CHAPTER 12 – FLIGHT INSTRUMENTS

LIST OF ILLUSTRATIONS

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 attitude and heading reference system (AHRS). Flight instruments provide the following basic information to the flight crew:

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: <0025>

- 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. A standby attitude indicator and standby altitude/airspeed indicator are provided. An independent standby compass provides aircraft heading in relation to magnetic north. An electronic clock provides the time source for the aircraft avionics equipment.

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. An electronic clock provides the time source for the aircraft avionics equipment. <0083>

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 attitude and heading reference system (AHRS) provides attitude, heading, position, angular rate and linear acceleration information.

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. <0025>

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 is a digital CRT and has the primary function of pictorially showing aircraft attitude, altitude, airspeed, flight director commands and flight mode annunciations. Inputs to the PFD's are from the selected AHRS and ADC's. Commands are set on the flight control panel, air data reference panel and display control panels.

Each PFD is a digital CRT and has the primary function of pictorially showing aircraft attitude, altitude, airspeed, flight director commands and flight mode annunciations. Inputs to the PFD's are from the selected IRS and ADC's. Commands are set on the flight control panel, air data reference panel and display control panels.<0025>

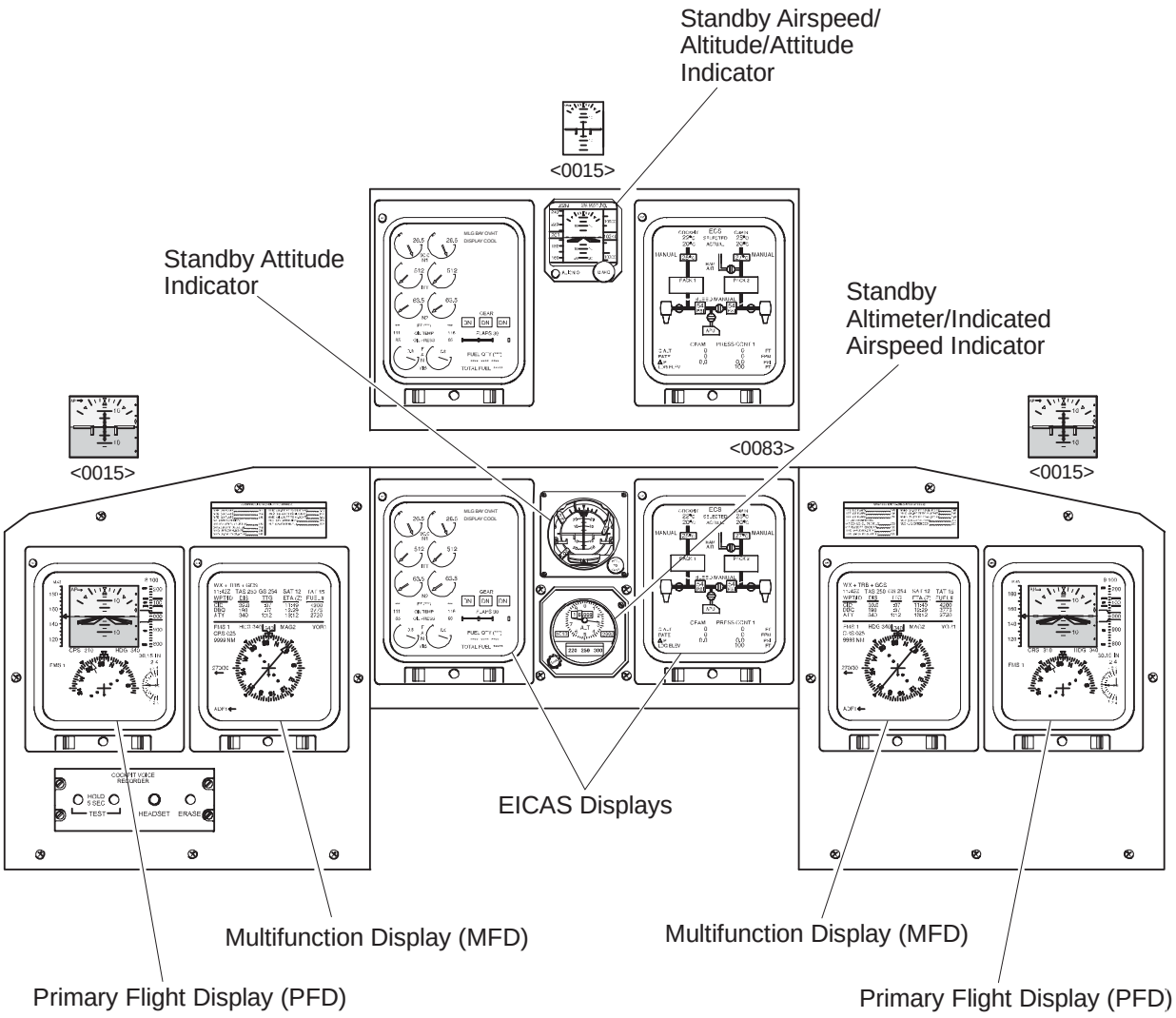
The PFD's function as the following instruments:

- Attitude heading indicator (ADI)
- Horizontal situation indicator (HSI)
- Radio magnetic indicator (RMI)
- Radio altimeter indicator
- Airspeed indicator (Mach and IAS)
- Vertical speed indicator (VSI).

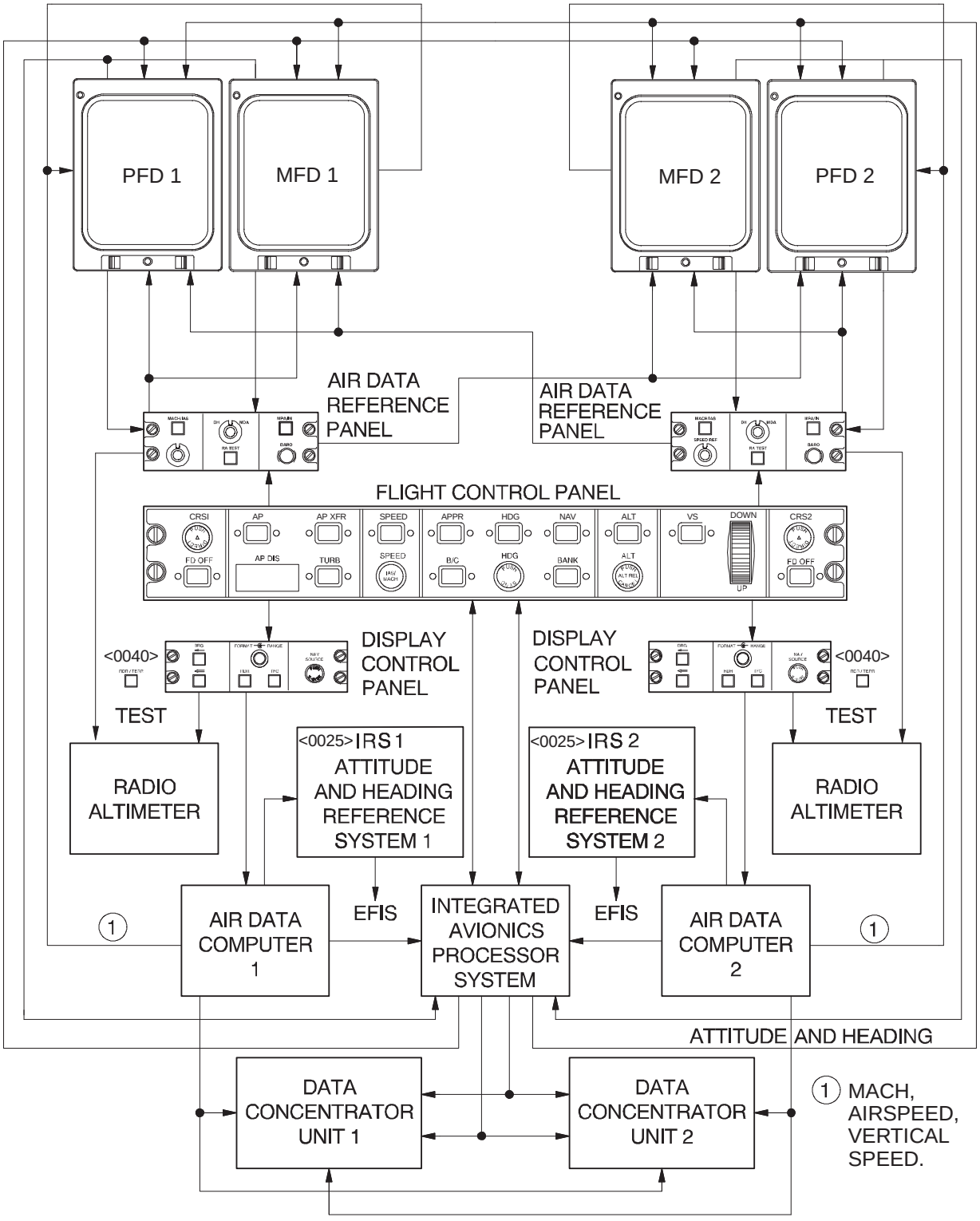
Each of the MFDs acts as a navigation system display and has a primary function of showing current heading (compass) and course information. The MFDs can also display moving map navigation pictorials, navigation sensor data, weather radar targets, and TCAS traffic (see Chapter 18). Cross side compass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

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 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. The MFD information cannot be transferred to the PFD. Selecting the EICAS position 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.

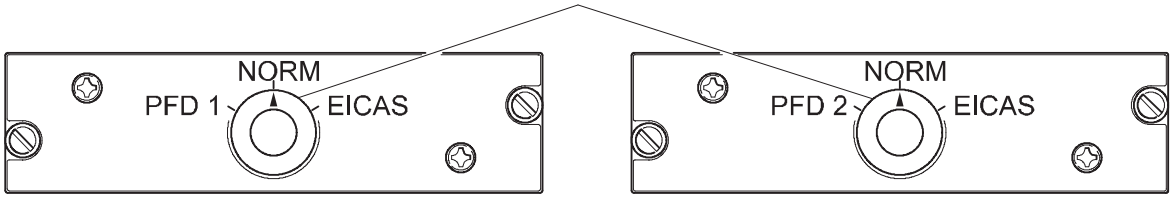


Electronic Flight Instrument System (EFIS) <MST>
Figure 12–20–1



EFIS Interface – Block Schematic <MST>
Figure 12–20–2

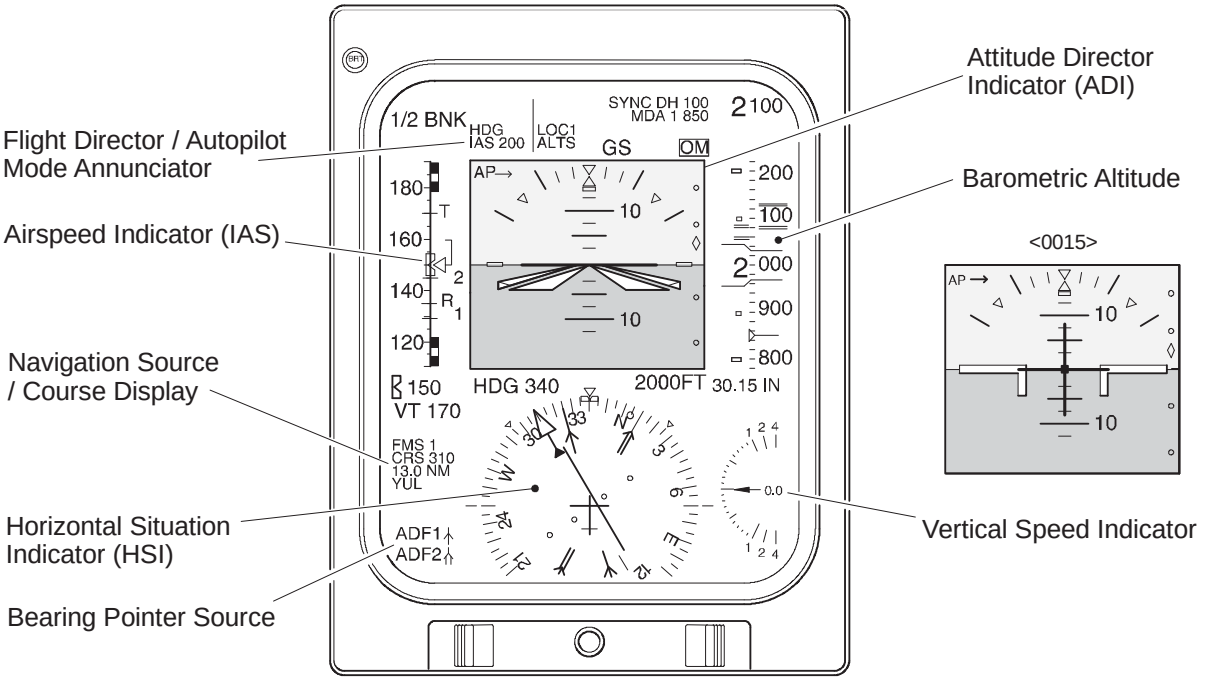
Display Selector
Used to change the pilot or copilot MFD display.
- PFD 1 or 2 – MFD changes to a PFD display and PFD display goes blank.



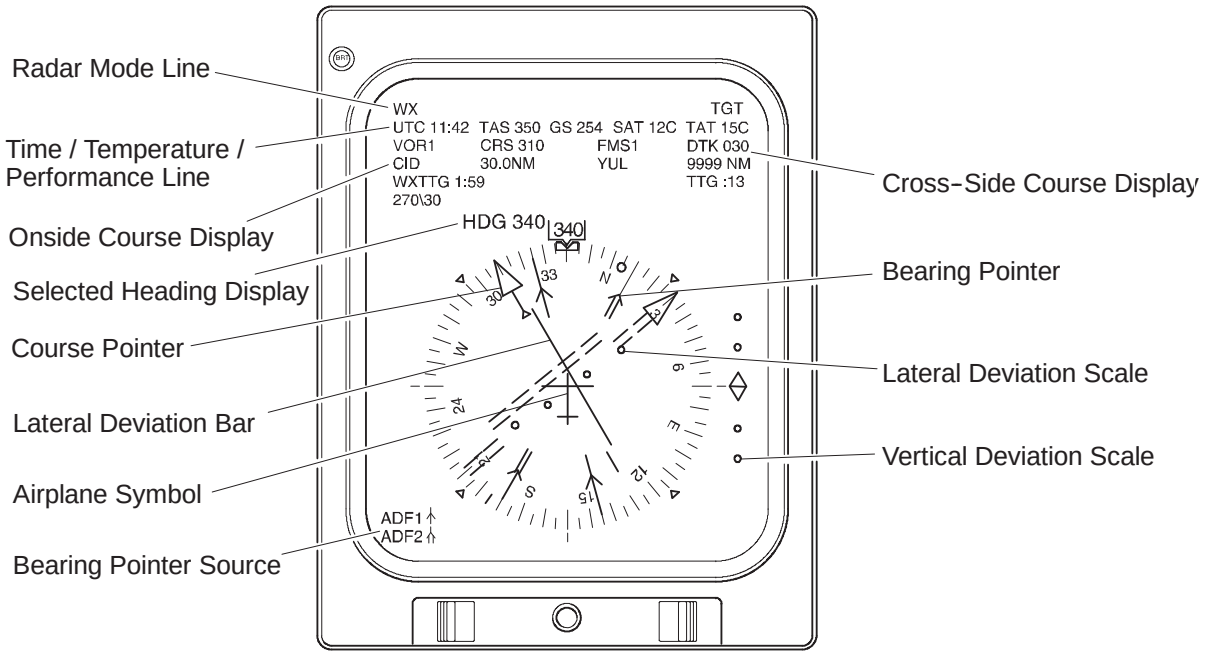
Pilot's Display Reversionary Panel
Pilot's Side Panel

Copilot's Display Reversionary Panel
Copilot's Side Panel

Display Selection
Figure 12–20–3



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 <MST>
Figure 12–20–4

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.

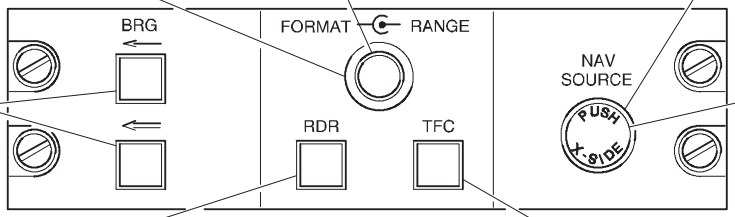
If one display control panel fails, the other panel can be used to control all four electronic flight displays. This is done by selecting the DSPL CONT knob, on the Source Selector Panel, to the 1 or 2 position as required.

FORMAT – Outer Selector
Used to select MFD format. Format selections are HSI compass, navaid sector, present position map (PPSN), plan map, TCAS and weather radar.

RANGE – Inner Selector
Used to select range displayed on MFD. Range selections are: 5, 10, 20, 40, 80, 160, 320 and 640 NM.

NAV SOURCE
Used to select navigation source. Clockwise rotation will be FMS1, VOR/LOC1, OFF, VOR/LOC2 and FMS2.

BRG
Used to select next waypoint that bearing pointer will indicate direction to.



PUSH X-SIDE
Used to display opposite side navigational source on MFD.

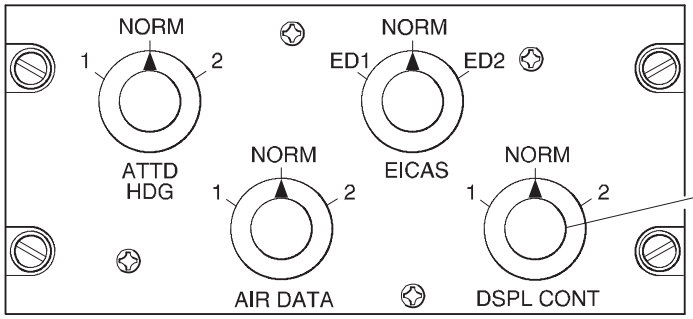
RDR
Used to select weather radar display.

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

TFC (TCAS)
Used to directly select TCAS traffic display on MFD. Range selections are 5, 10, 20 and 40 NM.

<0040>

RDR / TERR
Used to select weather radar display, terrain display or both.



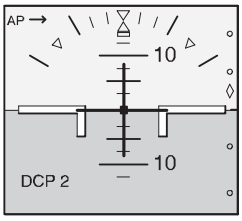
Source Selector Panel
Center Pedestal

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.

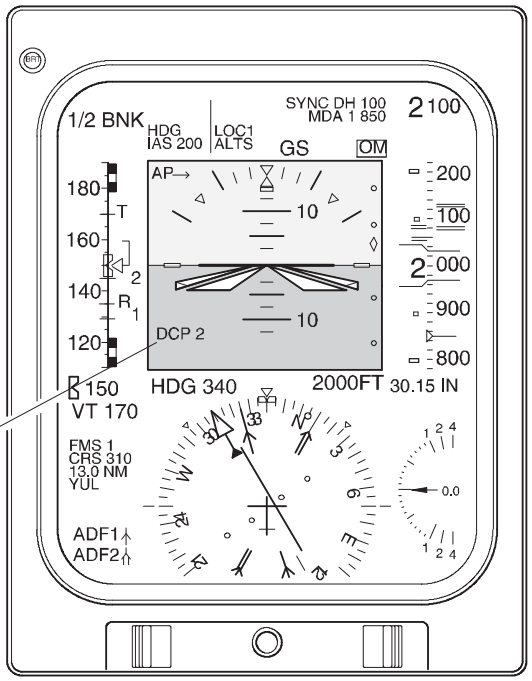
Display Control and Source Selector Panels <MST>
Figure 12–20–5

<0015>

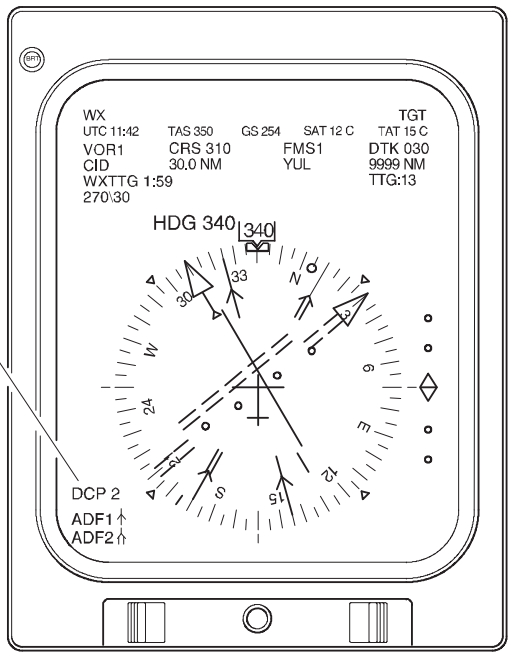


DCP 1 or 2 (amber)
Indicates that single display control panel source has been selected.

- 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 <MST>
Figure 12–20–6

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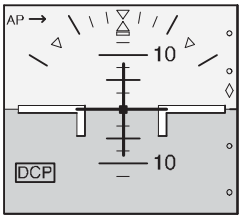
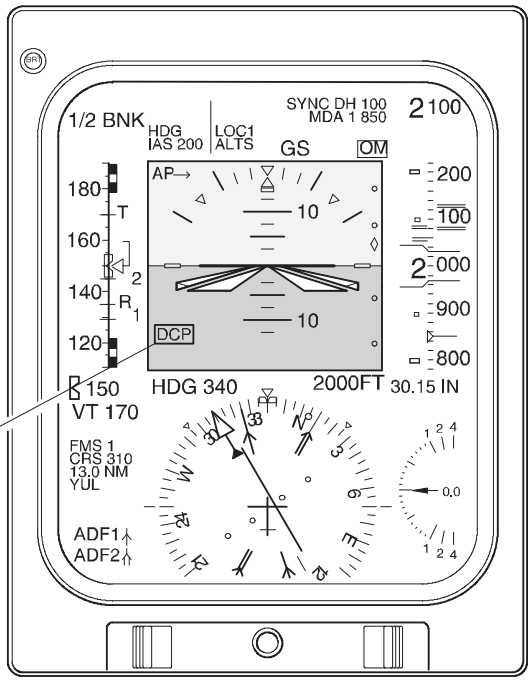
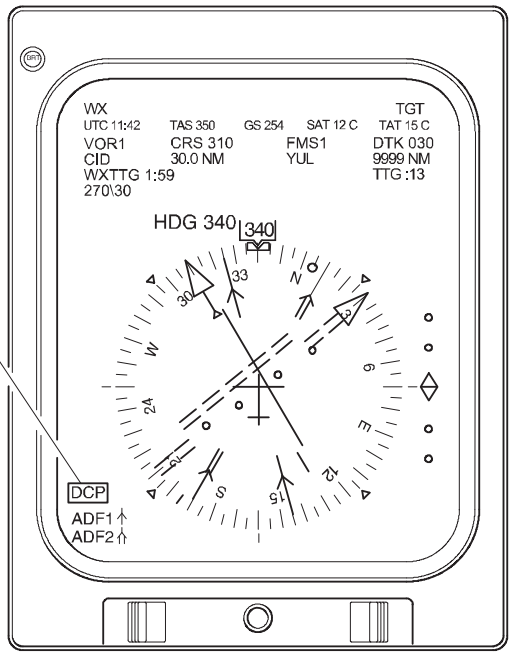




DCP, DCP 1 or DCP 2 Flag (red)
Indicates that selected display control panel has failed.

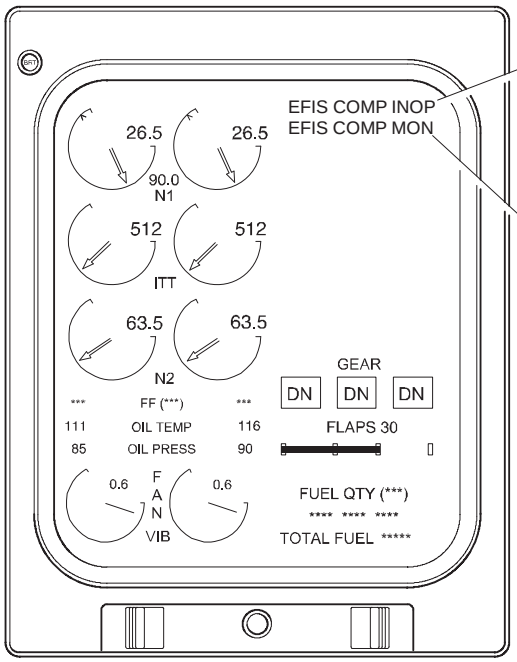
Primary Flight Display
Pilot's and Copilot's Instrument Panels



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

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

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

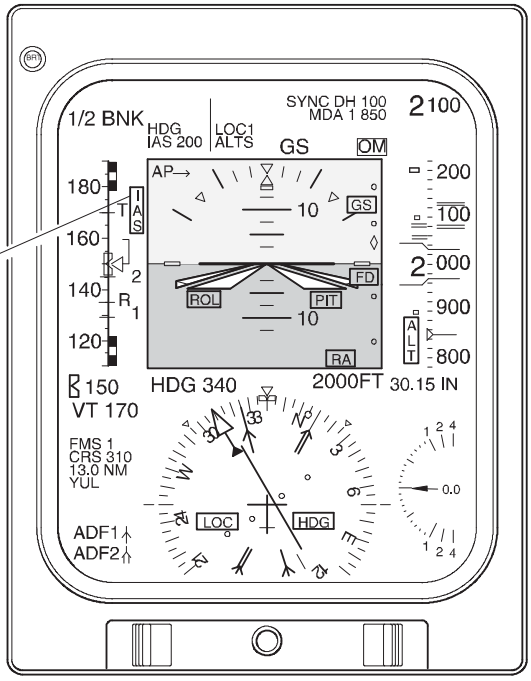


EFIS COMP MON caution (amber)
Indicates that a comparator miscompare has been detected.

<0006>

Primary Page

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



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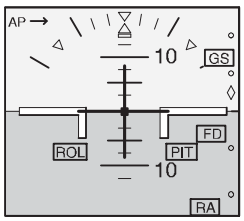

Primary Flight Display
Pilot's and Copilot's Instrument Panels

EFIS Abnormal Indications <MST>
Figure 12–20–8

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.

D. 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 ESS	4	D10	
		MFD 1			D11	
	Control Panel	EFIS CONT PNL 1			C9	
	Copilot's Flight Instruments	PFD 2	DC BUS 2	2	K1	
		MFD 2			K2	
	Control Panel	EFIS CONT PNL 2			K3	

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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 3).

A. Pitot Static System

The pitot static system supplies pitot and static air pressures to the ADCs, the standby altitude/attitude/airspeed indicator 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).

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).<0083>

The pilots and copilots pitot static probes each consist of a pitot mast (P1 and P2) and two static ports (S1 and S2). 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 (P3) supplies pressure inputs to the standby altitude/attitude/airspeed indicator.

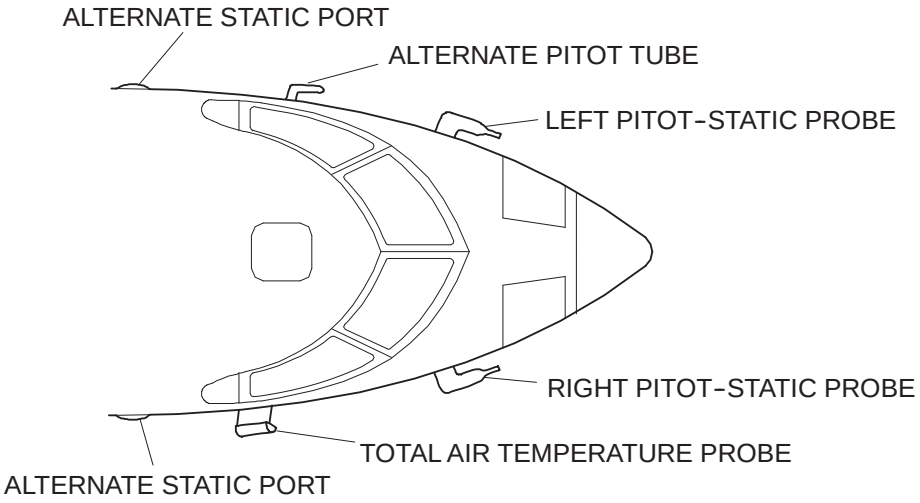
The alternate pitot probe (P3) supplies pressure inputs to the integrated standby instrument (ISI).<0083>

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.

Two Mach transducers supply primary Mach compensation data to the stall protection computer. The transducers are connected to the left and right pitot static system and provide a means of isolating a leaky transducer from the rest of the pitot static system. via the static source selectors. The selectors are controlled by mechanical selectors on the pilot’s and copilot’s side consoles.



Pitot Static System – General
Figure 12–30–1

B. Air Data

The air data system provides computed air data (speed, altitude and temperature) information to the following systems:

- Integrated avionics preocessor system (IAPS)
- Attitude and heading reference system (AHRS)
- Inertial reference system (IRS) <0025>
- Stall protection computer and flap ECU
- Air traffic control transponders and TCAS
- Flight control computers and flight director
- Electronic flight instrument system (EFIS) and engine indication and crew alerting system (EICAS) displays.

The air data system provides the following air data parameters:

- Pressure altitude and barometric–corrected altitude
- Vertical speed, indicated airspeed, Mach number and true airspeed (TAS)
- IAS reference (automatically through the AP control or manually through the air data reference panel)
- Static air temperature (SAT)
- Calibrated and indicated airspeed (CAS / IAS)
- Overspeed warning (present airspeed and Vmo)
- 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})
- Vertical speed references.

C. Air Data Reference Panels

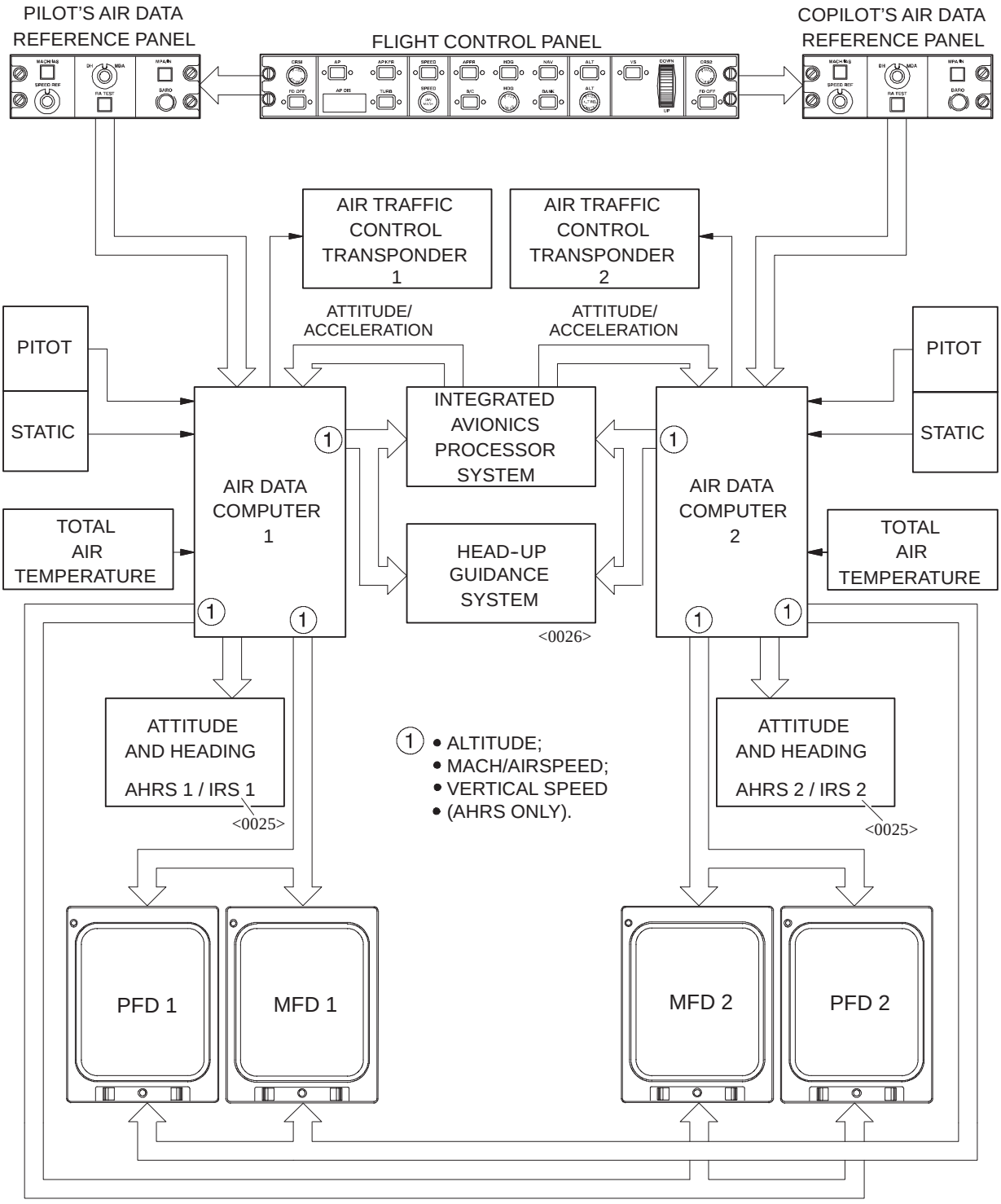
The air data reference panels (ARP) are located on the pilot's and copilot's side panels. Each ARP is used to enable selection of airspeed reference pointers and barometric correction for altitude.

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

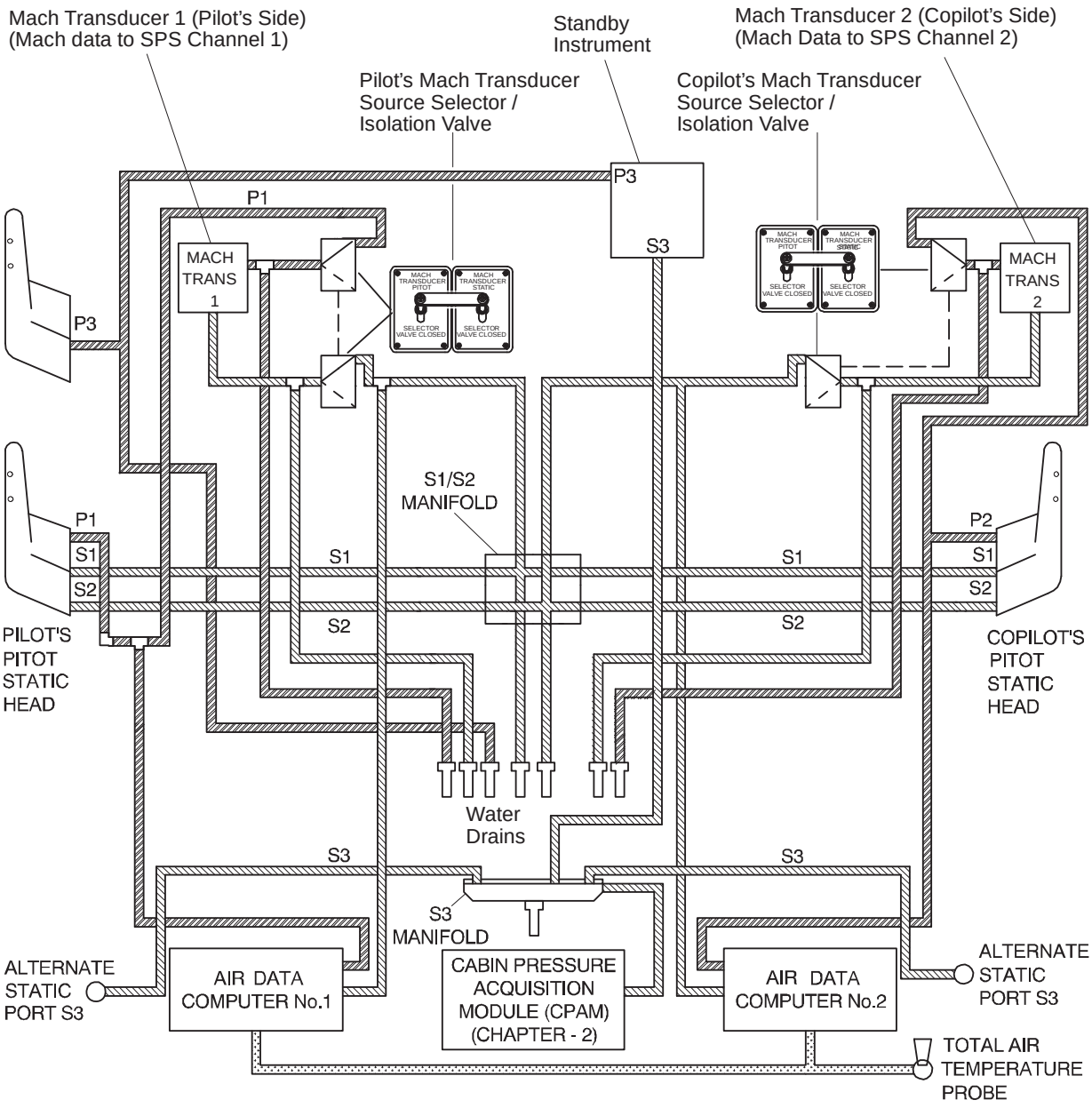
- The speed references section is used to select and input changes to the various target and speed settings (V1, VR, V2 and VT). Both PFDs will display the same values.

- 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 references section is used to select and input changes to the ADC barometric pressure, to select indicating units (hPa or inHg) and to 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.



Air Data System <MST>
Figure 12–30–2



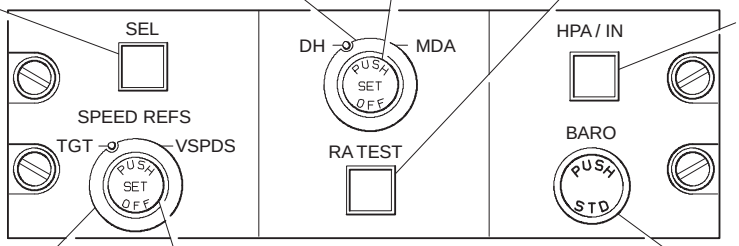
Pitot Static System
Figure 12–30–3

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.

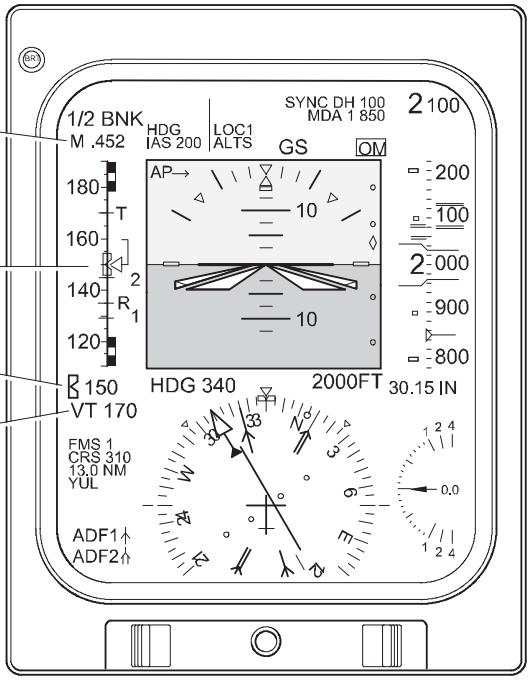
Air Data Reference Panel
Pilot's and Copilot's
Side Panels

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.

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.

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.

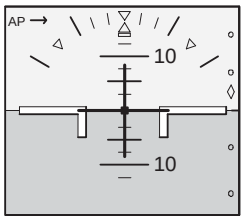
Airspeed Indicator

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



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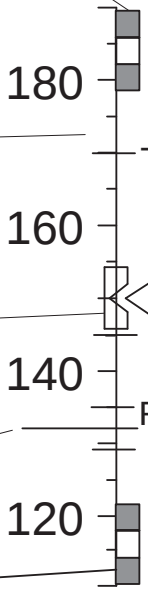


Indicated Airspeed Tape (white)
Moving tape that indicates current airspeed. Tape range is 40 to 400 knots with a display of 80 knots.
- Marks at 5 knot increments.
- Digits at 20 knot increments.

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

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

Indicated Airspeed Pointer (white)
Indicates current airspeed.

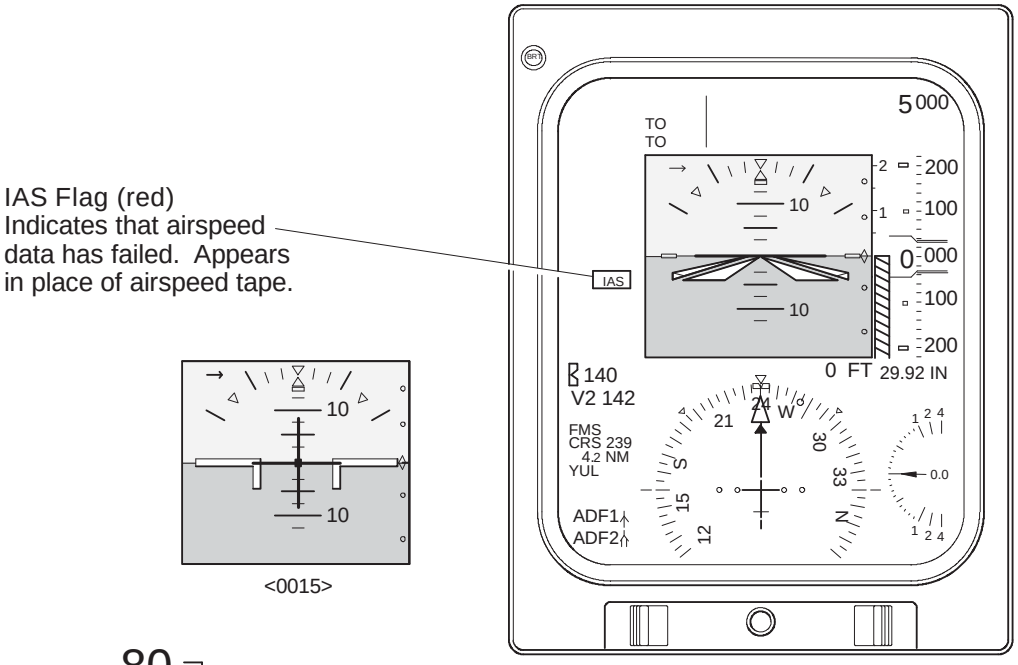
Speed Reference Bugs (cyan)
Removed 7.5 seconds after speed is exceeded (except target speed).
- 1 Takeoff decision speed (V1)
- R Rotate airspeed (VR)
- 2 Take-off safety speed (V2)
- T Target speed (VT)

Stall Speed Indicator (green line)
Indicates 1.25 times the computed stall speed. Displayed in flight only. <FAA>

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 <MST>
Figure 12–30–5



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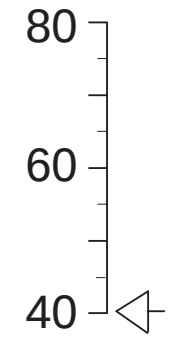
Primary Flight Display
Pilot's and Copilot's Instrument Panels

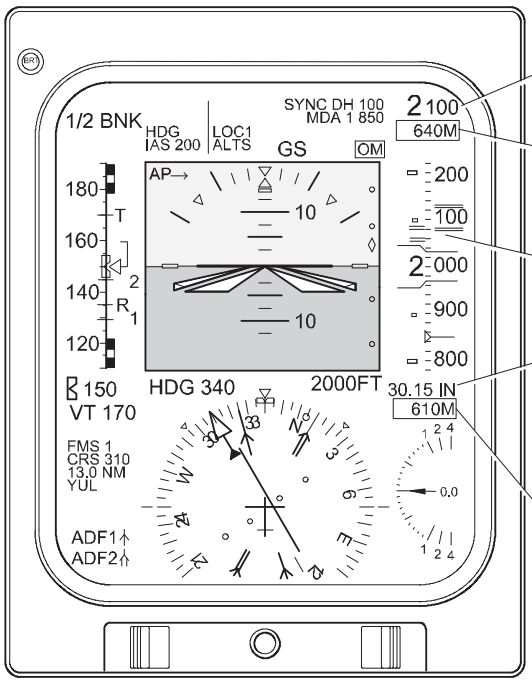


VT 170
V2 142
VR 136
V1 131

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 <MST>
Figure 12–30–6



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

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

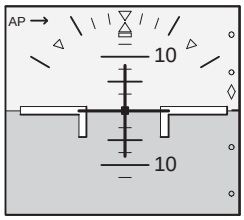
Metric Preselected Altitude Readout (magenta)
Indicates preselected altitude in meters.
Displayed when metric altimeter is selected on.

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.

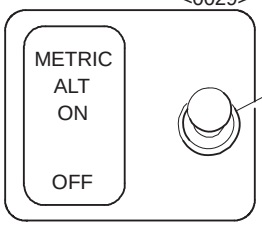
<0023> Barometric pressure setting readout flashes when:
- Airplane climbs through 17,800 ft and barometric pressure setting is not set to standard value.
- Airplane descends through 18,500 ft and barometric pressure setting is set to standard value.

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



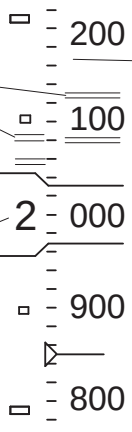
<0015>

<0029>



Metric Altimeter Switch
Center Pedestal

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.



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 <MST>
Figure 12–30–7

D. Altitude Alerts

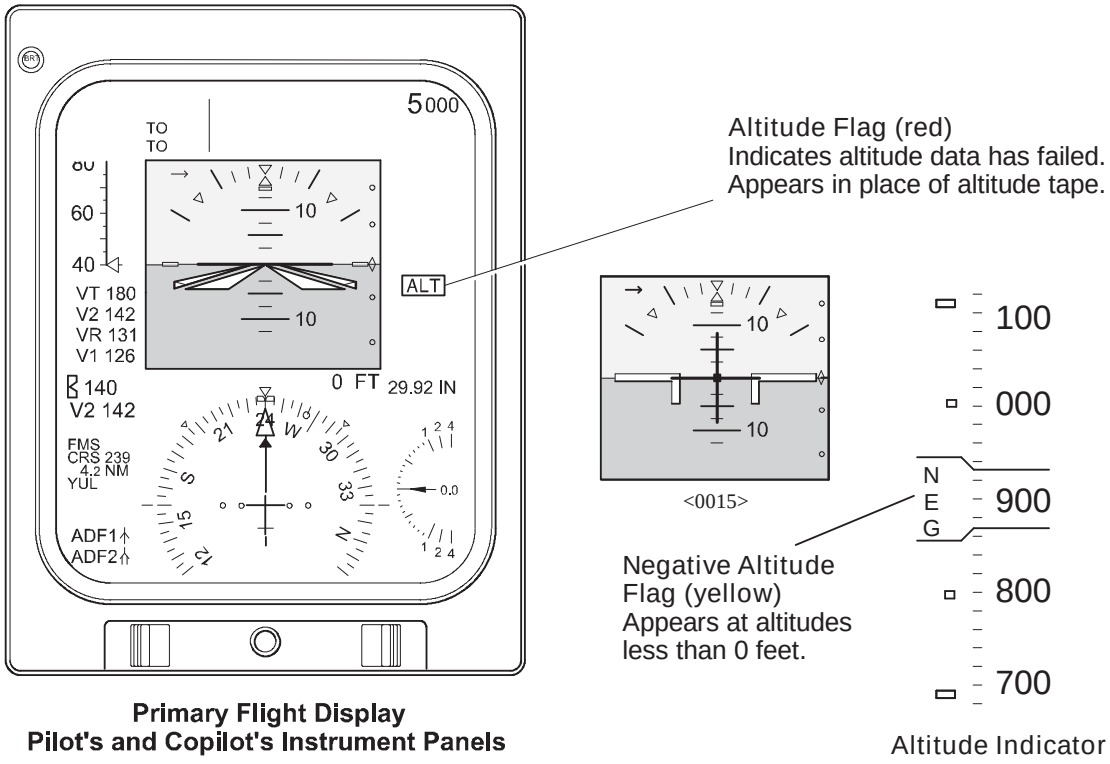
The altitude alert system alerts the flight crew that a preselected altitude has been reached or a deviation from a preselected altitude has occurred. When the aircraft is cleared to change altitude, the preselected altitude is set on the PFD through the flight control panel (FCP). There are three types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

- Acquisition mode
- Cross side tracking
- Deviation mode.

Pending Rectification

NOTE

An anomaly has been discovered in the ADC software which causes the aural altitude alerter (C–Chord) not to cancel if an AFCS transfer is made while the aural alert relay is energized. If the altitude alerter does not cancel automatically after 1 second because the AFCS transfer was operated while the aural alert relay was energized, briefly switch the AFCS transfer back to the previous setting. Once the aural altitude alerter cancels the AFCS transfer may be reselected as required.



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

Altitude Alerts <MST>
Figure 12–30–8

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

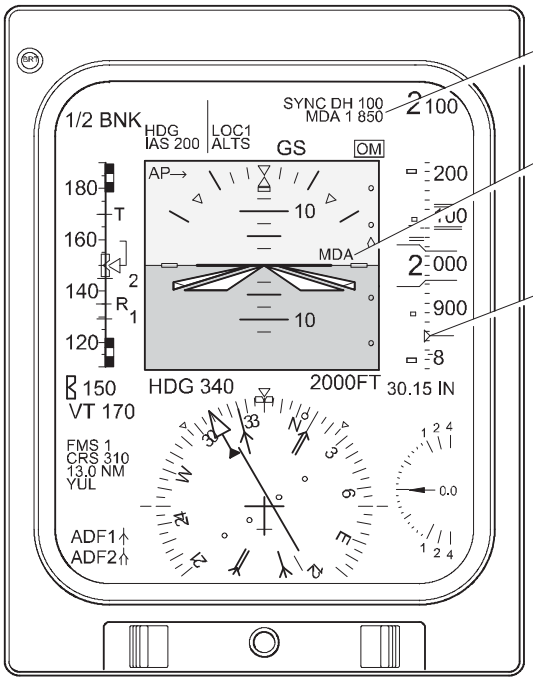
Each ADC compares the preselect altitude value from both computers for equality. If the values are not equal, the preselect altitude digits on the display change from magenta to cyan.

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. 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.

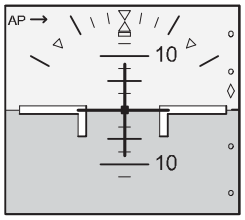


Primary Flight Display
Pilot's and Copilot's Instrument Panels

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

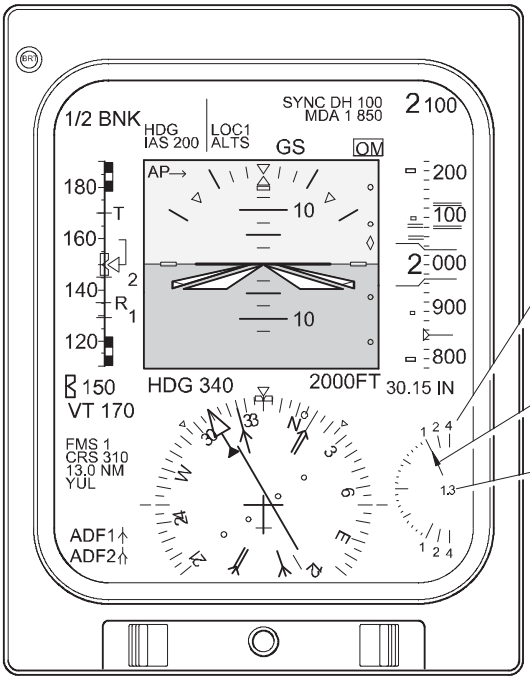
Minimum Descent Altitude Alert (amber)
Indicates that airplane has arrived at minimum descent altitude.

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



<0015>

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



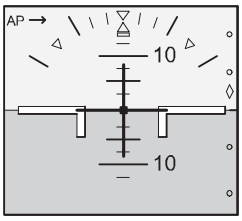
Primary Flight Display
Pilot's and Copilot's Instrument Panels

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).



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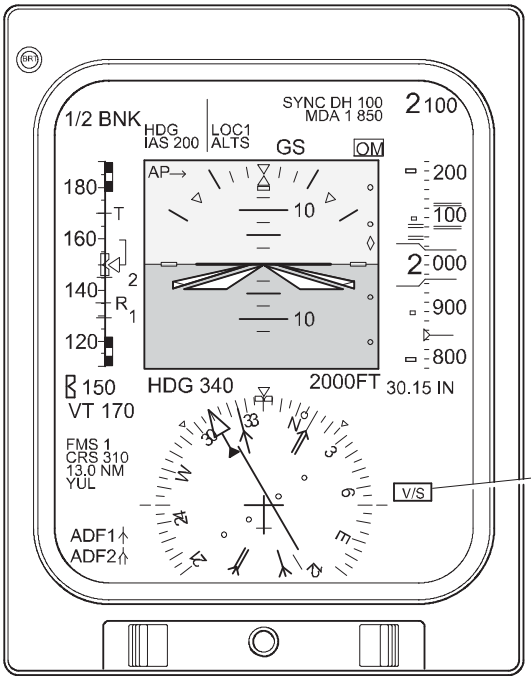
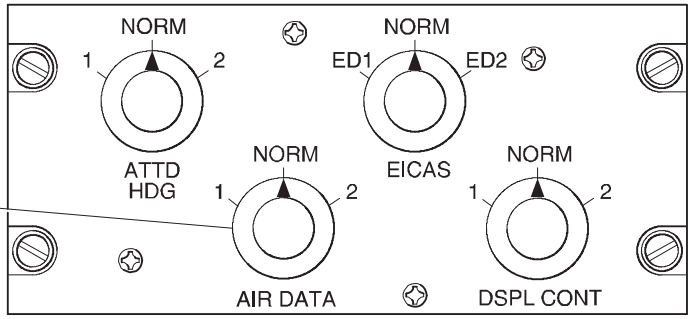


Primary Flight Display
Pilot's and Copilot's Instrument Panels

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

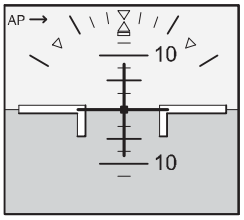
Vertical Speed Indication and Flag <MST>
Figure 12–30–10

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.



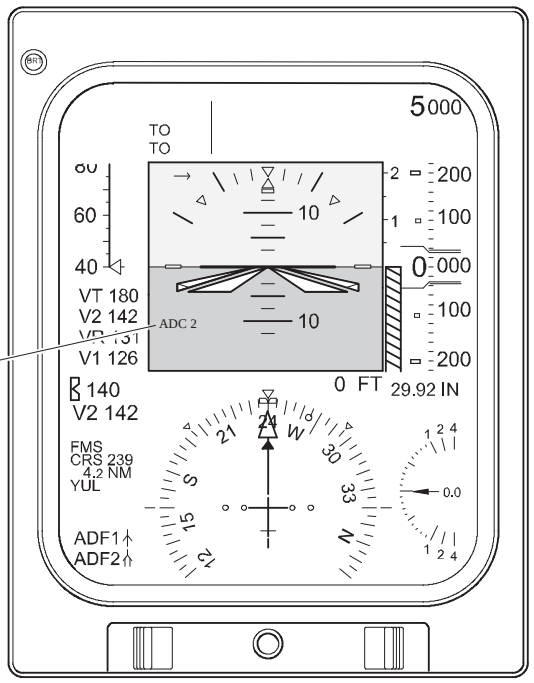
Source Selector Panel
Center Pedestal

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



<0015>

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 <MST>
Figure 12–30–12

I. System Circuit Breakers

SYSTEM	SUB-SYSTEM	CB NAME	BUS BAR	CB PANEL	CB LOCATION	NOTES
Flight Data	Air Data Computer	ADC 1	DC ESS	4	D3	
		ADC STBY	DC BAT	1	P8	
		ADC 2	DC BUS 2	2	H6	

1. RADIO ALTIMETER SYSTEM

The radio altimeter (RADALT) system provides an accurate measurement of absolute altitude (height above terrain) from 0 to 2500 feet AGL. Radio altitude information is supplied to the following:

There are two radio altimeter (RADALT) systems installed on the aircraft. Each system provides an accurate measurement of absolute altitude (height above terrain) from 0 to 2500 feet AGL. Radio altitude information is supplied from both radio altimeters to the following: <0045>

- PFD's
- Flight control systems
- Ground proximity warning system (GPWS)
- Enhanced ground proximity warning system (EGPWS) <0040>
- Traffic alert and collision avoidance (TCAS).

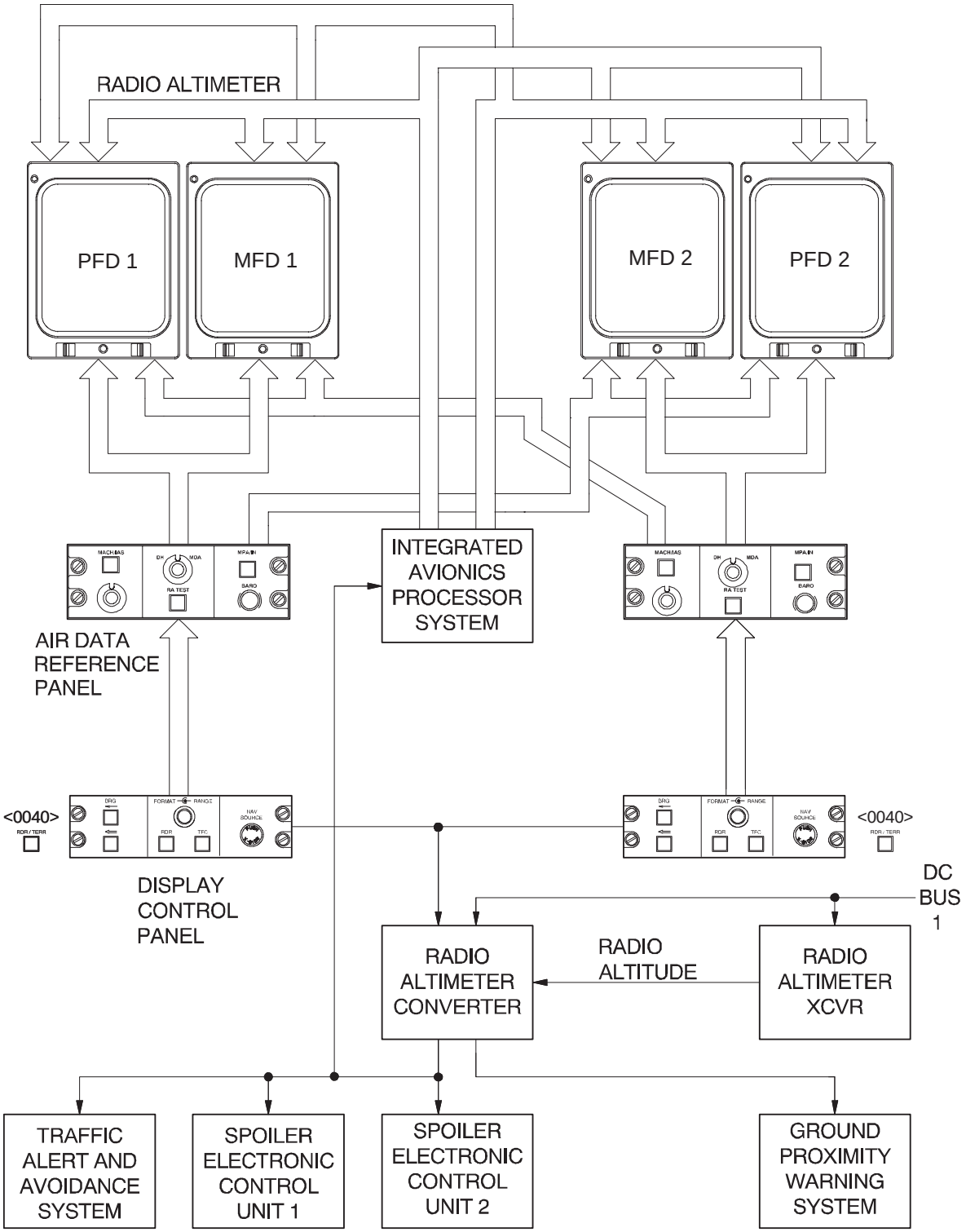
The radio altimeter provides the pilot's and copilot's PFDs with the following:

- 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 PFD's.

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.

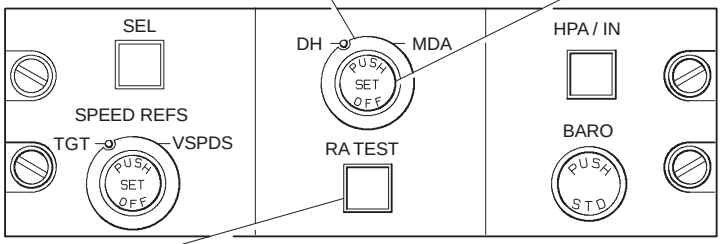
Decision height is set (from 0 to 999 feet) using either pilot's air data reference panel. A test button is provided on the air data reference panel to verify the operation of the radio altimeter system.



Radio Altimeter System <MST>
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.

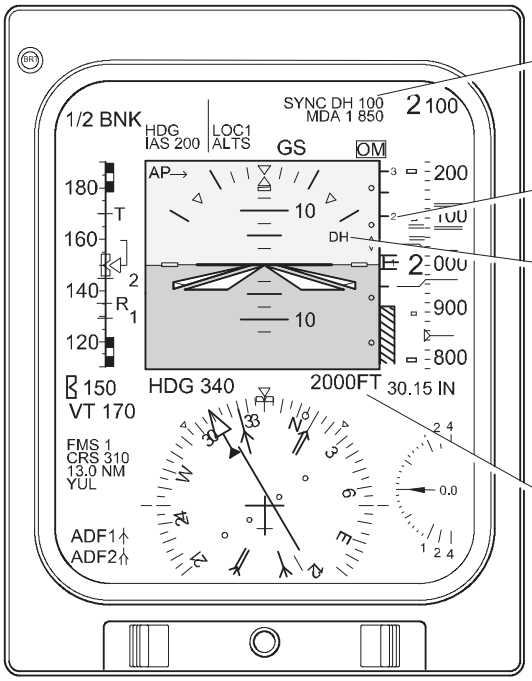
PUSH / SET / OFF
Used to adjust selected altitude readout.
- When pushed, the selected altitude readout (DH or MDA) is displayed on the PFD.
- When rotated, the selected altitude readout is adjusted (DH in 1 ft increments, MDA in 10 ft increments).
- When pushed again, the selected altitude readout is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



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

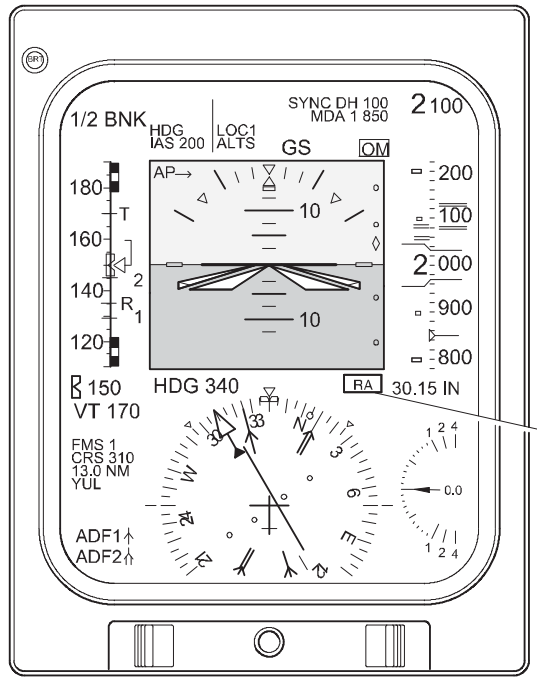
Decision Height Readout (cyan)
Indicates selected decision height as set on the air data reference panel (range is 0 to 999 feet).
- Red dashes indicate failed input.

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

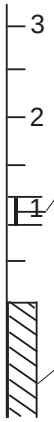
Decision Height Alert (amber)
Indicates that airplane has arrived at decision height.
- During go–around, alert is disabled at decision height +100 feet.
- Alerts inhibited below 5 feet.

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



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

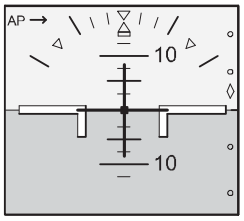
not included in <JAA>

Ground Bar (amber)
Indicates terrain.

Radio Altimeter

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

<0015>



Radio Altimeter Indication <MST>
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	K7	
		RAD ALT 2	DC BUS 2	2	L1	<0045>

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1. ATTITUDE AND HEADING REFERENCE SYSTEM

The attitude and heading reference system (AHRS) is a gyro reference system that generates angular rate and linear acceleration information about the aircraft axis.

The AHRS is a dual system with two independent attitude and heading computers. Each computer receives corrected heading information from an individual flux detector which sense the earth's magnetic field. Each computer also receives information from the same side air data system. This information, together with accelerometer sensor data, 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, GPWS, weather radar, fuel system, stall protection system, flight data recorder and data concentrator units.

These signals are also routed to the TCAS, EGPWS, weather radar, fuel system, stall protection system, flight data recorder and data concentrator units. <0040>

AHRS provides attitude and heading information to the electronic flight instruments. The PFD's display AHRS alignment flags during initialization (30 to 70 seconds). If aircraft primary power is lost, the AHRS will continue to operate on battery bus power for 11 minutes. 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.

AHRS mode selections are made using the pilot or copilot compass control panel. The AHRS normally operates in magnetic (MAG) mode. Directional gyro (DG) mode is intended to operate as a heading reference, only for a short period of time, near areas where magnetic disruptions exist and does not use data from the flux detector.

A slew switch is provided to change heading direction. The switch is operational in both MAG and DG modes. In DG mode it is used periodically to correct for drift. In MAG mode, it also causes the heading to slew in the selected direction. When the switch is released in MAG mode, the heading will slowly slave back to the heading defined by the flux detector.

2. INERTIAL REFERENCE SYSTEM <0025>

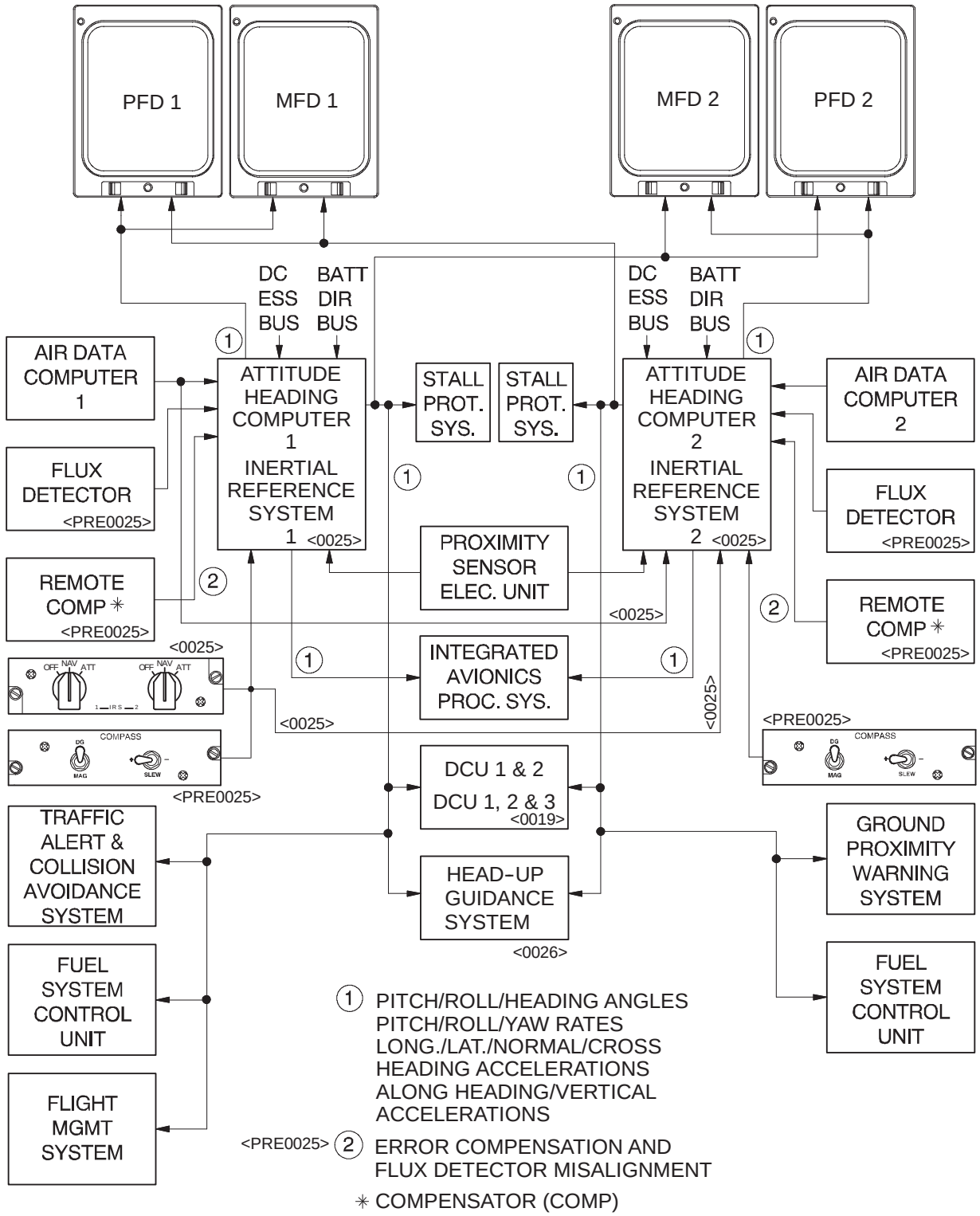
The inertial reference system (IRS) provides inertial outputs of attitude, heading, angular rates, linear acceleration and present position to be displayed on the flight displays and to be used by other avionics systems.

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, weather radar, 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.

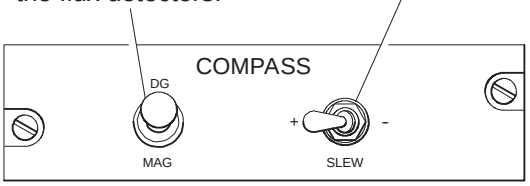


Attitude and Heading Reference System/Inertial Reference System <MST>
Figure 12–50–1

DG / MAG
Used to set AHRS mode
- DG – HSI performs like a directional gyro and does not use data from the flux detectors.
- MAG – HSI is continuously adjusted using data from the flux detectors.

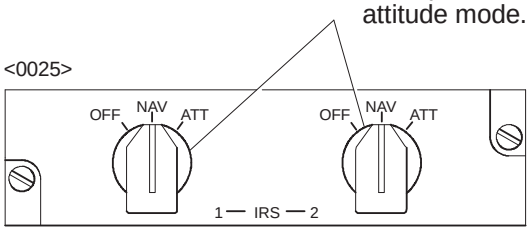
SLEW
Used to periodically correct heading when in DG mode. Will move reading in MAG mode, but returns to previous heading when switch is released.
- – – Slews HSI graphic reading to the right.
- + – Slews HSI graphic reading to the left.

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.



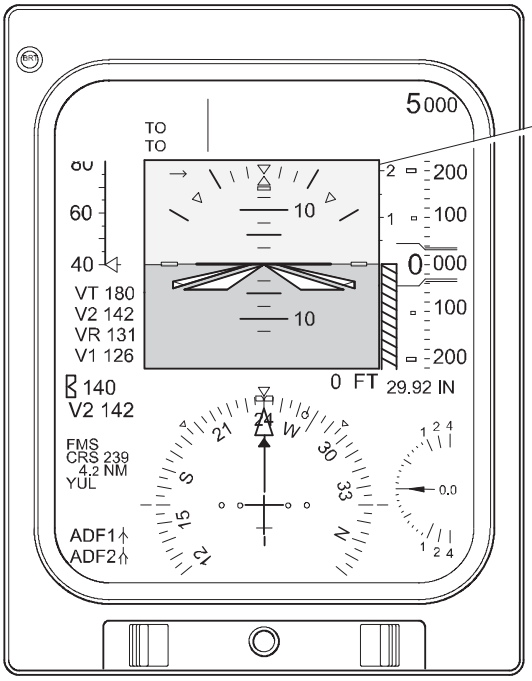
Pilot's and Copilot's Compass Control Panel
Center Pedestal

<0025>



IRS Mode Select Unit
Center Pedestal

Compass Control Panel/Inertial Reference System Mode Select Unit <MST>
Figure 12–50–2



Attitude Director Indicator

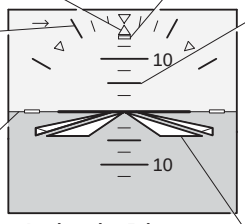
Primary Flight Display
Pilot's and Copilot's Instrument Panels

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.

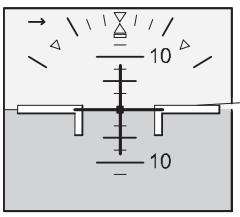
Pitch Tape (white)
Moving tape that indicates pitch attitude.
- Small marks at 2 ½ degree increments.
- Medium marks at 5 degree increments.
- Large marks and numbers at 10 degree increments.
- Red chevrons pointing towards zero pitch are displayed during extreme pitch attitudes.

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°



Attitude Director Indicator

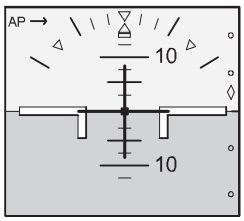
Horizon Line (white)
Indicates roll and pitch attitude relative to airplane symbol.
Horizon bar rotates to display roll attitude and moves vertically to display pitch attitude.
The boxes at ends of horizon bar represent airplane wing tips.



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

<0015>

Attitude Director Indications <MST>
Figure 12–50–3



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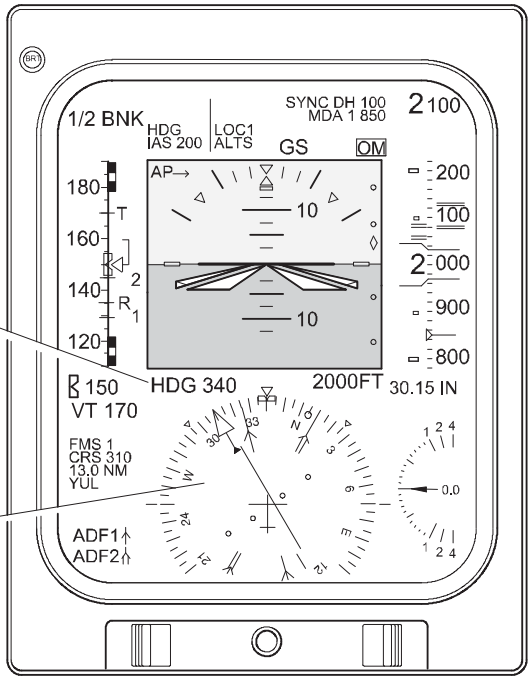


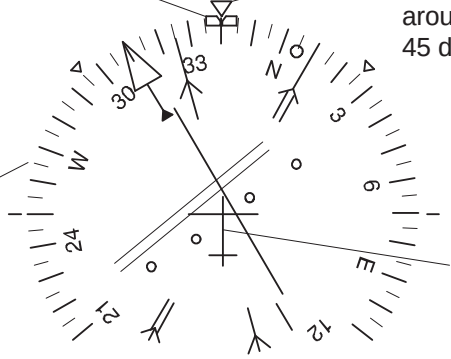
Selected Heading Readout (magenta)
Indicates selected heading as set using heading knob on flight control panel. Removed 5 seconds after heading is selected.

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 <MST>
Figure 12–50–4

A. Display Reversion

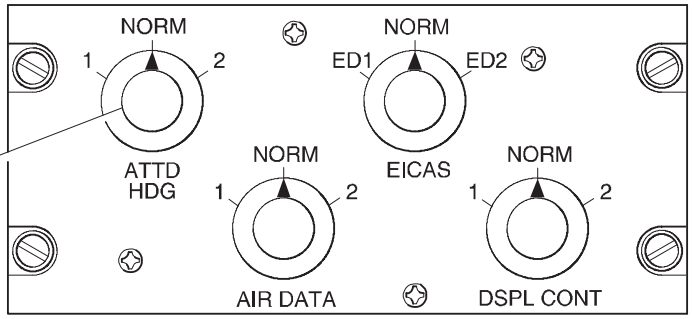
Display capability is maintained when sensor data failure occurs. Either PFD (or MFD when in PFD format) can be configured to display data from either attitude and heading reference system by operation of a reversionary switch on the source selector panel. Selection of alternate data sources is indicated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

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 a reversionary switch on the source selector panel. Selection of alternate data sources is indicated to the flight crew by yellow single source flag on the PFD and MFD. <0025>

ATTD HDG

Used to revert attitude and heading reference systems.

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

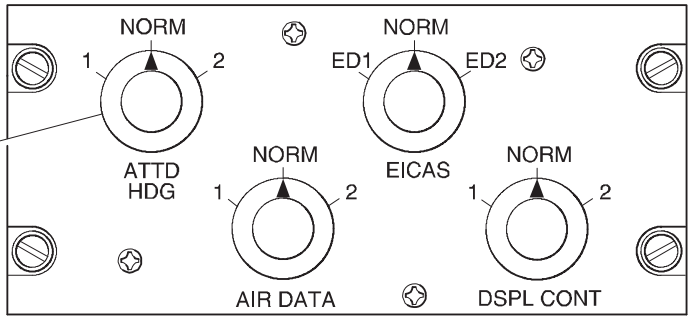


Source Selector Panel
Center Pedestal

ATTD HDG

Used to revert inertial reference systems.

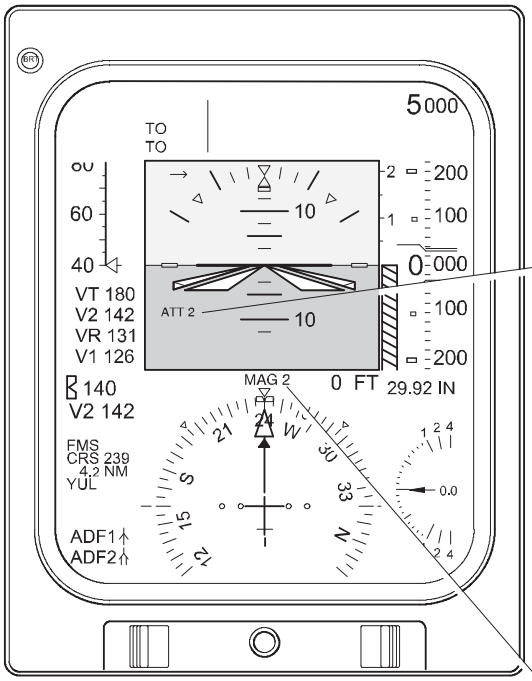
- NORM – Each inertial reference unit supplies data to the same side display.
- 1 – Inertial reference unit 1 supplies data to both pilot and copilot displays. An amber source message is displayed on both PFDs.
- 2 – Inertial reference unit 2 supplies data to both pilot and copilot displays. An amber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



<0025>

Source Selector Panel
Center Pedestal

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

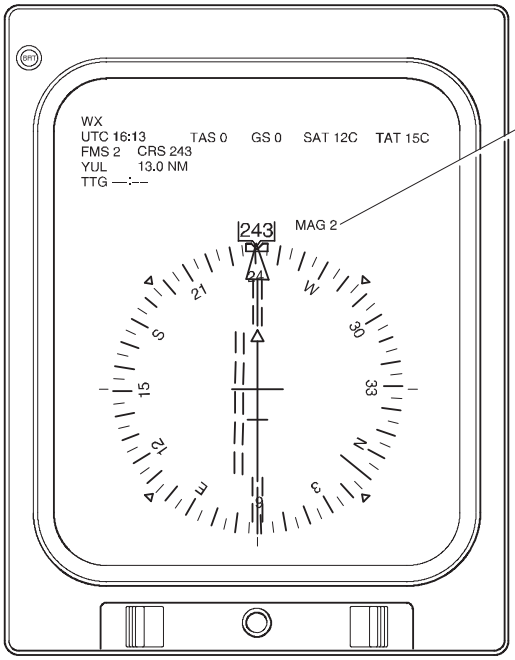


Primary Flight Display
Pilot's and Copilot's Instrument Panels

ATT 1 or 2 (amber)
Indicates that single attitude and heading source has been selected.

- ATT 1 - Attitude and heading computer 1 selected.
- ATT 2 - Attitude and heading computer 2 selected.

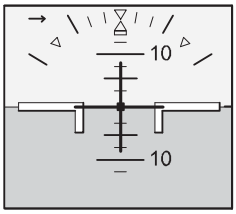
<0025> ATT 1 or 2 (amber)
Indicates that single inertial reference source has been selected.
ATT 1 – Inertial reference unit 1 selected.
ATT 2 – Inertial reference unit 2 selected



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

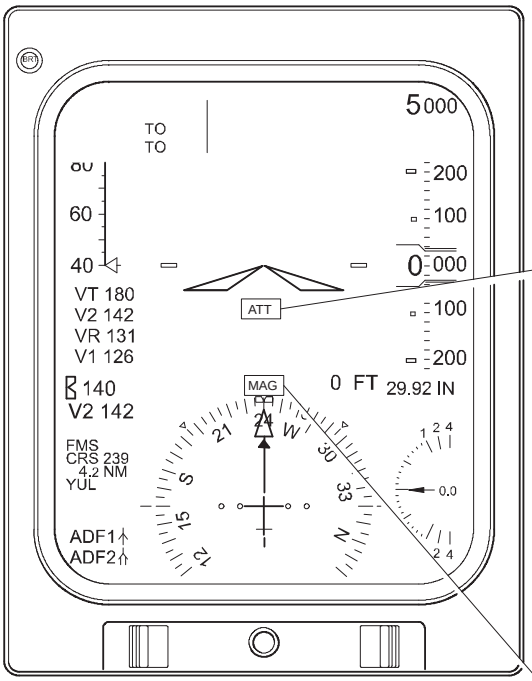
MAG 1, MAG 2, DG 1 or DG 2 (amber)
Indicates heading selection when a single attitude and heading source has been selected.

<0025> MAG 1, MAG 2, TRU 1 or TRU 2 (amber)
Indicates heading selection when a single Inertial reference source has been selected.



<0015>

Attitude and Heading Source Selection <MST>
Figure 12–50–6

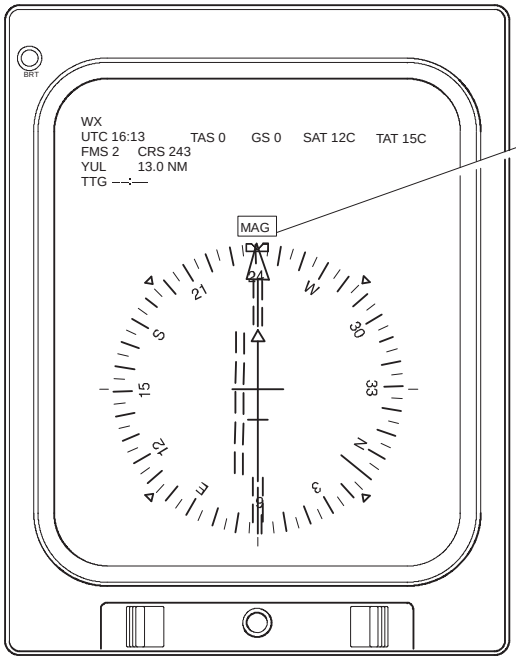


Primary Flight Display
Pilot's and Copilot's Instrument Panels

<0015>

ATT Flag (red)
Indicates that onside or both attitude and heading systems have failed.

<0025> 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 1 or DG Flag (red)
Indicates that onside or both attitude and heading systems are faulty or out of tolerance.

<0025> MAG or TRU Flag (red)
Indicates that onside or both inertial reference systems are faulty or out of tolerance.

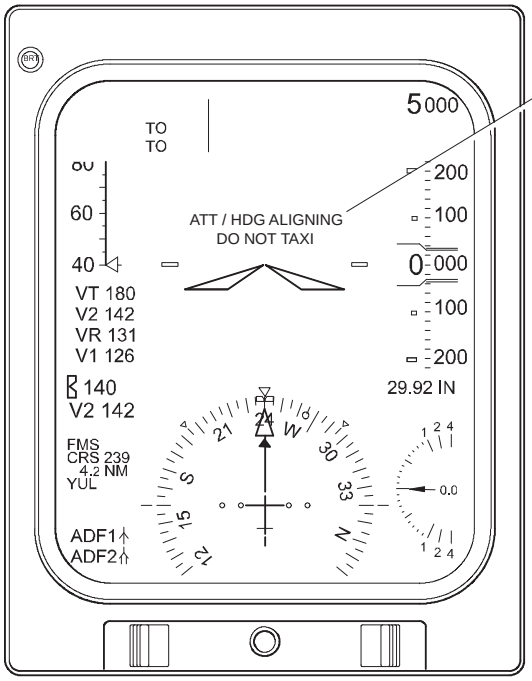
Attitude/Heading Source Failure Indications <MST>
Figure 12–50–7

B. Initialization and Alignment

AHRS initialization and operation occurs automatically when electrical power is established and the aircraft is stationary. Initialization in MAG mode takes about 70 seconds. DG mode requires a much longer time to initialize. In flight, initialization requires straight, unaccelerated level flight. The primary flight displays (PFD's) present a flashing initialization alignment message during initialization.

IRS initialization takes about 7 minutes at normal temperature. The IRS requires that the initial position be entered using the flight management system (FMS). The primary flight displays (PFD's) 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 aircraft is stationary on the ground or in straight and level flight. <0025>

The magnetic flux detectors used to originate heading information are sensitive to localized magnetic fields and magnetic anomalies. The effects and the procedural responses to these conditions are presented in the Collins AHS-85 / 85E Attitude Heading System Pilot's Guide.



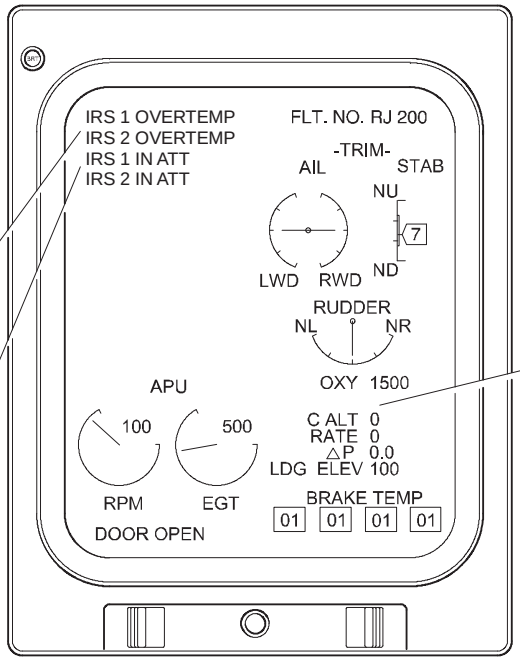
Primary Flight Display
Pilot's and Copilot's Instrument Panels

Alignment Annunciator (white)
Indicates attitude and heading alignment in process.

- DO NOT TAXI is also displayed when airplane is on the ground.

<0025> Alignment Annunciator (white)
Indicates inertial reference alignment in process.

<0015>



<0039>
7.2

<0039>
C TEMP 23°C

<0025>
IRS 1 (2) OVERTEMP status (white)
Indicates that an overtemperature condition exists.

<0025>
IRS 1 (2) IN ATT status (white)
Indicates that IRS is operating in attitude mode.

Status Page

Attitude/Heading Source Alignment Indications <MST>
Figure 12–50–8

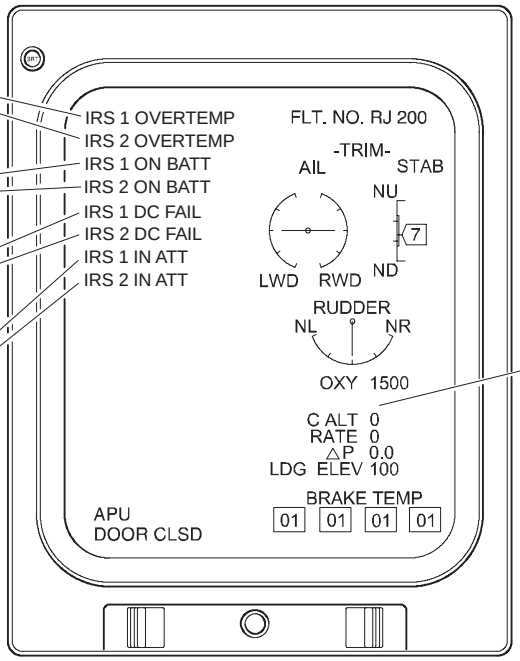
AHRS ALIGNMENT	
Mode	**Time to Align**
MAG (normal or on the ground)	70 seconds (No adverse motion sensed by the aircraft; Normal passenger movement is acceptable.)
DG	10 minutes
Airborne	10 to 35 seconds (The aircraft must remain in straight and level, unaccelerated flight.

IRS 1/2 OVERTEMP Status (white)
Comes on to indicate that an overtemperature condition exists.

IRS 1/2 ON BATT Status (white)
Comes on to indicate that IRS is operating on back–up power.

IRS 1/2 DC FAIL Status (white)
Comes on to indicate that IRS back–up power has failed.

IRS 1/2 IN ATT Status (white)
Comes on to indicate that IRS is operating in attitude mode.



Status Page

IRS – EICAS Messages <MST>
Figure 12–50–9

C. System Circuit Breakers

SYSTEM	SUB-SYSTEM	CB NAME	BUS BAR	CB PANEL	CB LOCATION	NOTES
Attitude and Heading Systems (AHRS)	Pilots System	AHRS FAN 1	DC ESS	4	D9	
		AHRS 1	DC ESS	4	D8	
		ATT/HDG 1	MAIN BAT DIR	5	A8	
	Copilots System	AHRS FAN 2	DC BUS 2	2	H15	
		AHRS 2			H14	
		ATT/HDG 2	MAIN BAT DIR	5	A9	
Inertial Reference System (IRS) <0025>	Pilots System	ATT/HDG 1	MAIN BAT DIR	5	A8	
		IRU 1	AC ESS	3	C2	
	Copilots System	IRU 2	AC BUS 2	2	B14	
		ATT/HDG 2	MAIN BAT DIR	5	A9	

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1. STANDBY INSTRUMENTS AND CLOCKS

A standby attitude indicator and a standby altimeter/airspeed indicator 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.

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. <0083>

A. Standby Attitude Indicator

The standby attitude indicator displays aircraft pitch and bank angles. It is a 28 VDC driven gyro that provides pitch and roll information for at least nine minutes after a power failure. It also serves as a standby ILS indicator to provide localizer and glideslope indications.

B. Standby Altitude/Airspeed Indicator

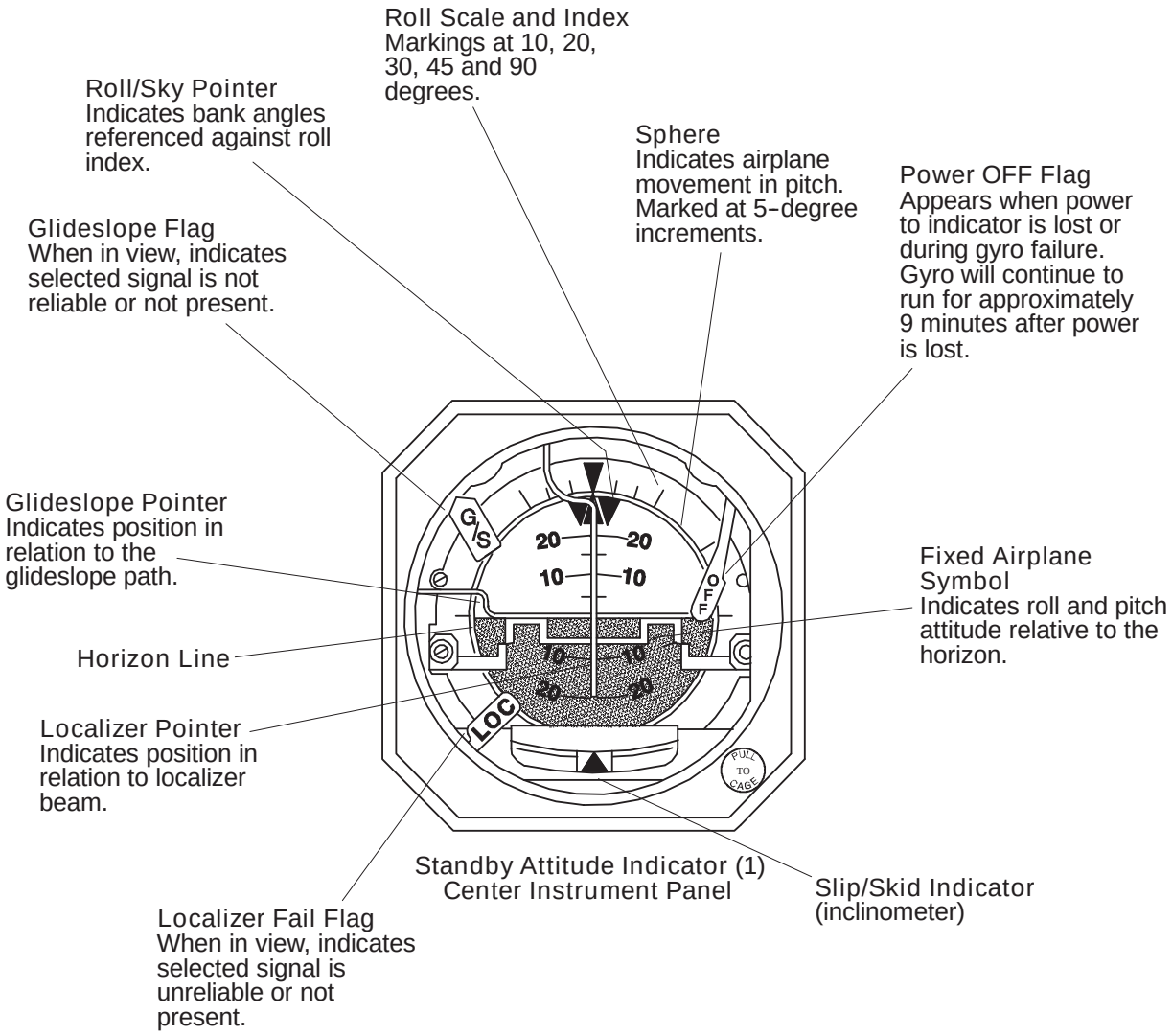
The standby altimeter/airspeed indicator displays barometric altitude from –1000 to +50,000 feet (±20). A BARO set knob is provided. The standby airspeed portion of the indicator displays non–corrected indicated airspeed from 60 to 450 knots (±3 knots).

C. Integrated Standby Instrument <0083>

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:

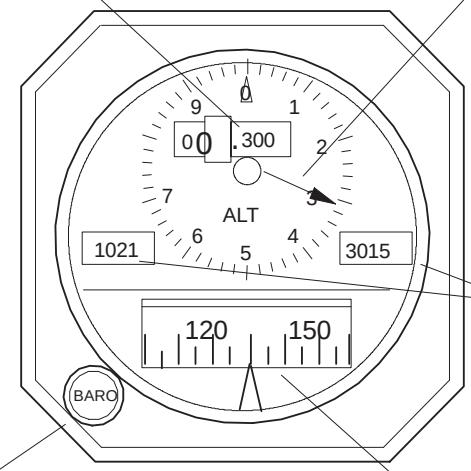
- Attitude display
- ILS deviation
- Altitude display (corrected)
- VMO display
- Airspeed display
- Static source error correction (SSEC)
- Mach number
- Barometric pressure
- Slip-skid indication



Standby Attitude Indicator
Figure 12–60–1

Altitude Readout
Indicates barometric altitude from –1000 to 50 000 feet, in 1,000–foot and 100 foot increments.

Altitude Pointer and Scale
Pointer indicates altitude in 100–foot increments as read from scale. Full circle for each 1,000 feet of altitude



HPA/IN HG Readouts
Indicates selected barometric pressure as expressed in Hectopascals and inches of mercury.

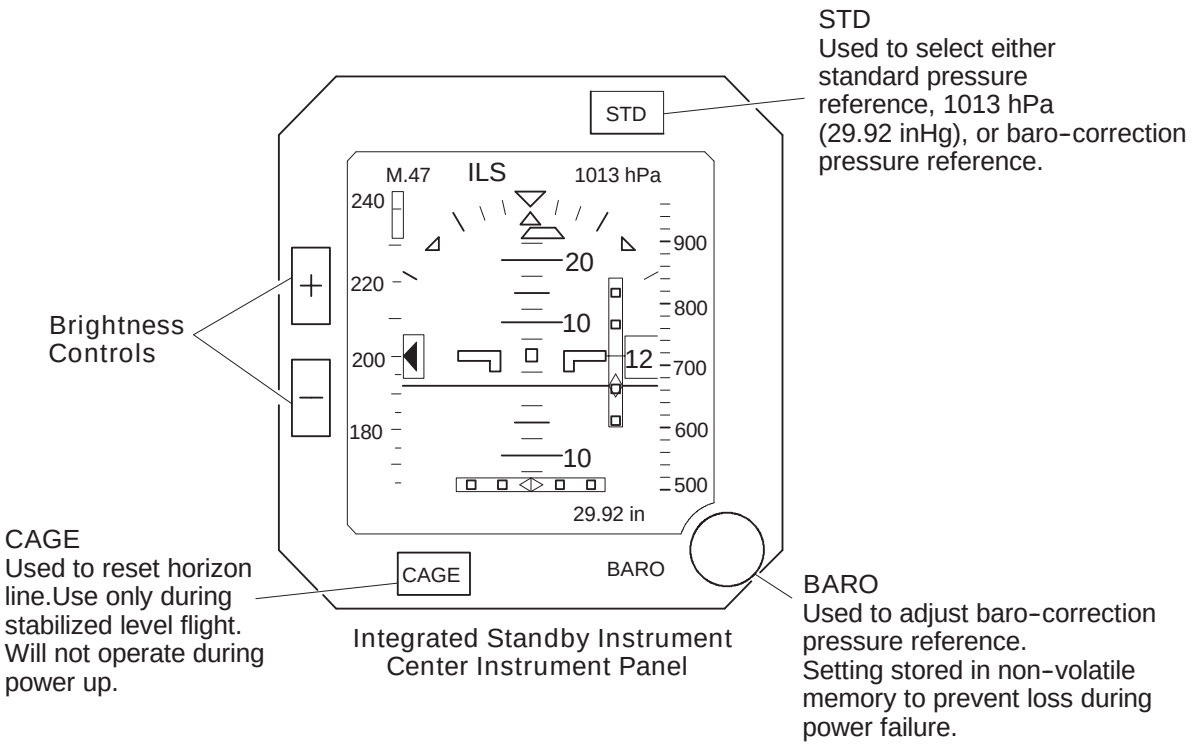
Barometric Set Knob
Used to change barometric pressure values as read at HPA/IN HG readouts.
Range for this standby instrument is as follows:
- from 952 to 1049 Hpa and
- from 28.2 to 30.99 in. Hg.

Standby Altimeter/ Airspeed Indicator

Indicated Airspeed Indicator
Indicates speed in knots, from 0 to 450 KIAS.

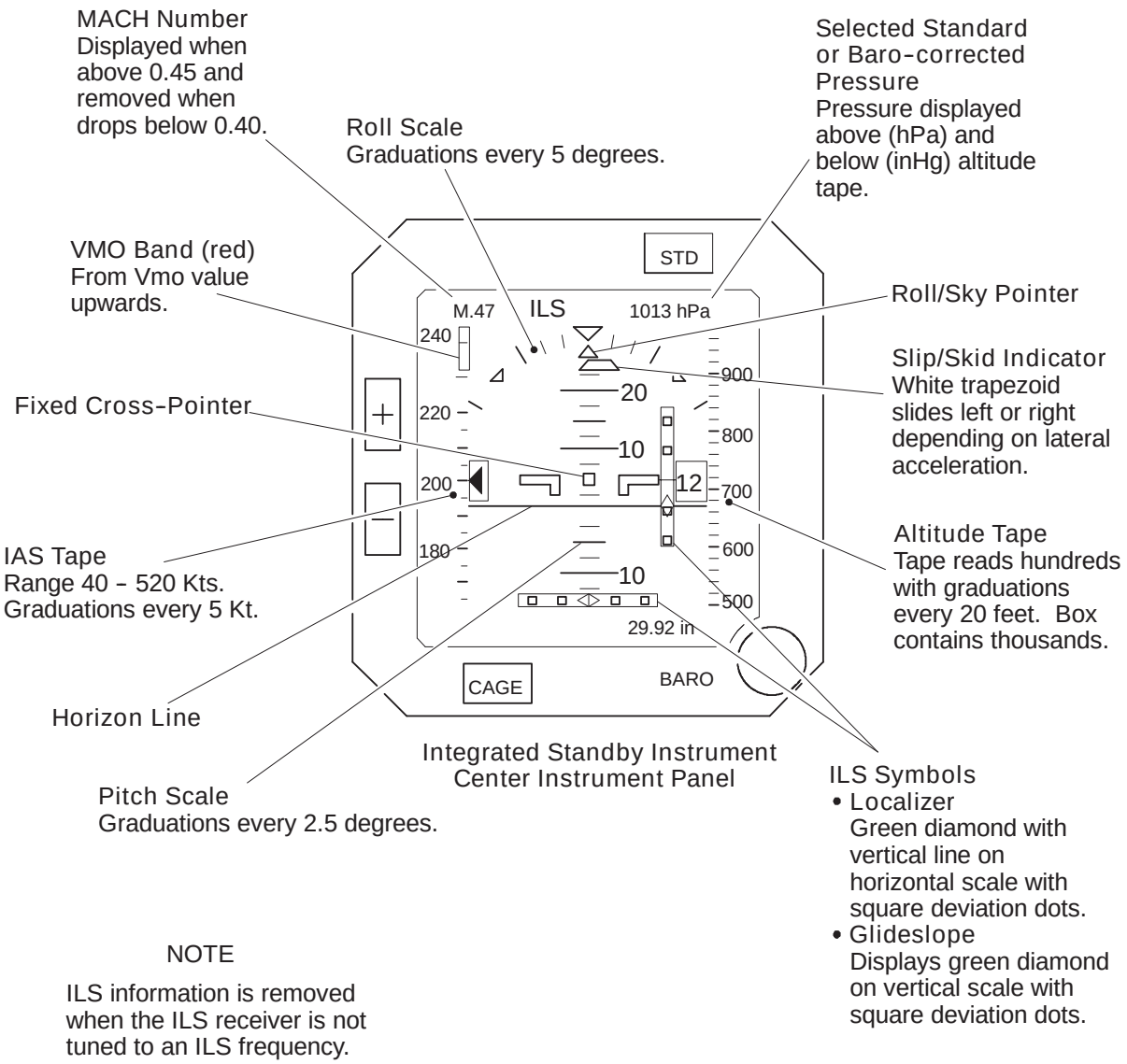
NOTE
Normal operation of standby altimeter/ indicated airspeed indicators is vibrator on. (circuit breaker CBP 1–1P2 closed).

Standby Altitude/Airspeed Indicator
Figure 12–60–2



Integrated Standby Instrument Center Instrument Panel

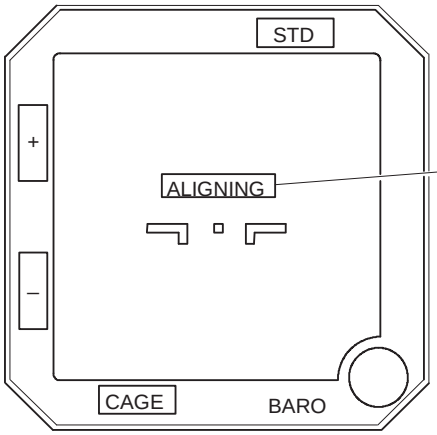
Integrated Standby Instrument <0083>
Figure 12−60−3



NOTE

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

Integrated Standby Instrument Scales <0083>
Figure 12–60–4



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.

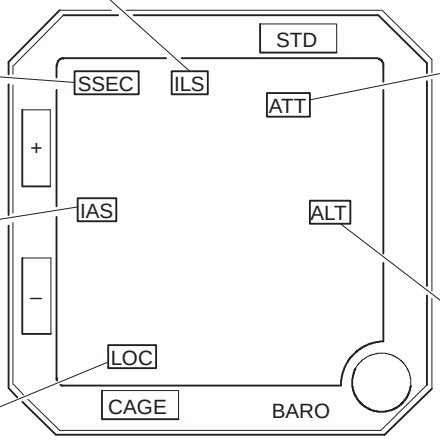
SSEC Flag (yellow)
Displayed when static source error correction cannot be computed.

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.



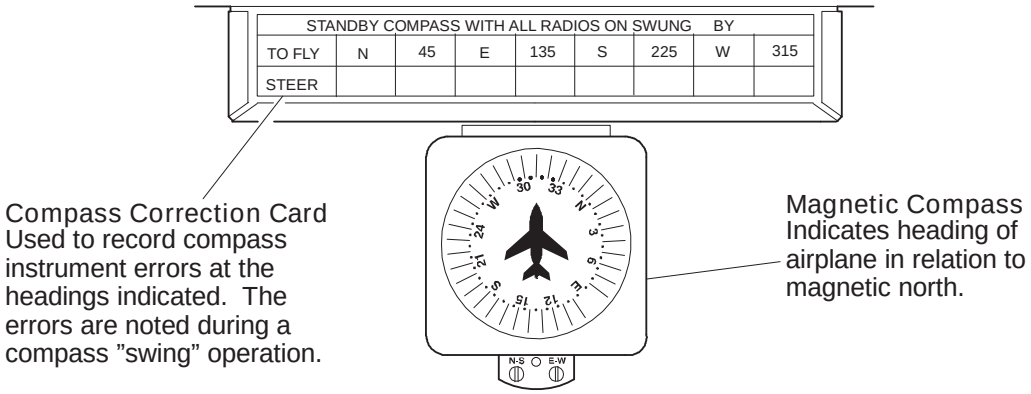
Standby Instrument
Center Instrument Panel

Integrated Standby Instrument Flags <0083>
Figure 12–60–5

D. Standby Magnetic 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. The compass can be illuminated by operating the standby compass switch on the miscellaneous lights panel.

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.



Standby Magnetic Compass
Windshield Center Post

Standy Magnetic Compass
Figure 12–60–6

E. Clocks

Effectivity:

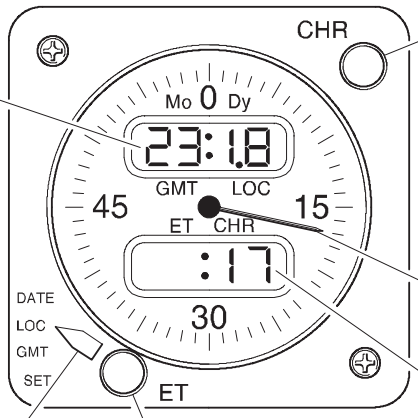
- Airplanes 7002 to7672

A digital electronic clock is installed on the pilot and copilot side panels. Each clock contains its own time base and each has GMT, CHR, local and ET functions. The clocks are the time base source for the aircraft avionics equipment. The clocks receive air/ground information from the PSEU to control the elapsed time function (flight time). The Pilots clock is powered from the DC battery bus and the copilots clock is powered from DC bus 2. In the event of a power failure, both clocks will be powered by the main battery direct bus. Current time is also displayed on the multifunctional displays.

Effectivity:

- Airplanes 7673 and subsequent

A digital electronic clock is installed on the pilot and copilot side panels. Each clock is capable of displaying date (GPS or internal 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 Greenwich mean time, local time or date.
- GMT is displayed in hours and minutes.
- LOC is displayed in hours and minutes. Date; alternately indicates month/day on the GMT display (for first second) and year (for next second).
- DATE alternately displays month/day (for first second) and year (for next second).

CHR
Used to start, stop and reset the CHR display and second hand. Overrides existing elapsed time display.
- First push starts chronometer
- Second push holds chronometer readout and second hand
- Third push resets second hand to zero and returns display to elapsed time

During time setting, CHR button is used to increment applicable value.

Second Hand

ET/CHR Display
Displays elapsed time or chronometer time.
- ET time is displayed in hours and minutes.
- CHR time is displayed in minutes.

NOTE

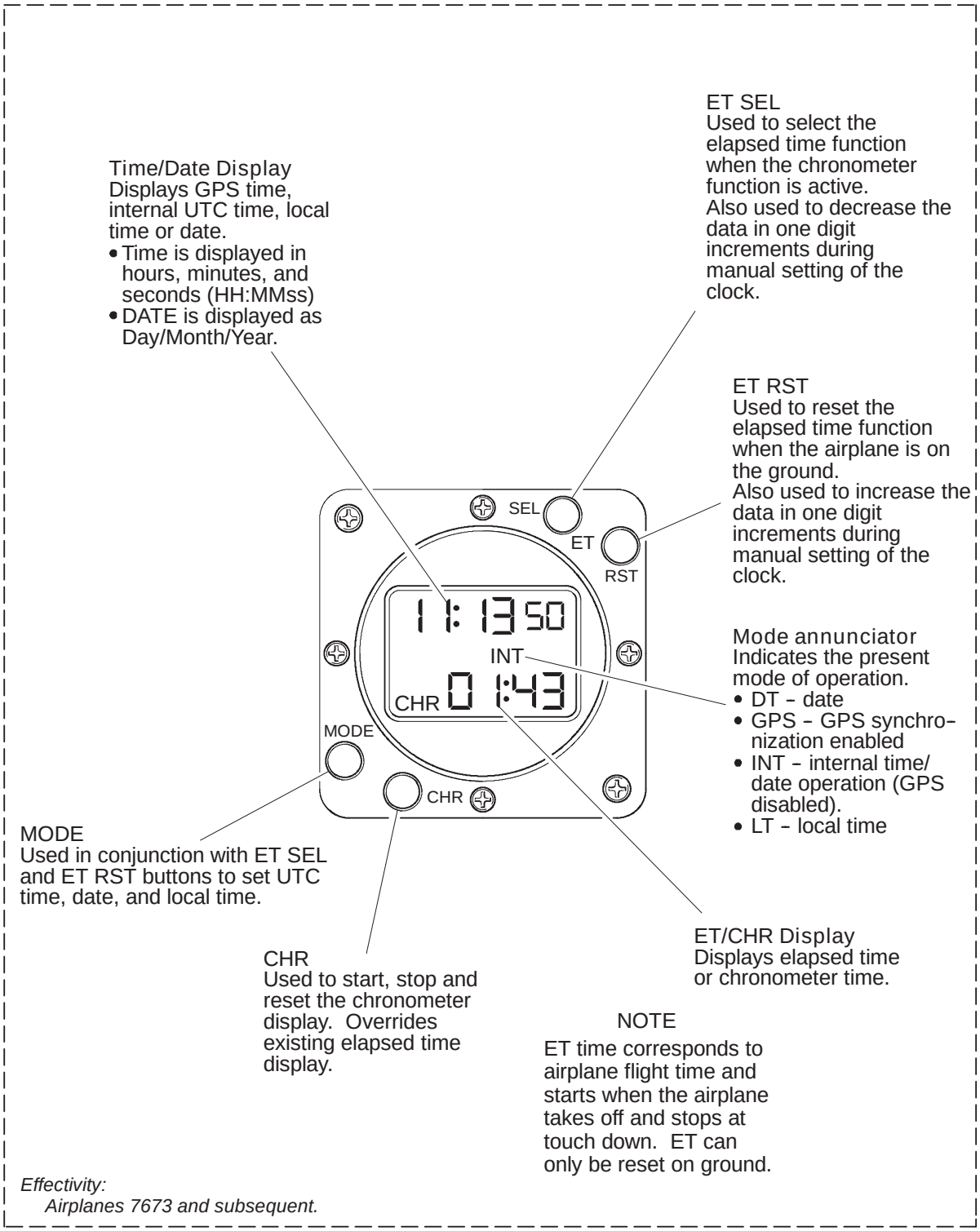
ET time corresponds to airplane flight time and starts when the airplane takes off and stops at touch down. ET can only be reset on ground.

Time Setting/Display Selector
Used in conjunction with ET/CHR buttons to set applicable readouts.
- SET cycles through GMT, LOC and day/month/year.
- GMT/LOC/DATE displays time or date at upper readout.

ET
Controls elapsed time readout and during time setting, selects the parameter to be set. Flashing parameter can be incremented by pressing CHR.

Effectivity:
Airplanes 7002 to 7672.

Clock Display <Airplanes 7002 to 7672>
Figure 12–60–7



Clock Display <Airplanes 7673 and Subsequent>
Figure 12–60–8

F. System Circuit Breakers

SYSTEM	SUB-SYSTEM	CB NAME	BUS BAR	CB PANEL	CB LOCATION	NOTES
Standby Instruments	Standby Attitude Indicator	STBY HORIZ	DC BAT	2	N10	
	Standby Airspeed, Altitude, Attitude Indicator	STBY INSTR				
	Integrated Standby Instrument <0083>	INT STBY INST				
	Clocks (A/C 7002 to 7672)	CLK 1	MAIN BAT DIR	5	A10	
		CLOCK 1	DC BAT	2	N11	
		CLK 2	MAIN BAT DIR	5	A11	
		CLOCK 2	DC BUS 2	2	H5	
	Clocks (A/C 7673 and subsequent)	CLOCK 1	DC BAT	2	N11	
			MAIN BAT DIR	6	B7	
		CLOCK 2			B8	
			DC BUS 2	2	H5	

1. HEAD-UP GUIDANCE SYSTEM <0026>

The head-up guidance system (HGS) projects instrument and airplane systems data holographically between the pilot and the pilot's windshield. Attitude, airspeed, flight path guidance and other information are displayed in symbolic format. HGS allows the pilot to fly the airplane during Category IIIa instrument approaches in a head-up position. A combiner optically diffracts (reflects) flight symbology to infinity and allows the pilot to look through the display without eye movement or shift in eye focus.

HGS consists of the following:

- Combiner,
  The combiner is mounted on the pilot's windshield frame and can be used during ground and flight operations. The combiner is deployed and stowed by actuating a lever on the RH side. An infrared transmitter and alignment detector automatically check if the optical element/combiner is out of position. The combiner also incorporates a manual/automatic brightness control.

- Control Panel,
  The control panel is used to set system references, flight and system test modes.

- Overhead Unit,
  The overhead unit contains a CRT to generate symbology and a lens to project the symbology on the combiner.

- Drive Electronics Unit,
  The drive electronics unit contains the CRT drive circuitry and power supplies.

- Computer Unit,
  The computer unit creates the flight symbology from airplane sensor data. HGS combines airplane situational information (speed, heading, pitch, roll, attitude), inertially sensed flight path and flight path acceleration information and guidance directed control inputs. Integration of airplane systems information and inputs, combined with flight data, allows the pilot to maneuver the airplane along the flight path with precise straight-in and glide path tracking.

If guidance data is being provided by AFCS, the combiner will echo AFCS data. During a HGS-guided approach, once the localizer and glideslope have been captured and the airplane has descended below 2,000 feet, the HGS can be selected to provide the desired type of approach guidance.

HGS modes are as follows:

- Primary (PRI) Mode,
  PRI mode can be used for take-off, cruise and landing.

- Flight Director (F/D) Mode,
  F/D mode can be used to fly F/D-generated approach guidance or to monitor a coupled approach.

- Visual Meteorological Conditions (VMC) Mode,
  VMC mode is used for visual approaches and landings without guidance.

- Modes AI and AII,
  These modes are used to manually fly precision approaches.

- Mode AIII,
  This mode is used for approach and landings to category IIIa minima.

NOTE

The provision of data for Low Visibility Take–offs, or Category II Operations or Category IIIa Operations does not constitute operational approval to conduct such operations.

- Clear (CLR) Mode,
  Clear mode is typically used during taxi to clear all symbology from the combiner.

- Test (TEST) Mode,
  Test mode is used by maintenance staff to diagnose faults, checkout and troubleshoot the system.

A. Combiner Symbology

Dependent upon HGS mode (see “DISPLAY CRITERIA” table) the combiner will display the following:

(1) Align HGS Message,
An ALIGN HUD message is displayed to indicate a combiner alignment problem.

(2) Boresight Symbol,
Pitch and roll data are referenced to the boresight symbol.

(3) Attitude Data,
Standard symbology is used for pitch and roll scales, pitch and roll indicator, slip / skid indicators. Pitch bars may be compressed. Extreme pitch attitude symbols (up / down pointing chevrons) are also used. Flags are used to indicate IRS source failures and IRS data miscompare.

(4) Heading Data,
A horizon line with a heading scale, index and heading readout and selected course data is provided. A 200–degree compass card is displayed during primary mode. Flags are used to indicate IRS source failures and heading data miscompare.

(5) Flight Path Data,
A flight path symbol indicates the airplane’s lateral and vertical flight path. The flight path symbol will mask (blank) other data. An acceleration symbol is also provided.

(6) Airspeed Data,
Standard symbology is provided for the airspeed indications; airspeed scale and tape, speed bugs, trend vectors and for the setting of V–speeds. An airspeed error symbol is provided that indicates a deviation (+/– 15 KIAS) from the selected airspeed. Checkerboard symbols are used as overspeed / low speed cues. The Mach readout comes on when Mach is greater than 0.45. Flags are used to indicate IAS and ADC failures and miscompares.

(7) Baro Altimeter Data,
Standard symbology is provided for the barometric altitude indications; altitude tape, altitude readout and altitude preselect. Barometric prerssure setting indications are not provided. MDA alert and readout data are provided. Display of metric altimeter data or preselects is not provided. Flags are used to indicate ALT failures.

(8) Radio Altimeter Data,
The selected decision height readout is displayed and decision height alerting is provided. Flags are used to indicate RA failures and miscompares are detected below 1,000 feet AGL. Radio altitude readouts are as follows:

- 2,500 feet to 1,000 feet – 50 foot increments
- 1,000 feet to 50 feet – 10 foot increments
- 50 feet to 10 feet – 5 foot increments
- Below 10 feet – 1 foot increments.

(9) Vertical Speed Data,
Vertical speed readouts are in 100 fpm or 1,000 fpm increments. A VS flag is used to indicate loss of vertical speed data from IRS 1.

(10) Navigation Data,
Standard symbology is used to depict navigation systems data:

- Lateral Deviation,
  Localizer deviation and excessive deviation are displayed. LOC flags are used to indicate a localizer failure or miscompare
- DME distance readouts are in 1 nm or 0.1 nm increments
- Selected VOR or LOC indications are provided. Navigation source failure flags are provided
- Marker beacon indications (OM, MM, IM) are provided
- Vertical Deviation,
  Glideslope deviation and excessive deviation indications are provided. GS angle readouts are provided. GS flags are used to indicate a glideslope failure or miscompare.

Effectivity:

- Airplanes equipped with the -503 HGS computer

NOTE

When the navigation source is the FMS, the bearing pointer will not be displayed on the HUD. The bearing pointer will only be displayed when the navigation source is provided by the ADF or VOR.

(11) Symbolic Runway,
During a Category IIIa approach, a runway symbol is displayed from 300 to 60 feet AGL. The runway is scaled (200 feet wide and 10,000 feet long) with tic marks representing the runway aim point (1,050 feet from the threshold).

(12) Windspeed and Direction,
A windspeed readout (up to 256 knots) and a direction arrow are provided.

(13) Windshear Indications and Guidance,
Windshear indications and guidance data are provided. Primary mode will automatically pop-up to provide guidance data.

(14) Groundspeed Readout,
Groundspeed indications are provided.

(15) Flare Cue,
The Flare Cue symbol comes on at 60 feet AGL and flashes until removed at 30 feet AGL. Indicates that the flare should be initiated but does not provide any guidance as to how the flare should be performed. The symbol is provided during all approaches except IIIa mode.

(16) Flare Command,
The Flare command symbol comes on during a Category IIIa approach and landing and provides guidance in performing the flare maneuver.

(17) Idle Message,
An IDLE message is provided indicating to the pilot to reduce the airplane's thrust to idle for touchdown. The message is displayed when the airspeed exceeds the correct airspeed (plus a wind factor) based upon the present altitude. If the airspeed is less than the desired, the message is delayed. The IDLE message, however, is forced to come on at 5 feet AGL regardless of airspeed.

(18) Approach Warning Message,
During a Category II or IIIa approach, below 500 feet AGL, an approach warning message is provided if the approach conditions exceed present tolerances or if any HGS failures are detected.

(19) Angle of Attack Limit,
Airplane angle of attack relative to stick shaker is indicated by distance between the AOA symbol and flight path symbol.

- If AOA and flight path symbol are aligned, then airplane is at stick shaker
- AOA symbol comes on below 1,500 feet if a windshear has been detected
- AOA symbol comes on when the airplane is within 2 degrees of stick shaker.

(20) Flight Director Guidance Cue,
The guidance cue represents lateral and vertical attitude commands required for the selected low visibility approach and landing:

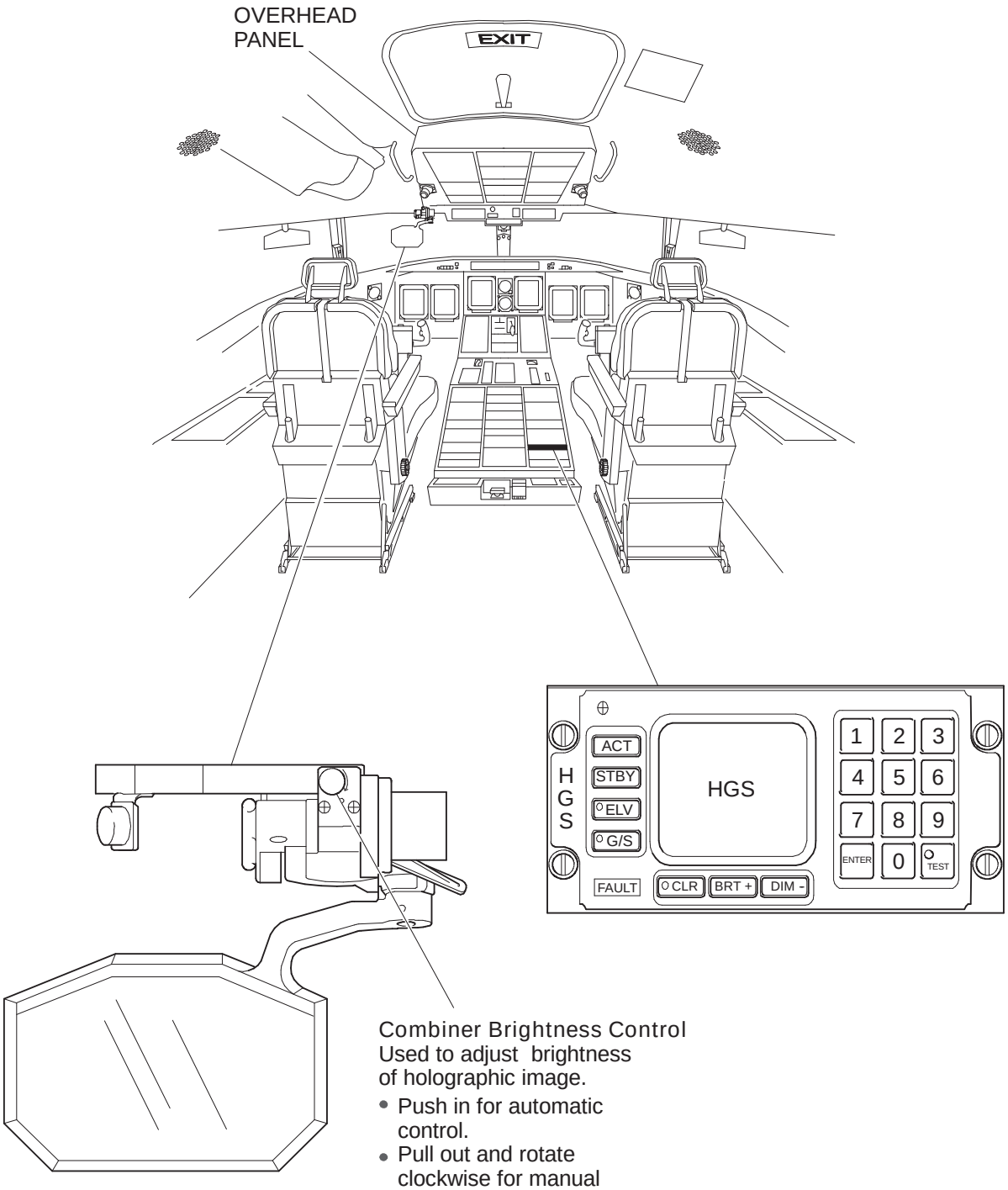
- During Category I or II operations, displayed until 80 feet AGL, and
- During Category IIIa operations, displayed until touchdown
- An F/D flag is used to indicate flight director failure.

(21) Flight Mode Annunciations,
Lateral armed / captured and vertical mode annunciations are provided. Autopilot status indications and mistrim indications (aileron, elevator and rudder) are provided.

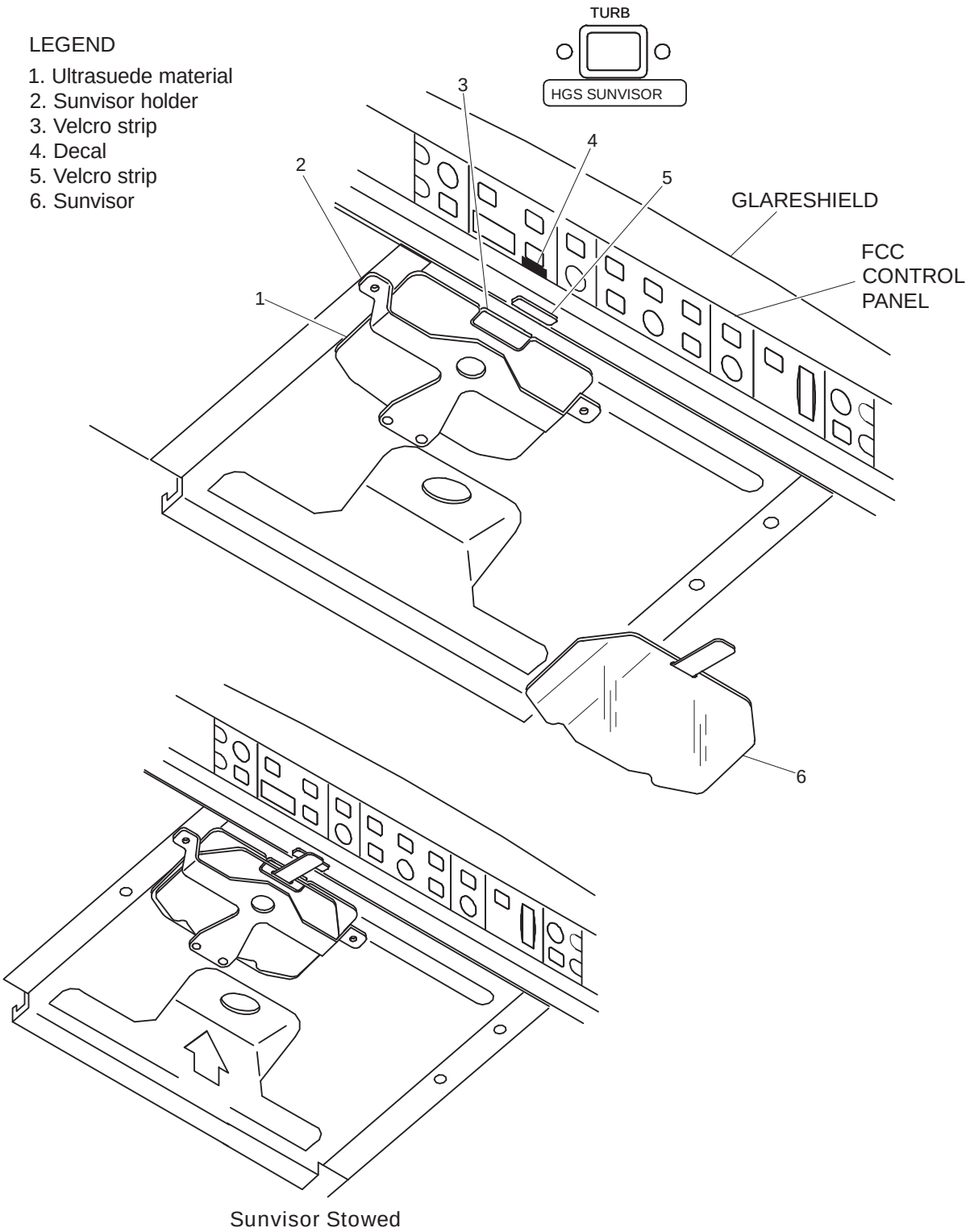
(22) Autopilot, Yaw Damper & Mistrim Indications,
A yaw damper message is provided to indicate that the yaw damper is disengaged. Mistrim flags (elevator, aileron and rudder trims) are provided to indicate out–of–trim conditions.

NOTE

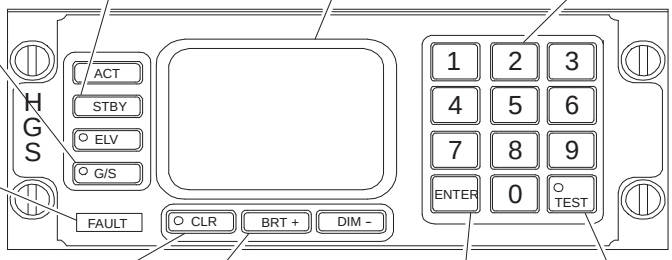
HGS entry of landing runway elevation is to be made prior to any type of landing using the HGS.



HGS System
Figure 12–70–1



Head–up Guidance System Sunvisor
Figure 12–70–2



HGS Control Panel (1)
Center Pedestal

ELV and G/S mode select keys (momentary action) Used in conjunction with numeric keypad and + /– keys to input runway elevation and glideslope angle data into HGS.

- CRT line cursor comes on to indicate entry area.

ACT and STBY mode select keys (momentary action) Used to select applicable HGS mode.

LED Display Indicates mode selected for display on HGS combiner unit

Numeric Keypad Used to input numeric data (runway elevation and glideslope angle into HGS.

FAULT lamp (amber) Comes on to indicate communications fault between computer unit and control panel.

CLR key (momentary action) When pressed: clears active mode displayed HGS combiner.

BRT+ and DIM – keys (momentary action):

BRT/DIM: Used to adjust brightness of CRT.

+ / – : Used with 0 to 9 number keys to input numerical data into HGS.

ENTER key (momentary action) Used to enter keypad data into HGS.

o Key annunciator lamp that comes on when the applicable mode / function has been selected.

TEST key (momentary action) Used by maintenance staff to initiate system test.

- When pressed, active mode display line indicates TEST
- Test mode has priority over all modes.

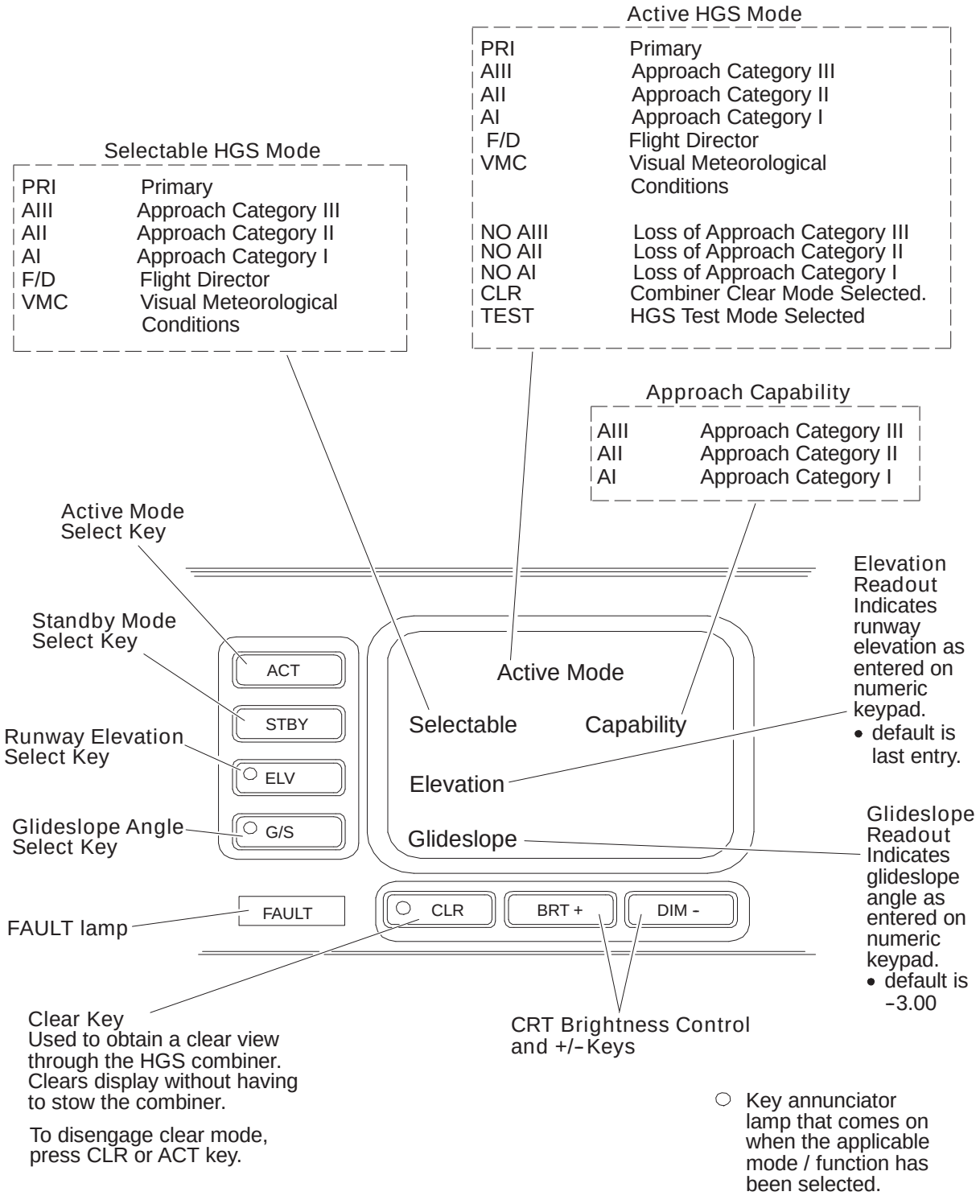
To start test mode:

- Press TEST & ENTER.

To halt test mode:

- Press TEST again.

Head–up Guidance System
Figure 12–70–3 Sheet 1



Head–up Guidance System
Figure 12–70–3 Sheet 2

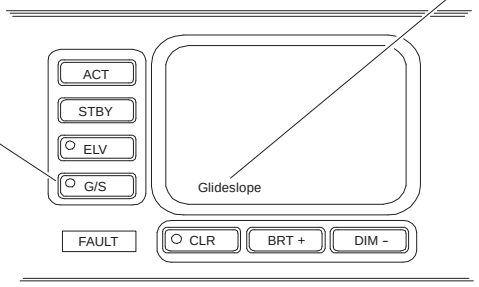
Glideslope (G/S) Mode Select Key
Press G/S to enter glideslope data. Arrow and CRT line cursor prompt to indicate entry. Use keypad to enter 3–digit glideslope angle. Use ENTER key to select value for use.

Use CLR key to correct entries.

During G/S data entry, BRT+ and DIM keys do not function.

Indicates glideslope angle selection (0.00 to –9.99).

“” ” used to indicate degrees. Decimal position is automatic.



HGS Control Panel (1)
Center Pedestal

Glideslope Angle Readout

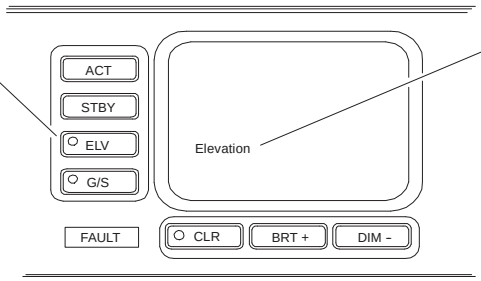
Glideslope Reference Line

HGS Combiner

ELEV Mode Select Key
Press ELEV to enter runway elevation data. CRT line cursor prompts to indicate entry. Use DIM– key to enter negative value. Use keypad to enter number. Use ENTER key to select value for use.

Use CLR key to correct entries.

Indicates runway elevation selection in feet (–9999 to 99999). Default is last entry.

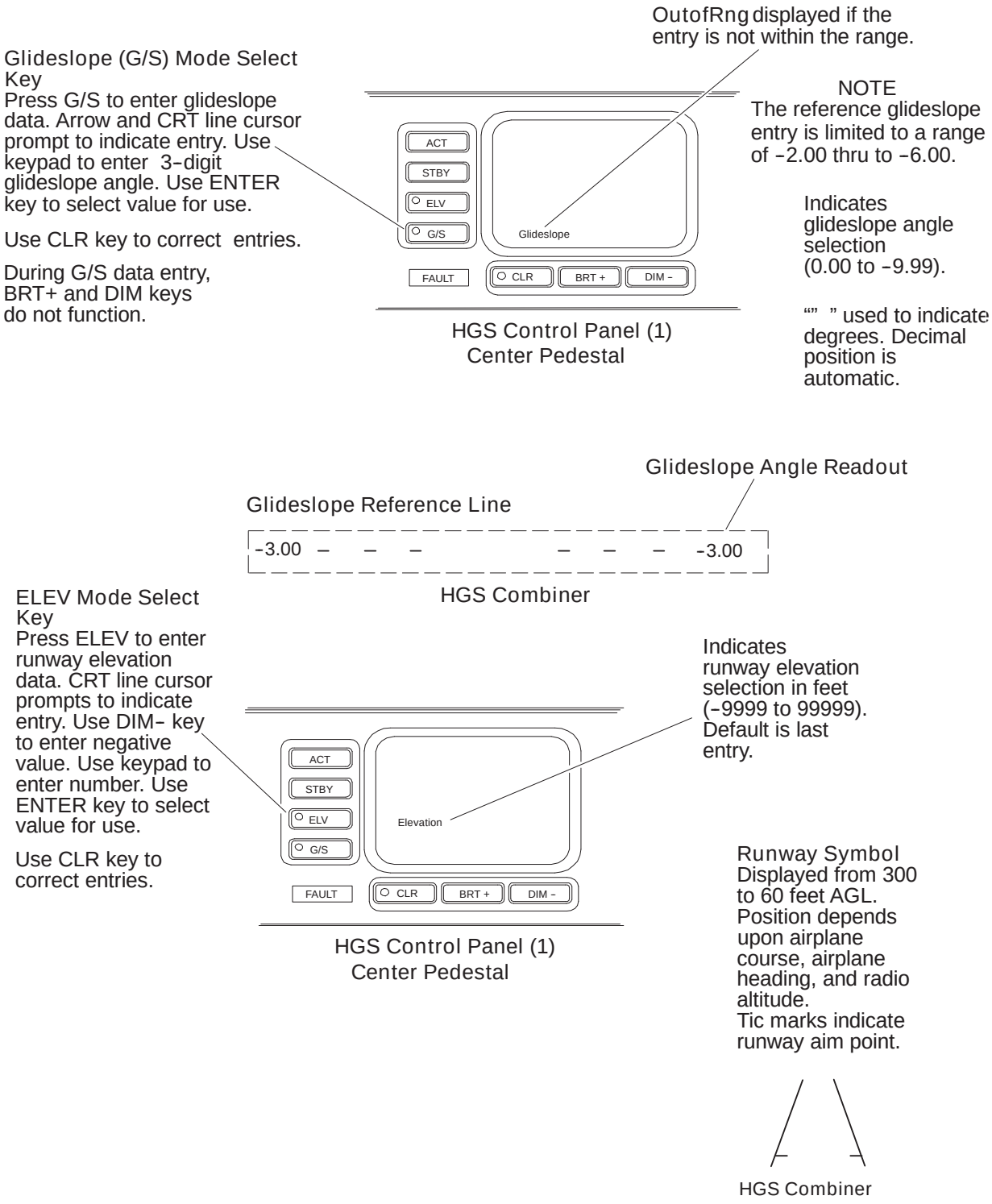


HGS Control Panel (1)
Center Pedestal

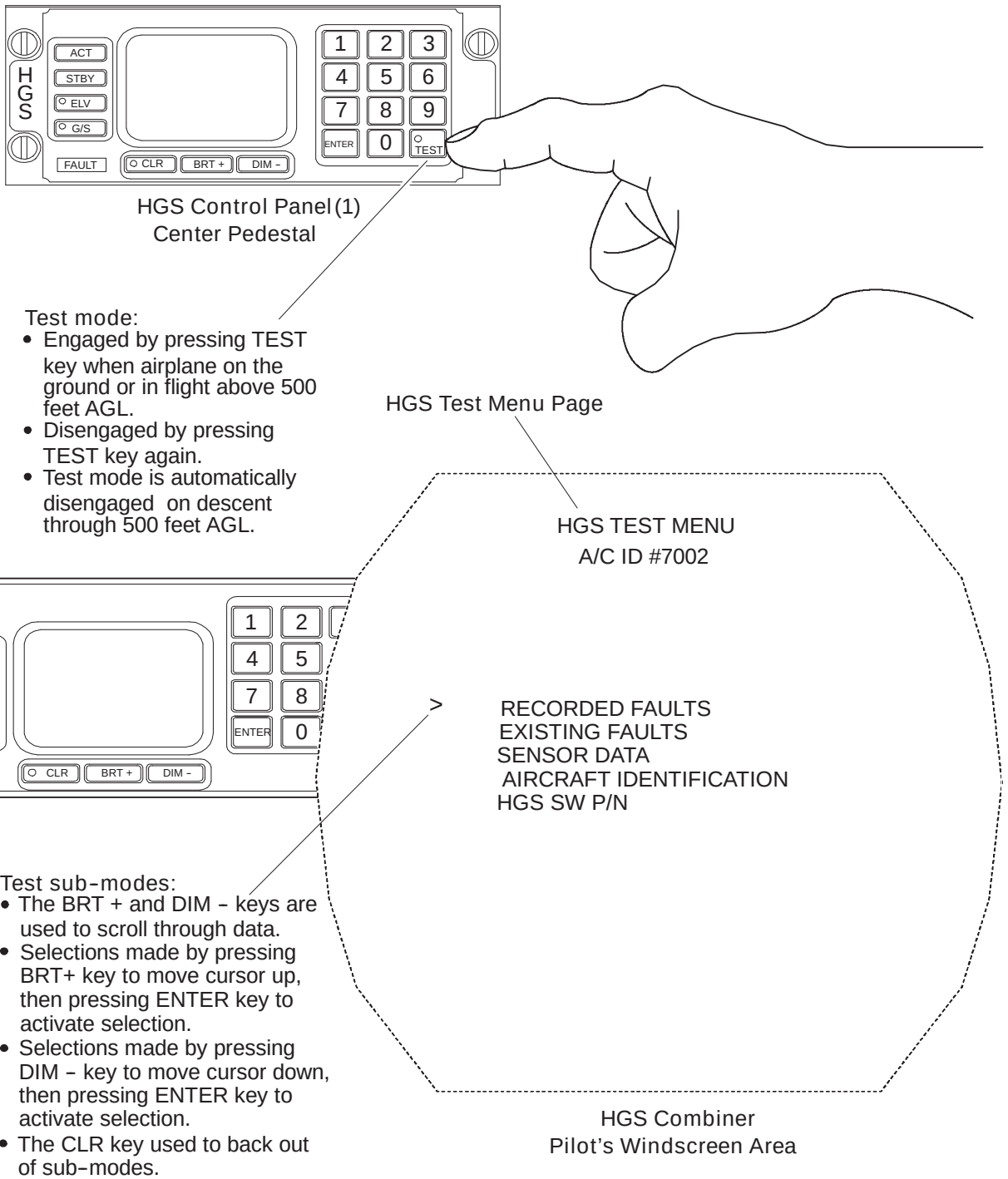
Runway Symbol
Displayed from 300 to 60 feet AGL. Position depends upon airplane course, airplane heading, and radio altitude.
Tic marks indicate runway aim point.

HGS Combiner

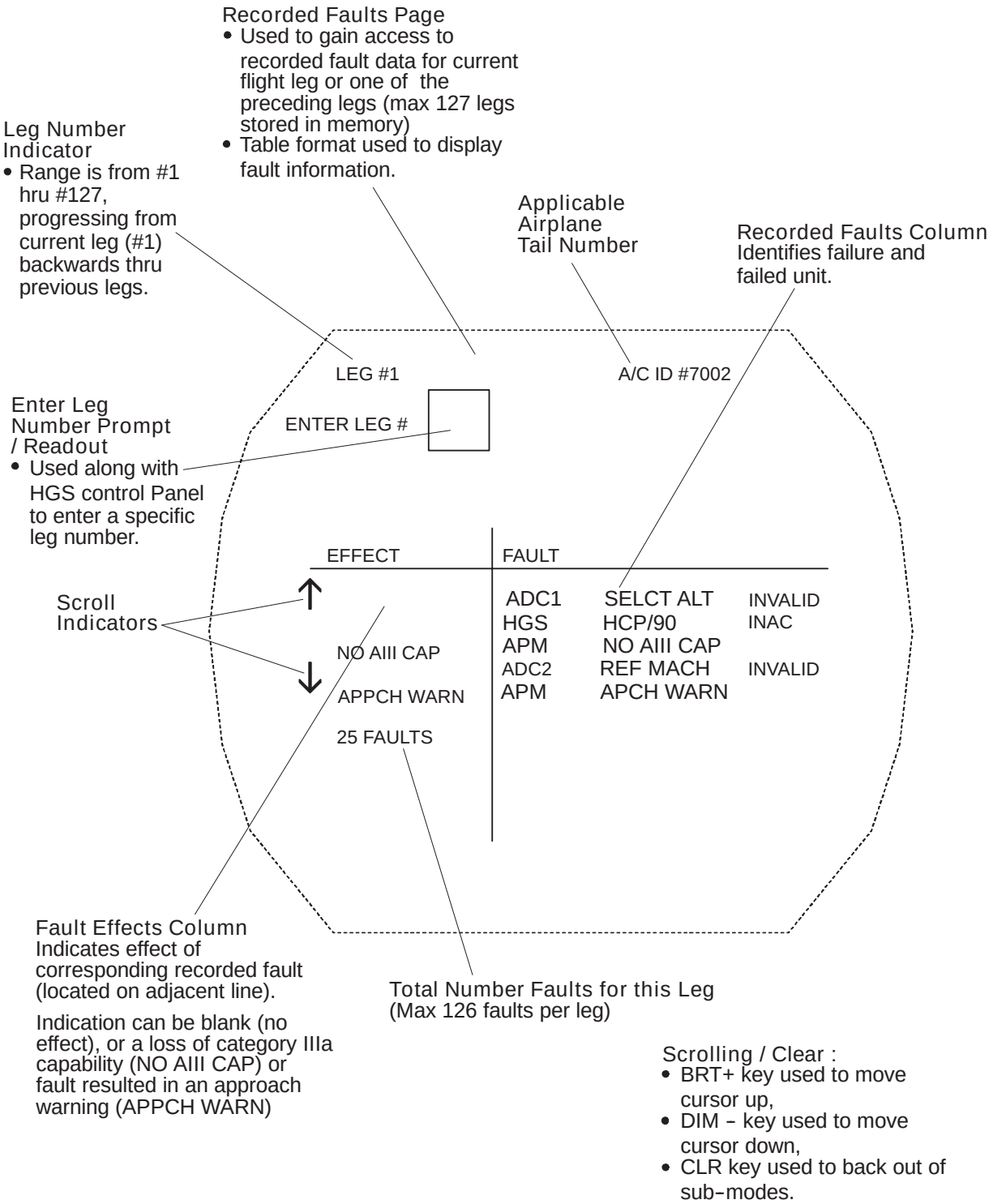
HGS Control Panel
Figure 12–70–4



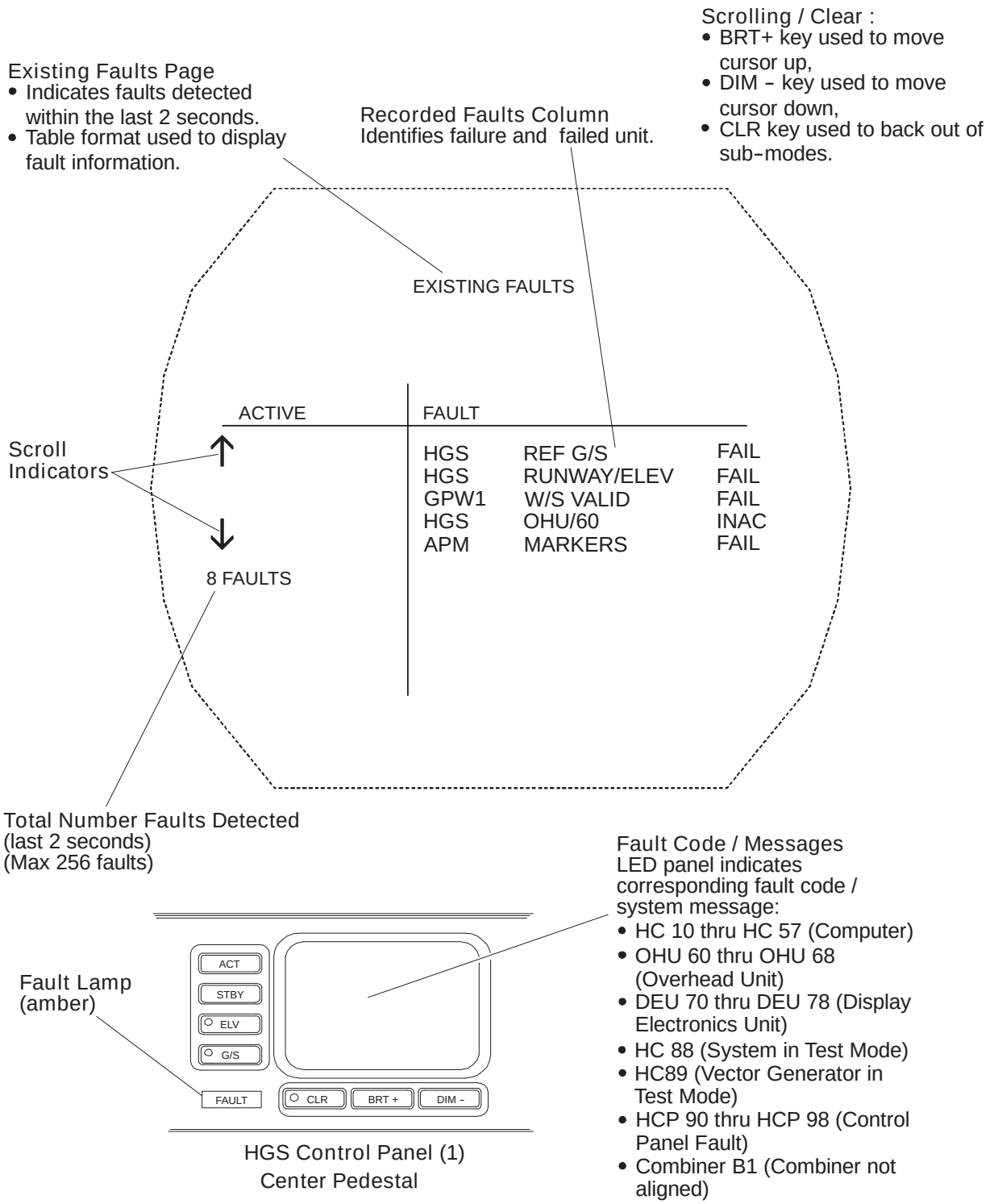
HGS Control Panel <Airplanes equipped with the (-503) HGS Computer>
Figure 12-70-5



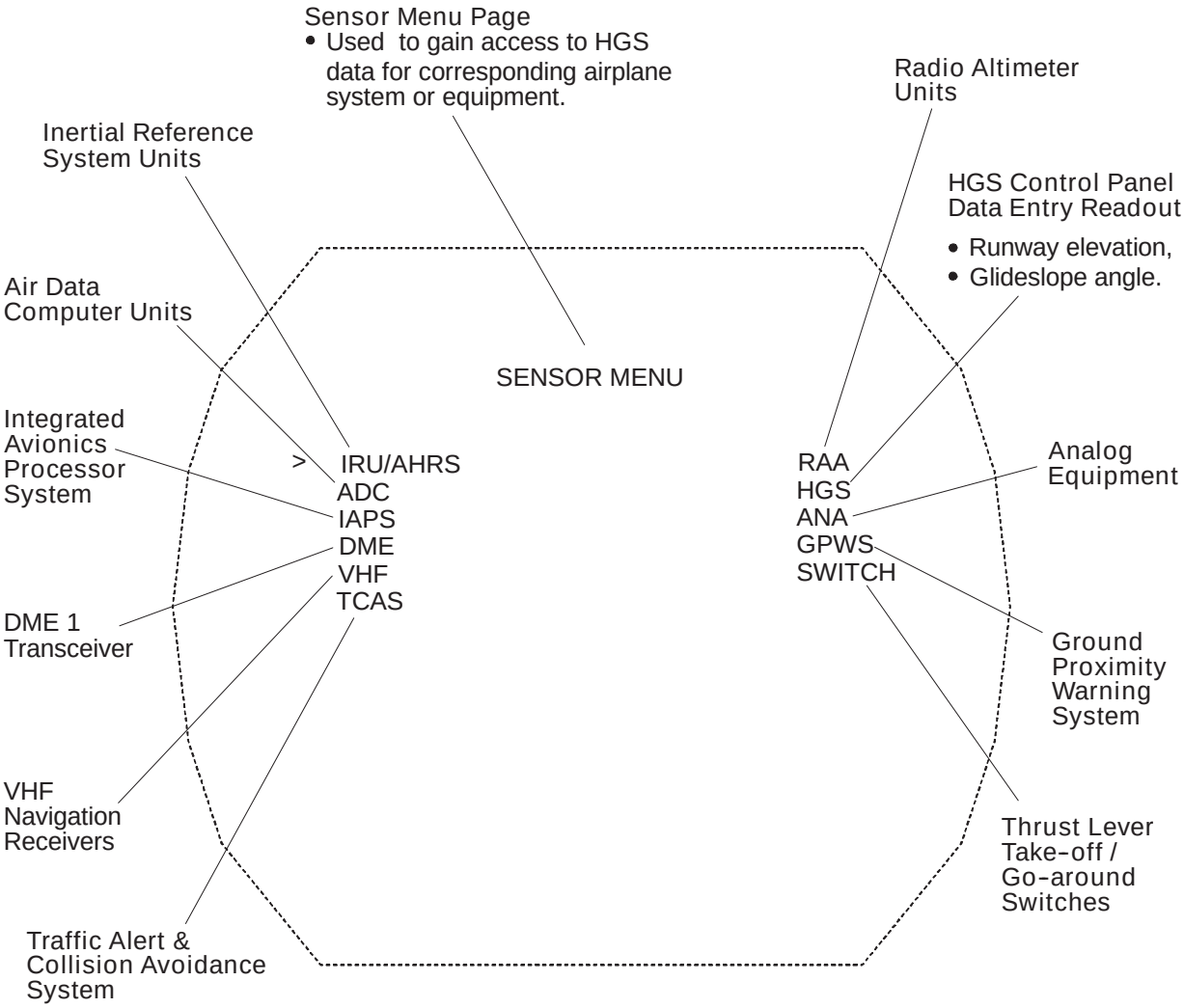
Head–up Guidance System – Test Mode Selections
Figure 12–70–6 Sheet 1



Head–up Guidance System – Test Mode Selections
Figure 12–70–6 Sheet 2



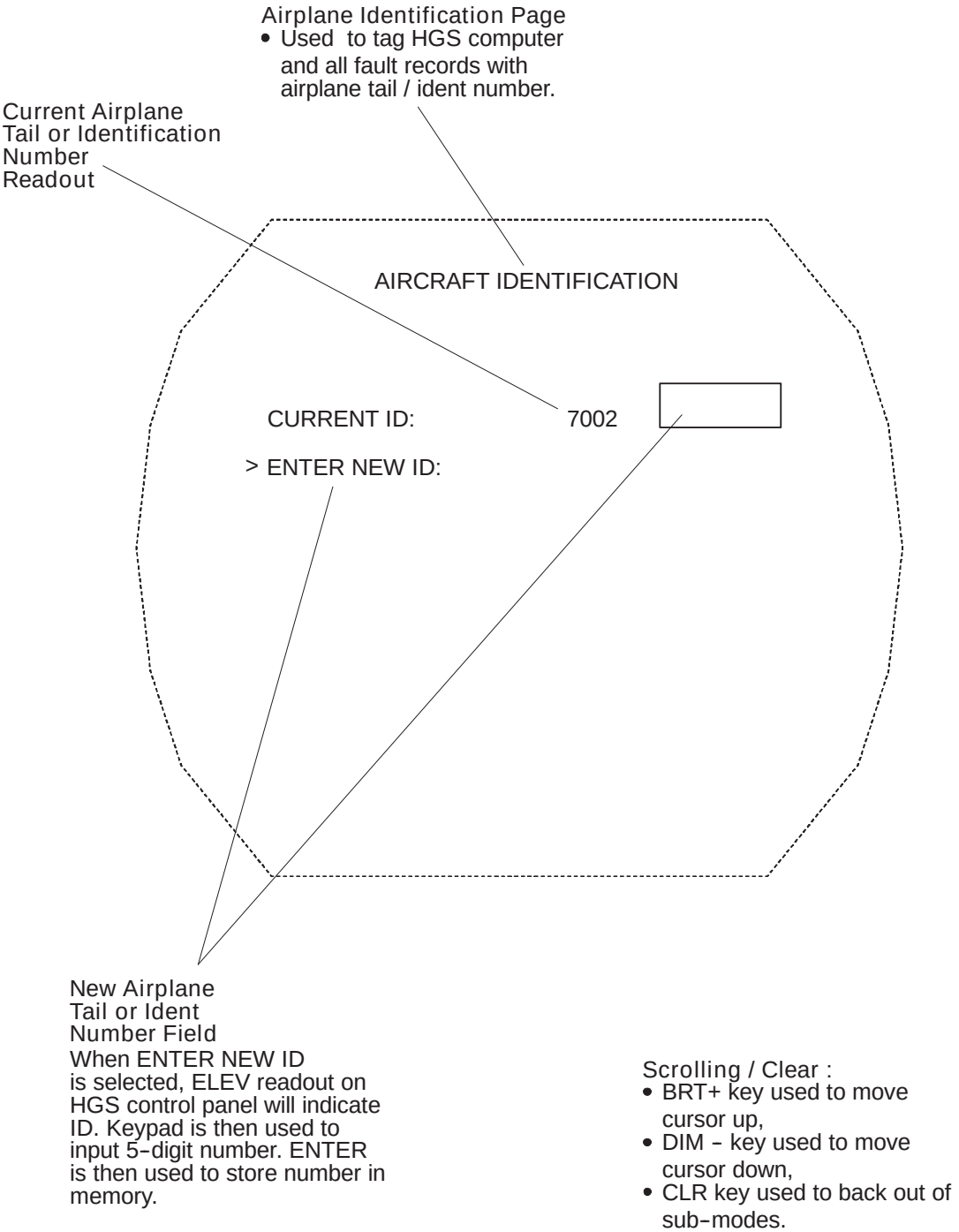
Head – up Guidance System – Test Mode Selections
Figure 12–70–6 Sheet 3



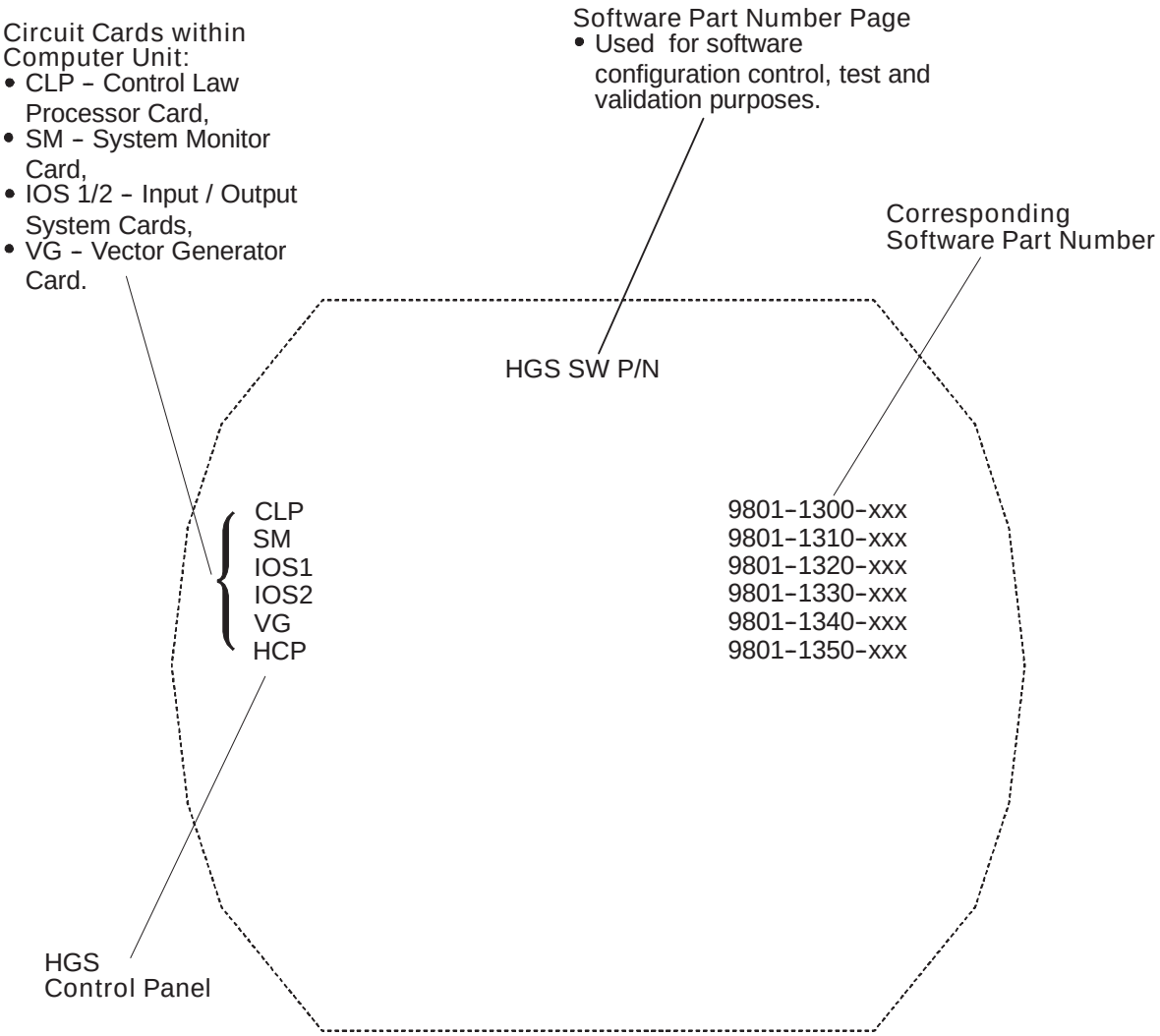
Menu Page Selections:

- BRT+ key used to move cursor up, then ENTER key used to activate selection.
- DIM – key used to move cursor down, then ENTER key used to activate selection.
- CLR key used to back out of sub–modes.

Head–up Guidance System – Test Mode Selections
Figure 12–70–6 Sheet 4



Head–up Guidance System – Test Mode Selections
Figure 12–70–6 Sheet 5



Clear:
• CLR key used to back out of sub–modes.

NOTE
Only the computer unit and the HGS control panel contain software.

Head–up Guidance System – Test Mode Selections
Figure 12–70–6 Sheet 6

B. Output to PFD's

HGS provides information via IAPS to enable the copilot to monitor the airplane's approach to the runway, check the performance of the HGS, and monitor the pilot's response to HGS commands. The PFDs will display the following:

(1) Excessive Lateral Deviation
Excessive localizer deviation is displayed.

(2) Excessive Vertical Deviation
Excessive glideslope deviation is displayed.

(3) Approach Status
The flight mode annunciator area will indicate the following:

- Selectable HGS mode (AIII, AII, or AI) displayed as a white message
- Captured HGS Mode (AIII, AII, or AI) displayed as a green message
- Loss of HGS Mode (AIII, AII, or AI) displayed as a red line through the green message
- HGS approach warning (APCH WARN) and HGS failure (HGS FAIL) displayed as red flags. EICAS will echo HGS FAIL as a status message (white)
- FLARE (amber) message (mode IIIa only) in the ADI area.

C. Audio Callouts

Ground proximity warning system mode 6 audio callouts are provided for ground closure awareness. Callouts are as follows:

- 500, approaching minimums, 100, minimums, and then
- 50 (if DH was not 50 feet), 40, 30, 20, 10.

D. Output to FDR

The HGS transmits the following data to the flight data recorder:

- HGS in use
- HGS fail message
- Approach warning.

E. Output to MDC

The HGS transmits the following data to the maintenance diagnostic computer:

- HGS unit failures; combiner, control panel, overhead unit, drive electronics unit or computer unit (when they occur)

- Input failures; RA 1 and RA 2, DME 1, VHF 1 and VHF 2, ADC 1 and ADC 2, IRS 1 and IRS 2, IAPS and TCAS (when they occur).

F. Approach Monitor for Category II Operations

The HGS monitors approach parameters during Category II operations (500 feet to 100 feet AGL) as follows:

- Tracking Monitor – This function evaluates the airplane's approach relative to localizer and glideslope deviation.

G. Approach Monitor for Category III Operations

The HGS monitors approach parameters during Category III operations (from 500 feet AGL). The following are checked:

- The autopilot has been disengaged

- The airplane's approach relative to airspeed, localizer and glideslope deviation and crosstrack rate, vertical speed, lateral and longitudinal position

- For possible unsafe landings by evaluating the sink rate, lateral displacement from runway centerline, airspeed relative to selected airspeed, crosstrack rate, roll angle, and distance traveled along the runway.

H. System Test/Fault Codes

The HGS continuously checks its operational status and if a fault is detected the system will blank the CRT and the combiner. EICAS and the PFDs will display applicable HGS failure / approach warning messages. The HGS control panel FAULT lamp will come on, the HGS control panel LED unit will display an applicable fault code.

I. HGS Mode Selections/Indications

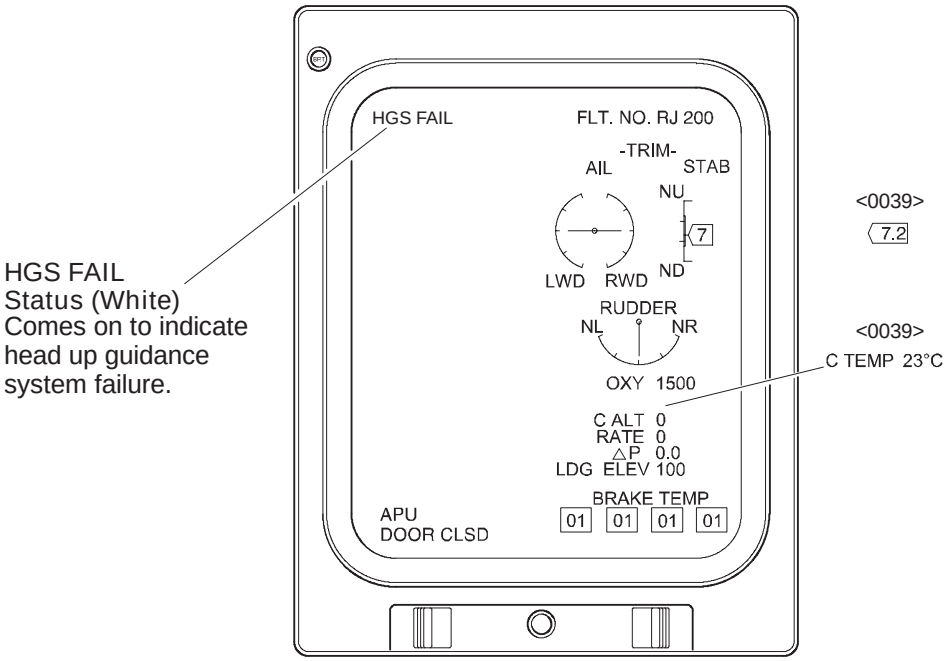
The HGS control panel is used to enter runway and glideslope data, to accomplish testing troubleshooting, to select HGS modes and to display the mode in use. Modes are indicated on the control panel as follows:

- The CRT line adjacent to the ACT key indicates the current active mode

- The CRT line adjacent to the STBY key indicates the next available / next selectable mode

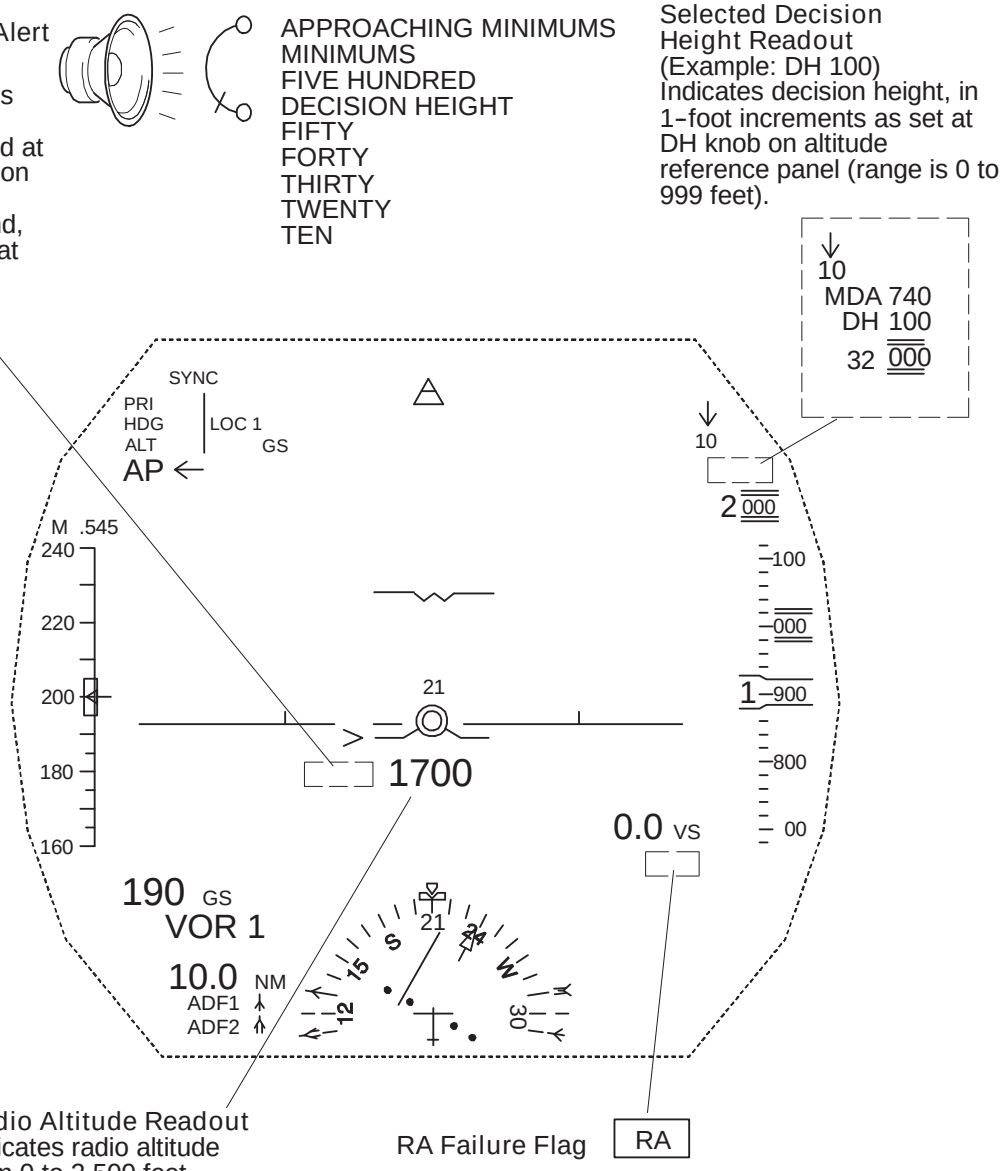
- The CRT line to the far right side of the STBY key indicates HGS capability (AIII, AII, AI).

The flight mode annunciator area of the HGS combiner and the PFDs will echo the corresponding HGS mode.

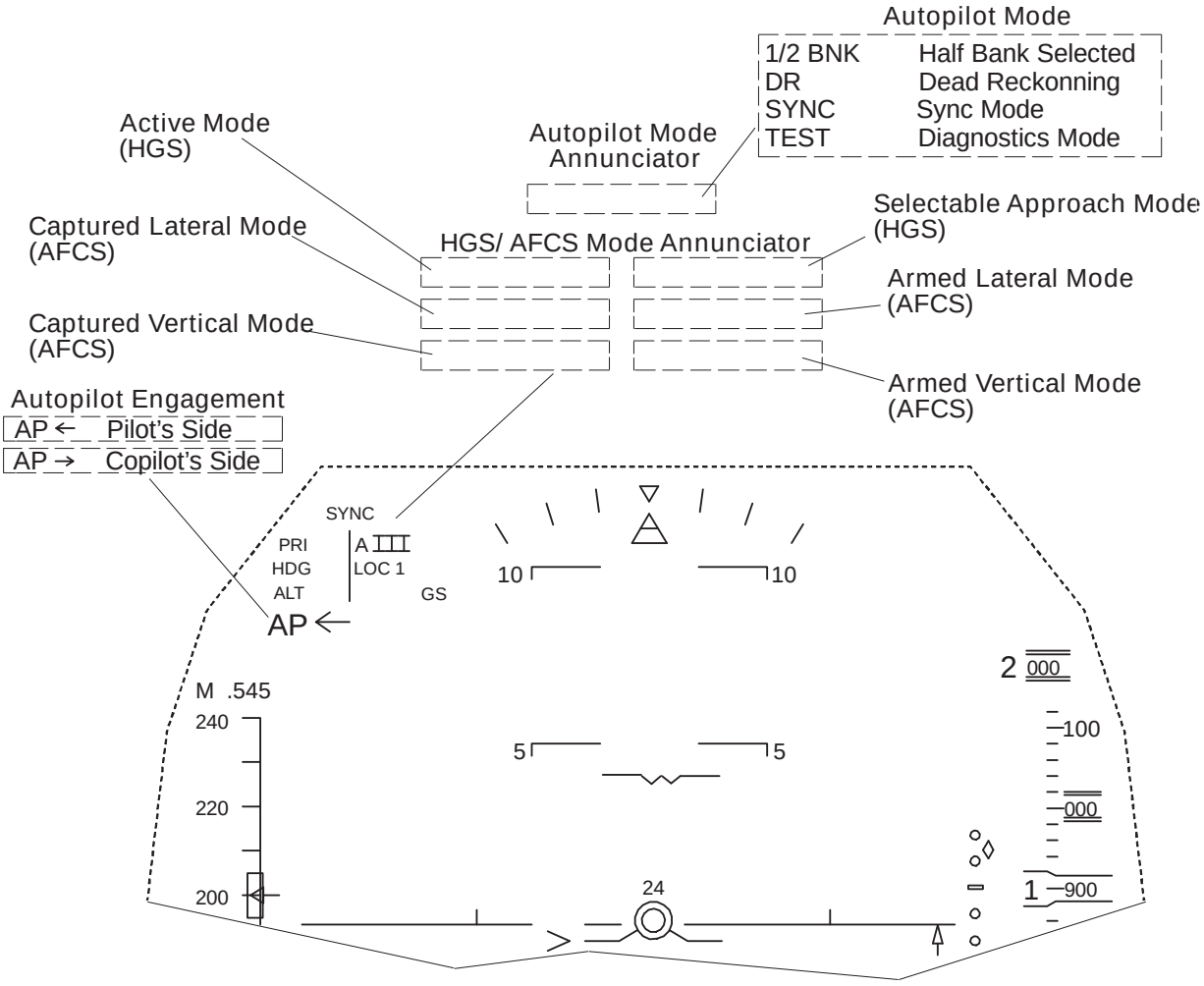


Status Page

HGS System – EICAS Messages <MST>
Figure 12–70–7



Primary Mode – Radio Altitude Indications
Figure 12–70–8



Active HGS Mode

PRI	Primary
AIII	Approach Category III
AII	Approach Category II
AI	Approach Category I
F/D	Flight Director
VMC	Visual Meteorological Conditions

Selectable Approach HGS Mode

PRI	Primary
AIII	Approach Category III
AII	Approach Category II
AI	Approach Category I

Loss of Approach Capability

AIII AII AI

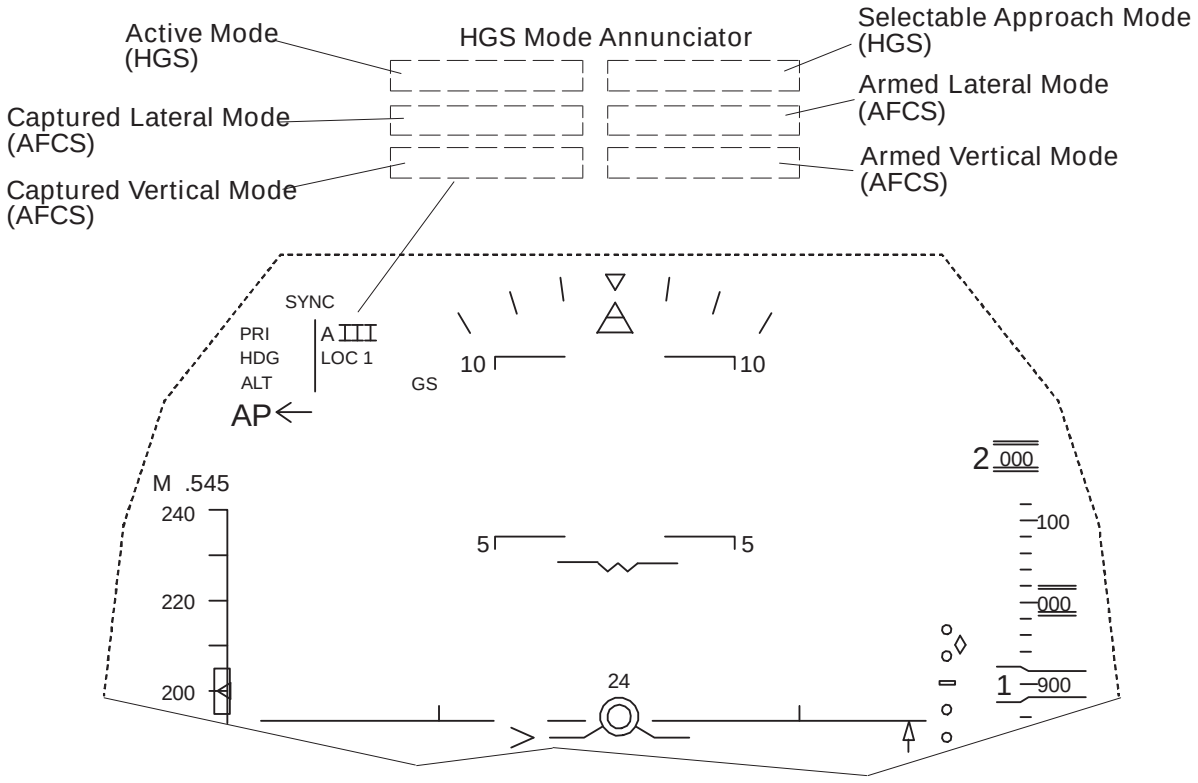
A boxed and flashing active AIII, or AII or AI mode annunciator indicates a loss of the indicated approach capability.

- HGS control panel will echo NO AIII, NO AII or NO AI, as applicable.

NOTE

1. On the ground, the PRI mode is the system default.
2. Annunciators flash to indicate a change.

HGS /AFCS Modes
Figure 12–70–9 Sheet 1



Captured Lateral Mode

ROLL	Roll Hold
GA	Go around
TO	Lateral Take-off
LOC 1(2)	LOC Captured
B/C1(2)	Back Course LOC Captured
VOR1(2)	VOR Captured
HDG	Heading Mode
FMS1(2)	FMS Captured

Armed Lateral Mode

LOC 1(2)	LOC Armed
B/C1(2)	Back Course LOC Armed
VOR1(2)	VOR Armed
FMS1(2)	FMS Armed

Captured Vertical Mode

GA/WS	Escape Guidance During WS
IAS	IAS Hold (ovsp if flashing)
MACH	Mach Hold (ovsp if flashing)
VS	Vertical Speed Hold
GS	Glideslope Captured
ALT	Altitude Hold
ALTSCAP	Selected Altitude Captured
DES Descent	Descent
GA Go-around	Go-around
TO/WS	Take-off Escape Guidance During Windshear
TO	Vertical Take-off
PTCH	Pitch Hold
ALTS	Selected Altitude Track

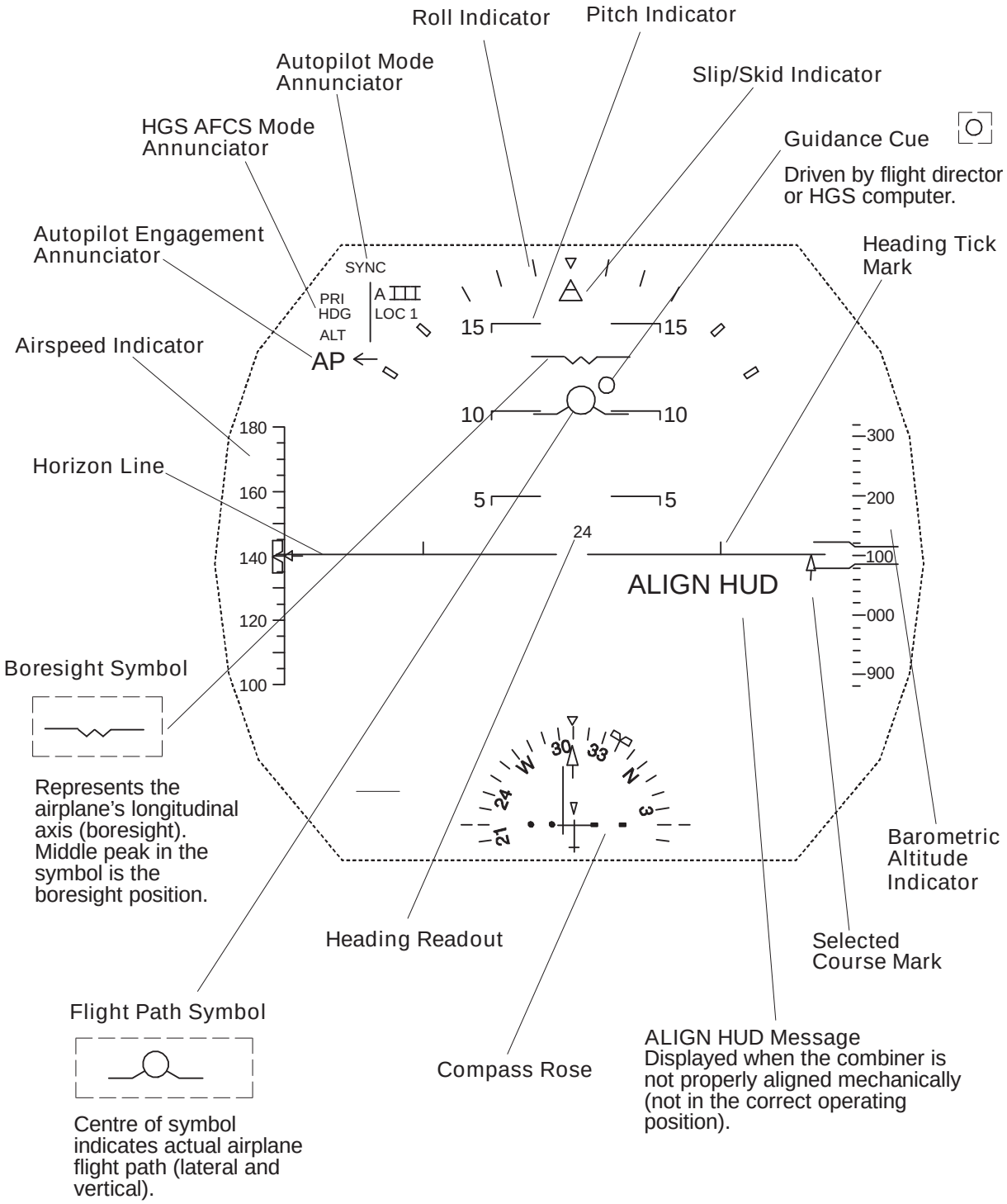
Armed Vertical Mode

GS	ILS GS Armed
ALTS	Selected Altitude Armed
ALTS	Selected Altitude Abort (if Flashing)

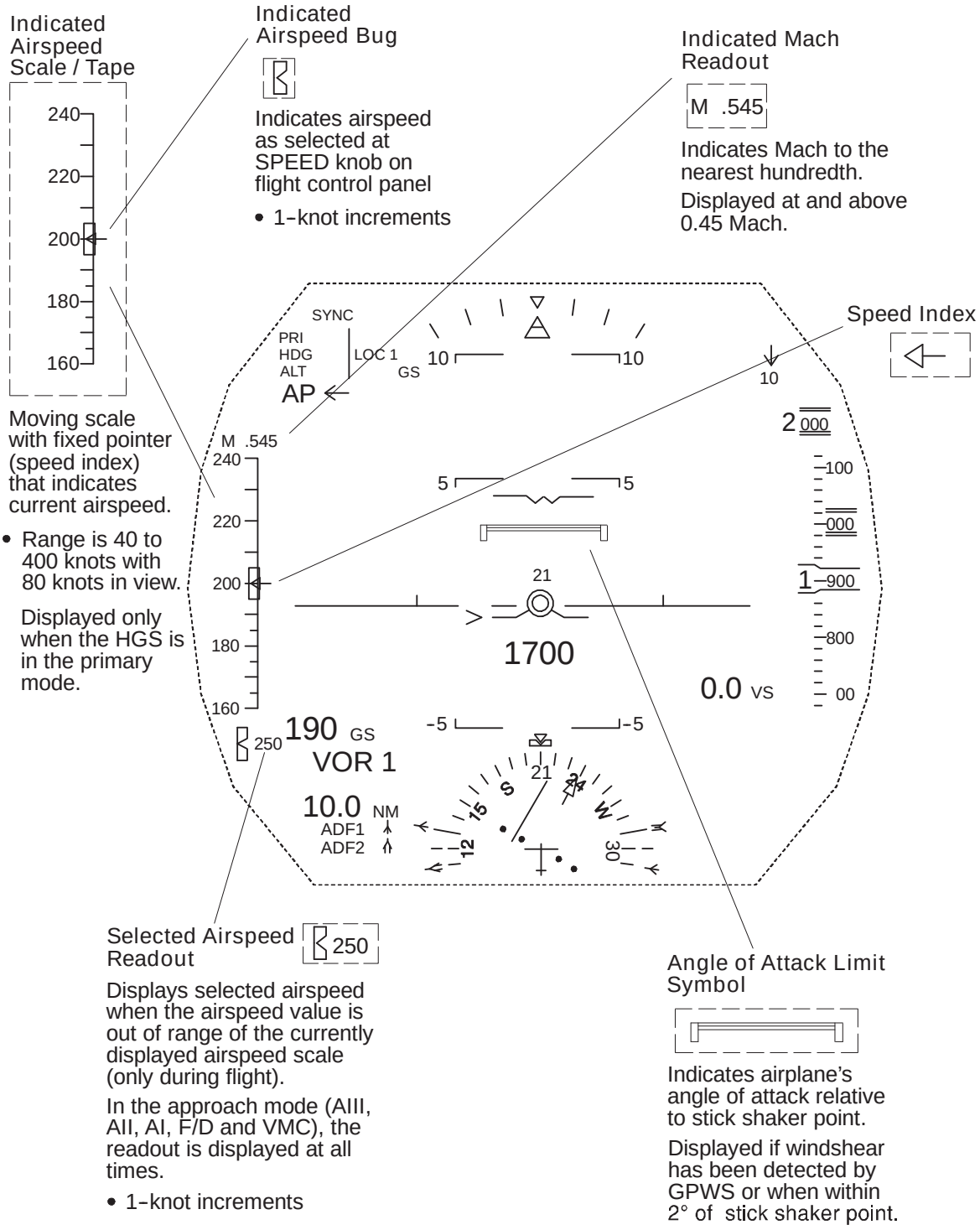
NOTE

1. On the ground, the PRI mode is the system default.
2. Annunciators flash to indicate a change.
3. PRI mode will automatically pop-up during windshear.

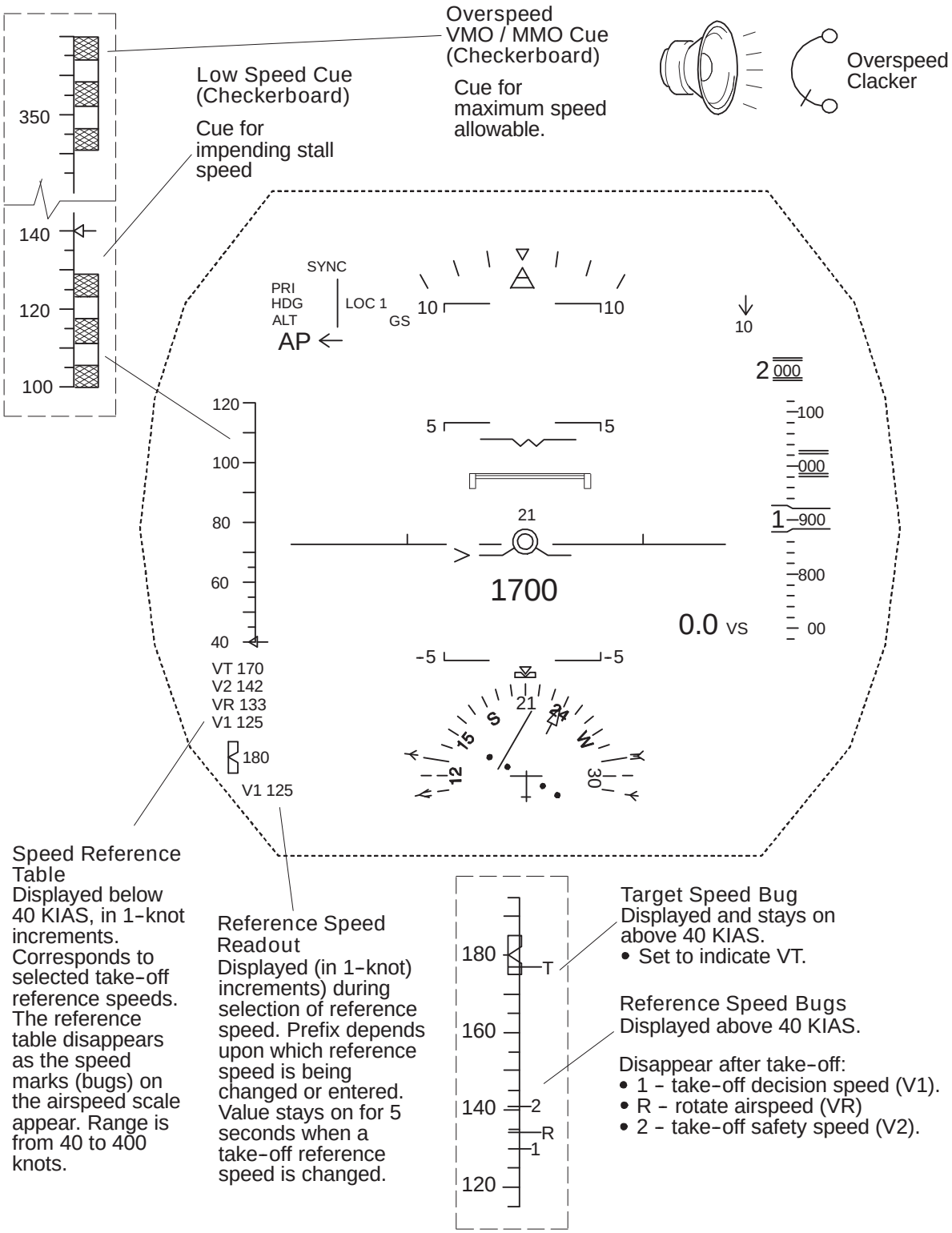
HGS /AFCS Modes
Figure 12–70–9 Sheet 2



HGS Combiner – General
Figure 12–70–10



Primary Mode – Airspeed Indications
Figure 12–70–11 Sheet 1



Primary Mode – Airspeed Indications
Figure 12–70–11 Sheet 2

IAS Failure Flag

- An IAS failure is indicated by the above failure flag and all airspeed data are removed.
- A miscompare is indicated by the same failure flag but airspeed data is retained. The flag flashes for 5 seconds when the miscompare is first detected and thereafter remains displayed until the condition is corrected.

Air Data Source

Default source is ADC 1 and is not annunciated.

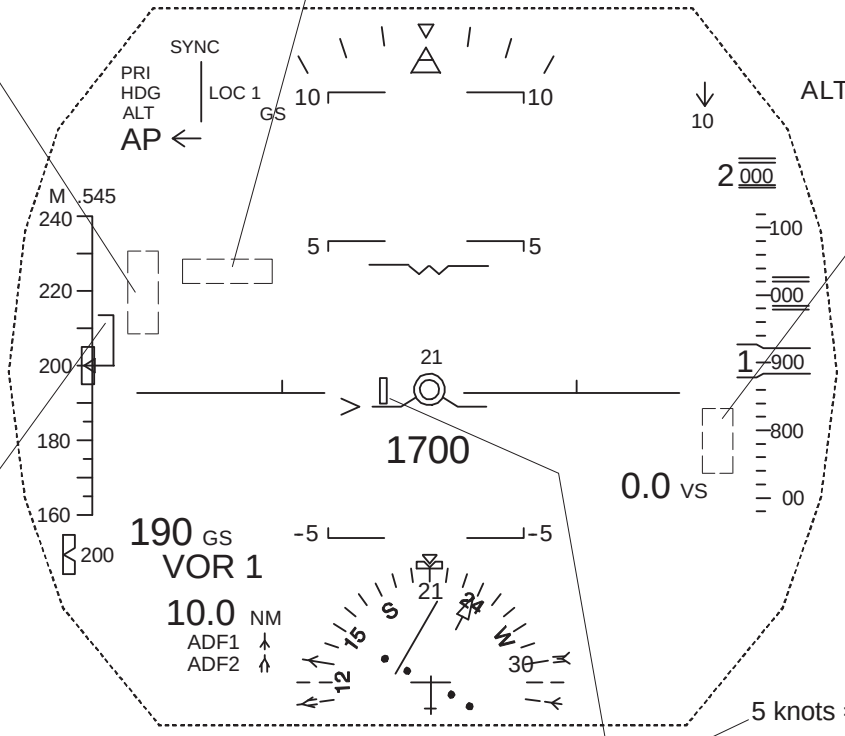
- Common source is displayed as ADC 1 or ADC 2, depending upon the air data source selected.

Air Data Failure

An ADC failure is indicated by displaying both the IAS and ALT failure flags, and all ADC–driven data are removed.

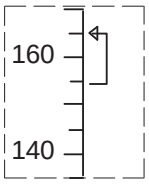
A miscompare is indicated by the same failure flags but all ADC–driven data are retained. The flags flash for 5 seconds when the miscompare is first detected and thereafter remain displayed until the condition is corrected.

ALT Failure Flag

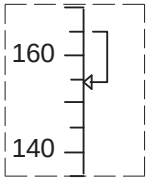


Airspeed Trend Vector

Predicted speed value, in the next 10 seconds, from current airspeed.



Vector travelling below the speed index indicates airplane deceleration.

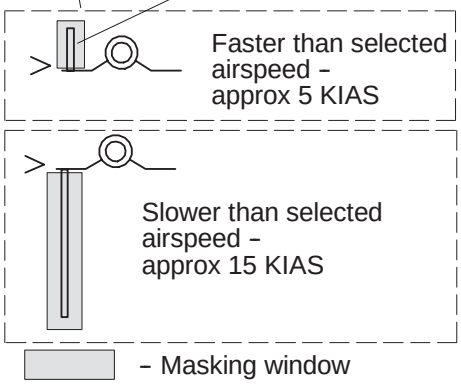


Vector travelling above the speed index indicates airplane acceleration.

Airspeed Error Symbol

Indicates airplane's deviation (max 15 KIAS) from selected airspeed. The symbol has a masking window which obscures most other symbols that it overlays except the guidance cue, runway lines, approach status message, TCAS box and windshear messsage.

5 knots = 1 degree

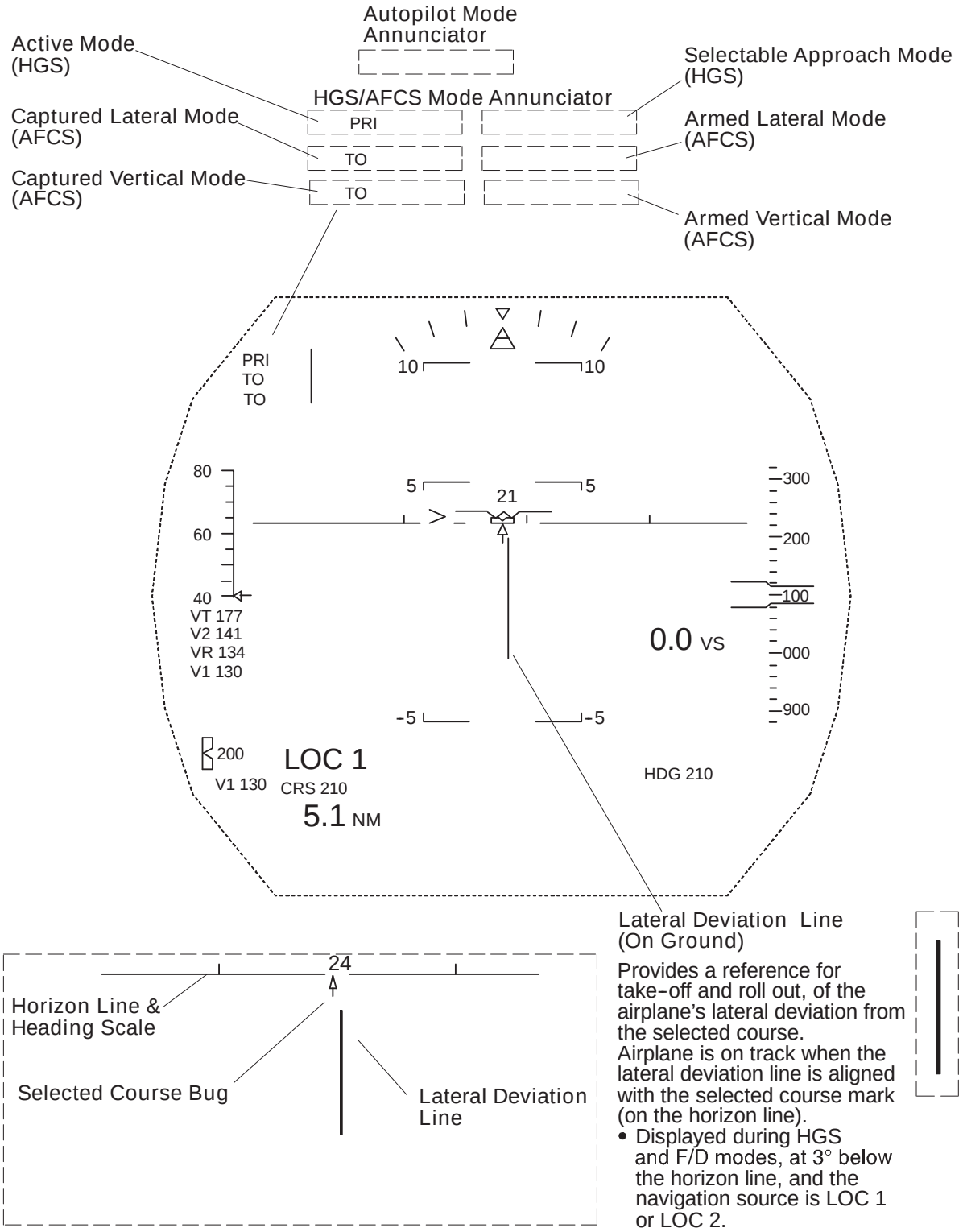


Faster than selected airspeed – approx 5 KIAS

Slower than selected airspeed – approx 15 KIAS

– Masking window

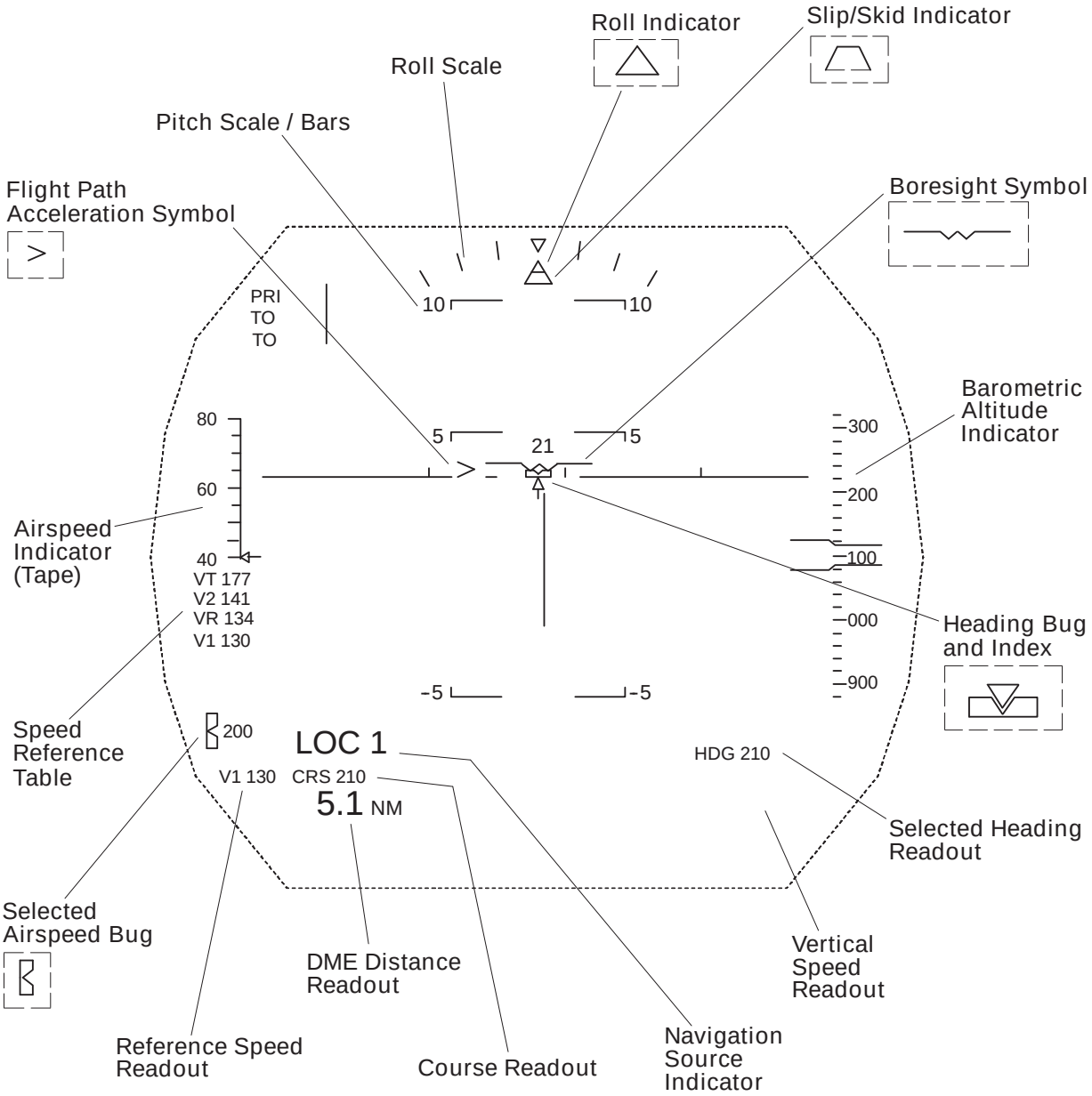
Primary Mode – Airspeed Indications
Figure 12–70–11 Sheet 3



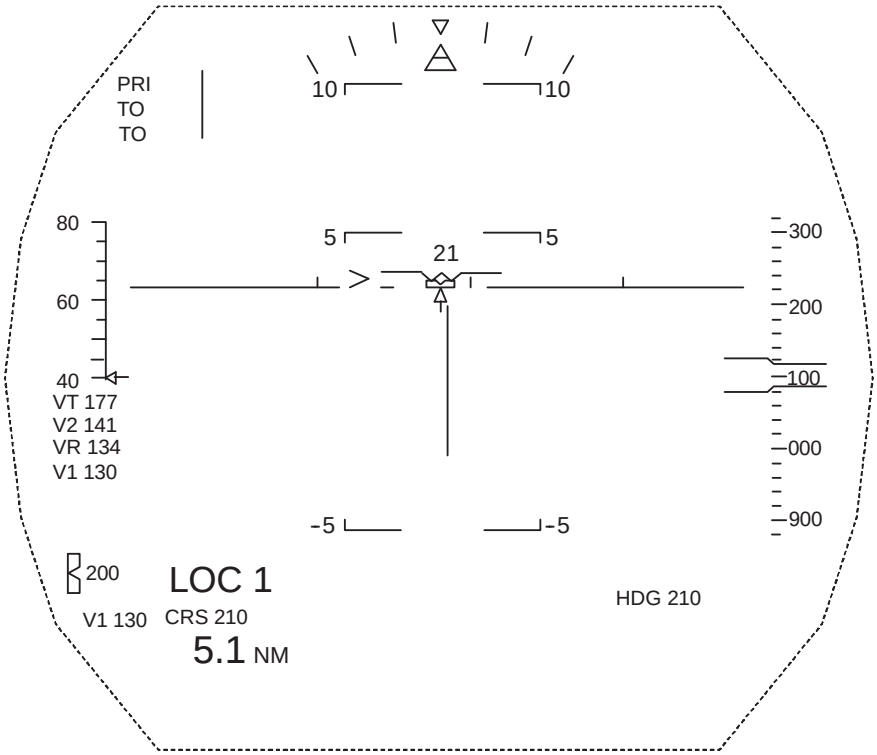
Provides a reference for take-off and roll out, of the airplane's lateral deviation from the selected course. Airplane is on track when the lateral deviation line is aligned with the selected course mark (on the horizon line).

- Displayed during HGS and F/D modes, at 3° below the horizon line, and the navigation source is LOC 1 or LOC 2.

Primary Mode – On Ground
Figure 12–70–12 Sheet 1



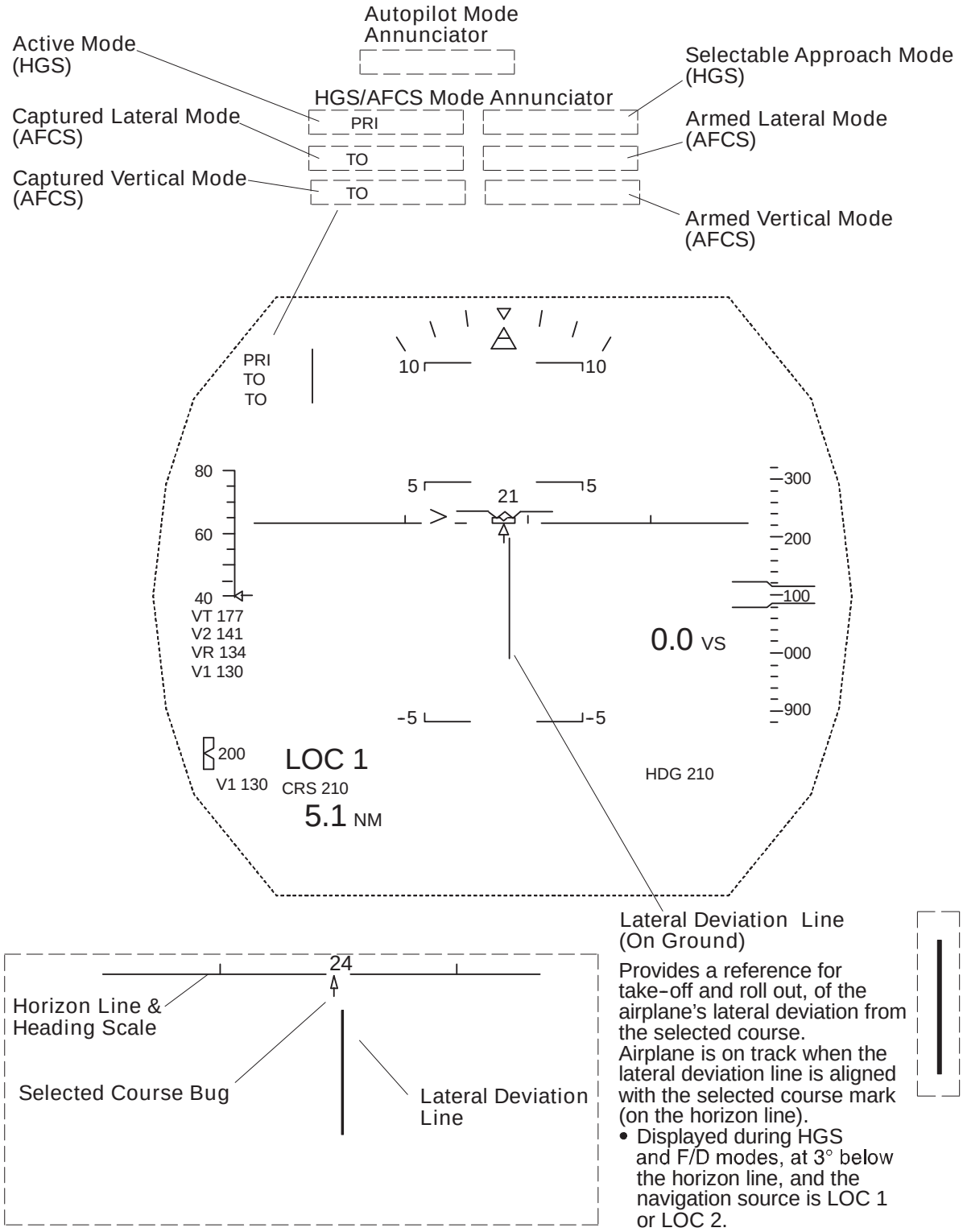
Primary Mode – On Ground
Figure 12–70–12 Sheet 2



The following symbols / readouts are not available when on the ground:

1820 B Baro Altitude Readout	↓ 10 Windspeed and Wind Vector
Airspeed readout, radio altitude readout and ground speed readout.	○ Guidance Cue
Compass rose and its associated symbols.	Airspeed Error Symbol
Flight Path Symbol	0.0 VS Vertical Speed Symbol

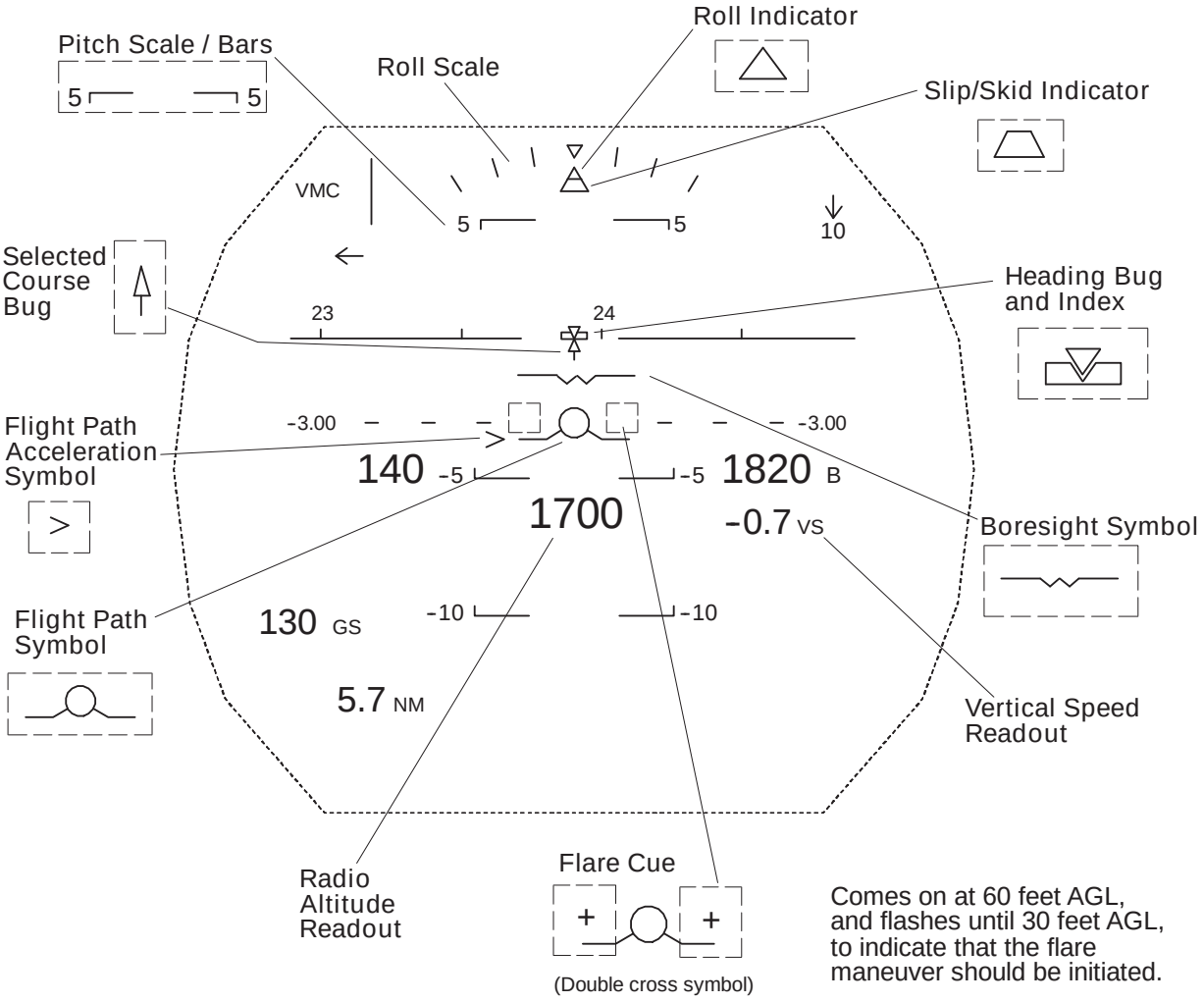
Primary Mode – On Ground
Figure 12–70–12 Sheet 3



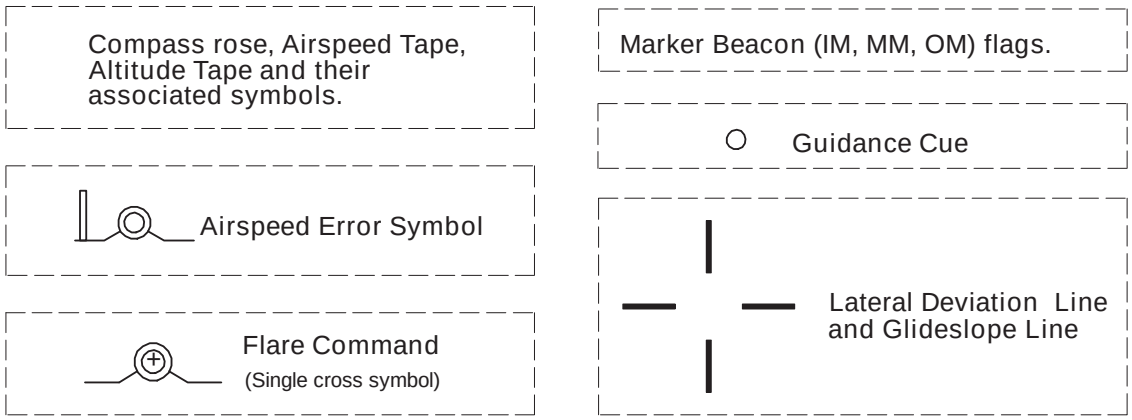
Provides a reference for take-off and roll out, of the airplane's lateral deviation from the selected course. Airplane is on track when the lateral deviation line is aligned with the selected course mark (on the horizon line).

- Displayed during HGS and F/D modes, at 3° below the horizon line, and the navigation source is LOC 1 or LOC 2.

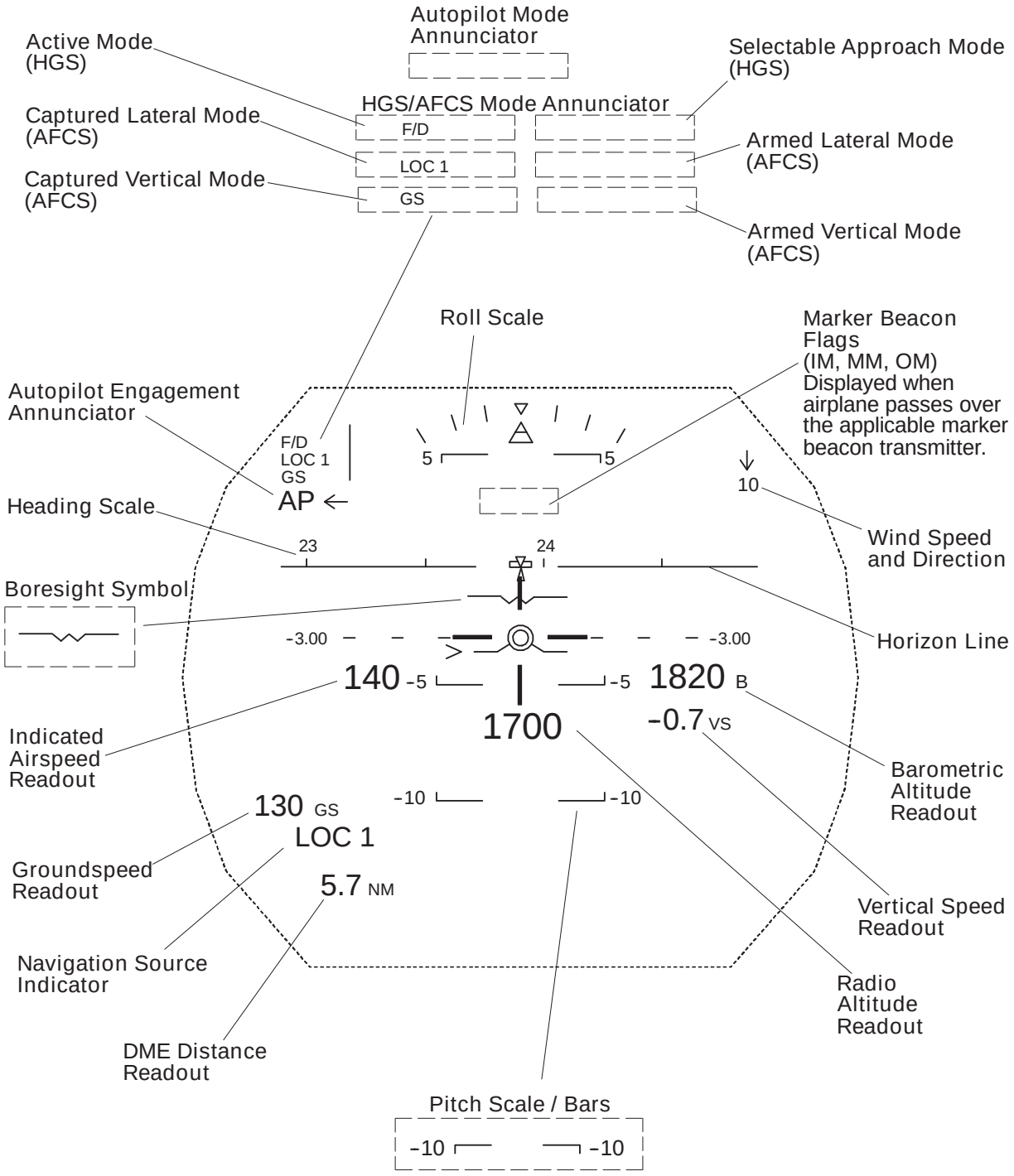
Visual Meteorological Conditions (VMC) Model – Approach and Landing
Figure 12–70–13 Sheet 1



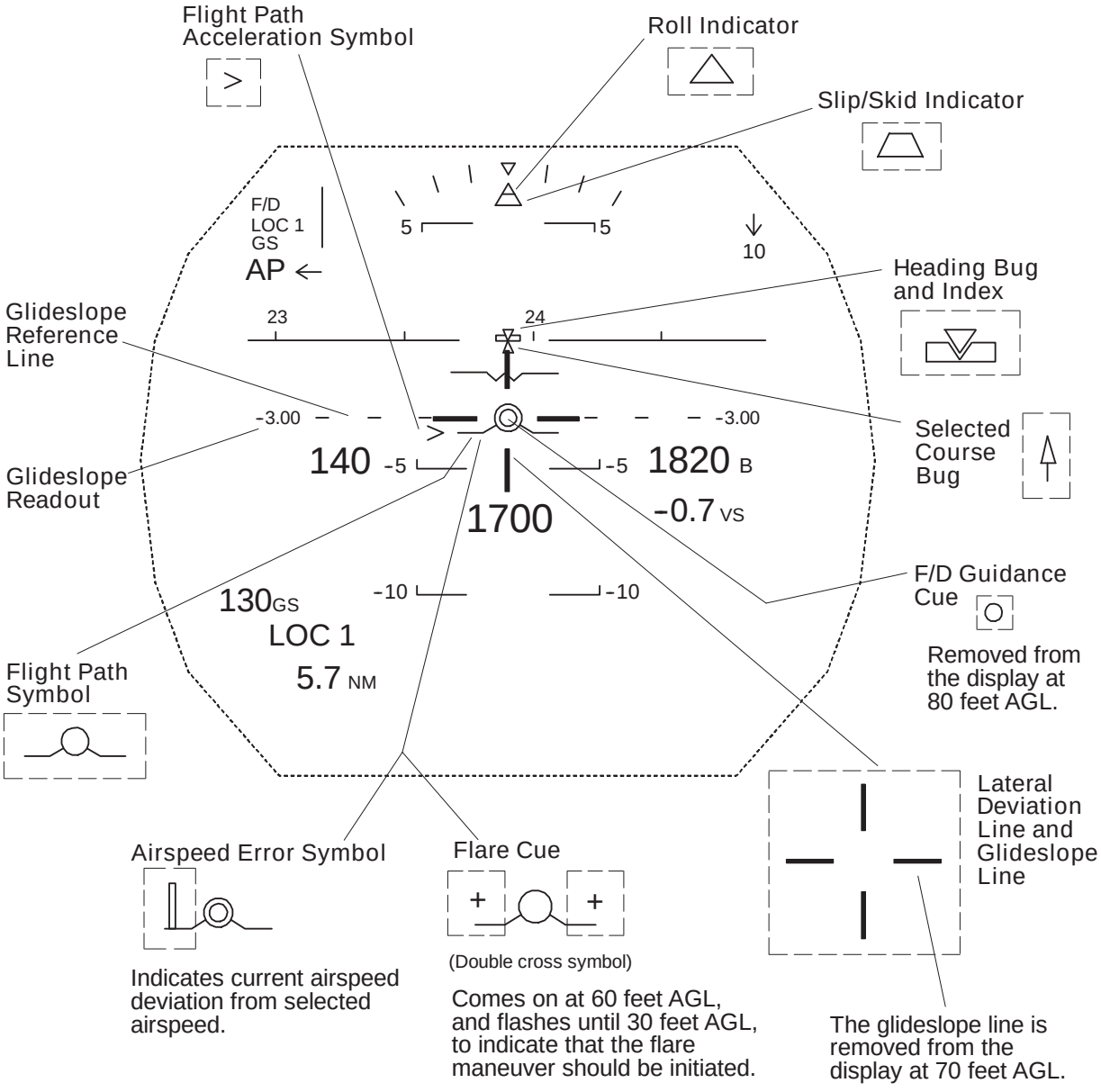
The following symbols / readouts are not available when in VMC mode:



Visual Meteorological Conditions (VMC) Model – Approach and Landing
Figure 12–70–13 Sheet 2



Flight Director (F/D) Model – Approach and Landing
Figure 12–70–14 Sheet 1

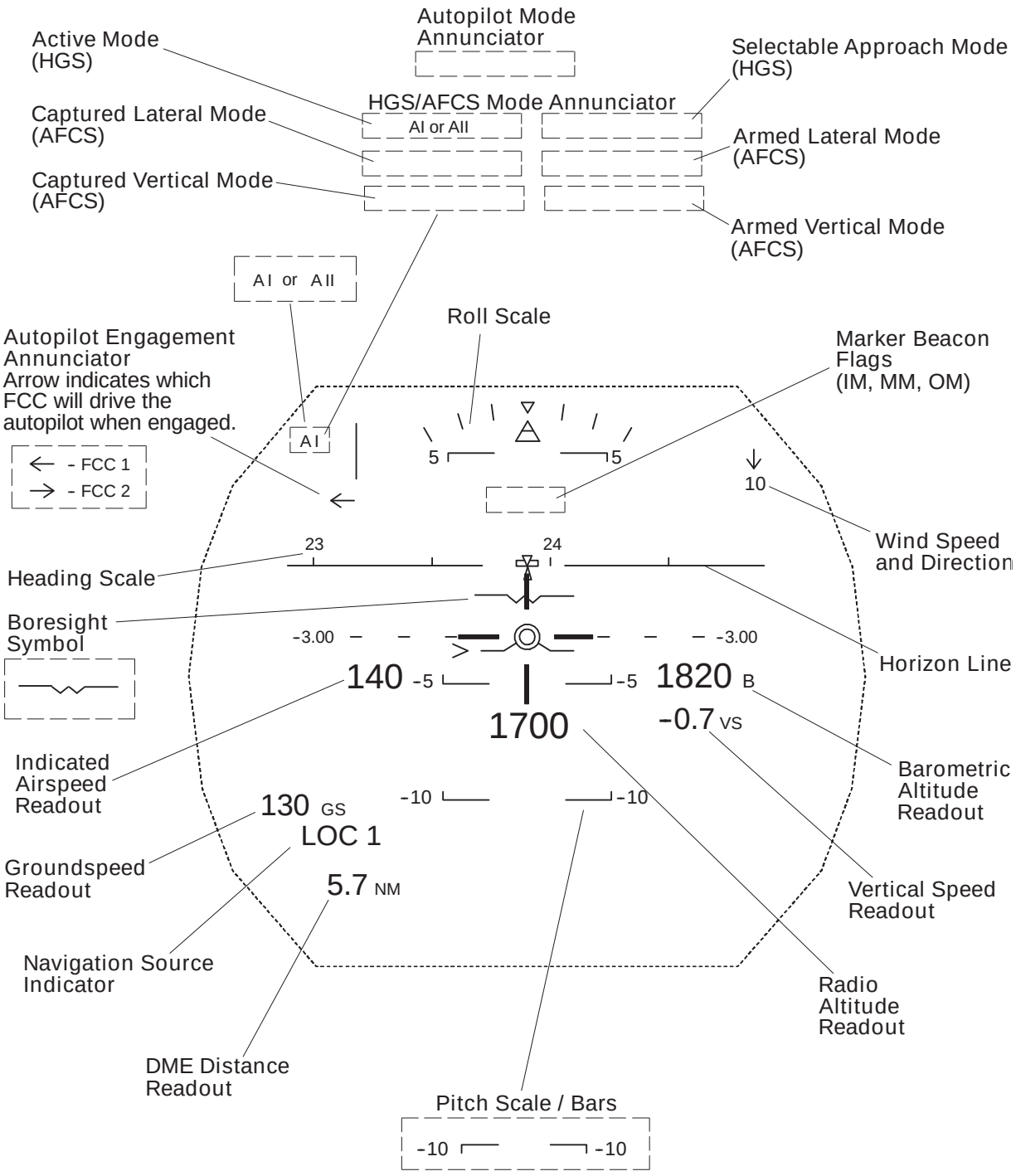


The following symbols / readouts are not available when in F/D mode:

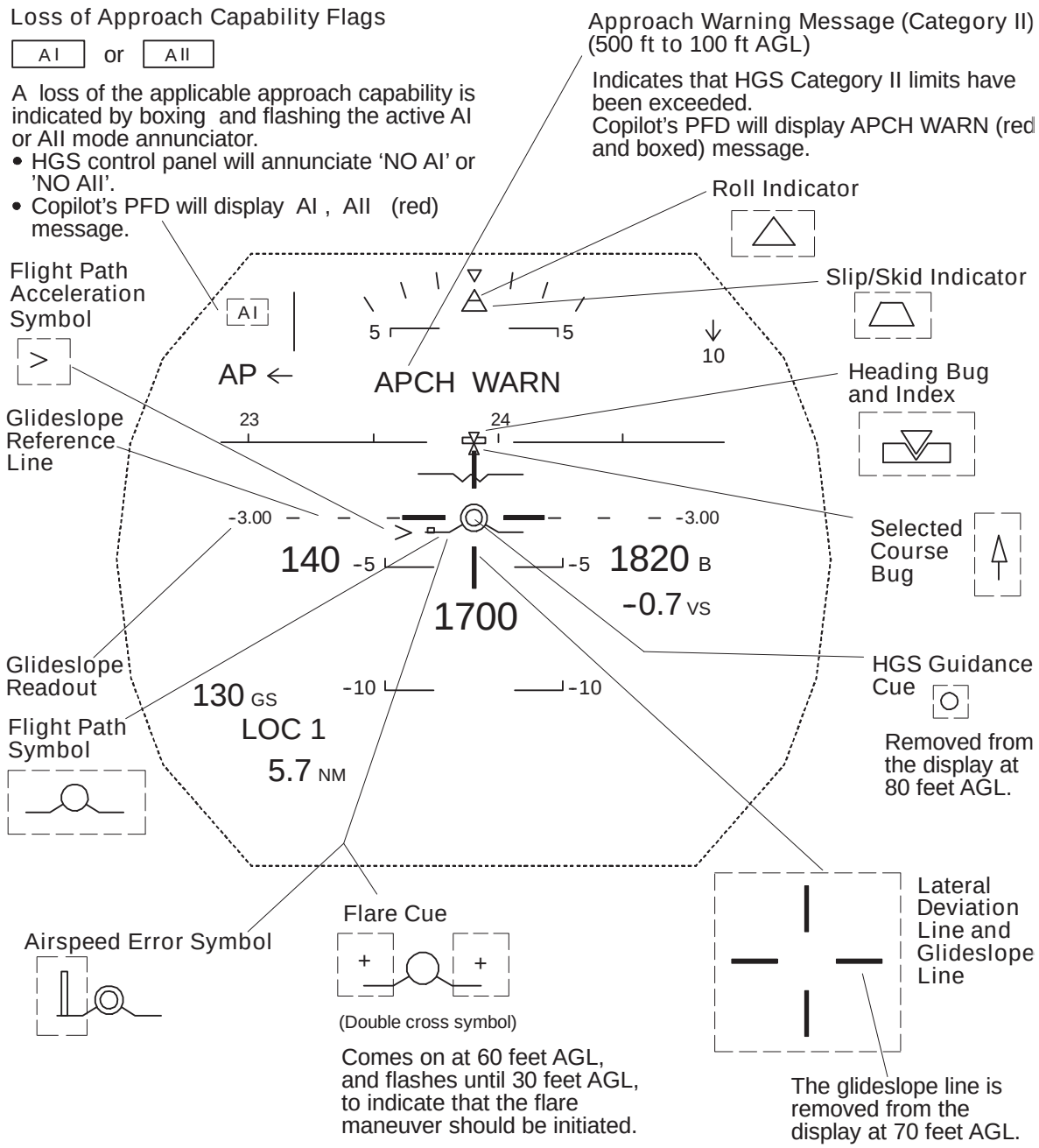
Compass rose, Airspeed Tape, Altitude Tape and their associated symbols.

Flare Command
(Single cross symbol)

Flight Director (F/D) Model – Approach and Landing
Figure 12–70–14 Sheet 2



Category I or II (AI or AII) Model Approach and Landing
Figure 12–70–15 Sheet 1

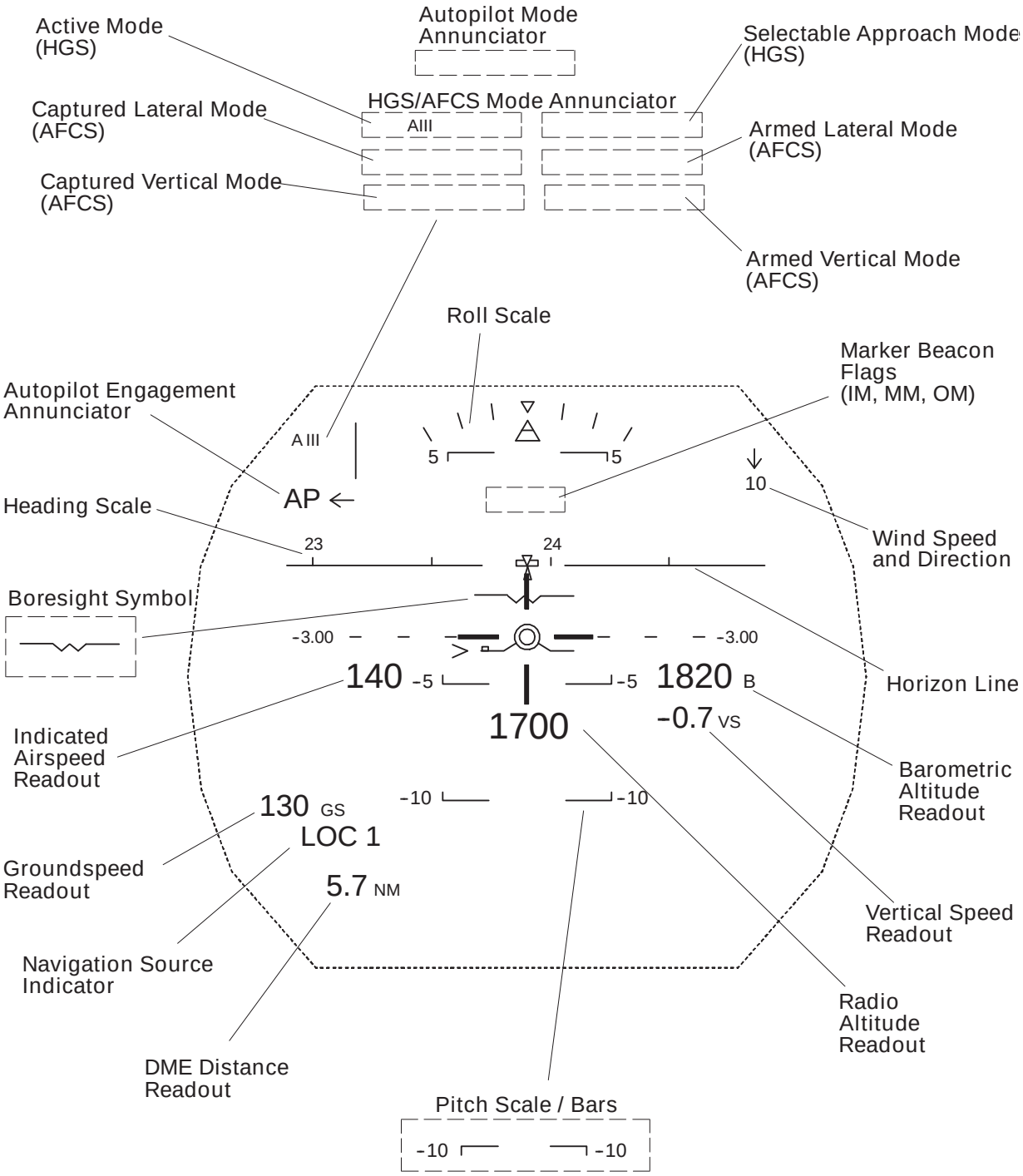


The following symbols / readouts are not available when in AI or AII mode:

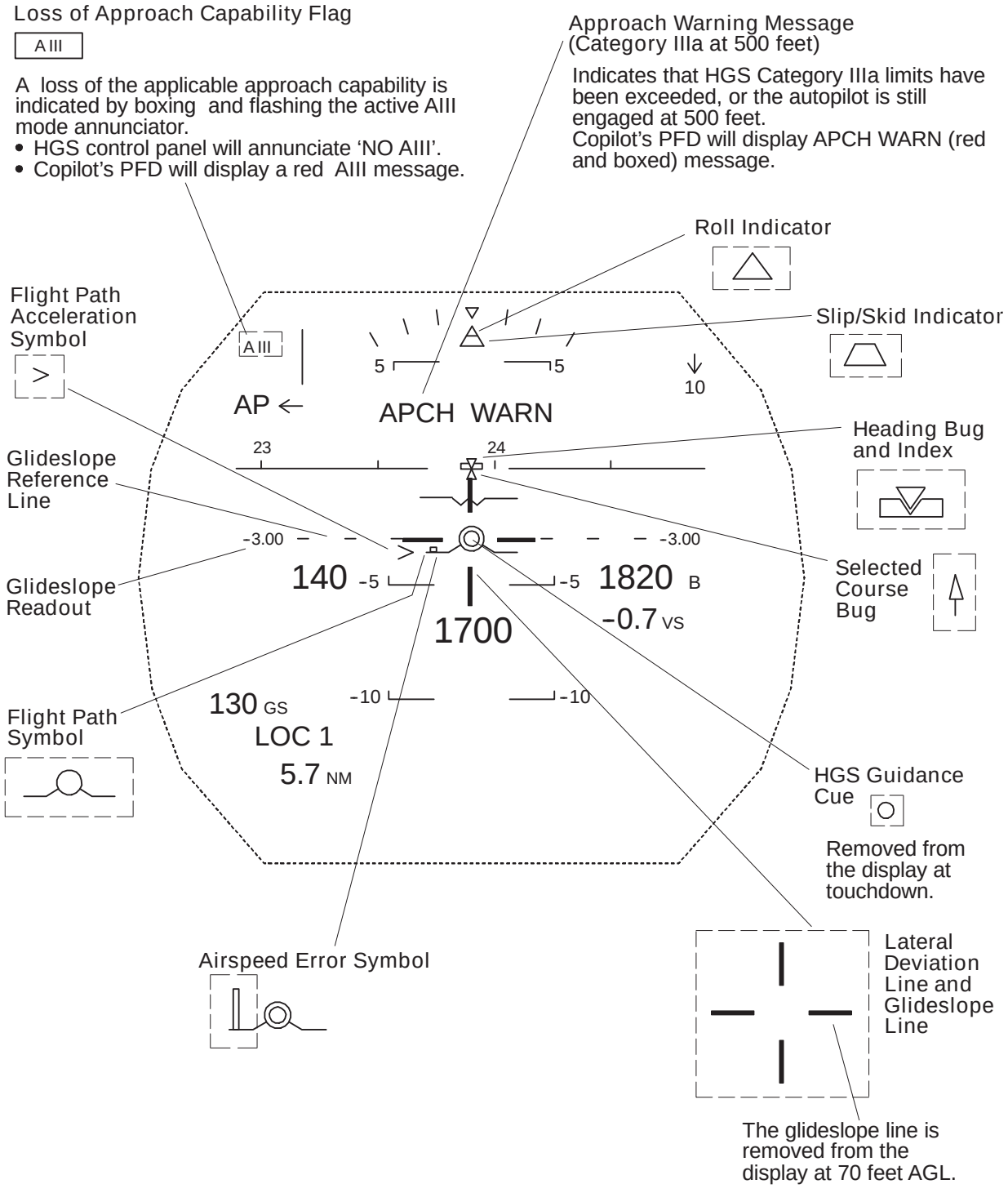
Compass rose, Airspeed Tape, Altitude Tape and their associated symbols.

Flare Command
(Single cross symbol)

Category I or II (AI or AII) Model Approach and Landing
Figure 12–70–15 Sheet 2



Category IIIa (AIII) Model Approach and Landing
Figure 12–70–16 Sheet 1



Category IIIa (AIII) Model Approach and Landing
Figure 12–70–16 Sheet 2

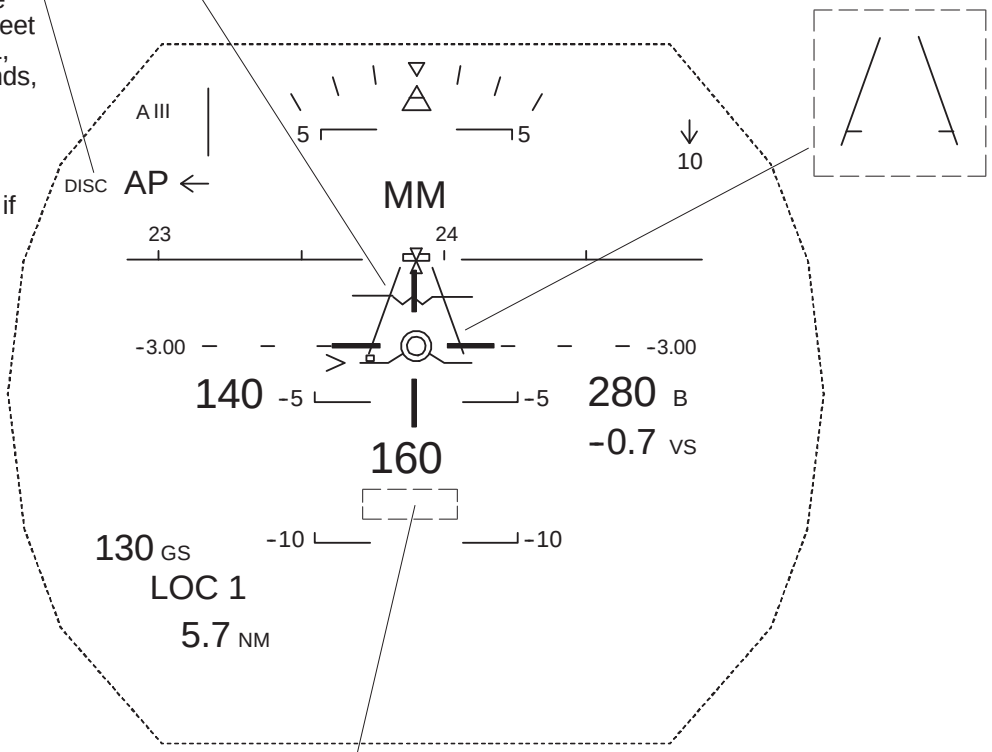
Runway Symbol
Represents the airplane's orientation relative to the runway. Displayed from 300 feet to 60 feet AGL. Position depends upon runway elevation, airplane heading, altitude, course setting, localizer deviation, and system resolution.

- Tick marks indicate runway aim point, which represents 1,050 feet from the runway threshold.
- Lines represent outline of runway threshold, scaled to a width of 200 feet.

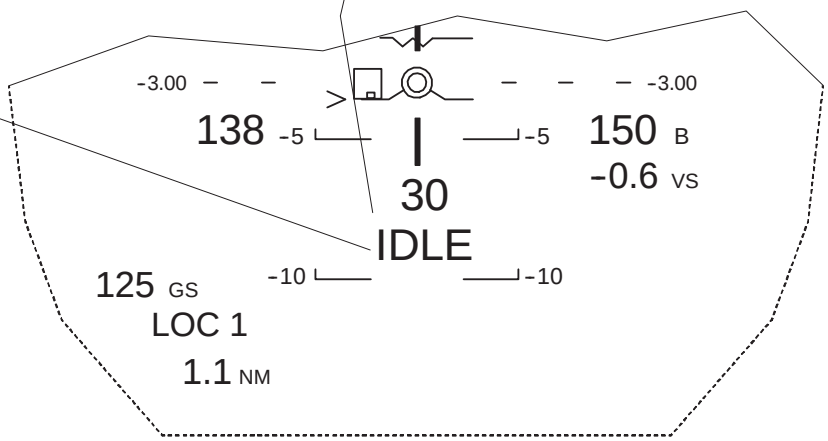
The symbol cues the pilot as to where to expect the real runway when adequate visibility is achieved and is used as an additional altitude awareness cue.

Autopilot Disconnect Message

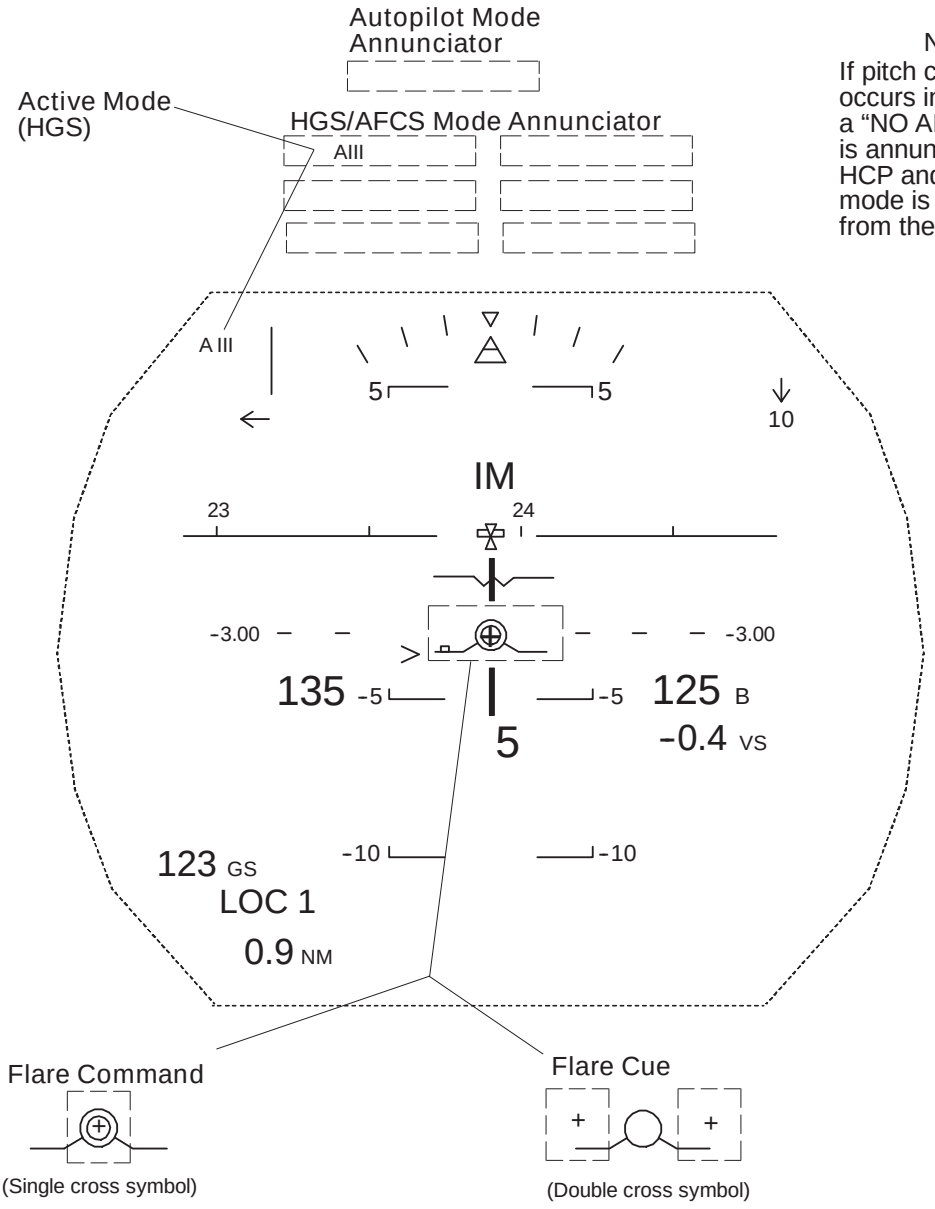
During a Category III approach, message comes on at 1,000 feet and at 650 feet AGL, flashes for 10 seconds, to indicate that the autopilot must be disconnected. An approach warning message comes on if the autopilot is not disengaged by 500 feet AGL.



IDLE Command Displayed during Category IIIa operations, when the HGS has determined that the thrust levers must be selected to IDLE.



Category IIIa (AIII) Model Approach and Landing
Figure 12–70–16 Sheet 3



NOTE

If pitch compression occurs in AIII mode, a “NO AIII” message is annunciated on the HCP and the HGS mode is removed from the combiner.

Flare Command

(Single cross symbol)

Displayed only during a Category IIIa approach. Provides guidance on how to perform the correct flare maneuver.

Flare Cue

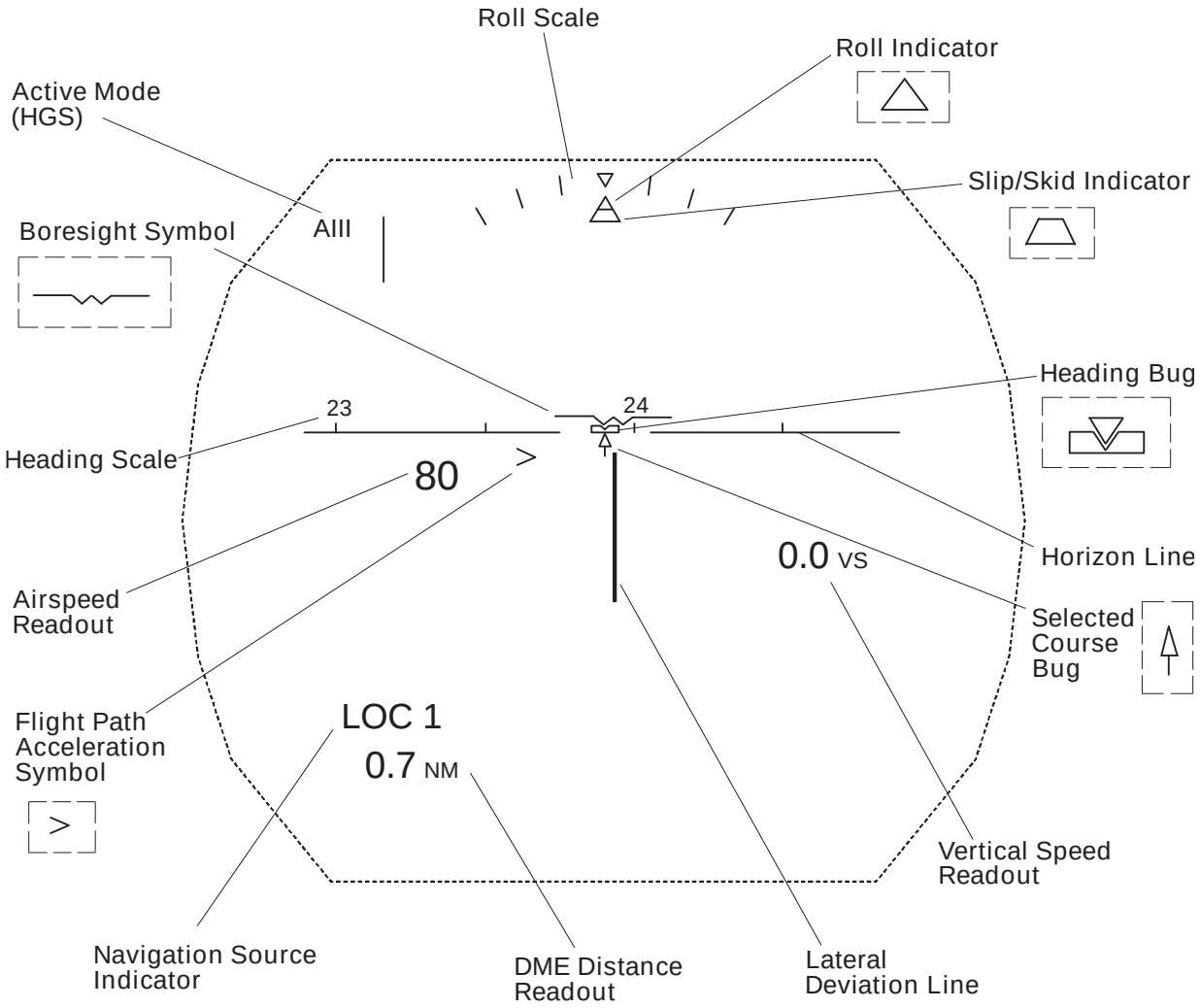
(Double cross symbol)

Comes on if a flare command is not available. Indicates that the flare maneuver should be initiated but not how to perform the maneuver.

The following symbols / readouts are not available when in AIII mode:

Flare cue, when flare command is available;
Compass rose, Airspeed Tape, Altitude Tape and their associated symbols.

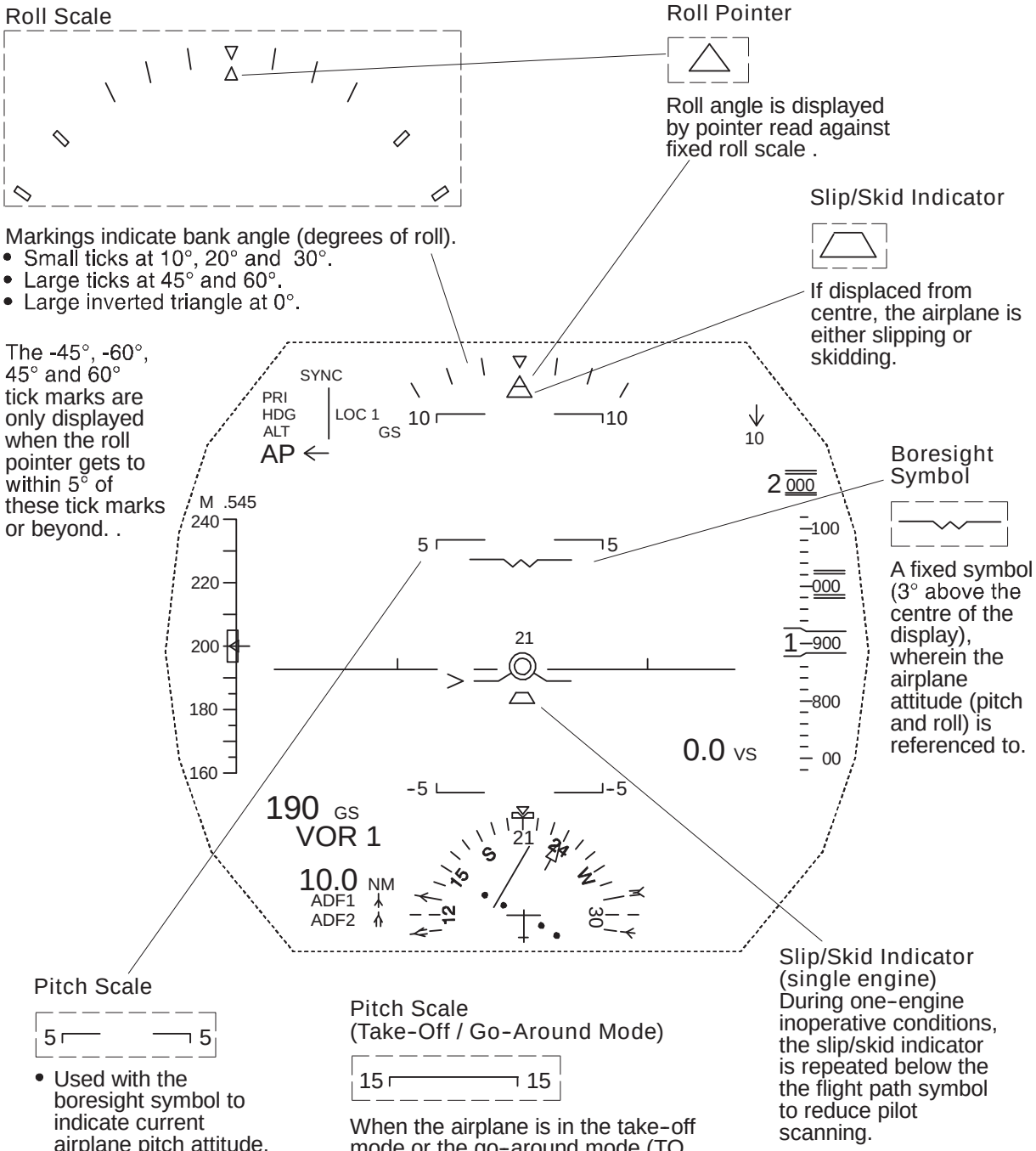
Category IIIa (AIII) Model Approach and Landing
Figure 12–70–16 Sheet 4



Rollout Indications on EFIS

Pilot's and copilot's PFDs will display a 'ROLLOUT' message upon airplane touchdown.

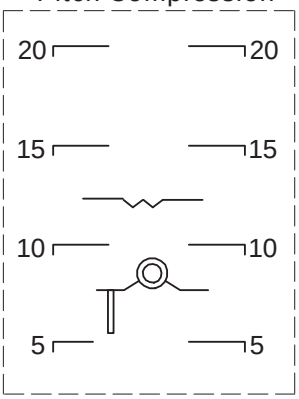
Rollout Mode
Figure 12–70–17

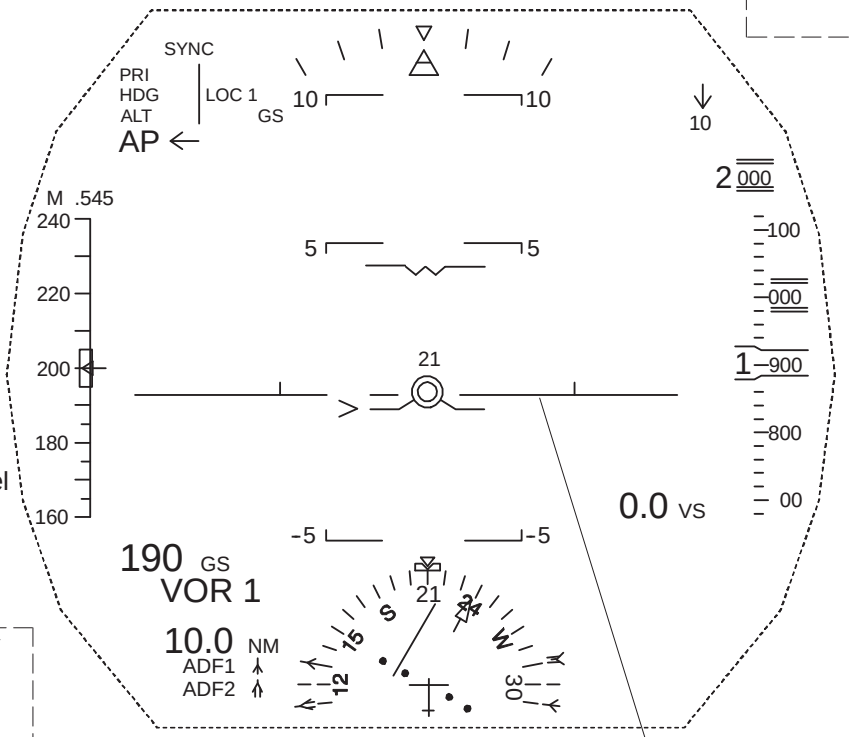


Primary Mode – Attitude Indications
Figure 12–70–18 Sheet 1

Unusual attitudes / Unusual AOAs
An unusual attitude or unusual AOA would result in either the horizon line or the flight path symbol exceeding the limits of their display areas. The affected symbol will then be ghosted (displayed in dashed lines). In this event, the vertical components of the attitude display will be compressed to provide a consistent display which is relatively correct to each other, although no longer conformal to the outside scene.

Pitch Compression





Extreme Pitch Chevron
Points to the direction of level flight during extreme pitch attitudes (<-20° and >+20°).

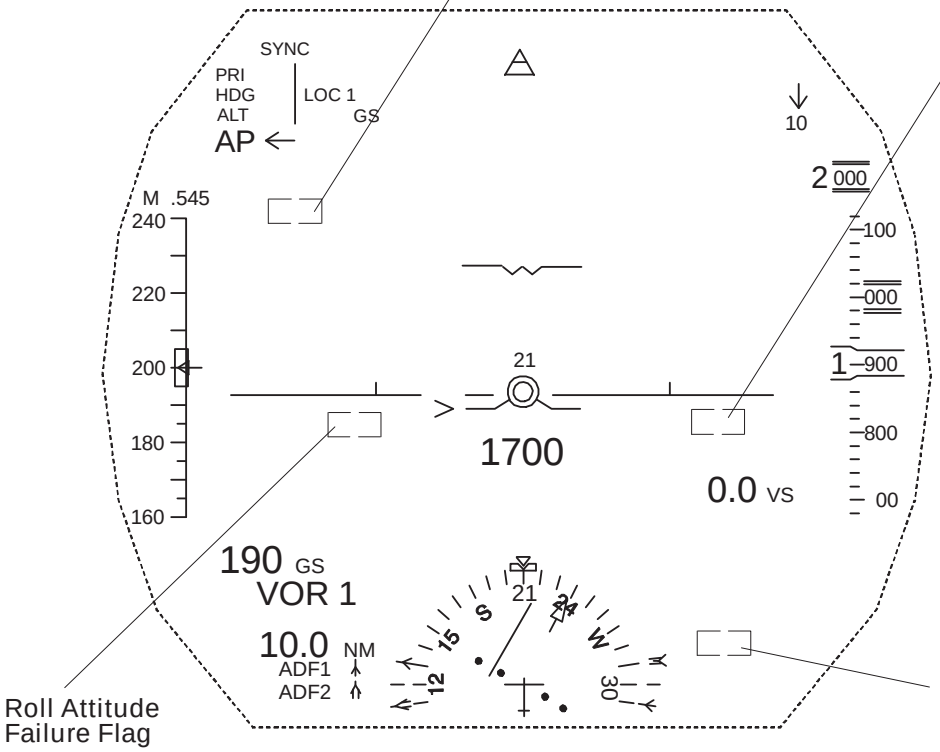
- The point of a downward pointing chevron represents +20° of pitch attitude.

- The point of an upward pointing chevron represents -20° of pitch attitude.

Horizon Line

The horizon line represents the airplane's zero degrees of pitch attitude (an artificial horizon which is not adjusted for the curvature of the earth).

Primary Mode – Attitude Indications
Figure 12–70–18 Sheet 2



NOTE
The HGS does not display IRS alignment messages, whether on the ground or during flight.

Attitude Source
- Default source is ATT 1 and is not annunciated.
- Common source is displayed as ATT 1 or ATT 2, depending upon the attitude source selected.
- The flight path symbol is not displayed when the off–side IRS is selected.

Pitch Attitude Failure Flag

PIT

- The pitch scale is removed if valid pitch data from the selected attitude source is lost.

Roll Attitude Failure Flag

ROL

- The roll scale is removed if valid roll data from the selected attitude source is lost.

Attitude Failure Flags

ROL and/or PIT and/or V/S

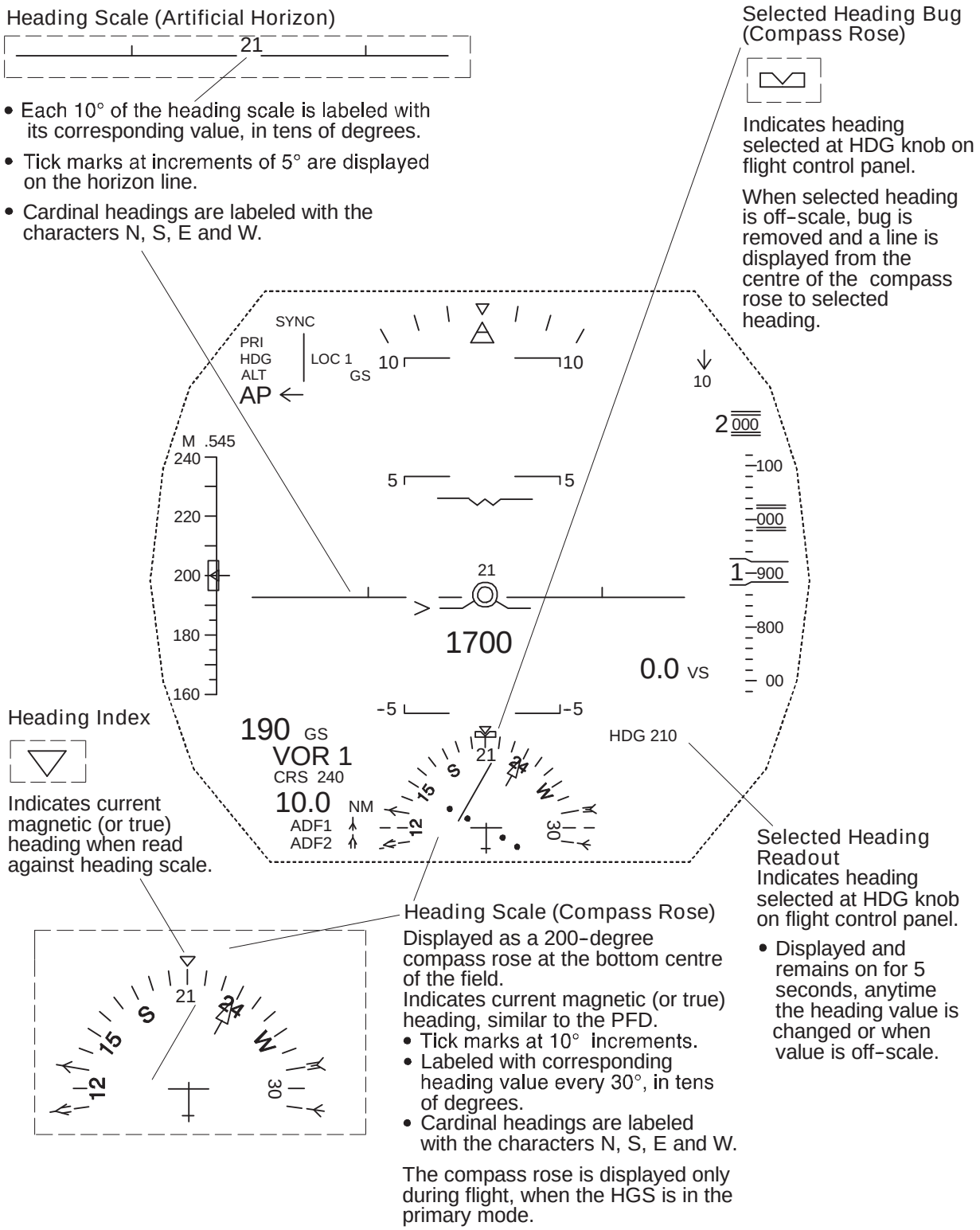
An IRS failure is indicated by the above failure flags and the affected attitude data is removed from the display.
A miscompare is indicated by the same failure flags but affected attitude data is retained. The flags flash for 5 seconds when the miscompare is first detected and thereafter remain displayed until the condition is corrected.

Vertical Speed Failure Flag

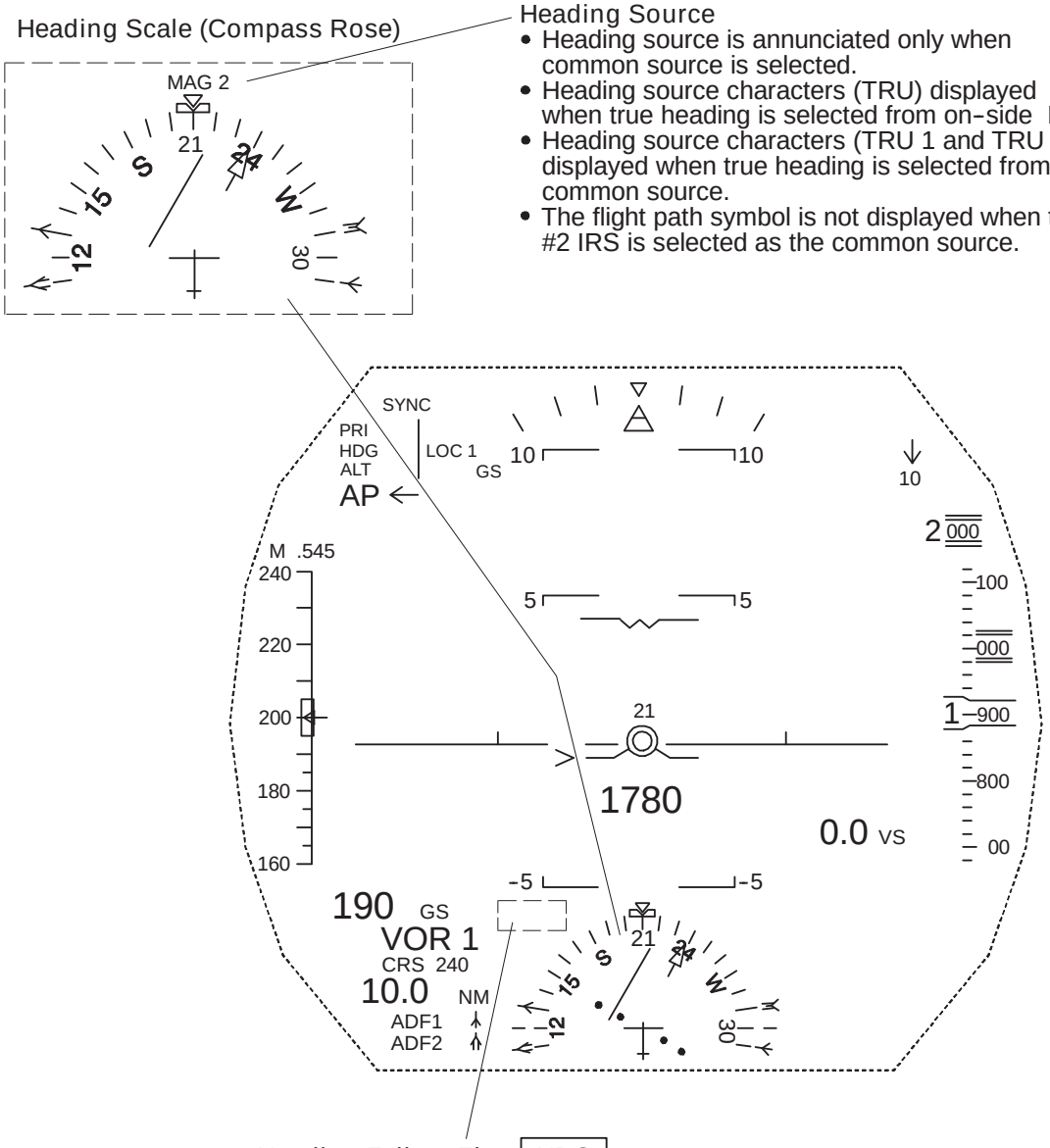
V/S

- The vertical speed scale is removed if valid vertical speed data from the selected attitude source is lost.

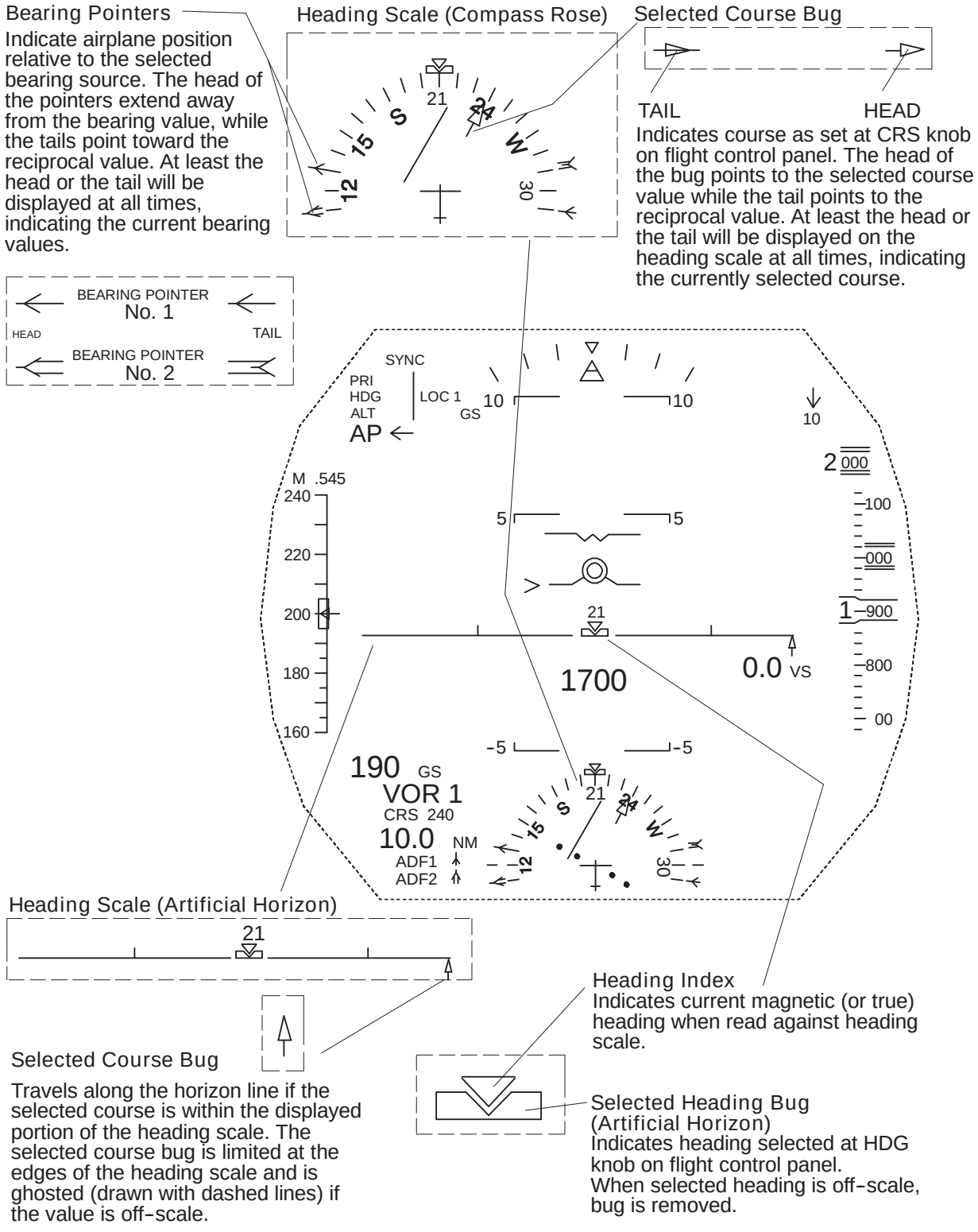
Primary Mode – Attitude Indications
Figure 12–70–18 Sheet 3



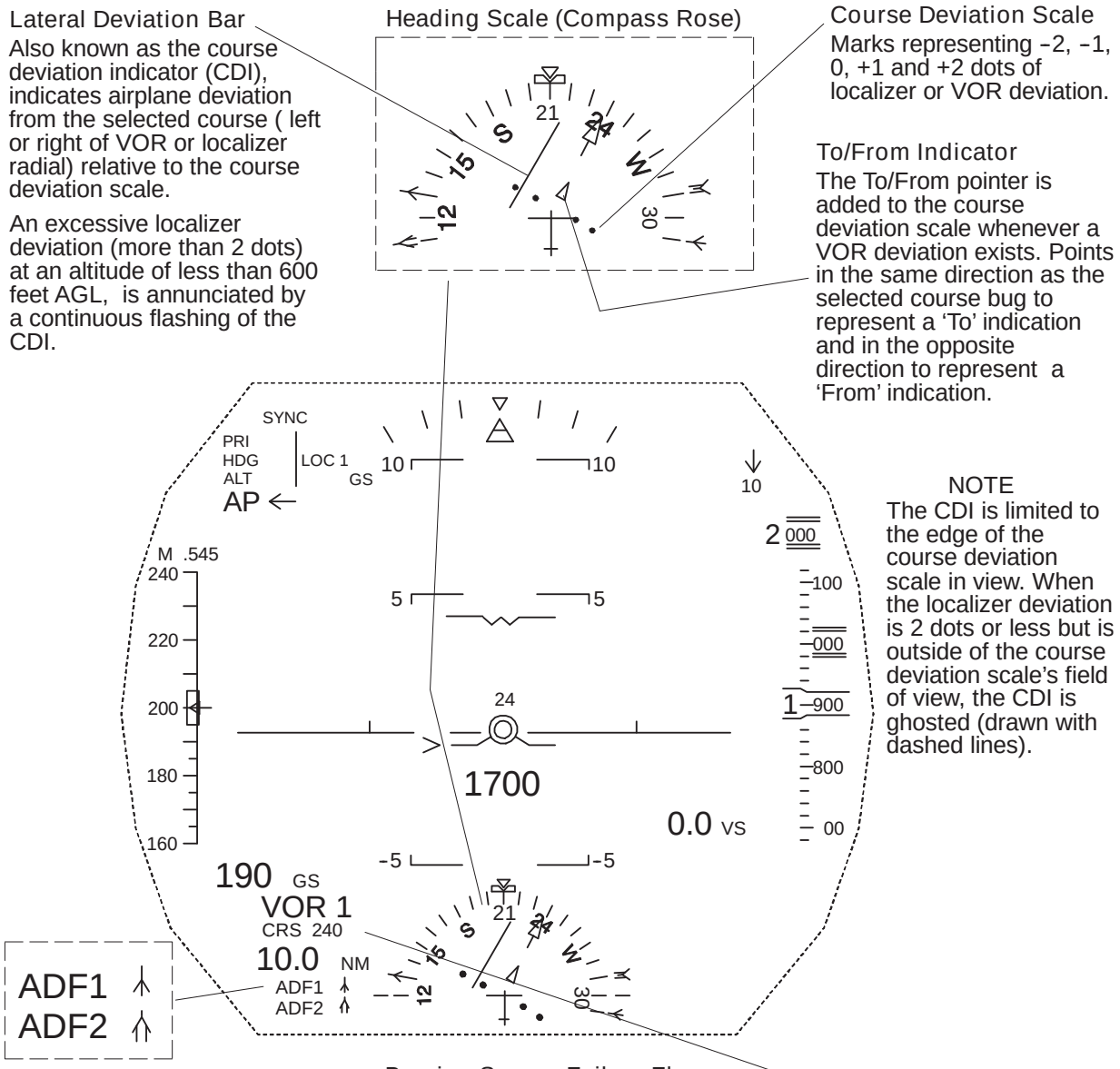
Primary Mode – Heading Indications
Figure 12–70–19 Sheet 1



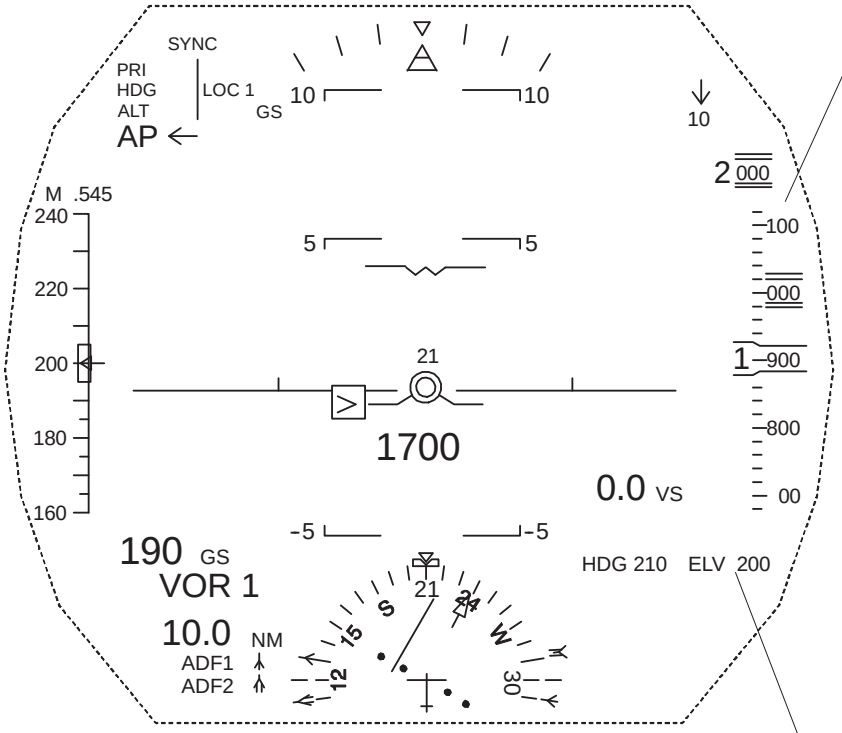
Primary Mode – Heading Indications
Figure 12–70–19 Sheet 2



Primary Mode – Course Indications
Figure 12–70–20 Sheet 1



Primary Mode – Course Indications
Figure 12–70–20 Sheet 2



Barometric Altitude Indicator (Tape)

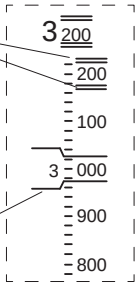
Analog indication of the airplane's barometric corrected altitude. Displayed only during the primary mode.

Moving vertical scale with fixed index (digital readout window) that indicates barometric corrected altitude, ranging from –200 to 50,000 feet, with 440 feet always in view.

The scale is similar in format and operation to the altitude tape in the PFDs.

- Small tick marks every 20 feet.
- Large tick marks every 100 feet with their corresponding numerical values in hundreds.
- The thousands numerical values are contained within the altitude index (window).

Altitude Select Bug
Double lines indicate selected altitude as set at ALT knob on flight control panel. Displayed only when selected altitude is within the scale in view.



Altitude Index
Altitude readout window which indicates the airplane's current barometric corrected altitude.

Runway Elevation Readout (Example: ELV 200)
Digital indication of the runway's elevation, in 1–foot increments.

- Displayed and remains on for 5 seconds, anytime the runway elevation value is changed at the HGS control panel..

NOTE

Ensure that the landing field elevation is correctly set at the HGS control panel and the cabin pressurization selector panel. Cross–check barometric pressure setting on PFDs and standby altimeter.

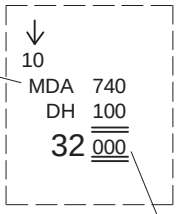
Primary Mode – Barometric Altitude Indications
Figure 12–70–21 Sheet 1

NOTE

1. The HGS does not display barometric pressure indications. Cross–check barometric pressure setting on PFDs and standby altimeter.
2. The HGS does not display barometric altitude in meters.

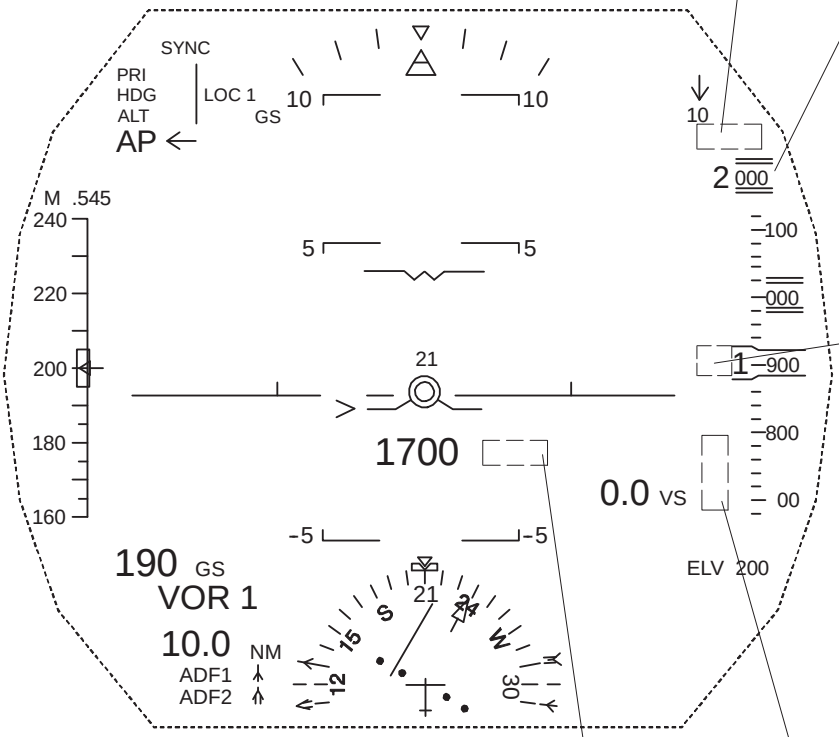
Selected MDA Readout
(Example: MDA 740)
Digital indication of the selected MDA, in 10–foot increments.

- Displayed and remains on for 5 seconds, anytime the MDA value is selected on the air data reference panel.

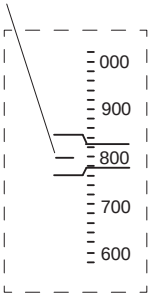


Selected Altitude Readout
Indicates the selected altitude value, with double lines drawn over and under the hundreds digits. Displayed in 100–foot increments (rounded–off to the nearest 100 feet).

- Flashes for 5 seconds when1,000 feet away from target (selected) altitude.



Negative Altitude Indicator
Annunciates altitudes less than 0 feet.



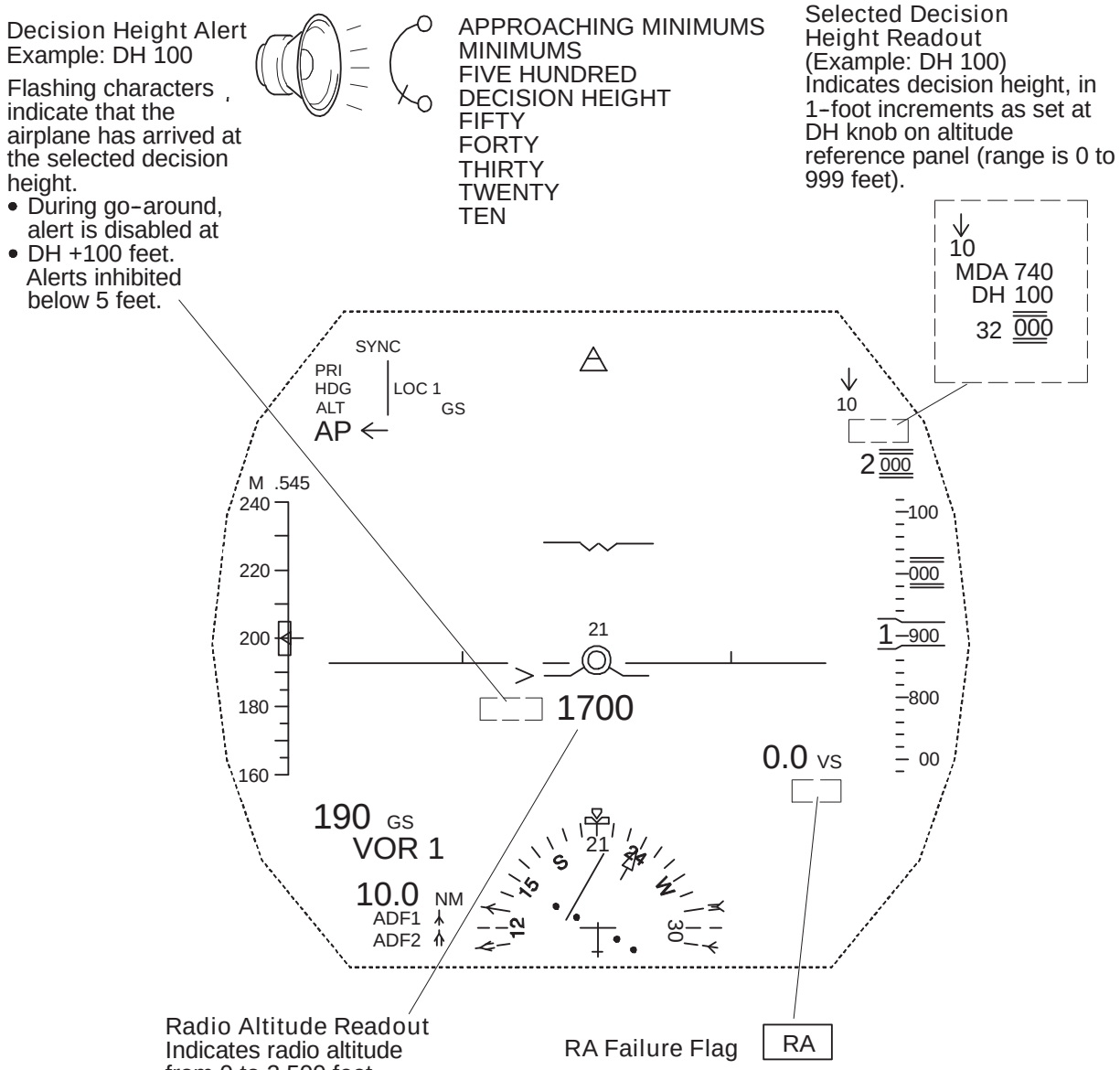
Minimum Descent Altitude (MDA) Alert

Consists of the characters 'MDA' which indicates the airplane's passage of the selected minimum descent altitude. The MDA message comes on at the MDA and flashes for 2 seconds and thereafter remains displayed until touchdown or until the airplane climbs above the selected MDA plus 100 feet.

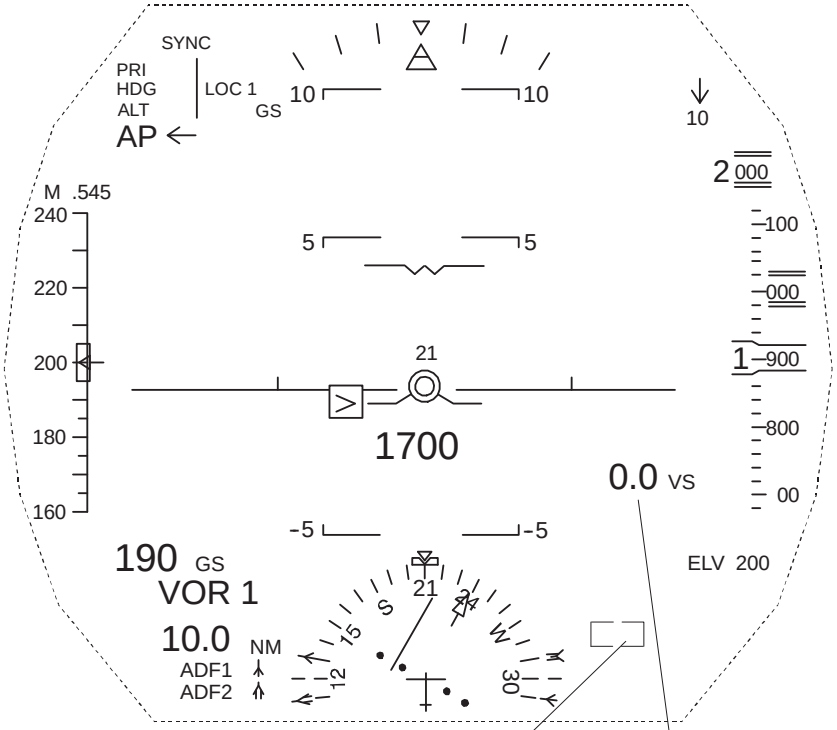
Altitude Failure Flag 

An altitude failure is indicated by the above failure flag and all altitude information is removed from the display. A miscompare between the altitude sources is indicated by the same failure flag but altitude data is retained. The flag flashes for 5 seconds when the miscompare is first detected and thereafter remains displayed until the condition is corrected.

Primary Mode – Barometric Altitude Indications
Figure 12–70–21 Sheet 2



Primary Mode – Radio Altitude Indications
Figure 12–70–22



Vertical Speed Failure Flag

V/S

Indicates loss of vertical speed data from pilot's IRS.

Flag appears in place of vertical speed readout.

Vertical Speed Readout

Indicates current vertical speed in feet per minute (fpm). Range is from –15,000 fpm to +15,000 fpm.

- Displayed in increments of 100 fpm when the vertical speed is less than 10,000 fpm (e.g. 2,500 fpm is displayed as 2.5).
- Displayed in increments of 1,000 fpm when the vertical speed is equal to or greater than 10,000 fpm (e.g. 10,000 fpm is displayed as 10).

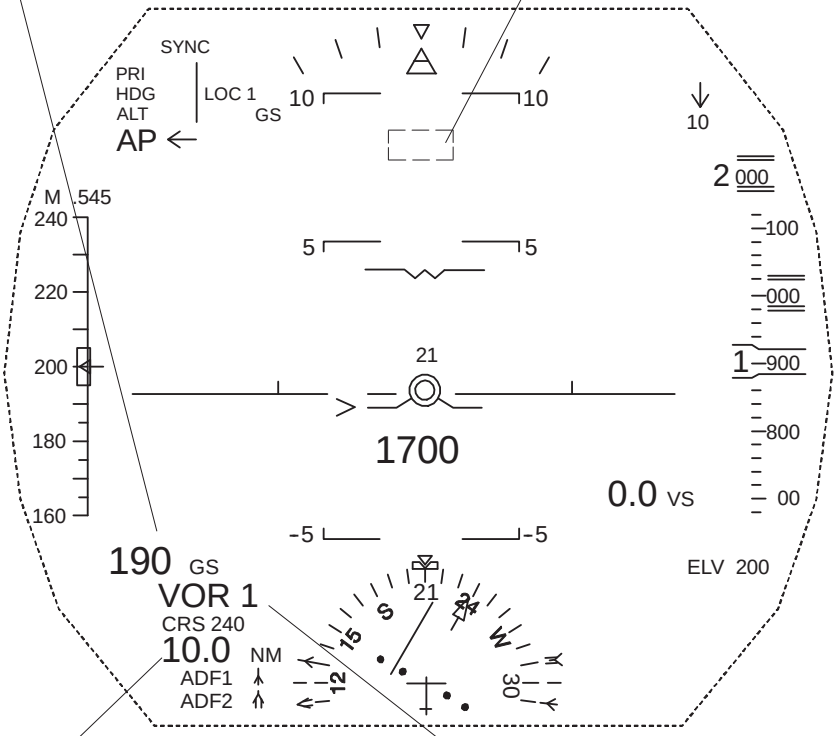
Primary Mode – Vertical Speed Indications
Figure 12–70–23

Ground Speed Readout
Airplane's ground speed displayed in 1–knot increments during flight.

- Dashes (––– GS) replace readout if ground speed data is invalid;
- If ground speed information is lost (loss of signal), readout is removed.

Marker Beacon Flags
Indicates airplane passage over the applicable marker beacon transmitter.

- IM – Inner marker
- MM – Middle marker
- OM – Outer marker



DME Distance Readout

Indicates DME distance (slant range) to tuned navigation aid:

- From 0 to 99.9 nautical miles (nm), displayed in 0.1–nm increments;
- Above 100 nm, displayed in 1.0–nm increments;
- Dashes (––– NM) replace readout if DME data is invalid;
- If DME information is lost (loss of signal), readout is removed.

DME Hold (H) Symbol

(Example: 10.0 H)

When DME hold is selected, 'H' replaces 'NM' characters on DME distance readout.

Navigation Source Indicator
Indicates navigation source as set at NAV SOURCE knob on display control panel.

The selected navigation source is displayed using the characters:

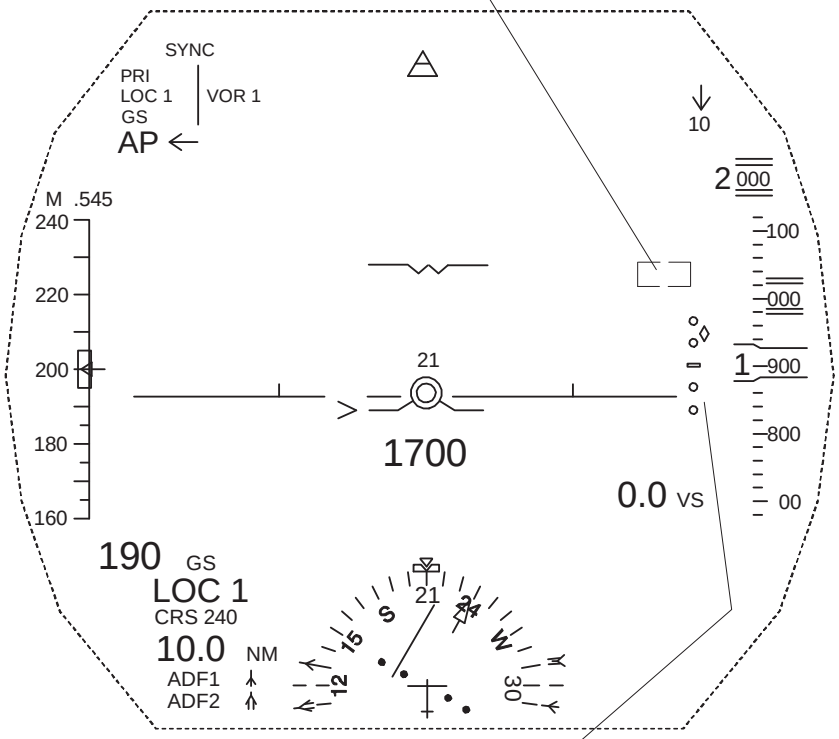
- VOR 1 or VOR 2,
- LOC 1 or LOC 2.
  (1 is on–side; 2 is off–side)

An FMS navigation source is not annunciated.

Primary Mode – Navigation/Position Indications
Figure 12–70–24 Sheet 1

Glideslope Failure Flag GS

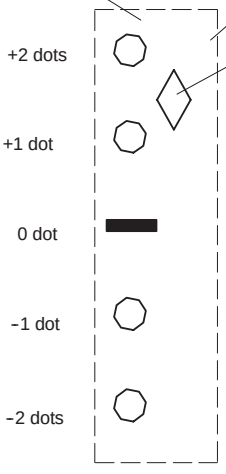
A glideslope failure is indicated by the above failure flag and all glideslope information is removed from the display. A miscompare between the glideslope deviation sources is indicated by the same failure flag but glideslope data is retained. The flag flashes for 5 seconds when the miscompare is first detected and thereafter remains displayed until the condition is corrected.



Glideslope Scale

Indicates the airplane's vertical deviation relative to the ILS glideslope beam. Displayed in the following conditions:

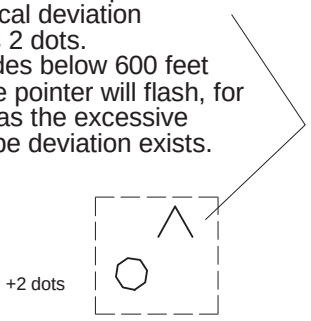
- Navigatioin source is LOC;
- Armed or captured vertical AFCS mode is GS;
- Altitude is above 50 feet AGL.



Glideslope Index

Vertical deviation pointer which retains its full diamond shape when travelling within the scale.

- The pointer changes to a half–diamond shape when the vertical deviation exceeds 2 dots.
- At altitudes below 600 feet AGL, the pointer will flash, for as long as the excessive glideslope deviation exists.



Primary Mode – Navigation/Position Indications
Figure 12–70–24 Sheet 2

Lateral Deviation Line (In Flight)

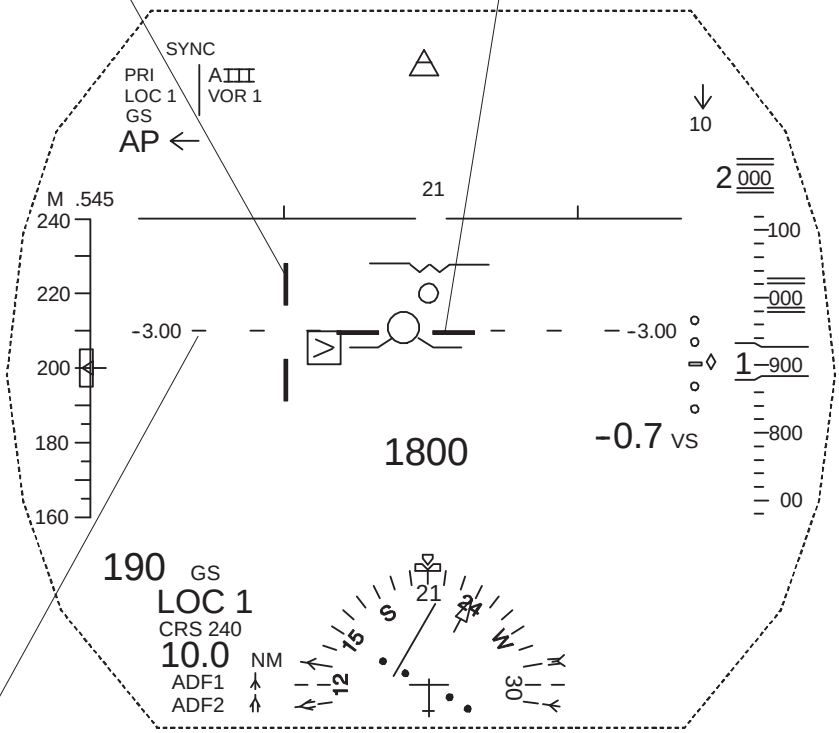
Provides an accurate indication of the airplane's lateral deviation from the selected course.
Airplane is on track when the lateral deviation line is aligned with the selected course mark (on the horizon line).

- Displayed during HGS approach and F/D modes.

Glideslope Line

Provides an accurate indication of the airplane's glideslope deviation.
Glideslope deviation is 0 when the glideslope line is aligned with the glideslope reference line.
Display criteria are:

- Displayed during approach and landing (AI, AII, AIII and F/D modes);
- Removed from the display 70 feet AGL.



Glideslope Reference Line

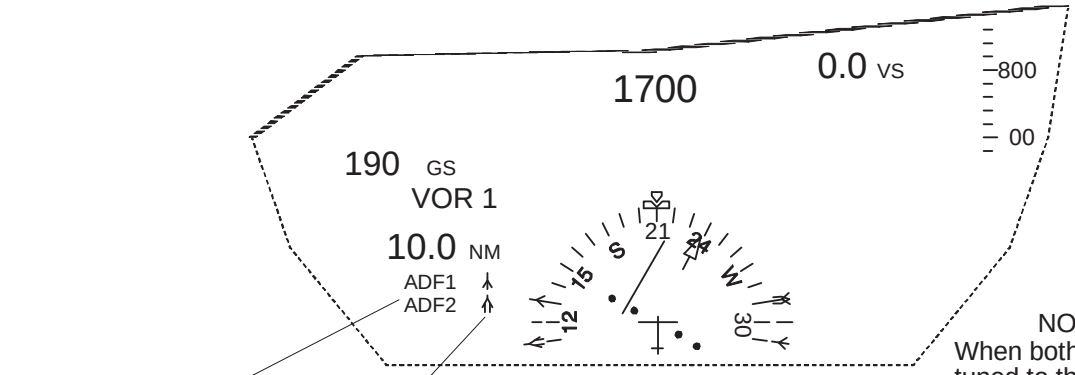
Provides a visual reference of the desired glide path to be flown, as entered through the HGS control panel (HCP).
The glideslope reference line also represents 0 glideslope deviation when it overlays the glideslope line.
Display criteria are:

- Always displayed during approach and landing, at any mode, except Rollout;
- In flight, other than during the approach and landing modes, the reference line is displayed for five seconds whenever the selected glideslope value is changed through the HCP.

Glideslope Readout

Digital indication of the selected reference glideslope value.
Displayed in conjunction with the glideslope reference line.

Primary Mode – Navigation/Position Indications
Figure 12–70–24 Sheet 3



NOTE
When both ADFs are tuned to the same station, the tails of the bearing pointers tend to appear merged.

Bearing Source Indicators
Indicates navigation source selected to obtain bearings.

Bearing Pointers

#1 – Pilot's side

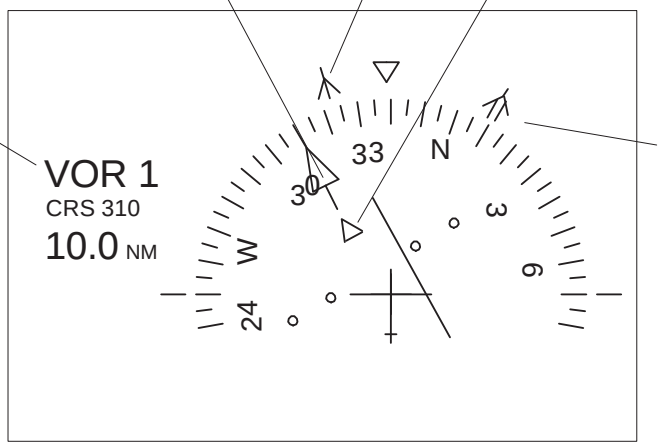
#2 – Copilot's side

#1 Bearing Pointer

To/From Indicator
- To–points to head side of selected course bug
- From–points to tail side of selected course bug.

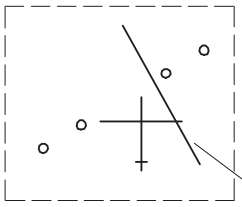
Selected Course Bug

Navigation Source Indicator



#2 Bearing Pointer

Course Deviation Scale



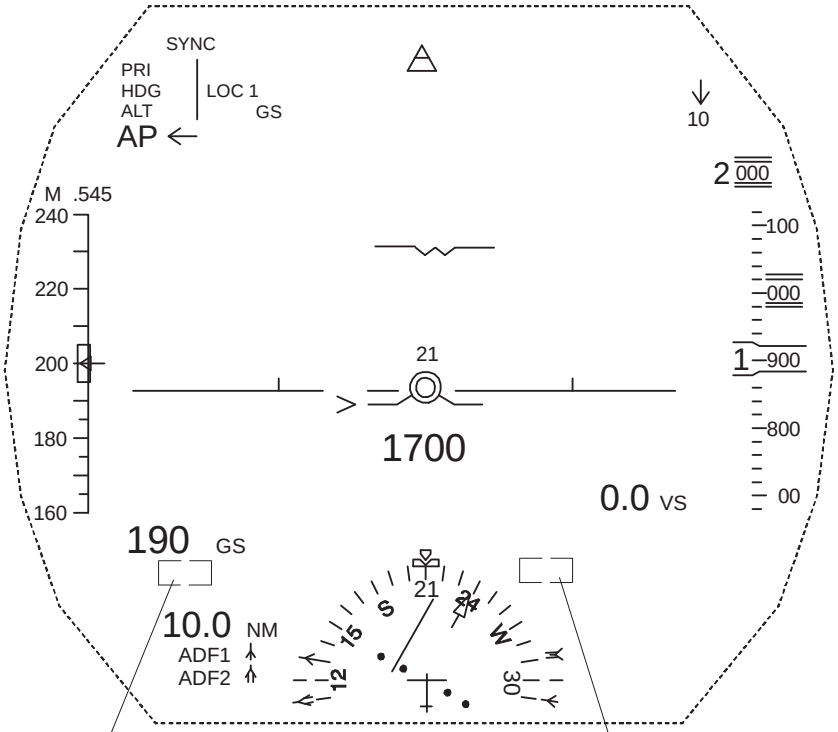
VOR mode:
- 1st dot is 5°
- 2nd dot is 10°.

LOC mode (depending upon runway length):
- 1st dot is 1°
- 2nd dot is 2°.

Lateral Deviation Bar
(Course Deviation Indicator)
Indicates left or right deviation from VOR or LOC beam.
- The CDI is limited to the edge of the course deviation scale in view. When the lateral deviation is outside of the field of view, the CDI is ghosted (drawn with dashed lines).

Primary Mode – Navigation/Position Indications
Figure 12–70–24 Sheet 4

NOTE
The HGS does not display a back course annunciation.



Navigation Source Failure Flags

LOC 1 LOC 2

VOR 1 VOR 2

A loss of valid information from the selected navigation source will cause the corresponding navigation data to be removed and the displayed navigation source indicator is boxed, as shown above.

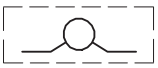
Localizer Failure FLag

LOC

A loss of valid localizer information from the selected navigation source will cause the CDI to be removed and a failure flag, as shown above is displayed.
A miscompare between the two sources of localizer deviaiton is indicated by the same failure flag but the CDI is retained. The flag flashes for 5 seconds when the miscompare is first detected and thereafter remains displayed until the condition is corrected.

Primary Mode – Navigation/Position Indications
Figure 12–70–24 Sheet 5

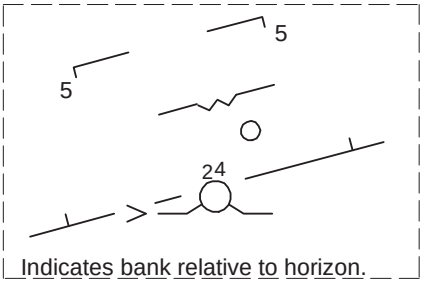
Flight Path Symbol



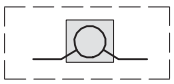
Centre of symbol indicates actual airplane flight path (lateral and vertical).
The flight path symbol is limited laterally and vertically so as not to overlay the indications at the edges of the display (i.e. airspeed and altitude scales).
The flight path symbol has a masking window which obscures most other symbols it overlays except:

- Guidance cue;
- Runway lines;
- Approach status message;
- TCAS box; and
- Windshear message.

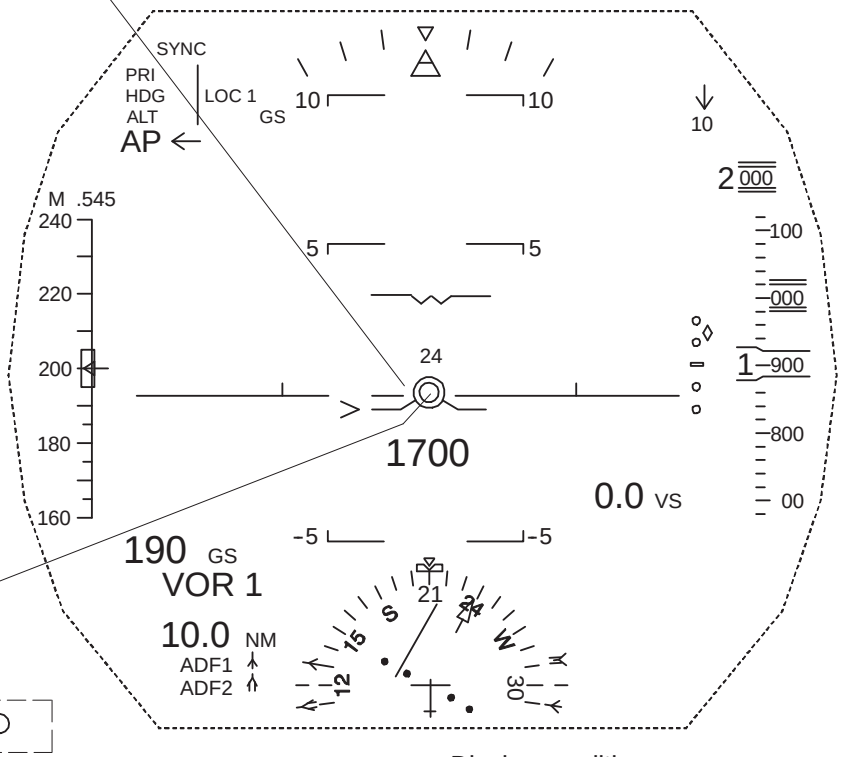
The flight path symbol is removed when an off-side attitude or heading source is selected.



Indicates bank relative to horizon.



– Masking window



Guidance Cue

Provides lateral and vertical attitude guidance with command inputs from either the flight director (F/D) or the HGS computer.

- Echos F/D commands during Primary (Flight) mode or F/D approach and landing mode.
- Displays HGS commands during Category I, II or III approach and landing modes.

To track F/D or HGS commands, overlay the flight path symbol on the guidance cue, using normal pitch, roll and yaw control inputs.

Display conditions:

- During an approach, the F/D guidance cue is removed at 80 feet AGL unless:
- a windshear condition exists; or
- during take-off or go-around, when the TO or GA mode is engaged.
- During an AI or an AII approach, the HGS guidance cue is removed at 80 feet AGL.
- During an AIII approach, the HGS guidance cue is removed at touchdown.

Primary Mode – Flight Path Indications
Figure 12–70–25 Sheet 1

Flare Cue

(Double cross symbol)

Provides an indication of when the flare maneuver should be initiated, but not how to perform the flare maneuver.

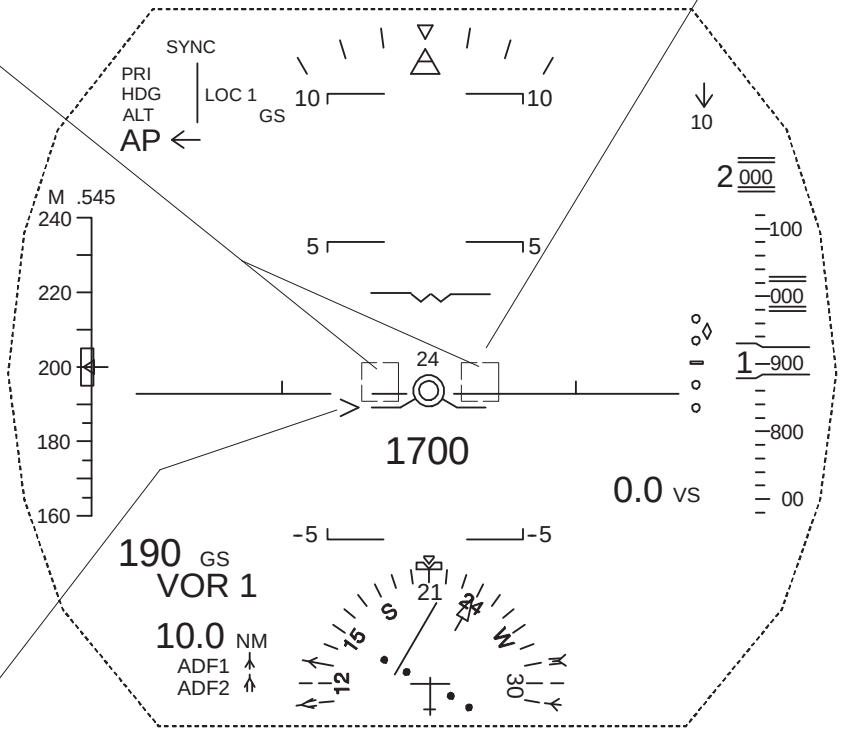
Display criteria:

- Displayed in flight during Primary (Flight) mode and F/D, VMC, AI and AII approach and landing modes.
- Comes on at 60 feet AGL, and flashes until 30 feet AGL.

Flare Command

(Single cross symbol)

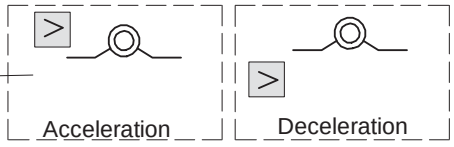
Displayed only during a Category III approach. Provides guidance on how to perform the correct flare maneuver.

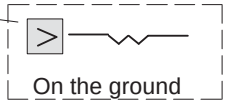


Flight Path Acceleration Symbol

Displays the inertial acceleration of the airplane along the flight path.

- If displayed above the flight path symbol, the airplane is accelerating. If displayed below the flight path symbol, the airplane is decelerating.
- On the ground, the flight path acceleration symbol is displayed off the left wing of the boresight symbol.
- During windshear conditions, below 400 feet AGL, the flight path acceleration symbol is removed.
- The symbol has a masking window which obscures most other symbols that it overlays except the guidance cue, runway lines, approach status message, TCAS box and windshear messsage.





- Masking window

Primary Mode – Flight Path Indications
Figure 12–70–25 Sheet 2

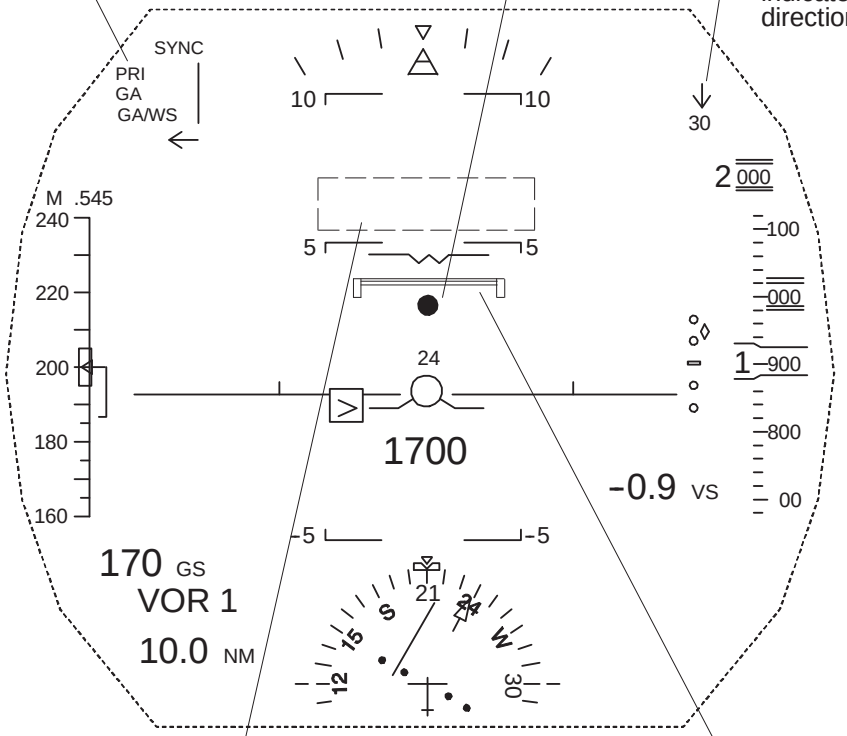
NOTE
If the HGS is operating during a windshear, the HGS primary mode (PRI) will automatically pop–up to provide guidance.

F/D Guidance Cue (Windshear)

The F/D guidance cue becomes solid and flashes for 3 seconds, then remains solid for as long as windshear escape guidance (TO/WS or GA/WS mode) is active.

Wind Speed and Direction

Displayed only in flight and when wind speed is more than 3 knots. Digital readout indicates wind speed from 0 to 256 knots at 1–knot increments. Wind vector (arrow) indicates relative direction.



Windshear Warning Message

WINDSHEAR

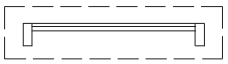
The windshear warning message is driven by the airplane's GPWS. The message flashes initially for 3 seconds, then comes on steady to indicate that a severe decreasing performance windshear condition has been encountered.

Windshear Caution Message

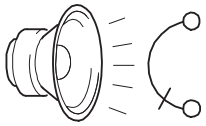
WINDSHEAR CAUTION

The windshear caution message is driven by the airplane's GPWS. The message indicates that an increasing performance windshear condition has been encountered.

Pitch Limit Marker (alpha–margin indicator)



- Displayed during a windshear warning or caution, when below 1,500 feet radio altitude, and / or when airplane is 25 from stick shaker point.
- Displays amount of pitch attitude change that can be made before airplane reaches stick shaker angle–of–attack.

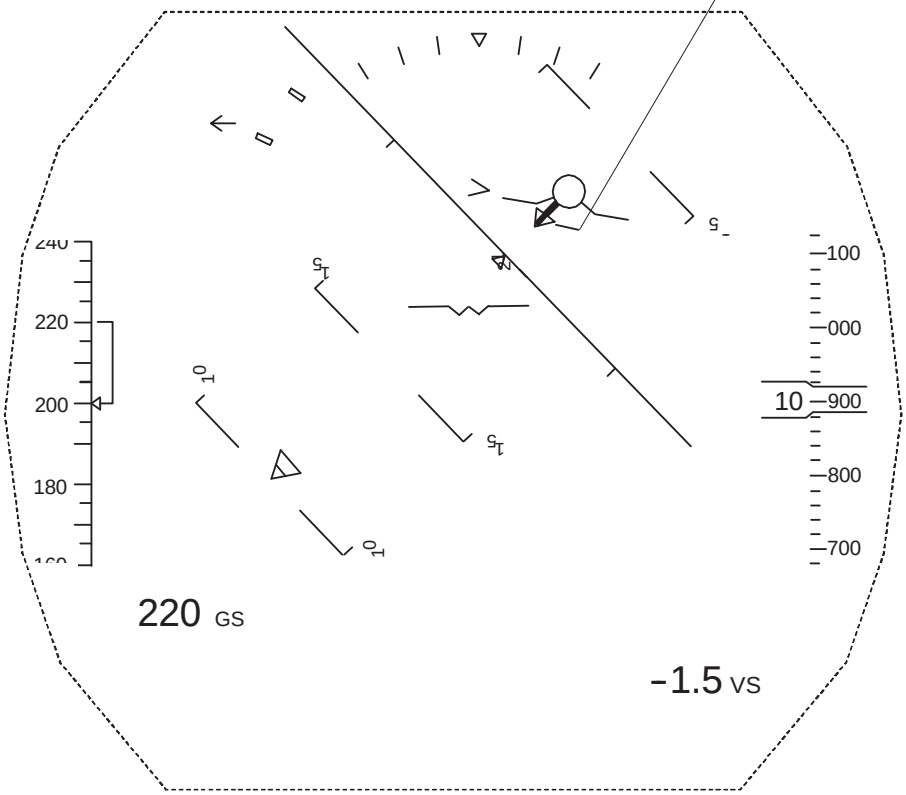


(siren)
"WINDSHEAR"
"WINDSHEAR"
"WINDSHEAR"

Primary Mode – Environmental Indications
Figure 12–70–26

Unusual Attitude Up Arrow

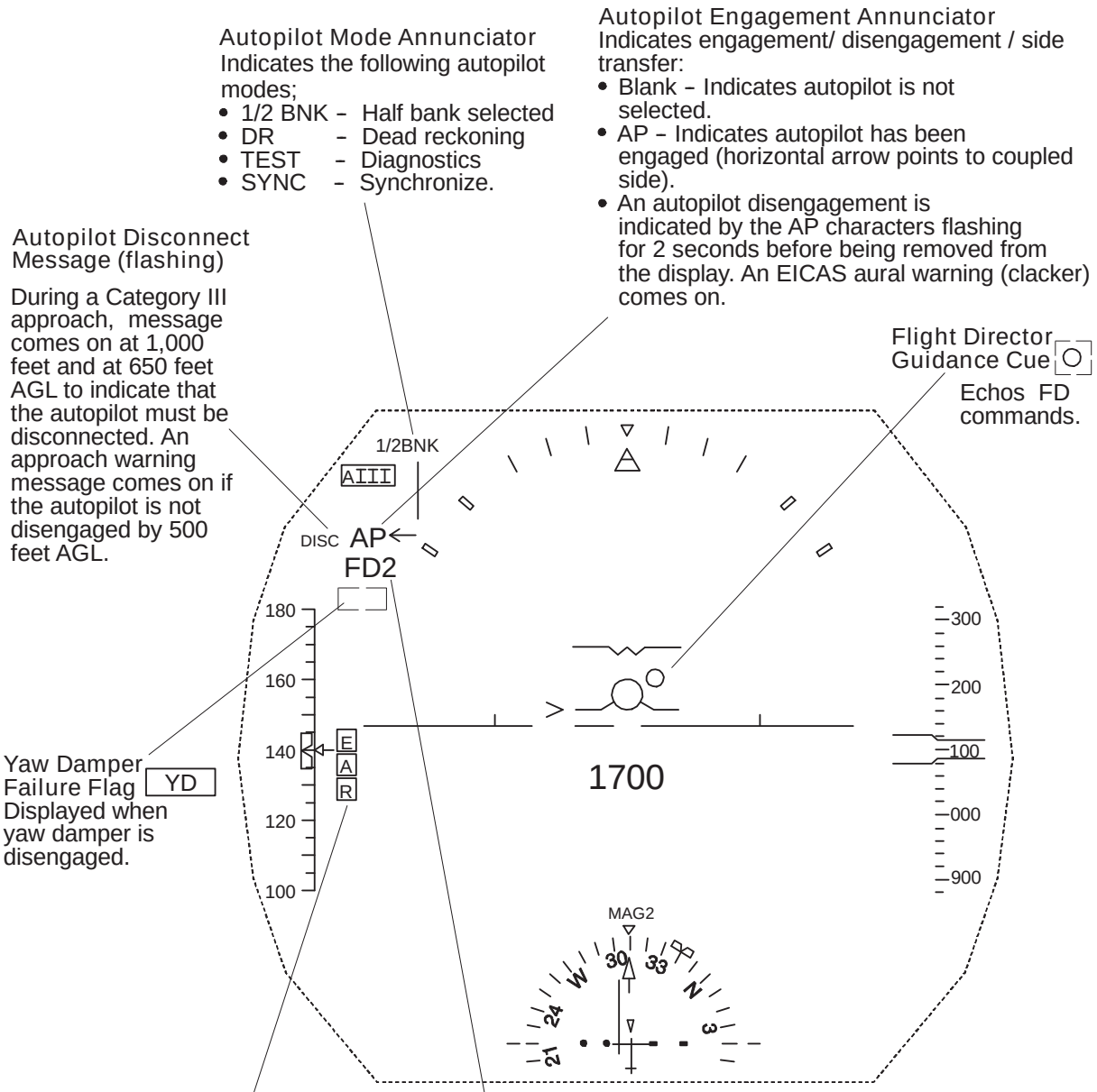
This symbol provides an indication of which way is up during unusual attitudes.The symbol is centered on the Flight Path symbol that points towards the Roll Pointer.



Note

The unusual attitude up arrow comes on and asssociated display declutter when:
Pitch = +30° / -20°, and/or
Roll = 65°

Unusual Attitude Display
Figure 12–70–27



Primary Mode – Autopilot/Flight Director
Figure 12–70–28

J. System Circuit Breakers

SYSTEM	SUB-SYSTEM	CB NAME	BUS BAR	CB PANEL	CB LOCATION	NOTES
Head-up Guidance System		HGS	AC ESS	3	C4	
			DC ESS	4	C5	

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