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Introduction

The flight instruments chapter includes the Electronic Flight Instruments System (EFIS), Air Data System (ADS), standby instruments, clock and radio altimeter.

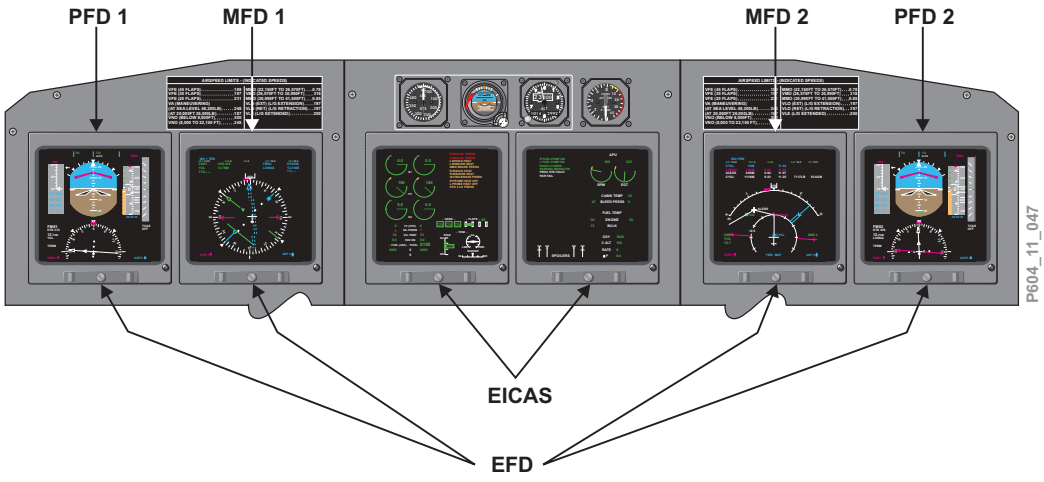
Electronic Flight Instrument System (EFIS)

The Electronic Flight Instrument System (EFIS) takes input data from airplane radios, sensors and control panels and displays the information on four Electronic Flight Displays (EFDs).

Two of the EFDs function as primary flight displays (PFD), and two EFDs function as multifunction displays (MFDs).

The color conventions used for the PFD and MFD symbology are:

White	For all scales and on-side FMS sensor data
Green	For on-side sensor data (non-FMS)
Yellow	For cross-side sensor data and caution information
Magenta	For pilot-selectable data
Cyan	For secondary information
Red	For warnings and failure flags



Electronic Flight Displays
Figure 11-1

Components and Operations

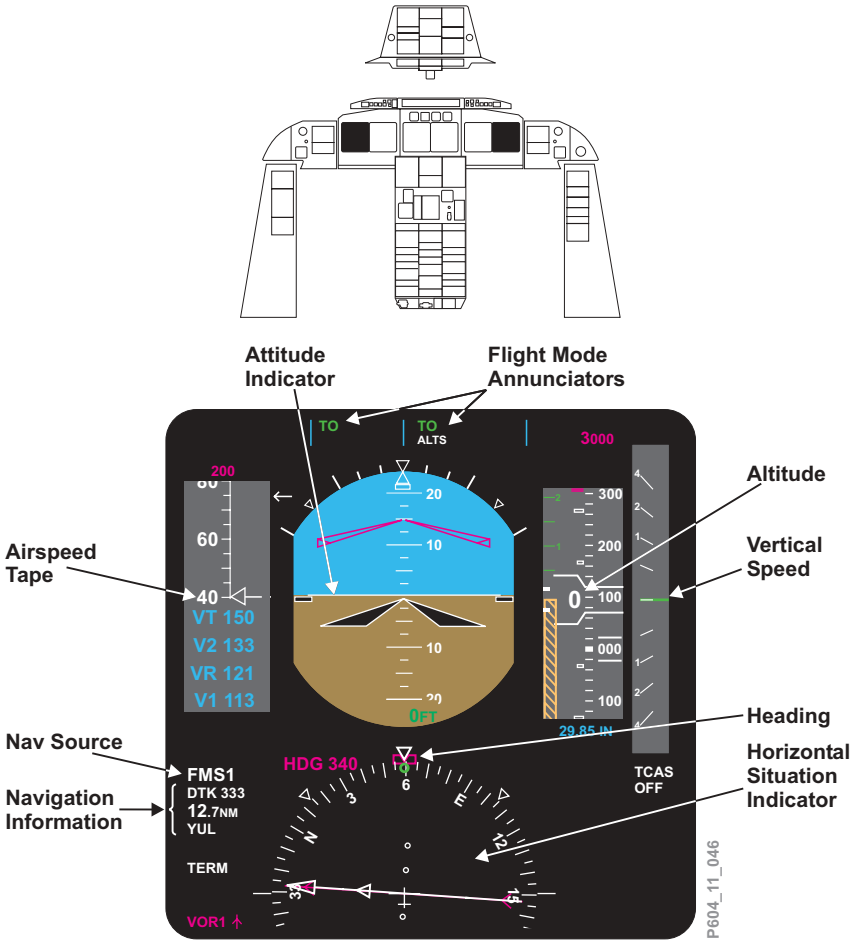
Primary Flight Display

The Primary Flight Display (PFD) presents the flight instruments in a typical “T” formation, which includes both the Attitude Director Indicator (ADI) and the Horizontal Situation Indicator (HSI).

The two PFDs are the outboard EFDs of the instrument panel. The PFDs come on automatically upon receiving DC power.

The following data is displayed on the PFD:

- Attitude
- Heading
- Airspeed
- Altitude
- Vertical Speed
- Flight Mode Annunciators
- Nav source and navigation information
- HSI



Primary Flight Display (PFD)

Figure 11-2

Multifunction Display

The MFDs present navigation information in pilot-selectable formats.

The MFDs are the displays located inboard of the PFDs. Like the PFDs, they come on automatically upon receiving DC power. The MFDs also provide reversionary backup displays for the PFD or the EICAS.

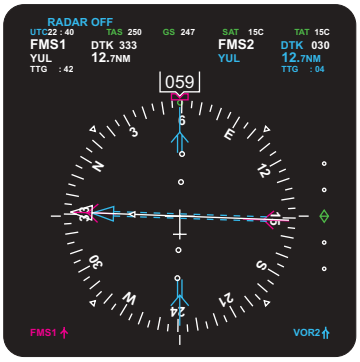
The following page formats may be displayed on the MFDs:

- HSI
- Nav Sector Map
- FMS Map
- Plan Map
- TCAS

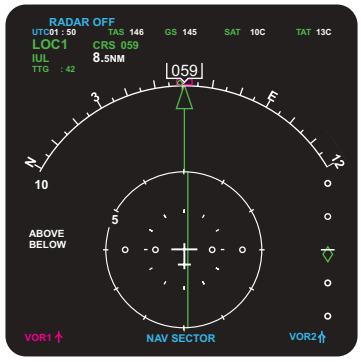
Additional MFD information includes:

- Weather Radar
- Terrain data (if EGPWS installed)
- Checklist (operated from the EICAS Control Panel)
- Reversion to PFD or EICAS
- Remote Text (Maintenance Diagnostic Computer and FMS Text)

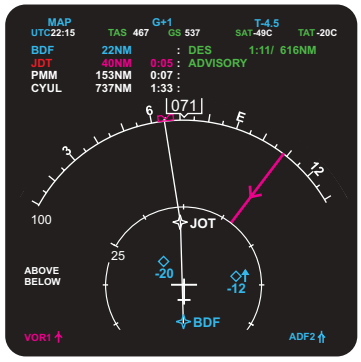
MFD FORMATS



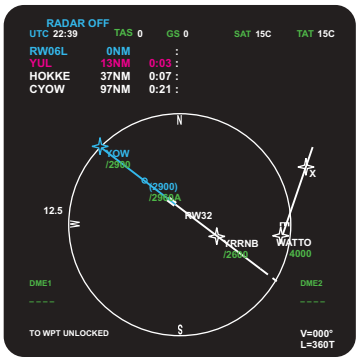
HSI FORMAT



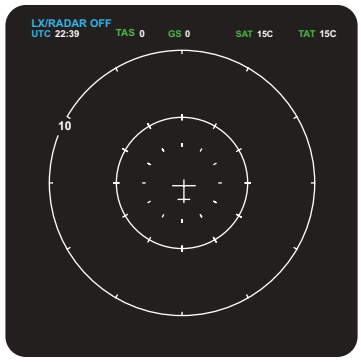
NAV SECTOR



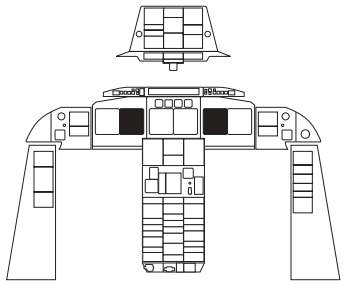
FMS MAP
TRAFFIC OVERLAY



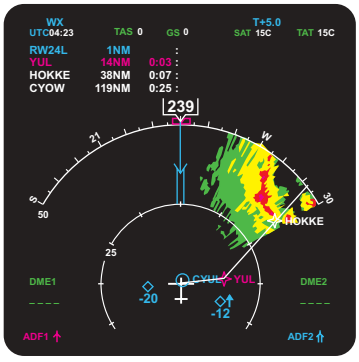
PLAN MAP FORMAT



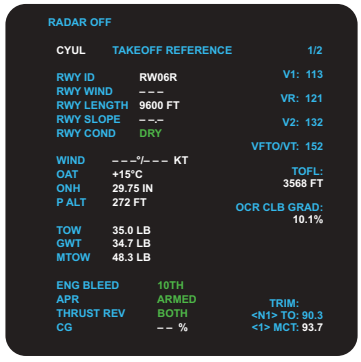
TCAS TRAFFIC DISPLAY



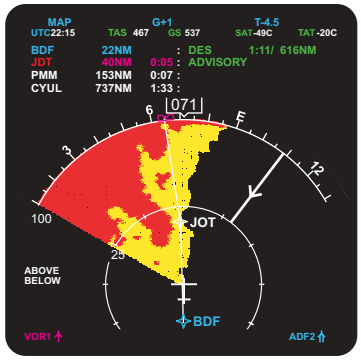
ADDITIONAL INFORMATION DISPLAYS



FMS MAP
WX OVERLAY
TRAFFIC OVERLAY



REMOTE TEXT



FMS MAP
TERRAIN OVERLAY

P604_11_030

Multifunction Display (MFD)

Figure 11-3

EFIS Comparator Monitor

Data displayed on the two PFDs is continuously compared for deviations. When defined trip levels are exceeded, the EFIS COMP MON caution EICAS message is displayed, and the flashing MASTER CAUTION lights are triggered.

The comparator monitor has two sections; the full-time comparators and the Category II comparators.

Full-Time Comparator

Full-time comparator warning is performed for pitch, roll, heading, altitude and airspeed data. Comparator warnings appear in yellow and flash temporarily on the PFD. They then remain displayed while the condition exists.

NOTE

A subsequent EFIS comparator monitor indication will not cause another Master Caution to flash. Only the comparator indication on the PFD will flash.

Pitch

Pitch comparator monitoring is enabled if both sides are using different Inertial Reference System (IRS) sources and both sources have not failed (any ATT flag). When enabled, if the pilot's and copilot's displayed pitch difference is greater than 4° when en route, or greater than 3° during approach, the pitch comparator warning "PIT" shows on the attitude indicator.

Roll

Roll comparator monitoring is enabled if both sides are using different IRS sources, and both sources have not failed (any ATT flag). When enabled, if the pilot's and copilot's roll difference is greater than 4° when en route, or greater than 3° during approach, the comparator warning "ROL" shows on the attitude indicator.

Heading

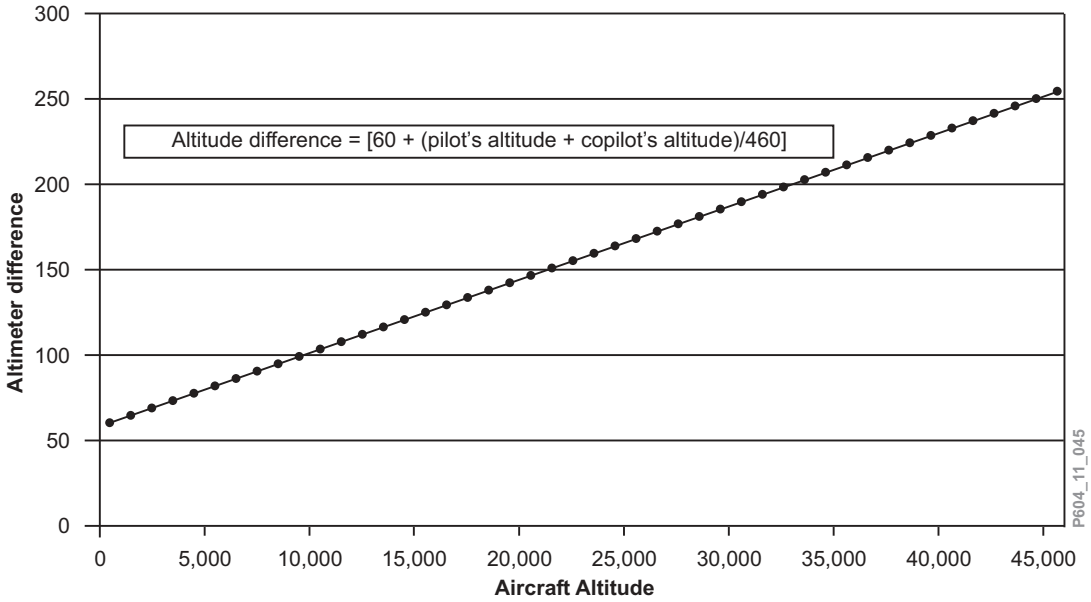
The heading comparator is enabled when:

- both sides are using the same heading reference (MAG or TRU)
- both sides are using different IRS sources, and
- both sources have not failed (no HDG flag)

If the heading comparator is enabled and the heading difference is greater than 6°, the heading comparator warning "HDG" shows on the compass arc.

Altitude

The altitude comparator is enabled if both sides are using different air data sources and both sides have not failed (no ALT flag). If the altitude comparator is enabled and the altitude difference is not within limits, the altitude comparator warning “ALT” shows vertically on the lower portion of the altitude scale. As the altitude increases, so do the altitude difference limits, as indicated by the following formula: if the ALT difference exceeds **[60 + (pilot’s altitude + copilot’s altitude)/460]** feet, the altitude comparator warning shows.



Altitude Comparator Graph

Figure 11-4

Indicated Airspeed

The airspeed comparator is enabled if both sides are using different air data sources, both sides have not failed (no IAS flag), and the indicated airspeed is greater than 90 knots. If the airspeed comparator is enabled and the airspeed difference is greater than 10 knots, the airspeed comparator warning “IAS” shows on the upper portion of the airspeed scale.

The following table summarizes the trip values for the full-time comparator monitoring functions:

SYSTEM	FLAG	VALUE
HEADING	HDG	> 6°
ROLL	ROL	> 3° Approach, > 4° En route
PITCH	PIT	> 3° Approach, > 4° En route
ALTITUDE	ALT	60 ft with BARO set within 0.02 inches. The amount of difference required to trigger the flag increases as altitude increases.
AIRSPEED	IAS	> 10 kts above 90 kts

Category II Comparator

Category II comparators are enabled if approach mode is selected and the DH is set below 200 feet. Comparator monitoring is performed for LOC, G/S and Radio Altimeter deviations.

The following conditions must be valid to enable the CAT II comparisons:

- the on-side RA is valid and RA is less than 1000 feet
- the cross-side data is valid
- the LOC on both sides are tuned identically and are valid
- approach mode is selected

LOC Deviation

When the LOC comparator is enabled and the pilot's and copilot's lateral deviations differ by more than a predetermined amount, a yellow "LOC" comparator flag shows in the compass arc. The amount of difference allowed varies with the location of the pilot's localizer. As the pilot's localizer moves toward the center of the display, the comparison tolerance decreases.

For example, when the pilot's side deviation pointer is at the center of the scale, the comparator allows up to approximately +½ dots of deviation error on the copilot's side before showing the comparator warning flag.

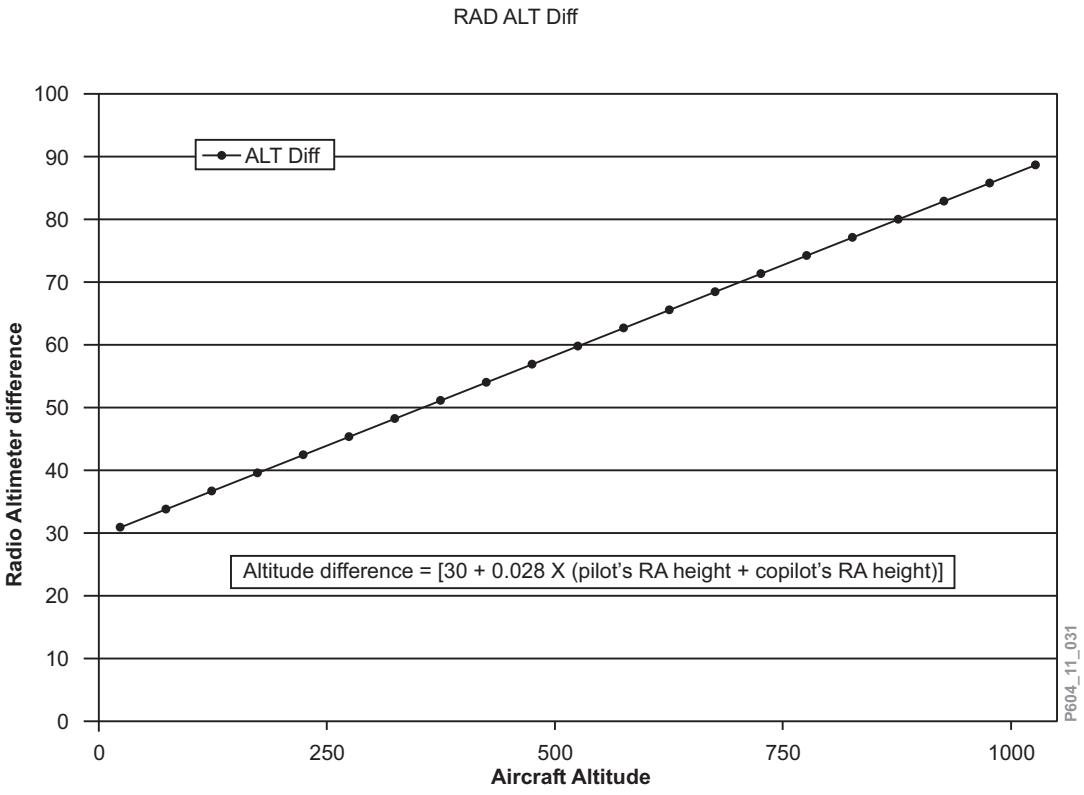
G/S Deviation

When the G/S comparator is enabled and the pilot's and copilot's lateral deviations differ by more than a predetermined amount, a yellow "GS" comparator flag shows below the glideslope scale. The limits vary with the position of the pilot's deviation pointer. As it moves closer to the centerline of the scale, the comparison tolerance decreases.

For example, when the pilot's side deviation pointer is at the center of the scale, the comparator allows up to approximately +¾ dots of deviation error on the copilot's side before showing the comparator warning flag.

RA Deviation

When the RA comparator is enabled and the pilot's and copilot's RA difference is not within limits, a yellow "RA" comparator flag shows below the attitude indicator. To enable the RA comparator, the on-side RA altitude is less than 1000 feet and the cross-side RA is valid. As the altitude increases, so do the RA difference limits increase as per the following formula: **[30 feet + 0.028 X (pilot's RA height + copilot's RA height)]**.

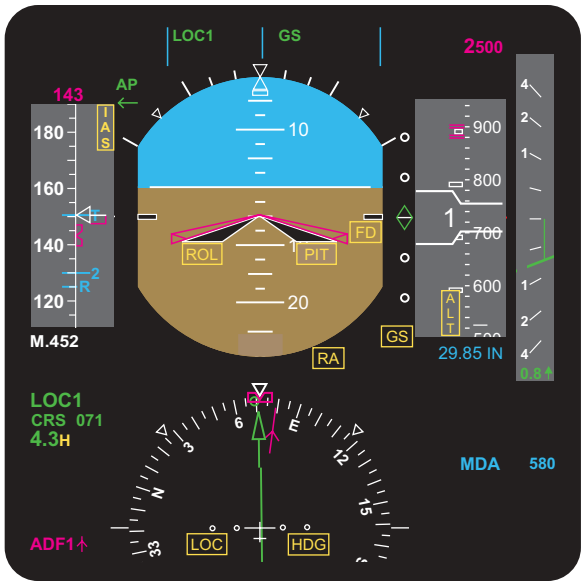


Radar Altimeter Deviation Limits Graph

Figure 11-5

Comparator Indications and EFIS Failure Displays

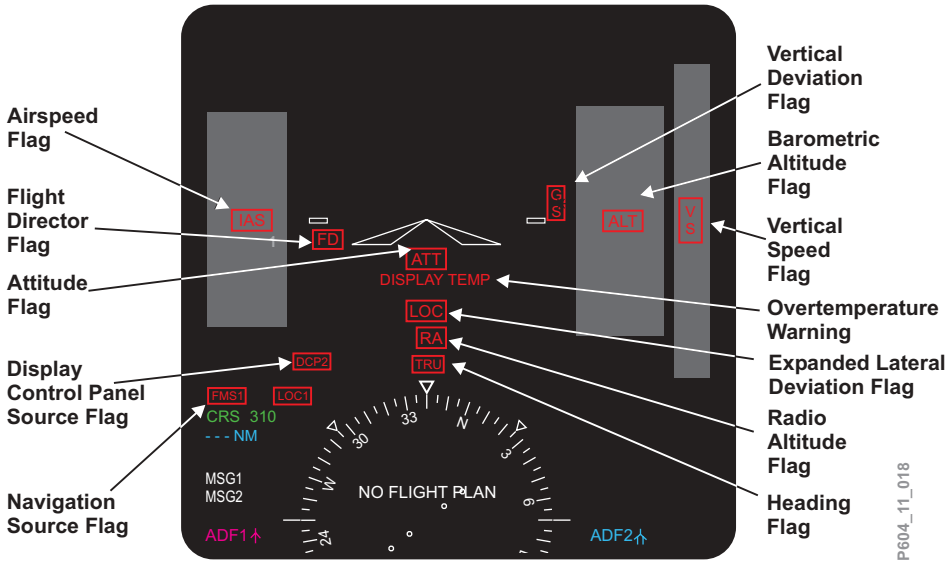
The Comparator warning icon on the PFD will remain displayed while the condition exists. If the comparator monitor fails, the Amber EFIS COMP MON INOP caution EICAS message is displayed, and the flashing MASTER CAUTION lights will be triggered.



PFD Comparator Annunciations

Figure 11-6

The failure of a selected source removes the respective scale or display and presents a red flag.



PFD Failure Displays

Figure 11-7

The following Failure Flags are available:

Failure flag label	Meaning	Items removed from display
ALT	Air Data Computer failure	Barometric altitude tapes, digital altitude readout, preselected altitude reference, digital preselect altitude, metric altitude readout and metric preselected altitude
ATT	Inertial Reference System failure	Sky/ground raster, pitch tape, roll pointer, roll scale, slip/skid indicator
DCP	Display Control Panel failure	Flight director bars
MAG, TRK, TRU	Heading Sensor input failure Inertial Reference System failure	The heading display is not removed, but the heading is not updated
FD	Flight Director failure	Flight director bars
FMS/GS/LOC/VOR	Respective Navigation System failure	Flight director bars Lateral deviation scale Red boxed Nav Source
GS	Glideslope failure	Vertical deviation scale and pointer
IAS	Air Data Computer failure	Airspeed tape and information
VS	Air Data Computer failure	Vertical speed scale pointer, digital readout
RA	Radio Altimeter failure	Analog radio altitude symbology, analog decision height marker and digital radio altitude

Air Data System

The Air Data System (ADS) uses air pressure and temperature information to calculate all of the parameters related to flight. It supplies the following information to EFIS for display:

- Altitude (ALT)
- Indicated Airspeed (IAS)
- Vertical speed (VS)
- True airspeed (TAS)
- Static Air Temperature (SAT), and
- Total Air Temperature (TAT)

The ADS also provides computed data to:

- Inertial Reference System (IRS)
- Flight Data Recorder (FDR)
- Stall Protection and Flap systems
- Air Traffic Control (ATC) transponders
- Traffic Collision Avoidance System
- Automatic Flight Control System (AFCS), and
- Engine Indication and Crew Alerting System (EICAS)

The Air Data System contains the following subsystems:

- Pitot-Static System
- Temperature Sensing System
- Air Data Computer System (ADC)
- Air Data Reference Panels (ADRPs)

Pitot-Static System

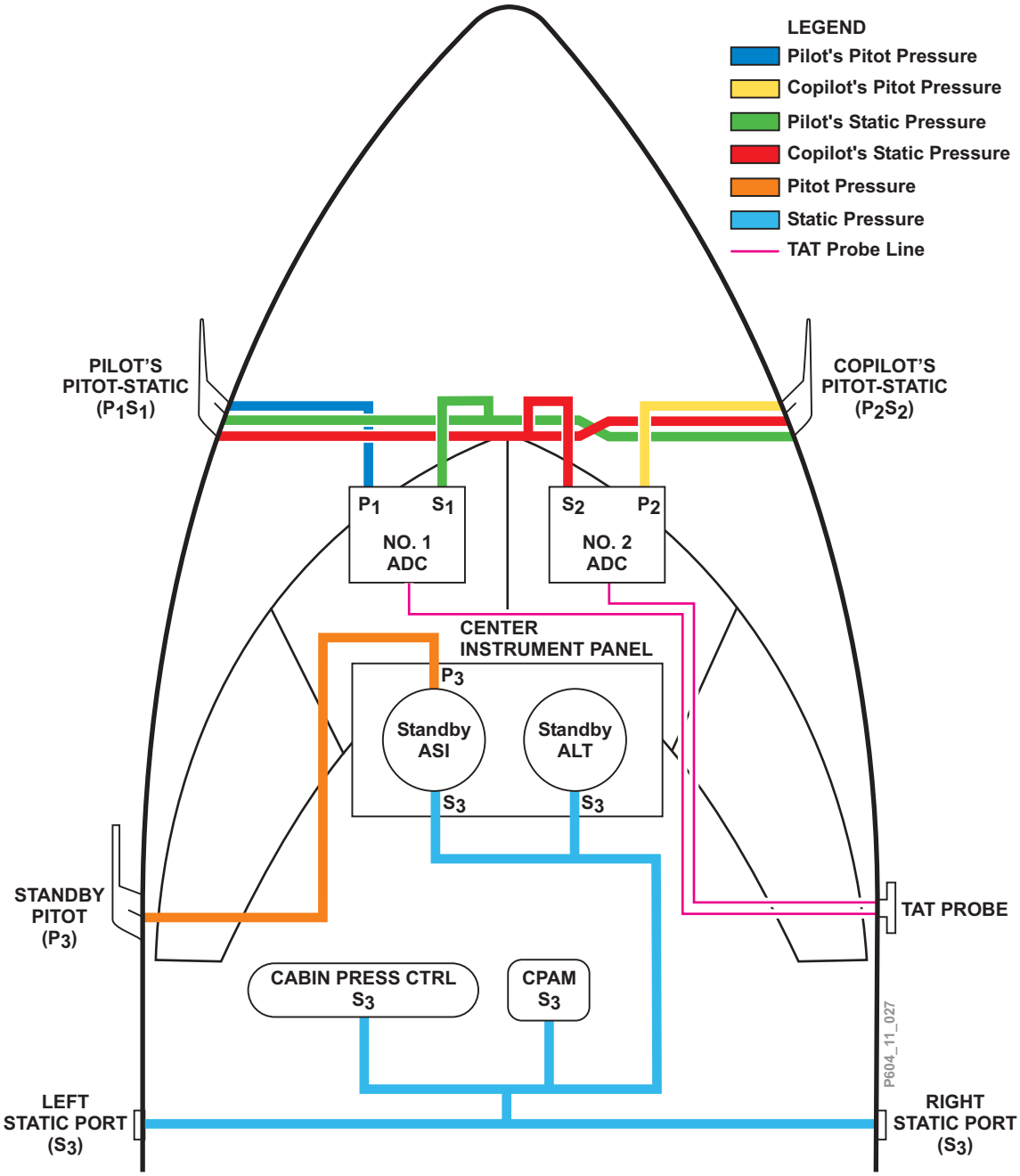
The pitot-static system includes:

- two main pitot-static systems
- one standby pitot-static system

The two main pitot-static systems designated P1/S1 and P2/S2 supply variable pressure inputs to the ADCs. The pitot pressure is sensed through an opening in the forward end of the pitot heads. The static pressure is ported through eight holes on the contoured midsection of the pitot head. Each static port consists of four holes; two on the upper side and two on the lower side of the pitot head. The S1 static port holes are forward and the S2 holes are aft along the pitot head. The contoured surface provides aerodynamic compensation to correct static pressure position error.

The P3 standby pitot system supplies pitot air pressure to the standby airspeed indicator. Two S3 standby static ports supply static pressure to the Cabin Pressure Acquisition Module (CPAM) Cabin Pressure Controller, standby airspeed indicator and standby altimeter.

Ice Protection is provided by electric heating elements for all pitot-static probes.



Pitot-Static Systems

Figure 11-8

Temperature-Sensing System

The temperature-sensing system receives data from a Total Air Temperature (TAT) Probe. The ADCs use the outputs from the probe to calculate the Static Air Temperature (SAT) and the True Airspeed (TAS)/Mach number. This information is displayed on the Primary Flight Displays (PFDs) and Multifunction Displays (MFDs).

Ice Protection is provided by electric heating elements.

Air Data Computers (ADCs)

The ADCs are digital, microprocessor-controlled units. The two ADCs receive on-side pitot and static air pressure information from the pitot-static system and air temperature information from the TAT probe.

The ADCs also receive operator/display selected input from the ADRPs and the Automatic Flight Control System (AFCS). From these inputs, the ADC calculates all necessary air data parameters and transmits the information to the applicable systems.

Air Data Calculations

The ADC calculates air data parameters for the following:

- Pressure altitude (corrected for static-port pressure errors)
- Barometric corrected altitude (inches of mercury or hectopascals)
- Vertical Speed
- Indicated airspeed (IAS)/Calibrated airspeed (CAS)
- Mach number
- Maximum airspeed (VMO/MMO)
- True airspeed (TAS)
- Static air temperature (SAT)
- Total air temperature (TAT)

Air Data Computations

The ADC computes data for the following:

- Preselect altitude
- Vertical speed reference
- Airspeed reference
- Mach reference
- IAS trend vector
- Secondary speed reference (V1, VR, V2 and VT)
- Flap overspeed limits (231, 197 and 189 Kts)

Air Data Transmission

The ADC sends the computed air data to the following systems and components:

- Flight Data Recorder (FDR)
- Radio Tuning Unit (RTU)
- Mode S Transponder
- Traffic Alert and Collision Avoidance System (TCAS)
- Primary Flight Display (PFD)/Multifunction Display (MFD)
- AFCS
- IRSs
- DCUs
- Ground Proximity Warning System (GPWS)
- Horizontal Stabilizer Trim Control Unit (HSTCU)
- Stall protection computer
- Flap Electronic Control Unit (FECU)

Controls and Indicators

Display Control Panel

The DCP provides the pilot and copilot with the controls needed to select the desired navigational features of the EFIS system. For the PFDs, this includes lateral and vertical navigation source information and bearing pointers. For the MFDs, this includes the format, range and display overlays. Each MFD/PFD pair has a dedicated DCP. If one of the DCPs should fail, the other DCP may be used to control both EFIS displays.

Format/Range Knob

Turning the (outer) FORMAT knob selects a desired on-side MFD display format for the associated MFD. There are five selectable display formats: HSI, NAV Sector, FMS Map, Plan Map and TCAS. The (inner) RANGE knob varies the display range scale on the MFD.

Navigation Source Knob

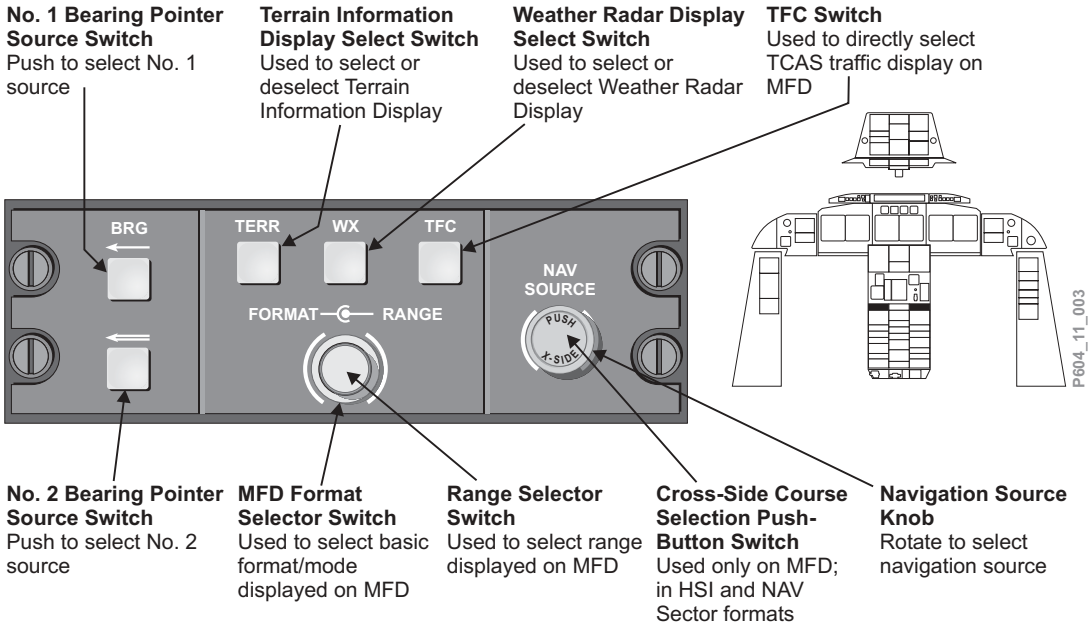
The NAV SOURCE knob selects the active navigation source. This action controls the selection of displayed information on each pilot's PFD/MFD. Possible selections are FMS 1, VOR 1, (or LOC 1), VOR 2 (or LOC 2) FMS 2 and FMS 3. Pushing the center of the knob alternately adds or removes cross-side NAV data on the MFD HSI and NAV sector displays only.

Bearing Pointers

The single-bar BRG pointer selects the No. 1 Bearing pointer for each pilot's PFD/MFD. Possible selections are VOR 1, ADF 1, FMS 1, and FMS 3 (if installed). The double-bar BRG pointer selects the No. 2 Bearing pointer for each pilot's PFD/MFD. Possible selections are VOR 2, ADF 2, FMS 2, and FMS 3 (if installed).

Information Overlay Buttons

The WX button selects weather radar and lightning detection system depictions on the MFD. This button sequentially selects weather radar information, or adds radar/lightning overlays. The Weather Radar is available on all dynamic map MFD formats, but is not available for HSI and Plan Map. The TFC button alternately selects or deselects the TCAS Traffic Map Overlay display on the associated MFD. The TERR button selects the terrain information and replaces the Weather Radar information. For more details about terrain overlay information, see the EGPWS section in Chapter 17 Navigation Systems.



Display Control Panel

Figure 11-9

Air Data Reference Panel

The Air Data Reference Panel (ADRP) is used to set speed, altitude and barometric pressure values, which are then sent to the EFIS for display. The two ADRPs are installed on the center pedestal. Each panel has three rotary knobs with inset pushbutton switches. The panel is divided into three sections: the speed reference section, the altitude reference section and the barometric pressure section.

- the Speed Reference section is used to make changes to airspeed references (V_1, V_R, V_2 and V_T)
- the Altitude Reference section is used to control the Minimum Descent Altitude (MDA) and Decision Height (DH) display on the EFIS. It also incorporates a test switch for the Radio Altimeter (RA)
- the Barometric Pressure section is used to make changes to the ADC barometric correction function

Speed Reference Section

To manually change the speeds posted on the V-Speed table, turn the TGT/VSPDS outer knob to either TGT (V_T), or VSPDS (V_1, V_R and V_2). Rotate the SET (inner) knob to change the speed values. In the VSPDS position the reference speeds can be alternately edited by pushing the SEL button and rotating the SET knob. The SET switch (inner knob) enables/disables the PFD display of the selected target or reference airspeed. These speeds are displayed below the IAS scale on the PFD and are located on the speed tape in their respective positions (V_1, V_R, V_2 and V_T).

Manually entered V-speeds will be displayed in cyan. For Precision-Plus-equipped aircraft, V-speeds can be computed and entered via the FMS where they will be displayed in cyan. Manually entered V-speeds in Precision-Plus-equipped aircraft are displayed in magenta.

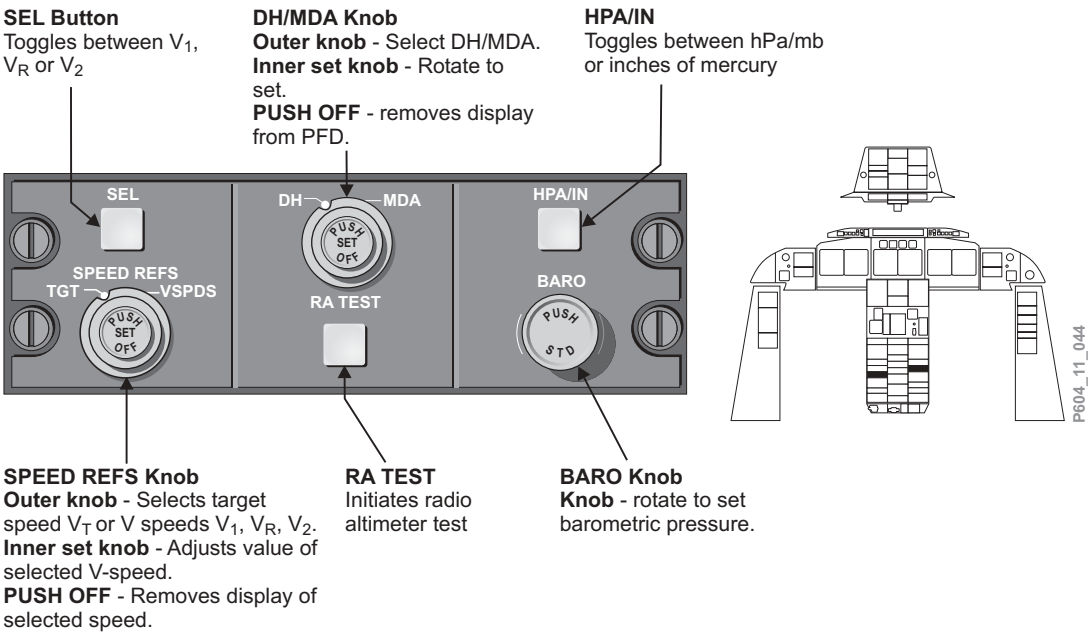
Altitude Reference Section

To change the altitude value displayed for either the Minimum Descent Altitude (MDA) or the Decision Height (DH), rotate the DH/MDA (outer) knob to select the altitude to be amended. The SET (inner knob) switch is rotated to change the values. These altitudes are displayed on the PFD below the altitude scale. The SET switch is pushed to enable or disable the display of either the DH or the MDA.

The Radio Altimeter (RA) test switch is depressed to conduct an internal test on the Radio Altimeter. The RA value on the bottom of the Attitude Direction Indicator will change to 50 feet and the rising runway symbology, located on the Radio Altimeter analog scale, moves down 50 feet.

Barometric Pressure Section

The Barometric (BARO) knob changes the barometric pressure. Pushing the SET switch selects standard barometric pressure (29.92 inches of mercury, or 1013 hectopascals). The value is displayed below the PFD altitude scale. The HPA/IN switch alternately selects barometric pressure correction in hectopascals (hPa), or inches of mercury (inHg).



Air Data Reference Panel

Figure 11-10

PFD Displays

Attitude Display

The attitude symbology provides pitch, roll and slip/skid information. IRS information is used to drive the attitude symbology. An inverted black V-bar airplane symbol denotes the aircraft's relative attitude on the Attitude Director Indicator (ADI).

Large-scale markings are placed at 10, 20, 30, 40, 50, and 65 degrees of pitch. Medium markings are placed at 5-degree intervals up to ± 30 degrees. Small tick marks are placed at 2.5-degree intervals up to ± 20 degrees.

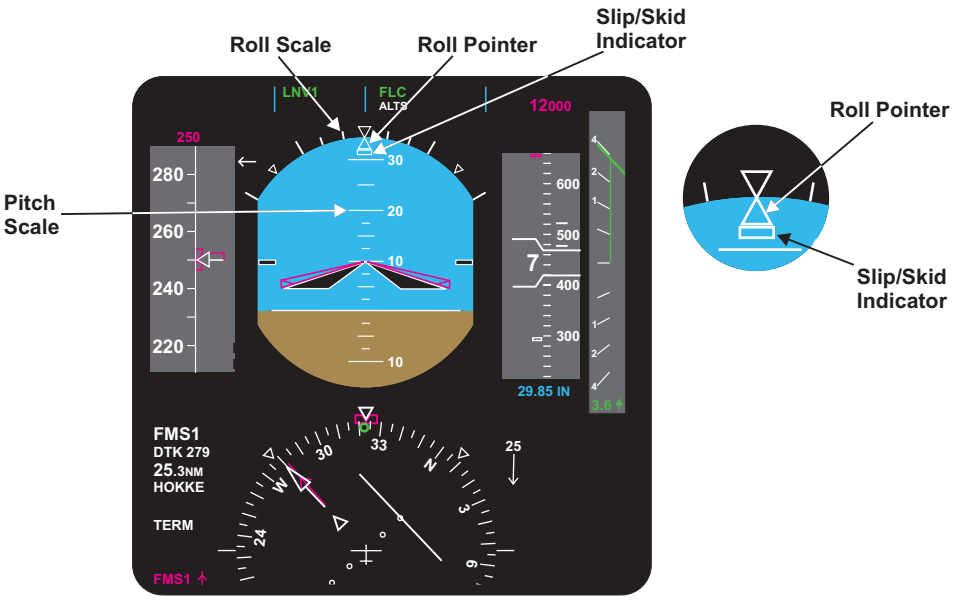
Roll scale markings are used to indicate airplane roll angles between ± 60 degrees. The roll pointer is used with the roll scale to indicate the airplane roll angle. The pointer is oriented perpendicular to the horizon line and next to the roll scale to represent degrees of roll (bank) angle. The roll pointer rotates about the center of the airplane symbol in response to changes in airplane roll angle.

Slip/Skid indicator

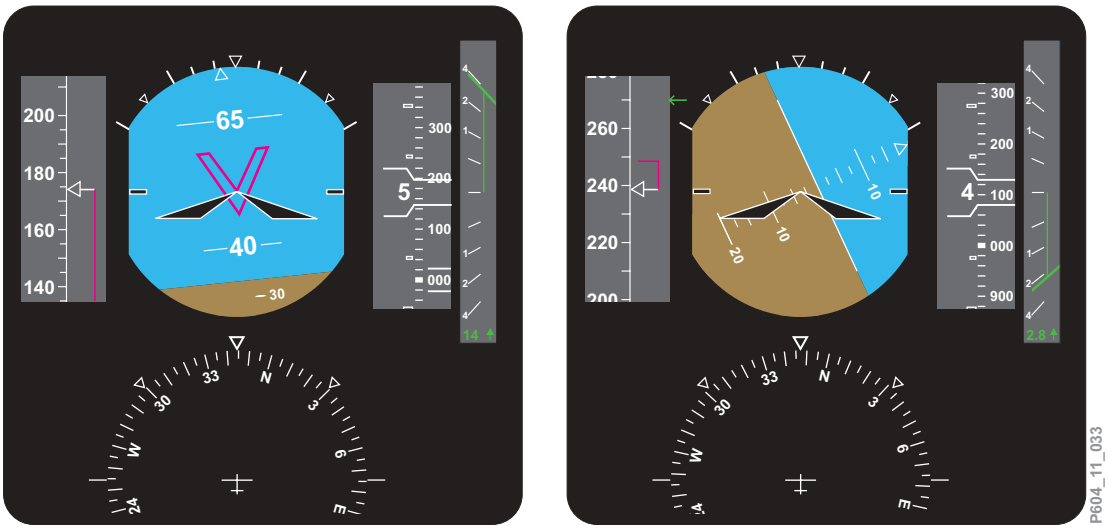
The slip/skid indicator is located just below the roll pointer and approximates the displacement of an inclinometer. The indicator is a small rectangular symbol. The slip/skid indicator is driven by lateral accelerations.

Unusual Attitude Display

If the airplane is flown into an unusual attitude, all non-necessary indications are removed. Unusual attitudes occur when pitch exceeds +30 degrees (up), or –20 degrees (down), or when roll exceeds 65 degrees. During excessive attitude, only pitch, roll airspeed and altitude are displayed. Red chevrons point toward zero in extreme pitch attitudes. A portion of blue or brown coloring representing sky or ground remains displayed, regardless of pitch attitude, to assist with orientation.



NORMAL ATTITUDE DISPLAY



UNUSUAL PITCH ATTITUDE

UNUSUAL BANK ANGLE ATTITUDE

P604_11_033

PFD Attitude Displays

Figure 11-11

Airspeed Displays

IAS Scale

The indicated airspeed scale is a vertical “moving tape” display. The IAS scale contains a line marking every 5 and 10 knots and a numeric label every 20 knots. If airspeed data becomes invalid, the scale is replaced with a red IAS annunciation.

IAS Pointer

This stationary triangle is displayed at the center of the IAS window. The current indicated airspeed is the IAS scale indication at the pointer.

IAS Trend Vector

The IAS Trend Vector is a magenta line that extends from the IAS pointer to predicted future airspeed. The head of the trend vector aligns with the IAS scale to predict what the airspeed will be in 10 seconds (if present acceleration is maintained). The vector extends up as airspeed increases and down as airspeed decreases. The trend vector is not displayed when the airplane is on the ground.

Mach Display

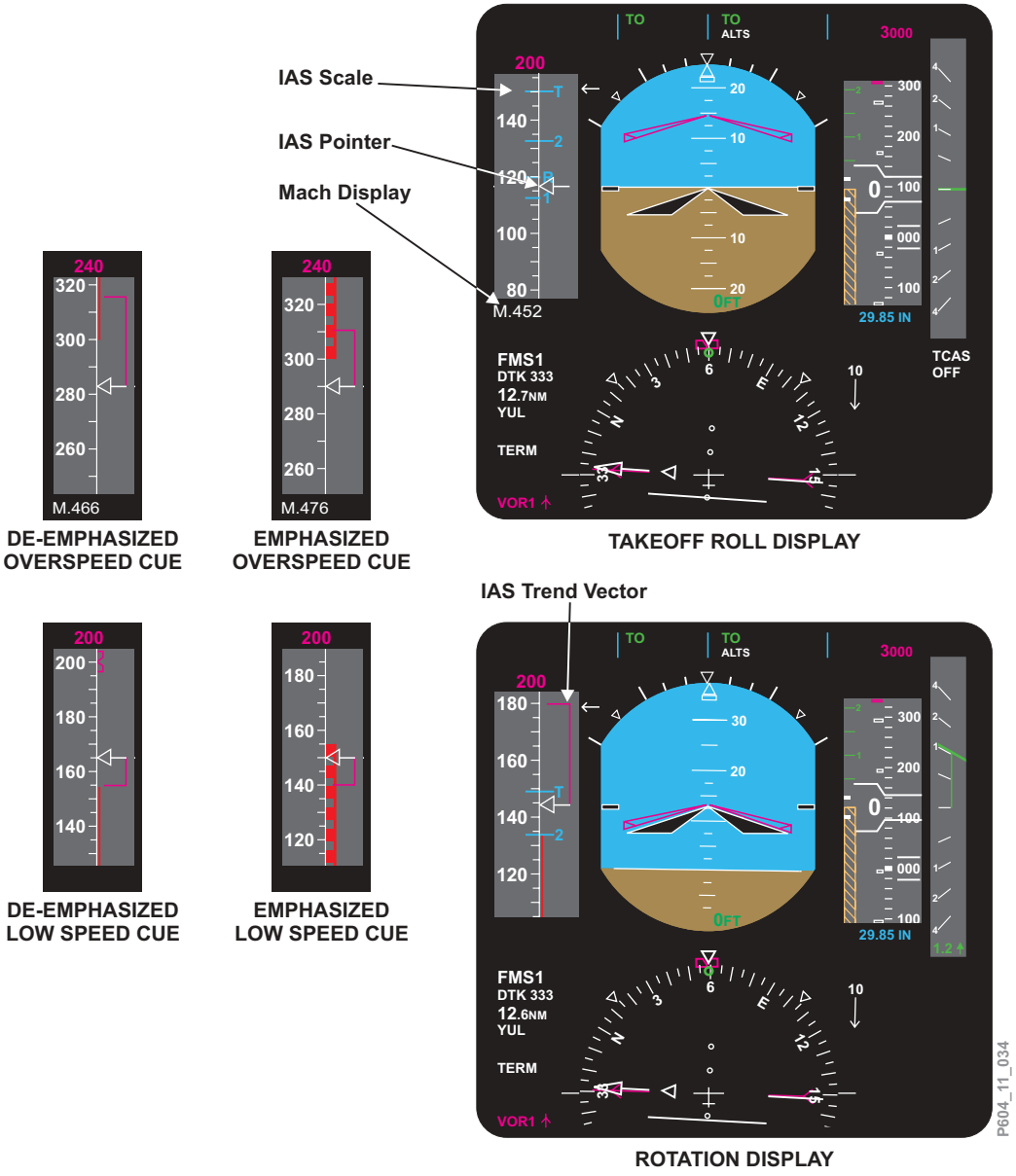
The current indicated Mach speed automatically displays below the airspeed scale with an M label as Mach increases above 0.450. This display is removed when Mach decreases below 0.400. Mach display changes in 0.002 increments.

Overspeed Cue

The overspeed reference is shown de-emphasized (red triple-width vertical bar) on the airspeed scale ascending from VMO/MMO to the top of the airspeed tape. The de-emphasized overspeed reference changes to an emphasized overspeed reference (red and gray checkerboard symbol) when the airspeed is two knots or greater into the VMO/MMO region. The de-emphasized overspeed reference also changes to an emphasized overspeed reference when the airspeed trend has been two knots or greater into the VMO/MMO region for five seconds or more.

Low Speed Cue

The Low Speed Cue indicates the aircraft’s impending stall speed and is generated by Angle-of-Attack information from the Auxiliary Angle-of-Attack vane. The Low Speed Cue indication is shown de-emphasized (red triple-width vertical bar) on the airspeed scale descending from impending stall speed to the bottom of the airspeed tape. The de-emphasized cue changes to an emphasized cue (red and gray checkerboard symbol) when airspeed is two knots or greater into the impending stall speed region. The de-emphasized cue also changes to an emphasized cue when the airspeed trend has been two knots or greater into the impending stall speed region for five seconds or more.



PFD Airspeed Display and Underspeed / Overspeed Cues

Figure 11-12

Speed Reference (Bug) Field

This line display shows a selected speed reference (bug) value that can be controlled using either Air Data Reference Panel (ADRP). The SPEED REFS knob and SEL button are used to sequentially select one of four available bugs, 1, R, 2, or T, corresponding to (V_1, V_R, V_2, or V_T) for display in this field.

The SET knob on the ADRP is used to change this value. The PUSH OFF switch on the ADRP enables/disables display of the selected bug. The bug position on the IAS scale automatically updates as the numeric values change. After five seconds of inactivity, the speed reference field display blanks.

Speed Reference (Bug) Table

The table displays on the lower portion of the IAS scale when airspeed is less than 40 knots. When the table displays, use the ADRP to select and change one of four airspeed bugs (V_1, V_R, V_2 or V_T).

NOTE

For Precision-Plus-equipped aircraft, V-speeds can be computed and entered via the FMS.

V_1 Bug

The reference marker is a cyan line followed by a 1. The V_1 bug is the takeoff decision speed reference. The V_1 bug is automatically removed at lift-off.

V_R Bug

The reference marker is a cyan line followed by an R. The V_R bug is the rotation speed reference. The bug display is automatically removed after the V_2 speed is exceeded.

V_2 Bug

The reference marker is a cyan line followed by a 2. The V_2 bug is the takeoff safety speed reference. The bug display is automatically removed after the V_2 speed is exceeded (V_2 + 40 knots + weight off wheels for 7 seconds).

V_T Bug

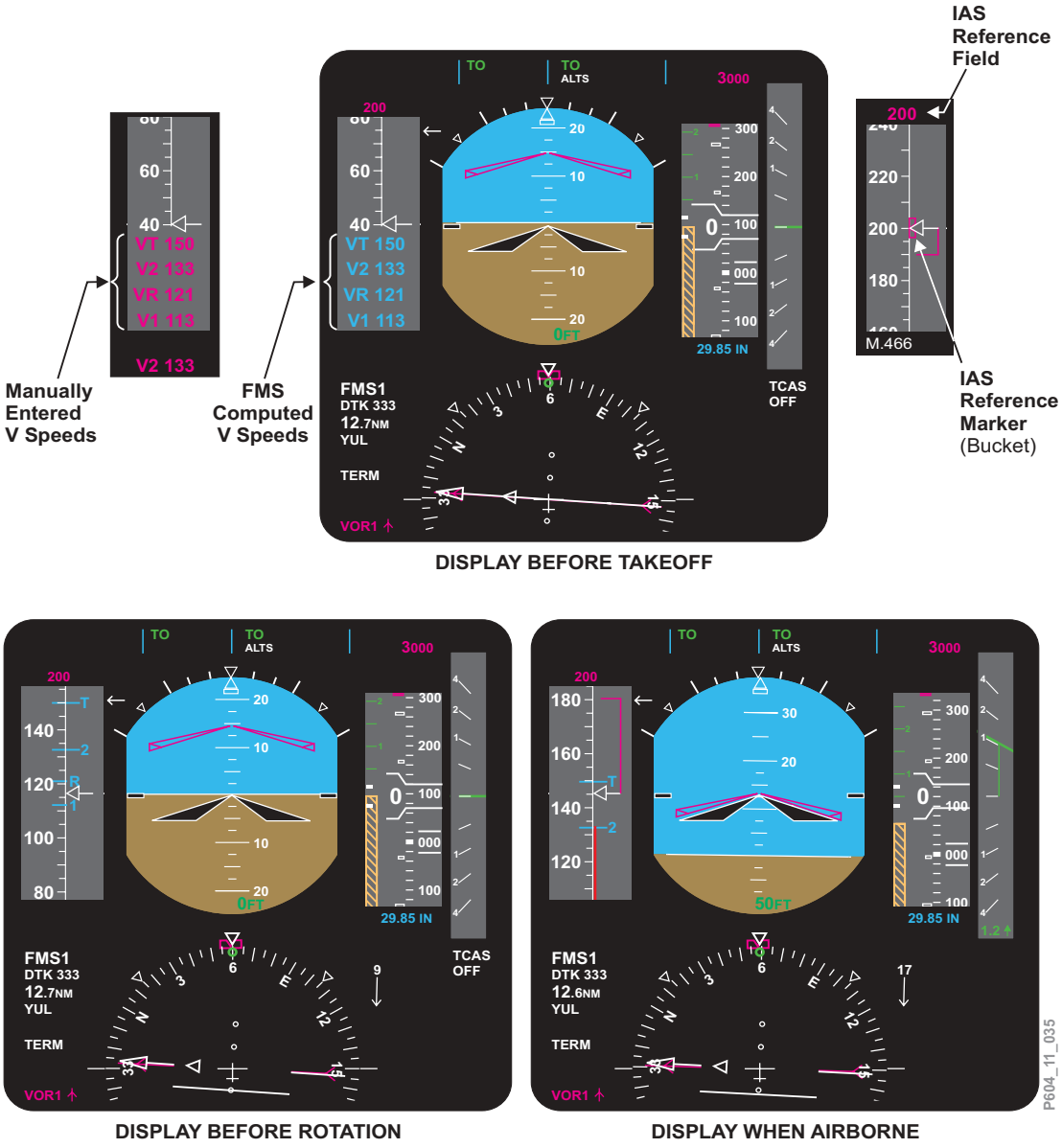
The reference marker is a cyan line followed by a T. The V_T bug is the target speed reference.

IAS Reference Field

The magenta display shows the selected IAS reference value. The value is marked by the notched-box (bucket) symbol on the IAS scale. Turn the SPEED knob on the FCP to set this value. While in Mach mode, turning the SPEED knob then sets a magenta selected Mach number at the top of the IAS scale and correspondingly moves the notched-box symbol on the IAS scale.

IAS Reference Marker

The magenta notched-box symbol is the IAS reference marker. The IAS reference marker is always selected for display and is set by the SPEED knob on the FCP. While in Mach mode, the IAS reference marker corresponds to the selected Mach number set in the reference field at the top of the IAS scale.



Speed Reference (Bug) Field

Figure 11-13

Altitude Displays

Barometric Altitude Display

The display simulates a rolling drum mechanism and is outlined by a white window. The present barometric corrected altitude displayed is the sum of the numeric "thousands" readout and the "hundreds" moving tape indication at the window. If barometric altitude data becomes invalid, the altitude displays are replaced with a red ALT annunciation.

NOTE

A metric barometric altitude readout may also be displayed below the pressure display. This boxed readout with an "M" label displays the barometric altitude in meters.

Fine Barometric Altitude Scale

The fine barometric altitude scale is a vertical "moving tape" display. The display window range is 450 feet. The scale contains a line marking every 20 feet and a numeric label every 100 feet. The scale moves down for increasing altitude.

Coarse Barometric Altitude Scale

The coarse barometric altitude scale is a non-numbered vertical "moving tape" display that helps visualize (preselected) altitude captures. Large rectangles on the scale represent 1000-feet altitude increments and small rectangles represent 500-foot increments. The display window range is 2250 feet. The scale moves down for increasing altitude.

Barometric Pressure Display

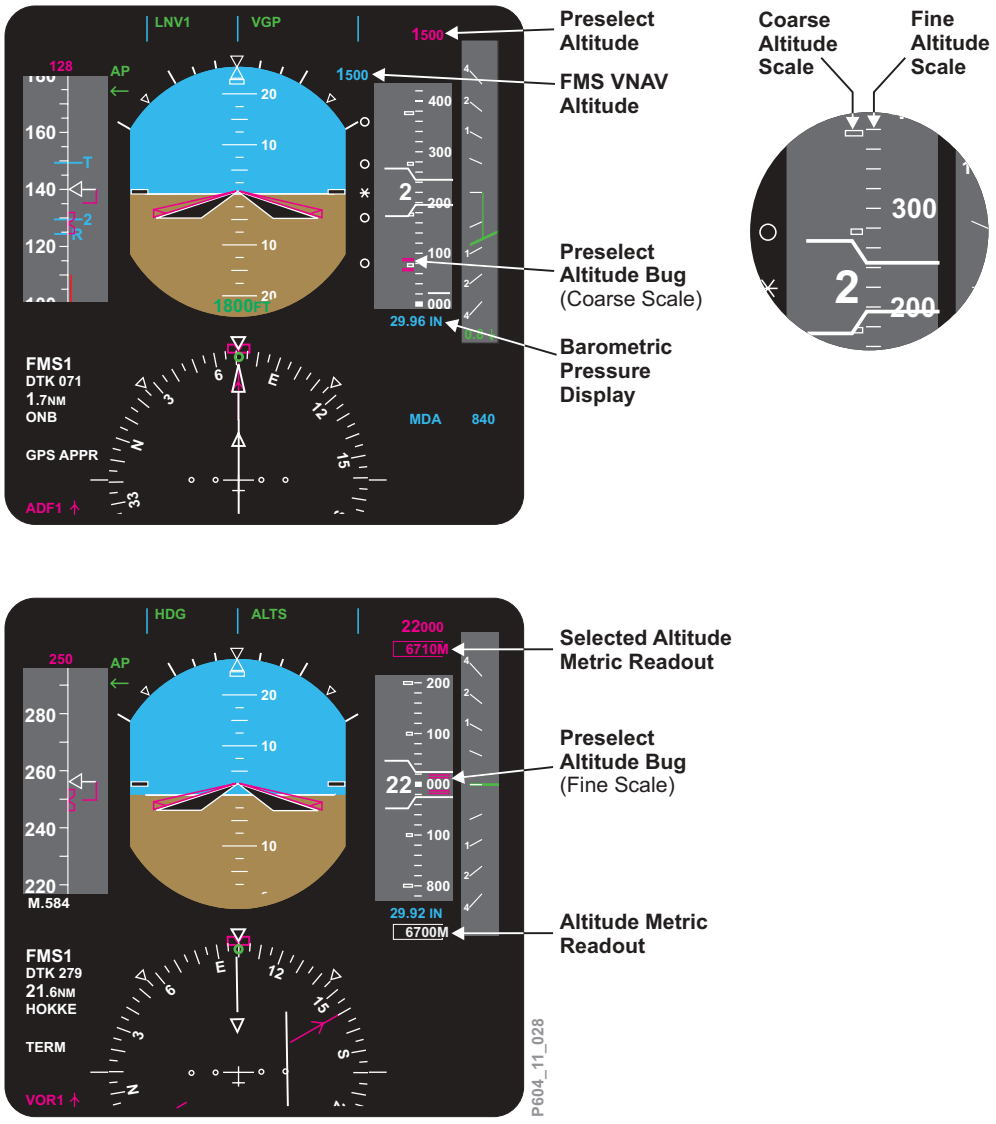
Barometric pressure correction is numerically displayed in either inches of mercury or in hectopascals (hPa). The correction value and format are set by the on-side ADRP.

Preselect Altitude Display

The preselected altitude is numerically displayed in magenta above the barometric altitude scales. The ALT knob on the FCP sets the value.

NOTE

A metric preselected altitude readout with an "M" label may also be displayed below the normal display. The boxed readout displays the preselected altitude in meters.



PFD Altitude Displays

Figure 11-14

Preselect Altitude Bug

The ALT set knob on the FCP is used to set the preselected altitude value. The preset altitude is displayed on the top of the altitude scale in magenta, and as a window on the coarse and fine altitude scales.

This four-line marker displays on the coarse and fine barometric altitude scales to mark the preselected altitude value. The marker is always in view on the coarse barometric altitude scale and then shows on the fine barometric altitude scale when in range.

The preselected altitude display and bug both change colors and/or flash as the airplane acquires a preselected altitude. These displays are normally magenta. Both displays flash magenta when the airplane approaches the preselected altitude and then become steady again at altitude capture.

Preselect Altitude Warnings

Preselect altitude warnings provide aural and visual signals. The aural warning signal is a one-second C-chord tone. After capture, the digital display flashes amber for minor altitude deviations. The bug and numeric display both flash amber for major altitude deviations.

The Air Data Computers use the preselected altitude data to initiate two different types of cues and warnings. These cues and warnings are initiated when the difference between the preselected and barometric altitude is greater than the programmed limits. The programmed limits are:

- minor deviation is ± 200 feet
- major deviation is ± 1000 feet

(See Chapter 4 Automatic Flight Control System for additional altitude preselect tracking information)

Preselect Altitude Cross-Side Tracking

Each ADC receives the preselected altitude via its on-side ADRP and the cross data bus. The ADCs compare the preselected altitude values of the two computers. If the values are not equal due to a bus failure, the digital preselect altitude indication changes from magenta to cyan when the adjustment knob is turned. If full bus operation is recovered, the two sides will synchronize to the value held by the coupled side ADC. The indication returns to magenta after synchronization has been achieved.

MDA Display

The Minimum Descent Altitude (MDA) is numerically displayed below the altitude scale. The on-side ADRP is used to select this display and set the appropriate value. An MDA alert displays near the left center of the ADI when the airplane is at the Minimum Descent Altitude. During the MDA alert the icon flashes yellow.

MDA Pointer

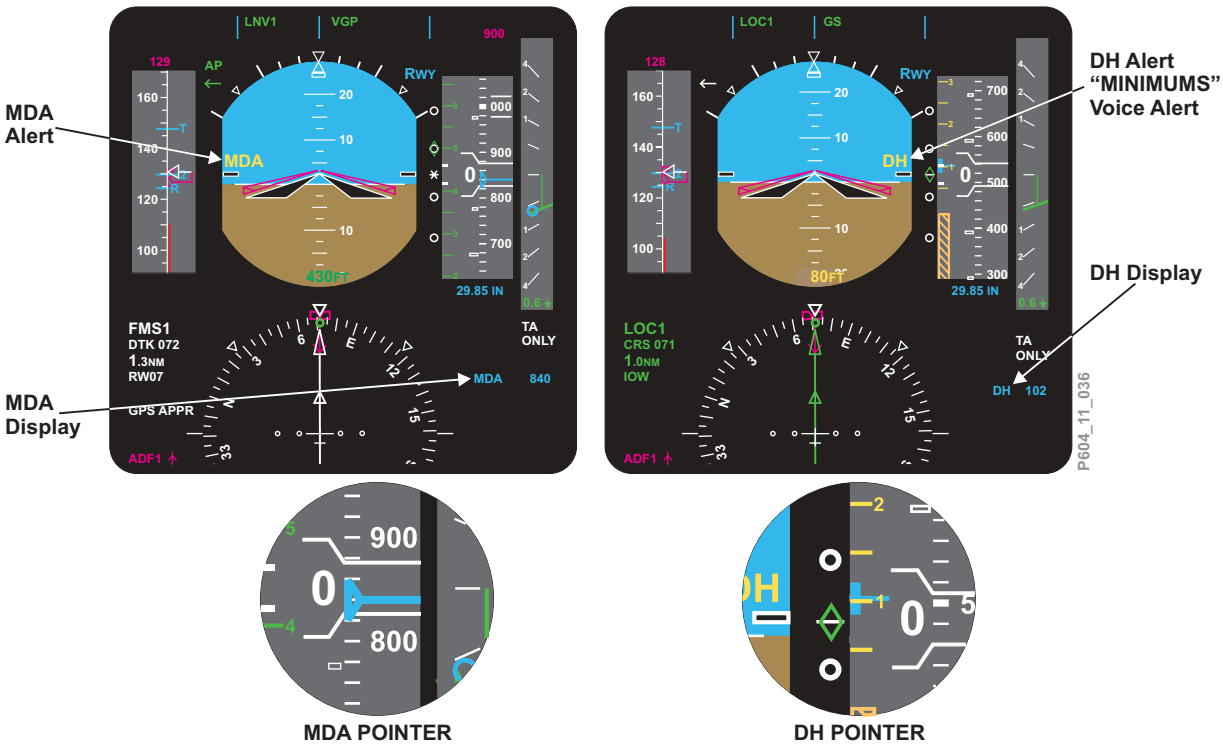
A cyan pointer marks the selected Minimum Descent Altitude on the fine barometric altitude scale. This pointer appears when the MDA display is selected and the value is in the display range. This pointer flashes during an MDA alert.

Decision Height Display

The Decision Height value is selected for display and set by the on-side ADRP. If this display is selected, it is automatically displayed once the aircraft has descended through 2500 feet above ground. If Decision Height data becomes invalid, the numeric values are replaced with red dashes.

A DH alert displays when the airplane is at or below Decision Height. On the right center of the attitude indicator, DH flashes in yellow, accompanied by the voice alert “MINIMUMS”.

There is also a DH Pointer which marks the selected Decision Height on the analog radio altitude scale. This pointer appears when the DH display is selected and the value is in the display range.



MDA and DH Displays

Figure 11-15

Vertical Speed Display

The current vertical speed is shown by a green pointer on a vertical white scale; the green pointer drags a green vertical line from the center of the scale. Vertical speed (when 200 feet/minute or greater) is numerically repeated at the bottom of the scale followed by an arrow pointing “up” for climb, or “down” for descent.

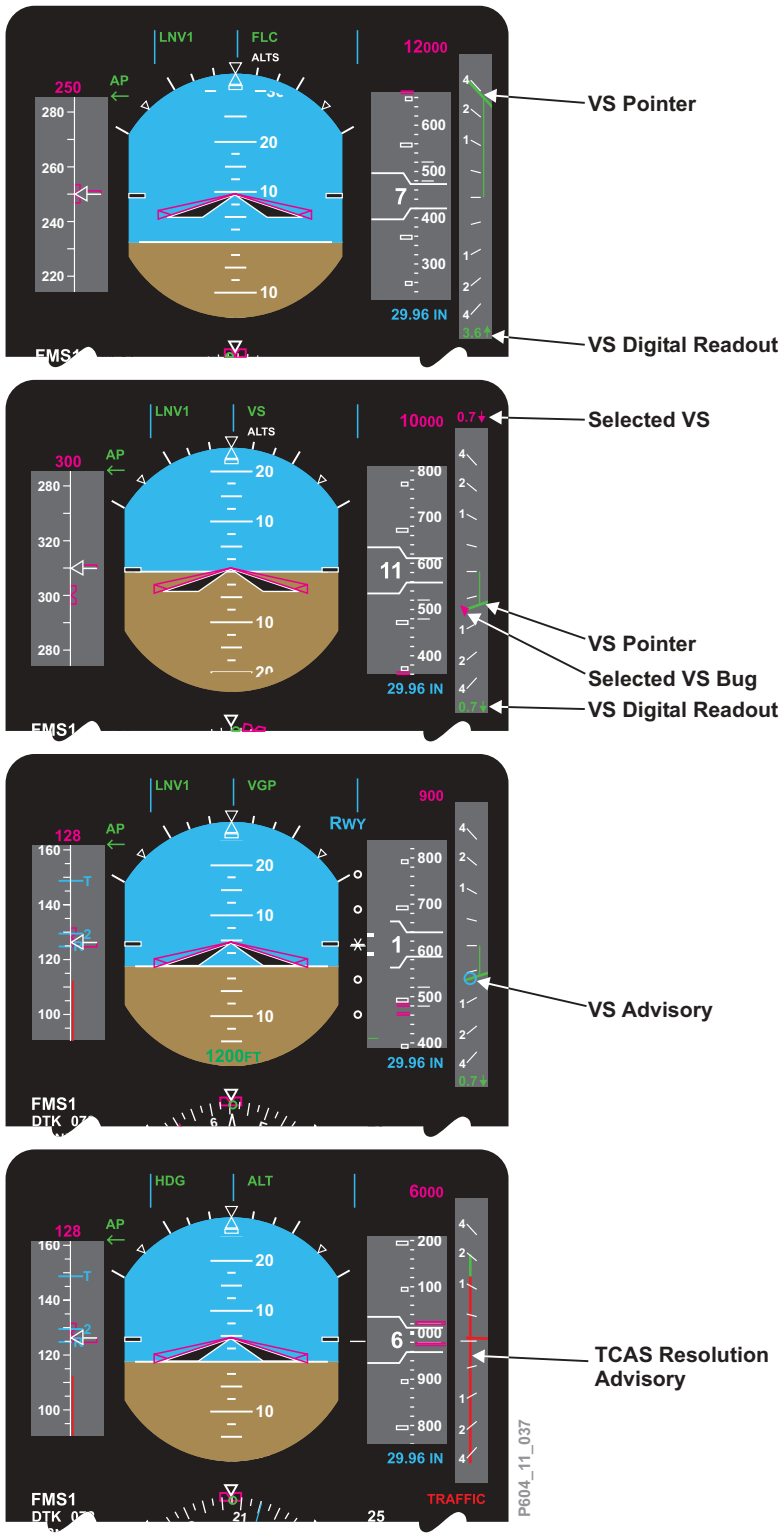
The vertical speed is selected by using the VS/Pitch Wheel on the FCP and the magenta numerical value is displayed at the top of the Vertical Speed scale with a corresponding up or down arrow as selected.

The FMS Vertical Navigation computer continuously calculates vertical speed required to reach the next point on the flight plan at the altitude required. The required vertical speed when greater than 500 fpm for FMS VNAV is displayed on the vertical speed scale in the form of a cyan circle.

NOTE

For Precision-Plus-equipped aircraft, the cyan circle will be displayed if VNAV is selected or VNAV advisory enabled.

TCAS advisories display on the VS scale as green or red lines. A green line shows a recommended “fly-to” range of vertical speeds. A red line shows “avoidance” or “exit” vertical speeds. TCAS modes and messages are also displayed below the VS scale as appropriate (see Chapter 17 Navigation Systems for further details).



PFD Vertical Speed Display

Figure 11-16

Navigation Displays

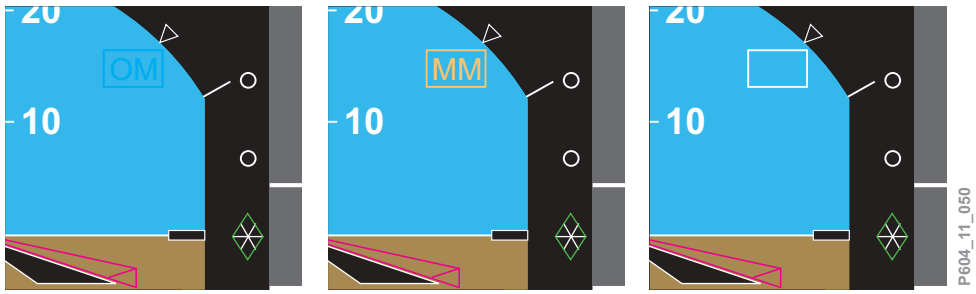
Vertical Deviation Display (GS, FMS and VNAV)

The ILS glideslope vertical deviation display appears when all conditions are met. Use the on-side DCP to select FMS or LOC as the active NAV source. If deviation data becomes invalid, this display is replaced with a red GS (flag) annunciation. When conducting a back course approach, the scale displays without a pointer or flag annunciation.

With LOC selected as the active NAV source, glideslope deviation is shown by the position of a diamond-shaped pointer relative to the deviation scale. The scale consists of two dots above and two dots below center. When the pointer moves to the top or bottom of the scale, it changes to a half diamond (triangle) pointing in the direction of the glideslope. A star against the same scale displays FMS glideslope vertical deviation.

Marker Beacon Annunciation

Marker beacon status is annunciated by a cyan boxed “OM” (Outer Marker), yellow boxed “MM” (Middle Marker), or by an empty white box (Inner Marker).



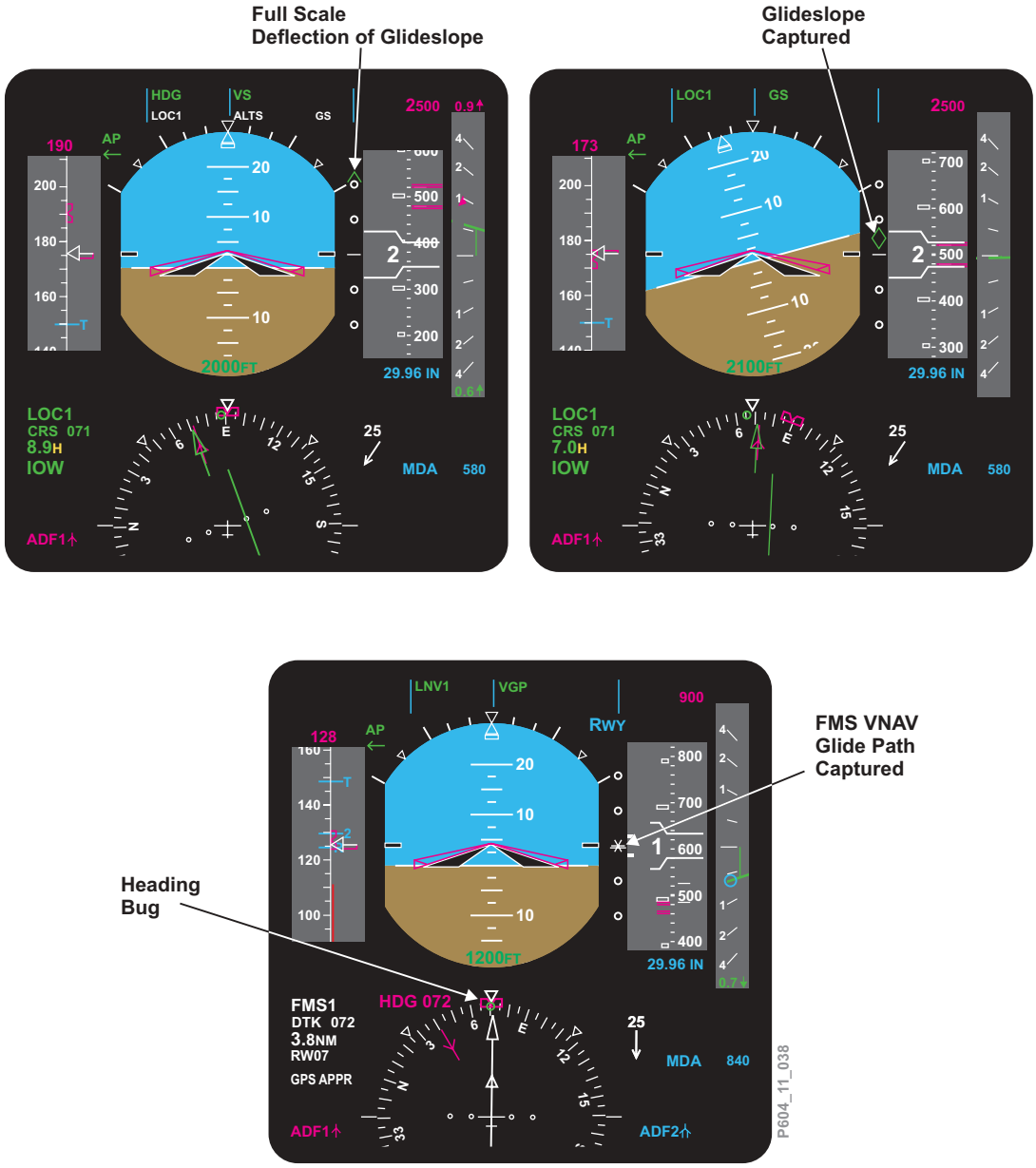
Marker Beacon Annunciations

Figure 11-17

Horizontal Situation Indicator (HSI) Function

The PFD has a Horizontal Situation Indicator located at the bottom center. It consists of an airplane symbol and a compass rose. The compass rose is graduated in five-degree marks, with numeric labels at every 10 degrees and letters at N, E, S and W. Airplane heading is read against the fore lubber line. Selected heading is set by the HDG knob on the Flight Control Panel, which moves a heading bug on both PFDs together. The digital value is displayed at the top left of the HSI while turning the HDG knob and remains displayed for a period of three seconds once HDG knob rotation is stopped.

Selected course VOR, LOC or desired FMS track is digitally presented, and also displayed by an arrow. Course or track deviation is displayed against a scale centered on the airplane. Two bearing pointers are available to display bearing to navigation stations or a flight plan TO waypoint.



PFD HSI Display

Figure 11-18

Multifunction Display Formats

Various information can be displayed on the five different display formats available on the Multifunction Display (MFD). Weather Radar or EGPWS Terrain information can be overlaid only on the active (dynamic) maps: Nav Sector, FMS Map, and TCAS formats.

The top two lines of all the different display formats present the following data (except for the remote text pages).

- **Radar mode line** (top line): Weather Radar mode of operation, gain, antenna stabilization and tilt; this is replaced with TERRAIN when in Terrain mode of EGPWS
- **Status line** (bottom line): UTC time, True Airspeed, Ground Speed, Static Air Temp and Total Air Temp

MFD Radar Mode and Status Lines

Figure 11-19

HSI Format

This display shows navigation information in a traditional 360-degree full compass rose format.

NOTE

Weather Radar, Terrain and TCAS information cannot be displayed in HSI format.

The following sections are part of the HSI format:

- **Status Line:** This line displays the current UTC time, True Airspeed (from ADC), Ground Speed (from FMS) and temperatures (from ADC)
- **On-side Course Display:** The (left) display window shows on-side course information in green, yellow or white (VOR / LOC on-side green, VOR / LOC cross-side yellow, FMS on-side white or FMS cross-side yellow). This information is the active NAV course data displayed on the on-side PFD

The top line annunciates the NAV source and shows a numeric course readout. The NAV source is selected on the DCP. The CRS readout shows the course to the selected navaid station or next waypoint (also indicated by a single-line course pointer).

The next line is a station identifier and numeric distance readout. The station identification of the tuned navaid or next waypoint displays with the distance to that position (in nautical miles). The NAV source is boxed and red if the NAV data is invalid.

- **Cross-side Course Display:** The (right) display window shows cross-side course information in cyan. This information is the active NAV course data displayed on the cross-side PFD. A dual dashed-line course cyan pointer also indicates cross-side course

NOTE

Cross-side course information is selected or deselected for display by the PUSH X-SIDE switch on the DCP.

Compass Rose

The compass rose contains index markings every five degrees and alphabetic or numeric markings displayed at 30-degree intervals. Additional fixed index marks display outside the compass rose perimeter at 45-degree intervals with respect to the lubber line.

Airplane Symbol

A stationary airplane symbol displays in the center of the compass rose. This symbol points directly toward the lubber line.

Lubber Line

The lubber line is a fixed symbol at the top of the compass rose. The current airplane heading is the compass reading directly under the lubber line.

Selected Heading Bug

A heading bug symbol marks a selected heading reference. Turn the HDG knob on the FCP to move the heading bug around the compass rose. Momentarily pushing the center switch (PUSH SYNC) of the knob resets the heading bug to the current airplane heading.

Selected Heading Display

This display numerically shows the position of the selected heading bug. This display appears when the HDG knob is turned and disappears three seconds after rotation stops.

Drift Angle Pointer

This pointer is a small green circle that shows the airplane drift angle.

Bearing Pointers

There are two bearing pointers that may be selected for display (BRG buttons on DCP). One pointer is a single bar and the other pointer is a dual bar. Each pointer shows the bearing to a selected navaid station or the next FMS waypoint. The appropriate source for the bearing pointer is displayed below it.

Course Pointers

The on-side course pointer is a solid-line pointer. This pointer shows the on-side NAV course. This value is numerically repeated in the on-side course display. Push the DCP X-SIDE button to display the cross-side cyan course pointer.

The cross-side course pointer is a dual dashed-line cyan pointer. This pointer shows the cross-side NAV course. This value is numerically repeated in the cross-side course display.

To/From Symbol

A triangle symbol shows “to” or “from” direction. This symbol turns as a part of the on-side course pointer and points toward the tuned station or next waypoint.

Lateral Deviation Bars

The lateral deviation bars are the center portions of the course pointers. Each bar moves left or right from the pointer to show lateral deviation from the NAV course.

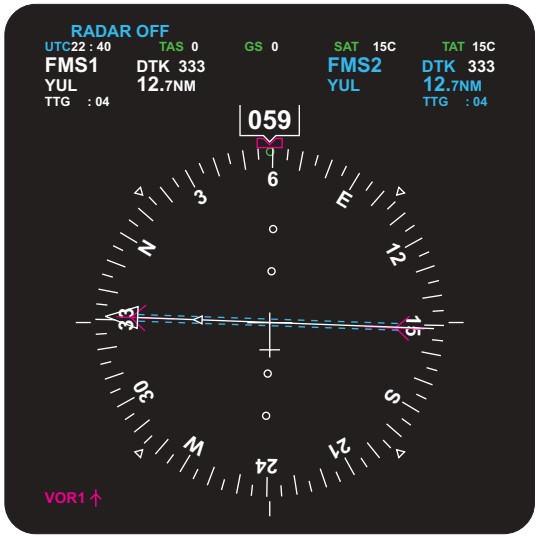
Lateral Deviation Scale

The lateral deviation scale consists of four dots that display perpendicular to the on-side course lateral deviation bar. Two dots display on either side of the airplane symbol.

Vertical Deviation Display

The ILS glideslope or the FMS VNAV vertical deviation display appears when all appropriate conditions are met. The on-side DCP selects LOC/FMS as the active NAV source. If, or as deviation data becomes invalid, this display is replaced with a red GS icon. When FMS VNAV deviation data is invalid, the deviation scale and pointer are removed. When making a back course approach, the scale displays without a pointer or flag annunciation.

ILS/GS vertical deviation is shown by the position of a green diamond-shaped pointer relative to the deviation scale; whereas a white star pointer shows the FMS VNAV vertical deviation. The scale consists of two dots above and two dots below center. If GS deviation becomes excessive, the pointer and scale flash yellow.



MFD HSI Format

Figure 11-20

NAV Sector Format

This display shows navigation information on an enlarged section of the compass rose. The following sections are part of the NAV sector format.

On-side Course Display

The (left) display window shows on-side course information in green, yellow or white (VOR/LOC on-side green, VOR/LOC cross-side yellow, FMS on-side white or FMS cross-side yellow). This information is the active NAV course data displayed on the on-side PFD.

Cross-side Course Display

The (right) display window shows cross-side course information in cyan. This information is the active NAV course data displayed on the cross-side PFD.

NOTE

Cross-side course information is selected or deselected for display by the PUSH X-SIDE switch on the DCP.

Range Rings

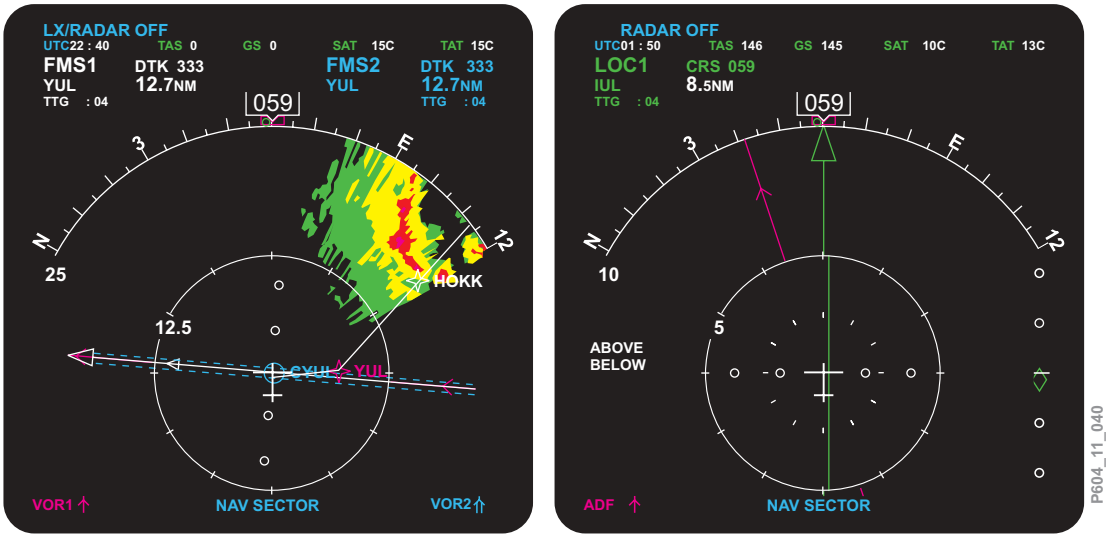
There are two range rings, which provide a distance scale to help visualize the airplane position relative to navaid symbols and weather radar targets. A distance annunciator displays by each ring. The RANGE knob (on the DCP) selects a desired display range. The possible full-scale ranges are 5, 10, 25, 50, 100, 200, 300 and 600 nm (maximum is 300 nm with WX selected on).

The outer range ring is a 120-degree sector of the compass rose. This arc contains index markings every five degrees and alphabetic or numeric markings every 30 degrees. The inner range ring is a circle that is centered on the airplane.

NAVAID Display

The NAVAID display shows airplane heading, selected heading, on-side course, cross-side course, bearing, vertical deviation and wind information.

The sector format may display (only) two or three navaid symbols. These symbols are generated using bearing/distance information (not FMS map data). VORTAC symbols with station identifiers display if the two actively tuned VOR stations are within range and data is valid. The TO waypoint of the FMS flight plan will also display. No other navaid symbols display on the sector format.



SECTOR FORMAT WITH CROSS-SIDE DATA SELECTED AND WEATHER RADAR OVERLAY

SECTOR FORMAT APPROACH

MFD Sector Format

Figure 11-21

FMS Map Format

This format shows a dynamic geographic depiction of the flight as it occurs. The map display is always centered on the airplane present position with current heading toward the top of the screen. The screen shows a moving map display of flight plan symbols and background navaid symbols relative to airplane present position.

NOTE

An FMS data window may be displayed on the FMS map.

Airplane Symbol

This symbol is a reference used to visualize airplane position relative to the geographic map and radar targets. The airplane symbol is stationary and always displayed in the center of the screen. The navaid symbol, radar targets and flight plan line move down the screen as the flight progresses.

Range Rings

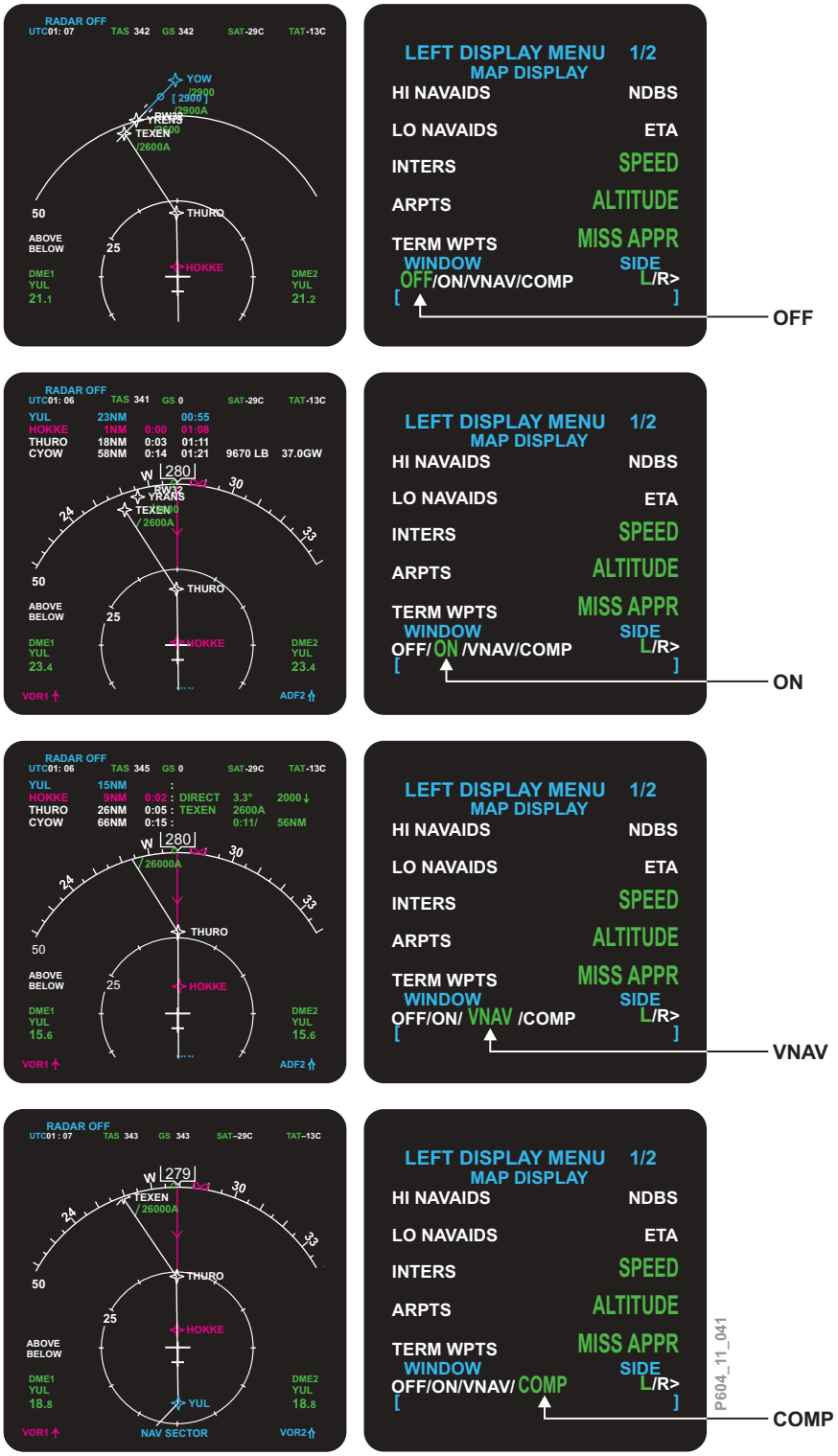
There are two range rings displayed, which provide a distance measuring scale. These rings show distance from the airplane. A distance annunciator displays by each ring. The RANGE knob (on the DCP) selects a desired display range. The possible full-scale ranges are the same as for NAV Sector format.

NAV Display

The NAV display shows the FMS flight plan line and a background navigation map. The map consists of navaid symbols generated from the FMS database. The FMS flight plan displays on the map as a solid white line. This track line consists of straight-line segments connecting consecutive flight plan waypoints. The TO waypoint displays in magenta. FMS-generated navaid and map symbols are cyan.

Data Window

The data window displays FMS progress parameters for the FROM, TO, NEXT and Destination waypoints in the flight plan. The CDU is used to select the various options of the data window. The data window can be selected to ON, COMP, VNAV, or OFF.



MFD Data Window

Figure 11-22

Plan Map Format

This format shows a static geographic depiction of a section of the flight plan (or a selected route). Use this map as a visual aid to enter a new flight plan/route or to plan a deviation from the flight plan/route.

The plan map is always presented with true North at the top of the screen. This screen shows flight plan/route symbols and background navaid symbols within range. The (dynamic) weather radar, terrain and TCAS cannot be overlaid onto the (static) plan map.

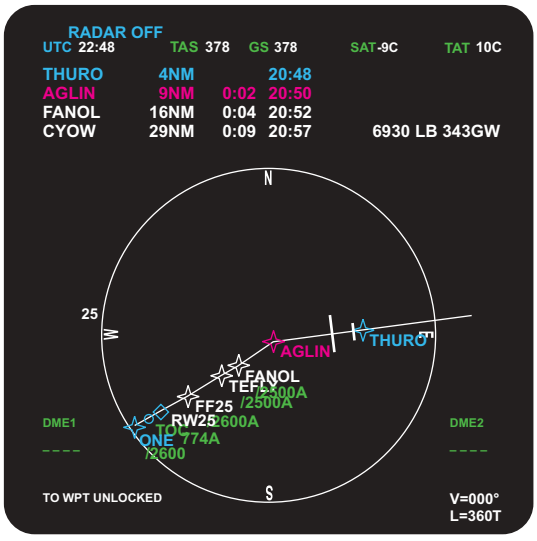
Optional “Precision Plus” FMS upgrades incorporate a 3D-map capability on the plan map page.

Range Ring

A range ring provides a distance measuring scale. This ring shows distance from the center waypoint. The range rings also display a range distance. The RANGE knob on the DCP selects the desired range. The possible full-scale ranges are 5, 10, 25, 50, 100, 200, 300, and 600 nm.

NAV Display

The NAV display shows the FMS flight plan or route line and a background navigation map. The map consists of navaid symbols generated from the FMS database. The FMS-generated navaids and map symbols are cyan. The active FMS flight plan/route displays on the map as a solid white line. This track line consists of straight line segments connecting consecutive waypoints. The TO waypoint displays in magenta.



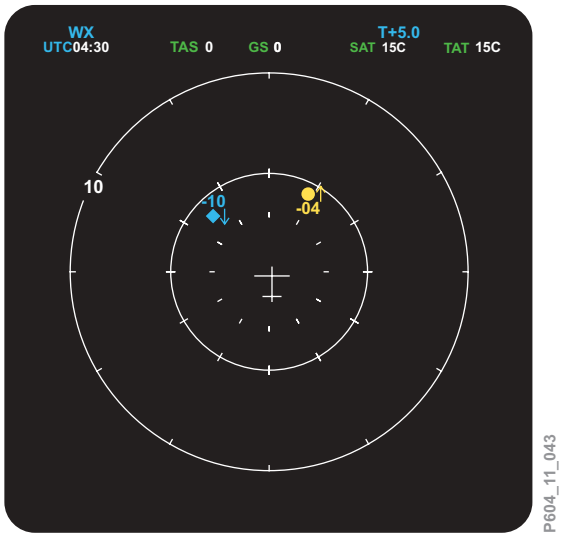
MFD FMS Plan Map Format

Figure 11-23

TCAS Format

The TCAS format provides a dynamic map with a complete 360-degree circular representation which is dedicated to TCAS information. Weather radar information can be overlaid on this page.

For further details on TCAS see Chapter 17 Navigation Systems.



MFD TCAS Format

Figure 11-24

Radio Altimeter

Description

The radio altimeter measures direct radio height (distance above terrain) for use by the Flight Control Computers (FCCs) and for display on the PFDs.

Components and Operation

The radio altimeter (RA) system consists of the following components:

- one Receiver/Transmitter
- one Radio Altitude Converter
- one Transmit Antenna
- one Receive Antenna
- Associated Components:
  - two Air Data Reference Panels (ADRPs)
  - two PFD Indicators

NOTE

In order to conform to JAA CAT II certification requirements, service bulletin 604-34-005 indicates that the installation of a second RA is required.

Receiver/Transmitter

The receiver/transmitter transmits, receives and processes RF signals to provide a display of radio altitude and decision height information on the pilot's and copilot's PFDs. The receiver/transmitter performs this function by measuring the difference in frequency between the transmitted and received signals. Internal monitoring and self-test capabilities are also provided.

Antennae

The system uses two identical, linearly polarized antennae, flush-mounted on the underside of the airplane along the centerline. The forward antenna is used to transmit and the aft antenna to receive.

Radio Altitude Display

The radio altitude of the aircraft is displayed both in digital and analog format on the PFD.

This numeric display appears at the bottom of the attitude indicator as the airplane descends through 2500 feet above ground level (AGL) and disappears as the airplane climbs through 2500 feet AGL.

Analog Radio Altitude Scale

A small window appears at the center of the scale as the airplane descends through 1250 feet AGL. This window marks the current radio altitude. This value is numerically repeated in the bottom portion of the attitude indicator.

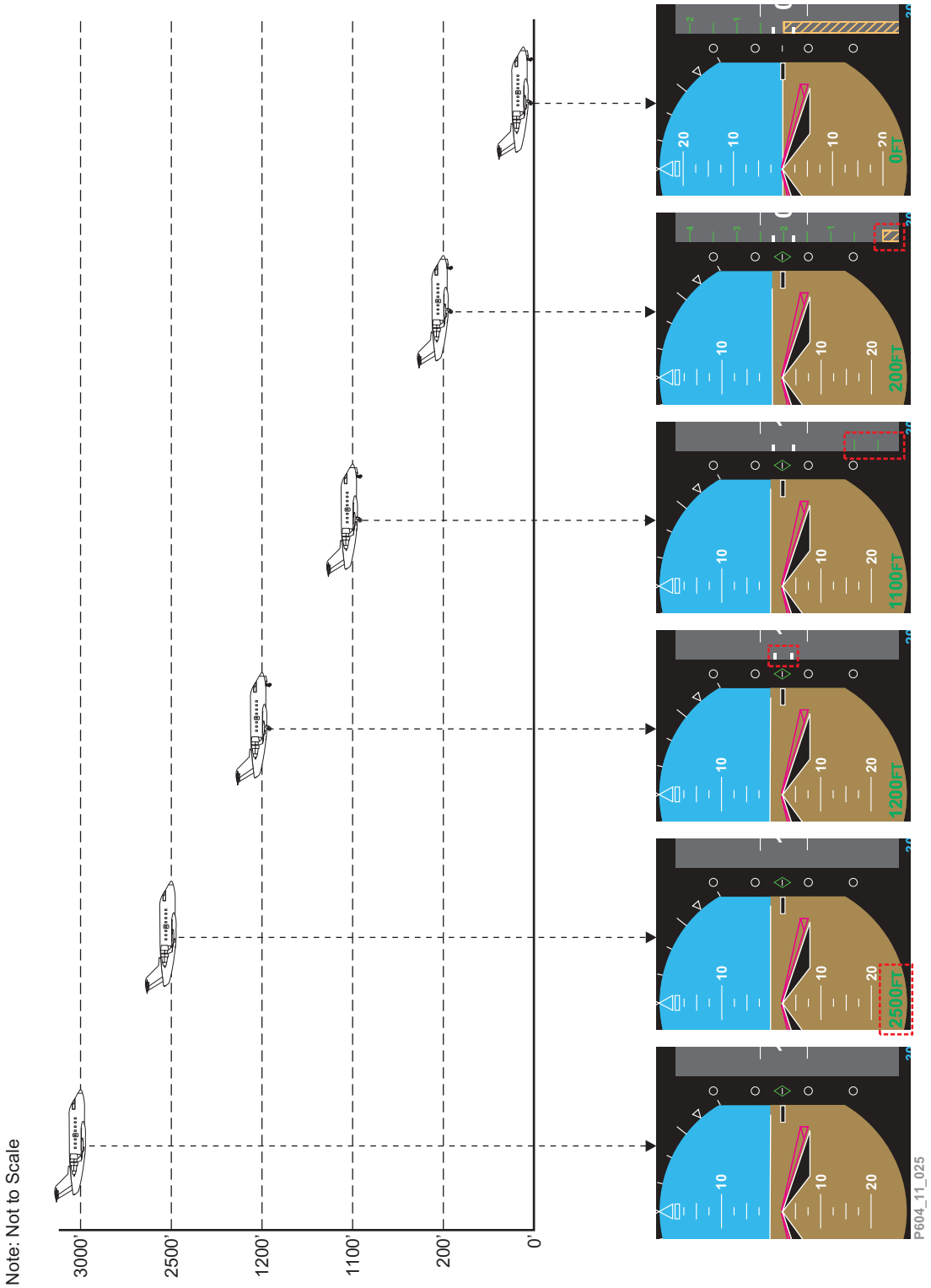
An analog radio altitude scale appears as the airplane descends through 1100 feet AGL. This analog scale is used in conjunction with the ground bar (rising runway) to assist in visualization of the aircraft's height above terrain. The scale contains line marks and single-digit numeric labels. Each digit indicates 100 feet of radio altitude.

NOTE

At Decision Height (DH), the numeric label and scale change from green to yellow.

Ground Bar (Rising Runway)

A ground bar displays on the analog radio altitude scale to represent the terrain. As the airplane descends through 200 feet AGL, the ground bar rises on the analog scale. At 0 feet radio altitude, the top of the ground bar aligns with the center of the scale.

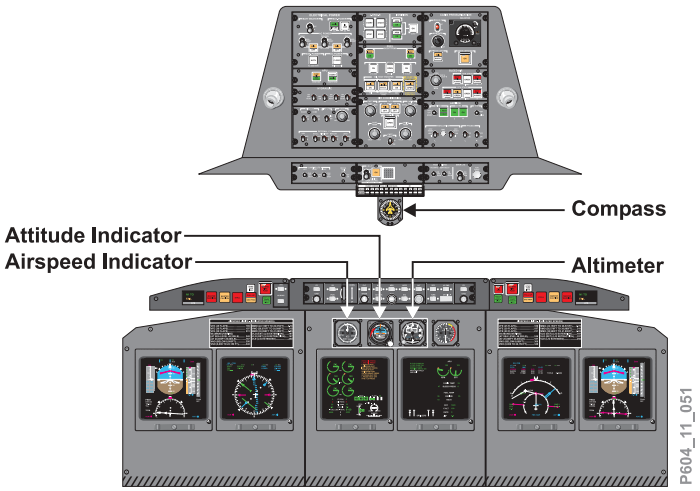


Radar Altimeter Display

Figure 11-25

Standby Instruments

The standby instruments include an airspeed indicator, altimeter, attitude indicator and compass.

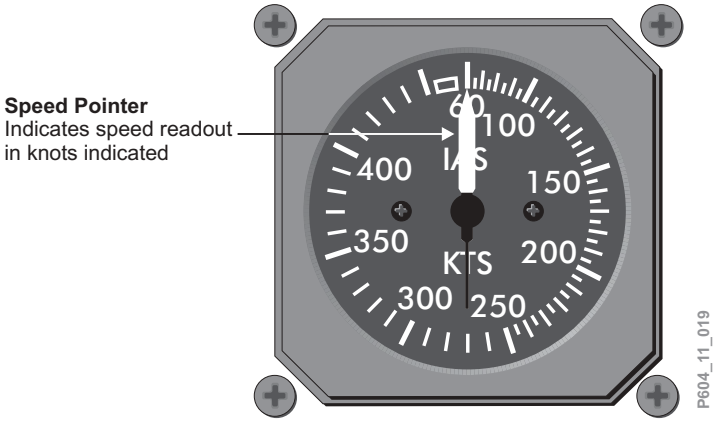


Standby Instruments Locator

Figure 11-26

Standby Airspeed Indicator

The airspeed indicator supplies non-corrected (indicated) airspeed. It uses the standby pitot source P3 and the standby static ports S3.

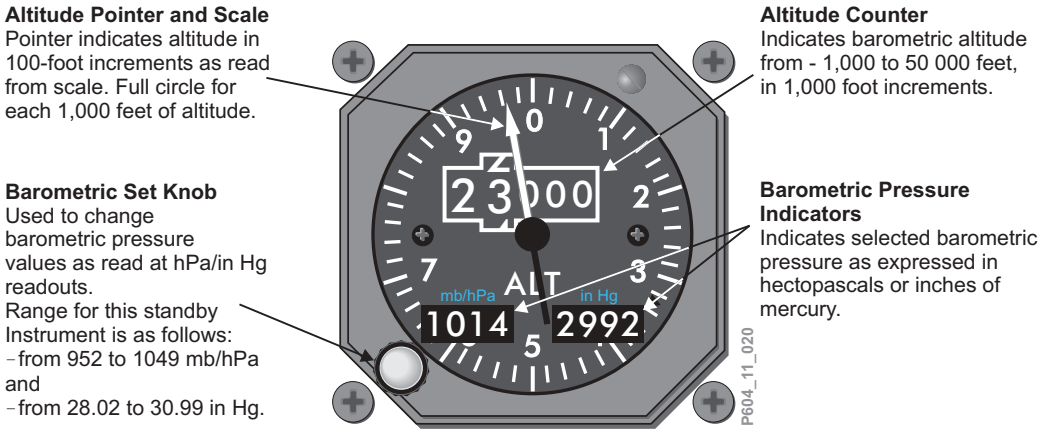


Standby Airspeed Indicator

Figure 11-27

Standby Altimeter

The standby altimeter incorporates an altitude pointer and an altitude counter. The altitude pointer and altitude counter operate through a mechanical linkage connected to a pressure capsule. The pressure capsule moves with changes in static pressure. Barometric correction is selected by a knob at the bottom right of the instrument and displayed in inches of mercury and hectopascals. The instrument receives its static pressure from the standby static ports S3.

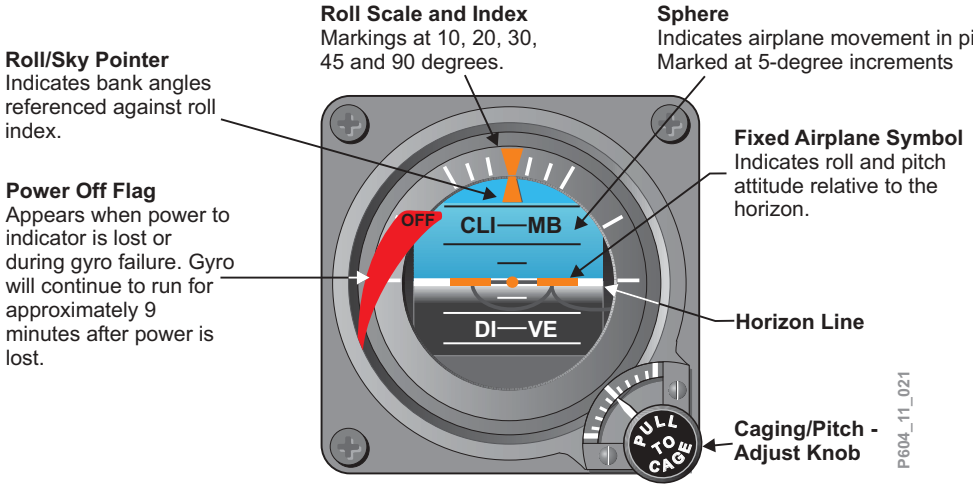


Standby Altimeter

Figure 11-28

Standby Attitude Indicator

The standby attitude indicator has an electrically-operated vertical gyroscope. The gyroscope is mechanically connected to the sphere to show attitude information. To cage or uncage the instrument, the PULL TO CAGE knob is pulled and turned. When the instrument is uncaged, the cage knob is turned to adjust the pitch reference.

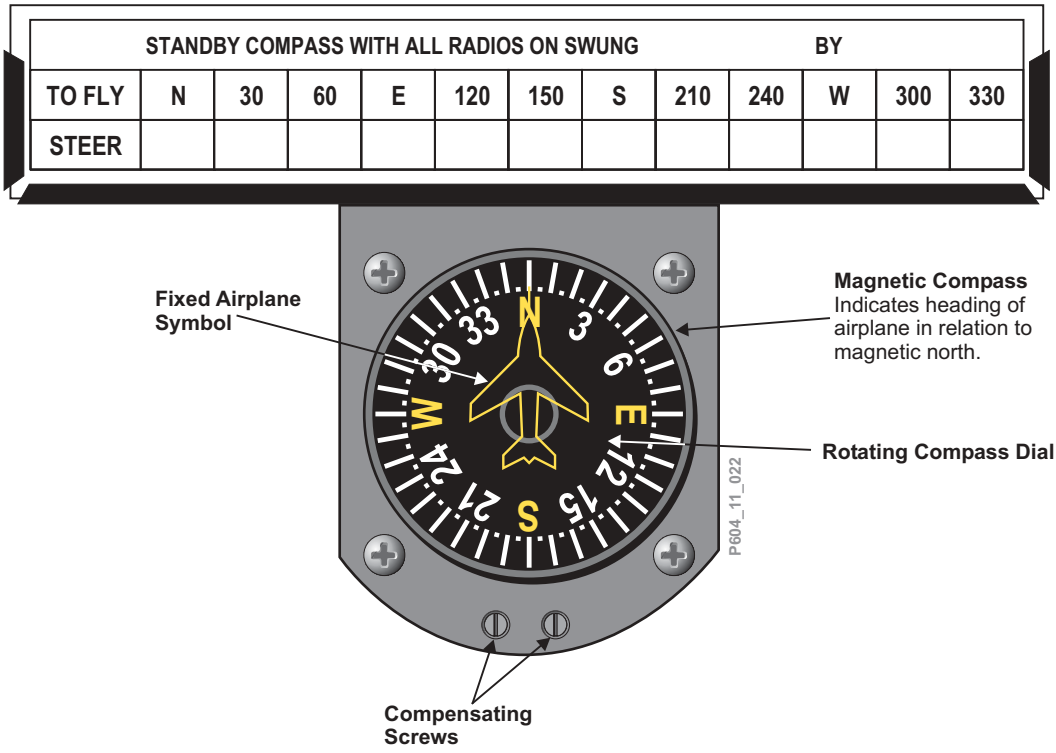


Standby Attitude Indicator

Figure 11-29

Standby Compass

The standby magnetic compass is a self-contained dry unit, which uses eddy current damping to prevent overshooting. The standby compass is installed below the overhead panel.

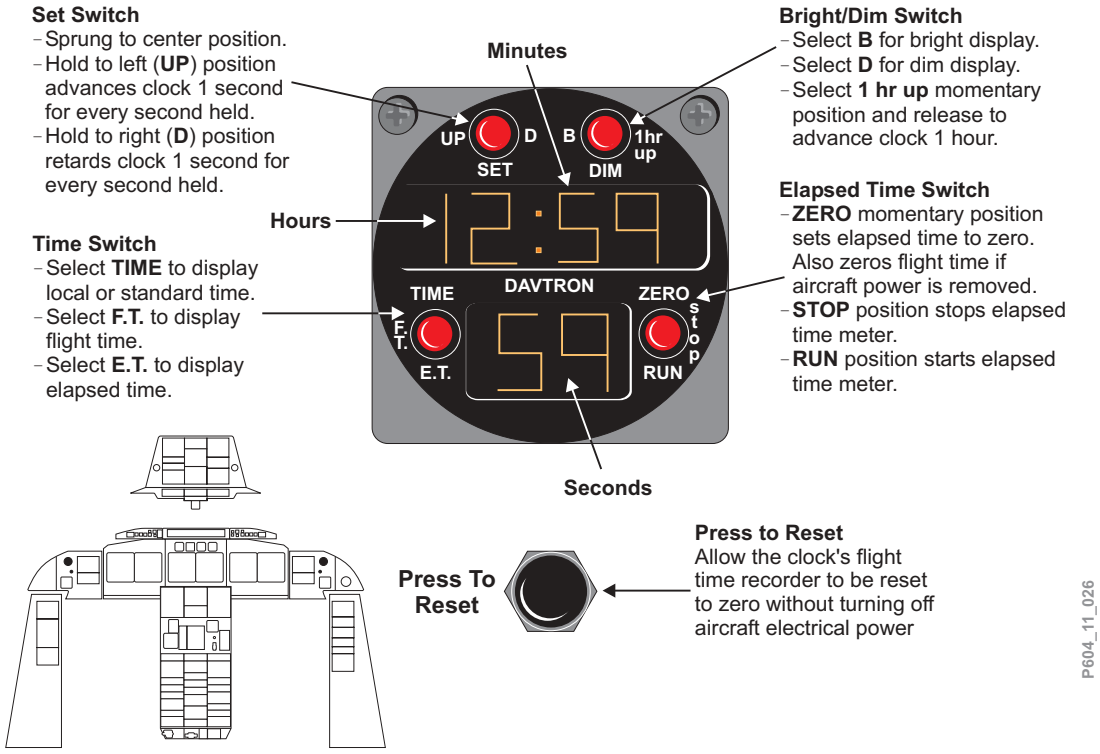


Standby Compass

Figure 11-30

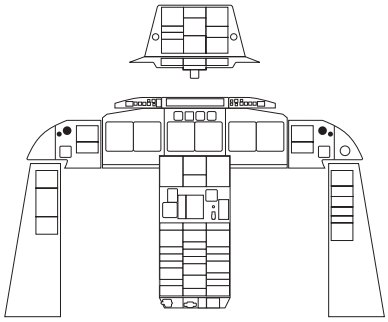
Aircraft Clocks

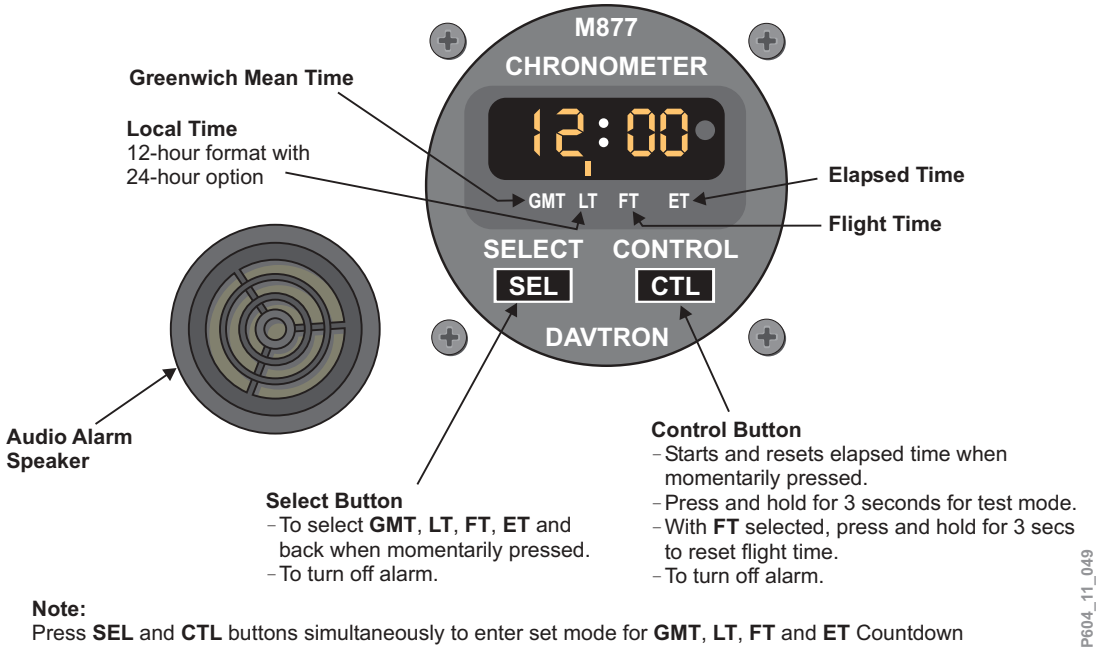
The digital clocks are located on the side panels of the pilot and copilot.
The clocks can display local time, flight time and elapsed time.
Starting with A/C 5331, the clocks have been changed to add a GMT time display.



Clock Prior to A/C 5331

Figure 11-31





Note:
Press **SEL** and **CTL** buttons simultaneously to enter set mode for **GMT**, **LT**, **FT** and **ET** Countdown

Clock A/C 5331 and Later

Figure 11-32

Display Reversionary Panel

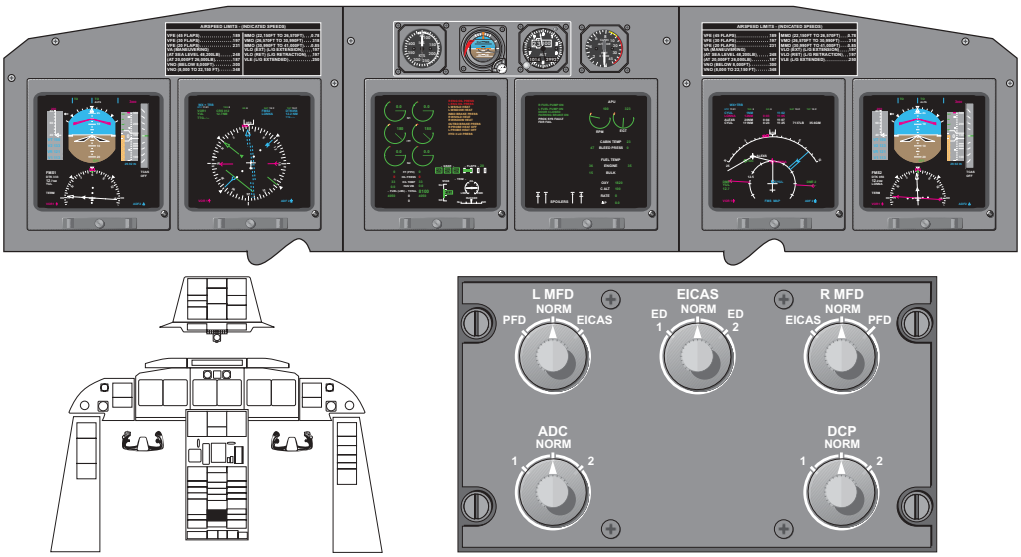
The display reversionary switches on the Display Reversionary Control Panel are used to select the desired reversion mode of the L(R) MFD.

Both the L MFD and the R MFD can be set to one of three positions:

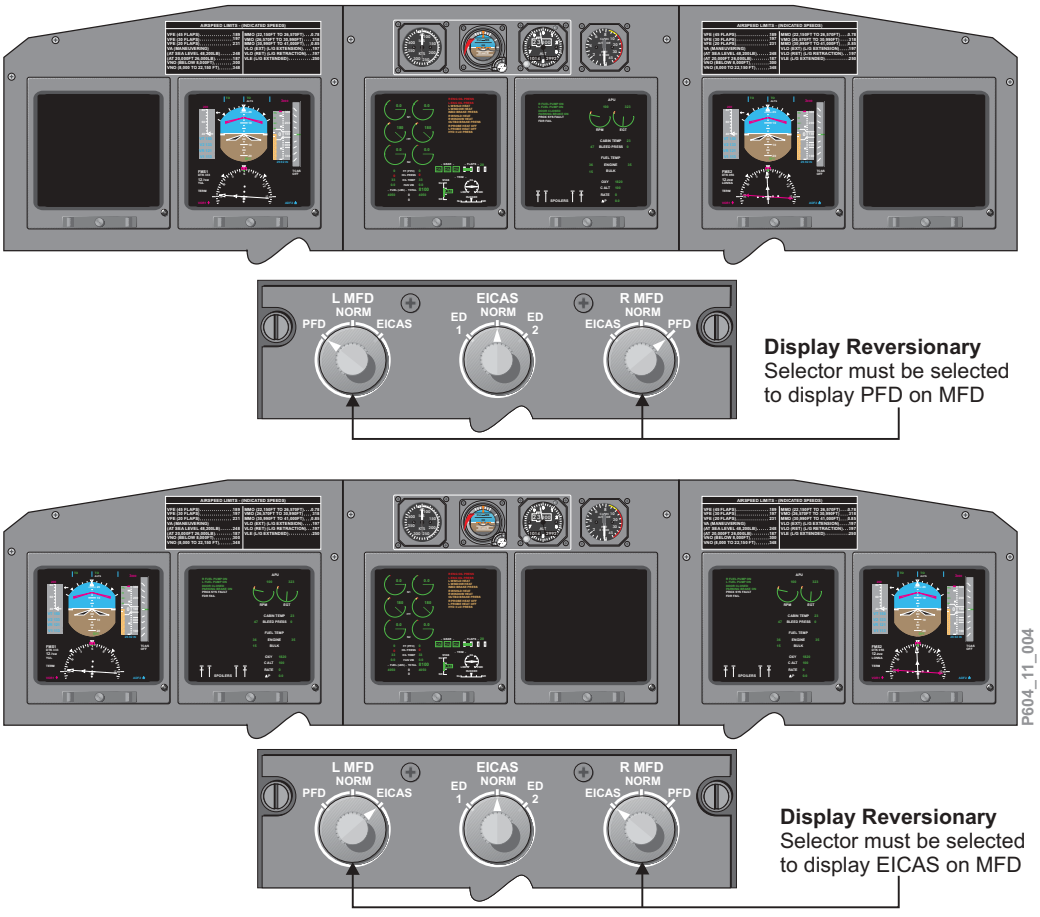
- **Norm**: The MFD operates in the NORM position and displays navigation, weather radar, terrain or TCAS information as selected on the Display Control Panel
- **PFD**: By turning either the L MFD or the R MFD rotary selector to PFD, the associated PFD is now transferred to the selected MFD
- **EICAS**: By turning either the L MFD or the R MFD rotary selector to EICAS, the STATUS page will be displayed on the selected MFD. The EICAS Control Panel then controls EICAS page selections

Abnormal Conditions

In the event of a DCP failure, a red boxed DCP shows on the affected PFD. To allow selection of the operating DCP, a reversionary selector switch is provided on the reversionary panel. This switch has three positions, NORM, 1, or 2. In the NORM position, each DCP controls its own MFD. In either the 1 or the 2 position, the remaining DCP controls the display on both MFDs.



REVERSIONARY SELECTORS -
DISPLAY REVERSIONARY CONTROL PANEL



Display Reversionary Panel

Figure 11-33

EICAS Messages

MESSAGE	MEANING	AURAL WARNING (IF ANY)
EFIS COMP MON	Indicates mismatch detected between on-side and cross-side data.	
EFIS COMP INOP	EFIS comparator has failed.	

EICAS Messages
Table 11-1