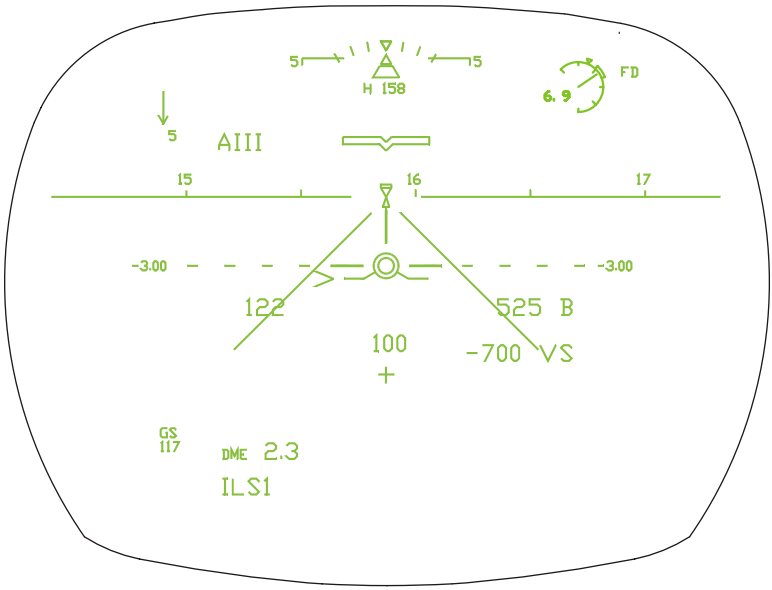
Head-Up
Guidance System
Model 4000

Rockwell Collins

HGS® Pilot Guide

With HCP Interface

Boeing 737-600/700/800/900



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Revision C

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Table of Contents

List of Figures

List of Tables

Record of Revisions

Pilot Guide Revision	HGS OPS Software	Date	Comments
A	341A-FLD-S00-11 (and prior software)	June 2002	Phase 2.0 Initial HGS 4000 release (October 2000)
B	341A-FLD-S00-11	June 2002	Phase 2.0
	341A-FLD-S00-15	Nov. 2003	Phase 3.0
C	341A-FLD-S00-11	June 2002	Phase 2.0
	341A-FLD-S00-15	Nov. 2003	Phase 3.0
	341A-FLD-S00-22	Dec. 2005	Phase 4.1
	341A-FLD-S00-23	Jan. 2006	Phase 4.2

NOTE: Initial HGS 4000 computer was Rockwell Collins part number 1500-2250-00X. This computer was replaced by Rockwell Collins part number 1500-2460-00X (June 2002) and subsequent part number computers.

Section 1: Introduction

This Pilot Guide is designed to acquaint you with the Model 4000 Rockwell Collins Head-Up Guidance System (HGS®) installed on Boeing 737-NG aircraft. It provides a description of the HGS, the modes of operation, HGS symbology, typical HGS flight operational procedures, and how to operate the HGS system through a generic flight profile.

The HGS is an electronic and optical system with unique features for displaying information in the pilot's forward field of view. The display is focused at optical infinity with flight and navigational data displayed to overlay the outside world.

Symbology has been optimized for full flight regime use and includes the application of Inertial Flight Path and Flight Path Acceleration. Guidance commands are provided by the HGS for low visibility takeoff and CAT III approach, landing, and rollout. During other operations, the Boeing 737 Digital Flight Control System (DFCS) Flight Director commands are displayed on the HGS Combiner. The system's unique Head-Up view of symbology and integration with aircraft systems allows for extremely precise manual aircraft control while enhancing situational awareness, energy management and the potential to avoid diversions due to weather-related airport capacity controls.

NOTE: The HGS installed on the Boeing 737 aircraft is certified for all phases of flight. Conduct HGS operations in accordance with the Airplane Flight Manual (AFM) HGS Supplement. If a conflict exists between the AFM and this Pilot Guide, the AFM will always take precedence.

The HGS Model 4000 has many different options that are configured by field loadable Operational Program Configuration (OPC) software. These configurations may vary between operators and aircraft.

The options available are:

- Dual or single FMS
- #1 ADF installed
- #2 ADF installed
- Autothrottle installed
- AIII Mode enabled
- Ground Deceleration Scale symbology enabled
- Tail Strike Avoidance symbology enabled
- Runway length displayed in meters or feet
- Ground Localizer Deviation Scale enabled
- AIII Rollout Guidance enabled (requires that AIII Mode is enabled)
- Angle of Attack symbology enabled
- Digital HAP installed
- Armed Flight Director Modes symbology enabled.
- Use of the MCDU or HCP for pilot data entry and mode selection
- Single or Dual HGS installation
- Flashing Pitch and Roll miscompare annunciations
- Display of Radio Altitude up to 2500 feet
- Use of GLS for AIII Approach Guidance
- Use of GLS for Low-Visibility Takeoff Guidance
- Inhibit the Single Channel autopilot annunciation
- Allow AIII guidance with Land 2 / Land 3 engaged

In this pilot guide, optional features are identified by this symbol: $^{\Delta}$. Descriptions identified with this symbol are only applicable to aircraft with the appropriate OPC options enabled.

Section 2:
HGS Description

Overview

The HGS is a high integrity, wide field of view Head-Up Display (HUD) system that is designed specifically for low visibility operations in the Boeing 737 aircraft. It consists of five Line Replaceable Units (LRUs), four of which are installed in the cockpit. Their functions are described below.

HGS LRU Functional Characteristics:

The HGS consists of the following five LRUs: (Figure 2-1 and Figure 2-2).

HGS Computer: The HGS Computer is rack mounted in the Electrical and Electronics Compartment and receives input data from aircraft sensors and equipment and converts this data to symbology. The HGS Computer contains power supplies and circuitry for signal amplification, distortion, and geometry corrections to drive the Cathode Ray Tube (CRT) in the Overhead Unit. The HGS Computer also monitors system and approach performance through extensive Built-In Test (BITE), input validation and Approach Monitor processing.

HGS Control Panel (HCP): The HGS Control Panel (HCP) is located in the aft pedestal and is used for selecting HGS modes of operation, setting glideslope angle, runway length, and elevation.

Overhead Unit (OHU): The OHU is located above the left pilot's head and contains the CRT and projection optics to project the symbolic image on the Combiner. The OHU also contains electronic circuitry for Combiner display brightness control.

Combiner: The Combiner is attached to the left forward windscreen upper sill beam structure and optically combines flight symbology with the pilot's view through the windscreen. The Combiner is designed to reflect the light projected from the OHU. The Combiner, in effect, acts as a wavelength selective mirror reflecting the CRT color (symbology) while allowing all other colors to pass through the glass.

HGS Annunciator Panel: The HGS Annunciator Panel is installed in the First Officer's instrument panel and provides HGS status and warning annunciations to the First Officer during CAT III approach, landing, and rollout operations.

One of two annunciator panels will be installed, either the Six Panel Annunciator or the digital HGS Annunciator Panel$^{\Delta}$ (HAP).

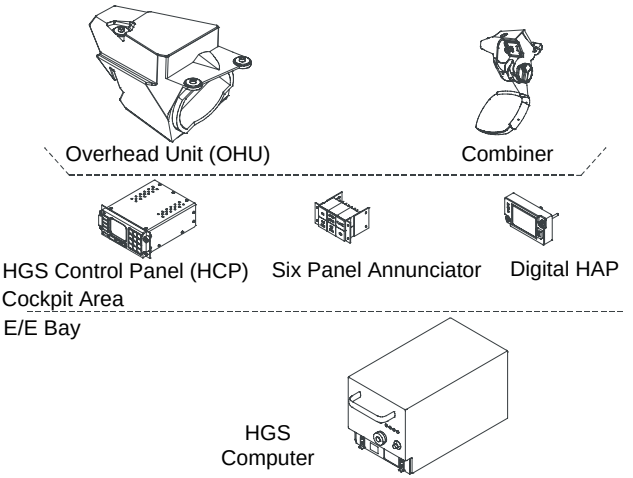

Figure 2-1:
HGS LRUs

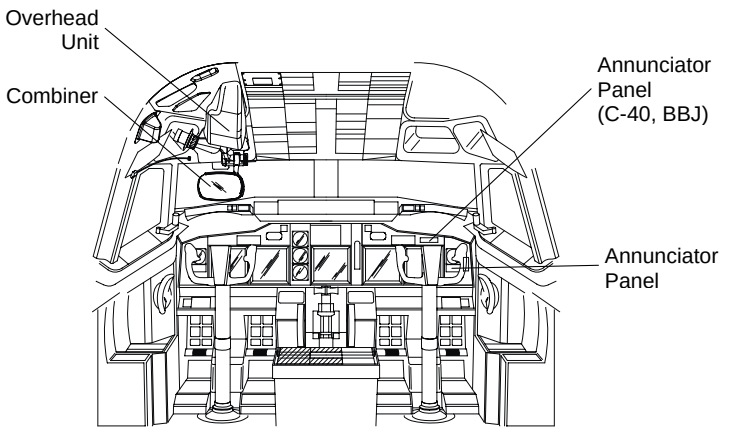

Figure 2-2:
HGS Cockpit Locations

HGS Control Panel (HCP)

The HCP allows the pilot to select HGS modes and enter required data. The HCP also displays selected modes, values entered, system test and status information. The HCP front panel contains mode, function, and data entry keys, along with a display field. The RWY, G/S, CLR, and TEST function keys contain an annunciator that indicates that the key has been selected. The annunciator extinguishes when the function is deselected or exited. There are four display lines, each containing 8 character positions capable of forming alphanumeric or symbolic characters. In the lower left corner of the HCP is a fault annunciator that illuminates any time an HGS BITE detected fault occurs.

HCP Display Brightness

The HCP display brightness control consists of two keys labeled “BRT+” and “DIM-”. Pressing the BRT+ key causes the HCP display intensity to increase and pressing the DIM- key causes the HCP display intensity to decrease. An ambient light sensor (Figure 2-3) adjusts the brightness based on the available lighting conditions. When the HGS is in a data entry (RWY or G/S), or TEST mode, these keys are not used, or are used for other purposes.

HCP switch back lighting is controlled separately by an external aircraft lighting control in order to maintain brightness consistent with similar cockpit displays.

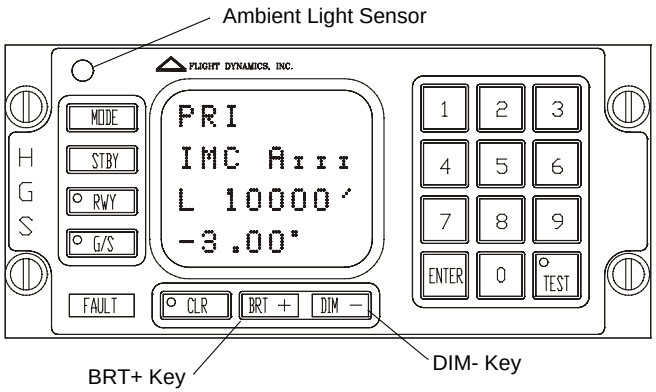

Figure 2-3:
HCP Brightness Controls

HCP Mode Selection and Data Entry

The MODE, STBY, RWY, and G/S keys Figure 2-4) are used to set modes and enter runway and glideslope data.

The **MODE** key is used to activate the mode shown on the STBY display line. The current mode is displayed on the MODE display line adjacent to the MODE key.

The **STBY** (standby) key is used to select the standby mode. Push the STBY key until the desired mode shows on the left side of the STBY display line. Note that AIII capability status is shown on the right side of the STBY line, when available.

The **RWY** key is used to set runway length and elevation values. In normal HGS operation, the RWY display line shows either the current runway length (on ground) or the current runway elevation (in flight). An “L” or an “E” is displayed before the number to indicate which value is being shown, and either a “ ' ” (for feet) or an “m” (for meters) shows after the number.

The **G/S** key is used to set the glideslope angle. The adjacent display line shows the current angle.

HCP Modes, runway length and elevation, and glideslope angle are stored in the HGS Computer. If power is interrupted, the last mode and values will be set when power is restored.

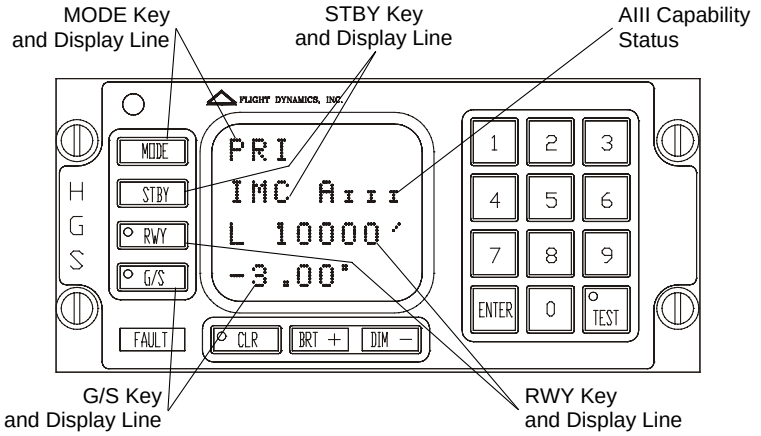

Figure 2-4:
Mode and Data Function Keys

Reference Glideslope Angle Entry: The G/S function key and the numeric keypad are used to enter the glideslope angle for the landing runway. Values can be entered from 0.00° to -9.99°.

For an HGS AIII approach operation$^{\Delta}$, the glideslope angle range is from -2.50° to -3.00°, inclusive. Setting a value outside of this range will prohibit AIII mode or result in a "NO AIII" annunciation if AIII is already the active mode.

To set the glideslope angle:

1. Push the G/S key.
2. Use the numeric keypad to enter the glideslope angle.

NOTE: The negative sign and the decimal point in the glideslope angle always show on the G/S display line when a new value is being entered. The pilot does not need to enter them.

3. Push ENTER to store the new value.

NOTE: The CLR key on the HCP acts as a backspace during data entry, erasing one character with each push.

Runway Length and Elevation Entry: The RWY function key and the numeric keypad are used to enter runway data. For takeoff, enter the runway length. For landing, enter the Touchdown Zone Elevation (TDZE) and Runway Useable Length Beyond Threshold values.

Runway length values can be entered from 0 to 99999 (feet or meters$^{\Delta}$). For HGS Ground Roll Guidance to be active during low visibility takeoff operations or Rollout Mode$^{\Delta}$ (see Modes of Operation) the runway length must be from 7500 to 13500 feet (2286 and 4115 meters).

Runway elevation values are always entered and displayed in feet regardless of the OPC configuration. Values from -9999 to 99999 feet can be entered.

To set the runway length:

1. On the ground: push the RWY key once. In flight: push the RWY key twice.
   a. The dot annunciator on the RWY key comes on.
   b. "LN>" and the current value show on the RWY display line.
2. Use the numeric keypad to enter the new runway length value.
   a. The original value blanks, and the new value shows on the RWY display line as number keys are pushed.
   b. A cursor ("_") shows the next data position.
3. Push the ENTER key to store the new value, or push the RWY key to initiate runway elevation entry. If the RWY key is pushed, push the ENTER key after entering the runway elevation to store both of the new runway values.

To set the runway elevation:

1. **On the ground:** push the RWY key twice. In flight: push the RWY key once.
   a. The dot annunciator on the RWY key comes on.
   b. "EL>" and the current value show on the RWY display line.
2. Use the numeric keypad to enter the new runway elevation value.
   a. The original value blanks, and the new value shows on the RWY display line as number keys are pushed.
   b. A cursor ("_") shows the next data position.
   c. Use the DIM- key to enter a negative value (an elevation below sea level).
3. Push the ENTER key to store the new value, or push the RWY key to initiate runway length entry. If the RWY key is pushed, push the ENTER key after entering the runway length to store both of the new runway values.

NOTE: The CLR key on the HCP acts as a backspace during data entry, erasing one character with each push.

To view the current value of runway length and elevation, push the RWY key without pushing any numeric keys. Then use the RWY key to toggle between the length and elevation values. Push the ENTER key to return to the normal display and retain the original values.

NOTE: If a data input is cleared by backspacing (no value input) and then the ENTER key is pushed, the original value is retained.

Clear Function

When not in data entry, the HCP CLR key (Figure 2-5) is used to blank (clear) all symbology from the Combiner display. This is indicated by the illumination of the dot annunciator on the Clear key and "CLR" replacing the current mode on the MODE display line. All other HGS functions will continue normally. Re-establishing the Combiner display is accomplished by pushing the Clear key again, changing modes, or pushing the TEST key.

Test Function

While on the ground, a momentary push of the TEST key initiates the HGS Built-In Test (BITE) and displays the HGS Test Menu on the Combiner. To exit the HGS Test Menu, push and release the TEST key.

The TEST key is also used to initiate an HCP display test. Push and hold the TEST key for 4 seconds to initiate the test. This test verifies that all display LEDs and dot annunciators on the HCP are functioning. The test repeats until the TEST key is pressed and released.

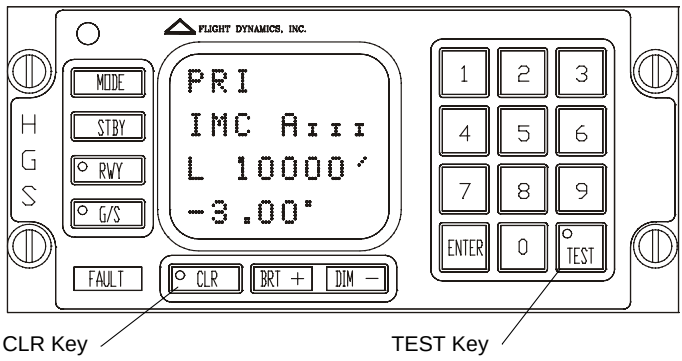

Figure 2-5:
CLR and TEST Keys

Combiner

The HGS Combiner (Figure 2-6) is positioned between the pilot and the forward windscreen such that an image projected from the OHU can be viewed by the pilot. The wide-field-of-view Combiner (26° vertical by 32° horizontal) is designed to position and focus the projected image so that symbology is superimposed on the view of the real world scene.

The Combiner assembly consists of mechanical and electrical components to hold and support the Combiner glass in three positions, and to control and monitor the Combiner's display brightness and position.

The Combiner glass comes with a removable protective cover. This soft fabric cover should be installed on the glass prior to stowing the Combiner and remain in place anytime the Combiner is not in use.

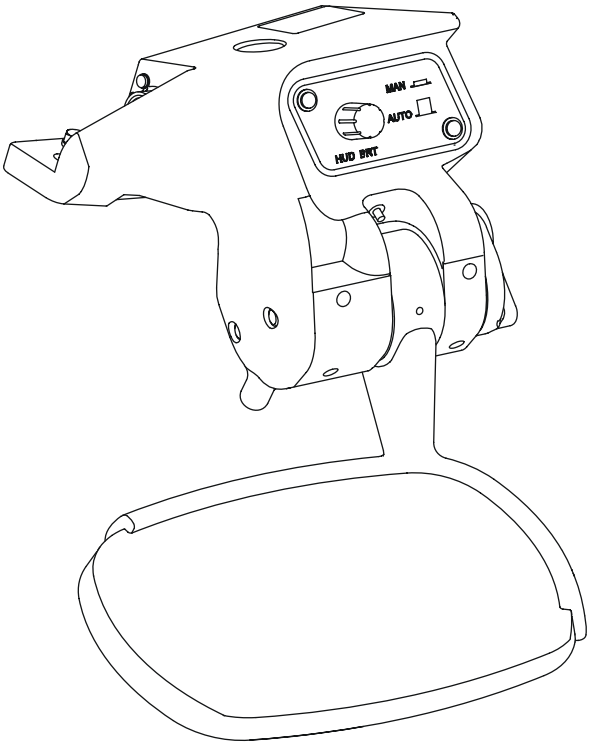

Figure 2-6:
HGS Combiner

Combiner Position

The Combiner has three positions: stowed, normal operating, and breakaway.

To release the Combiner from the stowed position, turn the lower portion of the release lever (Figure 2-7) toward the pilot and rotate the glass down and forward to the normal operating detent.

To stow the Combiner glass, grasp the Combiner glass structure, and rotate the glass aft and up until it locks in the stowed position.

Breakaway is a safety feature that lets the Combiner glass rotate toward the windshield during a sudden deceleration of the aircraft. The breakaway feature prevents or minimizes head injury during a high-G deceleration. The Combiner arm latches in the full breakaway position to prevent it from springing back towards the pilot. To release the glass from the breakaway position, hold it in one hand and push it slightly forward to remove pressure on the breakaway latch, and turn the release handle toward the windshield (Figure 2-7) and carefully guide the glass to the operating or stow position.

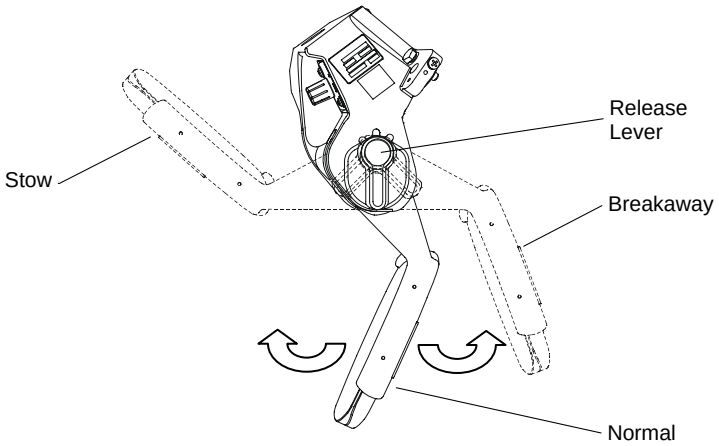

Figure 2-7:
Combiner Release Mechanism

Combiner Alignment Detector

Proper Combiner alignment is critical during visual operations to ensure the displayed symbology is accurately positioned and conformal with the real world. A Combiner Alignment Detector (CAD) monitors the position of the Combiner glass when in the normal operating position. If the Combiner is not aligned within tolerances, and the HGS is in VMC or IMC mode, an "ALIGN HUD" message will be displayed on the Combiner. If an "ALIGN HUD" message occurs, apply slight pressure, either fore or aft, on the Combiner glass until the "ALIGN HUD" message is removed. If the message cannot be removed with the glass in the operating detents, the HUD is not presenting conformal data, and should not be used.

Combiner Display Brightness

The Combiner has controls and sensors to set and adjust the HGS display brightness (Figure 2-8). The HUD BRT Control is found on the upper right portion of the Combiner unit. Specified adjustments are given in the two subsequent paragraphs:

Manual Brightness Mode (MAN): Push the HUD BRT Control knob in to select the manual brightness control mode (MAN). Rotate the knob clockwise to increase the Combiner display brightness; rotate the knob counter-clockwise to decrease the Combiner display brightness. In manual brightness mode, the Combiner display intensity remains at the selected brightness level.

NOTE: In the MAN mode and bright ambient light, it is possible that the Combiner display will not be visible.

Automatic Brightness Mode (AUTO): Pull the HUD BRT Control knob out to select the automatic brightness mode (AUTO). Rotate the knob clockwise to increase the Combiner display brightness; rotate the knob counter-clockwise to decrease the Combiner display brightness. The OHU then uses the signal level from the Ambient Light Sensor to adjust the brightness level automatically to maintain a constant contrast ratio (perceived brightness) as the aircraft flies through different ambient light conditions.

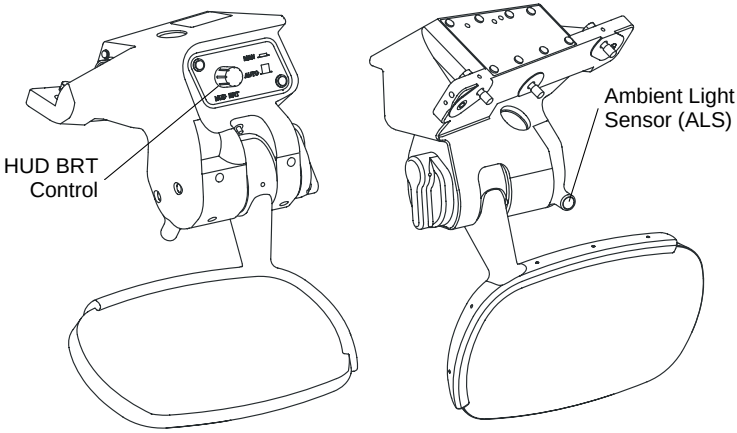

Figure 2-8:
Combiner Brightness Controls

HGS Annunciator Panel

In order to provide the high degree of safety necessary for manual CAT III low visibility operations, the First Officer (F/O) acts as an independent monitor and is required to assess the approach to the runway and the performance of the HGS and associated systems. To better perform these functions, the First Officer is provided an HGS Annunciator Panel that indicates HGS mode, status, and warnings for these operations.

There are two types of annunciator panels that may be used with the HGS: a digital HGS Annunciator Panel (HAP) and a discrete input Six Panel Annunciator. The correct OPC software must be loaded in order for the annunciator panel to operate correctly.

To test the annunciator panel, set the master BRT/DIM/TEST switch to TEST, or push and release the HCP TEST key. During a test, all legends on the HAP come on, or all lamps on the Six Panel Annunciator come on. To end the test, deselect TEST on the BRT/DIM/TEST switch, or push and release the HCP TEST key again.

Digital HGS Annunciator Panel

The HAP is a low profile, surface mount panel that provides ten annunciations that allow the first officer to monitor HGS operation (Figure 2-9). The HAP is installed on the first officer's instrument panel. The OPC option for the HAP must be enabled for the HAP to function.

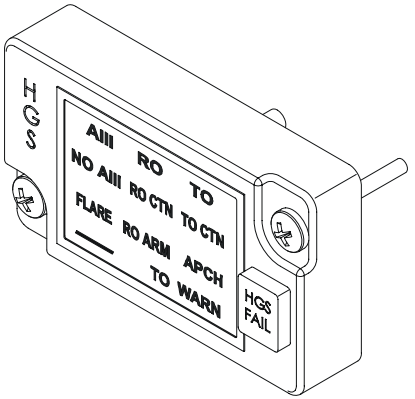

Figure 2-9:
Digital HGS Annunciator Panel

If AIII mode$^{\Delta}$ is enabled, the HAP displays these annunciations:

AIII (Green): Indicates that the HGS is operating in AIII mode and there are no AIII capability or approach monitor faults. It is displayed concurrently with the AIII mode annunciation on the Combiner.

NO AIII (Amber): Indicates that there was a loss of AIII capability above 500 feet AGL. "NO AIII" shows concurrently on the Combiner.

Flare (Green): Indicates that flare guidance is active in AIII mode. It is displayed when the flare guidance symbol ("+") is displayed on the Combiner.

APCH WARN (Red): Indicates that an approach warning has occurred. The "APCH WARN" annunciation flashes for 5 seconds then remains steady on. "NO AIII" and "APCH WARN" show concurrently on the Combiner. An approach warning occurs below 500 feet AGL if an AIII capability fault occurs or if the HGS approach monitor detects an out of tolerance approach.

HGS FAIL Button (Red): Indicates an HGS Computer communication failure to the HAP during an AIII approach below 500 feet AGL. When the button annunciation is lighted, all of the other annunciations are blanked. To turn the annunciation light off, push the button.

If Rollout Guidance$^{\Delta}$ is enabled, the HAP also displays these annunciations:

RO (Green): Indicates that rollout mode is active. It is displayed concurrently with the "RO" symbol on the Combiner.

RO ARM (White): Indicates that the HGS is capable of providing rollout guidance and rollout guidance is armed for automatic activation at touchdown.

RO CTN (Amber): Indicates a loss of rollout guidance capability below 500 feet AGL. It is displayed concurrently with the "RO CTN" symbol on the Combiner.

The TO annunciations are not currently used.

TO (Green): Not currently used. Displayed only during HAP BITE test.

TO CTN (Amber): Not currently used. Displayed only during HAP BITE test.

TO WARN (Red): Not currently used. Displayed only during HAP BITE test.

Six Panel Annunciator

If AIII mode$^{\Delta}$ is enabled, these annunciations are available (Figure 2-10):

AIII (Green on a black background): indicates that the AIII mode is active and that all required systems are available and valid. “AIII” appears simultaneously on the Combiner.

APCH WARN (Black legend on a red illuminated background): indicates an approach warning has occurred (approach tolerances have been exceeded, or the HGS is no longer AIII capable). An approach warning is only given below 500 feet above the TDZE. An “APCH WARN” message also appears on the Combiner.

FLARE (Green legend on a black background): indicates that Flare Guidance is active. It is intended to alert the F/O to monitor and ensure the flare execution. The “FLARE” message occurs when Flare Guidance is shown on the Combiner.

If Rollout Guidance$^{\Delta}$ is enabled, these annunciators are also available:

RO ARM (Green legend on a black background): indicates that the HGS is capable of providing Rollout Guidance and Rollout Guidance is armed. An “RO ARM” message also shows on the Combiner.

RO CTN (Black legend on an amber background): indicates a Rollout Caution (Rollout Guidance capability has been lost during the last 500 feet of an AIII approach, or during landing ground roll). An “RO CTN” message is also shown on the Combiner.

RO (Green legend on a black background): indicates that following an AIII approach, Rollout Guidance is active. An “RO” message is also shown on the Combiner.

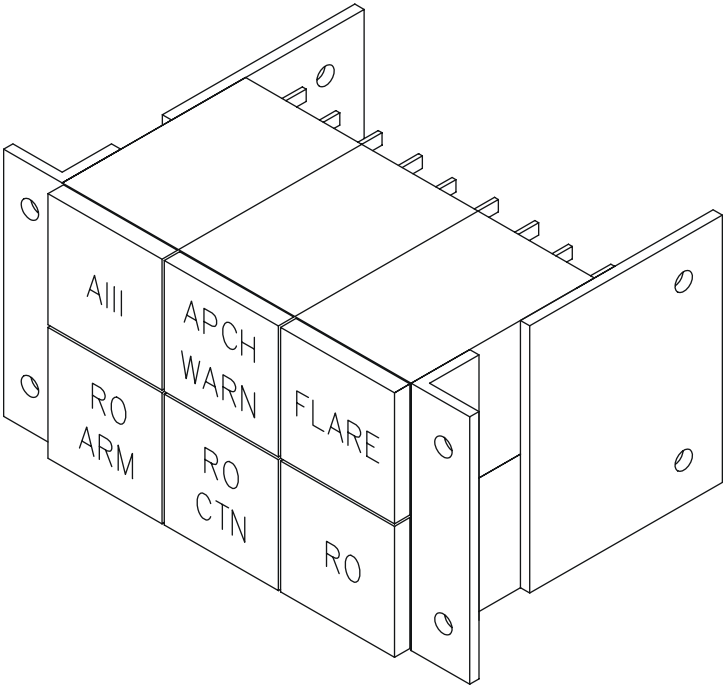

Figure 2-10:
HGS Annunciator Panel

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Section 3:
HGS Modes of Operation

Introduction

The HGS has five modes of operation, summarized in the following table.

Table 3-1: Modes of Operation

Mode	Flight Operation	Guidance Source
Primary	Takeoff, climb, enroute, descent, approach & landing	DFCS
	Low visibility takeoff	HGS
AIII approach$^{\Delta}$	ILS approach and landing	HGS
Rollout$^{\Delta}$	Rollout Guidance	HGS
IMC (Instrument Meteorological Conditions) approach	Autopilot/Flight Director approaches	DFCS
VMC (Visual Meteorological Conditions) approach	Visual approaches	NONE

NOTE: Rollout Guidance can be enabled only if AIII Mode is enabled.

The HGS mode of operation is displayed on the MODE display line of the HCP (Figure 3-1). The standby mode is displayed on the left portion of the STBY display line. Push the STBY key to change the standby mode. Push the MODE key to activate the standby mode.

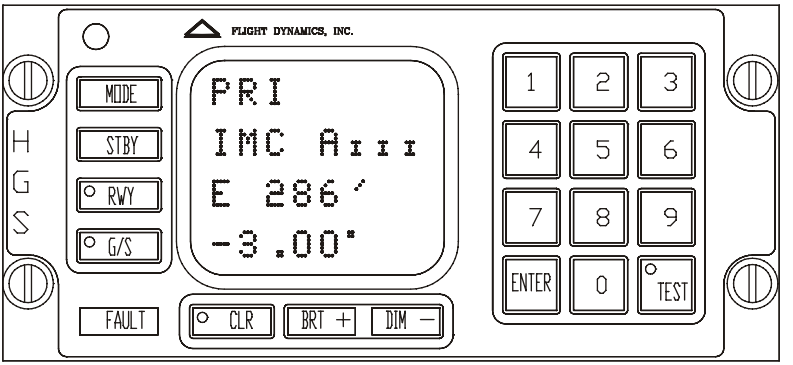

Figure 3-1:
HGS Control Panel

Each of the HGS modes is described in the following paragraphs. For information and illustrations of the symbols described in this section, refer to Section 4, "HGS Symbology" or Section 6, "Typical Flight Profile."

Primary Mode

There are two ways to select the HGS Primary mode:

- Push the STBY pushbutton until "PRI" shows on the STBY display line. Then push the MODE pushbutton. "PRI" replaces the current mode in use.
- Push a throttle Go-Around switch. This selects Primary mode independent of the mode indicated on the STBY display line.

In Primary mode in flight, the Combiner shows airspeed and altitude tapes along the left and right edges of the display, and a sectored Horizontal Situation Indicator (HSI) in the lower center of the display (Figure 3-2). This format is similar to the EFIS Primary Flight Displays (PFD), combining ADI, HSI, Airspeed, and Altimeter indications into one display.

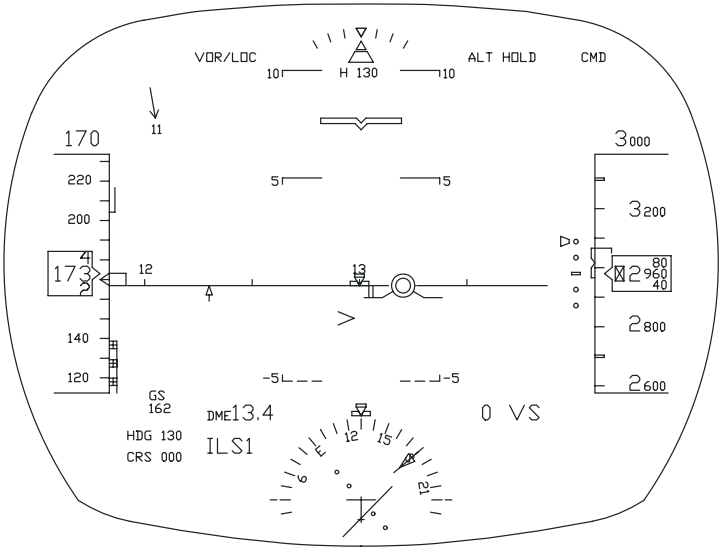

Figure 3-2:
Primary Mode Symbology - In Flight (example)

In Primary mode, the following symbology is shown on the Combiner:

- Aircraft Reference (Boresight) symbol
- Pitch attitude - scale and Horizon relative to Boresight
- Roll attitude - scale and Horizon relative to Boresight
- Heading - Horizon, HSI (in flight only) and digital display
- Airspeeds - CAS (tape), VS, Ground Speed, Speed Error Tape
- Altitudes - Barometric Altitude (tape), Digital Radio Altitude, Baroset, Selected Minimums
- AOA symbol$^{\Delta}$ (on ground only)
- Flight Path (in flight only)
- Flight Path Acceleration
- Slip/Skid Indicators
- Flight Director (F/D) Guidance Cue and modes (in flight only)
- Autothrottle modes
- Navigation data - ILS,GLS, VOR, DME, FMCS, Marker Beacons
- Wind Speed and Direction
- Selected parameters - Course, Heading, Airspeed and Altitude
- Flags
- Reference Glideslope Line (displayed during descent below 2500 feet RA).

During ILS/GLS/VOR operations:

- Course deviation is displayed as a CDI within the HSI.
- Glideslope data is presented on a Glideslope Deviation Scale adjacent to the Altitude Tape.

During LNAV and/or VNAV operations, vertical deviation is displayed on the vertical deviation scale in the lower right portion of the display based on FMC data.

Flight Director engaged and armed modes, Autothrottle modes, and Autopilot status are indicated across the top of the display similar to the Flight Mode Annunciations (FMA) head-down.

Typical Applications in Primary Mode

Primary mode is available and appropriate for these phases of flight:

- Takeoff
- Climbout
- Enroute
- Descent
- Approach (including non-precision and precision approaches using AFCS Flight Director guidance) Landing and Rollout.

Low Visibility Takeoff

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

These conditions are required for low-visibility takeoff operations:

- The HGS must be in the Primary mode.
- #1 and #2 VHF Nav Receivers must be tuned to an ILS frequency that is valid and selected for display.
- All transfer switches must be in the NORMAL position.
- The reference runway length entered into the HGS must be from 7,500 to 13,500 feet (2286 to 4115 meters).
- The Selected Course must be set to the magnetic heading of the takeoff runway.

The low visibility takeoff display (Figure 3-3 and Figure 3-4) incorporates a Ground Roll Reference Symbol, Ground Roll Guidance Cue and a Ground Localizer Line (or Ground Localizer Scale, if OPC option is selected).

The **Ground Roll Reference Symbol** is positioned below the Aircraft Reference Symbol. During rollout, the pilot tracks the localizer (and hence the runway centerline) by keeping the Ground Roll Reference Symbol on the Ground Roll Guidance Cue.

The **Ground Roll Guidance Cue** is positioned at the same vertical position as the Ground Roll Reference Symbol, and moves laterally to provide steer right or steer left commands to track the localizer. The cue is displayed when all conditions required for low visibility takeoffs are met. During rollout below 40 knots, if there is a miscompare between the #1 and #2 localizers, the Ground Roll Guidance Cue is removed and the localizer comparison flag ("LOC CMP") is displayed. Above 40 knots, a miscompare has no effect as long as the #1 localizer data is valid.

The **Ground Localizer Line** provides raw localizer information any time the aircraft is on the ground and the captain's NAV receiver is tuned to a localizer frequency. Localizer deviation is given relative to the Selected Course Mark on the Horizon Line.

If enabled, the **Ground Localizer Scale and Pointer**$^{\Delta}$ is displayed instead of the Ground Localizer Line. The Ground Localizer Scale has three marks, representing -1, 0, and +1 dots of deviation.

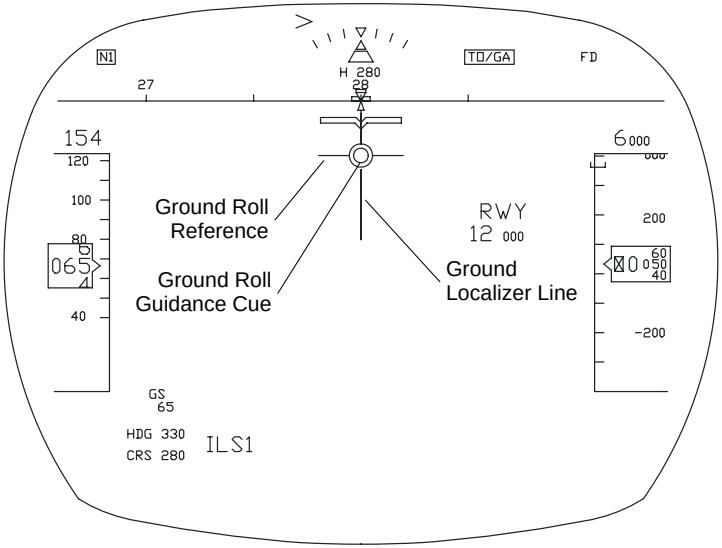

Figure 3-3:
Low Visibility Takeoff Roll (example 1)

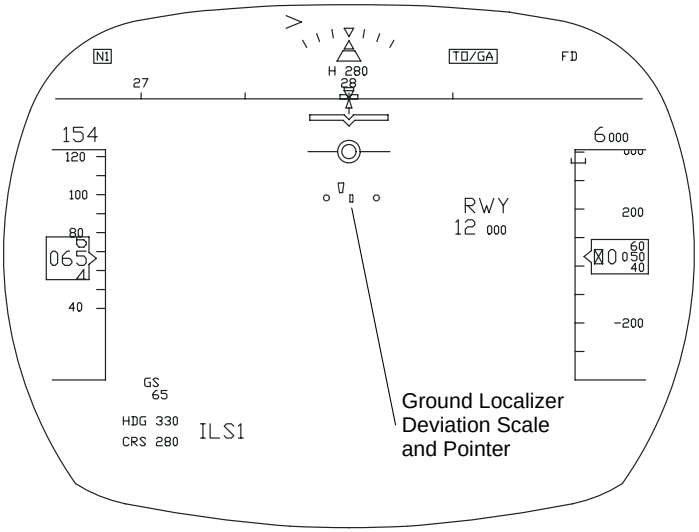

Figure 3-4:
Low Visibility Takeoff Roll (example 2)

Climbout

After rotation, the Primary mode display changes. The Ground Roll Reference Symbol, Ground Roll Guidance Cue, and localizer deviation information are removed and the climbout display shows on the Combiner. The climbout display (Figure 3-5) is similar to the in flight display (Figure 3-2) with the Airspeed and Altitude Scales along either edge of the display, the HSI at the bottom of the display, the Pitch Scale below the Aircraft Reference Symbol and the Flight Path symbol showing. The Flight Director Guidance Cue, the TO/GA Pitch Target Line, and additional Slip/Skid Indicators are also shown during climbout.

The TO/GA **Target Pitch Line** is a horizontal dashed line, initially placed at the top of the Combiner display. As pitch attitude increases during rotation, the vertical position of the Target Pitch Line changes in response to the pitch command from the Flight Director. The pilot responds to the pitch command by adjusting pitch so that the Aircraft Reference Symbol overlays the Target Pitch Line. The Target Pitch Line is displayed until the TO/GA mode is exited.

The Flight Director Guidance Cue is shown when the Aircraft Reference Symbol is within 2° of the Target Pitch Line, or when Radio Altitude is 50 feet, whichever occurs first. The pilot responds to Guidance Cue commands by overlaying the Flight Path symbol on the Guidance Cue. The Guidance Cue is displayed throughout the flight if the Flight Director is “ON” and pitch and roll commands are valid.

A full time **Slip/Skid indicator** is displayed as part of the Roll Scale. Additional Slip/Skid Indicators are displayed after rotation during any takeoff or go-around operation in Primary mode. The symbols are placed below the Flight Path and below the Aircraft Reference Symbol. They are designed to enhance lateral (yaw) control in the event of an engine failure. The additional Slip/Skid indicators are removed at 1000 feet (go-around) or 1500 feet.

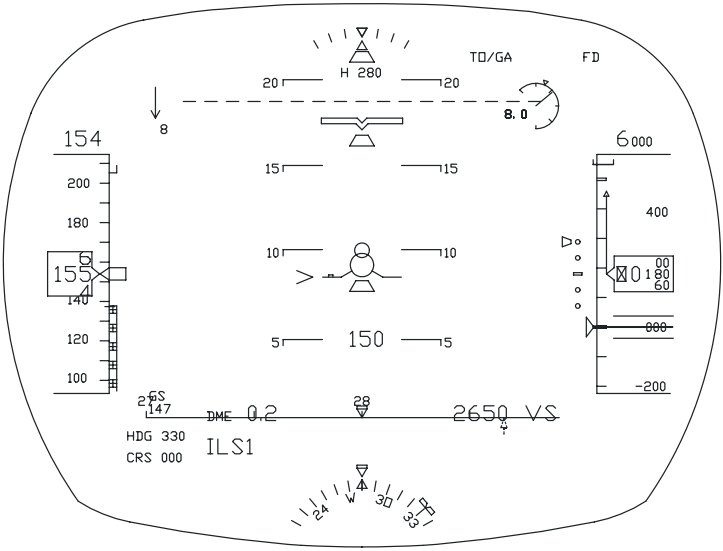

Figure 3-5:
HGS Primary Mode – Climbout (typical)

Primary Mode - Approach and Landing

If the Primary mode is used for an approach and landing, Flight Director guidance and navigation raw data are displayed. Additionally, the Reference Glideslope Line is displayed as the aircraft descends below 2500 feet RA. Once on the ground, the Ground Localizer Line or Ground Localizer Scale$^{\Delta}$ is displayed if the NAV receiver is tuned to the ILS or GLS (Figure 3-6).

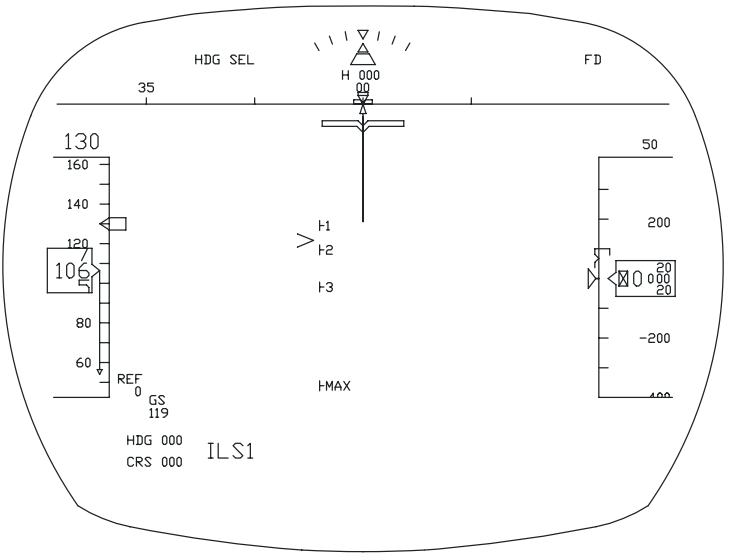

Figure 3-6:
HGS Primary Mode – Landing Rollout (typical)

AIII Approach Mode$^{\Delta}$

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

The HGS AIII Mode$^{\Delta}$ is specifically designed for manual ILS approach and landing operations to CAT III minimums. In the AIII Mode, the guidance cue gives flight path guidance derived from HGS internal approach and landing guidance algorithms. The OPC option for AIII mode must be enabled for AIII mode to function.

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, displaying instead ILS raw data in proximity to the flightpath group near the center of the display.

If RO Mode$^{\Delta}$ is not enabled, the HGS stays in AIII mode during rollout, but no guidance is provided. If RO Mode is enabled, the HGS changes to RO Mode at touchdown.

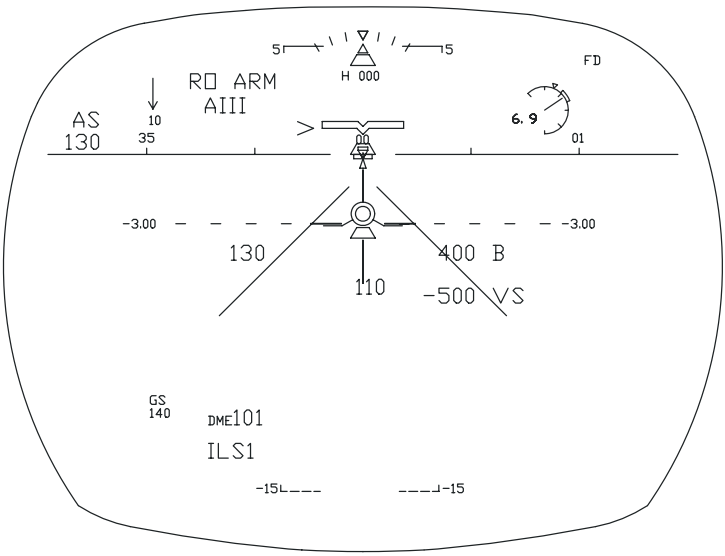

Figure 3-7:
HGS AIII Approach and Landing (typical)

AIII Mode Requirements and Conditions

AIII mode can only be used if the HGS is capable of providing AIII guidance. The HGS is capable of AIII guidance if no HGS faults are detected and if the systems that provide flight data to the HGS are configured and operating correctly. If the HGS is capable of providing AIII guidance, "AIII" is displayed on the right side of the STBY display line (Figure 3-8).

NOTE: In VMC mode, no AIII capability status is displayed.

Figure 3-8:
AIII Capable HCP Display

Even if the HGS is capable of providing AIII guidance, AIII mode cannot be activated until the following Approach On Course (AOC) conditions are satisfied:

- Both VHF Navigation Receivers are tuned to an ILS frequency.
- The difference between the aircraft's magnetic track and the Captain's Selected Course is less than 15 degrees.
- Radio Altitude is greater than 500 feet.
- VHF Nav #1 localizer deviation is less than approximately ¼ dot and glideslope deviation is less than approximately 1¼ dots for at least five seconds, or;
- VHF Nav #2 localizer deviation is less than approximately ¼-dot and glideslope deviation is less than approximately 1¼ dots for at least five seconds.

NOTE: AOC conditions must be satisfied at the time AIII mode is selected.

Selecting AIII Mode

There are two ways to select (activate) the AIII mode:

1. Arm AIII Mode for automatic selection.
2. Manually select AIII Mode.

NOTE: AIII mode can only be selected above 500 feet AGL. If it has not been selected when the aircraft descends below 500 feet AGL, all AIII capability messages are removed and AIII is no longer an available mode.

Arming AIII Mode for Automatic Selection

AIII mode can be armed before AOC conditions are satisfied so that AIII is automatically selected when AOC conditions become satisfied. This helps to reduce pilot workload during final approach. AIII can only be armed if all of these requirements are met:

- The HGS is in Primary or IMC mode.
- The HGS is AIII capable.
- The ILS is either tuned on the right or left side.
- Aircraft altitude is greater than 500 feet AGL.
- The Flight Director mode is not TO/GA.
- AOC conditions have not yet been satisfied.

To arm the AIII mode, push the STBY key on the HCP. "AIII ARM" replaces the standby mode and AIII capability status on the STBY display line (Figure 3-9). It is also displayed in the upper left corner of the Combiner display.

Figure 3-9:
AIII Arm HCP Display

When AOC conditions are met, the "AIII" portion of "AIII ARM" on the Combiner blinks for 5 seconds. After 5 seconds, AIII mode is automatically selected.

AIII can be disarmed (before AIII has been selected) by pushing the STBY key again. When STBY is pushed, all "AIII ARM" messages are removed and "IMC" is displayed on the STBY line. AIII mode can be armed again (before AOC) by pushing the STBY key two more times. (Pushing the STBY key once selects VMC as the standby mode.)

Manually Selecting AIII Mode

If AIII mode is not armed, it can be selected manually after AOC conditions are satisfied and before the aircraft descends below 500 feet AGL. When AOC conditions are satisfied, the "AIII" capability status (shown on the right side of the STBY display line) is removed, and "AIII" is displayed on the left side of the STBY display line (Figure 3-10) as an indication that AIII mode can be selected. At the same time, "AIII" flashes on the Combiner. To select AIII mode, push the MODE key.

Figure 3-10:
HCP Display: AIII In Standby

After AIII is either manually or automatically selected:

- The Combiner display shows AIII mode symbology.
- "AIII" is shown as the active mode in the upper left corner of the Combiner display and on the HCP MODE display line (Figure 3-11).
- The AIII panel on the Six Panel annunciator comes on; or,
- The AIII legend on the digital HAP$^{\Delta}$ comes on.

Figure 3-11:
HCP Display: AIII Active

Figure 3-12 and Figure 3-13 illustrate each of the methods for selecting the AIII mode.

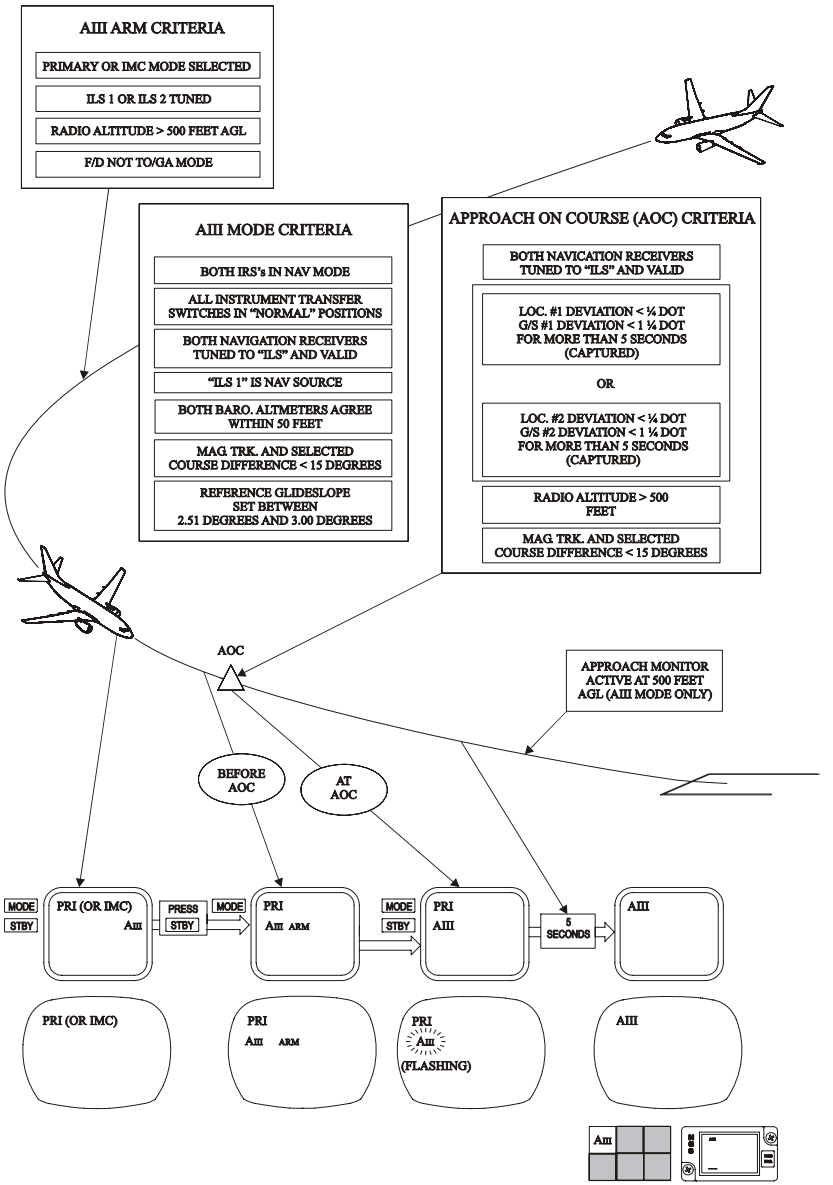

Figure 3-12:
Arming AIII Mode For Automatic Selection

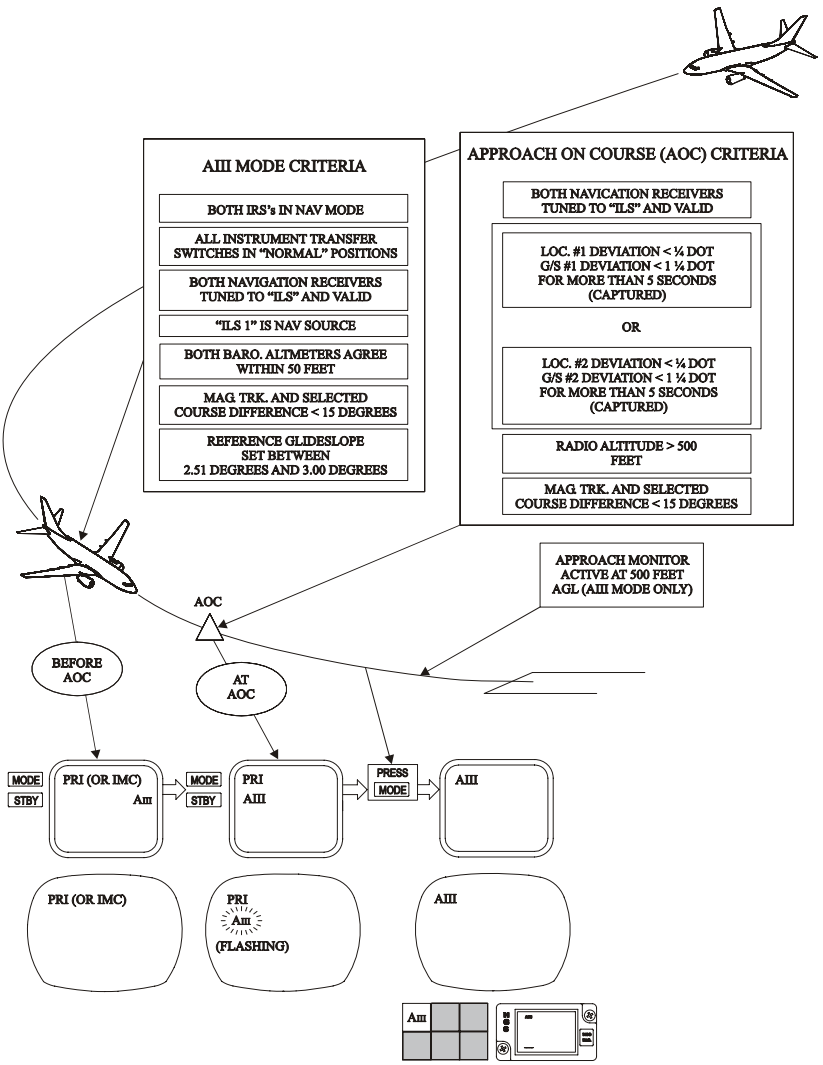

Figure 3-13:
Manual Selection of AIII Mode

System Monitoring

There are two types of monitoring that occur in AIII mode. One is HGS capability monitoring, which ensures that the HGS is capable of providing AIII guidance throughout the approach. The other is approach performance monitoring. The HGS monitors certain approach parameters to ensure that the parameters are within specified tolerances. Parameters include ILS deviation, vertical speed, airspeed, aircraft position and roll angle.

Above 500 feet AGL, only HGS capability tests are done. Loss of AIII capability is indicated as follows (Figure 3-14 and Figure 3-15):

- On the HCP: "NO AIII" is displayed on the MODE display line.
- On the Combiner: a boxed "NO AIII" is displayed in place of "AIII".
- On the Six-Panel Annunciator: the AIII lamp goes out.
- On the digital HAP: the "NO AIII" legend comes on.

The indications are displayed until a different mode is selected, or until the HGS becomes AIII capable again.

Below 500 feet AGL, both HGS capability and approach performance tests are done. If AIII capability is lost, or if an approach parameter is out of tolerance, an approach warning ("APCH WARN") is given. In instrument conditions, an approach warning should result in a missed approach.

Approach warning indications are (Figure 3-14):

- On the Combiner: "APCH WARN" is displayed above the Aircraft Reference Symbol.
- On the Six-Panel Annunciator: the APCH WARN panel comes on.
- On the digital HAP: the "APCH WARN" legend comes on.
- The HGS Guidance Cue is removed from the Combiner display.
- If Rollout Guidance$^{\Delta}$ is enabled, and RO Mode is armed, a rollout caution is given, and "RO CTN" replaces "RO ARM" on Combiner. The "RO CTN" legend on the HAP, or the "RO CTN" panel on the Six Panel Annunciator comes on.

If the approach warning was caused by a loss of AIII capability, both "APCH WARN" and "NO AIII" messages are displayed on the Combiner, and "NO AIII" is displayed on the HCP MODE line. On the digital HAP, only the "APCH WARN" legend comes on.

If the performance monitor detects a parameter out of tolerance, but the HGS is still AIII capable, an approach warning is given, but no indications of loss of AIII capability are given.

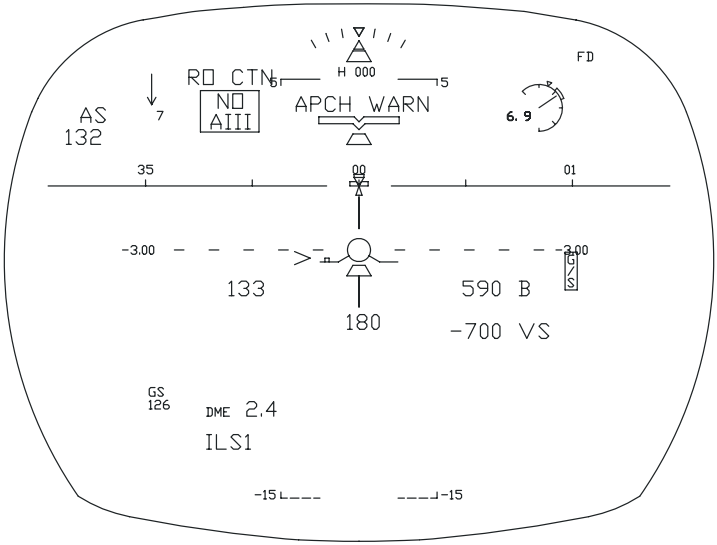

Figure 3-14:
HGS Loss of AIII and Approach Warning (example)

NOTE: The example above illustrates a glideslope failure at 180 feet that will result in the loss of AIII ("NO AIII"), an "APCH WARN" annunciation, the removal of glideslope raw data, and the removal of the Guidance Cue.

Figure 3-15:
HCP Display: Loss of AIII Capability

RO Mode$^{\Delta}$

At touchdown in AIII Mode$^{\Delta}$, the HGS automatically changes to RO Mode$^{\Delta}$. RO Mode gives guidance to track the runway centerline (Figure 3-16). In RO Mode, unnecessary symbology is removed to assist with the landing rollout. This includes changing the Flight Path Symbol to the Ground Roll Reference Symbol and the Guidance Cue to the Ground Roll Guidance Cue (lateral guidance only). The OPC option for RO Mode must be enabled for RO Mode to function. The OPC option for AIII Mode must be enabled to enable the OPC option for RO Mode.

Lateral deviation is shown by the Ground Localizer Line or the Ground Localizer Scale$^{\Delta}$.

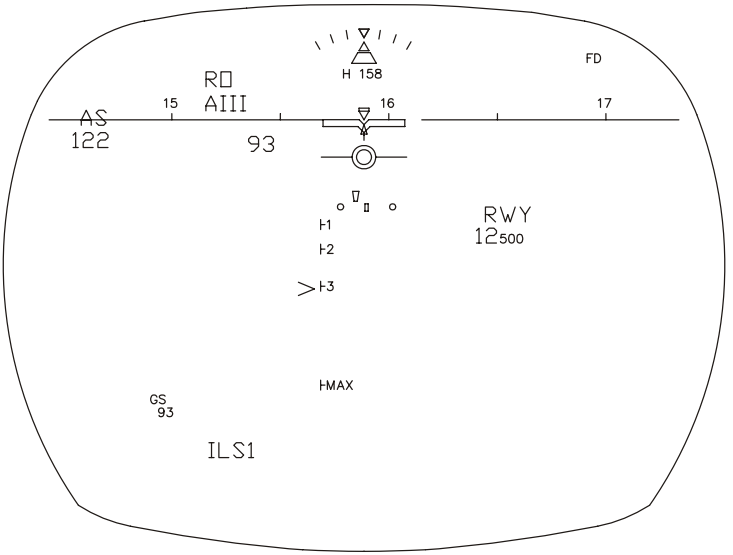

Figure 3-16:
RO Mode Symbology (example)

RO Mode Requirements and Conditions

These conditions are required for the HGS to change to RO Mode$^{\Delta}$ at touchdown:

- AIII Mode must be active before 500 feet AGL.
- #1 and #2 VHF Nav Receivers must be tuned to an ILS frequency that is valid and selected for display.
- All transfer switches must be in the NORMAL position.
- The reference runway length entered into the HGS must be from 7,500 to 13,500 feet (2286 to 4115 meters).
- The Selected Course must be set to the magnetic heading of the landing runway.
- There are no HGS faults.
- Data from required aircraft sensors is valid.

If the HGS loses capability to provide rollout guidance below 500 feet AGL or on the ground, a rollout caution (RO CTN) is given. If a rollout caution is given, “RO CTN” shows on the digital HAP$^{\Delta}$ or Six Panel Annunciator and replaces “RO” or “RO ARM” on the Combiner display. If the aircraft is on the ground, the Ground Roll Guidance Cue is removed.

IMC Approach Mode

The IMC mode (Figure 3-17) is an alternate approach mode primarily intended for Autopilot Flight Director approaches. Like the Primary mode, the IMC mode displays Flight Director guidance. The Guidance Cue is displayed when the pilot's Flight Director is active and both pitch and roll commands are valid.

The IMC mode provides approach symbology in the same format as the AIII approach mode. Altitude and airspeed data are displayed as digital values and navigation raw data is displayed in close proximity to the Flight Path group.

Once on the ground, the Ground Localizer Line or Ground Localizer Scale$^{\Delta}$ can be displayed the same as in the Primary mode.

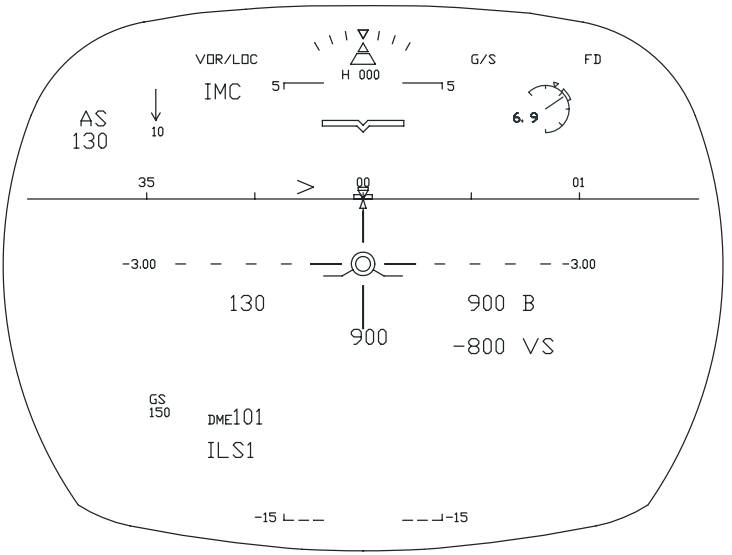

Figure 3-17:
HGS IMC Approach Mode Symbology (typical)

VMC Approach Mode

The VMC mode (Figure 3-18) is intended for visual approach operations. No Flight Director or HGS guidance is displayed. The VMC mode is intended to enhance the visual approach operation by allowing the pilot to establish and maintain the aircraft on the proper glide path to the runway without reference to a ground based landing system (ILS, VASI, etc.). During a VMC mode approach, Flight Path is used to control the approach to the runway visually. This is particularly beneficial during nighttime approaches or approaches with poor visual cues.

The VMC mode provides approach symbology in the same format as the AIII and IMC modes. However, navigation data is not displayed.

Refer to the Typical Flight Profile section later in this guide for additional VMC mode information.

NOTE: During an IMC or VMC approach, it is expected that the final phase of approach will be completed visually. The proper mechanical alignment of the HGS Combiner is extremely important during visual operations. Refer to the "Combiner Position" subsection in Section 2, "HGS Description."

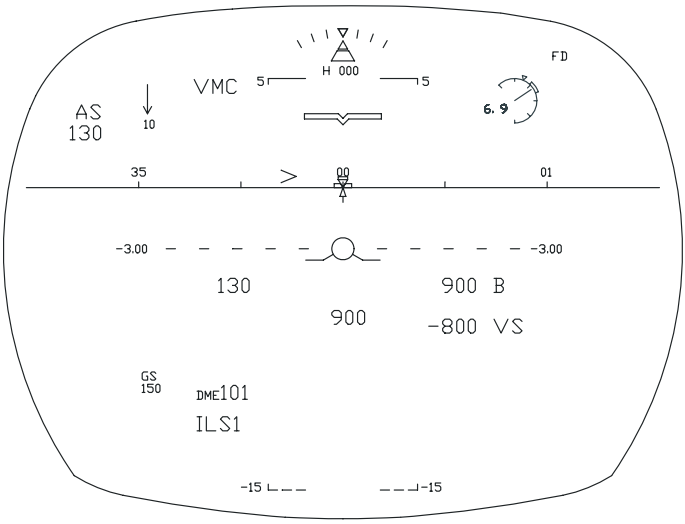

Figure 3-18:
HGS VMC Approach Mode Symbology (typical)

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Section 4:
HGS Symbology

This section provides detailed information about each HGS display symbol, flag, and data source indication. Symbology is organized in the following symbol groups:

- Aircraft Reference
- Aircraft Attitude
- Unusual Attitude
- Heading
- Category III
- Flight Path
- Angle of Attack
- Slip/Skid
- Speed
- Altitude
- Mode and Alert
- Navigation
- Flight Director/ Autopilot
- TCAS.

Within the symbol groups, each symbol has a detailed description and illustration. Failure Flags and Data Source Indications are described separately from other symbols.

This section concludes with a HGS Mode/Symbology Matrix that identifies the operating mode in which each symbol is displayed.

Aircraft Reference Symbology

Aircraft Reference Symbol

The Aircraft Reference symbol (Figure 4-1) commonly referred to as the Boresight symbol represents the projected centerline of the aircraft (boresight). The top center point of the symbol (the point of the top V) is the actual boresight point.

The Aircraft Reference symbol is positioned at a fixed location on the display 7° above the display's vertical center. Unlike other displayed symbols, it is not dependent on any sensor or equipment inputs. The display is similar in operation to the aircraft symbol on conventional attitude instruments and is always present when the HGS is powered and operating normally.

In the Unusual Attitude (UA) display, the Aircraft Reference symbol is fixed at display center to allow for a large Unusual Attitude Display and is not conformal.

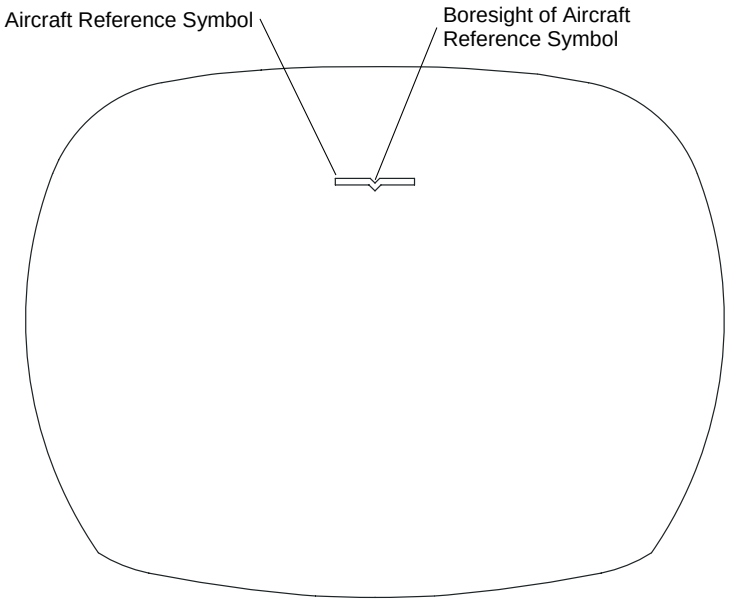


Figure 4-1:
Aircraft Reference Symbol

Aircraft Attitude Symbology

Horizon Line

The Horizon Line is displayed relative to the Aircraft Reference symbol and is positioned based on the current aircraft pitch and roll attitude (Figure 4-2). The vertical position of the Horizon Line relative to the boresight of the Aircraft Reference symbol indicates the pitch attitude. When the Horizon Line overlays the boresight, the aircraft is in a level (0°) pitch attitude. The roll attitude is displayed as the Horizon Line rolled left or right relative to the Aircraft Reference symbol. Because the Aircraft Reference symbol is mechanically and electronically positioned to represent the extended centerline of the aircraft (boresight), the Horizon Line is conformal with the real world horizon relative to the aircraft pitch and roll attitude.

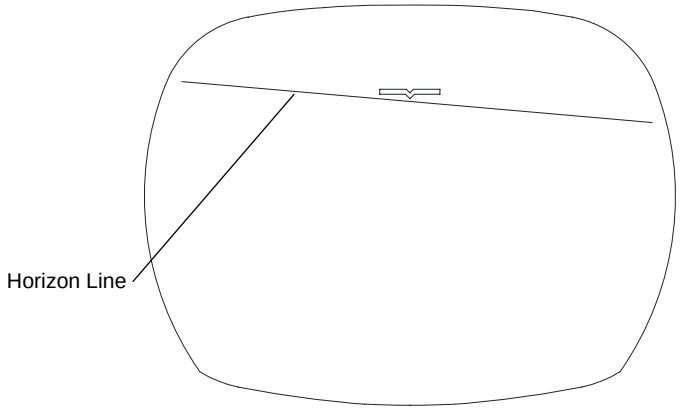


Figure 4-2:
Horizon Line

NOTE: Because of the earth's curvature, the Horizon 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 Horizon Line is visible (most noticeable above 2500 ft AGL). At cruising altitudes, there can be a significant separation between the Horizon Line and the horizon. This difference should not be interpreted as an error in the positioning of the Horizon Line.

Pitch Scale (Normal)

A pitch scale is displayed above and below the Horizon Line. It is scaled in five-degree increments from -20° to +25° and every ten degrees between ±30° and ±90°. At the ends of each pitch line is a vertical tic mark "pointing" in the direction of the Horizon Line and labeled with its corresponding pitch value. Solid pitch lines represent positive pitch angles and dashed pitch lines represent negative pitch angles. Pitch attitude is determined by the position of the Aircraft Reference symbol relative to the Pitch Scale.

Pitch Scale (Compressed)

When the aircraft attitude is such that the Horizon Line or the Flight Path symbol cannot be displayed conformally, the Pitch Scale is compressed (display compression) to allow these symbols to remain on the display. The positional relationship of these symbols is maintained relative to one another although the display is no longer conformal with the real world. Display compression can also result in the removal of certain Pitch Scale lines.

A chevron is displayed on the Pitch Scale to enhance interpretation of attitude when the scale is not conformal. Depending on pitch attitude (positive or negative pitch), a downward pointing chevron (positive pitch attitude) is placed with the tip on the 30° pitch line and an upward pointing chevron (negative pitch attitude) is placed with the tip on the -20° pitch line.

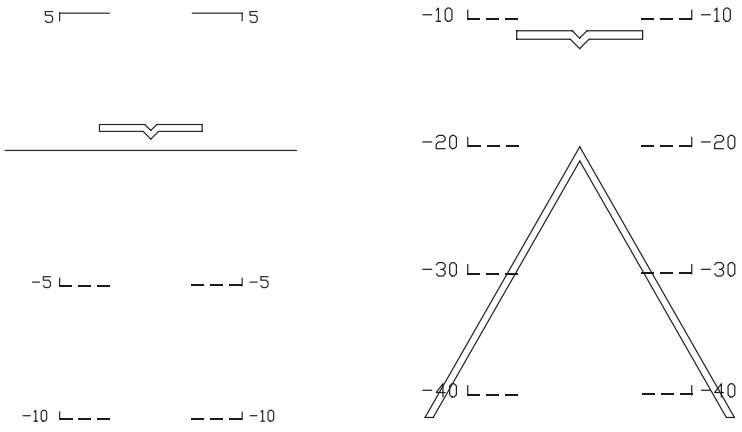


Figure 4-3:
Pitch Scale

TOGA Pitch Target Line

A TO/GA Pitch Target Line is displayed when all of the following conditions are true:

- Ground Speed greater than 65 knots
- Flight Director TO/GA mode is active
- Pitch command greater than 10° is received.

During the takeoff roll, the TO/GA Pitch Target Line is displayed as a horizontal dash line initially fixed at the top of the display (Figure 4-4). As the pitch attitude increases during rotation, its vertical position, relative to the Aircraft Reference Symbol, is made to correspond to the pitch command provided by the Flight Director. A pitch up command would have the TO/GA Pitch Target Line positioned above the Aircraft Reference symbol and a pitch down command would have the TO/GA Pitch Target Line positioned below the Aircraft Reference symbol. The command is satisfied by placing the Aircraft Reference symbol on the TO/GA Pitch Target Line.

Once in flight, and the Flight Director Guidance Cue is displayed, the spacing between the TO/GA Pitch Target Line and the Aircraft Reference symbol is equal to the difference between the Guidance Cue and Flight Path symbols. The TO/GA Pitch Target Line is displayed until the Flight Director TO/GA mode is exited.

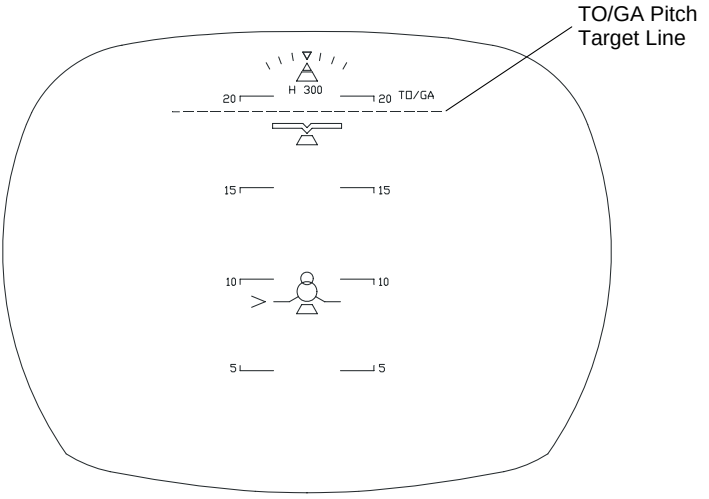


Figure 4-4:
TO/GA Pitch Target Line

Roll Scale and Pointer

The Roll Scale and Pointer (Figure 4-5) is positioned above the Aircraft Reference symbol. The Roll Scale is similar to the "Sky Pointer" on a conventional ADI. The pointer points to the corresponding roll attitude on the scale. The scale has tic marks for each 10° between -30° and +30°. Tic marks at ±45° and ±60° are added to the Roll Scale when the aircraft exceeds ±35° and ±50°, respectively.

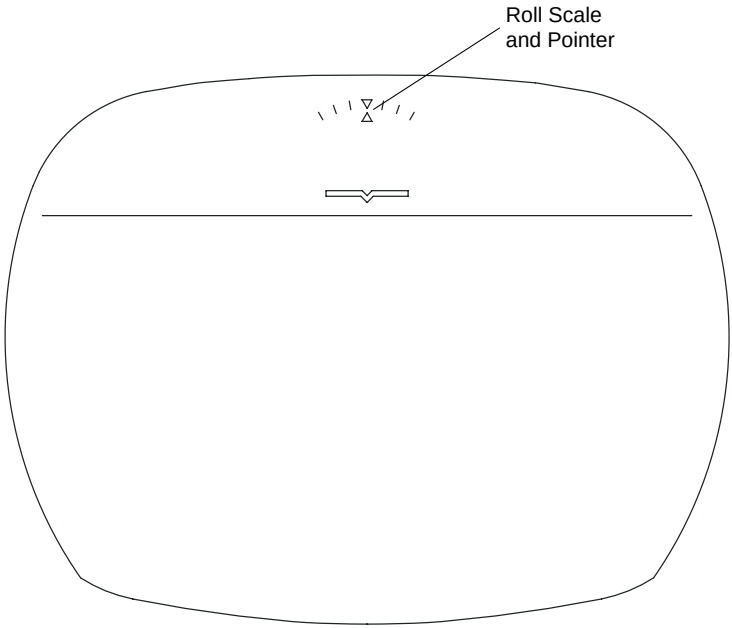


Figure 4-5:
Roll Scale and Pointer

Bank Warning Indicator

The Bank Warning Indicator consists of a bracket on either side of the Flight Path symbol (Figure 4-6). When displayed, these brackets indicate that a potentially dangerous bank angle condition exists during low altitude operation. The symbols are displayed when these two conditions are met:

- Radio Altitude is less than 100 feet
- The aircraft's roll angle exceeds 5°.

The symbols are removed when either of the following conditions are true:

- the roll angle is reduced to less than 3° or,
- Radio Altitude is greater that 100 feet.

When the Flight Path is aligned in roll with opposing ends of the two brackets, the roll angle is 8°.

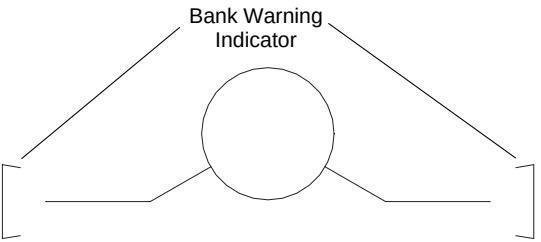


Figure 4-6:
Bank Warning Indicator

Tail Strike Pitch Limit$^{\Delta}$

The Tail Strike Pitch Limit$^{\Delta}$ symbol (Figure 4-7) is displayed relative to the Aircraft Reference symbol and indicates that the aircraft is at or approaching the Tail Strike Pitch Limit. Tail strike will occur if the Tail Strike symbol meets the Aircraft Reference symbol. The Tail Strike Pitch Limit symbol shows the pitch angle margin to tail strike during takeoff (including during a touch and go). The Tail Strike Pitch Limit symbol is displayed if the aircraft pitch angle approaches the tail strike angle or the pitch rate is too excessive during takeoff rotation (below 10 feet AGL). The OPC option for Tail Strike Avoidance symbology must be enabled for the Tail Strike Pitch Limit symbol to show.

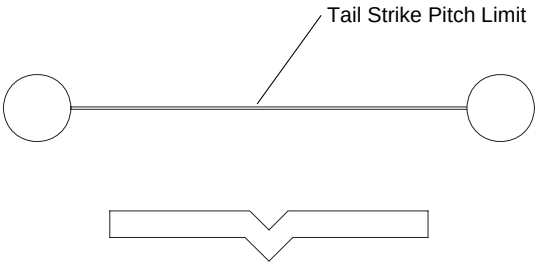


Figure 4-7:
Tail Strike Pitch Limit

Unusual Attitude (UA) Symbology

The HGS Unusual Attitude display (Figure 4-8 and Figure 4-9) is designed to aid the pilot in recognition of and recovery from Unusual Attitude situations. The UA symbology is intended to display attitude information in a manner similar to an Attitude Direction Indicator (ADI). The Unusual Attitude (UA) symbology is automatically activated or deactivated based upon the attitude of the aircraft. When the UA symbology is active, UA symbology replaces the currently selected operational mode symbology. (The HCP continues to display the currently selected operational mode symbology, annunciation, and data entry functions.)

The UA symbology is automatically activated whenever the pitch angle is less than –20° or greater than +35°, or whenever the roll angle is greater than 55°. The UA symbology automatically reverts to the previous display once the pitch angle is within –5° to +10° for 5 seconds, and the roll angle is less than 10° for 5 seconds.

In addition to the pitch scale line, a zenith symbol ✳ is displayed at the +90° point, and a nadir symbol ○ is displayed at the –90° point.

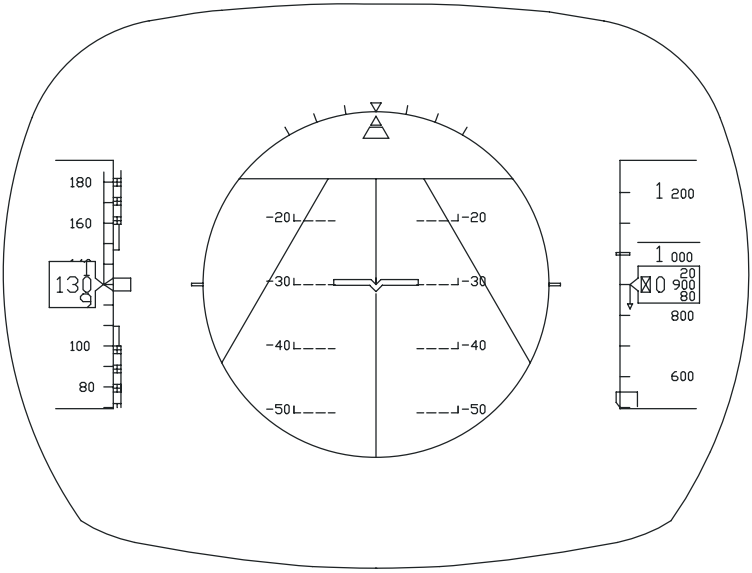


Figure 4-8:
Unusual Attitude - Pitch

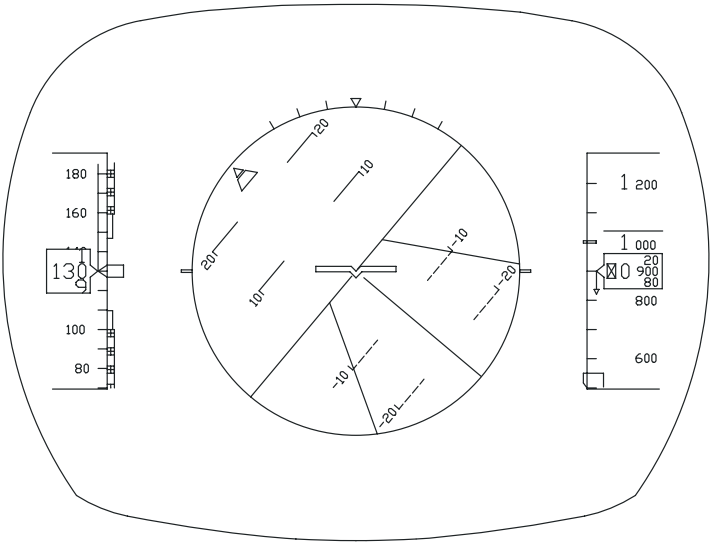


Figure 4-9:
Unusual Attitude - Roll

Heading and Track Symbology

Conformal Heading Scale and Index

Heading, represented in 5° increments (tic marks) and labeled every 10°, is displayed on the Horizon Line (Figure 4-10). Heading information is conformal with the real world so that a point on the earth underlying the "13" mark on the Heading Scale would take a heading of 130 degrees to fly over. The four Cardinal headings of North, South, East, and West are expressed as 00, 18, 09, and 27 respectively.

At the center of the Horizon Line is a downward pointing box/triangle called the Heading Index. This points to the actual heading of the aircraft (where the nose is pointing).

The aircraft's current heading is also displayed as a digital value preceded by an "H" directly below the Roll Scale Slip/Skid Indicator. The digital value is expressed to the nearest one degree with a heading of 0 (or 360) being displayed as "H 000".

Normally heading data is referenced to magnetic north. When the Heading Reference Switch (if installed) is placed in the TRUE position, heading data is referenced to true north. When operating at higher latitudes the heading reference will automatically switch to true if Magnetic Heading and Track from the ADIRU becomes unreliable. The Heading Reference Annunciation located beneath the Digital Heading indicates "TRU" when the heading reference is true north. When the heading reference is magnetic north, the heading Reference Annunciation indicates "MAG" for ten seconds, then is blank.

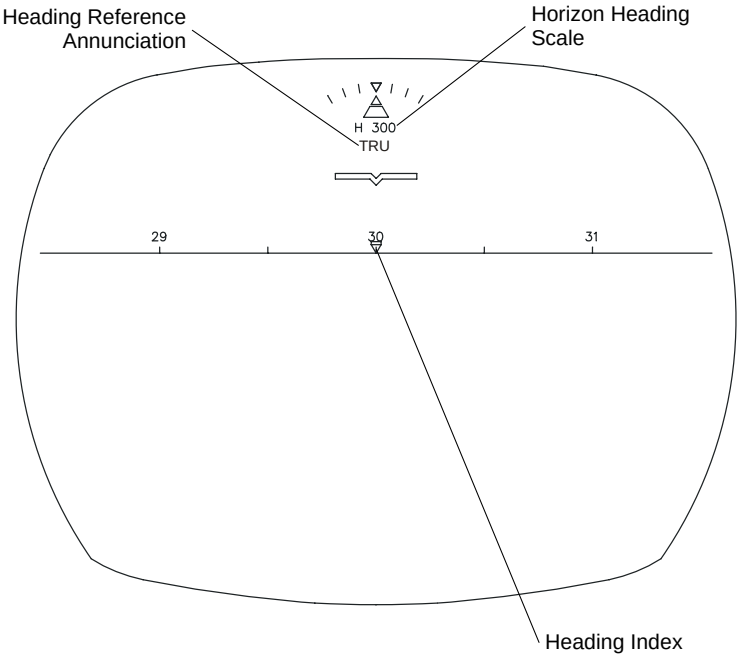


Figure 4-10:
Horizon Heading Scale

Heading Scale and Index (HSI)

A conventional sectored HSI (Figure 4-11) is positioned in the bottom center portion of the display in the Primary mode in flight. The HSI display consists of a partial compass rose spanning 210° with tic marks every 10°. Each 30° tic mark is labeled with its corresponding value in tens of degrees (e.g., label 13 is 130°). Cardinal headings are labeled with the characters "N", "S", "E", and "W". A downward pointing box/triangle, positioned above the center of the partial compass rose, represents the Compass Lubber Line and points to the current Magnetic heading.

A Drift Angle Pointer is displayed on the compass rose as a triangle pointing to the aircraft's current track. Current track can be magnetic north or true north depending on the position of the Heading Reference Switch.

The HSI is displayed in full (210° span) until either pitch or flight path angle cause the Horizon Line or the Flight Path symbol to reach its display limit above the HSI. As the pitch or flight path angle increases further, the HSI, and its associated symbology are "pushed" down until only a small portion of the HSI is visible. This allows the Horizon Line and Flight Path symbol to be positioned where the HSI is normally displayed without overlaying the HSI symbology. As the pitch or flight path angle decreases, and the Horizon Line or Flight Path symbol moves back toward the center of the display, the HSI and associated symbols are "pulled" back up on the display.

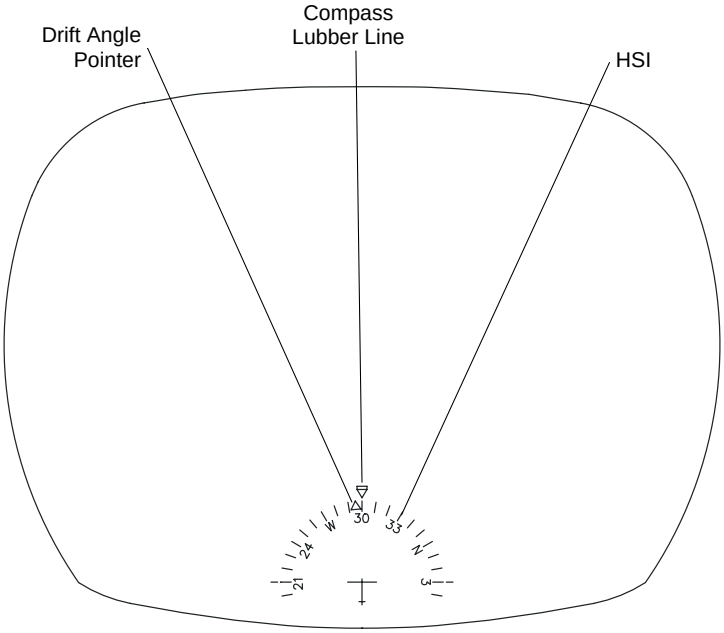


Figure 4-11:
HSI – with Drift Angle Pointer

Selected Course

Selected Course is displayed on the HSI, Horizon Line, and as a digital value (Figure 4-12).

- In the Primary mode, a Selected Course Mark (the head of the CDI) is displayed inside the HSI pointing to the corresponding Selected Course value. If the Selected Course value is outside the currently displayed heading 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.
- A Selected Course Mark is displayed below the Horizon Line pointing to the corresponding Selected Course value. The Selected Course Mark is surrounded by a 3° gap in the Horizon Line. If the Selected Course value is outside the currently displayed heading scale on the Horizon Line, then the Selected Course mark is ghosted to the side closest to the Selected Course.
- Digital Selected Course is displayed in one-degree increments in the lower left portion of the display preceded by the characters “CRS”. It is continually displayed in the Primary mode and for five seconds after selection in the IMC, VMC, or AIII modes. When in IMC, VMC, or AIII mode, if the Selected Course is changed, the new value will reappear for 5 seconds. It is displayed in one-degree increments as selected on the DFCS Mode Control Panel (MCP). A zero degree selection is displayed as “000”.

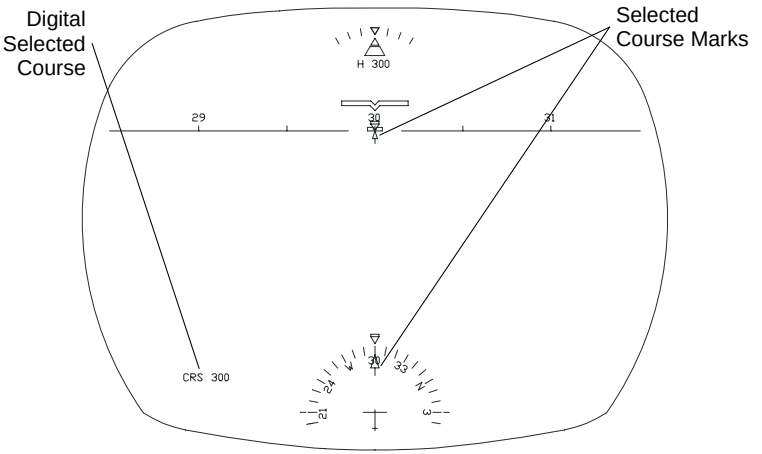


Figure 4-12:
Selected Course

Selected Heading

Selected Heading is displayed on both the HSI, and the Horizon Line. It is also displayed as a digital value (Figure 4-13).

In the Primary mode, a Selected Heading mark is displayed on the HSI indicating the corresponding selected heading. If the selected heading is outside the currently displayed heading scale on the HSI, then the Selected Heading mark is not displayed.

A Selected Heading mark is displayed on the Horizon Line indicating the corresponding Selected Heading value. If the selected heading is outside the currently displayed heading scale on the Horizon, then the Selected Heading mark is not displayed.

Digital Selected Heading is displayed in the lower left portion of the display preceded by the characters “HDG”. It is continually displayed in Primary mode and for five seconds after selection in the IMC, VMC, or AIII modes. When in IMC, VMC, or AIII mode, if the Selected Heading is adjusted, the new value will reappear for 5 seconds. It is displayed in one-degree increments as selected on DFCS Mode Control Panel (MCP). A zero degree selection is displayed as “000”.

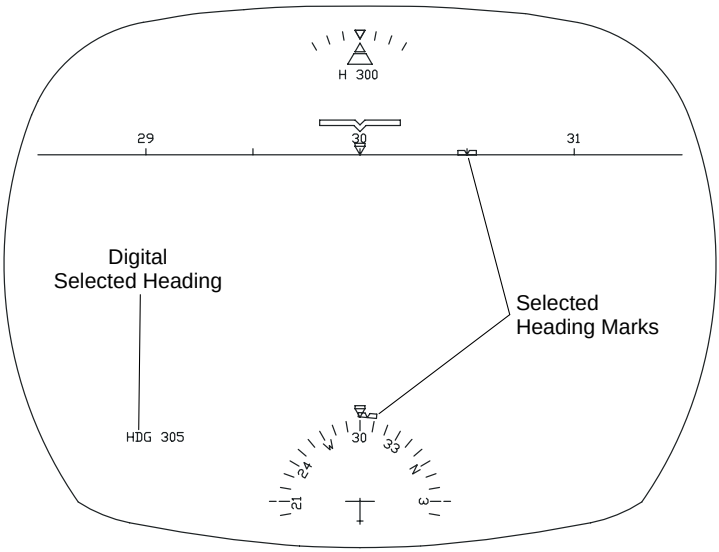


Figure 4-13:
Selected Heading

Bearing Source Annunciations

Bearing Pointers #1 and #2 (Figure 4-14) provide an indication of the aircraft's position relative to the Non-Directional beacon and are displayed when selected on the EFIS control panel. Pointer can be either VOR or ADF bearing.

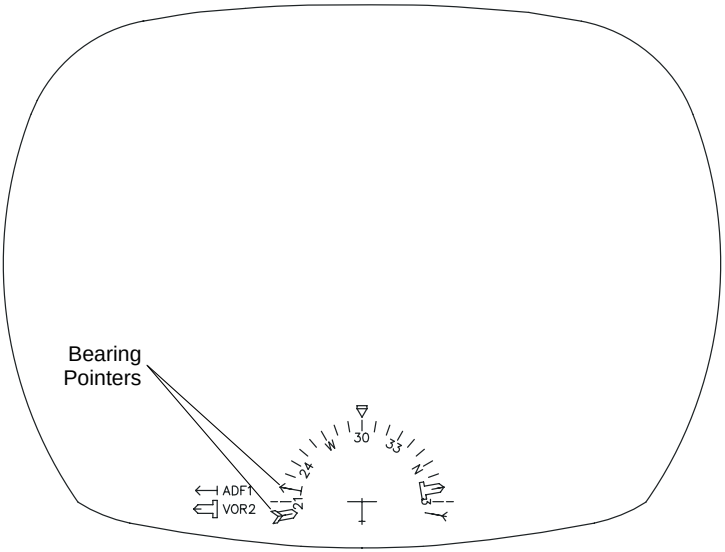


Figure 4-14:
ADF/VOR Bearing Indicators

VOR To/From

In the Primary mode, VOR To/From is displayed as a triangle on the CDI, just inside the Selected Course mark. A triangle pointing in the same direction as Selected Course indicates a "TO" condition. Pointing away from Selected Course indicates a "FROM" condition. The TO/FROM indicator is only displayed when the selected Nav source is VOR and while VOR deviation is valid (Figure 4-15).

In the IMC mode, the VOR To or From is annunciated by displaying either "TO" or "FROM" directly below the "VOR" Navigation Source Annunciation.

NOTE: This is also true in the AIII mode, but only if the Captain's Nav Receiver is tuned to a VOR frequency after the AIII mode is entered. This will also result in the loss of the AIII status ("NO AIII").

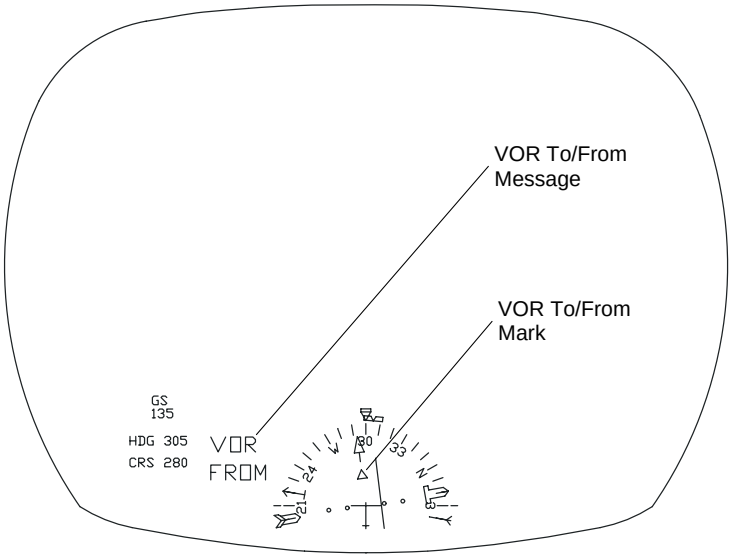
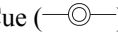


Figure 4-15:
TO/FROM Indication and Annunciation

Category III Symbology

Guidance Cue

The Guidance Cue symbol is the "Flight Director." It functions in the same way as a conventional single cue Flight Director, but is designed for control of Flight Path. For the pilot, the objective is to capture the Guidance Cue inside the Flight Path circle () using pitch and roll control inputs.

On the ground in the Primary mode when configured for a low visibility takeoff, or in Rollout Mode$^{\Delta}$, a Ground Roll Guidance Cue () provides HGS-derived lateral guidance commands relative to the Ground Roll Reference symbol (in place of Flight Path). This command provides for tracking the localizer during a low visibility takeoff or in Rollout Mode using rudder control inputs. Following the low visibility takeoff, and at the transition to "in-flight", the HGS-derived Ground Roll Guidance Cue is removed from the display and replaced by the Flight Director derived Guidance Cue when less than 2° of pitch command or 50 feet Radio Altitude occurs, whichever is first.

Whenever in-flight in either the Primary or IMC mode, and when the left seat pilot's Flight Director commands are in view (head-down), the Guidance Cue is driven by the Flight Director. Whenever the HGS AIII approach mode$^{\Delta}$ is active, the Guidance Cue is controlled by independently-derived pitch and roll command signals from the HGS Computer. The AIII Guidance Cue is designed for very fine tracking of the localizer and glideslope down to flare, after which it will command a flare maneuver while continuing to track the localizer laterally. It is removed from the display at touchdown. If the rollout option is selected, the Guidance Cue remains displayed through the rollout until the ground speed decreases to 25 knots. If the HGS is not AIII capable ("NO AIII" after the AIII mode is entered), then the Guidance Cue is removed from the display.

NOTE: When changing modes between Primary or IMC and AIII, the Guidance Cue switches between sources (DFCS or HGS). The Guidance Cue is continuously displayed, but a slight change in position may be observed.

Ground Roll Reference

The Ground Roll Reference symbol (Figure 4-16) provides a reference for the Ground Roll Guidance Cue during low visibility takeoff and AIII rollout$^{\Delta}$ operations. During low visibility takeoff, the symbol is positioned 1.5° below the Aircraft Reference Symbol until rotation. As the pitch attitude increases during takeoff rotation, the Ground Roll Reference is held on the Horizon Line until 3° of attitude is achieved. At this point, the Ground Roll Reference is replaced by the Flight Path symbol.

In Rollout Mode$^{\Delta}$ after an AIII approach$^{\Delta}$, the Ground Roll Reference symbol is added at main gear touchdown and remains until the aircraft ground speed decreases below 25 knots.

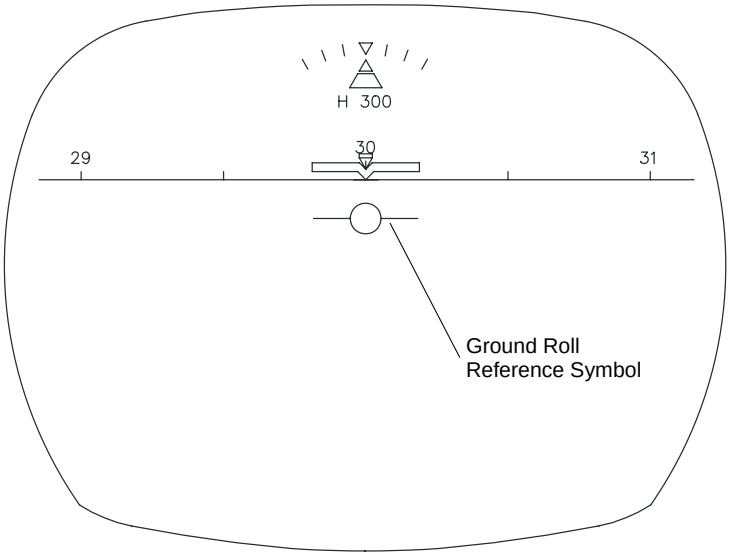


Figure 4-16:
Ground Roll Reference Symbol

Digital Runway Elevation

The Digital Runway Elevation (Figure 4-17) is displayed in the lower right portion of the display for a period of five seconds after either of the following occur:

- The AIII mode$^{\Delta}$ is selected
- The Runway Elevation value is changed during an AIII mode$^{\Delta}$ operation.

The display consists of the characters "ELV" followed by the runway elevation value entered on the HGS HCP.

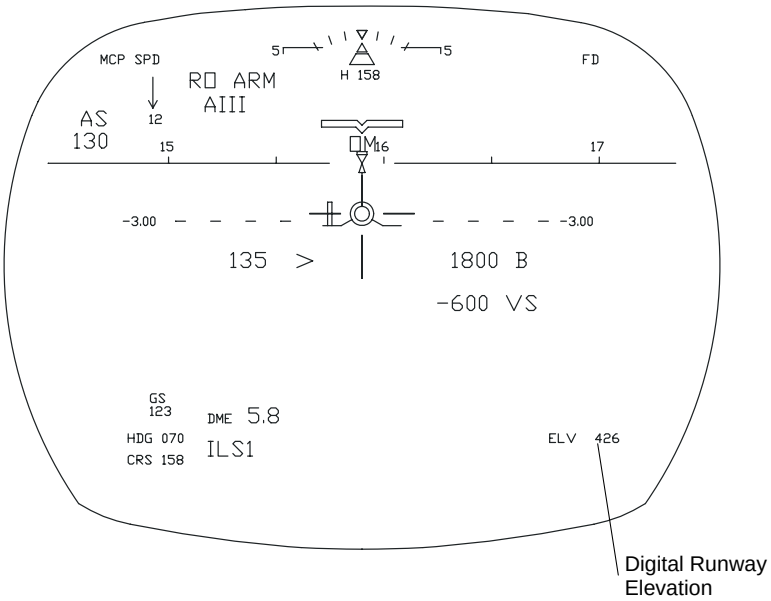


Figure 4-17:
Digital Runway Elevation

Digital Runway Length

The Digital Runway Length (Figure 4-18) is displayed in the lower right portion of the display for a period of five seconds after either of the following occur:

- The AIII mode$^{\Delta}$ is selected
- The Runway Length value is changed during an AIII mode$^{\Delta}$ operation.

In AIII above 500 feet AGL, if the Runway Length entered on the HCP is outside of Rollout Guidance$^{\Delta}$ capability (<7500 feet/2286 meters$^{\Delta}$ or >13500 feet/4115 meters) the digital value display flashes continuously to indicate the out of tolerance condition.

The display consists of the characters “LN” followed by the runway length value in feet or meters as entered on the HGS HCP. When the Runway Length is displayed in meters, a small “M” will follow the numeric display.

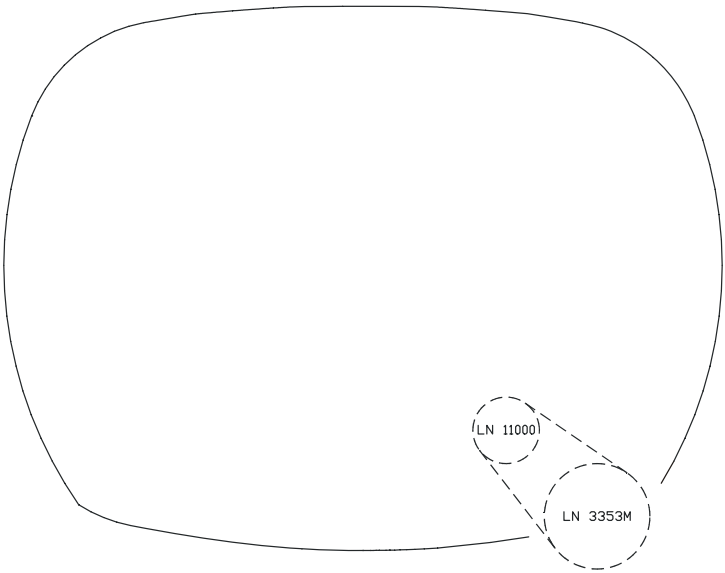


Figure 4-18:
Digital Runway Length (feet and meters)

Rollout Excessive Deviation

The Rollout Excessive Deviation symbol (Figure 4-19) indicates excessive localizer deviation during Rollout Mode$^{\Delta}$. It is only displayed in Rollout Mode after an AIII$^{\Delta}$ approach. It is a flashing triangle that points in the direction of the runway centerline. It is placed to the right of the Ground Roll Reference Symbol when the aircraft is right of centerline, and left of the Ground Roll Reference Symbol when the aircraft is left of centerline. If the OPC option for Rollout mode is not enabled, this symbol does not show.

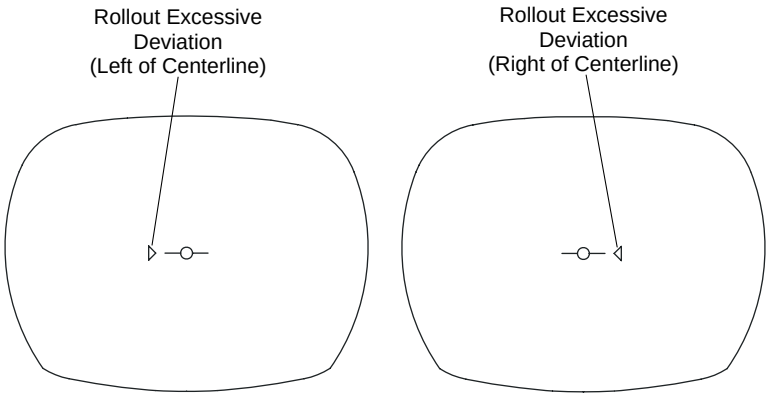


Figure 4-19:
Rollout Excessive Deviation

Runway Remaining

A digital Runway Remaining readout (Figure 4-20) is displayed to the right and below the Ground Roll Reference symbol during low visibility takeoff and in Rollout Mode$^{\Delta}$ following an AIII approach$^{\Delta}$. It indicates the length of runway remaining in feet or meters$^{\Delta}$, between the aircraft and the end of the runway.

The display consists of the characters "RWY" above the runway remaining value in feet or meters based on the runway length value entered on the HGS Control Panel. When Runway Remaining is displayed in meters, a small "M" follows the numeric display.

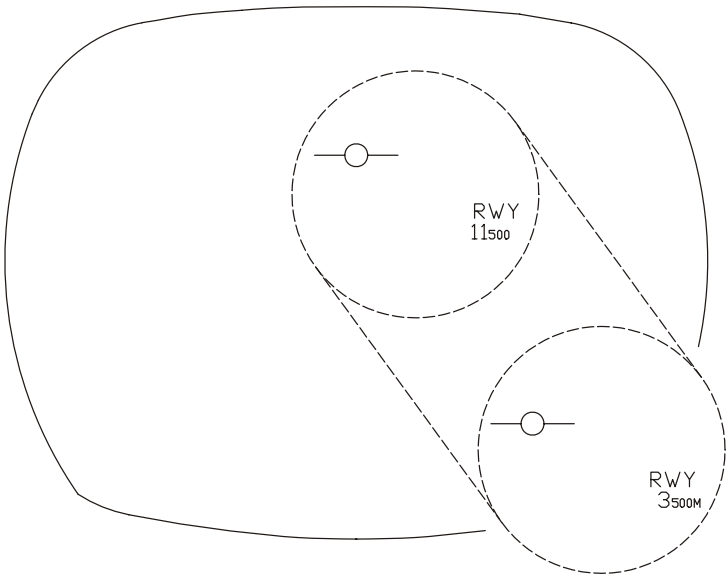


Figure 4-20:
Runway Remaining (feet and meters)

Runway Edge Lines

Runway edge lines (Figure 4-21) are displayed when the aircraft is at 300 feet and are removed at 60 feet during an AIII approach$^{\Delta}$. The edge lines consist of an outline of the two sides of the runway scaled to represent a width of 200 feet and a length of 8000 feet. Tic marks are displayed at the touchdown aimpoint representing 1050 feet from the runway threshold.

The aircraft's orientation to the runway is shown by displaying the runway symbols in perspective to the real world runway. This is dependent on setting Selected Course for the ILS approach as well as inputs from pitch, roll, heading, baro altitude, localizer deviation, glideslope deviation, and the glideslope angle and elevation entered on the HCP.

NOTE: Conformity of the symbolic runway to the real world runway depends on the above input signals but is affected most by heading errors. Heading errors can be attributed to errors in the published approach course, real runway heading, IRS magnetic heading data and Selected Course errors, all affected by natural magnetic variation over time and by inertial errors. It is not essential that the symbolic runway be perfectly aligned but that it provide a reasonable representation of the runway perspective when being flown in low visibility conditions (e.g., a CAT III approach and landing). In visual conditions, these errors can be significantly reduced or eliminated by adjusting the Selected Course to overlay the far end of the real runway.

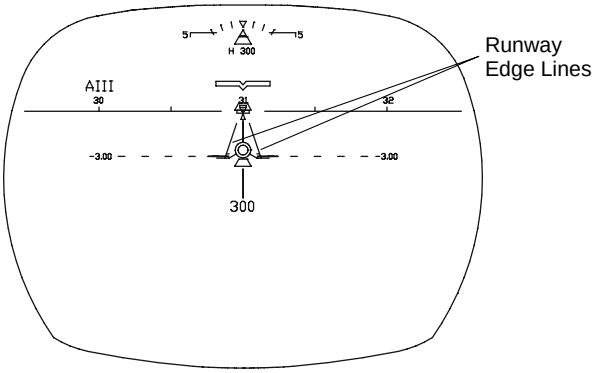


Figure 4-21:
Runway Edge lines

Idle Message

During an AIII approach$^{\Delta}$, part of the flare guidance includes a command for the pilot to reduce the aircraft thrust to idle for touchdown. This command is indicated by the characters “IDLE” displayed directly below the Flight Path and Digital Radio Altitude symbology (Figure 4-22).

The IDLE message is displayed when the aircraft is between 25 to 5 feet above the runway, depending on airspeed.

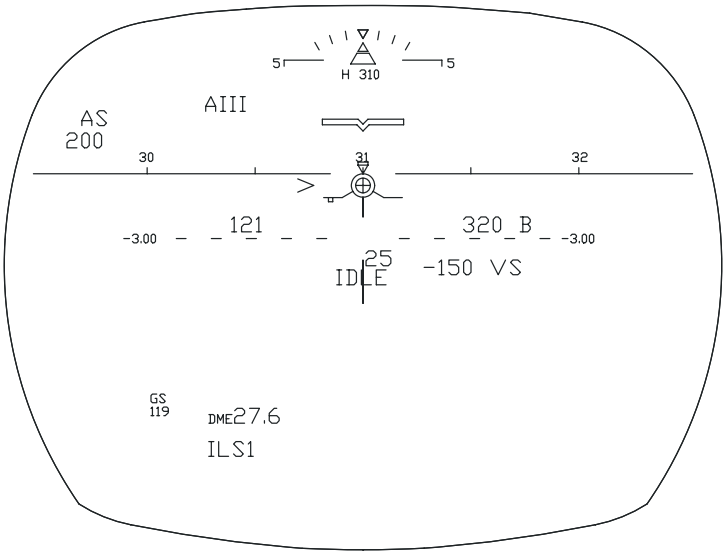


Figure 4-22:
“IDLE” Message

Flight Path Symbology

Flight Path

The Flight Path symbol (Figure 4-23) displays the actual flight path vector of the aircraft. The swept wings of the Flight Path symbol are angled downward 30° to the horizontal so that in a 30° level turn, the appropriate wing will overlay the Horizon Line.

The Flight Path symbol is inertially-derived and provides an instantaneous indication of where the aircraft is going. The pilot can maneuver the aircraft and "fly" Flight Path to the desired point. For example, if the pilot positions Flight Path above the Horizon Line, the aircraft is climbing. If it is pointed below the Horizon 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. For example, if the pilot positions Flight Path to overlay 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 display priority over all other symbols except the guidance cue and flare command symbology. For example, if any portion of another symbol is positioned anywhere inside the circular portion of the Flight Path symbol, that portion is not displayed.

The Flight Path symbol can be limited laterally by other symbology (tapes) or the display field-of-view (Figure 4-23). When this occurs, the Flight Path symbol is "ghosted" meaning it is displayed as dashed lines rather than solid lines. This indicates that the Flight Path symbol is no longer conformal with the real world scene.

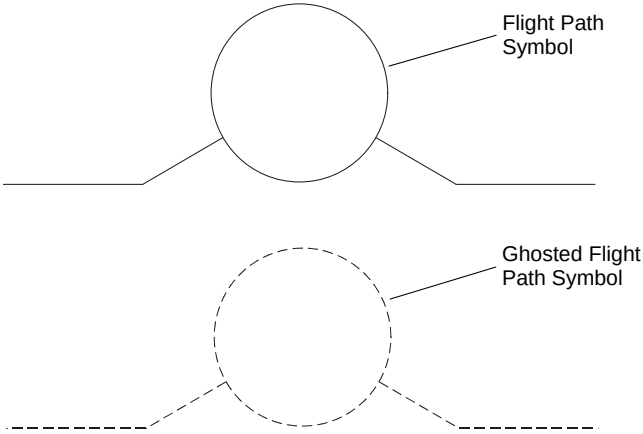


Figure 4-23:
Flight Path Symbols

Flight Path Acceleration

The inertial acceleration (or deceleration) of the aircraft along the flight path is indicated by the Flight Path Acceleration symbol " > " (Figure 4-24). This symbol is an indication of the total sum of all forces affecting the aircraft, including, thrust, drag, and the air mass the aircraft is moving through.

In flight, the Flight Path Acceleration symbol is positioned to the left of the Flight Path symbol. When Flight Path Acceleration is above the wing of the Flight Path symbol, the aircraft is accelerating. When it is below the Flight Path wing, the aircraft is decelerating. To maintain a steady state (neither accelerating nor decelerating), the Flight Path Acceleration symbol is positioned pointing to the Flight Path wing. When the aircraft is not in flight, or the Flight Path symbol is not displayed, then the Flight Path Acceleration symbol is positioned relative to the Ground Roll Reference Symbol. If the Ground Roll Reference symbol is not displayed, Flight Path Acceleration is positioned relative to the Aircraft Reference symbol.

NOTE: It is important to remember that flight path acceleration is affected by all forces on the aircraft and actually indicates the total forces at work. 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.

To avoid confusion in controlling aircraft thrust, the Flight Path Acceleration symbol is removed from the display when the HGS detects a low-level, decreasing performance wind shear below 400 feet AGL.

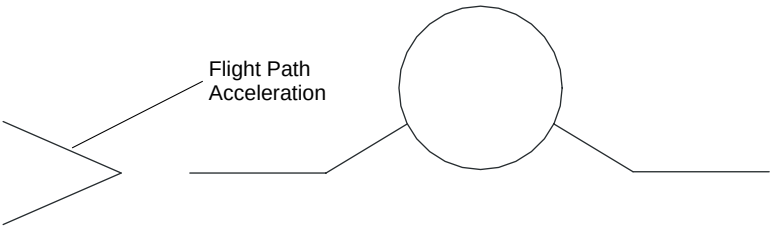


Figure 4-24:
Flight Path Acceleration

Ground Deceleration Scale$^{\Delta}$

The Ground Deceleration Scale$^{\Delta}$ (Figure 4-25) consists of four labeled marks displayed alongside the vertical path traveled by the Flight Path Acceleration symbol. Each Ground Deceleration Scale mark represents the deceleration level provided by the corresponding setting of the aircraft's automatic braking (Autobrake) system. Each mark is labeled with the corresponding Autobrake setting, and the vertical offset of each mark from the reference position (either the Ground Roll Reference or Aircraft Reference symbol) represents the deceleration level of the corresponding autobrake setting. The OPC option for the Ground Deceleration Scale symbology must be enabled for the Ground Deceleration Scale to show.

The vertical position of the Flight Path Acceleration symbol along the Ground Deceleration Scale shows the inertial deceleration of the aircraft with respect to the deceleration levels indicated by the marks.

During takeoff, the scale is not displayed, but is added to the display if a deceleration is sensed when the ground speed is above 50 knots and the airplane is still on the ground. Once displayed, the scale is removed when ground speed decreases below 25 knots, the airplane begins accelerating, or the airplane lifts off.

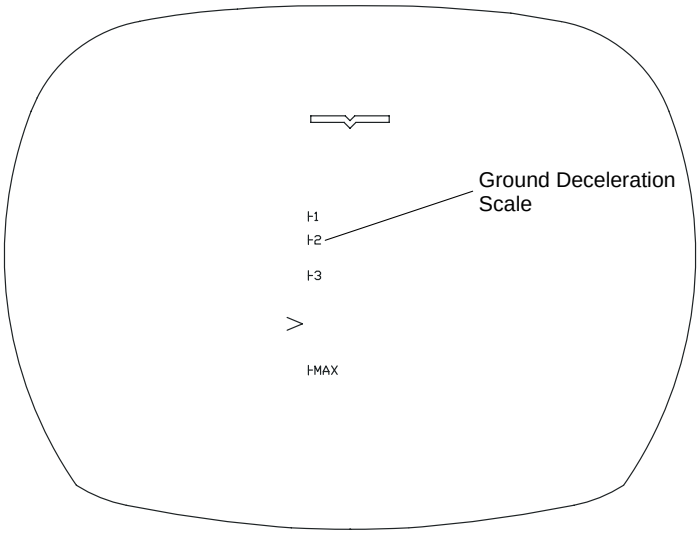


Figure 4-25:
Ground Deceleration Scale

Glideslope Reference Line

The Glideslope Reference Line (Figure 4-26) is a conformal display of the glideslope value entered on the HGS Control Panel (HCP). It consists of a series of dash lines positioned below the Horizon Line at an angle corresponding to the glideslope value entered on the HCP. If a -3.00° angle is entered, then the Glideslope Reference Line is positioned 3° below the Horizon Line and laterally centered on the display. The Glideslope Reference Line is displayed fulltime in IMC, VMC, and AIII modes. The Glideslope Reference Line is displayed in the Primary Mode when in descent below 2500 feet RA.

The digital glideslope value corresponding to the glideslope angle entered on the HCP is located at the outside ends of the Glideslope Reference Line. The Flight Path symbol has display priority over this digital value and will "blank" it if the Flight Path symbol moves to within a specified distance.

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 glideslope angle entered on the HCP. During visual approaches, a precise descent angle to the runway is maintained by overlaying the Glideslope Reference Line on the runway touchdown zone and then maintaining the Flight Path symbol on the Glideslope Reference Line.

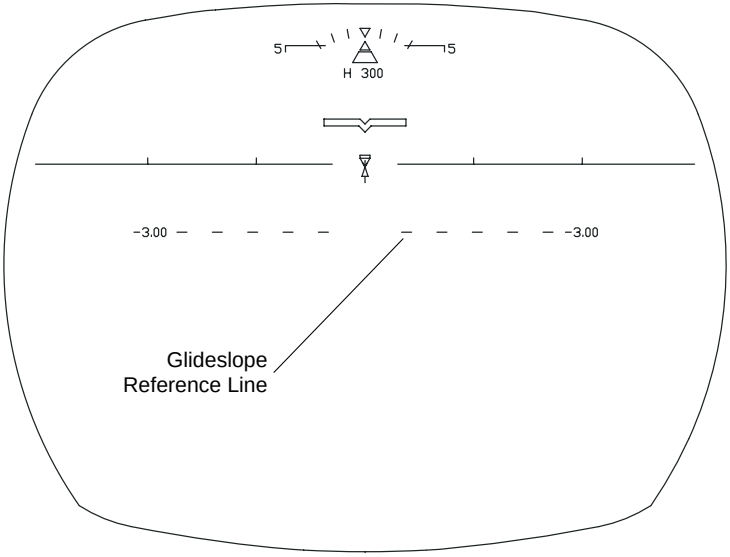


Figure 4-26:
Glideslope Reference Line

Angle Of Attack Symbology

AOA Limit

The AOA Limit symbol (Figure 4-27) 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.

The AOA Limit symbol is displayed during any of the following:

- Angle-of-attack is within 3.5° of stick shaker when Flaps are Up and 5° of stick shaker when Flaps are not Up.
- Whenever stick shaker is active
- Whenever the Windshear Guidance Cue is displayed.

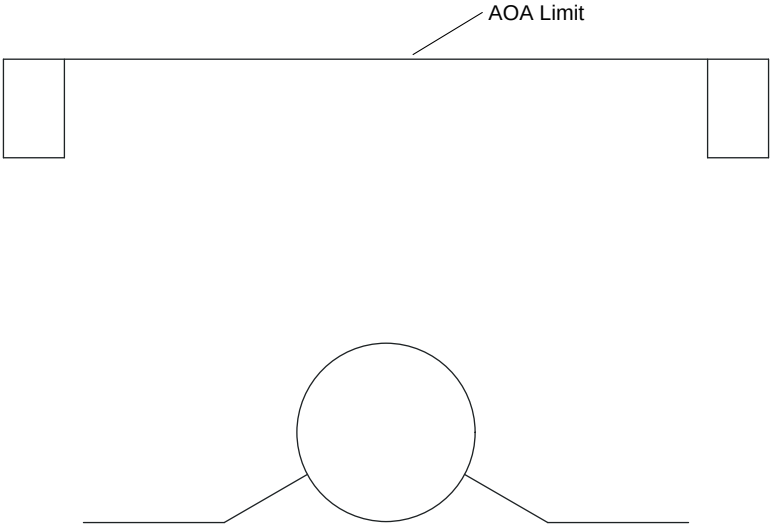


Figure 4-27:
AOA Limit

Angle of Attack Scale and Indicator$^{\Delta}$

The Angle of Attack$^{\Delta}$ (AOA) symbols are displayed in the upper right portion of the Combiner display anytime the aircraft is in flight and the angle of attack data is valid. Figure 4-28 shows the Angle of Attack Scale and Indicator, the Approach Reference Band and the Stick Shaker Trip Point. The OPC option for Angle of Attack symbology must be enabled for the AOA Scale and Indicator to show.

The Angle of Attack Scale and Indicator and the digital readout indicate the aircraft's current angle of attack. The distance between the tick marks on the scale represent represents a 5° change in angle of attack.

The **Approach Reference Band** is added to the scale after the first flap retraction to indicate the normal approach angles of attack.

The **Stick Shaker Trip Point** provides a visual indication of the proximity of the current angle of attack to the stick shaker angle of attack. It is displayed only if the stick shaker angle of attack is valid.

The **Angle of Attack Fault Annunciation** is a boxed "AOA" message that indicates the loss of valid Angle of Attack data. It is displayed to the left of the AOA symbology.

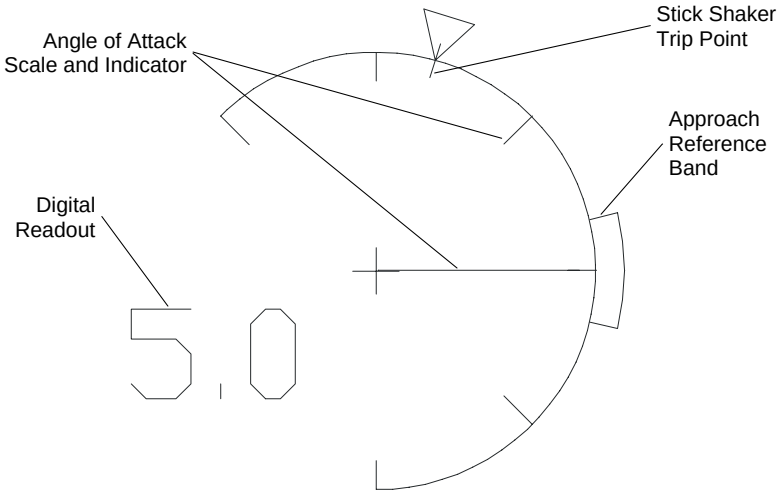


Figure 4-28:
Angle of Attack Symbols

Slip/Skid Symbology

Slip/Skid Indicators (SSI)

The Slip/Skid symbology (Figure 4-29) consists of three symbols:

- Roll Scale Slip/Skid Indicator referenced to and rotated with the Roll Scale Pointer or referenced to the UA Roll Scale Pointer (whichever is displayed).
- Aircraft Reference Slip/Skid Indicator referenced to the Aircraft Reference Symbol.
- Flight Path Slip/Skid Indicator referenced to the Flight Path symbol.

The Flight Path and Aircraft Reference Slip/Skid Indicators are only displayed during a takeoff, or a low-altitude go-around, to provide additional yaw reference in the case of an engine failure. At low altitude, the sensitivity of the Slip/Skid Indicators is enhanced to provide additional awareness.

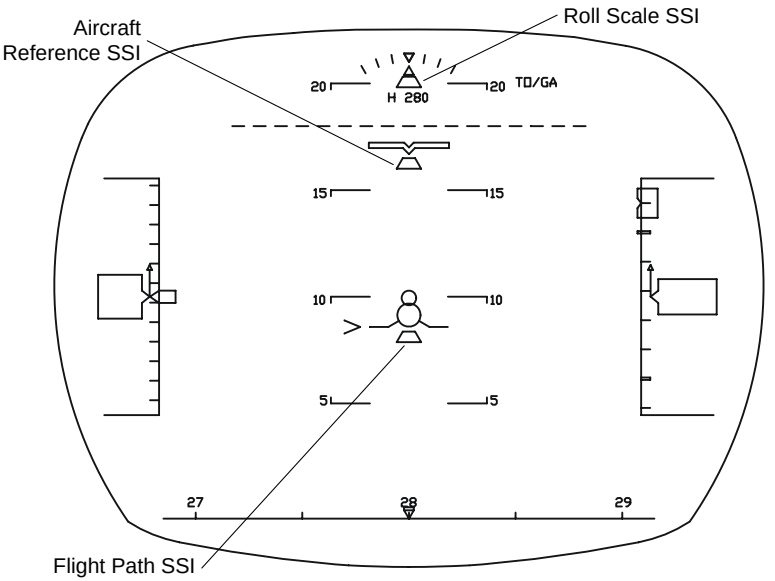


Figure 4-29:
Slip/Skid Indicators

Speed Symbology

Speed Error Tape

The Speed Error Tape (Figure 4-30) is displayed in all modes and shows the difference between the indicated airspeed and the reference (or "bug" airspeed) selected on the DFCS Mode Control Panel (MCP).

The Speed Error Tape is positioned on the left wing of the Flight Path symbol, adjacent to the Flight Path Acceleration symbol. If the airspeed is faster than the "bug" speed, the Speed Error Tape rises above the wing proportional to the speed error. Likewise, if the airspeed is slower than the "bug" speed, the Speed Error Tape falls below the wing. Each one-degree of Speed Error Tape length (approximately the diameter of the Flight Path circle) represents approximately five knots of airspeed error. The tape length is limited to 15 knots of error.

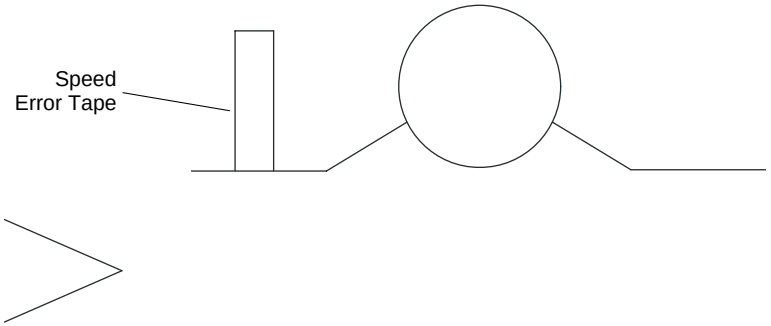


Figure 4-30:
Speed Error Tape

Airspeed Displays

Airspeed data is displayed in both analog and digital forms depending on the mode of operation (Figure 4-31, Figure 4-32, and Figure 4-35). In the Primary mode, the displayed airspeed information is comprised of the following:

1. **Maximum Allowable Airspeed:** is indicated by the lower end of a checkerboard tape growing downward from the top of the Airspeed Scale as the airspeed increases toward the Vmo limit. This symbol is inhibited on the ground.
2. **High Speed Buffet Speed:** is indicated by a "┘" symbol placed alongside the upper portion of the airspeed tape. The lower edge indicates the speed where the aircraft will encounter buffeting or the flaps should be extended.
3. **Computed Airspeed (CAS) and Airspeed Scale:** are displayed along the left edge of the display. The CAS is also displayed as a digital value within an airspeed odometer window. The Airspeed Scale displays a ±60 knot range. The Digital Airspeed Odometer includes the pointer for the Airspeed Scale. The overall range of the Airspeed Scale is 30 to 450 knots with tic marks every 10 knots, labeled every 20 knots.
4. **Airspeed Trend Vector:** displays as an arrow "↑" above or "↓" below the airspeed index. The length of the arrow is proportional to the trend value with the tip indicating the predicted airspeed in 10 seconds. It is displayed when the airspeed trend exceeds 4.5 knots and is removed when the trend is less than 3.5 knots or CAS is less than 30 knots.
5. **Mach:** indicated as a digital value displayed below the Airspeed Scale when Mach increases above 0.400 and removed when it decreases below 0.380.

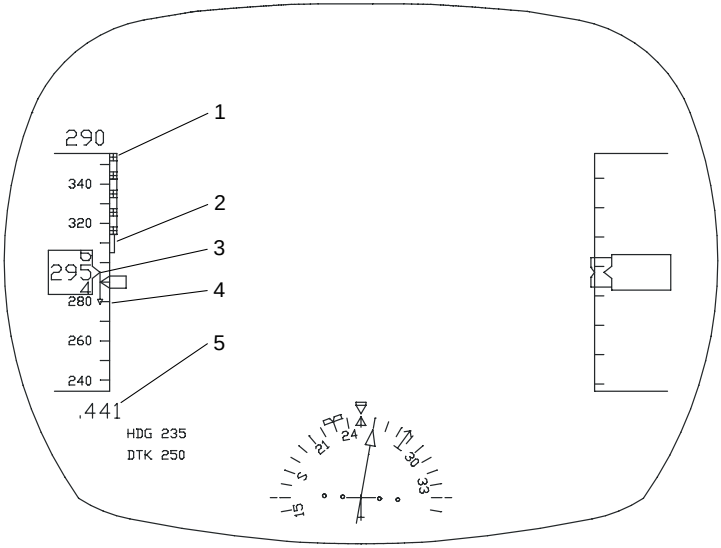


Figure 4-31:
Airspeed Tape Symbology – Primary Mode

6. **Digital Selected Airspeed/Mach:** is displayed directly above the Airspeed Scale. It is a digital readout of the aircraft's Selected Airspeed or Selected Mach. Selected Mach is only available in Primary Mode when the CDS is configured for PFD/ND.
7. **VREF +15 Bug**: positioned 15 knots above REF bug when REF bug is displayed.
8. **Reference Speed Indicator:** displayed at selected approach reference speed (when in view) and bug is displayed on the CDS. When bug moves off-scale at bottom of the airspeed tape it is replaced by a legend and digital readout.
9. **Selected Airspeed Mark:** is displayed in Primary Mode, positioned along the Airspeed Scale when the selected airspeed is within the scale's range. The selected airspeed value is selected on the DFCS Mode Control Panel (MCP).
10. **Minimum Operating Speed:** is indicated by a "ꓶ" symbol placed alongside the lower portion of the airspeed tape. The upper edge indicates the minimum maneuvering speed.
11. **Stick Shaker Airspeed:** is indicated by the upper end of a checkerboard tape growing upward from the bottom of the Airspeed Scale as the airspeed decreases toward stick shaker speed. This symbol is inhibited on the ground.
12. **Airspeed Disagree:** Airspeed Disagree: is indicated by the text "IAS DISAGREE" when airspeed from ADIRU1 disagrees from airspeed from ADIRU2 by more than 5 knots for 5 seconds. This message is also displayed in IMC, VMC, and AIII modes in the same location.

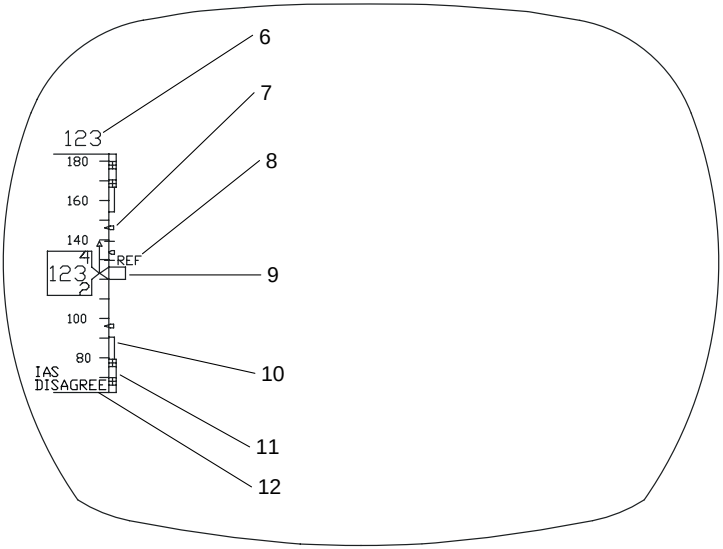


Figure 4-32:
Airspeed Tape Symbology – Primary Mode (Part 2)

V1 Speed: is indicated by a tic mark labeled “V1” when the V1 speed is within the Airspeed Scale and “V1” above the digital value when off the top of the Airspeed Scale.

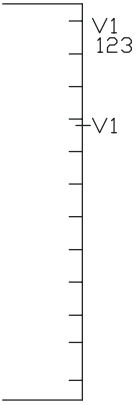


Figure 4-33:
V1 Speed Symbol

VR Speed: takeoff rotation speed is indicated by a tic mark labeled “VR” or “R” when the VR speed is within the Airspeed Scale. “R” is used only when VR within 5.5 knots of V1.

Figure 4-34:
Takeoff Rotation Speed Symbol

Climb-out Speed Indicator: a bug (◁) positioned on the Airspeed Scale at the Selected Airspeed +15 knots during T/O until first flap retraction.

Manual Bug 5 Speed Indicator: a bug (◁) positioned on the Airspeed Scale by selecting position 5 on the Engine Control Module Reference Speed select knob.

Takeoff Speed Bug: a bug (◁) positioned on the Airspeed Scale at 80 or 100 knots based on the CDS option selected.

Ground Speed: displayed in all modes, as a digital value, to the right of Mach. Ground speed is indicated in one-knot increments with the letters "GS" positioned on top of the numerical value.

Digital CAS: in any mode other than Primary mode, the Airspeed Scale and associated symbols are replaced with a digital readout of Computed Airspeed (CAS) (Figure 4-35). CAS is positioned relative to the Flight Path symbol when displayed, and relative to the Aircraft Reference symbol if Flight Path is not displayed. CAS is displayed in one-knot increments just below and to the left of Flight Path or the Aircraft Reference Symbol.

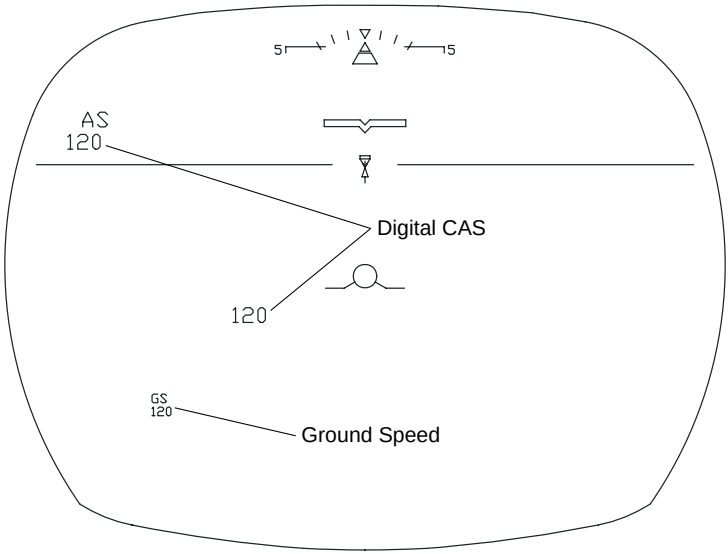


Figure 4-35:
Digital Airspeed Symbology

Flap Maneuver Speeds: are indicated by tic marks labeled with the flap position “UP”, “1”, “2”, “5”, “10”, “15”, and “25” along the Airspeed Scale when the Flap Maneuver Speeds are within the Airspeed Scale.

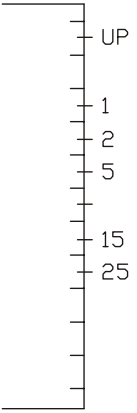


Figure 4-36:
Flap Maneuver Speeds

Wind Speed and Direction

The current Wind Speed and Direction (Figure 4-37) is displayed in the upper left portion of the display.

The Wind Speed is indicated by a digital value positioned directly below the Wind Direction arrow. It is displayed in one-knot increments from 6 to 256 knots.

The Wind Direction is referenced to the aircraft. A Wind Direction arrow pointing straight up (the 12 o'clock position) represents a direct tail wind. A Wind Direction arrow pointing to the right (the 3 o'clock position) represents a direct left crosswind.

The two parameters (direction and speed) are displayed when the aircraft is in flight and the Wind Speed exceeds 6 knots. The Wind Speed and Direction are removed when the Wind Speed drops below 4 knots.

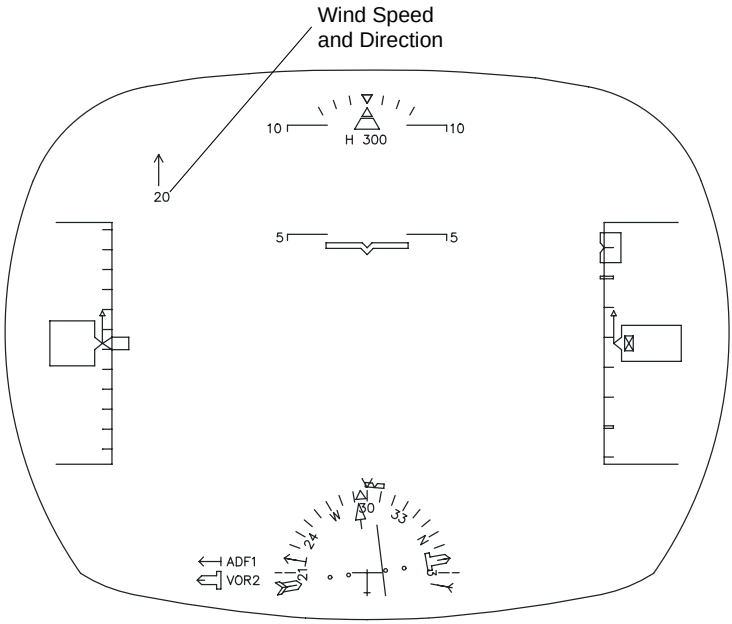


Figure 4-37:
Wind Speed and Direction

Flare Cue

The Flare Cue (Figure 4-38) is a pair of flashing " + " (plus symbols), one directly above each wing of the Flight Path symbol. The Flare Cue symbol is displayed in all modes except AIII as an indication to flare the aircraft. It is first displayed when the aircraft descends through 55 feet and is removed when the aircraft descends through 10 feet (Radio Altitude).

NOTE: The position of the Flare Cue is fixed relative to the Flight Path symbol wings and is not used to command or in any way provide guidance for the flare maneuver, but only to indicate the necessity to manually flare the aircraft.

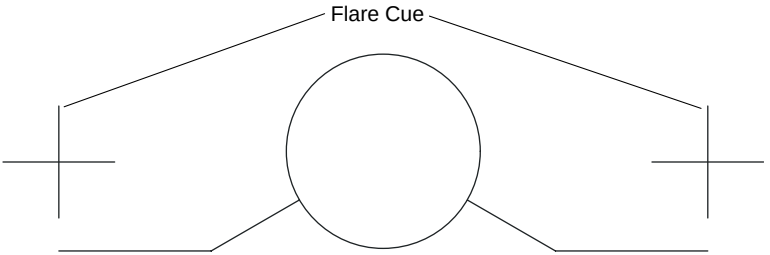


Figure 4-38:
Flare Cue

AIII Flare Command

In the AIII mode$^{\Delta}$, an HGS AIII Flare Command (Figure 4-39) is displayed. This consists of a plus symbol (“ + ”) initially positioned 2-3° directly below the Guidance Cue as the aircraft descends through 105 feet above the runway elevation. The AIII Flare Command indicates that HGS AIII flare guidance is being given and that the pilot should perform the flare maneuver by following the Guidance Cue upward on the display. The AIII Flare Command symbol initially flashes rapidly and then remains steady on. The symbol rises toward the Guidance Cue circle at a rate directly proportional to the expected flare pitch rate. At an altitude between 45 and 55 feet, the Flare Command and Guidance Cue meet (flare initiation) and continue rising together to command the flare maneuver, continuing until touchdown.

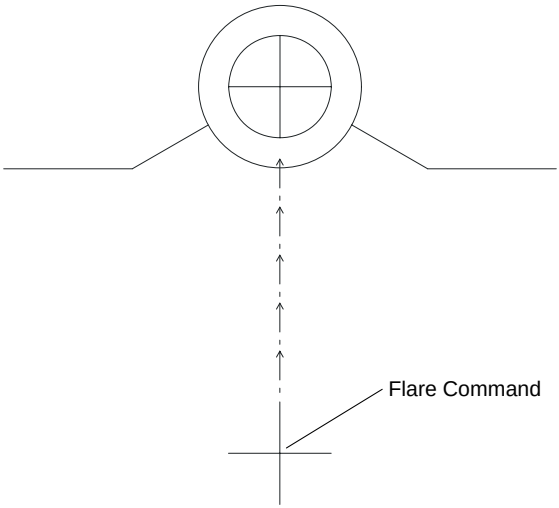


Figure 4-39:
AIII Flare Command

Altitude Symbology

Altitude Displays

Altitude data is displayed in both analog and digital forms, depending on the mode of operation. In the Primary mode, the displayed altitude information (Figure 4-40) is comprised of the following:

1. **Selected Altitude:** is displayed as a digital value in 100 foot increments directly above the Altitude Scale and as pointed to by the selected altitude mark "▯" positioned along the Altitude Scale when within the scale's range. If the selected altitude is outside the scales range, the mark is parked at the end of the scale on the appropriate end. The selected altitude value is selected on the DFCS Mode Control Panel (MCP).
2. **Altitude Trend Vector:** displays as an arrow "↑" above or "↓" below the altitude index. The length of the symbol is proportional to the trend value derived using vertical speed, with the tip indicating the predicted altitude in six seconds. It is displayed if the altitude trend exceeds 45 feet (in 6 seconds) and removed when the trend is less than 35 feet and is limited to remain within the Altitude Scale.
3. **Barometric (Baro) Altitude and the Altitude Scale:** Baro Altitude is displayed relative to the Altitude Scale along the right edge of the display and as a digital value (in 20-foot increments) within the Digital Odometer. The Altitude Scale displays a ±400 foot range. The Digital Odometer includes the pointer for the Altitude Scale. An "X" is used to show the absence of the most significant digit when the altitude is less than 10,000 feet. The overall range of the Altitude Scale is -9900 to 50,000 feet with tic marks every 100 feet, labeled every 200 feet.
4. **Baro Minimums Bug:** provides an indication of the aircraft's selected Minimum Descent Attitude (MDA). It travels along the Altitude Scale.
5. **Selected Minimums Readout:** provides a digital readout of the aircraft's selected DH or Minimum Descent Altitude, and is positioned alongside the lower left portion of the Altitude Scale.
6. **Altimeter Setting:** displayed as a digital readout of the pilot's current altimeter setting, directly below the Altitude Scale.
7. **Altitude Disagree:** is indicated by the test "ALT DISAGREE" when Baro Altitude from ADIRU1 disagrees from Baro Altitude from ADIRU2 by more than 200 feet for 5 seconds. This message is also displayed in IMC, VMC, and AIII modes in the same location.

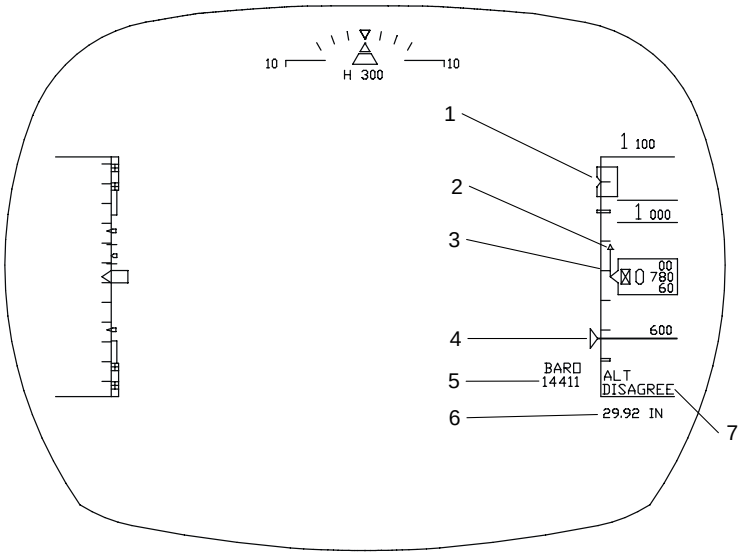


Figure 4-40:
Altitude Tape Symbology (Primary Mode)

Digital Barometric Altitude (AIII, VMC, and IMC Modes): The Altitude Scale and associated symbols (Figure 4-41) are not displayed in the AIII, IMC, or VMC mode. Instead, a digital readout of barometric altitude is displayed in 10-foot increments positioned just below and to the right, relative to the Flight Path or Aircraft Reference symbols. If the Flight Path symbol is not displayed, Barometric Altitude is displayed relative to the Aircraft Reference Symbol.

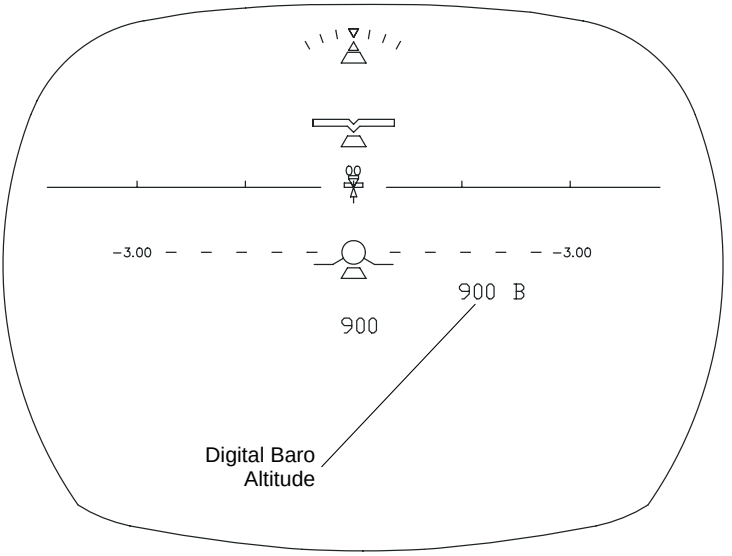


Figure 4-41:
Digital Barometric Altitude (AIII, VMC, IMC Modes)

Radio Altitude

A digital Radio Altitude (Figure 4-42) is displayed directly below the Flight Path symbol. The Radio Altitude value is removed from the display at 1500 (2500^{Δ}) feet when ascending and is again displayed at 1400 (2500^{Δ}) feet when descending. If the Flight Path symbol is not displayed, the Radio Altitude is displayed relative to the Aircraft Reference symbol.

The digital value is displayed in flight in twenty- foot increments between 2500 and 1500 feet, ten-foot increments between 1500 and 50 feet, five-foot increments between 50 and 10 feet, and one-foot increments between 10 feet and the ground. Radio Altitude is not displayed on the ground.

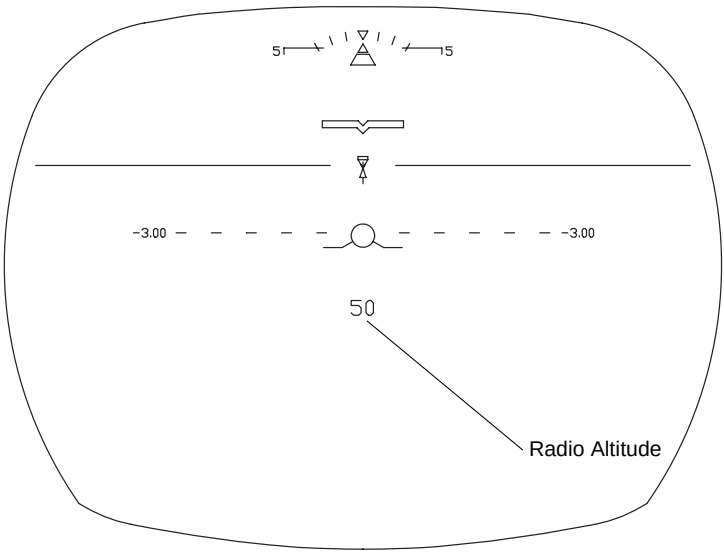


Figure 4-42:
Radio Altitude

Digital Vertical Speed

Digital Vertical Speed (Figure 4-43) indicates the aircraft's inertial vertical speed. Digital Vertical Speed is displayed in increments of 50 feet per minute. The Digital Vertical Speed value is displayed in the lower right corner of the display in Primary Mode and is followed by the characters "VS" as a label of the digital readout. In VMC, IMC, and AIII Modes$^{\Delta}$ the Digital Vertical Speed symbol is positioned below and to the right of the Flight Path symbol. Digital Vertical Speed is not displayed on the ground.

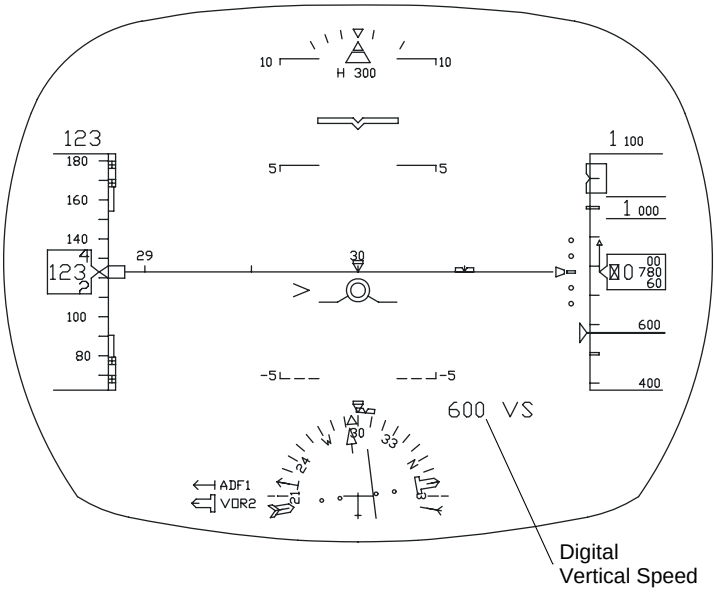


Figure 4-43:
Digital Vertical Speed – Primary Mode

Mode and Alert Symbology

Windshear Warning

A Windshear Warning (Figure 4-44) message ("WINDSHEAR") is displayed just above the Aircraft Reference symbol whenever the Ground Proximity Warning System (GPWS) detects a shearing condition, or the WXR Predictive Windshear is active and no Ground Proximity Warning is displayed. The Windshear Warning continues to display until the shearing condition is no longer active.

Windshear Guidance Cue

When a Windshear Warning is detected and the Flight Director is in the TO/GA mode, the Guidance Cue changes to the Windshear Guidance Cue (Figure 4-44). The HGS automatically switches to the Primary mode if the Flight Director TO/GA mode is selected in response to a windshear warning. In this case, the DFCS provides the windshear recovery guidance to exit the windshear condition. The Windshear Guidance Cue is displayed until the GPWS Windshear Warning is no longer active, in which case the normal Guidance Cue is displayed, and the Windshear Warning message is removed.

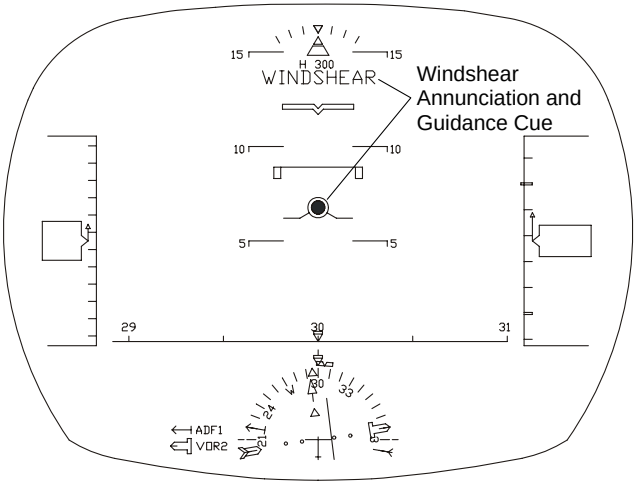


Figure 4-44:
Windshear Annunciation and Guidance Cue

Ground Proximity Warning (GPWS)

A Ground Proximity Warning ("PULL UP") is displayed above the Aircraft Reference symbol when GPWS has detected that the aircraft is on an unsafe path with respect to terrain.

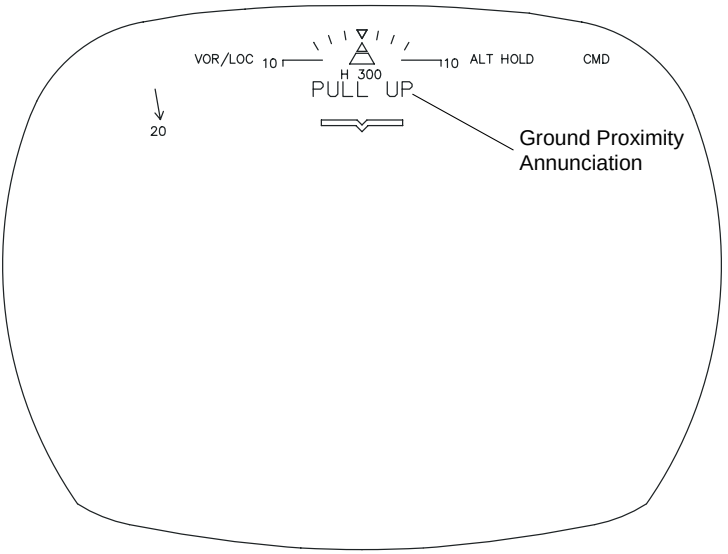


Figure 4-45:
Ground Proximity Warning Annunciation

Decision Height

A Decision Height annunciation “DH” is displayed to the left of the digital Radio Altitude when the selected Decision Height altitude has been reached. When descending through decision height, “DH” flashes for 3 seconds and then remains steady. “DH” is removed from the display when any of the following conditions occur:

- EFCP Reset switch is pressed
- Radio Altitude is 75 feet above Decision Height altitude
- Aircraft is no longer in flight.

Decision Height is not displayed if Radio Altitude is not displayed.

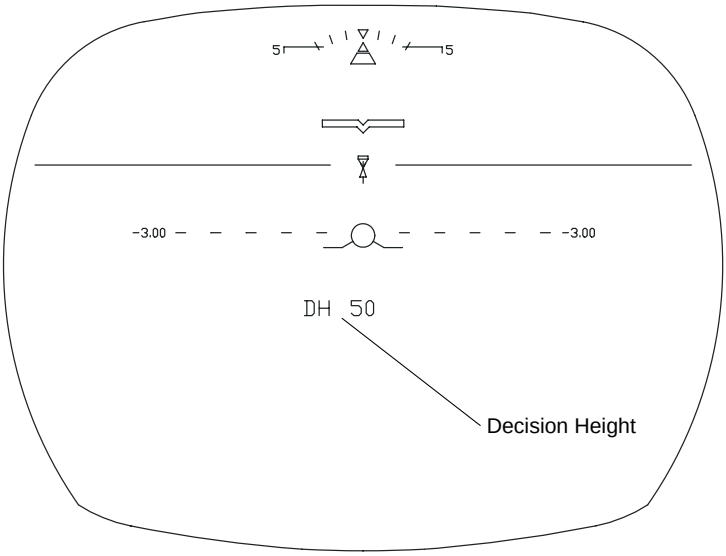


Figure 4-46:
Decision Height

HGS Mode/Status

HGS approach modes of operation (AIII, IMC, or VMC) are indicated in the upper left portion of the display just to the right of the Selected Airspeed (Figure 4-47). The Primary mode is not indicated, as it is uniquely identifiable by the Airspeed and Altitude Scales.

AIII Mode$^{\Delta}$ Annunciation

The HGS AIII mode$^{\Delta}$ is a decluttered approach mode that provides HGS calculated guidance and monitoring for low visibility approach and landings. The AIII mode is only available after the HGS has determined that it passes all of the internal integrity checks (commonly referred to as "AIII capable") and the Approach On Course (AOC) logic has been satisfied. AIII mode can be activated in two ways:

1. Arming AIII for automatic selection - AIII mode will be automatically selected when AOC criteria have been satisfied.
2. Manual selection - AIII mode is manually selected after AOC logic has been met.

Approach Warning (APCH WARN)

During AIII approaches$^{\Delta}$ below 500 feet, an "APCH WARN" message may be displayed in the top center portion of the display just above the Aircraft Reference symbol. This message is displayed if one of the following conditions exists:

- Approach monitoring tolerances are exceeded
- AIII capability is lost ("NO AIII").

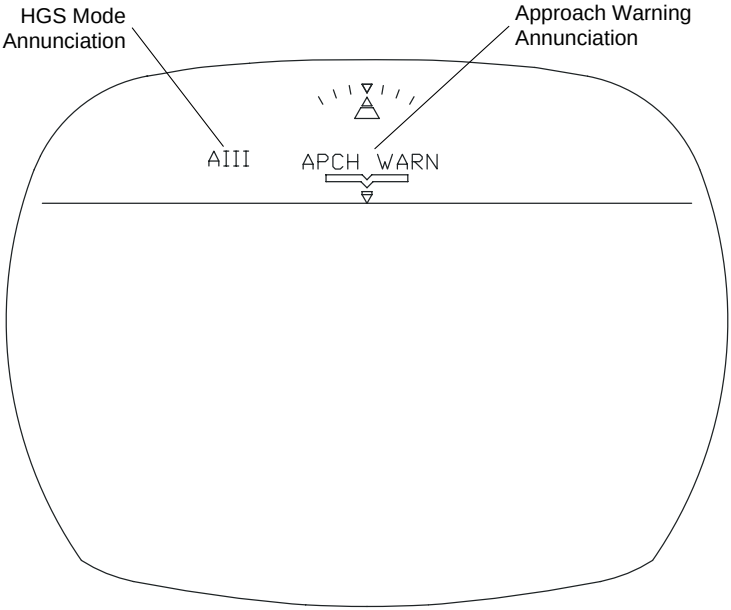


Figure 4-47:
HGS Mode/Status Annunciations

Tail Strike Warning Message$^{\Delta}$

The Tail Strike Warning Message$^{\Delta}$ provides an indication that a tail strike is likely during landing. During approach, tail strike monitoring is active below 100 feet wheel height until aircraft touchdown. The OPC option for Tail Strike Avoidance symbology must be enabled for the Tail Strike Warning Message to show.

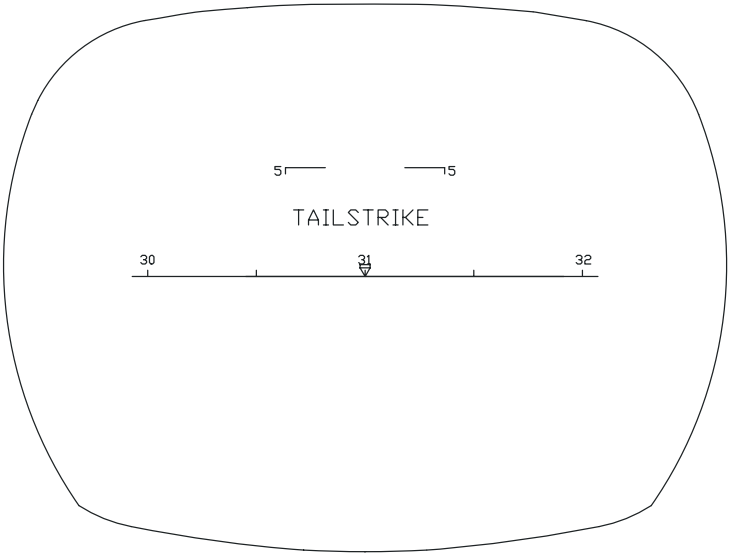


Figure 4-48:
Tail Strike Warning Message

Navigation Symbology

Marker Beacons

Marker Beacon passage is annunciated by the characters “OM”, “MM”, and “IM” for the Outer Marker, Middle Marker and Inner Marker; respectively. They are displayed individually below the Aircraft Reference symbol.

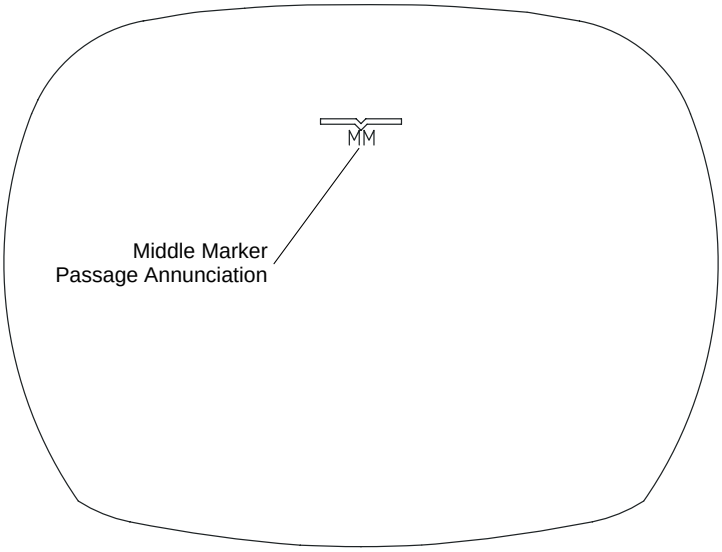


Figure 4-49:
Marker Beacon Annunciation

Digital Distance (DME/DTT)

Digital Distance (Figure 4-50) is displayed as a digital value preceded by "DME" in the lower left portion of the display. When the Navigation Radio is tuned to a GLS station, the digital value is preceded by "DTT" and indicates the distance to the runway threshold. The DME/DTT Distance is displayed in 0.1 nautical mile increments between 0 and 99.9 miles and in one nautical mile increments 100 miles and above. Digital Distance is not displayed on the ground.

Distance To Go

FMCS Distance To Go (to next waypoint) is displayed in the lower right portion of the display. Distance To Go is identified by the characters "NM" following the digital value and is displayed in 0.1 nautical mile increments between 0 and 99.9 miles and in one nautical mile increments 100 miles and above. Distance To Go is not displayed on the ground.

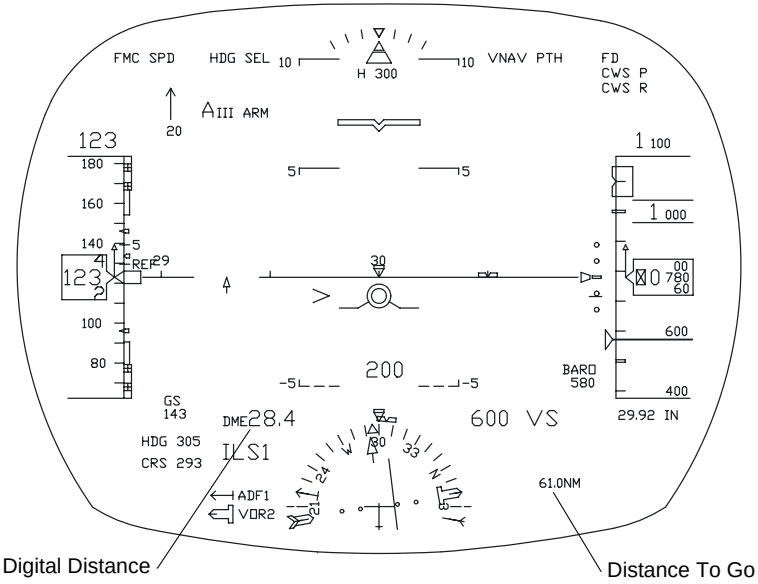


Figure 4-50:
Digital Distance

Navigation Source Annunciations

The Navigation Source Annunciation indicates the source of the navigation information being displayed (Figure 4-51). These annunciations are displayed in a fixed location in the lower left portion of the display. The possible Navigation Source Annunciations are:

- ILS1: indicates that the source for the localizer and glideslope deviation displayed is from side #1 (Nav transfer switch in "NORMAL" or "BOTH ON 1") and an ILS frequency is tuned.
- ILS2: indicates that the source for the localizer and glideslope deviation displayed is from side #2 (Nav transfer switch in "BOTH ON 2" position only) and an ILS frequency is tuned.
- GLS1: indicates that the source for the localizer and glideslope deviation displayed is from side #1 (Nav transfer switch in "NORMAL" or "BOTH ON 1") and a GLS Station ID is tuned.
- GLS2: indicates that the source for the localizer and glideslope deviation displayed is from side #2 (Nav transfer switch in "BOTH ON 2" position only) and a GLS Station ID is tuned.
- VOR1: indicates that the source for the VOR lateral deviation and TO/FROM information displayed is from side #1 (Nav transfer switch in "NORMAL" or "BOTH ON 1") and a VOR frequency is tuned.
- VOR2: indicates that the source for the VOR lateral deviation and TO/FROM information displayed is from side #2 (Nav transfer switch in "BOTH ON 2" position only) and a VOR frequency is tuned.
- VOR/ILS: indicates the NAV source cannot be determined due to a tuning conflict between the VOR and MMR receivers.

Navigation Source Annunciations are displayed in all modes except VMC.

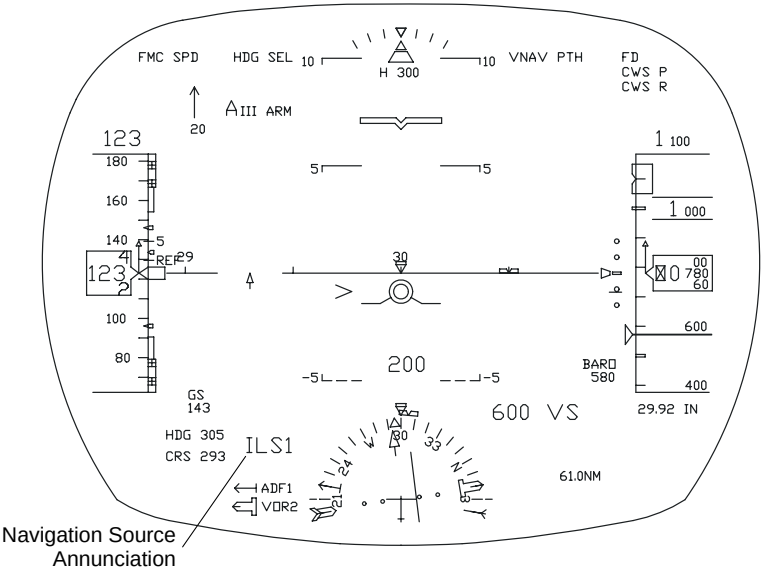


Figure 4-51:
Navigation Source Annunciation

Lateral Deviation - Primary Mode

In the Primary mode, Lateral Deviation is displayed on the HSI as a conventional CDI (Figure 4-52). 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, GLS, or VOR operations.

When the DFCS detects excessive localizer deviation during an ILS or GLS approach, the CDI flashes until the excessive deviation is no longer present. Loss of valid localizer or VOR deviation causes the CDI to be removed, but the scale remains.

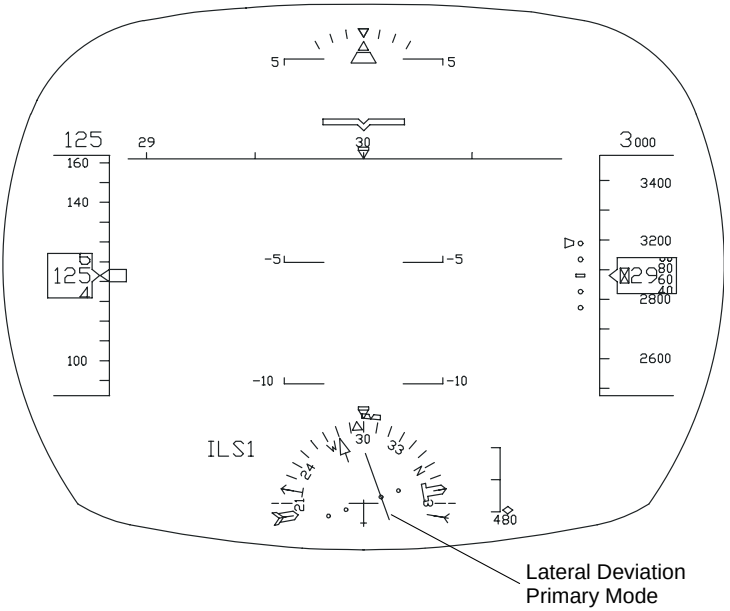


Figure 4-52:
Lateral Deviation - Primary

Lateral Deviation - AIII or IMC Mode

In the AIII$^{\Delta}$ or IMC modes, Lateral Deviation Line is displayed referenced to the Selected Course Mark (Figure 4-53).

Lateral Deviation is indicated by the displacement of the Lateral Deviation Line left or right of the Selected Course Mark. The gain of the Lateral Deviation Line depends on the type of operation. As a localizer deviation, the display gain is six times the actual localizer signal in order to make the localizer more sensitive for fine tracking tasks. This results in 1/5th of a dot (on the HSI) deviation when the localizer deviation line is displaced to either edge of the Selected Course gap in the Horizon Line. As a VOR deviation, the display gain is one.

In the IMC mode, the Lateral Deviation Line flashes similar to the CDI in the Primary mode, when the DFCS detects excessive localizer deviation. Loss of valid localizer or VOR deviation data causes the Lateral Deviation Line to be removed. Failure of the tuned source results in a boxed VOR or LOC failure message.

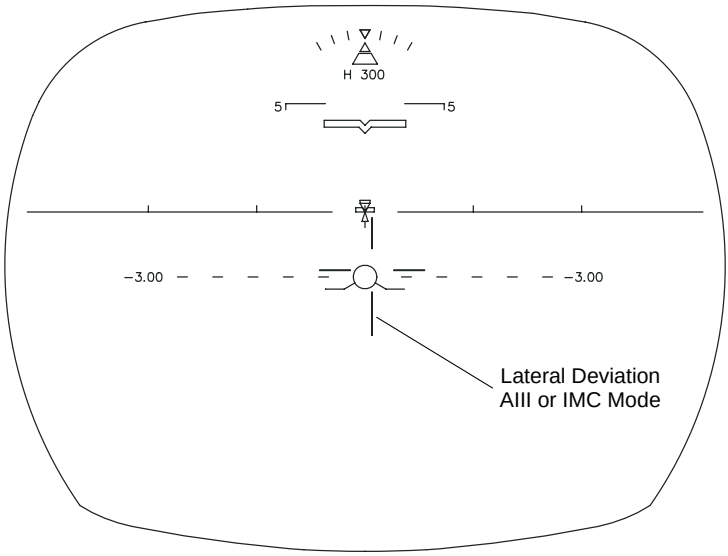


Figure 4-53:
Lateral Deviation - AIII or IMC

Ground Localizer Line - Primary, AIII, and IMC Modes

Either the Ground Localizer Line (Figure 4-54) or the Ground Localizer Deviation Scale and Pointer$^{\Delta}$ (Figure 4-55) is displayed in the Primary, AIII$^{\Delta}$ or IMC modes if the Captain's VHF Nav Receiver is tuned to an ILS frequency (or GLS Station ID – Primary or IMC modes only) and the localizer is valid while on the ground. The Ground Localizer Line is located slightly below the HGS Horizon Line and displays localizer deviation relative to the Selected Course mark.

In the Primary or IMC modes, the Ground Localizer Line is removed from the display at Aircraft Rotation and is again displayed at Aircraft Touchdown.

In the AIII mode$^{\Delta}$, the Ground Localizer Line is displayed at Aircraft Touchdown.

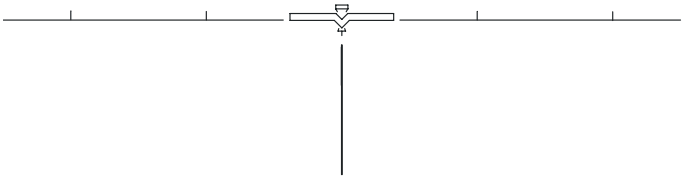


Figure 4-54:
Ground Localizer Line

Ground Localizer Deviation Scale and Pointer$^{\Delta}$

This symbol provides an indication of the aircraft's lateral deviation relative to the runway centerline. The aircraft's lateral orientation to the localizer is indicated by the position of the Localizer Deviation Pointer relative to the Localizer Deviation Scale. The Localizer Deviation Scale is a horizontal scale located just below the Ground Roll Reference Symbol. The Ground Localizer Deviation Scale consists of three marks indicating -1, 0, and +1 "dots" of deviation. The Ground Localizer Deviation Scale and Pointer are only displayed when the aircraft is not in flight. The OPC option for Ground Localizer Deviation Scale and Pointer must be enabled for the Ground Localizer Deviation Scale and Pointer to show.

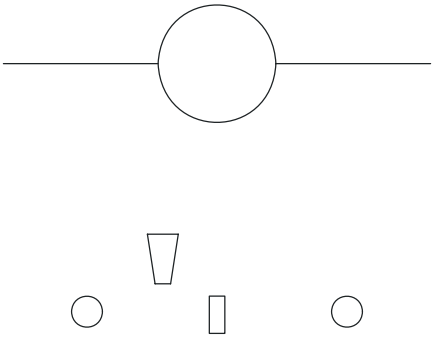


Figure 4-55:
Ground Localizer Deviation Scale and Pointer

Vertical Deviation - Primary and IMC Modes

The Vertical Deviation Scale and Index (Figure 4-56 and Figure 4-57) provides an indication of the aircraft's vertical deviation from the FMS vertical profile. Vertical deviation is determined by noting the location of the diamond shaped Vertical Deviation Index relative to the Vertical Deviation Scale located in the lower right corner of the display. The index is limited to a full-scale deflection of ±400 feet of vertical deviation. When limited, the digital value for the vertical deviation is displayed at the appropriate end of the scale.

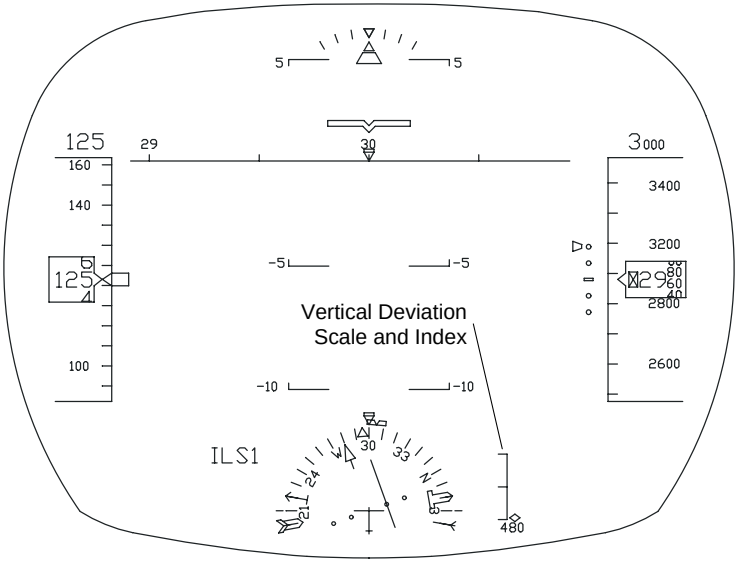


Figure 4-56:
Vertical Deviation – Primary Mode

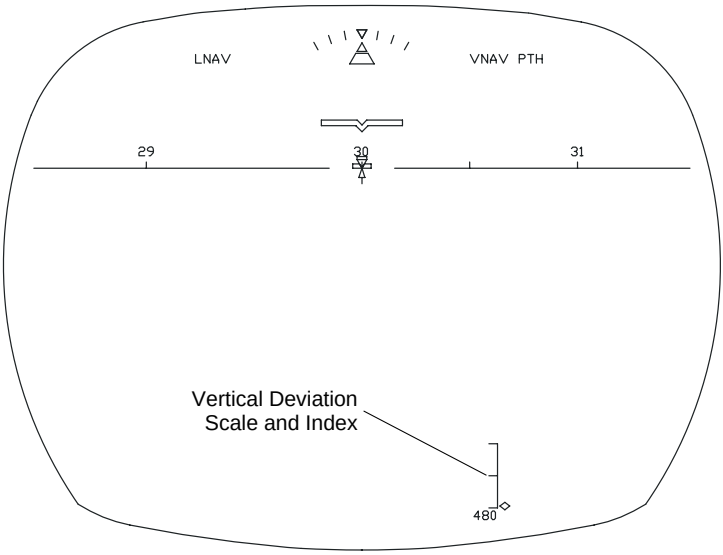


Figure 4-57:
Vertical Deviation – IMC Mode

Glideslope Deviation - Primary Mode

During ILS or GLS operations in the Primary mode, glideslope deviation is shown with the Glideslope Deviation Scale and Index displayed to the left of, and centered on, the Altitude Scale (Figure 4-58). The glideslope Deviation Scale replicates a conventional glideslope scale with ±1 and 2 dots.

When the DFCS detects excessive glideslope deviation during an ILS or GLS approach, the Glideslope Deviation Index flashes until the excessive deviation is no longer present. If glideslope data is not computed, the Glideslope Deviation Index is removed from the scale. Failure of the ILS Receiver (or MMR) causes the HGS to remove the Scale and Index and to display the Glideslope Fault Annunciation (boxed "G/S").

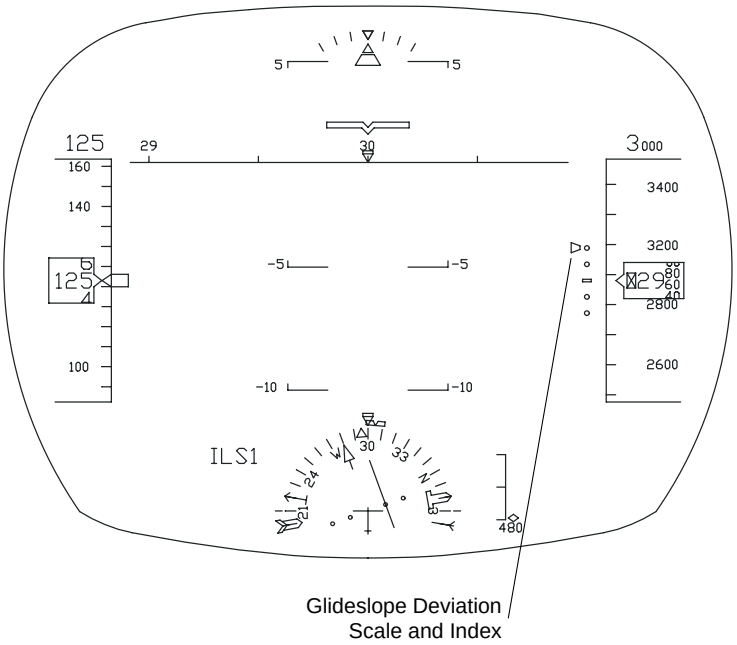


Figure 4-58:
Glideslope Deviation - Primary

Glideslope Deviation - AIII or IMC Mode

In the AIII$^{\Delta}$ or IMC modes, glideslope deviation is shown with the Glideslope Deviation Line. displayed as two horizontal bars referenced to the Glideslope Reference Line (Figure 4-59).

Glideslope deviation is indicated by the displacement of the Glideslope Deviation Line above or below the Glideslope Reference Line during ILS or GLS (IMC mode only) operations. The display gain is eight times the actual glideslope signal in order to make the glideslope more sensitive for fine tracking tasks. The Glideslope Deviation Line is removed from the display below 70 feet AGL.

Loss of valid glideslope data causes the Glideslope Deviation Line to be removed. In the IMC mode, the Glideslope Deviation Line flashes, similar to the Glideslope Deviation Index in Primary mode, when the DFCS detects excessive glideslope deviation. Failure of the ILS or MMR results in a boxed “G/S” message.

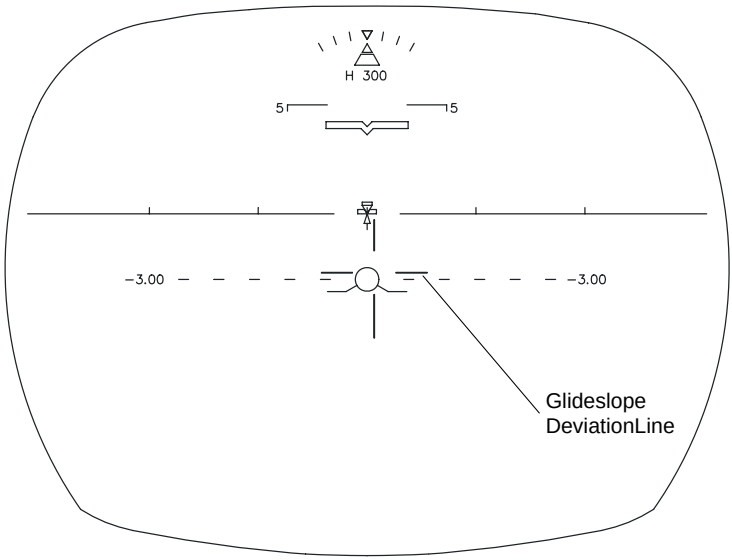


Figure 4-59:
Glideslope Deviation – AIII or IMC Mode

"ALIGN HUD" Message

An "ALIGN HUD" (Figure 4-60) message is displayed to indicate that the HGS Combiner glass is not properly aligned with the Overhead Unit when operating in the IMC or VMC approach modes. If an "ALIGN HUD" message occurs, apply slight pressure, either fore or aft, on the Combiner glass until the "ALIGN HUD" message is removed. If the message cannot be removed with the glass in the operating detents, the HUD is not presenting conformal data, and should not be used.

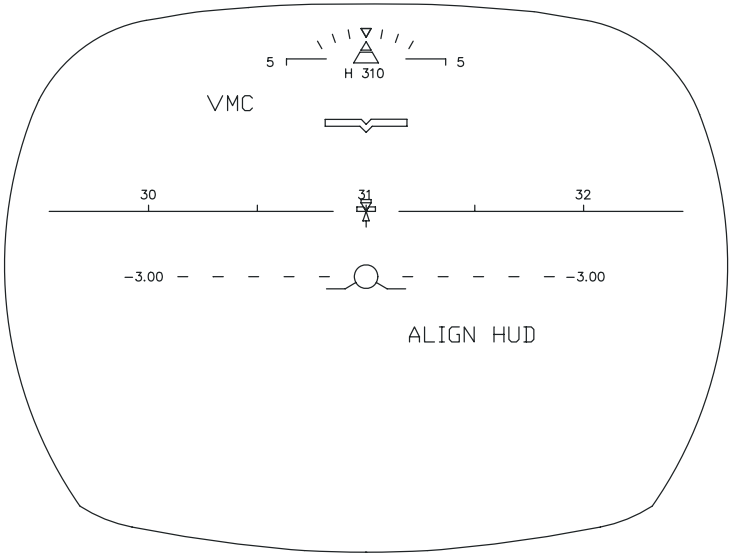


Figure 4-60:
“ALIGN HUD” Message

Flight Director/Autopilot Symbology

Autothrottle Mode Annunciations$^{\Delta}$

Autothrottle (A/T) Mode annunciations$^{\Delta}$, identical to the A/T mode annunciations on the DFCS Flight Mode Annunciator (FMA), are displayed in the upper left corner of the display (Figure 4-61). The OPC option for Autothrottle Installed must be enabled for Autothrottle mode annunciations to show. The following table lists the Autothrottle Mode annunciations displayed:

Table 4-1: Autothrottle Modes

AUTOTHROTTLE MODES	
Mode Annunciation	**Engaged Mode Name**
"N1"	N1 (thrust) Mode
"GA"	Go Around
"RETARD"	Descent Retard
"FMC SPD"	FMC Speed
"MCP SPD"	MCP Speed
"THR HLD"	Throttle Hold
"ARM"	Autothrottle Armed and no A/T mode engaged

A mode change or engagement causes the corresponding mode annunciation to be boxed for ten seconds thus highlighting the newly engaged mode.

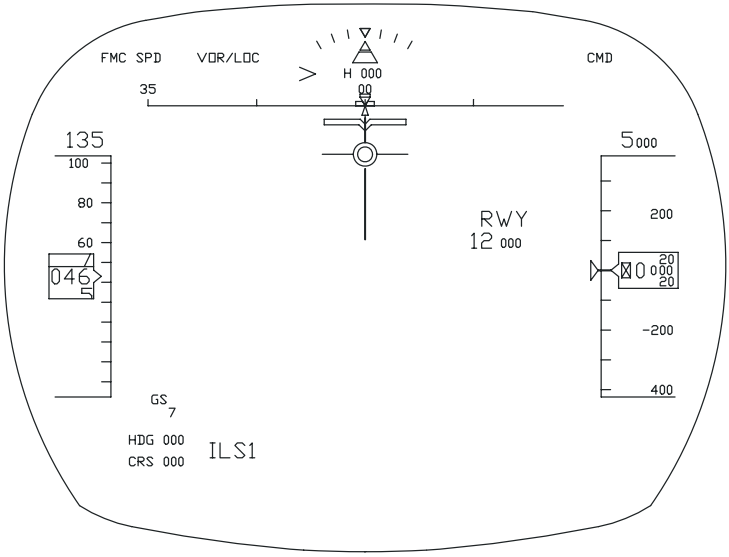


Figure 4-61:
Autothrottle Mode Annunciations

Flight Director Engaged and Armed$^{\Delta}$ Mode Annunciations

Flight Director (F/D) engaged mode annunciations (Figure 4-62) are displayed to the right and left of the roll scale at the top of the display. If the OPC option is selected, FD armed modes are also displayed. There is a horizontal line that separates the engaged and armed mode annunciations. The engaged mode annunciation is displayed above the line and the armed mode annunciation is displayed below the line. If the CDS is configured for PFD/ND, vertical modes are displayed to the right of the roll scale, and lateral modes are displayed to the left of the roll scale. If the CDS is configured for EFIS/MAP, vertical modes are on the left, and lateral modes are on the right. A mode change or engagement causes the corresponding mode annunciation to be boxed for ten seconds thus highlighting the newly engaged mode.

HGS Flight Director modes are similar to the F/D mode annunciations on the DFCS Flight Mode Annunciator (FMA). Table 4-2 and Table 4-3 list the vertical and lateral Flight Director Mode annunciations displayed:

Table 4-2: Flight Director Vertical Modes

Engaged Mode Annunciation	Engaged Mode Name	Armed Mode Annunciation	Armed Mode Name
“TO/GA”	Takeoff/Go-Around	N/A	N/A
“V/S”	Vertical Speed Hold	“V/S”	Vertical Speed Hold
“FLARE”	Flare	“FLARE”	Flare
“ALT ACQ”	Altitude Acquire	N/A	N/A
“ALT HOLD”	Altitude Hold	N/A	N/A
“VNAV ALT”	Vertical Nav Altitude	N/A	N/A
“VNAV SPD”	Vertical Nav Speed*	N/A	N/A
“VNAV PTH”	Vertical Nav Path*	N/A	N/A
“MCP SPD”	Level Change to MCP Selected Altitude	N/A	N/A
“G/P”	FMC Glidepath	“G/P”	“G/P”

Table 4-2: Flight Director Vertical Modes (continued)

Engaged Mode Annunciation	Engaged Mode Name	Armed Mode Annunciation	Armed Mode Name
N/A	N/A	"G/P V/S"	Glidepath Vertical Speed Hold
"G/S"	Glideslope	"G/S"	Glideslope
N/A	N/A	"G/S V/S"	Glideslope Vertical Speed Hold

Table 4-3: Flight Director Lateral Modes

Engaged Mode Annunciation	Engaged Mode Name	Armed Mode Annunciation	Armed Mode Name
"HDG SEL"	Heading Select	N/A	N/A
"VOR/LOC"	VOR or Localizer	"VOR/LOC"	VOR or Localizer
"LNAV"	Lateral Navigation*	N/A	N/A
"ROLLOUT"	Rollout	"ROLLOUT"	Rollout
"FAC"	FMC Final Approach Course	"FAC"	FMC Final Approach Course
"BCRS"	Backcourse	"BCRS"	Backcourse

*If operational.

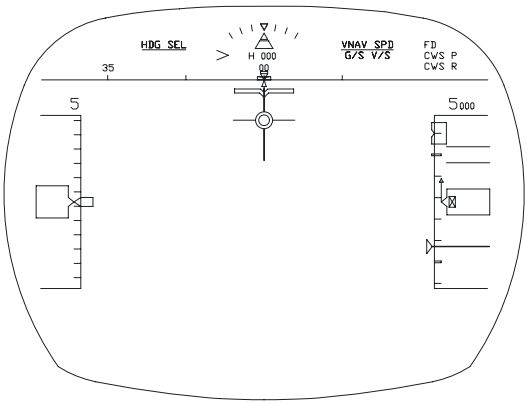


Figure 4-62:
Flight Director Mode Annunciations

Flight Director Mode Annunciations

An indication of the current Autopilot (A/P) status is displayed in the upper right portion of the display (Figure 4-63). Autopilot/Mode status annunciations are similar to the A/P mode annunciations on the DFCS Flight Mode Annunciator (FMA). This is indicated on three lines just above the Selected Altitude as follows:

Table 4-4: Autopilot Annunciations

A/P MODE/STATUS ANNUNCIATIONS	
First Line:	
"FD"	#1 Flight Director is ON and neither A/P is in command (CMD).
"CMD"	Either A/P is engaged in the command ("CMD") position.
"SINGLE CH" **NOTE: If the CDS is configured for EFIS/Map, the HGS displays "1 CH".**	The A/P detects localizer capture with only one channel engaged.
"TEST"	The autopilot is in test mode
"LAND3"	The fail-operational Autoland System in configured for an autoland
"LAND2"	The fail-operational Autoland System in configured for an Autoland however, minimums must be adjusted.
"NO AUTOLAND" **NOTE: "NO" is displayed in the first line, "AUTOLAND" is displayed in the second line.**	The fail-operational Autoland System in configured for an Autoland however, failures have occurred, and a pilot decision is required to continue the autoland.
"AUTOPILOT"	Autopilot Engaged Alert – Autopilot single channel is engaged below 100 feet RA
Second Line:	
"CWS P"	Either A/P channel is in the Control Wheel Steering Pitch Mode.
Third Line:	
"CWS R"	Either A/P channel is in the Control Wheel Steering Roll Mode.

A status change or engagement causes the corresponding mode annunciation to be boxed for ten seconds highlighting the status change or newly engaged mode.

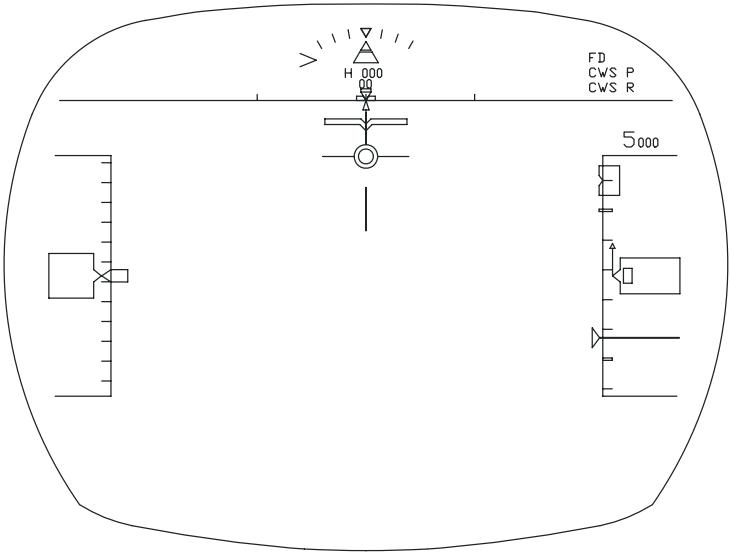


Figure 4-63:
Autopilot Status Annunciations

TCAS Symbology

TCAS Resolution Advisory Display

The HGS provides TCAS Resolution Advisories from the TCAS computer (Figure 4-64). The advisories are displayed in all modes in the form of Preventive and Corrective Advisory symbols that correspond to the indications displayed on the head down Traffic Advisory/Vertical Speed Indicator (TA/VSI).

Preventive Advisories

Preventive advisories do not require any action be taken by the crew to alter the flight path of the aircraft, but indicate an unsafe zone. These are displayed as a double lined bracket. On the unsafe side of the bracket, two angled lines are extended from the corners. The position of the bracket is determined by the vertical speed requirements 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 be positioned below the bracket. An up preventive bracket requires that the Flight Path symbol be positioned to remain above the bracket.

Corrective Advisories

Corrective advisories require positive action by the crew and are accompanied by a “fly to” region for Flight Path. This is displayed as a double lined box. Like the preventive bracket, angled lines are extended from the corners on the unsafe side, but in this case, either the top, the bottom, or both can be considered unsafe as indicated by the angled lines. The position of the box is determined by the vertical speed requirements output by TCAS 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 green band on a TA/VSI. It is also acceptable to fly outside the box on the safe side.

The lateral center of the bracket or box is fixed at the position of the aircraft’s current track. Whenever the Flight Path is in the unsafe zone, between the angled lines, then the angled lines flash on and off. Flight Path should be repositioned within the safe zone.

At times, there may be a situation where intruding 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. The proper response is to place Flight Path within the box, between the brackets, or between the unsafe side of a box and a bracket (safe zones).

Navigation data will continue to be displayed as well as the Guidance Cue, but the vertical component of the guidance is to be ignored in favor of the TCAS Resolution Advisory.

If TCAS is invalid, a boxed "TCAS FAIL" message is displayed (see Failure Flags and Data Source Indications). The display of TCAS advisories is dependent on the display of the Flight Path symbol.

Refer to the Typical Flight Profile section for an illustration of a TCAS Resolution Advisory (climb corrective).

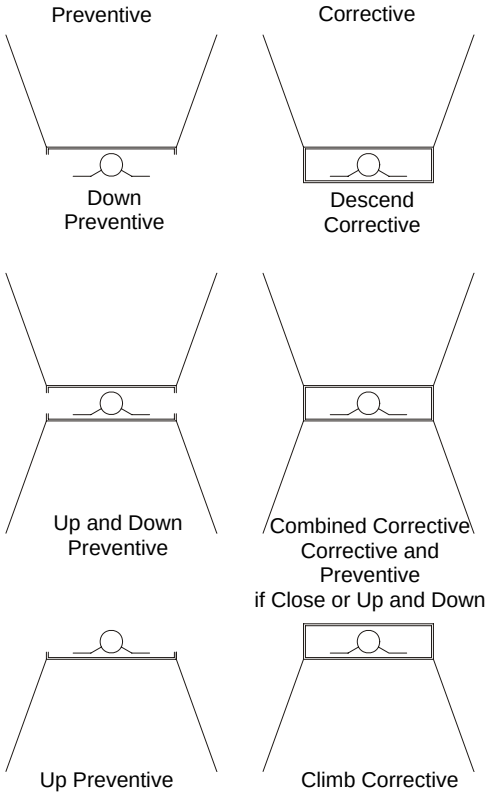


Figure 4-64:
TCAS Preventive and Corrective Advisories

Failure Flags and Data Source Indications

Failure Flags are displayed for invalid sensor statuses and miscompares between certain similar parameters (Figure 4-65). These are generally indicated by boxed annunciations for the affected parameters, and in the case of a failure, the removal of all symbols related to the fault. In some cases, symbols are removed as a result of other symbols being removed due to a failure.

Flags associated with a miscompare of similar data results in the display of a flag without the removal of the related symbols. In this case, the flag indicates that the applicable data should be verified by cross-checks with other cockpit displays.

Data source indications are provided in a few cases to annunciate the source of displayed data when other than normal.

Flags are provided for the following failures, miscompares, or alternate data sources:

Pitch or Roll (Attitude) failure: is indicated by the boxed characters "ATT" in the top center portion of the display, and the removal of all attitude information.

Pitch or Roll miscompare (> 5° for 1.5 seconds): is indicated by the characters "PITCH" in the top right center portion of the display or "ROLL" in the top left center portion of the display. Optionally, these annunciations may flash for 10 seconds when initially displayed.

Heading failure: is indicated by the boxed characters "HDG" in the lower center portion of the display and the removal of all heading data. In the Primary mode, this flag is positioned in the center of the HSI.

Airspeed failure: a Computed Airspeed failure is indicated by the boxed characters "SPD" vertically positioned replacing the Airspeed Scale in the Primary mode or horizontally positioned replacing the Digital Airspeed on the AIII, IMC, or VMC display.

Altitude failure: a Computed Airspeed failure is indicated by the boxed characters "ALT" vertically positioned replacing the Altitude Scale in the Primary mode or the horizontally positioned replacing the Digital Altitude on the AIII, IMC, or VMC display.

V1 (Takeoff Decision Speed) or VR failure: is indicated by the characters "NO VSPD" displayed adjacent to the Airspeed Scale and the removal of the appropriate data (takeoff only).

Maximum Operating Speed or Stick Shaker Airspeed failure: is indicated by the characters "SPD LIM" displayed adjacent to the top of the Airspeed Scale and the removal of the appropriate data.

Vertical Speed failure: is indicated by the boxed characters "VS" replacing the Vertical Speed. In AIII, IMC, or VMC modes, the boxed "VS" is displayed if Vertical Speed data is invalid or if no Vertical Speed data is received by the HGS. In Primary mode, the boxed "VS" is displayed if Vertical Speed data is invalid, and "-: - VS" is displayed if no data is received.

Selected Altitude failure: is indicated by the characters "SEL ALT" replacing the Digital Selected Altitude data.

Selected Airspeed failure: is indicated by the characters "SEL SPD" replacing the Digital Selected Airspeed data, or if NCD, the removal of Selected Airspeed data and replaced with three dashes.

Radio Altitude failure: is indicated by the boxed characters "RA" replacing the digital Radio Altitude data, or if NCD, the removal of the Radio Altitude data with no flag displayed.

Decision Height failure: is indicated by the boxed characters "DH" displayed adjacent to digital Radio Altitude or its flag, below 1500 feet RA.

Localizer Miscompare during a low visibility takeoff or rollout: is indicated by the characters "LOC CMP" displayed in the center of the display.

Vertical Deviation failure: is indicated by the boxed characters "VTK" (vertical deviation) displayed replacing the vertical deviation scale.

Flight Director failure: is indicated by the boxed characters "FD" positioned in the top right portion of the display and the removal of the Flight Director Guidance Cue.

TCAS Fault: is indicated by the boxed characters "TCAS FAIL" displayed in the lower left portion of the display.

Selection of the #2 IRS source (IRS transfer switch): is annunciated by the characters "ATT2" displayed in the lower right portion of the display. This indicates that the source of all IRS information used or displayed by the HGS (specifically pitch, roll, and heading) is the #2 IRS.

ILS failure: is indicated by the boxed characters "G/S" or "LOC".

DME failure: is indicated by a boxed "DME".

AOA failure: is indicated by a boxed “AOA”.

When a NAV DATA source cannot be determined due to a conflict between the VOR and ILS, a boxed “VOR/ILS” annunciation is displayed.

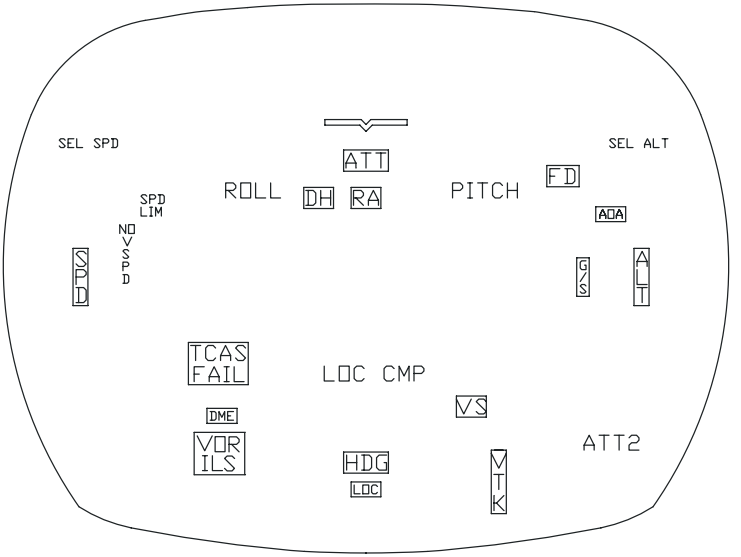


Figure 4-65:
Failure Flags and Data Source Indications

HGS Mode/Symbology Matrix

Table 4-5: Symbology Matrix

Symbol	Primary Mode		AIII Mode$^{\Delta}$		IMC Mode	VMC Mode
	In-Flight	Ground	Approach	Rollout$^{\Delta}$		
Reference Symbology						
Aircraft Reference Symbol	•	•	•	•	•	•
Attitude Symbology						
Attitude Fault Annunciation	•	•	•	•	•	•
Attitude Source Annunciation	•	•	•	•	•	•
Bank Warning Indicator	•		•		•	•
Horizon Line	•	•	•	•	•	•
Pitch Miscompare Annunciation	•	•	•	•	•	•
Pitch Scale	•		•		•	•
Roll Miscompare Annunciation	•	•	•	•	•	•
Roll Scale Index and Pointer	•	•	•	•	•	•
Tail Strike Pitch Limit$^{\Delta}$		•				
TO/GA Reference Line (5)	•					
Flight Path Symbology						
Flight Path	•		•		•	•
Flight Path Acceleration	•	•	•	•	•	•
Glideslope Reference Line			•		•	•
Ground Deceleration Scale$^{\Delta}$		•		•	•	•

Table 4-5: Symbology Matrix (continued)

Symbol	Primary Mode		AIII Mode		IMC Mode	VMC Mode
	In-Flight	Ground	Approach	Rollout		
Angle of Attack Symbology						
AOA Fault Annunciation	•		•		•	•
AOA Limit	•		•		•	•
AOA Scale and Indicator$^{\Delta}$	•		•		•	•
Heading and Track Symbology						
ADF/VOR Bearing Indicator #1$^{\Delta}$ (4)	•					
ADF/VOR Bearing Indicator #2$^{\Delta}$ (4)	•					
Bearing Source #1 Annunciation	•	•				
Bearing Source #2 Annunciation	•	•				
Heading Scale and Index	•	•	•	•	•	•
Selected Course Mark	•	•	•	•	•	•
Conformal Selected Heading Mark	•	•	•	•	•	•
Digital Heading	•	•	•	•	•	•
Digital Selected Course	•	•	•	•	•	•
Digital Selected Heading	•	•	•	•	•	•
Drift Angle Indicator	•					
Heading Fault Annunciation	•	•	•	•	•	•
Heading Reference Annunciation	•	•	•	•	•	•
Heading Scale (Half Compass Rose) and Index	•					
Selected Course Mark – HSI	•					
Selected Heading Mark – HSI	•	•				

Table 4-5: Symbology Matrix (continued)

Symbol	Primary Mode		AIII Mode		IMC Mode	VMC Mode
	In-Flight	Ground	Approach	Rollout		
Slip/Skid Symbology						
Aircraft Reference Slip/Skid Indicator (2)	•		•		•	•
Roll Scale Slip/Skid Indicator	•	•	•	•	•	•
Flight Path Slip/Skid Indicator	•		•		•	•
Speed Symbology						
Airspeed Scale and Index	•	•				
Airspeed Trend Vectors	•	•				
Climb-out Speed (V2+15) Indicator	•					
Computed Airspeed Fault Annunciation	•	•	•	•	•	•
Digital Airspeed – CAS			•	•	•	•
Digital Airspeed Odometer	•	•				
Digital Ground Speed	•	•	•		•	•
Digital Mach	•					
Digital Selected Airspeed/Mach	•	•	•	•	•	•
Flap Retraction & Extension Speed Indicator	•					
High Speed Buffet Tape	•					
Limit Speed Fault Annunciation	•	•				
Mach Fault Annunciation	•	•				
Manual Bug 5 Speed Indicator	•	•				

Table 4-5: Symbology Matrix (continued)

Symbol	Primary Mode		AIII Mode		IMC Mode	VMC Mode
	In-Flight	Ground	Approach	Rollout		
Maximum Operating Speed Tape	•					
Minimum Operating Speed Tape	•	•				
Reference Speed (VREF) Indicator	•	•				
Rollout Digital Ground Speed				•		
Selected Airspeed Fault Annunciation	•	•	•	•	•	•
Selected Airspeed Mark	•	•				
Speed Error Tape	•		•		•	•
Stick Shaker Speed Tape	•					
Take Off Reference Speed Bug		•				
Takeoff Decision Speed Indicator		•				
Takeoff Rotation Speed Indicator		•				
Takeoff Speeds Inoperative Annunciation		•				
Airspeed Miscompare Annunciation	•	•	•	•	•	•
Wind Speed and Direction	•		•		•	•
Altitude Symbology						
Altitude Trend Vector	•					
Baro. Altitude Scale and Index	•	•				
Barometric Altitude Fault Annunciation	•	•	•	•	•	•
Baro. Minimums Bug	•	•				
Digital Altitude Odometer	•	•				

Table 4-5: Symbology Matrix (continued)

Symbol	Primary Mode		AIII Mode		IMC Mode	VMC Mode
	In-Flight	Ground	Approach	Rollout		
Digital Barometric Altitude			•	•	•	•
Altitude Miscompare Annunciation	•	•	•	•	•	•
Digital Radio Altitude	•		•		•	•
Digital Selected Altitude	•	•				
Digital Vertical Speed	•		•		•	•
Radio Altitude Fault Annunciation	•	•	•	•	•	•
Selected Altitude Fault Annunciation	•	•				
Selected Altitude Mark	•	•				
Selected Minimums Readout	•	•				
Vertical Speed Fault Annunciation	•	•	•	•	•	•
Navigation Symbology						
Course Deviation Scale and Index	•					
Distance To Waypoint	•				•	
Digital Distance (DME or DTT)	•		•		•	•
DME Fault Annunciation	•	•	•	•	•	•
FMC NAV Source Annunciation	•				•	
Glideslope Deviation Fault Annunciation	•		•		•	
Glideslope Deviation Line			•		•	
Glideslope Deviation Scale and Index	•					

Table 4-5: Symbology Matrix (continued)

Symbol	Primary Mode		AIII Mode		IMC Mode	VMC Mode
	In-Flight	Ground	Approach	Rollout		
Ground Localizer Deviation Scale and Index$^{\Delta}$	•	•	•	•	•	
Ground Localizer Line		•		•	•	
Lateral Deviation Fault Annunciation	•	•				
Lateral Deviation Line			•		•	
Localizer Miscompare Annunciation	•	•		•		
Marker Beacon Annunciation	•		•		•	
Navigation Source Annunciation	•	•	•	•	•	
Vertical Deviation Fault Annunciation (7)	•				•	
Vertical Deviation Scale and Index (7)	•				•	
VOR To/From Annunciation			•		•	
VOR To/From Indicator	•	•				
Mode and Alert Symbology						
AIII Arm Annunciation	•					
Combiner Alignment Message					•	•
Decision Height Annunciation	•		•		•	
Decision Height Fault Annunciation	•		•		•	
Flare Cue	•				•	•

Table 4-5: Symbology Matrix (continued)

Symbol	Primary Mode		AIII Mode[Δ]		IMC Mode	VMC Mode
	In-Flight	Ground	Approach	Rollout[Δ]		
Ground Proximity Warning Message	•		•		•	•
HGS Approach Capability Annunciation	•					
HGS Mode Annunciation			•	•	•	•
Rollout Annunciation[Δ]			•	•		
Tailstrike Warning Message[Δ]	•		•		•	•
Windshear Warning Message (3)	•		•		•	•
Category III Symbology						
Approach Warning Message			•			
"IDLE" Message			•			
Digital Runway Elevation (1)			•			
Digital Runway Length			•	•		
Runway Remaining		•		•		
Rollout Excessive Deviation				•		
AIII Flare Command			•			
Ground Roll Guidance Cue (6)		•		•		
Ground Roll Reference (6)		•		•		
HGS Guidance Cue			•			
Runway Edge lines			•			

Table 4-5: Symbology Matrix (continued)

Symbol	Primary Mode		AIII Mode		IMC Mode	VMC Mode
	In-Flight	Ground	Approach	Rollout		
Flight Director/Autopilot Symbology						
Autopilot Status Annunciation	•	•	•	•	•	•
Autothrottle Mode Annunciation	•	•	•	•	•	•
F/D Lateral Engaged Mode Annunciations	•	•			•	
F/D Vertical Engaged Mode Annunciations	•	•			•	
F/D Lateral Armed Mode Annunciations$^{\Delta}$	•	•			•	
F/D Vertical Armed Mode Annunciation$^{\Delta}$	•	•			•	
Flight Director Fault Annunciation	•	•			•	
Flight Director Guidance Cue	•				•	
TCAS Symbology						
TCAS Fault Annunciation	•		•		•	•
TCAS Resolution Advisory	•		•		•	•

Notes:

(1) Displays for 5 seconds after mode activation or value change.

(2) See SLIP/SKID INDICATORS sections.

(3) Requires Flight Director TO/GA mode and (GPWS) Windshear Warning.

(4) Depends on the number of ADFs installed and the OPC configuration.

(5) See TO/GA REFERENCE LINE section.

(6) Displayed when configured for low visibility takeoff only.

(7) Displayed when the F/D is in the V/NAV mode.

Section 5:
Operations

This section provides information and recommended procedures for HGS operations. The HGS is approved for use throughout the full flight regime.

Approved operating procedures for the 737 with an HGS are the responsibility of the operator and the appropriate regulatory agency and are identified in the operations specification appropriate to the operator.

Approval must be obtained from the appropriate regulatory authority prior to conducting low visibility takeoff or CAT II or III approach and landing operations. Once authorized, all operations must be conducted in accordance with the operator's approved operating procedures.

Limitations

There are no added operational limitations for the Boeing 737 aircraft as a result of any operation with the HGS. However, a low visibility takeoff or AIII approach and landing operation may be restricted by an improperly configured aircraft or the lack of required sensor and equipment inputs to the HGS.

The First Officer should be prepared to clearly call out any items requiring immediate action by the Captain and to assume control and perform a go-around in the event any condition arises that the First Officer feels is hazardous.

NOTE: Call outs identified in this section are recommended and may be modified within the intended context to adapt to the operator's standard phraseology or preferences.

Normal Procedures

HGS procedures provided in this section are in addition to established standard operating procedures for the Boeing 737. In all cases, it is assumed that the left seat pilot (Captain) is the pilot flying (PF) and the right seat pilot (First Officer) is the pilot not flying (PNF).

Preflight

HGS.....ON

Lower the Combiner to its operating position and allow the HGS to warm-up for 2 - 5 minutes (generally, once an image is displayed on the Combiner the system is capable of normal operation).

HGS COMBINER.....SET

Verify symbology is displayed on the Combiner (may consist of little more than the Aircraft Reference Symbol and flags if IRS #1 is not aligned). If no symbology is visible, verify that the HCP FAULT and/or dot annunciator on the CLR (clear) key are not on. Set the Combiner HUD BRT control, in either the Auto or Manual mode, and adjust to the desired intensity. Select the IMC or VMC mode and verify the absence of the "ALIGN HUD" message. If necessary, reposition the Combiner to eliminate.

Following the Combiner check, Combiner may be stowed or symbology cleared (by selecting CLR on HCP) if not desired during any remaining preflight or taxi out.

HGS CONTROL PANEL.....SET/CHECK

Verification of the proper operation of all HCP displays can be accomplished by performing an HCP Display Test.

Runway Length and Elevation.....SET

Enter the published runway length in feet or meters$^{\Delta}$ for the departing runway (this is required for a low visibility takeoff operation). Enter the TDZE for possible return for landing (for the expected runway).

Glideslope Angle.....SET

Enter the glideslope angle for possible return for landing (for the anticipated runway).

Mode.....SET

Select or verify the Primary mode on the HCP.

HGS ANNUNCIATOR PANEL.....CHECK

Verification of the HGS Annunciator Panel (Six Panel or HAP) is accomplished with the master lamp test. To initiate a master lamp test, set the Master BRT/DIM/TEST switch to the TEST position. All the messages on the Annunciator Panel should come on.

The Annunciator Panel can also be tested using the test function of the HGS. To initiate an Annunciator Panel test, push and release the TEST key on the HCP. All the messages on the Annunciator Panel should come on for 2-5 seconds. Push TEST again to return the HGS to normal operation.

For illustrations of HGS symbology associated with the following normal procedures, refer to Section 6, "Typical Flight Profile."

Takeoff

To maintain proficiency, it is recommended that HGS low visibility takeoff procedures be used for takeoffs where conditions allow. Generally, anytime the departing runway has a localizer available and system/time constraints allow for the proper execution of the procedure. This table identifies the procedures for an HGS low visibility takeoff that are in addition to standard procedures.

Table 5-1: Takeoff Operations

CAPTAIN (PF)	FIRST OFFICER (PNF)
Before taking runway: – Set both VHF receivers to the ILS frequency. – Set Selected Course to the runway heading. – Verify "ILS1" (is indicated) as the Nav Source for the HGS display. – Position Combiner and confirm proper HGS operation and Primary mode.	– Standard procedures.
Cleared for Takeoff: – Taxi aircraft and align on runway centerline with the Aircraft Reference symbol positioned overlaying the runway centerline at the furthest distance that can be observed. A rolling takeoff is not recommended.	– Standard procedures.
– Readjust Selected Course to align the Selected Course Mark and Ground Localizer Deviation symbols with the runway centerline. – Verify display of Ground Roll Guidance Cue. – Adjust symbology intensity to allow runway markings and symbology to both be viewed clearly. – Call out "HGS SET"	– Verify localizer deviation display is centered.
– Initiate takeoff using standard procedures. – Use standard call outs.	– Use standard call outs. – Standard procedures
– Track runway centerline with HGS Guidance while visually augmenting with runway markings and lights	– Monitor head-down instruments. – Monitor localizer deviation. – Call out "CENTERLINE STEER LEFT/RIGHT" as necessary.
– At VR, rotate at the recommended rotation rate using the Aircraft Reference symbol and TO/GA Pitch Target Line and transition to Flight Path and the Flight Director Guidance Cue when it's displayed.	– Monitor head-down instruments. – Standard procedures. – Use standard call outs.

Climb/Cruise

Monitor and/or manually control the aircraft utilizing the HGS display. Use standard operating procedures.

NOTE: A particular advantage during operations near other aircraft, is that the pilot is able to monitor flight information on the HGS while looking out for traffic. The pilot should utilize the display of TCAS Resolution Advisory information when presented on the Combiner.

Descent

In the Descent - Approach checklist:

HGS.....SET & X-CHECKED

HGS approach and landing parameters shall be entered (PNF) and verified (PF). The proper operating configuration shall be established by the Captain (C).

HGS COMBINER.....SET

If the Combiner has been stowed, position the Combiner in the operating position. Verify normal operation of the HGS display. Check for the absence of the "ALIGN HUD" message in the IMC or VMC mode and reposition Combiner as necessary. Adjust the intensity of the display symbology with the HUD BRT Control as desired, considering the current and expected ambient and runway lighting conditions.

RUNWAY ELEVATION.....PNF/PF.....ENTER/VERIFY

On the HCP, enter the Touch Down Zone Elevation of the landing runway. If the TDZE is not available, use the closest airport elevation given.

RUNWAY LENGTH.....PNF/PF..... ENTER/VERIFY

On the HCP, enter the Runway Useable Length Beyond Threshold, in feet or meters$^{\Delta}$.

HCP GLIDESLOPE.....PNF/PF.....ENTER/VERIFY

On the HCP, enter the glideslope angle of the approach.

HGS MODE.....SET

On the HCP, select the desired mode. It is anticipated that the Primary mode will continue to be utilized for the approach intercept.

Prior to an HGS AIII approach$^{\Delta}$, the approach briefing should include a review of the approach procedures, and a reminder that the Captain will be Head-Up throughout the approach. The First Officer is to remain head-down to monitor all phases of the approach and landing. The AIII approach briefing should include a verbal review of all call outs, particularly with respect to approach minimums, in addition to other standard approach briefing items.

Approach and Landing

The HGS may be utilized during all approach and landing operations. Profiles, configurations, and speeds remain the same as for a similar head-down approach. Normally, all maneuvering prior to the final approach will be flown in the Primary mode. Flight Director guidance is displayed in either the Primary or IMC mode through standard MCP settings. Refer to page 5-9 "Supplemental Procedures" for Flight Director (Primary or IMC), Visual (VMC), and right seat or Autopilot-coupled monitored approach operations.

On ILS approaches, it is recommended that whenever possible, the HGS AIII mode$^{\Delta}$ and procedures be used to maintain proficiency, and to reinforce crew coordination and system confidence.

The following table identifies the procedures for an HGS AIII approach and landing that are in addition to standard operating procedures:

Table 5-2: Approach and Landing Operations

CAPTAIN (PF)	FIRST OFFICER (PNF)
– Verify that all system configuration requirements for an AIII approach are met. This is evident by the "AIII" displayed on the HCP prior to AOC. Establish a stable landing configuration as early as possible on final approach.	
– Observe "AIII ARM" on Combiner. – Call out "AIII ARM" when displayed.	– Select/Verify AIII ARM mode. Call out "AIII ARM ON THE RIGHT" (on HGS Annunciator Panel) when displayed.
At ILS (LOC & G/S) Intercept: – Observe "AIII" on Combiner. Call out "AIII". – Track ILS with HGS guidance. – Establish target airspeed prior to 500 feet. – Monitor for "NO AIII" annunciation and flags.	– Observe for "AIII" on annunciator panel. Call out "AIII on the right". – Monitor ILS tracking on head-down displays. – Monitor for loss of "AIII" annunciation and flags. Call out "NO AIII" when appropriate.

Table 5-2: Approach and Landing Operations (continued)

At 500 feet above TDZE: – Check altitude. – Track ILS and airspeed aggressively. – Monitor for "NO AIII" and/or "APCH WARN" annunciations and flags.	– Check altitude. Call out "500 FEET" – Monitor for loss of "AIII" and "APCH WARN" annunciations.
Below 500 feet: – Track ILS and airspeed aggressively. – Monitor for "NO AIII", "RO CTN" and/or "APCH WARN" annunciations and flags. – Perform go-around if "APCH WARN" is displayed or when "RO CTN" is displayed and landing is predicated on RO guidance. Call out "GO-AROUND, MAX POWER" when go-around is initiated.	– Monitor approach parameters relative to approach tolerances (Table 5-3). Call out any deficiencies as indicated. – Monitor for loss of "AIII", "RO CTN" and "APCH WARN" annunciations. Call out "APCH WARN" or "RO CTN" when annunciated without any response from the Captain. – Set power when directed for go-around. **100 feet above DH:** – Call out "100 FEET ABOVE MINIMUMS."
When landing cues become available: – Assimilate runway visual cues (discernable landing environment in sight). – Call out visual cue (i.e., "APPROACH LIGHTS" or "CUES").	– Remain head-down on instruments. – Monitor for DH and approach performance.
At or before DH: – Determine that adequate landing cues are available to assure a normal landing. – If so, call out "LANDING." – If not, call out "GO-AROUND, MAX POWER" and execute normal go-around.	– Remain head-down on instruments. – Continue to monitor approach performance.

Table 5-2: Approach and Landing Operations (continued)

DH to touchdown: – Follow guidance cue and perform flare and landing using HGS guidance while assimilating proper airplane positioning on runway by visual cues. Monitor "RO" annunciation and transition to rollout guidance. – Position throttles to idle on "IDLE" command.	– Remain head-down on instruments. – If "LANDING" call out not heard by 20 feet below DH, call out "GO-AROUND, MAX POWER" and assume control of aircraft and execute a normal go-around, otherwise; – Monitor flare maneuver following flare illumination on Annunciator Panel with particular attention to Radio Altitude and sink rate. – If any conditions arise that the First Officer considers hazardous, call out "GO-AROUND" and if necessary, take control of the aircraft.
Touchdown and rollout: – Perform normal touchdown and nose rotation (do not finesse), establish aircraft touchdown prior to 2500 feet (viewed from pilot position) to satisfy approach monitor. – Rollout using "RO" guidance and the Ground Roll Reference symbol. – Monitor for excessive deviation, ">" or "<", from localizer guidance and correct back to runway centerline. – Monitor runway remaining from the Runway Remaining readout and aircraft deceleration from the Ground Deceleration Scale presented along the acceleration cue symbology. – Use normal procedures to decelerate to taxi speed.	– Monitor localizer deviation (head-down) throughout rollout and call out "STEER RIGHT" or "STEER LEFT" if captain is not correcting to runway centerline and/or assume Head-Up posture after touchdown as directed or desired.

From 500 feet above the TDZE to touchdown, the F/O will monitor the following parameters in addition to other standard procedures. In the event any of the following limits are exceeded, the F/O will make the corresponding call out to the Captain.

Table 5-3: Approach Parameters and Tolerances

PARAMETER	LIMIT	CALL OUT
AIRSPEED	"Bug" speed ±5 knots (down to flare initiation)	"AIRSPEED"
LOCALIZER	±1/2 full scale on ADI expanded display	"LOCALIZER"
GLIDESLOPE	±1 dot (down to 100 feet)	"GLIDESLOPE"
SINK RATE	>1000 fpm (down to 50 feet)	"SINK RATE"
No flare, over flare, no throttle retard, long landing, excessive bank angle, or other hazard after flare initiation		"GO-AROUND"

Supplemental Procedures

HGS supplemental procedures consist of conventional takeoff operations, Flight Director precision and non-precision approaches, visual approaches, and windshear operations.

Takeoff (Normal w/o Steering Guidance)

When performing a takeoff using other than low visibility takeoff procedures, use the HGS Primary mode standard operating procedures. No HGS unique procedures are required. Use of the HGS display provides enhanced situational awareness, particularly in the event of any abnormal operation (e.g., an engine out) or a windshear.

Flight Director or Non-Precision Approaches

When performing a Flight Director precision or non-precision approach and landing, use the HGS Primary or IMC mode and follow standard operating procedures. No HGS unique procedures are required.

It is recommended that the Primary mode be used prior to and during the approach capture phase with the IMC mode selected following final course capture. In either the Primary or IMC mode, Flight Director guidance is displayed based on MCP/FCC operation. Figure 5-1 depicts an IMC approach.

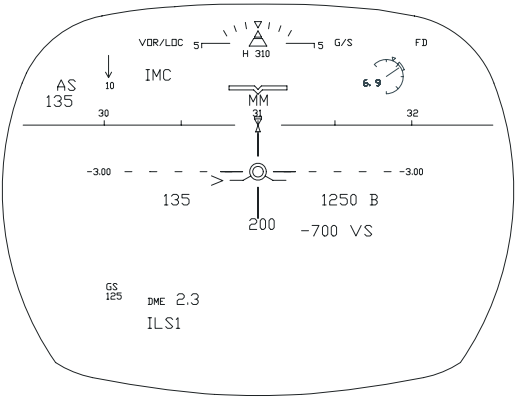


Figure 5-1:
IMC Approach

The IMC mode allows Flight Director approaches to be flown in the same approach display format as the HGS AIII approach mode. For an IMC ILS approach, the display information is the same as in the AIII mode except:

- The guidance cue is derived from the Flight Director and is removed from the display at 50 feet
- Flight Director modes are displayed
- The IMC mode is annunciated
- No approach monitoring or flare guidance is provided by the HGS. However, flare cues (“ + + “) are displayed for the visual flare.

Essentially, the IMC mode may be used during any conventional Flight Director approach that is approved for the basic airplane or the operator’s Operations Specification (e.g., a CAT I Flight Director ILS approach).

Visual Approach

The HGS VMC mode is used to enhance situational awareness, increase approach precision, and improve energy management when operating in visual conditions. This is particularly useful during visual approaches into airports without visual approach aids like a VASI. The principle benefit from the HGS when used for a visual approach is that the glidepath to the runway can be accurately controlled without use of ground based guidance signals. The HGS Glideslope Reference Line allows the pilot to track an inertial glideslope without concern for undershooting or overshooting the runway due to poor visual cues.

VMC visual approach procedures are inferred in the following figures illustrating an HGS VMC approach.

NOTE: Figure 5-2 to Figure 5-5 illustrate Combiner displays during a VMC approach, as well as the terrain that can be seen through the Combiner. The runway and runway markings do not show on the Combiner, but rather show through it.

VMC Approach – Lateral Alignment

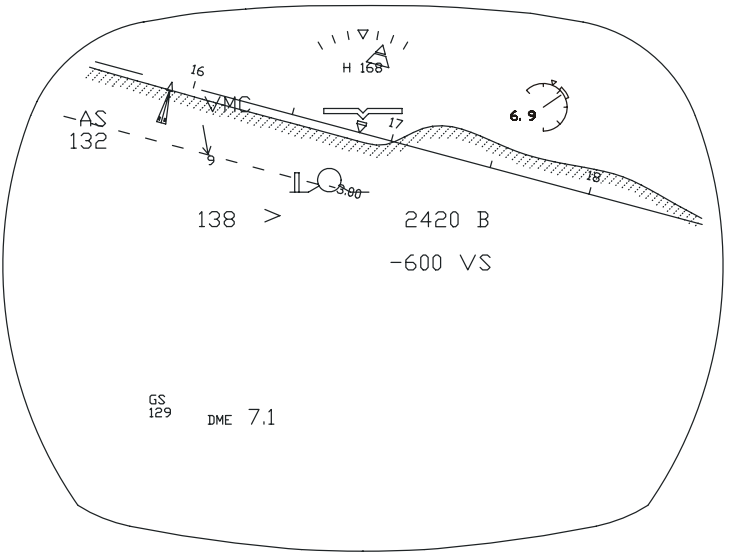


Figure 5-2:
VMC Approach – Lateral Alignment

In Figure 5-2, the pilot is maneuvering the aircraft to establish his intercept point. The phantom image in this case is representative of the real world horizon and runway. The aircraft is in a descending left turn to align the aircraft laterally with the runway. The aircraft is already below the desired glidepath indicated by the Glideslope Reference Line positioned short of (below) the runway touchdown zone.

VMC Approach – Vertical Alignment

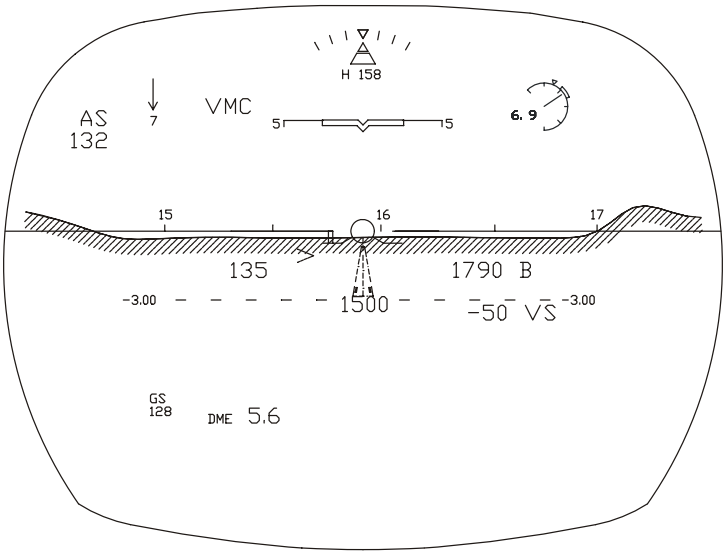


Figure 5-3:
VMC Approach – Vertical Alignment

Figure 5-3, the aircraft is now aligned laterally with the runway and the pilot has leveled the aircraft in order to intercept the proper glideslope angle. This is determined when the Glideslope Reference Line (dashed line) intersects the touchdown zone (TDZ) on the runway (as shown). If the dashed line is short of the TDZ, then the pilot must maintain a higher flight path angle until they intersect. If the dashed line is beyond the TDZ, then the pilot must increase the descent by placing the Flight Path symbol short of the TDZ until the dash line and TDZ are aligned.

Once the Glideslope Reference Line angle is established on the runway, the pilot maintains the proper glidepath by keeping Flight Path on the TDZ and Glideslope Reference Line and by making small corrections as necessary.

VMC Approach – On Glideslope

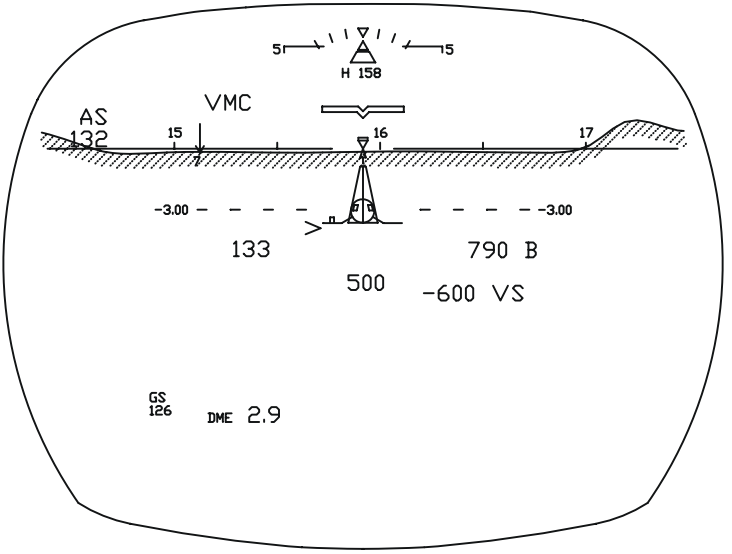


Figure 5-4:
VMC Approach – On Glideslope

Figure 5-4 illustrates the proper relationship of the VMC symbology and the runway for an on-glideslope approach at 500 feet. Airspeed control is maintained in the same manner as in other approach operations.

VMC Approach - Flare

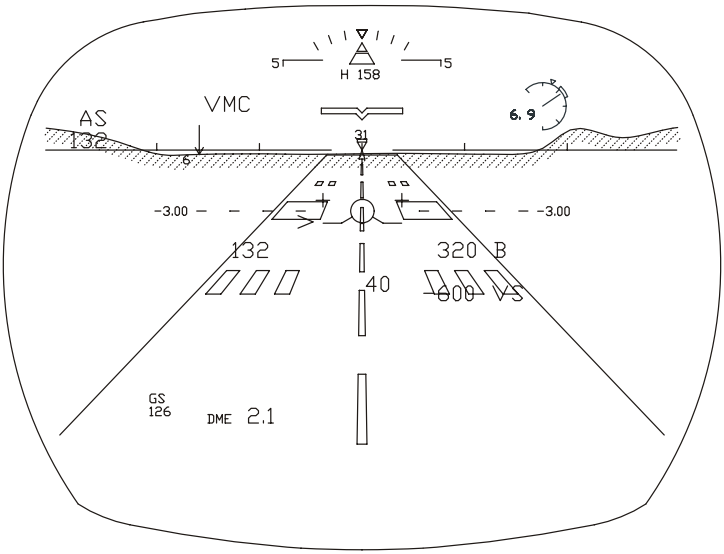


Figure 5-5:
VMC Approach - Flare

Flare and landing in the VMC mode is accomplished using normal visual procedures. Between 55 feet and 10 feet, the Flare Cue (two "+" symbols) are displayed above the Flight Path wings (Figure 5-5). The Flare Cue provides no guidance. It is only a reminder that the pilot must flare the aircraft.

Windshear

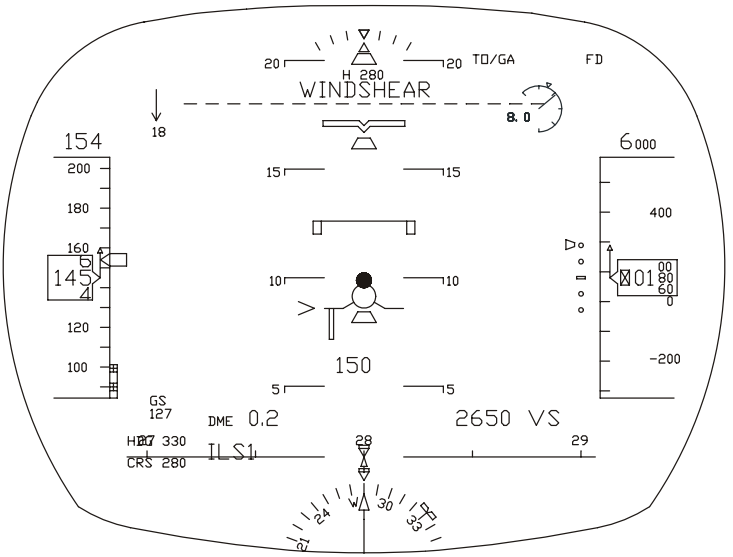


Figure 5-6:
HGS Windshear Display

In the event a windshear is encountered, the HGS displays a "WINDSHEAR" message as directed by the GPWS (Figure 5-6). If the Flight Director TO/GA mode is selected, Flight Director guidance can be used to exit the shear (assumes windshear guidance is available). In addition, whenever "WINDSHEAR" is indicated, the aircraft's margin to stick shaker is indicated by the display of the AOA bracket.

NOTE: Upon selection of TO/GA, the HGS changes to the Primary mode.

In addition to the GPWS windshear detection, DFCS recovery guidance, and AOA bracket symbology, several other HGS symbols may be used to anticipate and avoid windshear encounters. These are:

- The Flight Path symbol provides the pilot with instantaneous and continuously updated inertial flight path information. Consequently, it makes it possible for the pilot to judge the intensity of shearing winds as they begin to have an effect.
- Wind speed and direction symbols provide the pilot with information about the direction and magnitude of winds aloft. Erratic behavior of these symbols or sudden, major shifts in either wind direction or magnitude is an early indicator of a potentially shearing condition.
- The Flight Path Acceleration and Airspeed Error symbols are also very sensitive indicators of shearing winds. Any time these two symbols trend in opposite directions flight path could be affected by windshear. Airspeed and Groundspeed information is similarly affected. Shearing winds can often be detected when these values change in opposite directions.
- The integrated display of Flight Path, energy status, and environmental conditions, preceding or in addition to windshear warning and guidance, greatly enhances the pilot's awareness of windshear conditions. This combination also permits the pilot to make critical, time-sensitive decisions to successfully avoid or escape a windshear.

Follow operator established Windshear procedures. No HGS unique procedures are required.

Non-Normal Procedures

HGS non-normal procedures provided in this section are primarily related to an HGS degraded display or degraded capabilities.

Use of the HGS during non-normal operations related to other systems (e.g., engine failure) is recommended to the extent that information is available for display. Generally, during any non-normal operation where information continues to be displayed, then the source of that information is valid and the continued use of the information for flight operations is appropriate using normal crosscheck procedures. The unique properties associated with the integrated display of attitude, airspeed, altitude, flight path, energy status and environmental conditions, greatly enhances the pilot's awareness of flight conditions. This combination also enhances the pilot's ability to make critical, time-sensitive decisions.

Degraded Display

A degraded display exists any time one or more symbols is not displayed as a result of a fault condition. A fault condition can be due to a sensor failure, sensor data miscompare, or an HGS failure. Continued use of the display is dependent on the value of the remaining symbology.

Sensor Failure

The failure of an HGS display sensor will result in the removal of all display information dependent on that sensor. In some cases, the display source is based on the position of the FMC, IRS, or NAV transfer switches in the cockpit. In these cases, selection of the alternate source will restore the display. For example, when the IRS transfer switch is positioned in the "NORMAL" or "BOTH ON L" position, then the HGS receives and displays information relative to IRS #1 (left side source). If ADIRU #1 fails, by selecting "BOTH ON R", the HGS will display information from ADIRU #2, as this is now the left side source of information. In all cases, the HGS displays from the same source as is selected for the Captain's head-down displays.

In many cases, the loss of a sensor or even a single input parameter will result in the loss of multiple symbols. For example, the loss of Vertical Speed from the IRS will result in the removal of the digital Vertical Speed data and Flight Path and all its related symbols. A "VS" flag is displayed in this case.

Sensor Miscompare

The HGS monitors sensor parameters for validation based on a comparison with the offside sensor. For normal display purposes, IRS pitch and roll parameters are monitored along with airspeed and altitude. Any miscompare between ADIRU-IRs #1 and 2 of greater than 5° causes the appropriate miscompare message, "PITCH" or "ROLL", to be displayed on the Combiner. Any miscompare between ADIRU #1 and #2 airspeed of greater than 5 knots causes the "IAS DISAGREE" miscompare message to be displayed on the Combiner. Any miscompare between ADIRU #1 and #2 altitude of greater than 200 feet causes the "ALT DISAGREE" miscompare message to be displayed on the Combiner. If one of these messages is displayed, the appropriate data should be cross-checked with other cockpit displays to determine which source is correct.

For determination of the AIII approach$^{\Delta}$ capability, additional comparisons are performed. These are discussed in the "Degraded Capabilities" section on the next page.

HGS Failure

The HGS has extensive self-monitoring capability. If a fault is detected, that affects its ability to accurately display symbology, the entire display is turned off, and the HCP FAULT annunciator is illuminated. BITE detected failures will only be indicated as long as the fault is detected. Consequently, it is possible to observe a momentary interruption or fault indication followed by normal operation. In the event that a prolonged fault occurs, use of the HGS should be discontinued and the Combiner stowed.

Degraded Capabilities

A degraded capability exists any time a condition occurs which prevents the use of the HGS for a specific purpose (e.g., a low visibility takeoff/rollout, AIII approach, or a VMC (or IMC) visual approach). This degraded display condition can be the result of other sensor faults or miscompares, or as a result of an improperly configured aircraft. In any case, use of the display is dependent on the value of the remaining symbology or its remaining display capability and must be assessed by the pilot.

Low Visibility Takeoff

Low visibility takeoff capability may be lost due to the aircraft being improperly configured, the failure of a required sensor input, or failure of the HGS.

A low visibility takeoff configuration requires that all of the following conditions be satisfied:

- Aircraft is on the ground
- HGS Primary mode is selected
- Both NAV receivers are tuned to the departing runway ILS frequency
- Combiner is not stowed.

This configuration enables the display of the Ground Roll Reference symbol and identifies to the HGS that a low visibility takeoff is to be performed. This configuration also causes the HGS Computer to command the forward localizer antennas to be selected.

Additional requirements need to be met to allow the display of the Ground Roll Guidance Cue for takeoff. The additional aircraft configuration requirements include:

- IRS and NAV transfer switches are in the “NORMAL”.
- ADIRU #1 is in the NAV mode.
- The difference between the Captain’s Selected Course and the aircraft’s Magnetic Heading is less than 10° (provides a gross check of the Selected Course input for the takeoff).
- The runway length entered on the HCP is set for the departing runway and is from 7,500 feet to 13,500 feet (2286 to 4115 meters).

These configuration requirements and the validity of all required sensor and HGS inputs will result in the display of the low visibility takeoff symbology. The display of the Guidance Cue is also dependent on a localizer deviation comparison tolerance and the aircraft being within 4/5 of a dot of localizer deviation. (This is generally not until taxiing near or onto the runway.) If any of these conditions cannot be met prior to or while positioning on the runway, then the HGS low visibility takeoff cannot be performed.

AIII Approach$^{\Delta}$

The AIII capability$^{\Delta}$ is unique in that at any given time the HGS monitors system inputs to determine AIII capability. AIII status is indicated based on the assessment of specific requirements. The loss of the AIII status is indicated as follows:

- Loss of the AIII capability prior to Approach On Course (AOC) will cause the removal of the "AIII" status displayed on the right half of the HCP STBY display line. This however does not indicate that the AIII capability will not be available again prior to, or once, AOC is achieved.
- Loss of the AIII capability following AOC, and prior to the selection of the AIII mode, will cause the removal of the "AIII" status displayed on the left half of the HCP STBY display line or removal of the AIII Arm displayed on the HCP STBY line and the Combiner. The AIII (with AOC) criteria must be reacquired prior to 500 feet above the TDZE for the AIII mode to be available.
- Loss of the AIII capability following AIII mode selection is indicated by a "NO AIII" displayed on the Combiner and on the HCP MODE display line. If this occurs below 500 feet (above the TDZE), it results in the "APCH WARN" annunciations on the Combiner and HGS Annunciator Panel. The AIII capability will again be indicated if the capability is reacquired (independent of AOC or altitude).

- "RO" rollout guidance$^{\Delta}$ is provided after an AIII approach and status of "RO" capability is available below 500 feet AGL. "RO ARM" is displayed on the Combiner and the First Officer's Annunciator Panel when rollout guidance is available. Should "RO" not be available the "RO ARM" will be removed from the Combiner and First Officer's Annunciator Panel, and if the aircraft is below 500 feet AGL, a "RO CTN" (Rollout Caution) will be displayed. The pilot must determine whether to continue the approach or go-around dependent on whether landing minimums requires the use of rollout guidance.

AIII approach capability may also be lost due to the aircraft being improperly configured, the failure of required sensor inputs (including additional sensor comparison tolerances), or failure of the HGS. The aircraft configuration requirements for an AIII status at or following AOC are:

- Both IRS's must be in the NAV mode.
- All instrument transfer switches must be in the "NORMAL" position.
- Both VHF Navs must be tuned to the ILS frequency with "ILS1" selected as the Nav source prior to (at) ILS capture.
- Both Baro Altimeters must agree within 50 feet.
- Selected Course must be set within 15° of the final approach course.
- The TDZE must be properly set on the HCP.
- The glideslope angle entered on the HCP must be set from 2.50° to 3.00°.

Generally, no action is required if the AIII capability is lost prior to AOC. During the approach preparation, the pilots should ensure that all AIII aircraft configuration requirements are met or will be met, prior to or at AOC. Due to the less stringent AIII requirements prior to AOC, it is acceptable to proceed to and initiate the approach, establishing AOC before making a determination as to the availability of AIII. In any case, it is at the discretion of the Captain to determine (above 500 feet) if the approach should be discontinued or whether another approach method is used (if current conditions allow).

Any time the AIII capability is lost below 500 feet, or any time the "APCH WARN" is indicated, and the aircraft is currently in instrument conditions, then the approach shall be terminated and a go-around performed. A decision for another attempt at the approach, another approach method, or a diversion must be based on the available information and circumstances.

Visual Approach - VMC or IMC

If an “ALIGN HUD” message occurs, apply slight pressure, either fore or aft, on the Combiner glass until the “ALIGN HUD” message is removed. If the message cannot be removed with the glass in the operating detents, the HUD is not presenting conformal data, and must not be used for a visual approach.

Use of the HGS for other flight operations (e.g., Flight Director approaches using the Primary or IMC mode) depends on the data presented on the Combiner.

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Section 6:
Typical Flight Profile

A typical flight (Figure 6-1) using the HGS might be performed as follows:

- The HGS is used during a conventional or a low visibility takeoff in the Primary mode.
- The HGS is used in the Primary mode during climb to the assigned cruising altitude. The HGS allows the pilot to optimize aircraft performance with Flight Path and Flight Path Acceleration while simultaneously monitoring the flight's progress and monitoring for traffic.
- The HGS is used in the Primary mode for en-route navigation.
- The HGS is used in the Primary mode for the descent, using Flight Path to establish the proper glide path and airspeed control.
- Once established on the ILS approach (ILS captured), the AIII mode$^{\Delta}$ is engaged for precise, manually flown approach and landing guidance, capable of operations to CAT III minimums.
- Following touchdown, HGS rollout guidance$^{\Delta}$ provides precise localizer guidance to the pilot in order to maintain the aircraft on runway centerline in low and poor visibility conditions.

Alternatively, the HGS can be used during other types of operations including Flight Director/autopilot approaches, manual precision or non-precision approaches, and visual approaches utilizing the Primary, IMC, or VMC modes. The following HGS symbology illustrations and text depict a hypothetical flight profile as depicted above.

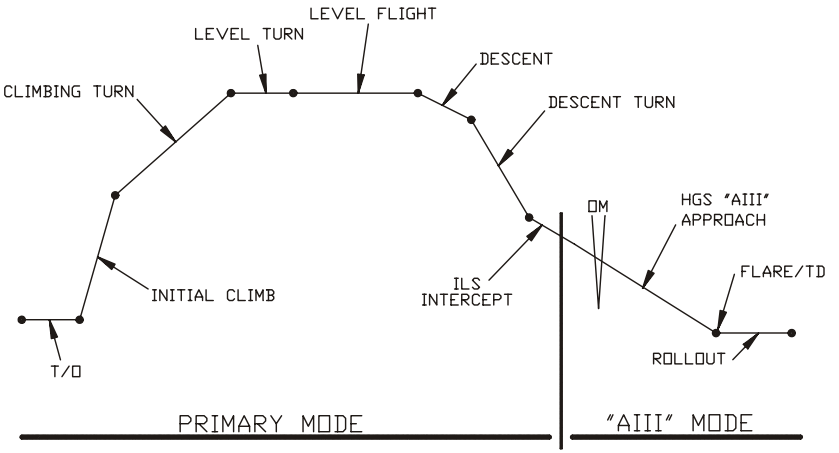

Figure 6-1:
Typical Flight Profile

Takeoff Ground Roll

For takeoff, the HGS Primary mode is selected.

When accomplishing a low visibility takeoff (Figure 6-2), the general operating procedure is to taxi the aircraft into takeoff position aligning with the runway centerline. Readjust the Selected Course as necessary to overlay the Selected Course and Ground Localizer Line symbols on the runway centerline. Advance power and begin takeoff roll. Using normal control inputs, follow the Guidance Cue and Ground Localizer symbols while visually augmenting with runway centerline markings and lights. The Guidance Cue and Ground Localizer Symbols are especially useful to assist in maintaining lateral control and successfully aborting or continuing the takeoff in case of an engine failure during the takeoff roll.

Figure 6-2 indicates a low visibility takeoff, accelerating through 65 knots with the Guidance Cue centered within the Ground Roll Reference symbol and the localizer centered under the Selected Course on runway 28. Target airspeed of 154 knots is set for the initial climb, 6000 feet for the assigned altitude, and an initial departure heading of 330 degrees is selected. The Flight Director TO/GA mode is active.

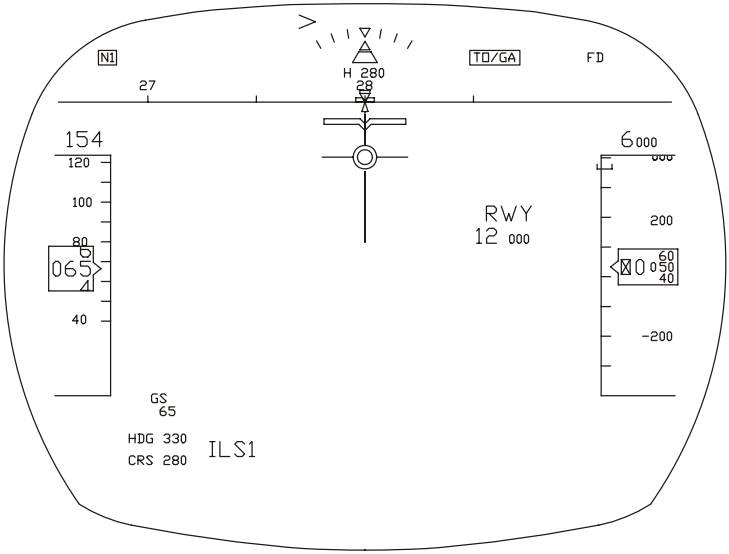

Figure 6-2:
Takeoff Ground Roll

Initial Climb

At rotation, a number of changes take place on the display (Figure 6-3). Flight Path is displayed, with Flight Path Acceleration now positioned relative to Flight Path. This is particularly helpful in determining a positive climb gradient and in optimizing climb performance. With appropriate power set and the selected airspeed achieved, placing the Flight Path symbol to null the Flight Path Acceleration will maintain airspeed. Alternately, the Flight Director commands can be followed. With the Flight Director TO/GA mode engaged, either the Guidance Cue or the TO/GA Target Pitch Line can be used to capture the Flight Director Command. Radio Altitude and the HSI are also displayed at rotation. The amount of HSI visible may be reduced due to display compression (non-conformal display) as a result of the increased pitch attitude.

In Figure 6-3, the aircraft pitch attitude is approximately 17° and the climb angle is approximately 9°. Flight Path is just below the Guidance Cue, likewise, the Aircraft Reference symbol is just below the TO/GA Target Pitch Line, indicating that the pilot needs to pitch up slightly to capture the Flight Director engaged in the TO/GA mode. Because of the pitch attitude, the HSI is pushed down partially. Radio Altitude is 150 feet while climbing out at 2650 FPM on the runway heading of 280°. The current Baro Altitude is 180 feet with a target altitude of 6000 feet and the Altitude Trend Vector indicating a little over 400 feet in six seconds. The target airspeed is 154 knots, which is one knot below the current airspeed. The aircraft's acceleration is zero, indicated by the position of the Flight Path Acceleration (caret). The wind, as determined by the IRU, is straight on the nose at eight knots giving an indicated ground speed of 147 knots.

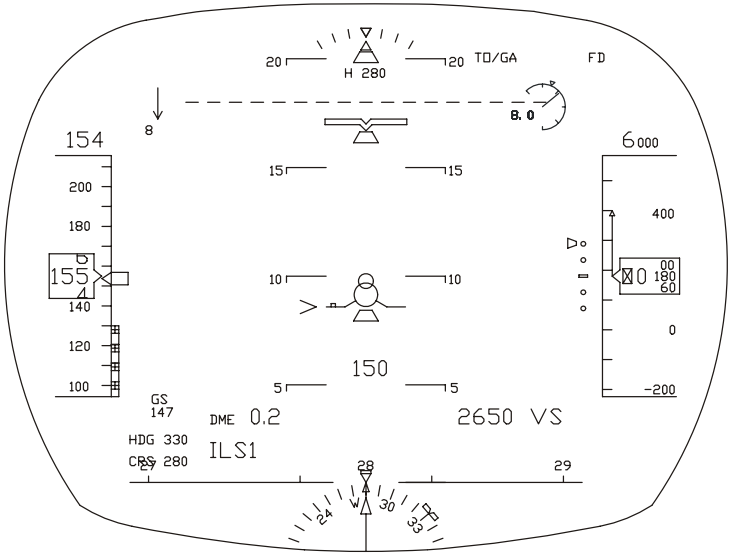

Figure 6-3:
Initial Climb

Climbing Turn

In Figure 6-4, the aircraft is banked 20° in a right coordinated climbing turn. The aircraft is currently turning through a heading of 310° to rollout on the 330° heading. The VOR is tuned and course set to track the 330° radial TO the station.

The aircraft is climbing through 2040 feet to the assigned altitude of 6000 feet and is accelerating slightly through 225 knots to the target speed of 230 knots. The autopilot is engaged in the command position ("CMD" displayed in the upper right of the display).

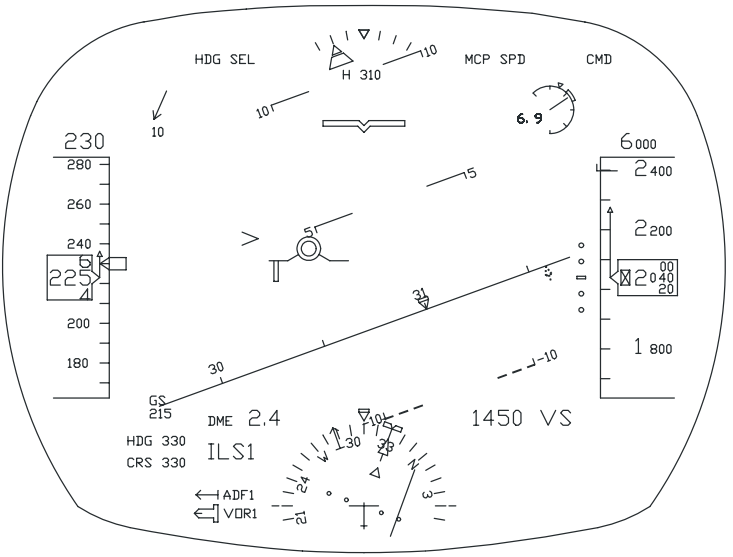

Figure 6-4:
Climbing Turn

Coordinated Turn

In a coordinated turn (Figure 6-5), the pilot needs only to maintain the Flight Path symbol centered on the horizon to maintain altitude. In a 30° bank, the angled portion of the Flight Path symbol wing will overlay the Horizon Line. This provides exceptional precision for altitude control in level flight maneuvering.

In Figure 6-5, the autopilot recently acquired the assigned altitude (boxed "ALT ACQ" message) and the aircraft is in a level left turn of 20°. The aircraft is currently turning through a heading of 280° toward the selected heading of 235° to intercept the 250° radial FROM the VOR station. The aircraft is accelerating through 235 knots to the target speed of 250 knots. The airspeed trend vector indicates that the airspeed will be about 245 knots in 10 seconds. There is a right quartering headwind resulting in a groundspeed of 217 knots.

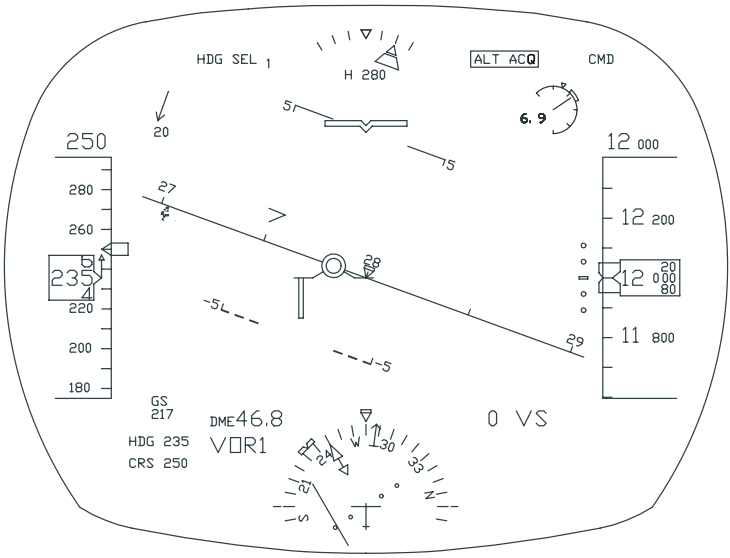

Figure 6-5:
Coordinated Turn

Level Flight

Straight and level unaccelerated flight (Figure 6-6) is easily maintained with Flight Path and Flight Path Acceleration. Holding the center of the Flight Path symbol level on the horizon and the Flight Path Acceleration (caret) on the Flight Path wing will accomplish this.

In Figure 6-6, the aircraft is level at 22,000 feet, 295 knots and Mach .792. Ground Speed is 275 knots as a result of the 21-knot right quartering headwind indicated by the wind arrow. The aircraft is being flown by the autopilot (CMD) with LNAV and VNAV modes selected and the aircraft is 82.4 nautical miles to the next waypoint.

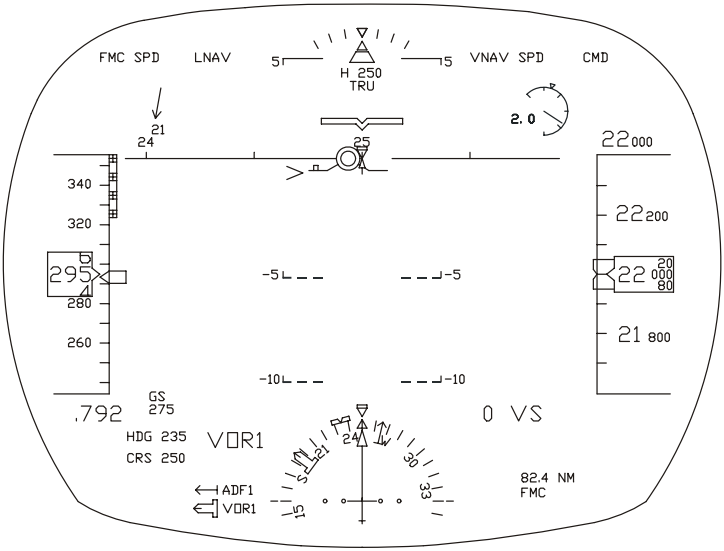

Figure 6-6:
Level Flight

Descent

In Figure 6-7, the new target altitude is 15,000 feet and the aircraft is descending through 19,840 feet. The descent profile and airspeed control are again monitored with Flight Path and Flight Path Acceleration. The desired descent rate is controlled by overlaying the Flight Path symbol on the desired descent angle. In this case about a 4° descent angle is providing a -1950 FPM vertical speed and the throttle has been adjusted to decelerate to the 290 knot target airspeed.

Due to the left quartering tailwind at this altitude, the aircraft is flown in a slight left crab angle to track the 250° Desired Track. This crab angle is evident by the lateral displacement of the Flight Path symbol relative to the Aircraft Reference symbol. If the crab angle is great enough to cause the Flight Path symbol to be limited by the airspeed or altitude tapes or the display field-of-view, then the Flight Path symbol becomes non-conformal and is displayed "ghosted" or as a dashed line symbol.

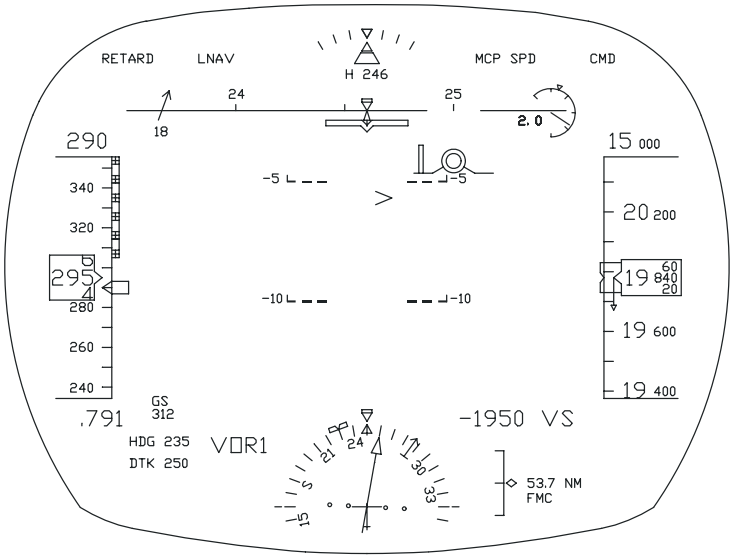

Figure 6-7:
Descent

Descending Turn

At higher descent (or ascent) angles, it is possible to cause the display to compress (non-conformal display) in pitch in order to allow the horizon line or Flight Path symbology to remain on the display.

In Figure 6-8, the high descent rate and negative pitch attitude is causing the pitch scale to compress. Flight Path is still correctly positioned relative to the symbolic attitude, but the Pitch Scale and Flight Path are no longer conformal to the real world. The aircraft's pitch attitude and descent angle are about -10° with the aircraft in a 30° right turn. The high descent rate is accentuated by the altitude rate depicted in the Altitude Scale, altitude trend vector, digital vertical speed, and the aircraft's acceleration without added thrust.

In negative pitch attitudes, a chevron is displayed with the point on the -20° pitch line in the direction of the Horizon Line. At positive pitch attitudes, the chevron is displayed with the point on the 30° pitch line in the direction of the Horizon Line. This is to enhance pitch situational awareness.

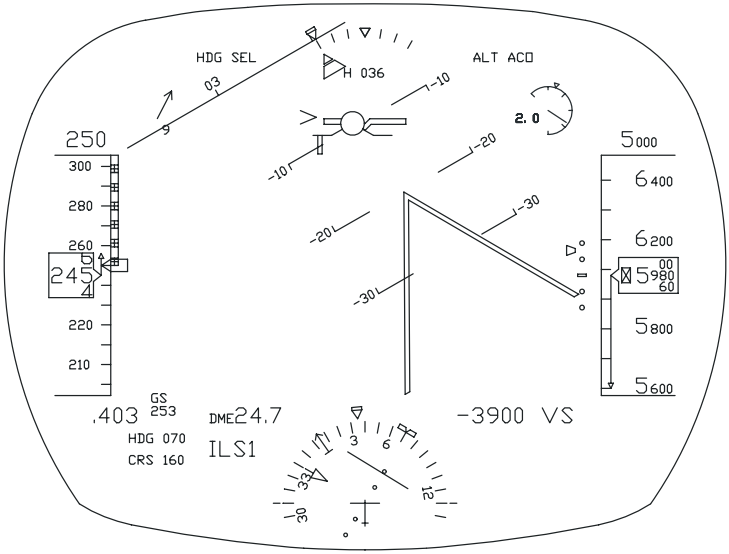

Figure 6-8:
Descending Turn

TCAS Resolution Advisory

TCAS Resolution Advisories (Figure 6-9) alert the pilot of traffic conflicts by indicating a potential threat (Preventive Advisory) or requiring a vertical evasive maneuver (Corrective Advisory) in order to maintain safe vertical separation.

A Preventive Advisory, displayed on the HGS by a double lined bracket above or below Flight Path, indicates an area to be avoided (unsafe zone) and does not require any action by the pilot. By keeping Flight Path out of the unsafe zone, indicated by the angle lines off the bracket, the traffic should not require evasive action. It is possible to have more than one preventive advisory.

A Corrective Advisory, displayed on the HGS by a double lined box (Figure 6-9) is an indication of a traffic threat that requires a vertical evasive maneuver. The advisory command is to place Flight Path within the box (fly to zone) or remain on the safe side of the box indicated by the opposite of the side with the angled lines. It is not possible to have more than one Corrective Advisory (separate boxes) but it is possible to have simultaneous Corrective and Preventive Advisories (above and below) that would be indicated by angled lines on both sides of the box or brackets. The vertical height of the box represents the 500 fpm fly to zone indicated by TCAS.

In Figure 6-9, a Corrective Advisory is displayed indicating that the pilot must promptly and smoothly climb from his current straight and level flight (in the unsafe zone) by placing the Flight Path in (or above) the fly to box. In this case, the angled lines out of the bottom of the box would be flashing on and off until the Flight Path is positioned within the safe zone.

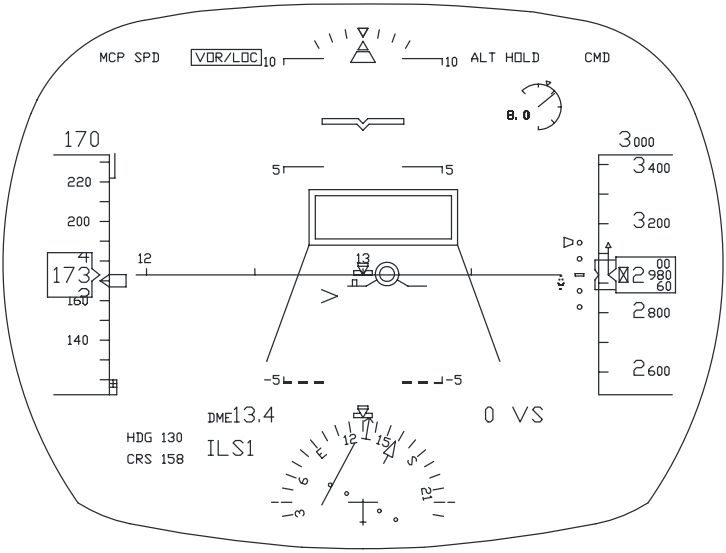

Figure 6-9:
TCAS Resolution Advisory

ILS Intercept

The Primary mode is the principle mode of operation for enroute navigation. The other HGS modes are predominantly used for approach. IMC and VMC modes can be selected at any time. The AIII mode$^{\Delta}$, which is intended for low visibility approaches, may only be selected after ILS capture.

In the Primary mode, the conventional HSI/CDI display is used for all course deviation indications whether localizer or VOR. When an ILS is selected and deviation is valid, the Glideslope Deviation Pointer is displayed. These displays enable the pilot to perform all normal navigation functions.

In Figure 6-10, the autopilot is being used to fly about a 30° intercept heading (130°) to the ILS course of 158°. The current assigned heading is indicated by the digital Selected Heading value and the heading bugs on the horizon and HSI. The ILS course is also indicated by the digital Selected Course value and the course pointer on the HSI and below the Horizon Line. When the horizon course pointer is selected outside the display field of view (in this case to the right at 158°), the pointer is positioned near the end of the Horizon Line and "ghosted" to indicate it is non-conformal. The aircraft is level at about 3000 feet (2980) intercepting from below the glideslope. The aircraft is 13.4 nautical miles from the (ILS) DME station and the aircraft is decelerating slightly to obtain the target airspeed of 170 knots.

If an AIII approach$^{\Delta}$ is planned, the pilot can either arm the HGS for automatic AIII selection at this point, or wait and select AIII mode manually after the ILS has been captured.

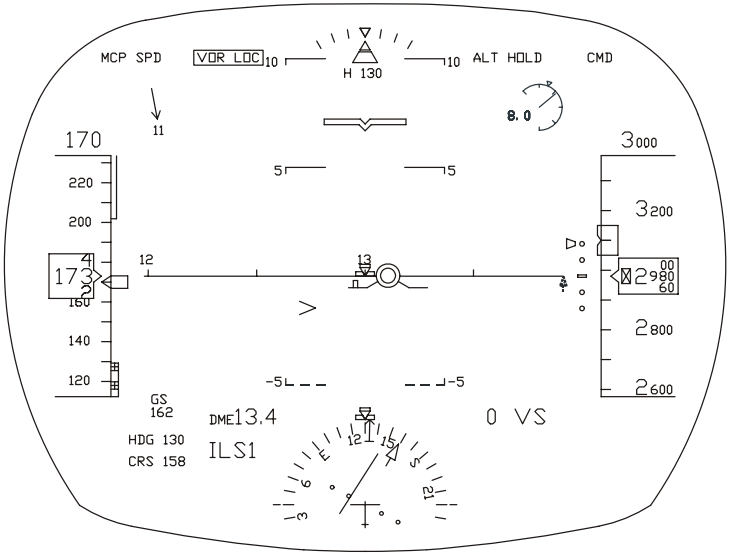

Figure 6-10:
ILS Intercept

ILS Capture

In Figure 6-11, the aircraft is just completing the turn to the final approach course and has captured the localizer and glideslope. The HGS is AIII capable$^{\Delta}$ and AOC conditions have just been met.

If AIII is armed for automatic selection, The "AIII" portion of the "AIII ARM" message flashes for 5 seconds, and then AIII mode$^{\Delta}$ is automatically selected.

If AIII is not armed for automatic selection, "AIII" flashes in upper left corner of the Combiner display (in Primary mode only) and "AIII" is displayed on the HCP STBY line.

At this point, the pilot has the following options:

- Select AIII mode by pressing the MODE key on the HCP.
- Delay the AIII mode selection, but select it prior to 500 feet above the TDZE.

NOTE: If AIII is not selected prior to 500 feet above the TDZE, AIII can no longer be selected and all AIII capability messages are removed from the Combiner and HCP.

- Push the STBY key on the HCP once to set IMC as the standby mode or push the STBY key twice to set VMC as the standby mode. Push the MODE key to select the standby mode.

NOTE: If the STBY key is pushed accidentally, AIII can be re-set as the standby mode. Push the STBY key twice if IMC shows on the STBY line, or push STBY once if VMC shows on the STBY line.

- Remain in Primary mode for landing.

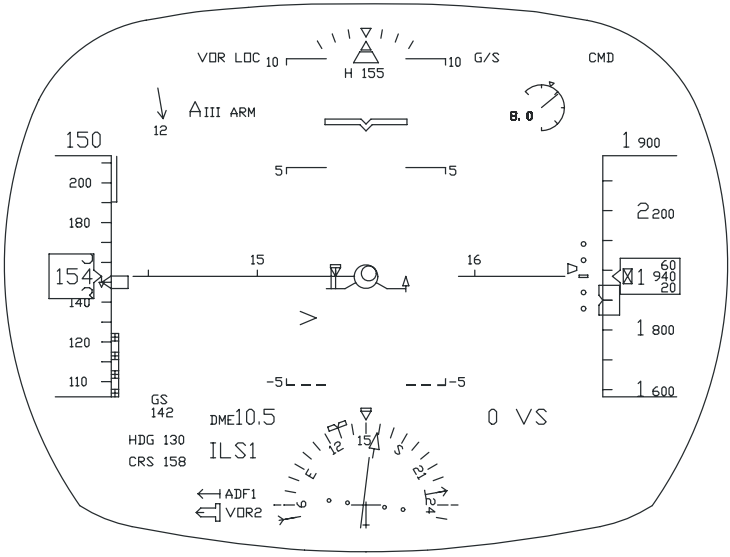

Figure 6-11:
ILS Capture

AIII Approach$^{\Delta}$

In Figure 6-12, the aircraft is in AIII mode$^{\Delta}$ and established on the ILS approach. The aircraft is on the localizer and slightly below the glideslope. The position of the Flight Path and Guidance Cue slightly above the Glideslope Reference Line indicates that the aircraft is correcting to the glideslope. The aircraft is descending at 600 FPM through 1800 feet over the Outer Marker (OM) at 5.8 miles. The aircraft is decelerating through 135 knots toward the target speed of 130.

NOTE: The Digital Runway Elevation value is only displayed for five seconds after the AIII mode is selected or whenever the value is changed.

Localizer deviation is now indicated with the Localizer Deviation Line positioned laterally relative to the Selected Course pointer. Glideslope deviation is now indicated with the Glideslope Deviation Line positioned vertically relative to the Glideslope Reference Line. When on course, these create a cross in the center of the display with the Flight Path and Guidance Cue in the middle.

NOTE: It is important to note that in the AIII mode the Guidance Cue is providing pitch and roll commands derived from the HGS. The Guidance Cue is now independent of the Flight Director and will provide guidance to aircraft touchdown.

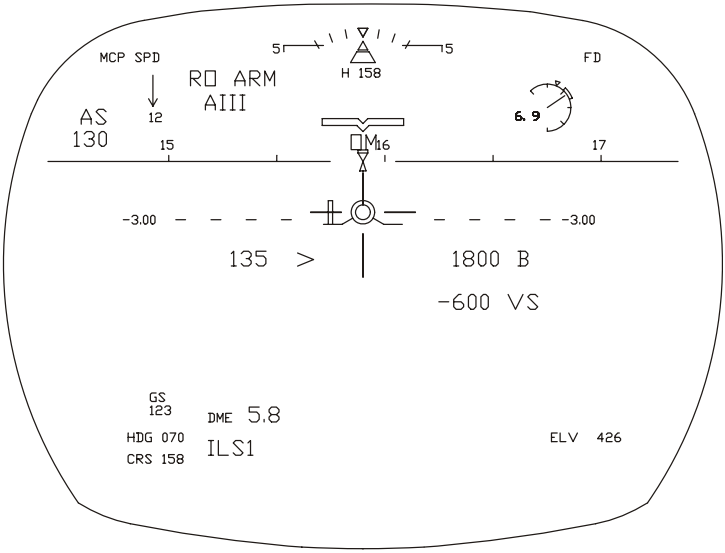

Figure 6-12:
AIII Approach

AIII Approach$^{\Delta}$ - 500 Feet

In Figure 6-13, the aircraft is on the localizer and glideslope and descending towards 500 feet.

At 500 feet, approach monitoring starts and continues until touchdown. This monitor will trigger the "APCH WARN" annunciation as a result of a performance monitor limit being exceeded. The HGS continues capability monitoring, which can also trigger an approach warning.

NOTE: Performance monitoring is related to the pilot's ability to track the ILS and flare guidance and the projected touchdown within the required touchdown limits including excessive lateral and vertical position, airspeed, sink rate, crosstrack rate and long landing.

When AIII mode is engaged, "RO ARM" will be displayed in the upper left portion of the Combiner and on the Annunciator Panel to inform the flight crew that the rollout guidance$^{\Delta}$ feature is armed and available to provide precise localizer rollout guidance on touchdown. Should rollout guidance not be reliable or available, the "RO ARM" will be removed from the Combiner and Annunciator Panel. In addition, if the aircraft is below 500 feet AGL, a "RO CTN" (Rollout Caution) will be displayed on the Combiner and in amber on the Annunciator Panel. The pilot must determine whether to continue the approach or go-around dependent on whether landing minimums requires the use of rollout guidance.

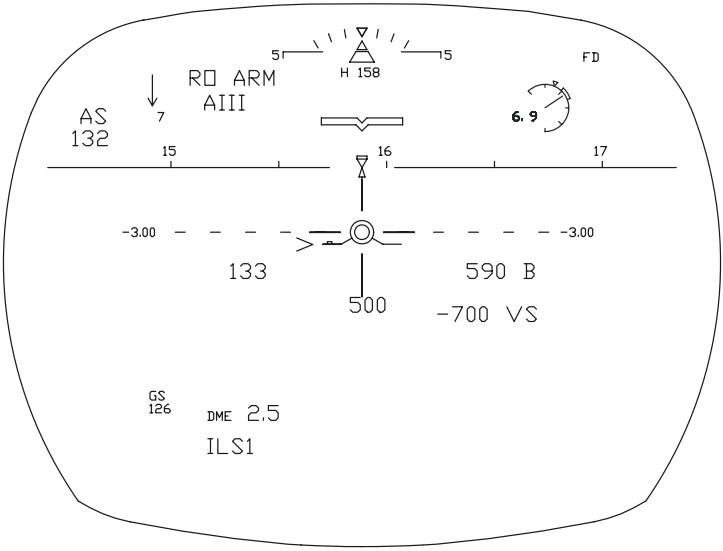

Figure 6-13:
AIII Approach - 500 Feet

AIII Approach$^{\Delta}$ - 300 Feet

In Figure 6-14, the aircraft is descending through 300 feet Radio Altitude, on speed and track. The two runway edge lines are drawn referenced to the Selected Course Mark on the Horizon Line so that if the real world runway were visible, the two would closely overlay.

Tracking the HGS Guidance Cue, and subsequently the ILS, amounts to centering and maintaining the Flight Path symbol over the Guidance Cue. Monitoring localizer and glideslope raw data relative to their null positions will assist in minimizing deviations and anticipating corrections. Airspeed control is accomplished by maintaining the Flight Path Acceleration caret aligned off the Flight Path wing with minimum Speed Error Tape showing. Any deviation in the ILS tracking or airspeed error is easily identified by these relationships.

The "AIII" annunciation displayed in the upper left corner is both an indication of the selected mode and the AIII capability status. As long as all required parameters and conditions are valid for a CAT III approach, the AIII status annunciation will remain. If a condition develops that invalidates a required parameter, then the AIII annunciation is removed and replaced with "NO AIII". Below 500 feet, this would also be displayed with an "APCH WARN" annunciation. Normal CAT III operations procedures would require a go-around anytime either of these occur below 500 feet AGL.

If the "RO CTN" message is displayed on the Combiner below 500 feet AGL, the pilot must execute a go-around if the landing conditions require the use of rollout guidance$^{\Delta}$.

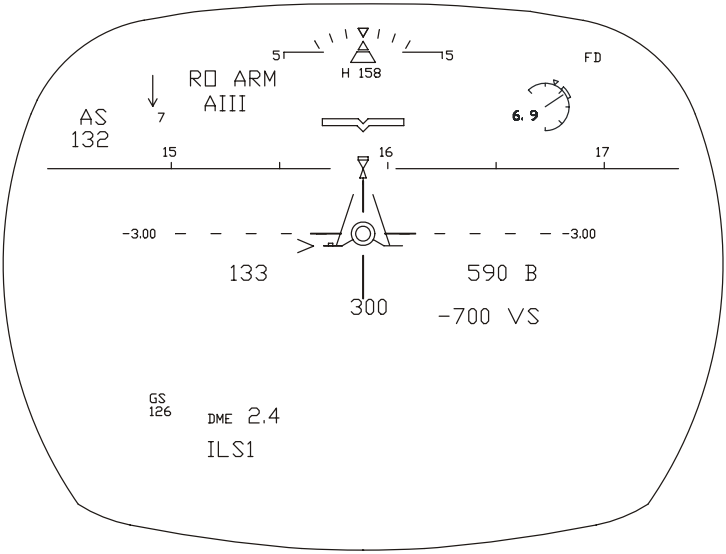

Figure 6-14:
AIII Approach - 300 Feet

AIII Approach$^{\Delta}$ - 100 Feet

In Figure 6-15, the aircraft is descending through 100 feet Radio Altitude, still on speed and track. At 105 feet AGL the AIII Flare Command is displayed (a flashing "+") 2-3° below Flight Path. The Flare Cue then starts moving up towards the Flight Path symbol and no longer flashes. The rate of closure between the two symbols is directly proportional to the aircraft's descent rate, providing an indication of the rate of input required to flare once the flare maneuver is initiated.

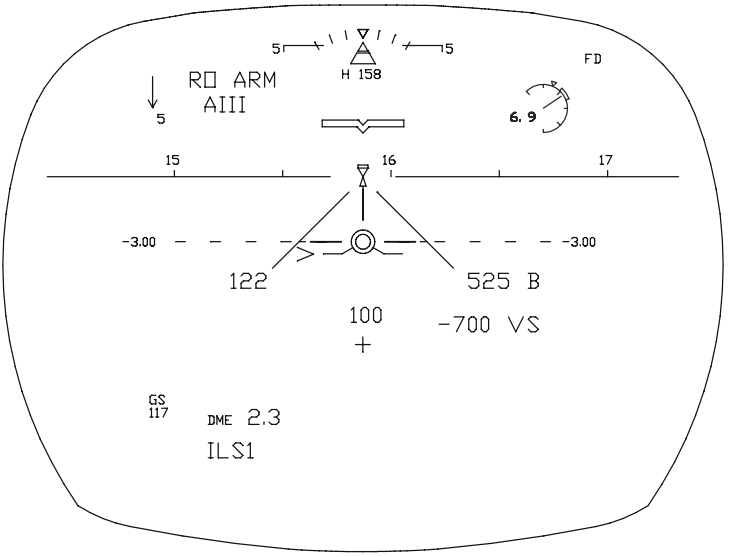

Figure 6-15:
AIII Approach - 100 Feet

AIII Approach$^{\Delta}$ - 45 Feet

In Figure 6-16, the aircraft is descending through 45 feet Radio Altitude and the Decision Height annunciation is displayed. The flare maneuver is initiated (between 45 and 55 feet AGL) when the AIII Flare Command symbol meets the center of the Flight Path Guidance Cue (as shown). At the same time, the “FLARE” lamp on the Six Panel Annunciator comes on, or the “FLARE” legend on the digital HAP comes on. The AIII Flare Command and Guidance Cue (now moving together) then command the Flight Path up through the flare maneuver, continuing until touchdown.

Airspeed is on target with only a one-knot airspeed error. The runway edge lines are no longer displayed (below 60 feet) because the actual runway must be in view by Decision Height. Glideslope deviation raw data is also no longer displayed (below 70 feet – extended glideslope) because the glideslope deviation data becomes unreliable below this point and is no longer used in the guidance computations. From Decision Height to touchdown, the pilot should track the HGS Guidance Cue while utilizing real world visual cues in assessing approach performance. The right seat pilot continues to monitor the approach head down through touchdown.

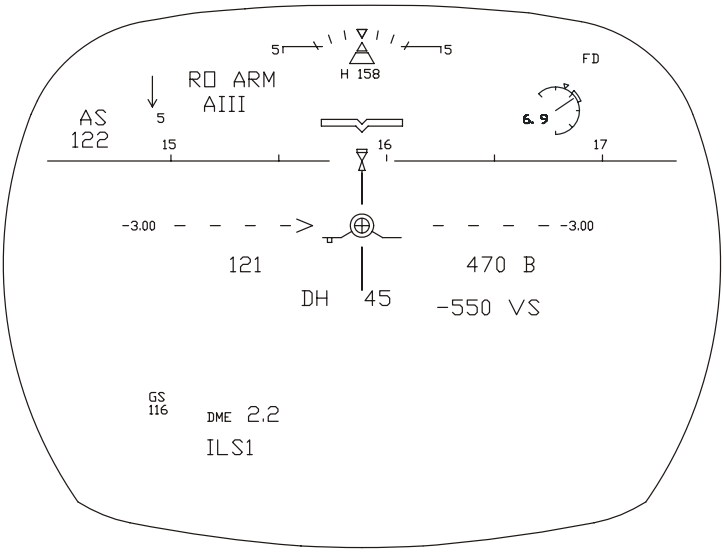

Figure 6-16:
AIII Approach - 45 Feet

AIII Approach$^{\Delta}$ - Flare/Touchdown

In Figure 6-17, the aircraft has been flared into the landing attitude. Radio Altitude is 15 feet and the "IDLE" message is displayed. The aircraft is decelerating through 120 knots and the aircraft is positioned over the centerline (localizer centered).

The flare maneuver is designed to transition the aircraft from the approach attitude to the touchdown attitude while maintaining positioning and performance requirements to meet touchdown criteria for CAT III landings. This includes continuing to track the runway localizer and establishing an acceptable touchdown sink rate while refraining from floating down the runway. The computed touchdown is not intended to "grease" the aircraft on but to firmly establish the aircraft on the ground within the acceptable touchdown footprint while tracking the centerline. In order to reduce the longitudinal touchdown distance, an "IDLE" command is displayed directing the pilot to reduce thrust to idle. The pilot is to follow the Guidance Cue while assimilating the external visual cues to assure the airplane lands within the touchdown zone. If the airplane will not land within the touchdown zone, a go-around must be executed.

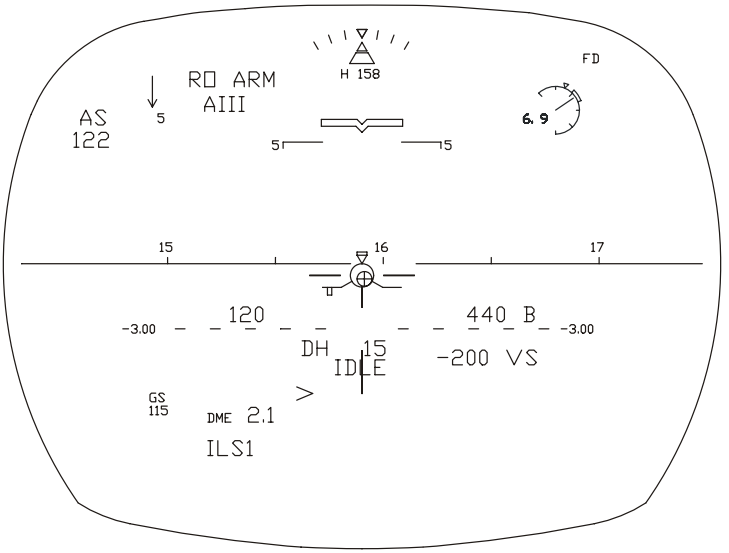

Figure 6-17:
AIII Approach - Flare/Touchdown

AIII Rollout[Δ]

Following touchdown, the display changes to remove unnecessary symbology to assist with the landing rollout (Figure 6-18). This includes changing the Flight Path Symbol to a Ground Roll Reference Symbol, the Guidance Cue to a Localizer Guidance Cue (lateral guidance only) and the Localizer Symbol to the Ground Localizer Line or Ground Localizer Deviation Scale and Pointer[Δ]. The pilot follows the Localizer Guidance Cue by overlaying the Ground Roll Reference Symbol over the Localizer Guidance Cue and monitoring the Ground Localizer Line while visually augmenting with runway centerline markings and lights to maintain runway centerline. The HGS provides a Ground Roll Reference Symbol and Localizer Guidance Cue for landing rollout along the runway, and a display of the runway remaining (in feet or meters[Δ]).

NOTE: A Ground Localizer Line or Ground Localizer Deviation Scale and Pointer[Δ] is displayed in either the AIII, IMC or Primary modes while the aircraft is on the ground and the selected Nav source is an ILS. Figure 6-18 is also representative of the IMC mode, except for the mode annunciation and Runway Remaining readout.

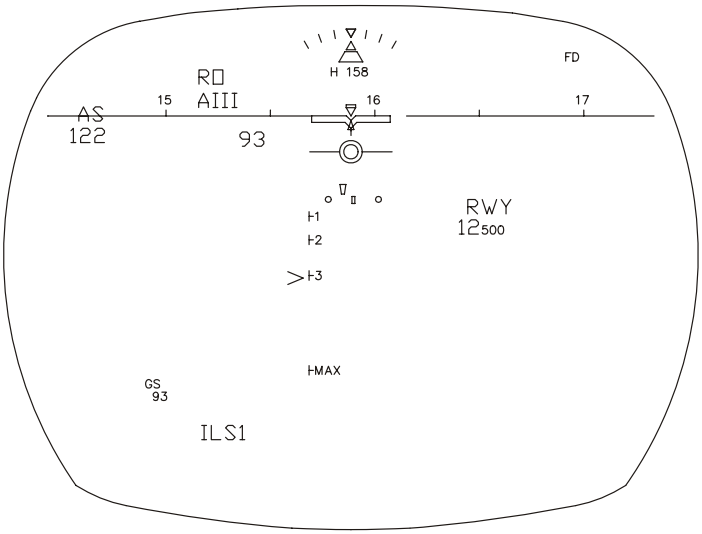

Figure 6-18:
AIII Approach - AIII Rollout

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Section 7:
Definitions

The following are definitions of terms associated with the HGS. These are provided for informational purposes to assist pilots in better understanding how and when certain functions occur. For text in italics, refer to other definitions.

Above Ground Level (AGL): for the purposes of the HGS, AGL is defined as the lesser of Radio Altitude or Corrected Altitude when the AIII mode$^{\Delta}$ is engaged, or Radio Altitude when AIII mode is not engaged.

Aircraft Aligned on Runway: for the purposes of the HGS, the aircraft is determined to be aligned on the runway when the difference between the Selected Course and Magnetic Heading is less than 10 degrees and localizer deviation is less than 4/5 of a dot (60μA) and the aircraft is not in flight.

Aircraft in Flight: for purposes of the HGS, the aircraft is defined to be in flight from the time Aircraft Rotation occurs until Aircraft Touchdown or until Aircraft on Ground.

Approach On Course (AOC): for purposes of the HGS, AOC is defined to occur when:

- Both VHF Navigation Receivers are tuned to an ILS frequency.
- The difference between the aircraft's magnetic track and the Captain's Selected Course is less than 15 degrees.
- Radio Altitude is greater than 500 feet.
- VHF Nav #1 or VHF Nav #2 localizer deviation is less than approximately ¼ dot and glideslope deviation is less than approximately 1¼ dots for at least five seconds.

Aircraft on Ground: for purposes of the HGS, Aircraft on Ground is defined to occur when Ground Speed is less than 40 knots and Radio Altitude is less than 20 feet.

Aircraft Rotation: for purposes of the HGS, Aircraft Rotation is defined to occur when Pitch Attitude is greater than 3° and the pitch attitude was previously less than 2° or Radio Altitude is greater than 5 feet.

Category II (FAA AC 120-29): an instrument approach procedure that provides approaches to minimums of less than DH 200 feet and RVR 2400 to as low as DH 100 feet and RVR 1200 feet.

Category III (FAA AC 120-28c): a precision instrument approach and landing with no DH, or a DH below 100 feet, and controlling RVR not less than 700 feet.

Corrected Altitude: for purposes of the HGS, Corrected Altitude is defined as the difference between Baro Altitude and the runway Touchdown Zone Elevation (TDZE), as entered on the HCP.

Decision Height (FAA AC 120-28c): a specified height at which a missed approach must be initiated if the required visual reference to continue the approach to land has not been established.

Glideslope Capture: for purposes of the HGS, glideslope capture is defined as when glideslope deviation is less than 90 μA (approximately 1 1/4 dot) for at least 5 seconds.

Localizer Capture: for purposes of the HGS, localizer capture is defined as when localizer deviation is less than 20 μA (approximately 1/4 dot) for at least 5 seconds.

Low Visibility Takeoff: for the purposes of the HGS, the aircraft configuration for a low visibility takeoff is when Aircraft in Flight is not true and both Nav Receivers are tuned to an ILS frequency and the Primary mode is selected.

Low Visibility Takeoff Initiation: for the purposes of the HGS, a low visibility takeoff is initiated when the aircraft is configured for a low visibility takeoff, Ground Speed is greater than 40 knots, and the aircraft is aligned on the runway.

Track Error: for purposes of the HGS, Track Error is defined as the difference between the aircraft Magnetic Track Angle and Selected Course.

Wheel Height: for the purposes of the HGS, Wheel Height is determined by correcting Radio Altitude for antenna position and pitch attitude effects.

Wheel Touch: for the purposes of the HGS, Wheel Touch is determined by monitoring for a threshold derived from Longitudinal Acceleration and Normal Acceleration below 6 feet Radio Altitude.

Acronyms

The following are definitions of acronyms, abbreviations, and symbols used in this publication.

A/C: ..... Aircraft
AC: ..... Advisory Circular or Alternating Current
ADI: ..... Attitude Director Indicator
ADF: ..... Automatic Direction Finding
ADIRU: ..... Air Data Inertial Reference Unit
AGL: ..... Above Ground Level
AIII or AIII: ..... Approach III (CAT III approach mode or status)
ALT: ..... Altitude
ALTN: ..... Alternate
AOA: ..... Angle Of Attack
AOC: ..... Approach On Course
AP or A/P: ..... Autopilot
APCH WARN: ..... Approach Warning
APP: ..... Approach
ARINC: ..... Aeronautical Radio, Inc.
AS: ..... Airspeed
A/T: ..... Autothrottle
ATT: ..... Attitude
Avg.: ..... Average
AWO: ..... All Weather Operations
AZ: ..... Azimuth
Baro or B: ..... Barometric
BITE: ..... Built-In-Test
BRT: ..... Bright/Brightness
C or CAPT: ..... Captain
CAD: ..... Combiner Alignment Detector
CAS: ..... Calibrated or Computed Airspeed
CAT: ..... Category
CDI: ..... Course Deviation Indicator
CDS: ..... Common Display System
CH: ..... Channel
CLR: ..... Clear
CMD: ..... Command
COMP or CMP: ..... Comparison or Computer
CRS: ..... Course
CRT: ..... Cathode Ray Tube
CWS P: ..... Control Wheel Steering Pitch
CWS R: ..... Control Wheel Steering Roll
DADC: ..... Digital Air Data Computer

DC: ..... Direct Current
DEU (HGS) - ..... Drive Electronics Unit
DEV: ..... Deviation
DFCS: ..... Digital Flight Control System
DH: ..... Decision Height
DME: ..... Distance Measuring Equipment
DTK: ..... Desired Track
DU: ..... Display Unit
E/E: ..... Electronics and Equipment
EFCP: ..... EFIS Control Panel
EFI: ..... Electronic Flight Instruments
EFIS: ..... Electronic Flight Instrument System
ELV or EL: ..... Elevation
FAA: ..... Federal Aviation Administration
FCC: ..... Flight Control Computer
FD or F/D: ..... Flight Director
FDAU- ..... Flight Data Acquisition Unit
FMA: ..... Flight Mode Annunciator
FMC: ..... Flight Management Computer
FMS: ..... Flight Management System
F/O: ..... First Officer
FPM: ..... Feet Per Minute
Ft: ..... Feet
GA: ..... Go-Around
GLS ..... GPS Landing System
GPS: ..... Global Positioning System
GPWS: ..... Ground Proximity Warning System
GS: ..... Ground Speed or Glideslope
G/S: ..... Glideslope (HCP Reference)
HC: ..... HGS Computer
HCP: ..... HGS Control Panel
HDG or H: ..... Heading
HGS: ..... Head-Up Guidance System
HLD: ..... Hold
HSI: ..... Horizontal Situation Indicator
HUD: ..... Head-Up Display
IAS: ..... Indicated Airspeed
ID: ..... Identification
ILS: ..... Instrument Landing System
IM: ..... Inner Marker
IMC: ..... Instrument Meteorological Conditions
INCAP: ..... Incapable
INOP: ..... Inoperative
INV: ..... Invalid
IRS: ..... Inertial Reference System

IRU: ..... Inertial Reference Unit
JAA: ..... Joint Airworthiness Authority
JAR: ..... Joint Aviation Regulations
KTS: ..... Knots
LCD: ..... Liquid crystal Display
LED: ..... Light Emitting Diode
LIM: ..... Limit
LN: ..... Length
LNAV: ..... Lateral Navigation
LOC: ..... Localizer
LRU: ..... Line Replaceable Unit
LVL: ..... Level
MAG: ..... Magnetic
MCP: ..... (DFCS) Mode Control Panel
MHDG: ..... Magnetic Heading
MM: ..... Middle Marker
MMR: ..... Multi-mode Receiver
N/A: ..... Not Applicable
NAV: ..... Navigation
NCD: ..... No Computed Data
ND: ..... Navigation Display
NDB: ..... Non-Directional Beacon
NM: ..... Nautical Miles
NORM: ..... Normal
OHU: ..... Overhead Unit
OM: ..... Outer Marker
OPC ..... Operational Program Configuration
RO: ..... Rollout Guidance
RO ARM: ..... Rollout Guidance Armed
RO CTN: ..... Rollout Guidance Caution
PDU: ..... Pilot Display Unit (OHU and Combiner)
PF: ..... Pilot Flying
PFD: ..... Primary Flight Display
PNF: ..... Pilot Not Flying
PRI: ..... Primary (mode)
PWR: ..... Power
RA: ..... Radio Altitude or Resolution Advisory
RALT or RAD ALT: ..... Radio Altitude
RAM: ..... Random Access Memory
RCVR: ..... Receiver
RDMI: ..... Radio Distance Magnetic Indicator
RNAV: ..... Area Navigation
RVR: ..... Runway Visual Range
RWY: ..... Runway (HCP)
SEL: ..... Select

SPD:..... Speed
STBY:.....Standby
SMYDC:.....Stall Management Yaw Damper Computer
TA/VSI: .....Traffic Advisory/Vertical Scale Indicator
TCAS:.....Traffic Collision Avoidance System
TDZ: .....Touch Down Zone
TDZE:.....Touchdown Zone Elevation
THR: ..... Throttle
T/O:.....Takeoff
TOGA or TO/GA:..... Takeoff/Go-around
VAC:.....Volts AC
VAL:..... Valid
VASI:.....Visual Approach Slope Indicator
VDC:.....Volts DC
VERT:..... Vertical
VHF: ..... Very High Frequency
VMC:..... Visual Meteorological Conditions
V1: ..... Takeoff decision speed
VMO:..... Maximum Operating Airspeed
VR: ..... Rotation speed
VREF:.....Reference speed
VNAV:.....Vertical Navigation
VOR:..... VHF Omni directional Range
VS or V/S: .....Vertical Speed
WXR:..... Weather Radar
XTK:..... Crosstrack deviation
µA:.....Micro amp
°: .....degrees
>:..... greater than or cursor
<:..... less than
Δ.....OPC Option