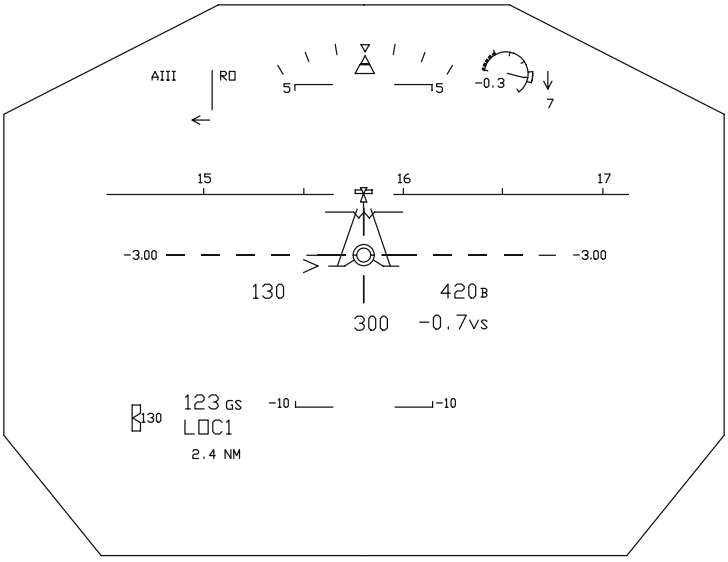
Head-Up
Guidance System

Rockwell Collins
Flight Dynamics

HGS® Pilot Guide
for the Bombardier CRJ 700



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Revision A

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Section 1:
Introduction

This Pilot Guide presents data related to Flight Dynamics' Head-Up Guidance System (HGS®) installed in the Bombardier Model CL600-2C10 (CRJ 700) aircraft. This guide describes the HGS and modes of operation, explains the symbology, and demonstrates HGS use in a typical flight profile.

The HGS is an electronic and optical system that displays information in the left-side pilot's forward field of view. The HGS focuses the display at optical infinity and presents flight and navigational data conformal to the real world. The system is certified for all phases of flight and has met the requirements for low-visibility takeoff and manual Category III approach, landing, and rollout.

The HGS optimizes symbology for full-flight regime use and includes the application of inertial flight path and flight path acceleration. HGS guidance is used for CAT I, II and III operations, low-visibility takeoff, and rollout (if enabled). FCS (Flight Control System) flight guidance is used for the PRI and F/D modes. HGS systems integration and unique symbology allow for extremely precise aircraft control while enhancing situational awareness and energy management.

NOTE: Conduct HGS operations in accordance with the Airplane Flight Manual (AFM) HGS supplement. If a conflict exists between the AFM and this Pilot Guide, use the AFM.

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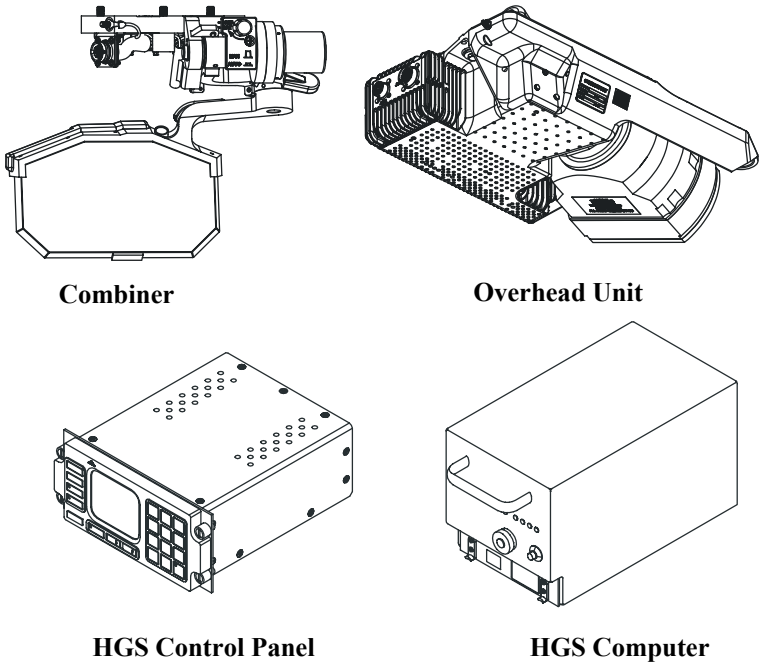
Section 2:
HGS Description

Overview

The Model 4200 HGS is a high-integrity, wide field of view head-up display (HUD) system designed for full-flight operations that include low-visibility takeoffs, landings, and rollout in the Bombardier CRJ-700 aircraft.

The HGS consists of four line-replaceable units (LRUs) (Figure 2-1):



Combiner **Overhead Unit**

HGS Control Panel **HGS Computer**

Figure 2-1:
HGS LRUs

The HGS uses aircraft sensors and systems to get the data and power for its operations. These data and power systems are identified in Appendix A.

The sections that follow give data about the location, purpose, and functionality of each of the four HGS LRUs:

- HGS Combiner
- HGS Control Panel (HCP)
- HGS Computer (HC)
- HGS Overhead Unit (OHU).

HGS Combiner

The Combiner assembly has mechanical components to hold and support the Combiner glass in three different positions. Electrical components also monitor the position of the glass and control the intensity of the display.

These subsections give more data about the HGS Combiner:

- Combiner Location
- Combiner Function
- Combiner Display Brightness
- Combiner Positions
- Combiner Alignment Detector.

Combiner Location

The Combiner is attached to the left-forward windscreen upper sill beam structure (Figure 2-2) between the left-side pilot and the forward windscreen. This position allows a normally-seated left-side pilot to see the HGS symbology projected by the OHU onto the Combiner glass.

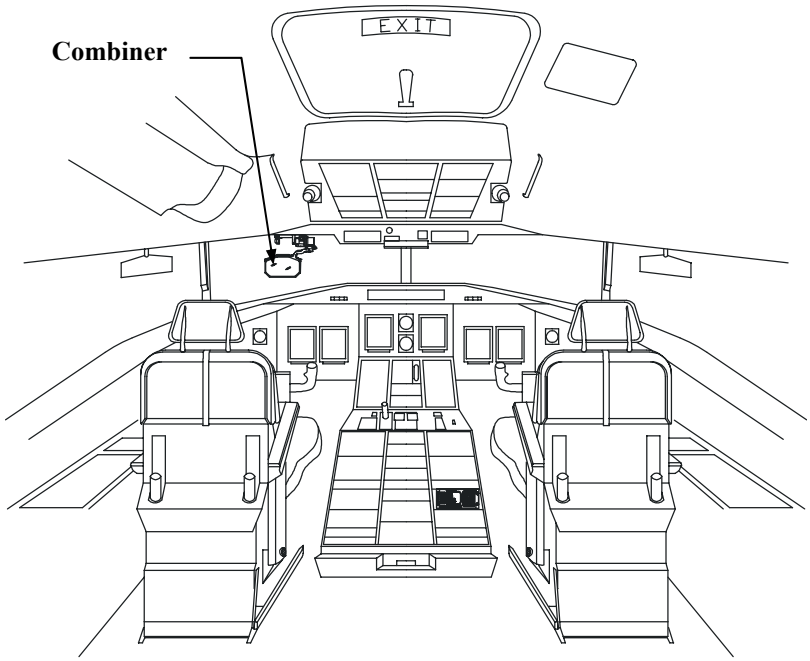


Figure 2-2:
HGS Combiner Location

Combiner Function

The Combiner reflects the CRT color while it lets all other colors pass through the glass. The Combiner optically combines flight symbology (of the reflected color) with the left-side pilot's view through the windscreen. The wide field-of-view Combiner (24° vertical by 30° horizontal) positions and focuses the projected image to superimpose the symbology on the left-side pilot's view of the real world.

Combiner Display Brightness

The Combiner display brightness control (HUD BRT) knob is located on the upper right side of the Combiner (Figure 2-3). Turn the HUD BRT knob to adjust the intensity.

- Rotate the knob clockwise to increase the display intensity.
- Rotate the knob counter-clockwise to decrease the display intensity.

Push the knob in to select the automatic (AUTO) brightness mode. Pull the knob out to select the manual (MAN) brightness mode.

The light plate is energized from the "MISC OVERHEAD LIGHTS" dimmer control.

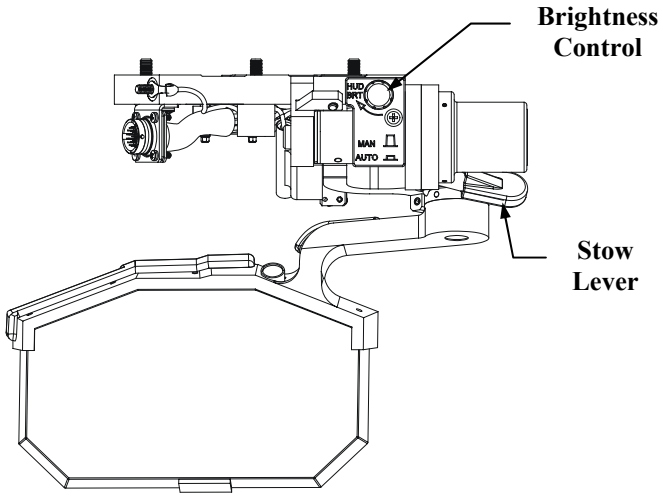


Figure 2-3:
HGS Combiner

Auto Mode: In AUTO mode, the intensity of the display changes automatically to maintain the contrast ratio set by the pilot. This gives a constant contrast ratio relative to the light conditions, so the display is visible without manual adjustment as the aircraft travels through different light conditions. The range is from nearly off to the maximum contrast ratio for the ambient light level.

Manual Mode: In MAN mode, the display intensity level does not change after it is set. Thus, when the aircraft travels through different light conditions, it is possible for the display to "disappear." In manual mode, display intensity can be any setting within the adjustable range—from no visible display to maximum available intensity.

Combiner Sun Visor

The Combiner has a sun visor to use in bright light. The sun visor is easily attached to and removed from the Combiner with Velcro®. When it is not in use, keep the sun visor in a holder under the windscreen glare shield.

Combiner Positions

CAUTION: DO NOT USE FORCE TO MOVE THE COMBINER GLASS OUT OF THE STOW, NORMAL, OR BREAKAWAY POSITIONS.

Stow Position: the position of the Combiner glass when not in use. To stow the Combiner glass from the normal position, push the stow lever (Figure 2-3) and hold the Combiner glass by the edges. Rotate the Combiner glass up and aft from the normal position to the stow position. When the Combiner glass is stowed, a lock holds it tightly in place.

Normal Position: the position of the Combiner glass while in use. To move the Combiner glass from the stow to the normal position, push the stow lever and hold the Combiner glass by the edges. Lower the Combiner arm until the Combiner glass is in the normal position detent. When the Combiner glass moves into the normal position , the OHU projects symbology onto the Combiner glass (after a warm-up period).

Breakaway Position: The Combiner can also breakaway forward from its normal position. This feature allows the Combiner to rotate horizontally forward and inboard during a sudden deceleration of the aircraft. The Combiner is designed to stay in place if it rotates to its maximum breakaway travel.

Combiner Alignment Detector

The Combiner also contains an infra-red optical sensing system to precisely monitor the normal position of the Combiner glass relative to the fixed part of the Combiner structure (Figure 2-4). The Combiner Alignment Detector (CAD) signals the OHU and HC if the Combiner is not within alignment tolerances when in the normal position. Combiner alignment is critical during visual operations (VMC mode) to make sure the HGS is symbology is conformal with the real-world scene.

An out-of-tolerance condition causes "ALIGN HUD" to show on the Combiner display. If "ALIGN HUD" shows, gently adjust the Combiner glass to remove the message.

NOTE: If the "ALIGN HUD" message cannot be removed, do not use the HGS.

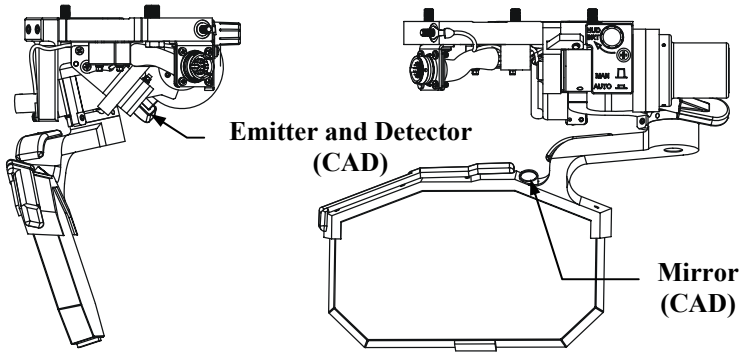


Figure 2-4:
Combiner Alignment Detector

HGS Control Panel

The HGS Control Panel (HCP) is located in the aft right side of the center pedestal and is available to both pilots (Figure 2-5).

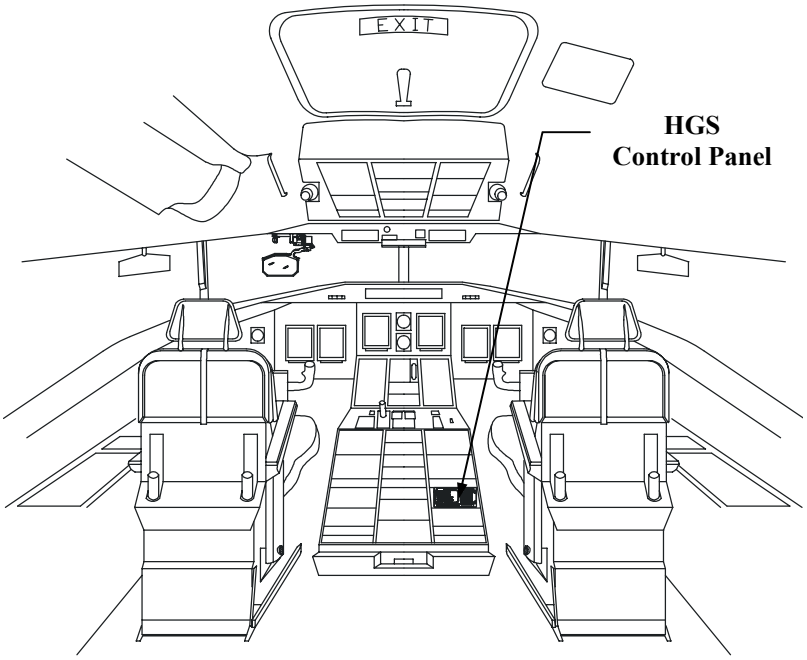


Figure 2-5:
HGS Control Panel Location

The HCP allows the flight crew to select HGS modes and enter required data. This data includes the glideslope angle, runway length and runway elevation. The HCP also displays selected modes, numbers entered, system test, and status data.

The HCP (Figure 2-6) contains mode, function, and data-entry pushbuttons, along with a display field. Four pushbuttons (RWY, G/S, CLR, and TEST) contain lights to show when they are active.

The CLR, BRT+, DIM-, pushbuttons, and numeric keypad allow operators to enter data. A FAULT light in the lower left corner of the HCP comes on when an HGS BIT (Built In Test) detected fault occurs.

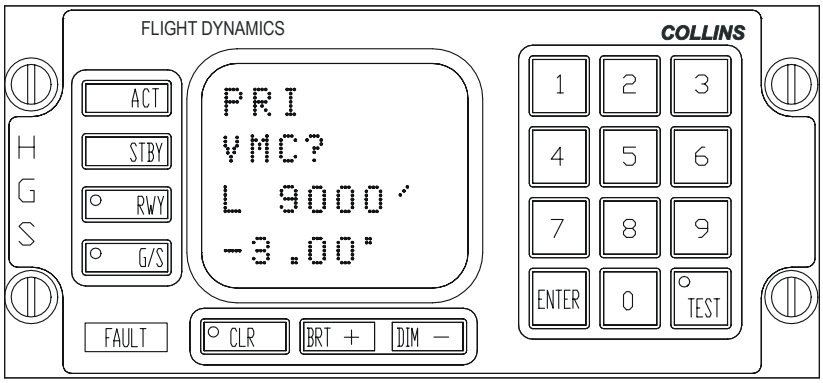


Figure 2-6:
HGS Control Panel (HCP)

The six primary HCP pushbuttons, and their associated displays, are:

ACT: Push the ACT pushbutton to move "PRI" from the STBY (standby) line to the ACT (active) line and make PRI the active mode.

STBY: Push the STBY pushbutton to change the mode on the STBY line. This change occurs only when "PRI" is on the ACT line.

NOTE: For more information related to ACT and STBY operations, see "HGS Modes of Operation" (Section 3).

RWY: Push the RWY pushbutton to enter a new Runway Length or Runway Touchdown Zone Elevation (TDZE). Typically, this is the data printed on instrument approach plate or other airport documentation. The RWY pushbutton data entry functions are covered in "Data-Entry Functions" later in this chapter.

G/S: Push the G/S pushbutton to enter a new glideslope angle for the landing runway (usually the glideslope angle that appears on instrument approach plates and other approach documentation, or the desired glide path angle for a visual approach). The G/S pushbutton data entry functions are covered in "Data-Entry Functions" later in this chapter.

ENTER: Push the ENTER pushbutton to arm the mode on the STBY line. Also, push to accept entries for runway length, runway elevation, and reference glideslope angle as covered in "Data-Entry Functions" later in this chapter.

TEST: Push the TEST pushbutton to enter the maintenance test mode. The TEST pushbutton light comes on and the ACT line shows TEST.

Three pushbuttons that control the HCP display are:

CLR: Push the CLR pushbutton to remove all symbology from the Combiner. When the CLR is pushed, the pushbutton light comes on, and the ACT display line shows "CLR." All other HGS functions continue normally.

The Combiner display returns when:

- The EGPWS senses a windshear condition
- The HGS senses an unusual attitude
- The go-around pushbutton is pushed
- The CLR pushbutton is pushed a second time
- The TEST pushbutton is pushed (on ground only).

NOTE: During data entry and TEST operations, the CLR pushbutton functions as a backspace pushbutton.

BRT+: Push the BRT+ pushbutton to increase the HCP's display brightness.

DIM–: Push the DIM– pushbutton to decrease the HCP's display brightness.

NOTE: When the RWY and G/S data entry functions are in use, or when the TEST mode is in use, the BRT+ and DIM– pushbuttons have different functions.

Data-Entry Functions

Use the data-entry functions to set the runway length, runway elevation, and a reference glideslope angle.

Runway Length Data Entry

For HGS-guided takeoffs and AIII approaches with rollout (if enabled), set the runway length, which can be in feet or meters (if enabled).

Follow these steps to set a new runway length. Figure 2-7 shows an example.

1. Push and release the RWY pushbutton until the RWY line shows an "L", followed by a solid arrow that points to the right, and the last accepted length. The RWY pushbutton light comes on.
2. Use the HCP keypad to enter the new runway length. The last accepted length is then replaced with the new length and a flashing cursor ("_"). Use the numeric keypad to put in the first number of the new runway length. Continue to use the keypad until the new runway length shows on the RWY line. If five digits are put in, the system removes the cursor and ignores further keypad entries. If an error is made, push the CLR pushbutton as a backspace. Each push of the CLR pushbutton erases the last digit.

NOTE: The HGS accepts only runway lengths from 5,000 to 13,500 feet (or 1,524 to 4,115 meters). If the runway length is longer than the upper limit, then "L 13500?" (or "L 4115?") on the RWY line flashes. If the runway length is less than the lower limit, then "L 5000?" (or "L 1524?") on the RWY line flashes.

3. After the RWY line shows the correct number, push the ENTER pushbutton. The RWY line shows the new length with a prime (" ′ ") for feet, or "m" for meters. The RWY pushbutton light goes off.

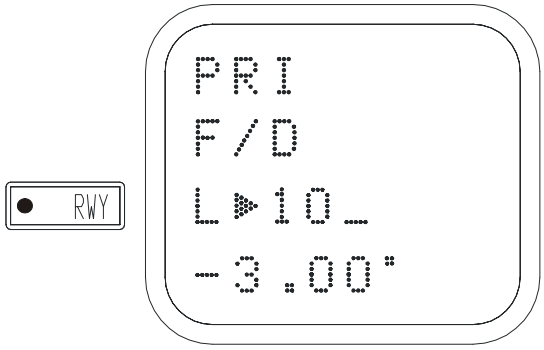


Figure 2-7:
Runway Length Data Entry (example)

Automatic Operations of Runway Length: The automatic operation for runway length data entry is:

- If the ENTER pushbutton is not pushed after a new runway length is entered, the new number is not accepted. If the STBY, RWY, G/S, or ACT pushbutton is pushed before the ENTER pushbutton is pushed, the runway length goes back to the number and status that were set when data entry started.
- After a power interruption or HC reset in flight, the runway length goes back to the last number and status set.
- After a power interruption or HC reset on the ground, the runway length becomes invalid (RWY line shows a "?").
- If the TEST pushbutton is pushed on the ground, the runway length becomes invalid (RWY line shows a "?").
- After a takeoff, when the aircraft climbs through 5000 feet above ground level (AGL), the runway length becomes invalid (RWY line shows a "?"). The runway length for the next runway should be set.
- When the aircraft lands and the airspeed is less than 20 knots, the runway length becomes invalid (RWY line shows a "?").

Runway Elevation Data Entry

Before HGS landings, set the runway elevation. Runway elevation is always in feet.

Follow these steps to set a new runway elevation. Figure 2-8 shows an example.

1. Push and release the RWY pushbutton until the RWY line shows an "E" that is followed by a space, a solid arrow that points to the right, and the last accepted elevation. The RWY pushbutton light comes on.
2. If the TDZE is below sea level, push the DIM- pushbutton. The last accepted elevation is replaced with a minus sign ("-") and a flashing cursor ("_") to its right.
3. If the Touchdown Zone Elevation (TDZE) is above sea level, use the numeric keypad to put in the first number of the new runway elevation. The last accepted elevation is then replaced with the new number and a flashing cursor ("_") to its right.
4. Use the numeric keypad to enter the new runway elevation number. If five digits are put in, the system removes the cursor and ignores further keypad entries. If an error is made, push the CLR pushbutton as a backspace. Each push of the CLR pushbutton erases the last digit.
5. After the correct number shows on the RWY line, push the ENTER pushbutton to accept the TDZE. This step removes the arrow and cursor and adds a prime (" ′ ") after the number to show the runway elevation in feet. The RWY pushbutton light goes off.

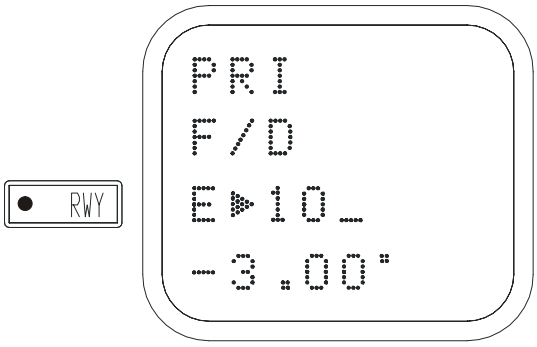


Figure 2-8:
Runway Elevation Data Entry (example)

Automatic Operations of Runway Elevation: The automatic operation for runway elevation data entry is:

- If the ENTER pushbutton is not pushed after a new runway elevation is entered, the new number is not accepted. If the STBY, RWY, G/S, or ACT pushbutton is pushed before the ENTER pushbutton is pushed, the runway elevation goes back to the number and status that were set when data entry started.
- After a power interruption or HC reset in flight, the runway elevation goes back to the last number and status set.
- After a power interruption or HC reset on the ground, the runway elevation becomes invalid (RWY line shows a "?").
- When the aircraft lands and the airspeed is less than 20 knots, the runway elevation becomes invalid (RWY line shows a "?").

Reference Glideslope Angle Data Entry

Set the reference glideslope angle to use the HGS for approach and landing.

The reference glideslope angle data entry limits are 0.00 to –9.99°.

Follow these steps to set a new reference glideslope angle number. Figure 2-9 shows an example.

1. Push and release the G/S pushbutton. The G/S line shows a solid arrow that points to the right, a minus sign ("–"), and the last accepted reference glideslope angle. The G/S pushbutton light comes on.
2. Use the keypad to put in the reference glideslope angle. When the keypad is pushed, the last accepted reference glideslope angle is removed and replaced with the new number, a space, and a flashing cursor ("_"). If three digits are put in, the cursor is removed and any other keypad entries are ignored. If an error is made, push the CLR pushbutton as a backspace and erase the last number. Push the G/S pushbutton to erase the entire entry.
3. After the correct numbers show on the G/S line, push the ENTER pushbutton to accept the new reference glideslope angle. This step adds "°" for degrees after the number. The G/S pushbutton light goes off.

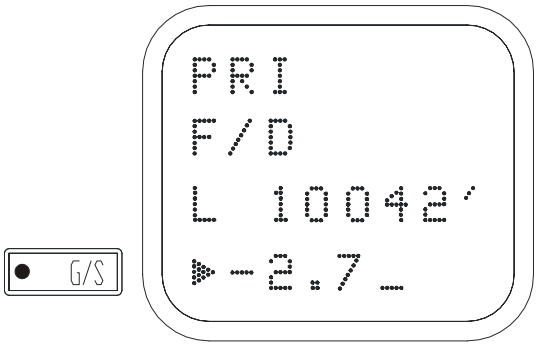


Figure 2-9:
Glideslope Data Entry (example)

Automatic Operations of Reference Glideslope Angle: The automatic operation for reference glideslope angle data entry is:

- If the ENTER pushbutton is not pushed after a new reference glideslope angle is entered, the new number is not accepted. If the STBY, RWY, G/S, or ACT pushbutton is pushed before the ENTER pushbutton is pushed, the reference glideslope angle goes back to the number and status that were set when data entry started.
- After a power interruption or HC reset in flight, the reference glideslope angle goes back to the last number and status set.
- After a power interruption or HC reset on the ground, reference glideslope angle becomes invalid (G/S line shows a "?").
- When the aircraft lands and the airspeed is less than 20 knots, the reference glideslope angle becomes invalid (G/S line shows a "?").

HCP Display Brightness

Use the HCP BRT+ and DIM- pushbuttons and the DSPL cockpit brightness control to set the intensity of the HCP to the intensity of the Radio Tuning Unit (RTU) and the FMS CDU displays:

1. Set the DSPL control at a point where the RTU and the FMS CDU first go off.
2. Push and hold the HCP BRT+ or DIM- pushbuttons to a point where the HCP display first goes off.
3. Use the cockpit DSPL control to adjust the intensity of the HCP, RTU and FMS CDU displays to a satisfactory level.

The backlighting of the HCP is set with the INTEG cockpit brightness control so that the backlighting of the HCP is the same as other cockpit panels.

HGS Computer (HC)

The Head-Up Guidance Computer (HC) (Figure 2-10) receives input signals from aircraft sensors and equipment and converts the data to symbology. The HC also evaluates system performance using extensive Approach Monitor, Built-in Test, and input validation processing. The HC is installed in the avionics bay below the cabin floor.

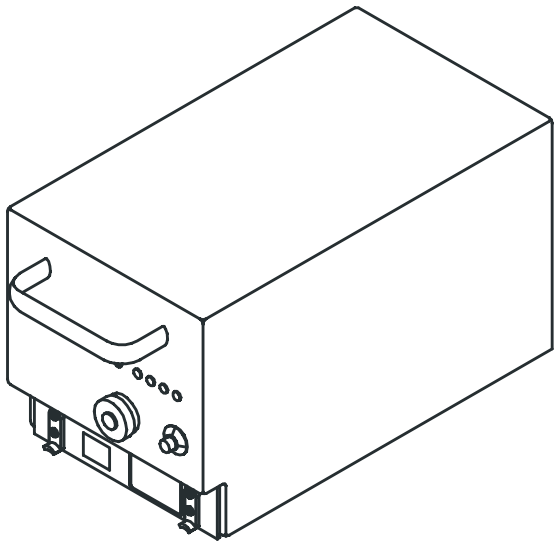


Figure 2-10:
HGS Computer

HGS Overhead Unit (OHU)

The Overhead Unit (OHU) is located above the left pilot's head (Figure 2-11) and positioned relative to the Combiner so that symbols such as the Glideslope Reference Line overlay the corresponding features of the outside world.

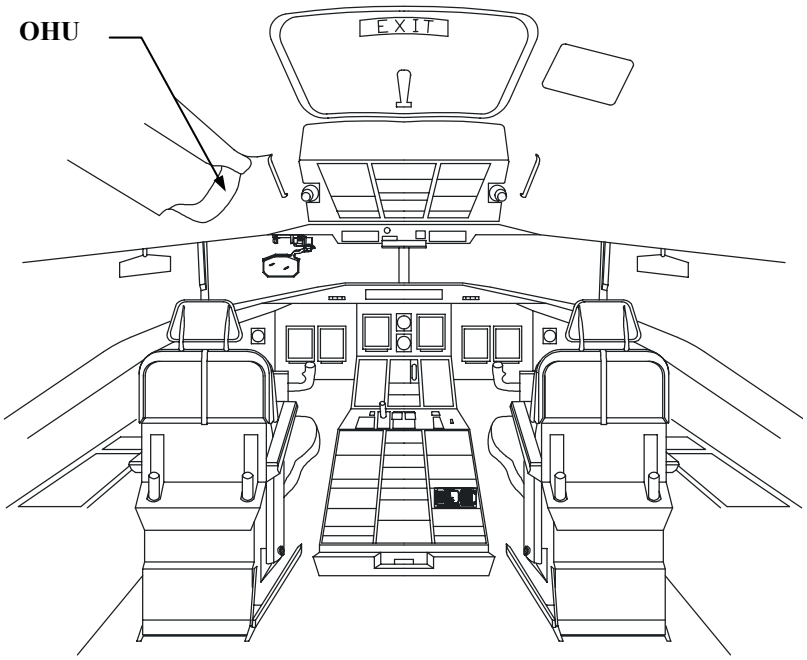


Figure 2-11:
OHU Location

The Overhead Unit (OHU) (Figure 2-12) contains CRT and projection optics to display symbolic images on the Combiner. The OHU also contains circuitry to control display intensity and monitor the Combiner's position.

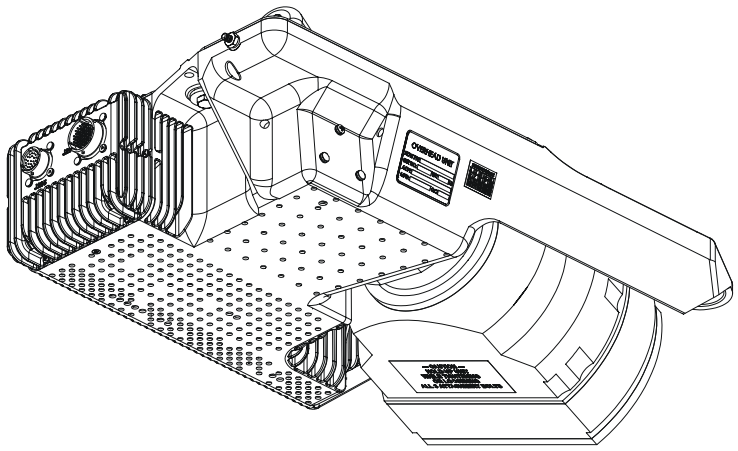


Figure 2-12:
Overhead Unit (OHU)

HGS Head-Down Data

The HGS head-down data is shown on the PFDs and the EICAS.

The PFD shows the active and armed HGS modes and the command field (Figure 2-13). When the flight crew selects an HGS mode, it flashes for 10 seconds and then is steady. If a mode becomes invalid, the message flashes for 10 seconds and is then removed. Refer to Table 2-1 for PFD message color indications. If the HGS fails, all PFD HGS data is removed and a red-boxed "HGS" flashes in the PFD HGS command field (Table 2-2) for ten seconds and then either is steady (if the decision height is less than 100 feet) or is removed (if the decision height is 100 feet or greater).

The EICAS also shows messages about data and conditions for the HGS. If the HGS senses an internal fault, "HGS FAIL" shows in white as a status message on the upper right part of the EICAS display.

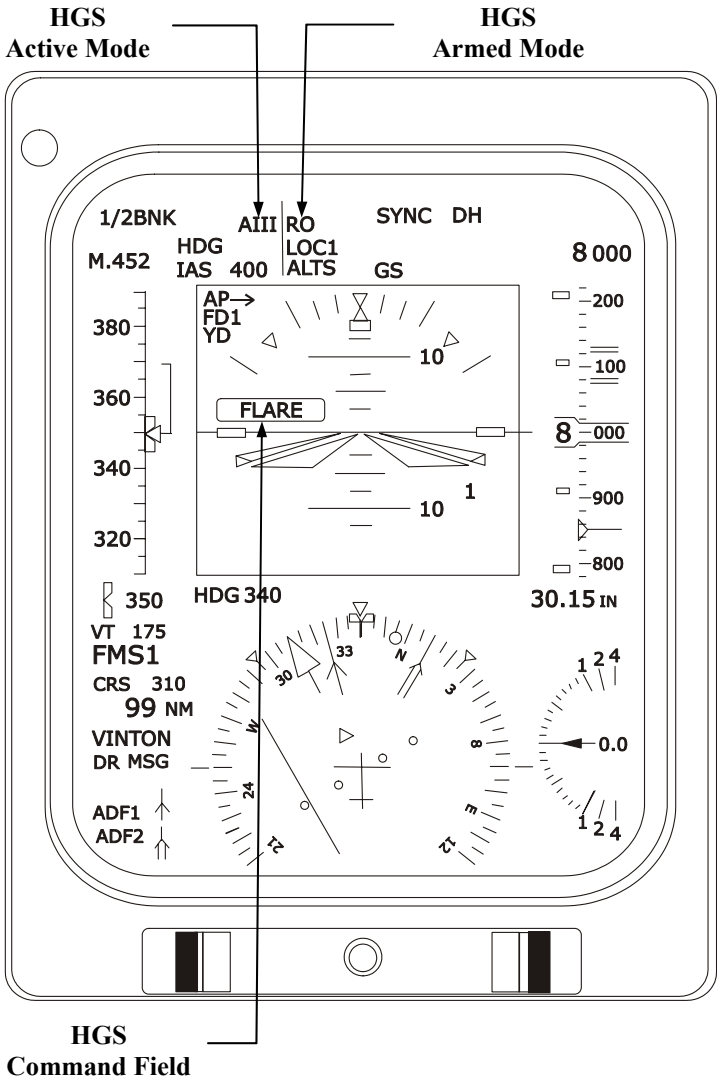


Figure 2-13:
PFD with HGS Data (example)

Table 2-1: HGS PFD Modes

HGS Mode	Color	Specifies:
AIII	Yellow	AIII Mode on STBY; AIII conditions not satisfied
AIII	White	AIII Mode armed
AIII	Green	AIII Mode active
AII	Yellow	AII Mode on STBY; AII conditions not satisfied
AII	White	AII Mode armed
AII	Green	AII Mode active
AI	Yellow	AI Mode on STBY; AI conditions not satisfied
AI	White	AI Mode armed
AI	Green	AI Mode active
RO	Yellow	RO Mode not valid
RO	White	RO Mode armed
RO	Green	RO Mode active
TO	Yellow	TO Mode not valid
TO	White	TO Mode armed
TO	Green	TO Mode active

Table 2-2: HGS PFD Command Fields

Command	Color	Specifies:
APCH WARN	Red	Approach Warning
FLARE	Green	Flare maneuver
RO CTN	Yellow	Rollout caution
TO WARN	Red	Takeoff warning
HGS	Red	HGS fail

Section 3:
HGS Modes of Operation

Introduction

The HGS Control Panel (HCP) always shows the current mode of operation on the ACT display line and the next available mode on the STBY display line. In Figure 3-1, PRI is the current mode and VMC is the next available mode.

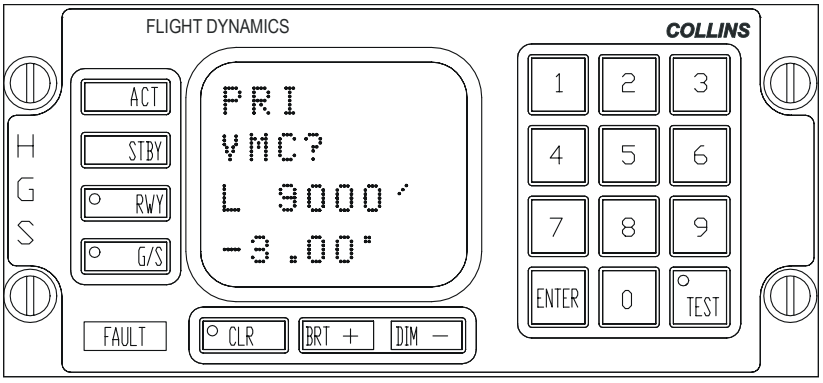


Figure 3-1:
HGS Control Panel (HCP)

Push the STBY pushbutton to change which mode shows on the STBY line. Push the ENTER pushbutton to arm the mode that shows on the STBY line (the question mark is removed).

When the armed mode conditions are met, the mode becomes the active mode and is shown on the ACT line.

When a mode other than PRI is active, PRI is the next available mode and is shown on the STBY line. To select PRI mode, push the ACT pushbutton.

NOTE: PRI is the only mode that is selected with the ACT pushbutton.

The Model 4200 HGS has eight modes of operation. The eight HGS modes are:

Primary Mode (PRI): available during all phases of flight from takeoff to landing.

Takeoff Mode (TO): available for low-visibility takeoff (LVTO) with expanded LOC guidance.

AIII Approach Mode (AIII): available for manual ILS approach and landing operations to Cat III minimums.

Rollout Mode (RO): available on the ground for runway guidance after a successful AIII approach and touchdown. Upon touchdown, the AIII mode automatically changes to RO (if enabled).

AII Approach Mode (AII): available for manual ILS approach and landing operations to CAT II minimums. With the applicable regulatory authority, use AII for CAT II approaches at Type 1 airfields.

AI Approach Mode (AI): available for manual ILS approach and landing operations to CAT I minimums. Use also during coupled autopilot approaches to monitor autopilot performance.

Flight Director Mode (F/D): available for Flight Director approaches that are either manual or autopilot coupled.

Visual Meteorological Conditions Approach Mode (VMC): available for visual approaches. No FCS or HGS guidance is available in VMC mode.

The Model 4200 HGS mode selection sequence requires that TO, AIII, AII, AI, F/D, and VMC modes are only available while PRI is the active mode.

For more data about the symbology that is specific to each mode, refer to Sections 4 (“HGS Symbology”) and 5 (“Typical Flight Profile”) of the Pilot Guide.

PRI Mode

To select PRI Mode at any time, push the ACT pushbutton.

When PRI Mode is the active mode:

- "PRI" shows on the HCP ACT line and on the upper left part of the Combiner display.
- The Combiner display shows Primary mode symbology.

In PRI Mode, the Combiner shows airspeed and altitude tapes on the left and right sides of the display and a sectored HSI in the lower center of the display (Figure 3-2). This display format is modeled after the EFIS Primary Flight Display (PFD), which combines ADI, HSI, Airspeed, and Altimeter data in one display.

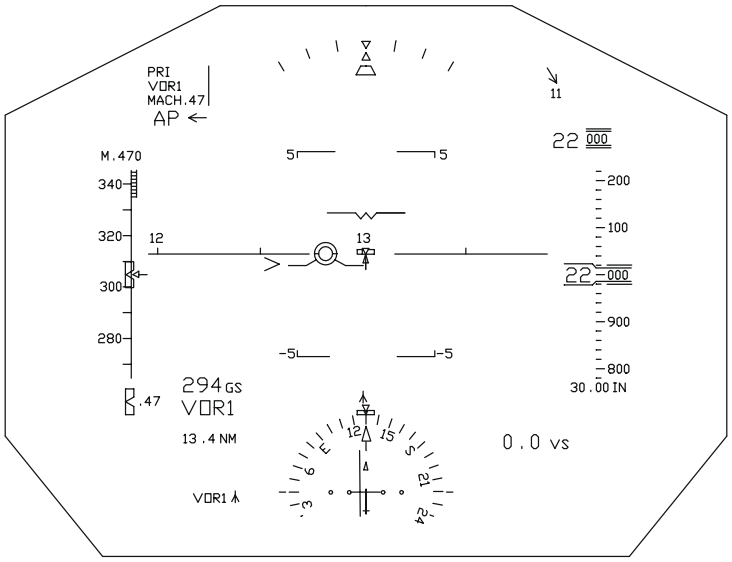


Figure 3-2:
Primary Mode Symbology (example)

The Combiner shows this data in PRI Mode:

- Aircraft Reference (Boresight) symbol
- Pitch attitude: scale and Zero-Degree Pitch Line
- Roll attitude: scale
- Heading: Zero-Degree Pitch Line, HSI
- Airspeeds: CAS (tape), VS, Ground Speed, Speed Error Tape
- Altitudes: Barometric Altitude (tape), Radio Altitude
- Flight Path
- Flight Path Acceleration
- Roll Scale Slip/Skid Indicator
- FCS Guidance Cue and modes
- Navigation data: ILS, VOR, DME, ADF, FMS, Marker Beacons
- Wind Speed and Direction
- Selected parameters: Course, Heading, Airspeed, and Altitude
- Flags

Typical Applications in PRI Mode

PRI Mode is available for all phases of flight and ground operations including:

- Takeoff
- Climb
- Enroute
- Descent
- Approach (includes non-precision and precision approaches that use FCS guidance)
- Landing

PRI Mode is available while the aircraft is on the ground. The HSI, Flight Path, Flight Path-related symbols, and FCS-Derived Guidance Cue do not show on this Combiner display (Figure 3-3).

Takeoff data and guidance are available only in the TO Mode. For more instructions about TO Mode, refer to the subsection “TO Mode” that follows this subsection on Primary Mode.

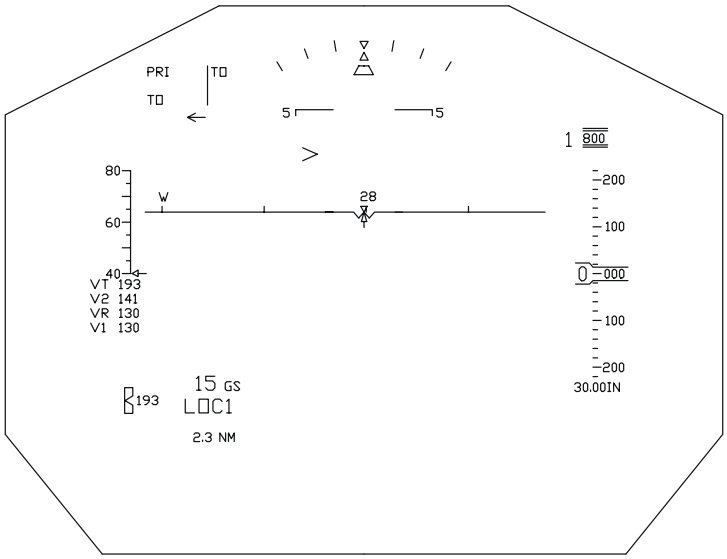


Figure 3-3:
Primary Mode Symbology on Ground (example)

Enroute Display in PRI Mode

Figure 3-4 shows a possible Combiner display while the aircraft is in flight. Note that the Flight Path symbol is non-conformal and thus is drawn with dashed lines (ghosted). The high wind speed and angle (directly from the left) cause the aircraft to crab into the wind to stay on the selected ground track. If the wind speed decreases or the wind direction angle decreases (relative to the aircraft centerline) the Flight Path symbol will become conformal and be drawn as a normal, non-ghosted, symbol.

The non-conformal display of the Flight Path symbol is also possible in other HGS modes. Refer to Section 4, “HGS Symbology” for more information.

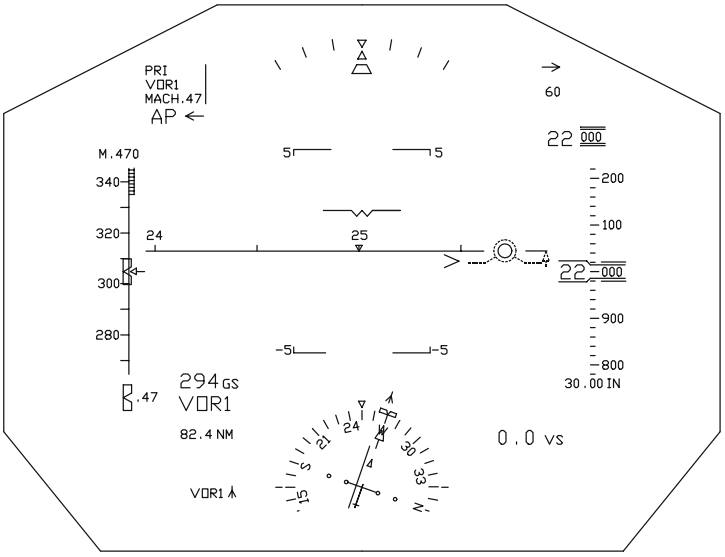


Figure 3-4:
Enroute Display in PRI Mode (example)

TO Mode

NOTE: Obtain operational approval from the appropriate regulatory authority before conducting HGS low-visibility operations.

TO Mode gives HGS computed guidance to track the runway centerline (Figure 3-6).

TO Mode Requirements and Conditions

The conditions necessary to arm TO Mode are:

- The aircraft is on ground.
- All reversion selections (ATTD HDG, AIR DATA, EICAS, DISP CONT, MFD reversion) are in NORM position.
- All sensors/input data are valid.
- There are no HGS BIT faults.
- #1 and #2 VHF NAV receivers are set to the localizer frequency.
- Runway length is set.
- DH is set to 100 feet or less.

Before TO can become the active mode, the aircraft must be aligned with the runway.

TO Mode Selection

To select TO Mode:

- Push the ACT pushbutton.
- Push the STBY pushbutton until “TO?” shows on the STBY line (Figure 3-5).
- Push the ENTER pushbutton to arm TO Mode.

NOTE: TO Mode can be armed at the gate if the necessary conditions are met.

- Align aircraft with the runway.
- Push the TO/GA pushbutton.
- PRI Mode is automatically set as the standby mode.

TO Mode is active until the aircraft ascends through 50 feet AGL. The HGS then changes to PRI Mode. In a rejected takeoff, the HGS changes to PRI Mode when the ground speed is less than 20 knots.

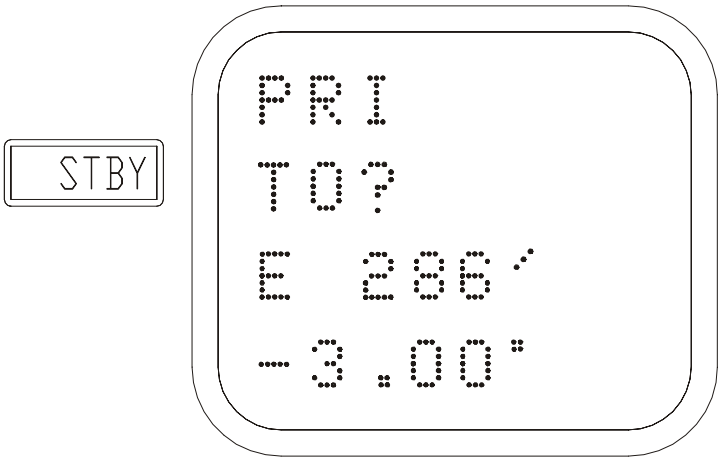


Figure 3-5:
TO Mode Selection (example)

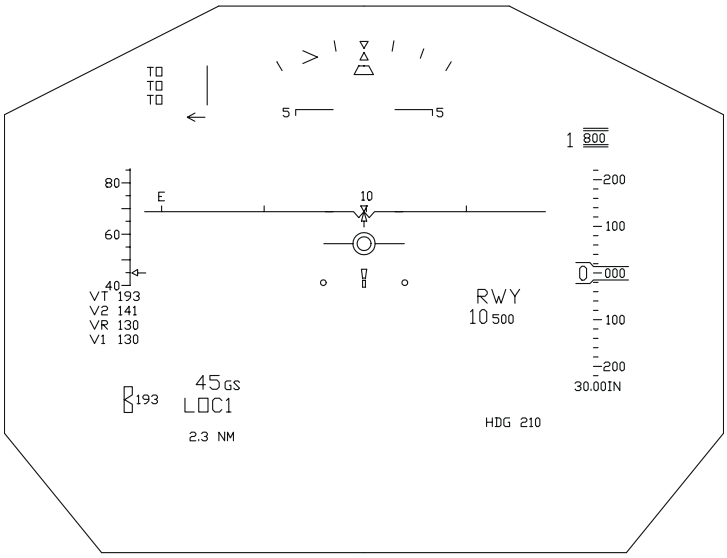


Figure 3-6:
TO Mode Symbology (example)

TO Mode Monitor

In TO Mode the HGS monitors these requirements:

- Sensors and input data
- HGS system integrity (BIT faults).

If the monitor finds a sensor or input data problem, or a BIT fault, TO capability is lost. These changes occur if any condition causes a loss of TO capability:

- “NO TO” shows on the HCP ACT line.
- “NO TO” flashes for 5 seconds and then is steady on the Combiner display.
- “TO” shows in yellow on the PFDs.
- The Guidance Cue is removed from the Combiner display.

If the ground speed is between 20 and 80 knots, a takeoff warning occurs: “TO WARN” shows on Combiner display and in red on the PFDs.

AIII Approach Mode

NOTE: Obtain operational approval from the appropriate regulatory authority before conducting HGS low-visibility operations.

The HGS AIII Mode is specifically designed for manual ILS approach and landing operations to CAT III minimums. In AIII Mode, the HGS removes the altitude and airspeed tape displays and replaces them with numeric representations (Figure 3-7). The HGS also replaces the HSI with ILS raw data in proximity to the flight path group near the center of the display. In the AIII mode, the guidance cue gives flight path guidance derived from HC internal approach and landing guidance algorithms.

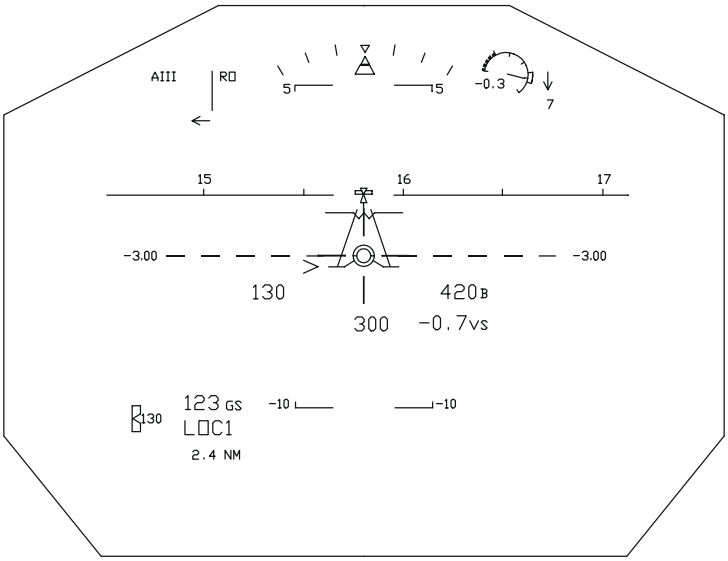


Figure 3-7:
AIII Approach Mode Symbology (example)

AIII conditions and more instructions can be found in “AIII Mode Requirements and Conditions,” “AIII Mode Selection,” and “AIII Mode Approach Monitors” in this subsection.

AIII Mode Requirements and Conditions

These AIII conditions are necessary to arm AIII Mode:

- The runway elevation is set.
- The G/S angle is set.
- IRS #1 and IRS #2 are in NAV mode.
- All reversion selections (ATTD HDG, AIR DATA, EICAS, DISP CONT, MFD reversion) are in NORM position.
- Basic attitude (pitch, roll, heading) data are within limits.
- All sensors/input data are valid.
- There are no HGS BIT faults.
- #1 and #2 VHF Navigation Receivers are tuned to the same localizer frequency.
- FCS armed lateral and vertical modes are LOC and GS.
- The aircraft is above 800 feet AGL.

NOTE: AIII Mode can be selected on the STBY line before some of the conditions necessary to arm the mode are met. "AIII" (with no question mark) shows on the HCP STBY line, but does not show as an armed mode on the Combiner display until all of the conditions necessary to arm the mode are met.

Before AIII can become the active mode, FCS captured modes must be LOC and GS.

AIII Mode Selection

Use this procedure to arm AIII Mode:

NOTE: AIII must be armed above 800 feet AGL.

1. Push the ACT pushbutton.
2. Push the STBY pushbutton until "AIII?" shows.
3. Push the ENTER pushbutton.

The AIII Mode is now armed. "AIII" shows on the HCP STBY line. When the FCS captures LOC and GS modes, "AIII" flashes in the upper left corner of the Combiner display, and the HGS changes to AIII Mode.

When AIII is the active mode:

- "AIII" shows on the HCP ACT line, on the upper left part of the Combiner display, and in green on the PFDs.
- The Combiner display shows AIII Mode symbology.
- PRI Mode is automatically set as the standby mode.

AIII Mode Approach Monitors

In AIII Mode the HGS monitors these requirements:

- Sensors and input data
- HGS system integrity (BIT faults)
- Approach and landing performance (below 500 feet AGL).

If the monitor finds a sensor or input data problem, or a BIT fault, AIII capability is lost. These changes occur if any condition causes a loss of AIII capability:

- "NO AIII" shows on the HCP ACT line (Figure 3-8).
- "NO AIII" flashes for 5 seconds and then is steady on the Combiner display (Figure 3-9).
- "AIII" shows in yellow on the PFDs.
- The Guidance Cue is removed from the Combiner display.

If the aircraft is above 500 feet AGL, these "NO AIII" displays stay until the HGS regains AIII capability, or until PRI Mode is selected.

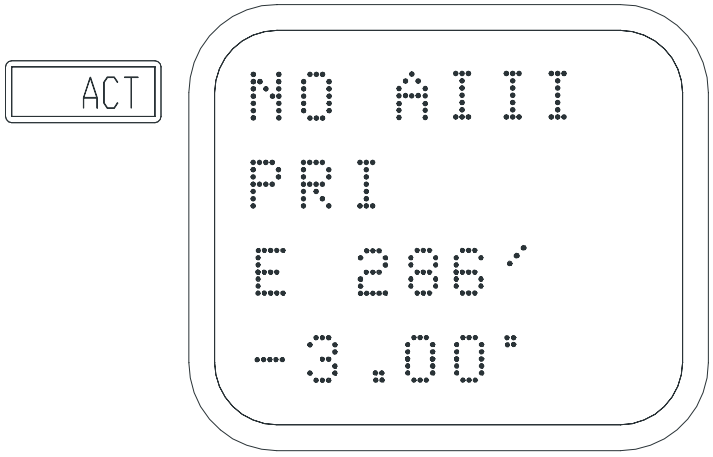


Figure 3-8:
NO AIII Display on HCP

Below 500 feet AGL, if AIII capability is lost, or approach and landing performance is out of tolerance, an approach warning occurs: “APCH WARN” shows on Combiner display (Figure 3-9) and in red on the PFDs. If an approach warning occurs, the left-side pilot should do a go-around, unless adequate visual cues are available.

Use of autopilot: If the autopilot is engaged and the HGS AIII Mode is active below 1000 feet AGL, “DISC” shows on the Combiner display as a reminder to disconnect the autopilot. If the autopilot is still engaged below 650 feet AGL, “DISC” flashes on the Combiner. Below 500 feet AGL, an approach warning occurs.

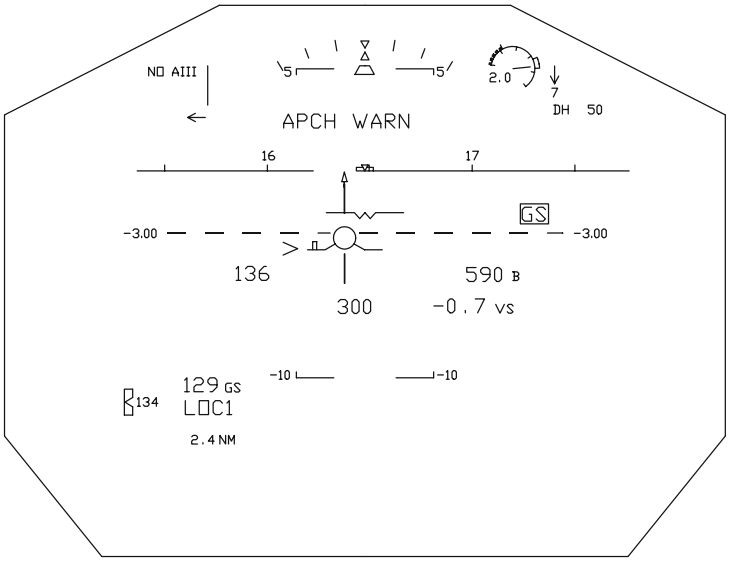


Figure 3-9:
NO AIII and Approach Warning (example)

NOTE: Figure 3-9 shows a glideslope failure at 300 feet that causes a loss of AIII. “APCH WARN” and “NO AIII” show on the Combiner display, and glideslope raw data and the Guidance Cue are removed from the Combiner display.

RO Mode

The HGS RO Mode (if enabled) gives guidance to track the runway centerline after an AIII approach (Figure 3-10).

RO Mode Requirements and Conditions

RO Mode is automatically armed when these conditions are met:

- All reversion selections (ATTD HDG, AIR DATA, EICAS, DISP CONT, MFD reversion) are in NORM position.
- All sensors/input data are valid.
- There are no HGS BIT faults.
- #1 and #2 VHF NAV receivers are set to the localizer frequency.
- Runway length is set within defined limits before the aircraft descends below 500 feet AGL.
- AIII Mode is active.

RO shows as the armed mode on the Combiner display and on the PFDs.

RO Mode Selection

The HGS changes automatically to RO Mode at touchdown after an AIII approach.

When RO is the active mode:

- "RO" shows on the HCP ACT line, on the upper left of the Combiner display, and in green on the PFDs.
- The Combiner display shows RO Mode symbology.
- PRI Mode is automatically set as the standby mode.

RO Mode stays the active mode until ground speed is less than 20 knots. The HGS then changes to PRI Mode.

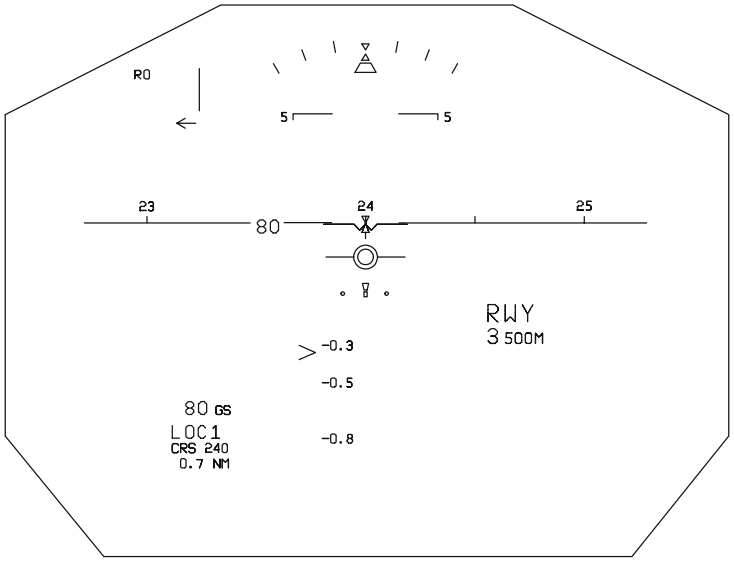


Figure 3-10:
RO Mode Symbology (example)

RO Mode Monitor

In RO Mode the HGS monitors these requirements:

- Sensors and input data
- HGS system integrity (BIT faults).

If the monitor finds a sensor or input data problem, or a BIT fault, RO capability is lost. These changes occur if any condition causes a loss of RO capability:

- “NO RO” shows on the HCP ACT line.
- “NO RO” flashes for 5 seconds and then is steady on the Combiner display.
- “RO” shows in yellow on the PFDs.
- The Guidance Cue is removed from the Combiner display.

If RO capability is lost, a rollout caution occurs: “RO CAUTION” shows on the Combiner display and “RO CAUT” shows in red on the PFDs.

AII Approach Mode

NOTE: Obtain operational approval from the appropriate regulatory authority before conducting HGS low-visibility operations.

The HGS AII mode is specifically designed for manual ILS approach and landing operations to CAT II minimums. The AII Approach Mode symbology (Figure 3-11) has the same format as the AIII Approach Mode symbology.

NOTE: In AII mode, the guidance cue is removed at 80 feet AGL.

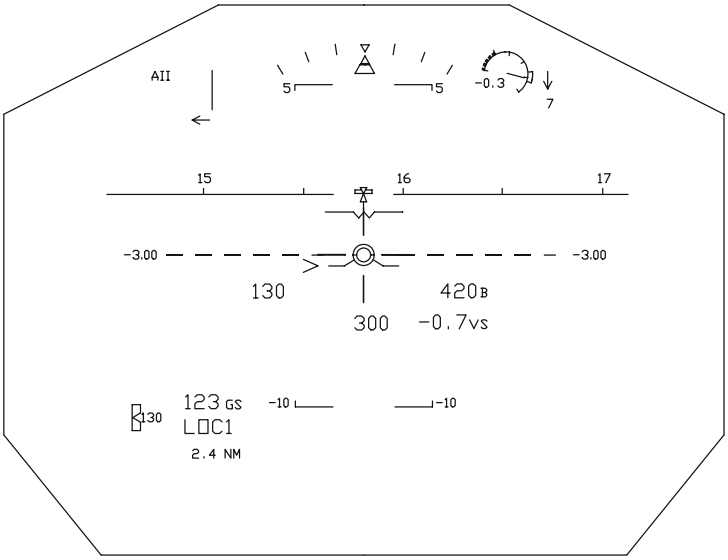


Figure 3-11:
AII Approach Mode Symbology (example)

AII Mode Requirements and Conditions

These AII conditions are necessary to arm AII Mode:

- The runway elevation is set.
- The G/S angle is set.
- IRS #1 and IRS #2 are in NAV mode.
- All reversion selections (ATTD HDG, AIR DATA, EICAS, DISP CONT, MFD reversion) are in NORM position.
- Basic attitude (pitch, roll, heading) data are within limits.
- All sensors/input data are valid.
- There are no HGS BIT faults.
- #1 and #2 VHF Navigation Receivers are tuned to the same localizer frequency.
- FCS armed lateral and vertical modes are LOC and GS.
- The aircraft is above 800 feet AGL.

NOTE: AII Mode can be selected on the STBY line before some of the conditions necessary to arm the mode are met. "AII" (with no question mark) shows on the HCP STBY line, but does not show as an armed mode on the Combiner display until all of the conditions necessary to arm the mode are met.

Before AII can become the active mode, FCS captured modes must be LOC and GS.

AII Mode Selection

Use this procedure to arm AII Mode:

NOTE: AII must be armed above 800 feet AGL.

1. Push the ACT pushbutton.
2. Push the STBY pushbutton until "AII?" shows.
3. Push the ENTER pushbutton.

The AII Mode is now armed. "AII" shows on the HCP STBY line. When the FCS captures LOC and GS modes, "AII" flashes in the upper left corner of the Combiner display, and the HGS changes to AII Mode.

When AII is the active mode:

- "AII" shows on the HCP ACT line, on the upper left part of the Combiner display, and in green on the PFDs.
- The Combiner display shows AII Mode symbology.
- PRI Mode is automatically set as the standby mode.

AII Mode Approach Monitors

In AII Mode the HGS monitors these requirements:

- Sensors and input data
- HGS system integrity (BIT faults)
- Approach and landing performance.

If the monitor finds a sensor or input data problem, or a BIT fault, AII capability is lost. These changes occur if any condition causes a loss of AII capability:

- "NO AII" shows on the HCP ACT line (Figure 3-12).
- "NO AII" flashes for 5 seconds and then is steady on the Combiner display (Figure 3-13).
- "AII" shows in yellow on the PFDs.
- The guidance cue is removed from the Combiner display.

If the aircraft is above 500 feet AGL, these "NO AII" displays stay until the AII conditions are met, or until PRI Mode is selected.

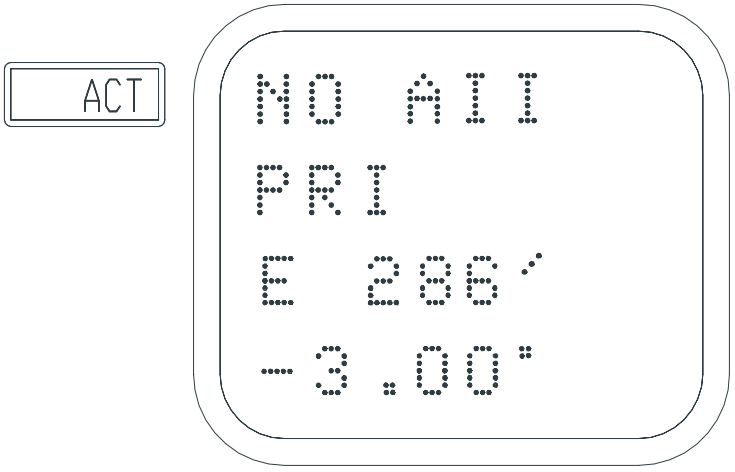


Figure 3-12:
NO AII Display on HCP

Below 500 feet AGL, if AII capability is lost, or approach and landing performance is out of tolerance, an approach warning occurs: “APCH WARN” shows on Combiner display (Figure 3-13) and in red on the PFDs. If an approach warning occurs, the left-side pilot should do a go-around, unless adequate visual cues are available.

NOTE: A coupled approach below 500 feet AGL results in an approach warning.

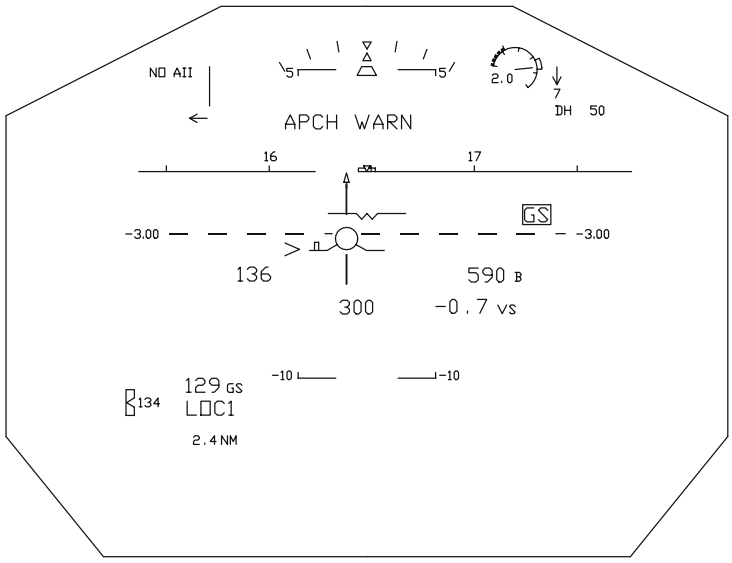


Figure 3-13:
NO AII and Approach Warning (example)

AI Approach Mode

NOTE: Obtain operational approval from the appropriate regulatory authority before conducting HGS low-visibility operations.

The HGS AI mode is specifically designed for manual ILS approach and landing operations to CAT I minimums. The AI Approach Mode symbology (Figure 3-14) has the same format as the AIII Approach Mode symbology.

NOTE: In AI mode, the guidance cue is removed at 80 feet AGL.

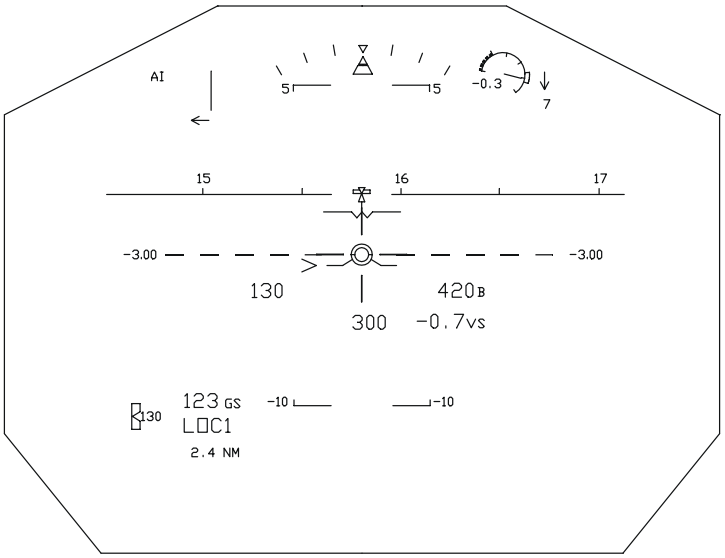


Figure 3-14:
AI Approach Mode Symbology (example)

AI Mode Requirements and Conditions

These AI conditions are necessary to arm AI Mode:

- The runway elevation is set.
- The G/S angle is set.
- IRS #1 and IRS #2 are in NAV mode.
- Basic attitude (pitch, roll, heading) data are within limits.
- All sensors/input data are valid.
- There are no HGS BIT faults.
- #1 and #2 VHF Navigation Receivers are tuned to the same localizer frequency.
- FCS armed lateral and vertical modes are LOC and GS.
- The aircraft is above 800 feet AGL.

NOTE: AI Mode can be selected on the STBY line before some of the conditions necessary to arm the mode are met. "AI" (with no question mark) shows on the HCP STBY line, but does not show as an armed mode on the Combiner display until all of the conditions necessary to arm the mode are met.

Before AI can become the active mode, FCS captured modes must be LOC and GS.

AI Mode Selection

Use this procedure to arm AI Mode:

NOTE: AI must be armed above 800 feet AGL.

1. Push the ACT pushbutton.
2. Push the STBY pushbutton until "AI?" shows.
3. Push the ENTER pushbutton.

The AI Mode is now armed. "AI" shows on the HCP STBY line. When the FCS captures LOC and GS modes, "AI" flashes in the upper left corner of the Combiner display, and the HGS changes to AI Mode.

When AI is the active mode:

- "AI" shows on the HCP ACT line, on the upper left part of the Combiner display, and in green on the PFDs.
- The Combiner display shows AI Mode symbology.
- PRI Mode is automatically set as the standby mode.

AI Mode Monitors

In AI Mode the HGS monitors these requirements:

- Sensors and input data
- HGS system integrity (BIT faults).

NOTE: The HGS does not monitor aircraft performance during AI Mode approaches.

If the monitor finds a sensor or input data problem, or a BIT fault, AI capability is lost. These changes occur if any condition causes a loss of AI capability:

- "NO AI" flashes for 5 seconds and then is steady on the Combiner display.
- "NO AI" shows on the HCP ACT line (Figure 3-15).
- "AI" shows in yellow on the PFDs.
- The Guidance Cue is removed from the Combiner display.

These "NO AI" displays stay until the AI conditions are met again or PRI Mode is selected.

Use of autopilot: The HGS AI Mode can be used to monitor a coupled autopilot approach.

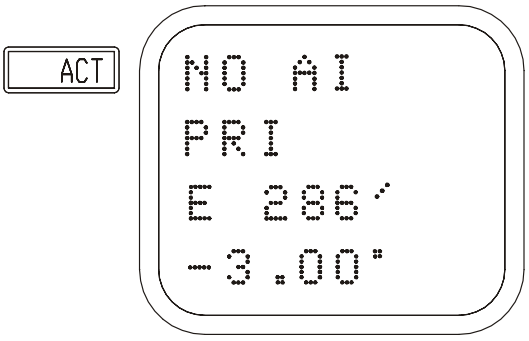


Figure 3-15:
NO AI Display on HCP

F/D Approach Mode

F/D (Flight Director) Mode is available for manual or autopilot-coupled FCS approaches. The F/D Mode approach symbology (Figure 3-16) has the same format as the AIII Approach Mode symbology, but guidance is based on commands from the FCS.

NOTE: In F/D Mode, the guidance cue is removed at 80 feet AGL.

F/D Mode Requirements and Conditions

Before F/D Mode can become the active mode, the FCS lateral armed or captured mode must be LOC.

F/D Mode Selection

Use this procedure to select F/D Mode:

1. Push the ACT pushbutton.
2. Push the STBY pushbutton until “F/D?” shows.
3. Push the ENTER pushbutton.

The HCP STBY line shows “F/D”. When the FCS lateral armed or captured mode is LOC, the HGS changes to F/D Mode.

When F/D is the active mode:

- “F/D” shows on the HCP ACT line and on the upper left part of the Combiner display.
- The Combiner display shows F/D Mode symbology.
- PRI Mode is automatically set as the standby mode.

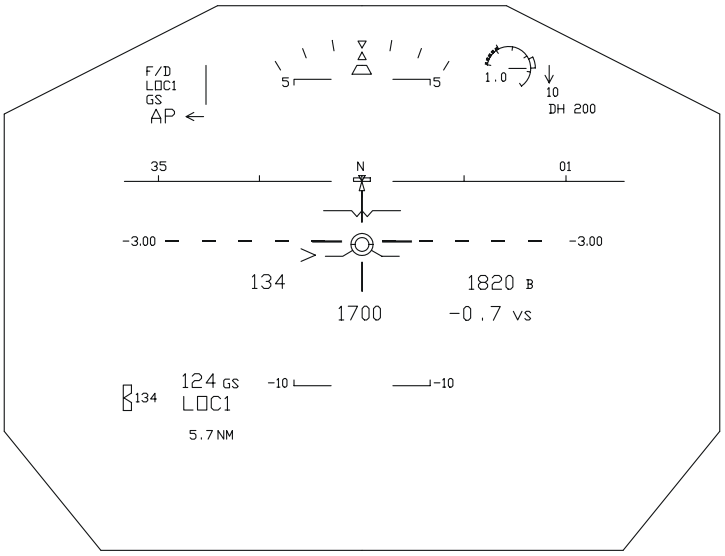


Figure 3-16:
F/D Approach Mode Symbology (example)

VMC Approach Mode

VMC Mode allows for visual approach operations. In VMC Mode the left-side pilot establishes and maintains the aircraft on the proper glide path to the runway without reference to a ground-based landing system (ILS, VASI, etc.). VMC Mode approach symbology (Figure 3-17) is in the same format as AIII, AII, AI, and F/D Modes with one exception: in VMC Mode the HGS does not show a guidance cue. Instead, the left-side pilot uses the Flight Path and Glideslope Reference Line to manually control the approach using visual cues. This is particularly beneficial during approaches at night or with poor visual cues.

VMC Mode Selection

Use this procedure to select VMC Mode:

1. Push the ACT pushbutton.
2. Push the STBY pushbutton until “VMC?” shows on the STBY line.
3. Push the ENTER pushbutton.

When VMC is the active mode:

- “VMC” shows on the HCP ACT line and on the upper left part of the Combiner display.
- The Combiner display shows VMC mode symbology (Figure 3-17).
- PRI Mode is automatically set as the standby mode.

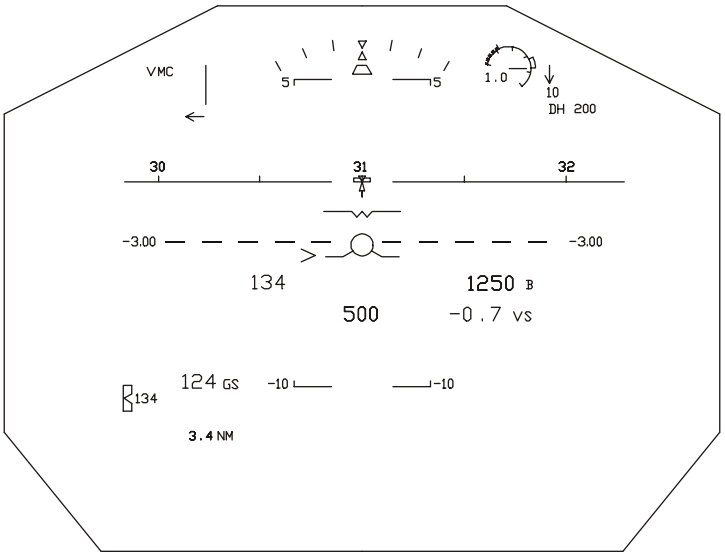


Figure 3-17:
VMC Approach Mode Symbology (example)

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Section 4:
HGS Symbology

HGS symbology descriptions and illustrations are presented in five subsections in the order listed:

- **Primary Mode Symbology**: Describes symbols used by Primary Mode and during takeoff.
- **Approach Modes Symbology**: Describes symbols used in AIII, RO, AII, AI, F/D and VMC Approach Modes.
- **Non-Normal Conditions Symbology**: Describes non-normal symbology, source messages, warning messages, failure flags, and miscompare flags.
- **Non-Conformal Displays**: Describes how the HGS displays certain symbols in a non-conformal manner depending on mode of operation and aircraft attitude.
- **HGS Modes/Symbology Matrix**: Lists all symbols and the HGS modes in which they can be displayed.

How to Use the Symbology Section

Many symbols are the same in Primary and the Approach modes. Common symbols are repeated in the "Primary Mode Symbology" and "Approach Modes Symbology" subsections. Symbols are grouped under each subsection according to attitude, airspeed, altitude, navigation, flight path, takeoff and rollout. This method helps locate desired symbol descriptions and illustrations.

Use the "HGS Modes/Symbology Matrix" at the end of this section as an overview of symbology and relevant HGS modes in which each symbol can be displayed.

Primary Mode Symbology

The Primary Mode symbology sets are similar to the EFIS Primary Flight Display. Symbol descriptions and illustrations are grouped in the following order:

- Attitude
- Airspeed
- Altitude
- Navigation
- Flight Path
- Takeoff

NOTE: Symbology illustrations used in this section show appearance, location, and relationship with associated symbology. Other symbols have been removed to aid quick identification and location on the HGS display of the referenced symbol.

Primary Mode Attitude Symbol Group

See Figure 4-1, Figure 4-2, and Figure 4-3. The Primary Mode Attitude Symbol Group has the symbols listed in Table 4-1.

Table 4-1: Primary Mode Attitude Symbol Group

Symbol	PRI		TO
	Ground	Flight	
Aircraft Reference	●	●	●
Roll Scale and Pointer	●	●	●
Zero-Degree Pitch Line	●	●	●
Pitch Scale	●	●	●
Conformal Magnetic Heading Scale (tic marks)	●	●	●
Conformal Magnetic Heading Index	●	●	●
HSI Heading Scale		●	
Roll Scale Slip/Skid Indicator	●	●	●
Aircraft Reference Slip/Skid Indicator		●	
Angle of Attack Limit		●	
Pitch Reference		●	●
Pitch Chevrons		●	

Aircraft Reference: The Aircraft Reference Symbol (Boresight symbol), represents the projected centerline of the aircraft (boresight). The vertex of the symbol is the actual boresight point.

The Aircraft Reference symbol is positioned at a fixed location on the display and, unlike other displayed symbols, it is not dependent on any sensor or equipment inputs. Its function is similar to the aircraft symbol on conventional attitude instruments and is always present when the HGS is powered and in normal operation.

Roll Scale and Pointer: The Roll Scale and Pointer are above the Aircraft Reference Symbol. The scale has tic marks at 10° increments between 0° and ±30°. Tic marks at 45° and 60° are also added to the roll scale when the aircraft exceeds ±40° and ±55°, respectively. The Roll Scale is similar to the "Sky Pointer" on a conventional ADI. The pointer points to the corresponding roll attitude on the scale.

Zero-Degree Pitch Line: The Zero-Degree Pitch Line is used with the Aircraft Reference symbol to represent the pitch attitude of the aircraft. When the Flight Path Symbol overlays the Zero-Degree Pitch Line, the aircraft is in level flight.

NOTE: Because of the earth's curvature, the Zero-Degree Pitch Line is only aligned with the physical horizon at 0 ft AGL. As the altitude of the aircraft increases, a separation between the horizon and the Zero-Degree Pitch Line is visible (most noticeable above 2500 ft AGL). At cruising altitudes, there can be a significant separation between the Zero Degree Pitch Line and the horizon. This difference should not be interpreted as an error in the positioning of the Zero-Degree Pitch Line.

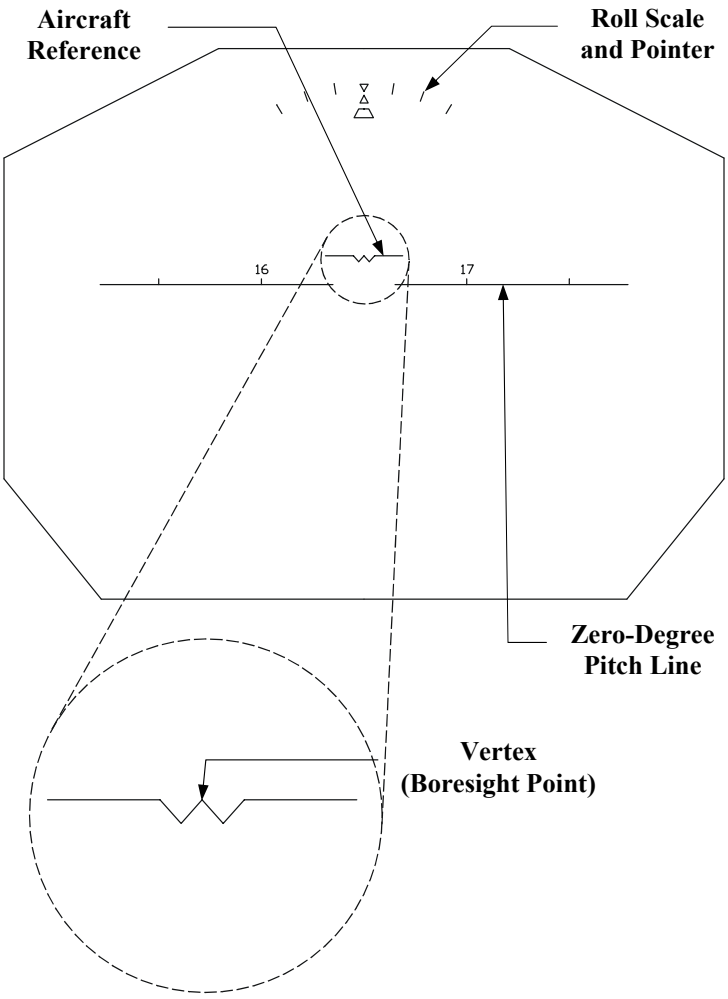


Figure 4-1:
PRI Mode Attitude Symbols

Pitch Scale: The Pitch Scale displays in five-degree increments from -20° to +30° and in ten-degree increments below -20° and above 30°. At the ends of the each pitch line is a vertical tic mark pointed in the direction of the Zero-Degree Pitch Line and labeled with its related scale (e.g., 5, -5, and so on). Vertical attitude is determined by noting where the scale is positioned in relation to the Aircraft Reference Symbol.

When the aircraft attitude is approximately ±8°, the Zero-Degree Pitch Line and the Flight Path Symbol cannot be displayed conformally. The Pitch Scale is compressed to allow these symbols to remain on the display. The position of these symbols is maintained relative to one another, but the display is no longer conformal with the real world. When display compression occurs, certain vertical scale lines are removed. See "Non-Conformal Display Characteristics" later in this section.

Conformal Magnetic Heading Scale (tic marks): The Conformal Magnetic Heading Scale is displayed on the Zero-Degree Pitch Line. The scale is marked every 5° (tic marks), and labeled every 10°. Magnetic Heading is conformal with the real world. For example: a point on the earth underlying the "13" mark on the Magnetic Heading Scale would take a heading of 130° to fly over. The four cardinal headings of North, South, East, and West are expressed as N, S, E, and W, respectively.

Conformal Magnetic Heading Index: At the center of the Zero-Degree Pitch Line is a downward-pointing triangle called the Magnetic Heading Index. This points to the actual Magnetic Heading of the aircraft (where the nose is pointing) and is positioned directly below (or above) the Aircraft Reference Symbol.

HSI (Horizontal Situation Indicator): A conventional-sectored HSI is positioned in the bottom center area of the display. The HSI display consists of a partial Magnetic Heading compass rose spanning 210° with tic marks every 10°. Each 30° tic mark is labeled with its corresponding value in tens of degrees (a label 13 is 130°). Cardinal headings of North, South, East, and West are expressed as N, S, E, and W, respectively. A downward-pointing triangle, positioned above the center of the compass rose, represents the Compass Lubber Line and the current magnetic heading.

The HSI remains displayed until either pitch or flight-path angle cause the Zero-Degree Pitch Line or the Flight Path symbol to reach a display limit above the HSI. Further increases in pitch of flight-path angle push the HSI and its related symbology down until only a small part of the HSI shows. As the pitch or flight path angle decreases, and the Zero-Degree Pitch Line or Flight Path Symbol moves toward the center of the display, the HSI and related symbols are "pulled" back up the display.

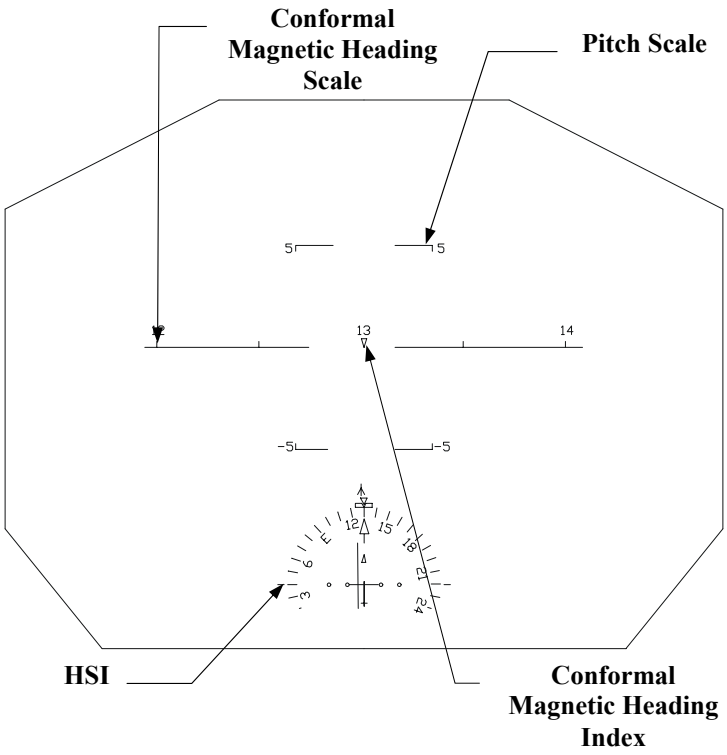


Figure 4-2:
PRI Mode Attitude Symbols

Roll Scale Slip/Skid Indicator: The Roll Scale Slip/Skid Indicator is located as part of the Roll Scale Pointer. The bottom portion of the Roll Scale Pointer moves laterally with respect to the top triangle portion of the pointer and is dependent on the lateral acceleration of the aircraft. The Roll Scale Slip/Skid Indicator functions like a conventional slip/skid indicator.

Aircraft Reference Slip/Skid Indicator: The Aircraft Reference Slip/Skid Indicator is displayed during a single engine takeoff. This Slip/Skid Indicator moves laterally underneath the Aircraft Reference symbol to show lateral acceleration of the aircraft.

Angle-of-Attack (AOA) Limit: The AOA Limit symbol shows when the angle of attack is 80% of the stick shaker angle of attack. It is positioned to indicate the difference between current angle of attack and the angle of attack at which stick shaker will occur. If the AOA Limit symbol is two degrees above the Flight Path symbol, stick shaker will occur if the angle of attack is increased by two degrees. The AOA Limit symbol is positioned on the Flight Path symbol (boxed ends set on the Flight Path wings) when stick shaker occurs.

Pitch Reference: A Pitch Reference shows during takeoff and climb with the FCS Vertical Mode set to TO or TO/WS. This symbol gives the best climb angle to use as a pitch attitude for takeoff climb. The pitch reference is positioned by the flap position and the difference between the V_R and V_2 settings. This symbol shows on the display until the flaps are retracted, or when the FCS Vertical Mode is changed.

Pitch Chevrons: There are two Pitch Chevrons located on the Pitch Scale. They point toward level flight. One is located with the point of its “V” at +30° (extreme pitch up), the other at -20° (extreme pitch down).

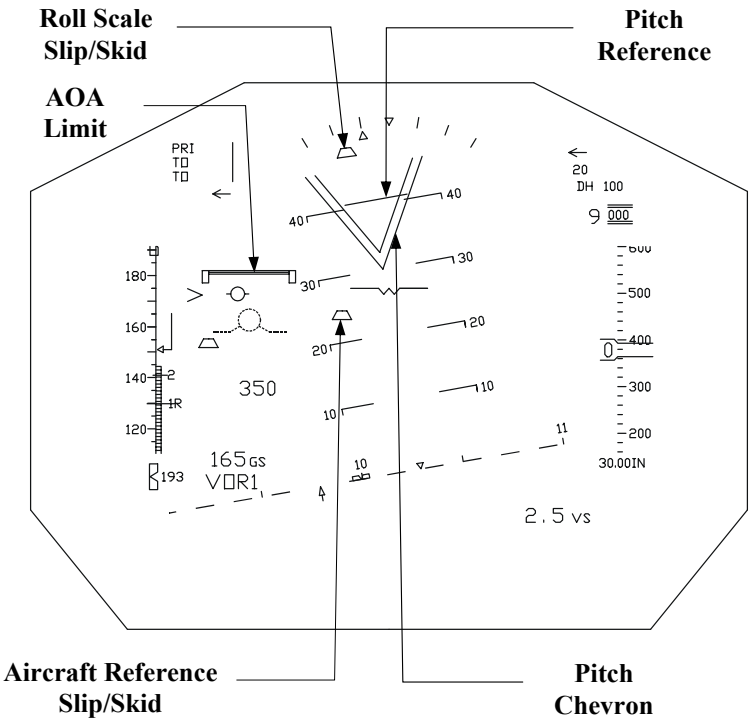


Figure 4-3:
PRI Mode Attitude Symbols

Primary Mode Airspeed Symbol Group

See Figure 4-4 thru Figure 4-8. Table 4-2 gives the Primary Mode Altitude Symbol Group.

Table 4-2: Primary Mode Airspeed Symbol Group

Symbol	PRI		TO
	Ground	Flight	
Computed Airspeed Scale and Index	●	●	●
Selected Airspeed/Mach	●	●	●
Mach Number		●	
Wind Speed and Direction		●	●
Selected Airspeed Mark	●	●	●
Maximum Operating Speed Tape		●	
Low-Speed Cue Tape		●	
Takeoff Speed Marks	●	●	●
Reference Airspeed Table	●		●
Airspeed Trend Vector	●	●	●
Ground Speed	●	●	●

Computed Airspeed Scale and Index: The ADC-based Computed Airspeed Scale (CAS) displays a ±40-knot range with an airspeed index at its center. The overall range of the Computed Airspeed Scale is 40 to 400 knots with tic marks at 5-knot increments between 40 and 200 knots and 10-knot increments between 200 and 400 knots. The tic marks are labeled every 20 knots.

Selected Airspeed/Mach: Selected Airspeed or Mach is displayed directly below the Airspeed scale. The Mach Number is displayed as a decimal point with two digits to the right.

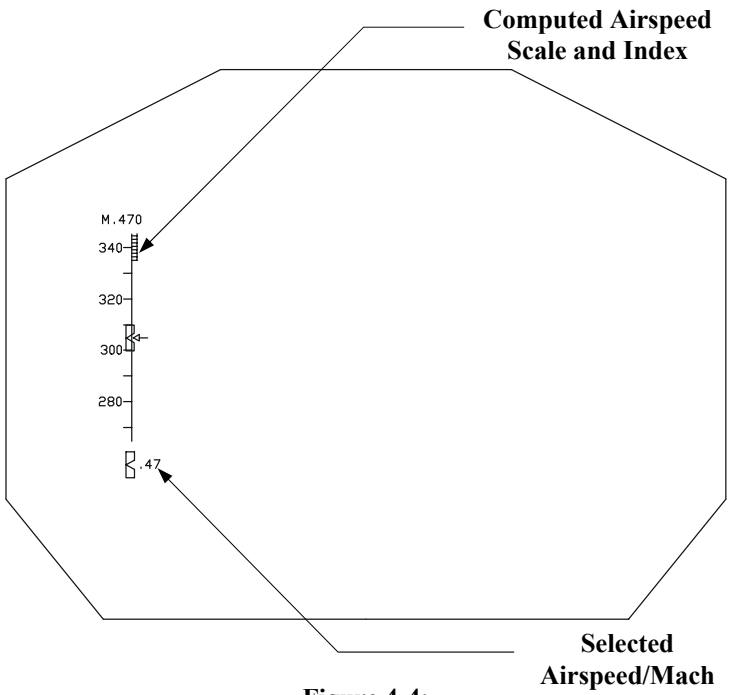


Figure 4-4:
PRI Mode Airspeed Symbols

Mach Number: The Mach Number is displayed directly above the airspeed scale as an "M" that is followed by a decimal point and the computed Mach speed of the aircraft. The Mach Number comes on when greater than 0.450. It is removed when less than 0.400.

Wind Speed and Direction: The current wind speed and direction, derived from the IRU, is displayed in the upper right corner of the display. Wind Speed is displayed directly below the Wind Direction arrow.

The Wind Direction arrow is referenced to the aircraft's heading and indicates the direction from which the wind is blowing. For example, a Wind Direction arrow pointing straight up (the 12 o'clock position) identifies a direct tail wind. A Wind Direction arrow pointing to the right (the 3 o'clock position) identifies a direct left crosswind.

The IRU based Wind Speed and Direction are displayed when the aircraft is in flight and wind speed exceeds 3 knots.

Selected Airspeed Mark: The Selected Airspeed Mark travels vertically on the Computed Airspeed Scale.

Maximum Operating Airspeed Tape: The Maximum Allowable Airspeed Tape shows as a "checkerboard" tape growing downward from the top of the Computed Airspeed Scale. The limit that the tape represents is a function of the following: aircraft Vmo, flap position, and landing gear configuration.

Low-Speed Cue Tape: The Low-Speed Cue Tape shows as a "checkerboard" tape growing from the bottom of the Computed Airspeed Scale.

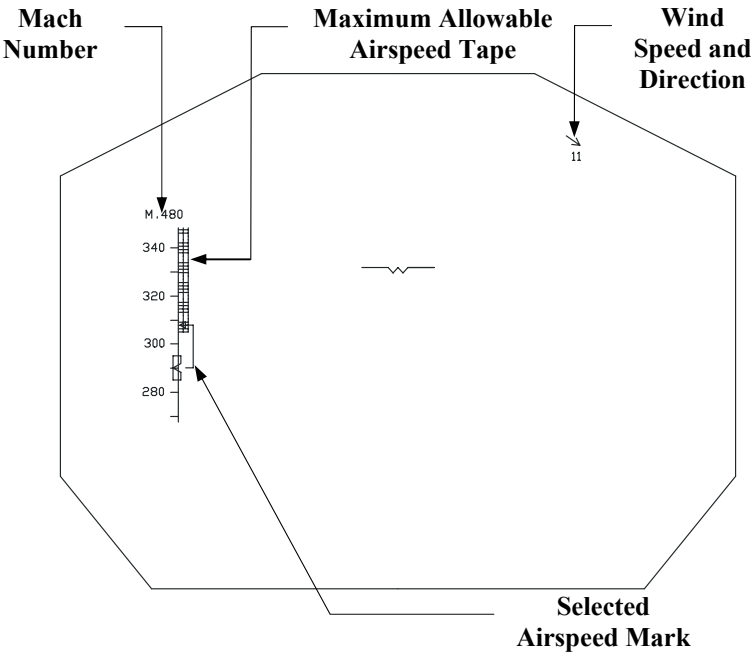


Figure 4-5:
PRI Mode Airspeed Symbols

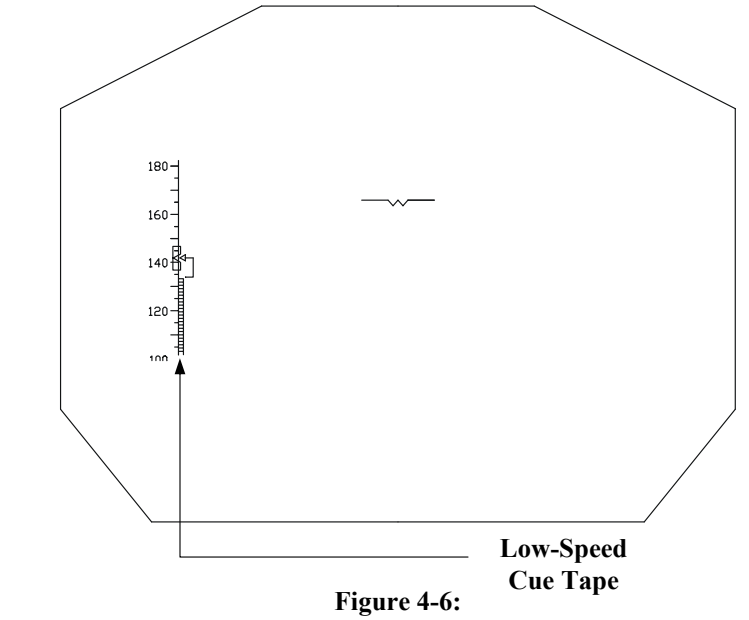


Figure 4-6:
PRI Mode Airspeed Symbols

Takeoff Speed Marks: Takeoff Speed Marks show on the Computed Airspeed Scale during takeoff and the initial climb when the speed is within the range displayed.

Reference Airspeed Table: Reference Airspeeds are displayed below the Computed Airspeed Scale when on the ground and CAS is less than 40 knots.

Airspeed Trend Vector: The Airspeed Trend Vector shows as a variable length line with a tail pointing toward the scale either above or below the Computed Airspeed Scale Index. The line length and the position of the tail indicates the predicted airspeed in 10 seconds. The Airspeed Trend Vector shows after the aircraft is airborne for more than 3 seconds.

Ground Speed: The IRS Ground Speed is displayed in the lower left corner of the display. Ground Speed is shown with the letters “GS” following the number.

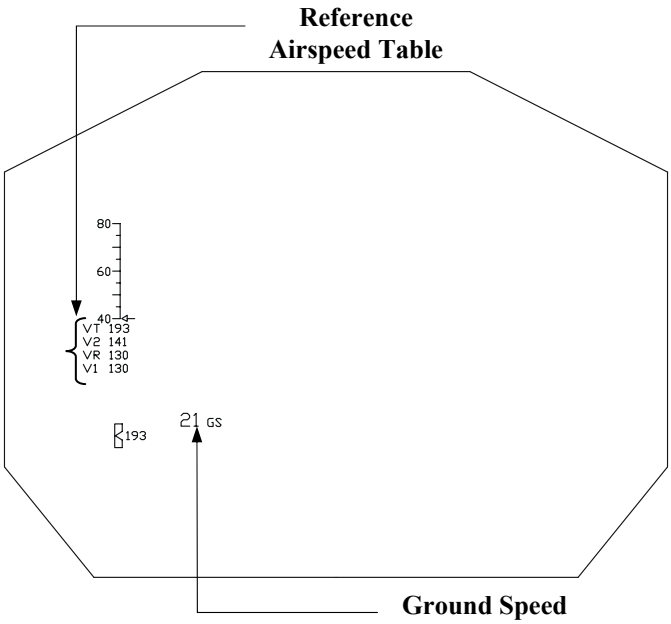


Figure 4-7:
PRI Mode Airspeed Symbols

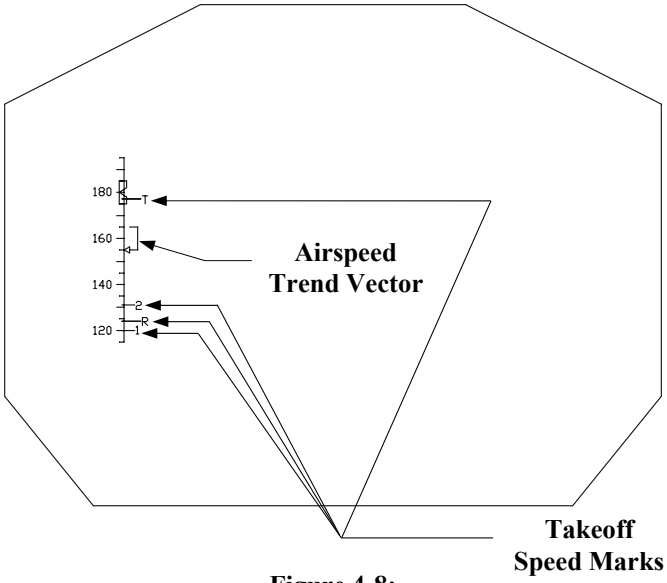


Figure 4-8:
PRI Mode Airspeed Symbols

Primary Mode Altitude Symbol Group

See Figure 4-9 thru Figure 4-11. Table 4-3 gives the Primary Mode Altitude Symbol Group.

Table 4-3: Primary Mode Altitude Symbol Group

Symbol	PRI		TO
	Ground	Flight	
Barometric Altitude Scale and Index	●	●	●
Barometric Pressure Setting	●	●	●
Selected Altitude	●	●	●
Selected Altitude Mark	●	●	●
Metric Altitude Readout	●	●	●
Radio Altitude		●	●
Selected Decision Height	●	●	●
Decision Height Message		●	
Selected Minimum Descent Altitude (MDA)	●	●	
MDA Alert Message		●	
Vertical Speed		●	
Runway Elevation	●	●	

Barometric Altitude Scale and Index: Barometric (Baro) Altitude is displayed relative to a vertical scale along the right edge of the display. The Altitude Scale displays a 440-foot range with an Altitude Index at its center. The overall range of the scale is -1000 to 50,000 feet with tic marks every 20 feet, labeled every 100 feet.

Barometric Pressure Setting: The Barometric Pressure Setting is displayed directly below the Altitude Scale. The number is followed by either “IN” for inches of mercury or “HPA” for hectopascals.

Selected Altitude: Selected Altitude is displayed in 100-foot increments directly above the Altitude Scale.

Selected Altitude Mark: The Selected Altitude Mark travels vertically along the Altitude Scale. When the Selected Altitude is within the displayed range on the Altitude scale, double horizontal lines above and below the hundreds component of the Selected Altitude are displayed.

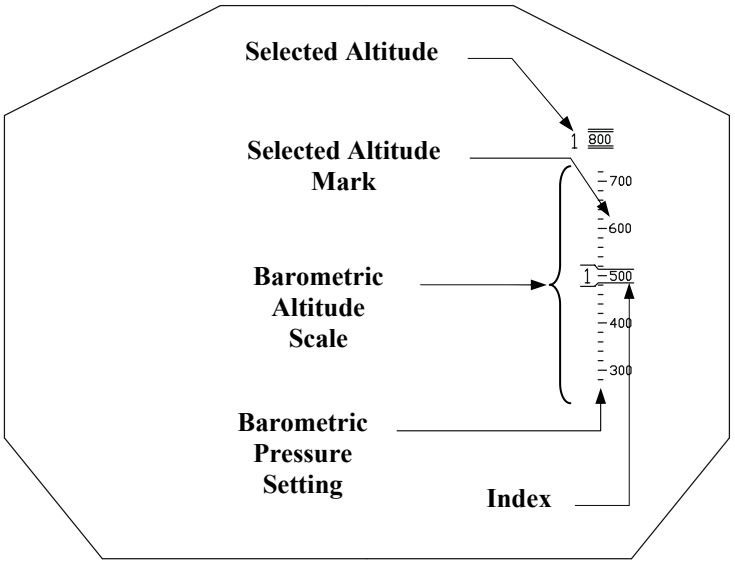


Figure 4-9:
PRI Mode Altitude Symbols

Metric Altitude Readout: A Metric Altitude Readout is displayed below the Altitude Scale to identify the altitude in meters; the letter “M” follows these numbers.

Radio Altitude: Radio Altitude is displayed directly below the Flight Path Symbol when Radio Altitude is less than or equal to 2,500 feet. If the Flight Path Symbol is not displayed, the Radio Altitude is displayed relative to the Aircraft Reference Symbol. It is displayed in 50-foot increments between 1000 and 2,500 feet, in 10-foot increments between 50 and 1000 feet, in 5-foot increments between 10 and 50 feet, and in 1-foot increments between 0 and 10 feet.

Selected Decision Height: Selected Decision Height shows as “DH” that is followed by numbers in the upper right corner of the display. Use the left-side ARP (Air-Data Reference Panel) to set the Selected Decision Height.

Decision Height Message: A Decision Height (DH) message is displayed to the left of the Radio Altitude display when the selected DH has been reached. “DH” flashes for 10 seconds and then is steady. The symbol is removed at 5 feet, or if the aircraft climbs above the Selected DH plus 100 feet.

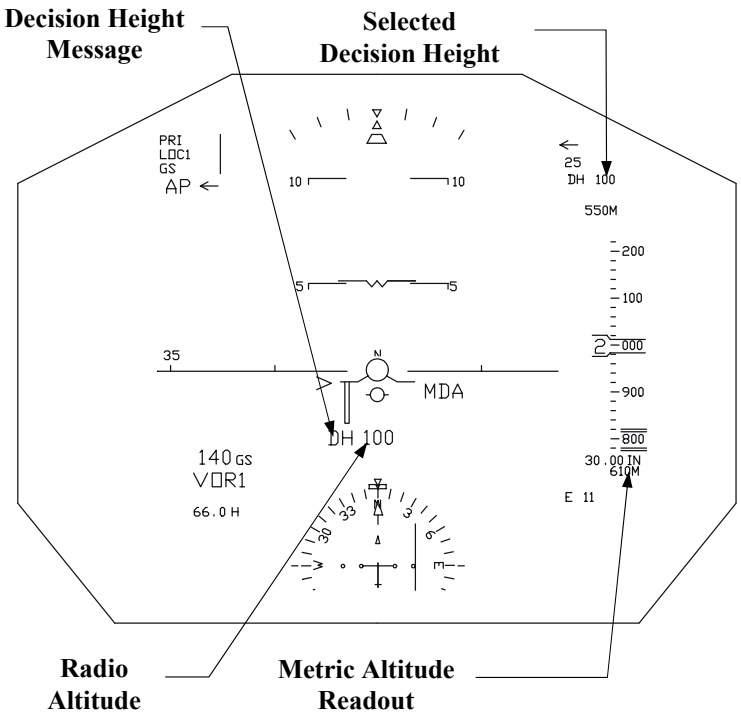


Figure 4-10:
PRI Mode Altitude Symbols

Selected Minimum Descent Altitude (MDA): The Selected MDA is displayed in the upper right corner of the display as “MDA” followed by the number.

MDA Alert Message: “MDA” is displayed to the right of center of the display when the selected MDA has been reached. It flashes for 2 seconds and then is steady.

Vertical Speed: Vertical Speed is displayed in the lower right corner of the display. Vertical Speed is displayed in 1000 feet per minute (FPM) increments. The displayed number is followed by the letters “VS”. The overall range of the Vertical Speed display is ±15,000 FPM.

Runway Elevation: shows the elevation entered on the HCP as “E” followed by the runway elevation in the lower right corner of the display. After the HCP runway elevation is changed, this symbol flashes for two seconds, shows for five seconds, and then is removed.

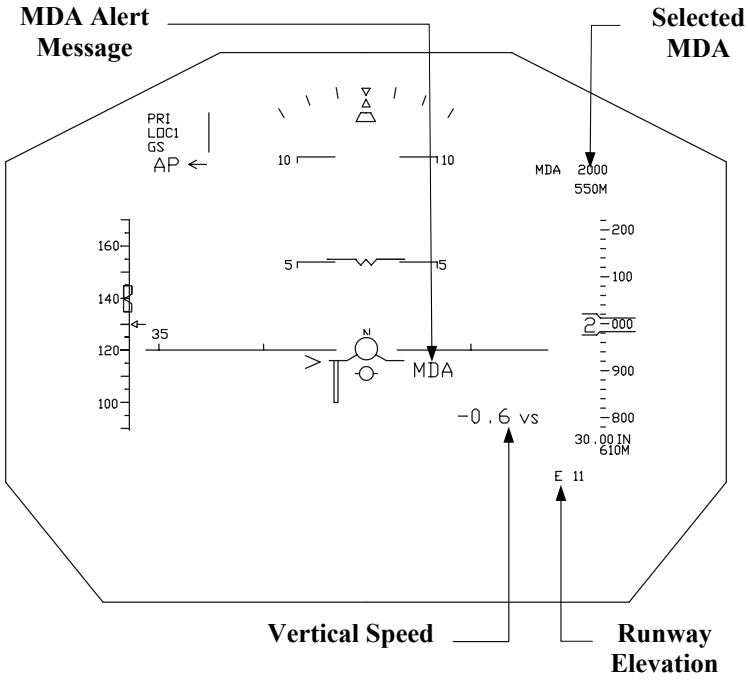


Figure 4-11:
PRI Mode Altitude Symbols

Primary Mode Navigation Symbol Group

See Figure 4-12 thru Figure 4-17. Table 4-4 gives the Primary Mode Navigation Symbol Group.

Table 4-4: Primary Mode Navigation Symbol Group

Symbol	PRI		TO
	Ground	Flight	
FCS Lateral Modes	●	●	●
FCS Vertical Modes	●	●	●
HGS Active Mode	●	●	●
HGS Armed Mode	●	●	
Autopilot Engaged Message		●	
Conformal Selected Heading Mark		●	●
Selected Heading Mark (HSI)		●	
Selected Heading	●	●	●
Conformal Selected Course Mark	●	●	●
Selected Course Mark (HSI)		●	
Selected Course/FMS Desired Track	●	●	●
Navigation Source	●	●	●
VOR TO/FROM Pointer (CDI)		●	
Lateral Deviation (CDI)		●	
Vertical Deviation Scale and Pointer		●	
DME/FMS Distance	●	●	●
Marker Beacons		●	
Heading Source	●	●	
Excessive Localizer Deviation		●	●
Excessive Glideslope Deviation		●	●

Table 4-4 continued on next page

Table 4-4, "Primary Mode Navigation Symbol Group," continued

Symbol	PRI		TO
	Ground	Flight	
FMS Waypoint Identifier		●	
FMS Messages		●	
FMS Reference Altitude		●	
FMS Vertical Speed		●	
Flight Director Transfer Message		●	
Bearing Source		●	
Bearing Pointers		●	

FCS Lateral Modes: The captured lateral FCS mode is shown underneath the active HGS mode on the left side of the Mode Separation Line (vertical line) in the upper left corner of the display. The armed lateral FCS mode is on the right side of the Mode Separation Line. See Table 4-5 for the FCS captured and armed lateral modes.

FCS Vertical Modes: The captured vertical FCS mode is shown underneath the captured lateral FCS mode on the left side of the Mode Separation Line in the upper left corner of the display. The armed vertical FCS mode is on the right side of the Mode Separation Line underneath the armed lateral FCS mode. See Table 4-6 for the FCS captured and armed vertical modes.

FCS captured and armed vertical modes are not available on the ground in TO Mode.

HGS Active Mode: The active HGS mode shows to the left of the Mode Separation Line in the upper left corner of the Combiner display. The symbol flashes for 5 seconds when the active mode changes. The abbreviations and their modes are:

"PRI"	Primary Mode is in use	"AI"	AI Mode is in use
"F/D"	F/D Mode is in use	"NO AI"	AI Mode cannot operate
"VMC"	VMC Mode is in use	"TO"	Takeoff Mode is in use
"AIII"	AIII Mode is in use	"NO TO"	TO Mode cannot operate
"NO AIII"	AIII Mode cannot operate	"RO"	Rollout Mode is in use
"AII"	AII Mode is in use	"NO RO"	RO Mode cannot operate
"NO AII"	AII Mode cannot operate		

HGS Armed Mode: The HGS armed mode shows to the right of the Mode Separation Line in the upper left corner of the Combiner display. The symbol flashes for 5 seconds when the armed mode changes. The abbreviations and their modes are:

"AIII"	AIII Mode is armed	"TO"	Takeoff Mode is armed
"AII"	AII Mode is armed	"RO"	Rollout Mode is armed
"AI"	AI Mode is armed		

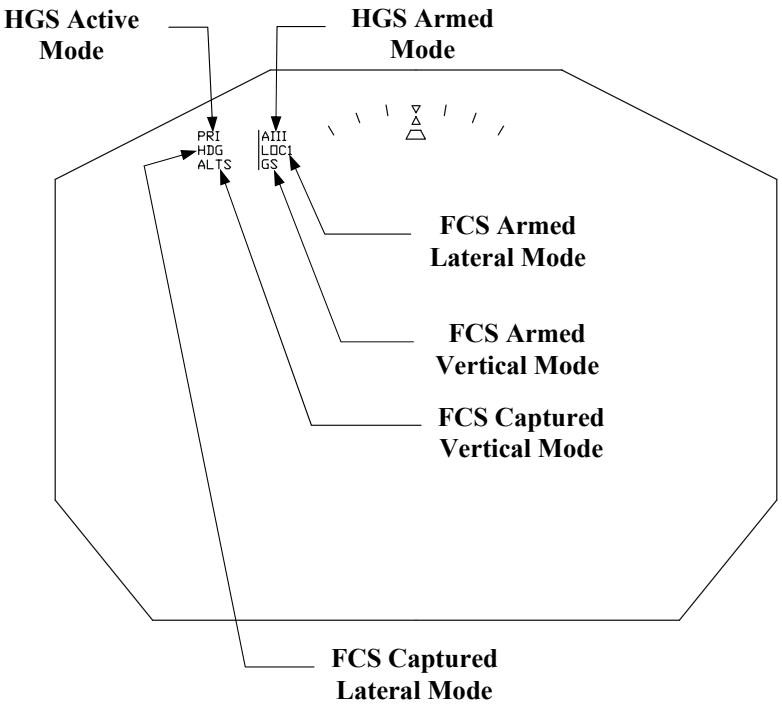


Figure 4-12:
PRI Mode Navigation Symbols

Table 4-5: PRI Mode FCS Lateral Modes

FCS Lateral Modes		
Captured	**Armed**	**Function**
“ROLL”	N/A	Roll hold
“GA”	N/A	Lateral go-around
“TO”	N/A	Takeoff
“HDG”	N/A	Heading select
“LOC 1” (or 2)	“LOC 1” (or 2)	LOC 1 or 2 arm/capture
“B/C 1” (or 2)”#	“B/C 1” (or 2)	Back Course 1 or 2 arm/capture
“VOR 1” (or 2)	“VOR 1” (or 2)	VOR 1 or 2 arm/capture
“B/C2”	“B/C2”	Back course localizer 1 or 2 arm/capture
“FMS 1” (or 2)	“FMS 1” (or 2)	FMS or FMS 1 or 2 arm/capture

Table 4-6: PRI Mode FCS Vertical Modes

FCS Vertical Modes		
Captured	**Armed**	**Function**
"PTCH"	N/A	Pitch hold
"GA"	N/A	Vertical go-around
"GA/WS"	N/A	Escape guidance during windshear and go-around
"TO"	N/A	Takeoff
"TO/WS"	N/A	Escape guidance during windshear and takeoff
"GS"	"GS"	Glideslope arm/capture
"ALTS"	"ALTS"	Selected altitude arm/track
"ALTS CAP"	N/A	Selected altitude capture
"~~ALTS~~"	N/A	Selected altitude invalid
"ALT"	N/A	Altitude hold
"MGP"	"MGP"	MSL GS arm/capture
"IAS" XXX	N/A	IAS hold (XXX = captured airspeed)
"MACH" .XX	N/A	Mach hold (.XX – selected Mach)
"VS" X.X ↑ or ↓	N/A	Vertical speed (X.X = selected vertical speed; arrows = up or down)
"DES" X.X	N/A	Vertical speed descent (X.X – profile vertical speed
"DES" XXXH	N/A	Airspeed descent (XXX = profile airspeed; H = high rate)
"DES" .XXH	N/A	Mach descent (.XX = profile Mach; H = high rate)
"CLM" XXXH	N/A	Airspeed climb (XXX = profile airspeed; H = high rate)
"CLM" .XXH	N/A	Mach climb (.X = profile Mach; H = high rate)

Autopilot Engaged Message: The Autopilot Engaged Message displays "AP" followed by a left- or right-pointing arrow when the autopilot is engaged. The arrow identifies which autopilot, left-side or right-side, is in operation. The symbol is in the upper left corner of the display. If flight-control failure occurs, the symbol flashes for 10 seconds and then is removed.

Conformal Selected Heading Mark: A Selected Heading Mark is displayed on the Zero-Degree Pitch Line to mark the Selected Heading. If the Selected Heading is outside the currently displayed heading scale on the Zero-Degree Pitch Line, then the Selected Heading Mark is not displayed.

Selected Heading Mark (HSI) A Selected Heading Mark is displayed on the HSI to mark the Selected Heading. If the Selected Heading is outside the currently displayed heading scale on the HSI, then the Selected Heading Mark is not displayed.

Selected Heading: Selected Heading is displayed to the right of the HSI as "HDG" followed by the selected heading. This symbol shows for 5 seconds when the selected heading is changed, and continuously if the aircraft heading is more than 100º from the selected heading.

Conformal Selected Course Mark: A Conformal Selected Course Mark is displayed below the Zero-Degree Pitch Line pointing to the related Selected Course. When the Selected Course is on the currently displayed heading scale, a 3° gap on the Zero-Degree Pitch Line shows around the Selected Course Mark. If the Selected Course is outside the currently displayed Heading Scale on the Zero-Degree Pitch Line, then the Conformal Selected Course Mark is "ghosted" to the side closest to the Selected Course. See "Non-Conformal Display Characteristics" later in this section.

Selected Course Mark (HSI): A Selected Course Mark is displayed at the head of the Course Deviation Indicator (CDI) inside the HSI. If the Selected Course is outside the currently displayed scale on the HSI, then the Selected Course Mark is not displayed. The reciprocal of the Selected Course is indicated by the tail of the CDI when in view.

Selected Course/FMS Desired Track: Selected Course/FMS Desired Track is displayed as "CRS" followed by the aircraft's selected course in left lower part of the display. This symbol shows for 5 seconds when the selected course is changed, and continuously if the aircraft course is more than 100º from the selected course.

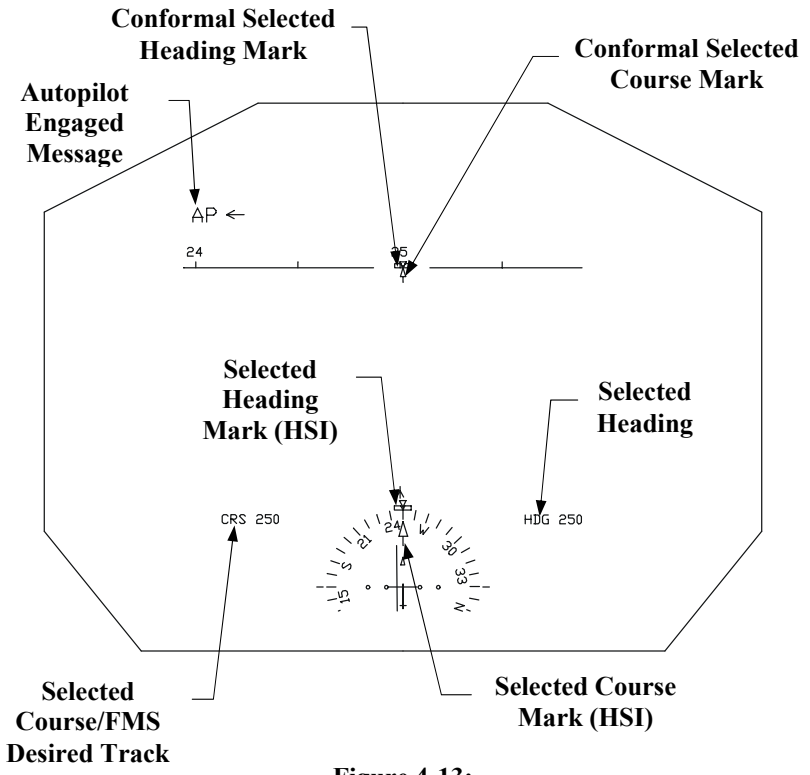


Figure 4-13:
PRI Mode Navigation Symbols

Navigation Source: The Navigation Source is in the lower left corner of the display shows the navigation source set on the Display Control Panel. The possible Navigation Sources are listed in Table 4-7.

Table 4-7: Primary Mode Navigation Sources

Symbol	Function
“LOC1”	#1 GS/LOC Receiver tuned and shows on left-side PFD
“LOC2”	#2 GS/LOC Receiver tuned and shows on left-side PFD
“FMS”	Single FMS installation: FMS is navigation source and shows on left-side PFD
“FMS1”	Dual FMS installation: #1 FMS is navigation source and shows on left-side PFD
“FMS2”	Dual FMS installation: #2 FMS is navigation source and shows on left-side PFD
“VOR1”	#1 NAV Receiver tuned to VOR (ILS #1 not tuned) and shows on left-side PFD
“VOR2”	#2 NAV Receiver tuned to VOR (ILS #2 not tuned) and shows on left-side PFD

VOR TO/FROM Pointer (CDI): VOR TO/FROM is displayed inside the Selected Course Mark. When pointing in the same direction as Selected Course, it indicates a “TO” condition; pointing away from the Selected Course, it indicates a “FROM” condition. The TO/FROM indicator is displayed when the Nav source is VOR and while VOR deviation is valid.

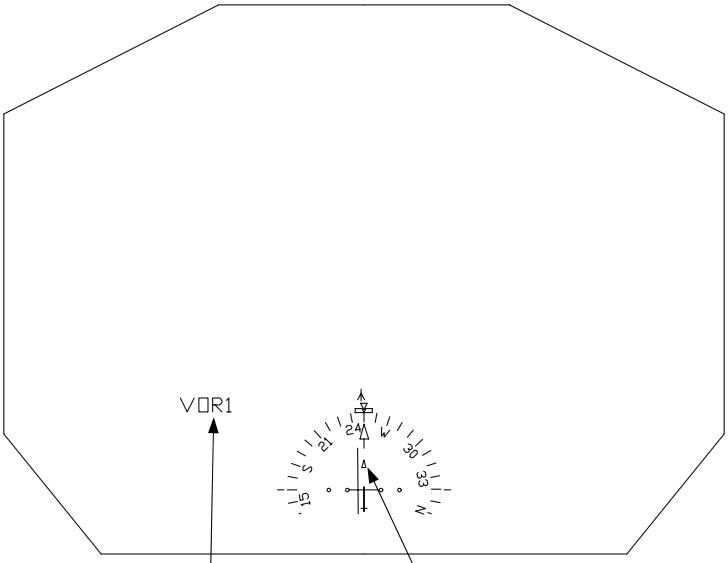


Figure 4-14:
PRI Mode Navigation Symbols

Lateral Deviation (CDI): Lateral Deviation is displayed on the HSI as a conventional Course Deviation Indicator (CDI). Displacement of the CDI with respect to its null position at the center of the ±2 dot scale is the indication of the current lateral deviation during ILS, VOR, or FMS operation.

Vertical Deviation Scale and Pointer: During ILS or FMS operations, Vertical Deviation is displayed as a pointer against a vertical scale on the right side of the display just inside and centered on the Altitude Scale. Displacement of the Vertical Deviation Pointer from its center position on the ±2 dot scale, indicates the current vertical deviation. When the NAV source is LOC, the pointer is a diamond. When the NAV source is FMS, the pointer is an asterisk ("*").

DME/FMS Distance: DME/FMS Distance is displayed in the lower left corner of the display. The distance is displayed in 0.1 nautical mile increments between 0 and 99.9 miles, and in one nautical mile increments above 99.9 miles. The distance is from the DME when the NAV source is VOR or LOC and from the FMS waypoint when FMS is selected. The distance is followed by "NM" or "H" for a "HOLD" mode.

Marker Beacons: Flying over a marker beacon is shown by the boxed letters "OM", "MM", "IM" for Outer Marker, Middle Marker, and Inner Marker, respectively. Each of the symbols flashes above the Aircraft Reference Symbol.

Heading Source: The current Heading Source shows above the HSI. This symbol gives the heading source, which is identified by one of the sets of characters that follow:

Symbol	Status
"MAG"	Normal
"MAG1"	Both on 1
"MAG2"	Both on 2
"TRU"	Normal
"TRU1"	Both on 1
"TRU2"	Both on 2

If the heading source is not valid, the Heading Source symbol is boxed.

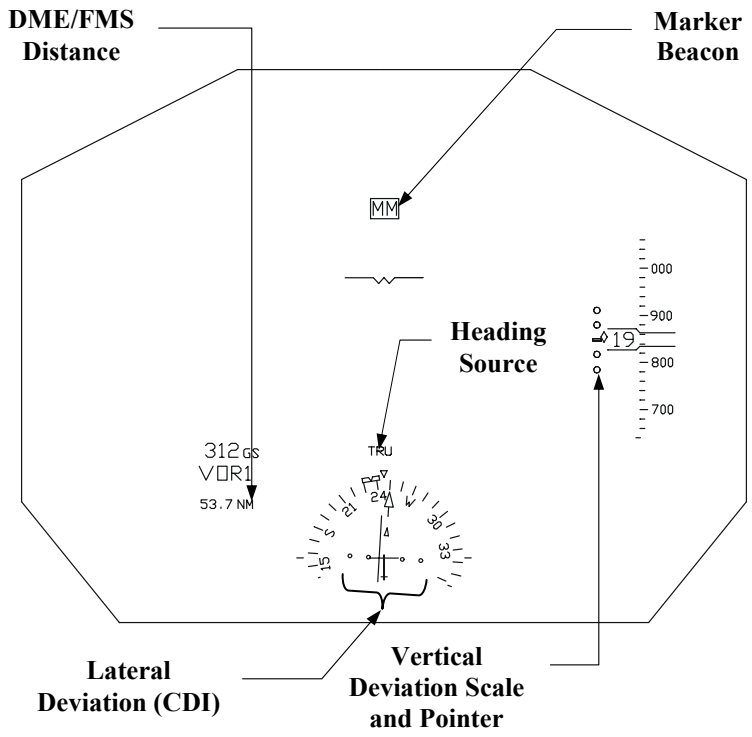


Figure 4-15:
PRI Mode Navigation Symbols

Excessive Localizer Deviation: Excessive Localizer Deviation shows as a right or left-pointing triangle to the side of the Flight Path symbol to give the direction of correction for the aircraft. The symbol flashes continuously until localizer deviation is within limits.

Excessive Glideslope Deviation: shows as a downward or upward-pointing triangle above or below the Flight Path symbol to give direction of correction for the aircraft. The symbol flashes continuously until the glideslope deviation is within limits.

FMS Waypoint Identifier: The FMS Waypoint Identifier identifies the next FMS waypoint on the flight plan. This symbol shows in the lower left corner of the display when flight-path data is set. If an FMS LNAV alert occurs, the symbol flashes continuously.

FMS Messages: The FMS Messages are shown on one to two lines to give data about FMS conditions. Eight characters can show on each line. This symbol shows under the FMS Waypoint Identifier and flashes continuously.

FMS Reference Altitude: FMS Reference Altitude is shown above the Altitude Scale when the FMS flight plan is in use. The altitude is followed by “VN” and is the next waypoint crossing altitude.

FMS Vertical Speed: FMS Vertical Speed followed by “VN” give the vertical speed that should be maintained to reach the FMS Waypoint Reference Altitude. It is displayed in the lower right corner of the display.

Flight Director Transfer Message: “FD2” below the HGS and FCS modes in the upper left corner of the Combiner display is shown when the left-side pilot’s Flight Director source is #2.

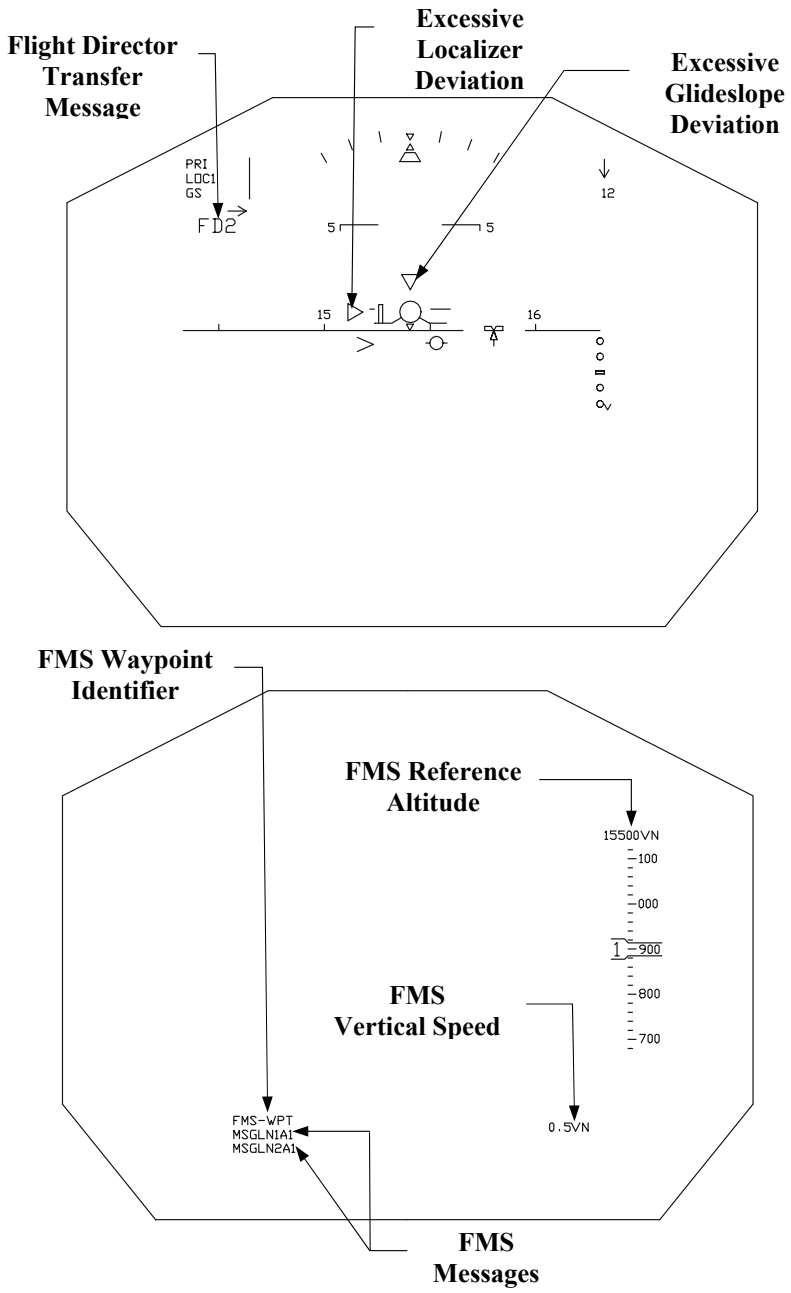


Figure 4-16:
PRI Mode Navigation Symbols

Bearing Source: Bearing Source #1 shows to the left of the HSI and Bearing Source #2 shows to the right of the HSI. Table 4-8 identifies the bearing source symbol and function.

Table 4-8: Primary Mode Bearing Source Annunciations

Symbol	Function
"ADF1"	#1 ADF Receiver tuned and shows on left-side PFD
"ADF2"	#2 ADF Receiver tuned and shows on left-side PFD
"FMS"	Single FMS installation: FMS is navigation source and shows on left-side PFD
"FMS1"	Dual FMS installation: #1 FMS is navigation source and shows on left-side PFD
"FMS2"	Dual FMS installation: #2 FMS is navigation source and shows on left-side PFD
"VOR1"	#1 NAV Receiver tuned to VOR and shows on left-side PFD
"VOR2"	#2 NAV Receiver tuned to VOR and shows on left-side PFD

Each set of characters is followed on the right by a Bearing Source symbol.

Bearing Pointers: these symbols are pointers that move on the outside of the HSI. As the symbols move, they identify the selected bearing source as it relates to the aircraft heading.

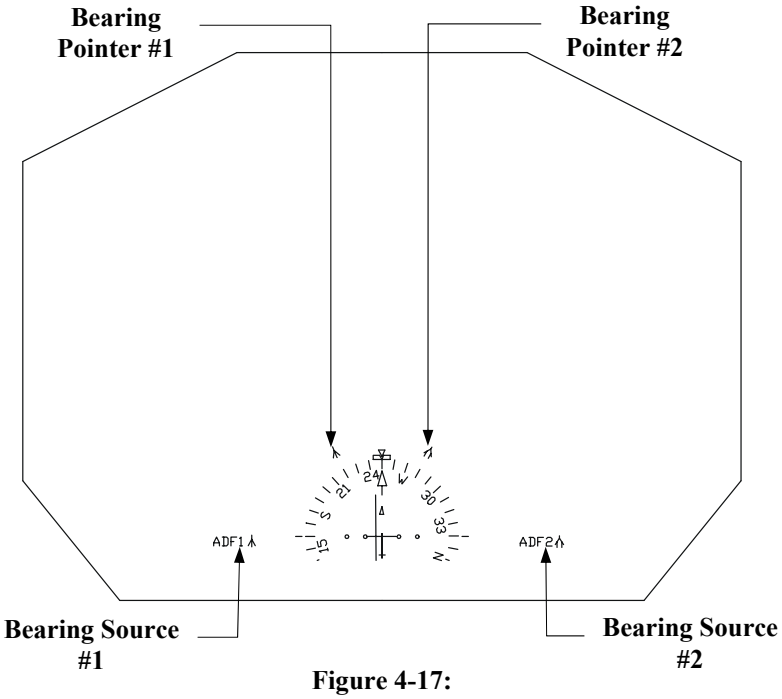


Figure 4-17:
PRI Mode Navigation Symbols

Primary Mode Flight Path Symbol Group

See Figure 4-18 thru Figure 4-20. Table 4-9 gives the Primary Mode Flight Path Symbol Group that moves together.

Table 4-9: Primary Mode Flight Path Symbol Group

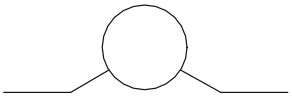
Symbol	PRI		TO
	Ground	Flight	
Flight Path Symbol		●	●
Flight Path Acceleration	●	●	●
Speed Error Tape		●	
FCS-Derived Guidance Cue		●	
Flight Path Slip/Skid Indicator		●	
Flare Cue		●	

Flight Path Symbol (FPS): The Flight Path Symbol is unique information not normally available on conventional head-down displays. The FPS shows the actual flight path vector of the aircraft. The gull wings of the FPS are angled downward at 30° to the horizon so that in a 30° level turn, the 30° angle overlays the Zero-Degree Pitch Line.

The FPS is inertially derived and gives an immediate indication of where the aircraft is going. The left-side pilot can maneuver the aircraft and "fly" the FPS to the desired point. For example, if the FPS is above the Zero-Degree Pitch Line, the aircraft is climbing. If it is below the Zero-Degree Pitch Line, the aircraft is descending. The Flight Path angle is indicated by the position of the center of the Flight Path circle relative to the pitch scale. If the FPS overlays the runway touchdown point and the Flight Path angle is -3°, then the aircraft is tracking a -3° approach angle to the runway touchdown point.

The Flight Path symbol is only displayed in flight and has priority over all other symbols except the Guidance Cue and Flare Command symbology. Any part of any other symbol that is within the circular portion of the FPS is not displayed.

The Flight Path symbol position can be limited laterally or vertically. When this occurs the FPS is "ghosted", meaning it is displayed as dashed lines rather than solid lines. This indicates that the FPS is no longer conformal with the real world scene. See "Non-Conformal Displays" later in this section for additional information.



Flight Path Symbol

"Ghosted" Flight Path Symbol

Figure 4-18:
PRI Mode Flight Path Symbols

Flight Path Acceleration: The inertial acceleration (or deceleration) of the aircraft along the flight path is indicated by the Flight Path Acceleration symbol. It is an indication of the total sum of all forces affecting the aircraft including thrust, drag, and the air mass through which the aircraft is moving. It represents the current energy state of the airplane. Therefore, it should not be thought of as a throttle indicator or command; however, it can be used very effectively to control speed or flight path angle.

In flight, the Flight Path Acceleration symbol is positioned to the left of the Flight Path Symbol. When the symbol is above the "wing" of the Flight Path symbol, the aircraft is accelerating. When it is below the Flight Path symbol wing, the aircraft is decelerating. When the symbol points directly at the left wing of the Flight Path symbol, it shows that the aircraft is in a steady state (neither accelerating nor decelerating).

If the Flight Path symbol is removed, the Flight Path Acceleration symbol is referenced to the Aircraft Reference Symbol.

On the ground, the Flight Path Acceleration symbol uses the Aircraft Reference or the Ground Roll Reference symbol as its reference.

Speed Error Tape: The Speed Error Tape displays the difference between the indicated airspeed and the selected airspeed. It is positioned on the left wing of the Flight Path symbol and rises above the wing when the airspeed is higher than selected, or falls below the wing when it is slower. Each one degree on the Speed Error Tape (about the diameter of the Flight Path circle) represents approximately five knots of airspeed error. The tape length is limited to 15 knots of error.

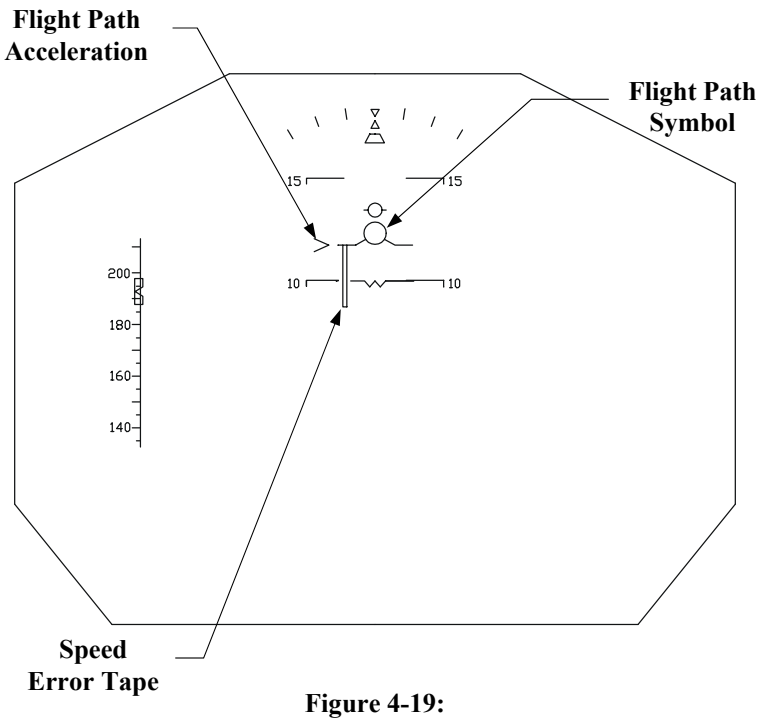


Figure 4-19:
PRI Mode Flight Path Symbols

FCS-Derived Guidance Cue: The FCS-Derived Guidance Cue can be thought of as a "Flight Path Director". It functions in the same way as a conventional single cue flight director. The object is to center the Guidance Cue inside the Flight Path circle using pitch and roll inputs. The lines on the Guidance Cue indicate roll commands.

During an EGPWS Windshear warning, the Guidance Cue becomes solid and flashes for 10 seconds and then is steady.

Flight Path Slip/Skid Indicator: A Flight Path Slip/Skid Indicator is displayed during a single engine approach or a single engine takeoff or go-around.

This Slip/Skid Indicator moves laterally underneath the Flight Path Symbol to show lateral acceleration of the aircraft.

Flare Cue: A Flare Cue reminds the left-side pilot to visually flare the aircraft. The Flare Cue is a pair of plus symbols ("+ +"): one shows on each side and directly above the wings of the Flight Path symbol. The Flare Cue flashes as the aircraft descends through 60 feet Radio Altitude, and continues flashing until the aircraft descends through 30 feet.

NOTE: The Flare Cue is fixed to the Flight Path Symbol and is not used to command or provide guidance for the flare maneuver.

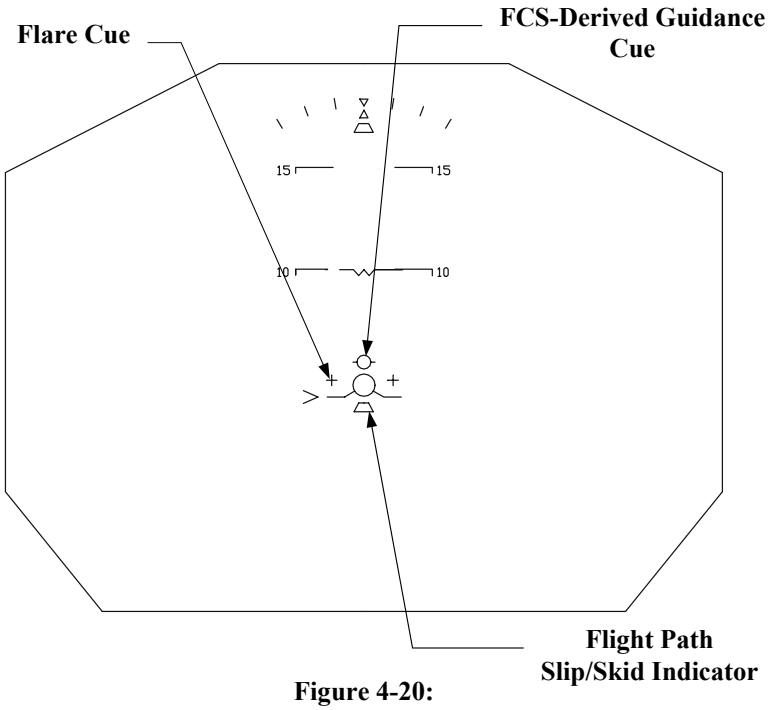


Figure 4-20:
PRI Mode Flight Path Symbols

Primary Mode Takeoff Symbol Group

See Figure 4-21 and Figure 4-22. Table 4-10 gives the Takeoff Mode Symbol Group.

Table 4-10: Primary Mode Takeoff Symbol Group

Symbol	PRI		TO
	Ground	Flight	
Ground Roll Reference			●
Ground Localizer Deviation Scale and Pointer			●
HGS-Derived Ground Guidance Cue			●
Runway Remaining			●
Deceleration Scale and Pointer	●		●

Ground Roll Reference: The Ground Roll Reference symbol is unique information not normally available on conventional head-down displays. It is a circle with straight "wings" on either side. The Ground Roll Reference shows the actual ground track of the aircraft.

Ground Localizer Deviation Scale and Pointer: If enabled, the Ground Localizer Deviation Scale and Pointer is displayed below the Ground Reference symbol. The pointer is centered when the aircraft is tracking the localizer. Pointer movement away from center shows the aircraft's lateral deviation from the runway centerline.

HGS-Derived Ground Guidance Cue: The HGS Ground Guidance Cue gives lateral guidance to track the runway center line during guided takeoffs.

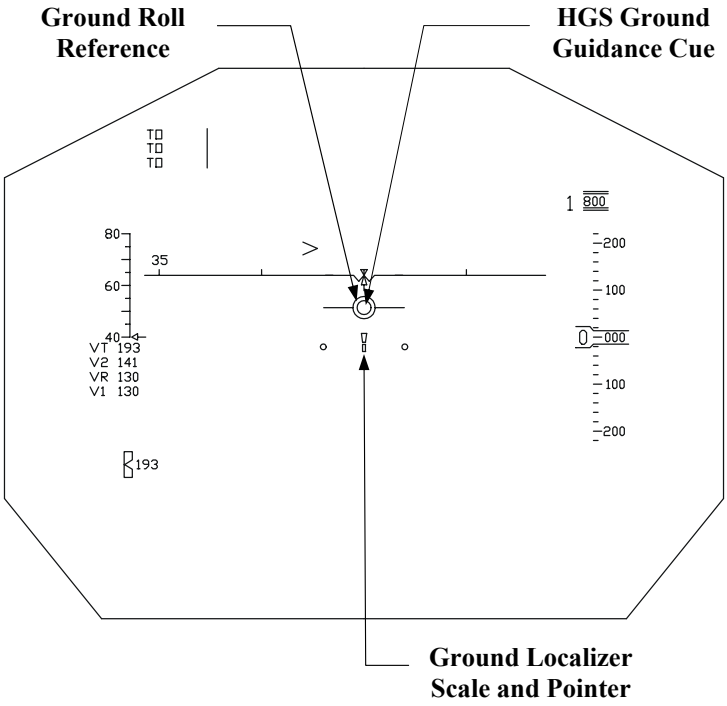


Figure 4-21:
PRI Mode Takeoff Symbols

Runway Remaining: If enabled, Runway Remaining shows the distance to the rollout end of the runway. It is shown on the right side of the display as "RWY" above distance.

When the runway remaining is in feet, the number is rounded to the next lowest 500 feet. When the runway remaining is less than 500 feet, "0" shows.

When the runway remaining is in meters, the numbers are followed by "M" and the number is rounded to the next lowest 100 meters. When the runway remaining is less than 100 meters, "0" shows.

Deceleration Scale and Pointer: If enabled, the Deceleration Scale and Pointer are displayed on the ground to show the rate of deceleration. The Deceleration Scale is located in the center of the display below the Ground Reference symbol. If ground speed reaches 50 knots during a rejected takeoff, the Deceleration Scale and Pointer show until ground speed is less than 20 knots.

The pointer (">") moves along the scale to show aircraft deceleration. The numbers show as -0.3, -0.5, and -0.8 G.

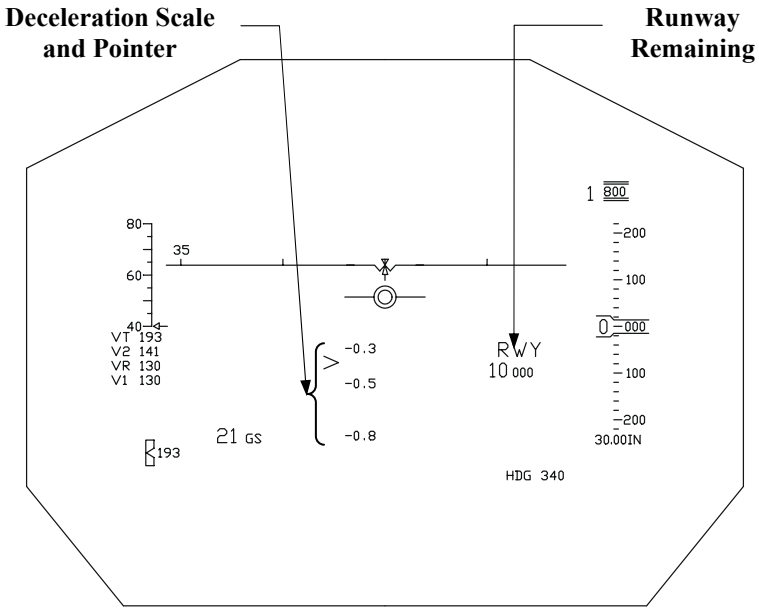


Figure 4-22:
PRI Mode Takeoff Symbols

Approach Modes Symbology

Many symbols are common to all HGS modes. Common Symbol descriptions and illustrations are duplicated in both the “Primary Mode Symbology” and “Approach Mode Symbology” parts of this section. Because AIII is the recommended approach mode, it is the focus of the approach mode symbol descriptions and illustrations that follow.

Symbols for AIII, AII, AI, RO, F/D, and VMC modes are described and illustrated in the following order:

- Attitude
- Airspeed
- Altitude
- Navigation
- Flight Path
- Rollout

Approach Modes Attitude Symbol Group

See Figure 4-23 thru Figure 4-26. Table 4-11 gives the symbols in the Approach Modes Attitude Symbol Group.

Table 4-11: Approach Modes Attitude Symbol Group

Symbol	AIII	AII	AI	RO	F/D	VMC
Aircraft Reference	●	●	●	●	●	●
Roll Scale and Pointer	●	●	●	●	●	●
Zero-Degree Pitch Line	●	●	●	●	●	●
Pitch Scale	●	●	●	●	●	●
Conformal Magnetic Heading Scale (tic marks)	●	●	●	●	●	●
Conformal Magnetic Heading Index	●	●	●	●	●	●
Roll Scale Slip/Skid Indicator	●	●	●	●	●	●
Angle-of-Attack Indicator	●	●	●		●	●
Angle-of-Attack Limit	●	●	●		●	●
Pitch Chevrons	●	●	●		●	●

Aircraft Reference: The Aircraft Reference Symbol (Boresight symbol), represents the projected centerline of the aircraft (boresight). The vertex of the symbol is the actual boresight point.

The Aircraft Reference symbol is positioned at a fixed location on the display and, unlike other displayed symbols, it is not dependent on any sensor or equipment inputs. Its function is similar to the aircraft symbol on conventional attitude instruments and is always present when the HGS is powered and in normal operation.

Roll Scale and Pointer: The Roll Scale and Pointer is above the Aircraft Reference Symbol. The scale has tic marks at 10° increments between 0° and ±30°. Tic marks at 45° and 60° are also added to the Roll Scale when the aircraft exceeds ±40° and ±55° respectively. The Roll Scale is similar to the "Sky Pointer" on a conventional ADI. The pointer points to the corresponding roll attitude on the scale.

Zero-Degree Pitch Line: The Zero-Degree Pitch Line is used with the Aircraft Reference symbol to represent the pitch attitude of the aircraft. When the Flight Path Symbol overlays the Zero-Degree Pitch Line, the aircraft is in level flight.

NOTE: Because of the earth's curvature, the Zero-Degree Pitch Line is only aligned with the physical horizon at 0 ft AGL. As the altitude of the aircraft increases, a separation between the horizon and the Zero-Degree Pitch Line is visible (most noticeable above 2500 ft AGL). At cruising altitudes, there can be a significant separation between the Zero Degree Pitch Line and the horizon. This difference should not be interpreted as an error in the positioning of the Zero-Degree Pitch Line.

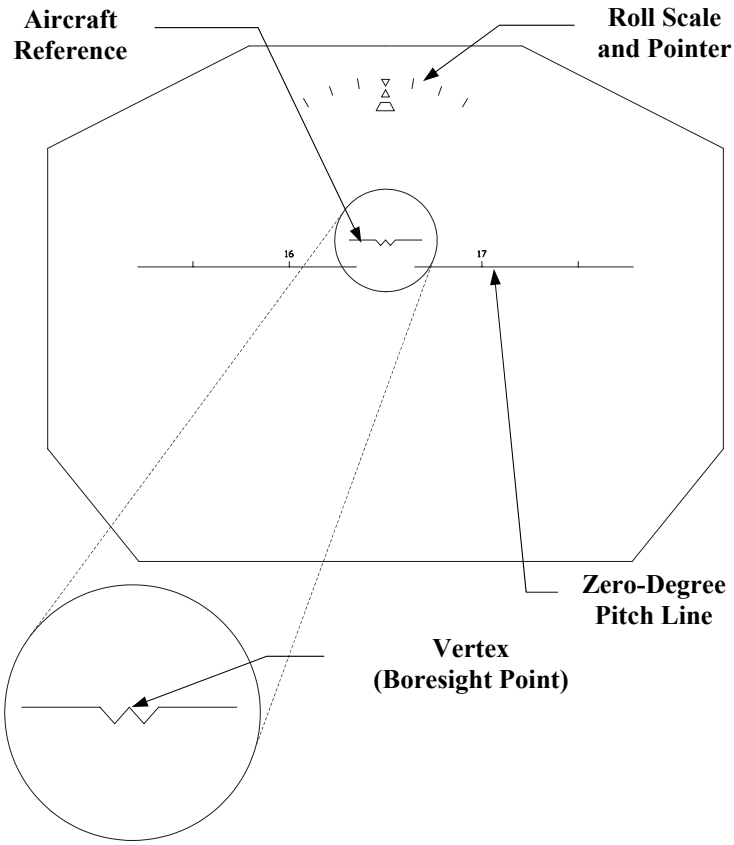


Figure 4-23:
Approach Modes Attitude Symbols

Pitch Scale: The Pitch Scale displays in five-degree increments from -20° to +30° and in ten-degree increments below -20° and above 30°. At the ends of the each pitch line is a vertical tic mark pointed in the direction of the Zero-Degree Pitch Line and labeled with its related scale (e.g., 5, -5, and so on). Vertical attitude is determined by noting where the scale is positioned in relation to the Aircraft Reference Symbol.

When the aircraft attitude is approximately ±8°, the Zero-Degree Pitch Line and the Flight Path Symbol cannot be displayed conformally. The Pitch Scale is compressed to allow these symbols to remain on the display. The position of these symbols is maintained relative to one another, but the display is no longer conformal with the real world. When display compression occurs, certain vertical scale lines are removed. See "Non-Conformal Display Characteristics" later in this section.

Conformal Magnetic Heading Scale (tic marks): The Conformal Magnetic Heading Scale is displayed on the Zero-Degree Pitch Line. The scale is marked every 5° (tic marks), and labeled every 10°. Magnetic Heading is conformal with the real world. For example: a point on the earth underlying the "13" mark on the Magnetic Heading Scale would take a heading of 130° to fly over. The four cardinal headings of North, South, East, and West are expressed as N, S, E, and W respectively.

Conformal Magnetic Heading Index: At the center of the Zero-Degree Pitch Line is a downward pointing triangle called the Magnetic Heading Index. This points to the actual Magnetic Heading of the aircraft (where the nose is pointing) and is positioned directly below (or above) the Aircraft Reference Symbol.

Roll Scale Slip/Skid Indicator: The Roll Scale Slip/Skid Indicator is located as part of the Roll Scale Pointer. The bottom portion of the Roll Scale Pointer moves laterally with respect to the top triangle portion of the pointer and is dependent on the lateral acceleration of the aircraft. The Roll Scale Slip/Skid Indicator functions like a conventional slip/skid indicator.

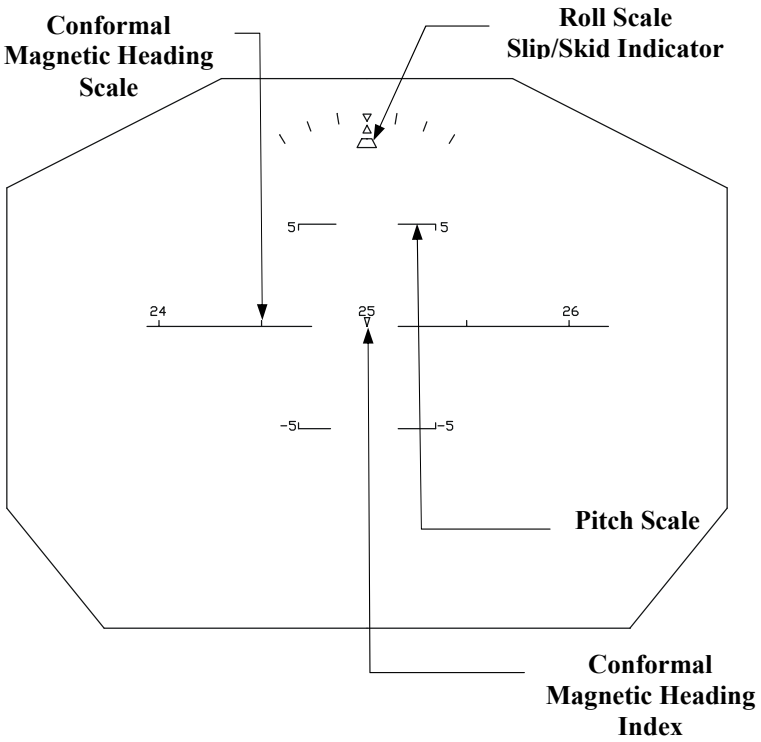


Figure 4-24:
Approach Modes Attitude Symbols

Angle-of-Attack (AOA) Indicator: If enabled, the Angle of Attack Indicator provides an indication of the aircraft angle of attack in digital and analog forms. The AOA pointer rotates within the AOA dial to provide an analog indication of the aircraft AOA.

The stick shaker pointer is a representation of the AOA that will result in a stick shaker occurrence. The area beyond the stick shaker pointer is a stay-out zone and is graphically symbolized by groups of lines.

The approach reference band is an indication of the normal AOA for approach, and is variable with changes to flap settings. Refer to Table 4-12 for Flap Positions and their related Maximum and Minimum AOA. The AOA digital readout is always displayed when the AOA indicator is active.

Table 4-12: CRJ 700 Approach Reference Band Positions

Flap Position	Maximum AOA	Minimum AOA
0º	6.9º	4.7º
10º	8.1º	5.7º
20º	8.0º	4.4º
30º	5.8º	2.9º
45º	4.3º	1.1º

Angle-of-Attack (AOA) Limit: The AOA Limit symbol shows when the angle of attack is 80% of the stick shaker angle of attack. It is positioned to indicate the difference between current angle of attack and the angle of attack at which stick shaker will occur. If the AOA Limit symbol is two degrees above the Flight Path symbol, stick shaker will occur if the angle of attack is increased by two degrees. The AOA Limit symbol is positioned on the Flight Path symbol (boxed ends set on the Flight Path wings) when stick shaker occurs.

Pitch Chevrons: There are two Pitch Chevrons located on the Pitch Scale. They point toward level flight. One is located with the point of its “V” at +30° (extreme pitch up), the other at -20° (extreme pitch down).

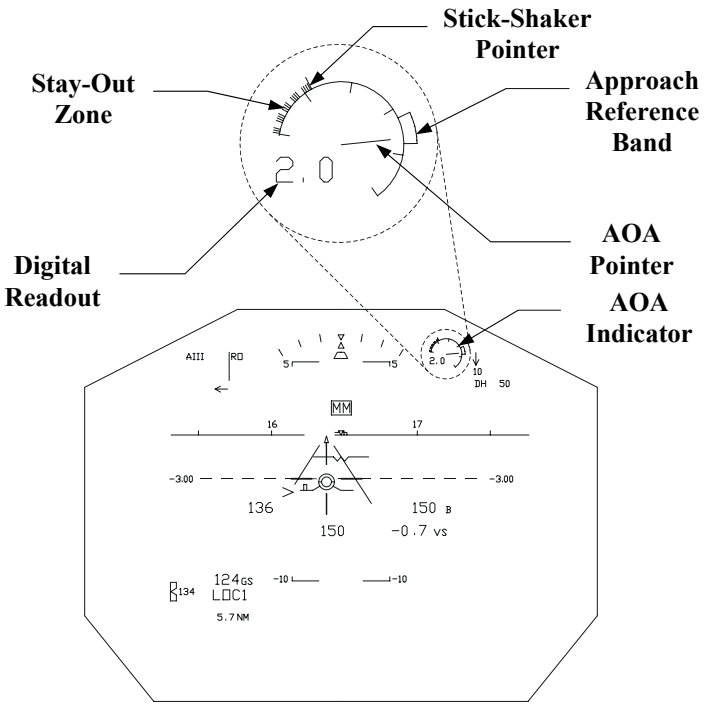


Figure 4-25:
Approach Modes Attitude Symbols

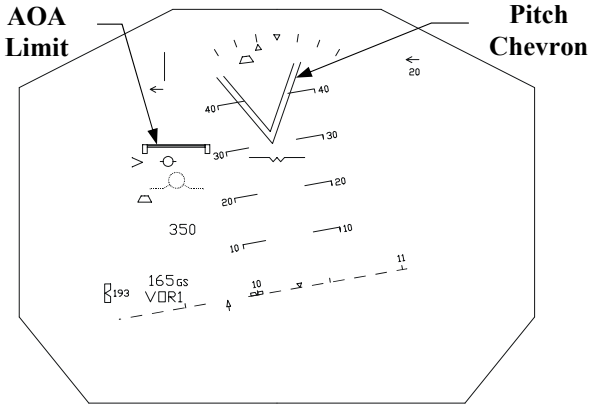


Figure 4-26:
Approach Modes Attitude Symbols

Approach Modes Airspeed Symbol Group

See Figure 4-27. Table 4-13 gives the Approach Modes Airspeed Symbol Group.

Table 4-13: Approach Modes Airspeed Symbol Group

Symbol	AIII	AII	AI	RO	F/D	VMC
Computed Airspeed	●	●	●	●	●	●
Selected Airspeed/Mach	●	●	●		●	●
Wind Speed and Direction	●	●	●		●	●
Ground Speed	●	●	●	●	●	●

Computed Airspeed: Computed Airspeed is positioned below and to the left of the Flight Path Symbol. It only shows values between 40 and 400 knots.

Selected Airspeed/Mach: Selected Airspeed or Mach is displayed in the lower left corner of the display. The Mach Number is displayed as a decimal point with two digits to the right.

Wind Speed and Direction: The current wind speed and direction, derived from the IRU, is displayed in the upper right corner of the display. Wind Speed is displayed directly below the Wind Direction arrow.

The Wind Direction arrow is referenced to the aircraft's heading and indicates the direction from which the wind is blowing. For example, a Wind Direction arrow pointing straight up (the 12 o'clock position) identifies a direct tail wind. A Wind Direction arrow pointing to the right (the 3 o'clock position) identifies a direct left crosswind.

The IRU based Wind Speed and Direction are displayed when the aircraft is in flight and wind speed exceeds 3 knots.

Ground Speed: The IRS Ground Speed is displayed in the lower left corner of the display. Ground Speed is shown with the letters "GS" following the number.

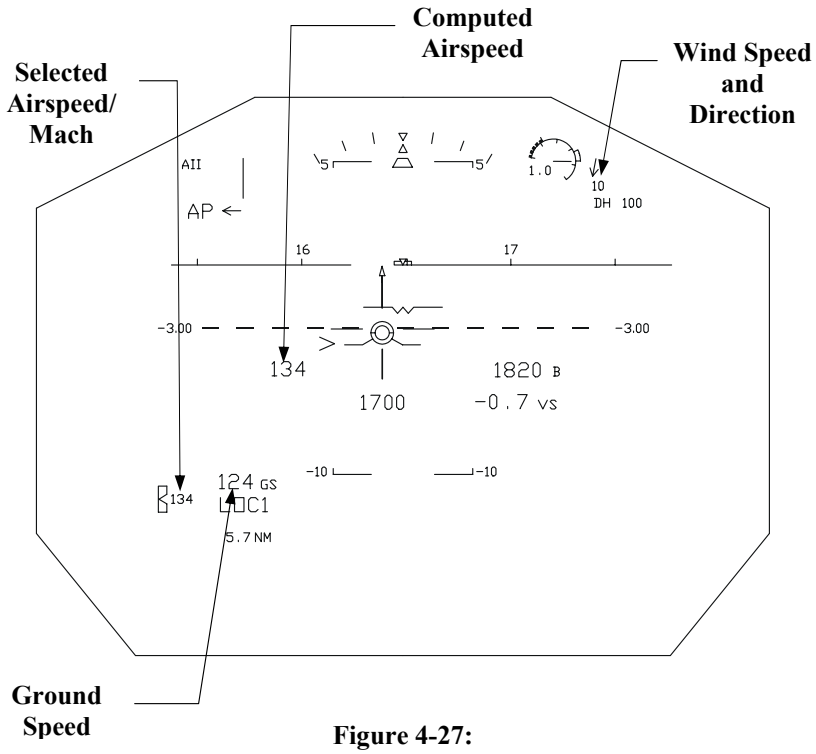


Figure 4-27:
Approach Modes Airspeed Symbols

Approach Modes Altitude Symbol Group

See Figure 4-28 and Figure 4-29. Table 4-14 gives the Approach Modes Altitude Symbol Group.

Table 4-14: Approach Modes Altitude Symbol Group

Symbol	AIII	AII	AI	RO	F/D	VMC
Barometric Altitude	●	●	●		●	●
Radio Altitude	●	●	●		●	●
Selected Decision Height	●	●	●		●	●
Decision Height Message	●	●	●		●	●
Selected Minimum Descent Altitude (MDA)	●	●	●		●	●
MDA Alert Message	●	●	●		●	●
Vertical Speed	●	●	●		●	●

Barometric Altitude: Barometric Altitude is positioned below and to the right of the FPS and is followed by the letter “B”. It moves with the Flight Path group.

Radio Altitude: Radio Altitude is displayed directly below the Flight Path Symbol when Radio Altitude is less than or equal to 2,500 feet. If the Flight Path Symbol is not displayed, the Radio Altitude is displayed relative to the Aircraft Reference Symbol. It is displayed in 50-foot increments between 1000 and 2,500 feet, in 10-foot increments between 50 and 1000 feet, in 5-foot increments between 10 and 50 feet, and in 1-foot increments between 0 and 10 feet.

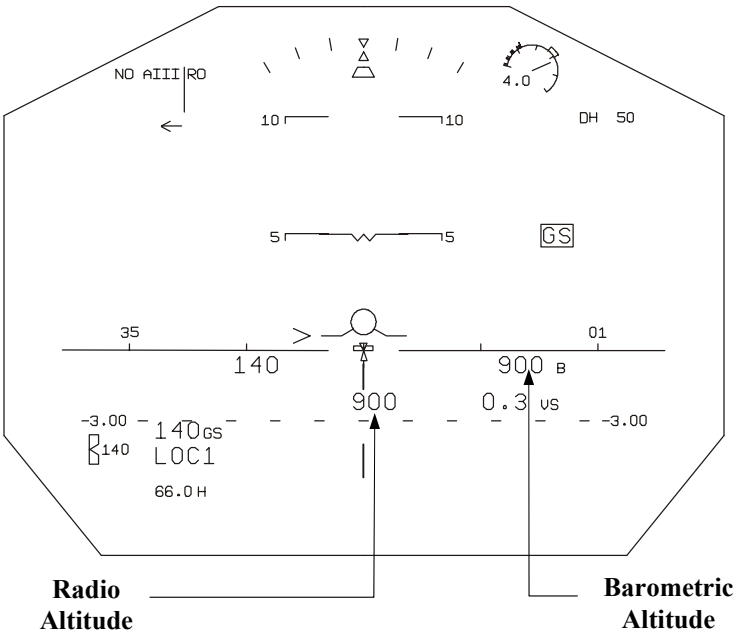


Figure 4-28:
Approach Modes Altitude Symbols

Selected Decision Height: Selected Decision Height shows as “DH” that is followed by numbers in the upper right corner of the display. Use the left-side ARP (Air-Data Reference Panel) to set the Selected Decision Height.

Decision Height Message: A Decision Height (DH) message is displayed to the left of the Radio Altitude display when the selected DH has been reached. “DH” flashes for 10 seconds and then is steady. The symbol is removed at 5 feet, or if the aircraft climbs above the Selected DH plus 100 feet.

Selected Minimum Descent Altitude (MDA): The Selected MDA is displayed in the upper right corner of the display as “MDA” followed by the number.

MDA Alert Message: “MDA” is displayed to the right of center of the display when the selected MDA has been reached. It flashes for 2 seconds and then is steady.

Vertical Speed: Vertical Speed is displayed in the lower right corner of the display. Vertical Speed is displayed in 1000 feet per minute (FPM) increments. The displayed number is followed by the letters “VS”. The overall range of the Vertical Speed display is ±15,000 FPM.

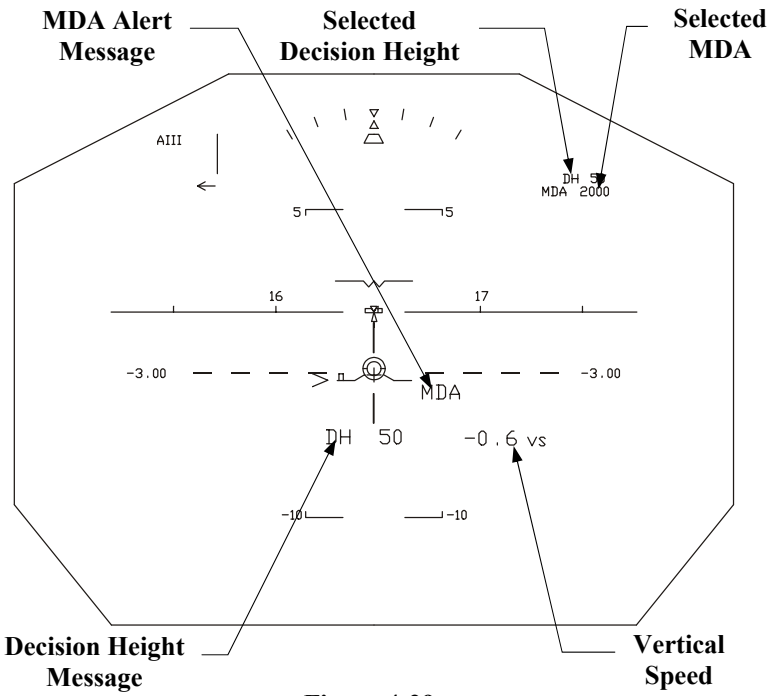


Figure 4-29:
Approach Modes Altitude Symbols

Approach Modes Navigation Symbol Group

See Figure 4-30 thru Figure 4-36. Table 4-15 gives the Approach Modes Navigation Symbol Group.

Table 4-15: Approach Modes Navigation Symbol Group

Symbol	AIII	AII	AI	RO	F/D	VMC
FCS Lateral Modes					●	
FCS Vertical Modes					●	
HGS Active Mode	●	●	●	●	●	●
HGS Armed Mode	●					
Autopilot Engaged Message			●		●	●
Conformal Selected Heading Mark	●	●	●		●	●
Selected Heading	●	●	●	●	●	●
Conformal Selected Course Mark	●	●	●	●	●	●
Selected Course/FMS Desired Track	●	●	●	●	●	●
Runway Edge Lines	●					
Navigation Source	●	●	●	●	●	
Lateral Deviation Line	●	●	●		●	
Glideslope Deviation Line	●	●	●		●	
DME/FMS Distance	●	●	●	●	●	●
Marker Beacons	●	●	●		●	●

Table 4-15 continued on next page

Table 4-15, "Approach Modes Navigation Symbol Group," continued

Symbol	AIII	AII	AI	RO	F/D	VMC
Heading Source					●	●
Excessive Localizer Deviation	●	●	●	●	●	
Excessive Glideslope Deviation	●	●	●		●	
FMS Waypoint Identifier					●	
FMS Messages					●	
FMS Reference Altitude					●	
FMS Vertical Speed					●	
Flight Director Transfer Message					●	
Autopilot Disconnect Message	●					

FCS Lateral Modes: The captured lateral FCS mode is shown underneath the active HGS mode on the left side of the Mode Separation Line (vertical line) in the upper left corner of the display. The armed lateral FCS mode is on the right side of the Mode Separation Line. See Table 4-16 for the FCS captured and armed lateral modes.

FCS Vertical Modes: The captured vertical FCS mode is shown underneath the captured lateral FCS mode on the left side of the Mode Separation Line in the upper left corner of the display. The armed vertical FCS mode is on the right side of the Mode Separation Line underneath the armed lateral FCS mode. See Table 4-17 for the FCS captured and armed vertical modes.

HGS Active Mode: The HGS active mode shows to the left of the Mode Separation Line in the upper left corner of the Combiner display. The symbol flashes for 5 seconds when the active mode changes. The abbreviations and their modes are:

"PRI"	Primary Mode	"AI"	AI Mode
"F/D"	F/D Mode	"NO AI"	AI Mode cannot operate
"VMC"	VMC Mode	"TO"	Takeoff Mode
"AIII"	AIII Mode	"NO TO"	TO Mode cannot operate
"NO AIII"	AIII Mode cannot operate	"RO"	Rollout Mode
"AII"	AII Mode	"NO RO"	RO Mode cannot operate
"NO AII"	AII Mode cannot operate		

HGS Armed Mode: The HGS armed mode shows to the right of the Mode Separation Line in the upper left corner of the Combiner display. The symbol flashes for 5 seconds when the armed mode changes. The abbreviations and their modes are:

"AIII"	AIII Mode armed	"TO"	Takeoff Mode armed
"AII"	AII Mode armed	"RO"	Rollout Mode armed
"AI"	AI Mode armed		

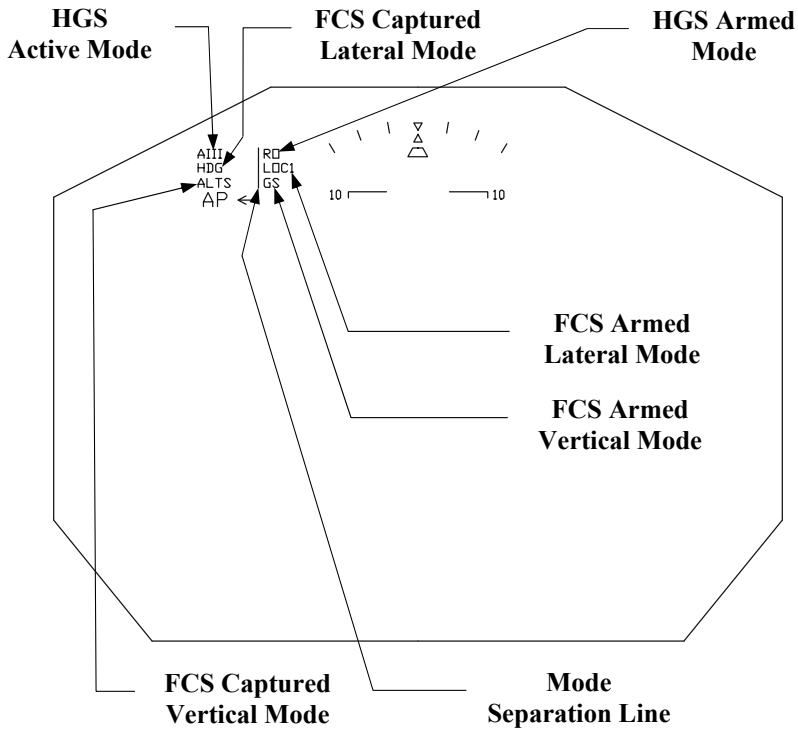


Figure 4-30:
Approach Modes Navigation Symbols

Table 4-16: Approach Modes FCS Lateral Modes

FCS Lateral Modes		
Captured	**Armed**	**Function**
“ROLL”	N/A	Roll hold
“GA”	N/A	Lateral go-around
“TO”	N/A	Takeoff
“HDG”	N/A	Heading select
“LOC 1” (or 2)	“LOC 1” (or 2)	LOC 1 or 2 arm/capture
“B/C 1” (or 2)	“B/C 1” (or 2)	Back Course 1 or 2 arm/capture
“VOR 1” (or 2)	“VOR 1” (or 2)	VOR 1 or 2 arm/capture
“B/C2”	“B/C2”	Back course localizer 1 or 2 arm/capture
“FMS 1” (or 2)	“FMS 1” (or 2)	FMS or FMS 1 or 2 arm/capture

Table 4-17: Approach Modes FCS Vertical Modes

Vertical Modes		
Captured	**Armed**	**Function**
"PTCH"	N/A	Pitch hold
"GA"	N/A	Vertical go-around
"GA/WS"	N/A	Escape guidance during windshear and go-around
"TO"	N/A	Takeoff
"TO/WS"	N/A	Escape guidance during windshear and takeoff
"GS"	"GS"	Glideslope arm/capture
"ALTS"	"ALTS"	Selected altitude arm/track
"ALTS CAP"	N/A	Selected altitude capture
"~~ALTS~~"	N/A	Selected altitude invalid
"ALT"	N/A	Altitude hold
"MGP"	"MGP"	MSL GS arm/capture
"IAS" XXX	N/A	IAS hold (XXX = captured airspeed)
"MACH" .XX	N/A	Mach hold (.XX – selected Mach)
"VS" X.X ↑ or ↓	N/A	Vertical speed (X.X = selected vertical speed; arrows = up or down)
"DES" X.X	N/A	Vertical speed descent (X.X – profile vertical speed
"DES" XXXH	N/A	Airspeed descent (XXX = profile airspeed; H = high rate)
"DES" .XXH	N/A	Mach descent (.XX = profile Mach; H = high rate)
"CLM" XXXH:	N/A	Airspeed climb (XXX = profile airspeed; H = high rate)
"CLM" .XXH	N/A	Mach climb (.X = profile Mach; H = high rate)

Autopilot Engaged Message: The Autopilot Engaged Message displays "AP" followed by a left- or right-pointing arrow when the autopilot is engaged. The arrow identifies which autopilot, left-side or right-side, is in operation. The symbol is in the upper left corner of the display. If a flight-control failure occurs, the symbol flashes for 10 seconds and then is removed.

NOTE: The Autopilot Engaged Message is shown in AIII and AII modes when the autopilot is engaged; however, the autopilot must be disconnected above 500 feet AGL or an approach warning will occur.

Conformal Selected Heading Mark: A Selected Heading Mark is displayed on the Zero-Degree Pitch Line to mark the Selected Heading. If the Selected Heading is outside the currently displayed heading scale on the Zero-Degree Pitch Line, then the Selected Heading Mark is not displayed.

Selected Heading: Selected Heading is displayed on the lower right part of the display as "HDG" followed by the selected heading. This symbol shows for 5 seconds when the selected heading is changed, and continuously if the aircraft is more than 100º from its selected heading.

Conformal Selected Course Mark: A Conformal Selected Course Mark is displayed below the Zero-Degree Pitch Line pointing to the related Selected Course. When the Selected Course is on the currently displayed heading scale, a 3° gap on the Zero-Degree Pitch Line shows around the Selected Course Mark. If the Selected Course is outside the currently displayed Heading Scale on the Zero-Degree Pitch Line, then the Conformal Selected Course Mark is "ghosted" to the side closest to the Selected Course. See "Non-Conformal Display Characteristics" later in this section.

Selected Course/FMS Desired Track: Selected Course/FMS Desired Track is displayed as "CRS" followed by the aircraft's selected course in left lower part of the display. This symbol shows for 5 seconds when the selected course is changed, and continuously if the aircraft is more than 100º from its selected course.

Runway Edge Lines: Runway Edge Lines are displayed between 300 feet AGL and 60 feet AGL. The aircraft's orientation to the runway is shown with the runway symbols in perspective to the real world runway. The lateral position of the Runway Edge Lines is set by the Selected Course.

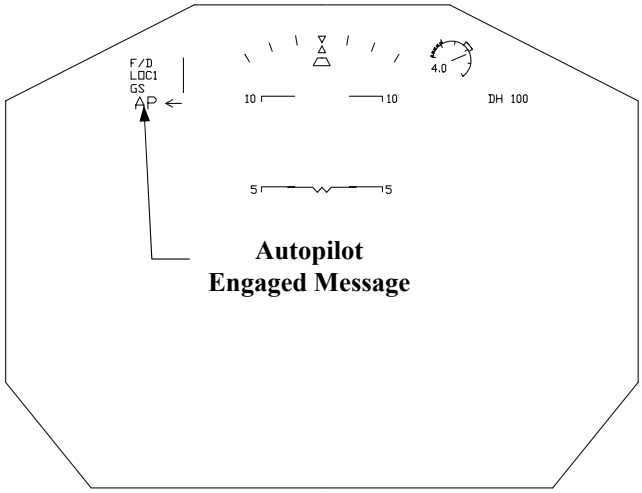


Figure 4-31:
Approach Modes Navigation Symbols

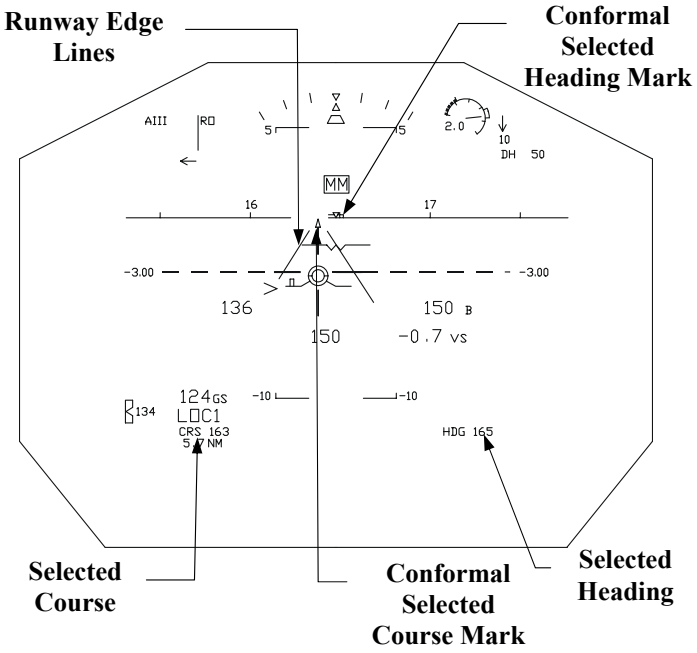


Figure 4-32:
Approach Modes Navigation Symbols

Navigation Source: The Navigation Source is in the lower left corner of the display shows the navigation source set on the Display Control Panel. The possible Navigation Source Annunciations are listed in Table 4-18.

Table 4-18: Approach Modes Navigation Sources

Symbol	Function
“LOC1”	#1 GS/LOC Receiver tuned and shows on left-side PFD
“LOC2”	#2 GS/LOC Receiver tuned and shows on left-side PFD
“FMS”	Single FMS installation: FMS is navigation source and shows on left-side PFD
“FMS1”	Dual FMS installation: #1 FMS is navigation source and shows on left-side PFD
“FMS2”	Dual FMS installation: #2 FMS is navigation source and shows on left-side PFD
“VOR1”	#1 NAV Receiver tuned to VOR (ILS #1 not tuned) and shows on left-side PFD
“VOR2”	#2 NAV Receiver tuned to VOR (ILS #2 not tuned) and shows on left-side PFD

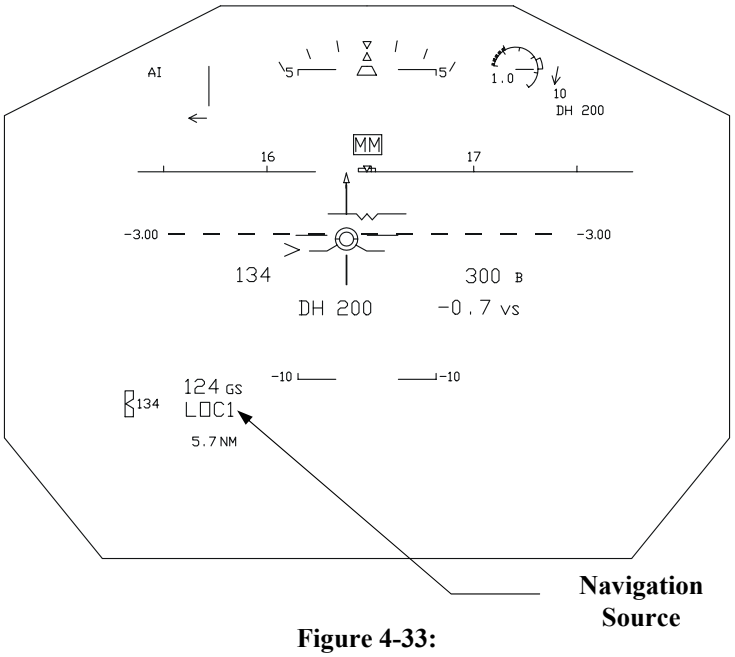


Figure 4-33:
Approach Modes Navigation Symbols

Lateral Deviation Line: shows as a vertical line with a gap in the center to give the lateral deviation of the aircraft from the selected course. When the aircraft is on course, this line aligns with the Conformal Selected Course Pointer on the Zero-Degree Pitch Line.

Glideslope Deviation Line: shows as a horizontal line with a gap in the center to give the vertical deviation of the aircraft from the reference glideslope.

The Glideslope Deviation Line is not displayed above the Zero-Degree Pitch Line. The G/S Deviation Line is removed at 70 feet AGL.

DME/FMS Distance: DME/FMS Distance is displayed in the lower left corner of the display. The distance is displayed in 0.1 nautical mile increments between 0 and 99.9 miles, and in one nautical mile increments above 99.9 miles. The distance is from the DME when the NAV source is VOR or LOC and from the FMS waypoint when FMS is selected. The distance is followed by “NM” or “H” for a “HOLD” mode.

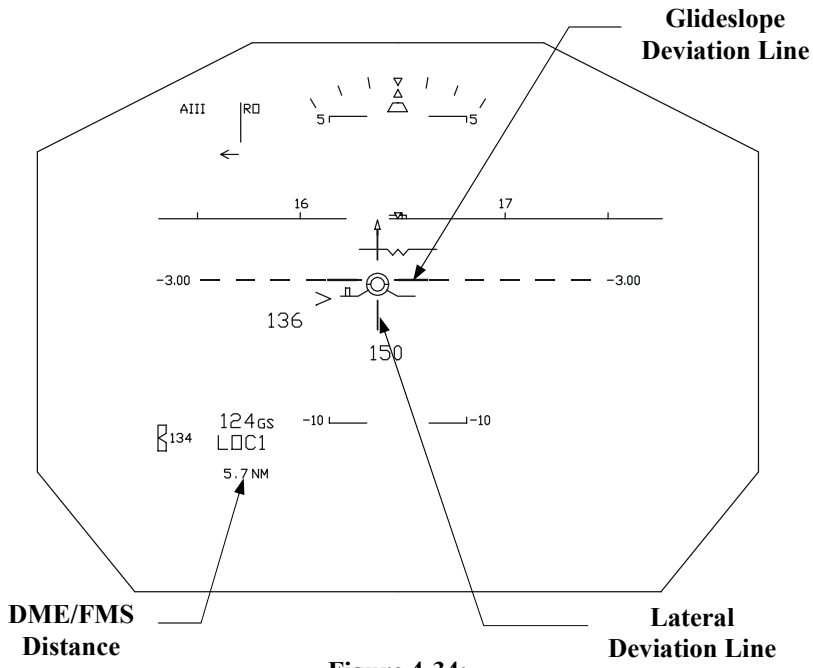


Figure 4-34:
Approach Modes Navigation Symbols

Marker Beacons: Flying over a marker beacon is shown by the boxed letters “OM”, “MM”, “IM” for Outer Marker, Middle Marker, and Inner Marker respectively. They are displayed individually above the Aircraft Reference Symbol.

Heading Source: The current Heading Source shows in the lower center part of the display. This symbol gives the source of the heading, which is identified by one of the sets of characters that follow:

Symbol	Status
“MAG”	Normal
“MAG1”	Both on 1
“MAG2”	Both on 2
“TRU”	Normal
“TRU1”	Both on 1
“TRU2”	Both on 2

If the heading source is not valid, the Heading Source symbol is boxed.

Excessive Localizer Deviation: Excessive Localizer Deviation shows as a right or left-pointing triangle to the side of the Flight Path symbol to give the direction of correction for the aircraft. The symbol flashes continuously until the localizer deviation is within limits.

Excessive Glideslope Deviation: shows as a downward or upward-pointing triangle above or below the Flight Path symbol to give direction of correction for the aircraft. The symbol flashes continuously until the glideslope deviation is within limits.

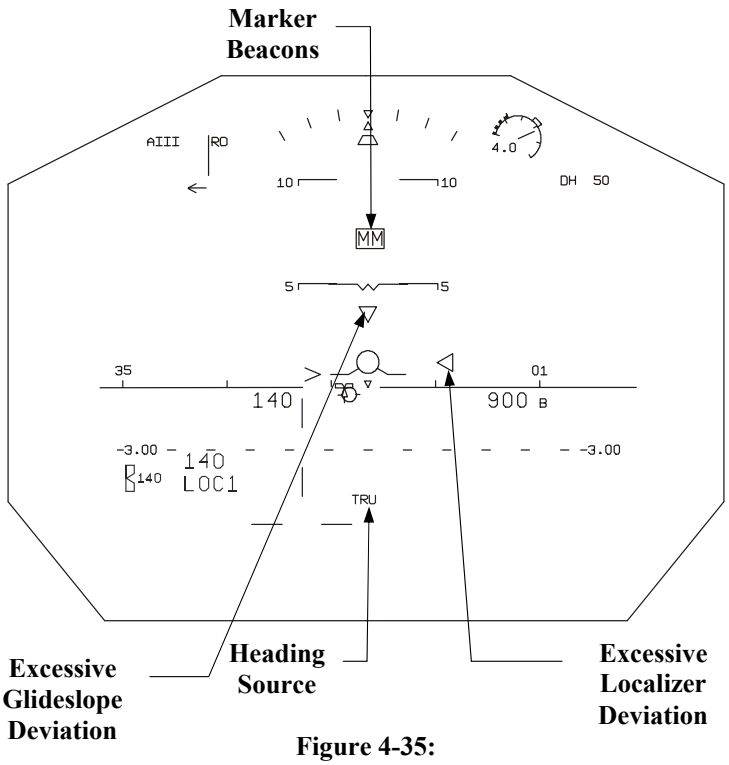


Figure 4-35:
Approach Modes Navigation Symbols

FMS Waypoint Identifier: The FMS Waypoint Identifier identifies the next FMS waypoint on the flight plan. This symbol shows in the lower left corner of the display when flight-path data is set. If an FMS LNAV alert occurs, the symbol flashes continuously.

FMS Messages: The FMS Messages are shown on one to two lines to give data about FMS conditions. Eight characters can show on each line. This symbol shows under the FMS Waypoint Identifier and flashes continuously.

FMS Reference Altitude: FMS Reference Altitude is shown above the Altitude Scale when the FMS flight plan is in use, the altitude is followed by "VN" and is the next FMS flight plan altitude.

FMS Vertical Speed: FMS Vertical Speed followed by "VN" give the vertical speed that should be maintained to reach the FMS Waypoint Reference Altitude. It is displayed in the lower right corner of the display.

Flight Director Transfer Message: "FD2" below the HGS and FCS modes in the upper left corner of the Combiner display is shown when the left-side pilot's Flight Director source is #2.

Autopilot Disconnect Message: shows "DISC" to the left of the "AP" symbol on the Combiner display when AIII Mode is active and the autopilot is engaged. This symbol first shows at 1,000 feet AGL. However, when the aircraft below 650 feet AGL, the symbol "DISC" flashes.

If the autopilot is not disconnected by 500 feet AGL the Approach Warning ("APCH WARN") message comes on.

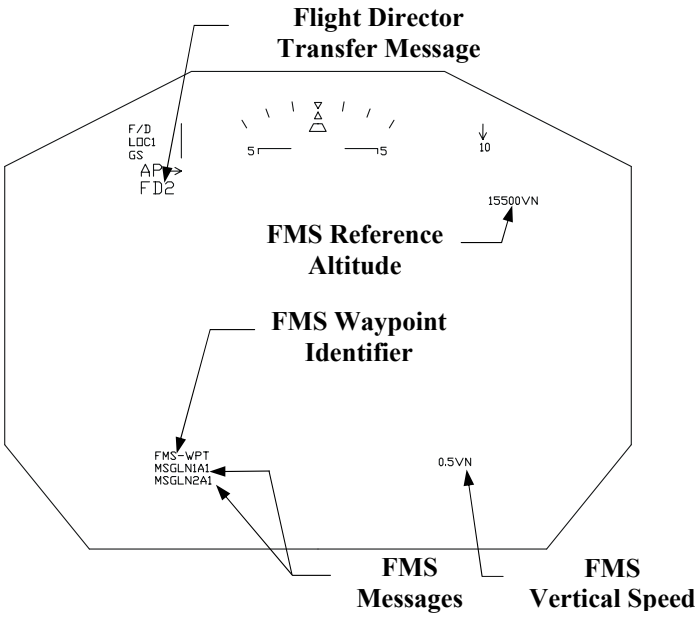


Figure 4-36:
Approach Modes Navigation Symbols

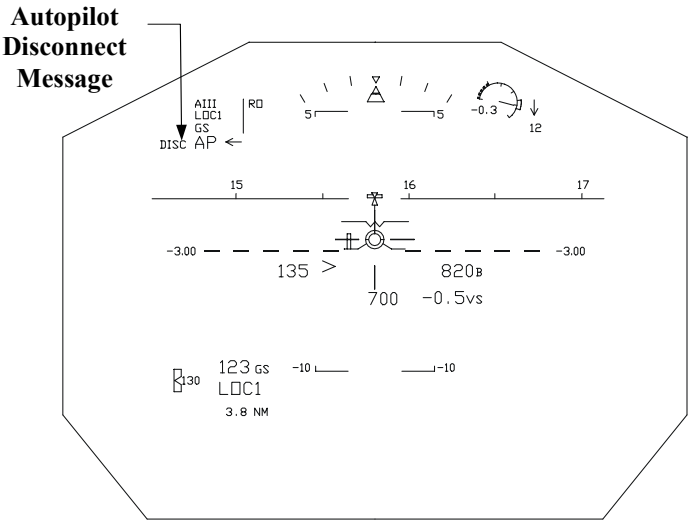


Figure 4-37:
Approach Modes Navigation Symbols

Approach Modes Flight Path Symbol Group

See Figure 4-38 thru Figure 4-42. Table 4-19 gives the Approach Modes Flight Path Symbol Group.

Table 4-19: Approach Modes Flight Path Symbol Group

Symbol	AIII	AII	AI	RO	F/D	VMC
Flight Path Symbol	●	●	●		●	●
Flight Path Acceleration	●	●	●	●	●	●
Speed Error Tape	●	●	●		●	●
HGS-Derived Guidance Cue	●	●	●			
FCS-Derived Guidance Cue					●	
Glideslope Reference Line	●	●	●		●	●
Flight Path Slip/Skid Indicator	●	●	●		●	●
“IDLE” Message	●					
Flare Command	●					
Flare Cue		●	●		●	●

Flight Path Symbol (FPS): The Flight Path Symbol is unique information not normally available on conventional head-down displays. The FPS shows the actual flight path vector of the aircraft. The gull wings of the FPS are angled downward at 30° to the horizon so that in a 30° level turn, the 30° angle overlays the Zero-Degree Pitch Line.

The FPS is inertially-derived and gives an immediate indication of where the aircraft is going. The left-side pilot can maneuver the aircraft and "fly" the FPS to the desired point. For example, if the FPS is above the Zero-Degree Pitch Line, the aircraft is climbing. If it is below the Zero-Degree Pitch Line, the aircraft is descending. The Flight Path angle is indicated by the position of the center of the Flight Path circle relative to the pitch scale. If the FPS overlays the runway touchdown point and the Flight Path angle is -3°, then the aircraft is tracking a -3° approach angle to the runway touchdown point.

The Flight Path symbol is only displayed in flight and has priority over all other symbols except the Guidance Cue and Flare Command symbology. Any part of any other symbol that is within the circular portion of the FPS is not displayed.

The Flight Path symbol position can be limited laterally or vertically. When this occurs the FPS is "ghosted", meaning it is displayed as dashed lines rather than solid lines. This indicates that the FPS is no longer conformal with the real world scene. See "Non-Conformal Displays" later in this section for additional information.

Flight Path Symbol **"Ghosted" Flight Path Symbol**

Figure 4-38:
Approach Modes Flight Path Symbols

Flight Path Acceleration: The inertial acceleration (or deceleration) of the aircraft along the flight path is indicated by the Flight Path Acceleration symbol. It is an indication of the total sum of all forces affecting the aircraft including thrust, drag, and the air mass through which the aircraft is moving. It represents the current energy state of the airplane. Therefore, it should not be thought of as a throttle indicator or command, however it can be used very effectively to control speed or flight path angle.

In flight, the Flight Path Acceleration symbol is positioned to the left of the Flight Path Symbol. When the symbol is above the "wing" of the Flight Path symbol, the aircraft is accelerating. When it is below the Flight Path symbol wing, the aircraft is decelerating. When the symbol points directly at the left wing of the Flight Path symbol, it shows that the aircraft is in a steady state (neither accelerating nor decelerating).

If the Flight Path symbol is removed, the Flight Path Acceleration symbol is referenced to the Aircraft Reference Symbol.

On the ground, the Flight Path Acceleration symbol uses the Aircraft Reference or the Ground Roll Reference symbol as its reference.

Speed Error Tape: The Speed Error Tape displays the difference between the indicated airspeed and the selected airspeed. It is positioned on the left wing of the Flight Path symbol and rises above the wing when the airspeed is higher than selected, or falls below the wing when it is slower. Each one degree on the Speed Error Tape (about the diameter of the Flight Path circle) represents approximately five knots of airspeed error. The tape length is limited to 15 knots of error.

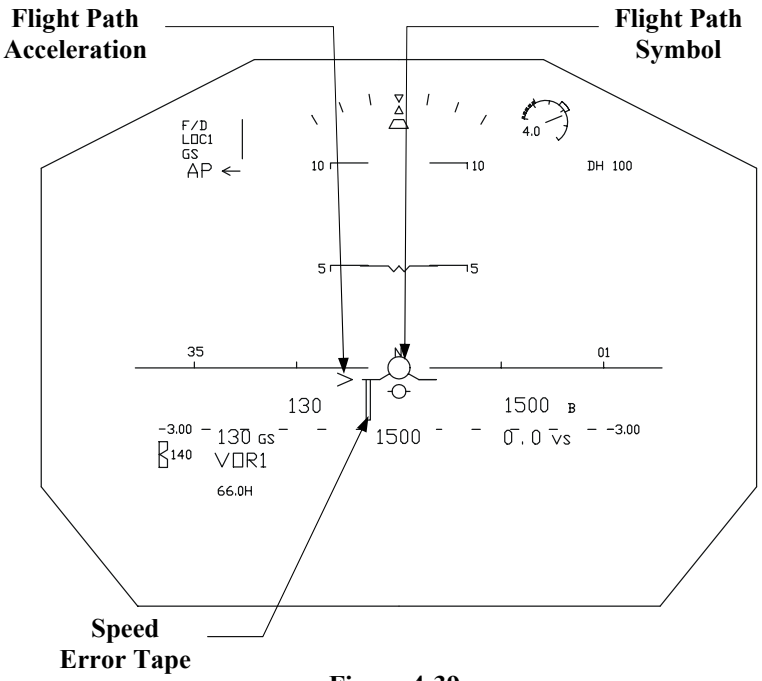


Figure 4-39:
Approach Modes Flight Path Symbols

HGS-Derived Guidance Cue: during AIII, AII, and AI Modes, the HGS-Derived Guidance Cue can be thought of as a "Flight Path Director". It functions in the same way as a conventional single cue flight director. The object is to center the Guidance Cue inside the Flight Path circle using pitch and roll inputs. The lines on the Guidance Cue indicate roll commands.

NOTE: When the HGS modes change from Primary to AIII, AII, or AI, the Guidance Cue can make a small change in its position. This change is caused when the source for the Guidance Cue changes from FCS to HGS.

In AII and AI Modes, the HGS-Derived Guidance Cue shows on the Combiner display when the RA is greater than 80 feet.

FCS-Derived Guidance Cue: The FCS-Derived Guidance Cue can be thought of as a "Flight Path Director". It functions in the same way as a conventional single cue flight director. The object is to center the Guidance Cue inside the Flight Path circle using pitch and roll inputs. The lines on the Guidance Cue indicate roll commands.

During an EGPWS Windshear warning, the Guidance Cue becomes solid and flashes for 10 seconds and then is steady.

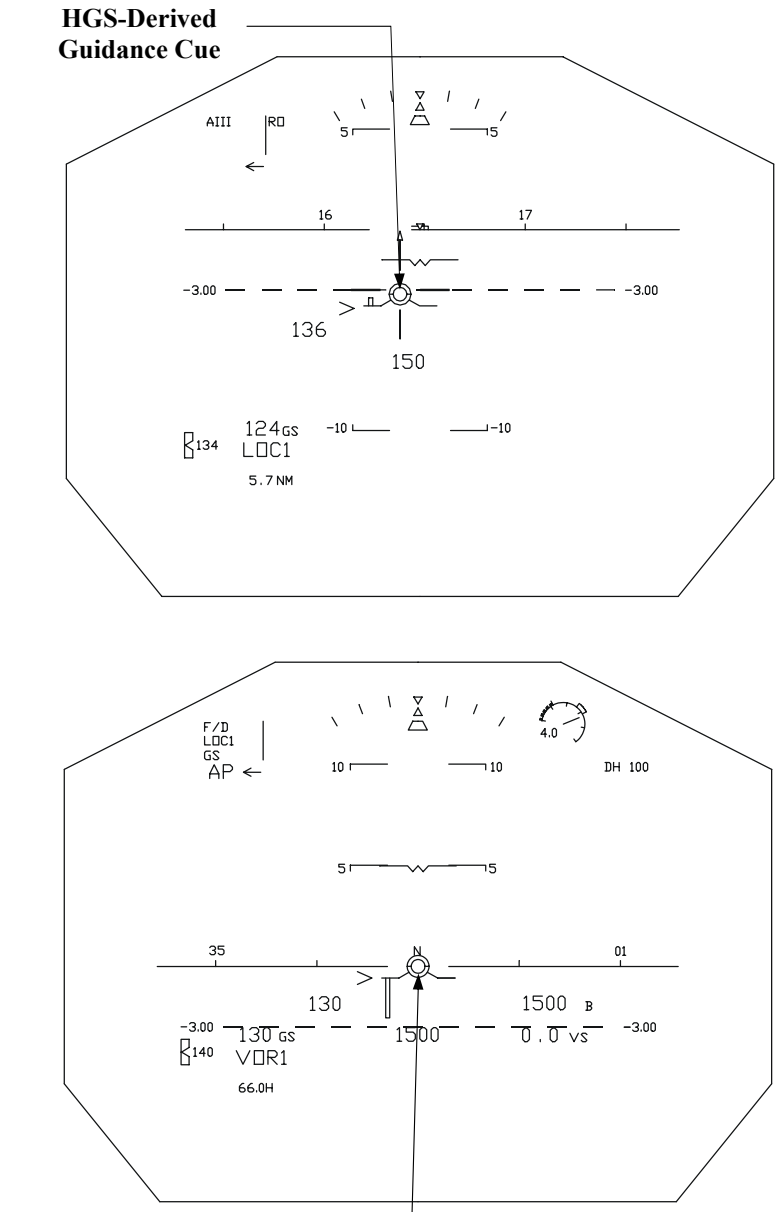


Figure 4-40:
Approach Modes Flight Path Symbols

Glideslope Reference Line: The Glideslope Reference Line is a conformal display of the glideslope angle entered on the HGS Control Panel (HCP). It is a series of dashed lines positioned below the Zero-Degree Pitch Line. If a -3.00 degree angle is entered, then the Glideslope Reference Line is positioned 3° below the Zero-Degree Pitch Line and centered on the display. At the outside ends of the Glideslope Reference Line is a number that shows the selected glideslope angle.

Because the Glideslope Reference Line is a conformal display, positioning the Flight Path Symbol over the Glideslope Reference Line results in the aircraft flying a descent angle equal to the selected glideslope angle. During visual approaches, by overlaying the Glideslope Reference Line on the runway touchdown zone and then maintaining the Flight Path Symbol on the Glideslope Reference Line, the selected descent angle is maintained to the runway.

Flight Path Slip/Skid Indicator: A Flight Path Slip/Skid Indicator is displayed during a single engine approach or a single engine takeoff or go-around.

This Slip/Skid Indicator moves laterally underneath the Flight Path Symbol to show lateral acceleration of the aircraft.

IDLE Message: The “IDLE” message is displayed to remind the left-side pilot to reduce the aircraft thrust to idle for touchdown. The “IDLE” message is displayed directly below the Radio Altitude symbology.

The “IDLE” message shows in AIII mode only.

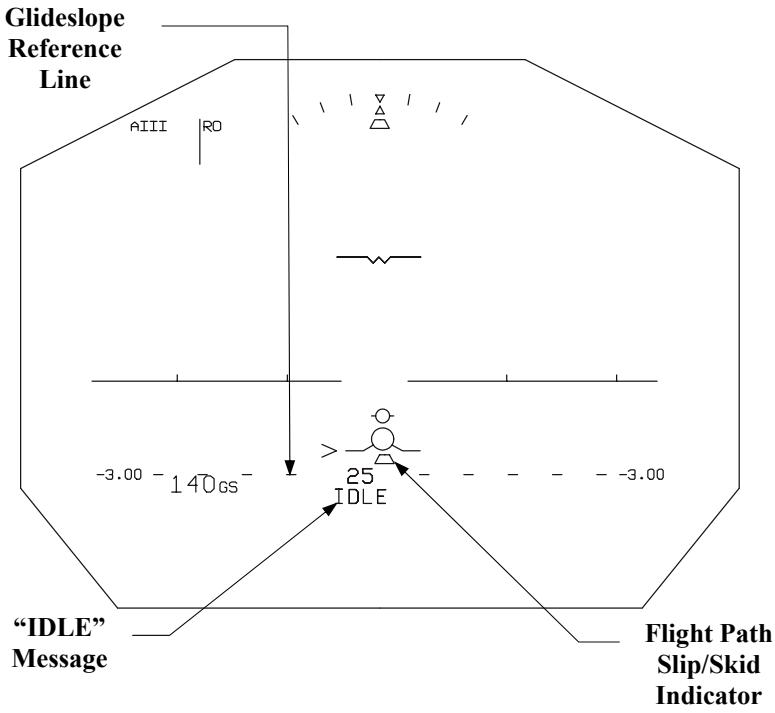


Figure 4-41:
Approach Modes Flight Path Symbols

Flare Command: At flare initiation height in AIII mode, a Flare Command is displayed as a "plus" ("+") symbol positioned approximately 3° below the Guidance Cue. The Flare Command symbol flashes and rises toward the Guidance Cue at a rate directly related to the aircraft descent rate until the Flare Cue embeds itself in the Guidance Cue. The Flare Command then becomes the Guidance Cue. The left-side pilot follows the Guidance Cue to perform the flare maneuver through touchdown.

Loss of the AIII flare guidance results in the loss of AIII status and an approach warning (APCH WARN) message.

The flare command shows in AIII mode only.

Flare Cue: A Flare Cue reminds the left-side pilot to visually flare the aircraft. The Flare Cue is a pair of plus symbols ("+ +"); one showing on each side and directly above the wings of the Flight Path symbol. The Flare Cue flashes as the aircraft descends through 60 feet Radio Altitude, and continues flashing until the aircraft descends through 30 feet.

NOTE: The Flare Cue is fixed to the Flight Path Symbol and is not used to command or provide guidance for the flare maneuver.

The Flare Cue shows in AII, AI, F/D, and VMC modes.

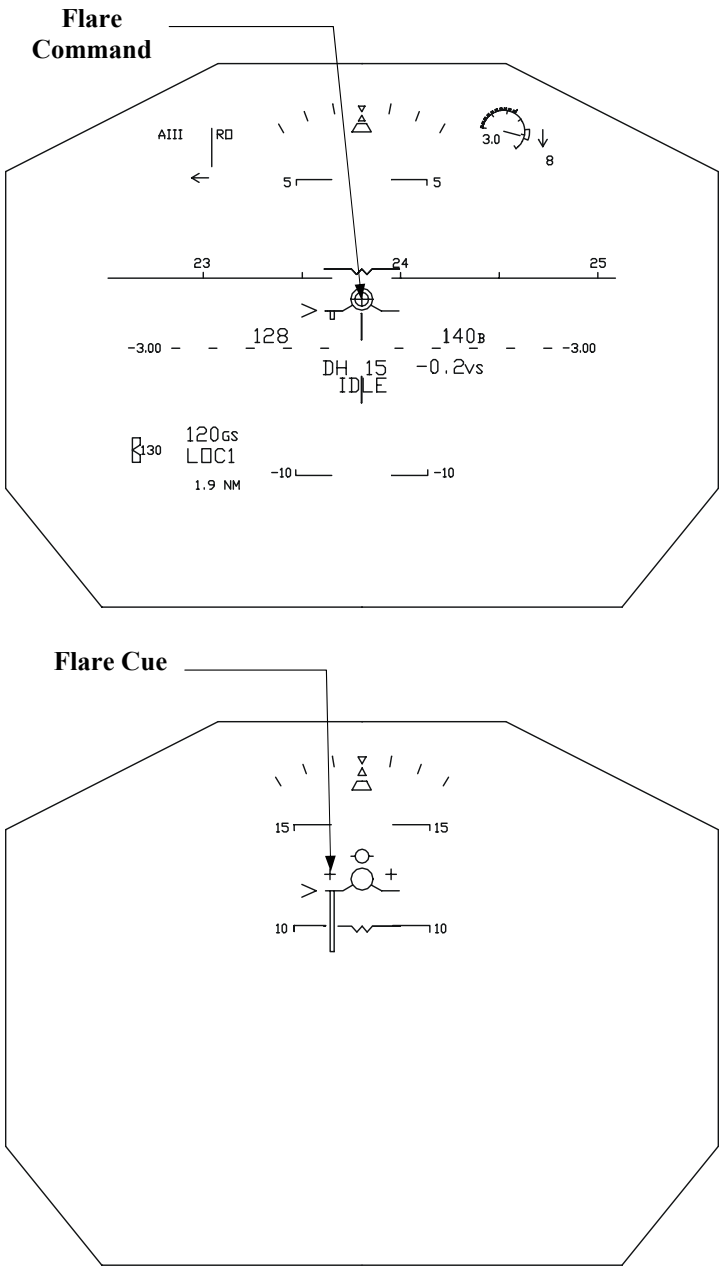


Figure 4-42:
Approach Modes Flight Path Symbols

Approach Modes Rollout Symbol Group

See Figure 4-44 thru Figure 4-43. Table 4-20 gives the Rollout Mode Symbol Group.

Table 4-20: Approach Modes Rollout Symbol Group

Symbol	AIII	AII	AI	RO	F/D	VMC
Ground Roll Reference				●		
Ground Localizer Deviation Scale and Pointer				●		
HGS-Derived Ground Guidance Cue				●		
Runway Remaining				●		
Deceleration Scale and Pointer[1]	●	●	●	●	●	●
Ground Localizer Line[2]	●	●	●		●	

[1] shows only if Deceleration Scale is enabled.
[2] shows only if Rollout Mode is not enabled.

Ground Roll Reference: The Ground Roll Reference symbol is unique information not normally available on conventional head-down displays. It is a circle with straight "wings" on either side. The Ground Roll Reference shows the actual ground track of the aircraft.

Ground Localizer Deviation Scale and Pointer: If enabled, the Ground Localizer Deviation Scale and Pointer is displayed below the Ground Reference symbol. The pointer is centered when the aircraft is tracking the localizer. Pointer movement away from center shows the aircraft's lateral deviation from the runway centerline.

HGS-Derived Ground Guidance Cue: The HGS Ground Guidance Cue gives lateral guidance to track the runway center line during guided rollout.

Runway Remaining: If enabled, Runway Remaining shows the distance to the rollout end of the runway. It is shown on the right side of the display as "RWY" above distance.

When the runway remaining is in feet, the number is rounded to the next lowest 500 feet. When the runway remaining is less than 500 feet, "0" shows.

When the runway remaining is in meters, the numbers are followed by "M" and the number is rounded to the next lowest 100 meters. When the runway remaining is less than 100 meters, "0" shows.

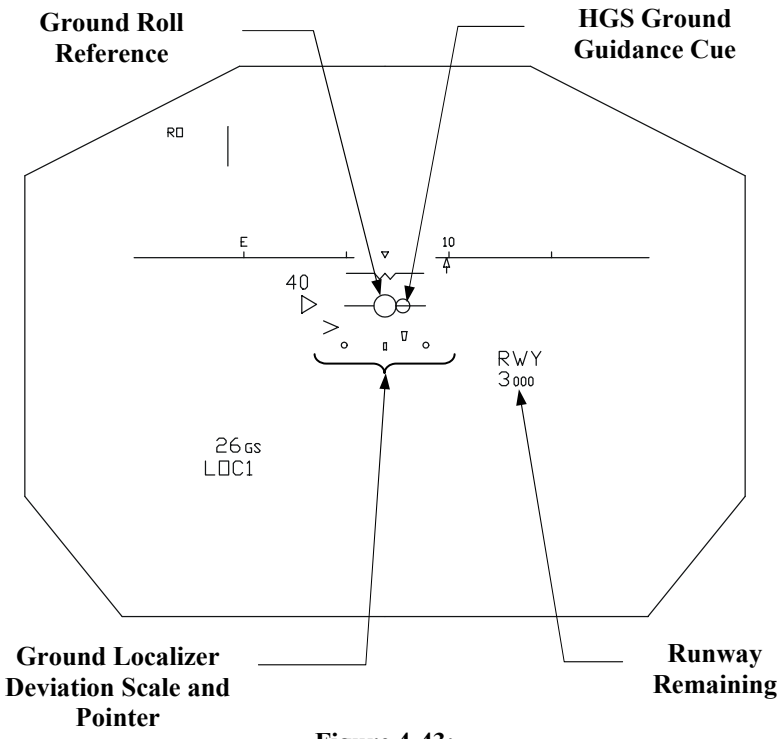


Figure 4-43:
Approach Modes Rollout Symbols

Deceleration Scale and Pointer: If enabled, the Deceleration Scale and Pointer are displayed on the ground to show the rate of deceleration. The Deceleration Scale is located in the center of the display below the Ground Reference symbol. The scale displays during rollout until ground speed is less than 20 knots.

The pointer (“>”) moves along the scale to show aircraft deceleration. The numbers show as -0.3, -0.5, and -0.8 G.

Ground Localizer Line: shows as the aircraft’s precise lateral position when the aircraft is on the ground. When the aircraft is on course, this symbol aligns with the Conformal Selected Course Pointer on the Zero-Degree Pitch Line.

This symbol is removed when the Ground Speed is less than 20 knots.

The Ground Localizer Line does not show if the Rollout Mode option is enabled.

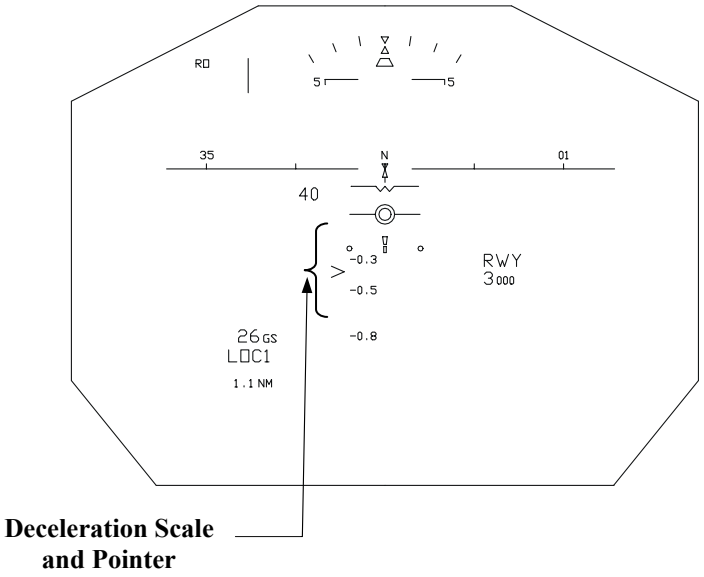


Figure 4-44:
Approach Modes Rollout Symbols

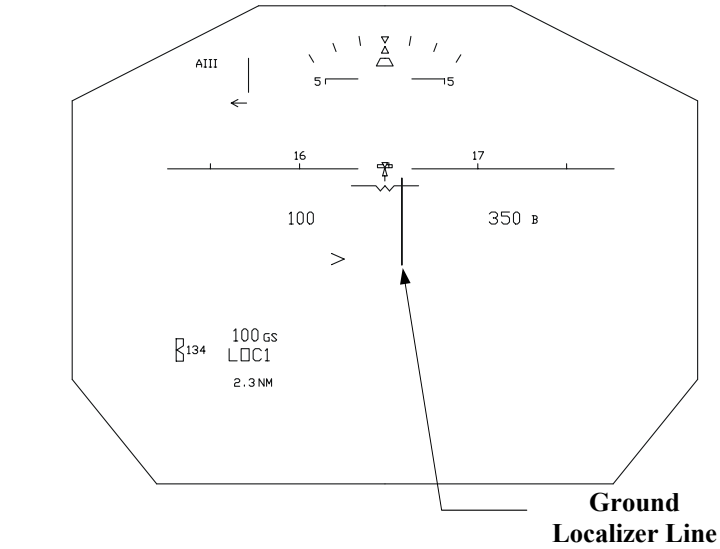


Figure 4-45:
Approach Modes Rollout Symbols

Non-Normal Conditions Symbology

Symbology for non-normal conditions is divided into these five subsections:

- Non-Normal Symbology
- Source Messages
- Warning Messages
- Failure Flags
- Miscompare flags

Non-Normal Symbology

See Figure 4-46 thru Figure 4-48. Table 4-21 gives the symbols in the Non-Non-Normal Group.

Table 4-21: Non-Normal Symbology

Symbol	PRI		TO	AIII	AII	AI	RO	F/D	VMC
	Ground	Flight							
Unusual Attitude[1]		●		●	●	●		●	●
TCAS		●	●	●	●	●		●	●
Windshear Alert[1]		●	●	●	●	●	●	●	●

[1]Unusual Attitude and Windshear Alert automatically change HGS Mode to PRI.

Unusual Attitude: A unique Unusual Attitude display replaces the existing display when any of these occur:

- Pitch-up attitude exceeds 30º
- Pitch-down attitude exceeds -20º
- Roll angle exceeds 65º

After the aircraft pitch and roll attitudes are less than 10º for more than five seconds, the HGS changes to the PRI mode.

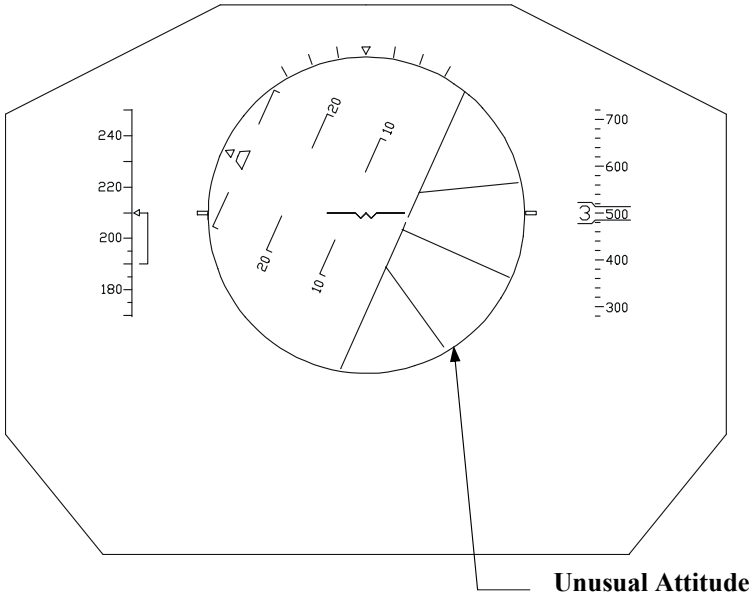


Figure 4-46:
Non-Normal Symbols

TCAS: The HGS shows TCAS Resolution Advisories from the TCAS computer. TCAS advisories do not show when the Unusual Attitude display is active.

Preventive Advisory: Preventive advisories do not require any action by the crew to alter the flight path of the aircraft, but indicate an unsafe zone. These advisories show as a double-line bracket with two angled lines that extend from the corners on the unsafe side of the bracket. The position of the bracket is determined by the vertical speed requirement output by TCAS and represents the vertical flight path position that is safe. If a down preventive bracket is displayed, then the Flight Path symbol should remain below the bracket. An up preventive bracket requires that the Flight Path symbol should remain above the bracket. Traffic avoidance is achieved by keeping the Flight Path out of the unsafe zone. The HGS can have more than one preventive advisory at a time.

Corrective Advisory: Corrective advisories require an immediate vertical evasive maneuver by the crew and are accompanied by a "fly-to" region for Flight Path. This advisory shows a double-lined box. Like the preventive bracket, angled lines extend from the corners on the unsafe side, but in this case the top, bottom, or both can be considered unsafe as indicated by the double lines. The position of the box is determined by the vertical speed requirements output by TCAS corresponding to the green band on the PFD's Vertical Speed Indicator (VSI) and represents the vertical flight path position that is safe. The height of the box represents the 500-fpm fly-to zone indicated by TCAS corresponding to the PFD VSI green band. It is also acceptable to fly outside the box on the safe side.

At times, traffic is both above and below the aircraft. In these cases, the indication can be both corrective and/or preventive advisories with unsafe zones on opposite sides. Although it is not possible to have more than one corrective advisory (separate boxes), if a preventive symbol overlaps a corrective symbol, or two preventive symbols overlap, the two symbols will merge into a combined corrective advisory. In this case, both the top and bottom are considered unsafe, and the advisory command is to maneuver to position the Flight Path Symbol within the box.

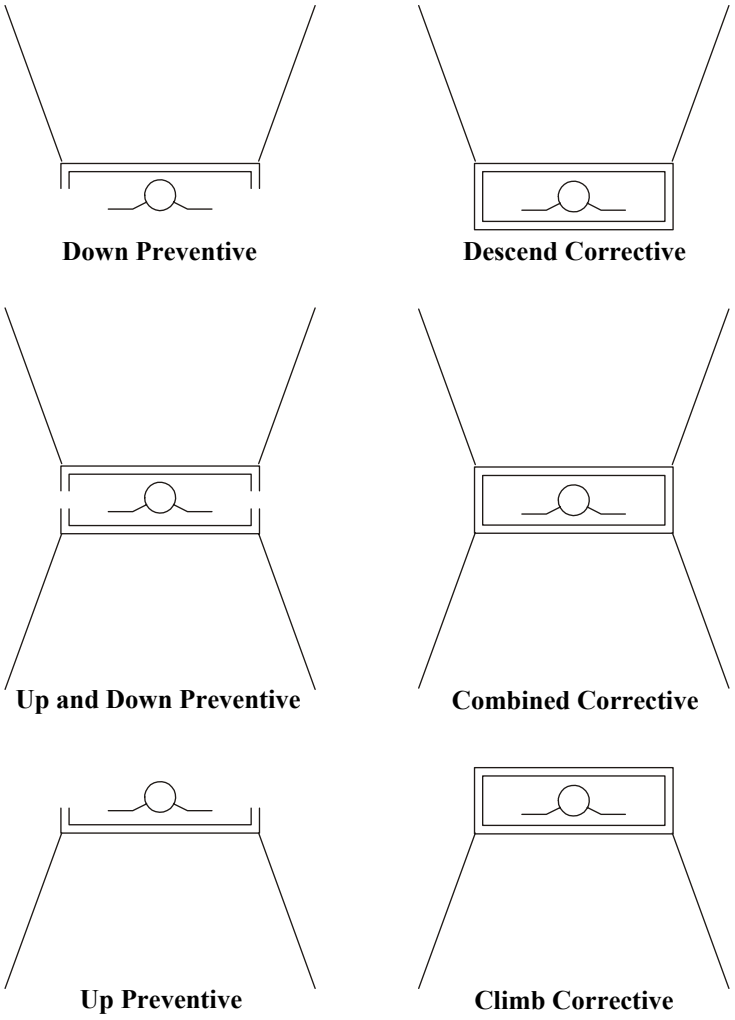


Figure 4-47:
Non-Normal Symbols

Windshear Alert: A Windshear Caution or Windshear Warning message will be displayed above the Aircraft Reference Symbol during windshear conditions, as directed by the aircraft's Enhanced Ground Proximity Warning System (EGPWS). The Windshear Caution is displayed on two lines. Both the Windshear Warning and Windshear Caution flash for 10 seconds when first displayed.

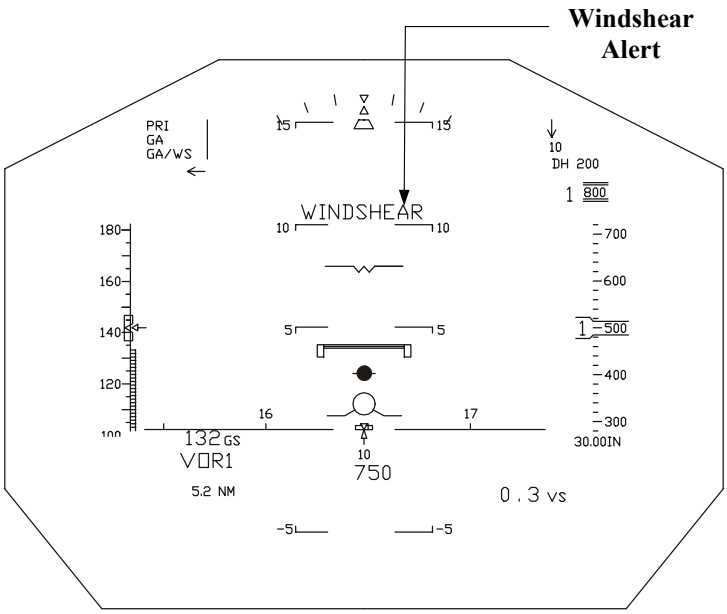


Figure 4-48:
Non-Normal Symbols

Source Messages

These symbols show on the Combiner display only if a non-normal source selection occurs.

See Figure 4-49. Table 4-22 gives the symbology for the Source Messages Symbology Group.

Table 4-22: Source Messages Symbology Group

Symbol	PRI		TO	AIII	AII	AI	RO	F/D	VMC
	Ground	Flight							
Attitude Source	●	●	●			●	●	●	●
Air Data Source	●	●	●			●	●	●	●
Display Control Panel Source	●	●	●			●	●	●	●
Autopilot Operational Status	●	●	●			●	●	●	●

Attitude Source: The Attitude Source is shown on the left upper part of the Combiner display. When the Reversionary Switching Panel (RSP) ATTD HDG switch is set to 1, “ATT1” is displayed; when the ATTD HDG switch is set to 2, “ATT2” is displayed.

Air Data Source: The Air Data Source is shown on the left upper part of the Combiner display. When the RSP AIR DATA switch is set to 1, “ADC1” is displayed; when the AIR DATA switch is set to 2, “ADC2” is displayed.

Display Control Panel Source: The Display Control Panel Source is shown on the left upper part of the Combiner display. When the RSP DISP CONT switch is set to 1, “DCP1” is displayed; when the DISP CONT switch is set to 2, “DCP2” is displayed.

Autopilot Operational Status: The Autopilot Operational Status is displayed in the upper left part of the display. One of four messages show when necessary:

Symbol	Flight Control System Status
"1 / 2BNK"	Half Bank
"SYNC"	FD Synchronize
"DR"	Dead Reckoning
"TEST"	Diagnostics

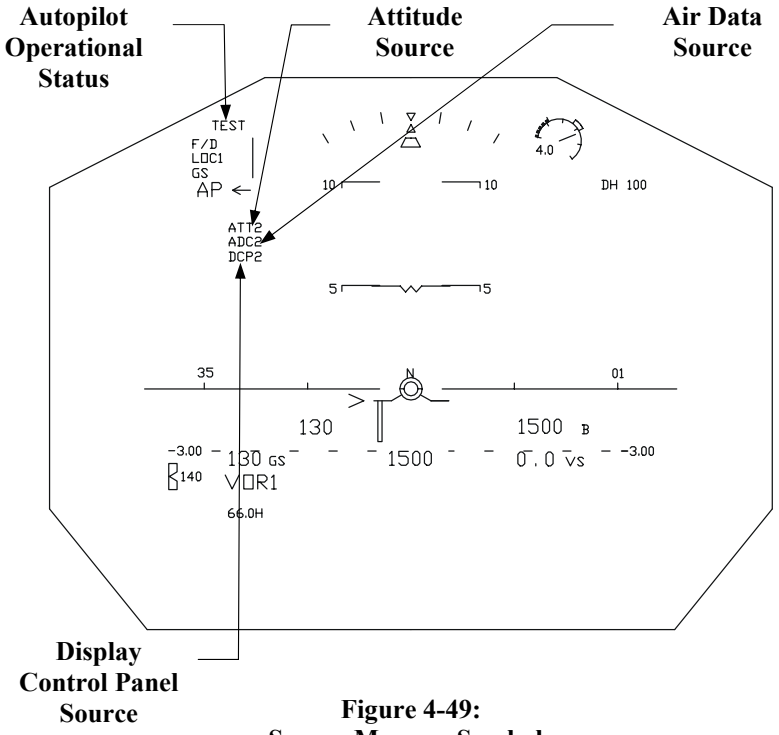


Figure 4-49:
Source Message Symbols

Warning Messages

See Figure 4-50 thru Figure 4-54. Table 4-23 gives the symbology for the Warning Annunciations Symbology Group.

Table 4-23: Warning Messages Symbology Group

Symbol	PRI		TO	AIII	AII	AI	RO	F/D	VMC
	Ground	Flight							
"ALIGN HUD"	●	●	●	●	●	●	●	●	●
"APCH WARN"				●	●				
"NO AIII"				●					
"NO AII"					●				
"NO AI"						●			
"NO TO"			●						
"TO WARN"			●						
"NO RO"							●		
"RO CAUTION"							●		
"PULL UP"		●		●	●	●		●	●
"TERRAIN"		●		●	●	●		●	●
Yaw Damper Disengaged	●	●	●	●	●	●	●	●	●

"ALIGN HUD": An "ALIGN HUD" message shows when the Combiner is not properly aligned.

NOTE: If the "ALIGN HUD" message cannot be removed, do not use the HGS.

Approach Warning (APCH WARN): During AIII and AII approaches an "APCH WARN" message is displayed below 500 feet when either of the following occur:

- No AIII or No AII status
- Approach tolerances are exceeded.

NOTE: The "APCH WARN" is disabled in AII Mode below 80 feet AGL. If "APCH WARN" appears in AII Mode above 80 feet AGL, it remains until landing.

"APCH WARN" is centered over the Flight Path symbol. It flashes for 10 seconds and then is steady. Refer to Appendix A, "Reference Information," subsection "Approach Monitoring," or to Section 3, "Modes of Operation," for more data and instructions.

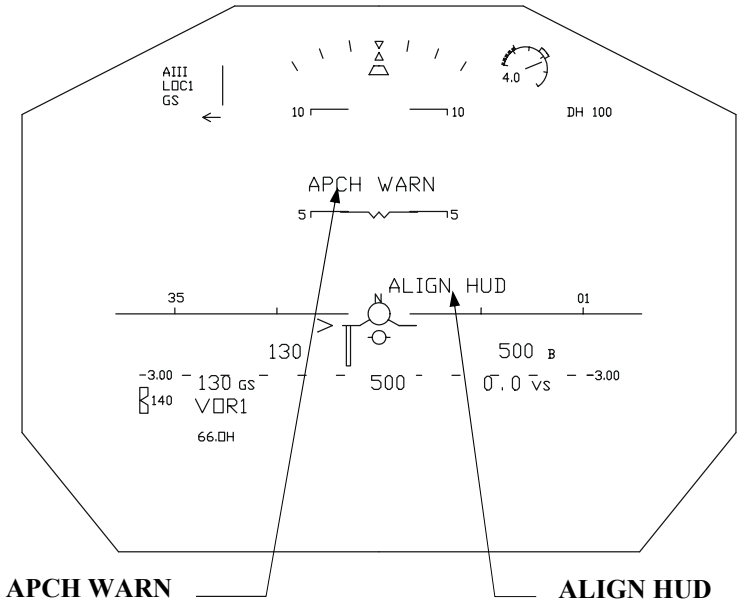


Figure 4-50:
Warning Symbols

“NO AIII”: Once AIII mode has been selected, a loss of Category III capability causes a “NO AIII” message to be displayed to the left of the Mode Separation Line. “NO AIII” flashes for 5 seconds and then remains steady. This symbol continues to be displayed until another mode is selected, or until Category III capability is regained.

“NO AII”: Once AII mode has been selected, a loss of Category II capability causes a “NO AII” message to be displayed to the left of the Mode Separation Line. “NO AII” flashes for 5 seconds and then remains steady. This symbol continues to be displayed until another mode is selected, or until Category II capability is regained.

“NO AI”: Once AI mode has been selected, a loss of Category I capability causes a “NO AI” message to be displayed to the left of the Mode Separation Line. “NO AI” flashes for 5 seconds and then remains steady. This symbol continues to be displayed until another mode is selected, or until Category I capability is regained.

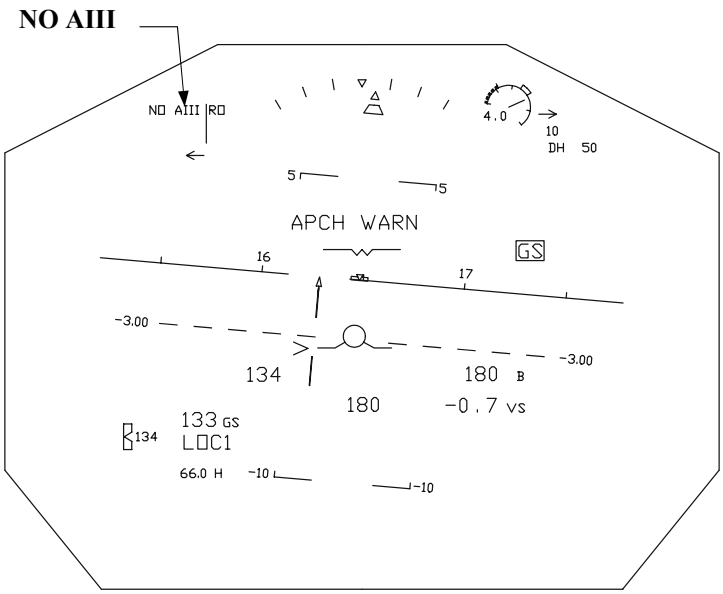


Figure 4-51:
Warning Symbols

"NO TO": "NO TO" to the left of the Mode Separation Line shows that the conditions necessary for TO operation are no longer met, so the TO Mode cannot operate. "NO TO" flashes for 5 seconds and then is steady.

"TO WARN": "TO WARN" is displayed above the Aircraft Reference Symbol when conditions for TO mode no longer exist and the aircraft is between 20 and 80 knots. "TO WARN" flashes for 10 seconds and then is steady.

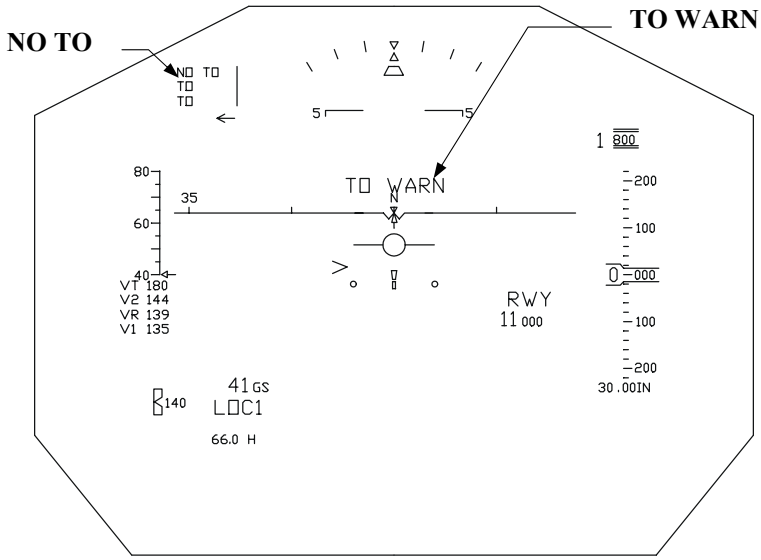


Figure 4-52:
Warning Symbols

"NO RO": "NO RO" to the left of the Mode Separation Line shows that the conditions necessary for RO operation are no longer met, so the RO Mode cannot operate. "NO RO" flashes for 5 seconds and then is steady.

"RO CAUTION": "RO CAUTION" is displayed above the Aircraft Reference Symbol on the ground when "NO RO" is displayed. "RO CAUTION" flashes for 10 seconds and then is steady.

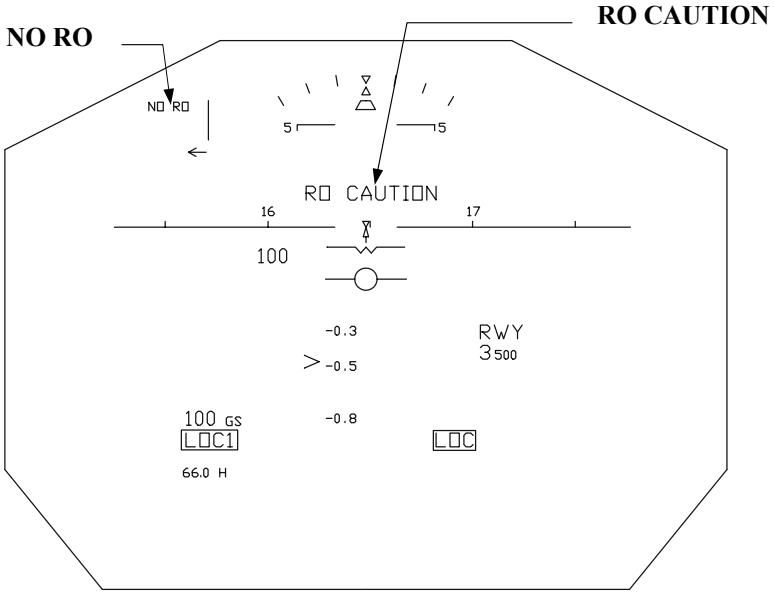


Figure 4-53:
Warning Symbols

“PULL UP”: When the Enhanced Ground Proximity Warning System issues a Pull up message, “PULL UP” is displayed above the Aircraft Reference Symbol. It is a higher priority message than the “TERRAIN” message. This symbol flashes continuously.

“TERRAIN”: When the Enhanced Ground Proximity Warning System issues a TERRAIN message, “TERRAIN” is displayed above the Aircraft Reference Symbol. It is a lower priority message than the “PULL UP” message. This symbol flashes continuously.

Yaw Damper Disengaged: “YD” displayed in the upper left part of the display indicates the yaw damper is not engaged.

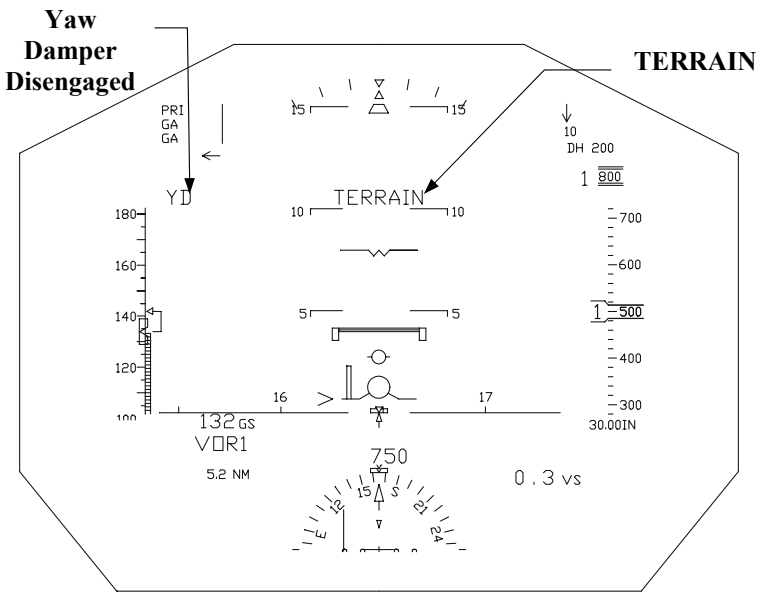


Figure 4-54:
Warning Symbols

Failure Flags

Failure flags are displayed for invalid sensor status. These are generally indicated by large-character boxed messages of the affected parameters, and removal of the symbols related to the fault. In some cases, the HGS removes other related symbols as required.

Table 4-24 lists the sensor status flags that can be displayed by the HGS. See Figure 4-55 for display locations.

Table 4-24: Sensor Failure Flags

Flags	PRI		TO	AIII	AII	AI	RO	F/D	VMC
	Ground	Flight							
Pitch[1]	●	●	●	●	●	●	●	●	●
Roll[1]	●	●	●	●	●	●	●	●	●
Heading[1]	●	●	●	●	●	●	●	●	●
Airspeed[1]	●	●	●	●	●	●	●	●	●
Altitude[1]	●	●	●	●	●	●	●	●	●
Radio Altitude[1]	●	●	●	●	●	●	●	●	●
Localizer	●	●	●	●	●	●	●	●	
Flight Director[1]	●	●	●	●	●	●	●	●	●
Vertical Speed[1]	●	●	●	●	●	●	●	●	●
Glideslope	●	●		●	●	●		●	
Navigation Source	●	●	●	●	●	●	●	●	
Vertical Deviation		●						●	
Bearing		●							
TCAS Status	●	●	●	●	●	●	●	●	●

[1]Symbol flashes for 10 seconds when first displayed.

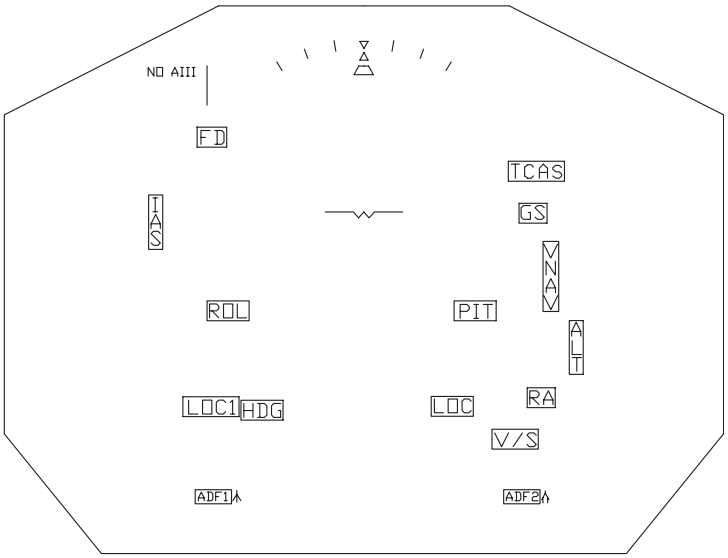


Figure 4-55:
Failure Flag Symbols

Miscompare Flags

Miscompare flags are displayed for miscompares between certain similar parameters. These are indicated by small-character boxed messages of the affected parameters. The messages flash until the master warn reset is pushed and then are steady. A miscompare of similar data results in the display of a flag without removal of the related symbols. In this case, the flag indicates that the applicable data should be verified by crosschecks with other cockpit displays.

Table 4-25 lists the sensor miscompare flags that can be displayed by the HGS. See Figure 4-56 for display locations.

Table 4-25: Sensor Miscompares

Flags	PRI		TO	AIII	AII	AI	RO	F/D	VMC
	Ground	Flight							
Pitch	●	●	●	●	●	●	●	●	●
Roll	●	●	●	●	●	●	●	●	●
Heading	●	●	●	●	●	●	●	●	●
Altitude	●	●	●	●	●	●	●	●	●
Airspeed		●	●	●	●	●	●	●	●
Localizer	●	●	●	●	●	●	●	●	
Glideslope	●	●	●	●	●	●	●	●	
Radio Altitude	●	●	●	●	●	●	●	●	●
Aileron Mistrim[1]	●	●	●	●	●	●	●	●	●
Elevator Mistrim[1]	●	●	●	●	●	●	●	●	●
Rudder Mistrim[1]	●	●	●	●	●	●	●	●	●

[1]Symbols are large size characters, and do not flash

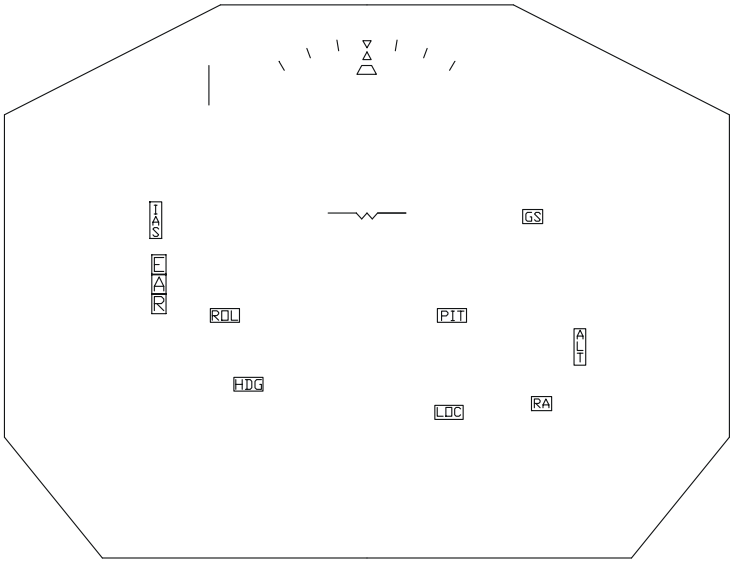


Figure 4-56:
Miscompare Symbols

Non-Conformal Displays

The HGS displays certain symbols in a non-conformal manner depending on aircraft attitude and HGS mode of operation.

Exclusion Window

Generally, critical flight path symbols have display priority over other symbols. Such critical symbols will “blank”, that is, “write over” symbols of lower display priority. The Flight Path Symbol is one of these symbols. For example, when it moves over the Pitch Scale, it can cause a portion of the Pitch Scale to be excluded from the display (Figure 4-57). The excluded part of the Pitch Scale is defined by the size of the invisible rectangular box around the Flight Path Symbol, and the portion of the box that “touches” the Pitch Scale.

Clipped Symbols

Symbols are also clipped when the aircraft attitude causes the HGS to position certain symbols outside the display boundary. This occurs to the HSI when either pitch or flight path angle causes the Zero-Degree Pitch Line or the Flight Path Symbol to reach its display limit above the HSI (Figure 4-57). As the pitch or flight path angle increases further, the HSI is “pushed” down towards the bottom of the Combiner display.

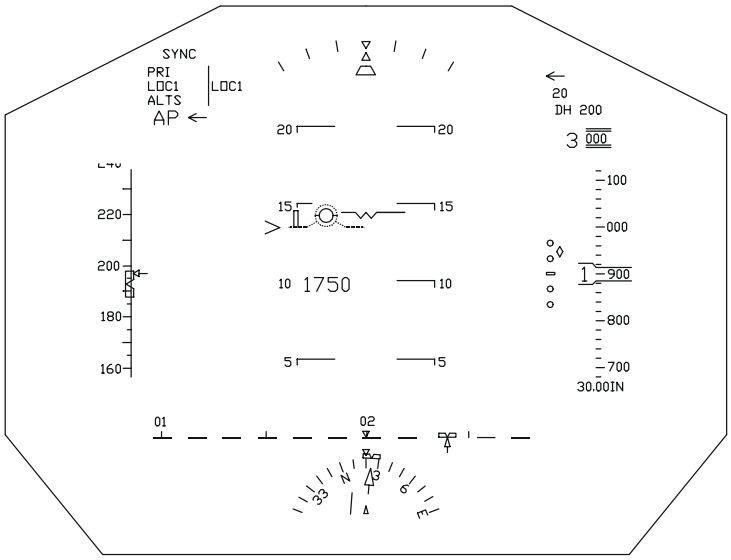


Figure 4-57:
Non-Conformal Symbols

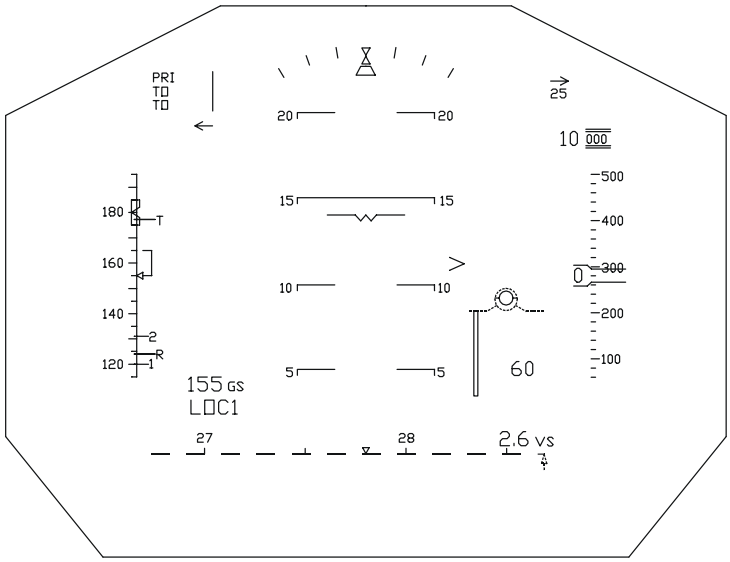
Limited and Ghosted Symbols

The HGS "limits" some symbols to always remain inside the Combiner display boundaries set by the HGS.

Depending on the symbol, it may be "ghosted" and may cause other symbols to be "ghosted". For example, if the aircraft attitude is such that the Zero-Degree Pitch Line is no longer conformal to the real world, it is "ghosted" (comprised of dashed lines). When the Zero-Degree Pitch Line is "ghosted," the Flight Path Symbol is also ghosted (Figure 4-58). The limited symbol is displayed at the edge of the Combiner display to indicate in which direction the left-side pilot needs to fly the aircraft to acquire the conformal display. Once a symbol is ghosted, it will remain ghosted until the display is conformal again.

Pitch Scale Compression

When the aircraft attitude is such that the Zero-Degree Pitch Line or the Flight Path Symbol cannot be displayed conformally, the Pitch Scale is compressed to allow these symbols to remain on the display (Figure 4-58). The position of these symbols is maintained relative to one another, but the display is no longer conformal with the real world. When the pitch attitude is approximately -17° or 25°, the 5° pitch lines are removed.



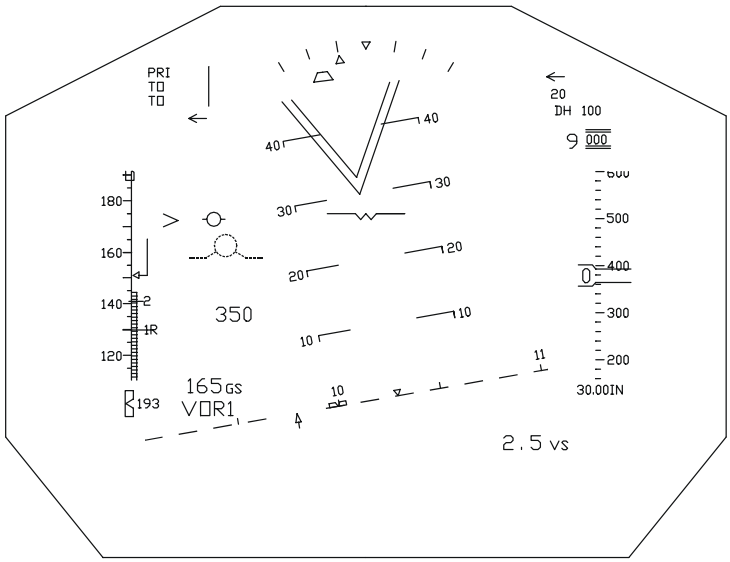


Figure 4-58:
Non-Conformal Symbols

HGS Modes/Symbology Matrix

Table 4-26 lists symbols associated with the categories defined above. The table shows in which HGS modes a symbol can be displayed. Symbols are described in the "Primary Mode Symbology" and "Approach Modes Symbology" subsections in the order listed in this table.

Table 4-26: HGS Modes/Symbology Matrix (page 1 of 7)

Symbol	PRI		TO	AIII	AII	AI	RO	F/D	VMC
	Ground	Flight							
Attitude Symbology									
Aircraft Reference	●	●	●	●	●	●	●	●	●
Roll Scale and Pointer	●	●	●	●	●	●	●	●	●
Zero-Degree Pitch Line	●	●	●	●	●	●	●	●	●
Pitch Scale	●	●	●	●	●	●	●	●	●
Conformal Magnetic Heading Scale (tic marks)	●	●	●	●	●	●	●	●	●
Conformal Magnetic Heading Index	●	●	●	●	●	●	●	●	●
HSI Heading Scale		●							
Roll Scale Slip/Skid Indicator	●	●	●	●	●	●	●	●	●
Aircraft Reference Slip/Skid Indicator		●							
Angle-of-Attack Indicator				●	●	●		●	●
Angle-of-Attack Limit		●		●	●	●		●	●
Pitch Reference		●	●						
Pitch Chevrons		●		●	●	●		●	●

Table 4 26. HGS Modes/Symbology Matrix (page 2 of 7)

Symbol	PRI		TO	AIII	AII	AI	RO	F/D	VMC
Airspeed Symbology									
Computed Airspeed Scale and Pointer	●	●	●						
Computed Airspeed				●	●	●	●	●	●
Selected Airspeed/Mach	●	●	●	●	●	●		●	●
Mach Number		●							
Wind Speed and Direction		●	●	●	●	●		●	●
Selected Airspeed Mark	●	●	●						
Maximum Operating Speed Tape		●							
Low-Speed Cue Tape		●							
Takeoff Speed Marks	●	●	●						
Reference Airspeed Table	●		●						
Airspeed Trend Vector	●	●	●						
Ground Speed	●	●	●	●	●	●	●	●	●
Altitude Symbology									
Barometric Altitude Scale and Index	●	●	●						
Barometric Altitude				●	●	●		●	●
Barometric Pressure Setting	●	●	●						
Selected Altitude	●	●	●						
Selected Altitude Mark	●	●	●						
Metric Altitude Readout	●	●	●						
Radio Altitude		●	●	●	●	●		●	●
Selected Decision Height	●	●	●	●	●	●		●	●
Decision Height Message		●		●	●	●		●	●

Table 4 26. HGS Modes/Symbology Matrix (page 3 of 7)

Symbol	PRI		TO	AIII	AII	AI	RO	F/D	VMC
	Ground	Flight							
Selected Minimum Descent Altitude (MDA)	●	●		●	●	●		●	●
MDA Alert Message		●		●	●	●		●	●
Vertical Speed		●		●	●	●		●	●
Runway Elevation	●	●							
Navigation Symbology									
FCS Lateral Modes	●	●	●					●	
FCS Vertical Modes	●	●	●					●	
Autopilot Engaged Message		●				●		●	●
Conformal Selected Heading Mark		●	●	●	●	●		●	●
Selected Heading Mark (HSI)		●							
Selected Heading	●	●	●	●	●	●	●	●	●
Conformal Selected Course Mark	●	●	●	●	●	●	●	●	●
Selected Course Mark (HSI)		●							
Selected Course/FMS Desired Track	●	●	●	●	●	●	●	●	●
Runway Edge Lines				●					
Navigation Source	●	●	●	●	●	●	●	●	
VOR TO/FROM Pointer (CDI)		●							
Lateral Deviation (CDI)		●							
Vertical Deviation Scale and Pointer		●							
Lateral Deviation Line				●	●	●		●	
Glideslope Deviation Line				●	●	●		●	
DME/FMS Distance	●	●	●	●	●	●	●	●	●

Table 4 26. HGS Modes/Symbology Matrix (page 4 of 7)

Symbol	PRI		TO	AIII	AII	AI	RO	F/D	VMC
	Ground	Flight							
Marker Beacons		●		●	●	●		●	●
HGS Active Mode	●	●	●	●	●	●	●	●	●
HGS Armed Mode	●	●		●					
Heading Source	●	●						●	●
Excessive Localizer Deviation		●	●	●	●	●	●	●	
Excessive Glideslope Deviation		●	●	●	●	●		●	
FMS Waypoint Identifier		●						●	
FMS Messages		●						●	
FMS Reference Altitude		●						●	
FMS Vertical Speed		●						●	
Flight Director Transfer Message		●						●	
Bearing Source		●							
Bearing Pointers		●							
Autopilot Disconnect Annunciation				●					
Flight Path Symbology									
Flight Path Symbol		●	●	●	●	●		●	●
Flight Path Acceleration	●	●	●	●	●	●	●	●	●
Speed Error Tape		●		●	●	●		●	●
HGS-Derived Guidance Cue				●	●	●			
FCS-Derived Guidance Cue		●						●	
Glideslope Reference Line				●	●	●		●	●
Flight Path Slip/Skid Indicator		●		●	●	●		●	●
“IDLE” Message				●					

Table 4 26. HGS Modes/Symbology Matrix (page 5 of 7)

Symbol	PRI		TO	AIII	AII	AI	RO	F/D	VMC
	Ground	Flight							
Flare Command				●					
Flare Cue		●			●	●		●	●
Ground Symbology									
Ground Roll Reference			●				●		
Ground Localizer Deviation Scale and Pointer			●				●		
HGS-Derived Ground Guidance Cue			●				●		
Runway Remaining			●				●		
Deceleration Scale and Pointer	●		●	●	●	●	●	●	●
Ground Localizer Line				●	●	●		●	
Non-Normal Symbology									
Unusual Attitude		●		●	●	●		●	●
TCAS		●	●	●	●	●		●	●
Windshear Alert		●	●	●	●	●	●	●	●
Source Annunciations Symbology									
Attitude Source	●	●			●	●	●	●	●
Air Data Source	●	●			●	●	●	●	●
Display Control Panel Source	●	●			●	●	●	●	●
Autopilot Operational Status	●	●			●	●	●	●	●

Table 4 26. HGS Modes/Symbology Matrix (page 6 of 7)

Symbol	PRI		TO	AIII	AII	AI	RO	F/D	VMC
	Ground	Flight							
Warning Annunciations Symbology									
"ALIGN HUD"	●	●	●	●	●	●	●	●	●
"APCH WARN"				●	●				
"NO AIII"				●					
"NO AII"					●				
"NO AI"						●			
"NO TO"			●						
"TO WARN"			●						
"NO RO"							●		
"RO CAUTION"							●		
"PULL UP"		●		●	●	●		●	●
"TERRAIN"		●		●	●	●		●	●
Yaw Damper Disengaged	●	●	●	●	●	●	●	●	●
Sensor Failure Flags									
Pitch	●	●	●	●	●	●	●	●	●
Roll	●	●	●	●	●	●	●	●	●
Heading	●	●	●	●	●	●	●	●	●
Airspeed	●	●	●	●	●	●	●	●	●
Altitude	●	●	●	●	●	●	●	●	●
Radio Altitude	●	●	●	●	●	●	●	●	●
Localizer	●	●	●	●	●	●	●	●	
Flight Director	●	●	●	●	●	●	●	●	●
Vertical Speed	●	●	●	●	●	●	●	●	●

Table 4 26. HGS Modes/Symbology Matrix (page 7 of 7)

Symbol	PRI		TO	AIII	AII	AI	RO	F/D	VMC
	Ground	Flight							
Glideslope	●	●		●	●	●		●	
Navigation Source Annunciations	●	●	●	●	●	●	●	●	
Vertical Deviation		●						●	
Bearing		●							
TCAS Status	●	●	●	●	●	●	●	●	●
Sensor Miscompares									
Pitch	●	●	●	●	●	●	●	●	●
Roll	●	●	●	●	●	●	●	●	●
Heading	●	●	●	●	●	●	●	●	●
Altitude	●	●	●	●	●	●	●	●	●
Airspeed		●	●	●	●	●	●	●	●
Localizer	●	●	●	●	●	●	●	●	
Glideslope	●	●	●	●	●	●	●	●	
Radio Altitude	●	●	●	●	●	●	●	●	●
Aileron Mistrim	●	●	●	●	●	●	●	●	●
Elevator Mistrim	●	●	●	●	●	●	●	●	●
Rudder Mistrim	●	●	●	●	●	●	●	●	●

Section 5:
Typical Flight Profile

A typical flight profile for the HGS includes these phases of flight (Figure 5-1):

- During takeoff in TO Mode, including operations down to minimum RVR (with regulatory approval).
- During the climb to the assigned cruising altitude in PRI mode. The left-side pilot can use Flight Path and Flight Path Acceleration to optimize the aircraft's performance, and to simultaneously monitor the flight's progress and monitor for other traffic.
- While enroute for navigation in PRI mode.
- During the descent in PRI mode, using Flight Path to establish the appropriate glide path and airspeed control. Again, the pilot can also use the HGS to monitor for other traffic and do normal terminal area maneuvers.
- Once established on the ILS approach (ILS captured), using AIII mode for precise manually flown approach and landing guidance capable of operations to CAT III minimums. The AII mode is used for HGS guidance for manually flown approaches to CAT II minimums. The AI mode is used for HGS guidance for manually flown approaches to CAT I minimums. The F/D mode is used for FCS guidance for CAT II, CAT I, and non-precision approaches (LOC). The VMC mode is used for visual approaches to get a precise visual approach path to the runway touchdown zone.
- During a guided rollout (if enabled) after an AIII approach.

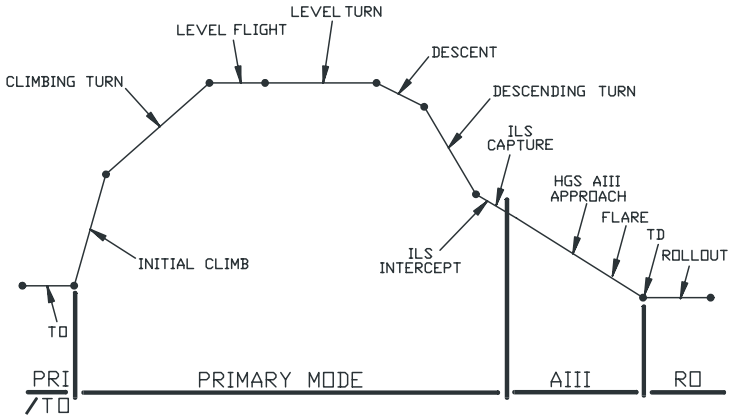


Figure 5-1:
Typical Flight Profile

This section begins by describing Primary Mode profiles from takeoff to landing. The section concludes with profiles for AIII, AII, AI, F/D, and VMC approach operations. Descriptions and illustrations are provided for each of the following flight profiles:

- Takeoff Ground Roll
- Initial Climb
- Climbing Turn
- Level Flight
- Level Turn
- Descent
- Descending Turn
- ILS Intercept
- ILS Capture
- AIII Approach – Beginning the Approach
- AIII Approach – 300 Feet
- AIII Approach – 50 Feet
- AIII Approach – Flare/Touchdown
- AIII Rollout
- AII Approach
- AI Approach
- F/D Approach
- VMC Approach

Takeoff Ground Roll

For Takeoff Mode:

1. Select PRI Mode from the HCP.

NOTE: For instructions on mode selection, see Section 3, "HGS Modes of Operation."

2. Enter the runway length on the HCP.
3. Complete all procedures to set the LOC:
   - Tune the #1 and #2 VHF Nav Receivers to the departing runway ILS frequency
   - Set the ILS-selected course
   - Select ILS Nav.
4. Set TO Mode on the HCP STBY line.
5. Taxi into takeoff position over the runway centerline. If necessary, adjust the selected course to align the selected course and ground localizer line on the runway centerline.
6. Push the TO/GA pushbutton.
7. If all TO conditions are satisfactory for the HGS, TO Mode starts automatically. "TO" also shows on the HCP ACT line.
8. Continue takeoff procedures.
9. Use the HGS ground localizer symbology and guidance for takeoff.

Figure 5-2 shows:

- Ground reference symbol and guidance cue show position of aircraft
- Localizer set for Runway "28"
- Runway remaining is 11,500 feet
- Selected altitude set at 10,000 feet for initial climb
- Ground speed at 44 knots
- Target airspeed set at 180 knots in initial climb.

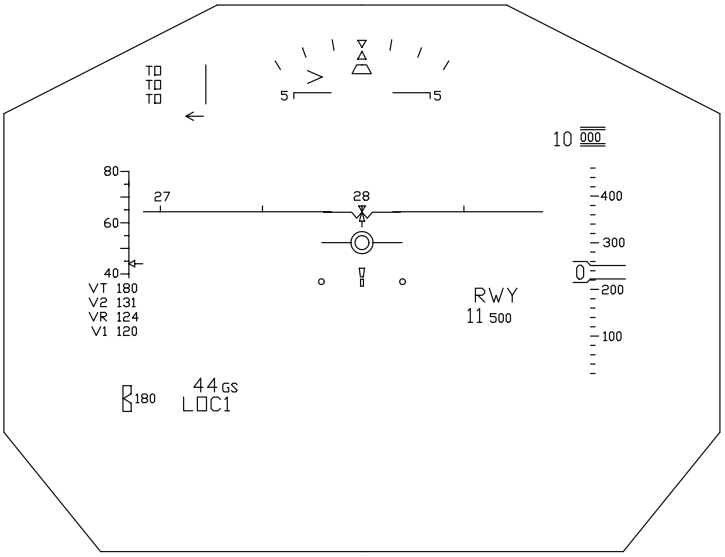


Figure 5-2:
Takeoff Mode Ground Roll

Initial Climb

At a Radio Altitude of 50 feet, the HGS automatically changes from TO Mode to PRI Mode. “PRI” shows on the ACT line of the HCP.

Changes occur in the Combiner display after takeoff:

- Symbology for Flight Path and Flight Path Acceleration show. With the power set and the aircraft at the selected airspeed, the left-side pilot can pitch the airplane up to the Flight Path Acceleration symbol for a constant airspeed.
- Symbology for Radio Altitude shows. If the FD lateral or vertical captured mode is TO, the HSI does not show on the Combiner display.
- The Flight Path symbol and the Zero-Degree Pitch Line are “ghosted” (dashed lines replace solid lines) when the view on the Combiner display is compressed and becomes non-conformal.

Figure 5-3 shows:

- Pitch attitude is about 14°
- Climb angle is about 8°
- “Ghosted” Flight Path symbol overlays Guidance Cue symbol
- Zero-Degree Pitch Line is “ghosted”
- Wind is straight off nose of aircraft at 8 knots
- Selected altitude is 10,000 feet
- Baro Altitude is 280 feet
- Flight Path Acceleration symbol shows that speed increases
- Ground speed is 144 knots
- Selected airspeed is 180 knots
- Airspeed is 155 knots
- HSI does not show because the Flight-Director captured lateral mode is TO
- Radio Altitude is 60 feet during climb at 2600 FPM on heading of 278°.

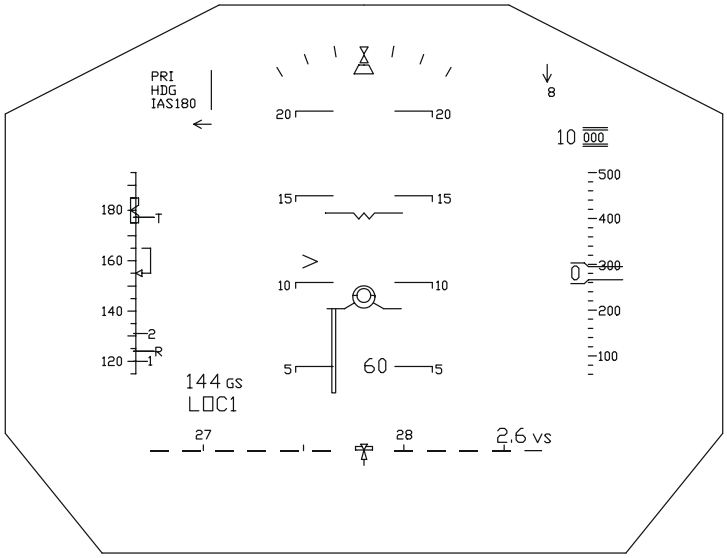


Figure 5-3:
Initial Climb

Climbing Turn

During a climbing turn, the pilot keeps the FCS-Derived Guidance Cue centered in the Flight Path symbol as necessary.

Figure 5-4 shows:

- Aircraft is banked 20° in right-coordinated climbing turn
- Aircraft turns through heading of 310° to rollout on 330° heading
- VOR is tuned and course is set to intercept 330° radial TO station
- Selected altitude at 10,000 feet
- Altitude at 2,900 feet
- Selected airspeed at 230 knots
- Airspeed at 225 knots.

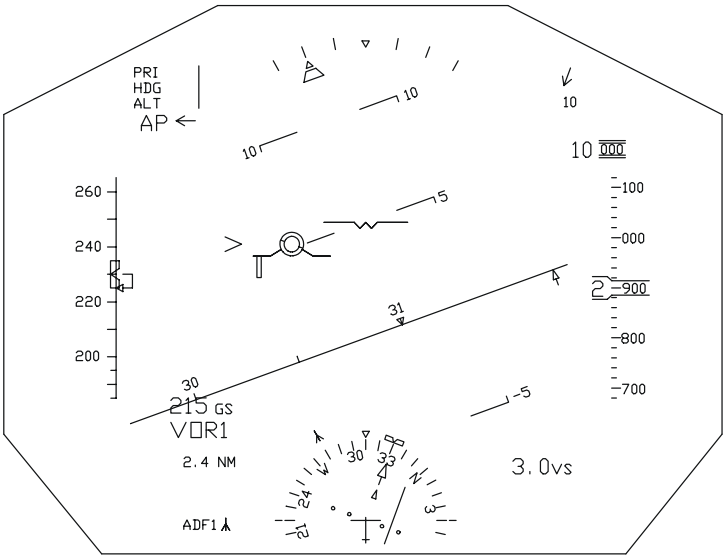


Figure 5-4:
Climbing Turn

Level Flight

To maintain straight and level flight at the selected airspeed, keep the Flight Path symbol on the Zero-Degree Pitch Line and the Flight Path Acceleration symbol on the Flight Path wing.

Figure 5-5 shows:

- Aircraft is level at 22,000 feet and 305 knots.
- Wind arrow indicates a 21 knot, right-quartering headwind resulting in a ground speed of 288 knots.
- Autopilot is engaged with course set at 250° FROM the VOR and in MACH hold.

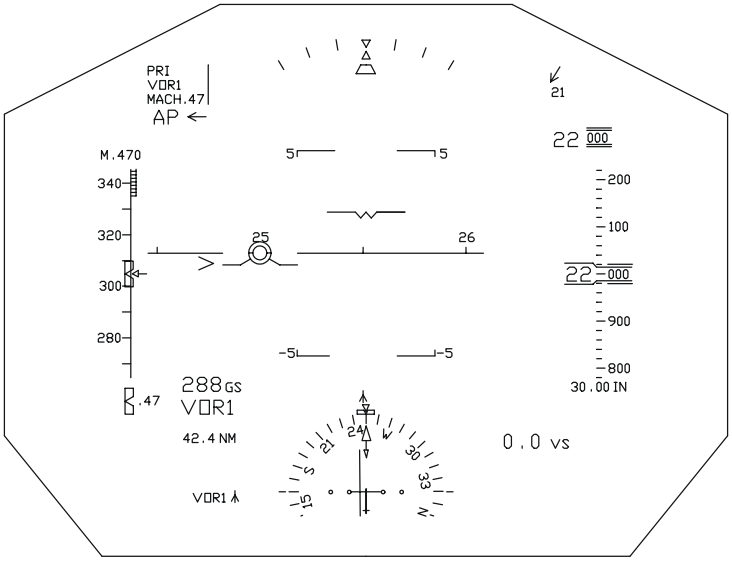


Figure 5-5:
Level Flight

Level Turn

To maintain the selected altitude in a level turn, keep the Flight Path symbol centered on the Zero-Degree Pitch Line. In a 30°-bank level turn, the "wing" of the Flight Path symbol overlays the Zero-Degree Pitch Line.

Figure 5-6 shows:

- Aircraft is banked 30° in level-left coordinated turn
- Aircraft turns through heading of 280° toward selected heading of 235° to intercept 250° radial FROM VOR station
- Selected speed at 230 knots
- Airspeed at 235 knots; thus, Speed Error Tape is above Flight Path symbol.

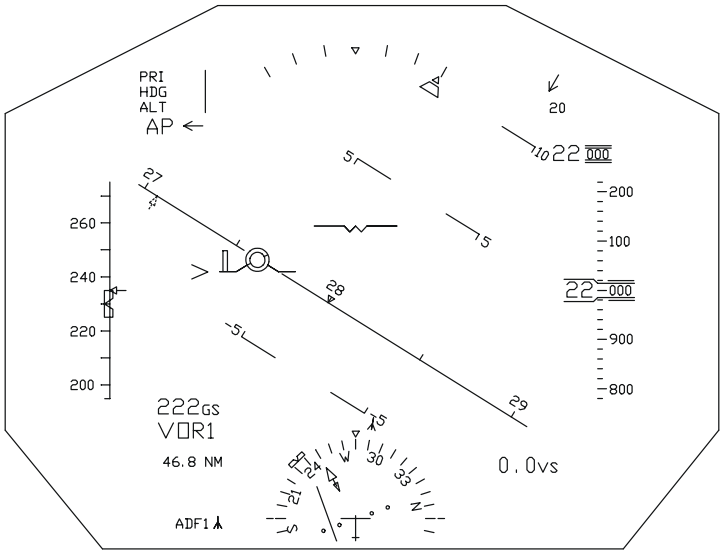


Figure 5-6:
Level Turn

Descent

During a descent, the pilot continues to keep the Guidance Cue centered in the Flight Path symbol as necessary.

Figure 5-7 shows:

- Selected altitude is 15,000 feet and the aircraft is descending through 19,840 feet
- Selected airspeed is 290 knots
- Airspeed is 297 knots, thus the Speed Error Tape is above Flight Path symbol
- Aircraft is decelerating, which is shown by Airspeed Trend Vector and Flight Path Acceleration symbols
- Left-quartering tailwind at 18 knots causes aircraft to fly in slight left-crab angle for 250° VOR radial. Crab angle causes lateral displacement of Flight Path symbol relative to Aircraft Reference symbol

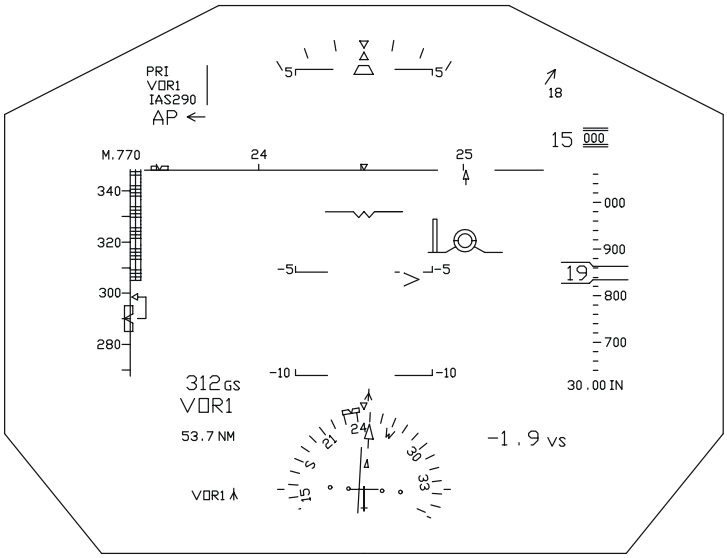


Figure 5-7:
Descent

Descending Turn

Figure 5-8 shows:

- Aircraft's pitch attitude and descent angle are about -5° in a 30° right turn
- Aircraft descends through 6,000 feet toward the Selected Altitude of 5,000 feet at 2100 FPM
- Airspeed is at 230 knots
- Because of the descent angle, the aircraft accelerates without added thrust, as shown by the Acceleration Caret and the Airspeed Trend Vector.

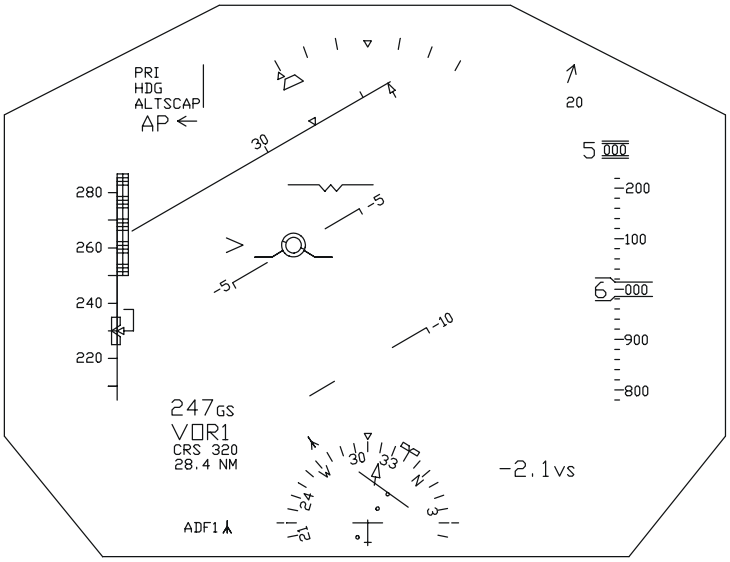


Figure 5-8:
Descending Turn

ILS Intercept

In PRI Mode, the HSI/CDI shows all course deviations whether Localizer, VOR, or FMS. When ILS is selected, the glideslope scale and deviation pointer are displayed.

Figure 5-9 shows:

- Autopilot is engaged at a 30° intercept heading (130°) to the ILS course of 158°
- Heading Mark and HSI show selected heading
- The Selected Course and the Selected Course Mark (below the Zero-Degree Pitch Line and on the HSI) show the ILS course. In this example, the ILS course is outside field-of-view (158°), thus the pointer is "ghosted" on the right end of Zero-Degree Pitch Line.
- Aircraft level at 3,000 feet with intercept from below glideslope
- Aircraft is 13.4 nautical miles from DME station
- Aircraft decelerates to selected airspeed of 150 knots.

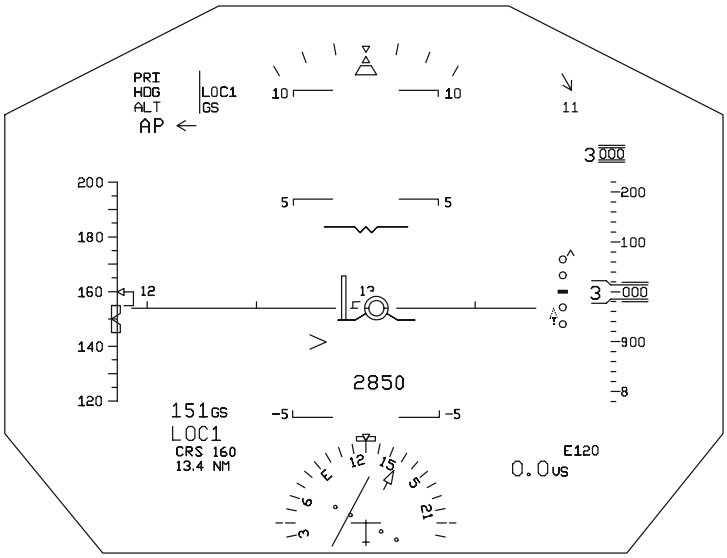


Figure 5-9:
ILS Intercept

ILS Capture

Figure 5-10 shows the Combiner display immediately before ILS capture. AIII mode is armed and the aircraft has completed the turn to the final approach. When the ILS is captured, the HGS will automatically change to AIII mode.

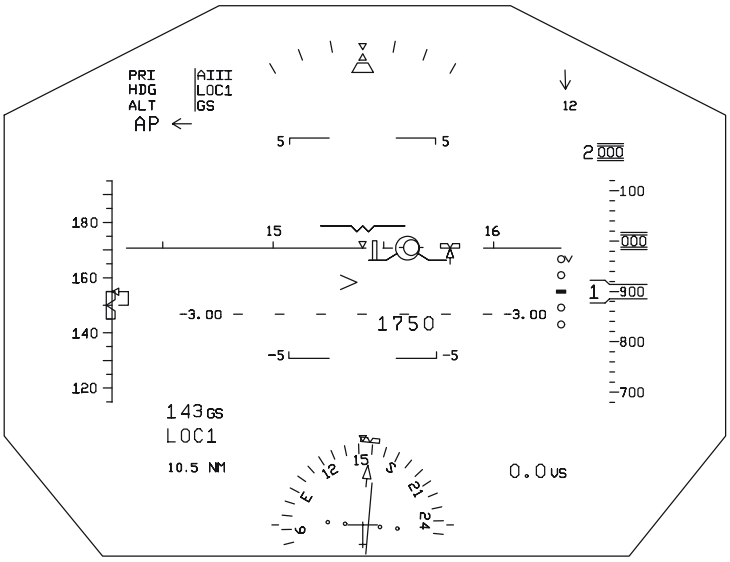


Figure 5-10:
ILS Capture

AIII Approach - Beginning the Approach

Figure 5-11 shows:

- AIII Mode active, RO Mode armed
- Aircraft on localizer and glideslope
- Guidance Cue is in center of Flight Path symbol and is above –3.00° Reference Glideslope line (aircraft correcting to glideslope)
- Aircraft descends at 500 FPM through 1820 feet (1700 AGL) over the Outer Marker (OM) at 5.8 nautical miles
- Aircraft decelerates through 135 knots toward selected airspeed of 130 knots

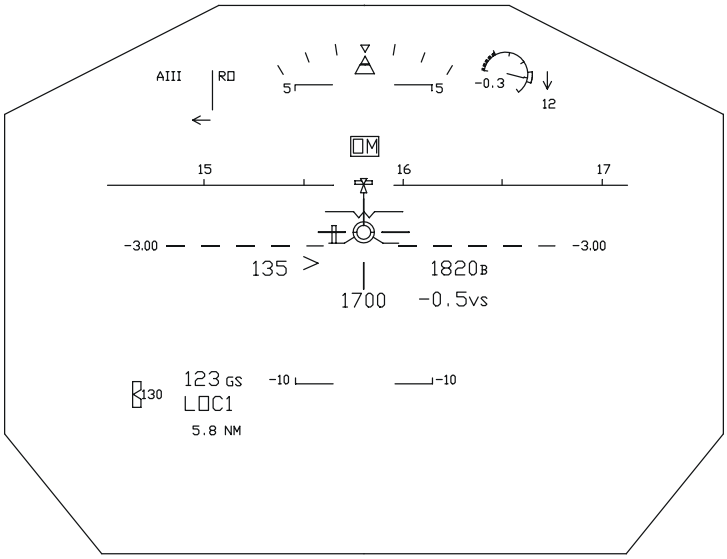


Figure 5-11:
AIII Approach

At the point Figure 5-11 shows, the HGS displays Localizer Deviation as vertical bars laterally positioned relative to the Selected Course pointer and Glideslope Deviation as horizontal bars vertically positioned relative to the Reference Glideslope line. When centered, these bars create a cross in the center of the display with the Flight Path and HGS Guidance Cue in the middle.

In AIII mode, the Guidance Cue gives pitch and roll commands derived by the HGS and gives guidance all the way to touchdown.

AIII mode includes an approach monitoring function that is active from 500 feet AGL to touchdown. This monitor controls the "APCH WARN" message in the event of a system fault (i.e., sensor, equipment or HGS failure) or if the aircraft exceeds a performance monitor limit. Performance monitoring is related to the left-side pilot's ability to track the ILS and flare guidance, and to the projected touchdown being within the required touchdown limits, including excessive lateral and vertical position, airspeed, sink rate, crosstrack rate and long landing.

HGS RO Mode: If RO Mode is enabled, it is automatically armed when AIII Mode is active. "RO" shows to the right of the vertical line in the upper left corner of the Combiner display (Figure 5-11). When RO Mode is armed, "RO" flashes for 5 seconds and then is steady.

AIII Approach—300 Feet

Figure 5-12 shows:

- Aircraft descends through 300 feet Radio Altitude
- Aircraft at 130 knots and on speed
- Runway Edge Lines show in perspective and are set relative to the Conformal Selected Course Pointer to overlay “real-world” runway.

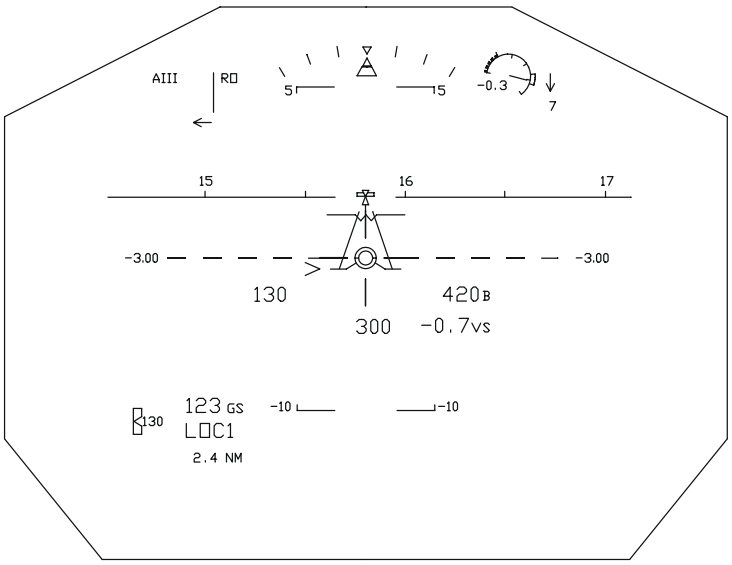


Figure 5-12:
AIII Approach—300 Feet

The environmental conditions for nominal CAT III operations are usually stable, so the HGS symbology is stable. The pilot then:

- Centers and maintains the Flight Path symbol over the cue to track the HGS Guidance Cue, and subsequently the ILS.
- Monitors raw localizer and glideslope data relative to their null positions to help minimize deviations and anticipate corrections.
- Controls airspeed by maintaining the Flight Path Acceleration symbol aligned off the Flight Path wing.

These relationships allow the pilot to easily identify any deviations in the ILS tracking or any airspeed error.

The “AIII” in the Combiner’s upper-left corner shows the selected mode and approach status. This AIII status message remains as long as all required parameters and conditions are valid for a CAT III approach. If a condition develops that invalidates a required parameter, the HGS replaces the “AIII” message with “NO AIII”. Below 500 feet, the HGS also displays an “APCH WARN” message. If an approach warning occurs, the left-side pilot should do a go-around, unless adequate visual cues are available.

AIII Approach—50 Feet

Figure 5-13 shows:

- Aircraft descends through 50 feet Radio Altitude.
- Decision Height annunciation shows beside the Radio Altitude.
- When Flare Command ("+") moves into center of Guidance Cue, flare maneuver should start. "FLARE" shows in green on PFDs.
- Airspeed is 129 knots and the selected airspeed is 130 knots.
- The Runway Edge Lines do not show below 60 feet. This allows the pilot to make the decision to land on visual cues only at DH with no influence from synthetic inputs.
- Glideslope deviation raw data does not show below 70 feet AGL because the glideslope is unreliable at this point and the HGS no longer uses it for guidance computations. The HGS is in Glideslope extension to accurately give touchdown guidance.
- From decision height to touchdown, the left-side pilot should track the HGS Guidance Cue while using real world visual cues to assist in assessing approach performance.
- First officer continues to monitor approach, head-down, through touchdown.

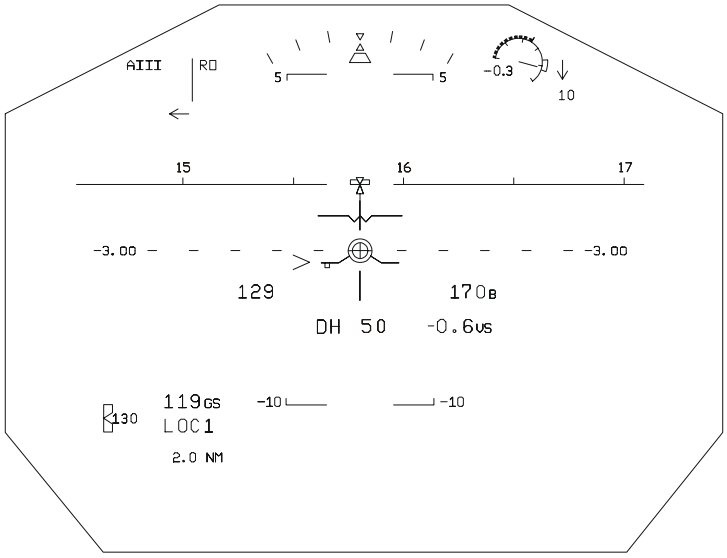


Figure 5-13:
AIII Approach—50 Feet

AIII Approach—Flare/Touchdown

A flare maneuver transitions the aircraft from the approach attitude to the touchdown attitude.

The computed touchdown is designed to firmly establish the aircraft on the ground within the acceptable touchdown footprint, while tracking the runway centerline.

Figure 5-14 shows:

- Aircraft is flared into landing attitude
- Aircraft descends through 15 feet AGL
- "IDLE" shows on Combiner display to remind left-side pilot to idle power
- Aircraft slows through 128 knots
- Aircraft is in position over centerline of runway

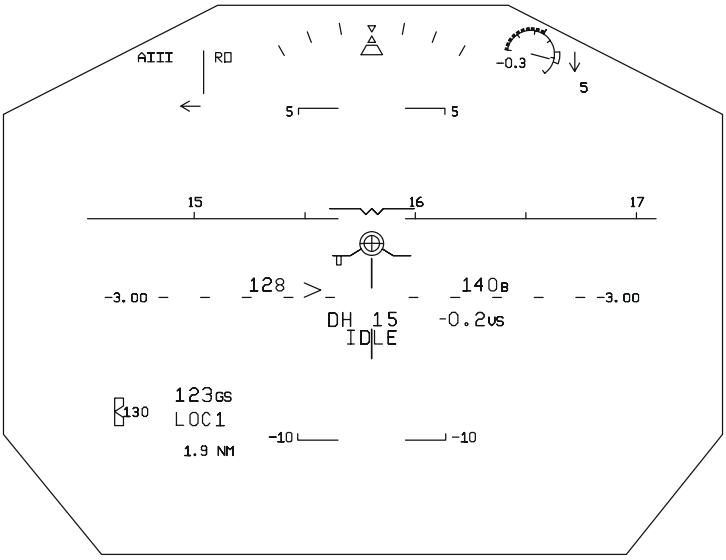


Figure 5-14:
AIII Approach—Flare/Touchdown

AIII Rollout (if enabled)

Figure 5-15 shows:

- At touchdown in AIII Mode, HGS automatically changes to RO Mode (if enabled)
- "RWY" gives remaining runway of 3,500 meters (if enabled)
- Ground Guidance Cue and Ground Localizer Deviation Scale and Pointer give a precise indication of aircraft's lateral deviation from runway center line
- Ground speed is 80 knots.

When the aircraft starts to decelerate, the Deceleration Scale shows on rollout. The Deceleration Pointer (">") shows the deceleration rate (in "Gs") caused by braking. When the ground speed is less than 20 knots, the HGS changes automatically to PRI Mode.

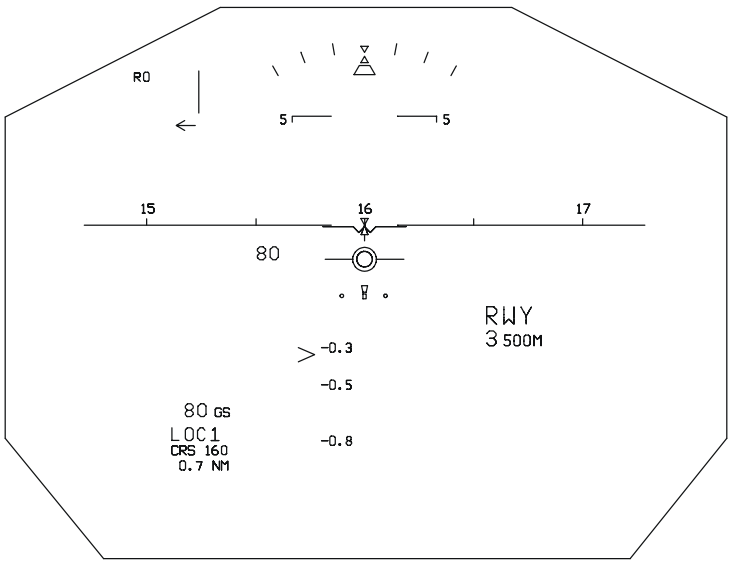


Figure 5-15:
AIII Rollout (if enabled)

Rollout with Localizer Line (if RO Mode not enabled)

Figure 5-16 shows rollout with localizer line symbology. This display shows after touchdown following an approach in PRI, AIII, AII, AI, or F/D if RO Mode is not enabled.

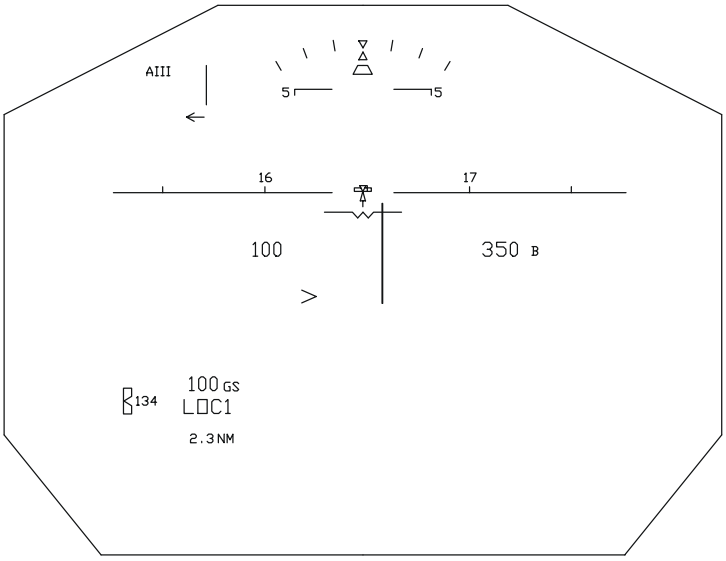


Figure 5-16:
Rollout with Localizer Line

AII Approach

The AII approach mode display is similar to an AIII approach with the differences shown in Figure 5-17.

- The HGS active mode is AII
- Guidance Cue is removed at 80 feet AGL
- AII approach monitor is active only to 80 feet AGL.

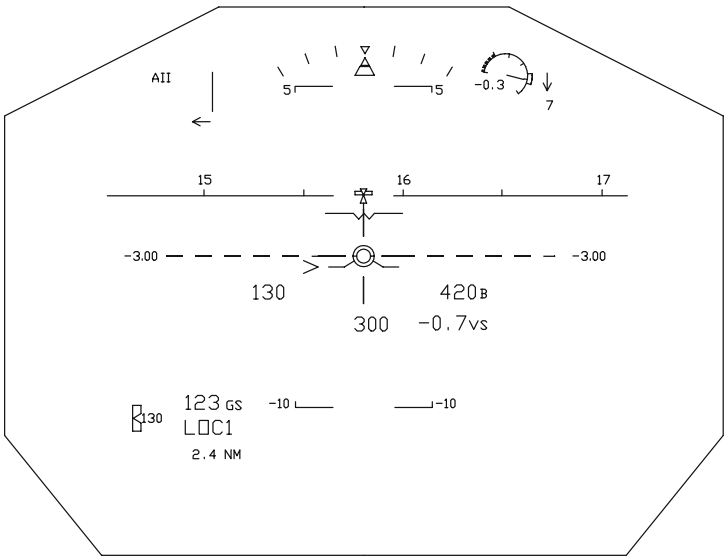


Figure 5-17:
AII Approach—300 Feet

AI Approach

The AI approach mode display is similar to an AIII approach with the differences shown in Figure 5-18.

- The HGS active mode is AI
- Guidance Cue is removed at 80 feet AGL
- AI approach monitor does not include aircraft performance, and is only active to 80 feet AGL
- Approach warnings are not given.

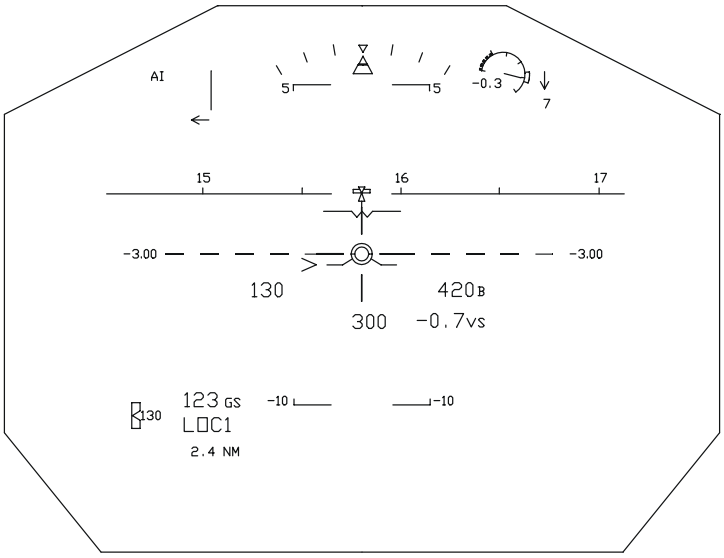


Figure 5-18:
AI Approach—300 Feet

Flight Director Approach (F/D)

The F/D mode allows the pilot to fly an FCS approach using the same approach display format as the HGS AIII approach mode. In the F/D Mode, the Guidance Cue is controlled by the FCS.

The F/D approach mode display is similar to an AIII approach with the differences shown in Figure 5-19.

- The HGS active mode is F/D.
- The HGS derives the guidance cue from the FCS and removes it from the display at 80 feet.
- The HGS displays FCS modes.
- The HGS shows the F/D Mode on the Combiner display and the PFDs.
- The HCP ACT line shows “F/D”.
- The HGS does not monitor the approach or give flare guidance. However, the HGS shows flare cue (“+ +”) for the visual flare.

The left-side pilot can use the F/D Mode during a standard Flight Director approach that is approved for the basic airplane or the operator’s Operations Specification (e.g., a CAT I Flight Director approach).

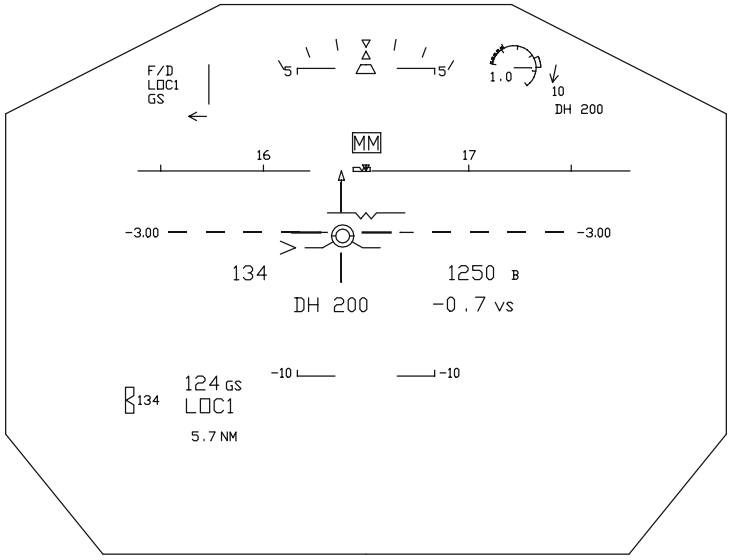


Figure 5-19:
F/D Approach

Visual Approach

The HGS VMC mode makes situational awareness better during a visual approach. This is particularly useful during visual approaches into airports without visual approach aids like a VASI. For a visual approach, the HGS allows the left-side pilot to accurately control the glidepath to the runway without using ground-based guidance signals.

The Combiner displays shows the Glideslope Reference Line as it relates to the real-world runway touchdown point. The left-side pilot uses Flight Path on the touchdown point to fly the aircraft, which causes the aircraft to track an inertial-based glideslope. The left-side pilot then has accurate descent path data to prevent undershooting or overshooting the runway because of poor visual cues or depth perception.

The subsections in the list that follows give data and instructions about how to use the HGS VMC Mode:

- Establishing the Intercept Point
- Intercepting the Touchdown Zone
- Reaching Glidepath Position at 500 Feet
- Accomplishing Flare and Landing
- Basic Rollout

Establishing the Intercept Point

In Figure 5-20, the left-side pilot maneuvers the aircraft to establish the intercept point. The aircraft is in a descending left turn to align itself laterally with the runway.

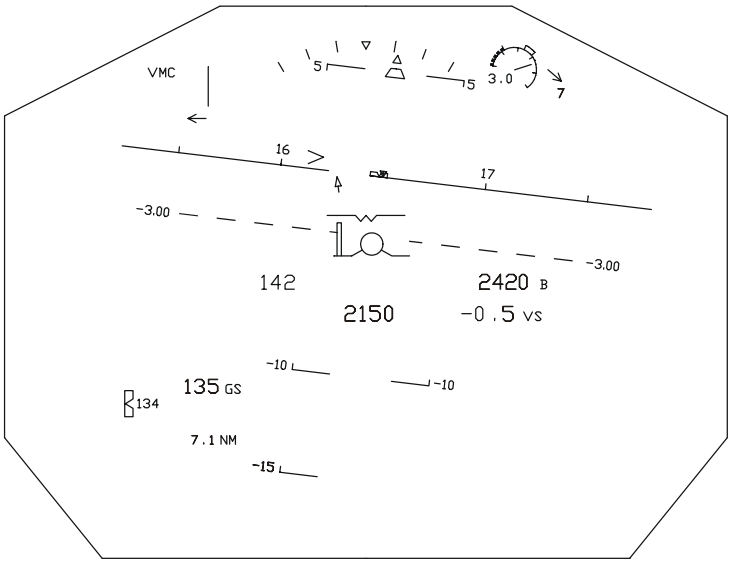


Figure 5-20:
VMC Mode Approach—Lateral Alignment

Intercepting the Touchdown Zone

In Figure 5-21, the aircraft is now aligned laterally with the runway, and the left-side pilot has leveled the aircraft to intercept the correct glideslope angle.

If the Glideslope Reference Line is below the Touch Down Zone (TDZ), the left-side pilot must fly a higher flight path angle until the line and the TDZ intersect. If the Glideslope Reference Line is above the TDZ, the left-side pilot must increase the descent, which occurs when the Flight Path symbol is set below the TDZ until the Glideslope Reference Line and the TDZ are aligned.

When the Glideslope Reference Line is on the TDZ, the left-side pilot makes small corrections to keep the Flight Path on the TDZ and the Glideslope Reference Line.

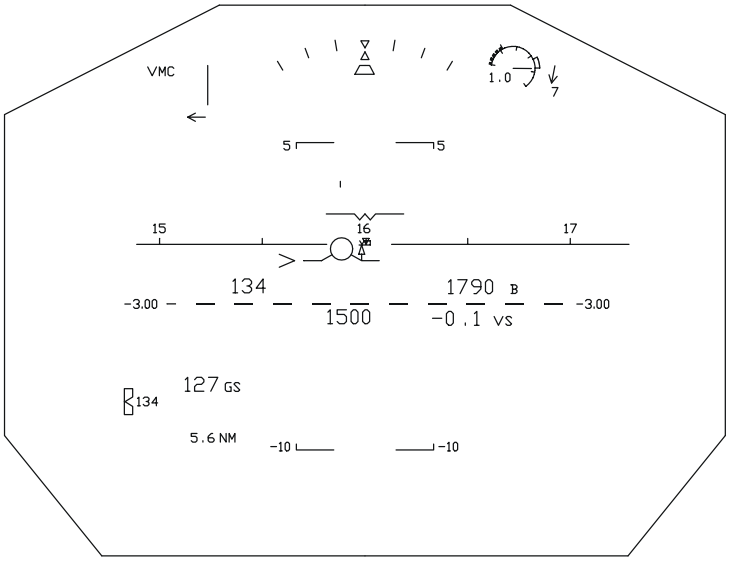


Figure 5-21:
VMC Approach—Intercepting the Touchdown Zone

Reaching Glidepath Position at 500 Feet

Figure 5-22 shows VMC symbology at 500 feet AGL. When the Glideslope Reference Line overlays the TDZ, keep the Flight Path on the Glideslope Reference Line to fly a 3° glidepath. The left-side pilot keeps airspeed control the same as during other approach operations.

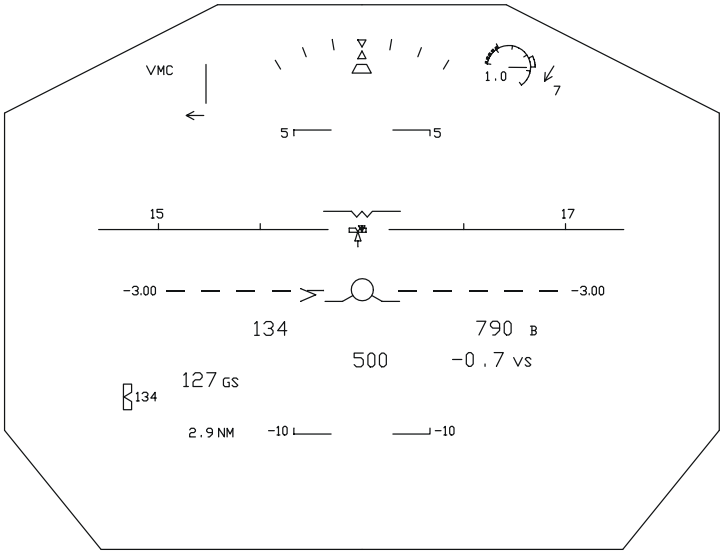


Figure 5-22:
VMC Approach—Glidepath Position at 500 Feet

Accomplishing Flare and Landing

The left-side pilot uses the usual visual cues and landing procedures to accomplish flare and landing in the VMC mode (Figure 5-23). Between 60 and 30 feet RA, the Flare Cue symbol (+ +) flashes continuously.

NOTE: The Flare Cue is fixed to the Flight Path Symbol and is not used to command or provide guidance for the flare maneuver.

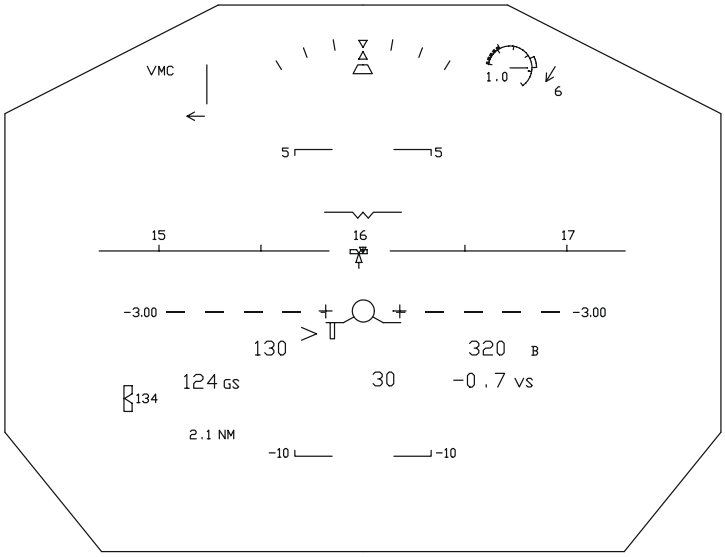


Figure 5-23:
VMC Mode—Flare and Landing

Basic Rollout

Figure 5-24 shows basic rollout symbology. This display shows after touchdown after a VMC Mode approach. This display also shows after PRI, AII, AI, or F/D approaches if RO Mode is enabled.

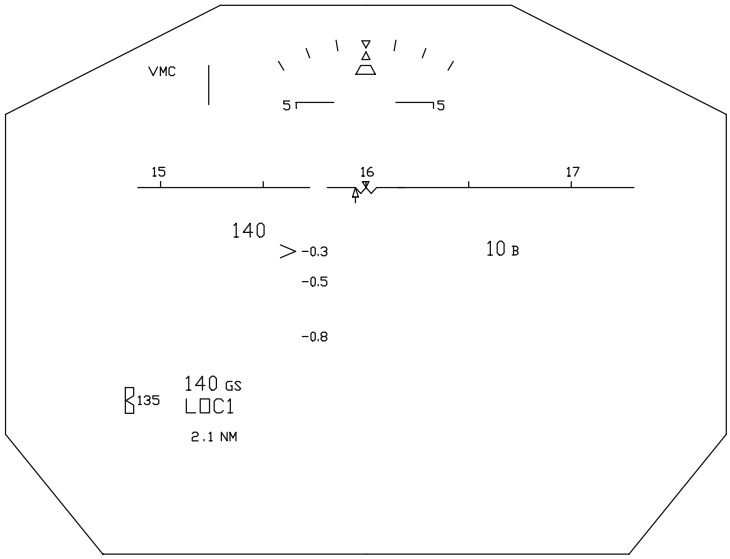


Figure 5-24:
Basic Rollout

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Appendix A:
Reference Information

This appendix presents information related to the topics listed below:

- HGS Interface
- Right-Side Monitoring Requirements
- Approach Monitoring
- Built-In Tests
- HGS Test
- HCP Display Test.

HGS Interface

The subsections that follow give data related to the HGS interface:

- HGS Interface Block Diagram
- HGS Interconnect
- Sensor and Equipment Inputs.

HGS Interface Block Diagram

Figure A-1 gives the HGS interface block diagram.

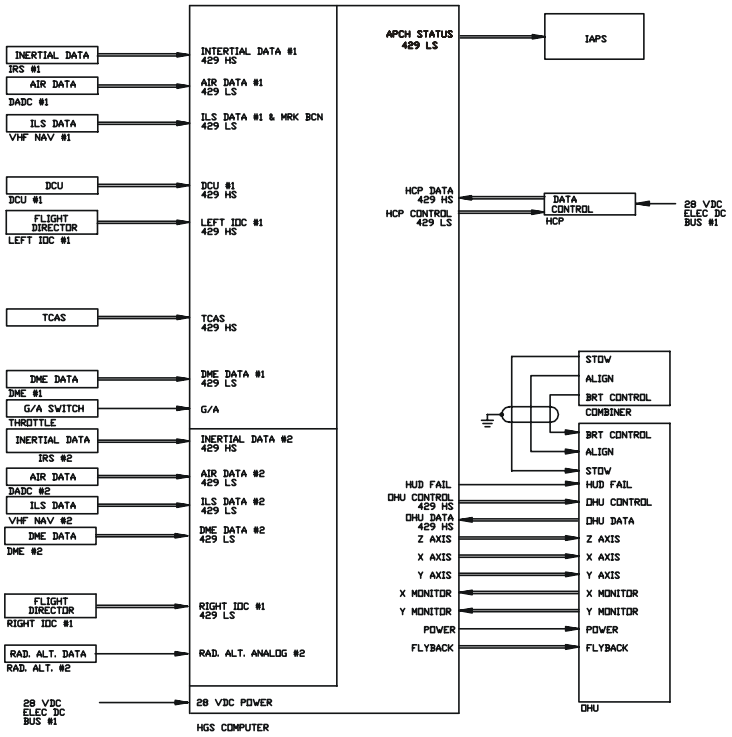

Figure A-1:
HGS Interface Block Diagram

HGS Interconnect

The HGS interconnect consists of video signals between the HC and OHU. The HC and HCP transmit bi-directional data about HGS modes, functions, data entry, and system status. The HC also receives video feedback signals and LRU status (Built-In Test) data and gives outputs to the EFIS.

Sensor and Equipment Inputs

The HGS receives inputs from redundant sensor and equipment systems to meet the requirements of a fail-passive CAT III approach and landing system. The HGS receives these inputs through dual independent input/ output subsystems contained within the HC. These inputs include digital and analog data and related status signals from these sensors and equipment:

- Dual Inertial Reference System (IRS) for primary attitudes, headings, body accelerations, body rates, inertial vertical speed, ground speed and environmental data
- Dual Air Data Computers (ADC) for altitude and airspeed data
- Dual VHF Navigation Receivers for VOR, ILS and Marker Beacon data
- Dual Radio Altimeter Systems for altitude above ground data
- Dual Flight Control Systems (FCS) for command signals, modes and status
- Dual Distance Measuring Equipment (DME) for station slant range distance
- TCAS for traffic avoidance data
- IAPS for ARP, RSP, EGPWS, FCP, and FMS data.

Below is a list of parameters the HGS uses or displays that the flight crew can select manually.

- Use the Flight Control Panel (FCP) or power lever GA switches to select FCS modes and to enter selected altitude, selected airspeed, selected heading and selected course
- Use the left-side Air Data Reference Panel (ARP) to enter the Decision Height and barometric altitude.
- Use the Reversionary Switching Panel (RSP) to make reversion selections.

Right-Side Monitoring Requirements

Low-visibility operations require a high degree of safety. The HGS helps the flight crew assess the approach to the runway, centerline tracking, and the performance of the HGS and associated systems. The right-side pilot analyzes the takeoff, approach, and rollout procedures and monitors the performance of the HGS system and its related sensors. The right-side pilot also uses data on the EFIS system (PFD and EICAS).

Expanded Localizer

HGS low-visibility operations require the expanded localizer to allow the right-side pilot to monitor lateral deviations during TO, AIII, and RO Modes. The scaling represents the limit for lateral deviation when the pointer is just going out of view on either side of the scale.

Approach Monitoring

The HC contains an independent processor called the System Monitor. During approach, the System Monitor has three functions:

- Determine the status of the systems, configuration and data required for an AIII, AII or AI approach
- Make sure HGS symbology is positioned accurately (Critical Symbol Monitoring, see “Built-In Tests”)
- Make sure an AIII or AII approach is flown successfully (Approach Monitoring).

If the System Monitor detects an HGS or sensor fault, a configuration problem, or a data problem, AIII, AII, or AI capability is lost. Below 500 feet AGL an approach warning (APCH WARN) is given in AIII or AII Mode.

The Approach Monitor is active in AIII or AII Mode when aircraft altitude is less than 500 feet AGL. In AII Mode, the monitor is not active below 80 feet AGL. The Approach Monitor operates as both a tracking monitor and a flare monitor (AIII only). If the Approach Monitor finds an out of tolerance condition, an approach warning is given.

The tracking monitor evaluates the state of the approach relative to:

- Airspeed error
- Localizer deviation
- Glideslope deviation
- Crosstrack rate.

The flare monitor evaluates (AIII only):

- The aircraft sink rate
- Lateral displacement from the centerline of the runway
- Pitch rate
- Airspeed error
- Crosstrack rate
- Late flare initiation
- Flare guidance tracking
- Roll angle
- Touchdown distance from the threshold (long landing).

The System Monitor automatically starts a functional test of the Approach Monitor when the system is AIII or AII capable and the glideslope and localizer are captured. If the HGS fails this test, it loses AIII or AII capability.

Ground Guidance Monitoring

During TO or RO Mode, the System Monitor has two functions:

- Determine the status of the systems, configuration and data required for ground guidance
- Make sure HGS symbology is positioned accurately (Critical Symbol Monitoring, see "Built-In Tests").

If the System Monitor detects an HGS or sensor fault, a configuration problem, or a data problem, TO or RO capability is lost. If TO capability is lost and ground speed is between 20 and 80 knots, a takeoff warning is given. If RO capability is lost during rollout, a rollout caution is given.

Built-In Tests

The HGS contains extensive self-test hardware and software, which continuously analyze the HGS's operational status. When the Built-In Test (BIT) detects a fault in portions of the HC or OHU, the HGS blanks the Combiner to prevent the display of misleading data. The HCP FAULT light comes on as an additional indication of a BIT-detected fault. The HGS shows these faults as a two-digit number on the HCP while in TEST. On the HC a light comes on to indicate which LRU has a fault.

The subsection that follows contains data related to HGS BIT.

Background BITs

The HC continuously performs BIT functions in the background as it does normal display and guidance calculations. The HGS does all tests in approximately two seconds during system power-up and an operator-initiated test (see "HGS TEST").

The background tests done as a function of BIT include:

- **Critical Symbol Monitor**: verifies certain critical symbols are positioned properly by comparing the display output back to expected aircraft sensor input numbers
- **Window Comparator Test**: verifies video deflection signals against references for deflection position monitoring
- **Power Supply Monitors**: verifies required power supply voltages

- **CRT Deflection Circuitry**: monitors CRT operation
- **Input Converters**: verifies HGS Computer and HCP input converters
- **Processors**: verifies basic arithmetic and logical functions of each processor and its activity
- **Processor Memory**: verifies all processor RAM and program memory
- **Program Execution**: verifies proper execution of software programs
- **Combiner Alignment** determines the proper alignment of the Combiner when in the normal position.

HGS Test

HGS Test functions apply primarily to maintenance. Therefore, flight crews are not required to use HGS Test during normal operations. The subsections in the list that follows give data related to HGS Test because the operator starts the test from the cockpit.

NOTE: An operator-initiated test may clear a fault by resetting the HGS, returning the system to normal operation.

- HGS Test Parameters
- HGS Test Start
- HGS Test Menu.

HGS Test Parameters

The Test Mode can be entered only on the ground when ground speed is less than 10 knots.

HGS Test Start

To start an HGS Test:

1. Push the HCP TEST pushbutton, and see that the light in the upper-left corner of the pushbutton comes on. The HGS automatically exits from these functions if they are active:
   - Elevation data entry
   - Glideslope data entry
   - Clear function.
2. The HGS initially does all BIT functions. This test blanks the Combiner display and causes the HCP FAULT light to come on until the system passes all the tests (approximately two seconds if normal). If the BIT fails, the HCP FAULT light stays on, a fault code is shown on the HCP STBY display line, and “HGS FAIL” shows in red on the PFDs. Additionally, on the fault, the Combiner display could remain blank. If BIT detects more than one fault, the HC displays all fault codes in two-second intervals, repeating until all the faults are cleared.
3. Record any fault code data for maintenance action. If there are no faults, “TEST” shows on the ACT display line and the HGS TEST MENU (Figure A-2) shows on the Combiner.

The cursor (“>”) indicates the current selection. Use the HCP BRT+ (up) and DIM- (down) pushbuttons to move the cursor to a menu item. Push the ENTER pushbutton to select the menu item.

In data displays, an arrow indicates additional data is available for viewing. The arrows point up and/or down next to the data fields. Use the BRT+ and DIM- pushbuttons to scroll the displays.

To manually exit the Test function, push the TEST pushbutton.

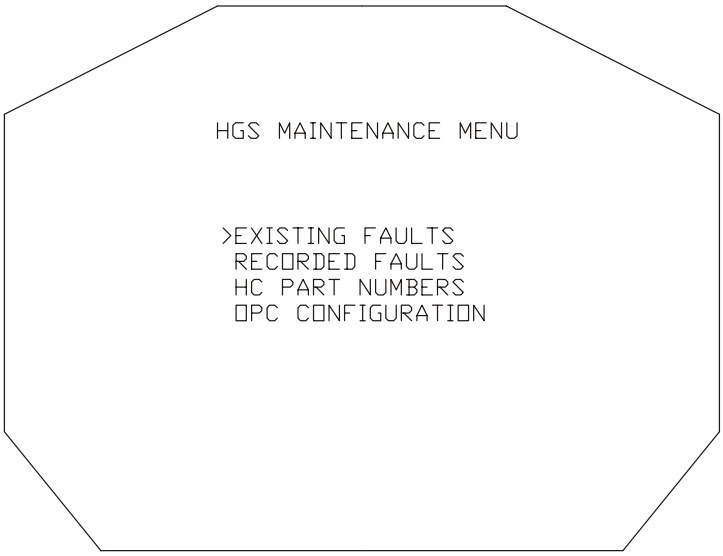

Figure A-2:
HGS Maintenance Menu Display (example)

A brief explanation of each Test Menu item is contained in the subsections that follow:

- Existing Faults
- Recorded Faults
- HC Part Numbers
- OPC Configuration.

Existing Faults

The Existing Faults display shows all of the current faults. Faults that have an effect show in reverse of the order in which they are found. The most recent shows on the top, the oldest is on the bottom. Faults that have no effect show after all faults that do have an effect. If no faults are identified, "NO ACTIVE FAULTS" shows on the display. A fault stays on the display for two seconds after it becomes inactive.

The display shows a maximum of five faults at one time. When more than five faults are identified, a down arrow shows to the left of the bottom fault on the display. Use the DIM- pushbutton to move down the list. When the display does not show the top of the list, an up arrow shows to the left of the top fault on the display. Use the BRT+ pushbutton to move up the list. Figure A-3 is an example of an Existing Faults display.

To go back to the HGS Maintenance Menu, push the HCP CLR pushbutton. To go out of the Maintenance Test Submode, push the TEST pushbutton.

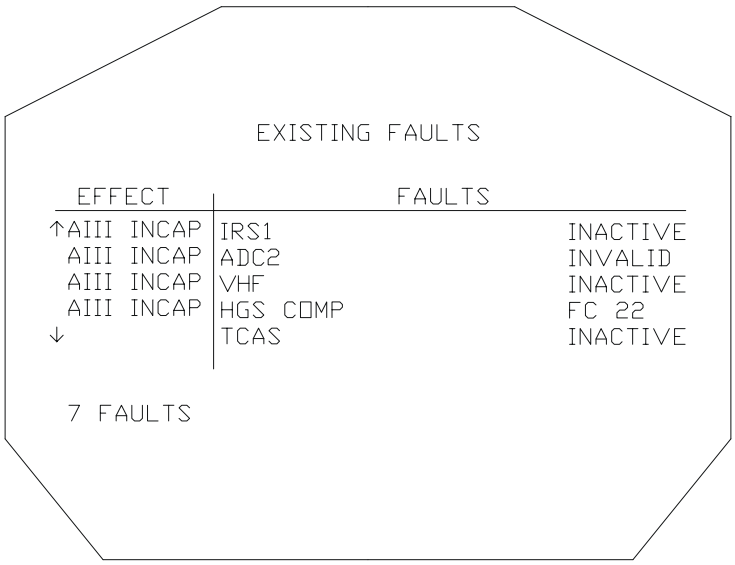

Figure A-3:
Existing Faults Display (example)

Recorded Faults

The Recorded Faults display shows the faults stored in the HGS Computer non-volatile memory. Figure A-4 is an example of a Recorded Faults display.

This Combiner display gives access to all recorded fault data that are kept in the Computer. These data include:

- **LEG**: shows which flight leg is on the display. The flight legs are numbered from the most recent (-1) to the oldest (-128). A flight leg starts after the aircraft exceeds 10 knots ground speed. The leg continues until the aircraft touches down and slows through 10 knots ground speed. When there are 128 recorded flight legs, a new flight leg erases the oldest flight leg.
- **DATE AND TIME**: shows when the flight leg started. The date format is DDMMYY (day, month, year). The time format is HRMINZ (hours, minutes, Zulu).
- **ENTER LEG #**: to change to a different flight leg, the leg number is put in with the HCP numeric keypad. The box area shows the number as it is put in.
- **XXX LEGS**: shows the total number of flight legs that are kept in the Computer's non-volatile memory.
- **EFFECT**: shows the highest-level flight deck effect caused by the fault at the time it is recorded.
- **FAULTS**: shows the LRU and type of fault detected. If all signals from an LRU have the same fault, or the whole data bus from the LRU is inactive, then only one fault is recorded.
- **XX FAULTS**: shows the total number of faults for the flight leg on the Combiner display. The maximum number of faults for a leg is 80.

The display shows a maximum of five faults at one time. When more than five faults are recorded, a down-arrow shows to the left of the bottom fault on the display. Use the DIM- pushbutton to move down the list. When the display is not at the top of the list, an up-arrow shows to the left of the top fault on the display. Use the BRT+ pushbutton to move up the list.

When “RECORDED FAULTS” is selected from the HGS Maintenance Menu, the HCP RWY and G/S lines are replaced with “LEG –X” on the RWY line and an arrow that points to the right, a minus sign and a flashing cursor (“_”) on the G/S line. The Combiner shows “ENTER LEG #” and a box below the current flight leg number. Use the HCP numeric keypad to put in another leg number. The new number shows on the HCP G/S line and in the box on the Combiner display. If a mistake is made, use the HCP CLR pushbutton as a backspace to erase the last input. When the new number is set, push the HCP ENTER pushbutton. The new flight leg then replaces the current leg.

NOTE: If a number larger than the recorded number of flight legs is put in, it is ignored. The “ENTER LEG #” box is blanked, and the current flight leg stays on the display.

To change which flight leg is shown use the BRT+, DIM-, and ENTER pushbuttons. To change the Combiner display to a more recent flight leg, push BRT+, then push ENTER. Each push of the ENTER pushbutton changes the Combiner display to the subsequent flight leg. To change to a previous flight leg, push DIM-, then push ENTER. Each push of the ENTER pushbutton changes the Combiner display to the next previous flight leg.

To go back to the HGS Maintenance Menu, push the HCP CLR pushbutton (with no number on the G/S line). To go out of the Maintenance Test Submode, push the TEST pushbutton.

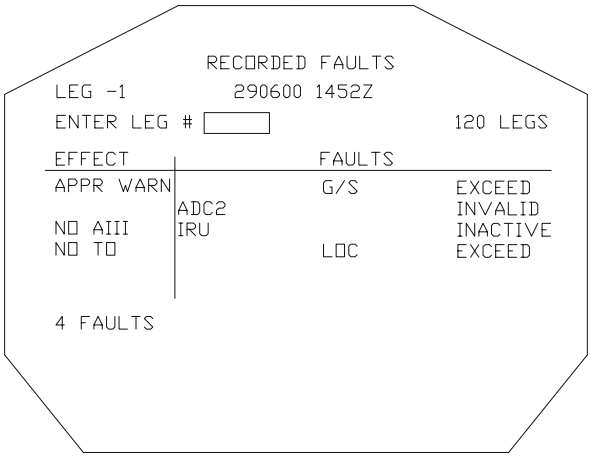

Figure A-4:
Recorded Faults Display (example)

HC Part Numbers

The HC Part Numbers display shows the HGS Computer hardware and software part numbers. Figure A-5 is an example of the part numbers in the HC subsystems.

NOTE: Figure A-5 part numbers are for example only.

To go back to the HGS Maintenance Menu, push the HCP CLR pushbutton. To go out of the Maintenance Test Submode, push the TEST pushbutton.

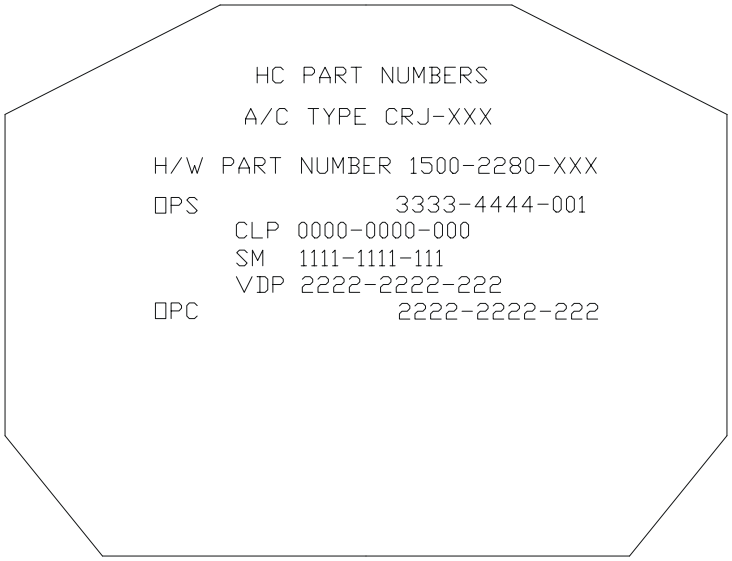

Figure A-5:
HC Part Numbers Display (example)

OPC Configuration

The OPC Configuration display shows the HGS Operational Program Configuration. Use this display to make sure that the HGS contains a copy of the actual aircraft configuration. Figure A-6 is an example of the OPC Configuration display.

To go back to the HGS Maintenance Menu, push the HCP CLR pushbutton. To go out of the Maintenance Test Submode, push the TEST pushbutton.

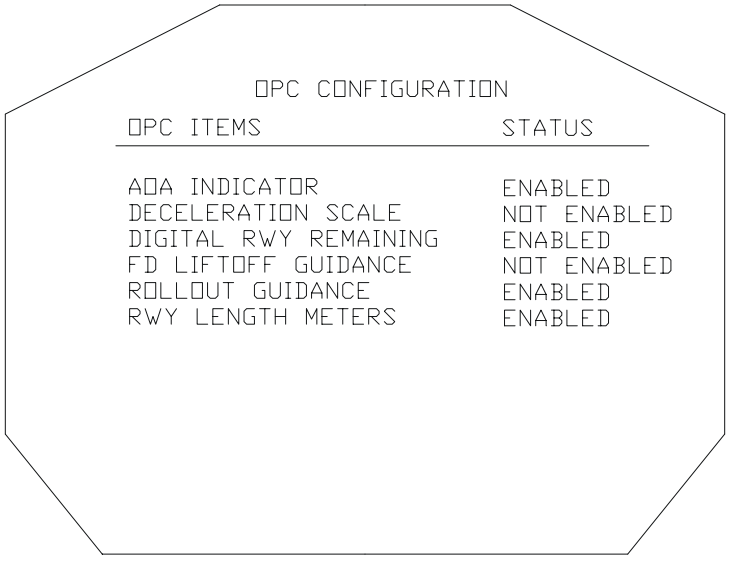

Figure A-6:
OPC Configuration Display (example)

HCP Display Test

The HCP Display Test makes sure that the HCP LED displays and pushbutton lights operate correctly. Figure A-7 shows the HCP Display Test sequence.

The test occurs in the sequence that follows:

1. Push and hold the HCP TEST pushbutton for more than four seconds to start the test. The TEST pushbutton light comes on and stays on during the test.
2. The ACT line comes on first for 2 seconds and then goes off.
3. The STBY line comes on for 2 seconds and then goes off.
4. The RWY line and the RWY pushbutton light come on for 2 seconds and then go off.
5. The G/S line, the G/S and CLR pushbutton lights, and the HCP FAULT light come on at the same time and stay on for 2 seconds. Then they go off.
6. The test repeats until the TEST pushbutton is pushed again.

The usual operation of the other HCP switches makes sure that they operate correctly.

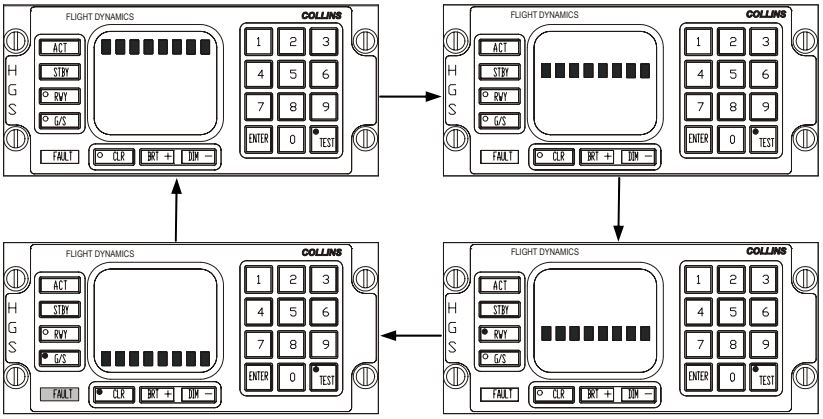

Figure A-7:
HCP Display Test

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Appendix B:
Definitions, Abbreviations, Acronyms

Definitions

These definitions are terms used by the HGS. They are provided for informational purposes to assist pilots to better understand how and when certain HGS functions occur.

Above Ground Level (AGL):

- Equal to corrected altitude when radio altitude is greater than 2500 feet
- Equal to the lesser of radio altitude and corrected altitude when radio altitude is greater than 50 feet
- Equal to radio altitude when radio altitude is less than 50 feet.

Aircraft Aligned on Runway: occurs when the difference between Selected Course and Magnetic Heading is less than 10 degrees and the absolute value of Localizer Deviation is less than one degree for more than two seconds and the aircraft is not in-flight.

Aligned with ILS: occurs when:

- Both NAV Receivers are tuned to an ILS frequency and valid, and
- Either both Glideslope #1 and Localizer #1 are captured; or both Glideslope #2 and Localizer #2 are captured, and
- Track Error is less than 15°.

Aircraft In Flight: occurs from the time the aircraft goes Weight Off Wheels.

Aircraft On Ground: occurs when either main landing gear Weight On Wheels is detected.

Category (CAT) I: a precision instrument approach which provides for approaches to a DH of not less than 200 feet/60m and visibility of not less than 2400 feet/800m, or an RVR of 1800 feet/550m with operative touchdown zone and runway centerline lights.

Category (CAT) II: a precision instrument approach, which provides for approaches to a DH between 200 feet/60m and 100 feet/30m and a RVR of not less than 1200 feet/350m.

Category (CAT) III: FAA AC 120-28D defines CAT III as a precision instrument approach and landing with a minimum of 50 feet DH and an RVR of not less than 700 RVR or 200 meters. CAT III operations approval may allow lower takeoff minimums of 300 feet RVR or 75 meters.

Corrected Altitude: the difference between barometric corrected altitude and the HCP Runway Elevation.

Decision Height (DH): The RA height at which the required runway visual reference must be seen, or else a missed approach must be initiated.

Flight Leg: begins when the aircraft accelerates through 10 knots IRS ground speed. A Flight Leg ends when the aircraft decelerates through 10 knots IRS ground speed or an HC reset occurs.

Glideslope Capture: occurs when glideslope deviation is less than 0.42 degrees (90 μA) for at least 5 seconds. Equivalent to 1.2 dot deflection.

Glideslope Deviation: correlation of glideslope deviation (micro-amps) to glideslope deviation (degrees) is 0.7° = 150 μA = 2 dots of deflection (0.175 DDM).

Landing Rollout: starts at Aircraft On Ground and ends when ground speed is less than 20 knots.

Localizer Deviation: correlation of localizer deviation (micro-amps) to localizer deviation (degrees) is 150 μA = 2 dots of deflection (0.155 DDM).

Localizer Capture: occurs when Localizer Deviation is less than 0.34 degrees (20 μA) for at least 5 seconds. Equivalent to 0.27 dot deflection.

Low-Visibility Takeoff: aircraft is configured for a Low Visibility Takeoff when the aircraft is not in flight and both NAV Receivers are tuned to an ILS frequency and Takeoff mode is selected, the Combiner is not stowed, and the aircraft is aligned with the runway.

Track Error: difference between aircraft magnetic track angle and selected course.

Unusual Attitude: occurs when the aircraft pitch attitude is greater than +30° or -20° or the roll angle is greater than 65° left or right bank.

Weight Off Wheels: occurs when the aircraft left and right main landing gears detect weight off wheels.

Acronyms and Abbreviations

A/C ..... Aircraft
ACT ..... Active
ADC ..... Air Data Computer
ADF ..... Automatic Direction Finder
ADI ..... Attitude Direction Indicator
AGL ..... Above Ground Level
ALT ..... Altitude
AOA ..... Angle of Attack
AP ..... Autopilot
APCH ..... Approach
APPR ..... Approach
ARP ..... Air Data Reference Panel
ATT ..... Attitude
ATTD ..... Attitude
Baro. ..... Barometric
B/C ..... Back Course
BIT ..... Built In Test
BNK ..... Bank
BRG ..... Bearing
BRT ..... Brightness
CAD ..... Combiner Alignment Detector
CAS ..... Computed Airspeed
CAT ..... Category
CAUT ..... Caution
CDI ..... Course Direction Indicator
CDU ..... Control Display Unit
CLM ..... Climb
CLP ..... Control Law Processor
CLR ..... Clear
COMP ..... Comparison
CONT ..... Control
CRS ..... Course
CRT ..... Cathode Ray Tube
CTN ..... Caution
DADC ..... Digital Air Data Computer
DC ..... Direct Current
DCP ..... Display Control Panel
DCU ..... Data Concentrator Unit
DDM ..... Difference in Depth of Modulation
DES ..... Descent
DEV ..... Deviation
DH ..... Decision Height

DISC ..... Disconnect
DISP ..... Display
DME ..... Distance Measuring Equipment
DSPL ..... Display
EFIS ..... Electronic Flight Instrument System
EGPWS ..... Enhanced Ground Proximity Warning System
EICAS ..... Engine Indication and Crew Alerting System
ELEC ..... Electrical
FCP ..... Flight Control Panel
FCS ..... Flight Control System
FD ..... Flight Director
F/D ..... Flight Director
FMS ..... Flight Management System
FPM ..... Feet Per Minute
FPS ..... Flight Path Symbol
GA ..... Go-Around
G/A ..... Go-Around
GS ..... Ground Speed
G/S ..... Glideslope
H ..... Hold
HC ..... HGS Computer
HCP ..... HGS Control Panel
HDG ..... Heading
HGS® ..... Head-Up Guidance System
HPA ..... Hectopascals
HSI ..... Horizontal Situation Indicator
HUD ..... Head Up Display
H/W ..... Hardware
IAPS ..... Integrated Avionics Processor System
IAS ..... Indicated Airspeed
ILS ..... Instrument Landing System
IM ..... Inner Marker
IN ..... Inches
INCAP ..... Incapable
INTEG ..... Integrated
IRS ..... Inertial Reference System
IRU ..... Inertial Reference Unit
LED ..... Light Emitting Diode
LNAV ..... Lateral Navigation
LOC ..... Localizer
LRU ..... Line Replaceable Unit
LVTO ..... Low Visibility Takeoff
MAG ..... Magnetic
MDA ..... Minimum Descent Altitude
MFD ..... Multifunction Flight Display

MGP ..... MSL GS arm/capture
MISC ..... Miscellaneous
MM ..... Middle Marker
MSL ..... Mean Sea Level
NAV ..... Navigational
NM ..... Nautical Mile
NORM ..... Normal
OHU ..... Overhead Unit
OM ..... Outer Marker
OPC ..... Operational Program Configuration
OPS ..... Operational Program Software
PFD ..... Primary Flight Display
PTCH ..... Pitch
RA ..... Radio Altitude or Resolution Alert
RAD. ALT. ..... Radio Altimeter
RAM ..... Random Access Memory
RO ..... Roll Out
RSP ..... Reversionary Switching Panel
RTU ..... Radio Tuning Unit
RVR ..... Runway Visual Range
RWY ..... Runway
SM ..... System Monitor
STBY ..... Standby
TCAS ..... Traffic Alert and Collision Avoidance System
TDZ ..... Touchdown Zone
TDZE ..... Touchdown Zone Elevation
TO ..... Take Off
TRU ..... True
VASI ..... Visual Approach Slope Indicator
VDC ..... Volts Direct Current
VDP ..... Video Display Processor
VHF ..... Very High Frequency
VMC ..... Visual Meteorological Conditions
VNAV ..... Vertical Navigation
VOR ..... VHF Omnidirectional Range
VS ..... Vertical Speed
VSI ..... Vertical Speed Indicator
WS ..... Windshear

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