CHAPTER 12 – FLIGHT INSTRUMENTS

LIST OF ILLUSTRATIONS

STANDBY INSTRUMENTS AND CLOCKS

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1. INTRODUCTION

Flight instruments include the electronic flight instrument systems, standby instruments and clocks. Data for the flight instruments is provided by an air data system, radio altimeter and inertial reference system (IRS). Flight instruments provide the following basic information to the flight crew: <1025>

- Altitude (barometric/radio)
- True Airspeed
- Airspeed (MACH/KIAS)
- Temperature Data
- Airspeed Trend
- Airplane Attitude
- Vertical Speed
- Heading Information
- Overspeed Warning
- Navigation Information

Electronic flight instruments consists of a primary flight display (PFD) and a multifunctional display (MFD) for each pilot. An integrated standby instrument (ISI) provides standby attitude, altitude and airspeed information to the flight crew. An independent standby compass provides aircraft heading in relation to magnetic north. A electronic clock provides the time source for the aircraft avionics equipment.

Air data provided by a pitot-static system and a temperature probe provide the flight instruments with speed, altitude and temperature data. The radio altimeter provides an accurate measurement of height above terrain at low altitudes. The inertial reference system (IRS) provides attitude, heading, position, angular rate and linear acceleration information. <1025>

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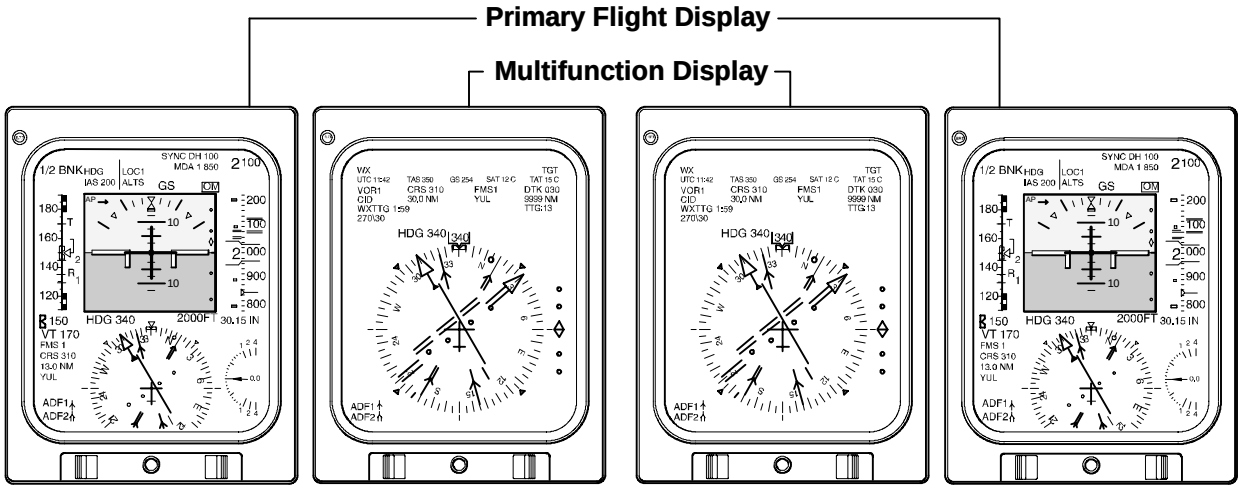
1. ELECTRONIC FLIGHT INSTRUMENT SYSTEM

All basic flight information is presented to the flight crew on Electronic Flight Instrument System (EFIS) displays. Each pilot instrument panel contains a primary flight display (PFD) and a multifunctional display (MFD). All four displays are electronically identical to permit transfer of display data.

Each PFD has the primary function of pictorially showing aircraft attitude, altitude, airspeed, flight director commands and flight mode annunciations.

Each of the MFDs acts as a navigation system display and has a primary function of showing current heading (compass) and course information. The MFDs can also display moving map navigation pictorials, navigation sensor data, weather radar targets, and TCAS traffic (see Chapter 18). Cross–side compass information and backup navigation information can be superimposed on either display. EICAS information can also be displayed on either MFD.



EFIS – General <1015>
Figure 12–20–1

A. Display Reversion

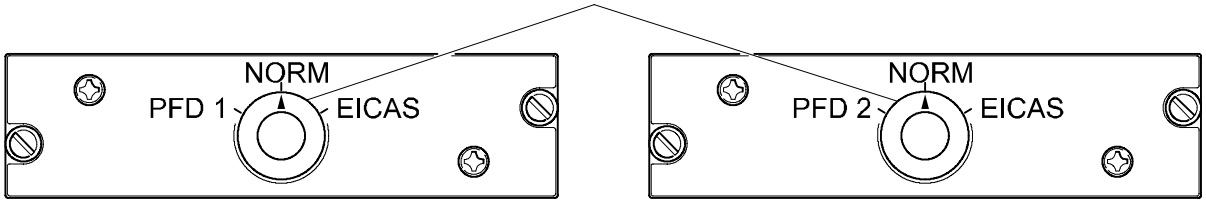
Two display reversionary panels are installed in the flight compartment. One panel is installed on the pilot's side panel and the other panel is installed on the copilot's side panel. In the event of a primary flight display (PFD) failure, all data normally displayed on it can be transferred to the adjacent MFD by turning the display selector knob on the respective reversionary panel to the PFD position.

NOTE

The MFD information cannot be transferred to the PFD.

Selecting the EICAS position, on the reversionary panel, will initially display the EICAS status page on the respective MFD. All the other EICAS pages are available for display on the MFD, through selections on the EICAS control panel.

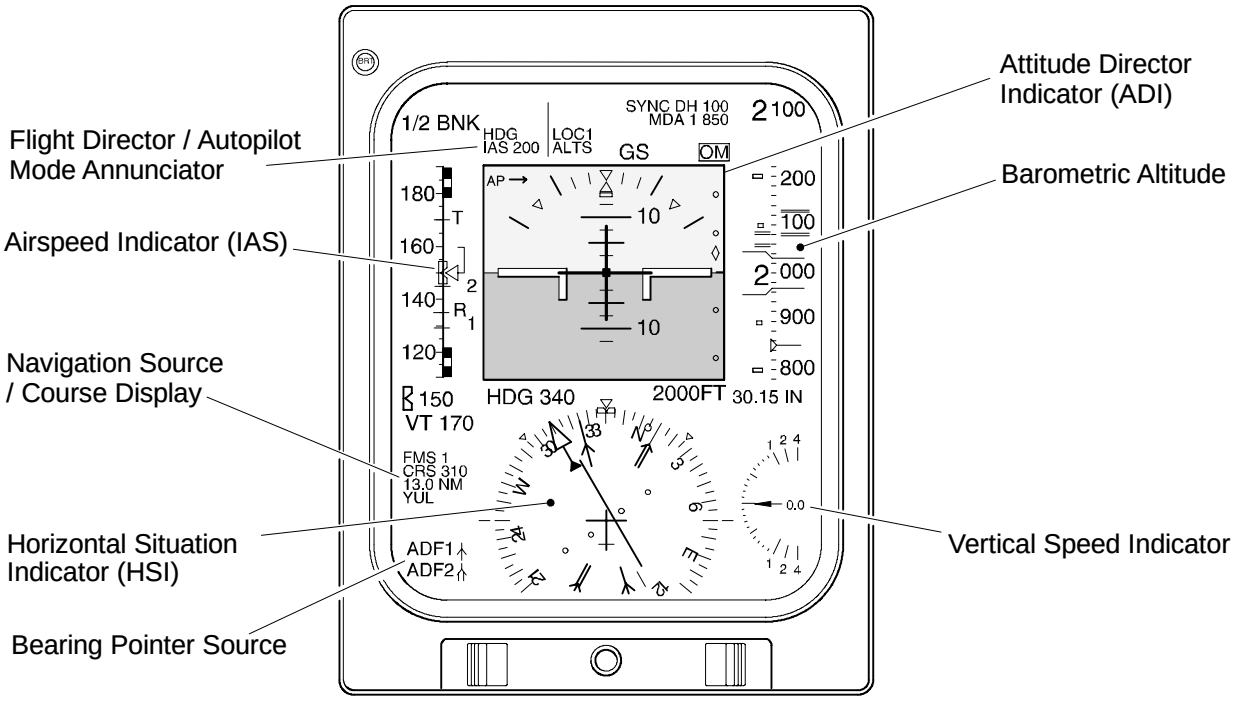
Display Selector
Used to convert the pilot's or copilot's MFD to display EICAS or PFD information.
- EICAS - All EICAS information is available on the respective MFD through selection on the ECP.
- PFD - Power is removed from the respective PFD. All PFD information is then displayed on the MFD.



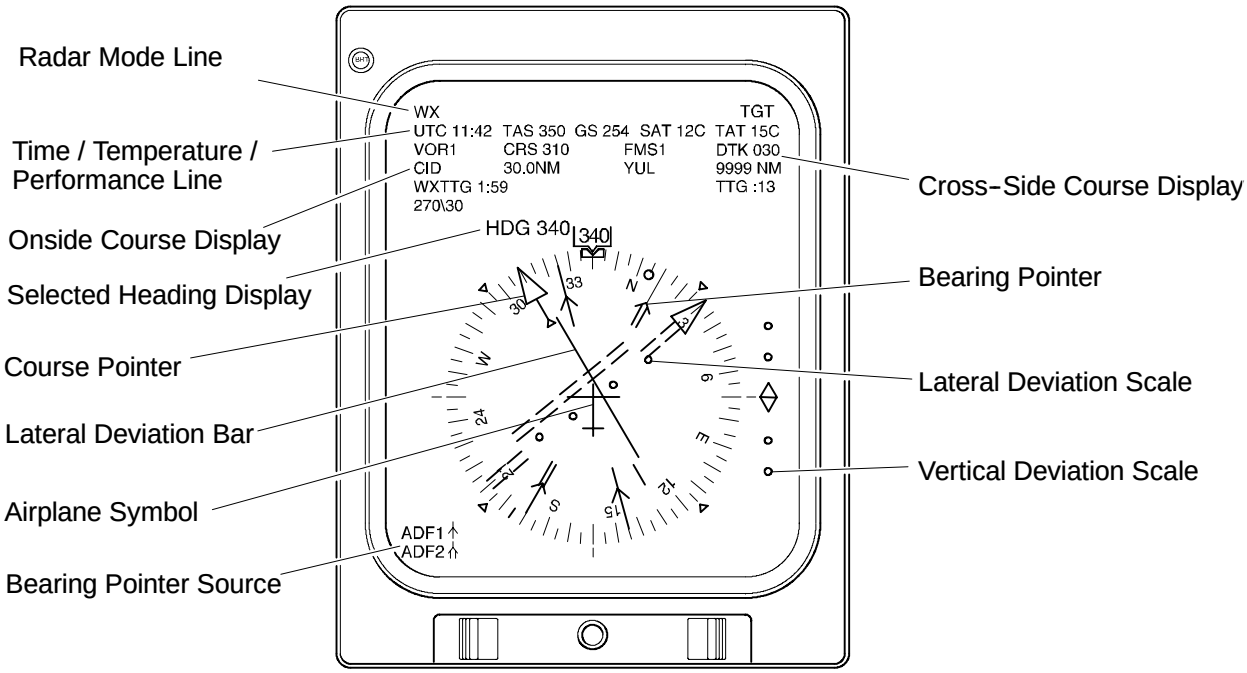
Pilot's Display Reversionary Panel
Pilot's Side Panel

Copilot's Display Reversionary Panel
Copilot's Side Panel

Display Selection
Figure 12-20-2



Primary Flight Display
Pilot's and Copilot's Instrument Panels



Multifunction Display - HSI Mode
Pilot's and Copilot's Instrument Panels

Primary Flight Display and Multifunction Display <1015>
Figure 12-20-3

B. Display Control

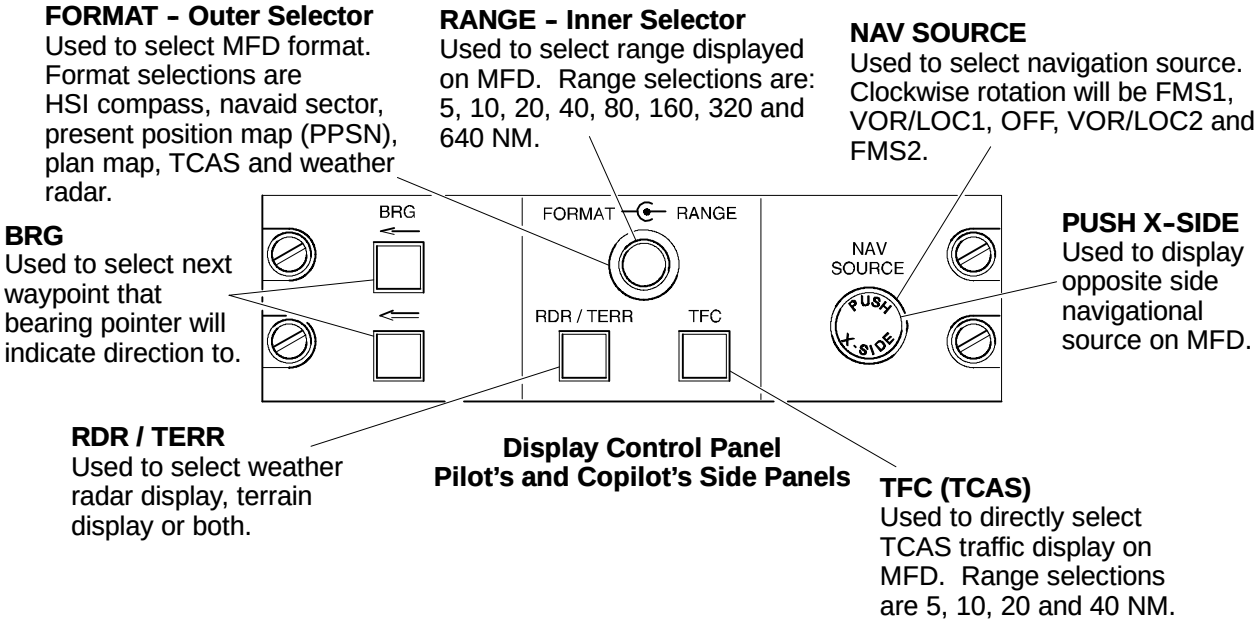
Two display control panels are installed in the flight compartment. One panel is installed on the pilot's side panel and the other panel is installed on the copilot's side panel. Each panel provides the pilot and copilot control of their respective PFD and MFD.

The control selections are as follows:

- MFD format selection
- Bearing pointer selection
- Navigation source selection
- Cross side navigation data and course display

The rotary FORMAT knob can be used to select one of the following navigation formats:

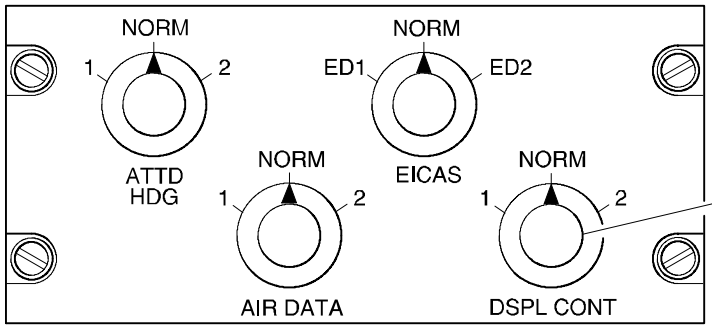
- HSI compass
- Navaid sector map
- TCAS
- FMS present position map
- FMS plan map
- Weather radar



Display Control Panel
Pilot's and Copilot's Side Panels

Display Control Panel <2040>
Figure 12–20–4

If one display control panel fails, the other panel can be used to control all four electronic flight displays. This is done by selecting the DSPL CONT knob, on the Source Selector Panel, to the 1 or 2 position as required.

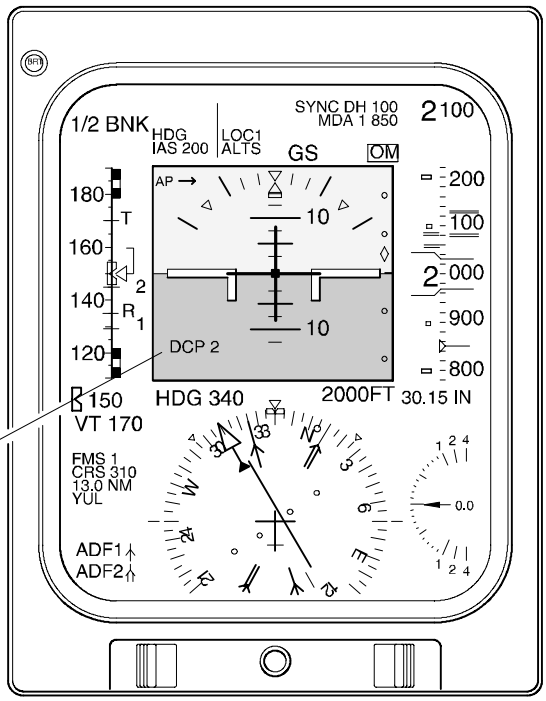


Source Selector Panel
Centre Pedestal

DISPL CONT
Used to revert pilot or copilot display control panel.

- NORM - Each display control panel controls its respective displays.
- 1 - Pilots display control panel controls all four displays. An amber source message is displayed on all displays.
- 2 - Copilots display control panel controls all four displays. An amber source message is displayed on all displays.

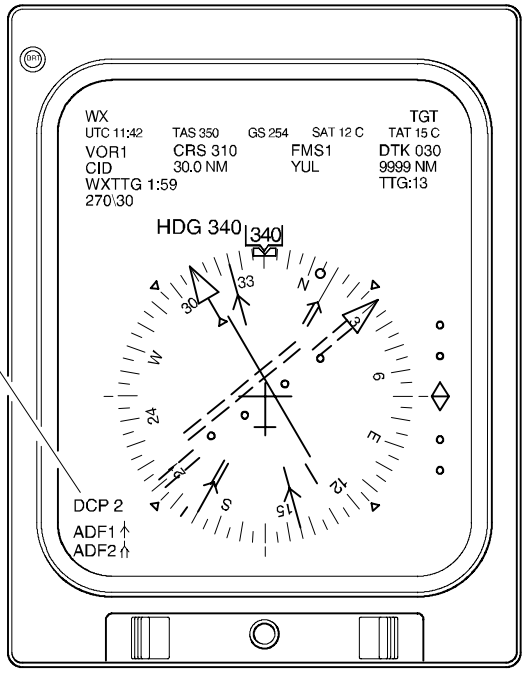
Source Selector Panel
Figure 12–20–5



DCP 1 or 2 (amber)
Indicates that single display control panel source has been selected.

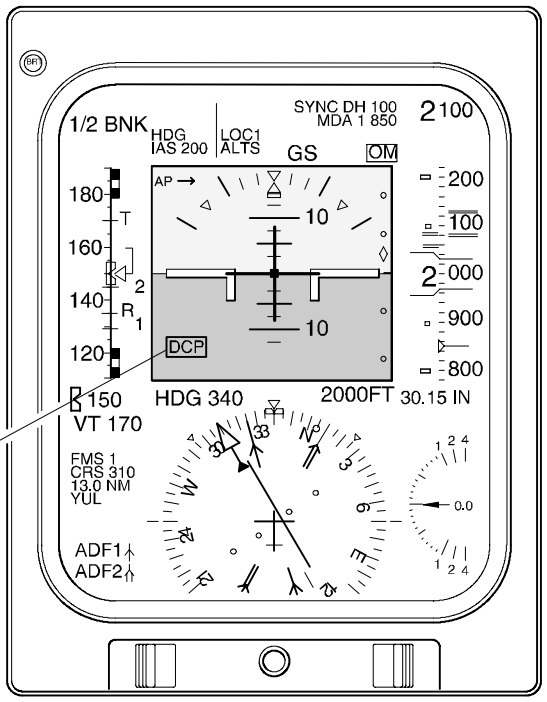
- DCP 1 - Pilot's display control panel selected.
- DCP 2 - Copilot's display control panel selected.

Primary Flight Display
Pilot's and Copilot's Instrument Panels

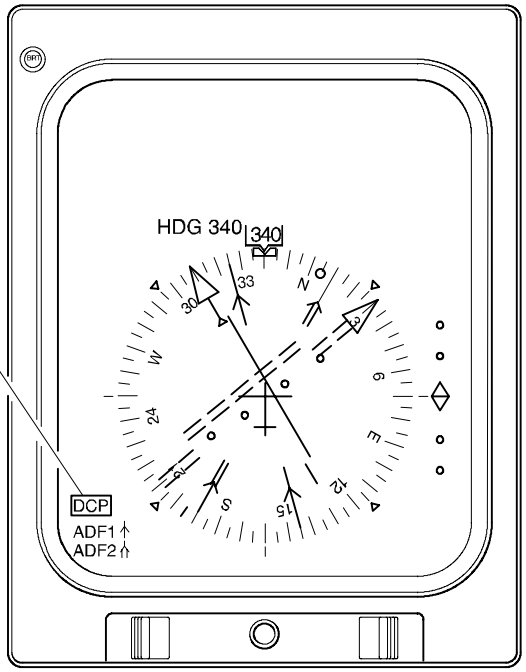


Multifunction Display – HSI Mode
Pilot's and Copilot's Instrument Panels

Display Control Source Indications <1015>
Figure 12–20–6



Primary Flight Display
Pilot's and Copilot's Instrument Panels



Multifunction Display – HSI Mode
Pilot's and Copilot's Instrument Panels

DCP, DCP 1 or DCP 2 Flag (red)
Indicates that selected display control panel has failed.

Display Control Source Flags <1015>
Figure 12–20–7

C. Comparator Function

A comparison of displayed data is performed by each PFD to ensure that the same data is shown on both PFDs. Comparison of roll, pitch, heading, altitude and airspeed information is performed continuously. Comparison for radio altitude, flight director pitch, ILS localizer and ILS glide slope are performed during precision landing. When a miscompare condition is detected, the miscompare indicator on both PFDs will flash amber for 5 seconds then come on steady, as long as the miscompare exists. An EFIS COMP MON caution message is also displayed on the EICAS primary page.

If the comparator monitor function is not available, an EFIS COMP INOP caution message is displayed on the EICAS primary page.

Comparator Indications

Heading (HDG) – The HDG indicator will display when the attitude is < 20 degrees and the difference is > 6 degrees.

Roll Attitude (ROL) – The ROL indicator will display when the difference is > 4 degrees before glideslope capture, and 3 degrees after.

Pitch Attitude (PIT) – The PIT indicator will display when the difference is > 4 degrees before glideslope capture, and 3 degrees after.

Indicated Airspeed (IAS) – An IAS difference of > 10 knots with the IAS > 90 knots will cause the IAS indicator to display. Airspeed indication tolerances are shown in the table that follows:

Airspeed (Knots)	Indicator Tolerances (Knots)	Difference Between Left and Right Indications (Knots)	ISI Tolerances (Knots)
60	±5	±3	±5
80	±3	±3	±4
100	±3	±3	±3
120	±3	±3	±3
140	±3	±3	±3
160	±3	±3	±3
180	±3	±3	±5
200	±3	±3	±5
260	±3	±3	±5
300	±3	±5	±5
360	±3	±5	±6

Altitude (ALT) – An ALT difference of > .002 X ABS (ALT1 + ALT2) will cause the ALT indicator to display. Altitude indication tolerances are shown in the table that follows:

NOTE

The following tables show comparator tolerances and should not be confused with operational tolerances.

D. Non RVSM Table

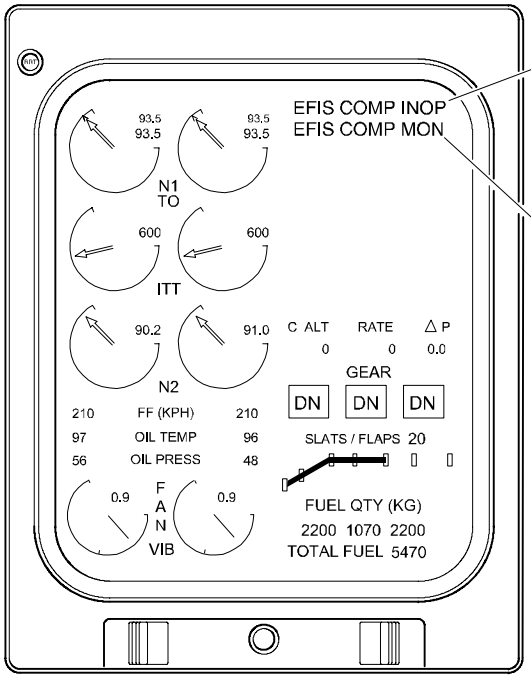
ALTITUDE (Feet)	PFD 1 and PFD 2 Tolerance (Feet)	ISI Tolerance (Feet)	The ALT comparator flashes when the altitude difference between the PFD's exceed (Feet)
-1000	±20	±20	64
0	±20	±20	60
1000	±20	±20	64
5000	±31	±30	77
10000	±38	±50	103
15000	±54	±60	130
20000	±62	±75	186
25000	±72	±100	203
30000	±82	±120	220
41000	±110	±153	238

E. RVSM Table

ALTITUDE (Feet)	PFD 1 and PFD 2 Tolerance (Feet)	ISI Tolerance (Feet)	The ALT comparator flashes when the altitude difference between the PFD's exceed (Feet)
-1000	±20	±20	64
0	±20	±20	60
1000	±20	±20	64
4000	±27	±30	77
10000	±30	±50	103
16000	±32	±65	130
22000	±32	±85	155
29000	±32	±110	186
33000	±32	±130	203
37000	±32	±140	220
41000	±32	±153	238

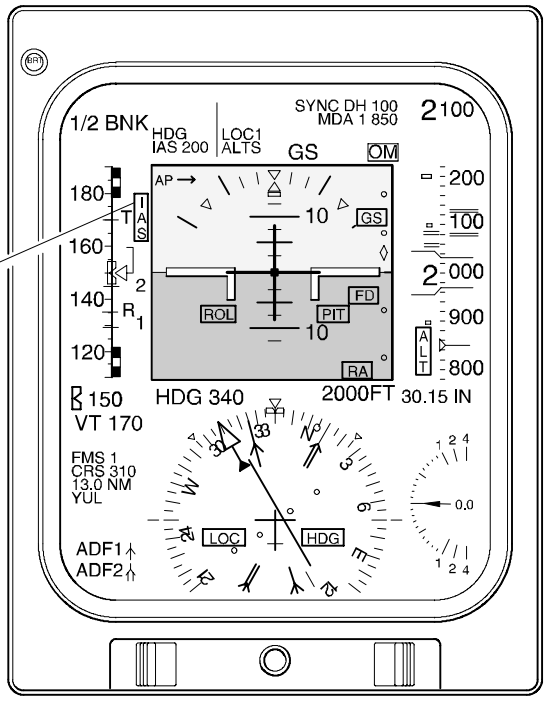
EFIS COMP INOP caution (amber)
Indicates that comparator information for one or both PFDs is not available.

EFIS COMP MON caution (amber)
Indicates that a comparator miscompare has been detected.



Primary Page

Comparator Warnings (amber)
Indicate that a comparator miscompare has been detected.



Primary Flight Display
Pilot's and Copilot's Instrument Panels

EFIS Abnormal Indications <1001, 1015>
Figure 12–20–8

F. System Circuit Breakers

SYSTEM	SUB–SYSTEM	CB NAME	BUS BAR	CB PANEL	CB LOCATION	NOTES
Electronic Flight Instruments	Pilot's Flight Instruments	PFD 1	DC ESSENTIAL	2	V10	
		MFD 1			V11	
	Dimming Control	EFIS CRT DIMMING			U4	
	Display Control Panels	EFIS CONT PNL 1			U7	
		EFIS CONT PNL 2	DC BUS 2		K3	
	Copilot's Flight Instruments	PFD 2			K1	
		MFD 2			K2	

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1. AIR DATA SYSTEM

Two air data computers (ADC 1 and ADC 2) provide the primary flight displays (PFD) with air data consisting of airspeed, altitude and vertical speed. The ADCs also provide computed air data (speed, altitude and temperature data) to various aircraft avionics systems. The ADCs convert pitot and static air pressure to electrical signals. The ADCs use static pressure to produce the altitude data and combine static and pitot pressure to produce the airspeed data. Resistance changes from a total air temperature (TAT) probe provide the ADCs with temperature data. The system is controlled by the air data reference panels and has warning and alert capabilities integrated with the EICAS. Selected speeds and altitude are set using the flight control panel (refer to Chapter 03-20-01).

A. Pitot Static System

The pitot static system supplies pitot and static air pressures to the ADCs, the integrated standby instrument (ISI) and the cabin pressure control panel (CPCP). The system consists of two pitot/static probes, an alternate pitot probe, alternate static ports and a total air temperature probe (TAT).

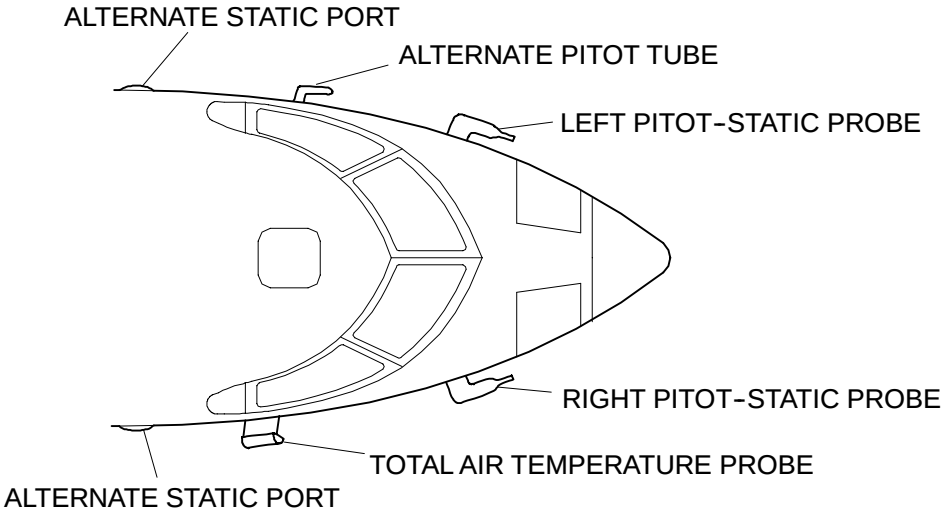
Each pitot static probe consists of a pitot mast and two static ports. Pitot pressure from each probe is supplied to the same side ADC. Static pressure from each probe is supplied to each ADC.

The alternate pitot probe and static ports supply pressure inputs to the integrated standby instrument (ISI).

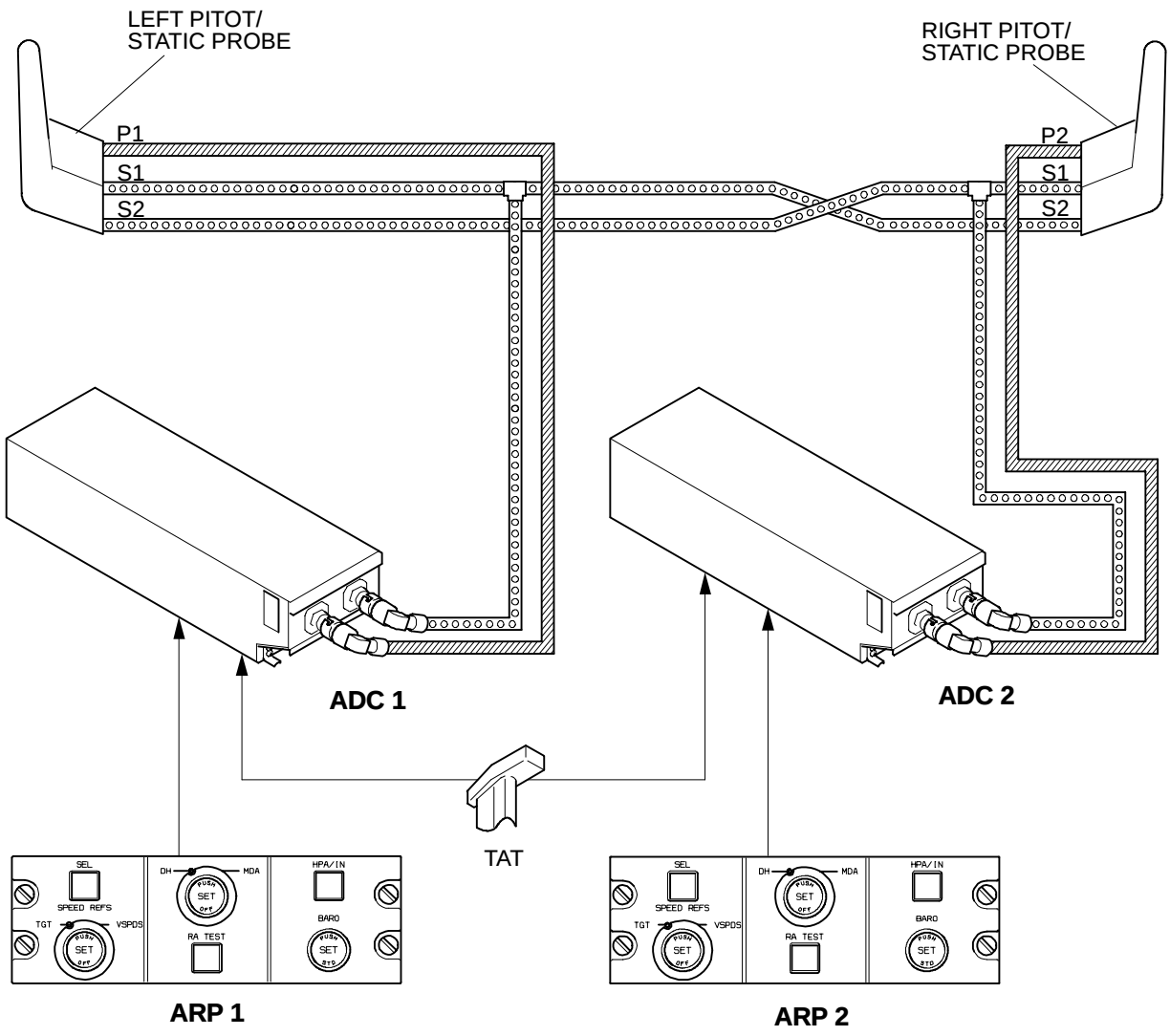
Electric heating elements protect the pitot-static and TAT probes from icing (refer to Chapter 15, Ice and Rain Protection).

NOTE

TAT probe readings are inaccurate when the aircraft is on the ground, due to probe heating to protect it from icing. TAT probe readings cannot be used to obtain the ambient static temperature before take-off.



Pitot Static System – General
Figure 12–30–1



Air Data System (ADS)
Figure 12–30–2

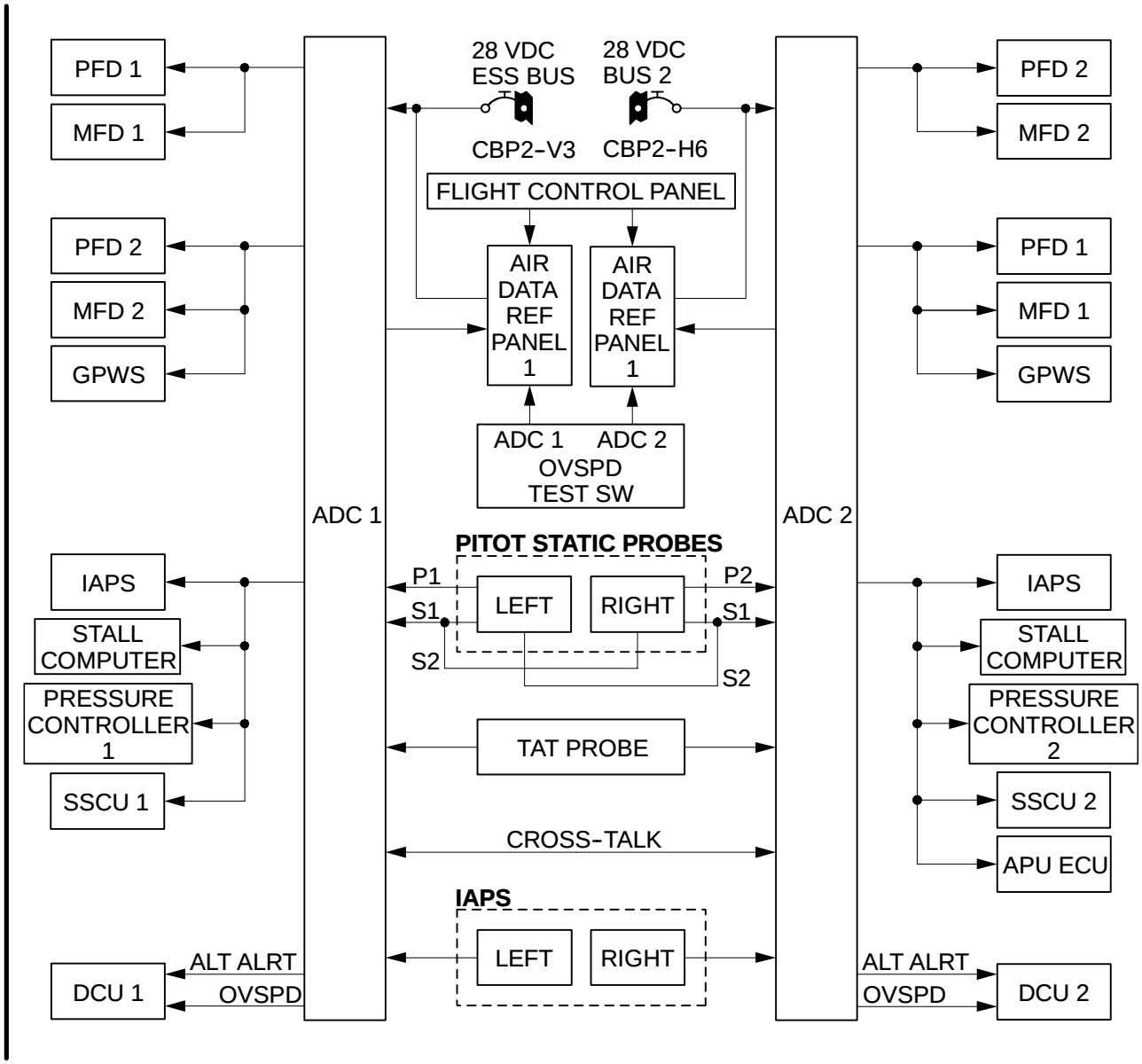
B. Air Data

The air data system provides the following air data parameters:

- Pressure altitude (corrected for static pressure errors)
- Vertical speed
- Calibrated and indicated airspeed (CAS / IAS)
- Mach number
- True airspeed
- Static air temperature (SAT)
- Total air temperature (TAT)
- Temperature variations from international standard atmosphere (ISA)

In addition to the above parameters, the air data system computes and controls the following reference values and parameters:

- Preselect altitude
- Airspeed trend vector
- Maximum allowable speed (V_{MO})
- Maximum allowable Mach (M_{MO})
- Baro corrected value
- Vertical speed references



Air Data System – Block Diagram
Figure 12–30–3

C. Air Data Reference Panels

The air data reference panels (ARP) are located on the pilot's and copilot's side panels. Each ARP is used to enable selection of airspeed reference pointers and barometric correction for altitude.

Each ARP functions with the same-side ADC, display control panel, primary flight display and multifunctional display. The ARP is divided into three sections:

- The speed references section is used to select and input changes to the various target and speed settings (V1, VR, V2 and VT). Both PFDs will display the same values.
- The altitude references section is used to set minimum descent altitude (MDA) and decision height (DH) values and to initiate radio altimeter self test.
- The barometric reference section is used to:
  - select and inputchanges to the ADC barometric pressure.
  - select indicating units (hPa or inHg).
  - set standard barometric pressure.
- Each PFD can have a different barometric pressure setting. The last value selected is retained in the ADC memory for the next power up.

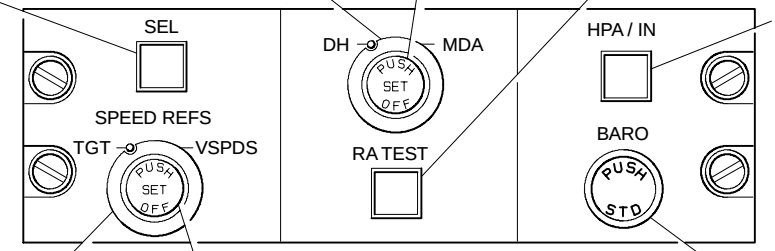
DH / MDA
Used to select decision height or minimum descent altitude.
- DH – Decision height readout is selected to be adjusted.
- MDA – Minimum descent altitude readout is selected to be adjusted.

PUSH / SET / OFF
Used to adjust selected altitude readout.
- When pushed, the selected altitude readout (DH or MDA) is displayed on the PFD.
- When rotated, the selected altitude readout is adjusted (DH in 1–ft. increments, MDA in 10–ft. increments).
- When pushed again, the selected altitude readout is removed.

SEL
Used to alternately select V1, VR or V2 to the edit field when VSPDS is selected.

RA TEST
Used to initiate radio altitude test.

HPA / IN
Used to alternately select the barometric pressure to be displayed in hectoPascals or inches of mercury.



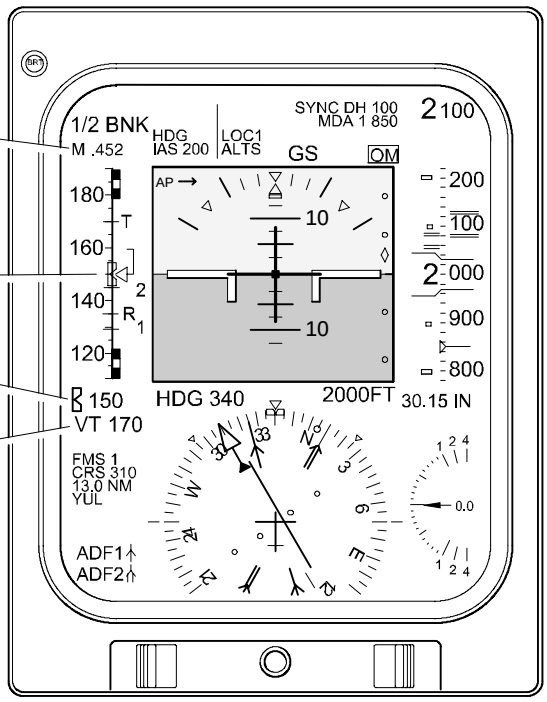
Air Data Reference Panel
Pilot's and Copilot's
Side Panels

BARO
Used to adjust barometric pressure.
- When pushed, the barometric pressure is set to the standard value of 29.92 inHg or 1013 hPa.
- When rotated, the barometric pressure setting is adjusted.

TGT / VSPDS
Used to select target or V speeds.
- TGT – VT speed is selected to be displayed on the edit field.
- VSPDS – V1, VR and V2 speeds are selected to be displayed on the edit field. Alternate selection of V1, VR and V2 is made using SEL.

PUSH / SET / OFF
Used to adjusts the selected speed readout displayed on the edit field.
- When pushed, the selected speed readout is displayed.
- When rotated, the selected speed readout is adjusted.
- When pushed again, the selected speed readout is removed.

Air Data Reference Control Panel
Figure 12–30–4



Primary Flight Display
Pilot's and Copilot's Instrument Panels

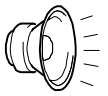
Mach Readout (white)
Indicates Mach speed. Displayed when Mach is above 0.45 and is removed when Mach is below 0.40.

Airspeed Indicator

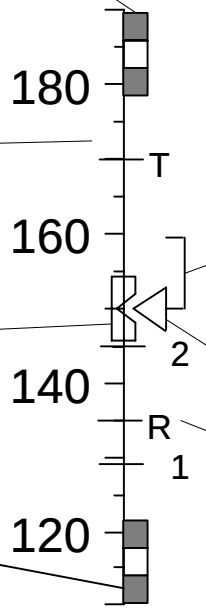
IAS /Mach Reference (magenta)
Indicates airspeed as selected using the speed knob on flight control panel.

Speed Reference (cyan)
Indicates reference speed as set by pilot using the speed reference knob on air data reference panel.

Overspeed Cue (red/black checkerboard)
Assends from Vmo/Mmo to top of tape window to indicate maximum speed allowable. If speed is more than 3 kts greater than Vmo or equivalent Mmo, overspeed clacker sounds. Warning continues until speed is 3 kts below Vmo/Mmo.



CLACKER
TONE



Indicated Airspeed Tape (white)
Moving tape that indicates current airspeed. Tape range is 40 to 400 knots with a display of 80 knots.
- Marks at 5 knot increments.
- Digits at 20 knot increments.

IAS Bug (magenta)
Indicates airspeed reference marker as set by pilot using the speed knob on flight control panel.

Trend Vector (magenta)
Indicates predicated airspeed within next 10 seconds.

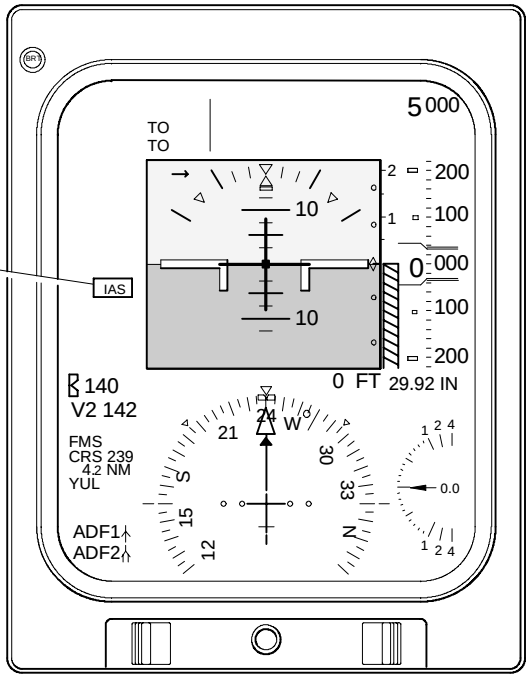
Indicated Airspeed Pointer (white)
Indicates current airspeed.

Speed Reference Bugs (cyan)
Removed 7.5 seconds after speed is exceeded (except target speed).
- 1 Takeoff decision speed (V1)
- R Rotate airspeed (VR)
- 2 Take-off safety speed (V2)
- T Target speed (VT)

Low Speed Cue (red/black checkerboard)
Descends from stick shaker speed to edge of tape window and acts as cue to impending stall speed. Displayed 3 seconds after lift-off. If AOA data fails, checkerboard stops at 100 kts. and is replaced by a yellow line up to 120 kts.

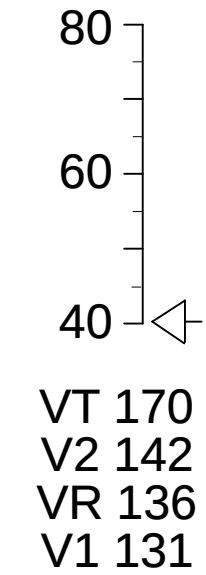
Airspeed Indicator

Indicated Airspeed and Mach Indications <1015>
Figure 12-30-5



IAS Flag (red)
Indicates that airspeed data has failed. Appears in place of airspeed tape.

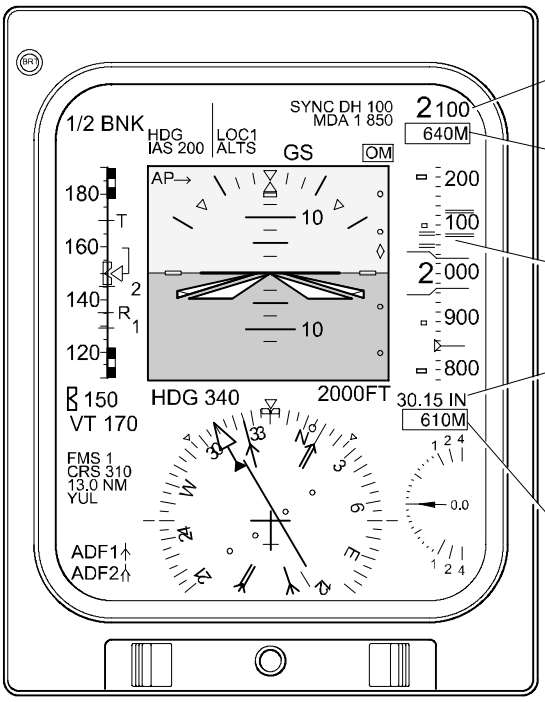
Primary Flight Display
Pilot's and Copilot's Instrument Panels



Speed Reference Table (cyan)
Displayed on ground only.
Indicates reference speeds as set using speed reference knob on the air data reference panel.

Airspeed Indicator

Indicated Airspeed Flag – Primary Flight Director <1015>
Figure 12–30–6



Preselected Altitude Readout (magenta)
Indicates preselected altitude to nearest 100 feet, as set using altitude knob on flight control panel.

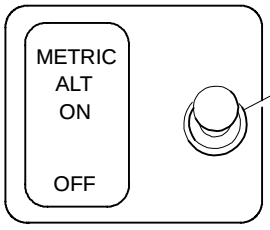
Metric Preselected Altitude Readout (magenta)
Indicates preselected altitude in meters. Displayed when metric altimeter is selected on.

Altitude Indicator

Barometric Pressure Setting Readout (cyan)
Indicates selected barometric pressure expressed in inches of mercury or hectoPascals, as set using barometric knob and on air data reference panel.

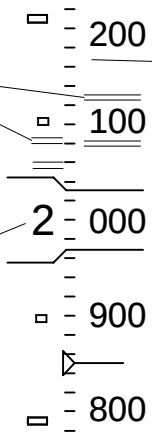
Metric Altitude Readout (white)
Indicates airplane altitude in meters. Displayed when metric altimeter is selected on.

Primary Flight Display
Pilot's and Copilot's Instrument Panels



METRIC ALT
- ON – Metric altitude readout and metric preselected altitude readout are displayed on PFDs.
- OFF – Metric altitude readout and metric preselected altitude readout go out.

Metric Altimeter Switch
Center Pedestal



Preselect Altitude Bug (magenta)
Lines at coarse and fine tape indicate preselected altitude as set using altitude knob on flight control panel.

Altitude Readout (white)
Indicates airplane barometric altitude.

Barometric Altitude Tape (white)
Moving tape with fixed window (digital readout) that indicates barometric altitude from –1,000 to 50,000 feet with a display of 450 feet.

Fine Tape
- Marks at 20 foot increments.
- Digits at 100 foot increments.

Coarse Tape
- Small rectangles at 500 foot increments.
- Large rectangles at 1000 foot increments.

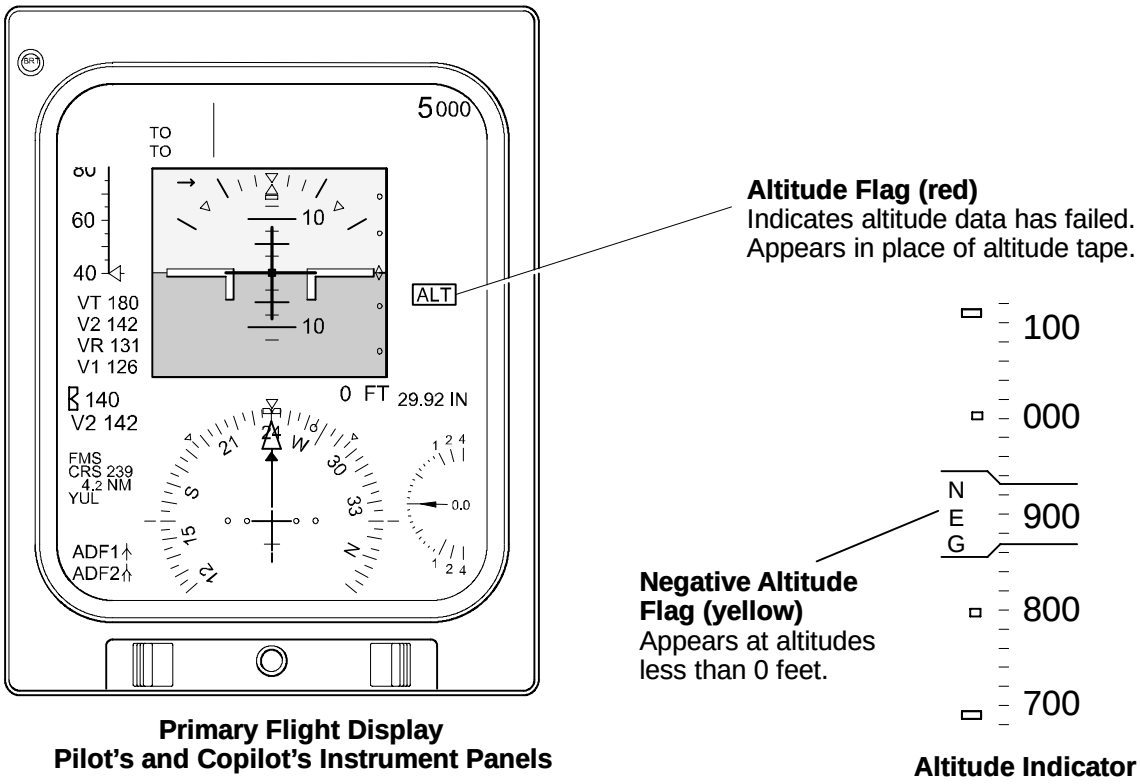
Altitude Indicator

Altitude Indications <1015,1029>
Figure 12–30–7

D. Altitude Alerts

The altitude alert system alerts the flight crew that a preselected altitude has been reached or a deviation from a preselected altitude has occurred. When the aircraft is cleared to change altitude, the preselected altitude is set on the PFD through the flight control panel (FCP). There are three types of alerts that can occur:

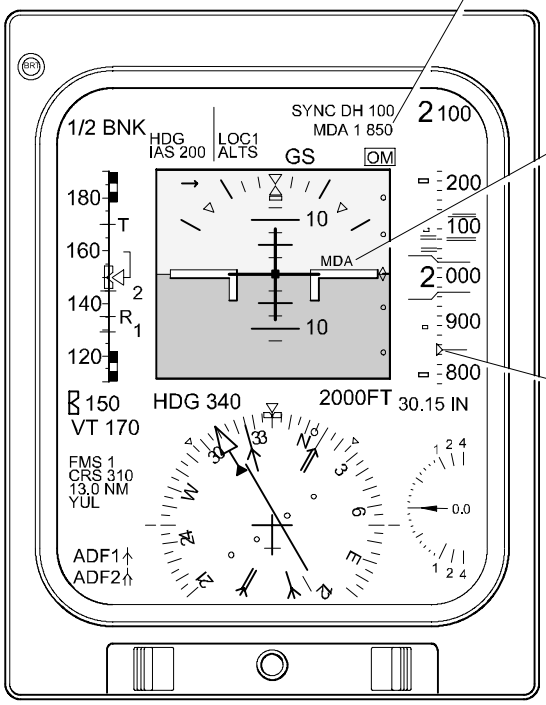
- Acquisition mode
- Cross side tracking
- Deviation mode



Primary Flight Display
Pilot's and Copilot's Instrument Panels

Altitude Indicator

Altitude Flag – PFD <1015>
Figure 12–30–8



Minimum Descent Altitude Readout (cyan)
Indicates MDA as set on the air data reference panel.

Minimum Descent Altitude Alert (amber)
Indicates that airplane has arrived at minimum descent altitude.

Minimum Descent Altitude Pointer (cyan)
Indicates MDA, as set on the air data reference panel.
- Disappears when out of range.
- Flashes during MDA alert.

Primary Flight Display
Pilot's and Copilot's Instrument Panels

Minimum Descent Altitude Indications <1015>
Figure 12–30–9

E. Acquisition Mode

Altitude alerts are inhibited in approach mode, when glideslope is captured and there are valid autopilot steering commands. The ADC will set a one second acquisition alert warning (altitude C-cord warning aural) and flash the preselected altitude readout when the present altitude is within ±1,000 feet of capturing the preselected altitude. The readout will stop flashing when the altitude is within ±200 feet of the preselected altitude. The alert can be cancelled by pressing the altitude knob on the flight control panel.

F. Cross Side Tracking

Each ADC compares the preselected altitude value from both computers for equality. If the values are not equal, the preselected altitude digits on the display change from magenta to cyan.

G. Deviation Mode

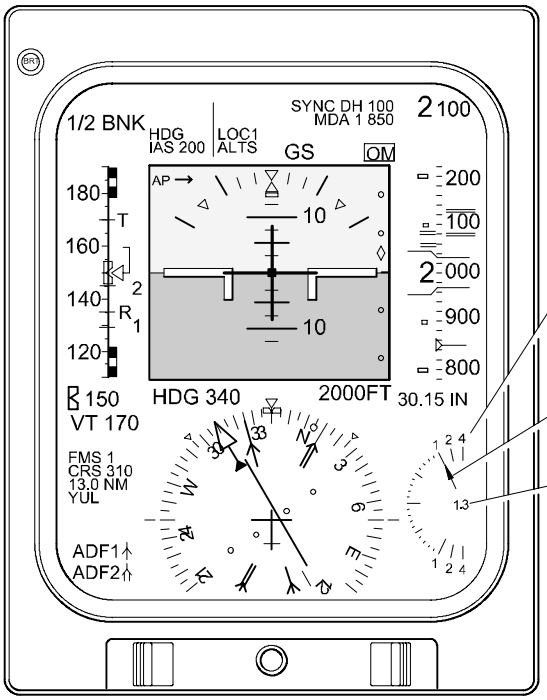
After the preselected altitude is captured, if the altitude deviates from the preselected altitude by more than ±200 feet, a deviation alert warning (aural “C” chord) will be set and the preselected altitude readout and bug will change from magenta to amber and begin to flash. The readout and bug will return to normal once the altitude is back within deviation limits. A deviation alert will also be made if the airplane has gone within the acquisition limits on an altitude capture but then deviates by more than 100 feet from the preselected altitude.

H. Low Speed Cue

The low speed cue provides an indication of the speed margin to stick shaker during normal low speed maneuvers and approaches to stall. The top of the low speed cue corresponds to the onset of the stick shaker.

NOTE

A high pitch rate at low airspeed may cause the stick shaker airspeed to be higher than that indicated at the top of the low speed cue. Respect the stick shaker warning to ensure adequate margin to full stall.



Primary Flight Display
Pilot's and Copilot's Instrument Panels

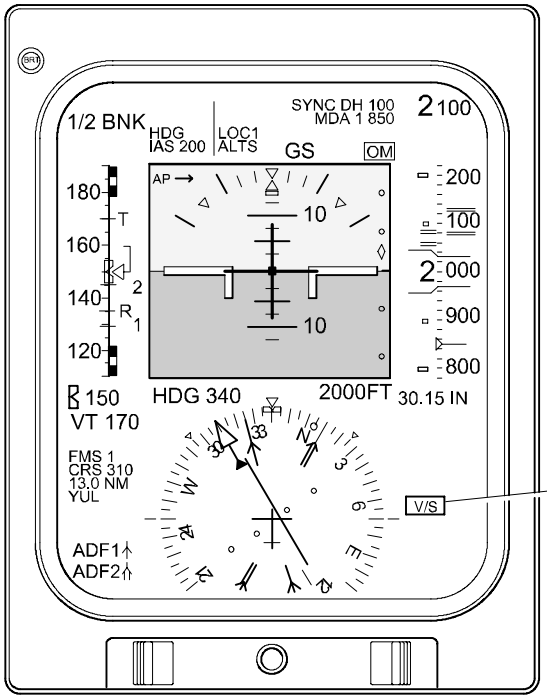
Vertical Speed Scale (white)
Non-linear scale of vertical speed between ±4,000 feet per minute.
- Small ticks at ± 250 FPM.
- Large ticks at ± 500 FPM.
- Digits at ±1,000, ± 2,000 and ± 4,000 FPM.

Vertical Speed Pointer (green)
Indicates vertical speed in feet per minute.

Vertical Speed Readout (green)
Indicates current vertical speed from 0 to 15,000 FPM.
- From 0 to 9,950 FPM, display is at 100 FPM.
- Above 9,950 FPM, display is at 1,000 FPM.
- If rate is greater than 10,000 FPM, decimal point disappears.

NOTE

Vertical speed pointer and readout turn red when a TCAS resolution advisory is issued and speed is not within corrective limits (refer to Chapter 18).



Primary Flight Display
Pilot's and Copilot's Instrument Panels

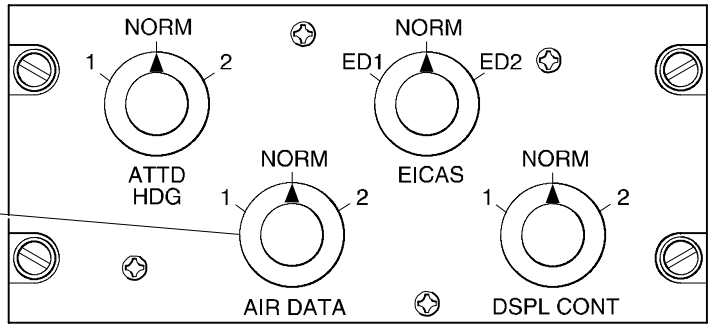
Vertical Speed Flag (red)
Indicates that vertical speed data has failed. Appears in place of vertical speed scale, pointer and readout.

Vertical Speed Indication and Flag <1015>
Figure 12–30–10

I. Air Data Reversion

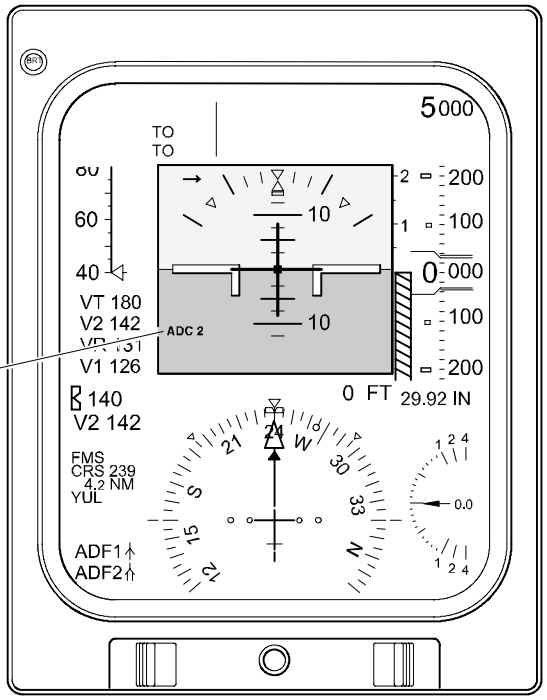
Normally, each ADC provides data to the same side PFD. If one ADC should fail, the other computer may be used to supply data to both PFDs. This is done by selecting the AIR DATA knob, to the 1 or 2 position, on the Source Selector Panel.

AIR DATA
- NORM – Each air data computer supplies data to the same side display.
- 1 – Air data computer 1 supplies data to both pilot and copilot displays. An amber source message is displayed on both PFDs.
- 2 – Air data computer 2 supplies data to both pilot and copilot displays. An amber source message is displayed on both PFDs.



Source Selector Panel
Center Pedestal

Source Selector – Air Data Panel
Figure 12–30–11



ADC 1 or 2 (amber)
Indicates that single air data computer source has been selected.
- ADC 1 – Air data computer 1 selected.
- ADC 2 – Air data computer 2 selected.

Primary Flight Display
Pilot's and Copilot's Instrument Panels

Air Data Flags – Primary Flight Display <1015>
Figure 12–30–12

J. System Circuit Breakers

SYSTEM	SUB-SYSTEM	CB NAME	BUS BAR	CB PANEL	CB LOCATION	NOTES
Air Data	Computer	ADC 1	DC ESSENTIAL	2	V3	
		ADC 2	DC BUS 2		H6	

1. RADIO ALTIMETER SYSTEM

There are two radio altimeter (RAD ALT) systems installed on the aircraft. Each system provides an accurate measurement of absolute altitude (height above terrain) from -20 to 2500 feet AGL. Radio altitude information is supplied from both radio altimeters to the following: <1045>

- PFD's
- Spoiler and Stabilizer control units (SSCUs)
- Enhanced ground proximity warning system (EGPWS) <2040>
- Traffic alert and collision avoidance system(TCAS)

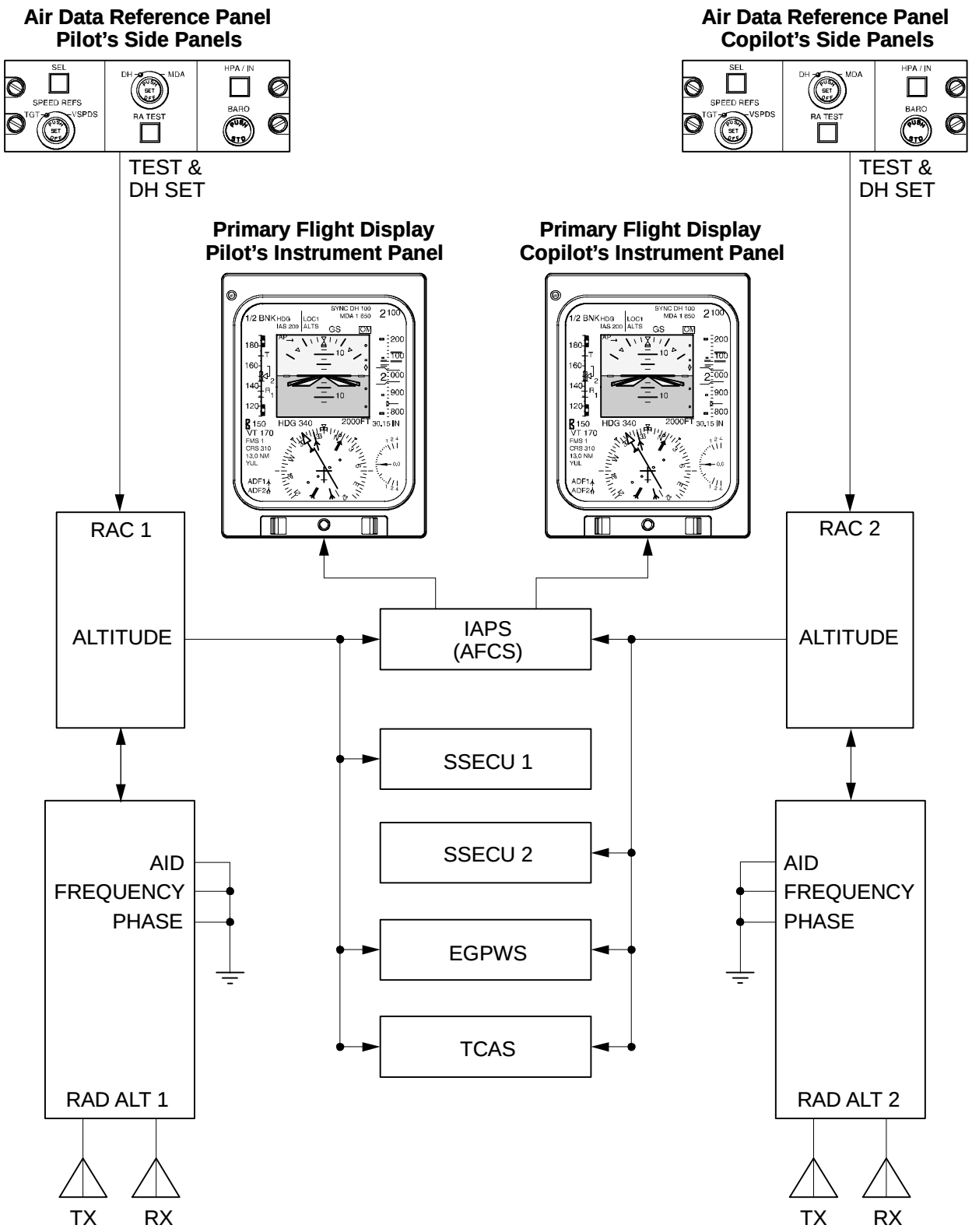
The radio altimeter provides the pilot's and copilot's PFDs with the following:

- Radio altitude readout
- Decision height readout
- Decision height alerts and radio altimeter fail flags

When a failure is detected during flight, a red warning flag is displayed on the PFDs

The radio altitude display is displayed as both a digital and a moving tape readout. The digital readout appears as the aircraft descends through 2,500 feet. The tape is an analog scale that is displayed when the airplane is below an altitude of 1,225 feet.

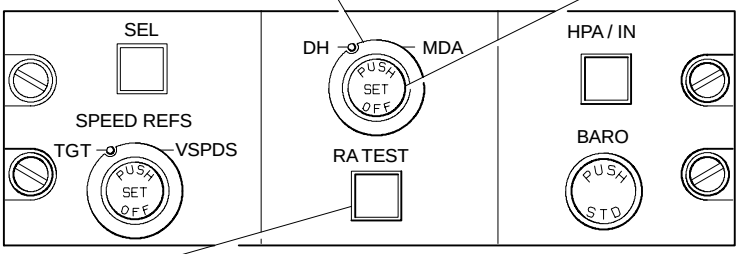
Decision height is set (from 0 to 999 feet) using either pilot's air data reference panel. A test button is provided on the air data reference panel to verify the operation of the radio altimeter system.



Radio Altimeter ISystem – Block Diagram <1045>
Figure 12–40–1

DH / MDA
Used to select decision height or minimum descent altitude.
- DH – Decision height readout is selected to be adjusted.
- MDA – Minimum descent altitude readout is selected to be adjusted.

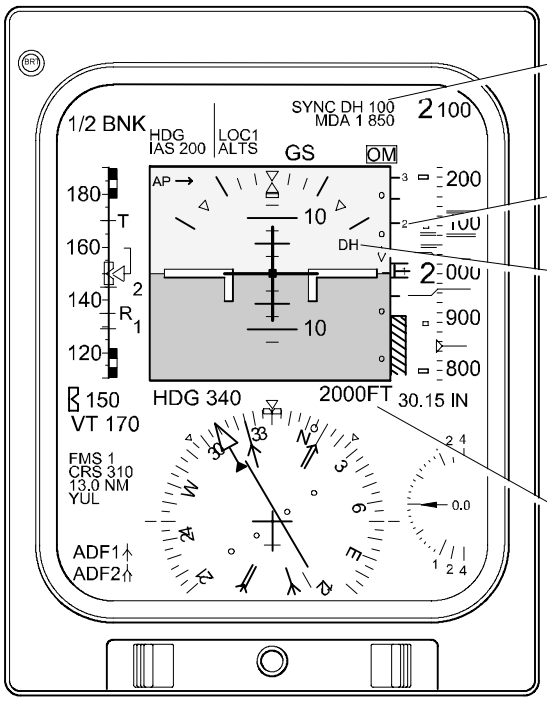
PUSH / SET / OFF
Used to adjusts selected altitude readout.
- When pushed, the selected altitude readout (DH or MDA) is displayed on the PFD.
- When rotated, the selected altitude readout is adjusted (DH in 1 ft increments, MDA in 10 ft increments).
- When pushed again, the selected altitude readout is removed.



Air Data Reference Panel
Pilot's and Copilot's Side Panels

RA TEST
Used to initiate radio altitude test.

Air Data Reference Control Panel
Figure 12–40–2



Primary Flight Display
Pilot's and Copilot's Instrument Panels

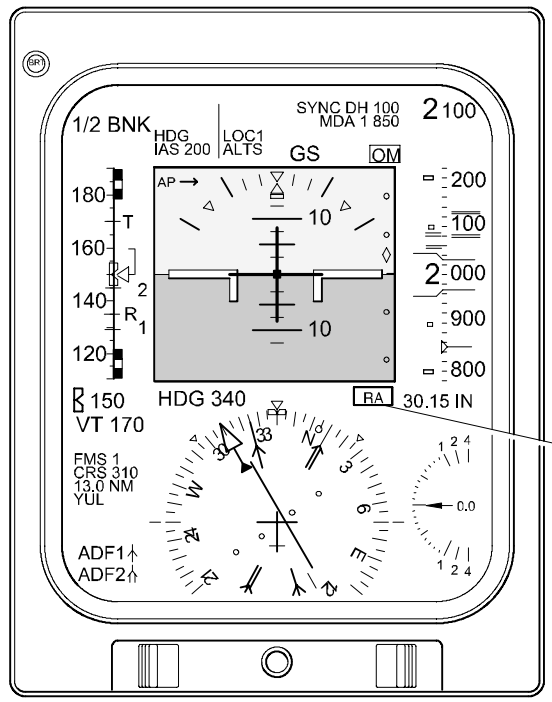
Decision Height Readout (cyan)
Indicates selected decision height as set on the air data reference panel (range is 0 to 999 feet).
- Red dashes indicate failed input.

Radio Altimeter
Indicates current radio altitude.
- Displayed upon descent below 1,225 feet RA.

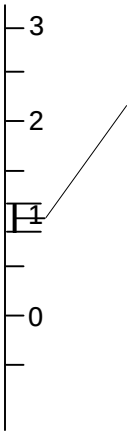
Decision Height Alert (amber)
Indicates that airplane has arrived at decision height.
- During go-around, alert is disabled at decision height +100 feet.
- Alerts inhibited below 5 feet.

DECISION HEIGHT

Radio Altitude Readout (green)
Indicates radio altitude from 0 to 2,500 feet.
At decision height, readout turns amber.
- Displayed upon descent below 2,500 feet RA.



Primary Flight Display
Pilot's and Copilot's Instrument Panels



Radio Altimeter

Decision Height Pointer (cyan)
Indicates selected decision height as set on the air data reference panel.
- Disappears when out of range.

RA Flag (red)
Indicates that radio altitude data has failed.
Appears in place of radio altitude readout.

Radio Altimeter Indication <1015,JAA>
Figure 12-40-3

A. System Circuit Breakers

SYSTEM	SUB-SYSTEM	CB NAME	BUS BAR	CB PANEL	CB LOCATION	NOTES
Radio Altimeter	Altimeter	RAD ALT 1	DC BUS 1	1	J4	
		RAD ALT 2	DC BUS 2	2	J2	<1045>

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2. INERTIAL REFERENCE SYSTEM <1025>

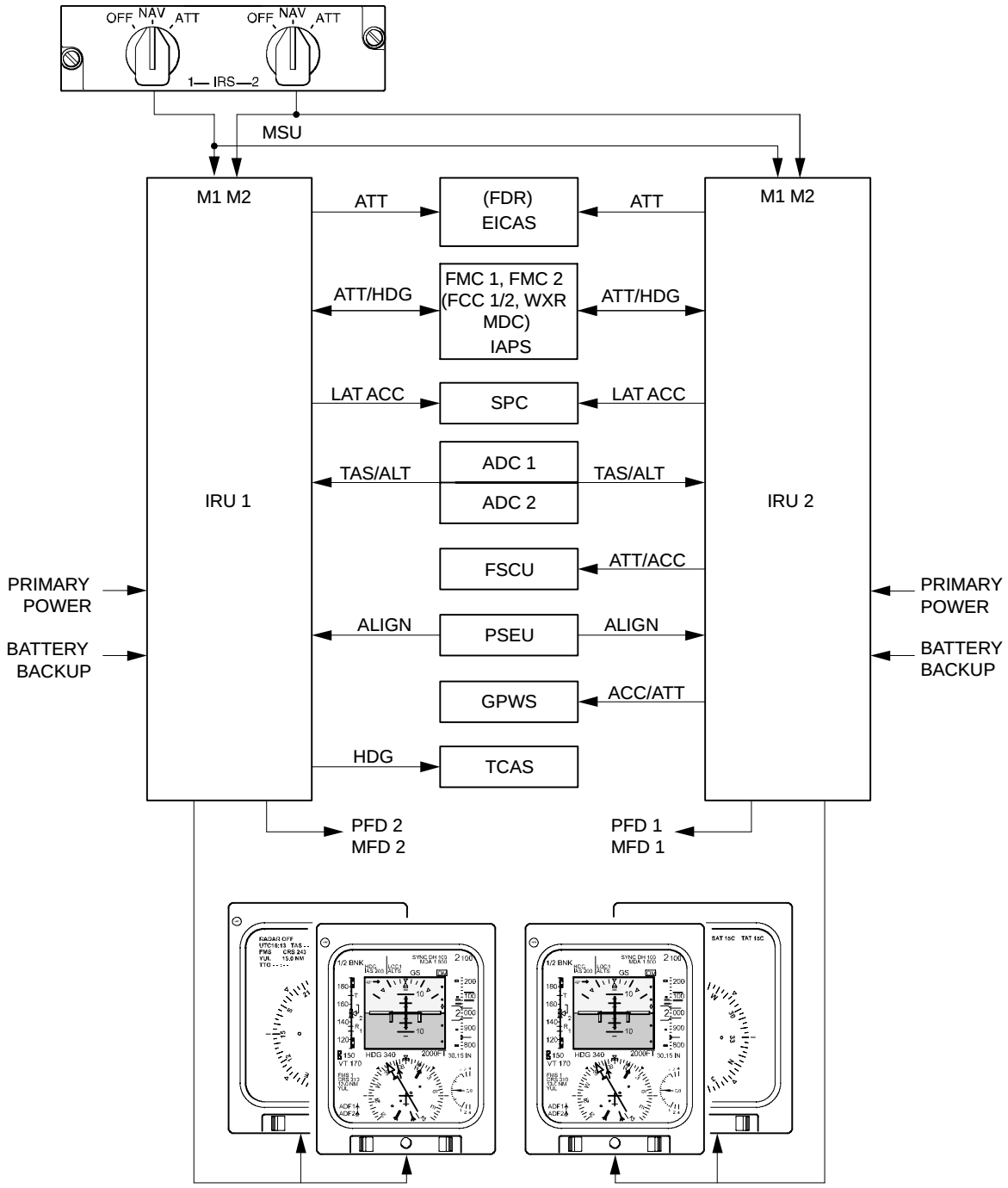
The inertial reference system (IRS) provides inertial outputs of attitude, heading, angular rates, linear acceleration and present position to be displayed on the flight displays and to be used by other avionics systems.

The IRS is a dual system with two inertial reference units (IRU) and a dual mode select unit (MSU). Each IRU receives information from the same side air data system. The IRU measures inertial motion sensed by the inertial instruments and computes attitude and heading data. This information is processed and sent to the integrated avionics processor system which interfaces with the flight control computers and flight management computers. These signals are also routed to the TCAS, EGPWS, fuel system, stall protection system, flight data recorder and data concentrator units. The MSU provides pilot selection of the IRS modes.

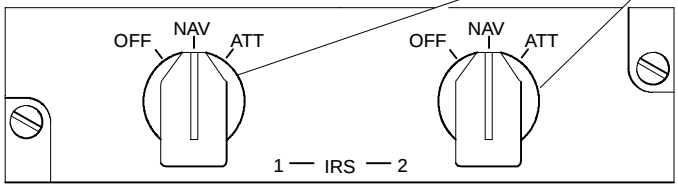
The IRS provides attitude and heading information to the electronic flight instruments. Attitude is displayed on the attitude direction indicator (ADI) of the primary flight displays and heading is displayed on the horizontal situation indicator (HSI) portions of the displays. Heading is selected to magnetic or true using the flight management system (refer to Chapter 18).

The IRS normally operates in navigation mode. In navigation mode, it is not possible to update the IRS position, however, it is possible to perform a rapid realignment while on the ground.

Attitude mode is a reversionary mode, used when the IRU has detected an inertial failure or inaccuracies of the navigation operation in flight. Attitude mode does not provide position data. In attitude mode, the heading may drift and must be corrected using the flight management system (FMS). If the FMS is not available, the EICAS control panel can be used to make heading corrections. Attitude mode is annunciated on the EICAS status page.



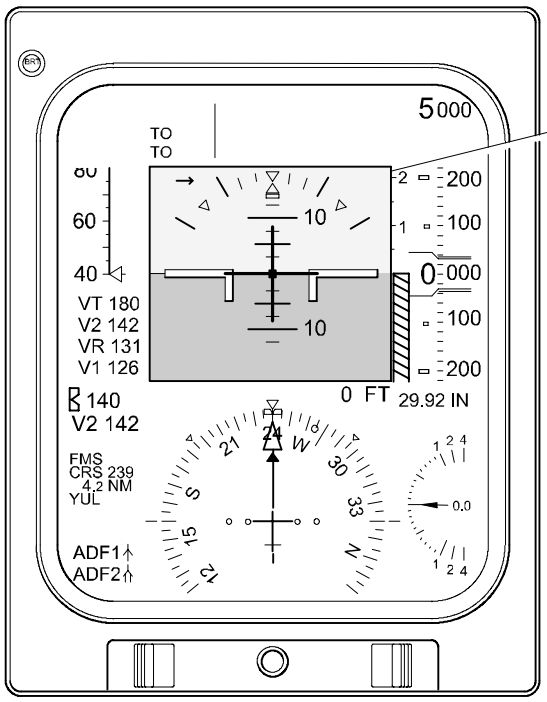
Inertial Reference System Interface <1015,1025>
Figure 12–50–1



IRS Mode Select Unit
Center Pedestal

1 – IRS – 2
Used to select IRS mode.
- OFF – Removes power from IRS.
- NAV – IRS operates in navigation mode
- ATT – IRS operates in attitude mode.

Inertial Reference System Mode Select Control Panel <1025>
Figure 12–50–2

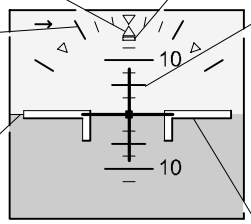


Attitude Director Indicator

Primary Flight Display
Pilot's and Copilot's Instrument Panels

Slip / Skid Indicator (white)
Indicates lateral acceleration. Moves with roll pointer. Lateral displacement from center of roll pointer indicates airplane is slipping or skidding.

Roll Pointer (white)
Indicates roll angle Pointer rotates along fixed roll scale.



Attitude Director Indicator

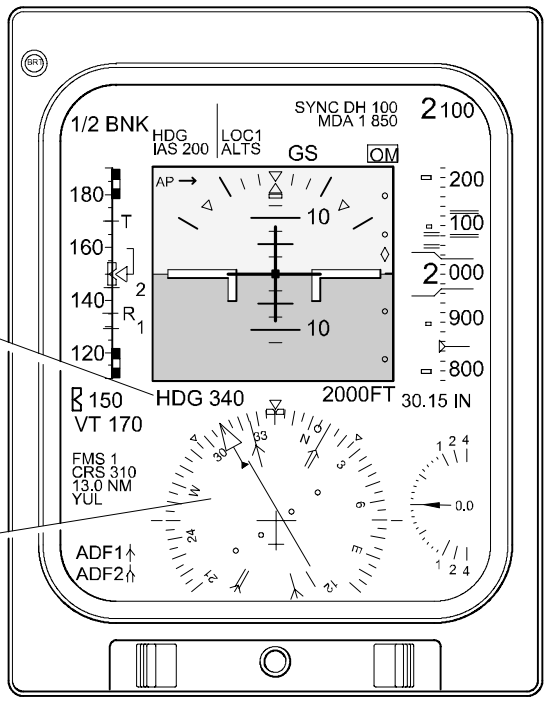
Pitch Tape (white)
Moving tape that indicates pitch attitude.
- Small marks at 2 ½ degree increments.
- Medium marks at 5 degree increments.
- Large marks and numbers at 10 degree increments.
- Red chevrons pointing towards zero pitch are displayed during extreme pitch attitudes.

Roll Scale (white)
Fixed scale that indicates roll attitude.
- Small marks at 10 and 20°
- Large marks at 30 and 60°
- Small triangle at 45°

Horizon Line (white)
Indicates roll and pitch attitude relative to airplane symbol. Horizon bar rotates to display roll attitude and moves vertically to display pitch attitude.

Airplane Symbol (black)
Indicates position of airplane in relation to horizon index.

Attitude Director Indicator <1015>
Figure 12–50–3



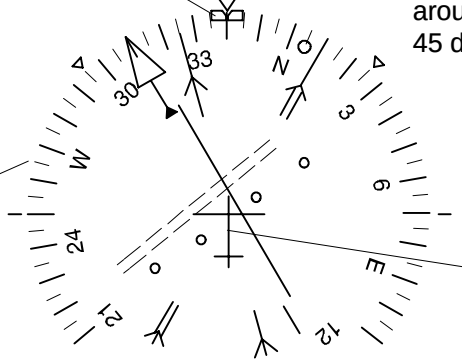
Selected Heading Readout (magenta)
Indicates selected heading as set using heading knob on flight control panel. Removed 5 seconds after heading is selected.

Horizontal Situation Indicator

Primary Flight Display
Pilot's and Copilot's Instrument Panels

Selected Heading Bug (magenta)
Indicates selected heading as set using heading knob on flight control panel. When bug is off scale, a dashed line is displayed from center of compass to selected heading.

Lubber Line (white)
Fixed reference for reading current airplane heading. Fixed index marks are located around compass rose at 45 degree increments.



Compass Rose (white)
Rotating card indicates airplane current magnetic heading under fixed lubber line.

- Small marks at 5 degree increments.
- Larger marks at 10 degree increments.
- Digits and cardinal points at 30 degree increments.

Airplane Symbol (white)
Indicates center of compass rose.

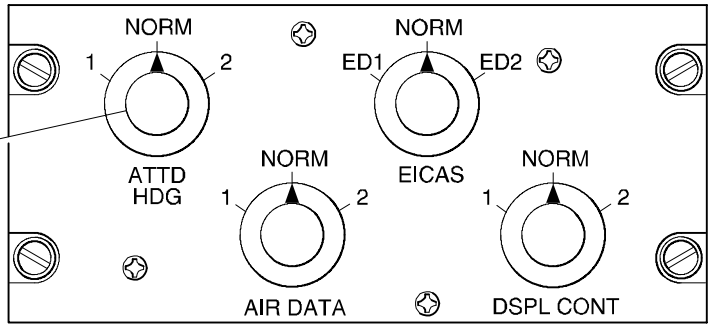
Horizontal Situation Indicator

Selected Heading Readout <1015>
Figure 12-50-4

A. Display Reversion

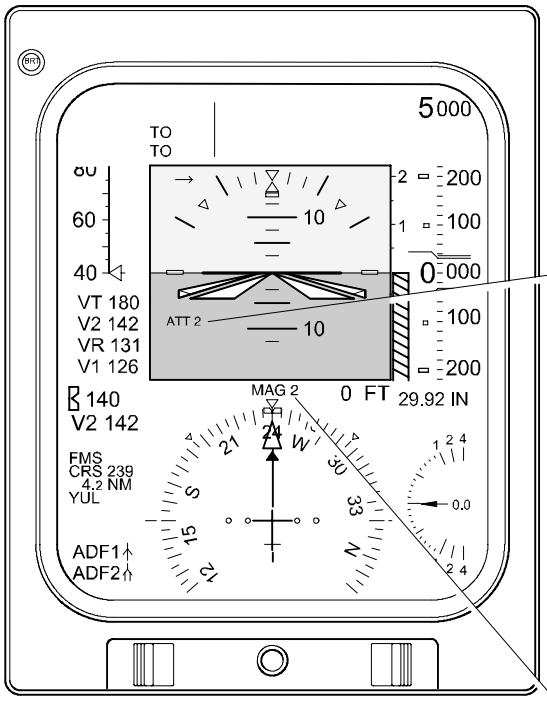
Display capability is maintained when sensor data failure occurs. Either PFD (or MFD when in PFD format) can be configured to display data from either inertial reference system by operation of the ATT HDG knob on the source selector panel. Selection of alternate data sources is indicated to the flight crew by a yellow single source flag on the PFD and MFD.

ATTD HDG
- NORM – Each inertial reference unit supplies data to the same side display.
- 1 – Inertial reference unit 1 supplies data to both pilot and copilot displays. An amber source message is displayed on both PFDs.
- 2 – Inertial reference unit 2 supplies data to both pilot and copilot displays. An amber source message is displayed on both PFDs.



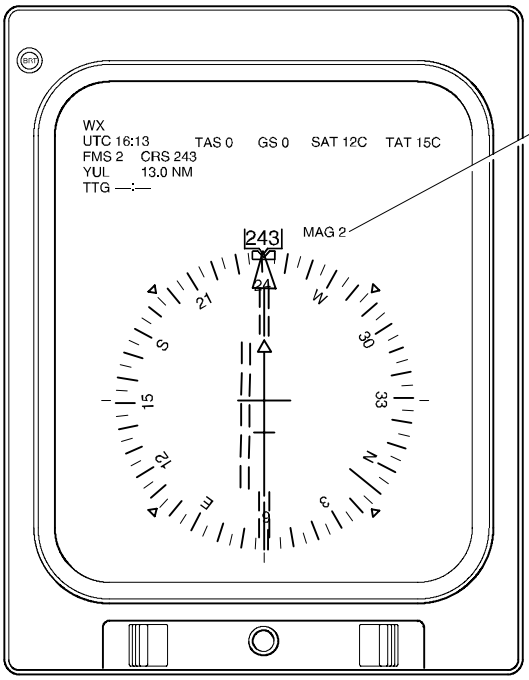
Source Selector Panel
Center Pedestal

Source Selector Panel <1025>
Figure 12–50–5



Primary Flight Display
Pilot's and Copilot's Instrument Panels

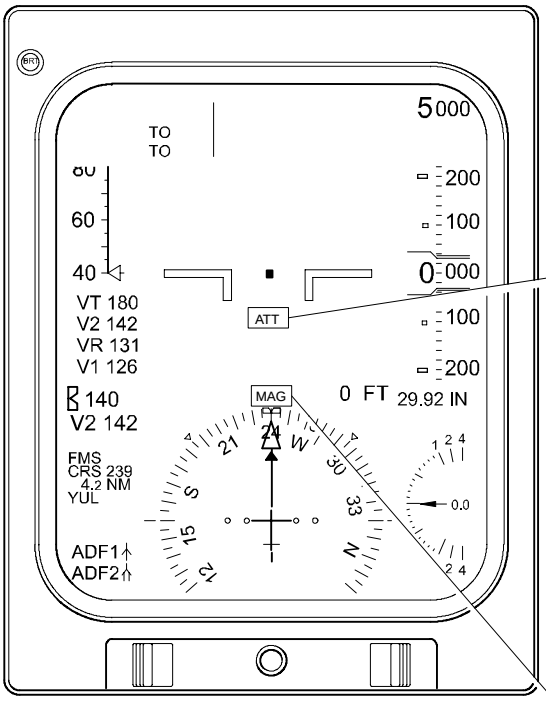
ATT 1 or 2 (amber)
Indicates that single inertial reference source has been selected.
- ATT 1 - Inertial reference unit 1 selected.
- ATT 2 - Inertial reference unit 2 selected



Multifunction Display – HSI Mode
Pilot's and Copilot's Instrument Panels

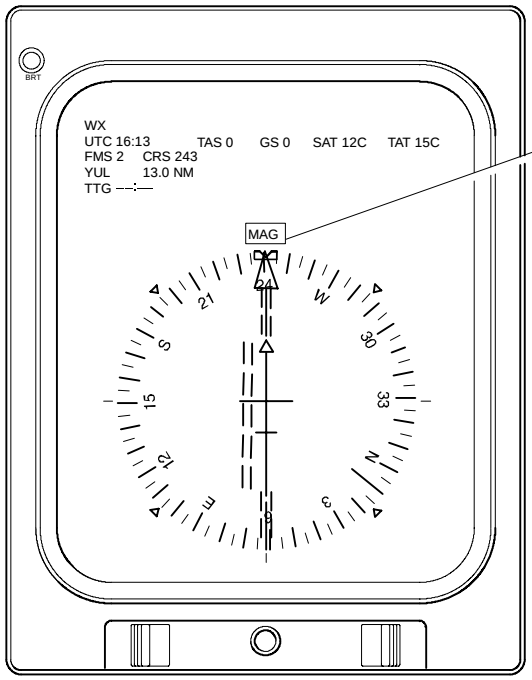
MAG 1, MAG 2, TRU 1 or TRU 2 (amber)
Indicates heading selection when a single Inertial reference source has been selected.

Attitude and Heading Source Selection <1015, 1025>
Figure 12–50–6



Primary Flight Display
Pilot's and Copilot's Instrument Panels

ATT Flag (red)
Indicates that onside or both inertial reference systems have failed.



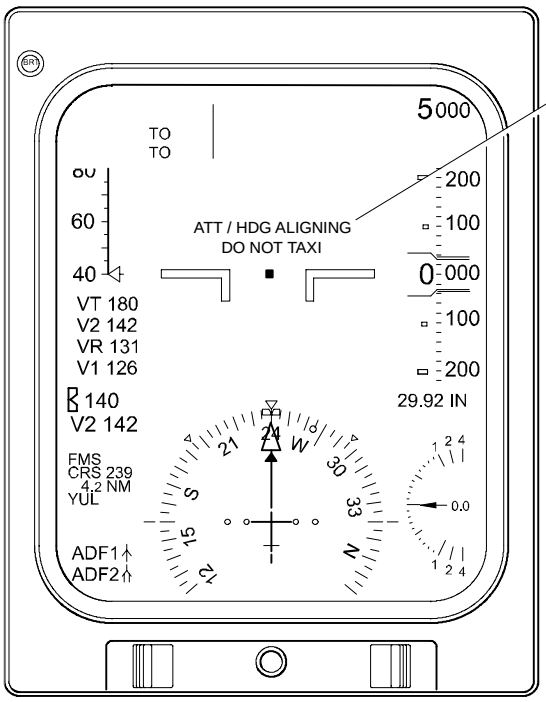
Multifunction Display – HSI Mode
Pilot's and Copilot's Instrument Panels

MAG or TRU Flag (red)
Indicates that onside or both inertial reference systems are faulty or out of tolerance.

Attitude/Heading Source Failure Indications <1015,1025>
Figure 12–50–7

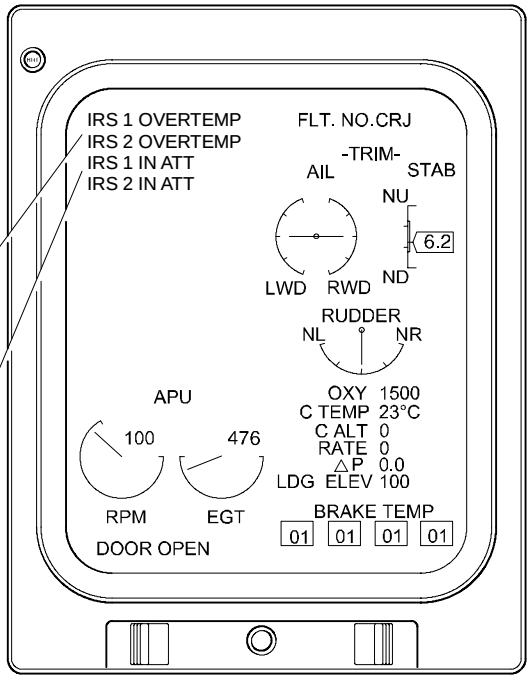
B. Initialization and Alignment

IRS initialization takes about 7 minutes at normal temperature. The IRS requires that the initial position be entered using the flight management system. The primary flight displays present a flashing initialization alignment message during initialization. Upon successful alignment, the IRS will automatically sequence into navigation mode. Attitude alignment takes 1 minute or 34 seconds when switching from navigation to attitude mode, provided the airplane is stationary on the ground or in straight and level flight. <1025>



Primary Flight Display
Pilot's and Copilot's Instrument Panels

Alignment Annunciator (white)
Indicates inertial reference alignment in process.



Status Page

IRS 1 (2) OVERTEMP status (white)
Indicates that an overtemperature condition exists.

IRS 1 (2) IN ATT status (white)
Indicates that IRS is operating in attitude mode.

Attitude/Heading Source Alignment Indication <1015,1025>
Figure 12–50–8

C. System Circuit Breakers

SYSTEM	SUB–SYSTEM	CB NAME	BUS BAR	CB PANEL	CB LOCATION	NOTES
Inertial Reference System	Attitude Heading	ATT HDG 1	DC ESSENTIAL	2	V8	
		ATT HDG 2	DC BUS 2		K4	
	IRS Fan	IRU FAN	AC BUS 2		C12	<1025>

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1. STANDBY INSTRUMENTS AND CLOCKS

An integrated standby instrument is located between the EICAS displays on the center instrument panel. A standby compass is located below the center of the overhead instrument panel. A clock is installed on both the pilot and copilot side panels.

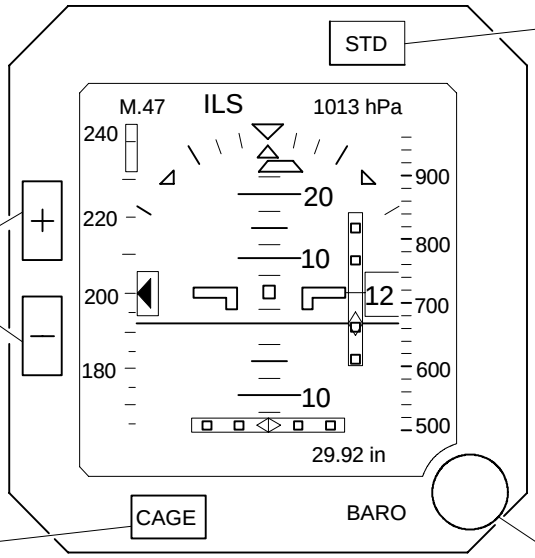
A. Integrated Standby Instrument

The integrated standby instrument (ISI) provides standby attitude, altitude and airspeed information to the flight crew. To retain full operational capability under emergency conditions the ISI is powered by the battery bus. The ISI uses inputs from the alternate pitot probe and static ports.

The ISI displays the following information:

- Attitude display
- ILS deviation
- Altitude display (corrected)
- VMO display
- Airspeed display
- Static source error correction (SSEC)
- Mach number
- Barometric pressure
- Slip-skid indication

STD
Used to select either standard pressure reference, 1013 hPa (29.92 inHg), or baro-correction pressure reference.



Brightness Controls

CAGE
Used to reset horizon line.Use only during stabilized level flight. Will not operate during power up.

BARO
Used to adjust baro-correction pressure reference. Setting stored in non-volatile memory to prevent loss during power failure.

Integrated Standby Instrument Center Instrument Panel

Integrated Standby Instrument
Figure 12–60–1

MACH Number
Displayed when above 0.45 and removed when drops below 0.40.

Roll Scale
Graduations every 5 degrees.

Selected Standard or Baro-corrected Pressure
Pressure displayed above (hPa) and below (inHg) altitude tape.

VMO Band (red)
From Vmo value upwards.

Roll/Sky Pointer

Slip/Skid Indicator
White trapezoid slides left or right depending on lateral acceleration.

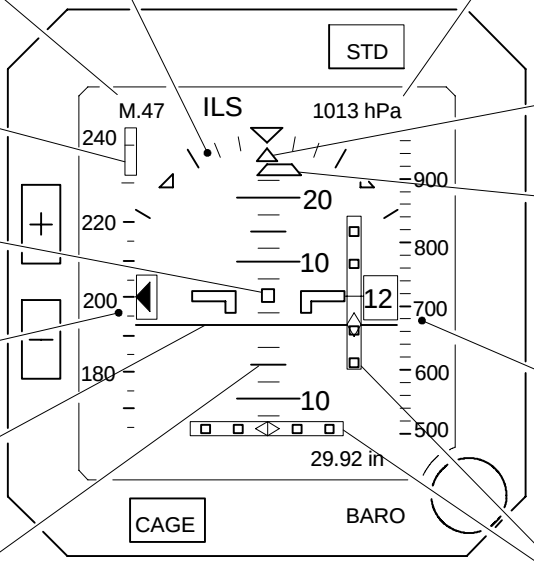
Fixed Cross-Pointer

IAS Tape
Range 40 – 520 Kts.
Graduations every 5 Kt.

Altitude Tape
Tape reads hundreds with graduations every 20 feet. Box contains thousands.

Horizon Line

Pitch Scale
Graduations every 2.5 degrees.



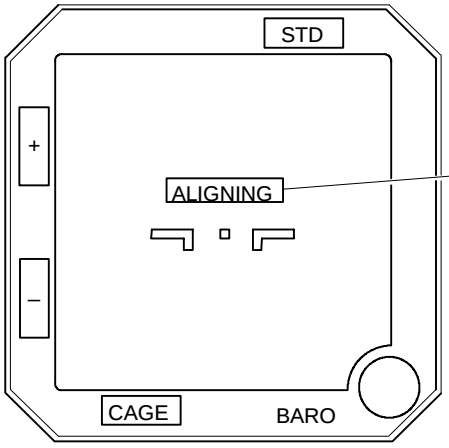
Integrated Standby Instrument Center Instrument Panel

ILS Symbols
- **Localizer**
  Green diamond with vertical line on horizontal scale with square deviation dots.
- **Glideslope**
  Displays green diamond on vertical scale with square deviation dots.

NOTE

ILS information is removed when the ILS receiver is not tuned to an ILS frequency.

Integrated Standby Instrument Scales
Figure 12–60–2



ALIGNING Flag
Displayed during power-up and initialization.

Standby Instrument
Center Instrument Panel

ILS Flag (red)
Displayed when both localizer and glideslope functions fail. Localizer and glideslope scales and pointers are removed.

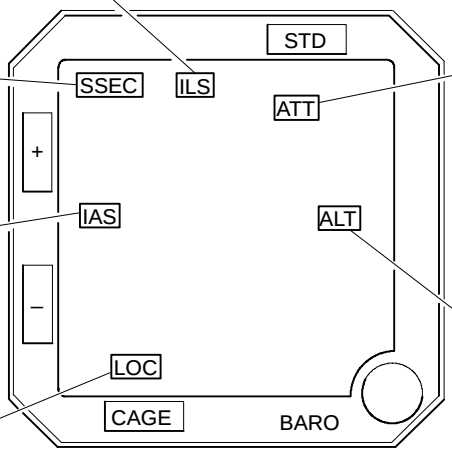
SSEC Flag (yellow)
Displayed when static source error correction cannot be computed.

ATT Flag (red)
Displayed when an attitude failure is detected. Blue and brown background, pitch and roll scales and roll/sky pointer are removed.

IAS Flag (red)
Displayed when airspeed cannot be computed or displayed. Airspeed tape and pointer are removed.

ALT Flag (red)
Displayed when a computation or display malfunction is detected. Altitude scale is removed.

G/S Flag (red) G/S
or
LOC Flag (red)
Displayed when a glideslope or localizer failure is detected. Corresponding glideslope or localizer scale and pointer are removed.



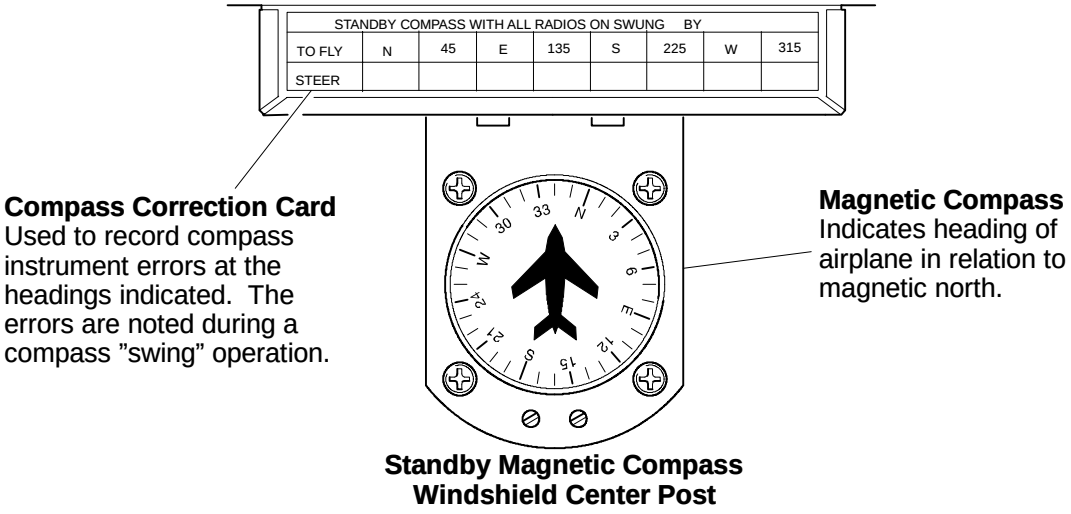
Standby Instrument
Center Instrument Panel

Integrated Standby Instrument Flags
Figure 12–60–3

B. Standby Compass

The standby compass is independent and does not interface with other systems. It is a self contained dry compass which uses eddy current damping to prevent overshooting. A miniature aircraft pointer indicates aircraft heading in relation to magnetic north on a rotating vertical compass card.

A compass correction card, mounted above the instrument, is used to record the values that must be added to or subtracted from the compass indications to correct for the influence of magnetic materials contained in the aircraft and magnetic fields from the avionics systems near the compass. The compass can be illuminated by operating the standby compass switch on the miscellaneous lights panel.



Standby Magnetic Compass
Figure 12–60–4

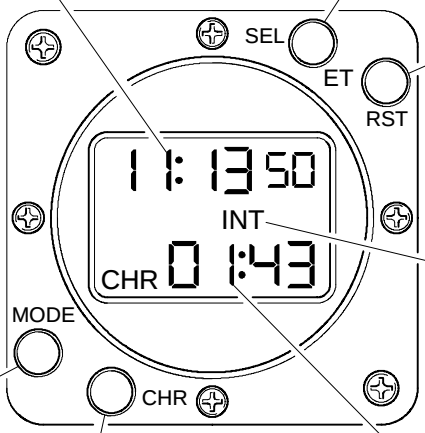
C. Clocks

A digital electronic clock is installed on the pilot and copilot side panels. The clocks have the capability of being synchronized with the Global Positioning System (GPS). Each clock is capable of displaying date (GPS or internal Universal Time Coordinated (UTC), current time (GPS, internal UTC, or local), chronometer (CHR), as well as elapsed time (ET) functions. The clocks are synchronized to the GPS input as soon as valid GPS information is received. In the case of invalid GPS data or signal loss, the clocks will operate in internal (INT) mode using the integrated time base of each clock. If there is a valid GPS signal, the clocks do not need to be set, as this will be done automatically at power up. The flight crew can disable the the GPS signal by entering the time setting mode. The clocks will then ignore the GPS signal until the next primary power reset. The MODE, ET SEL and ET RST buttons are used to set the time and date. To set the clock, push the MODE button for two seconds, then push the MODE button again to toggle between UTC hours and minutes (when the INT is lit), year, month, and day, (when the DT is lit), and local time hours and minutes (when the LT is lit). In any of these modes, the ET SEL button is used to decrease the data and the ET RST button is used to increase the data. Data changes are in increments of one digit for each press of the ET SEL or ET RST button. At any time during the time setting process, pressing the MODE button for a minimum of two seconds will exit the time setting mode and restart the clock operation.

Time/Date Display
Displays GPS time, internal UTC time, local time or date.
- Time is displayed in hours, minutes, and seconds (HH:MMss)
- DATE is displayed as Day/Month/Year.

ET SEL
Used to select the elapsed time function when the chronometer function is active.
Also used to decrease the data in one digit increments during manual setting of the clock.

ET RST
Used to reset the elapsed time function when the airplane is on the ground.
Also used to increase the data in one digit increments during manual setting of the clock.



Mode annunciator
Indicates the present mode of operation.
- DT – date
- GPS – GPS synchronization enabled
- INT – internal time/ date operation (GPS disabled).
- LT – local time

MODE
Used to select the mode of operation (DT, GPS, INT, LT) and also used in conjunction with ET SEL and ET RST buttons to set UTC time, date, and local time.

CHR
Used to start, stop and reset the chronometer display. Overrides existing elapsed time display.

ET/CHR Display
Displays elapsed time or chronometer time.

NOTE
ET time corresponds to airplane flight time and starts when the airplane takes off and stops at touch down. ET can only be reset on ground.

Effectivity:
- *Airplanes 15016 and subsequent.*

Clock Display with GPS Synchronization
Figure 12–60–5

D. System Circuit Breakers

SYSTEM	SUB-SYSTEM	CB NAME	BUS BAR	CB PANEL	CB LOCATION	NOTES
Standby Instruments and Clocks	Integrated Standby Instrument	INT STBY INST	BATTERY BUS	2	N10	
	Clocks	CLOCK 1 (PILOTS)			N11	
			MAIN BATTERY DIRECT BUS	6	B7	
		CLOCK 2 (COPILOTS)			B8	
			DC BUS 2	2	H5	