATIC SYSTEM

The airplane Pitot-Static system provides altitude and airspeed information to the flight crew. Cabin pressure reference to determine differential pressure (DELTA P) is also provided by the system. DELTA P information is indicated on the CABIN DELTA P gage located on the left hand side of the copilot's instrument panel.

Three redundant and independent systems comprise the airplane pitot-static system. This redundancy makes sure a clear representation of pitot static information is displayed on the PFDs preventing possible confusion of the flight crew in the event of system failure. Each of the three systems consists of a pitot probe and two static ports.

Pitot probes are located at the airplane nose and the static ports are installed in an array of three on each side of the outer cockpit fuselage section. The top forward static port on each side is tied to the pilot's pitot-static system, bottom forward static port to the copilots and the aft port to the standby system.

The total and static air pressure from system components is fed directly to an Air Data Module. The Air Data Modules (ADMs) for the pilot and copilot pitot-static systems are located in the nose of the airplane. The pilot's pitot-static system sends pitot-static pressure readings information to the respective ADM. The ADM then converts the pitot-static pressures to a raw electrical signal transferring the signal to a Modular Avionics Unit (MAU). The MAU then calculates the air density, airplane altitude, dynamic pressure, and airspeed. The information is then presented on the cockpit displays.

To prevent a possible system failure from an ice buildup on the probes or static ports, the system is electrically anti-iced. Pitot-Static anti-ice failure information is conveyed through the EICAS system by sensors located in line with each probe and port anti-ice power source. Once the system is in operation the sensors detect the amount of current being sent to each heater and send a corresponding signal to an MAU.

# PITOT-STATIC SYSTEM SCHEMATIC

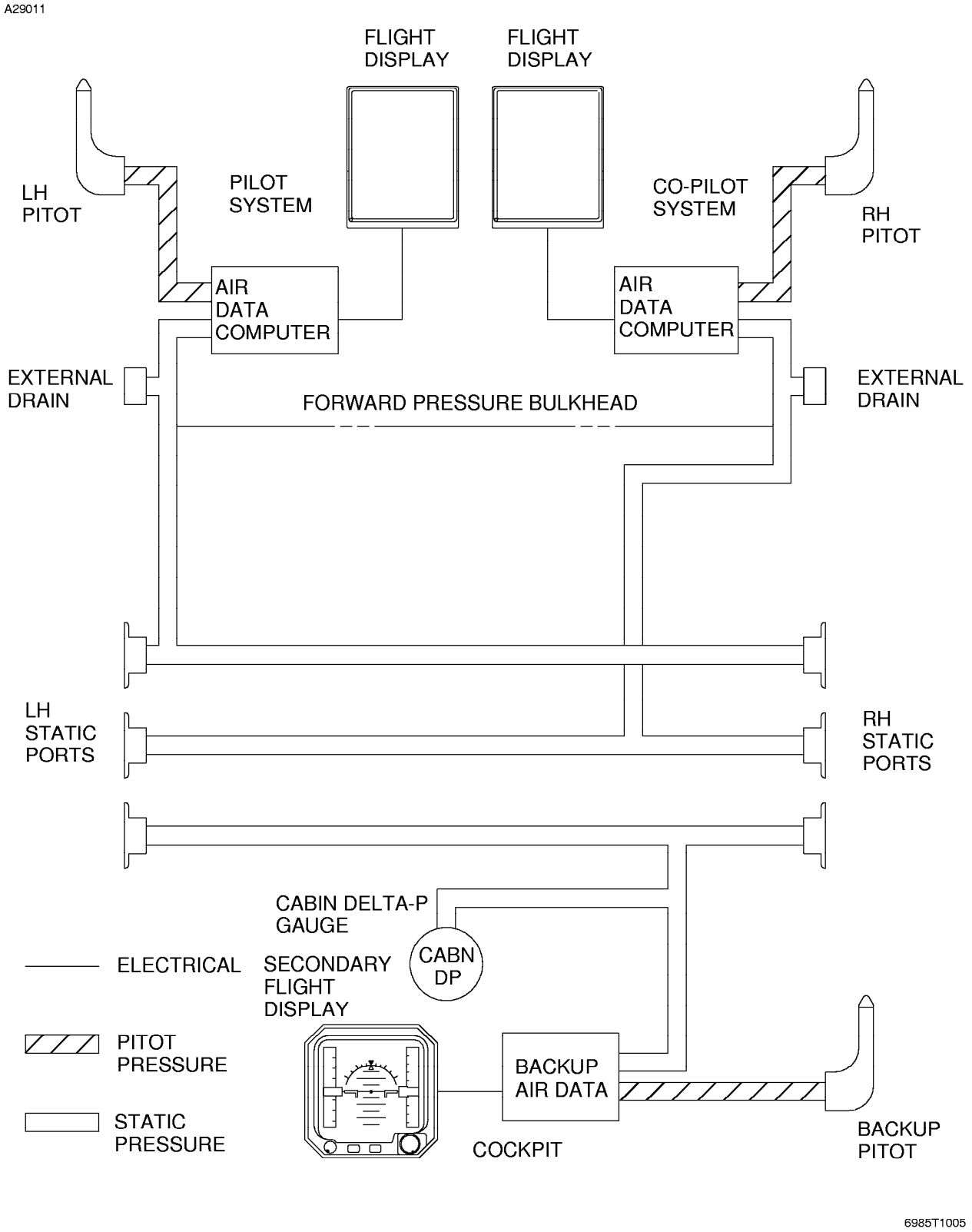


Figure 3-1

## ELECTRONIC DISPLAY SYSTEM (EDS)

The EDS provides information from remote sensors concerning automatic flight control systems, flight management systems, caution and warning systems, engine performance and airplane performance. It displays this data in digital form on the pilot's primary flight displays (PFDs) and multifunction displays (MFDs).

Organization of the displays is as follows:

Primary flight display (PFD) - Integrates attitude, heading, air data information, and flight director modes with command bars, weather radar, and navigation information. Combines information from these separate sources into one easily interpreted comprehensive display.

Multifunction display (MFD) - Displays heading, navigation map, weather radar, optional checklist, and optional traffic and collision avoidance system (TCAS) information.

Engine Instrument and Crew Alerting System (EICAS) - Displays engine data, flight control data, systems status data, and warning/caution/advisory/status messages.

## DC-840 DISPLAY CONTROLLER

The Honeywell DC-840 display controller is the main interface between the MAUs and the PFDs. Two controllers are installed, one above each PFD. Command buttons are installed on each controller to allow selection of PFD operating modes and navigation display functions.

### DISPLAY CONTROLLER FUNCTIONS

HSI Button -

Pressing the HSI button toggles the PFD display between the Full and Arc mode compass displays. The full compass display shows the entire compass rose, the arc display mode shows a segment 120° wide, with the airplane heading in the middle. The default display at power up is full compass.

WX/TERR Button -

Pressing the WX/TERR button selects weather video (WX) or terrain video (TERR) for display on the on-side PFD Arc mode. If the HSI format is Full Compass when the WX/TERR button is activated it will automatically switch to Arc mode with WX displayed on the initial activation and then cycle to TERR after being pushed a second time.

# DC-840 DISPLAY CONTROLLER

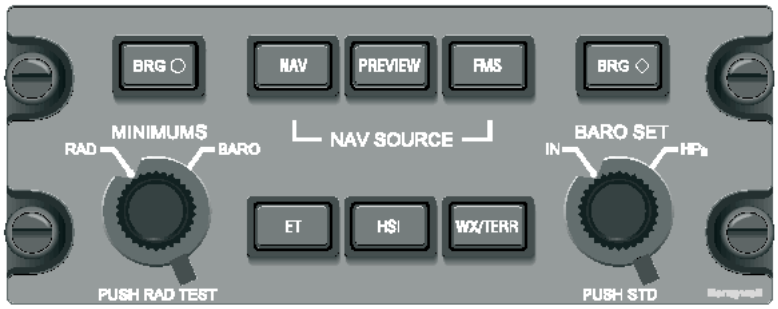


Figure 3-2

ET Button –

The first activation of the ET pushbutton selects the Elapsed Timer (ET) clock for display. The elapsed timer can be preset using the TIMERS page on the MCDU. If a preset time has been set, activation of the ET pushbutton will cause the elapsed timer to count down. If a preset time has not been set (elapsed timer = 0), activation of the ET pushbutton will cause the elapsed timer to count up. Additional activation of the ET pushbutton will be the same for both the count up and count down modes as follows:

Start (Count up/down)--> Stop--> Reset--> Start

If the selection remains in the reset state for ten minutes, or the ET pushbutton is held depressed for two seconds, the elapsed timer display will be selected as off. When the reset mode is selected following a count down from a preset value, the elapsed timer is set to zero and the elapsed timer preset value set using the MCDU will be deselected.

When the elapsed timer has counted down to zero, the elapsed time digital readout shall turn reverse video (subdued white with black letters) and the elapsed timer shall automatically start counting up.

During the first five seconds of counting up, elapsed timer readout shall be flashed 1 second on and .5 seconds off after which the digits shall turn to amber and continue the count up process.

Power-up default = Elapsed Timer not displayed

VOR/LOC Pushbutton -

The VOR/LOC pushbutton toggles through the available short range radio navigation sources for display of their corresponding data on the on-side PFD display. Sources available are VOR and localizer. The source selection for alternate activation of the VOR/LOC pushbutton shall be as follows:

On-side VOR/LOC --> Cross-side VOR/LOC --> On-side VOR/LOC

Selection of this pushbutton with any FMS source selected will cancel that source as displayed on the PFD and shall fall into the above sequence.

Power-up default = On-side VOR/LOC

PREVIEW Pushbutton -

With an FMS as the selected displayed navigation source, the available short range radio navigation sources may be previewed. The PREVIEW pushbutton toggles through the available VOR/LOC sources for preview on the on-side PFD. The format sequence for alternate activation of the PREVIEW pushbutton shall be as follows:

On-side VOR/LOC --> Cross-side VOR/LOC --> Off --> On-side VOR/LOC

With a previewed navigation source displayed and the active flight director lateral mode transitions from LNAV (FMS) to App VOR, App Loc, or BC Loc, the previewed navigation source is transitioned to the active navigation source display.

Activation of this pushbutton without a displayed FMS navigation source results in no change to the display.

Power-up default = Preview off

FMS Pushbutton -

The FMS pushbutton toggles through the available FMS sources for display on their corresponding data on the on-side PFD display. The source selection for alternate activation of the FMS pushbutton shall be as follows:

On-side FMS --> Cross-side FMS --> On-side FMS

Selection of this pushbutton with any VOR/LOC source selected will cancel that source as displayed on the PFD and shall fall into the above sequence.

Power-up default = Inactive

Baro Set Knob -

Setting of the barometric set value for the on-side air data function is accomplished using the Baro Set knob located on the DC-840. The Baro Set knob is a dual concentric knob. The outer knob allows for selection of the displayed barometric setting to be based on a inches of mercury (IN) or Hectopascals (HPa). The inner knob is used to select the barometric set value. The barometric set value is calculated by the ADS function after the Control I/O function sends it raw knob position data from the controller. Setting the barometric set value to the standard atmospheric pressure value is accomplished by activating the standard button located on the end of the Baro Set Knob.

BRG O -

The Bearing Circle pushbutton allows for the selection of VOR1, ADF1 or FMS1 for the on-side PFD HSI display. The bearing pointer selection with alternate activation of the pushbutton shall be as follows:

Off --> VOR1 --> ADF1 --> FMS1 --> Off

When only one ADF is installed, the sequence for the bearing circle selection with alternate activation of the pushbutton shall be as follows:

Off -->VOR1 -->ADF ¨FMS1 -->Off

Power-up default = Last Setting

BRG ◇ -

The Bearing Diamond pushbutton allows for the selection of VOR2, ADF2 or FMS2 for the on-side PFD HSI display. The bearing pointer selection with alternate activation of the pushbutton shall be as follows:

Off ¨VOR2 ¨ADF2 ¨FMS2 ¨Off

When only one ADF is installed, the sequence for the bearing diamond selection with alternate activation of the pushbutton shall be as follows:

Off ¨VOR2 ¨ADF ¨FMS2 ¨Off

Power-up default = Last Setting

PFD Navigation Source Selection -

Selection of the navigation source data displayed on the on-side PFD is selected using the three navigation source selection pushbuttons VOR/LOC, PREVIEW, and FMS.

Minimum Select Knob -

Setting of the minimum value displayed on the on-side PFD is accomplished using the Minimum Select knob located on the DC-840. The Minimum Select knob is a dual concentric knob. The outer knob allows for selection of the minimum value to be based on a radio altitude (RAD) minimum or a barometric altitude (BARO) minimum. The inner knob is used to select the minimum value. The rate of change of the minimum select value shall be variable based on the rate of knob rotation. The slower rate of change shall allow for precise setting of the data (one click of the knob equals 10 feet). For a RAD minimum, the value shall start at 200 feet. For a BARO minimum, the value shall start at 1500 feet.

Power-up default = dashed (no value)

Radio Altitude Test -

Located on the end of the Minimum Select Knob is the Radio Altitude Test pushbutton. Activation of the pushbutton shall initiate the radio altimeter's self test function.

## COLLINS AHS-3000 ATTITUDE HEADING AND REFERENCE SYSTEM

The Dual Collins AHS-3000 Attitude Heading and Reference System (AHRS) is installed as standard equipment on the Citation Sovereign. Attitude, heading and accelerometer functions are provided for display to the flight crew on the Honeywell Primus EPIC Integrated Avionics System. Each AHS-3000 unit is comprised of three components, the AHS-3000 Attitude Heading Computer, the ECU-3000 External Compensation Unit, and the FDU-3000 Flux Detector Unit. These units operate in unison to provide the flight attitude and heading information for all flight conditions.

The AHS-3000 is a solid-state strap-down attitude heading and reference system using quartz based inertial sensor technology. Primary functions for the AHS-3000 are to provide pitch, roll and heading information for use by the cockpit displays, flight control and management system, weather radar stabilization, Enhanced Ground Proximity Warning Module (EGPWM), and TCAS systems.

### MODES OF OPERATION

Initialization begins immediately after primary power is applied to the AHS-3000 unit. The power-up test takes approximately 5 seconds to verify the Attitude Heading Computer is capable of performing the basic operating mode functions. After initial power is applied, the Attitude Heading Computer sets the attitude and heading invalid bits causing the HDG and ATT flags to be displayed on the PFDs. During initialization the compass card on the PFDs will turn to a North heading and then slowly rotate clockwise back to a North heading after the process is complete. Initialization of the AHRS unit takes approximately 35 to 50 seconds on the ground.

In normal mode the AHRS uses valid true airspeed (TAS) from the air data modules, to improve attitude accuracy. If the true airspeed data are not available or are invalid, the system will automatically revert to the basic mode to operate autonomously. If true airspeed becomes valid again during basic mode operation, the system will revert to normal mode. Transition between normal and basic modes is controlled by the availability and validity of true airspeed data, and the transition is performed automatically in both directions.

In slaved mode, the heading loop of the AHS-3000 attitude and heading reference unit (AHRU) is supplied with magnetic heading data from the magnetic sensor unit (flux valve). The heading output is magnetic heading referenced to local magnetic north. The earth rate and gyro drift correction factors are updated continuously during slaved operation.

A dot/cross type of heading sync indicator is displayed at the top left of the horizontal situation indicator (HSI) display in the primary flight display (PFD). The scale is green and the pointer is white. During straight and level flight the indicator will be stabilized between the dot "o" and the cross "+". and may temporarily drift to one side or the other. This indicates normal operation in the slaved mode. After a turn, the indicator should return to a centered indication within two minutes. The heading sync indicator can be quickly re-synchronized by cycling the DG/SLAVE/TEST switch to DG and back to SLAVE. The heading sync indicator is removed from the HSI when DG mode is selected, when there is an invalid flux valve heading, and when there is an invalid magnetic heading.

In DG (directional gyro) mode, the heading may be set as desired by the L SLEW (left) and R SLEW (right) switch of either AHRS system, after DG is selected on the appropriate system switch (DG/SLAVE/TEST). In DG mode the system acts as a free gyro; there is no magnetic input, and no update of earth rate and gyro drift estimation will be performed.

The AHRS basic mode is annunciated in the upper left corner of the MFD (i.e., AHRS BASIC-1-2), in white, if the AHRS is not in a normal mode.

## AIRSPEED DISPLAY

The indicated airspeed display is to the left of the attitude display on the primary flight display. The display consists of a "rolling digit" window in the center of an airspeed vertical tape. The resolution of the rolling digits is one knot. The moving vertical tape moves behind the window and is labeled every 10 knots below 200 KIAS and every 20 knots above 200 KIAS, with the larger numbers at the top of the scale. The range of the airspeed scale is 30 to 900 knots with tick marks every 10 knots beginning at 30 KIAS. The airspeed tape parks at 30 or 900 knots as applicable.

V-Speeds can be selected by use of the line select keys located on the Multi-Function Control Display Units (MCDUs). The bugs are labeled V1 ($V_1$), VR ($V_R$), V2 ($V_2$), VENR ($V_{ENR}$) (this airspeed is automatically displayed whenever $V_1$, is selected for display; $V_{ENR}$ is set to a fixed value of 180 knots), $V_{REF}$, and $V_{APP}$. The bugs are positioned on the right outside edge of the airspeed tape. They consist of a horizontal T-shaped symbol with its respective label positioned to the right of the symbol. All the takeoff set bugs will be removed from the display when the airplane airspeed exceeds 230 knots and the landing speed bugs are removed upon touchdown.

$V_1$ and $V_R$ can be set equal to each other. In the event that this occurs, the display reading will be 1R when they are equal.

## TREND VECTOR

A magenta airspeed trend vector is displayed on the right side of the airspeed tape. This trend vector indicates the direction of acceleration of the airplane. For accelerations of less than 0.1 knots/second the trend vector will not be active.

An airspeed trend vector, which displays an indication of the direction and rate of airspeed change, extends vertically from the apex of the current airspeed value display window. It extends upward for acceleration and downward for deceleration. The trend vector represents a prediction of what the airspeed will be in 6 seconds if the current rate of change is continued.

Loss of valid calibrated or true airspeed information along with a loss of valid acceleration or pitch from the AHRS, will remove the trend vector from the airspeed display.

## AIRSPEED/MACH REFERENCE BUG READOUT

The Airspeed/Mach digital readout is displayed at the top of the indicated airspeed tape in cyan, during FLC CAS or FLC MACH active pitch modes. The cyan reference bug to the right edge of the airspeed tape also indicates the selected airspeed graphically. If the selected airspeed is off of the scale a half-sized bug will be shown at the appropriate end of the airspeed scale.

In the event valid airspeed information is lost from the air data modules, the airspeed digital readout will turn to amber dashes "-----" and the reference bug will be removed

### OVERSPEED INDICATIONS

Below 8000 feet altitude the limiting airspeed ($V_{MO}$) is 270 KIAS; between 8000 feet and 29,833 feet the limiting airspeed is 305 KIAS. When one of these limits is exceeded, the airspeed indication in the window to the left of the attitude display in the PFD will be changed to red and an amber indication, also to the left of the attitude sphere, will indicate MAX SPEED. A red thermometer type tape is also presented on the inside of the airspeed scale. The thermometer extends from $V_{MO}/M_{MO}$ to larger airspeeds on the tape and appears in the indication as the airspeed reaches into the range near $V_{MO}/M_{MO}$. A horizontal barber pole line will be positioned at the $V_{MO}$ value representing the maximum operating airspeed. When the limiting airspeed is exceeded the overspeed warning aural alert will sound, and will continue to sound until the airspeed is reduced below the limit speed.

**NOTE**

The aural warning system consists of two separate units which receive input from airplane anomalies of overspeed, autopilot off and altitude alert. The units will output aural signals to both the headphones and speakers.

### LOW AIRSPEED AWARENESS BAR

A red low airspeed awareness bar is positioned on the inside of the airspeed tape and shall extend upwards from the bottom of the airspeed tape to a position defined by the following formula: Top of the LAA bar = KIAS x Stall Warning ratio. To this effect the top of the bar will correspond to 1.1 $V_S$. Loss of valid calibrated airspeed information or AOA info will cause the LAA bar to be removed from the tape. Weight-On-Wheels indication also removes the LAA bar.

### AIRSPEED MISCOMPARE

When the monitor warning system (MWS) detects an airspeed miscompare, an amber boxed "IAS" will appear in the top half of the airspeed tape.

## MACH NUMBER DISPLAY

A green digital readout of indicated Mach number is displayed directly below the airspeed tape. The mach display will appear as the airplane reaches 0.450 Mach and remain until decelerating through 0.400 Mach. Mach readout resolution is .001 Mach.

# TYPICAL AIRSPEED DISPLAY

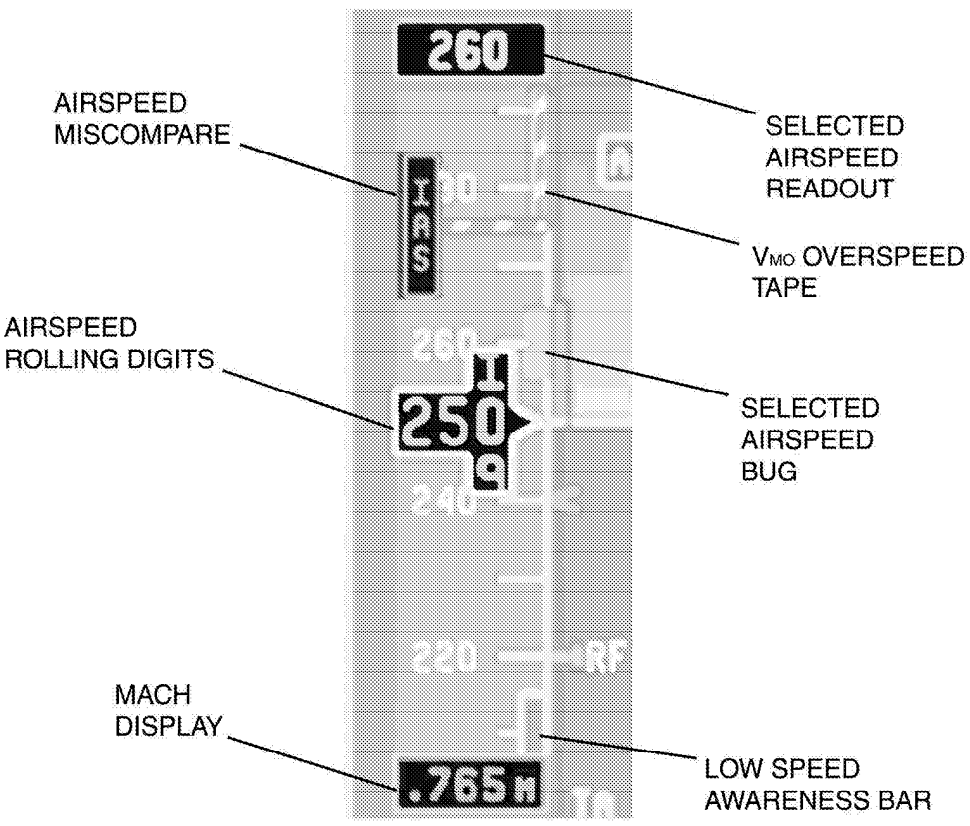


Figure 3-3

## ALTITUDE DISPLAY

The altitude display is located to the right of the attitude display on the Primary Flight Display (PFD). The altitude is indicated by means of a vertical tape display which has a “rolling digit” window in the center of an altitude vertical tape. The resolution of the digits is 20 feet. The hundreds, thousands, and ten thousands digits are larger digit numerals than the others. The vertical tape moves behind the window and displays a tape 550 feet both above and below the present indicated altitude, with the larger numbers at the top of the scale. The range of the altitude window is from -2000 to +60,000 feet with tick marks located at 100 feet increments. Single-line chevrons denote the 500 feet increments and double-line chevrons the 1000 feet marks. The chevrons extend back to the approximate midpoint of the altitude tape and are connected with each other by a vertical line.

The barometric pressure setting is controlled by a BARO knob on the DC-840 display controller. A STD button, in the BARO SET knob, allows a change to a barometric altimeter setting of 29.92 in. Hg. (or 1013 millibars) by simply pressing it. The baro correction setting display is located just below the altitude display. The BARO knob will change the altitude correction by 0.01 in. Hg. per click.

Standby altitude indications are available from the standby flight display (standby airspeed/ altitude/attitude indicator) which is discussed under Standby Flight Display System later in this section.

### ALTITUDE TREND VECTOR

An altitude trend vector is displayed on the left edge of the altitude tape and provides an indication of the rate of altitude change. The trend vector extends vertically from the apex of the current altitude display window. The vector extends up for positive vertical trends and down for negative values. The vector represents a prediction of what the altitude will be in 6 seconds if the current vertical speed is maintained. For altitude trend values less than +/- 20 feet, the altitude trend vector display shall be removed.

## VERTICAL SPEED INDICATION

The vertical speed information is displayed in the upper right hand area of each PFD and is comprised of a scale, digital readout, and target speed. The range of the vertical speed indicator is 0 to ±6000 feet-per-minute with enhanced resolution from 0 to ±2000 feet-per-minute with tick marks every 500 feet for the first ±2000 feet-per-minute climb or descent rates.

The vertical speed indicator is a fixed type meter display. Selected vertical speed targets are displayed in the vertical speed readout box located at the top of the vertical speed indicator. A cyan vertical speed bug is displayed at the selected vertical speed tick mark on the indicator.

# TYPICAL ALTITUDE DISPLAY

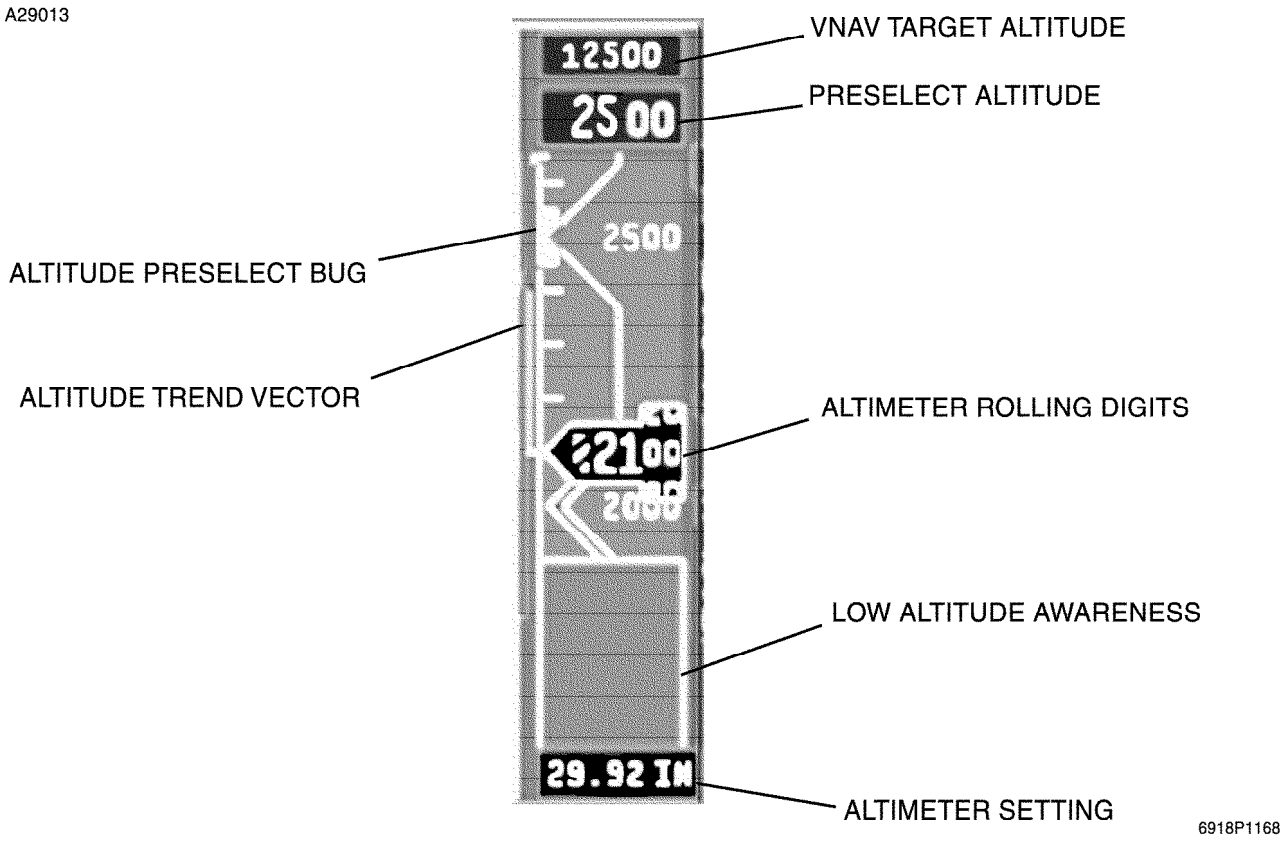


Figure 3-4

## ROLL POINTER/SLIP SKID DISPLAY

The slip skid display is located at the top of the attitude display in the PFD. Coordinated flight is depicted as an alignment of the triangle with the associated rectangular block directly under the triangle.

## RAM AIR TEMPERATURE INDICATOR

Ram Air Temperature is displayed on the pilot and copilot MFDs in the Engine section of the EICAS display.

# VERTICAL SPEED DISPLAY

A29014

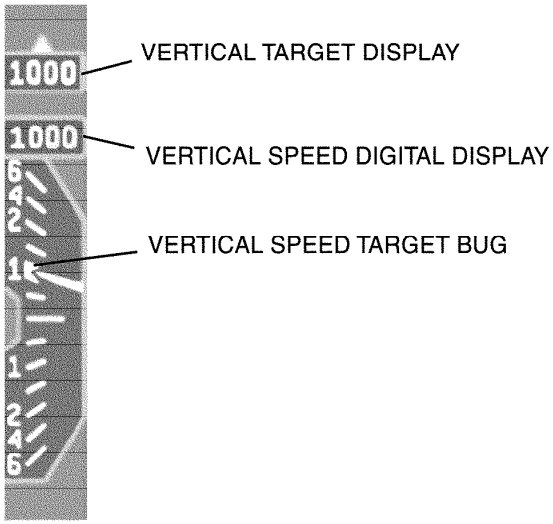


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Figure 3-5

## STANDBY ENGINE INSTRUMENTS

A standby engine indicator is installed between the MFDs in the center instrument panel. The indicator combine six liquid crystal displays to relay engine $N_1$%, $N_2$%, and ITT°C information to the flight crew in the event of a loss of power to the EICAS system. Power is normally provided to the standby engine instruments by the RH feed bus. In the event that this power source becomes unavailable, a standby battery located in the nose compartment will supply electrical power. A placard showing engine operating limits is located directly below the information display.

In the event of a FADEC becoming unreliable the standby engine indicator has the redundancy of using a second FADEC to provide the flight crew with engine power and temperature information. During initial power up the standby indicator will display all eights (8s) and flash these digits for approximately three seconds. If the display shows all dashed lines, the information on the ARINC-429 serial bus data line is invalid or a signal has been lost.

## FLIGHT HOUR METER

The quartz hour meter, located next to the right circuit breaker panel, displays the total flight time on the airplane in hours and tenths. The landing gear squat switch activates the meter when the weight is off the gear. A small indicator on the face of the instrument rotates when the hour meter is in operation. It receives DC power from the FLT HR METER circuit breaker located on the left circuit breaker panel.

## STANDBY FLIGHT DISPLAY

A Standby Flight Display (SFD) System indicator is located in the center instrument panel between the pilot and copilot MFDs. This DC-powered AMLCD combines a standby attitude indicator, altimeter, and airspeed indications into one composite instrument. A Mach indication is also included in the instrument. Information for the SFD is obtained from the standby air data module via a dedicated ARINC-429 data bus.

The SFD is a stand alone unit containing inertial sensors for the measurement and presentation of aircraft pitch and bank attitudes. Application of 28-volt DC power to the display system initiates the attitude initialization process, which is identified by the display of the message “attitude initializing” in yellow on the SFD. The duration of the initialization process is normally less than 180 seconds.

The attitude display has an instantaneous display range of 360° of bank and 50° of pitch. A moving tape on the right side of the display includes a “rolling digit” depiction of altitude. Altitude tape information is displayed in 100 foot increments. Barometric pressure is set in the altitude display by a knob on the bottom right of the bezel; clockwise rotation increases the pressure setting and counterclockwise decreases it. The setting is displayed simultaneously in millibars at the top right of the display and in inches of mercury at the bottom right. On the left side of the display is a moving tape showing airspeed. The tape is marked in ten knot increments with a “rolling digit” display in the center. The airspeed display becomes active at 40 knots. The Mach number is displayed in the upper left corner of the display. The Mach display range is 0.300 to 0.999 Mach.

Failure flag indications for airspeed and altitude are red crosses covering the appropriate tape box, with all indications removed from within the box. The failure flags for the Mach indication and Baro Setting are a series of four red dashes in the appropriate display area.

A light sensor is located on the bottom left side of the instrument case. It provides ambient light level data to the backlight control system to ensure optimum display brightness. The lighting level can still be controlled manually from the center instrument panel light rheostat control.

# STANDBY FLIGHT DISPLAY


Figure 3-6

The navigation display is selected by the APR button on the bottom of the display bezel. Pressing the button results in display of ILS localizer and glideslope information from NAV 1 receiver. The ILS can be flown by reference to the ILS localizer and glideslope display on the standby horizontal situation indicator.

Power to the SFD is controlled by a switch marked STDBY PWR ON/OFF/TEST located on the electrical control panel at the lower right corner of the pilot's instrument panel. The SFD receives power from the RH feed bus, normally supplied by the RH generator. In the event this power source becomes unavailable the standby battery located in the nose compartment will supply electrical power to the standby instruments.

The battery pack is constantly charged by the airplane's electrical system, and should therefore be fully charged in the event of an electrical power failure. The STDBY PWR switch must be ON for automatic transfer to battery power to occur. The SFD will operate for a minimum of 30 minutes on battery power. An amber POWER ON light next to the STDBY PWR switch illuminates when the SFD is turned ON and the airplane's electrical system is not charging the emergency power supply batteries. When the SFD switch is held to the springloaded TEST position, a self-test of the battery and circuits is accomplished. The green GYRO TEST light, also next to the STDBY GYRO switch, will illuminate if the test is satisfactory and the battery is sufficiently charged.

When NAV 1 is tuned for ILS operation, pressing the APR button will select ILS localizer and glideslope display. Pressing the button a second time will provide back course display, and pressing it a third time will revert the display to non-ILS format.

Maximum allowable airspeed ($V_{MO}$) is displayed in analog form by a red warning strip on the airspeed tape. When $V_{MO}$ is reached, the numerals on the numeric airspeed display change from white to red. When the maximum allowable Mach number ($M_{MO}$) is reached, the numeric Mach number display will also change from white to red.

A built-in test system (BIT) will automatically detect any failure of the display at power up or during continuous operation. If the pilot desires to test the system after it is powered up, pressing the ATT button will initiate a self-test. If a failure is detected, the appropriate part of the display is replaced with a message indicating the failure. Where it is not possible to display an appropriate message, the display backlight is switched off.

## ELECTRONIC STANDBY HORIZONTAL SITUATION INDICATOR

The Electronic Standby Horizontal Situation Indicator (EHSI) is a three-inch instrument located on the center instrument panel. The EHSI provides short range navigational guidance in case of PFD failure, Flight Director failure, or primary electrical system failure. The EHSI is “hard-wired” to the NAV 1 receiver and is powered by the emergency DC bus.

The EHSI displays compass heading, glideslope and localizer deviation and airplane position relative to VOR radials. The compass card is graduated in 5° increments and a lubber line is fixed at the fore and aft positions. Azimuth markings are fixed at 45°, 135°, 225°, 270°, and 315° on the compass face. A fixed reference airplane is in the center of the EHSI, aligned longitudinally with the lubber line markings.

The course cursor is set by a knob on the instrument. Once set, the cursor rotates in its set position with the compass card. The course deviation bar, which forms the inner segment of the course cursor, rotates with the course cursor.

A blue ADF needle, which displays ADF 1 bearings, rotates around the outer portion of the dial.

A heading (HDG) flag will appear in the instrument when the compass system is OFF, the heading signal from the SFD becomes invalid, primary power to the indicator is lost, or the error between the displayed heading and the received signal becomes excessive.

The course deviation bar moves laterally in the HSI, in relation to the course cursor. Course deviation dots in the HSI act as a displacement reference for the course deviation bar. When tracking a VOR, the outer dot represents 10°, while on an ILS localizer it represents 2.5°. White TO-FROM flags point to or from a station along the VOR radial when operating on a VOR. A red warning flag comes into view when power is OFF, when NAV information is unreliable, or when signals from the NAV receiver are not valid. The standby HSI displays only NAV 1 information.

The glideslope deviation pointer is located to the right side of the display. When receiving glideslope information during an ILS approach, the green deviation pointer will be uncovered by the red VERT warning flag which will normally be visible. If an ILS frequency is not tuned and being received, or the ILS signal is unusable or unreliable, the deviation pointer will be covered by the red warning flag.

# STANDBY HSI


Figure 3-7

## DIGITAL CLOCK

The Honeywell Primus EPIC integrated Avionics system uses an integrated digital clock. A section in the PFDs labeled CLOCK is located at the lower left hand side of the display. The digital readout provides the time of day in hours, minutes and seconds in the HH:MM:SS format.

### Elapsed Timer

The ET button on the DC-840 display controller replaces the Groundspeed/Time-to-Go (GSPD/TTG) display with a digital clock display. The digital clock can be started, stopped, and reset with multiple pushes of the digital clock display. Functions of the elapsed timer are count up, count down, hold, and reset as selected by the Display Controller function. Additionally, there is a preset function using the TIMERS page on the Multifunction Control Display Unit (MCDU).

The first activation of the ET pushbutton selects the Elapsed Timer clock for display. If a preset time has been set on the TIMERS page of the MCDU, activation of the ET pushbutton will cause the elapsed timer to count down. If a preset time has not been set (elapsed timer = zero), activation of the ET pushbutton will cause the elapsed timer to count up. Additional activation of the ET pushbutton will be the same for both the count up and count down modes as follows:

Start (Count up/down) ---> Stop ---> Reset ---> Start

If the selection remains in the reset state for 10 minutes, or the ET pushbutton is held depressed for 2 seconds, the elapsed timer display will be selected to off. When the reset mode is selected following a count down from a preset value, the elapsed timer is set to zero and the elapsed timer preset value set using the MCDU will be deselected.

# DIGITAL CLOCK AND ELAPSED TIME DISPLAY

A29016


6918P1168

Figure 3-8

## ANGLE-OF-ATTACK/STALL WARNING SYSTEM

The Angle-Of-Attack (AOA) and Stall Warning system senses airflow relative to airplane angle of flight and provides that information for display and stall prevention. A stall warning angle-of-attack transducer (SWAAT) actually senses AOA and combines the AOA and stall warning functions into one Line Replaceable Unit (LRU). Each LRU consists of an AOA vane and a Stall Warning Computer.

The AOA/Stall Warning system is made up of a left and right channel. Pilot and Copilot systems receive input information from the following: Anti-Ice switch, transducer, landing gear position inputs, MAU inputs, Weight-On-Wheels input, and computes a normalized angle-of-attack for display in the AOA section of the PFDs. Outputs to the stick shakers are also computed. Low Airspeed Awareness (LAA) information is also displayed on the inside of the indicated airspeed tape.

A pilot activated self test mode is available by placing the Rotary Test Knob to the AOA position. In this position all related EICAS messages will be displayed, the AOA meter will function, stick shaker activation will occur.

Indications for the system are provided by the AOA PFD section and the AOA indexer located at the top center of the glareshield. Range for the AOA indicator is from 0.1 (zero lift condition) to 1.0 (maximum lift condition).

# ANGLE-OF-ATTACK DISPLAY AND INDEXER

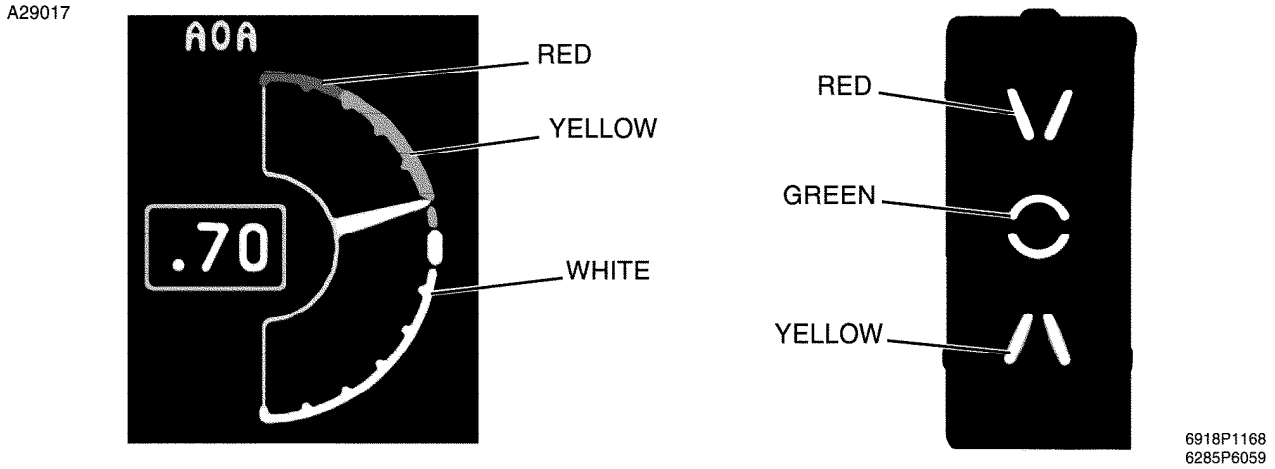



Figure 3-9

The area at the lower part of the scale **(0.1 to 0.57)** represents the normal operating range of the airplane, except for approach and landing. The narrow white arc **(0.57 to 0.63)** covers the approach and landing range and the middle of the white arc, 0.6, represents the optimum landing approach ($V_{APP}$ or $V_{REF}$). The yellow range **(0.63 to 0.85)** represents a caution area where the airplane is approaching a critical angle-of-attack. The red arc **(0.85 to 1.0)** is a warning zone that represents the area just prior to stick shaker activation and continuing to full stall. At an indication of approximately **0.79 to 0.88** (depending on flap setting and rate of deceleration) in the warning range, the stick shaker will activate.

If the AOA system loses power or becomes inoperative for other reasons the needle will deflect to the top of the scale and stow at a 1.0 indication. A red X will also appear at the ADI slow/fast indication. The airplane may not be flown if the stick shaker is found to be inoperative on the preflight check, or if the angle-of-attack system is otherwise inoperative.

A stick shaker is located on both the pilots' control columns, approximately 9 inches down from the control wheel and on the forward side. The stick shaker provides tactile warning of impending stall. The angle-of-attack transmitter causes the stick shaker to be powered when the proper threshold is reached.

**WARNING**

**IF THE ANGLE-OF-ATTACK VANE HEATER FAILS AND THE VANE BECOMES ICED, THE STICK SHAKER MAY NOT OPERATE OR MAY ACTIVATE AT NORMAL APPROACH SPEEDS.**

# AVIONICS

The Citation Sovereign is equipped with the Honeywell PRIMUS EPIC Integrated Avionics System. It is an automatic flight guidance, flight management, and electronic display system with four Active-Matrix Liquid Crystal Display (AMLCD) units.

Four Modular Avionics Units (MAUs) are installed on the Citation Sovereign and comprise the heart of the Primus EPIC system. Two are located in the nose avionics compartment and two in the aft tailcone avionics compartment. The two nose installed MAUs receive pitot-static information to be presented on the Honeywell DU-1080 AMLCD panels located in the cockpit. Attitude heading information is provided to the MAUs through the dual attitude heading and reference system (AHRS).

Navigation and communications tuning are primarily performed using two Multifunction Control Display Units (MCDUs), which integrate these functions within the Flight Management System. The MCDUs are located on the forward section of the center pedestal.

The baseline avionics system includes the following subsystems:

Radio Management Capability - Dual
VHF Communication (VHF COMM) - Dual
VHF Navigation Systems (VOR, Marker Beacon, Localizer, Glideslope) - Dual
Distance Measuring Equipment (DME) - Dual
Automatic Direction Finder (ADF), with provisions for an optional second unit
Global Positioning System (GPS) - Dual
Mode S Transponder - Dual
Audio/Intercom/Passenger Address System - Dual
Electronic Display System (EDS) - Dual
Air Data System (ADS) - Dual
Automatic Flight Control System (AFCS) - Dual
Flight Management System (FMS) - Dual
Weather Radar
Engine Indicating and Crew Alerting System (EICAS)
Aural Warning / Tone Generation System - Dual
Fault Recording and Ground Maintenance Access and Downloading Capabilities
Radio Altimeter (RA)
Clock - Dual on EDS
Enhanced Ground Proximity Warning System (EGPWS)
Traffic Collision Avoidance System (TCAS)
Antennas (TCAS Directional, ADF, GPS, WX, and Radio Altimeter)
Takeoff and Landing Data Computer
Attitude and Heading Reference System (AHRS) - Dual (not Honeywell)
Angle-of-Attack Sensor (AOA)

# MULTIFUNCTION CONTROL DISPLAY UNIT (MCDU)

The Multifunction Control Display Unit (MCDU) is capable of controlling several functions of the Citation Sovereign avionics system. 12 line select buttons, 6 on each side of the MCDU display screen, a dual concentric knob, command select buttons, and an alphanumeric keypad allow for command inputs to the MCDUs.

The MCDU is the central control unit for the Primus EPIC integrated communications system. Line select buttons are used to simplify operation by the flight crew of radio frequency tuning, selection and memory storage. Any selectable radio parameter can be changed by pushing the corresponding line select button to place the cursor box around the inactive frequency on the display. Once selected, the frequency is tuned with the TUNING knobs located on the lower right hand side of the MCDU display screen.

A viewable area of 14 rows by 24 columns is available on the display screen. This area is also divided into sections associated with the appropriate radio function (COM, NAV, ADF etc.). A paging system is used to identify and control the radio associated with the EPIC integrated communications system.

## LINE SELECT BUTTONS

Pushing a line select button causes the data field associated with that button to be highlighted. Transfer of information from the scratchpad will also be attempted if available and the data is valid for that particular radio or function. The cursor will allow the TUNING knobs to change the digits or modes selected. In some cases the line select buttons will toggle modes or recall a stored frequency. Additionally, if the line select button is pushed and held, the ADF and ATC memories are recalled, or the system enters or exits the COM NAV direct tune mode.

## SCRATCHPAD AREA

Radio tuning information can be entered using the scratchpad area on the bottom line of the MCDU display. Alphanumeric data after being typed directly into the scratchpad can be transferred to a destination field. Destination field identification is accomplished by pressing the corresponding line select button. Validation of the format is determined by the field the data is to be transferred to. If the data is valid the field will accept the input from the scratchpad. In the event of an invalid format the "INVALID ENTRY message is displayed. Pressing the CLR (clear) button will remove the "INVALID ENTRY" message. Scratchpad data is cleared once it is transferred to the appropriate destination.

## RADIO FREQUENCY SWAPPING

Three types of radio frequencies can be displayed. The ACTIVE frequency is displayed in green and is set for receiving and transmitting. A STANDBY frequency is shown in white directly below the active frequency, this frequency is usually the one changed using the TUNING knobs or the scratchpad. The third frequency is the MEMORY frequency that is stored for later use.

Selection of the STANDBY frequency for use occurs by pressing the line select button next to the ACTIVE frequency. This causes the STANDBY to "swap" positions making it the ACTIVE frequency and vice versa.

## VHF COM/NAV RADIO OPERATIONS AND TUNING

Primary control of the VHF COM radios is through the MCDU. The standard equipment COM 1 and COM 2 radios are supported by the MCDU.

Each MCDU contains two types of radio display pages. The main page is the RADIO 1/2 and the detail page is COM. A detail page for each COM radio is used. To display the RADIO 1/2 page press the RADIO button once. RADIO 1/2 gives tuning access to change frequencies on COM 1 or COM 2, ACTIVE and PRESET COM frequency access, and capability to move to the COM detail pages.

Tuning of the COM radios is accomplished by accessing the RADIO 1/2 page. The inactive PRESET frequencies will be displayed in white under their respective COM radio display section. Using the concentric tuning knobs on the MCDU panel will allow direct tuning of the PRESET frequency. Once the PRESET frequency is tuned pressing the line select button next to the ACTIVE frequency will change the PRESET and ACTIVE frequency positions, making the PRESET frequency now ACTIVE. Direct tuning of the ACTIVE frequency is made possible by using the scratchpad as explained previously in this section.

Accessing the COM detail pages allows the flight crew to tune COM 1 and COM 2 storage frequencies for later use. Separate detail pages for each COM radio are available to the flight crew. The COM detail pages allow for direct tuning of the ACTIVE COM frequency through the scratchpad function. PRESET tuning in the COM detail page is available through the use of the TUNING knob. Each COM detail page also allows for the entry of up to 12 frequencies to be stored for later use using the MEMORY feature.

NAV radio functions are also accessed in the RADIO 1/2 page. Frequency tuning/storing for the NAV radios is operated identically to the COM radios.

Refer to the Honeywell Primus EPIC Pilot's Manual, Part No. A28-1146-168-V1, or later revision for a complete description of radio operations and functions.

## TRANSPONDER AND TCAS RADIO OPERATIONS AND TUNING

The RADIO 1/2 page is the main controlling page for tuning transponder code information. Two transponder detail pages label XPDR/TCAS 1 and 2 are accessed by pressing the line select button next to the TCAS/XPDR display line.

Direct tuning of the transponder code can be accomplished using keypad inputs with the cursor box around the XPD code select line on the RADIO 1/2 page. Pressing the line select button next to the IDENT line will IDENT the transponder to the ATC facility upon request.

TCAS/XPDR Detail page 1/2 will show the ACTIVE and PRESET transponder frequencies. Default for the PRESET Transponder code is 1200 (VFR). Along with the transponder code the detail page will also display pressure altitude, selected transponder module, airplane ID (N12345), the IDENT line select button, and RADIO 1/2 return to line.

# MULTIFUNCTION CONTROL DISPLAY UNIT (MCDU)

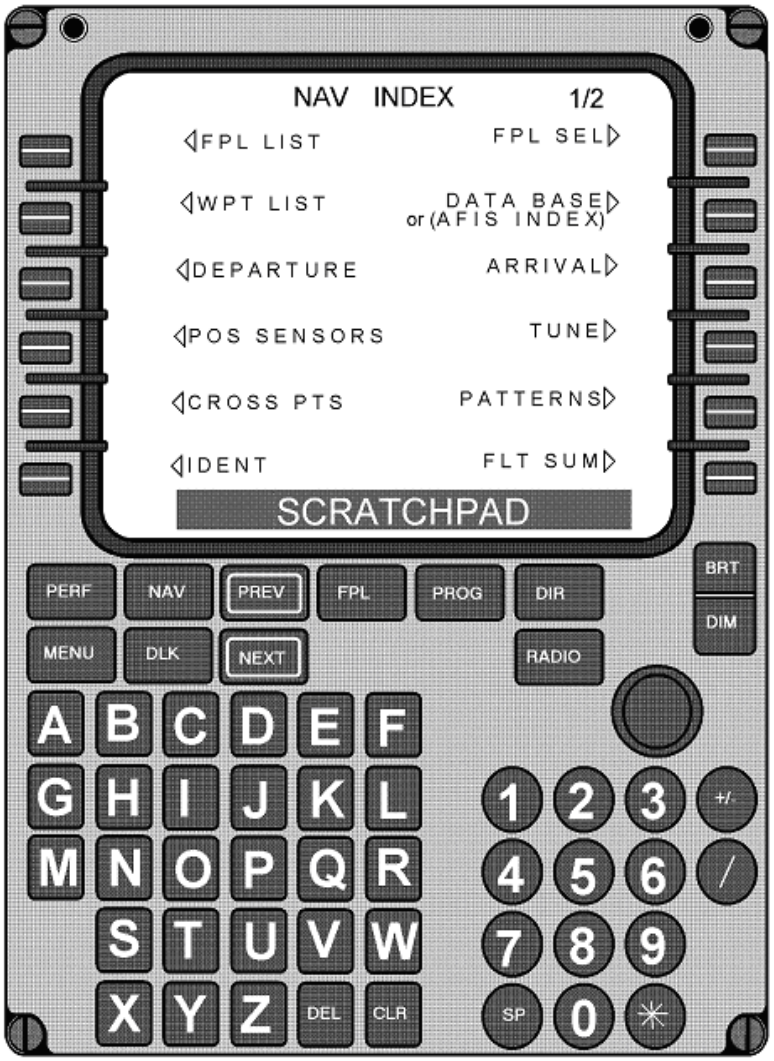



Figure 3-10

## CURSOR CONTROL DEVICE (CCD)

Two Honeywell CC-950 Cursor Control Devices (CCDs) are installed in the center pedestal in the cockpit. The CCD consists of a trackball, three display selection buttons, a conical switch, a TCAS window selection button, a dual concentric knob, and an enter button on either side of the palm rest.

Three display selection keys correspond to the respective crewmember displays. The pilot CCD controls DU1, DU2 and DU3, the copilot CCD controls DU2, DU3 and DU4. In the case where the pilot and copilot may have selected the same display, the last cursor to select the display will have priority. The default position of the corresponding CCD is the pilot's CCD to DU2 and copilot's CCD to DU3.

### PFD OPERATION

CCD operation for the PFD is limited to changing the range of the HSI display when in the Arc mode. When the CCD is active on the PFD, the trackball and Enter buttons have no effect and no cursor is displayed.

Range is able to be changed on the PFD anytime the PFD is in the Arc Mode and is selected on the CCD. Selections available for the range are 5, 10, 25, 50, 100, 200, 300, 500, and 1000 NM. PFD and MFD range will be synchronized any time the MFD is in the MAP mode.

# CURSOR CONTROL DEVICE (CCD)

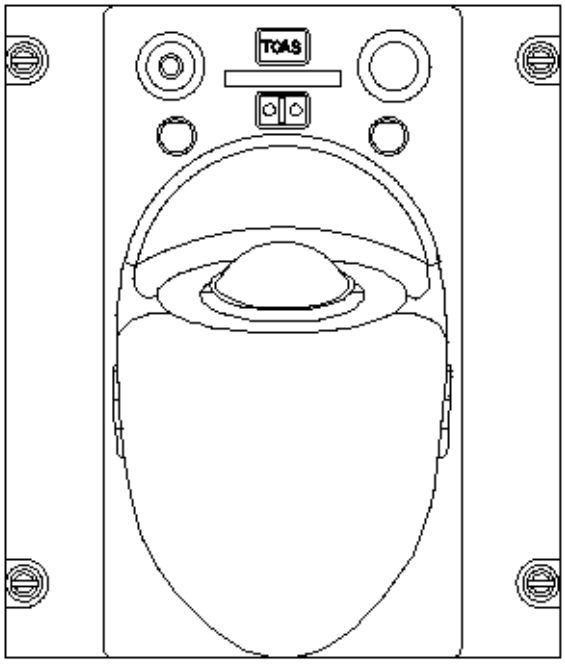



Figure 3-11

## MFD OPERATION

Operation of the MFDs using the CCD will allow the flight crew to control radio tuning, MAP/Plan range control, TCAS window control, checklist control, flight plan designator, and drop down menu operation. The default position of the CCD on the MFD format is the COM unit STANDBY frequency. The CCD cursor box will be displayed in this position on initial power up, initial selection of MFD format, and after 20 seconds of inactivity.

## RADIO TUNING

The radio tuning default position on the MFD of the CCD is the displayed COM unit's STANDBY frequency. At power-up, the displayed COM and NAV unit is the on-side unit. The active radio unit being controlled by the CCD (COM, NAV or XPDR) will be highlighted by boxing the unit's STANDBY frequency, or ACTIVE channel for the XPDR, and the displayed frequency information will be in a larger white font.

### COM Tuning

Tuning of the COM frequency is accomplished by using the dual concentric knob at the upper right on the CCD. This will change the PRESET frequency in the MFD COM display box. To activate the PRESET frequency, with the CCD selected to the desired COM radio box, press either of the Enter buttons on the side of the palm rest.

### NAV Tuning

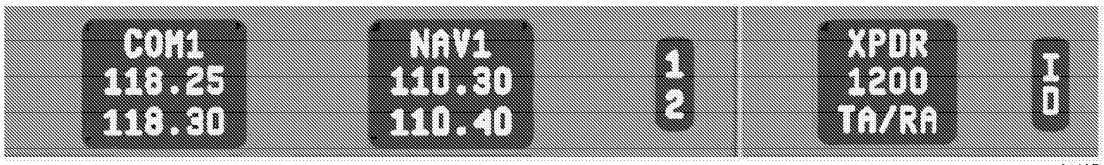
The CCD must be selected to the active MFD by pressing the display control buttons at the top of the CCD. Once the active MFD is selected, tuning of the NAV radios is effected by rolling the trackball until the desired NAV radio box is selected at the bottom of the MFD. Once the cursor is moved to the desired NAV radio, the STANDBY frequency can be tuned with the dual concentric knob on the CCD. Pressing the command button on either side of the CCD will make the STANDBY frequency ACTIVE.

### COM1/NAV1 - COM2/NAV2 Radio Selection

The displayed COM/NAV unit pairing can be changed from COM/NAV1 to COM/NAV2 by activating the 1 - 2 selection box to the right of the COM/NAV tuning box. Move the CCD cursor to this box and press either command button on the side of the palm rest to switch the active unit pairing.

# FREQUENCY DISPLAY (MFD)

A29019




6918P1171

Figure 3-12

### XPDR TUNING

The displayed XPDR is the same as the primary XPDR selected on the XPDR details page on the MCDU. Tuning of the XPDR code is accomplished by first selecting the code value. To select the code value, the CCD must be activated on the MFD by pressing the respective display select button on the CCD. Once the cursor is active in the display, use the trackball to move the CCD cursor over the XPDR code. With the XPDR code chosen, the desired code can be selected using dual concentric knob on the CCD. The outer knob changes the left two digits and the right digits are changed by the inner knob.

### MFD RANGE CONTROL

Range control for the MAP/Plan formats on the MFD are controlled through the CCD. Range control is selected by either of two ways: toggle the MFD display selection button on the CCD until the range value on the display is highlighted as active, or use the trackball to move the cursor over the range value on the display and click either command button on the side of the palm rest. Range can then be selected by using either knob on the CCD. The available range values are 5, 10, 25, 50, 100, 200, 300, 500, and 1000 NM. The range value for the MAP or Plan formats is independent. The range default value at power-up is 100 NM.

#### MFD MENU OPERATION

Four display control dropdown menus are available at the top of the MFD. These are the CHECKLIST Menu, TCAS, MAP, and PLAN. Moving the cursor with the trackball to the desired dropdown arrow and then pressing either command button on the side of the palm rest will activate the menu. Pressing the command button on either side of the palm rest while the cursor is over the MENU title put the MFD into the respective mode.

## STUCK MICROPHONE PROTECTION

An automatic out-of-time feature is incorporated to avoid the problem of the communications system becoming locked in the Transmit mode. After approximately two minutes have elapsed of continuous transmission, the COMM turns the respective transmitter OFF and sounds a beep to alert the flight crew to the automatic shutoff. The respective COMM radio then reverts to the receive mode eliminating a stuck microphone button problem.

## MODULAR AVIONICS UNITS (MAUs)

Four Modular Avionics Units are installed in the Citation Sovereign. Two nine-user slot versions are located in the forward avionics bay and two five-user slot versions are located in the aft avionics bay. Due to the nature of the computer processing, one unit is now used to perform the tasks that required individual processors in the past.

## MODULAR RADIO CABINETS (MRCs)

Two Honeywell MRC-855A Modular Radio Cabinets (MRCs) are installed in the Citation Sovereign, both are located in the aft avionics bay. The MRCs integrate all communication, navigation functions including VOR, ADF, DME, ILS, VHF Communication and Diversity Mode S transponder modules. Each major function has its own associated module with a self contained power supply.

## VHF COMMUNICATIONS

### HONEYWELL PRIMUS EPIC INTEGRATED RADIO AND AUDIO SYSTEM

The integrated radio and audio system installed in the Citation Sovereign is of the dual configuration, with system 1 controlling the pilot's side COMM/NAV functions and system 2 controlling the copilot's side. The integrated radio system interfaces with the Multi-function Control Display Units (MCDUs), AV-850A Audio Control Panel, Cursor Control Devices (CCDs), PFDs, and MFDs.

### VHF COMMUNICATIONS SYSTEM

Located in the Modular Radio Cabinet (MRC) are two Honeywell TR-865A Digital VHF Communications Modules. The TR-865A provides two-way air-to-air and air-to-ground communication in the 118.00 to 136.975 MHz frequency range with 8.33 kHz spacing.

Frequency and squelch control are provided from the Network Interface Bus. Analog audio is digitized by the COM unit cluster module and output on the digital audio bus. Digital audio is selectable and decoded in each audio panel. Along with a digital audio output a separate analog output is available with a sufficient bandwidth for SELCAL and ACARS data compatibility.

Two CCDs are installed at the back of the center pedestal. For radio tuning the mouse trackball can be moved into the correct position until the COM 1 or 2 box is highlighted at the bottom of either MFD. Once selected the frequency display will be in a larger font size. The active frequency select box will be outlined in green. Frequencies for COM 1 and COM 2 are shown with the active frequency on top and in green. Turning the dial to the top right of either of the CCDs will change the inactive frequency. Pressing the command buttons on either side will swap the inactive (white) frequency to the active frequency (green).

## VHF NAVIGATION MODULE

Housed in the Modular Radio Cabinet is the Honeywell NV-855 Navigation Module. This module enables VOR enroute and terminal navigational and area guidance, Localizer/Glideslope (LOC/GS), and Marker Beacon (MKR) distance to runway threshold information. The VOR/LOC receiver operates in the frequency range of 108.00 to 117.95 MHz in 50 KHz increments. A glideslope frequency range of 329.15 to 335.0 MHz is also available in 150 kHz increments. Localizer and Glideslope channels are automatically paired by the receiver. The Marker Beacon receiver operates at 75 MHz and has a high/low sensitivity switch located on the AV-950A audio panel.

## DISTANCE MEASURING EQUIPMENT (DME) MODULE

Dual Distance Measuring Equipment (DME), DM-855, modules are installed in the Modular Radio Cabinets. Each DME module operates in the 960.0 to 1215.0 MHz frequency range. The DME modules are capable of tracking four channels to provide slant range distance, ground speed, time to station and ident information. Two additional channels track station ident of preset channels for rapid acquisition when activated. DME frequencies are automatically paired with the VHF NAV or MLS channels depending on display selection.

Control for the NAV 1 and 2 radios is available using the MCDU NAVIGATION page.

## AUTOMATIC DIRECTION FINDER (ADF) MODULE

One DF-855 ADF module is installed in the pilots Modular Radio Cabinet (MRC 1) enabling navigational and area guidance by associated NDB stations on the ground. Provisions for a second optional ADF module installed in MRC 2 exist. It operates in the frequency band of 190.0 to 1799.5 kHz being tunable down to 0.5 kHz increments. In addition the maritime frequency range of 2181 to 2183 kHz can be selected for emergency listening.

Two selectable bandwidths are available for flight crew selection. The narrow band mode reduces noise during navigation use and the wide band mode will improve clarity when listening to voice signals.

Audio from the ADF is transmitted from the digital audio bus to each AV-850A audio control panel.

## TRANSPONDER MODULE

The dual ATC diversity Mode S transponder system enables aircraft identification, altitude reporting, and data link capability. The diversity Mode S transponder systems are part of the integrated radio system. The transponder function is a module in the radio cabinet. Code and mode selection and altitude data is given over the system network interface bus. The transponder gives data and control to the TCAS computer through an ARINC 429 link. Each transponder has dedicated dual antennas for TCAS operation. The transponder is an International Civil Aviation Organization (ICAO) Level 3 transponder.

## HF COMMUNICATION

An optional single or dual Honeywell KHF 1050 high frequency radio system is available. The KHF 1050 is a solid-state high frequency single sideband transceiver system which provides voice and data communication. Data communication is through an external modem.

## AUDIO/INTERPHONE SYSTEM

The digital audio system is part of the integrated radio system in that the audio digitization occurs within the remote mounted radio cabinets, even for radios such as the HF (high frequency) which are not inherently part of the Honeywell system. There is no separate remote mounted audio integrating LRU (line replacement unit) required. Audio is transmitted digitally from each side's cabinet on a shielded twisted wire pair to all audio panels in the system. All audio from one side is contained on the single digital bus.

The system gives the following functions:

-Interphone link between crewmembers
-Operation of communication and radio navigation audio systems with individual volume controls.
-Input of audio warnings (TCAS, GPWS, AW tones etc.)
-Operation of maintenance interphones
-CVR (calibrated voltage ratio) output
-PA (passenger address) selection and switched microphone output. (A separate A/CHIME amplifier is required).
-Audio bus interfaces
-Dual digital audio bus inputs
-Analog interphone audio bus
-Mask, boom, and hand MIC (microphone) inputs
-Selected MIC output to each transceiver
-Audio output drivers for cockpit and cabin speakers and interphone, headphone and CVR interfaces
-Five audio warning inputs
-Two maintenance crew interfaces.

# AV-850A AUDIO CONTROL PANEL

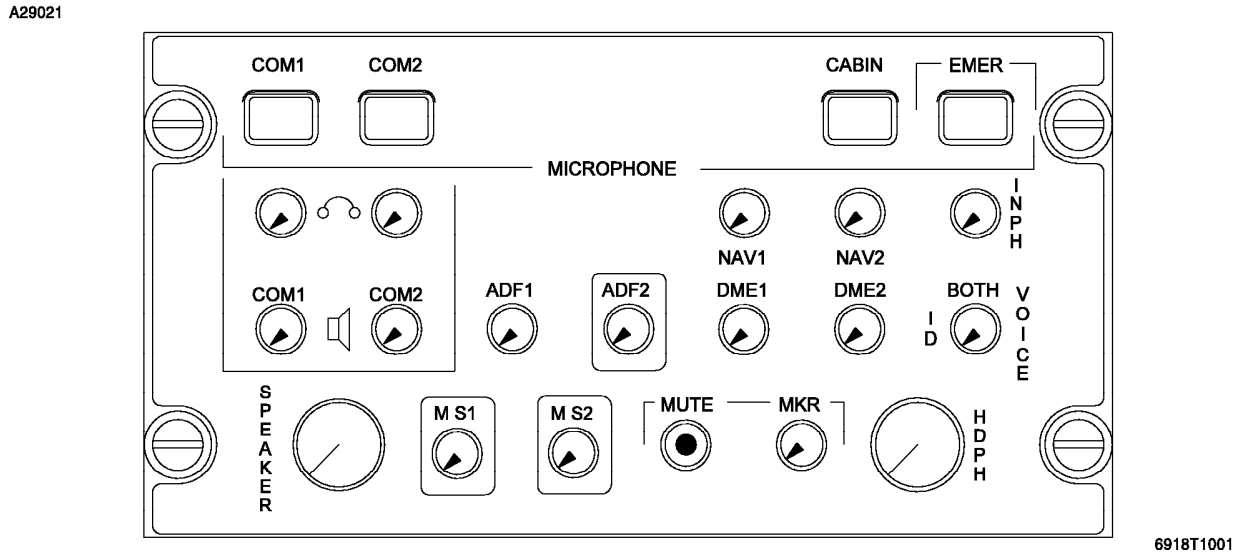



Figure 3-13

## AUDIO CONTROL PANEL

Two AV-850A audio control panels are installed in the cockpit instrument panel, one each on the pilot's and copilot's side. These units receive digital audio from the remote NAV and COM units through a high speed digital audio bus on each side of the airplane. Each panel selects the proper channels from the digital audio and creates a headphone and speaker signal.

Located at the top edge of each panel is a row of microphone select buttons. Once pushed these buttons connect the on-side microphone with the selected radio and enable the audio associated with that radio. This is regardless of the position of the ON/OFF buttons. Activation of the audio ON/OFF buttons latches it and the associated audio is turned off. Pushing the button energizes the audio to the headphone and speaker while also enabling volume adjustment through rotation of the popped up button.

Three rows of audio selector buttons and various microphone selector arrangements are on the panel. Inputs for intercom, crew annunciation, crew communication, hot microphone, and full time emergency warning inputs from airplane systems are also incorporated.

Digitized operation provides the advantage of allowing for each individual volume control to be adjusted independently by each flight crew member. An example of this would be when the pilot wants to have a loud COM 1 and a soft COM 2 and the copilot wants the VOR to be loud and COM 1 to be soft with a moderate COM 2, the audio panel can adjust each input individually.

# COCKPIT VOICE RECORDER

A35154

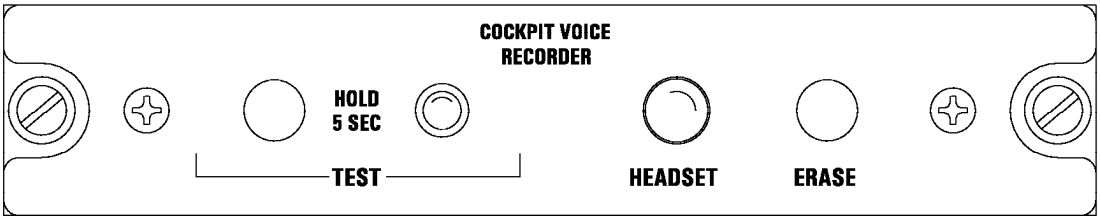



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Figure 3-14

## COCKPIT VOICE RECORDER

An FA2100 cockpit voice recorder (CVR) system provides a continuous 60-minute record of all voice communications originating from the cockpit as well as sounds from warning horns and bells. The system is protected by a 5-ampere circuit breaker (CVR) located in the LH power J-Box.

The sensitive microphone is located in the instrument panel near the lower right corner of the fire tray. The system is energized when the battery switch is in the BATT position. The control panel, located on the center pedestal, contains a TEST button, and an ERASE button. System operation is checked by pressing the TEST button. When the TEST button is held down for five seconds illumination of the green light on the control panel indicates correct functioning of the voice recorder system. Pressing the ERASE button for approximately 2 seconds will cause the entire record to be erased. Erasure can only be accomplished on the ground with the main entry door opened.

The installation is equipped with a 5-G switch which will activate any time the airplane is subjected to a five-G force; this will disable the system's erasure mechanism until a reset button on the G-switch is pressed. The switch is directly mounted to the CVR tray structure and is located in the tailcone. The CVR is also equipped with an underwater locator device which is located with the recorder mechanism in the tailcone.

## DIGITAL FLIGHT DATA RECORDER (PARTS 5 AND 135)

On airplanes which are equipped with one or more passenger seats and are operated under FAR Part 5 or 135, a digital flight data recorder (FDR), which continuously records at least 27 parameters of airplane and systems operation, is required. The optional L3 Communications FA2100 recorder installed in the Citation Sovereign records the information digitally by a solid state method and records up to 25 hours of data. Recorder operation requires no attention from crew members. An FDR FAIL CAS message will illuminate if the flight data recorder malfunctions or if power to the system fails. The flight data recorder receives 28-volt DC power through a 5-ampere circuit breaker (FDR) on the right circuit breaker panel powered by the right avionics bus.

# AUTOMATIC FLIGHT CONTROL SYSTEMS (AFCS)

## PRIMUS EPIC INTEGRATED AVIONICS SYSTEM

The Honeywell Primus Epic Integrated Avionics System combines previously separate avionics systems into a more unified system. Digital busses and interconnecting computer circuits provide capabilities and performance that have been unattainable in the past. The four modular avionics units (MAUs) manage most of the airplane subsystems including the flight management system (FMS), automatic flight control system (AFCS), and the electronic flight instrument system (EFIS).

The integrated avionics system, consists of the Collins AHS-3000 Attitude Heading and Reference System (AHRS), the Honeywell Traffic Collision and Avoidance System II (TCAS II), the Primus Epic integrated radio system, the Primus 880 weather radar system, and the RT-300 radio altimeter system.

The automatic flight guidance, FMS, and electronic display systems (EDS) are operated through cockpit sensors, displays, and controls which direct the computers. Command for flight director guidance, autopilot, yaw dampers, and automatic trim (Stabilizer and Mach Trim) originates with the AFCS. Attitude and heading information from the AHRS and air data information from the Air Data Modules is fed into the MAUs, which control the flight of the airplane and optimize performance.

A central serial wiring network, consisting of redundant buses of the avionics standard communications bus (ASCB) nomenclature, connects all the units on a bus. Left and right back-up busses connect units on their respective sides of the airplane, assuring communication redundancy. Further redundancy is assured by the integrated avionics computer (IAC) that communicates fault isolation between the flight guidance computer, the electronic display system (EDS), and the FMS, keeping a fault in one area from affecting other IAC functions.

A more detailed discussion of operation is found in the Primus EPIC for the Citation Sovereign, Pilot's Manual Pub. No. A28-1146-168, or later edition, which is provided with the Citation Sovereign. The Pilot's manual must be immediately available to the flight crew at all times.

## AFCS ROLE WITHIN THE COCKPIT

The Primus EPIC Automatic Flight Control System (AFCS), as installed in the Citation Sovereign, provides the following functions:

-Autopilot (including automatic pitch trim)
-Yaw Damper
-Flight Director Guidance

The autopilot functions will include pitch and roll control. The yaw damping function will include dutch roll damping and turn coordination.

## AFCS DESCRIPTION

The AFCS portion of the Primus EPIC system consists of the following components:

-AFCS processing within each MAU
-Single Guidance Panel (GP)
-Pedestal mounted pitch wheel
-Elevator, aileron, and rudder servos and brackets

The AFCS function is hosted in the Modular Avionics Unit (MAU). The Citation Sovereign installation contains two AFCS, to provide both manual and automatic reversion and interface capabilities sufficient to maintain full AFCS functionality, despite the absence of the other AFCS (due to failure). The fail-operational design of the AFCS provides automatic reversion following in-flight failure of an MAU. The reversion will be annunciated to the crew, but will result in no changes to the mode selection or engage status. Disturbance to the aircraft due to AFCS reversion will be minimal.

# PRIMUS EPIC SYTEM BLOCK DIAGRAM

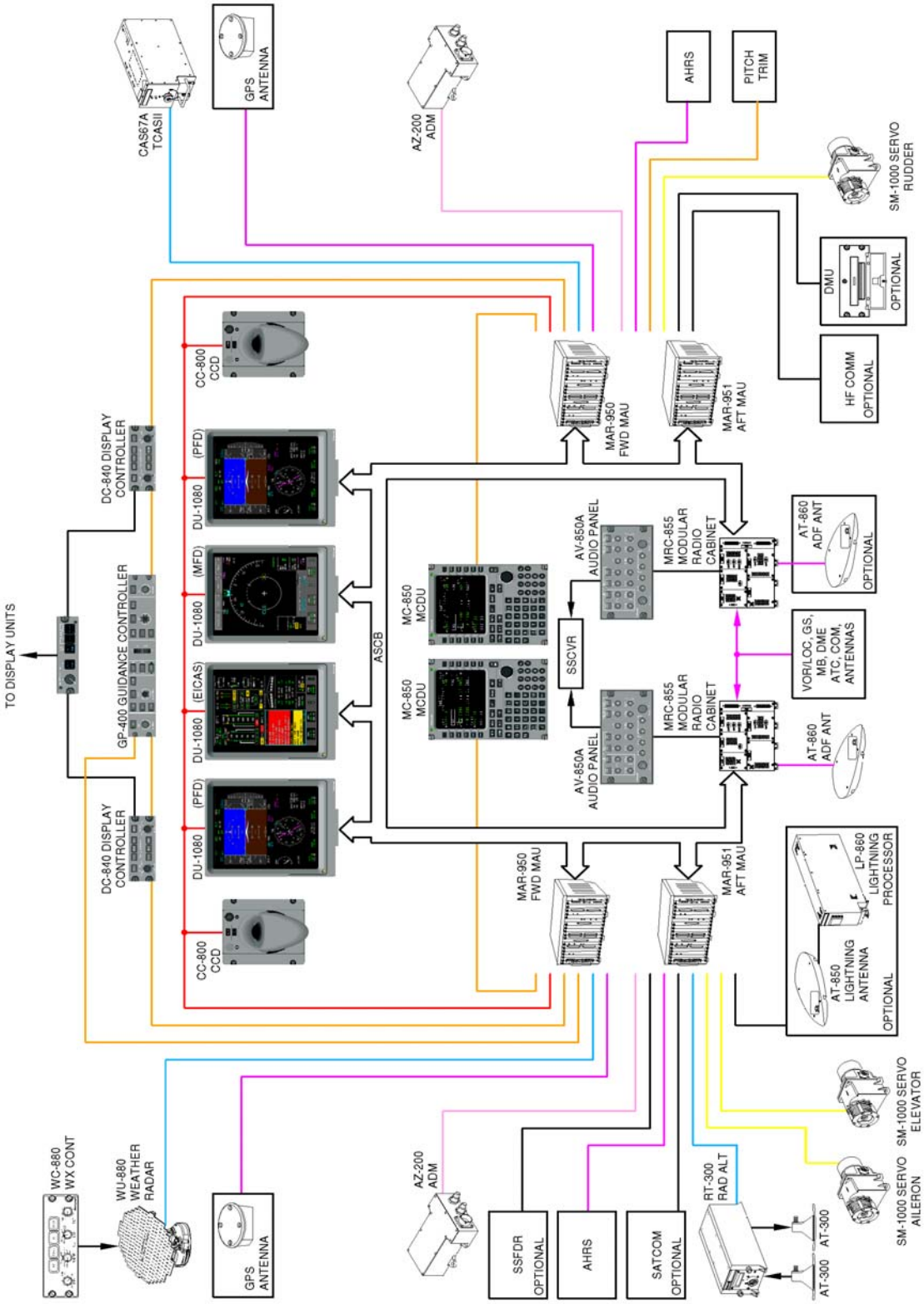



Figure 3-15

## GP-400 FLIGHT GUIDANCE CONTROLLER

The GP-400 Guidance Control Panel is the main interface between the flight crew and the Automatic Flight Control System. A single guidance control panel provides the means for selection of all AFCS functions except the master AFCS channel, Takeoff / Go Around mode (TOGA), Touch Control Steering and Quick Disconnect. Additional functions related to display control are also included within the guidance panel. The display control functions controlled via the guidance panel include: course pointers, heading bug, speed bug, pre-selected altitude reference, and flight director command bars out of view.

The AFCS functions controlled by way of the guidance panel include: flight director modes, pitch wheel references, engagement of the autopilot, and yaw damper function and selection of left or right Primary Flight Display (PFD) data to be used by the AFCS. The same pushbuttons will be used to activate and deactivate each function (toggle on/off).

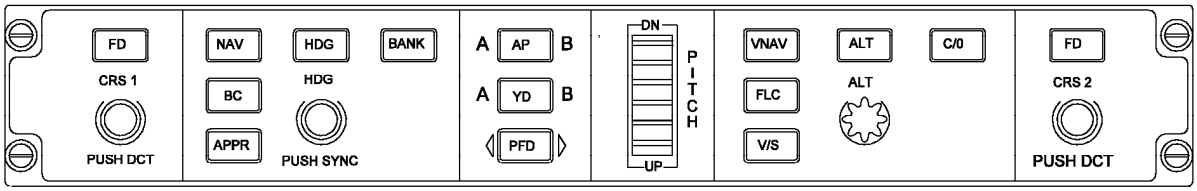
The flight crew may input vertical speed and pitch hold command changes via either pitch wheel (GP-400 or pedestal mounted unit). The pedestal mounted pitch wheel input to the Primus Epic system is through a Control I/O module.

### Servos and Actuators

Automatic control of the aircraft aileron, elevator, and rudder surfaces will be performed via SM-1000 servos. The SM-1000 servo will mount into a SB-1200 bracket. The servo bracket has a 2-inch drum diameter. The servo drum cable grooves are designed to interface with 1/8-inch diameter control system cable.

## GP-400 FLIGHT GUIDANCE CONTROL PANEL

A29075




6918T1001

Figure 3-16

The SM-1000 parallel servo is capable of interfacing with each AFCS channel via a digital bi-directional CAN bus, a motor enable discrete, and a clutch enable discrete. The servo will only accept commands from the priority AFCS channel. If more than one AFCS is shown as priority, no commands will be accepted. Excitation for the servo drum position synchro will only be provided by the priority channel. Preliminary servo selection will be made based on predicted control system loads and linkage ratio information provided by Cessna.

## Flight Control Interfaces

The primary interface to the AFCS is via the Avionics Standard Communication Bus (ASCB). The ASCB provides bi-directional communication between the primary functions within the Primus EPIC™ avionics system. The ASCB is also the medium by which the majority of the external aircraft system information is distributed to the AFCS and other avionics functions.

The AFCS interfaces directly to selected functions beyond the core MAU avionics system. These direct interfaces are warranted due to the nature and criticality of particular functions performed by the AFCS. The direct interfaces provide for faster transmission and reception of data for functions that are timecritical, thus minimizing data transmission lag times. The direct interfaces also provide alternate paths for selected signals in order to meet the safety requirements of the associated functions. Detail on the AFCS interfaces to external systems is provided in the following paragraphs.

### Control Surface Travel

-The maximum deflections for each elevator are 15° trailing-edge down and 15° trailing-edge up.
-The maximum deflections for each aileron are 14° trailing-edge down to 21° trailing-edge up.
-The maximum deflection for the rudder is ± 30.5°.
-The control column gearing to elevator, aileron, and rudder surface travel will be linear for normal autopilot inputs.

### Spoiler Interface

The Citation Sovereign uses combination speed brake/spoiler panels. The middle 3 panels in each wing are modulated and perform the speed brake and spoiler functions. The inboard most and outboard most panels are non-modulated panels that only perform the speed brake function.

### Control Wheel Interface

The AFCS will receive two discrete signals from the pilot and copilot control wheels, autopilot disconnect and touch control steering (TCS). The signals are provided by momentary switches on both control wheels:

Autopilot disconnect: The autopilot disconnect switches will be of the normally closed type and wired in series to ground. The output of the switches will be connected both to the guidance panel and directly to the AFCS within the MAU (Actuator I/O Proc Module Lane A). Dual paths are provided for the signal to meet safety requirements per the top-level system safety analysis. When either input path indicates open, autopilot engagement is inhibited but YD engagement is allowed. The signal also serves to silence the aural warnings in case of an abnormal AP disconnect.

TCS: The TCS switches will be of the normally open type and wired in parallel to ground. The output of the switches will be connected to the guidance panel. The guidance panel will re-transmit the status of the discrete input to the AFCS via private line serial bus. The TCS function will be active whenever the input is grounded. The TCS function momentarily releases the autopilot clutches, if engaged, and re-synchronizes the flight director.

### Throttle Interface

The AFCS will receive a discrete Take-Off/Go Around (TOGA) signal from the throttle quadrant. The ground/open signal will be provided by a momentary normally open switch in either throttle handle, and connected to both channels of the AFCS via the guidance panel. The signal will be used to initiate either take-off or go around modes in the flight director, based upon current conditions, and to disconnect the autopilot, if engaged.

### Aircraft Flight Control System

The control system requirements imposed by the autopilot and yaw damper are necessary to make sure the aircraft and its control system will provide a stable, controllable platform.

Requirements imposed by the autopilot and yaw damper on the aircraft flight control system are as follows:

Surface backlash, as seen by the servo or actuator, will not exceed 0.25° of surface deflection.
Total Control system Breakout friction will not exceed 20% of the authority limits of the servo or actuator, including breakout friction. Ideally, the control system friction should be less than 10% of the servo or actuator authority.

## GENERAL AFCS OPERATION

The AFCS is capable of performing the following functions:

-Flight director guidance
-Automatic pilot, including automatic pitch trim
-Yaw Damper

The dual channel architecture of the AFCS is configured in a master/slave arrangement. The high priority channel will provide control functions, while the low priority channel operates in a back-up mode as a 'hot' spare. In the event that the channel in control detects a failure, or is otherwise disabled, priority will switch to the other channel. The new master channel will continue to provide the required functions, with minimal disturbance to the aircraft during the transition. If possible, the original channel in control will recover from the invalid condition and take up the role of the low priority channel. Assignment of priority will alternate between channels on power-up in order to limit the exposure of either channel to a latent fault to one flight. Crew activated AFCS channel selection can be accomplished through an MCDU page. The autopilot/yaw damper actuators and the pitch trim interface will only be driven by the priority channel. Concurrent operation of the actuators by both channels of the AFCS is not be allowed. In order to maintain continuity of operation between channels, the low priority channel will slave itself to the high priority channel for the following functions:

-PFD selection
-Selection of flight director modes
-Engage status of AP/YD
-Guidance references:
  - Pitch hold reference
  - Roll hold reference
  - Altitude hold reference
  - Vertical speed reference
  - Heading hold reference

The listed references are those controlled within the AFCS. Other references used by the AFCS are drawn from displayed sources and not synchronized between AFCS channels.

## Flight Director Guidance

Through the flight director, the AFCS will provide flight guidance outputs for display on the primary flight displays (PFD). The flight director function will consist of the following elements:

-Mode selection
-Computation of guidance
-Data management and source selection
-Command bar output for display

### Display Presentation

The AFCS will output pitch and roll commands for display as the flight director command bars on the PFD. Where single source sensor data is to be used, the command bar computations will use data from the sensor suite selected via the PFD select pushbutton on the guidance panel. The AFCS will also output mode annunciation data and the PFD selection for display on both PFDs.

### EFIS Management of Data from the AFCS

The EFIS will receive flight director data from both AFCS channels and will select the data for display as follows:

-The targets and PFD selection (coupled status) will be based on the high priority AFCS.
-Pitch and roll command bars and mode annunciations will be displayed from the AFCS channel on the same side as the PFD (i.e. command bars and modes from AFCS A are displayed on the left PFD, etc.). If one of the flight directors is failed, both PFDs will display data from the remaining flight director and an indication will be provided on the PFD.

## AFCS Management of Guidance Data

Data used to compute guidance commands and mode control will be consistent with that displayed on the selected side PFD. Therefore, the AFCS will manage guidance data by acquiring its data from the same sources as those displayed on the coupled PFD. This will be accomplished via the following process:

1. Based on the PFD indication (left or right), the AFCS will use the following guidance data displayed on the selected PFD to handle its computation:

   -Air data source
   -Attitude source
   -NAV source
   -Course error
   -Heading error
   -Lateral and vertical path deviations and associated validity flags
   -Distance to station
   -Tuned-to-NAV and To/From status
   -Inner, middle and outer marker data
   -Radio altitude and associated validity flag

2. The source of other guidance information will be selected per the source identifier received from the selected PFD. The data received from the other units include:

   -Flight Management System (FMS):
   - Lateral steering command and associated validity flag
   - VNAV targets and associated validity flags
   - VNAV sub-mode selection flags
   -Air Data Computer (ADC):
   - Pressure altitude
   - Vertical speed
   - Mach
   - Calibrated airspeed (CAS)
   - True airspeed (TAS)
   - Dynamic pressure
   - VMO
   - MMO
   -Monitor Warning (MW):
   -Pre-selected altitude

The AFCS will select the Air Data Module (ADM) data to be used based on the air data information displayed on the PFDs with exception of the barometric adjusted altitude. The source for barometric-adjusted altitude data will be selected according to the following:

#1 barometric-adjusted altitude if the coupled PFD is the pilot’s PFD
#2 barometric-adjusted altitude if the coupled PFD is the copilot’s PFD

In order to prevent discontinuities of path control, applicable AFCS guidance modes will be dropped when sources of data to the selected PFD are changed. Refer to section 3.2 for specific cancellation criteria for each of the guidance modes.

The AFCS will select the Attitude and Heading Reference System (AHRS) data to be used based on the attitude information displayed on the PFDs. If an AHRS is flagged invalid, both sensors are flagged invalid or an ARHS miscompare occurs, the AP and YD will disengage and all FD modes will be canceled.

The AFCS will select the Air Data Module (ADM) data to be used based on the air data information displayed on the PFDs. The AFCS will use data from the Air Data System (ADS) displayed on the selected PFD for outer loop mode targets, and average the sensor data from the two displayed ADSs for gain programming, damping and limiting. If an ADS is flagged invalid, the AFCS will use the unflagged ADS. If an ADS miscompare occurs, the AP and YD will disengage.

The AFCS will use radio data from both PFDs if the following conditions are met:

-Both PFDs are displaying the same approach guidance source (ILS).
-Both navigation sources are valid.
-Both PFDs indicate they are receiving the same radio frequency from the NAV receivers.
-Both PFDs are receiving radio information from independent radios.

While operating in this dual sensor mode (CAT II approach requirement), the AFCS will utilize approach navigation data as follows:

-The AFCS will use averaged deviation data as long as both sources are unflagged and tracking (no miscompares detected).
-The AFCS will revert to single PFD status using the unflagged source, if one PFD or the radio data is invalid.
-The AFCS will revert to single PFD status using the most reasonable source if both are unflagged, but not tracking (miscompare detected).

If during the dual approach track mode, the displayed data on one of the two PFDs becomes invalid, the AFCS will continue the approach using the valid data from the remaining PFD.

After a transition from dual approach track status, the AFCS will revert to the selected single PFD status (couple) in effect prior to acquisition of dual PFD status if the displayed data is valid, else the other PFD shall be selected as coupled.

The AFCS will receive radio altimeter information displayed on both PFDs. The AFCS will vote the radio altitude data as long as both radio altimeters are unflagged and tracking (no miscompare detected).

**NOTE**

Even though the Citation Sovereign is a single radio altimeter installation, the AFCS will still vote the data displayed on the two PFDs.

The servo to surface gear ratio will be constant to within 20% for the range of surface normally controlled by the autopilot or yaw damper. Typically, the range of surface that will be controlled by the autopilot or yaw damper will be within ±15° of the surface position at engagement.

The control system will not have a resonance frequency that matches within 10% of a body resonance frequency.

## FLIGHT DIRECTOR MODES OF OPERATION

The AFCS mode selection will be accomplished using the guidance panel and the TOGA buttons in the throttle handles. The following tables identify the mode capabilities and show EFIS annunciation examples that will exist:

### Lateral Flight Director Modes

| Button | Mode | Annunciation |
|---|---|---|
| HDG (GP) | Heading Select | HDG |
| LNAV (GP) | Lateral Navigation Modes:<br>Based on displayed navigation source (FMS, VOR, Localizer) | LNAV<br>VOR<br>LOC |
| APPR (GP) | Lateral Approach Mode (VOR displayed) | VAPP |
| BC (GP) | Back Course | BC |
| BANK (GP) | High/Low Bank (HDG mode only) | |

### Vertical Flight Director Modes

| Button | Mode | Annunciation |
|---|---|---|
| FLC (GP) | Flight Level Change | FLC |
| None | Automatic Altitude Preselect | ASEL |
| ALT (GP) | Altitude Hold | ALT |
| VS (GP) | Vertical Speed Hold | VS |
| VNAV (GP) | Vertical Navigation Modes:<br>Requested by FMS | <br>VFLC<br>VASEL<br>VALT<br>VPTH<br>VGP |

## Multi-Axis Flight Director Modes

| Button | Mode | Annunciation |
|---|---|---|
| APPR (GP) | Approach (ILS) | LOC / GS |
| TOGA (Throttle) | Go-Around | GA |
| TOGA (Throttle) | Take-Off | TO |
| EDM | Emergency Descent Mode | EDM |

## Basic Flight Director Modes

| Button | Mode | Annunciation |
|---|---|---|
| None | Roll Hold | ROL |
| | Roll Hold Submode: Wings Level | ROL |
| | Roll Hold Submode: Heading Hold | ROL |
| None | Pitch Hold | PIT |
| None | Flight Director Standby | None |

Only one vertical mode and one lateral mode may be captured at any time. However, up to two vertical arm modes and one lateral arm mode may be armed simultaneously.

Armed and captured modes will be displayed on the PFD. Mode transition from arm to capture will be indicated on the PFD.

### Heading Select Mode (HDG)

The heading select mode will be activated via the HDG pushbutton on the guidance panel. The heading select mode will also be activated whenever a NAV mode, APPR mode or BC is armed.

During HDG, all armed lateral flight director modes are allowed, but a capture of any armed lateral mode will cancel the heading select mode.

The AFCS will generate roll command outputs to align the aircraft with the heading target displayed on the selected PFD. The AFCS will receive a heading error from the PFD, and use the information to compute roll commands to turn the aircraft to the selected target. If the heading bug is turned through more than 180° but less than 360°, the AFCS will compute commands to follow the bug all the way around to the target and not turn in the shortest arc. Logic will be applied such that the AFCS provides guidance to the selected target using the shortest arc when on the ground. The on-ground logic will prevent the aircraft from turning in the wrong direction following take-off, due to maneuvering the aircraft may have done on the ground while taxiing. The bank limit selection will automatically be set to the low bank limit (17°), once the absolute value of the bank angle is less than 6° after ascending through an altitude of 35,050 feet. The bank limit selection will automatically be set to the high bank limit (27°), once the absolute value of the bank angle is less than 6° after descending through an altitude of 34,950 feet. The bank angle can be toggled between the high and low bank limits by means of the BANK pushbutton on the guidance panel. When the heading select mode is active with the low bank limit, a green arc, or 'eyebrow' is displayed between ±17° on top of the attitude sphere on the PFD.

The roll rate commands generated by the heading mode will be limited to 4.0°/sec.

## LATERAL NAVIGATION MODES (LNAV, VOR & LOC)

Lateral navigation modes are selected by pressing the NAV button. Navigation source information for the AFCS is determined by the NAV source on the selected PFD. The following navigation sources may be activated: VOR, Localizer, and LNAV (FMS course navigation).

Upon arming any NAV mode, HDG select mode is automatically activated. HDG select mode will be canceled upon capture of the selected NAV mode.

The AFCS will generate flight director roll guidance commands for interception, capture, and tracking of the above listed conditions when they are displayed on the selected PFD. In order to maintain continuity between the navigation display and flight director calculations, the AFCS will input and select data consistent with the selected PFD data.

> **FMS LNAV** - The AFCS will receive a lateral steering command and a validation signal from the FMS indicated on the selected PFD. The FMS lateral steering command will align the airplane with the FMS flight plan.

The flight director is capable of performing an automatic transition from FMS navigation to an approach or back course mode via the approach preview mode. A previewed approach may be established on EFIS by selecting the localizer preview display and setting the appropriate course. In order to use this feature the selected NAV source must be FMS, and the NAV radio must be tuned to localizer frequency. The previewed approach is then armed by pushing the APPR or BC button on the GP-400 guidance panel. Once the capture criteria have been met for the approach the LOC or BC will capture and the new lateral mode will replace LNAV.

**VOR LNAV** - If the selected VOR station is retuned to another VOR frequency the VOR mode will cancel and rearm automatically if in the VOR capture, track, or overstation phase.

When the airplane is passing over the VOR transmitter, in the cone-of-confusion, the VOR mode will fly towards the selected course reference. If the selected course remains unchanged from that selected before entry into the cone-of-confusion, the previously computed wind correction angle will continue to be applied and VOR mode will not command a turn toward the selected course pointer. Changes of course pointer setting when overstation will result in an equivalent change in the course hold reference. If DME information is available, the cone-of-confusion entry boundary will be estimated based upon distance to transmitter and altitude, or VOR TO/FROM transition.

## APPROACH MODES (LOC/GS & VAPP)

Approach modes will be selected by pressing the APPR button. Available front course approach options are ILS (localizer and glideslope) and VOR (lateral only). Back course (BC) options are for lateral direction only.

AFCS will generate flight director roll and pitch guidance commands for capture and tracking of the above approach paths as displayed on the selected PFD. When any APPR mode is armed, HDG select mode will be automatically activated and cancels automatically once the desired approach path is intercepted and the airplane is considered established.

**ILS** - ILS lateral/vertical capture and guidance will be established based on data from the selected PFD. The localizer must be captured before the glideslope in order to prevent an inadvertent descent. Altitude select mode (ASEL) will be inhibited during glideslope capture and tracking.

**BACK COURSE (BC)** - Localizer Back-Course (BC) mode is selected by pressing the BC button on the guidance panel. Once BC mode is armed, HDG select is automatically activated. Once the localizer back-course is captured, HDG select mode will cancel and APPR mode will command AFCS flight control inputs.

## TAKEOFF/GO-AROUND MODE (TO) OR (GA)

Pressing the TO/GA button in the throttle lever will activate the flight director go-around (GA) mode when airborne. Once pressed the flight director will receive guidance information setting the FD display on the PFD to 10° nose-up wings level target attitude. No autopilot functions except for the Flight Director are active in the GA mode.

Takeoff (TO) mode is activated when the TO/GA button on the throttle is depressed on the ground. The flight director will move to a 13° nose-up wings level target attitude. No autopilot functions except for the Flight Director are active in the TO mode.

## VERTICAL SPEED (VS) SELECT MODE

The vertical speed select mode will be activated via the VS pushbutton on the guidance panel.

During vertical speed, all armed pitch flight director modes are allowed, but a capture of any armed pitch mode will cancel the vertical speed mode.

The AFCS will generate pitch command outputs to align the aircraft vertical rate with the VS target displayed on the PFD. When VS mode is active, the target will be adjustable via either pitch thumbwheel. The VS target will be synchronized to the present vertical speed at entry to the VS mode and during activation of the TCS switch while in VS mode. The air data information to be used for closed loop control will be from the same ADC as is displayed on the selected PFD with exception of the barometric adjusted altitude.

The pilot may maneuver to a new vertical speed reference without canceling the VS mode. This is done by depressing the TCS pushbutton and maneuvering the aircraft to another vertical speed.

The AFCS pitch guidance will not generate commands to exceed Vmo or $M_{mo}$ when in the vertical speed mode. When a potential overspeed condition is detected, the VS flight director pitch commands will be limited to 3 knots less than $V_{mo}$ or $M_{mo}$, as determined by the FLC control law. When the AFCS is not following the selected reference due to an overspeed condition, an indication will be displayed on the PFD.

The AFCS pitch guidance shall not provide forward-looking overspeed protection of the bird strike $V_{mo}$ at FL080 during descents.

## ALTITUDE SELECT (ASEL) MODE

The altitude select mode will be armed automatically when the aircraft is flying at a continuous vertical rate of greater than 1 foot/sec toward the pre-selected altitude displayed on the selected PFD for 5 seconds. The pre-selected altitude target can be adjusted via the altitude pre-select knob on the guidance panel.

The AFCS will generate pitch command outputs to capture the preselect altitude displayed on the selected PFD. Once the reference altitude is reached, the altitude hold mode will be activated.

The air data information to be used in computing these commands will be from the same ADS as is displayed on the selected PFD with exception of the barometric adjusted altitude. The AFCS will use baro-corrected altitude in ALT SEL mode.

## ALTITUDE HOLD (ALT) MODE

The altitude hold mode will be selected via the ALT pushbutton on the guidance panel. The altitude hold mode will also be activated automatically following pre-select altitude captures (when altitude has been acquired).

The pilot may maneuver to a new altitude reference without canceling the altitude hold mode. This is done by depressing the TCS pushbutton and maneuvering the aircraft to the new altitude.

During altitude hold, all armed pitch flight director modes are allowed, but a capture of any armed pitch mode will cancel the altitude hold mode.

The AFCS will generate pitch command outputs to maintain the altitude when the hold mode is selected. When in altitude hold mode, the altitude hold reference may be synchronized via activation of the TCS switch. The altitude hold reference is re-initialized if the mode is selected, and the AP is engaged at a later time. The air data information to be used for altitude hold closed loop control will be from the same ADC as is displayed on the selected PFD with exception of the barometric adjusted altitude.

If the ALT mode is selected when the aircraft is in a climb or descent, the AFCS will generate pitch commands to zero the vertical speed and then smoothly capture the selected altitude without multiple overshoots.

## FLIGHT LEVEL CHANGE (FLC) MODE

The flight level change mode will be selected via the FLC pushbutton on the guidance panel, except when VNAV is active. During FLC, all armed pitch flight director modes are allowed, but a capture of any armed pitch mode will cancel the FLC mode. The AFCS will generate pitch command outputs to capture and track the speed reference displayed on the selected PFD. This reference may be IAS or Mach. Automatic transfer from IAS to Mach speed reference (or vice versa) will take place based on logic within the AFCS System during climb or descent. When the aircraft is in a climb towards a higher preselect altitude and the speed transitions from 0.63 to 0.64 MACH or the aircraft climbs through 28,000 ft, the speed reference will automatically change from IAS to MACH. The switching will be indicated on the PFD by changing the speed reference above the speed tape. When the aircraft is in a descent towards a lower preselect altitude and speed transitions from 304 to 305 knots or the aircraft descends through 29800 ft, the speed reference will automatically change from MACH to IAS. Upon initial activation of FLC, the speed reference selected will be MACH if either the current speed is greater than or equal to 0.64 MACH or the altitude is greater than or equal to 28,000 ft. The C/O pushbutton on the guidance panel can override the reference.

When TCS is activated during FLC mode, the IAS/Mach speed reference will be synchronized to the current IAS/MACH value. The speed reference will synchronize to the current IAS/MACH value at FLC mode engagement or autopilot engagement while FLC is active.

The AFCS will use the pre-select altitude from the Monitor Warning System to determine the desired course of action:

> If the pre-select altitude is above the aircraft's present altitude but inadequate thrust is applied to achieve and maintain the speed reference to the altitude, the FLC mode will climb at the maximum speed it can achieve. The FLC mode will not direct the aircraft to fly away from the preselect altitude (descend) in order to obtain the desired speed reference.
>
> If the pre-selected altitude is below the aircraft's present altitude but there is excessive thrust, the FLC mode will descend at the slowest speed it can achieve above the speed reference. The FLC mode will not direct the aircraft to fly away from the preselect altitude (climb) in order to obtain the desired speed reference.

The air data information will be from the same side ADC as displayed on the selected PFD with exception of the barometric adjusted altitude.

The AFCS pitch guidance will not generate commands to exceed $V_{mo}$ or $M_{mo}$ when in FLC mode. When a potential overspeed condition is detected, the FLC control law will command a pitch maneuver to maintain a speed reference 3 knots less than the Vmo or Mmo values received from the selected ADC. When the AFCS is not following the selected reference due to an overspeed condition, indication will be displayed on the PFD.

The AFCS pitch guidance shall not provide forward-looking overspeed protection of the bird strike $V_{mo}$ at FL080 during descents.

## VERTICAL NAVIGATION (VNAV, VFLC, VPTH, VASEL, VALT, VGP)

Pressing the VNAV button will activate the vertical navigation (VNAV) mode. VNAV will signal the AFCS to select track sub-modes based on valid targets from the selected FMS. While in another VNAV mode the flight crew will have the capability to activate the VFLC mode by pressing the FLC button. AFCS will transmit the FLC pressed signal to the FMS, which will then determine the proper mode transition.

**VNAV Arm (VNAV)** - AFCS will transition to VNAV Arm when the VNAV button is pressed, the active vertical mode on will remain engaged. Upon a valid mode request from the FMS, AFCS will transition to one of the following sub-modes:

**VNAV Flight Level Change (VFLC)** - AFCS guidance commands are based on the altitude and IAS/MACH speed target from the FMS. The VFLC function will act in the same manner as FLC mode, with speed and altitude reference from the FMS.

**VNAV Path (VPTH)** - AFCS vertical speed guidance commands will be based on a vertical speed target received from the selected FMS. VPTH and VS modes perform identically with the exception of the reference source.

**VNAV Altitude Select Capture (VASEL)** - AFCS will arm the VASEL mode based on selected FMS altitude. VASEL will be displayed on the PFD during altitude capture but will not be indicated during arm.

**VNAV Altitude Hold (VALT)** - AFCS will automatically transition to VALT upon capture of the FMS selected altitude. If the FMS requests a direct transition into the altitude hold mode, the AFCS will maintain that altitude upon transition request.

**VNAV Glidepath (VGP)** - AFCS will coordinate with the FMS for arming and capturing of the VGP mode. Once captured VGP mode operates in the same manner as the GS mode and ASEL will be inhibited once VGP capture is established.

AFCS pitch guidance will not generate commands to exceed $V_{MO}$ or $M_{MO}$ when in VFLC or VGP modes.

## PITCH HOLD (PIT)

Upon pressing the autopilot engage button, the AFCS will enter the pitch hold mode (PIT) if no vertical flight director guidance mode is active. Pitch hold mode will also be activated if a roll flight director mode is active and no vertical flight director mode is active. PIT will be displayed at the top of the PFD in green.

Pitch references are modifiable, within pitch limits, through flight crew inputs to either pitch thumb-wheel. Thumb-wheel inputs will result in pitch commands of ±3-degrees. Pressing the TCS button on the control wheel will also allow the flight crew to change the pitch angle within limits.

## ROLL HOLD (ROL)

If no lateral flight director guidance mode is active and the autopilot is engaged in a bank of greater than 6-degrees roll hold mode will be entered by the AFCS. Also if a vertical flight director mode is selected, with no lateral mode selected, and the bank angle is greater than 6-degrees, roll hold will become active.

In the event that the bank angle is greater than 35-degrees when roll hold mode is entered, it will be reduced to the hold limit of 35-degrees. Roll rate commands from AFCS will be limited to 5.5-degrees/sec.

### Wings Level (ROL)

Wings level is a submode of roll hold. Activation of this mode will occur, if no flight director guidance mode is active with the autopilot engaged in a bank of less than 6-degrees, with a vertical flight director mode and no lateral mode and a bank angle of less than 6 degrees, the roll hold mode is active and the bank reference is set to less than 6-degrees, or the TOGA button is pressed.

### Heading Hold (ROL)

Heading hold mode is activated when the autopilot is engaged and wings level mode has maintained a bank of less than 3-degrees for ten seconds. Heading reference will be the heading the airplane is rolled out on when heading hold becomes active.

## EMERGENCY DESCENT MODE (EDM)

The Monitor Warning System (MWS) will determine when to begin the EDM activation. once the request for EDM is received the AFCS will automatically cancel any non-approach flight director mode and initiate heading hold and FLC. An airspeed target that provides a $V_{MO}$ descent speed and a heading that is less than 90-degrees of current heading at a bank angle of 30-degrees.

The autopilot must be activated for the airplane to enter EDM. EDM will be activated by the MWS upon cabin pressure exceedance of 13,500 feet when the airplane pressure altitude is 30,000 feet or greater. EDM automatically sets the altitude preselect to 15,000 feet and the pilot must power to idle, or the descent rate will be reduced to maintain the $V_{MO}$ descent speed.

## AUTOPILOT REVERSION

The autopilot installed in the Citation Sovereign is of the dual channel type for system fail-operational capability. Automatic reversion to either channel in the case of a malfunction is annunciated to the flight crew through the EICAS system. Reversion to the functional channel is seamless and requires no flight crew action.

## ALTITUDE ALERTING SYSTEM

An altitude alerting system provides a visual indication of when the airplane is within 1000 feet of a preselected altitude and normalizes when the airplane is within 200 feet of the preselected altitude. After capture, the system will reactivate if the airplane departs more than 200 feet from the selected altitude. As the airplane approaches within 1000 feet of the preselected altitude, the color of the altitude display will change to amber and the altitude alert warning tone will sound for one second. As the airplane approaches to within 200 feet of the selected altitude, the display will change back to blue. If the airplane again deviates from the selected altitude by more than 200 feet, the altitude display will change to amber and the altitude alert tone will sound for one second. The display will remain amber until the airplane returns to within 200 feet of the altitude, or until the altitude selection is reset. The altitude selection is set into the upper right corner of the primary flight display (PFD) by means of the ALT knob on the GP-400 guidance panel.

The altitude alert function works in conjunction with altitude preselect (ASEL) mode, which is described below. The only difference in operation of altitude alert function alone is that the flight director and/or autopilot need not be engaged for altitude alert to function. The altitude alert annunciations are controlled by the pertinent flight director, which is selected by the autopilot couple switch (AP XFER FD1/AP XFER FD2), and are therefore based on the barometrically corrected altitude displayed on the same side of the cockpit. If the altitude set knob is moved or the glide slope capture mode is active, the annunciations of altitude alert will be cancelled.

The autopilot can be engaged in any reasonable attitude; however, unless touch control steering (TCS) is used in conjunction with autopilot engagement, the autopilot will roll wings level if engaged while in a bank. If the bank is less than six degrees at engagement, the autopilot will hold the heading indicated when the autopilot is engaged. If the bank is over six degrees at engagement, it will hold the heading indicated when the airplane rolls through six degrees of bank on the way to wings level. If a lateral mode is disengaged, the autopilot will hold the heading existing at the moment of disengagement. If the turn controller is out of the center detent position, the autopilot will not engage.

## TOUCH CONTROL STEERING

Touch control steering (TCS) enables the airplane to be maneuvered manually during autopilot operation without cancellation of any selected flight director modes. To use touch control steering, press the TCS button, maneuver the airplane and release the TCS button. TCS is operable with all autopilot modes. During TCS operation the yaw damper will remain engaged.

If the autopilot is engaged in a bank and it is desired to hold the bank, press the TCS button, engage the autopilot and release the TCS button. The bank will be maintained if it is in excess of six degrees. The airplane may be rolled level with the turn knob. The memory function holding the autopilot in a bank will be canceled when the turn knob is moved out of detent.

In the case of Flight Level Change (FLC) (IAS or MACH annunciated) mode, vertical speed (VS) mode or altitude hold (ALT) mode, the TCS button may be depressed and the airplane maneuvered to a new reference. When the TCS button is released, the flight director/autopilot will maintain the new reference.

## PITCH SYNCHRONIZATION

When flying the airplane manually and using the flight director, the command bars may be matched to the existing pitch attitude, or if a vertical mode has been selected the pitch reference may be changed, by pressing the touch control steering (TCS) button and maneuvering the airplane to a new pitch attitude. When the TCS button is released, the command bars will synchronize to the airplane attitude existing at the moment of release. If a vertical mode is selected (ALT, VS, FLC), the flight director/autopilot will hold the vertical reference existing at the time of release.

# ELECTRONIC FLIGHT INSTRUMENT SYSTEM (EFIS)

The Electronic Display System (EDS) and the Electronic Flight Instrument System (EFIS) are both parts of the comprehensive Primus EPIC Integrated Avionics System. EFIS is the part of the integrated system that displays flight altitude, airspeed, vertical speed, airplane attitude, heading, course orientation, flight path commands, weather and mapping presentations, as well as system source annunciations. EFIS is a subsystem of the Electronic Display System in the Primus EPIC Integrated Avionics and Flight Control System. The remaining units of the display system, which bear on the subjects of airplane attitude, heading, and display and control, (i.e., flight instrument system) are discussed here. This includes the reversionary and dimming controllers, primary flight displays (PFDs), multifunction displays (MFDs), and the display system symbol generators.

Four flat panel displays are used along with conventional and new controls that maximize the capabilities of the flat panel displays. Two conventional PFD display controllers and two Cursor Control Devices (CCD) provide control of the displays.

## ELECTRONIC FLIGHT INFORMATION SYSTEM (EFIS) COMPONENTS

The EFIS includes the following system components:

Full Color LCD Display Units (DU)

- Primary flight display (PFD) for each pilot
- Multi-function display (MFD)
- Engine indicating (EI) and crew alerting system (CAS) display (EICAS)

Display Controls

- PFD Display Controller (2)
- Cursor Control Device (2)
- Guidance panel
- Multi-function control display units (MCDU) (2)
- Sensor reversionary, display reversionary, and display dimming controls

EFIS Related Processing

- Graphics generation processing is contained within the DUs.
- Monitor and Warning processing occurs within the MAU processor modules.
- Control processing occurs in the Control I/O modules.

System Interconnect

- The Display Units are connected directly to the ASCB system buses for communication with the rest of the avionics suite.
- The PFD display controllers concentrate the avionics related switches in the cockpit and transmit the data to the Control I/O modules.
- Display reversion controls are wired directly into the display units.
- The Cursor Control Devices are connected directly to the DUs.

## PRIMARY FLIGHT DISPLAY (PFD)

The PFD consists of the following:

- Attitude Display
- Slip/Skid Indicator
- Flight Director Command Bars (single cue or cross pointer)
- Flight Director Mode Annunciations
- Autopilot Mode Annunciations
- Angle of Attack (AOA)
- Vspeeds (Automatic/Manual)
- Vertical Deviation Pointer and Scale
- Radio Altitude
- Decision Height
- Marker Beacons
- Altimeter Scale and Digital Displays
- Source Annunciations
- GPWS/Windshear Annunciations
- Minimum Descent Altitude
- Airspeed Scale and Digital Displays
- Elapsed Timer
- Vertical Speed Scale and Digital Display
- Heading
- Drift Bug
- Lateral Deviation Scale
- Bearing 1/2
- Distance
- FMS Messages
- Preview Mode
- Weather Radar Returns
- TCAS Resolutions Advisories
- Source Miscompare

## ATTITUDE DISPLAY

### Attitude Sphere / Artificial Horizon

The artificial horizon is the sky and ground shading representation displayed behind the attitude pitch tape. The artificial horizon will consist of a horizon stabilized sky/ground solid color representation. For pitch angles greater than 25 degrees, the attitude shading indicates the direction to the sky or ground as appropriate by preserving a portion of sky or ground shading.

### Aircraft Symbol

A reference aircraft symbol is displayed in the attitude sphere. Single cue and cross-pointer symbols are selectable from the MCDU Display setup page. The apex of the single cue aircraft symbol will be centered in the attitude sphere when single cue is selected. When cross pointer has been selected, the center square of the cross pointer aircraft symbol is displayed centered in the attitude sphere.

The reference aircraft symbol color is normally white but can change color depending on the display of the TCAS pitch targets as follows:

<u>Red Aircraft Symbol</u>

The Aircraft Symbol will be displayed Red for the following conditions:

Up Advisory Avoidance Zone is displayed AND AHRS Pitch Angle < Up Advisory Pitch Target OR Down Advisory Avoidance Zone is displayed AND AHRS Pitch Angle > Down Advisory Pitch Target

Green Aircraft Symbol

The Aircraft Symbol will be displayed Green for the following conditions:

Fly-To Zone is displayed attached to the Up Advisory Avoidance Zone AND AHRS Pitch Angle ≥ Up Advisory Pitch Target AND AHRS Pitch Angle ≤ Up Advisory Pitch Target + variable separation OR Fly-To Zone is displayed attached to the Down Advisory Avoidance Zone AND AHRS Pitch Angle ≤ Down Advisory Pitch Target AND AHRS Pitch Angle ≥ Down Advisory Pitch Target variable separation.

**Pitch/Roll Range**

The Pitch and Roll ranges are as follows:

Pitch

Degrees of Motion: ±90°, hard limited

Roll

Degrees of Motion: 360°

**Pitch Tape**

The pitch tape is displayed through the center of the attitude display. The pitch tape is horizon stabilized and shall be capable of showing at least ±20° with pitch attitude at 0°. The pitch tape is linear with markings every 2.5° from 0° to ±10° and every 5° between 10° and 30°. The pitch tape is labeled with numbers on both sides of the tick marks through +30°/-20° and in the middle of the tick mark for greater than +30°/-20°. The scale is labeled with the following indices:

| UP | Down |
|---|---|
| 10 | 10 |
| 20 | 20 |
| 30 | 30 |
| 40 | 45 |
| 60 | 60 |
| 90 | 90 |

# PRIMARY FLIGHT DISPLAY

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Figure 3-17

The pitch tape will appear to go behind the aircraft symbol and the radio altitude digits, if displayed.

The pitch tape will park at -90 or 90 degrees, respectively.

Removal of the horizon line uses a logical hysteresis filter using absolute pitch angle with an upper bound of 25°, and a lower bound of 24°. The horizon line is displayed in the area with sky and ground shading (including outside the truncated sphere).

**Excessive Pitch Indications**

For large pitch angles, the display will always show the direction to the sky (cyan) or ground (brown) as appropriate. Hollow red pitch attitude warning chevrons are placed on the pitch tape so that they come into view when pitch equals -7° and +21°. There are two pitch down chevrons increasing in size as pitch up angle increases. There are three pitch up chevrons increasing in size as the pitch down angle increases.

**Roll Scale**

A roll scale is displayed on the top of the ADI sphere. The roll scale is linear and marked with tick marks at ±10°, ±20°, ±30°, and ± 60°. An inverted triangle will mark 0° and ±45°.

**Invalid**

Loss of valid pitch or roll information from the Attitude and Heading Reference System (AHRS) will cause the removal of the pitch tape, roll pointer, and flight director bars. The entire attitude sphere will be displayed in cyan and a red "ATT FAIL" flag will be displayed in the top of the attitude sphere.

**ROLL POINTER/SLIP-SKID DISPLAY**

The bottom half of the roll pointer is used as a slip skid (lateral acceleration) indicator. Under zero lateral acceleration, the roll pointer and slip-skid indicator form a triangle. With lateral acceleration, the slip-skid indicator will move sideways. It will move to the left for positive inputs (right lateral acceleration) and to the right for negative inputs (left lateral acceleration). When lateral acceleration reaches the predetermined limit, an arrow is displayed attached to the indicator pointing in the direction of the indicator movement.

The roll pointer/slip skid indicator contains two alignment marks that line up vertically to assist the pilot in determining zero slip-skid. These alignment marks are displayed in the center near the edges of the roll pointer and the slip skid indicator.

**Invalid**

Loss of valid lateral acceleration, pitch, or roll information from the AHRS will be indicated by an amber X over the indicator.

**Attitude Source Annunciations**

Attitude source annunciations "ATT1" or "ATT2" (boxed) is displayed at the top of the attitude sphere to the left of the roll zero index marker in reverse video (amber background with black text), when appropriate.

The attitude source annunciation will be suppressed when the pilot and co-pilot displayed sources are the on-side AHRS. When both the pilot and co-pilot displayed sources are the same, "ATT1" or "ATT2", as appropriate, will be displayed in amber on both PFDs. The appropriate annunciation will also be displayed in amber when both the pilot and co-pilot displayed sources are the cross-side AHRS.

**Display Logic**

The attitude source annunciation is displayed in reverse video (amber background with black text) or will be blank (not displayed) based on the following attitude source combinations as displayed on PFD1 and PFD2:

| Pilot PFD | Co-Pilot PFD |
|---|---|
| ATT1(Blank) | ATT2(Blank) |
| ATT1(Amber) | ATT1(Amber) |
| ATT2(Amber) | ATT2(Amber) |
| ATT2(Amber) | ATT1(Amber) |

**Invalid**

The "ATT1" and "ATT2" annunciators will not be removed for a failure.

**Low Bank Limit Arc**

Whenever the Automatic Flight Control System (AFCS) is in the Low-Bank mode, a green arc will be displayed immediately above the attitude sphere extending ±17° from wings level.

**Invalid**

Loss of valid information from both AFCS will cause the removal of the low bank limit arc.

**Excessive Attitude Declutter**

The display will be decluttered for excessive attitude defined as follows:

Bank greater than ±65° or
Pitch greater than 30° up or
Pitch greater than 20° down

The logic has 2° of hysteresis to prevent flashing symbols on and off. Therefore, the symbology will be restored under the following conditions:

Bank returns to less than ±63° and
Pitch returns to less than 28° up and
Pitch returns to less than 18° down

The symbology that is removed to declutter the display is as follows:

- Low Bank Limit Arc
- Autopilot .AP ENG. and .TCS ENG. Annunciations
- Flight Director Mode Annunciations
- Flight Director .FD FAIL. Annunciation
- Selected Airspeed Bug - CAS
- Single Cue Flight Director Command Bar
- Cross Pointer Flight Director Command Bars
- VNAV Target Altitude Display
- VNAV Target Altitude Bug
- Decision Height Display
- Radio Altitude Failure Annunciation
- Vertical Deviation Annunciation
- Decision Height Minimum Indication
- Minimum Descent Altitude Display
- Selected Vertical Speed Bug
- Vertical Deviation Pointer and Scale
- TCAS Up Advisory Avoidance Zone
- "HDG" Comparison Monitor Annunciation
- "RAD" Comparison Monitor Annunciation
- "LOC" Comparison Monitor Annunciation
- "GS" Comparison Monitor Annunciation
- Preview Mode Vertical Deviation Pointer and Scale
- FMS Annunciations "APPR", "XTK", "MSG", "DR" and "DGR"
- TCAS Down Advisory Avoidance Zone
- Vertical Deviation Failure Indication (excluding the .EMER DESCENT. mode annunciation)
- Selected Airspeed Readout - Mach
- Minimum Descent Altitude Indication
- Minimum Descent Altitude Bug
- Autopilot Coupled Arrows
- Selected Airspeed Readout - CAS
- "EICAS" Comparison Monitor
- Radio Altitude Display
- Selected Airspeed Bug . Mach
- Takeoff VSpeed Display
- Takeoff VSpeed Bugs
- Takeoff VSpeed Preview Display
- Landing VSpeed Bugs
- ATT TEST Annunciation
- "VTA" Annunciation
- Selected Vertical Speed Display
- Approach Cue
- TCAS Mode Annunciations
- Marker Beacons

### AHRS Test Mode

When the AHRS test mode is active, attitude data will be displayed, but a red "ATT TEST" will be displayed in the exact location of the "ATT FAIL" annunciation. "ATT FAIL" will have priority over "ATT TEST". A red "HDG TEST" annunciation will also be displayed in the upper portion of the compass card. All heading information will remain displayed.

### Attitude Miscompare Annunciation

When both a Pitch and Roll attitude miscompare is detected by the EDS monitoring software, an "ATT" annunciation will be located in the attitude sphere's upper right area. The annunciation will have display priority over all scale markings. The annunciation will toggle amber reverse video (amber background with black text -> amber text with black background) 1 second on and .5 seconds off for the first 5 seconds the annunciation is displayed, then become steady (amber text with black background). The annunciation will be displayed by appearing to slide from the top edge onto the attitude shading tape. The annunciation will be removed when an attitude miscompare is no longer detected.

If only a pitch miscompare is detected, a "PIT" comparison monitor annunciation will be displayed as described above in place of the "ATT" annunciation.

If only a roll miscompare is detected, a "ROL" comparison monitor annunciation will be displayed as described above in place of the "ATT" annunciation.

The "ATT", "PIT" and "ROL" comparison monitor annunciations are displayed in the same location.

### Invalid

Loss of valid attitude information from AHRS causes the removal of the boxed "ATT", "PIT", or "ROL" annunciation.

## AUTOPILOT/FLIGHT DIRECTOR ANNUNCIATIONS

Flight Director (FD) mode annunciations are read from the priority Automatic Flight Control System (AFCS) over the ASCB.

### AP Engage/Disengage Annunciation

The AP engage/disengage annunciations will be displayed on the PFD above the attitude sphere. AP engage status is shown by displaying in green an "AP ENG" annunciation and an arrow pointing left or right, depending upon which AFCS is being displayed on the PFD. On a normal disengage, the "AP ENG" annunciation will be replaced with a reverse video amber "AP" annunciation. The amber "AP" annunciation will be displayed for approximately two and one half seconds then it will be removed. On an abnormal disengage, the "AP" annunciation shall toggle between reverse video amber and amber (amber background with black text --> amber text with black background) until the pilot acknowledges with the quick disconnect or the autopilot is re-engaged.

### Invalid

If the priority autopilot is invalid, the remaining autopilot will be read for AP engage/disengage status.

### Touch Control Steering (TCS)

When TCS is active, the green "AP ENG" annunciation will be replaced by a white "TCS ENG" annunciation. An amber "AP" annunciation has priority over the "TCS" annunciation and cannot be replaced by "TCS ENG".

### Invalid

If the priority autopilot is invalid, the remaining autopilot shall be read for AP engage/disengage and TCS status.

### Flight Director Command Bars

The Flight Director (FD) command bars are displayed in the middle of the attitude sphere. They can be displayed in a single cue or a cross-pointer style, as selected on the MCDU display setup page. The single-cue and cross-pointer FD command bars have the same display priority over other display information as the pitch tape.

### Display Limits

The FD command bar movement is scaled to match the attitude pitch tape. The FD command bar is limited to ±20° pitch command and ±20° roll command.

### Invalid

Loss of valid pitch or roll command information from the FD (AFCS) will cause the removal of the FD command bars. An amber "FD FAIL" annunciation (amber text with black background) is displayed centered above the attitude sphere.

### Flight Director mode Annunciations

The mode annunciations are located above the attitude sphere with lateral annunciations on the left and vertical annunciations on the right. The armed state will be displayed in white in the outboard positions of each annunciation window. The captured state will be displayed in green in the inboard position of each annunciation window. Transitions from arm to capture will cause the appropriate capture annunciation to toggle reverse video for 5 seconds before becoming steady.

### Emergency Descent Vertical Mode (EDM)

When the Flight Guidance Computer indicates that Emergency Descent Mode (EDM) is active, the annunciation shall be "EMER DESCENT" in red (white letters with red background) located above the attitude sphere in place of the vertical and lateral modes. While EDM mode is active, no other vertical or lateral modes, captured or armed, will be displayed.

### Invalid

Loss of valid Flight Director information from the AFCS causes the removal of the lateral and vertical mode annunciations. An amber "FD FAIL" annunciation (amber text with black background) will be displayed centered above the attitude sphere.

### PFD Select Annunciation

Green PFD select arrows (pointing left or right) are displayed above the attitude sphere, as appropriate. The pointer of the arrow corresponds to the selected PFD that is to be used for guidance coupling. The PFD select arrow will remain green when the on-side Flight Director is being displayed. If the cross-side Flight Director is being displayed, the select arrow will be amber.

### Invalid

Loss of valid Flight Director will cause the PFD select arrow to be removed.

## VERTICAL DEVIATION DISPLAY

The vertical deviation scale will be displayed to the right of the attitude sphere as a pointer moving on a scale when VOR/LOC or FMS is selected as the primary navigation source. The scale will consist of an empty rectangular box with two circles (referred to as 'dots') above and below the line. The distance between the scale dots and box is linear. The pointer parked position is equivalent to 2 dots. The pointer is a truncated triangle.

### Vertical Deviation Annunciator Window

The selected Vertical Deviation source is displayed above the vertical deviation scale in white letters. The possible source annunciations include FMS and GS and each are displayed as appropriate.

### Glideslope Display

The PFD displays data from the on-side or cross-side glideslope receivers, as selected by the Display Control function, when the NAV receiver is tuned to a localizer frequency. The EFIS reads the data in units of DDM and retransmits the data on the ASCB in units of micro-amps (µA). The output on the ASCB is not limited, but the pointer will park at ±300 µA (±.35 DDM). When parked, half of the pointer is in view at the limited position.

The Glideslope display is removed when the Flight Director Lateral mode is back course armed or captured.

### Invalid

Loss of valid deviation information from the NAV receiver will be indicated by removing the vertical deviation pointer and overlaying a red X over the scale. If the NAV source is a previewed NAV source, loss of valid deviation information is indicated by removal of the pointer only.

### VNAV Display

The PFD can display data from the on-side or cross-side Flight Management System (FMS), as selected by the Display Control function, whenever the deviation is valid. The scaling on the display will change as a function of FMS Approach mode. The pointer will park at ±1000 ft. (±300 ft. for approach mode). When parked, half of the pointer will be in view at the limited position.

### Invalid

Loss of valid deviation information from the FMS is indicated by removing the deviation pointer and scale. The scale will remain if valid previewed vertical deviation for a short range nav source is being displayed.

### Vertical Track Alert Annunciation

A "VTA" (vertical track) annunciation message will be displayed above the VNAV vertical deviation scale. The annunciation is driven by the displayed FMS.

### Glideslope Miscompare Annunciation

When a glideslope miscompare is detected, the boxed GS comparison monitor annunciation will be displayed by appearing to zoom into view (from a single point) in the attitude sphere's right side just below the attitude sphere's centerline. The annunciation will have display priority over all scale markings. The annunciation toggles reverse video amber (amber background with black text --> amber text with black background) 1 second on and .5 seconds off for the first 5 seconds the annunciation is displayed and then become steady. The annunciation will be removed when a glideslope miscompare is no longer detected.

### Invalid

Loss of valid deviation information from the NAV receiver will cause the removal of the "GS" annunciation.

## EXPANDED LOCALIZER DISPLAY

The Expanded Localizer deviation presents lateral deviation information with a greater precision than the Compass card lateral deviation display. The Expanded Localizer display is displayed below the attitude sphere as a pointer moving on a scale when Localizer is selected as the primary navigation source. The scale consists of a filled rectangular box with one circle (referred to as 'dot') to the left and right of the filled box. The distance between the scale "dots" and the filled rectangular box is linear. The pointer parked position is equivalent to 1 dots. The pointer will be a truncated triangle.

The Expanded Localizer display will be removed when the Flight Director Lateral mode is back course armed or captured.

### Localizer Deviation

The PFD can display data from the on-side or cross-side localizer, as selected by the Display Control function, when the NAV receiver is tuned to a localizer frequency. The EFIS reads the data from the ASCB in units of DDM and retransmits the data on ASCB in units of micro-amps (µA). The displayed and transmitted data is formatted to display the same as the lateral deviation display. For deviation values outside the limits of the scale, the deviation pointer will park at the appropriate end of the scale with half the pointer remaining in view.

### Invalid

Loss of valid deviation information from the NAV receiver is indicated by removing the lateral deviation pointer and overlaying a red X over the scale.

## RADIO ALTITUDE DISPLAY

Radio Altitude is provided on the ASCB bus and is displayed in a digital readout.

### Radio Altitude Digital Readout

The digital readout for radio altitude is displayed in the lower part of the attitude sphere. The digital readout is centered in the sphere and located as high as possible while remaining below the roll cross-pointer command bar. The radio altitude display range is from -20 to +2500 feet. For radio altitudes greater than +2500 feet, the digital readout is removed. For radio altitudes greater than 2500 feet the GGF value will continue to 2700 feet where it will be upper limited. This is needed for the Decision Altitude functionality. For radio altitudes less than -20 feet, the digits are replaced by a -RA- annunciation. The resolution on the digital readout is 5 feet from -20 to +200 feet (rounded to the nearest 5 feet), 10 feet from +200 to +1500 feet (rounded to the nearest 10 feet), and 50 feet from +1500 to +2500 feet (rounded to the nearest 50 feet.

### Radio Altimeter Test

During radio altimeter test the display of Radio Altimeter is allowed regardless of validity. Radio altimeter test is inhibited when the flight director mode indicates approach capture.

### Radio Altitude Miscompare

When a radio altitude miscompare is detected by the EDS monitoring software, a "RAD" annunciation (boxed) and in reverse video amber (amber background with black text) is located in the attitude sphere's lower center area. The annunciation will have display priority over all scale markings. The annunciation will toggle reverse video amber (amber background with black text --> amber text with black background) 1 second on and .5 seconds off for the first 5 seconds the annunciation is displayed then become steady (amber text with black background). The annunciation will be removed when a radio altitude miscompare is no longer detected.

### Invalid

Loss of valid radio altitude information will cause an amber "-RA-" annunciation to be displayed in the box at the same location as the radio altitude digital readout.

### Decision Altitude

Decision Altitude (DA) is set in the cockpit by the on-side Display Control function. The digital readout will be displayed below the attitude sphere and to the right. The data range corresponds with the radio altitude range (<2500 ft). The DA display will power up default to dashed (no value). The first control knob turn will start the display reading at 200 feet. Each knob click equals 10 feet resolution. The DA display will be removed for settings below 20 feet. The label "RAD MIN" will be directly above the DA digital readout position. When Minimum Descent Altitude (BARO) has been selected, the DA value is replaced with the desired MDA value and the DA label is replaced with the MDA label "BARO MIN".

### Invalid

Loss of valid DA setting from the Display Control function will cause the DA Display to be amber dashed.

### DA Indication

During descent, when radio altitude is equal to DA + 100 feet, an empty box will be displayed in the upper left portion of the attitude sphere. When radio altitude is equal to or less than the DA setting, a "MIN" annunciation will appear in the empty box on the attitude sphere. The DA indication is inhibited on the ground and through climb out until radio altitude is greater than DA + 100 feet.

### Invalid

Loss of valid radio altitude information on ASCB or valid DA setting from the Display Controller causes the DA indication to be inhibited.

## MARKER BEACONS

Marker beacons are transmitted by the NAV receiver. The markers are always displayed from the selected NAV VOR/LOC source. If the selected source is other than VOR/LOC, the markers are displayed from the on-side NAV receiver. The markers are displayed outside the right hand corner of the attitude sphere, directly above the localizer miscompare annunciation when active and toggle reverse video 1 second on and .5 seconds off for as long as corresponding marker is active. The transition of a marker annunciation has a debounce of 500 milliseconds.

### Marker Display

The marker beacon display consists of a boxed character with the character displayed as follows:

Outer Marker - O
Middle Marker - M
Inner Marker - I

## ALTIMETER DISPLAY

Altitude information is transmitted by the on-side and cross-side Air Data System functions as selected by the Display Control function. The display system reverts to on-side data in the event that the Display Control function fails. The altimeter display is located to the right of the attitude sphere at the edge of the PFD display.

### Altitude Tape

The altitude tape shows altitude within a ±550 foot window. The altitude tape direction are large numbers at the top of the scale. There is a tick mark at each 100 foot increment, except for the increments coincident with a chevron. The scale is labeled every 500 feet. The altitude tape has a doubled lined chevron at each 1000 foot increment and a single lined chevron at each 500 foot increment. The chevrons extend back to the approximate midpoint of the altitude tape and is connected to each other with a vertical line. The left side of the current value window is angled at the same slope as the chevrons.

### Invalid

Loss of valid altitude information from the Air Data Function will cause the altitude tape scale markings to be removed and the altitude tape will have a red "X" written over it.

### Altitude Rolling Drum Display

The altitude digital readout in the current value window of the altitude tape rolls. The last two digits roll in 20 foot increments. A boxed cross-hatch symbol is used to show the absence of the ten thousands digit in the digital readout display when barometric altitude is below 10,000 feet. The boxed cross-hatch is part of the rolling action. The digital readout is capable of displaying altitudes in the range of -2000 to +60,000 feet.

### Invalid

Loss of valid altitude information from the ADS causes the removal of the digits in the current value window.

### Trend Vector

The altitude trend vector display is an indication of estimated altitude over six seconds. This indication is a thermometer that travels on the outside of the altitude tape, along its left side. For altitude trend values greater than the displayable range of the altitude tape, the altitude trend display will park at the top or bottom of the altitude tape. For altitude trend values less than ± 20 feet, the altitude trend display will be removed.

**NOTE**

The .six second. estimate is calculated by air data.

**Invalid**

Loss of valid altitude information from the ADS causes the removal of the trend vector and trend vector scale.

**Baro Set**

Baro set data is displayed directly below the altitude tape. Baro set information can be displayed in inches of mercury (In-Hg) or hectopascals (hPa), as selected by the Display Control function. An "IN" label is displayed to the right of the readout when In-Hg is selected. An "HPA" label is displayed to the right of the readout when hPa is selected.

The layout of the English barometric correction display is 'XX.XX' with a minimum of two digits to the left of the decimal place. The resolution is .01 In-Hg.

The layout of the metric barometric correction display is 'XXXX' with a minimum of one digit. The resolution is 1.0 hPa.

Setting the barometric set value to the standard atmospheric pressure value is accomplished by activating the standard (STD) button located on the end of the Baro Set Knob. When activated a "STD" label is displayed in place of the Baro Set Digits and label as defined above. The Baro Set digits and label are brought back into view when the Baro Set has been scrolled from the STD values. Scrolling back to the Standard values will not cause the "STD" label to replace the Baro Set digits and label.

Loss of valid Display Control function causes the display to revert to the last displayed format or In- Hg if a cold start is subsequently encountered.

**Invalid**

Loss of valid altitude information from the ADS causes the removal of the Baro set display. Loss of valid Baro set information from the Display Control function causes the Baro set display to amber dash the digital readout.

### Metric Altitude

Metric altitude is displayed directly above the current value altitude window. This display is generated by converting barometric altitude to meters. The layout of the metric altitude digits is .XXXXX. with a minimum of one digit. The resolution is one meter. An "M" is to the right of the digital readout. The function is selected for display from the MCDU display setup page.

### Invalid

In the event of invalid Display Control function, the display will revert to the "on" condition. Loss of valid altitude information from the ADS causes the removal of the metric altitude display.

### Altitude Preselect Display

The altitude preselect knob is located on the GP-400. Rotation of this knob changes the altitude select value and bug displayed on both PFDs. The rate of change of the altitude select value is variable based on whether barometric altitude (BARO) minimums have been selected for display by either pilot. Selected data is transmitted by the GP-400 Flight Guidance Controller. Power up default for the display is blank.

### Minimums Resolution

When barometric altitude (BARO) minimums have been selected for display by either pilot, the resolution of the altitude select knob changes from one click equals 100 feet to one click equals 10 feet when the altitude preselect value is less than the BARO set value plus 1000 feet. For decreasing values, the resolution is 10 feet when within 1000 feet of the BARO value. For increasing values, the resolution is 10 feet for the first ten clicks (100 feet), then to 100-foot resolution.

### Metric Resolution

When the altitude preselect is displayed in metric, the slower rate of change is 50 meters per click. When the BARO minimums resolution conditions are met, the resolution for increasing values will be 5 meters per click.

If Metric altitude is selected from English altitude the altitude select resolution is 1 meter until the altitude select knob is turned once.

### Digital Display

A boxed digital readout is displayed above the altitude tape and has the range capability of -2000 to 47000 feet. A minimum of three digits will always be displayed, with leading zeros if necessary. When the altitude alert or departure from altitude are active, the boxed digital readout is displayed amber reverse video. The altitude departure indication is inhibited when either glideslope or VGP mode is captured.

The layout of the English Selected Altitude readout is 'XXXXX' with a minimum of three digits, using leading zeros as necessary.

The layout of the Metric Selected Altitude readout is 'XXXXX' with a minimum of three digits, using leading zeros as necessary. The metric Selected Altitude digits have an "M" label.

If English altitude is selected from Metric altitude the altitude select resolution is 1 foot until the altitude select knob is turned once.

### Alert Preselect Bug

The altitude preselect bug moves along the inside left edge of the altitude tape and its position corresponds to the altitude preselect digital readout. The altitude select bug is shaped like a notched rectangle. The color of the bug matches the color of the altitude preselect digital readout. A half bug symbol is used to indicate that the preselected altitude is off the altitude scale and is displayed at the appropriate end of the tape.

### Invalid

Loss of valid altitude select information from the Flight Guidance Panel causes the digital readout to be replaced with amber dashes, the bug to be removed, and altitude alert annunciation to be inhibited. Loss of valid altitude information from the ADS causes the removal of the digital readout and the bug. At power-up, the digital readout is blanked and the bug removed until an altitude preselect value is selected.

### Low Altitude Awareness

Radio altitude is used to drive the low altitude awareness display on the altitude tape. When the radio altitude is less than 550 feet, the lower portion of the altitude tape is shaded brown. The upper edge of the brown is bordered with a Amber line. The display moves into view linearly between 550 feet and 0 feet. At 0 feet, the lower portion of the altitude tape is completely filled by the brown display.

### Invalid

Loss of valid radio altitude information causes the removal of the low altitude awareness display and the Amber line.

### Minimum Descent Altitude Display

MDA is set in the cockpit by the Display Control function. The MDA display/label and the DH display/label shares the same position on the PFD.

### MDA Digital Readout

When barometric altitude (BARO) minimums have been selected for display by either pilot, the resolution of the altitude select knob is variable based on the rate of knob rotation. The slower rate of change of the minimum select value allows for precise setting of the data with one click of the knob equal to 10 feet. The data range zero to 16,000 feet. The layout of the minimum descent altitude digits is XXXXX with a minimum of two digits. Above the digital readout is the label "BARO MIN". The digital readout is removed for MDA set less than 20 feet.

### MDA Bug

An MDA bug travels along the outside of the altitude tape and its position corresponds to the MDA digital readout. The bug is a rectangular "D". The MDA bug has a line extending from the middle of the bug across the altitude tape. The MDA bug will go out of view beyond the ends of the altitude tape.

### MDA Indication

**NOTE**

Determination of .MIN. annunciation is performed by Monitor Warning.

When barometric altitude is equal to MDA + 100 feet, an empty box will be displayed in the upper left portion of the attitude sphere (same location as for the DH indication). When barometric altitude is equal to or less than the MDA setting, a "MIN" annunciation appears in the empty box on the attitude sphere. The MDA indication is inhibited on the ground and through climb out until barometric altitude is greater than MDA + 100 feet.

### Invalid

Loss of valid altitude information causes the removal of the MDA bug and the MDA indication is inhibited. If the MDA Set Valid is invalid, the MDA digital readout is amber dashed and the bug is removed.

### FMS VNAV Altitude Target and Bug

The FMS transmits altitude targets whenever a VNAV profile has been entered into the active flight plan. The target is displayed by a digital readout above the selected altitude readout. The layout of the VNAV target altitude readout is XXXXX with a minimum of one digit. The VNAV target altitude digits are rounded to a resolution of 10 feet.

The altitude target digital readout is displayed from the displayed FMS whenever the following conditions are met:

VNAV altitude alert is enabled and
VNAV altitude target is valid and
Any of the following VNAV modes are active (captured): VFLC, VASEL, VALT, VPTH

A corresponding VNAV altitude bug shaped like a hollow arrowhead moves along the outside of the altitude tape. Off scale indications are given by using a half-bug symbol at the ends of the scale, as appropriate.

### VNAV Altitude Alerting

Whenever the VALT alert discrete is set from the FMS, the digital readout turns amber.

### Invalid

Loss of valid altitude information from the ADS or values < -2000.0 or > 65,000.0 causes the removal of the digital readout and the bug.

### Air Data Source Annunciations

Air Data source annunciations are displayed at the top of the attitude sphere to the right of the roll zero index marker. The air data source annunciation is suppressed when the pilot and co-pilot displayed sources are the on-side ADS. When both the pilot and co-pilot displayed sources are the same, "ADC1" or "ADC2" annunciation, as appropriate, is displayed in amber on both PFDs. The appropriate annunciation is also displayed in amber when both the pilot and co-pilot displayed sources are the cross-side ADS.

**Display Logic**

Air Data Source Annunciation (Color)

| Pilot PFD | Co-Pilot PFD |
|---|---|
| ADC1 (Blank) | ADC2 (Blank) |
| ADC1 (Amber) | ADC1 (Amber) |
| ADC2 (Amber) | ADC2 (Amber) |
| ADC2 (Amber) | ADC1 (Amber) |

**Air Data Test Mode**

When the air data function has been selected to test mode from the MCDU test page, the PFD displays the data from the air data function but displays ADC TEST in the space occupied by the ADC source annunciation.

**Altitude Miscompare Annunciation**

When an altitude miscompare is detected, a "ALT" annunciation is displayed by appearing to slide from the outside edge onto the top half of the altitude tape. The boxed annunciation has display priority over all scale markings. The annunciation toggles reverse video (amber background with black text --> amber text with black background) 1 second on and .5 seconds off for the first 5 seconds the annunciation is displayed then becomes steady. The annunciation is removed when the altitude miscompare condition is cleared.

**Invalid**

Loss of valid altitude information from the Air Data function causes the removal of the "ALT" annunciation.

**AIRSPEED DISPLAY**

Airspeed information is transmitted by the on-side and cross-side Air Data System as selected by the Display Control function. The display system reverts to on-side data in the event that the Display Control function fails. The airspeed display is left of the attitude sphere at the edge of the PFD display.

**Airspeed Tape**

The airspeed tape shows airspeed about a ±40 knots window. The airspeed tape direction moves down for increasing airspeed and up for decreasing airspeed. There are tick marks on the airspeed tape for every 10 knots beginning at 30 knots. The center of the tape has an enhanced tick mark extending from the edge of the rolling drum display to outside the tape a distance equal to the length of the Vspeed bugs. The tape is labeled every 10 knots below 200 knots and every 20 knots above 200 knots. The airspeed tape will park at 30 or 900 knots respectively.

### Invalid

Loss of valid calibrated airspeed information from the ADS causes the airspeed tape scale markings to be removed and the airspeed tape will have a red "X" written over it.

### Airspeed Rolling Drum Display

The airspeed digital readout in the current value window of the airspeed tape will roll down for increasing airspeed and up for decreasing airspeed. The last digit will roll in 1 knot increments. Below 30 knots, the digital readout freezes at 30 and the digits are removed from the lower portion of the airspeed tape (region <30 knots). Above 900 knots the digital readout will park at 900 knots. The right edge of the current value window is notched to fit the airspeed reference bug.

### Airspeed Filtering

The Airspeed display is filtered utilizing a split filter design that provides a low speed averaging filter and a high speed averaging filter. The low speed averaging filter is active from 0 to 165 knots and uses a time constant of 0.6 seconds. The high speed averaging filter will be active above 165 knots and shall use a time constant of 1.1 seconds. The high speed averaging filter will remain active until airspeed has dropped below 160 knots.

### Overspeed/Stall Warning Indication

The indicated airspeed digits change to red (white digits with red background) when the current airspeed exceeds maximum operating airspeed as transmitted by the ADS by 1 knot or when indicated airspeed exceeds the flap speed limit. The indicated airspeed digits change to amber when the trend vector exceeds maximum operating airspeed as transmitted by the ADS by 1 knot or when indicated airspeed exceeds the flap speed limit.

### Invalid

Loss of valid calibrated airspeed information from the ADS causes the removal of the digits in the current value window.

### Airspeed Trend Vector

The airspeed trend vector display is an indication of acceleration direction. This indication is a thermometer that travels on the outside of the airspeed tape, along its right side. The trend vector algorithm uses filtered inertial acceleration to estimate what the aircraft velocity will be in 6 seconds. The trend vector will inhibited for airspeed accelerations of less than .1 knots/second or airspeeds less than 40 knots.

**Invalid**

Loss of valid calibrated or true airspeed information from the ADS, valid longitudinal acceleration or pitch valid from AHRS causes the removal of the trend vector.

**Airspeed/Mach Reference Bug and Readout**

The airspeed/Mach reference digital readout is displayed directly above the airspeed tape when the active pitch mode is FLC CAS, or FLC MACH. The set point is sent by the available AFCS. The digital readout represents airspeed or Mach speed as selected by the available AFCS. A bug shaped like a heading bug travels along the right inside edge of the airspeed tape corresponding to the speed reference digital readout. Off scale speed targets are indicated by using a half-bug positioned at the appropriate end of the airspeed tape. The layout of the CAS selected airspeed readout is 'XXX', with a minimum of two digits and will be rounded to a resolution of 1 knot. The layout of the Mach selected airspeed readout is '.XXX', with a minimum of three digits, using leading zeros as necessary. The Mach selected airspeed readout will be rounded to a resolution of 0.01 Mach.

**Invalid**

Loss of valid calibrated airspeed/Mach information from the ADS or loss of valid speed reference information from the available AFCS causes the reference digital readout to be amber dashed and the bug to be removed.

**FMS VNAV Speed Bug and Readout**

The FMS transmits speed bug information to be displayed as a bug on the airspeed scale. The bug is displayed as an arrowhead. For Mach targets, the bug is positioned by multiplying the reference digital readout by the ratio of current airspeed to current Mach number. Half-bug indications are used to indicate off-scale targets. A digital readout of the bug value are displayed directly above the airspeed tape when the active vertical mode is VNAV. The digital readout represents indicated airspeed or Mach target as selected by the priority AFCS or FMS depending on FD Mode.

The layout of the CAS selected airspeed readout is 'XXX', with a minimum of two digits and is rounded to a resolution of 1 knot. The layout of the Mach selected airspeed readout is '.XXX', with a minimum of three digits, using leading zeros as necessary. The Mach selected airspeed readout will be rounded to a resolution of 0.01 Mach.

**Invalid**

Loss of valid calibrated airspeed information from the ADS, loss of both valid CAS and MACH speed target information from either FMS or AFCS depending on FD Mode, or no active VFLC mode causes removal of the VNAV speed bug and will amber dash the digital readout.

**Vmo Thermometer**

A thermometer is positioned on the inside of the airspeed tape and extends from the Vmo value to the end of the tape in the direction of increasing airspeed. This thermometer can be displayed slim or wide depending upon whether the airspeed or trend vector is approaching Vmo. A horizontal line is positioned at the Vmo value. The horizontal barber pole is a representation of Maximum Operating Airspeed.

If the airspeed trend vector is > Maximum Operating Airspeed then a slim vertical barber pole will be displayed along the right side of the airspeed tape from the top of the tape to Vmo. The slim bar enable uses a hysteresis filter with an upper bound of Vmo . 5.0 knots and a lower bound of Vmo 8.0 knots. The hysteresis filter uses either calibrated airspeed or the airspeed trend vector in its calculation as follows:

If the slim vertical barber pole is displayed because the airspeed is within 5.0 knots of Vmo the hysteresis filter uses Calibrated Airspeed in its calculation.

If the slim vertical barber pole is displayed because the trend vector is greater than the Vmo, the hysteresis filter uses airspeed trend vector in its calculation.

If the calibrated airspeed is > Vmo + 1 knot, then a wide vertical barber pole will be displayed along the right side of the airspeed tape from the top of the tape to Vmo. The wide bar enable uses a hysteresis filter with an upper bound of Vmo + 1.0 knot and a lower bound of Vmo 3.0 knots. The hysteresis filter uses calibrated airspeed in its calculation.

**Invalid**

Loss of valid calibrated airspeed information from the ADS causes the removal of the Vmo thermometers.

**Low Speed Awareness Bar**

A red low speed awareness bar is positioned on the inside of the airspeed tape and extends upwards from the bottom of the airspeed tape to a position defined by the following equation:

Top of Low Speed Awareness Bar = Indicated Airspeed * Stall Warning Ratio

**NOTE**

The top of the bar corresponds approximately to 1.1 VS (VS = Stall Speed). The computation uses unfiltered airspeed from the ADS function.

The Low Speed Awareness Bar is filtered with a 10 second average filter after its position has been computed.

**Invalid**

Loss of valid calibrated airspeed information or loss of valid AOA information will cause the removal of the low speed awareness bar. A weight on wheels indication will cause the removal of the low speed awareness bar.

**Mach Digital Readout**

A Mach digital readout is displayed directly below the airspeed tape. The display appears at .450 Mach and be removed at .400 Mach. If mach from the ADS is less than 0.0 or greater than 0.999 the mach digits will be replaced by three dashes. The character "M" will be directly next to the digital readout. The layout of the mach digits will be XXX with a minimum of three digits using leading zeros as necessary. The mach digits will be displayed to a resolution of 0.001.

**Invalid**

Loss of valid calibrated airspeed information from the ADS causes removal of the Mach display. Loss of valid Mach information causes the Mach display to amber dash the digital readout.

**Vspeed Display**

Vspeeds are selected using menu pushbuttons located on both MCDUs. The Vspeed bugs shall be displayed on the right outside of the airspeed tape.

**Vspeed Bug**

The bugs are displayed as a "T" rotated 90° clockwise. Each "T" bug is labeled with an attached identifier that is up to two letters in length. The identifier is visible when the Vspeed bug is overlapped by the trend vector. The identifiers are as follows:

| Speed | Label |
|---|---|
| V1 | 1 |
| VR | R |
| V2 | 2 |
| VENR | E |
| VREF | RF |
| VAPP | AP |

Additionally, V1 and VR can be set equal to each other. For readability of the identifiers under this condition, the character "1" will occupy the first character position and the character "R" will occupy the second character position. The effect will be that the "T" bugs will overlay each other followed by the identifier "1R" when V1 and VR are equal. The rest of the speeds are separated by at least three knots by the Display Control function.

VENR is defined as the single engine en-route speed. VENR is a fixed speed and will be shown at the defined speed only when V1 is enabled for display. VENR will be displayed at 180 knots.

**Vspeed Window**

When Mach is below the .45 display enable value, the first available takeoff Vspeed will be displayed. This value will be displayed until the corresponding bug shows up on the airspeed tape. At this point, the next available takeoff Vspeed bug off the scale, in the increasing speed direction, is displayed. In the event that any takeoff Vspeeds are not set or displayed, and the aircraft is on the ground, an amber "VSPD" annunciation will be displayed in the window. The display will be in the format of "identifier=XXX", where XXX is in the units of knots. The VSpeed digits are rounded to a resolution of 1 knot.

**Vspeed Preview**

When airspeed is less than 30 knots and on-ground is indicated, the four takeoff speeds will be previewed on the bottom half of the airspeed tape. The Vspeed values will be displayed in the order of 1, R, 2, and E, with E on top. The display of each Vspeed value will be in the format of the value/bug symbol/identifier. A Vspeed value preview will be replaced with three dashes unless a value is entered for display from the MCDU.

**Invalid**

Loss of valid or test calibrated airspeed information from the ADS causes removal of the Vspeed bugs and display.

**Airspeed Miscompare Annunciation**

When the Monitor Warning System (MWS) detects an airspeed miscompare, an "IAS" annunciation will be located in a box inside the top half of the airspeed tape and will be displayed by appearing to slide from the outside edge onto the airspeed tape. The boxed annunciation will have display priority over all scale markings. The annunciation will be removed when the MWS no longer detects an airspeed miscompare.

**Invalid**

Loss of valid airspeed information from ADS causes the removal of the "IAS" annunciation.

**Flight Guidance Controller (FGC) Overspeed Protection Annunciation**

The FGC overspeed protection annunciation will be displayed when the available FGC indicates overspeed protection. The annunciation is located to the left of the attitude sphere. The annunciation is displayed vertically as MAX SPD.

**Invalid**

Loss of valid FGC information inhibits the FGC overspeed protection annunciation.

**Flap Deployment Speed Awareness**

Flap deployment speeds are indicated by three full time bugs on the outside of the airspeed tape. The bugs are displayed as a "T" rotated 90 degrees clockwise with its corresponding label to the right of the T.

If the value of any bug position goes beyond either end of the airspeed tape, that bug will be removed. When the selected Indicated Airspeed reaches 293.5 knots (all three flap bugs are below the airspeed tape), then an annunciation .F (down arrow) is displayed outside of the airspeed tape and near the bottom of the airspeed tape. When the selected Indicated Airspeed drops to 291.5 knots, the .F (down arrow). annunciation will be removed.

If the selected Barometric Altitude > 18,100 feet and selected Barometric Altitude is valid, then the flap bugs will be removed. The label and position of each bug is as follows:

| Label | Position |
|---|---|
| F7 | 250 KCAS |
| F15 | 200 KCAS |
| F35 | 175 KCAS |

When current airspeed exceeds the Flap speed limit value as defined in the Flap Speed Limit conditions below, the digital readout of current airspeed turns red. When the Flap Speed Limit value is exceeded by the airspeed trend vector, the digital readout of current airspeed turns amber. The Flap speed limit used by the airspeed readout color logic is determined from the deployment conditions as follows:

Flap Speed Limit Conditions

If 3.5 degrees < Flap Position $\leq$ 11 degrees and Flap position valid, then the speed limit value is 250 KCAS.

If 11 degrees < Flap Position $\leq$ 20 degrees and Flap position valid, then the speed limit value is 200 KCAS.

If Flap Position > 20 degrees and Flap position valid, then the speed limit value is 175 KCAS.

**Invalid**

Loss of valid calibrated airspeed information from the ADS will cause the removal of the Flap deployment speed bugs.

**Approach Que**

The Approach Que is shaped like an arrowhead and is positioned on the edge of the airspeed tape at the airspeed value calculated by the following formula:

Approach Que Position = 1.3 Vstall = 1.3 / 1.1 * Stall Warning Ratio * Indicated Airspeed

**NOTE**

The computation should use unfiltered airspeed from the ADS function.

**Invalid**

Loss of valid indicated airspeed information or loss of valid AOA information will cause the removal of the approach que. A weight on wheels indication will cause the removal of the approach que.

**VERTICAL SPEED DISPLAY**

Vertical speed information is transmitted by the on-side and cross-side ADS as selected by the Display Control function. The display system reverts to on-side data in the event that the Display Control function fails.

**Vertical Speed Dial Display**

Vertical speed indicates altitude rate and is comprised of a scale, digital readout and target speed. The scale shows vertical speeds about a ±6000 foot/minute range. The scale is non-linear with enhanced resolution for the range between ±2000 feet/minute. A tapered pointer representing current vertical speed is provided. For vertical speeds greater than ±6000 FPM, the pointer will park at ±6000 FPM. The scale has tick marks at each 500 FPM increment between ±2000 FPM, inclusive. The scale is labeled at the ±1000 FPM, ±2000 FPM, ±4000 FPM, and ±6000 FPM tick marks outside the dial with a single digit representing the thousands value.

**Invalid**

Loss of valid vertical speed information from the ADS causes the vertical speed scale markings to be removed and the vertical speed scale area will have a red "X" written over it.

**Vertical Speed Digital Display**

A current value window is located above or below the vertical speed scale depending upon altitude rate. If altitude rate ≥ 300 then Vertical speed digits are displayed above the scale. If altitude rate is ≤ - 300 then the Vertical speed digits are displayed below the scale. The digits are not displayed at vertical speeds > -300 and < 300 FPM. When the displayed vertical speed exceeds +/- 9950 FPM, the digital readout is limited to +/- 9999 FPM. The resolution of the display is 50 FPM between +/- 1000 FPM and 100 FPM for values greater than +/- 1000 FPM

Hysteresis of 50 FPM is provided such that the digital display is brought into view at 300 FPM during increasing values of vertical speed and the display is removed at 250 FPM on decreasing values of vertical speed.

**Invalid**

Loss of valid vertical speed information from the ADS causes the removal of the digits in the current value window.

**Vertical Speed Target Bug and Readout**

The vertical speed target digital readout is displayed above the vertical speed digital readout. The data for the readout can come from the priority AFCS when the FD vertical mode Vertical Speed is active or the FMS when either the FD vertical mode VNAV Path (VS) or VGP mode is active. The digital readout is rounded to the nearest 50 FPM for targets ≤ 1000 FPM and to the nearest 100 FPM for targets > 1000 FPM. The layout of the selected vertical speed digits is 'XXXX'. Positive speed targets are indicated with an up arrow directly above the annunciator and speed target value. Similarly, negative speed targets are indicated with a down arrow directly below the annunciator and speed target value.

The speed target bug is a notched rectangular bug such that when the speed target and current speed value are identical, the vertical speed pointer head fits in the notch of the speed target bug. For vertical speed targets greater than ±6000 FPM, the bug will become a half-bug and park at ±6000 FPM.

**Invalid**

Loss of valid vertical speed information from the ADS or loss of valid vertical speed target information from the AFCS or FMS will cause the removal of the speed target bug and readout and will be replaced by amber dashes.

### Heading Display

The AHRS transmits heading information for display on the PFD. The AHRS source is selected by the Display Control function. The source will default to on-side AHRS in the event that the Display Control function is invalid. The heading display will take on two distinct formats as selected by the Display Control function. The full compass consists of a 360° heading display that moves counterclockwise for positive increasing heading angles. The arc mode is a partial expansion of the 360° compass to show +/- 50 degrees about the current heading.

### Heading Scale

The heading display is capable of display between 1° and 360° with a 50°/sec minimum slew rate. The heading scale displays ±180° of heading information in the compass mode and +/- 50° of heading information in the arc mode. A long tick mark is displayed every 10°. A short tick mark is displayed at each intermediate 5° point. Each 30° tick mark is labeled with characters as follows: N, 3, 6, E, 12, 15, S, 21, 24, W, 30, and 33. In both the compass and arc modes, a box with a digital readout of current heading is provided. The bottom of the box is notched to fit inside the heading bug. In addition, a white outline of the compass arc is provided. An aircraft symbol is displayed in the center of the compass in compass mode, and at the bottom of the compass in arc mode.

### Heading Alignment Mode

Heading is displayed as described above during the initialization sequence of the Collins AHRS. During initialization the AHRS performs the following:

An align mode indication is output to ASCB.

The Heading data is set to fail warn.

The Heading output is decremented from a North Heading back to North over the course of the initialization sequence and then returns to actual heading.

### Invalid

When the AHRS is not in alignment mode, a loss of valid heading information from the AHRS causes the removal of the tick mark labels and a red "HDG FAIL" annunciation (white letters with a red background) is displayed in the top of the compass arc. The digital readout will also be dashed.

When the AHRS is in alignment mode, a loss of valid heading information from the AHRS causes a red "HDG FAIL" annunciation (white letters with a red background) to be displayed in the top of the compass arc.

## ANGLE OF ATTACK DISPLAY

### Angle of Attack Display and Window

The Angle of Attack indicator (AOA) is located to the left of the heading display in the window with the heading "AOA". The display consists of a fixed arc scale, pointer, and digital readout. The scale contains three segments: white, amber, and red representing ranges of angles of attack.

The AOA indicator display can be turned on or off by selecting the appropriate mode on the MCDU Display Setup page. The selectable modes are: .AUTO., .ON., .OFF.. These modes are defined as follows:

-AUTO AOA Window is brought into view and remains in view full time. AOA Indicator is brought into view when flap position is 3 degrees or greater or the landing gear is down.
-ON AOA Window and Indicator are brought into view and displayed full time.
-OFF AOA Window and Indicator are removed from view and remain off until .AUTO. or .ON. is
selected.

### Angle of Attack Test Mode Annunciation

The Angle of Attack display shall continue to display the angle of attack data during a pilot initiated test. When the angle of attack system is in test mode an amber .TEST. annunciation shall overwrite the bottom portion of the AOA scale.

### Invalid

Loss of valid or functional test Arinc 429 data from the AOA computer shall cause the angle of attack scale area to be overlayed with a red "X".

### Angle of Attack Digital Display

A current value readout is located to the left of the angle of attack scale. The digital readout displays angles of attack from 0.0 to 1.0. The layout of the AOA Display is XX with a minimum of two digits using a leading zero as necessary. The AOA Display is rounded to resolution of 0.01.

The color of the digits are displayed as follows:

| | |
|---|---|
| Segment 1 Digits - White | $0.20 \leq AOA \leq 0.60$ |
| Segment 2 Digits - Amber | $0.61 \leq AOA \leq 0.80$ |
| Segment 3 Digits - Red | $0.81 \leq AOA < 1.00$ |

The digital readout box background is black (no fill) when the pointer is in the white and amber ranges. The digital readout box background changes to red when the pointer is in the red range. The digital readout is limited to the appropriate value when either of these values is exceeded.

**Invalid**

Loss of valid or functional test Arinc 429 data from the AOA computer causes 3 amber dashes to be displayed.

**BEARING POINTER DISPLAYS AND WINDOW**

The EFIS receives bearing information from the on-side and cross-side VOR, ADF, and FMS over ASCB. VOR (MAG) and FMS (True) data are heading card referenced (absolute) and ADF data is case referenced (relative). When displaying FMS against a Magnetic referenced heading card, the bearing pointer must be compensated by the use of magnetic variation.

The bearing pointers are displayed when valid and selected for display by the Display Control function.
The circle (unfilled) bearing pointer is used for pilot side sources. The diamond (unfilled) bearing pointer is used for co-pilot side sources.

**Bearing Pointer Source Annunciations Window**

The bearing pointer sources are annunciated to the left of the heading display in the window with the heading "BRG PTR" when the bearing source is VOR, ADF, or FMS. The annunciations are displayed as "VOR1", "VOR2", "ADF1", "ADF2", "ADF", "FMS1", or "FMS2". The bearing annunciations will be removed when the bearing source if OFF.

**Bearing Circle Select Pushbutton**

The Bearing Circle pushbutton allows for the selection of VOR1, ADF1 or FMS1 for the on-side PFD HSI display. The bearing pointer selection with alternate activation of the pushbutton are as follows:

Off - VOR1 - ADF1 - FMS1 - Off

When only one ADF is installed, the annunciation ADF1 is replaced with ADF.

Power-up default = Last Setting

**Bearing Diamond Select Pushbutton**

The Bearing Diamond pushbutton allows for the selection of VOR2, ADF2 or FMS2 for the on-side PFD HSI display. The bearing pointer selection with alternate activation of the pushbutton are as follows:

Off - VOR2 - ADF2 - FMS2 - Off

When only one ADF is installed, the annunciation ADF2 will be replaced with ADF.

Power-up default = Last Setting

**Invalid**

Loss of valid heading information from the AHRS or loss of valid bearing information from the NAV receiver or FMS causes the removal of the absolute (VOR and FMS) bearing pointers, as appropriate.

**ET WINDOW**

An elapsed timer clock is displayed to the left of the heading display in a window identified by the heading "ET".

Elapsed time digital readout displays hours, minutes, and seconds in the format "H:MM:SS". Functions of the elapsed timer are count up, count down, hold, and reset as selected by the Display Controller function. Additionally, there is a preset function using the TIMERS page on the MCDU.

The first activation of the ET pushbutton selects the Elapsed Timer (ET) clock for display. If a preset time has been set on the TIMERS page of the MCDU, activation of the ET pushbutton will cause the elapsed timer to count down. If a preset time has not been set (elapsed timer = zero), activation of the ET pushbutton will cause the elapsed timer to count up. Additional activation of the ET pushbutton will be the same for both the count up and count down modes as follows:

Start (Count up/down)-->Stop-->Reset-->Start

If the selection remains in the reset state for ten minutes, or the ET pushbutton is held depressed for two seconds, the elapsed timer display will be selected as off. When the reset mode is selected following a count down from a preset value, the elapsed timer is set to zero and the elapsed timer preset value set using the MCDU will be deselected.

Power-up default = Elapsed Timer not displayed

**Count Down Complete Indication**

When the elapsed timer has counted down to zero, the elapsed timer automatically starts counting up. During the first five seconds of counting up, elapsed timer readout remains white after which the digits turn to amber and continue the count up process.

**Invalid**

Loss of valid Display Control information causes the digital readout to be dashed.

**CLOCK WINDOW**

A digital clock depicting system time of day is displayed to the left of the heading display in a window identified by the heading "CLOCK".

**Clock Digital Display**

The time of day data is displayed as a digital readout centered on the first line and is provided by the MAU. The clock digital readout displays minutes and seconds in the format "HH:MM:SS".

**Invalid**

Loss of valid time of day information from the MAU causes the time of day digital readout to be dashed.

## WEATHER RADAR DISPLAY

Weather Radar modes and annunciations are displayed to the left of the heading display in a window identified by the heading "WEATHER".

Weather radar returns may be displayed on the heading compass display when the compass display is in the arc mode and weather radar returns have been selected for display by the Display Control function.

### Range Display

A half-range range ring is displayed at one-half of the arc mode compass radius. A range annunciation is displayed at the end of the half-range range ring and the range annunciation is equal to one-half of the selected weather radar range.

### WX Mode Annunciations and Window

The WX mode annunciations are displayed when the radar returns are selected for display on the PFD or when weight is on wheels and a transmit mode is active (all weather radar modes except OFF and Standby). The WX mode annunciation is located to the left of the heading display in the window with the heading "WEATHER". The mode annunciations are: “WX/OFF”, “FAIL”, "WAIT", "STBY", "FSTBY", "TEST", "WX", "WX/T", "WX/RCT", "WX/GCR", “W/R/T”, "GMAP", and "FPLN".

The WX mode annunciation will flash 1 second on and .5 seconds off whenever any of the following conditions are met:

-The WX mode is WAIT.

-A transmitting mode is active (TEST, WX, WX/T, WX/RCT, WX/GCR, GMAP), the MFD is in the plan mode, and Weight-On-Wheels is true.

-The WX mode is FPLN and target enable = ON.

The WX mode annunciation will be replaced with a "WX/OFF" annunciation when the radar is in the off mode. The "WAIT", "FSTBY", and "STBY" annunciations will have priority over all other modes in the order listed and only one will be active at any one time.

### Transmit Annunciator

Transmitting modes when on the ground cause an amber "TX" annunciator to flash 1 second on and .5 seconds off regardless of the display selection. This annunciator is located in the lower left corner of the Heading Display.

### Tilt Setting

Weather radar antenna tilt setting data is displayed directly below the WX mode annunciations. The data is displayed to a .5 degree resolution for tilt angles between +/-10 degrees, and to a 1 degree resolution for angles ≥ +/-10 degrees. The data will be proceeded with a "T" label. The data will be followed with an arrow that points up for positive angles and points down for negative angles. The data is further followed with an "A" label whenever the auto-tilt function is active.

### Stabilization Mode Annunciation

Whenever the radar stabilization is off, a "STAB" annunciation is displayed directly below the target alert/variable gain line.

### Target Alert/Variable Gain Annunciation

The target alert mode annunciation and the variable gain indicator is displayed directly below the tilt display. Only one will be displayed at a time with the target alert mode annunciation having priority over the variable gain indicator. When target alert mode is selected, a "TGT" annunciation will be displayed. When the radar detects an alert condition, the "TGT" will flash 1 second on and .5 seconds off as long as the alert condition exists. Variable gain indication is displayed as an amber digital readout of knob rotation when the variable gain mode has been selected. The indication consists of a label "G" followed by a percentage readout of knob rotation and a "%" label.

### Sector Scan

As an indication that WX returns have been selected for display, the weather radar display sector is indicated by tick marks on the half-range ring. The left and right position of the tick marks are +/-60°, referenced to current heading. When the WX system is operating in the Sector Scan mode, the left and right tick mark positions will be +/-30°. The portion of the half-range ring between the tick marks will be dashed to provide further indication of the display sector.

### Invalid

Indication by the weather radar of internal failure causes the replacement of the mode annunciation with an amber "FAIL" annunciation.

## WAYPOINT/DME WINDOW

The WAYPOINT/DME window is displayed to the right of the heading display. The window has the heading WAYPOINT when an FMS is selected as the navigation source. The window has the heading DME when a VOR is selected as the navigation source. The WAYPOINT or DME windows contain similar information for either the long range navigation source or the short range navigation source. The following information is provided:

-TO Waypoint Identifier or DME Station Identifier
-TO Waypoint Distance or DME Distance
-TO Waypoint Estimated Time En-route or DME Estimated Time En-route
-FMS provided Groundspeed or DME provided Groundspeed
-FMS RNP

### Identifier

The layout of the FMS distance identifier is 'XXXXXX'. The FMS waypoint identifier shall be flashed 1 second on and .5 seconds off when a waypoint sequencing alert condition is active. The layout of the DME identifier is 'XXXX'. The DME identifier is right justified.

### Invalid

When FMS identifier is displayed, the loss of valid identifier information from the FMS will cause the removal of the identifier. When DME identifier is displayed, the loss of valid identifier information from the DME will cause the removal of the identifier.

### Distance Readout

The FMS distance digital readout range is 4095 NM. From 0-99.9 NM, the information is rounded to the nearest .1 NM and the resolution shall be .1 NM. For distances greater than 99.9 NM, the information is rounded to the nearest 1 NM and the resolution of the display shall be 1 NM. The digital readout is labeled with the annunciator "NM".

The DME distance digital readout range is 999 NM. From 0-99.9 NM, the information shall be rounded to the nearest .1 NM and the resolution shall be .1 NM. For distances greater than 99.9 NM, the information is rounded to the nearest 1 NM and the resolution of the display is 1 NM. The digital readout is labeled with the annunciator "NM".

### Invalid

When FMS distance is displayed, the loss of valid distance information from the FMS causes the digital readout to be dashed. When DME distance is displayed, the loss of valid identifier information from the DME causes the digital readout to be dashed.

### Estimated Time En Route (ETE) Readout

The FMS Estimated Time En-route (ETE) is displayed directly below the distance readout. The ETE display line has a label "MIN" preceded by the ETE value readout. Estimated time en route to the TO waypoint is received from the FMS. For ETE less than one hour, the ETE is displayed as two characters. For ETE equal to or greater than one hour, the ETE is displayed as hours and minutes, i.e. H+MM. The maximum displayable ETE is 9 hours and 59 minutes (9+59).

The DME Estimated Time En-route (ETE) is displayed directly below the distance readout. The ETE display line has the label "MIN" preceded by the ETE value readout. Estimated time en route to the DME station is received from the DME. For ETE less than one hour, the ETE is displayed as two characters. For ETE equal to or greater than one hour, the ETE is displayed as hours and minutes, i.e. H+MM. The maximum displayable ETE is 9 hours and 59 minutes (9+59).

### Invalid

When FMS ETE is displayed, the loss of valid ETE information from the FMS causes the ETE digits to be replaced with a dash, a plus sign, and two dashes (.-+--.) . The "MIN" label will remain.

When DME ETE is displayed, the loss of valid ETE information from the DME causes the ETE digits to be replaced with a dash, a plus sign, and two dashes (.-+--.) . The "MIN" label will remain.

### Groundspeed (GSPD) Readout

The FMS groundspeed readout range is 0 to 999 knots exclusive with the value rounded to the nearest knot. The digital readout is labeled with the annunciator "KTS" (knots).

The DME groundspeed readout range is 0 to 999 knots exclusive with the value rounded to the nearest knot. The digital readout is labeled with the annunciator "KTS" (knots).

### Invalid

When FMS groundspeed is displayed, the loss of valid groundspeed information from the FMS shall cause the groundspeed digits to be replaced with amber dashes.

When DME groundspeed is displayed, the loss of valid groundspeed information from the DME shall cause the groundspeed digits to be replaced with amber dashes.

### DME Hold Annunciation

The DME Hold indication is transmitted over ASCB by the MRC. DME Hold is indicated by an amber "H" displayed adjacent to the DME distance readout.

### Invalid

Loss of valid system status from the MRC shall cause the DME Hold annunciation to be removed.

### RNP Display

The RNP is displayed on the PFD whenever the FMS is selected as the Primary Navigation Source. This will indicate to the pilot that 2 dots deflection is equal to the RNP value. If FMS1, then it will display RNP value from FMS1. If FMS2, then it will display RNP value from FMS2. The text RNP is displayed below the DME information and above the FMS annunciations on the right side of the HSI (lower portion of the PFD). Below the text RNP, the RNP format is XX.X for values greater than or equal to 10.0 and X.XX for values less than 10.0. After the number the text "NM" in white will be shown. The RNP and value colors will always match the FMS lateral deviation color (magenta or amber).

### Invalid

Loss of valid RNP information from the FMS causes the RNP value readout to be replaced with amber dashes.

### FMS STATUS WINDOW

The FMS STATUS window is displayed in the lower right of the PFD display area. The FMS STATUS window contains FMS provided annunciations. The displayed annunciations are as follows:

-Mode Annunciation
-Approach APPR
-Offset XTK
-CDU Message MSG
-Dead Reckoning DR
-Degrade DGR

The messages are displayed vertically stacked. The "XTK" and "APPR" annunciations share the same location, with "APPR" having priority. The "MSG" annunciation is displayed above the "XTK/APPR" messages and flash 1 second on and .5 seconds off. The "DR" and "DGR" annunciations share the same location, with "DR" having priority, located below the "XTK/APPR" messages.

## WIND WINDOW

The WIND window is displayed in the lower right of the PFD display area. The WIND window contains wind speed and direction information that is transmitted by the displayed FMS. Wind data is displayed in the format of Cartesian or Polar coordinates. The displays consist of wind speed digital readout(s) and wind direction arrow(s) indicating the direction of the wind.

### Polar Format

The layout of the polar wind speed digits is XXX. The polar wind speed digits are rounded to a resolution of 1 knot and shall be right justified.

The polar wind speed direction arrow is positioned according to the FMS wind angle parameter. If wind angle = 0.0, then the polar wind speed direction arrow is pointed to the 6 o.clock position indicating a headwind. The polar wind speed direction arrow will rotate about its center in a counter-clockwise direction for decreasing values and clockwise for increasing values.

The polar wind display is compensated by magnetic variation provided by the FMS.

If FMS wind speed < 0.0 or > 999.0, then the polar wind speed digital readout display shall be removed.

### Invalid

Loss of valid wind data from the FMS, or valid heading data, or valid magnetic variation data shall cause the polar wind speed digital readout display to be removed.

## PREVIEW MODE OPERATION

When FMS is the displayed navigation source on the PFD, VOR/ILS course deviation and vertical deviation may be previewed on the compass card formats of the PFD. Previewed NAV source data is selected by the Display Control function.

### Lateral Deviation

When preview mode is selected for display, a course arrow and deviation bar is displayed on the compass card. For VOR/LOC previewed course, turning the course select knob causes the arrow to move around the compass with the same selection gradient used for VOR/LOC course arrow selection. The lateral movement of the deviation bar on the preview course arrow is scaled to match that of the lateral deviation pointer for LOC source.

### Vertical Deviation

The vertical deviation scale adjacent to the attitude sphere is displayed in the preview mode. If the NAV receiver is tuned to a localizer frequency any valid pointers will also be displayed.

### Preview Course Information

The preview course readout is a representation of dcSelectedCourse. The layout of the preview course readout is XXX with a minimum of three digits using leading zeros as necessary.

### Previewed Source Annunciation

A source annunciation of the previewed NAV is displayed to the right of the active navigation source annunciation. The possible NAV source annunciations for preview are: "VOR1", "VOR2", "LOC1" and, "LOC2".

### Invalid

Loss of valid lateral deviation information from the NAV receiver will remove the previewed course arrow/deviation bar.

### FMS Map Display

An FMS map display can be selected on the PFD when the primary navigation source is FMS and the Arc mode has been selected by the display controller. The FMS map is limited to the display of waypoints only. Flight plan symbols will not be displayed to conflict with any of the panel windows.

### Waypoint Display

The display format is capable of displaying up to 4 waypoints maximum. Each waypoint's position is defined by its latitude and longitude with respect to aircraft present position. The waypoint is labeled to the right with an identifier up to six characters in length. Track lines will connect the active waypoints of the flight plan with their successor waypoint as long as the current waypoint is not followed by a discontinuity and the successor waypoint is valid.

### Invalid

Loss of valid heading information from AHRS or loss of valid waypoint information from FMS will cause the removal of all waypoint symbols. One waypoint labeled as invalid by the FMS will only cause the removal of the waypoint in question.

## TCAS DISPLAY SYMBOLOGY

A resolution advisory (RA) is a display indication given to the pilot recommending a maneuver to increase vertical separation relative to an intruding aircraft. There are two types of RAs - Corrective and Preventive. A corrective RA instructs the pilot to deviate from current vertical speed to avoid the intruder. A preventive RA instructs the pilot to avoid certain deviations from the current vertical speed.

### ADI Pitch Target Symbology

The ADI pitch target symbology will appear only when an RA is indicated by the TCAS computer. The symbology consists of a possible combination of one or two red trapezoidal shaped avoidance zones and a green rectangular shaped fly to zone. The avoidance and fly to zones rotate with the pitch scale under roll conditions. The aircraft symbol color is a function of the target zone location as follows:

Red - when an RA is present and the aircraft is located within the avoidance zone
Green - when within the fly to zone

When there is an RA advisory condition, the flight director command bars will be removed. The aircraft symbol changes colors as described in Section Titled Aircraft Symbol. The advisory avoidance zone color will be red. The advisory fly-to zone color will be green.

### TCAS Advisory Avoidance and Fly-To Zones

The TCAS up advisory avoidance zone indicates there is an intruder below the aircraft that should be avoided and is indicated with a trapezoid. The TCAS down advisory avoidance zone indicates there is an intruder above the aircraft that should be avoided and is indicated with a trapezoid. The fly-to zone is displayed when there is a corrective advisory present or don't climb and don't descend. If it is other than a preventative, there are only pitch targets.

### TCAS Mode Annunciations

The TCAS mode annunciations are displayed to the left and below of the lateral deviation scale. The annunciations have the following priority:

-When TCAS indicates functional test, a "TCAS TEST" annunciation will be displayed in red.

-When TCAS is valid or in functional test and TCAS indicates Standby, a "TCAS OFF" annunciation will be displayed.

-When the below conditions are present, a "TCAS FAIL" annunciation will be displayed.

- -TCAS bus fails
- -TCAS indicates TCAS System failure
- -TCAS Control Word indicates Failure or No Computed Data
- -TCAS Control Word indicates No Control Function Possible
- -TCAS Vertical RA indicates Failure
- -TCAS computer fails

-When TCAS indicates TA only mode, a "TA ONLY" annunciation will be displayed.

When none of the above TCAS annunciations are currently displayed, no annunciation will be displayed. TCAS mode annunciations will only be displayed when TCAS is installed in the aircraft.

**RA FAIL ANNUNCIATION**

When any of the following conditions are true, the TCAS RA advisory will be removed and an "RA FAIL" annunciation will be displayed to the left and below of the lateral deviation scale. The conditions are as follows:

-When TCAS Vertical RA indicates .Failure Warning. or .No Computed Data.
-True airspeed is invalid
-Advisory altitude rate is greater than 4400 fpm
-Combined control, up advisory, and down advisory states do not satisfy valid resolution advisory conditions.
-Vertical Speed is invalid

**ENHANCED GROUND PROXIMITY WARNING FUNCTIONS**

The Enhanced Ground Proximity Warning Module (EGPWM) performs the following functions:

-Ground Proximity Caution and Warning
-Windshear Caution and Warning
-Terrain/Obstacle Awareness Caution and Warning

Each of these functions have associated annunciations and these are displayed in the same area on the Primary Flight Display.

**EGPWM Annunciation Display Priority**

The following priority, from highest to lowest, is used to determine which annunciation is displayed if more than one is active:

PULL UP (ground proximity warning OR terrain/obstacle awareness warning)
WIND SHEAR (warning)
GND PROX (ground proximity caution OR terrain/obstacle awareness caution)
WIND SHEAR (caution)

**Ground Proximity Warning System Annunciations**

Ground proximity warning system information comes from the Enhanced Ground Proximity Warning Module (EGPWM).

### Ground Proximity Caution

When a ground proximity caution is indicated, a boxed "GND PROX" annunciation is displayed in the upper right corner of the attitude sphere. The boxed "GND PROX" annunciation toggles reverse video 1 second on and .5 second off for the first 5 seconds the annunciation is displayed then becomes steady. The annunciation will be removed when a ground proximity caution is no longer indicated.

### Invalid

Loss of valid GPWS information causes the boxed "GND PROX" annunciation to be removed.

### Ground Proximity Warning

When a ground proximity warning is indicated, a boxed "PULL UP" annunciation will be displayed in the upper right corner of the attitude sphere. The boxed "PULL UP" annunciation will toggle reverse video 1 second on and .5 second off for the first 5 seconds the annunciation is displayed then becomes steady. The annunciation will be removed when a ground proximity warning is no longer indicated.

### Windshear Warning System Annunciations

Windshear warning system information comes from the Enhanced Ground Proximity Warning Module (EGPWM).

When a windshear warning or caution is indicated, a boxed "WIND SHR" annunciation is displayed in the upper right corner of the attitude sphere. The annunciation will toggle reverse video 1 second on and .5 second off for the first 5 seconds the annunciation is displayed then becomes steady. The annunciation will be removed when the windshear warning or caution is no longer indicated.

### Invalid

Loss of valid windshear information from causes the boxed "WIND SHR" annunciation to be removed.

### WX/EGPWS Bus Failure Annunciation

A "WX" bus failure annunciation is displayed boxed on the right side of the range ring when a Weather Radar bus failure is indicated and Weather Radar is selected for display.

A "TERR" bus failure annunciation is displayed boxed on the right side of the range ring when a Terrain bus failure is indicated and Terrain is selected for display.

A "RNG" failure annunciation is displayed boxed on the right side of the range ring when the display range commanded is < 2.5 or > 9999.

The WX, TERR, and RNG failure annunciations are displayed mutually exclusive.

# MULTIFUNCTION DISPLAY (MFD)

The MFD contains 4 menu format selections at the top of the MFD display and full time display of generic information located in the lower half of the display.

The menu format selections are associated with an MFD format, which can be activated by positioning the cursor over the desired menu title button and pressing the "Enter" button on the CCD. The menu buttons are "CHECKLIST" menu, "TCAS" menu, "MAP" menu, and "PLAN" menu. The table below shows what options are selectable features of each of these formats.

## MFD Menus

| Menu: CHECKLIST | Menu: TCAS | Menu: MAP | Menu: PLAN |
|---|---|---|---|
| Normal Checklist<br>Abnormal Checklist<br>Emergency Checklist | Range Control<br>Flight Level Selection<br>Norm/Above/Below Selection<br>Expanded | Navaids On/Off<br>Airports On/Off<br>Waypoint Idents On/Off<br><br>Vertical Profile On/Off<br>TCAS Traffic On/Off<br>DME1 Display On/Off<br>DME2 Display On/Off<br>Weather Radar, or Terrain<br>FMS1 Display On/Off | Navaids On/Off<br>Airports On/Off<br>Waypoint Idents On/Off<br><br>Vertical Profile On/Off<br>DME1 Display On/Off<br>DME2 Display On/Off<br>Aircraft Centered, or Waypoint Centered<br>FMS1 Display On/Off<br>FMS2 Display On/Off |
| | | FMS2 Display On/Off | Designator On/Off |
| | | Designator On/Off | |
| | | No Takeoff On/Off | |
| | | SCMS Display On/Off | |
| | | Maintenance Display On/Off | |

The MFD display consists of the following:
. Static Air Temperature
. True Airspeed
. Ground Speed
. Weather Radar Operating Modes and Display
. Lightning Sensor Data and Display
. Wind Display
. Distance to Waypoint
. Estimate Time En Route
. Heading
. Heading Select
. Flight Plan
. Vertical Profile
. Checklist
. TCAS Traffic Advisory
. EICAS system Displays
. Integrated Maintenance Test

A representative MFD display is shown in Figure 15-1 along with descriptive callouts of individual display items.

# TYPICAL MULTIFUNCTION DISPLAY


## MAP MODE SHOWING TCAS

Figure 3-18

## GENERAL MFD INFORMATION

This section describes general information that is displayed regardless of which MFD format is selected for display. The data resides in the lower left corner, the lower right corner, and the bottom portion of the display format. Each of the general areas of the MFD are described as follows:

- The lower left corner is further segmented into two display windows. The top left window contains the selected TCAS modes, the middle left window contains the selected weather radar and lightning sensor system modes.

- The lower right corner is further segmented into three display windows. The top right window contains readouts of RAT, SAT, and ISA air temperatures, the middle right window contains readouts of true air speed and ground speed, the lower right window contains the waypoint identifier and time-to-go displays.

- The bottom portion of the display contains a dashboard type display with display windows. The left most window contains the VHF Com active and preset frequencies. The middle left window contains the VHF Nav active and preset frequencies. The middle window contains the source annunciation (#1 or #2) for both the Com and Nav radios. The middle right window contains the active ATC Code and selected TCAS modes. The right most window, when displayed, will indicate Transponder Ident reply as "ID".

## TCAS WINDOW

TCAS Modes are displayed in a TCAS window within the lower left display area directly below the DME window and above the WEATHER window. TCAS mode annunciations are displayed in a single row on the third line of TCAS information (the first line is for flight level, the second is for above/below/normal/expanded). The annunciations are displayed whenever the MFD format is Map mode.

## WEATHER WINDOW

Weather Radar Modes and status are displayed in a window within the lower left display area. The window is identified by the header "WEATHER".

### WX Mode Annunciations

The WX mode annunciations are displayed on the top line of the WEATHER window. The mode annunciations are: "WX/OFF", "FAIL" "WAIT", "STBY", "FSTBY", "TEST", "WX", "WX/T", "WX/RCT", "WX/GCR", "W/R/T", "GMAP", and "FPLN". The WX mode annunciation will flash 1 second on and .5 seconds off whenever any of the following conditions are met:

- The WX mode is WAIT

- A transmitting mode is active (TEST, WX, WX/T, WX/RCT, WX/GCR, GMAP), the MFD is in the plan mode, and Weight-On-Wheels is true or when FPLN and target enable is on.

- The WX mode is FPLN and target enable = ON The WX mode annunciation will be replaced with a "WX/OFF" annunciation when the radar is in the off mode. The "WAIT", "FSTBY", and "STBY" annunciations will have priority over all other modes in the order listed and only one will be active at any one time.

### Invalid

Indication by the weather radar of internal failure causes the replacement of the mode annunciation with an amber "FAIL" annunciation.

### Tilt Setting

Weather radar antenna tilt setting data is displayed directly below the WX mode annunciations. The data is displayed to a .5 degree resolution for tilt angles between +/-10 degrees, and to a 1 degree resolution for angles $\geq$ +/-10 degrees. The data is proceeded with a "T" label. The data is followed with an arrow that points up for positive angles and points down for negative angles. The data is further followed with an "A" label whenever the auto-tilt function is active.

### Target Alert/Variable Gain

The target alert mode annunciation and the variable gain indicator is displayed directly below the tilt display. Only one will be displayed at a time with the target alert mode annunciation having priority over the variable gain indicator. When target alert mode is selected, a "TGT" annunciation will be displayed. When the radar detects an alert condition, the "TGT" will flash 1 second on and .5 seconds off as long as the alert condition exists. Variable gain indication is displayed as a digital readout in the format .XXX. with a resolution of 1 when the variable gain mode has been selected. The indication consists of a label "G" followed by a percentage readout of knob rotation and a "%" label. For invalid data, the label will be removed.

### Stabilization Mode Annunciation

Whenever the radar stabilization is off, a "STAB" annunciation will be displayed directly below the target alert/variable gain line.

### Lightning Sensor System Modes and Annunciations

The Lightning Sensor System is an optional display selected by the Aircraft Personality Module (APM). When enabled, these modes will also be displayed within the "WEATHER" window in the lower left display area. The bottom line of the window is reserved for lightning sensor system data. LSS mode annunciations appear on the MFD display regardless of the selected MFD mode. The LSS mode annunciations are as shown below, along with the annunciator color and enabling signal.

| LSS MODE | ANN MODE & COLOR | ENABLING SIGNAL |
|---|---|---|
| LSS Off | "LX/OFF" Green | LX Power |
| LSS Interface Failure | "LX" Amber | See Note |
| LSS Fault Detected | "LX/FAIL" Amber | LX Fault |
| Standby Mode | "LX/STBY" Green | LX Standby |
| Clear Mode | "LX/CLR Green | LX Clear |
| Test Mode | "LX/TEST" Green | LX Test Mode |
| Antenna Input Inhibited | "LX/INHB" Green | LX Ant Inhib |
| Heading Input Deselected | "LX/HDG" Green | LX Hdg Invalid |
| Self Calibration Mode | "LX/CAL" Green | LX Auto Cal |
| Normal Operation Mode | "LX" Green | LX Normal |

**NOTE**

Activated when the LSS is on (LX Power) and the ASCB bus is inactive.

### TEMP WINDOW

Temperature information is displayed in the window within the lower right display area. The window is identified by the heading "TEMP". The TEMP window displays the following information:

-Relative Air Temperature (RAT)
-Standard Air Temperature (SAT)
-International Standard Atmosphere Deviation (.ISA)

**Relative Air Temperature (RAT)**

The Relative Air Temperature (RAT) is a representation of the air temperature at the inlet of the engine with the lower temperature. The RAT display line has the label "RAT" followed by the RAT value readout with fractional degrees truncated.

The layout of the RAT digits are XXX with a minimum of one digit. The RAT digits are rounded to a resolution of 1 degree and are right justified. The range of the RAT display is ≥ -99.0 and ≤ 99.0. Values outside of this range are invalid.

**Invalid**

Loss of valid air temperature information from the ADS causes the RAT value readout to be replaced with dashes.

**Static Air Temperature (SAT)**

The Static Air Temperature (SAT) is a representation of the temperature at a point at rest relative to the ambient air. The SAT display line has the label "SAT" followed by the SAT value readout with fractional degrees truncated.

The layout of the SAT digits is "XXX" with a minimum of one digit. The RAT digits are rounded to a resolution of 1 degree and are right justified.

The range of the SAT display is ≥ -99.0 and ≤ 99.0. Values outside of this range are invalid.

**Invalid**

Loss of valid air temperature information from the ADS causes the SAT value readout to be replaced with dashes.

**International Standard Atmosphere (ISA)**

The International Standard Atmosphere (ISA) is a uniform reference for temperature. The Delta ISA display line has the label "ISA" followed by the ISA value readout with fractional degrees truncated.

The layout of the .ISA digits are "XXX" with a minimum of one digit. The RAT digits are rounded to a resolution of 1 degree and are right justified.

The range of the .ISA display is ≥ -99.0 and ≤ 99.0. Values outside of this range are invalid.

**Invalid**

Loss of valid air temperature information from the FMS causes the ISA value readout to be replaced with dashes.

**SPEED WINDOW**

Aircraft Speed information is displayed in the SPEED window within the lower right display area. The window is identified by the heading "SPEED". The SPEED window displays the following information:

-True Airspeed (TAS)
-Groundspeed (GSPD)

**True Airspeed (TAS)**

True Airspeed is displayed in the SPEED window. The TAS display line has the label "TAS" followed by the TAS value readout with fractional knots truncated. The readout is limited to the range of 0 through 999 knots inclusive.

The layout of the TAS digits is "XXX" with a minimum of one digit. The range of the TAS display is $\geq$ 0.0 and $\leq$ 999.0. Values outside of this range are invalid.

**Invalid**

Loss of valid airspeed information from the AD causes the TAS value readout to be replaced with dashes.

**Groundspeed (GSPD)**

Groundspeed is displayed in the SPEED window. The Groundspeed display line has the label "GSPD" followed by the Groundspeed value readout with the value rounded to the nearest knot. The data is from the displayed FMS and is limited to the range of 0 through 999 knots inclusive.

The layout of the GSPD digits is "XXX" with a minimum of one digit. The range of the GSPD display is $\geq$ 0.0 and $\leq$ 999.0. Values outside of this range are invalid.

**Invalid**

Loss of valid ground speed information from the FM causes the GSPD value readout to be replaced with dashes.

## DEST WINDOW

Aircraft destination information is displayed in the DEST window within the lower right display area. The window is identified by the heading "DEST". The DEST window displays the following information:

-Destination Waypoint Identifier
-Estimated Time En-route

### Destination Waypoint Identifier

The Destination Waypoint Identifier is displayed in the DEST window. The FMS Destination waypoint identifier is transmitted over ASCB by FMS. The layout of the Destination Waypoint Identifier digits is "XXXXXX" and is right justified. The text character "?" is used if the requested character is not one of the supported characters.

### Invalid

Loss of valid identifier information from the FM causes the removal of the identifier.

### Estimated Time En Route (ETE) Readout

Estimated Time En-route (ETE) is displayed in the DEST window. The ETE display line has a label "MIN" preceded by the ETE value readout. Estimated time en route to the TO waypoint is received from the FMS and displayed directly below the TO waypoint identifier. For ETE less than one hour, the ETE is displayed as two characters. For ETE equal to or greater than one hour, the ETE is displayed as hours and minutes, i.e. H+MM. The maximum displayable ETE is 9 hours and 59 minutes (9+59).

The range of the ETE display is $\geq$ 0.0 and $\leq$ 599.0. Values outside of this range are invalid.

### Invalid

Loss of valid ETE information from FM causes the ETE digits to be replaced with a dash, a plus sign, and two dashes ("-+--"). The "MIN" label will remain.

## DME 1 & DME 2 WINDOWS

Display of either or both of the primary short range navigation data can be selected for display on the MAP drop down menu bar. Each can be selected on/off independently by using the CCD to highlight the menu item and then clicking either "enter" pushbutton on the CCD palm rest. A checkmark in the adjacent square indicates that the DME1 and/or DME2 data is selected for display. Power-up default = Last Setting.

When selected for display the DME1 window is displayed on the left above the TCAS window. When selected for display the DME2 window is displayed to the right above the TEMP window. The windows has the heading "DME1" or "DME2" as appropriate. The following information is provided:

-DME Station Identifier
-DME Distance
-DME Hold annunciation

**DME Station Identifier**

The DME Station Identifier is transmitted over ASCB by the DME.

The layout of the DME identifier is 'XXXX' and is right justified. The text character "?" shall be used if the requested character is not one of the supported characters.

**Invalid**

Loss of valid identifier information from the DM cause the removal of the identifier.

**DME Distance Readout**

The EFIS receives distance information from DME over ASCB. Distance is displayed in the "DME" window directly below the DME Station Identifier.

The range of the distance readout is zero to +524 NM. From 0-99.9 NM, the information is rounded to the nearest .1 NM and the resolution is 1 NM. For distances greater than 99.9 NM, the information is rounded to the nearest 1 NM and the resolution of the display is 1 NM. The digital readout is labeled with the annunciator "NM".

**Invalid**

Loss of valid distance information from the DM causes the digital readout to be replaced with dashes.

**DME Hold Annunciation**

The DME Hold indication is transmitted over ASCB by the DME. DME Hold is indicated by a amber "H" displayed adjacent to the DME distance readout.

**Invalid**

Loss of valid system status from the DM causes the DME Hold annunciation to be removed.

## RADIO TUNING AND STATUS DISPLAY

The Radio Tuning and Status display is located across the entire bottom of the MFD display. The Radio Tuning and Status display consists of the following:

-COM active frequency - selectable between on-side and cross-side radio
-COM standby frequency - selectable between on-side and cross-side radio
-NAV active frequency - selectable between on-side and cross-side radio
-NAV standby frequency - selectable between on-side and cross-side radio
-Transponder Code selection and annunciation
-Transponder ID (identification) annunciation
-Transponder mode selection and annunciation
-On-side and Cross-side radio selection and annunciation

## MAP DISPLAY FORMAT

The MFD MAP format can be selected by placing the cursor over the MAP menu selection and selecting enter on the CCD. The following paragraphs describe the elements associated with the Map format.

### MAP Menu Bar

The MAP Menu will be displayed when the cursor is moved over the menu prompt and selecting the enter button on the CCD. Repeating this action closes the menu.

The Map menu includes non-exclusive selections represented as check boxes. They are:

1. Navaids, Airports, Waypoint Identifier, Vertical Profile, and Traffic.
2. DME1 and DME2.
3. Maintenance
4. No Takeoff
5. Designator
6. SCMS

The Map also includes exclusive selection represented as radio buttons. They are:

1. Weather, Terrain, and Off.
2. FMS1 and FMS2.

### Heading Display

The information to construct the heading display is transmitted by the AHRS. The AHRS source is selected by the Display Control function. The source defaults to on-side AHRS in the event that the Display Control function is invalid.

### Heading Scale

The heading scale displays the current MFD Heading +/-90°. A long tick mark is displayed every 10°. A short tick mark is displayed at each intermediate 5° point. Each 30° tick mark is labeled with characters as follows: N, 3, 6, E, 12, 15, S, 21, 24, W, 30, and 33. An aircraft symbol is displayed at the arc center. The heading scale rotates counterclockwise for increasing MFD Heading and clockwise for decreasing MFD Heading relative to the center of the aircraft symbol.

**NOTE**

> The rotating elements of the heading scale display include the cardinal heading labels, ("N", "E", "S", and "W" at 0, 90, 180, and 270 degrees respectively), the intermediate heading labels ("3", "6", "12", "15", "21", "24", "30", and "33" at 30, 60, 120, 150, 210, 240, 300, and 330 degrees respectively) and the heading scale tick marks.

The range of the heading scale is limited from 1° to 360°. A compass heading value of 0° is represented as 360°.

When the AHRS test mode is active, heading data is displayed with a "HDG TEST" annunciator. This annunciation is displayed in the same place as the "HDG FAIL" annunciation. The fail annunciator has priority over the test annunciator.

### Invalid

When the AHRS is not in alignment mode, a loss of valid heading information from the AHRS causes the removal of the intermediate and cardinal heading labels and a red "HDG FAIL" annunciation (white letters with a red background) is displayed in the top of the compass arc.

When the AHRS is in alignment mode, a loss of valid heading information from the AHRS causes a red "HDG FAIL" annunciation (white letters with a red background) to be displayed in the top of the compass arc.

### Heading Readout

A digital readout of heading is located in a partial box at the top of the heading lubber line. The bottom portion of the box is notched for the heading bug.

-The heading readout shall be limited from 1° to 360°.
-A compass heading value of 0° will be represented by 360°.
-The heading readout shall be rounded to a resolution of 1°.
-The layout of the heading digital readout is 'XXX' with a minimum of three digits, using leading zeros as necessary.

### Invalid

When the AHRS is not in alignment mode, a loss of valid heading information from the AHRS causes the heading readout to be replaced by dashes.

### Heading Source Annunciation

The heading source annunciation is displayed above and to the left of the digital readout box. When the normal on-side heading source is displayed on both MFDs (whether selected on DU2 or DU3), no source annunciation is given unless DG mode has been selected. In this case, a white "DG1" annunciation is shown on the pilot's MFD (when selected on DU2) and a white "DG2" is shown on the copilot's MFD (when selected on DU3).

Heading source information is selected by the on-side Display Control function. In the event ATT/HDG1 reversion is selected, an amber MAG1 or DG1 is displayed on the pilot's MFD (when selected on DU2) and the copilot's MFD (when selected on DU3). If ATT/HDG2 reversion is selected, an amber MAG2 or DG2 is displayed on the pilot's MFD (when selected on DU2) and on the copilot's MFD (when selected on DU3). If both pilot and copilot sources are cross-side, a white MAG2 or DG2 is displayed on the pilot MFD (when selected on DU2) and a white MAG1 or DG1 is displayed on the copilot MFD (when selected on DU3).

### Invalid

The heading source annunciation will be removed for invalid heading data or a display control failure.

### Selected Heading Display

Heading select information is transmitted by the Display Control function. An associated digital readout with a "HDG" label is provided full time in the upper left hand corner of the display. The layout of the selected heading display is 'XXX' with a minimum of three digits, using leading zeros as necessary. The selected heading display is rounded to a resolution of 1 degree. The range of the selected heading digits is 1° to 360°. A selected heading value of 0° is represented as 360°.

### Invalid

Loss of valid heading information from the AHRS or loss of valid data from the Display Control function will dash the HDG digital readout.

**Selected Heading Bug**

Heading select information is transmitted by the Display Control function. An associated heading bug is provided full time on the display.

The heading bug can go out of view. At the point the bug goes out of view, an arrow pointing to the shortest direction to the bug is displayed above the compass arc. The arrow is removed the same time the bug comes into view.

**Invalid**

Loss of valid heading information from the AHRS or loss of valid data from the Display Control function removes the selected heading bug and dash the HDG digital readout.

**Drift Bug Display**

The actual track bug is displayed on the compass arc as a hollow triangle. This data is transmitted by the FMS.

**Invalid**

Loss of valid heading information from the AHRS or valid angle information from FMS causes the removal of the drift bug.

**Navigation Source Annunciators**

Navigation source is displayed in the upper right corner of the display as selected by the on-side Display Control function. The navigation sources displayed are "FMS1" and "FMS2".

**Destination Waypoint Identifier**

The Destination Waypoint Identifier is displayed in the upper right corner of the display as selected by the on-side Display Control function. The waypoint identifier displayed is from the selected FMS. The FMS Destination waypoint identifier is transmitted over ASCB by FMS. The waypoint identifier is flashed 1 second on and .5 seconds off when a waypoint sequencing alert condition is active.

-The layout of the FMS distance identifier is 'XXXXXX'.
-The FMS distance identifier is right justified.
-Text character "?" is used if the requested character is not one of the supported characters.
-IF FMS distance to go is < 0.0 OR > 999.0 then the FMS distance identifier is removed.

**Invalid**

Loss of valid identifier information from the FMS or invalid distance rang causes the removal of the identifier.

**TO Waypoint Distance Readout**

The TO Waypoint Distance Readout is displayed in the upper right corner of the display as selected by the on-side Display Control function. The waypoint identifier displayed is from the selected FMS. The EFIS receives distance information from FMS over ASCB.

The distance digital readout range is 9999 NM for FMS. From 0-99.9 NM, the information is rounded to the nearest .1 NM and the resolution is .1 NM. For distances greater than 99.9 NM, the information is rounded to the nearest 1 NM and the resolution of the display is 1 NM. The digital readout is labeled with the annunciator "NM".

**Invalid**

Loss of valid distance information from the FM causes the digital readout to be replaced with dashes.

**Estimated Time En Route (ETE) Readout**

The Estimated Time En Route to the TO Waypoint is displayed in the upper right corner of the display as selected by the on-side Display Control function. The waypoint identifier displayed is from the selected FMS. The ETE display line has a label "MIN" preceeded by the ETE value readout. For ETE less than one hour, the ETE is displayed as two characters. For ETE equal to or greater than one hour, the ETE is displayed as hours and minutes, i.e. H+MM and will have a "+" label between the hours(H) readout and the minutes(MM) readouts. The maximum displayable ETE is 9 hours and 59 minutes (9+59).

The FMS estimated time en route digits are rounded to a resolution of 1 minute.

The FMS estimated time en route digits are right justified.

**Invalid**

Loss of valid ETE information from FM causes the ETE digits to be replaced with amber dashes. The "MIN" label shall remain.

**Wind Display**

The MFD wind display contains wind speed and direction information that is transmitted by the displayed FMS. Wind data is displayed in the format of Cartesian or Polar coordinates. The displays consist of wind speed digital readout(s) and wind direction arrow(s) indicating the direction of the wind.

**Polar Format**

The layout of the polar wind speed digits is "XXX". The polar wind speed digits are rounded to a resolution of 1 knot and are right justified.

The polar wind speed direction arrow is positioned according to the FMS wind angle parameter. If wind angle = 0.0, then the polar wind speed direction arrow is pointed to the 6 o.clock position indicating a headwind. The polar wind speed direction arrow rotates about its center in a counter-clockwise direction for decreasing values and clockwise for increasing values.

The polar wind display is compensated by magnetic variation provided by the FMS.

If FMS windspeed < 0.0 or > 999.0, then the polar wind speed digital readout display will be removed.

**Invalid**

Loss of valid wind data from the FMS, or valid heading data, or valid magnetic variation data causes the polar wind speed digital readout display to be removed.

**Flight Plan Data**

Flight plan waypoints, navaids, and airports are transmitted by the selected FMS. Flight plan symbols will not be displayed to conflict with any of the panel windows included but not limited to the vertical profile display, bearing/distance display. They will also not extend above the heading arc. Flight plan symbols will not be displayed to conflict with the TCAS .no bearing. readouts or Peaks/EGPWS mode annunciations.

In MAP mode, flight plan symbology is referenced to the heading. In PLAN mode, the aircraft symbol rotation is referenced to heading.

**Waypoint Display**

The display format is capable of displaying up to 16 waypoints maximum. Each waypoint's position is defined by its latitude and longitude with respect to aircraft present position. The waypoint is labeled to the right with an identifier up to six characters in length. Track lines connect the active waypoints of the flight plan with their successor waypoint as long as the current waypoint is not followed by a discontinuity and the successor waypoint is valid.

### Waypoint Radial

For each waypoint marked as a waypoint radial, a track line is drawn from the waypoint in the opposite direction of waypoint initial course the length of the waypoint distance.

### Waypoint Non-Display Features

When a waypoint is a transition point that has no identifier or symbol, the waypoint will not be displayed. If the waypoint is not part of the primary flight plan, it will also not be displayed. Top-of-Climb (TOC), Top-of-Descent (TOD), and Bottom-of-Step-Climb (BOSC) waypoints will be displayed without altitude information.

### Invalid

Loss of valid heading information from AHRS or loss of valid waypoint information from FMS causes the removal of all waypoint symbols. One waypoint labeled as invalid by the FMS will only cause the removal of the waypoint in question.

### Navaid Display

Navaids are selected for display by on the MAP drop down menu bar. The display is capable of displaying up to 10 navaid symbols. The navaid location is based on its latitude and longitude with respect to aircraft present position. The navaid is labeled to the right with an identifier up to 4 characters in length.

### Invalid

Loss of valid heading information from AHRS or loss of valid navaid information from FMS causes the removal of all navaid symbols. One navaid labeled as invalid by the FMS will only cause the removal of the navaid in question.

### Airport Display

Airports are selected for display on the MAP drop down menu bar. The display is capable of displaying up to 9 airport symbols. The airport location is based on its latitude and longitude with respect to aircraft present position. The airport is labeled to the right with an identifier up to 4 characters in length.

### Invalid

Loss of valid heading information from AHRS or loss of valid airport information from FMS causes the removal of all airport symbols. One airport labeled as invalid by the FMS will only cause the removal of the airport in question.

### Holding Patterns

The holding pattern symbol is racetrack shaped and is displayed at the appropriate waypoint as transmitted by the FMS. The leg length, turn radius, and inbound course data required to draw the holding pattern are also transmitted by the FMS. The racetrack symbol is drawn to scale and changes in size as appropriate with Map range changes.

### Invalid

Loss of valid heading information from AHRS or loss of valid information from FMS causes the removal of the racetrack symbol.

### Lateral Deviation Display

A digital readout of FMS lateral deviation is displayed in the lower portion of the map display. The format is deviation in miles followed by an "L" label when left of course (positive distances) or an "R" label when right of course (negative distances). For distances equal to zero miles, no label is displayed. The distance is rounded to the nearest .01 mile up to .99 miles and to the nearest .1 mile from 1.0 miles up to 99.9 miles. Greater than 99.9 miles, the display is rounded to the nearest mile. This display is moved above the vertical profile, no takeoff, checklist, or TCAS zoom windows when vertical profile is selected for display. The FMS lateral deviation digits is right justified.

If (ABS(FMS lateral deviation digital readout) > 999), then the FMS lateral deviation display will be removed.

### Invalid

Loss of valid lateral deviation data from the FMS shall cause the removal of the lateral deviation display.

### Vertical Profile Display

Vertical profile data is displayed at the bottom of the MFD format, centered between the lower left hand and lower right hand display windows. Vertical profile modes and symbology data is transmitted by the displayed FMS. The Vertical Profile format will be displayed when selected from the MAP drop down menu bar.

The vertical profile is an unfolding of the lateral map in the vertical plane corresponding to the VNAV profile. Dynamically, the aircraft will remain fixed in the center of the vertical field at the left hand side of the format. The map moves up and down with altitude relative to actual aircraft altitude. The map also moves from right to left as a function of aircraft distance. Display distance is controlled by the same method used on the lateral map. The vertical presentation will show a delta altitude of ±6000 feet from actual aircraft altitude. No vertical flight plan data extends outside of the vertical profile window.

**Invalid**

Loss of valid flight plan information from FMS, or valid altitude information from the ADS causes the vertical profile window and aircraft symbol to remain, but all other flight plan information is removed.

Vertical Profile Symbols

The vertical profile display is limited to 5 symbols maximum. This includes waypoints, transition points, and TOC/TOD/BOSC waypoints. The points are arranged in order from the nose of the aircraft to the last point and are transmitted as a delta distance from the previous waypoint.

**Map Starting Point**

Starting altitude is defined as an altitude at zero distance from the nose of the aircraft symbol. When the discontinuity bit is set, no track line is drawn from the nose of the aircraft to the first map point.

**Waypoints**

This symbol is consistent with the waypoint display of the lateral map format except the identifier is located directly above the waypoint symbol. Each waypoint is displayed with its identifier and altitude constraint. The altitude is identified further by type of constraint as follows:

| Symbol | Type of constraint |
|---|---|
| FL300 | At or Below |
| FL300 | At or Above |
| FL300 | At |
| FL300 | Predicted |

The waypoint identifier and altitude constraint data are transmitted as part of the waypoint data from FMS. The altitude constraint is displayed in its entirety as feet or as flight level (three digits proceeded with the label "FL"), as determined by FMS. For waypoints that define holding patterns, a "HOLD" annunciation is added below the altitude information. Track lines will connect the active waypoints of the flight plan with their successor waypoint as long as the current waypoint is not followed by a discontinuity and the successor waypoint is valid. The EFIS must calculate the last track line displayed if any of the five waypoints are outside the vertical profile window range.

### Waypoint Non-Display Features

When a waypoint is a transition point that has no identifier or symbol, the waypoint will not be displayed. If the waypoint is not part of the primary flight plan, it also will not be displayed.

### Invalid

Loss of valid heading information from AHRS or loss of valid waypoint information from FM cause the removal of all waypoint symbols. One waypoint labeled as invalid by the FMS will only cause the removal of the waypoint in question.

### Altitude Preselector

The altitude preselector is shown on the vertical profile map as a horizontal dashed line. This value corresponds to the value displayed above the altitude tape on the PFD.

### Invalid

Loss of valid altitude preselect data from the MWS or valid barometric altitude from ADS will cause the removal of the altitude preselect line.

### Flight Plan Designator

The Flight Plan Designator function can be used on the MFD display in either the MAP or PLAN formats by selecting the Designator selection in either of these drop down menus. After the designator function is selected, the MFD or PFD drop down menu is closed and a new menu titled "Designator" is brought into view in place of the format menu. The designator menu has four selections; "Home", "Prev", "Next", and "Draw". The "Draw" function is the default selection that is highlighted when the designator menu is first entered. The display of the designator menu is accompanied by the display of the designator. The designator is set to the aircraft present position as the initial home position or reference point. In addition to the designator display, a display of designator position latitude and longitude is displayed in a "Designator" window in the lower central portion of the MFD.

There are two ways to exit the "Designator" menu. The first method utilizes a quick exit .box. that is brought into view when the menu is displayed. The exit "box" is shown to the right of the cursor and will move to the line that the cursor is currently on. Moving the cursor over the box and selecting "enter" with the CCD will exit the menu. The selection window will be defaulted to the Map menu selection arrow. The second exit method is a timeout after 20 seconds of inactivity. The selection window will be defaulted to the Com preset window. Power-up default = Designator Off

### Designator Symbol

When the designator has been selected for display a square cyan "Designator" symbol is displayed at the aircraft present position as the initial home position or reference point. If the designator is moved from this initial position by using the draw function a dashed cyan line is displayed connecting the designator symbol and the reference point. If there is a waypoint downtrack from the designator a green dashed line is displayed connecting the designator symbol and the next waypoint downtrack.

### Designator Window

When the designator has been selected for display a .Designator. window is displayed in the lower portion of the MFD with the "Designator" label depicted in grey. This window contains the designator position latitude and longitude readouts in cyan. When the "draw" function is active, a white message "PRESS MFD SELECT FOR MENU" will be displayed above the latitude and longitude readouts. Additionally, the designator distance and bearing will be displayed in cyan.

The designator window will be moved above the vertical profile window when the vertical profile mode is selected for display.

### Designator Window Lat/Lon Display

Designator latitude and longitude digital readouts is displayed in the lower left hand corner of the "Designator" window in cyan. The readouts are structured in two rows with "latitude in degrees- minutes" above "longitude in degrees-minutes".

The latitude readout is preceded with either a cyan "N" or "S" symbol as appropriate. The readout will be labeled with cyan degrees and minutes symbols.

The longitude readout is be preceded with either a cyan "E" or "W" symbol as appropriate. The readout is labeled with cyan degrees and minutes symbols.

### Designator Window Bearing/Distance Readout

Designator bearing and distance digital readouts is displayed in the lower right hand corner of the "Designator" window in cyan when the designator is offset from the reference waypoint. The readout is structured in two rows, with "bearing in degrees" above "distance in nautical miles".

The bearing digital readout uses three digits rounded to the nearest degree and is labeled with a white degrees symbol.

The distance readout is rounded to a resolution of 0.1 NM when distance is less than 100 NM and is rounded to 1.0 NM when distance is greater than 1 NM. The distance readout is labeled with a white "NM" abbreviation for nautical mile.

### Designator Menu Operations

This menu has four selections; "Home", "Prev", "Next", and "Draw". The "Draw" function is the default selection that is highlighted when the designator menu is first entered. When the draw function is active the designator menu is removed and a white message "PRESS MFD SELECT FOR MENU" is displayed in the designator window.

### Draw Function

After the draw function is selected, the designator menu is closed and the designator function then becomes linked to the trackball. The trackball operation allows for 360° of designator travel, allowing the desired location to be reached quickly. Using the trackball, when the designator is offset from the home position or a waypoint, pushing either button on the side of the CCD transmits the latitude/longitude (LAT/LON) of the designator to the FMS scratchpad as a requested waypoint. The EFIS will signal FMS for five seconds that the CCD pushbutton has been pressed and FMS will receive the designator's latitude and longitude from EFIS.

### Next Function

The "Next" selection from the designator menu allows sequencing through all of the waypoints of the active flight plan, skipping discontinuities. When at the last displayed waypoint, the "Next" selection sends the designator to the aircraft present position first waypoint.

### Prev Function

The "Prev" selection from the designator menu allows sequencing through all of the waypoints of the active flight plan in reverse, skipping discontinuities. When at the aircraft present position first waypoint, the "Next" selection sends the designator to the last waypoint.

### Home Function

If the designator has been moved away from the reference point with the CCD, the first left or right selection of the coolie hat sets the designator back to the current reference point. The second left or right selection resets the designator's reference point to the aircraft present position.

### Invalid

The designator symbol, bearing/distance readout and Lat/Lon readout is removed whenever the FMS flight plan is removed due to invalid heading information or invalid FMS information.

### Weather Radar Display

Weather radar (WX) returns is displayed when selected for display from the MAP drop down menu bar using the CCD.

### WX Mode Annunciations and Window

The WX mode annunciation is located to the left of the heading display in the window with the heading "WEATHER". The mode annunciations are: "WX/OFF", "FAIL", "WAIT", "STBY", "FSTBY", "TEST", "WX", "WX/T", "WX/RCT", "WX/GCR", "W/R/T", "GMAP", and "FPLN".

The WX mode annunciation will flash 1 second on and .5 seconds off whenever any of the following conditions are met:

- The WX mode is WAIT.
- A transmitting mode is active (TEST, WX, WX/T, WX/RCT, WX/GCR, GMAP), the MFD is in the plan mode, and Weight-On-Wheels is true.
- The WX mode is FPLN and target enable = ON.
- The WX mode annunciation will be replaced with a "WX/OFF" annunciation when the radar is in the off mode. The "WAIT", "FSTBY", and "STBY" annunciations will have priority over all other modes in the order listed and only one will be active at any one time.

### Target Alert Annunciation

The target alert mode annunciation and the variable gain indicator is displayed directly below the tilt display. Only one is displayed at a time with the target alert mode annunciation having priority over the variable gain indicator. When target alert mode is selected, a "TGT" annunciation will be displayed. When the radar detects an alert condition, the "TGT" will flash 1 second on and .5 seconds off as long as the alert condition exists. Variable gain indication is displayed as an amber digital readout of knob rotation when the variable gain mode has been selected. The indication consists of a label "G" followed by a percentage readout of knob rotation and a "%" label.

### WX Returns

| Return | WX | GMAP |
|---|---|---|
| Level 1 | Green | Cyan |
| Level 2 | Yellow | Yellow |
| Level 3 | Red | Magenta |
| Level 4 | Blue | N/A |
| Level 5 | White | White |
| Level 6 | Magenta | N/A |
| Level 7 | Cyan | |

If WX Erase is indicated, the WX returns are erased before screen updates continue.

### Sector Scan

As an indication that WX returns have been selected for display, the weather radar display sector is indicated by tick marks on the half-range ring. The left and right position of the tick marks are +/-60°, referenced to current heading. When the WX system is operating in the Sector Scan mode, the left and right tick mark positions are +/-30°. The portion of the half-range ring between the tick marks are dashed to provide further indication of the display sector.

### Invalid

Indication by the weather radar of internal failure causes the replacement of the mode annunciation with an amber "FAIL" annunciation.

### Lightning Strike and Alert Display

Lightning (LX) data from the Lightning Sensor System (LSS) is displayed when the LSS is enabled for display via the Aircraft Personality Module and power is on. The EFIS is capable of displaying up to 16 strikes, three of which can be alerts. The number of symbols actually displayed is indicated by LX Strike Count.

### LX Strike Intensity

The lightning strike symbol is as follows:

| LX Strike Intensity | Symbol |
|---|---|
| Level 1 - Light | Lightning Bolt, no arrowheads |
| Level 2 - Medium | Lightning Bolt, one arrowhead |
| Level 3 - Heavy | Lightning Bolt, two arrowheads |
| Alert | Lightning Bolt, no arrowheads |

### LX Symbol Display Position

The lightning strike symbol is displayed at a position based on LX Strike Bearing and LX Strike Distance. When an LX alert is shown, the lightning symbol is displayed at the maximum display range at the proper LX Alert Bearing.

### Invalid

Loss of valid lightning information from the LSS causes the removal of the lightning symbols.

### Terrain Display

Terrain mapping is displayed when selected from the MAP drop down menu bar, or if a Terrain/Obstacle awareness caution or warning condition is set and Auto Popup has been enabled from the on-side MCDU TAWS page. The Terrain annunciations are displayed directly above the TEMP window when DME2 data is not selected for display. When DME2 is selected for display the annunciations are displayed directly above the DME2 data. The Terrain annunciations are displayed on two lines. The first line contains the Terrain mode. The second line is located below the first and contains Peaks information.

### Terrain Mode Annunciations

The available modes and annunciations for the Terrain display are described below:

| Mode Annunciation | Description |
|---|---|
| TERRAIN | Terrain Selected |
| TERRAIN INHIBIT | Terrain Display Overide selected from the MCDU TAWS page |
| TERRAIN N/A | Terrain Not Available |
| TERRAIN FAIL | Terrain Fail Condition |
| TERRAIN TEST | EGPWM Self Test Active as selected from the MCDU Test page |
| RANGE MISMATCH | Miscompare between MFD Range and EGPWM Range |

### Invalid

A failure indication from the EGPWM causes the removal of the terrain information and will annunciate "TERRAIN FAIL".

**Terrain Mapping**

The Display function of the EGPWM provides an image of local terrain forward of the aircraft. The image is enhanced to highlight terrain or obstacle threats. This is accomplished by using variable density dot patterns in green, yellow or red. The density and color are a function of absolute terrain elevation. Terrain or Obstacle alerts are depicted by painting the threat as solid yellow or red, as appropriate.

The standard MFD terrain format colors are listed below:

| Color | Display Colors and patterns |
|---|---|
| Solid Red | Terrain threat area - warning. |
| Solid Yellow | Terrain threat area - caution. |
| High Density Red Dots | Terrain more than 2000 feet above aircraft altitude. |
| High Density Yellow Dots | Terrain between 1000 and 2000 feet above aircraft altitude. |
| Low Density Yellow Dots | Terrain that is 500 feet (250 feet with gear down) below to 1000 feet above aircraft altitude. |
| Solid Green | Highest terrain not within 500 (250 with gear down) feet of aircraft altitude. May appear with dotted yellow terrain when the aircraft altitude is within 500 feet (250 feet with gear down) of terrain. |
| High Density Green Dots | Terrain that is the middle elevation band when there is no red or yellow terrain areas within range on the display. |
| Low Density Green Dots | Terrain that is the lower elevation band when there is no red or yellow terrain areas within range on the display. |
| Black | No significant terrain. |
| Low Density Cyan Dots | Terrain elevation equal to 0 feet MSL. |

**Invalid**

Loss of valid Terrain video data when selected for display causes an amber "TERR" message to be displayed on the right side of the half range ring.

### Peaks Information

Peaks information is calculated by the EGPWM and is shown as a digital readout directly below the Terrain mode annunciation. The data is presented as two elevation numbers indicating the highest and lowest terrain currently being displayed. The elevation numbers indicate terrain in hundreds of feet above sea level (MSL). The terrain elevation numbers are displayed with the highest terrain number first, then a "/", with the lowest terrain number next. The format is "144/085".

The highest terrain number is shown in the same color as the highest terrain color pattern on the display and will be shown in white when the digital value is "000". The lowest terrain number is shown in the same color as the lowest terrain color pattern on the display and will be shown in black (blank) when flying over water or relatively flat terrain (no appreciable difference in terrain elevations).

### Invalid

Loss of valid Peaks Information or loss of valid terrain display causes the Altitude digital readout to be removed and three amber dashes to be displayed for each altitude. The format is "---/---".

## PLAN DISPLAY

The MFD Plan format can be selected by placing the cursor over the Plan menu selection and selecting enter on the CCD.

### Heading Display

The Plan display is always displayed as North up. Heading information for this format is transmitted by the AHRS. The AHRS source is selected by the Display Control function. The source defaults to on-side AHRS in the event that the Display Control function is invalid. North is indicated in the upper left hand corner with an upward pointing arrow labeled in its center with an "N".

In this mode, heading data is used to orient the aircraft as it moves around on the active flight plan. A range ring is used to indicate distance on the display. The ring is labeled on the left with the half-range distance. Displayed FMS Magnetic Variation is used in conjunction with magnetic heading to orient the aircraft symbol.

### Invalid

Loss of valid heading information from the AHRS causes the removal of the aircraft symbol and a red "HDG FAIL" annunciation is displayed above the half-range ring. The flight plan data continues to be displayed.

### No Takeoff Window

The No Takeoff window has a "NO TAKEOFF" window header and provides the pilots with individual text messages describing the cause of a NO TAKEOFF advisory or warning CAS message. The No Takeoff window is activated from the MAP menu by selecting the enter button in the CCD.

The No Takeoff window display consists of nine lines of text each containing up to two text messages.

The No Takeoff window display has a vertical divider line separating the left side text messages from the right side text messages.

The No Takeoff text messages will be displayed in the No Takeoff window filling the left side of the window top to bottom first and then the right side of the window top to bottom as needed.

## CHECKLIST DISPLAY

The Checklist window is activated by positioning the cursor on the Checklist Menu button and selecting the Enter button on the CCD. The Checklist menu has no selections but performs the activation of the Checklist window.

## AIRCRAFT DIAGNOSTIC MAINTENANCE SYSTEM

When the Aircraft Diagnostic Maintenance System (ADMS) is selected for display by the Display Control function, control of the central display area of Display Unit Three will only be transferred to the CMC function.

The maintenance display is intended for maintenance only and is not intended for use during flight crew operation or procedures.

### Software Configuration Monitor System (SCMS)

When the Software Configuration Monitor System (SCMS) is selected for display by the Display Control function the SMCS window is provided in the map/plan portion of the MFD. The SCMS display is intended for maintenance only while the aircraft is on ground and is not intended for use during flight crew operations or procedures.

The SCMS window will display "confirm", "page up", and "page down" labels. The window will also display SCMS text and title lines and labels. The confirmation annunciation will be displayed if the top level system part number has changed. The data content displayed (system level part number, ICAO address, and APM settings) are generated by the SCMS requirements.

## TCAS MAP DISPLAY

TCAS data will be displayed on the MFD Map format's flight plan when the pilot selects "Traffic" for display from the MAP menu using the CCD. TCAS traffic advisories will overlay the normal Map flight plan.

### TCAS Display Symbols

There are four types of traffic symbols, based on threat level, used in the TCAS traffic display. They are Resolution Advisory (RA), Traffic Advisory (TA), Proximate Traffic (PT), and Other Traffic (OT). The type of threat for each target is determined by the TCAS computer.

### Two-Mile Range Ring

Whenever Traffic information is selected for display on the MFD from the Map drop down menu bar, a ring of twelve small circles (or dots) are placed in a radius of two nautical miles around the OAS. The dots are arranged so that one dot is placed at each of the clock hour positions, the OAS current heading being twelve o'clock. The two mile range ring is displayed proportional to the current MFD range selection. When the MFD range is $\geq$25 NM, the range ring will be removed.

### Threat Aircraft at the Resolution Advisory (RA) Level

The RA symbol is square in shape and is filled. The RA symbol is positioned to depict intruder aircraft's relative bearing and distance from own aircraft. RA targets which are off scale will be indicated by placing one half of the symbol at the edge of the active display area. The half symbol labeled normally.

### Invalid

Loss of valid information from TCAS cause the removal of RA symbols and 2 NM range ring

### Threat Aircraft at the Traffic Advisory (TA) Level

The TA symbol is circular in shape and is filled. The TA symbol is positioned to depict a threat aircraft's relative bearing and distance from own aircraft. TA targets which are off scale is indicated by placing one half of the symbol at the edge of the active display area. The half symbol is labeled normally.

### Invalid

Loss of valid information from TCAS causes the removal of TA symbols and 2 NM range ring.

**Proximate Traffic (PT)**

The PT symbol is depicted to display proximate traffic. The PT symbol is diamond in shape and is filled. The PT symbol is positioned to depict a proximate aircraft's relative bearing and distance from own aircraft. PT targets that are beyond the displayed range are removed.

**Invalid**

Loss of valid information from TCAS causes the removal of PT symbols and 2 NM range ring

**Other Traffic (OT)**

The OT symbol is depicted to display other non-threat aircraft. The OT symbol is diamond in shape and is unfilled. The OT symbol is positioned to depict the other aircraft's relative bearing and distance from own aircraft. OT targets that are beyond the displayed range are removed.

**Invalid**

Loss of valid information from TCAS causes the removal of OT symbols and 2 NM range ring

**Intruder Vertical Speed Indication**

The TCAS computer monitors the vertical speed of traffic in own aircraft's vicinity and filters the traffic into traffic with vertical speeds greater than or equal to 500 FPM, and traffic with vertical speeds less than 500 FPM. Traffic with vertical speeds greater than or equal to 500 FPM have a vertical arrow located directly to the right of the corresponding traffic symbol. The arrow points down for descending traffic and up for ascending traffic. The color of the arrow matches that of the corresponding traffic symbol.

**Invalid**

Loss of valid vertical speed indication from TCAS causes the removal of the vertical speed arrow.

**Intruder Relative Altitude Display**

When relative altitude of an intruder aircraft is available, a data tag indicating relative altitude is displayed with the corresponding traffic symbol. The data tag is centered above the traffic symbol preceded with a "+" if the intruder aircraft is above own aircraft's altitude and centered below the traffic symbol preceded with a "-" if the intruder aircraft is below own aircraft's altitude. If the intruder is at own aircraft's altitude, the data tag is centered above the symbol without any polarity sign. The relative altitude data tag consists of two digits indicating hundreds of feet. The color of the relative altitude data tag matches the color of the corresponding traffic symbol.

**Invalid**

Loss of valid relative altitude information from TCAS causes the removal of the relative altitude data tag.

**Intruder Absolute Altitude Display**

Flight Level (absolute altitude), of the intruder aircraft is displayed when selected from the TCAS drop down menu bar using the CCD. The EFIS calculates the absolute altitude by adding the relative altitude provided by the TCAS computer to own aircraft's barometric altitude. The absolute altitude is displayed in place of the relative altitude data tag. Absolute altitude consists of three digits indicating hundreds of feet. Leading zeros is displayed and the displayed value is rounded to the nearest 100 feet. Absolute altitude is replaced with relative altitude whenever a RA or TA condition is encountered. The color of the absolute altitude data tag matches the color of the corresponding traffic symbol. The EFIS automatically resets this selection to relative altitude display after 15 seconds. When absolute altitude is selected, an annunciator "FLT LVL" is located above the "ABOVE"/"BELOW" annunciator.

**Invalid**

Loss of valid barometric altitude information from the ADS causes the display of relative altitude information.

**No Bearing Target Readout**

In the event that an RA or TA target is encountered that does not have a bearing available for display, the information for that target is displayed in text directly above the lower left hand TCAS display window. The data uses two text lines. The first line contains data for the highest priority no bearing target and the second line contains data for the second highest priority no bearing target.

The data follows the following format:

where: Type = RA or TA
Range = Range to target from own aircraft
Relative Altitude = Altitude difference
(up and down arrow) = Direction of vertical rate of target ($\geq$500 FPM)

Example: A target creating an RA at 1.2NM, 600 feet below own aircraft and climbing $\geq$500 FPM = RA 1.2 -600 (up arrow)

### Above/Below/Normal Target Filtering

The EFIS is responsible for filtering TCAS targets according to relative altitude limits selected from the TCAS drop down menu bar. The limits are expressed as altitudes relative to the present aircraft altitude. When the normal mode is selected, the EFIS will display all target symbols between ±2700 relative altitude. An annunciator "NORMAL" is displayed in the TCAS window. When above mode is selected, the EFIS will display all targets from -2700 to +7500 relative altitude. An annunciator "ABOVE" is displayed in the TCAS window. When below mode is selected, the EFIS will display all targets from +2700 to -7500 relative altitude. An annunciator "BELOW" is displayed in the TCAS window. When "EXPANDED" (unrestricted) is selected, the EFIS displays all targets from ±7500 relative altitude. An annunciator "EXPANDED" is displayed in the TCAS window. The minimum value selected at any time is 2700 feet. The maximum value selected at any time is 9900.

### Invalid

Loss of valid altitude select mode information from TCAS causes the unit to revert to normal mode with all target symbols between ±2700 relative altitude displayed.

### TCAS ZOOM WINDOW

A TCAS zoom window is displayed in the MFD Map and Plan modes when TCAS is selected with the cursor using the CCD or the "TCAS" button is pushed on the CCD. The TCAS zoom window is displayed in the same window as the checklist display. When the TCAS zoom window is displayed in the Plan mode, the flight plan is shifted up such that the entire range ring is visible above the TCAS zoom window. When selected for display by the CCD, the TCAS zoom window will overlay on top of any checklist or vertical profile. When the TCAS zoom window is deselected for display by the CCD, the condition of the checklist or vertical profile will be restored to the same state that existed prior to the display of the TCAS zoom window.

## Attitude Director Indicator (ADI)

The ADI includes the following:

- Attitude pitch tape
- Attitude shading
- Aircraft symbol
- Slip–skid indicator
- Attitude source annunciator
- Low bank limit arc
- Attitude declutter
- Roll pointer and a roll scale

# Attitude Director Indicator

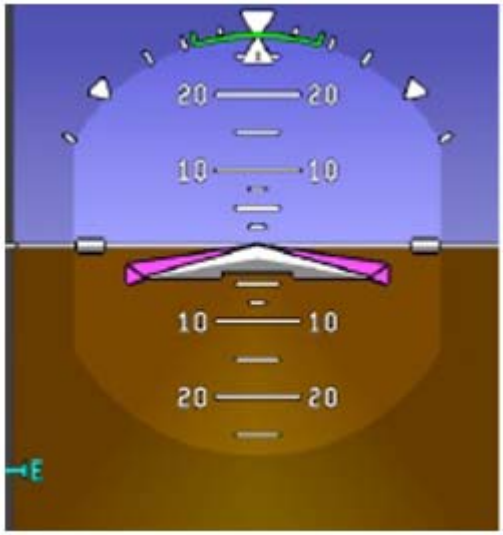



Figure 3-19

## AIRPLANE SYMBOL

A reference aircraft symbol is displayed in the attitude sphere. Single cue and cross-pointer symbols are selectable from the MCDU Display setup page. The apex of the single cue aircraft symbol is centered in the attitude sphere when single cue is selected. When cross-pointer has been selected, the center square of the cross-pointer aircraft symbol is displayed centered in the attitude sphere.

### Red Aircraft Symbol

The aircraft symbol changes to red for the following conditions:

- Up Advisory Avoidance Zone is displayed from the TCAS, and the AHRS Pitch Angle < Up Advisory Pitch Target.

- Down Advisory Avoidance Zone is displayed from the TCAS, and the AHRS Pitch Angle > Down Advisory Pitch Target.

### Green Aircraft Symbol

The aircraft symbol changes to green for the following conditions:

- Fly-To Zone is displayed attached to the Up Advisory Avoidance Zone, and the AHRS Pitch Angle ≥ Up Advisory Pitch Target.

**NOTE**

AHRS Pitch Angle ≤ Up Advisory Pitch Target, is dynamically calculated based on TAS (true airspeed) to allow a window of 500 fpm (feet per minute). This allows a greater minimum separation at lower TAS than at higher TAS.

- Fly-To Zone is displayed attached to the Down Advisory Avoidance Zone and AHRS Pitch Angle ≤ Down Advisory Pitch Target, and AHRS Pitch Angle ≥ Down Advisory Pitch Target - 2.5°.

## FD COMMAND BARS

The FD command bars are displayed in the middle of the attitude sphere. They can be displayed in a single cue or a cross-pointer style, as selected on the MCDU display setup page. If valid pitch or roll command information from the FD (AFCS) is lost, the command bars are removed and FD FAIL is displayed above the attitude sphere.

## PITCH TAPE

The pitch tape is in the center of the ADI. The pitch tape is horizon stabilized and it displays +/- 25° with pitch attitude at 0°. The pitch tape is linear with markings every 2.5° from 0° to +/- 10° and every 5° between 10° and 30°. The pitch tape is labeled with numbers on both sides of the tick marks through +30°/-20° and in the middle of the tick mark for greater than +30°/-20°. The scale is labeled at pitch up 10°, 20°, 30°, 40°, 60°, and 90°. It is labeled at pitch down of 10°, 20°, 30°, 45°, 60°, and 90°.

For large pitch angles, the display always shows the direction to the cyan sky or brown ground as appropriate. Hollow red pitch attitude warning chevrons are placed on the pitch tape so that they come into view when pitch reaches 7° nosedown or 21° nose-up. The two pitch-down chevrons increase in size as pitch up angle increases. Three pitch-up chevrons increase in size as the pitch down angle increases.

## ROLL POINTER/SLIP-SKID DISPLAY

A linear roll scale at the top of the ADI sphere is marked with tick marks at +/- 10°, +/- 20°, +/- 30°, and +/- 60°. An inverted triangle marks 0° and +/- 45°.

The bottom of the roll pointer is the slip/skid indicator.

## LOW BANK LIMIT

When the AFCS is in the Low Bank mode, a green arc is displayed immediately above the attitude sphere extending +/- 17° from wings level. The low bank limit arc is removed from the display if valid information is lost from both AFCS's.

## ATTITUDE MISCOMPARE

When an attitude miscompare is detected, a PIT annunciator boxed is displayed in the ADI’s 2:00 o’clock position. The annunciator has priority over all scale markings. It toggles PIT to PIT 1 second on and 1 second off, then displays PIT steadily. The miscompare annunciator is removed from the display when the miscompare is no longer detected.

## EXCESSIVE ATTITUDE DECLUTTER

The display is decluttered, for excessive attitude: bank greater than 65°, pitch up of more than 30°, or pitch down of more than 20°.

The symbols that are removed to declutter the display are listed below:

- FD mode annunciators and command bars
- Marker beacons
- Vertical deviation scale, pointer, and annunciator
- Speed bugs and readout
- Radio altitude and decision height set
- Altitude select data
- All flags including FD fail flag, LAT/VERT deviation flags, speed/altitude target flags, and radio altitude flag
- All comparators except attitude (ATT), airspeed (IAS), and altitude (ALT)
- TCAS pitch target display.

## RADIO ALTITUDE DISPLAY

### Radio Altitude Digital Readout

The digital readout for radio altitude is centered in the lower part of the attitude sphere, below the aircraft symbol. The radio altitude display range is from -20 to +2500 ft. The resolution on the digital readout is as follows:

- 5 ft between - 20 and +200 ft.
- 10 ft between +200 and +1500 ft.
- 50 ft between +1500 and +2500 ft.

When the aircraft is above 2500 AGL (above ground level), the RA digital readout is removed from the display.

### Radio Altitude Miscompare

When a radio altitude miscompare is detected by the EDS monitoring software, a RAD annunciator is displayed in the attitude sphere's lower center area. The annunciator covers the pitch scale markings. The annunciator toggles RAD to RAD for 1 second on and .5 seconds off for 5 seconds and then displays RAD steadily. The annunciator is removed from the display when the miscompare is no longer detected.

### Radio Altitude Failure Indication

If the radio altimeter information is lost, - RA - is displayed in place of the radio altitude display.

### Decision Altitude (DA) Readout

The DA is set in the cockpit by the on-side display controller. The digital readout appears just outside the 5:00 o'clock position of the ADI. The data range corresponds with the radio altitude range (<2500 ft).

Loss of valid DA setting from the display control function generates amber dashes in place of the altitude. Also, the DA display defaults at power-up to amber dashes. The first control knob turn starts the display reading at 200 ft., each knob click equals 10 ft resolution, and the DA display is removed for settings below 20 ft. The label RAD MIN is directly above the DA digital readout position. When minimum descent altitude (BARO) has been selected, the MDA value replaces the DA and the BARO MIN label replaces the RAD MIN label.

### DA Annunciator

During descent, when radio altitude reaches DA + 100 ft, an empty box appears in the upper left of the attitude sphere. When radio altitude is equal to or less than the DA setting, a MIN annunciator appears in the empty box at the 10:00 o'clock position of the ADI. The DA indicator is inhibited on the ground and through climb-out until radio altitude is greater than DA + 100 ft. The DA indicator is inhibited if valid RA information is lost, or the display controller setting for DA is invalid.

## MARKER BEACONS

Marker beacons are transmitted by the NAV receiver. The markers are displayed outside the right-hand corner of the attitude sphere, directly above the localizer miscompare annunciator. They are always displayed from the selected NAV VOR/LOC source. If the selected source is other than VOR/LOC, the markers are displayed from the on-side NAV receiver when active and toggle reverse video 1 second on and .5 seconds off for as long as corresponding marker is active.

The outer ( O ), middle ( M ), and inner ( I - white) marker beacon annunciators are displayed in a white box under the vertical deviation scale. When the aircraft passes over each marker beacon, the annunciator flashes continuously. Normally, only one annunciator is displayed at a time.

## ILS ANNUNCIATIONS

The vertical deviation scale is displayed to the right of the attitude sphere as a pointer moving on a scale when VOR/LOC or FMS is selected as the primary navigation source. The scale consists of an empty rectangular box with two dots above and below the line. The distance between the scale dots and box is linear. The pointer is a truncated triangle that parks at 2 1/2 dots positions on the top and bottom of the scale.

The selected Vertical Deviation source is displayed above the vertical deviation scale in white. The possible source annunciations include FMS and GS.

### Glideslope Display

The PFD displays data from the on-side or cross-side glideslope receivers, as selected by the display controller, when the NAV receiver is tuned to a localizer frequency. The glideslope pointer is green. The glideslope display is removed when the FD lateral mode is back course armed or captured

### Glideslope Deviation Limits

| Pointer Position | Deviation (in µA) |
|---|---|
| Parked (Top) | 300 µA |
| 2 Dots Up | 150 µ |
| 1 Dot Up | 75 µ |
| Center | 0 µA |
| 1 Dot Down | -75 µA |
| 2 Dots Down | -150 µA |
| Parked (Bottom) | -300 µA |

### Invalid

If valid deviation information from the NAV receiver is lost, the vertical deviation pointer is removed and an X is drawn over the scale. If the NAV source is a previewed NAV source, loss of valid deviation information is indicated removing the pointer.

### VNAV Deviation Scaling

The PFD can display data from the on-side or cross-side FMS, when selected by the display controller, whenever the deviation is valid. When in FMS VNAV, the pointer is magenta. The scaling on the display changes as a function of the FMS approach mode. The pointer parks at ±1000 ft. (±300 ft. for approach mode). When parked, only 1/2 of the pointer is visible at the limited position. If valid deviation information from the FMS is lost, the deviation pointer and scale are removed. The scale remains if valid previewed vertical deviation for a short range nav source is being displayed.

### VNAV Approach Deviation Limits

| Pointer Position | Deviation (in µA) |
|---|---|
| Parked (Top) | -300 ft |
| 2 Dots Up | -150 ft |
| 1 Dot Up | -75 ft |
| Center | 0 ft |
| 1 Dot Down | 75 ft |
| 2 Dots Down | 150 ft |
| Parked (Bottom) | 300 ft |

### Vertical Track Alert (VTA)

The VTA is locate on top of the vertical deviation scale. It is always annunciated in flashing amber inverse video (i.e., VTA to VTA ). The VTA annunciator indicates that the aircraft is approaching an FMS programmed vertical track profile that will require an altitude change. Pilot attention will be required to reconfigure the FD/AP modes appropriate to the altitude change.

### Glideslope Miscompare

When a glideslope miscompare is detected, a GS annunciator boxed is displayed in on the lower side of the glideslope scale and to the right. The annunciator has priority over all scale markings. It toggles GS to GS 1 second on and 1 second off, then displays PIT steadily. The miscompare annunciator is removed from the display when the miscompare is no longer detected.

## LATERAL DEVIATION DISPLAY

### Expanded Localizer

The expanded localizer deviation displays lateral deviation information with a greater precision than the compass card lateral deviation display. The Expanded Localizer display is displayed below the attitude sphere as a pointer moving on a scale when localizer is selected as the primary navigation source. The scale consists of a filled rectangular box with one dot to the left and right of the filled box. The distance between the scale dots and the filled rectangular box is linear. The pointer parks at 1 1/2 dots. The pointer is a green truncated triangle. The Expanded Localizer display is removed the FD mode is back course armed or captured.

### Localizer Deviation

The PFD can display data from the on-side or cross-side localizer, as selected on the display controller, when the NAV receiver is tuned to a localizer frequency. The output from EFIS is not limited and should reflect the input data converted to mA.

### Lateral Deviation Limits

| Pointer Position | Deviation (in µA) |
|---|---|
| Parked (Right) | 37.5 µA |
| 1 Dot Right | 25 µA |
| Center | 0 µA |
| 1 Dot Left | -25 µA |
| Parked (Left) | -37.5 µA |

### Invalid

If valid deviation information from the NAV receiver is lost, the lateral deviation pointer is removed and an X is place over the scale.

## Horizontal Situation Indicator (HSI)

The heading display takes on two formats that are selected by toggling the HSI button on the display controller. The full compass, consists of a 360° heading display that moves counterclockwise for increasing heading angles. The arc mode, shows 50° either side of the current heading. Information for the heading display comes from the AHRS. The AHRS source is selected on the reversionary control panel. The source defaults to on–side AHRS in the event that the display control function is invalid.

# HORIZONTAL SITUATION INDICATOR


Figure 3-20

**PFD With Full Compass View**

# ARC MODE HSI


Figure 3-21

**Compass Rose**

The heading display is capable of displaying between 1° and 360° with a 50°/sec minimum slew rate. The heading scale displays +/- 180° of heading information in the full compass mode and ±50° of heading information in the arc mode. Long tick marks are displayed every 10°, short tick marks are displayed at each intermediate 5° point. Each 30° tick mark is labeled with characters as follows: **N** , **3** , **6** , **E** , **12** , **15** , **S** , **21** , **24** , **W** , **30** , and **33** . In both the compass and arc modes, a **white** bracket with a **green** digital readout of current heading is displayed at the top of the compass rose. The bottom of the box is notched so the heading bug fits inside it. In addition, a **white** outline of the compass arc is displayed. A **white** aircraft symbol is displayed in the center of the full compass, and at the bottom of the compass in arc mode.

### Heading Alignment Mode

Heading is displayed as described above during the initialization sequence of the Collins AHRS. During initialization the AHRS performs the following:

- A align mode indication is output by the AHRS
- The Heading data is set to fail warn.

The Heading output decrements from a North heading back to North over the course of the initialization sequence and then returns to actual heading.

### Invalid Heading

When the AHRS is not in alignment mode, and valid heading information from the AHRS is lost, the tick marks and labels are removed, and HDG FAIL is annunciated at the top of the compass arc. The digital readout changes to amber dashes.

### Heading Miscompare

When a heading miscompare is detected, a HDG annunciation is displayed to the left of the airplane symbol within the compass card area. The annunciation toggles amber HDG to black HDG the first 5 seconds the annunciation is displayed then displays HDG steady. The annunciation is removed when the heading miscompare is no longer detected.

### Heading Source Annunciators

The heading source annunciation is displayed above and to the left of the digital readout box. When the normal on-side heading source attributed to both PFDs, no source annunciation is displayed unless the directional gyro (DG) mode has been selected. In this case, DG1 is annunciated on the pilot's side and a DG2 is shown on the copilot's side. Heading source information is selected by the on-side Display Control function. If ATT/HDG1 reversion is selected, MAG1 or DG1 is displayed on both PFDs. If ATT/HDG2 reversion is selected, MAG2 or DG2 is displayed on both PFDs. If both pilot and copilot sources are cross-side, MAG2 or DG2 is displayed on the pilot PFD and MAG1 or DG1 is displayed on the copilot PFD. The heading source annunciation is not be removed for a failure.

### Heading Select Display

Selected heading information consists of a cyan selected heading digital readout below the HDG label and a cyan heading select bug on the outer edge of the heading scale that is positioned on the compass at the position indicated by the digital readout.

### Invalid Heading Select

If valid heading information from the AHRS or valid data from the display controller are lost the heading bug is removed from the display and the HDG digital readout becomes amber dashes.

### Course Select Displays

The selected course pointer rotates around the center of the HSI. The course pointer is green when SRN (short-range navigation) is selected on the display controller. The course pointer is positioned by turning the on side CRS1/CRS2 knob on the guidance panel. Pushing the PUSH DIR button in the middle of the COURSE knob slews the course pointer to a zero deviation course to the station (with a valid VOR signal). The PUSH DIR button has no effect on sources other than VOR. The source identifier and course digital readout are displayed above and to the right of the heading display. The source readout is labeled VOR1 or LOC1 if from pilot's side or VOR2 or LOC2 if from copilot's side.

### Desired Track Displays

The desired track operates identically to the course pointer. However the desired track pointer is magenta when FMS is selected on the display controller. The desired track pointer is positioned by the FMS The source identifier and desired track digital readout are displayed in magenta above and to the right of the heading display. The source readout is labeled FMS1 it is the pilot's side FMS or FMS2 if it is the copilot's FMS.

### Invalid Course/Desired Track Annunciations

If valid heading information from the AHRS, valid information from the display controller, or information from the displayed FMS are lost, the course/desired track pointer is removed and the digital readout becomes amber dashes.

**NOTE**

The CRS/DTK pointer, and digital readout are amber when pilot or copilot NAV source is cross-side or the same.

### Lateral Deviation

Lateral deviation information comes from the radios or the FMS, depending on the primary navigation source. This information is displayed inside the HSI of both arc and compass modes.

The deviation bar is the middle portion of the selected course pointer. The lateral deviation scale consists of four dots, two to the left of the aircraft symbol and two to the right. Both the scale and the deviation bar rotate with selected course. The pointer/scale rotates with the course pointer. The pointer parks at 2 1/2 dots when the deviation is beyond the limits of the scale. The deviation bar matches the color of the CRS/DTRK pointer (i.e., green / magenta ).

| Pointer Position | FMS Deviation | Localizer Deviation | VOR Deviation |
|---|---|---|---|
| Zero Dot | 0 NM | 0 µA | 0° |
| 1 Dot Right | 2.5 NM | 0.75 µA | -5° |
| 2 Dots Right | 5 NM | 1.50 µA | -10° |
| 1 Dot Left | -2.5 NM | -0.75 µ | 5° |
| 2 Dots Left | -5 NM | -1.50 µ | 10° |

**Lateral Deviation Fail**

If lateral deviation information is not available, the CDI is replaced by an X .

**Drift Bug Display**

The difference between the aircraft heading and the aircraft ground track is the drift angle. Drift angle information is displayed on the HSI in both ARC and Compass mode by a magenta inverted triangle drift bug that moves long the outer edge of the compass rose. The source of the FMS data for the drift bug display is the on-side FMS.

**TO/FROM Arrow**

The TO/FROM indicator is a solid white triangle at either the nose or tail of the airplane symbol on the HSI.

If the aircraft is on airway centerline, the lateral deviation indicator overlies the TO/FM indicator. TO arrow is displayed as long as the selected course pointer is within +/- 90° of the bearing to the selected NAV source. The TO/FROM indicator is removed for LOC, and GS operation. The arrow is removed if valid information from the NAV receiver is lost.

**Localizer Miscompare**

When a localizer miscompare is detected, a LOC annunciation is displayed to the right side of the airplane symbol within the compass card area. The annunciation toggles LOC to LOC the first 5 seconds the annunciation is displayed then displays LOC steady. The annunciation is removed when the localizer miscompare is no longer detected.

### Bearing Pointer Displays and Window

The EDS receives bearing information from the on-side and cross-side VOR, ADF, and FMS over ASCB. VOR (MAG) and FMS (True) data are heading card referenced (absolute) and ADF data is case referenced (relative). When displaying FMS against a magnetic referenced heading card, the bearing pointer is compensated by the use of magnetic variation.

### Bearing Pointers

The bearing pointers are displayed when valid and selected for display by the display controller. The cyan circle bearing pointer identifies NAV 1. The white diamond bearing pointer identifies NAV 2.

### Bearing Pointer Window

Bearing pointer sources are annunciated to the left of the heading display in the window with the heading BRG PTR. The annunciators are: VOR1, VOR2, ADF, FMS1, and FMS2 and their color matches the color of the bearing pointer with which they are associated. The bearing pointers are removed if valid heading information from the AHRS is lost or valid bearing information from the NAV receiver or FMS is lost.

## Monitor Warning System

The Monitor Warning System performs the following functions:

- Message Management . The MWS monitors aircraft and avionics system status and outputs messages, coded by priority, to the CAS display.
- Altitude Alerting . The MWS monitors the aircraft altitude and compares it with the selected altitude received from the guidance panel. When appropriate, the MWS will alert the crew of altitude capture or departure from the selected altitude.
- Comparison Monitoring . The MWS monitors displayed sensor data and compares the sensor data from both PFDs against each other. When there is a discrepancy of significance, the crew is alerted of the comparison difference.
- Aural Warning Function . The aural warning function is performed by the MWS.

### CREW ALERTING SYSTEM (CAS) DISPLAY

The Crew Alerting System Display is comprised of the following functions:

- One column of messages with a maximum display of 12 messages.
- Most recent/higher criticality messages are displayed at the top of the column.
- 26 Characters per line maximum.
- One message status line.
- CAS message scrolling via Cursor Control Device.
- Master warning/caution panel interface.

### CAS Display - General

The Citation Sovereign Primus Epic System is configured with two Master Warning Systems hosted on individual processor modules, one installed in Modular Avionics Unit (MAU) 1 and one in MAU 4. Signals for use by the MWS are provided over ASCB from each of the avionics sub-systems, and typically input to a generic or custom I/O module for non-ASCB equipment.

The CAS display area comprises the left lower midsection of the usable EICAS display space. The color convention and displayed priority for the messages on the CAS display are defined as follows:

- RED - Warning (Crew Acknowledgement Required)
- AMBER - Caution (Crew Acknowledgement Required)
- CYAN - Advisory (Crew Acknowledgement Not Required)

### Master Warning Interface

The main crew interface with the CAS display is through the pilot and copilot Acknowledgment buttons mounted in front of each pilot on the instrument panel. This is used to acknowledge messages displayed in the CAS display area. The pushbutton function will be discussed in a later section of this document.

### CAS Message Scroll

Warning messages are not scrolled from the CAS display. However, all remaining messages for which display space is not available can be scrolled if all displayed messages have been acknowledged (i.e., warning and caution). The scroll up/down function is accomplished using the cursor control device. Warning messages are acknowledged with the Master Warning Button.

All messages to be scrolled off must be acknowledged. Caution messages are acknowledged via the master caution button and advisory messages are acknowledged 5 seconds after they first appear on the CAS display.

When a new CAS message becomes active and CAS messages are scrolled off the display, the new message is placed at the top of its respective color stack, and the entire CAS message list from that point down in priority is brought back into view automatically. Thus, if all active messages are scrolled off the display and a new caution message becomes active, the new caution message is placed at the top of all the active caution messages, and all active caution and advisory messages are brought into view, within the limits of the CAS display. If the new message is an advisory message, it would be placed at the top of all active advisory messages, and only all active advisory messages are brought into view, within the limits of the CAS display.

### CAS Message Status Line

When a message is active, but not displayed (more than twelve active messages, or message(s) scrolled off the CAS display), the last line on the CAS column provides the status of the non-displayed or scrolled message(s).

### END Message

The end of the message stack is indicated by a white message "END" being displayed. The "END" message will be inhibited when no CAS messages are active. When displayed, it will be center justified.

## MESSAGE MANAGEMENT

The Monitor Warning function monitors the status of various aircraft systems on a continuous basis and alerts the crew, as required, via the displays. In addition to prioritizing the messages for display, the Monitor Warning function also controls message timing and crew acknowledgment.

### Enable Requirements

A message is enabled when it is not present on the active stack, and all the required enabling discrete inputs are set and remain set for the debounce time. The standard debounce time is 300 msec unless otherwise specified on a per message basis. The standard debounce is added when a different debounce is specified in the message logic. If these conditions are satisfied, the message will be activated by:

- Placing it at the top of the active message level stack for the appropriate criticality level.
- Setting the acknowledge status to unacknowledged for warning, caution, and advisory messages.

**NOTE**

Certain messages change color. Changes from less severe color to more severe are accomplished by removing the message from the old color block and adding it to the new color block as an unacknowledged message. Changes from more severe to less severe are accomplished by removing the message from old color block and adding it to the new color block with the same acknowledge status it had before.

A message is removed when the message is active and one of its required enabling discrete inputs is not set for at least 300 msec. The message is disabled and removed from the active message stack. A disabled message is removed regardless of whether it is acknowledged or unacknowledged.

### Acknowledge Requirements

An active warning or caution message is considered acknowledged after either the pilot.s or the copilot.s respective acknowledge button has been depressed.

**NOTE**

LATERAL MODE OFF and VERTICAL MODE OFF Messages are considered acknowledged 5 seconds after the master caution button has been depressed.

An active advisory message is considered acknowledged 5 seconds after it appears on the CAS display. All acknowledged messages will not reverse toggle video.

### CAS Message Display Functions

The CAS message display consists of one column of 12 lines with a maximum character string length of 26 characters per line. The thirteenth line is used as a message status line.

**CAS Message Display Requirements**

The messages are displayed according to the priorities shown below:

| Message | Criticality | Level |
|---|---|---|
| Warning Message | Highest | 3 |
| Caution Message | Second | 2 |
| Advisory Message | Third | 1 |
| End Message | Last | 0 |

All messages will be in chronological order for each type or message (warning, caution, or advisory). The most recent message will appear at the top of its appropriate level stack. New warning and caution messages toggle reverse video until they are acknowledged. Acknowledged messages remain steady. New advisory messages toggle reverse video for 5 seconds and then remain steady in non-reverse video state.

The master warning Annunciator output from the MAU will be turned on and be steady, whenever there is any unacknowledged warning message in the display. Otherwise, it will be off. With the master warning output from the MAU ON, the Annunciator will flash. When either member of the crew activates the master warning reset button, all warning messages whose status is unacknowledged will be set to acknowledged.

The master caution annunciator output from the MAU will be turned on and be steady, whenever there is any unacknowledged caution message in the display. Otherwise, it will be off. With the master caution output from the MAU ON, the annunciator will flash. When either member of the crew activates the master caution reset button, all caution messages whose status is unacknowledged and displayed will be set to acknowledged.

**NOTE**

LATERAL MODE OFF and VERTICAL MODE OFF Messages are considered acknowledged 5 seconds after the master caution button has been depressed.

Any caution messages not visible on the CAS display will not have their acknowledge status modified.

All advisory messages will have their status set to acknowledged 5 seconds after they are first visible on the CAS display.

### Message Scrolling

The message scrolling operation is as follows:

1. The number of messages scrolled off the top and bottom of the EICAS window are counted by color and placed in a scroll count window located at the bottom of the message stack. The scroll count window is separated from the message stack by a gray bar.

2. When unacknowledged messages have been scrolled off the top or bottom, the corresponding scroll digits and scroll arrows turn to inverse video.

3. If the count for a particular set of scroll digits is greater than 99, the displayed value parks at 99.

4. When a particular set of scroll digits = 00, the corresponding scroll digits and arrow are removed and the remaining scroll digits and arrows are justified away from the center to the left or right edge.

5. The white "END" message is not counted for the purposes of determining the count. As there are no other white messages, scroll digits for white messages will never be displayed.

6. Clockwise rotation of the CCD knob causes messages that have been scrolled off the top to be moved into the display window. All of the messages in the window will move down. Any messages at the bottom would be scrolled off.

7. When no scrollable messages are active, I.E. all cyan and amber messages are inactive, the entire scroll window is removed. This includes the rotation arrow, the scroll digits, the scroll arrows and the gray bar.

### Takeoff Phase Message Inhibit (Global)

The Takeoff Phase Message Inhibit (TOPI) is considered a global inhibit. In order to minimize crew workload during the takeoff phase of flight, most messages will be inhibited during this phase, as indicated in Inhibit column labeled TOPI, in Error! Reference source not found. The takeoff phase is defined as follows:

The TOPI inhibit becomes active (latch set conditions) when any of the following is true:

1. The aircraft transitions from on ground to in air.
2. Either the left or right airspeed transitions from less than 80 knots to more than 80 knots.

The TOPI inhibit becomes inactive (latch reset conditions) when any of the following is true:

1. The aircraft has been in the air for more than 25 seconds.

2. Either the left or right pressure altitude (altitude corrected to 29.92 inches of mercury) is more than 400 feet above the field elevation. The field elevation is the pressure altitude that is latched when the aircraft is on the ground. If the pressure altitude changes while the aircraft is on the ground, perhaps due to meteorological changes, then the field elevation will track it. When the aircraft transitions to in air, the last value of the field elevation is remembered. Each left and right altitude is compared to it.s respective field elevation.

3. Either the left or right airspeed is less than 50 knots.

4. The TOPI inhibit has been active for more than 90 seconds.

When neither set or reset conditions are true, the TOPI inhibit retain its previous value. When a set condition and reset condition are both true, the reset condition takes priority and overrides the set condition. The power on default of the TOPI inhibit is inactive. Latch conditions that are the result of invalid data do not change the state of the TOPI inhibit. The weight on wheel status is the blended weight on wheels status calculated by the In Air/On Ground inhibits.

**Landing Phase Message Inhibit (Global)**

The Landing Phase Message Inhibit (LOPI) is considered a global inhibit. In order to minimize crew workload during the landing phase of flight, most messages will be inhibited during this phase, as indicated in Inhibit column labeled LOPI, in Error! Reference source not found. The landing phase is defined as follows:

The LOPI inhibit becomes active (latch set conditions) when any of the following is true:

1. The aircraft transitions from in air to on ground.
2. The radio altitude transitions from more than 200 feet AGL to less than 200 feet AGL.

The LOPI inhibit becomes inactive (latch reset conditions) when any of the following is true:

1. The aircraft has been on the ground for more than 25 seconds.
2. The radio altitude is greater than 400 feet AGL.
3. Either the left or right airspeed is less than 50 knots.
4. The LOPI inhibit has been active for more than 90 seconds.

When neither set or reset conditions are true, the LOPI inhibit retains its previous value. When a set condition and reset condition are both true, the reset condition takes priority and overrides the set condition. The power on default of the LOPI inhibit is inactive. Latch conditions that are the result of invalid data do not change the state of the LOPI inhibit. The weight on wheel status is the blended weight on wheels status calculated by the In Air/On Ground inhibits

**Bus Fail Inhibit BFI (Non Global)**

In order to prevent nuisance messages during engine start and during a bus failure in flight, selected messages are inhibited when the respective power bus voltage falls below a certain point. The bus status is determined by examining the contactors surrounding each bus. Those messages inhibited during the Bus Fail mode are indicated in Error! Reference source not found. The Bus Fail Inhibit is included as part of the enabling logic for the message.

**Engine Fail Inhibit -EFI (Non Global)**

In order to minimize crew workload during an engine failure, selected messages are inhibited when the respective engine has failed. The engine failure is determined as follows: engine off signal and throttle lever angle is larger than 6.0°. The Engine Fail Inhibit is included as part of the enabling logic for the message.

**Engine Shutdown ESDI (Non Global)**

In order to prevent nuisance messages during engine shutdown, selected messages are inhibited when the respective engine is in shutdown mode. The engine shutdown status is determined as follows: engine off signal, and throttle lever angle is less than or equal to 6.0°; or engine start. Those messages inhibited during the Engine Shutdown Inhibit mode will be indicated in Error! Reference source not found. The Engine Shutdown Inhibit (ESDI) is included as part of the enabling logic for the message.

**On Ground Inhibit (WOW)**

To prevent nuisance messages, selected messages are inhibited when the aircraft is on the ground and others are inhibited when the aircraft is airborne. The aircraft is considered to be on the ground when both left and right WOW modules indicate that the aircraft is not in the air. Left and right WOW module status are synthesized in the Monitor Warning System from 3 redundant inputs on each side, respectively. They are: direct discrete input from WOW module (WOW MODULE DISCRETE) and 1 WOW from each of the 2 FADEC's A and B (FADEC 429, label 272, bit 22 Raw weight on wheels). The WOW MODULE DISCRETE is a GND/OPEN signal with a GND indicating ON Ground. The On Ground indication from the FADEC WOW is a 1 (One). Left and right WOW Module status is captured as WOW DISCRETE L and WOW DISCRETE R respectively.

**MAU WOW Miscompare**

MAU WOW MISCOMPARE is triggered after 20 second debounce when left and right WOW modules disagree.

## ALTITUDE ALERTING

The altitude alerting function is controlled by the MWS. The MWS receives the selected altitude on ASCB from the Control I/O module. Barometric altitude is received from the air data function selected for display on the coupled PFD. The MWS outputs an altitude alert discrete and altitude departure discrete. Whenever the preselect knob is in motion, a discrete is issued by the Control I/O module on ASCB. When the "in-motion" logic is active, altitude alert is inhibited for 5 seconds.

### Altitude Alerting Operation

As the aircraft approaches the selected altitude, an aural alert is provided when the aircraft is 1000 feet from the altitude target. Additionally, the altitude alert discrete is activated on ASCB and is used to activate the altitude alert logic on each side PFD. The ASCB discrete remains active until the aircraft altitude is within 180 feet of the preselected altitude target or deviates by more than 1020 feet from the selected altitude at which point it becomes inactive.

No warning signals are generated within a 200-foot band of the selected altitude. If the aircraft should subsequently deviate from the selected altitude by more than 200 feet, and the preselected altitude has not been changed for the last 5 seconds, an aural alert is generated and the altitude departure discrete on ASCB is activated. The ASCB discrete remains active until the aircraft altitude is within 180 feet of the preselected altitude target or deviates by more than 1020 feet from the selected altitude at which point it becomes inactive.

During approach, when the ILS Glideslope is captured, the altitude alert function will be disabled.

## COMPARISON MONITORING

In order to provide the required level of data integrity required by regulations, the MWS monitors certain display data, and provides an indication on ASCB when there is a disagreement between data sources.

## MISCOMPARE PARAMETERS

| Miscompare Parameter | Trip Threshold |
|---|---|
| Pitch | +/-5 degrees |
| Roll | +/-6 degrees |
| Heading | +/-10 degrees |
| Barometric Altitude | +/-200 feet |
| Indicated Airspeed | +/-20 knots |
| LOC Lateral Deviation | +/-40 mV |
| LOC Vertical Deviation | +/-50 mV |
| Radio Altitude | See Note |

Under certain conditions, the data source monitoring will be inhibited. Those conditions are as listed:

- The Miscompare monitor of indicated airspeed will be inhibited if both displays are not ≥ 60 knots.
- The Miscompare monitor of LOC lateral deviation and LOC vertical deviation shall be performed only when both displayed primary navigation sources are localizer.
- The Miscompare monitor of LOC vertical deviation shall be inhibited if the back course lateral flight director mode is armed or captured and the armed or captured vertical mode is not Glideslope.
- The appropriate Miscompare monitor shall be inhibited when the input source to both displays is the same or when affected data group or status indicates invalid data.
- All trip thresholds will be debounced 1 second on and 1 second off.

**NOTE**

Radio Altitude trip threshold will be set to the following:
Threshold = 10 + .0625(abs(Pilot Radio Altitude) + abs(Copilot Radio Altitude))

**CAS Comparison Monitor**

The Monitor Warning function has a CAS comparison monitor. This monitor compares the displayed message stacks being generated by the two Monitor Warning Functions. In the event of a miscompare between the two functions an annunciation will be displayed at the bottom of the CAS message window. The annunciation will be in inverse video and will be either MW1 or MW2 depending on which Monitor Warning Function has the CAS priority. MW1 indicates that a miscompare exists and Monitor Warning 1 has CAS priority.

On the Display Setup (DISP SETUP) page on the Multifunction Display and Control Unit there is a selection: MW1/MW2. This selection allows the crew to toggle the displayed CAS message list between MW1 and MW2. The default setting is the Monitor Warning Function with CAS priority.

## AURAL WARNING

The Aural Warning Function (AWF) resides within the MAU. There are two Aural Warning Functions within the Primus Epic system for the Citation Sovereign aircraft. The two Aural Warning Functions operate in a master/slave mode. It is a self-monitoring system such that in the case of a failure of the master AWF, the slave AWF automatically becomes the new master.

The AWF has memory space for 2 minutes of audio capacity. Both tones and voices can be accommodated. Output from the MAU to the audio panel is provided over two independent buffered audio outputs from the control I/O modules. For aural warning prioritization with external aural warning generators, the control I/O modules also provide an aural mute input and output discrete.

The Enhanced Ground Proximity Warning Module (EGPWM) needs to receive feedback that an aural message requested by the EGPWM via ASCB parameter VoiceReqId, has been acknowledged by the Aural Warning System with the same ID as what was sent. This is required for some of the logic throughout the EGPWM system. This information is sent from the AWF on ASCB parameter awctone. For testing purposes, all voices that can be sent by the EGPWM are allowed to be played by the AWF.

The basic priority scheme is as follows:

1. The landing gear horn and overspeed horn are implemented in a Cessna provided aural warning unit. They do not inhibit anything and they are not inhibited by anything. They both cannot be active simultaneously.
2. Warnings have higher priority than cautions.
3. Warnings shall be prioritized as follows:
   - Windshear
   - EGPWM
   - Monitor Warning
4. Cautions shall be prioritized as follows:
   - EGPWM
   - TCAS - Corrective Resolution Advisory, Preventative Resolution Advisory
   - TCAS - Traffic Advisory
   - Monitor Warning
5. Advisory
   Monitor Warning

The signal Aural Mute (GIOTHREE/GIOFOUR output) controlled from the Aural Warning function allows the AWF to inhibit the TCAS aurals when higher priority EGPWM/EICAS aurals are playing. The inhibit is active while EGPWM aurals are playing and during the first occurrence of warning aurals (see below). TA AURAL TRAFFIC ALERT from the TCAS system allows it to inhibit lower priority EICAS aurals.

EICAS aurals that are repeated are a lower priority than the first occurrence of any other aural. Two or more repeat aurals that are active simultaneously alternate. There is no way for a repeating EICAS aural to "lock out" the other aurals.

The appearance of certain EICAS messages is annunciated with either a chime or voice. The audio generation is governed by the following:

Red Messages - Double chime repeats up to 3 times until acknowledged by pressing Master Warning. Selected messages produce a spoken voice in aircraft configured for voice instead of the double chime.

Messages that produce a voice and the text of the message are determined on a case by case basis for each EICAS message.

3 Repeat Exception - The red NO TAKEOFF aural repeats continuously until acknowledged.

**NOTE**

Enabling logic for all warning (red) message aurals are accomplished independently and performed within the Aural Warning function in the Monitor Warning system.

Amber messages - Single chime. Multiple messages appearing simultaneously produce but 1 chime. The case where the red double chime and a single chime become active at the same time produces only the red double chime.

Tone/Voice Selection - A configuration selection exists that may be used on a per aircraft basis to enable EICAS voices. The Aircraft Personality Module . Installed Options has an option Aural Warning Voice Enable (ApmInstalledOptions_awVoiceEnable). It.s default setting is 0 (Tones). It is set to 1 to select Voices. The selection affects only the EICAS message aurals and not the aural warning discrete tones, the EGPWS, or the TCAS aurals.

Male/Female Voice Selection - For those EICAS aurals that have a voice a second configuration selection exists that may be used on a per aircraft basis to select between male and female voices. The Aircraft Personality Module - Installed Options has an option Male Voice Enable. Its default setting is 0 (Female). It is set to 1 to select Male Voices.

Error! Reference source not found, lists tones and their qualities. Error! Reference source not found.

## TONE DEFINITION

| Tone Activation | Definition (Duration) |
|---|---|
| Master Warning | Double Chime (Repeated up to 3 times or acknowledge by pressing Master Warning before that) |
| Autopilot Disconnect | Alternating 350/250 Hz sine wave with a 0.5 second pause at the end of tone (Continuous until acknowledge using AP disconnect switch) SCN_245, SCN_510 |
| Master Caution | Single Chime |
| Altitude Alert | "C" Chord - 659.2 Hz + 1046.5Hz sine wave (1 second) |
| Vertical Track Alert | "C" Chord (0.2 sec on, 0.15 sec off, 0.2 sec on) SCN_ |
| Trim Clacker | 200 Hz Tone Burst at 16 Hz repetition rate, 50% duty cycle. |
| PHONE CALL | Alternating 1100 Hz/900 Hz sine wave (SCN_37, SCN_247) |
| SELCAL VHF 1-2<br>HF 1-2 | 1000 HZ Chime followed by a 850 Hz chime<br>(SCN_37, SCN_ 247) |

## EGPWM VOICE DEFINITION

| ALERT/WARNING CONDITION | BASIC VOICE MENU |
|---|---|
| MODE 1 PULL UP | PULL UP |
| MODE 1 SINKRATE | SINKRATE (pause) SINKRATE |
| MODE 2 PULL UP PREFACE | TERRAIN TERRAIN (preface precedes warning) |
| MODE 2 PULL UP | PULL UP |
| MODE 2 TERRAIN | TERRAIN |
| TERRAIN AWARENESS PREFACE | TERRAIN TERRAIN (preface precedes warning) |
| TERRAIN AWARENESS WARNING | PULL UP |
| TERRAIN AWARENESS CAUTION | CAUTION TERRAIN (pause) CAUTION TERRAIN |
| OBSTACLE AWARENESS PREFACE | OBSTACLE OBSTACLE (preface precedes warning) |
| OBSTACLE AWARENESS WARNING | PULL UP |
| OBSTACLE AWARENESS CAUTION | CAUTION OBSTACLE (pause) CAUTION OBSTACLE |
| MODE 3 DONT SINK | DON.T SINK (pause) DON.T SINK |
| MODE 4 TOO LOW TERRAIN | TOO LOW TERRAIN |
| MODE 4 TOO LOW GEAR | OO LOW GEAR |
| MODE 4 TOO LOW FLAPS | TOO LOW FLAPS |
| TCF TOO LOW TERRAIN | TOO LOW TERRAIN |
| MODE 5 GLIDESLOPE | GLIDESLOPE |
| MODE 6 MINIMUMS 500 | (non precision approach only) |
| MODE 7 WINDSHEAR WARNING | (SIREN) WINDSHEAR WINDSHEAR WINDSHEAR |

The EPIC system provides two ground open discrete outputs (Aural Gain Curve Select L/R) at MAU1 and MAU2 that causes the aural warning unit to change gain curves. The output will transition to ground when landing gear becomes down and locked OR 2 seconds after flaps become ≥5 degrees. The output will transition to open when landing gear is up AND flaps become < 5 degrees. The enabling logic is as follows:

HIGH GAIN (GND): (GEAR DOWN & LOCKED L OR GEAR DOWN & LOCKED R OR 2 Seconds after Flap Surface Position ≥ 5 degrees).

LOW GAIN (OPEN): (NOT GEAR DOWN & LOCKED L AND NOT GEAR DOWN & LOCKED R AND Flap Surface Position < 5 degrees).

**Cockpit Speaker Mute**

The EPIC system provides a single cockpit speaker mute ground/open output (Speaker Mute). A ground output indicates cockpit speaker OFF. This output is used to drive a relay that will break the cockpit speaker audio line when the cockpit speaker is selected OFF and light the appropriate annunciators on the cockpit speaker mute switches.

The EPIC system receives a ground/open input from each of two cockpit speaker mute switches (Cockpit Speaker Mute L/R). A ground on either input causes the speaker mute output to toggle.

The EPIC system also receives two ground/open reset inputs (Speaker Mute Reset L/R). An open on either reset input indicates that the mute output should reset to the speaker ON state. The mute switch has no effect while either reset input is active. The reset input is triggered when oxygen mask is selected on the Headset/Mask Mic select switches.

The speaker mute output defaults to the speaker ON state at power up.

**Trim Clacker Aural**

An aural exists to alert the pilots to a possible stabilizer trim runaway. The aural is triggered by a pitch trim Tach feedback that lasts longer than 1 second and the pilot is not commanding primary trim. As a consequence of the logic for this aural the following is true:

- The trim Clacker is not heard when the pilots are commanding primary trim on the control wheel.
- The trim Clacker is heard if the autopilot runs primary trim for more than 1 second. Otherwise, the trim Clacker will not be heard.
- The trim Clacker is heard after 1 second when the pilots are commanding secondary trim on the pedestal.
- If the stabilizer were to move by itself for more than 1 second the trim Clacker will be heard.

The aural will sound with the following enabling logic:

(NOT Primary Stab Trim Command L OR NOT Primary Stab Trim Command R) AND Sec Stab Tach Running

**Autopilot Disconnect Aural**

An aural exists to alert the pilots that the Autopilot has been disconnected. The aural sounds whenever the FCS indicates that the AP has transitioned from engaged to the AP is not engaged. Logic for the #1 (or A) AP having priority follows (identical logic exists for the #2 or B side):

Transitions From: (AP Engaged 1A and AP Engaged 1B) TO: NOT (AP Engaged 1A and AP Engaged 1B) The aural is continuous until acknowledged by pushing AP disconnect switch. The aural must sound one time before it can be acknowledged.

The Autopilot disconnect Aural has two priorities, abnormal (high priority) and normal [low priority].

An abnormal disconnect occurs when the autopilot disconnects (disengages) because of some type of failure.

A normal disconnect occurs when the disconnect occurs because of pilot action. Either AP button on Guidance Panel or quick disconnect button is pushed.

**Vertical Track Alert Aural**

An aural exists to alert the pilots that a vertical waypoint has met. The aural is triggered by the priority FMS in response to VNAV waypoints. Logic for the #1 FMS having priority follows (identical logic exists for the #2 side).

FMS1 Vertical Track Alert

## MONITORS

### Emergency descent mode (EDM) Monitor

The Monitor Warning System determines when to request Emergency Descent activation. If the PFD Couple Status Selected ADS Pressure Altitude is > 30000 feet and the bleed monitor 429 General Status inputs (Left or Right) indicate Emergency Descent L OR Emergency Descent R and the Autopilot is engaged (Autopilot Engaged), then the Monitor Warning will enable Emergency Descent Mode.

The EDS receives the MW Emergency Descent Mode, sets Selected Altitude to 15000 Feet and positions the selected altitude bug on the altitude tape and sets the digital readout accordingly.

**NOTE**

> The AFCS Customer Requirements Specification for the Cessna Citation Sovereign Aircraft contains the specific requirements for the Emergency Descent Mode. The information in the following paragraph reguarding mode activity and settings is provided as reference information.

If the Emergency Descent Mode is received from the Monitor Warning, and the AP is engaged, the FCS will automatically cancel any non-approach flight director mode and initiate heading hold and FLC. The FCS sets the Flight Director EDM Mode active. The FCS will assume an airspeed target that provides a $V_{mo}$ descent and a heading reference 90 degrees less than current magnetic heading. In addition, the FCS will use the coupled PFD.s altitude targets initiated by the Monitor Warning System to carry out the EDM maneuver. All flight director mode selections on the guidance panel are inhibited until after the autopilot is disengaged and then re-engaged.

The EMERGENCY DESCENT CAS message is enabled if the priority FCS indicates Flight Director DM Mode Active. The CAS message will also enable the Aural Alert .Emergency Descent.

### CMC Interface Fault Reporting Monitors

Each Monitor Warning System (MWS) process reports the status of the raw, non-source selected, ASCB input interfaces to the CMC for each consumed ASCB group. If the ASCB group goes to the invalid or stale state, an interface fault report is generated with no debouncing.

### Graphics Test Data Monitor

The graphics test data monitor will determine the states for the DU X Graphics Test Fail discrete parameters, where X is the DU instance, based on data input from each DU. The intent is to monitor the DU processor's capability or generate graphics. The graphics test monitor will output a 'TRUE' if a DU fails its test on parameters DU 1 Graphics Test Fail, DU 2 Graphics Test Fail, DU 3 Graphics Test Fail or DU 4 Graphics Test Fail.

**Flight Data Recorder Output Monitor**

The FDR Data Output monitors will output data required for the flight data recorder.

**Left Avionics Contactor**

The parameter L Avionics Contactor On will be set TRUE, when Avionics contactor L is ≥ 22.5 Volts.

**Right Avionics Contactor**

The parameter R Avionics Contactor On will be set TRUE, when Avionics contactor R is ≥ 22.5 Volts.

**APU Contactor**

The parameter APU Contactor On will be set TRUE, when APU GEN is ≥ 23.0 Volts.

**External Power Contactor**

The parameter External Power Contactor On will be set TRUE, when the External Power Contactor is ≥ 23.0 Volts.

**No Takeoff Window Monitors**

Certain CAS messages factor into the no takeoff window monitor. The following sections describe the logic for setting the respective monitors.

**Park Brake On**

If the PARKING BRAKE ON Caution or Advisory message is set, then T/O Monitor Park Brake is set to ACTIVE.

**Park Brake Pressure Low**

If the PARKING BRAKE LOW PRESSURE Caution message is set, then T/O Monitor Park Brake Press is set to ACTIVE.

**Cabin Door Open**

If the CABIN DOOR OPEN Caution message is set, then T/O Monitor Cabin Door is set to ACTIVE.

**Gust Lock On**

If the GUST LOCK ON Advisory message is set, then T/O Monitor Gust Lock is set to ACTIVE.

**Pitch/Roll Disconnect**

If the PITCH/ROLL DISCONNECT Caution message is set, then T/O Monitor Pitch/Roll Disconnect is set to ACTIVE.

**Flap Position**

If the Flap Surface Position is < 6 Degrees OR (Flap Surface Position is > 8 Degrees AND Flap Surface Position is < 14 Degrees) OR Flap Surface Position is > 16 Degrees, then T/O Monitor Flap Position is set to ACTIVE.

**Rudder Trim**

If the Rudder Trim is < -0.130 Inch OR the Rudder Trim Final is > 0.130 Inch, then T/O Monitor Rudder Trim is set to ACTIVE.

**NOTE**

Rudder Trim Final is produced both FCS1 and FCS 2 functions. The monitor is capable of receiving the parameter from either function (i.e. if FCS1 is valid, use the FCS 1 parameter. If FCS 1 is invalid and FCS 2 is valid, use the FCS 2 parameter.)

**Rudder Bias**

If the Rudder Bias is < 14.15 Inch, then T/O Monitor Rudder Bias is set to ACTIVE.

**Stabilizer Trim**

If the Stabilizer Trim Position Final is < -6 Degrees OR the Stabilizer Trim Position Final is > -2 Degrees OR Stabilizer T/O Range Switch is NOT in T/O Range, then T/O Monitor Stabilizer Trim is set to ACTIVE. Note a 70% bi-directional hysteresis is applied to the position.

**NOTE**

Stabilizer Trim Position Final is produced both FCS1 and FCS 2 functions. The monitor should be capable of receiving the parameter from either function (i.e. if FCS1 is valid, use the FCS 1 parameter. If FCS 1 is invalid and FCS 2 is valid, use the FCS 2 parameter.)

**Aileron Trim**

If the Aileron Trim Final is < -0.094 Inch OR the Aileron Trim Final is > 0.094 Inch, then T/O Monitor Aileron Trim is set to ACTIVE.

**NOTE**

Aileron Trim Final is produced both FCS1 and FCS 2 functions. The monitor should be capable of receiving the parameter from either function (i.e. if FCS1 is valid, use the FCS 1 parameter. If FCS 1 is invalid and FCS 2 is valid, use the FCS 2 parameter.)

**Speed Brakes**

If the [(Position Command Modulated = Deployed) AND (NOT #3 Resolver Position AND #8 Resolver Position)] OR [(Position Command Modulated = Deployed) AND (#3 Resolver Position AND NOT #8 Resolver Position)] OR ([Position Command Modulated = Stowed for more than 3 Seconds OR Position Command Modulated = Not (Stowed more than 3 Seconds )] AND #3 Resolver Position AND #8 Resolver Position), then T/O Monitor Speed Brakes is set to ACTIVE.

**Roll System**

If the Roll System T/O Range Switch is NOT within T/O Range, then T/O Monitor Roll System is set to ACTIVE.

**Fuel Quantity Monitor**

The fuel quantity is received from the FUEL QTY function in BCD format. The MW function will used the received data and produce fuel quantities for the left and right tanks. The fuel quantity will be represented in kilograms or pounds depending on the APM setting. The MW function will also produce separate dedicated quantities in pounds regardless of the APM settings.

**Left Fuel Quantity - Pounds (Dedicated)**

Fuel Qty Left Pounds is equal to sum of the (Fuel Qty Left Pounds Thousands x 1000), (Fuel Qty Left Pounds Hundreds x 100), (Fuel Qty Left Pounds Tens x 10) and (Fuel Qty Left Pounds Ones).

Fuel Qty Left Pounds Status is VALID, if the L Fuel Probe Fail Lbs is indicating NORMAL OPERATION AND the FUEL QTY Group is FRESH AND VALID AND the L Fuel Qty Lbs SSM is indicating NORMAL OPERATION.

**Left Fuel Quantity - Kilograms or Pounds**

If the Fuel Weight Units indicates Kilograms, then Fuel Qty Left is equal to sum of the (Fuel Qty Left Kilograms Thousands x 1000), (Fuel Qty Left Kilograms Hundreds x 100), (Fuel Qty Left Kilograms Tens x 10) and (Fuel Qty Left Kilograms Ones). Fuel Qty Left Status is VALID, if the L Fuel Probe Fail Kgs is indicating NORMAL OPERATION AND the FUEL QTY Group is FRESH AND VALID AND the L Fuel Qty Kgs SSM is indicating NORMAL OPERATION.

Otherwise if the Fuel Weight Units indicates Pounds, Fuel Qty Left is equal to Fuel Qty Left Pounds and Fuel Qty Left Status is equal to Fuel Qty Left Pounds Status.

**Right Fuel Quantity - Pounds (Dedicated)**

Fuel Qty Right Pounds is equal to sum of the (Fuel Qty Right Pounds Thousands x 1000), (Fuel Qty Right Pounds Hundreds x 100), (Fuel Qty Right Pounds Tens x 10) and (Fuel Qty Right Pounds Ones). Fuel Qty Right Pounds Status is VALID, if the R Fuel Probe Fail Lbs is indicating NORMAL OPERATION AND the FUELQTY Group is FRESH AND VALID AND the R Fuel Qty Lbs SSM is indicating NORMAL OPERATION.

**Right Fuel Quantity - Kilograms or Pounds**

If the Fuel Weight Units indicates Kilograms, then Fuel Qty Right is equal to sum of the (Fuel Qty Right Kilograms Thousands x 1000), (Fuel Qty Right Kilograms Hundreds x 100), (Fuel Qty Right Kilograms Tens x 10) and (Fuel Qty Right Kilograms Ones). Fuel Qty Right Status is VALID, if the R Fuel Probe Fail Kgs is indicating NORMAL OPERATION AND the FUELQTY Group is FRESH AND VALID AND the R Fuel Qty Kgs SSM is indicating NORMAL OPERATION.

If the Fuel Weight Units indicates Pounds, Fuel Qty Right is equal to Fuel Qty Right Pounds and Fuel Qty Right Status is equal to Fuel Qty Right Pounds Status.

**Minimums Alert Monitor**

The Minimums Alert Monitor will compare displayed minimum values and displayed radio altitude data. Separate monitors are available for both the pilot and copilot for Decision Height (DH) and Minimum Descent Altitude (MDA).

The Minimum Alert Monitor will be disabled when the aircraft is on the ground. The Minimum Alert Monitor will be enabled after the Copilot DH Value + 100 ft (Pilot DH Value + 100 ft) is less than the Copilot Rad Alt Value (Pilots Rad Alt Value) OR the Copilot MDA Value + 100 ft (Pilot MDA Value + 100 ft) is less than the Copilot Baro Alt Value (Pilots Baro Alt Value) depending on the copilots(pilots) DH/MDA selection.

If the pilot/copilot has selected decision height, the Copilot Minimums Alert or Pilot Minimums Alert will be set as follows:

- 'None' - If the Copilot DH Value (Pilot DH Value) is less than 20 feet OR the Copilot DH Value + 100 ft (Pilot DH Value + 100 ft) is less than the Copilots Rad Alt Value (Pilots Rad Alt Value).

- 'Armed' - If the Copilot DH Value (Pilot DH Value) is less than the Copilots Rad Alt Value (Pilots Rad Alt Value) AND the Copilot DH Value + 100 ft (Pilot DH Value + 100 ft) is greater than or equal to the Copilot Rad Alt Value (Pilots Rad Alt Value)

- 'Alert' - If the Copilot Rad Alt Value (Pilot Rad Alt Value) less than or equal to the Copilot DH Value (Pilot DH Value)

If the pilot/copilot has selected minimum descent altitude, the Copilot Minimums Alert or Pilot Minimums Alert will be set as follows:

- 'None' - If the Copilot MDA Value (Pilot MDA Value) is less than 20 feet OR the Copilot MDA Value + 100 ft (Pilot MDA Value + 100 ft) is less than the Copilot Baro Alt Value (Pilots Baro Alt Value)

- 'Armed' - If the Copilot MDA Value (Pilot MDA Value) is less than the Copilots Baro Alt Value (Pilots Baro Alt Value) AND the Copilot MDA Value + 100 ft (Pilot MDA Value + 100 ft) is greater than or equal to the Copilot Baro Alt Value (Pilots Baro Alt Value)

- 'Alert' - If the Copilot Baro Alt Value (Pilot Baro Alt Value) less than or equal to the Copilot MDA Value (Pilot MDA Value)

### Flight Leg Number Monitor

The Flight Leg Number monitor will determine the number of flight legs performed during one calendar day. The Flight Leg Number will increment, by 1, based on a WOW transition from 'in air' to 'on ground'. The Flight Leg Number will be reset (initialized to 1) after the calendar date is incremented (unless the aircraft is still in the air). In this case the flight leg number will remain at the previous value until a warm start or on-ground status is obtained.

### MW Priority Monitor

Each MWS instance will produce a 'Priority' status parameter, MW1 Level A Priority and MW2 Level A Priority. This parameter allows consumers to source select data produced by the Priority MWS. At power-up, MWS initializes its Priority to 'Not-Priority'. After the delay time has elapsed since the start of MWS, the Priority will be set to 'Priority' if the other MWS's data is invalid or continues to transmit 'Not-Priority'. The delay associated with MW1 is 500 msec and MW2 is 700 msec. Once a MWS function assumes a Priority of 'Priority', it does not relinquish that priority until it fails. The only exception is when both MWS's Priority signals are set to 'Priority', MWS2 will assume a Priority of 'Not-Priority'.

### CAS Checksum

Each MWS will generate the CAS message list even though only one will be driving the display of the CAS messages at any one time. Each MWS will perform a checksum on the active (messages that are displayed in the CAS window, and messages that are scrolled off the display) CAS message list and output its results on the ASCB for the cross-side MWS, MW1 CAS Message Checksum and MW2 CAS Message Checksum.

### DME Hold Monitor

Each MWS will generate an inversion of the DME Hold input from the Modular Radio Cabinet system.

# ENGINE INDICATING AND CREW ALERTING SYSTEM (EICAS)

The status of the aircraft systems is displayed in the cockpit for the pilots on the EICAS display unit. The EICAS format can be selected between the 2 middle display units in the cockpit.

The system status is displayed in digital and/or analog format. When an analog format is used, a 3D shaded pointer moves along a static scale to indicate the value. When a digital presentation is used, the system parameter is displayed as a number. Invalid data due to system failures are displayed as 3 amber dashes on the digital presentations. The EICAS display is divided into 7 functional areas, as shown in the figure to the right. Flow bars are used to separate the functional areas.

## EICAS DISPLAY AREAS

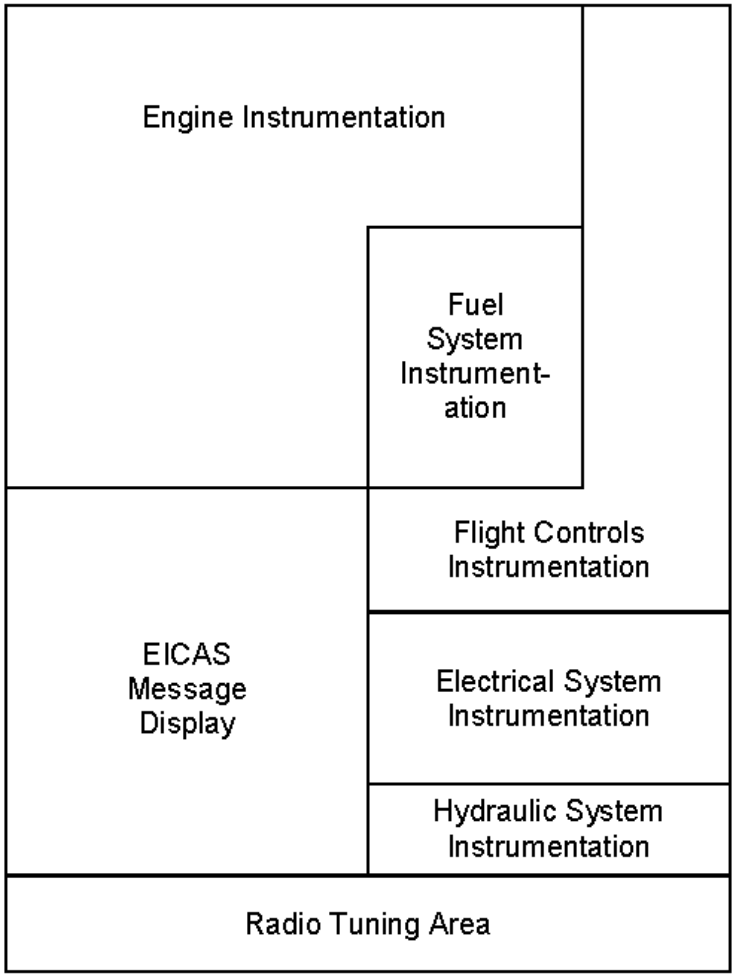



Figure 3-22

# FLIGHT CONTROLS INSTRUMENTATION

### Aileron Trim Display

Aileron trim position is displayed on the EICAS display as a linear function of actuator travel. The nominal range of aileron trim travel is ±0.315”, corresponding to ±10° of surface travel. However, the displayed range of the aileron trim extends only to ±0.285”, to allow for component tolerance buildup. The pointer will park at the end of the scale for values beyond the scale. The pointer is removed when the position data is invalid.

The functioning of the display is different for on the ground versus in air operation.

Takeoff Phase Inhibit (TOPI) true or On Ground mode - A green safe takeoff band is displayed. The pointer is white when inside the takeoff band, amber when outside. The NO TAKEOFF message is also triggered when the pointer is outside of the takeoff band. The takeoff band is ±0.094”, inclusive, of actuator travel.

TOPI false and In Air mode - The green safe takeoff band is removed. The pointer is always white. The NO TAKEOFF message is not triggered.

### Stabilizer Trim Display

Stabilizer trim position is displayed on the EICAS display as a linear function of stabilizer surface rotation. The range of stabilizer travel is +1.2° to -6.9°, inclusive. When outside of the range, the pointer parks at the ends, but the digital display continues to show values beyond the range. The pointer is removed when the position data is invalid. The functioning of the display is different for on the ground versus in air operation.

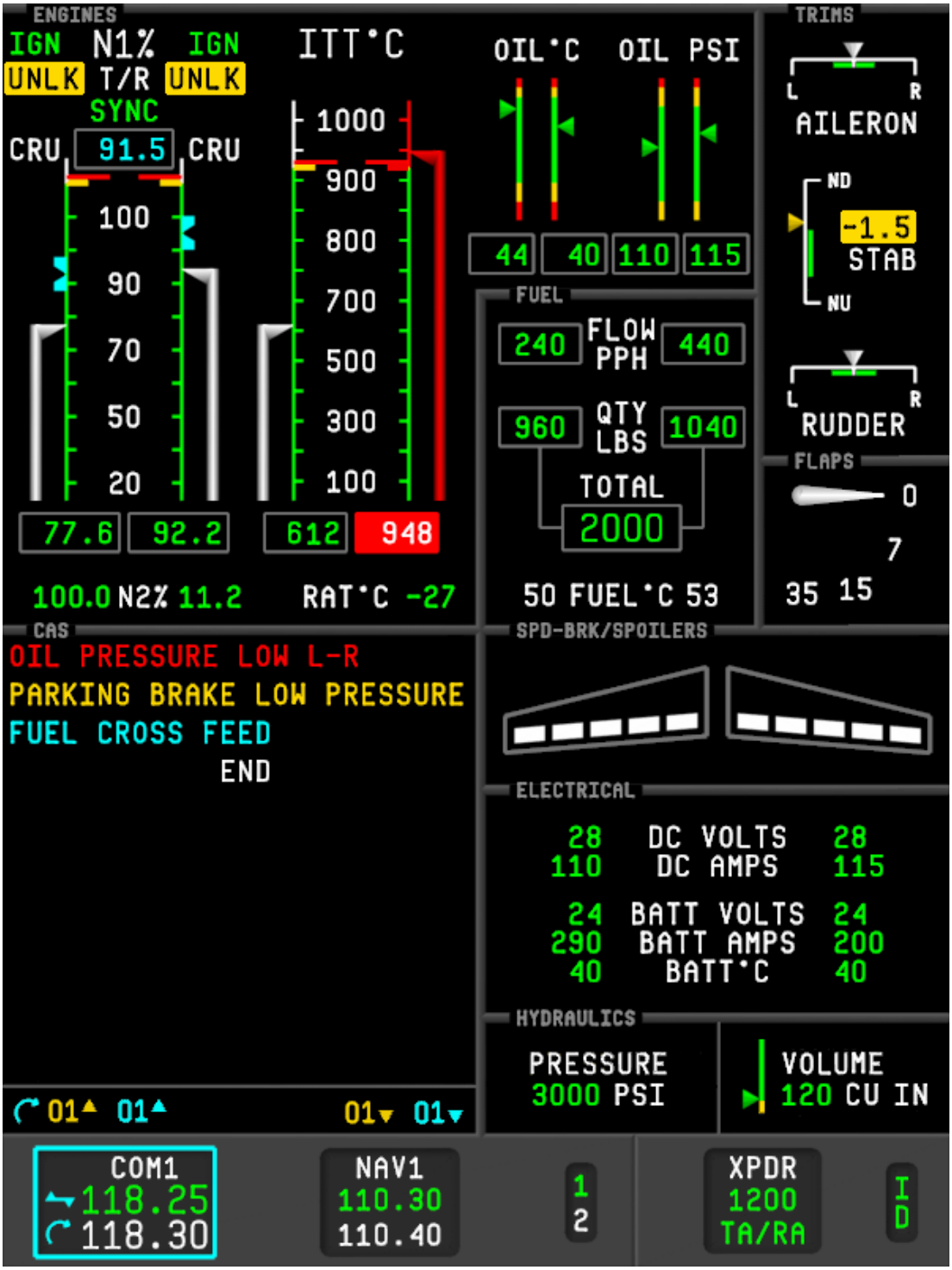
TOPI true or On Ground mode - A green safe takeoff band is displayed. The pointer is white when inside the takeoff band, amber when outside. The NO TAKEOFF message is also triggered when the pointer is outside of the takeoff band. The takeoff band is from -2.0° to -6.0°, inclusive, of displayed surface travel. An additional redundant switch exists that is or’ed with the position to trigger the NO TAKEOFF message and the pointer color change. Either the switch in the unsafe configuration or the position sensor in the unsafe configuration will cause the unsafe configuration to be indicated.

TOPI false and In Air mode - The green safe takeoff band is removed. The pointer is always white. The NO TAKEOFF message is not triggered.

### Stabilizer Trim Digital Display

Stabilizer trim position is displayed digitally in increments of 0.1°. The color of the digits tracks the pointer color. When the pointer is white, the digits are white. When the pointer is amber, the digits are black text on amber inverse video. When the stabilizer position data is invalid, 3 amber dashes are displayed.

# EICAS DISPLAY




**MFD WITH EICAS DISPLAYED**

Figure 3-23

### Rudder Trim Display

Rudder trim position is displayed on the EICAS display as a linear function of actuator travel. The nominal range of rudder trim travel is ±0.390”, corresponding to ±3° of surface travel. However, the displayed range of the rudder trim extends only to ±0.370”, to allow for component tolerance buildup. The pointer will park at the end of the scale for values beyond the scale. The pointer is removed when the position data is invalid.

The functioning of the display is different for on the ground versus in air operation.

TOPI true or On Ground mode - A green safe takeoff band is displayed. The pointer is white when inside the takeoff band, amber when outside. The NO TAKEOFF message is also triggered when the pointer is outside of the takeoff band. The takeoff band is ±0.130”, inclusive, of actuator travel.

TOPI false and In Air mode - The green safe takeoff band is removed. The pointer is always white. The NO TAKEOFF message is not triggered.

### Flap Panel Synoptic

The flap position is indicated with a synoptic flap pointer that ranges from 0° to 35°. The pointer rotation parks at the indication values of 0° and 35°. If the position data is invalid, the pointer will remain at the last known setting and change to amber.

### Speedbrake/Spoiler Panel

The speedbrake/spoiler display is a generalized wing shape with annunciators for 5 panels on each side. The inboard and outboard panel on each wing are non-modulated panels, which means they have 2 states: up or down. The middle 3 panels on each wing are modulated panels, meaning that they have a continuous set of states.

The idea of the synoptic is to indicate at the beginning of panel deployment. The synoptic shows the same presentation regardless of the amount of panel deployment. If a sensor failure has been detected, the synoptic shows the most likely position of the panels, but the indication is amber. In the air, the display of the effect of roll input on the modulated panels is suppressed. The operation of the mechanical system driving the panels is the same in the air and on the ground, but the display of that operation is suppressed.

### Fuel System Instrumentation

The fuel system instrumentation includes the following displays:

1. Fuel flow for left and right engines
2. Fuel quantity in the left and right fuel tanks
3. Total aircraft fuel quantity
4. Fuel temperature in the left and right fuel tanks.

An aircraft configuration selection exists to allow the selection of fuel flow and quantity in metric or english units.

### Fuel Flow Digital Readout

Fuel flow is displayed on the EICAS in 20 PPH (pound per hour) increments. A 70% bi-directional hysteresis function is applied to prevent digit oscillation. 3 amber dashes are displayed when the fuel flow rate is invalid and certain other conditions are met.

The metric fuel configuration changes the presentation to metric units. In this case, the PPH legend changes to KGH and the displayed quantity is in kilograms per hour instead of pounds per hour.

### Fuel Quantity Digital Readout

Individual fuel tank quantity and aircraft total fuel quantity are displayed on the EICAS. Rounding and filtering is implemented in the fuel quantity system, so there is no need for additional rounding logic in the EICAS.

When the metric fuel configuration is selected, the LBS label changes to KGS.

The EICAS display resolution is 1 lb/1 kg. Due to the rounding in the fuel quantity system, the total system resolution is 20 lbs/10 kgs.

When an individual tank quantity displayed value becomes less than 500 lbs, it changes from green normal text to black text on amber inverse video. When the total fuel quantity displayed value becomes less than 1000 lbs, it changes from green normal text to black text on amber inverse video. Values at the respective trip points of 500 lbs and 1000 lbs are green.

When the display is selected as kilograms, the trip points change to 230 kgs and 460 kgs for the individual and total displays, respectively.

3 amber dashes are displayed in the individual tank quantity display and the total quantity display if the data is invalid or if any probe in that tank has failed.

### Fuel Tank Temperature Digital Readout

Fuel tank temperature is displayed on the EICAS in 1°C increments. A 70% bi-directional hysteresis function is applied to prevent digit oscillation. 3 amber dashes are displayed when the value is invalid. Otherwise, the display is white full time.

### Electrical System Instrumentation

The electrical systems indications are arranged into 2 columns, one for the left side electrical systems, and one for the right side systems.

The electrical system instrumentation includes the following displays:

1. DC generator voltage
2. DC generator current
3. Battery voltage
4. Battery current
5. Battery temperature

### Generator Voltage Digital Readout

Generator voltage is displayed on the EICAS in 1 Volt increments. A 70% bi-directional hysteresis function is applied to prevent digit oscillation.

## Generator Voltage Digital Readout

| Voltage Range | Condition | Text Color | Text Display |
|---|---|---|---|
| V < -3V | Invalid Data | | 3 amber dashes are displayed. |
| -3 V ≤V < 23 V | Generator Off | Green on Black | The color changes to green when the corresponding engine is not running or during and for 2 minutes after engine start. Engine start is determined by closure of either side engine start contactor or APU start contactor. Values less than 0 are displayed as 0. |
| | Undervoltage | Black on Amber | |
| 23 V ≤V ≤ 29 V | Normal | Green on Black | |
| 29 V <V ≤ 35 V | Overvoltage | Black on Amber | |
| 35 V <V | Invalid Data | | 3 amber dashes are displayed |

Figure 3-24

### Generator Current Digital Readout

Generator current is displayed on the EICAS in 5 Amp increments. A 70% bi-directional hysteresis function is applied to prevent digit oscillation. Computed display values of 5 amps or below are displayed as 0 amps.

The digit color is normally green. The digit color changes to black text on amber inverse video when the associated DC GEN O'CURRENT message is active. The DC GEN O'CURRENT message has the appropriate engine start logic to prevent nuisance alerts.

When the input is invalid, the digits are replaced with 3 amber dashes.

### Battery Voltage Digital Readout

Battery voltage is displayed on the EICAS in 1 Volt increments. A 70% bi-directional hysteresis function is applied to prevent digit oscillation.

## Battery Voltage Digital Readout

| Voltage Range | Condition | Text Color | Text Display |
|---|---|---|---|
| V < -3 V | Invalid Data | | 3 amber dashes are displayed. |
| -3 V ≤V < 23 V | Battery Off/ Undervoltage | Black on Amber | The color is green during and for 2 minutes after engine start. Engine start is determined by closure of either side start contactor or APU start contactor. Values less than 0 are displayed as 0. |
| | Starting | Green on Black | |
| 23 V ≤V ≤ 29 V | Normal | Green on Black | |
| 29 V <V ≤ 35 V | Overvoltage | Black on Amber | |
| 35 V <V | Invalid Data | | 3 amber dashes are displayed |

Figure 3-25

### Battery Current Digital Readout

Battery current is displayed on the EICAS in 5 Amp increments. A 70% bi-directional hysteresis function is applied to prevent digit oscillation. Computed display values of 5 amps or -5 amps are displayed as 0 amps.

The digit color is normally green. The digit color changes to black text on amber inverse video when the associated BATTERY O'CURRENT message is active.

The BATTERY O'CURRENT message has the appropriate engine start logic to prevent nuisance alerts.

When the input is invalid, the digits are replaced with 3 amber dashes.

### Battery Temperature Digital Readout

Battery temperature is displayed on the EICAS in 1°C increments. A 70% bi-directional hysteresis function is applied to prevent digit oscillation.

## Battery Temperature Digital Readout

| Temperature Range | Condition | Text Color | Text Display |
|---|---|---|---|
| T < -70°C | Invalid Data | | 3 amber dashes are displayed |
| -70°C ≤ T < -20°C | Cold | Black on Amber | |
| -20°C ≤ T ≤ 63°C | Normal | Green on Black | |
| 63°C < T ≤ 160°C | Over temp | White on Red | |
| 160°C < T | Invalid Data | | 3 amber dashes are displayed |

Figure 3-26

### Hydraulic System Instrumentation

The hydraulic system instrumentation includes the following displays:

1. Hydraulic system pressure.
2. Fluid volume in the hydraulic reservoir. An analog presentation is also included for quick recognition.

### Hydraulic Pressure Digital Readout

The pressure in the hydraulic system is displayed on the EICAS in 100 PSI increments. A 70% bi-directional hysteresis function is applied to prevent digit oscillation. The hydraulic pressure is smoothed with a 1 second time constant filter.

## Hydraulic Pressure Digital Readout

| Pressure Range | Condition | Text Color | Text Display |
|---|---|---|---|
| P < -100 PSI | Invalid Data | | 3 amber dashes are displayed |
| -100 PSI ≤ P ≤ 100 PSI | Pump Failure | Black on Amber | Value of 0 is displayed. The color changes to green when: Aux Pump Off **AND** Left engine not running **AND** Right engine not running **AND** aircraft on ground. |
| | Engine Shutdown | Green on Black | |
| 100 PSI < P ≤ 2200 PSI | Low Pressure | Black on Amber | |
| 2200 PSI < P < 3800 PSI | Normal | Green on Black | |
| 3800 PSI ≤ P ≤ 4000 PSI | Overpressure | Black on Amber | |
| 4000 PSI < P | Invalid Data | | 3 amber dashes are displayed |

Figure 3-27

### Hydraulic Reservoir Volume Display

The volume of the hydraulic fluid in the reservoir is displayed on the EICAS in 10 Cubic Inch (CU IN) increments. A 70% bi-directional hysteresis function is applied to prevent digit oscillation. The pointer and digital display change color to match the corresponding band.

## Hydraulic Reservoir Volume Display

| Volume Range | Condition | Band Color | Text Display |
|---|---|---|---|
| V < 0 CU IN | Invalid Data | | 3 amber dashes are displayed. The pointer is removed. |
| 0 CU IN ≤ V < 120 CU IN | Fluid Low | Black on Amber | The reservoir has 7 CU IN unusable volume. Therefore, values less than 7 CU IN are displayed as 0 and the bug parks at the bottom of the tape. |
| 120 CU IN ≤ V ≤ 700 CU IN | Normal | Green on Black | |
| 700 CU IN < V | Invalid Data | | 3 amber dashes are displayed. The pointer is removed. The reservoir will vent fluid in excess of 700 CU IN. |

Figure 3-28

### Engine Instruments

The philosophy that was used for the engine instruments is as follows:

1. Dual tapes are used, one for each engine.
2. The bugs don't jump unless the underlying value jumps.
3. Amber means that continued operation may result in an exceedance. When an engine parameter enters into selected amber regions, the FADEC will start a timer that corresponds to the engine installation manual limit for that condition. When the timer expires, the FADEC will set an exceedance bit, causing the indication for that parameter to change to red.
4. Red means an exceedance has occurred and the engine may need a maintenance inspection upon landing.
5. Portions of the display are exaggerated with a non-linear scale to make the display more useful.
6. Data is taken first from the preferred FADEC channel. If the preferred channel is invalid, then the other channel is used. In selected cases, an amber annunciation will be given.
7. The oil pressure and temperature limits change in a predefined way based on engine operating mode. The oil temperature limits change to allow ground warming. The oil pressure limits change to accommodate the flow regulated oil system.
8. The bug and text colors correspond to the positioning of the color bands they are pointing to. This is not directly enforced by EICAS, but rather a side effect of deliberate arrangement. For the oil pressure and temperature, the bands are coded in EICAS and the colors comes from the FADEC in control. For the N1 and ITT, the bands come from the FADEC not in control and the colors come from the FADEC in control.

# N1/N2 DISPLAY

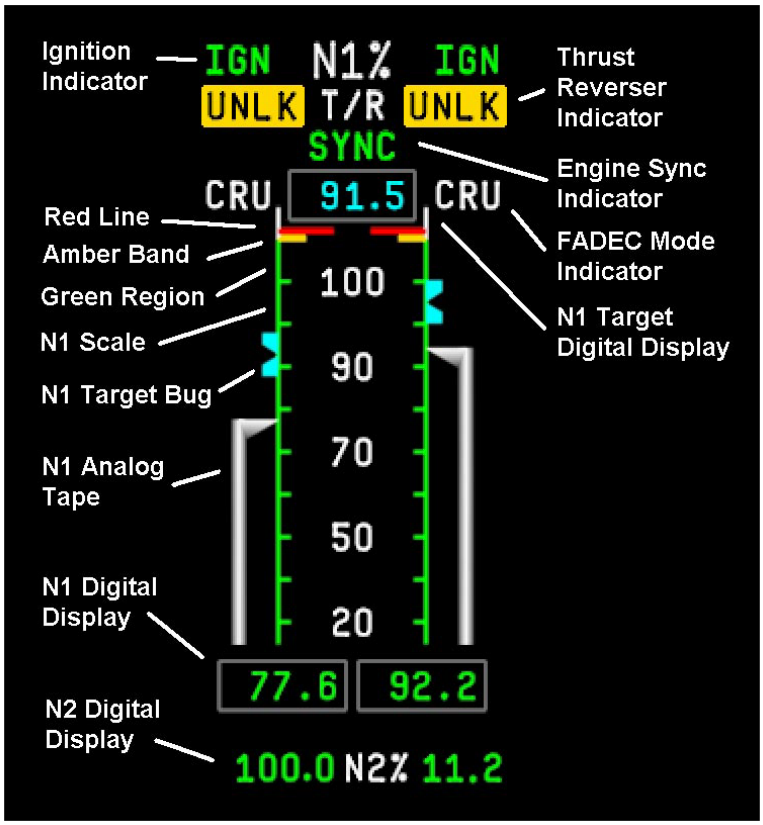



Figure 3-29

**Ignition Indicator**

The text 'IGN' is displayed in green text at the top of the N1 tape when the respective engine ignitors are on.

**Engine Sync Indicator**

The text 'SYNC' is displayed in green text when the engines are in sync.

### Thrust Reverser Indicator

This annunciation is triggered by a combination of discrete inputs to the MAU according to the following table:

## Thrust Reverser Modes Table

| Armed + 1 sec off | Unlock | Deploy | Mode | On Ground | | In Air | |
|---|---|---|---|---|---|---|---|
| | | | | Color | Indication | Color | Indication |
| No | No | No | Stowed | <none> | <blank> | <none> | <blank> |
| Yes | No | No | Armed | White on Black | ARM | Black on Amber | ARM |
| No | Yes | No | Missing Indication | Black on Amber | UNLK | Black on Amber | UNLK |
| Yes | Yes | No | Unlock | White on Black | UNLK | Black on Amber | UNLK |
| No | No | Yes | Missing Indication | Black on Amber | DPLY | White on Red | DPLY |
| Yes | No | Yes | Missing Indication | Black on Amber | DPLY | White on Red | DPLY |
| No | Yes | Yes | Missing Indication | Black on Amber | DPLY | White on Red | DPLY |
| Yes | Yes | Yes | Deploy | Green on Black | DPLY | White on Red | DPLY |
| Invalid Data | | | Sensor Failure | Amber on Black | --- | Amber on Black | --- |

Figure 3-30

### FADEC Mode Indicator

The FADEC mode indicator displays in white text what detent the FADEC thinks that the throttles are in. This is determined by using only the first true condition in the FADEC Mode Table below. Note that there are 2 entries for T/O. The second entry is provisions for an ATTCS function. ATTCS increases the engine power above the takeoff rating in the event of opposite engine failure or TLA being pushed above the takeoff detent. This function is currently active, but has no effect. The FADEC switches to another table, but the table values are the same.

# FADEC MODE TABLE

A28851

| Condition | Indication |
|---|---|
| TLA is in idle detent | <blank> |
| TLA is in cruise detent | CRU |
| TLA is in max continuous detent | MCT |
| TLA is in or above takeoff detent and ATTCS/APR is not activated | T/O |
| TLA is in or above takeoff detent and ATTCS/APR is activated | T/O |
| TLA is between detents | <blank> |

Figure 3-31

**N1 Scale**

The N1 scale forms the basis for determining the position of the N1 target bug, the N1 analog tape, the red line and the amber band. The movement of each of the 4 symbols is forced to stay on the scale by restricting the range to 20.0% $\leq$ N1 $\leq$ 108.0%.

**N1 Red Line**

The red line lays over (takes precedence over) the N1 scale. The red line is removed when it is invalid. There is nothing in the EICAS to prevent each engine from having a different red line. The region of the N1 scale above the red line changes to red when the tape is red.

**N1 Amber Band**

The amber band extends from the red line down to the steady state red line value. The amber band lays over (takes precedence over) the N1 scale. The amber band changes to red when the tape is red. The amber band is removed when either the red line or steady state red line are invalid. There is nothing in the EICAS to prevent each engine from having a different amber band.

**N1 Green Region**

A green region exists from the bottom of the amber band down the bottom of the scale. The green region is a portion of the N1 scale that is green instead of the normal white. The scale digits remain white. The green region is replaced with the normal white color when the steady state red line is invalid.

### N1 Target Digital Display

The N1 target corresponds to last detent that the throttle was in. N1 target is displayed in increments of 0.1%. A 70% bi-directional hysteresis function is applied to prevent digit oscillation. The N1 target comes from the FADEC not in control. This value is also used to drive the N1 target bug.

The N1 target has one digital display to service two engines. The value that is displayed is the minimum of the 2 processed values. The N1 target digital display is cyan. When either value is invalid, 3 amber dashes are displayed.

A value of -1.0% is used by the FADEC to indicate that the N1 target bug and digital display should be removed. The “No Bug” value does not contribute to the minimum calculation for the digital display, and if both left and right engines are in the “No Bug” condition, the N1 target digital display and the surrounding gray box are removed.

### N1 Target Bug

The N1 target bug uses the same value that is calculated for the N1 target digital display before the minimum of the two engines is selected. If the N1 target for an engine is invalid, the bug is removed. The N1 target bug changes to amber any time the N1 target and N1 value are coming from the same FADEC.

A value of -1.0% is used by the FADEC to indicate that the N1 target bug and digital display should be removed. In the “No Bug” condition, the N1 target bug is removed. The bug graphic lays under (is subordinate to) the N1 analog tape. When the N1 display value and the N1 target are equal within the graphic resolution of the display, the pointer of the N1 tape shall nest in the bottom half of the divot of the N1 target bug.

### N1 Target FADEC Operation

Engine thrust is directly related to N1 speed. The FADEC calculates the appropriate N1 speed setting corresponding to TLA position, and compensates this setting for ambient temperatures and pressures, aircraft bleed off-takes and operating modes. The FADEC then regulates to this N1 as the primary engine control.

The N1 target displayed value is a separate calculation that computes the value of N1 that corresponds to a specific throttle detent, according to the phase of flight that the aircraft is in. The following table provides a brief description of how the FADEC calculates the N1 target display value.

In the table to the right, the definition of Previous is: when transitioning from one detent position to another, leave the previously posted detent indication active until the next detent position is entered.

# N1 TARGET INDICATION

| TLA Position | N1 Target Indication | |
|---|---|---|
| | GEAR DOWN | GEAR UP |
| Cutoff | No Bug | No Bug |
| Idle Detent | Take-off | Cruise |
| Between Idle and Cruise | Take-off | Cruise |
| Cruise Detent | Take-off | Cruise |
| Between Cruise and Max Continuous | Take-off | Previous |
| Max Continuous Detent | Take-off | Max Cont |
| Between Max Continuous and Take-off | Take-off | Previous |
| Take-off Detent | Take-off | Take-off |
| Between Take-off and APR | Previous | Previous |
| APR Detent | APR | APR |
| Take-off Detent APR Triggered | APR | APR |
| Between Reverse Idle and Max Reverse Detent | Max Reverse | No Bug |
| Max Reverse Detent | Max Reverse | No Bug |
| In Take-off With Other Engine Failed | APR | APR |
| When Failed | No Bug<br>Amber<br>Dash Digits | No Bug<br>Amber<br>Dash Digits |

Figure 3-32

**N1 Display Value Computation**

Display smoothing is applied. N1 is displayed in increments of 0.1%. A 70% bidirectional hysteresis function is applied to prevent digit oscillation. A special exception to rounding and smoothing applies in the vicinity of the engine limits. When the tape is either amber or red, the normal rounding and smoothing are suspended and the raw value is rounded up and displayed. The special exception is needed because the FADEC could be determining the color based on the raw value, and the display is showing a different smoothed value.

### ITT Scale

The ITT scale forms the basis for determining the position of the ITT analog tape, the red line and the amber band. The movement of the 3 symbols is forced to stay on the scale by restricting the value to 100°C $\leq$ ITT $\leq$ 1025°C.

### ITT Red Line

The red line lays over (takes precedence over) the ITT scale. The red line is removed when it is invalid. There is nothing in the EICAS to prevent each engine from having a different red line. The region of the ITT scale above the red line changes to red when the tape is red.

### ITT Amber Band

The amber band extends from the red line down to the steady state red line value. The amber band lays over (takes precedence over) the ITT scale. The amber band changes to red when the tape is red. The amber band is removed when either the red line or steady state red line are invalid. There is nothing in the EICAS to prevent each engine from having a different amber band.

### ITT Green Region

A green region exists from the bottom of the amber band down to the bottom of the scale. The green region is a portion of the ITT scale that is green instead of the normal white. The scale digits remain white. The green region is replaced with the normal white color when the steady state red line is invalid.

### ITT Display Value Computation

Display smoothing is applied. ITT is displayed in increments of 1°C. A 70% bi-directional hysteresis function is applied to prevent digit oscillation.

A special exception to rounding and smoothing applies in the vicinity of the engine limits. When the tape is either amber or red, the normal rounding and smoothing are suspended and the raw value is rounded up and displayed. The special exception is needed because the FADEC could be determining the color based on the raw value, and the display is showing a different smoothed value.

EICAS will display negative numbers down to -999°C as long as the FADEC does not flag the data as invalid.

### RAT Display

A display of Ram Air Temperature (also known as Total Air Temperature) is displayed on EICAS. RAT is the static air temperature plus the compressive effect of the aircraft airspeed. It is used to determine icing potential.

The displayed value is the first valid value of outside air RAT value from either the left side system (left FADEC in control and left air data) or the right side system (right FADEC in control and right air data). The outside air RAT is determined by applying a correction in the EPIC system for engine inlet effects.

RAT°C is displayed in increments of 1°C. A 70% bi-directional hysteresis function is applied to prevent digit oscillation. The digits are green full time. When it is invalid, 3 amber dashes are displayed.

# EICAS Messaging

## EICAS Message Stack

An area exists on the EICAS display that is used to show aircraft status in the form of EICAS messages. Each message has a condition that causes it to be displayed. When the message is displayed, the crew then takes appropriate action.

The Sovereign EICAS uses 3 colors for messages: red, amber and cyan. Red messages are associated with a need for immediate crew action. Amber messages indicate the need for possible future corrective action. Cyan messages are advisory/informational in nature.

The EICAS display can accommodate over 100 separate conditions with only 12 lines of text. This is accomplished by using the CCD to scroll the display. The scrolling is accomplished by first selecting the window. Either knob can then be used to scroll the messages.

The text area is made up of 12 lines of 26 characters each, with an additional line at the bottom for scrolling status. When any amber or cyan message is active, the status line is displayed. If there are no active amber or cyan messages, the status line and the gray line above it are removed. The scroll feature functions full time, even when only 1 amber or cyan message is present.

If the system is unable to compute the messages to be displayed, the message window will show a red 'X'.

## Message Display

Message processing has 3 steps. First, the trigger conditions for the message are calculated to determine if the message should be added to the stack. The text and color of the messages, along with the logic requirements for each message is defined in the EICAS Interface Requirements section of this documents. Second, if the message is to be added to the stack, it is inserted at the top of it’s respective color block. Depending on color, an attention getting aural alert may be triggered. See: Aural Warning EICAS Message Tones. Third, the messages status is then set to unacknowledged. Unacknowledged messages flash inverse video until they are acknowledged.

Certain messages change color. Color changes are accomplished by removing the message from the old color block and adding it to the new color block as an unacknowledged message.

The red message block is displayed at the top and can not be scrolled off the display. Red messages are acknowledged using the master warning button.

The amber message block is displayed below the red block and can be scrolled off the display using the scroll feature if they have been acknowledged. If the top of the amber block, where the message is to be inserted, has been scrolled off, it is brought back into view. Amber messages are acknowledged using the master caution button, unless the message is scrolled off. Amber messages that are scrolled off are not acknowledged. The cyan message block is displayed below the amber block and can also be scrolled off the display if they have been acknowledged. If the top of cyan block, where the message is to be inserted, has been scrolled off the top, it is brought back into view. The amber block will remain obscured. If the top of the cyan block has been scrolled off the bottom, it will not be brought back into view. For example, a cyan message appearing will not cause amber messages to scroll off. Instead, the message will become active out of view and the respective scroll count will flash inverse video. Cyan messages are automatically acknowledged after 5 seconds, unless the message is scrolled off. Cyan messages that are scrolled off do not automatically acknowledge until they are scrolled into view for 5 seconds.

Finally, the white END message is displayed below the cyan message block.

**Message Scrolling**

The scrolling operation is as follows:

1. The number of messages scrolled off the top and bottom of the EICAS window are counted by color and placed in a scroll count window located at the bottom of the message stack. The scroll count window is separated from the message stack by a gray bar.

2. When unacknowledged messages have been scrolled off the top or bottom, the corresponding scroll digits and scroll arrows flash inverse video.

3. If the count for a particular set of scroll digits is greater than 99, the displayed value parks at 99.

4. When a particular set of scroll digits = 00, the corresponding scroll digits and arrow are removed and the remaining scroll digits and arrows are justified away from the center to the left or right edge.

5. The white “END” message is not counted for the purposes of determining the count. As there are no other white messages, scroll digits for white messages should never be displayed.

6. Clockwise rotation of the CCD knob causes messages that have been scrolled off the top to be moved into the display window. All of the messages in the window will move down. Any messages at the bottom would be scrolled off.

# EICAS INDICATIONS

| Description |
|---|
| ITT Scale |
| ITT Red Line |
| ITT Amber Band |
| ITT Green Region |
| |
| Ignition Indicator |
| Thrust Reverser Indicator |
| Engine Sync Indicator |
| FADEC Mode Indicator |
| N1 Target Digital Display |
| N1 Red Line |
| N1 Amber Band |
| N1 Green Region |
| N1 Target Bug |
| N1 Scale |
| |
| |
| N1 Analog Tape |
| N1 Digital Display |
| N2 Digital Display |
| |
| |
| |
| |
| ITT Analog Tape |
| ITT Digital Display |
| RAT Display |
| |
| EICAS Message Stack |
| EICAS Message Status Line |

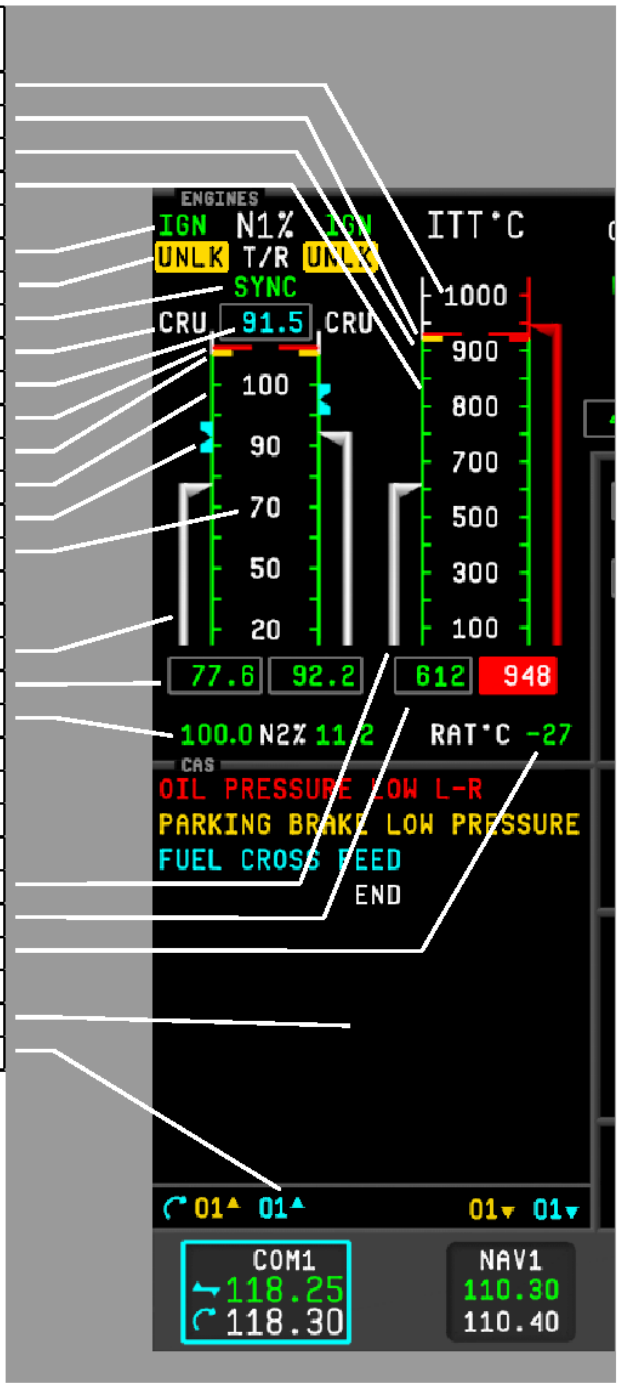
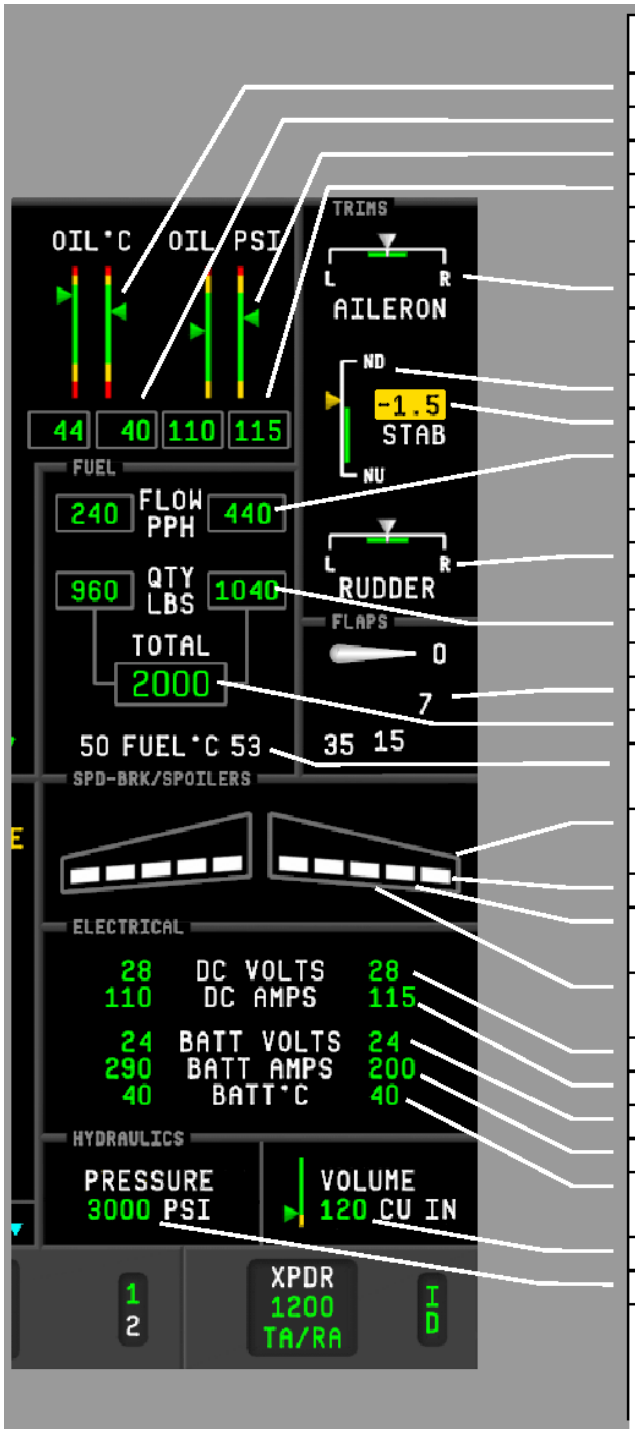



Figure 3-33 (Sheet 1 of 2)

# EICAS INDICATIONS




| Description |
|---|
| Oil Temperature Analog Tape |
| Oil Temperature Digital Display |
| Oil Pressure Analog Tape |
| Oil Pressure Digital Display |
| |
| |
| Aileron Trim Display |
| |
| |
| Stabilizer Trim Display |
| Stabilizer Trim Digital Display |
| Fuel Flow Digital Readout |
| |
| |
| Rudder Trim Display |
| |
| Fuel Quantity Digital Readout |
| |
| Flap Panel Synoptic |
| Total Fuel Quantity Digital Readout |
| Fuel Tank Temperature Digital Readout |
| Speedbrake/Spoiler Panel Philosophy |
| Speed Brakes - Non Modulated |
| Speed Brakes - Modulated - On Ground Operation |
| Speed Brakes - Modulated - In Air Operation |
| Generator Voltage Digital Readout |
| Generator Current Digital Readout |
| Battery Voltage Digital Readout |
| Battery Current Digital Readout |
| Battery Temperature Digital Readout |
| Hydraulic Reservoir Volume Display |
| Hydraulic Pressure Digital Readout |

Figure 3-33 (Sheet 2)

7. When no scrollable messages are active, I.E. all cyan and amber messages are inactive, the scroll window symbology is removed. This includes the rotation arrow, the scroll digits, the scroll arrows and the gray bar.

8. The message stack is computed independently by 2 redundant systems. If there is a miscompare for more than 2 seconds, and both monitor warning processes have been valid for 2.5 minutes, an amber MW1 or MW2 will be displayed in the middle of the scroll window. When this happens, a selection on the MCDU will be enabled to allow switching between the 2 message stacks. The pilots would then flip back and forth to find the offending message.

**EICAS General Operation**

The EICAS messages for the Sovereign are defined in the table below. Unless otherwise specified:

1. Invalid data does not cause messages to be displayed.

2. If a message is triggered, but invalid data causes the color to be uncertain, the lowest color is displayed.

3. Invalid data does not trigger the 7 major inhibits (i.e. the messages are otherwise enabled).

4. The debounce is the amount of time the condition must be true before the message is posted or an existing message is promoted from a less severe color to a more severe color. Messages marked with ‘STD’ have a standard debounce of 300 ms.

5. When a message is either removed or demoted from a more severe color to a less severe color, the condition must remain true for 300 ms before the message is removed or demoted.

6. Messages for redundant systems are combined into 1 line when multiple systems experience failures. For example, PITOT/STATIC COLD L-RSTBY has 7 possible combinations: L, R, STBY, L-R, L-STBY, R-STBY, L-R-STBY.

7. Messages with different colors for redundant systems are NOT combined. For example, if PITOT/STATIC COLD L is active as amber and PITOT/STATIC COLD R is active as cyan, the messages are not combined.

8. Message colors for the same system are mutually exclusive. For example, PITOT/STATIC COLD L cannot be displayed as both amber and cyan at the same time.

9. A large number of EICAS messages have some sort of inhibit in order to reduce crew workload and nuisance messages. On the following tables,

TOPI = TakeOff Phase Inhibit
LOPI = Landing Operations Phase Inhibit
ESDI = Engine ShutDown Inhibit
EFI = Engine Fail Inhibit
BFI = Bus Fail Inhibit
On Ground = On Ground Inhibit
In Air = In Air Inhibit

The ESDI, EFI, BFI, On Ground and In Air inhibits are applied before the debounce. If the message is defined to have a latching action, that occurs after the debounce. The TOPI and LOPI inhibits are applied after the latch or debounce.

10. In order to meet safety assessment requirements, redundant processing elements are used. After power on or other processor reset condition, the backup processing elements will synchronize their latch states to the master processing element. This syncronization happens only once, and only on the backup elements.

11. Inhibits and debounce identified with an asterisk indicates a special modification that is specified in the message description. Frequently, this means that some other processing is used in place of the default processing defined above. For definition, see the respective message section for details.

# EICAS MESSAGES BY AREA

| Red | Amber | Cyan | Message Name | | LOPI | TOPI | ESDI | EFI | BFI | On Ground | In Air |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | **Flight Data Recorder** | | | | | | | | |
| | | C | FDR FAIL | | L | T | | | B | | |
| | | | **Honeywell** | | | | | | | | |
| | A | | MAU 1-2-3-4 O'TEMP | | L | T | | | | | |
| | A | | MAU 1-2-3-4 FAIL | | L | T | | | B | | |
| | | | END | | | | | | | | |
| | A | | DU 1-2-3-4 O'TEMP | | L | T | | | | | |
| | A | | CHECK DU 1-2-3-4 | | L | T | | | B | | |
| | A | | CONFIGURATION MISMATCH | | L | T | | | | | A |
| | A | | MONITOR WARNING FAIL L-R | | L | T | | | B | | |
| | A | | ASCB BUS FAIL | | L | T | | | B | | |
| | | C | AP FAIL A-B | | L | T | | | B | | |
| | | C | YD FAIL A-B | | L | T | | | B | | |
| R | | | EMERGENCY DESCENT | | | T | | | | | |
| | A | | AP STAB TRIM INOP | | L | T | | | B | | |

Figure 3-34 (Sheet 1 of 5)

| Red | Amber | Cyan | Message Name | | LOPI | TOPI | ESDI | EFI | BFI | On Ground | In Air |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | A | | RETRIM L-R WING DOWN | | L | T | | | | | |
| | A | | RETRIM NOSE UP-DOWN | | L | T | | | | | |
| | A | | FD MODE OFF | | L | T | | | | G | |
| | | C | GROUND PROX FAIL | | L | T | | | B | | |
| | | C | WINDSHEAR FAIL | | L | T | | | B | | |
| | | C | TERRAIN FAIL | | L | T | | | B | | |
| | | C | TAWS FLAP OVERRIDE | | L | T | | | | | |
| | | C | TAWS GLIDESLOPE CANCEL | | L | T | | | | | |
| | | C | TERRAIN INHIBIT | | L | T | | | | | |
| | | C | TAWS AUDIO INHIBITED | | L | T | | | | | |
| | | | **Doors** | | | | | | | | |
| | A | | CABIN DOOR OPEN | | L | T | | | B | | |
| | A | | NOSE DOOR OPEN L-R | | L | T | | | | | |
| | A | | BAGGAGE DOOR OPEN | | L | T | | | B | | |
| | A | | EMERGENCY EXIT OPEN | | L | T | | | B | | |
| | A | | TAILCONE DOOR OPEN | | L | T | | | | | |
| | | | **Interiors** | | | | | | | | |
| | A | | LAVATORY DOOR | | L | T | | | | | |
| | | | **Flight Controls** | | | | | | | | |
| | A | | PITCH/ROLL DISCONNECT | | L | T | | | B | | |
| | | C | GUST LOCK ON | | L | T | | | B | | |
| | A | | RUDDER BIAS FAULT | | L | T | | | B | | |
| | A | | PRIMARY STAB TRIM FAIL | | L | T | | | B | | |
| | A | | STAB TRIM MONITOR WARNING | | L | T | | | | | |
| | A | | SECONDARY STAB TRIM FAIL | | L | T | | | | | |
| | A | | MACH TRIM FAIL | | L | T | | | B | | |
| | A | | ROLL SYSTEM CONTROL FAULT | | L | T | | | B | | |
| | A | | FLAPS FAIL | | L | T | | | B | | |
| | A | | SPEED BRAKES | | | T | | | | | |
| | | | **Hydraulics** | | | | | | | | |
| | | C | AUX HYDRAULIC PUMP ON | | L | T | | | | | |
| | A | C | HYDRAULIC PRESSURE LOW L-R | | | T | S | | | | |
| | A | | HYDRAULIC VOLUME LOW | | | T | | | | | |
| | | | **Brakes** | | | | | | | | |
| | A | C | PARKING BRAKE ON | | L | T | | | | | |
| | A | | PARKING BRAKE LOW PRESSURE | | L | T | | | | | A |
| | A | | ANTISKID FAIL | | | T | | | B | | |
| | | C | MAIN WHEEL SPINDOWN FAIL | | | | | | | | |

Figure 3-34 (Sheet 2)

| Red | Amber | Cyan | Message Name | | LOPI | TOPI | ESDI | EFI | BFI | On Ground | In Air |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | **Propulsion** | | | | | | | | |
| R | | | OIL PRESSURE LOW L-R | | | T | S | F | | | |
| | | C | OIL FILTER BYPASS L-R | | L | T | S | | | | |
| | A | C | OIL LEVEL LOW L-R | | L | T | S | | | | A |
| | A | | ENGINE CHIP DETECT L-R | | L | T | S | | | | |
| | A | | FUEL FILTER BYPASS L-R | | L | T | S | | | | |
| | A | | RAT HEAT FAIL L-R | | L | T | S | | B | | |
| | A | | T/R ARMED L-R | | | T | | | | G | |
| | A | | T/R UNLOCK L-R | | | T | | | B | G | |
| R | | | ENGINE FIRE L-R | | | | | | | | |
| | A | | ENG FIRE DETECT FAIL L-R | | L | T | | | B | | |
| | A | | ENG FIRE BOTTLE LOW 1-2 | | L | T | | | | | |
| | | C | ATTCS ARMED | | L | | | | | | |
| | A | | ATTCS INOP | | L | | | | | | A |
| R | | | ENGINE FAILED L-R | | | | | | | | |
| | | C | ENGINE SHUTDOWN L-R | | | | | | | | |
| | | C | ENGINE DISPATCH LIMIT L-R | | L | T | | | | | A |
| R | | | ENGINE VIBRATION L-R | | | T | S | F | | | |
| | A | | ENGINE CONTROL FAULT L-R | | L | T | | F | B | | |
| | A | | GROUND IDLE L-R | | | T | S | | | G | |
| | | | **APU** | | | | | | | | |
| R | | | APU FIRE | | | | | | | | |
| | A | | APU FIRE DETECT FAIL | | L | T | | | | | |
| | | | **Fuel** | | | | | | | | |
| | A | | FUEL LEVEL LOW L-R | | L | T | | | | | |
| | A | | FUEL PRESSURE LOW L-R | | L | T | S | F | | | |
| | | C | FUEL FW SHUTOFF L-R | | L | T | | | | | |
| | A | | FUEL FW S/O TRANSIT L-R | | L | T | | | B | | |
| | A | C | FUEL BOOST PUMP ON L-R | | L | T | S | | | | |
| | A | | FUEL MOTIVE VLV FAIL L-R | | L | T | S | | | | |
| | A | C | FUEL CROSS FEED | | L | T | | | | | |
| | A | | FUEL CROSS FEED TRANSIT | | L | T | | | B | | |
| | | | **ECS and Bleed Air** | | | | | | | | |
| R | | | BAGGAGE FIRE | | L | T | | | | | |
| | | C | FIRE BOTTLE LOW BAG-APU | | L | T | | | | | |
| | | C | FIRE BOTTLE LOW BAGGAGE | | L | T | | | | | |
| | A | C | BAGGAGE HEAT FAIL | | L | T | S | | | | |
| | A | | ACM O'TEMP | | L | T | | | | | |
| | A | | DUCT O'TEMP CABIN | | L | T | | | | | |
| | A | | DUCT O'TEMP COCKPIT | | L | T | | | | | |
| | A | | HP VALVE FAIL L-R | | L | T | S | F | B | | A |

Figure 3-34 (Sheet 3)

| Red | Amber | Cyan | Message Name | | LOPI | TOPI | ESDI | EFI | BFI | On Ground | In Air |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | A | | BLEED AIR O'TEMP L-R | | L | T | | | | | |
| | A | C | BLEED SELECT NOT NORM L-R | | L | T | | | | | |
| | A | | PRESS SOURCE NOT NORM | | L | T | | | | | |
| | A | | ACM BLEED LEAK | | L | T | | | | | |
| | A | | SUPPLY BLEED LEAK L-R | | L | T | | | | | |
| | A | | WING BLEED LEAK L-R | | L | T | | | | | |
| | A | | STAB BLEED LEAK | | L | T | | | | | |
| | | | **Anti-Ice** | | | | | | | | |
| | A | | BLEED AIR MONITOR FAIL | | L | T | | | B | | |
| | | C | ANTI-ICE ON ALL | | L | T | | | | | |
| | | C | ANTI-ICE ON ENGINE/STAB | | L | T | | | | | |
| | A | C | ENG ANTI-ICE COLD L-R | | L | T | S | | | | |
| | A | C | STAB ANTI-ICE COLD L-R | | L | T | | | | | |
| | A | C | WING ANTI-ICE COLD L-R | | L | T | | | | | |
| | A | C | INBD WING A/I COLD L-R | | L | T | | | | | |
| | A | | ENG ANTI-ICE O'TEMP L-R | | L | T | | | | | |
| | A | | STAB ANTI-ICE O'TEMP L-R | | L | T | | | | | |
| | A | | WING ANTI-ICE O'TEMP L-R | | L | T | | | | | |
| | | | WING A/I CROSSFLOW OPEN | | L | T | | | | | |
| | | | **Pressurization** | | | | | | | | |
| R | A | C | CABIN ALTITUDE | | L | T | | | B | | |
| | A | | EMERGENCY PRESSURIZATION | | L | T | | | | | |
| | | | **Electrical** | | | | | | | | |
| | A | C | BUS TIE CLOSED | | L | T | | | | | |
| | A | | DC EMER BUS L-R | | L | T | | | | | |
| | A | | BATTERY O'CURRENT L-R | | L | T | | | | | |
| | A | C | BATTERY OFF L-R | | L | T | | | | | |
| R | | | BATTERY O'TEMP L-R | | L | T | | | | | |
| | A | | DC GEN O'CURRENT L-R-APU | | L | T | | | | | |
| R | A | | DC GEN OFF L-R-APU | | L | T | S | | | | |
| | A | | AOA/STALL WARN FAIL L-R | | L | T | | | B | | |
| | A | | AOA HEAT FAIL L-R | | L | T | | | | | |
| | A | | WINDSHIELD HEAT INOP L-R | | L | T | S | | B | | |
| | A | | WINDSHIELD OVERTEMP L-R | | L | T | | | | | |
| | | C | AC BEARING L-R | | L | T | | | | | A |
| | A | C | REMOTE CB TRIPPED | | L | T | | | B | | |
| | A | | WOW MISCOMPARE | | L | T | | | B | | |
| | | | **Avionics** | | | | | | | | |
| | | C | SELCAL VHF 1-2 HF 1-2 | | L | T | | | | | |
| | | C | PHONE CALL | | L | T | | | | | |
| R | | C | NO TAKEOFF | | L | | | | | | A |

Figure 3-34 (Sheet 4)

| Red | Amber | Cyan | Message Name | | LOPI | TOPI | ESDI | EFI | BFI | On Ground | In Air |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | C | AHRS BASIC L-R | | L | T | | | | | |
| | A | C | PITOT/STATIC COLD L-R-STBY | | L | T | | | B | | |
| | A | | AVIONICS O'TEMP COCKPIT | | L | T | | | | | |
| | A | | AVIONICS O'TEMP NOSE | | L | T | | | | | |

Figure 3-34 (Sheet 5)

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### Bus Fail Inhibit

In order to prevent nuisance messages during engine start and during a bus failure in flight, selected messages are inhibited when the respective power is determined by examining the contactors surrounding each bus.

## BUS FAIL INHIBIT MESSAGES

| Inhibit this Message/Input | When this Power Bus is Off | Note | Inhibit this Message/Input | When this Power Bus is Off | Note |
|---|---|---|---|---|---|
| Cockpit Fan Fail L | LH AVN | | Cockpit Fan Fail R | RH AVN | |
| | | | Nose Fan Fail | RH ELEC | |
| | | | FDR FAIL | RH AVN | |
| MAU 1 FAIL | LH AVN + 60 sec | 4 | MAU 2 FAIL | RH AVN + 60 sec | 4 |
| ASCB BUS FAIL (MAU 1 input) | LH AVN | 2 | ASCB BUS FAIL (MAU 2 input) | RH AVN | 2 |
| MAU 3 FAIL | (LH ELEC and LH START) + 60 sec | 1, 4 | MAU 4 FAIL | (RH ELEC and RH START) +60 sec | 1, 4 |
| ASCB BUS FAIL (MAU 3 input) | LH ELEC and LH START | 1, 2 | ASCB BUS FAIL (MAU 4 input) | RH ELEC and RH START | 1, 2 |
| MONITOR WARNING FAIL L (MAU 1 input) | LH AVN + 60 sec | 4, 5 | MONITOR WARNING FAIL R (MAU 2 input) | RH AVN + 60 sec | 4, 5 |
| MONITOR WARNING FAIL L (MAU 3 input) | (LH ELEC and LH START) + 60 sec | 1, 4, 5 | MONITOR WARNING FAIL R (MAU 4 input) | (RH ELEC and RH START) + 60 sec | 1, 4, 5 |
| AP FAIL A | (LH AVN or RH AVN) + 120 sec | 3, 4 | AP FAIL B | (LH AVN or RH AVN) + 120 sec | 3, 4 |
| YD FAIL A | (LH AVN or RH AVN) + 120 sec | 3, 4 | YD FAIL B | (LH AVN or RH AVN) + 120 sec | 3, 4 |
| AP STAB TRIM INOP | (LH AVN or RH AVN) + 120 sec | 3, 4 | | | |
| CHECK DU 1 | LH AVN | | CHECK DU 2 | RH START | |
| ASCB BUS FAIL (DU 1 input) | LH AVN | 2 | ASCB BUS FAIL (DU 1 input) | RH START | 2 |
| CHECK DU 3 | LH AVN | | CHECK DU 4 | RH AVN | |
| ASCB BUS FAIL (DU 3 input) | LH AVN | 2 | ASCB BUS FAIL (DU 4 input) | RH AVN | 2 |
| ASCB BUS FAIL (MRC 1 input) | LH EMER | 2 | ASCB BUS FAIL (MRC 2 input) | RH AVN | 2 |
| GROUND PROX FAIL | LH AVN + 60 sec | 4 | | | |
| TERRAIN FAIL | LH AVN + 60 sec | 4 | | | |
| WINDSHEAR FAIL | LH AVN + 60 sec | 4 | | | |

Note 1: MAU 3 and MAU 4 dual power inputs - both power inputs must be off before the message is inhibited.
Note 2: ASCB BUS FAIL - only the respective input is inhibited when power is off.
Note 3: AP FAIL, YD FAIL and AP STAB TRIM INOP - both left and right sides are inhibited when either left or right power is off.
Note 4: + xx sec means that the message/input is inhibited when the bus is off and for that amount of time after the power is on.
Note 5: MONITOR WARNING FAIL - only the respective input is inhibited.

Figure 3-35 (Sheet 1 of 2)

# BUS FAIL INHIBIT MESSAGES

| Inhibit this Message/Input | When this Power Bus is Off | Note | Inhibit this Message/Input | When this Power Bus is Off | Note |
|---|---|---|---|---|---|
| PITOT/STATIC COLD L | LH ELEC | | PITOT/STATIC COLD R | RH ELEC | |
| | | | PITOT/STATIC COLD STBY | RH EMER | |
| CABIN DOOR OPEN | LH ELEC | | | | |
| BAGGAGE DOOR OPEN | LH ELEC | | EMERGENCY EXIT OPEN | RH ELEC | |
| ROLL SYSTEM CONTROL FAULT | LH ELEC | | RUDDER BIAS FAULT | RH EMER | |
| PITCH/ROLL DISCONNECT | LH ELEC | | MACH TRIM FAIL | RH ELEC | |
| GUST LOCK ON | LH ELEC | | | | |
| PRIMARY STAB TRIM FAIL | LH ELEC | | | | |
| FLAPS FAIL | LH ELEC | | | | |
| FUEL FW S/O TRANSIT L | LH START | | FUEL FW S/O TRANSIT R | RH START | |
| FUEL CROSS FEED TRANSIT | LH ELEC | | | | |
| RAT HEAT FAIL L (A channel) | LH ELEC | 1 | RAT HEAT FAIL L (B channel) | RH ELEC | 1 |
| RAT HEAT FAIL R (A channel) | LH ELEC | 1 | RAT HEAT FAIL R (B channel) | RH ELEC | 1 |
| T/R UNLOCK L | LH ELEC | | T/R UNLOCK R | RH ELEC | |
| ENG FIRE DETECT FAIL L | LH START | | ENG FIRE DETECT FAIL R | RH START | |
| ENGINE CONTROL FAULT L (A channel) | LH START | 2 | ENGINE CONTROL FAULT L (B channel) | RH START | 2 |
| ENGINE CONTROL FAULT R (A channel) | LH START | 2 | ENGINE CONTROL FAULT R (B channel) | RH START | 2 |
| HP VALVE FAIL L (Fail input only) | LH ELEC | 3 | HP VALVE FAIL R (Fail input only) | RH ELEC | 3 |
| CABIN ALTITUDE (L input) | LH EMER | 4 | CABIN ALTITUDE (R input) | RH ELEC | 4 |
| AOA/STALL WARN FAIL L | LH ELEC | | AOA/STALL WARN FAIL R | RH ELEC | |
| WINDSHIELD HEAT INOP L | LH ELEC | | WINDSHIELD HEAT INOP R | RH ELEC | |
| REMOTE CB TRIPPED (L input) | LH ELEC | 5 | REMOTE CB TRIPPED (R input) | RH ELEC | 5 |
| WOW MISCOMPARE (L input) | LH ELEC | 6 | WOW MISCOMPARE (R input) | RH ELEC | 6 |
| ANTISKID FAIL | LH ELEC | | | | |
| BLEED AIR MONITOR FAIL L | LH EMER | | BLEED AIR MONITOR FAIL R | RH ELEC | |

Note 1: RAT HEAT FAIL - only the respective channel (A or B) is inhibited when power is off
Note 2: ENGINE CONTROL FAULT - only the respective channel (A or B) is inhibited when power is off
Note 3: HP VALVE FAIL - selected cases are inhibited only
Note 4: CABIN ALTITUDE - only selected cases are inhibited on the respective side (L or R) when power is off
Note 5: REMOTE CB TRIPPED - only the respective side (L or R) is inhibited when power is off
Note 6: WOW MISCOMPARE - only the respective side (L or R) is inhibited when power is off

Figure 3-35 (Sheet 2)

The EICAS system is designed in such a way that there is minimization of oscillating digits which can be a nuisance in digital displays. If a display becomes invalid for any reason, the display will change to amber dashes.

## REVERSIONARY OPERATION

Both PFDs can be manually reverted, or displayed on an MFD, in order to provide redundancy and safety in case of a display failure. The EICAS can be reverted to either MFD, if necessary. The system is designed, however, so that MFD data cannot be displayed on a PFD. If the pilot's PFD should fail, the PFD data can be reverted to the pilot's MFD; if the EICAS display should then fail, manual reversion of the EICAS display to the copilot's MFD is the remaining option. In this case, regardless of which MFD is selected, the Primus EPIC system forces the EICAS data to the copilot's MFD.

# REVERSIONARY CONTROLLER


Figure 3-36

The left knob of the EICAS reversionary controller controls the position of the EICAS display. The NORM position places the EICAS display at its normal location on the center display unit; the L position places it on the pilot's multifunction display (MFD), and the R position places it on the copilot's MFD. The right knob (center position) directs which symbol generator (SG) is providing the display symbology for the DUs. The symbol generator is part of the integrated avionics computer (IAC). The center (NORM) position selects SG number 1 to drive the pilot's PFD, MFD, and the EICAS, and SG number 2 to drive the copilot's PFD, and MFD. The position SG1 selects symbol generator number 1 to drive all five display units, and SG2 position selects symbol generator number 2 to drive all five displays.

Each MAU has two channels which are completely independent of one another. Normally channel A of MAU 1 is used for the left engine EICAS display and channel A of MAU 2 is used for the right engine EICAS display. There are two momentary switches on the reversionary controller by means of which the pilot may select channel B of either data acquisition unit to be the display source of the engine. When a DAU reversion is selected it will be annunciated in amber between the engine fan RPM and the ITT indications on the EICAS display.

# ENHANCED GROUND PROXIMITY WARNING SYSTEM (EGPWS)

## GENERAL

The EGPWS is a terrain awareness and alerting system that gives aural warnings and cockpit displays that the pilot uses to avert impending situations that can jeopardize the aircraft's safety. For additional information, refer to an applicable Aircraft Flight Manual (AFM) or EGPWS aircraft flight manual. The EGPWS uses aircraft inputs including:

- Geographic Position
- Attitude
- Altitude
- Airspeed
- Glideslope Deviation.

These are used with internal terrain, obstacles, and airport databases to predict a potential conflict between the aircraft flight path and terrain or an obstacle. If a terrain or obstacle conflict exists, the egpws sounds an audio caution or warning alert, and shows a display of the situation. The egpws alerts the pilot as to excessive glideslope deviation too low with flaps or gear not in landing configuration. It can also warn of excessive bank angles and altitude callouts, severe windshear conditions are also annunciated in certain types of aircraft.

The EGPWS incorporates several enhanced features:

**Terrain Alerting and Display (TAD)** - The TAD is a graphic display of the surrounding terrain that is displayed on the weather radar indicator, EFIS, or a dedicated display. The aircraft's position is superimposed on the internal terrain topography database that is within the display range selected. All terrain that is above the aircraft or 2000 ft below the aircraft altitude is displayed in the cockpit.

**Peaks** - Peaks is a TAD supplemental feature that displays additional terrain features to enhance the pilot's situational awareness, independent of the aircraft's altitude. This includes digital elevations for the highest and lowest displayed terrain, additional colored elevation bands, and a representation of 0 MSL elevation (sea level and its corresponding shoreline).

**Obstacles** - Obstacles is a feature that uses the obstacle database to alert and display potential obstacle conflicts. GND PROX and warning visual alerts are displayed and audio alerts are sounded when a conflict is detected. When TAD is enabled, obstacles are graphically displayed similar to terrain.

**Envelope Modulation** - A process feature called envelope modulation uses the internal database to tailor EGPWS alerts at certain geographic locations to reduce nuisance alerts and give added protection.

**Terrain Clearance Floor (TCF)** - The terrain clearance floor feature adds another element of protection by alerting the pilot of a possible premature descent. This is used for non-precision approaches and is based on the current aircraft position relative to the nearest runway.

**Runway Field Clearance Floor (RFCF)** - RFCF is similar to the TCF feature except that RFCF is based on the current aircraft position and height above the destination runway based on geometric altitude. This improves protection at locations where the destination runway is significantly higher than the surrounding terrain.

**Aural Declutter** - The aural declutter feature reduces repetitive aural warning messages.

**Geometric Altitude** - Geometric altitude is based on GPS altitude. It is a computed pseudo-barometric altitude that is designed to reduce or eliminate altitude errors resulting from temperature extremes, nonstandard pressure altitude conditions, and altimeter miss-sets. This ensures an optimal EGPWS alerting and display capability.

Some of these features were added to the EGPWS as the system evolved and are not present in all enhanced ground proximity warning computers (TAWC). For the specific TAWC part number and functions, refer to an applicable Aircraft Flight Manual (AFM) or EGPWS Aircraft Flight Manual Supplement (AFMS).

In later versions, the TAWC conducts radio altitude reasonableness checks based on the computed terrain clearance (pseudo-radio altitude). Computed terrain clearance is computed by subtracting the elevation of the (database) terrain below the aircraft from geometric altitude above sea level (ASL). Radio altitude is considered unreasonable when it indicates a terrain clearance that is less than the computed terrain clearance by more than 2000 ft. For example, if the computed terrain clearance is 10,000 ft and the radio altitude is any value (0-2500 ft), then the radio altitude is considered unreasonable. This is only performed if TAD is enabled, high integrity terrain and position data are available, and the computed terrain clearance is greater than 4000 ft. This feature reduces the potential for nuisance alerts caused by false tracking of the radio altimeter.

## SYSTEM DESCRIPTION

The EGPWS uses input signals from other onboard systems. The full compliment of these other systems depends on the EGPWS configuration and options selected. Systems that monitor altitude, airspeed, attitude, glideslope, and position are required for both the basic and enhanced versions of EGPWSs. Accelerations, angle–of–attack (AOA), and flap position are required for windshear. Inputs are also required for discrete signal and control input.

# EGPWS System Diagram

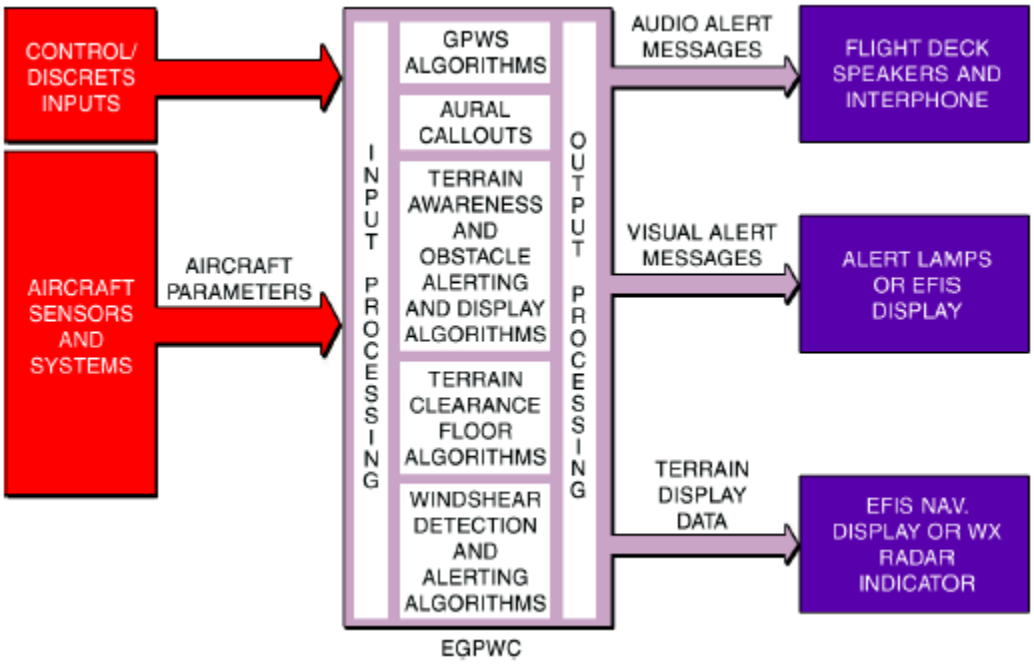


Figure 3-37

The EGPWS uses signals from the following systems:

Air data

- Uncorrected and corrected barometric altitude
- Altitude rate
- Computed airspeed
- True airspeed
- Static air temperature are provided by air data system
    - Radio altitude is provided by a radio altimeter system.

Radio altimeter system (or ancillary system)

- Decision height
- Decision height altitude.

Other system outputs are listed below:

FMS, IRS, attitude and heading reference system (AHRS), and accelerometers output

- Pitch and roll attitude
- Latitude and longitude position
- Body normal and longitudinal accelerations
- Magnetic and true track angles
- Magnetic and true heading
- Inertial altitude
- Groundspeed
- Type.

Global positioning system

- Latitude and longitude position
- True track angle
- GPS altitude
- Groundspeed
- Horizontal and vertical figure of merit (HFOM/VFOM)
- Horizontal integrity limit (HIL)
- Sensor status.

VHF NAV receiver

- Glideslope
- Localizer
- ILS tuned
- Selected runway heading
- Display range.

AOA vane or stall warning

- AOA
- Stick shaker margin.

EGPWS APM options are used to tell the system the type of aircraft and interface that it is on. These are defined and established during the EGPWS installation. EGPWS output functions are the result of APM options reads each time the EGPWS is powered on. APM options include:

- Decision height
- Landing flaps selected or flap position discretes
- Landing gear selected
- Terrain display range
- Status discretes such as glideslope valid, localizer valid, radio altitude valid associated with analog signal inputs.

Control discretes control EGPWS functions. These include:

- EGPWS test
- Glideslope cancel
- Glideslope inhibit or glideslope back-course
- Terrain (display) select
- Terrain inhibit
- Flap override
- Audio inhibit
- Altitude callout enable
- Steep approach enable
- ILS tuned discretes.

**EGPWS System Outputs**

The EGPWS gives both audio and visual outputs. Audio outputs are sent as specific alert phrases, and altitude callouts or tones are sounded by the speaker, and by the cockpit interphone system for use in the headset. Audio output levels are established during the installation of the EGPWS. These EGPWS audio outputs can be inhibited by other systems that have a higher priority (i.e., windshear), or using cockpit switches. The EGPWS audio's can inhibit other system audio outputs such as TCAS.

Visual outputs give discrete alert and status annunciations, and display terrain video when a compatible display system is installed. The discrete visual alerts coincide with audio caution and warning alerts to maximize the terrain alerting capability. Status annunciations tell the pilot about the status of the EGPWS (i.e., GPWS INOP) or if other functions have been selected.

Terrain video is generated by the TAWC based on the aircraft’s current position relative to the surrounding terrain. This video is displayed on a weather radar indicator, EFIS display, or a dedicated display unit.

**Ground Proximity**

The EGPWS incorporates the functions of the basic GPWS. This includes the following alerting modes:

Mode 1 -Excessive descent rates with SINK RATE and PULL UP aural warnings.

Mode 2 -Excessive terrain closure rates with TERRAIN, TERRAIN and PULL UP aural warnings.

Mode 3 -Altitude loss after takeoff with DON'T SINK, DON'T SINK aural warning.

Mode 4 -Unsafe terrain clearance with TOO LOW TERRAIN, TOO LOW GEAR, and TOO LOW FLAPS aural warnings.

Mode 5 -Excessive deviation below glideslope with a GLIDESLOPE aural warning.

Mode 6 -Advisory callouts with BANK ANGLE, MINIMUMS, and selected altitudes aural warnings.

Mode 7 -Windshear alerting is included for specific aircraft types.

Mode 7 windshear caution and/or warning alerts are used when a EGPWS windshear threshold is exceeded. The EGPWS calculates these 7 basic functions by comparing the aircraft position to an internal terrain database to output alerts and displays that show the pilot the aircraft's situation.

**EGPWS Database**

The EGPWS internal database consists of four subsets:

1. A worldwide terrain database of varying degrees of resolution.
2. An obstacles database containing cataloged obstacles 100 ft or greater in height located within North America and portions of the Caribbean (expanding as data is obtained).
3. A worldwide airport database containing information on hard surface runways 3500 ft or longer in length. For a specific list of the airports included, refer to Honeywell document 060-4267-000.
4. An envelope modulation database to support the envelope modulation feature.

All of these databases are constantly updated. Notification of a database update is done using service bulletins. Database updates are distributed on CD and are down loaded by the way of the data loading system (DLS).

## ALERT MODES

Because the majority of controlled flight into terrain (CFIT) accidents occur near an airport, and the fact that aircraft operate in close proximity to terrain near an airport, the terrain database contains higher resolution grids for airport areas. Lower resolution grids are used outside airport areas where aircraft en route altitude make CFIT accidents less likely and terrain feature detail is less important to the flightcrew.

The EGPWS receives present position, track, and groundspeed from FMS or GPS. With this information, the EGPWS is able to display a graphical plan view of the aircraft relative to the terrain and advise the flightcrew of a potential conflict with the terrain or obstacle. Conflicts are recognized and alerts sounded when terrain violates specific computed envelope boundaries on the projected flight path of the aircraft. Alerts can be in the following form:

- Visual light annunciation of a caution or warning.
- Audio enunciation based on the type of conflict.
- Color enhanced visual display of the terrain or obstacle relative to the forward look of the aircraft.

The terrain display is shown on the weather radar indicator, EFIS display, or a dedicated EGPWS display and may or may not be displayed automatically. The sections that follow describe functions of the EGPWS basic and enhanced features, and system input and output requirements.

**Mode 1 Excessive Descent Rate**

Mode 1 alerts for excessive descent rates with respect to altitude AGL are active for all phases of flight. This mode has inner and outer alert boundaries,

Penetration of the outer boundary activates the GND PROX on the PFD, and the “SINK RATE, SINK RATE” audio alert annunciator. Additional “SINKRATE, SINKRATE” messages occur for each 20% degradation. Penetration of the inner boundary activates the PULLUP on the PFD, and changes the audio message to “PULL UP” and repeats continuously until the inner warning boundary is exited.

**NOTE**

The “PULL UP” audio message can be preceded by a “Whoop, Whoop” sound in some configurations based on the audio menu option selected.

If a valid ILS glideslope front course is received and the aircraft is above the glideslope centerline, the outer (sinkrate) boundary is adjusted to desensitize the sinkrate alerting. This prevents unwanted alerts when the aircraft is safely capturing the glideslope (or repositioning to the centerline) from above the beam.

The EGPWS offers a steep approach option for some aircraft types that desensitizes the alert boundaries to permit steeper than normal approaches without unwanted alerts.

**Mode 2 Excessive Closure to Terrain**

Mode 2 alerts help protect the aircraft from impacting the ground when rapidly rising terrain with respect to the aircraft is detected. Mode 2 is based on radio altitude and on how rapidly radio altitude is decreasing (closure rate). Mode 2 exists in two forms, 2A and 2B.

**MODE 2A ALERTS**

Mode 2A is active during climb-out, cruise, and initial approach (flaps not in the landing configuration and the aircraft not on glideslope centerline). If the aircraft penetrates the Mode 2A caution envelope, the aural message “TERRAIN, TERRAIN” is generated and the PFD GND PROX caution is displayed. If the aircraft continues to penetrate the envelope, the PULLUP annunciator is displayed on the PFD and the aural warning message “PULL UP” is repeated continuously, until the warning envelope is exited.

**NOTE**

The “PULL UP” audio message can be preceded by a “Whoop, Whoop” sound in some configurations based on the audio menu option selected.

When the aircraft exits the warning envelope, if terrain clearance continues to decrease, the aural message “TERRAIN” is given until the terrain clearance stops decreasing. In addition, the visual alert remains on until the aircraft has gained 300 ft of barometric altitude, 45 seconds has elapsed, or landing flaps or the flap override switch is activated.

In later versions of EGPWS, the Mode 2A upper limit is reduced to 1250 ft for all airspeeds when the TAD function is on. This enhances the TAD alerting capability, resulting from high integrity GPS altitude and geometric altitude data. The Mode 2A envelope is lowered in order to reduce the potential for nuisance alerts during an approach.

**MODE 2B ALERTS**

Mode 2B uses a desensitized alerting envelope that permits normal landing approach maneuvers close to terrain without causing unwanted alerts. Mode 2B is automatically selected with flaps in the landing configuration (landing flaps or flap override selected) or when making an ILS approach with glideslope and localizer deviation less than 2 dots. It is also active during the first 60 seconds after takeoff.

In later versions of EGPWS, Mode 2B is selected when the aircraft is within 5 NM and 3500 ft of the destination airport (independent of configuration) and the TAD function is on. This enhances the TAD alerting capability, resulting from high integrity GPS altitude and geometric altitude data. The Mode 2B envelope is selected in order to reduce the potential for nuisance alerts during an approach.

During an approach, if the aircraft penetrates the Mode 2B envelope with either the gear or flaps not in the landing configuration, the aural message “TERRAIN, TERRAIN” is sounded and the PFD GND PROX caution is annunciated. If the aircraft continues to penetrate the envelope, the PULLUP annunciator is displayed and the aural message “PULL UP” is repeated until the warning envelope is exited. If the aircraft penetrates the Mode 2B envelope with both gear and flaps in the landing configuration, the aural “PULL UP” messages are suppressed and the aural message “TERRAIN” is repeated until the envelope is exited.

**Mode 3 Altitude Loss After Takeoff**

Mode 3 gives alerts for significant altitude loss after takeoff or low altitude go-around (less than 245 ft AGL) with gear or flaps not in the landing configuration. The amount of altitude loss that is permitted before an alert is given is a function of the height of the aircraft above the terrain. This protection is available until the EGPWS determines that the aircraft has gained sufficient altitude that is no longer in the takeoff phase of flight. Significant altitude loss after takeoff or during a low altitude go-around, activates the PFD GND PROX caution annunciation and the aural message “DON’T SINK, DON’T SINK”. The aural message is only sounded twice unless altitude loss continues. Upon establishing a positive rate of climb, the GND PROX goes off and the aural alert stops. If the aural declutter feature is disabled, the warning is sounded continuously until positive climb is established.

**Mode 4 Unsafe Terrain Clearance**

Mode 4 alerts are given for insufficient terrain clearance with respect to phase of flight, configuration, and speed. Mode 4 alerts exist in three forms, 4A, 4B, and 4C.

- Mode 4A is active during cruise and approach with the gear and flaps not in the landing configuration.

- Mode 4B is active during cruise and approach with the gear in the landing configuration and flaps not in the landing configuration.

- Mode 4C is active during the takeoff phase of flight with either the gear or flaps not in the landing configuration. Mode 4 alerts display the GND PROX annunciator and sound aural messages.

To reduce nuisance alerts caused by over-flying another aircraft, the upper limit of the Mode 4A/B alerting curve can be reduced (from 1000) to 800 ft. This occurs if the airplane is above 250 kts with gear and flaps not in landing configuration and a sudden change in radio altitude is detected. This is intended to eliminate nuisance alerts while flying a holding pattern and an aircraft over-flight occurs (with 1000 foot separation).

With version -210 and later models, Mode 4 airspeed expansion is disabled (upper limit held at lowest airspeed limit) when the TAD function is enabled and available. This is due to the enhanced alerting capability given with TAD, resulting from high integrity GPS altitude and geometric altitude data. This change to the Mode 4 envelopes reduces the potential for nuisance alerts when the aircraft is not in the landing configuration.

**MODE 4A ALERTS**

Mode 4A alert is active during cruise and approach with the gear and flaps up. This mode alerts the crew during cruise for inadvertent flight into terrain, where terrain is not rising significantly, or the aircraft is not descending excessively. It also alerts to protect against an unintentional gear-up landing. Below 1000 ft AGL and above 190 kts airspeed, the Mode 4A aural alert is “TOO LOW TERRAIN”. This alert is dependent on aircraft speed so the alert threshold is ramped between 500 ft at 190 kts to 1000 ft at 250 kts.

Below 500 ft AGL and less than 190 kts airspeed, the Mode 4A aural alert is “TOO LOW GEAR”.

For either Mode 4A alert, subsequent alert messages occur only if penetration of the envelope increases by 20%. GND PROX is annunciated on the PFD and aural messages stop when the Mode 4A alert envelope is exited. If the aural declutter feature is disabled, Mode 4A alert messages are repeated continuously until the Mode 4A envelope is exited.

**MODE 4B ALERT**

Mode 4B is active during cruise and approach, with gear down and flaps not in the landing configuration. Below 1000 ft AGL and above 159 kts airspeed, the Mode 4B aural alert is “TOO LOW TERRAIN”. This alert is dependent on aircraft speed such that the alert threshold is ramped between 245 ft at 159 kts to 1000 ft at 250 kts.

Below 245 ft AGL and less than 159 kts airspeed, the Mode 4B aural alert is “TOO LOW FLAPS”.

For turboprop and select turbofan aircraft, the “TOO LOW FLAPS” warning curve is lowered to 150 ft AGL and less than 148 kts. The pilot can disable the “TOO LOW FLAPS” alert by engaging the flap override switch (if installed). This silences the Mode 4B flap alert until it is reset by the pilot.

If the aircraft's radio altitude decreases to the value of the minimum terrain clearance (MTC), the GND PROX annunciator is displayed on the PFD and the aural message "TOO LOW TERRAIN" is sounded. For either Mode 4B alert, subsequent alert messages occur only if penetration of the envelope increases by 20%. GND PROX is annunciated on the PFD and aural messages stop when the Mode 4B alert envelope is exited.

**MODE 4C ALERT**

The Mode 4C alert is intended to prevent inadvertent controlled flight into the ground during takeoff climb into terrain that produces insufficient closure rate for a Mode 2 alert. After takeoff, Mode 4A and 4B give this protection.

Mode 4C is based on an EGPWS computed MTC floor, that increases with radio altitude. It is active after takeoff when the gear or flaps are not in the landing configuration. It is also active during a low altitude go-around if the aircraft has descended below 245 ft AGL. At takeoff, the MTC is zero feet. As the aircraft climbs, the MTC is increased to 75% of the aircraft's radio altitude (averaged over the previous 15 seconds). This value is not allowed to decrease and is limited to 500 ft AGL for airspeed less than 190 kts. Beginning at 190 kts, the MTC increases linearly to the limit of 1000 ft at 250 kts. If the aircraft's radio altitude decreases to the value of the MTC, the GND PROX is annunciated on the PFD and the aural message "TOO LOW TERRAIN" is sounded.

The GND PROX annunciator goes out and aural messages stop when the Mode 4C alert envelope is exited.

**Mode 5 Excessive Deviation Below Glideslope Alert**

Mode 5 has two levels of alerting when the aircraft descends below glideslope and activates the GND PROX annunciator on the PFD and aural messages. The first level alert occurs when below 1000 ft radio altitude and the aircraft is 1.3 dots or greater below the beam. This turns on the GND PROX and is called a soft alert because the audio message "GLIDESLOPE" is sounded at half volume. Twenty percent increases in the glideslope deviation cause additional "GLIDESLOPE" messages that are sounded at a progressively faster rate. The second level alert occurs when the aircraft is below 300 ft radio altitude with 2 dots or greater glideslope deviation. This is called a hard alert because a louder "GLIDESLOPE, GLIDESLOPE" message is sounded every 3 seconds and continuing until the hard envelope is exited. The GND PROX remains on until glideslope deviation is less than 1.3 dots.

To avoid unwanted below glideslope alerts, when capturing the localizer between 500 and 1000 ft AGL, alerting is varied in the following ways:

- Below glideslope alerts are enabled only if the localizer is within 2 dots, landing gear and flaps are selected, glideslope cancel is not active, and a front course approach is determined.

- The upper altitude limit for the alert is modulated with vertical speed. For descent rates above 500 fpm, the upper limit is set to the normal 1000 ft AGL. For descent rates lower than 500 fpm, the upper limit is reduced to a minimum of 500 ft AGL. Both alert levels are desensitized below 150 ft AGL to let normal beam variations nearer the ground, and to reduce the possibility of nuisance alerts.

Mode 5 alerts can be canceled by pushing the glideslope cancel switch (if installed). The EGPWS interprets this switch one of two ways depending on the installation configuration.

1. A standard glideslope cancel switch can be used to manually cancel Mode 5 alerting any time below 2000 ft AGL. This switch is automatically reset when the aircraft descends below 30 ft or climbs above 2000 ft AGL.

2. An alternate glideslope cancel switch can be used to manually cancel Mode 5 alerting at any time and at any altitude. The cancel can be reset by again pushing the cancel switch, or, it is automatically reset if the gear or flaps are raised, or when the aircraft is on the ground (weight-on-wheels (WOW) switch). Due to the nature of the alternate cancel switch, this method requires that there be a cockpit annunciation that glideslope cancel is in effect.

EGPWS Mode 5 alerts are inhibited during backcourse approaches to prevent nuisance alerts due to false fly up lobes from the glideslope. The TAWC determines a backcourse approach if either:

1. The aircraft's magnetic track is greater than 90° from the runways approach course, or
2. A glideslope inhibit discrete is set.

### Mode 6 Advisory Callouts

Mode 6 EGPWS advisory callouts are sounded based on the menu selected option established at installation. These callouts consist of predefined radio altitude-based voice callouts or minimum descent altitude (MDA) and an excessive bank angle warning. There are no visual alerts that are associated with these callouts.

| Callout | Occurs At Feet Above Ground Level |
|---|---|
| “RADIO ALTIMETER” | 2500 |
| “TWENTY FIVE HUNDRED” | 2500 |
| “ONE THOUSAND | 1000* |
| “FIVE HUNDRED | 500 |
| “FOUR HUNDRED | 400 |
| “THREE HUNDRED | 300 |
| “TWO HUNDRED” | 200 |
| “APPROACHING MINIMUMS" | MDA, DH+80 |
| “APPROACHING DECISION HEIGHT” | MDA, DH+100 |
| “PLUS HUNDRED” | MDA, DH+100 |
| “FIFTY ABOVE” | MDA, DH+50 |
| “MINIMUM” | MDA, DH |
| “MINIMUMS MINIMUMS” | MDA, DH |
| “DECISION HEIGHT” | MDA, DH |
| “DECIDE” | MDA, DH |
| “ONE HUNDRED” | 100 |
| “EIGHTY” | 80 |
| “SIXTY” | 60 |
| “FIFTY” | 50 |
| “FORTY” | 40 |
| “THIRTY FIVE” | 35 |
| “THIRTY” | 30 |
| “TWENTY” | 20 |
| “TEN” | 10 |
| “FIVE” | 5 |

* Can be barometric altitude above the field elevation for some aircraft types.

In some cases, a callout is stated twice (e.g., “MINIMUMS, MINIMUMS”) but in all cases, a callout is only sounded once per approach. DH based callouts (approaching minimums, minimums, etc.) require the landing gear to be down. They are sounded when the aircraft is descending through the radio altitude corresponding to the selected DH, or the baro corrected altitude corresponding to the selected MDA setting. These also have priority over other altitude callouts when overlapping. For example, if DH is set to 200 and both “TWO HUNDRED” and “MINIMUMS” are valid callouts, then only “MINIMUMS” is called out at 200 ft AGL. DH plus based callouts (e.g., approaching minimums) are only applicable for aircraft that input a DH altitude to the EGPWS. Consequently, not all EGPWS installations can use these callout options.

Due to the variety of altitude callout choices available, it is not possible to identify every combination in this manual. Refer to the appropriate Aircraft Flight Manual or EGPWS Aircraft Flight Manual Supplement for callout identification in a specific application.

**SMART 500-FOOT CALLOUT**

Another feature available in the altitude callouts (options) is a Smart 500-foot callout. When selected, this callout assists pilots during a non-precision approach by enunciating “FIVE HUNDRED” feet in addition to any other altitude callout described above. The EGPWS determines a non-precision approach when glideslope is greater than 2 dots deviation (valid or not) or a back-course approach is detected. This feature adds the 500-foot callout during non-precision approaches and removes the 500-foot callout on precision approaches when it is part of the callout option.

The callout “BANK ANGLE, BANK ANGLE” advises of an excessive roll angle. The EGPWS uses several excessive bank angle envelopes to support Air Transport, Business, or Military aircraft types (only Air Transport and Business are described below).

**BUSINESS BANK ANGLE ALERTS**

The business envelope is defined for turbo-prop and jet business aircraft, bank angles in excess of:

- ±10° between 5 and 30 ft,
- ±10 to 40° between 30 and 150 ft,
- ±40 to 55° between 150 and 2450 ft,

produce the bank angle advisory (shaded area). Bank angle advisories are inhibited below 5 ft.

## TRANSPORT BANK ANGLE ALERTS

The Air Transport basic bank angle limits are similar to the Business Aircraft bank angle limits except above 150 ft the bank limit remains at 40.

### Mode 7 Windshear Alerting

Mode 7 alerts the pilot if the aircraft encounters windshear. Two alerting envelopes are used; either a WINDSHEAR alert, or a WINDSHEAR alert. Each has distinctive aural and visual indications for the pilot.

EGPWS windshear alert is used for certain (but not all) aircraft types and is a function of additional input signals and are used in windshear calculations. These inputs are established during the installation of the EGPWS and they are described in the appropriate AFM or EGPWS AFMS. WINDSHEAR alerts are given if an increasing headwind, or decreasing tailwind, and/or severe updrafts exceed a defined threshold. These are characteristics that precede a microburst.

When a WINDSHEAR is enabled and the aural message “CAUTION, WINDSHEAR” is sounded, the lamps remain on for as long as the aircraft is exposed to conditions in excess of the caution alert threshold.

The windshear caution audio alerting can be disabled at installation so that only windshear warning alerts are given.

## WINDSHEAR WARNING

WINDSHEAR alerts are given if a decreasing headwind, or increasing tailwind, and/or a severe downdraft, exceed a defined threshold. These are characteristic of conditions within or when exiting a microburst.

WINDSHEAR is annunciated on the PFD and, if installed as an option, a siren is sounded, followed by the message “WINDSHEAR, WINDSHEAR, WINDSHEAR”. WINDSHEAR remains on for as long as the aircraft is exposed to conditions in excess of the warning alert threshold. The aural message is not repeated unless another separate windshear event is detected. The threshold is adjusted as a function of available climb performance, flight path angle, airspeeds significantly different from normal approach speeds, and unusual fluctuations in static air temperature (SAT) (typically associated with the leading edge of a microburst).

Mode 7 windshear alerting is active under the following conditions:

- During takeoff; from rotation until an altitude of 1500 ft AGL is reached
- During approach; from an altitude of 1500 ft down to 10 ft AGL
- During a missed approach; until an altitude of 1500 ft AGL is reached.

## ENHANCED FUNCTIONS

### Envelope Modulation

Due to terrain features at or near certain airports around the world, normal operations have resulted in nuisance or missed alerts at these locations in the past. With the introduction of accurate position information and a terrain and airport database, it is possible to identify these areas and adjust the normal alerting process to compensate for the condition.

The EGPWS envelope modulation feature improves alert protection and expands alerting margins at these identified airports. This feature is automatic and requires no flightcrew action.

Modes 4, 5, and 6 are expanded at certain locations to give alerting protection consistent with normal approaches. Modes 1, 2, and 4 are desensitized at other locations to prevent nuisance alerts that result from unusual terrain or approach procedures. In all cases, very specific information is used to correlate the aircraft position and phase of flight before the envelopes are modulated.

## TERRAIN CLEARANCE FLOOR

The terrain clearance floor (TCF) function (enabled with TAD) enhances the basic GPWS modes by alerting the pilot of descent below a defined TCF regardless of the aircraft configuration. The TCF alert is a function of the aircraft's radio altitude and distance (calculated from latitude/longitude position) relative to the center of the nearest runway in the database, that includes all hard surface runways greater than 3500 ft in length. The TCF envelope is defined for all runways, and extends to infinity, or until it meets the envelope of another runway. The envelope bias factor is typically 1/2 to 2 NM and varies as a function of position accuracy.

In later versions, the TCF alert envelope and envelope bias factor are improved. The alert envelope is limited to a minimum of 245 ft AGL adjacent to the runway. The envelope bias factor is reduced (moved closer to the runway) when more accurate aircraft position and runway position information is known. This is typically 1/3 to 1 NM and it better protects against landing short events.

Also in these later versions, runway selection logic is improved to better identify the destination runway. Comprehensive aircraft position and navigation information is used to evaluate proximity runways and determine the most likely destination runway for all alerting purposes.

### Runway Field Clearance Floor

A runway field clearance floor (RFCF) feature is included. This is similar to TCF except that RFCF is based on the current aircraft position and height above the destination runway, using geometric altitude (instead of radio altitude). This improves protection at locations where the runway is significantly higher than the surrounding terrain.

TCF and RFCF alerts display GND PROX on the PFD and the aural message “TOO LOW TERRAIN” is sounded. The audio message is sounded once when initial envelope penetration occurs and again only for additional 20% decreases in radio altitude. The GND PROX annunciator remains on until the TCF envelope is exited.

### Terrain Look Ahead Alerting

Another enhancement the internal terrain database can be used for is to look ahead of the aircraft and detect terrain or obstacle conflicts with greater alerting time. This is done based on aircraft position, flight path angle, track, and speed relative to the terrain database image forward the aircraft. Using look ahead calculations, both GND PROX and PULLUP are generated if terrain or an obstacle conflict with ribbons projected forward of the aircraft.

These ribbons project down, forward, then up from the aircraft with a width starting at 1/4 NM and extending out at ±3 degrees laterally (more if the aircraft is turning). The look-down and up angles are a function of the aircraft flight path angle, and the look-down distance is a function of the aircraft’s altitude with respect to the nearest or destination runway. This relationship prevents unnecessary alerts when the aircraft is taking off or landing. The look-ahead distance is a function of the aircraft’s speed, and distance to the nearest runway.

A terrain conflict with the aircraft caution ribbon displays GND PROX on the PFD and the aural message “CAUTION TERRAIN, CAUTION TERRAIN” or “TERRAIN AHEAD, TERRAIN AHEAD” is sounded. An obstacle conflict sounds a “CAUTION OBSTACLE, CAUTION OBSTACLE” or “OBSTACLE AHEAD, OBSTACLE AHEAD” message. The caution alert is typically sounded 60 seconds ahead of the terrain/obstacle conflict and is repeated every 7 seconds as long as the conflict remains within the caution area.

When the obstacle is within the warning ribbon (typically 30 seconds prior to the terrain/obstacle conflict), PULLUP is annunciated on the PFD and the aural message “TERRAIN, TERRAIN, PULL UP” or “OBSTACLE, OBSTACLE, PULL UP” is sounded with “PULL UP” repeating continuously while the conflict is within the warning area.

In later versions, the look-ahead alerting calculations are improved to account for higher airspeeds (about 300 kts or greater). The look-ahead distance is designed to sound a 60 second warning alert for up to 8 NM look-ahead (as opposed to 30 seconds or up to 4 NM). The aural message is established during the initial installation of the EGPWS as a function of whether or not the terrain and obstacles features are enabled and the alert is selected from an audio menu. Refer to an applicable AFM or EGPWS AFMS for specific application information for additional information.

**Terrain Alerting and Display**

When a compatible weather radar, EFIS, or other displays are available and turned on, the EGPWS terrain alerting and display (TAD) feature displays an image of the surrounding terrain represented in various colors and intensities.

Peaks enhances the display characteristics to show a higher degree of terrain awareness independent of the aircraft's altitude. Terrain and obstacles (if enabled) forward of the aircraft are displayed. Obstacles are displayed in the cockpit as terrain, using the same display coloring scheme.

**NOTE**

With respect to peaks display, terrain and or obstacles are always based on (and scaled for) the geographic range on the display. Consequently, terrain and/or obstacles outside of the selected display range and defined display sweep do not have any effect on the displayed image.

**PEAKS DISPLAY**

The peaks display shows a graphical plan-view image of the surrounding terrain as varying density patterns of green, yellow, and red. The selected display range is also indicated on the display and an indication that TAD is active and is either indicated on the display (i.e., TERR in a color dependent on the installation) or by an adjacent indicator. The peaks display includes:

- The digital display of the highest and lowest terrain/obstacle elevations are annunciated.
- The solid or lower density color bands are displayed, including the addition of the sea level (0 ft MSL).

Each color and intensity represents terrain (and obstacles) below, at, or above the aircraft's altitude based on the aircraft's position with respect to the terrain in the database. If no terrain data is available in the terrain database, the area is displayed in a low-density magenta color. Terrain more than 2000 ft below the aircraft, or within 400 (vertical) feet of the nearest runway elevation, is not displayed (black).

When a caution alert is triggered, the terrain (or obstacle) that created the alert is changed to solid yellow (100% density).

When a PULLUP alert is triggered, the terrain (or obstacle) that created the alert is changed to solid red (100% density).

**NOTE**

When a TAD GND PROX or PULLUP alert is active, the display cells surrounding the target are enlarged (surrounding cells are lit). This lets a smaller terrain or obstacle (e.g., a single tower) to be seen better on the display.

The transition between green and yellow is below the aircraft in order to account for altimeter and/or terrain/obstacle height errors. Also, the transition altitudes between colors are biased upward proportional to the descent rate when greater than 1000 fpm. This gives approximately 30 seconds of advanced terrain display. Pilots must note that any yellow or red painted terrain is at, or above the aircraft's altitude and correct terrain clearance needs to be maintained. Based on the display system used, there can be additional terrain display features. These are defined as installation options and permits the following:

- Automatic display of terrain on the cockpit display (TAD pop-up) in the event that a GND PROX or PULLUP alert is triggered as described in terrain look ahead alerting. In some cases, an active display type must be selected first.

- Auto-range when pop-up occurs. When a pop-up display is shown on the EFIS, it automatically ranges the display for terrain as defined for the display system configuration (typically 10 NM).

When the terrain display is on, digital values representing the highest terrain/obstacle elevation and the elevation for the lowest color band are displayed. These are based on the range selected (terrain in view). The location of the digital values vary for the display used. In this manual, digital displays are shown in the lower right corner of the display. These elevations are expressed in hundreds of feet above sea level (e.g., 125 is 12,500 ft MSL) with the highest elevation on top and the lowest on the bottom. In the event that there is no appreciable difference in the terrain/obstacle elevations (flat terrain), only the highest value is displayed.

The color of the elevation value displayed matches the color of the terrain display (i.e., the digits are red if the terrain/obstacle with that elevation is depicted as red in the terrain plan view, yellow if yellow, etc.).

When the aircraft is 500 ft or less (250 ft with the gear down) above the terrain in view ( yellow or red is displayed), the peaks color scheme is identical to the standard display, with the exception of the addition of cyan sea level.

**NOTE**

- 1. Some displays do not support cyan and do not display sea level in this case.

- 2. Differences can exist between the highest terrain/ obstacle being displayed and the digital elevation value/color of the peaks numbers at or near the top and sides of the display.

When the aircraft is greater than 500 ft (250 with gear down) above the terrain in view (no yellow or red displayed), additional ( green ) color bands are displayed. These added bands are computed and displayed as a function of the highest and lowest elevations in view.

**OTHER EGPWS DISPLAYS**

EGPWS Displays - Visual messages are displayed on the PFD to accompany aural messages generated by the EGPWS for ground proximity conditions. Ground proximity is annunciated on the ADI and initially flashes for five seconds then remains on until the condition is no longer detected.

**TCF/TAD INOP and INHIBIT**

The EGPWS TCF and TAD functions are available when all required data is present and usable. Aircraft position and other parameters are monitored and verified for adequacy in order to perform these functions. If EGPWS is determined to be invalid or unavailable, the system displays terrain inoperative or unavailable annunciators and removes the terrain display, if it is active.

TAD/TCF functions can be inhibited manually using a cockpit mounted terrain inhibit switch. Neither losing nor inhibiting TAD/TCF effects the basic GPWS functions (Modes 1-7).

**Geometric Altitude**

Based on GPS altitude, geometric altitude is a computed pseudo-barometric altitude [above sea level (ASL)] designed to reduce or eliminate errors potentially induced in corrected barometric altitude by the following:

- Temperature extremes
- Nonstandard pressure altitude conditions
- Altimeter miss-sets.

This optimizes the EGPWS terrain alerting and display capability. Geometric altitude also permits EGPWS operations in queens field elevation (QFE) or corrected barometric altitude relative to field elevation) environments without custom inputs or special operations procedures.

Geometric altitude requires GPS altitude input with its associated vertical figure of merit (VFOM) and receiver autonomous integrity monitoring (RAIM) failure indication, standard (uncorrected) altitude, radio altitude, groundspeed, roll angle, and aircraft position (latitude and longitude). Corrected barometric altitude, SAT, GPS type, and the number of satellites tracked are used if available. The geometric altitude is computed by blending a calculated nonstandard altitude, runway calibrated altitude (determined during takeoff), GPS calibrated altitude, radio altitude calibrated altitude (determined during approach), and barometric altitude (if available). Estimates of the VFOM for each of these are determined and applied in order to determine its weight in the final altitude. The blending calculation gives the most weight to altitudes with a higher estimated accuracy, reducing the effect of less accurate altitudes.

Each component altitude is also checked for reasonableness using a window monitor computed from GPS altitude and its VFOM. Altitudes that are invalid, not available, or fall outside the reasonableness window, are not included in the final geometric altitude value. The geometric altitude calculation is designed to continue operation when one or more of the altitude components are not available. If all component altitudes are invalid or unreasonable, the GPS altitude is used directly. If GPS altitude fails or is not present, then the EGPWS reverts to using corrected barometric altitude alone.

The geometric altitude function is fully automatic and requires no pilot action other than setting the corrected barometric altitude on the altimeter.

### Aural Message Priority

Two or more messages can be activated simultaneously, so a message priority has been established. Messages at the top of the list are sounded before or immediately override a lower priority message even if it is already in progress.

| Message | Alert Modes |
|---|---|
| “Windshear, Windshear, Windshear” (Notes 4 and 10) | 7 |
| “Pull Up” (Notes 8, 9, and 11) | 1, 2, TA |
| “Terrain Terrain” | 2, TA |
| “Obstacle, Obstacle” (Note 3) | TA |
| “Terrain” | 2 |
| “Minimums” (Notes 1 and 3) | 6 |
| “Caution Terrain, Caution Terrain” (Notes 3 and 6) | TA |
| “Caution Obstacle, Caution Obstacle” (Notes 3 and 7) | TA |
| “Too Low Terrain” | 4, TCF |
| Altitude Callouts (Note 3) | 6 |
| “Speed Brake, Speed Brake” (Note 3) | 6 |
| “Too Low Gear” | 4A |
| “Too Low Flaps” | 4B |
| “Sink Rate, Sink Rate” | 1 |
| “Don’t Sink, Don’t Sink” | 3 |
| “Glideslope” | 5 |
| “Approaching Minimums” (Notes 2 and 3) | 6 |
| “Bank Angle, Bank Angle” (Note 3) | 6 |
| “Caution Windshear” (Notes 3, 4, and 5) | 7 |

Message Alert Modes

TA = Terrain Look-Ahead Alert
TCF = Terrain Clearance Floor

NOTES:

1. Can also be “Minimums, Minimums”, “Decision Height” or “Decide”.
2. Can also be “Approaching Decision Height”, “Fifty Above”, “Plus Hundred”.
3. Message is dependent on aircraft type or option selected.
4. Windshear detection alerts given for some aircraft types.
5. Caution alert if not disabled.
6. Can also be “Terrain Ahead, Terrain Ahead”.
7. Can also be “Obstacle Ahead, Obstacle Ahead”.
8. Can also be “Terrain Ahead Pull Up”.
9. Can also be “Obstacle Ahead Pull Up”.
10. Can be preceded by siren.
11. Can be preceded by a “Whoop, Whoop” alert.

# Traffic Alert and Collision Avoidance System (TCAS)

## INTRODUCTION

The TCAS is an independent airborne system that does not rely on ATC for control or coordination. It detects unsafe traffic conflicts with other transponder-equipped aircraft and assists the flightcrew in avoiding intruders inside a protected airspace. This is done by interrogating surrounding aircraft Mode A, Mode C, and Mode S transponders, tracking their responses, and issuing advisories to the flightcrew of the vertical separation from intruders.

### TCAS Operation

Vertical guidance to avoid midair collisions is computed using two levels of advisories:

- TA (Traffic Advisories) - TAs indicate the range, bearing, and relative altitude of the intruder to aid in visual acquisition of the intruder.
- RA (Resolution Advisories) - RAs indicate what vertical maneuver must be executed to assure safe separation.

Each type of advisory has a corresponding aural message that is sounded by the TCAS computer and broadcast in the cockpit.

Mode A equipped intruders can only be detected and displayed as TAs. Intruders not equipped or not using their transponder are invisible to TCAS.

TCAS generates both RAs and TAs when the TA/RA mode is selected on the MCDU RADIO 1/2 page. The two types of advisories correspond to time-based protection zones around the aircraft. The airspace around the TCAS aircraft where a RA is annunciated represents the warning area, while the larger airspace that results in a TA being annunciated is the caution area.

Only one Mode S transponder in the protected aircraft is required for TCAS operation. When two Mode S transponders are installed, the selected transponder is used by TCAS, the other operates as a backup. The TCAS receiver/computer uses its directional antenna to display intruder bearing.

A TCAS map overlay and a TCAS zoom format can be displayed on the MFD. The two formats are mutually exclusive. The traffic symbols displayed are limited to the eight highest priority intruders in order to avoid clogged displays with low priority intruders.

Each pilot can control the on-side TCAS display independent of the selected controls on the other side.

### MCDU Transponder (XPDR)/TCAS Radio Control

The transponder and TCAS radios are controlled using the two MCDUs mounted in the center console. Some TCAS controls are also available on the MFD TCAS menu. They are described below. The XPDR/TCAS system supports one or two transponders.

In each MCDU, there are three types of display pages used to control the transponders. The main transponder page is RADIO 1/2, the detail transponder page is XPDR/TCAS 1/2, and the detailed TCAS page is XPDR/TCAS 2/2.

### MFD Menu Controls

There are two pulldown menus that control TCAS displays. The non-exclusive Traffic selection on the Map Menu selects traffic for display on the Map display. The TCAS menu is used to control the display of TCAS information on the TCAS window on the MFD.

### TCAS MENU

The TCAS menu contains three types of selections:

- Range - The Range button when selected means the TCAS display range can be changed using the concentric knobs on the CCD. Clockwise rotation of the knob increases range, counterclockwise rotation decreases range.

The range control is only for the zoom or pop-up display. It is adjustable by first selecting the range function. The range can only be changed when the cyan prompt is on the range display. Set the range value using the upper concentric knob on the CCD, as indicated by the knob button prompt on the menu. The range value is displayed to the lower right of the TCAS circle on the bottom of the MFD display. Ranges available are 6, 12, 20, 40, 80, and 120 miles. The default value is the 6 mile range. This range control does not control the display range for TCAS on the map overlay. The map range control is used for that format.

- Flt Lvl - Clicking the CCD ENTER button selects flight level information for display on the TCAS display. When flight level is selected, the flight level targets is displayed. The green check mark indicates that absolute altitude is being displayed. Removing the check returns to the relative altitude display.

- Four exclusive buttons can be used to change the perspective of the TCAS display. Only one can be selected at a time.

  -Norm
  -Above
  -Below
  -Expanded

# MCDU


## MCDU SHOWING TCAS/XPDR MENU

Figure 3-38

## DISPLAY INFORMATION

Messages concerning bearing information are displayed on two lines of text in the upper right side of the TCAS window whenever the system encounters an RA or TA target that has range but no bearing information for display. The color of each line is based on the type intruder. The first line contains the message RA NO BRG in red for an RA without bearing and the second line contains the message TA NO BRG in amber for a TA without bearing information.

The TCAS range ring boundary is a white full arc shown at the limits of the display window. The distance between the arc and the aircraft symbol is displayed in NM to the right of the arc.

The range ring is proportional to the selected range on the MFD, since the MC-800 MFD controller controls the map/plan mode range.

TCAS uses four color-coded symbols to map traffic and to locate aircraft which present a potential threat on the MFD. These symbols are a red solid square, an amber solid circle, a cyan solid diamond, and a hollow cyan diamond. These symbols represent traffic which has been identified and determined to pose a level of threat as, respectively, resolution advisory (RA), traffic advisory (TA), proximate traffic, and other traffic.

Red represents an immediate threat to TCAS equipped aircraft, and prompt action is necessary to maneuver for avoidance. Red color is used only in conjunction with a resolution advisory (RA). Amber represents a moderate threat (traffic advisory or TA) to TCAS equipped aircraft and a visual search is recommended to prepare for avoidance of the intruder. Amber is only used in conjunction with traffic advisory (TA) traffic. Other traffic is represented by cyan color.

# MFD TCAS MENU CONTROLS

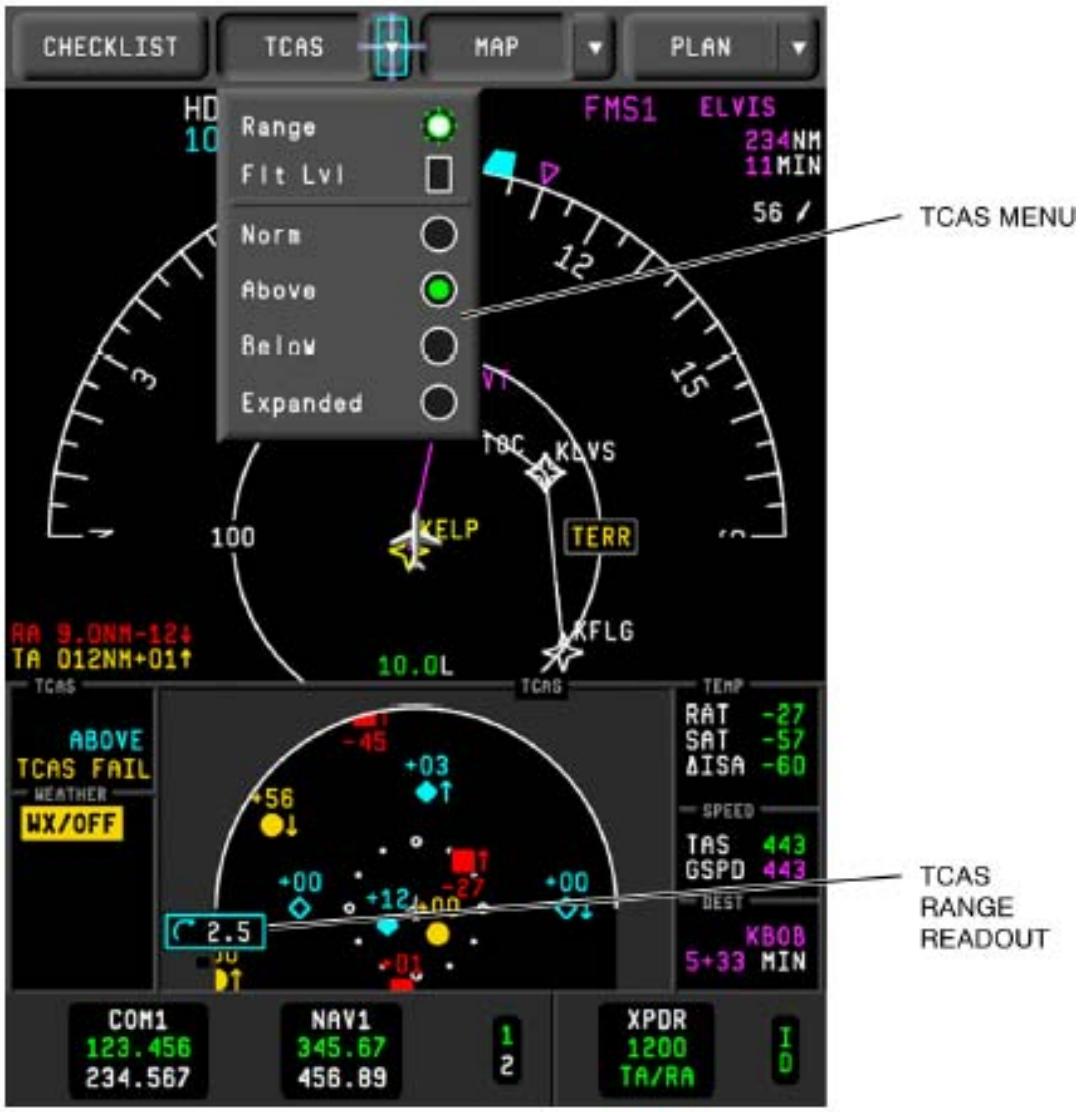


Figure 3-39

## TCAS Displays

TCAS is displayed on the Map display, using the CCD to check the TCAS box on the Map menu. The TCAS zoom display is displayed on the lower portion of the MFD screen by activating the TCAS menu. The TCAS zoom format is a dedicated display with unique range control. The TCAS map overlay uses the map range setting.

When a TA or RA is encountered and the Map format is not in view at a range of less than 50 NM, the TCAS zoom format automatically pops into view. The TCAS zoom format has display priority over the weather and checklist formats when an auto pop-up occurs.

When the TCAS zoom format, is activated, TCAS is displayed on the Map display and the upper MFD window is removed. As long as the zoom pop-up display is active, the Map TCAS display remains dormant. It returns to the Map display when the zoom pop-up deactivates. The TCAS zoom format can also be deactivated by selecting the checklist display using the checklist button on the Map pop-up menu.

A fixed range ring is displayed in the TCAS zoom format. It gives a spatial reference for the distance of the displayed intruders. The range ring is positioned in the center of the zoom display, and it is positioned horizontally and vertically so the top of the ring is in view at the top of the zoom display, but only 180° of arc are shown. The white digital range readout is given in nautical miles on the lower left side of the range ring in a cyan box and a tuning cursor that denotes the range can be changed using the CCD concentric knobs. The range readout displays the TCAS zoom range selected using the cursor control device (CCD) inner knob when the range function is enabled on the TCAS menu.

The CCD inner knob icon is displayed to the left of the TCAS zoom range readout when the CCD inner knob is used to set range. Only one rate of adjustment is used to adjust the range and the value increments/decrements in one-range increment per click of the knob. Clockwise rotation increases the TCAS zoom range value, counterclockwise rotation decreases the value. The TCAS zoom range is a linear scale where the maximum and minimum values are the limits of the scale. When the range value reaches the maximum or minimum value, the readout stays at that value. The knob turns above the maximum and below the minimum have no effect. The first knob click in the opposite direction begins increment/decrement back through the available ranges.

**NOTE**

The zoom range selection affects only the zoom format.

The 3 NM range ring gives a unique symbolic reference to determine the proximity of the traffic targets. The 3 NM range ring is a ring of twelve small circles (or dots) positioned in the center of the TCAS zoom format, placed in a radius of 3 NM around the aircraft symbol. The circles are arranged so that one circle is positioned every 30 degrees (i.e., 0 degrees, 30 degrees, 60 degrees, etc.). The circles placed at 0 degrees, 90 degrees, 180 degrees, and 270 degrees are larger in diameter than the remaining circles. The diameter of the 3 NM range ring is scaled to reflect the selected zoom range.

The 3 NM range ring is displayed when the TCAS zoom range is 6 NM, 12 NM, or 20 NM and it is not labeled. The range of the zoom format defaults to 6 NM each time the zoom format is displayed in the lower MFD window. When an RA or TA is detected, the range is automatically reset to 6 NM if the zoom format is displayed at a range greater than 12 NM.

The TCAS menu and CCD are used to select TCAS range, normal or expanded modes, and absolute (ABS) or relative altitude for the on-side displays.

**TCAS TARGET TYPES**

The type of target is determined by its symbol and color. The following are target types:

- Resolution Advisory Target - These are threat targets. To protect the aircraft, avoidance action must be taken.
- Advisory Target - These are potential threats, if conditions do not change.
- Proximate Target - These could be a potential threat if they change direction or altitude.
- No Threat Target - These are targets that are being processed but are currently not a threat.

**No Bearing Target**

These are targets whose transponder is being received (code and altitude) but the TCAS system is unable to determine the bearing to them.

**Vertical Speed Symbol**

If the intruders vertical speed is 500 fpm or greater, a vertical arrow (up or down) is placed to the right of the intruder symbol, and it points in the direction of the intruder's vertical speed. The arrow is the same color as the intruder symbol.

**Relative Altitude Display**

Relative altitude is the altitude difference between the intruder aircraft and the present aircraft altitude. The relative altitude values are rounded off to the nearest 100 feet. A + or - is used to indicate whether the intruder is above or below the present aircraft altitude. The remaining two characters are the relative altitude in hundreds of feet.

**NOTE**

Absolute altitude is replaced with relative altitude whenever a RA or TA condition is encountered.

If the intruder aircraft is located below the present aircraft altitude, the relative altitude is displayed below the intruder symbol. If the intruder aircraft is located above the present aircraft altitude, the relative altitude is displayed above the intruder symbol. The display color of the relative altitude is the same color as the intruder symbol.

### Absolute Altitude

The absolute altitude display can be selected for display using the TCAS menu on the MCDU. When absolute altitude is displayed, the actual altitude is displayed in a three-digit format (i.e., 060 equals 6000 feet, or 310 equals 31,000 feet). The absolute altitude display times out 20 seconds after it is selected and the display reverts to relative altitude.

The absolute altitude values are rounded off to the nearest 100 feet. If the intruder aircraft is located below the present aircraft altitude, the intruder absolute altitude is displayed below the intruder symbol. If the intruder aircraft is located above the present aircraft altitude, the intruder absolute altitude is displayed above the intruder symbol. The display color of the intruder absolute altitude is the same color as the intruder symbol.

### No Bearing Targets

The no bearing display is a text field that consists of an underlined NO BEARING annunciation and information about the two most critical no bearing intruders. The no bearing display #1 and #2 consists of a RA/TA annunciation, range readout, altitude readout, and climb/descend indication. The TCAS computer automatically prioritizes the most critical no bearing available intruders into the first two no bearing displayed intruders.

If the no bearing 1 or 2 intruder is considered a resolution advisory target, the display is red, otherwise, it is amber. If the condition is extremely urgent, the display flashes.

## PFD TCAS DISPLAYS

### Attitude Director Indicator

A resolution advisory (RA) is an automatic display indication given to the pilot recommending a maneuver to increase vertical separation relative to an intruding aircraft.

TCAS resolution advisory commands are composed of either one or two avoidance zones and up to one fly-to zone. The commands provide flight path vector (FPV) guidance information to the flightcrew to recommend or prohibit a maneuver and prevent hazardous encounters with intruding aircraft.

The up avoidance zone, when displayed, extends from the top of the ADI to a FPV target based on current groundspeed and vertical speed corrective guidance. The down avoidance zone, when displayed, extends from the bottom of the ADI to a FPV target based on current, groundspeed and vertical speed corrective guidance.

The up avoidance zone is displayed when a down advisory (descend corrective) is received. A down avoidance zone is displayed when an up advisory (climb corrective) is received. When either single corrective is received, the fly-to zone is displayed on the end of the avoidance zone symbol unless a preventive is indicated. If a preventive command is indicated, the fly-to zone symbols are suppressed. When both a corrective and a preventive are received simultaneously, the fly-to zone is displayed between the avoidance zones. The fly-to zone symbols are compressed as the preventive and corrective commands begin to merge. The fly-to zone is compressed until a minimum fly-to zone height remains. The minimum fly-to zone height is compressed no further to ensure that a flyable command is displayed.

To aid in the pilot's compliance with the corrective and/or preventive, the colors of the flight path angle (FPA) symbol, flight path vector speed error tape, and flight path angle acceleration pointer change. If the FPA is in the avoidance zone, the symbols are red, otherwise, they are green. The avoidance and fly-to zones rotate with the pitch scale under roll conditions. The aircraft symbol color changes as a function of the target zone location as follows:

- Red - avoidance zone
- Green - fly-to zone.

When there is a RA condition, the flight director command bars are removed. The zones represent pitch angles that should be left at once and pitch angles to fly-to.

# PFD TCAS DISPLAY

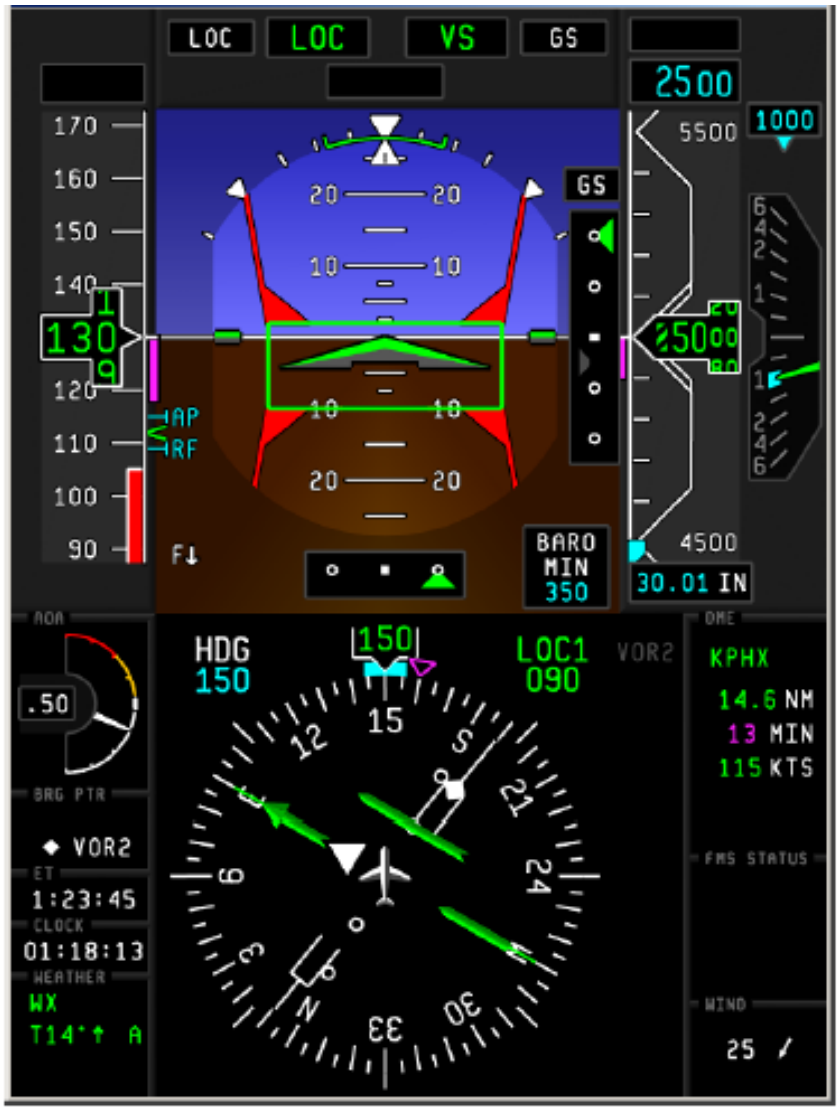


Figure 3-40

## TCAS Aural Alerts

Aural alerts are announced over the aircraft audio system. The aural alert audio levels are preset and not crew-adjustable. The alerts accompany the visual TA and RA displays and the audio is softened or strengthened based on the urgency of the situation.

TRAFFIC ADVISORY AURAL ALERTS

| TA Aurals | Meaning/Action |
|---|---|
| "Traffic, Traffic" | Traffic in the area. |

RESOLUTION ADVISORY AURAL ALERTS

| RA Aurals | Meaning/Action |
|---|---|
| "Monitor Vertical" | Certain changes in vertical speed are not safe. |
| "Maintain Vertical Speed, Maintain" | Maintain current vertical rate. |
| "Maintain Vertical Speed, Crossing Maintain" | Promptly adjust vertical speed to the rate indicated. |
| "Climb, Climb" | Immediately begin to climb at the rate indicated. |
| "Descend, Descend" | Immediately begin to descend at the rate indicated. |
| "Adjust Vertical Speed, Adjust" | Smoothly adjust the vertical speed to the rate indicated. |
| "Climb, Crossing Climb, Climb, Crossing Climb" | Start a climb at the indicated rate. The flight paths of this aircraft and the intruder crosses at present altitude. |
| "Descend, Crossing Descend, Descend, Crossing Descend" | Start a descent at the indicated rate. The flight paths of this aircraft and the intruder crosses at present altitude. |

| RA Aurals | Meaning/Action |
|---|---|
| "Increase Climb, Increase Climb" | Immediately increase climb rate. |
| "Increase Descent, Increase Descent" | Immediately increase descent rate. |
| "Climb, Climb Now!, Climb, Climb Now!" | This message follows a descent advisory when TCAS has determined that a reversal of vertical speed is necessary to give adequate separation. |
| "Descend, Descend Now!, Descend, Descend Now!" | This message follows a climb advisory when TCAS has determined that a reversal of vertical speed is necessary to give adequate separation. |
| "Clear of Conflict" | Confirms the encounter has ended and the separation is increasing. |

**AURAL WARNING INHIBIT CONDITIONS**

Certain TCAS warnings are inhibited under the following conditions:

- No Increase Descent commands are issued at altitudes less than 1450 ft above ground level (AGL) when the aircraft is descending or at altitude less than 1650 ft AGL when the aircraft is climbing.
- No Descent commands are issued at altitudes less than 1000 ft AGL when the aircraft is descending or at altitude less than 1200 ft AGL when the aircraft is climbing.
- No RAs (TCAS reverts to TAs only) are issued at altitudes less than 900 ft AGL when the aircraft is descending or at altitudes less than 1000 ft AGL when the aircraft is climbing.
- No TAs are issued when the intruder altitude is less than 380 ft AGL.
- No aural advisories are issued at altitudes less than 400 ft AGL when the aircraft is descending or at altitude less than 600 ft AGL when the aircraft is climbing.

**NOTE**

The above altitudes are determined using the radio altimeter system.

# Weather Radar System

## INTRODUCTION

The PRIMUS- 880 Weather Radar Systems are lightweight, X-band digital radar that are designed for weather detection and ground mapping.

The primary purpose of the systems is to detect storms along the flightpath and give the crew a visual color indication of rainfall intensity and turbulence content. After proper evaluation, the crew can chart a course to avoid storm areas.

## SYSTEM OVERVIEW

The PRIMUS- 660/880 Weather Radar, is a lightweight X-band digital color radar designed for weather detection and analysis and ground mapping. This radar uses a magnetron with a 10 kW nominal power output. The system is consists of the following:

- WU-880 Integrated Receiver/Transmitter/Antenna (RTA) unit
- Two WC-880 weather radar controllers
- MFD virtual controller
- PFD Controller.

The RTA is mounted in the nose of the aircraft. The PRIMUS- 880 uses a 24-inch antenna.

The virtual controller consist of the CCDs and the WX mode information displayed on the MFD pulldown menu.

The RTA transmits and receives X-band radio frequency energy for the purposes of weather detection and ground mapping (GMAP). The transmitted signals are sent directly to the antenna from the transmitter circuitry, which is mounted on the rear of the antenna. Echo signals received by the antenna are applied directly to the receiver. The RTA receiver gain is adjustable to increase or decrease the receiver sensitivity when performing GMAP or weather analysis. There is also a rain echo attenuation compensation technique (RCT) function available to allow the RTA to adjust sensitivity automatically to compensate for attenuation losses caused by the weather target.

The system range can be adjusted to six different distances between 10 and 300 NM, and a target alert option can be activated to alert the pilot when severe weather outside of the selected range is detected. The system can detect storms up to 300 NM from the aircraft.

The antenna sweep is selectable for either normal sweep mode (120°) or sector scan sweep mode (60°). Normal sweep covers 60° for each side of the aircraft. Sector scan covers 30° for each side. The WX radar system has an OFF option, and also a SLV option, where one controller can be off and the other can control both radar sweeps. There are also standby and forced standby modes, in which the unit is on but not active.

The antenna tilt is manually adjustable, using the cursor control device (CCD) in 1° increments between -15° down and +15° degrees up with respect to the horizon. When the stabilization feature is active, the antenna tilts to maintain its line-of-sight with respect to the horizon within the 30° pitch attitude limit, regardless of the aircraft attitude. The antenna can be stabilized in the pitch and roll axis through attitude information from the IRU.

The 880 system contains functions for turbulence detection and altitude compensated tilt (ACT). ACT adjusts the antenna tilt in relation to the aircraft altitude and selected range so the radar remains pointed at the horizon. The radar processes return signals in order to determine if a turbulence signature is present. Turbulence detection can only be engaged in the WX mode and at selected ranges of 50 NM or less.

The WX menu and CCD control the WX display of WX information on the MFD in the Map mode only. All display data is controlled using the weather radar controller described below. Weather can be displayed on the PFD using the display controller WX/TERR button. Weather can be displayed on either the full or partial compass display on the HSI section of the PFD.

**SYSTEM DISPLAYS**

The PRIMUS- 880 Weather Radar System displays weather on the primary flight display (PFD) horizontal situation indicator (HSI).

The Cessna Sovereign PRIMUS EPIC configuration is a dual system configuration. When dual controllers are used and neither one is turned off, weather radar displays are controlled by the on-side controller. If one controller is turned off, the radar displays are controlled by the active controller.

When the system is in the weather detection mode, storm intensity levels are displayed in four bright colors on a black background. Areas of very heavy rainfall are displayed in magenta, heavy rainfall in red, less severe rainfall in yellow, moderate rainfall in green, and little or no rainfall in black (background). Areas of detected turbulence are displayed in soft white.

The ground mapping mode improves the resolution and enhances small targets at short ranges. The reflected signals from various ground surfaces are displayed as magenta, yellow, or cyan (most to least reflective).

# MULTIFUNCTION DISPLAY/PRIMUS 880 WEATHER RADAR

A29082


6985P1006

Figure 3-41

## WARNING

THE WEATHER SYSTEM PERFORMS ONLY THE FUNCTIONS OF WEATHER DETECTION OR GROUND MAPPING. IT IS NOT INTENDED TO BE USED OR RELIED UPON FOR PROXIMITY WARNING OR ANTICOLLISION PROTECTION. WEATHER RADAR CONTROLS.

Control and display menus are described below. Weather radar is called up for display using the WX/TERR button on the display controller. It is displayed on the MFD Map mode using the MAP virtual controller. The format of the data is controlled using the weather radar controller.

### PFD WEATHER RADAR DISPLAY CONTROL

**WX/TERR Button** - The WX/TERR button selects weather video (WX) or terrain video (TERR) for display on the on-side PFD Arc mode. If the HSI format is Full Compass when the WX/TERR button is activated, the WX/TERR button sequence is:

Full Compass --> Arc Mode WX --> Arc Mode Terrain --> Arc Mode --> Arc Mode

If FMS is the primary navigation source the button sequence is as follows:

Full --> Arc with FMS and WX --> Arc with FMS and Terr --> Arc with FMS --> Arc with FMSx and WX

If WX or TERR are selected and HSI transitions to compass then WX or TERR are deselected Power-up default is WX and TERR off.

### MFD WEATHER RADAR DISPLAY CONTROL

**Weather On MAP Menu** - The MAP menu, is used to select weather for display. Weather is an exclusive button with Terrain or Off, meaning that either Weather or Terrain of Off can be selected, but not two or more. When weather is selected, weather data is displayed on the MFD.

### WEATHER (WX) RADAR CONTROLLER

Controls and display features of the WX radar controller are described below. Lighting for all legends and controls on the indicator are controlled by the aircraft panel.

Single or dual controls can be used. When a single controller is used, all weather radar displays show the same radar data. When dual controllers are used, weather radar displays are controlled by the controller for that side, or either controller can be slaved to the other for identical radar displays throughout the radar system.

# PRIMUS 880 RADAR CONTROLLER


Figure 3-42

## Dual Control Table

| Left Controller Mode | Right Controller Mode | Left Side (Note 1) | Right Side (Note 1) | RTA Mode |
|---|---|---|---|---|
| OFF | OFF | OFF | OFF | OFF |
| OFF (SLV) | STBY | STBY | STBY | STBY |
| STBY | OFF (SLV) | STBY | STBY | STBY |
| OFF (SLV) | ON | ON | ON | ON |
| ON | OFF (SLV) | ON | ON | ON |
| STBY | ON | STBY/2 | ON/2 | ON/2 |
| ON | STBY | ON/2 | STBY/2 | ON/2 |
| ON | ON | ON/2 | ON/2 | ON |
| STBY | STBY | STBY | STBY | STBY |

**NOTE**

1. ON is used to indicate any selected radar mode.
2. SLV means that displayed data is controlled by opposite side controller.
3. XXX/2 means that display is controlled by the on-side control for the antenna sweep direction associated with that control. (/2 implies two controllers are on.)
4. In standby, RTA antenna is centered on the azimuth with 15  upward tilt. Video data is suppressed. The transmitter is inhibited.
5. The multifunction display (MFD) repeats left-side data.

## CONTROLLER SWITCHES AND CONTROLS

The range switches are two momentary contact buttons that are used to set the operating radar range. WX ranges can be set from 5 to 300 NM (nautical miles) full scale. In the flight plan (FPLN) mode, ranges of 500 and 1000 miles can be set. The up arrow selects increasing ranges, and the down arrow selects decreasing ranges. One-half the selected range is annunciated at the one-half scale range mark on the display.

**NOTE**

For dual controller installations, the weather radar range is controlled by the on-side weather radar controller.

**TURB (Turbulence) Button** - The TURB switch is used to select the TURB mode. The TURB mode displays areas of turbulence detected by the WX system in a soft white pattern on the WX display. The TURB button toggles the turbulence mode on and off.

**STAB (Stabilizer) Button** - Pushing the STAB button engages or disengages the stabilization function that automatically compensates for aircraft roll and pitch maneuvers.

**TGT (Target) Button** - The TGT button engages or disengages the radar target alert feature. Target alert can be selected out to the 300-mile range. When selected, target alert monitors beyond the selected range and 7.5 degrees on each side of the aircraft heading. If a return with certain characteristics is detected in the monitored area, the target alert changes from the TGT armed annunciator to the TGT warning annunciator. The target advises the pilot of a potentially hazardous condition directly in front of and outside the selected range. When the amber warning is received, the pilot must select longer ranges to view the target. Target alert is inactive within the selected range.

Selecting target alert forces the system into the preset gain condition. Target alert can be selected in the WX RCT and FPLN modes.

## Target Alert Characteristics

| Selected Range (NM) | Target Depth (NM) | Target Range (NM) |
|---|---|---|
| 5 | 2 | 5-155 |
| 10 | 2 | 10-160 |
| 25 | 4 | 25-150 |
| 50 | 4 | 50-150 |
| 100 | 6 | 100-175 |
| 200 | 6 | 200-250 |
| 300 | 6 | 300-350 |
| FP (Flight Plan) | 2 | 5-155 |

**SECT (Sector) Button** - Pushing the SECT button toggles the system between the normal 14 looks/minute 120° scan and the faster update, 20 looks/minute 60° sector scan.

**TILT Knob** - The rotary TILT knob is used to set the tilt angle of the antenna beam with relation to the aircraft's longitudinal axis. Turning the knob clockwise (cw) tilts the beam upward to +15°; turning the knob counterclockwise (ccw) tilts the beam downward to -15°.

A digital readout of the antenna tilt angle is annunciated on the display.

## WARNING

TO AVOID FLYING UNDER OR OVER STORMS, FREQUENTLY SELECT MANUAL TILT TO SCAN BOTH ABOVE AND BELOW THE AIRCRAFT. ALWAYS USE MANUAL TILT FOR WEATHER ANALYSIS.

The MODE switch is a rotary switch used to select one of the following functions:

**OFF** - In this position the radar system is off. WX is displayed in the mode field.

**SBY** (Standby) - In this position the radar system is placed in standby, a ready state, with the antenna scan stopped. The transmitter is inhibited, and the display memory is erased. SBY is displayed in the mode field. Selecting SBY before the end of the warm-up period (approximately 45 seconds), results in WAIT being displayed in the mode field.

**WX** (Weather) - Selecting WX places the radar system in the weather detection mode. The system is fully operational and all internal parameters are set for en route weather detection. If WX is selected before the end of the initial RTA warm-up period (approximately 45 seconds), WAIT is displayed. In the WAIT mode, the transmitter and antenna scan are inhibited and the memory is erased. When the warm-up period is over, the system automatically switches to WX mode and WX is displayed in the mode field. In preset gain, the system is calibrated.

## Rainfall Rate Color Cross Reference

| Color | Rainfall Rate (inches/hr) | Rainfall Rate(mm/hr) |
|---|---|---|
| Green | .04-.16 | 1-4 |
| Yellow | .16-.47 | 4-12 |
| Red | .47-2 | 12-50 |
| Magenta | Greater than 2 | Greater than 50 |
| Cyan | REACT mode | REACT mode |
| Dim White | Turbulence | Turbulence |

**RCT (Rain Echo Attenuation Compensation Technique) Button** - The RCT switch position is used to select the RCT mode. The RCT mode compensates for attenuation of the radar signal as it passes through rainfall. The cyan field indicates areas where further compensation is not possible. Any target detected within the cyan field cannot be calibrated and must be considered severe weather. All targets in the cyan field are displayed as fourth level precipitation ( magenta ).

Selecting RCT forces the system to preset gain. When RCT is selected, the RCT legend is displayed.

**GMAP - GMAP** places the radar system in the ground mapping mode. GMAP sets the system to enhance returns from ground targets. RCT compensation is inactive.

**CAUTION**

WEATHER TARGETS ARE NOT CALIBRATED WHEN THE RADAR IS IN GMAP MODE. BECAUSE OF THIS, GMAP MODE SHOULD NOT BE USED FOR WEATHER DETECTION.

As a constant reminder that GMAP is selected, GMAP is displayed and the color scheme is changed to cyan, yellow, and magenta. Cyan represents the least reflective return, yellow is a moderate return, and magenta is a strong return.

If GMAP is selected before the end of initial RTA warm-up period (approximately 45 seconds), WAIT is displayed.

In the WAIT mode, the transmitter and antenna scan are inhibited and the memory is erased.

When the warm-up period is over, the system automatically switches to GMAP mode and GMAP is displayed in the mode field.

## WARNING

THE SYSTEM ONLY PERFORMS WEATHER DETECTION AND GROUND MAPPING. IT IS NOT TO BE RELIED UPON FOR GROUND PROXIMITY WARNING OR ANTI-COLLISION PROTECTION.

**FP (Flight Plan)** - In the FP position, the WX transmitter is placed in standby and the map range is selected up 1000 NM. The flight plan data from the selected FMS is displayed. Weather and lightning sensor system (if selected for display) underlays the flight plan data.

**NOTE**

When weather is not selected for display, the MFD has its own range control.

**TST** - The TST position selects the radar test mode. A special test pattern is displayed to verify system operation.

TEST is displayed in the mode field.

## WARNING

WHEN THE AIRCRAFT IS ON THE GROUND AND FORCED STANDBY (FSBY) IS OVERRIDDEN, THE RADAR TRANSMITTER IS ON AND EMITTING X-BAND MICROWAVE ENERGY IN THE TEST MODE. REFER TO THE MAXIMUM PERMISSIBLE EXPOSURE LEVEL (MPEL) IN THIS CHAPTER.

**GAIN Knob** - The gain control knob controls receiver gain.

Variable gain is used for additional weather analysis and for ground mapping.

Pushing the GAIN control knob activates the radar in the preset, Calibrated Gain mode. Calibrated Gain mode is the normal mode for weather avoidance.

In calibrated gain, the GAIN control knob cannot be turned. Pulling the GAIN control knob activates the variable gain mode.

In the WX mode, variable gain can increase receiver sensitivity over the calibrated level to show very weak targets, or it can be reduced below the calibrated level to eliminate weak returns.

## WARNING

HAZARDOUS TARGETS ARE REMOVED FROM THE DISPLAY WITH LOW VARIABLE GAIN SETTINGS.

Variable gain also reduces the level of strong returns from ground targets.

Minimum gain is set when the knob is in the fully ccw position.

Gain increases as the knob is turned cw from fully ccw position to the 12 o'clock position. At the 12 o'clock position, both the gain and the sensitivity time control (STC) are at maximum levels. Additional cw rotation removes STC.

At the full cw position, gain is at maximum and the STC is at minimum.

STC reduces receiver gain at the start of the trace, increasing it as more distant returns are received. With STC, a uniform display of cell strength is displayed for both near and distant cells.

The variable (VAR) legend annunciates variable gain. Selecting RCT , or TGT forces the system into preset gain. Preset gain is not annunciated.

**MODE ANNUNCIATION BOXES**

The MFD mode box is located on the left side of the display above the WX menu. The PFD mode box is displayed above the right radio display at the bottom of the HSI.

| Annunciator | R/T Mode |
|---|---|
| WAIT | RTA in warm-up |
| RCT | REACT mode |
| FSBY | Forced standby |
| STBY | Standby |
| TEST | Test mode |
| WX | Weather mode (Note 1) |
| VAR | Variable gain |
| WX/T | Weather and turbulence (Note 2) |
| R/T | RCT and turbulence (Note 2) |
| GMAP | Ground mapping mode |
| FPLN | Flight plan mode |
| FAIL | RTA fail (Note 3) |
| STAB | Stabilization off |
| TGT | Target alert enabled (Note 5) |
| GCR | Normal WX with ground clutter reduction |

NOTES:

1. When weather radar is invalid, WX is displayed.
2. Turbulence detection is only available on the PRIMUS- 880.
3. When on the ground and the weather test display is selected, weather failures are indicated by fault codes in the tilt angle field.
4. Early versions of the P1000 annunciate TX when the radar is in the warm-up mode. In later versions, the warm-up is indicated by WAIT.
5. When target alert is enabled and a level 3 weather return is detected in the forward 15° antenna scan, TGT is displayed.

**Weather Radar Self-Test**

## WARNING

OUTPUT POWER IS RADIATED IN TEST MODE

The PRIMUS 880 Digital Weather Radar System has a self-test mode and a maintenance function. The WX Test mode is selected by setting the mode switch to the TST. Moving the switch position to any other setting removes the test display.

Follow the procedure to conduct a complete WX self-test.

Step 1

Set the mode select knob on the weather radar controller to the TST position. Verify that the test pattern, has the following:

- Half-range mark and alphanumerics are displayed in white.
- RADAR OK is displayed
- Half-range distance is 50 NM.

Step 2

Use the SECT button weather radar controller to reduce the scan from ±60° to ±30°.
- Verify that the change is made to both MFD radar screens.
- Verify that the sweep rate increases from 12 to 25 scans per minute.

Step 3

Select another weather radar controller select button to deselect the SECT button input. Verify that both screens and scans are returned to the ±60° sweep and 12 times per minute scan rate.

Step 4

On the weather radar controller, push the SBY button in the air, or select the OFF position on the mode select switch to remove the test and weather display from the MFD.

**Color Bands** - A series of black/ green / yellow / red / cyan / white / magenta /blue bands indicate that the signal to color conversion circuits are operating normally.

The maintenance function lets the pilot or the line maintenance technician determine the major fault areas. The fault data can be displayed in one of two ways (selected at the time of installation):

TEXT FAULT - Plain English text indicating the failure is placed in the test band.
FAULT CODE - A fault code is displayed (refer to the maintenance manual for an explanation).

## WEATHER RADAR OPERATING PROCEDURES

### Preliminary Control Settings

Select the MODE, GAIN, and TILT control, as shown below, before powering up the aircraft electrical system.

| | |
|---|---|
| MODE switch | Off |
| GAIN control | Preset position |
| TILT knob | +15° |

### Precautions

If the radar system is to be operated in any mode other than standby while the aircraft is on the ground:

- Direct nose of aircraft so that antenna scan sector is free of large metallic objects such as hangars or other aircraft, for a distance of 100 feet (30 meters), and tilt antenna fully upwards.
- Do not operate the radar during aircraft refueling or during refueling operations within 100 feet (30 meters).
- Do not operate the radar if personnel are standing too close to the 270 degree forward sector of aircraft.
- Operating personnel must be familiar with FAA AC 20-68B.

### Power-Up

On power-up, select either the standby or test mode. When power is first applied, the radar is in WAIT mode up to 60 seconds to let the magnetron warm up. Power sequences ON-OFF-ON lasting less than the initial wait period results in a 6-second wait period. After warm-up, follow the test procedure described above.

**Standby**

When SBY is selected, the antenna is stowed in a tilt-up position and is neither scanning nor transmitting. If two controllers are installed, both must be selected to SBY for the system to be in standby.

Standby must be selected any time the operator wants to keep system power on without transmitting.

**Radar Mode - Weather**

For purposes of weather avoidance, pilots are urged to familiarize themselves with FAA Advisory Circular AC 00-24B (1-20-83), Subject: THUNDERSTORMS.

To assist the pilot in categorizing storms as described in AC 00-24B, the radar receiver gain is calibrated in the WX mode with the VAR Gain not selected in the WX menu. The radar is not calibrated when variable gain is being used (i.e., VAR Gain selected on the WX menu), but calibration is restored if RCT or target alert is selected.

To better interpret the display, targets are displayed in various colors. Each color represents a specific level of precipitation.

In the WX mode, the PRIMUS - 660/880 Weather Radar System displays five levels as black, green, yellow, red, and magenta (in increasing order of intensity).

REACT (RCT) is used in WX mode to compensate for attenuation of the radar signal as it passes through a storm. It does this by increasing the gain of the receiver as weather is detected.

The RCT button selects and deselects the cyan field display that indicates the receiver is at maximum gain and the reference levels are at final values. Any returns detected beyond that point are displayed as magenta. (Selecting RCT prevents variable gain from operating.)

Target alert can be selected in any WX range except 300 NM. The target alert circuit monitors for red level or greater targets within ±7.5 degrees of aircraft heading.

**Radar Mode - Ground Mapping**

When the ground mapping mode is selected, the TILT control is turned down until the proper amount of terrain is displayed. The degree of down-tilt depends upon the aircraft altitude and the selected range.

**In-Flight Troubleshooting**

The PRIMUS- 880 Digital Weather Radar System displays troubleshooting information in one of two formats:

- Fault codes
- Text faults.

The selection is made at the time of installation. The following paragraphs describe access and use of this information.

If the fault codes option is selected, fault codes are shown in place of the tilt angle. The TEXT FAULTS option displays English text as well as fault codes in the radar test pattern areas.

Critical functions in the RTA are continuously monitored. Each fault condition has a corresponding 2-digit fault code (FC). Additionally, a fault name, a pilot message, and a line maintenance message are associated with each fault condition.

The following faults can be accessed on the ground or while airborne:

- Display, indicator, or RTA malfunction
- FAIL annunciator on weather indicator or EFIS display.

If the feature TEXT FAULTS is enabled, the radar test pattern area displays plain English text fault information. If it is not enabled, only the fault code is shown (one at a time) on the indicator or EFIS display.

**NOTE**

In this installation with TEXT FAULTS enabled, the fault codes are also displayed as part of the FAIL annunciator (e.g., FAIL 13).

**TEST MODE WITH TEXT FAULTS ENABLED**

When airborne, if the radar is in the TEST mode, current faults are displayed. When on the ground (weight-on-wheels active) and the radar is in the TEST mode, current faults are displayed, followed by up to 32 faults from the last 10 power-on cycles. The historic faults are displayed going from the most recent to the oldest, and are cycled every two antenna sweeps (approximately 8 seconds). The power-on count (POC) number indicates how many power-on counts back into the history the fault occurred. After the last fault, an END OF LIST message is displayed. To recycle through the list again, exit and re-enter the TEST mode.

| Field No. | Description |
|---|---|
| 1 | Pilot message |
| 2 | Line maintenance message |
| 3 | Fault code/power-on count |
| 4 | Fault name |
| 5 | Transmit ON/OFF |
| 6 | Strap code |

NOTES:

1. If airborne, only fault fields 1, 2, and 3 are displayed.
2. If airborne, only the current faults are displayed.
3. Strap codes indicate the configuration that was done at the time of installation. Refer to the System Description and Installation manual for further explanation.

## In-Flight Roll Compensation Adjustment of the PRIMUS- 880 Weather Radar System

This radar is normally attitude stabilized and automatically compensates for roll and pitch maneuvers. In-flight roll compensation can be done using the procedure steps below.

1. If two controllers are installed, one must be turned off. If an indicator is used as the controller, the procedure is the same as given below.
2. Fly to an altitude of 10,000 ft AGL or greater.
3. Set WX range to 25 NM.
4. Adjust the tilt down until a solid band of ground clutter is visible on the screen. Then adjust the tilt until the green region of the ground returns. Start at about 20 NM.
5. On the WX menu, deselect RCT (no check in the box).
6. Turn the STAB box on and off four times within three seconds. A display with text instructions is displayed. The radar unit is in the roll offset adjustment mode.
7. Select the GAIN box on the WX menu and adjust the gain value using the CCD knob to make a roll offset adjustment. The offset range is from -2.0° to +2.0°. The polarity of the gain value is such that clockwise rotation causes the antenna to move down when scanning on the right side.
8. While flying straight and level, adjust the gain value until the ground clutter display is symmetrical.
9. Deselect VAR Gain. When the VAR Gain is deselected, the display returns to the previous message.
10. Select the STAB button to go to the next menu (pitch offset) or select and deselect it three times to exit.

**NOTE**

Once set, the roll compensation is stored in nonvolatile memory in the RTA. It is not erased when the system is powered down.

### MAXIMUM PERMISSIBLE EXPOSURE LEVEL (MPEL)

Heating and radiation effects of weather radar can be hazardous to life. Personnel should remain at a safe distance from the radiating antenna in order to be outside the envelope in which radiation exposure levels equal or exceed 10 mW/cm2, the limit recommended in FAA Advisory Circular AC No. 20-68B, August 8, 1980, Subject: Recommended Radiation Safety Precautions for Ground Operation of Airborne Weather Radar. The radius R, distance to the maximum permissible exposure level boundary, is calculated for the radar system on the basis of radiator diameter, rated peak-power output, and duty cycle. The greater of the distances calculated for either the far-field or near-field is based on the recommendations outlined in AC No. 20-68B.

The American National Standards Institute, in their document ANSI C95.1-1982, recommends an exposure level of no more than 5 mW/cm2.

Honeywell recommends that operators follow the 5 mW/cm2 standard.