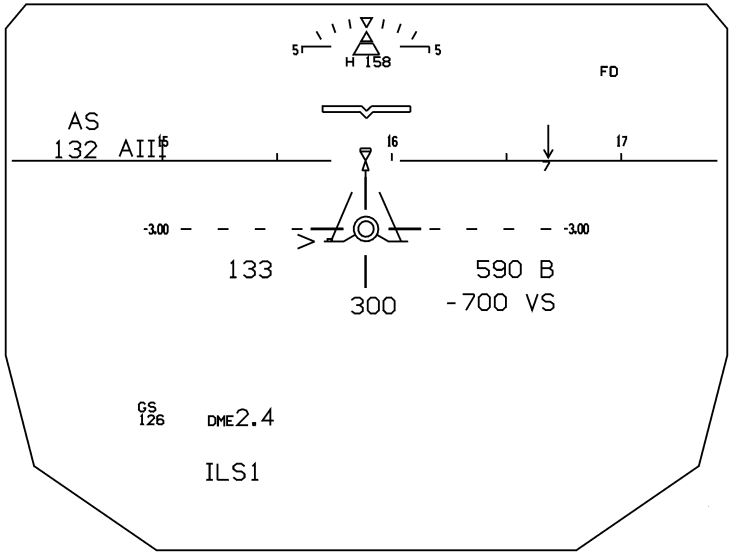
Head-Up
Guidance System
HGS® Model 2350

HGS
Pilot Guide

Boeing 737 - NG (PFD/ND)



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Introduction

This Pilot Guide is designed to acquaint you with the Flight Dynamics Head-Up Guidance System (HGS®) installed on Boeing 737-NG (PFD/ND) aircraft. It provides a description of the HGS, the modes of operation and HGS symbology. It also discusses HGS flight operational procedures and how to operate the HGS system through a typical 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 in an accurate one-for-one relationship. The system is FAA certified for all phases of flight and has met the requirements for Low Visibility Takeoffs and manual Category I, II and IIIa approach and landings.

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 IIIa approach and landing operations and by the Boeing 737 Digital Flight Control System (DFCS) during other operations. The system's unique head-up view of symbologies 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, use the AFM.

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HGS Description

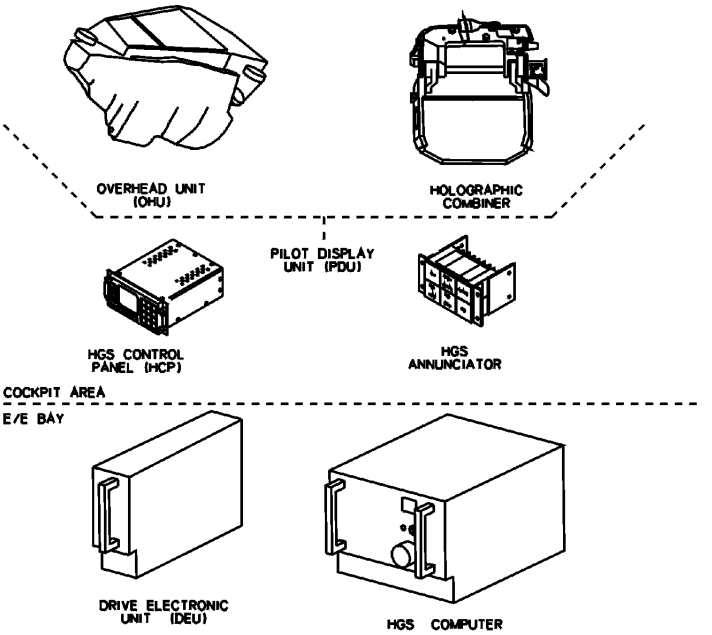
The HGS is a high integrity, wide field of view Holographic Head-Up Display (HUD) system that is designed specifically for low visibility operations in the Boeing 737 aircraft. It consists of six Line Replaceable Units (LRU), four of which are positioned within the cockpit. Their functions are described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

HGS LINE REPLACEABLE UNITS (LRU):

The Flight Dynamics HGS consists of the following six LRU's:

- **HGS Computer -** receives input signals from aircraft sensors and equipment and converts this data to symbology. The HGS Computer also evaluates both system and approach performance through extensive Built-In Test (BITE), input validation and Approach Monitor processing.
- **HGS Control Panel (HCP)** - is used for setting glideslope angle, runway length and elevation, and for selecting HGS modes of operation.
- **Drive Electronics Unit (DEU)** - receives signals from the HGS computer and conditions these signals to drive the Cathode Ray Tube (CRT) in the OHU. The DEU contains power supplies and electronic circuitry for signal amplification, distortion and geometry corrections, and system monitoring.
- **OverHead Unit (OHU)** - contains the CRT and projection optics to display the symbolic image on the Combiner. The OHU also contains electronic circuitry for display intensity control and system monitoring.
- **Combiner** - optically combines flight symbology with the pilot's view through the windscreen. The Combiner is designed to reflect the light projected from the CRT in the OHU. The Combiner, in effect, acts as a wavelength selective mirror reflecting the CRT color while allowing all other colors to pass through the glass.
- **HGS Annunciator Panel** - provides HGS status and warning annunciations to the First Officer during CAT IIIa approach and landing operations.

The HGS interfaces with a number of aircraft sensors and systems for the data and power required for HGS operations. These data and power systems are identified in the Appendix.


OVERHEAD UNIT
(OHU)
HOLOGRAPHIC
COMBINER
PILOT DISPLAY
UNIT (PDU)
HGS CONTROL
PANEL (HCP)
HGS
ANNUNCIATOR
COCKPIT AREA
E/E BAY
DRIVE ELECTRONIC
UNIT (DEU)
HGS COMPUTER

HGS LRU'S

HGS LRU LOCATIONS:

The Combiner is attached to the left forward windscreen upper sill beam structure. It is positioned to display HGS symbology when viewed from the pilot's normal seated position.

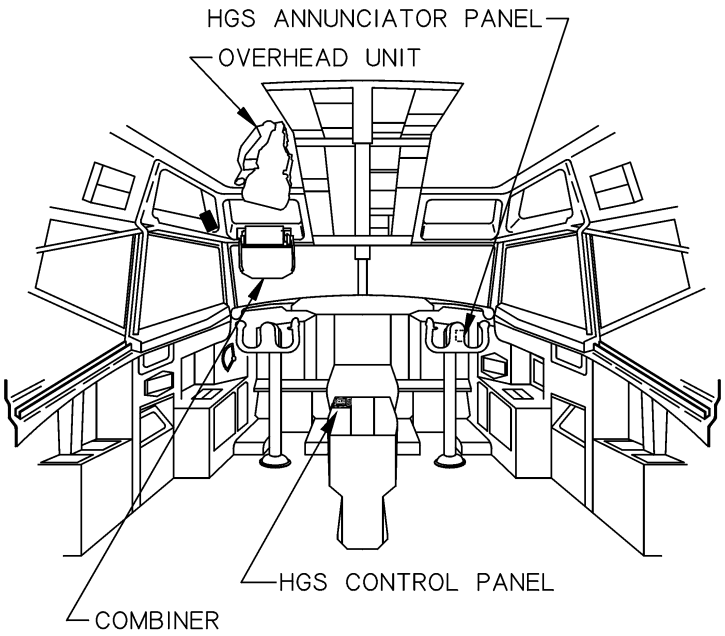
The OHU is located above the left pilot's head in specially designed mounting hardware that provides the proper spatial relationship with respect to the Combiner and the airframe. This relationship permits the various symbols, such as the artificial horizon, to overlay the corresponding features of the outside world.

The HGS Control Panel (HCP) is located in the aft pedestal, and is available to both pilots.

The HGS Annunciator Panel is installed in the First Officer's instrument panel.

The DEU is located on the E1-3 shelf in the E&E compartment.

The HGS Computer is located on the E4-1 shelf in the E&E compartment.



COCKPIT HGS LRU'S

HGS LRU FUNCTIONAL CHARACTERISTICS:

Normal operation of the HGS requires both routine DFCS inputs and HGS specific mode selections, data entry, and display brightness adjustments. Mode changes and data entry are made on the HCP and display brightness is controlled selectively on the HCP and Combiner.

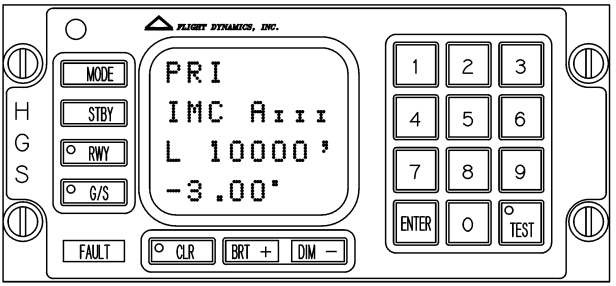
HGS CONTROL PANEL (HCP)

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. Four of the keys contain LED annunciators for indication of engagement. 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 which illuminates any time an HGS BITE detected fault occurs.

HCP MODE AND DATA ENTRY

There are four mode/function keys. These four keys and their associated displays are:

- **MODE** - The MODE key is used to select the desired mode from the available modes displayed on the standby display line. The current mode is always displayed on the display line adjacent to the MODE key.
- **STBY** - The STBY (Standby) key is used to cycle through the available standby modes. Each available mode is individually indicated on the left side of the display line adjacent to the STBY key. The HGS AIII capability status is also displayed on this line when available.
- **RWY** - Depressing this key engages the Runway data entry function for entering runway length and elevation. The adjacent display line indicates the current value entered or being entered. (An HCP runway length display is illustrated below. An HCP runway elevation display is illustrated on page 3-1.)
- **G/S** - Depressing this key engages the Reference Glideslope data entry function. The adjacent display line indicates the current value entered or being entered.



HGS CONTROL PANEL (HCP)

The MODE and STBY operation is explained further in the Modes of Operation section. The RWY and G/S keys are used in conjunction with the numeric keypad to input the appropriate runway length, elevation, and glideslope angle into the HGS.

RUNWAY DATA ENTRY

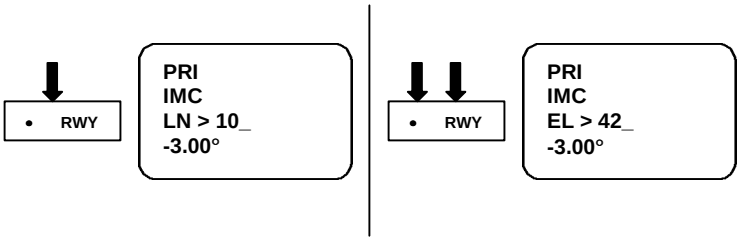
The Runway function key (RWY), together with the numeric keypad, is used to enter any of three values depending on whether taking off or landing. For takeoff the runway length is entered. For landing either the Touch Down Zone Elevation (TDZE) or runway elevation is entered. Typically, these values are the published runway length and TDZE as presented on instrument approach plates. Runway length values can be entered between 0 and 99999 feet but are required to be between 7500 and 13500 feet to display HGS ground roll guidance for low visibility takeoff operations (see Modes of Operation). Runway elevation values can be entered between -9999 and 99999 feet, with the "DIM-" key used to enter the negative sign.

The Runway values are changed by pressing the RWY key on the HCP. If on the ground, press once for runway length and twice for runway elevation. If in-flight, press once for runway elevation and twice for runway length. This will illuminate the dot annunciator in the upper left corner of the RWY key and display the current value on the adjacent line, preceded by either "LN" (length) or "EL" (elevation) and an arrow ">", as an indication of being in the data entry mode (see illustration below). Pressing a numeric key on the keypad then causes the original value to blank and the numeric to display in the first available position followed by a flashing cursor ("_"). Additional numeric keys are pressed to complete the desired value. If in the process an error is made, the "CLR" key acts as a backspace, erasing the character prior to the cursor with each press. With a desired value input, press the RWY key again to remain in the data entry mode for the other runway value, or press the "ENTER" key to accept the new value(s). New values are not accepted into the system until the data entry mode is exited by pushing the “ENTER” key. This extinguishes the dot annunciator, removes the "LN" or "EL", arrow (“>") and flashing cursor ("_") and adds the character " ' " (for Feet) following the new value.

When the aircraft is <u>not in</u> flight, and the RWY data entry mode is not active, the data presented on the runway display line is runway length indicated by the first character "L", followed by the current runway length value. To observe the elevation value, go into the RWY data entry mode.

When the aircraft is <u>in</u> flight, and the RWY data entry mode is not active, the data presented on the runway display line is runway elevation indicated by the first character "E", followed by the current runway elevation value. To observe the length value, go into the RWY data entry mode.

At any time, pressing the RWY key once or twice without making any input allows verifying either value without changing. Press the "ENTER" key to exit the entry mode and retain the original values. Likewise, if a data input is cleared by backspacing (no value input) and then “ENTER” is pressed, the original value is retained.



RWY LENGTH AND ELEVATION DATA ENTRY EXAMPLES

REFERENCE GLIDESLOPE ENTRY

The Reference Glideslope function key (G/S) on the HCP is used to enter the glideslope angle for the landing runway. Typically, this is the published glideslope angle as presented on the instrument approach plates or other approach documentation or the desired glide path angle for a visual approach. Values can be entered between 0.00° and -9.99°.

Changing the Reference Glideslope value is performed in the same manner as the Runway entry described above.

For an HGS AIII approach operation, the Reference Glideslope value must be entered between the values of -2.51 and -3.00°. Any other value will disallow the AIII status ("NO AIII" indicated if AIII mode is already selected) following approach capture.

HCP Modes and the Runway and Glideslope values entered are stored in the HGS Computer so that if power is interrupted, the last mode and value will be restored when power is returned.

CLEAR FUNCTION

The Clear function key (CLR) has multiple purposes. The primary function of the Clear key is to allow the pilot to remove (clear) all symbology from the Combiner display. This is indicated by the lack of symbology on the Combiner, 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 deselecting the function by again pressing the Clear key, changing modes, or entering TEST.

The clear key is also used during data entry and TEST operations as a backspace key. (Refer to the Appendix for additional information related to the TEST functions.)

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

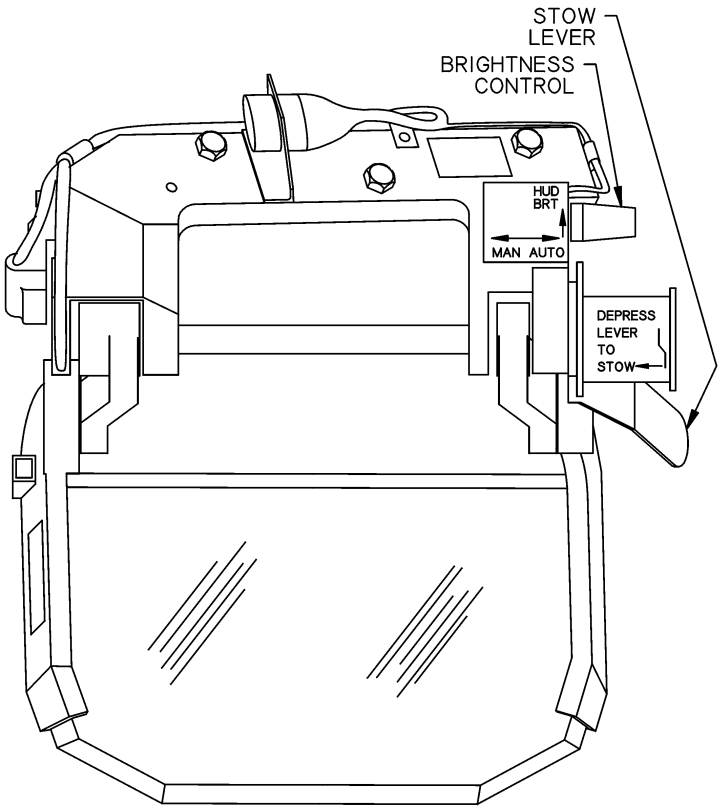
HCP AMBIENT LIGHT SENSING

The HCP display brightness is adjusted automatically based on the ambient light on the HCP. The ambient light is measured by a sensor located in the upper left corner of the HCP front panel. Manual adjustment of the HCP intensity is limited by the ambient light condition.

COMBINER

The HGS holographic Combiner, illustrated below, 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 (24° vertical by 30° horizontal) is designed to position and focus the projected image so that symbology is in effect superimposed on the view of the real world scene.

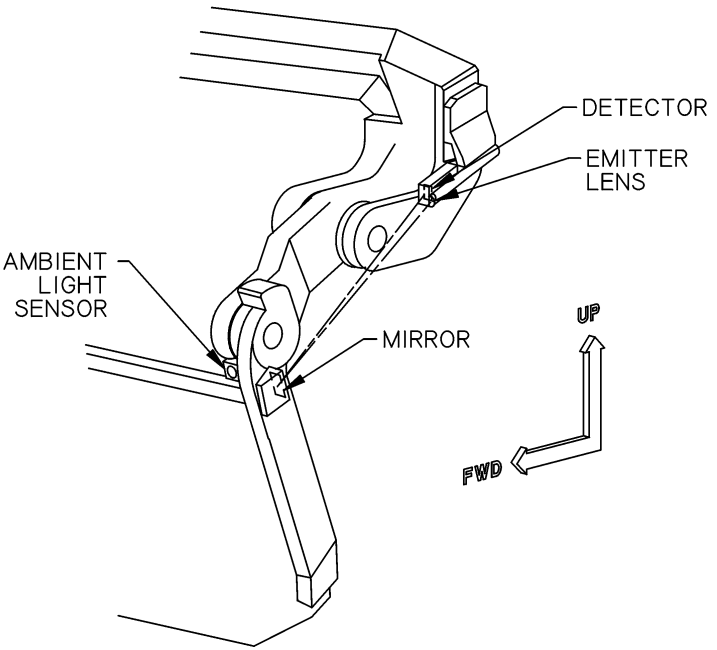
The Combiner assembly consists of mechanical and electrical components to hold and support the Combiner glass in various positions, and to control and monitor the Combiner's position and display brightness.



HGS COMBINER

COMBINER DISPLAY BRIGHTNESS

The Combiner display brightness control is located on the upper right portion of the Combiner. The control consists of a control knob that can be positioned either in or out and rotates for adjustment. Positioning the knob in or out selects either the manual or automatic brightness control mode, respectively. In manual mode, the display intensity remains constant at the level of intensity selected by the pilot. In the automatic mode, the display intensity is automatically varied to provide a constant contrast ratio and is dependent on the ambient light as detected by an ambient light sensor on the Combiner. This allows for automatic increases or decreases in the display intensity so as to remain visible without manual adjustment as the aircraft travels into varying ambient light conditions. In either display mode, rotation of the knob in a clockwise direction will increase the display intensity, counter-clockwise decreases display intensity. The manual adjustment ranges from no display to maximum available intensity. The automatic adjustment ranges from a nearly off display to a level corresponding to the maximum contrast ratio for the existing ambient light level.



COMBINER AMBIENT LIGHT SENSOR AND COMBINER AMBIENT DETECTOR

COMBINER STOW AND BREAKAWAY

The glass portion of the Combiner can be rotated aft and up into a stowed position. Stowing and unstowing the Combiner glass is accomplished by depressing the stow handle against the stow shaft housing and rotating the glass to the stowed position.

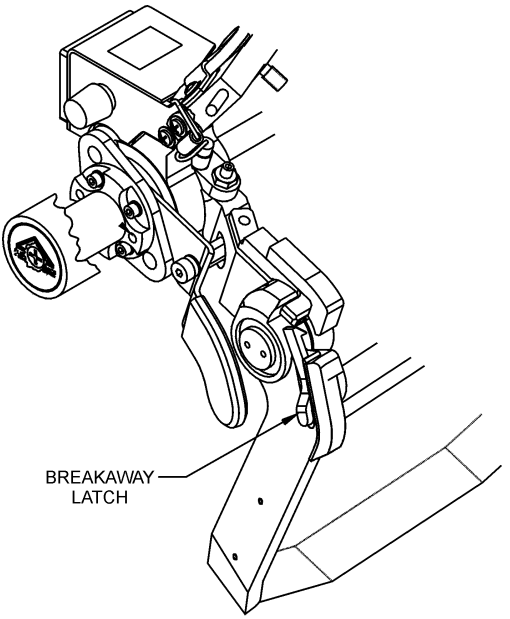
WARNING: BEFORE RELEASING THE BREAKAWAY LATCH, HOLD THE COMBINER GLASS MOUNTING ARM TO PREVENT THE GLASS FROM SPRINGING BACK TO THE NORMAL OPERATING POSITION. FAILURE TO HOLD THE COMBINER GLASS COULD RESULT IN INJURY TO THE OPERATOR OR DAMAGE TO THE COMBINER.

The Combiner also has a breakaway feature that allows it to be displaced forward from its normal operating position. The breakaway feature allows the Combiner to rotate forward against a spring joint. A latch holds the Combiner in the forward position until it is depressed allowing the Combiner to return to the normal operating position.

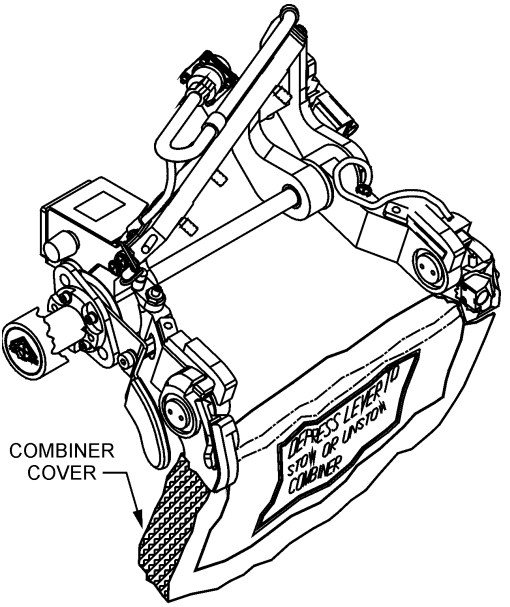
A stow switch located in the Combiner mechanical assembly is used to signal that the Combiner is not in the operating position detent. This causes the OHU to shut off the CRT and signal the HGS Computer that the Combiner is out of the operating position.

The Combiner also contains an infrared optical sensing system to precisely monitor the operating position of the Combiner relative to the fixed portion of the Combiner structure. This Combiner Alignment Detector (CAD) consists of an infrared emitter, mirror and infrared detector that generates signals relative to the Combiner's position. These signals are sent to the OHU for processing and on to the HGS Computer if the Combiner is not within alignment tolerances when in the operating position. This is particularly critical during visual operations in order to ensure that the displayed symbology is accurately positioned conformal to the real world scene. In the IMC or VMC modes, an out of tolerance condition results in an "ALIGN HUD" message being displayed on the Combiner. If this occurs, push the Combiner forward slightly out of its operating position and allow the Combiner to return on its own (this allows it to find its own position) to eliminate the error. Another means is to apply slight pressure either fore or aft on the Combiner glass until the "ALIGN HUD" message is removed. If the message can not be eliminated, then the VMC mode should not be used.

The Combiner glass comes with a removable protective cover installed. This soft fabric cover should be installed on the glass prior to stowing the Combiner. To install the protective cover, slip the Combiner glass into the fabric pocket and secure the Velcro flap over the glass.



COMBINER BREAKAWAY LATCH



COMBINER COVER

HGS ANNUNCIATOR PANEL

The HGS Annunciator Panel provides indications to the right seat pilot for HGS mode, status, and warning during an AIII approach. The annunciations consist of:

- A green "AIII" legend indicating that the AIII mode is active and that all required systems and equipment are valid.
- An "APCH WARN" (Approach Warning) legend against a red illuminated background indicating that either system or approach conditions are out of tolerance.
- A green "FLARE" legend to indicate that the flare portion of the guidance is active.

NOTE: The "RO ARM", "RO CTN", and "RO" annunciations are provisioned for future operations and are not currently used.

Each annunciator is tested by illumination during an HGS TEST operation. In addition, selection of the Caution/Advisory Lights Test can also cause the illumination of the HGS annunciators when provided. The cockpit Master Bright/Dim switch controls the HGS Annunciators intensity.

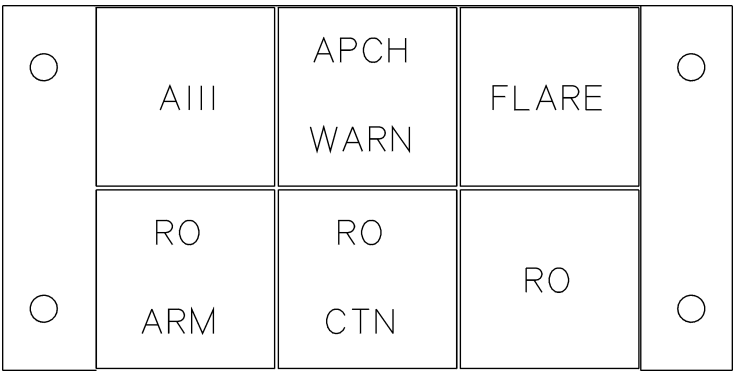
RIGHT SIDE MONITORING REQUIREMENTS

In order to provide the high degree of safety necessary for manual CAT IIIa 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.

HGS ANNUNCIATIONS

Three HGS annunciations are provided to the F/O, all related to AIII mode operations.

- "AIII" - Once the AIII mode is selected on the HCP, the AIII status is indicated as a green "AIII" annunciation. The loss of the AIII annunciation correlates to the loss of the AIII indications on the Combiner and HCP, and the display of "NO AIII". Conditions that will cause the loss of the AIII status are associated with the loss or failure of required sensor or equipment inputs to the HGS, or Built-In Test detected faults within the HGS.
- "APCH WARN" - The red "APCH WARN" (Approach Warning) message can only be displayed below 500 feet above the TDZE and indicates that the approach should not be continued. It is displayed simultaneously with the same warning on the Combiner any time:
    1. An out-of-tolerance condition exists as determined by the Approach Monitor (see APPROACH MONITORING);
    2. A loss of AIII capability exists (see AIII STATUS);
- "FLARE" - The green "FLARE" annunciation is an indication to the F/O that the flare guidance is active and corresponds to the display on the Combiner of the AIII Flare Command when it is merged with the Guidance Cue. This annunciation is intended to prime the F/O to monitor the flare execution.



HGS ANNUNCIATOR

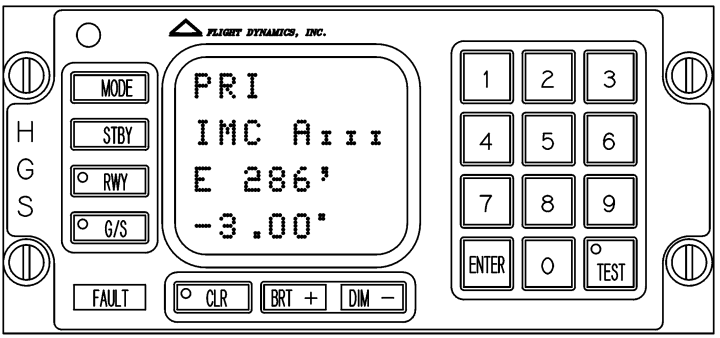
Modes of Operation

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

Mode	Flight Operation	Guidance Source
PRI (Primary)	Takeoff, climb, enroute, descent, approach & landing	DFCS
	Low Visibility Takeoff	HGS
AIII Approach	CAT II or IIIa ILS approach & landing	HGS
IMC (Instrument Meteorological Conditions) Approach	DFCS Autopilot/Flight Director approaches	DFCS
VMC (Visual Meteorological Conditions) Approach	Visual approaches	NONE

The HGS mode of operation is always displayed on the "MODE" display line of the HCP (refer to the illustration below). The next available HGS mode is always displayed on the left portion of the "STBY" (STANDBY) display line. Each press of the STBY key causes another available mode to display on the display line. Selection of the desired standby mode is accomplished by pressing the MODE key. The mode indicated in the left portion of the STBY line at the time that the MODE key is pressed is the new mode entered.

Each of the HGS modes is described in the following paragraphs. For additional information about specific symbology descriptions and illustrations, refer to the Symbology and Typical Flight Profile sections later in this guide.



HGS CONTROL PANEL (HCP)

PRIMARY MODE

The HGS PRIMARY ("PRI") mode can be used during all phases of flight from takeoff to landing. This can include Low Visibility Takeoff operations utilizing HGS Ground Roll Guidance, all enroute operations and either non-precision or precision approaches to CAT I or II minimums utilizing DFCS Flight Director guidance and/or raw data.

The PRIMARY mode displays attitude information in the form of a horizon line and pitch scales positioned relative to an Aircraft Reference symbol. Airspeed and altitude are displayed in tapes along the left and right edges of the display. A sectored HSI is displayed in flight in the lower center of the display. This display format is modeled after EFIS Primary Flight Displays (PFD) combining ADI, HSI, Airspeed and Altimeter indications into one display device. Information displayed in the Primary mode includes:

- 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
- Flight Path (in flight only)
- Flight Path Acceleration
- Slip/Skid Indicators
- DFCS Flight Director (F/D) Guidance Cue and modes (in flight only)
- Autothrottle modes
- Navigation data - ILS, VOR, DME, FMCS, Marker Beacons
- Wind Speed and Direction
- Selected parameters - Course, Heading, Airspeed and Altitude
- Flags

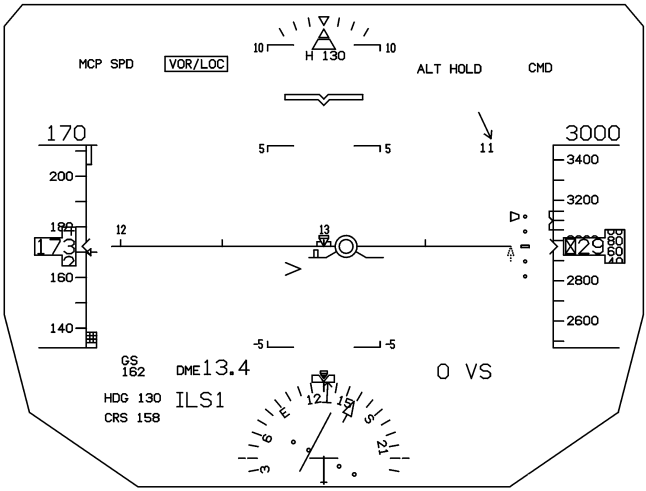
On the ground, several symbols including the HSI, Flight Path, and the DFCS Flight Director guidance cue are not displayed. These symbols are automatically displayed during the takeoff rotation, once the aircraft is in flight.

During any takeoff operation in the PRIMARY mode, the pilot is given a TO/GA Pitch Target Line and a Flight Director Guidance Cue. The TO/GA Pitch Target Line is displayed as a horizontal dash line initially positioned at the top of the display. As the pitch attitude increases during rotation, its vertical position relative to the Aircraft Reference symbol is adjusted to display the pitch command from the Flight Director. The command is satisfied by placing the Aircraft Reference symbol on the TO/GA Pitch Target Line once in flight. Initially, the DFCS Flight Director Guidance Cue is displayed when the Aircraft Reference is within 2º of the TO/GA Pitch Target Line or when climbing through 50 feet Radio Altitude, whichever occurs first. This command is satisfied by placing the Guidance Cue within the Flight Path symbol. The TO/GA Pitch Target Line remains displayed until the DFCS TO/GA mode is exited. The DFCS Flight Director Guidance is displayed throughout the flight when the Captain's Flight Director is selected "ON" and both pitch and roll commands remain valid.

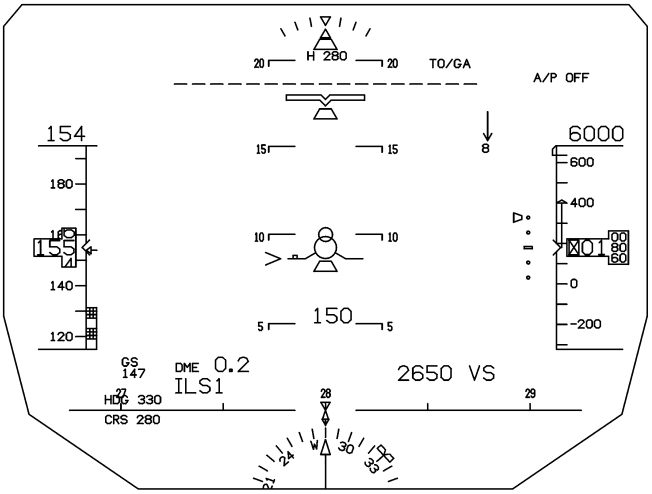
A full time slip-skid symbol is displayed as part of the roll scale (the lower portion of the pointer). During any takeoff (after rotation) or go-around operation (below 1000 feet), additional slip-skid symbols are displayed to enhance lateral (yaw) control in the event of an engine failure. These two additional symbols are displayed relative to the Aircraft Reference and Flight Path symbols and are removed above 1500 feet.

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

To enhance mode control, if the HGS is in a mode other than PRIMARY, depressing a throttle Go-Around switch will cause the PRIMARY mode to be selected independent of the STBY mode indicated on the HCP.



HGS PRIMARY MODE SYMBOLOGY – FLIGHT (typical)



HGS PRIMARY MODE – CLIMBOUT (typical)

PRIMARY MODE - LOW VISIBILITY TAKEOFF

The PRIMARY mode includes specialized symbology used for a Low Visibility Takeoff. The display supports visual runway centerline tracking and enhances situational awareness.

NOTE: Approval must be obtained from the appropriate regulatory authority prior to conducting HGS Low Visibility Takeoff operations.

This Low Visibility Takeoff display incorporates a Ground Roll Reference symbol, Ground Roll Guidance Cue, and a Ground Localizer Line. The HGS-derived Ground Roll Guidance Cue provides lateral guidance relative to the Ground Roll Reference symbol to track the localizer. The cue is displayed once all inputs required to calculate the guidance are available. This includes having a runway length entered within the range of 7,500 to 13,500 feet, both receivers tuned to the ILS, all transfer switches in their NORMAL position, and Selected Course set to correspond to the takeoff runway magnetic heading.

The Ground Roll Reference symbol is positioned just below the Aircraft Reference symbol. The Ground Roll Guidance Cue is positioned vertically centered to the Ground Roll Reference symbol and laterally provides the pilot with a steer left or steer right command to keep the aircraft on the localizer and subsequently tracking the runway centerline. If the cue is right of the Ground Roll Reference symbol then the pilot would need to apply right rudder to again center the two symbols. At rotation, the Ground Roll Reference and Guidance Cue symbols are replaced by the Flight Path symbol.

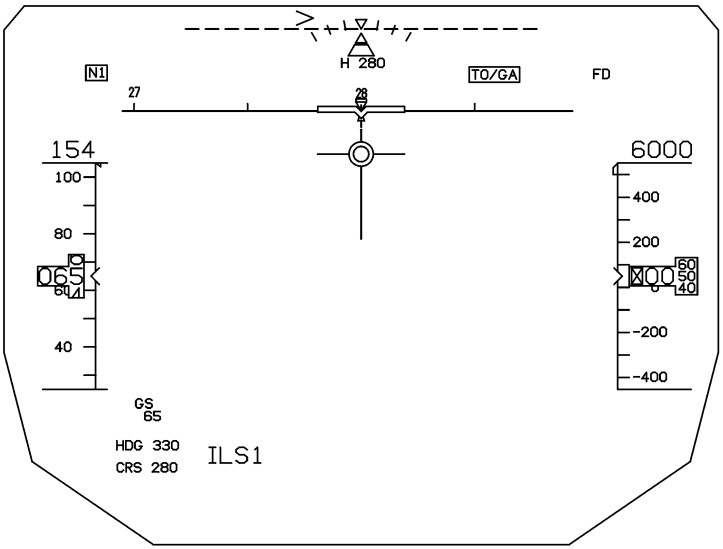
A Ground Localizer Line provides raw localizer information any time the aircraft is on the ground and the Captain's Nav Receiver is tuned to a Localizer frequency. The localizer deviation is presented relative to the Selected Course mark on the horizon.

During a Low Visibility Takeoff, a miscompare between the localizer #1 and #2 signals will cause the loss of localizer and guidance cue symbols and the display of a localizer comparison flag ("LOC CMP"). At 40 knots, the current Selected Course and Runway Length values are latched to allow the continuation of the takeoff in the event either of these parameters fail. Either of these is again selectable following rotation or when the groundspeed becomes less than 40 knots.

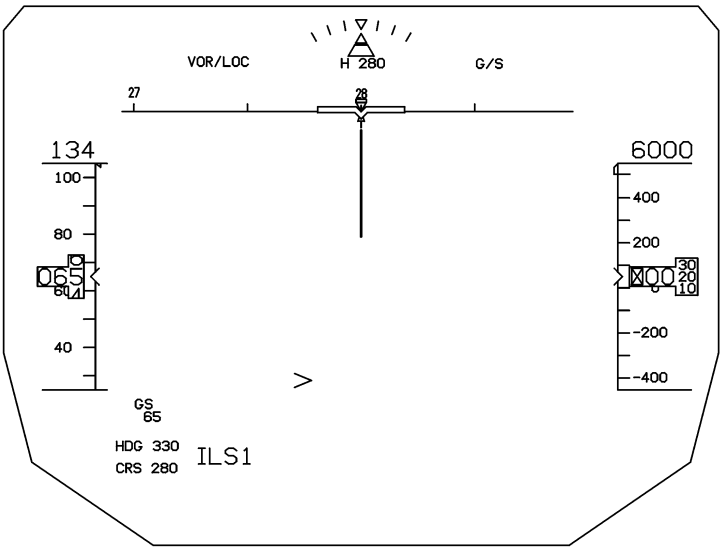
Refer to the Appendix for additional information about Low Visibility Guidance requirements.

PRIMARY MODE - APPROACH AND LANDING

If the PRIMARY mode is used for an approach and landing, Flight Director guidance and navigation raw data is displayed. Once on the ground, the Ground Localizer Line is again displayed (if ILS tuned) to enhance centerline tracking.



HGS PRIMARY MODE – LOW VISIBILITY TAKEOFF ROLL (typical)



HGS PRIMARY MODE – LANDING ROLLOUT (typical)

AIII APPROACH MODE

NOTE: Approval must be obtained from the appropriate regulatory authority prior to conducting Category II or Category IIIa operations.

The HGS AIII mode is specifically designed for manual ILS approach and landing operations to CAT III minimums and must be used for all CAT II or III operations on the Boeing 737 not otherwise approved for these operations. With respect to the Primary mode, altitude and airspeed tape displays are removed and replaced with digital representations. The HSI is also removed, with ILS raw data now being displayed in proximity to the flightpath group around the center of the display. In the AIII mode, flight path guidance is provided by the guidance cue which is now derived from HGS internal approach and landing guidance algorithms, and is independent from any DFCS derived or displayed Flight Director guidance.

The HGS AIII mode is dependent on the availability of all required systems and approach capture logic. Because of these requirements, the AIII mode is not identified as a selectable standby mode until these requirements are met. However, the AIII capability is indicated to the pilot by an AIII status annunciation. This is displayed on the HCP (at any time) and on the Combiner (after approach capture in the PRIMARY mode only) when AIII capable.

Approach capture logic, referred to as Aircraft On Course (AOC), is dependent on the following criteria:

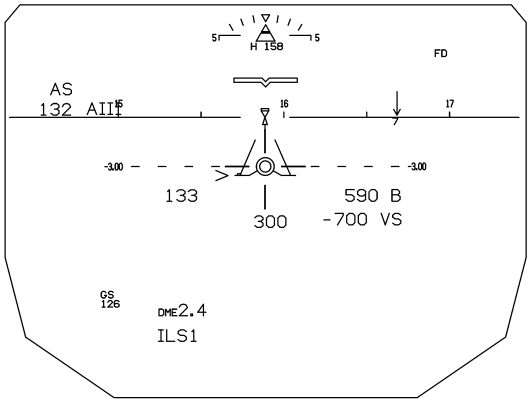
- Both VHF Navigation (Nav) Receivers tuned to an ILS frequency, and;
- VHF Nav #1 localizer deviation is less than approximately 1/4 of a dot and glideslope deviation is less than approximately 1 and 1/4 dots for at least five seconds, or;
- VHF Nav #2 localizer deviation is less than approximately 1/4 of a dot and glideslope deviation is less than approximately 1 and 1/4 dots for at least five seconds, and;
- The difference between the aircraft's magnetic track and the Captain's Selected Course is less than 15 degrees, and
- Radio Altitude is greater than 500 feet.

NOTE: Once AOC is satisfied, subsequent deviations outside AOC tolerances prior to AIII mode selection will cause a loss of the ability to select the AIII mode until AOC is again satisfied.

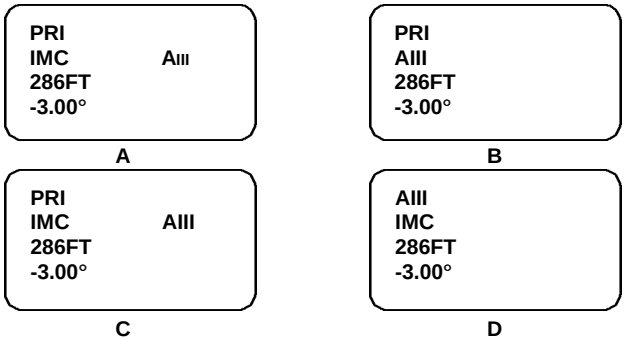
Prior to AOC, if AIII mode required systems and conditions are valid, an "AIII" is displayed in the right portion of the HCP STBY display line (see the HCP display example A, shown in the following illustration). This is the indication that the HGS is AIII capable, and will be selectable, once the AOC conditions listed above are met. This is independent of the current mode of operation.

Once the AOC conditions are met, to denote that the AIII capability has been upgraded to a selectable mode, the "AIII" is replaced by "AIII" and is now displayed on the left portion of the STBY line (see the HCP display example B). At this same time, if the PRIMARY mode is active, a flashing "AIII" is also displayed on the Combiner. These indicate that the AIII mode can now be selected by pressing the MODE key.

Now, assuming the PRIMARY mode is active, if the STBY key is pressed prior to the MODE key, the "AIII" is moved to the right portion of the STBY display line, and is replaced with "IMC" on the left (see the HCP display example C). This will also eliminate the flashing "AIII" on the Combiner. The STBY key pressed again replaces the "IMC" with "VMC", and if pressed again displays "AIII" on the left to complete the cycle. As always, pressing the MODE key selects the mode indicated in the STBY line left position.



HGS "AIII" APPROACH AND LANDING MODE SYMBOLOGY (typical)



HCP DISPLAY (example A-D)

With the AIII mode selectable (example B or C), selection of the AIII mode must be made before the aircraft descends below 500 feet above the runway elevation. If it is not selected prior to 500 feet, the AIII mode is no longer selectable, reverting to "IMC" displayed on the STBY line left side. Also, the flashing "AIII" on the Combiner is no longer displayed.

When the AIII mode is selected, the AIII mode symbology is displayed on the Combiner and "AIII" is displayed on the HCP MODE line (example D), on the Combiner, and on the First Officer's (F/O's) HGS Annunciator Panel. These "AIII" annunciations represent the HGS mode, but also the HGS AIII approach status. The "AIII" may be lost as a result of the invalid state of a required system or other logic condition detected as a function of HGS monitoring (see below).

Once on the ground, the Ground Localizer Line can be displayed the same as in the PRIMARY mode.

SYSTEM MONITORING

In the AIII mode, the HGS monitors the overall performance relative to the integrity of all required sensors and equipment and the pilot's approach and landing performance. An acceptable determination of these requirements is indicated by the "AIII" status and the lack of an "APCH WARN" annunciation.

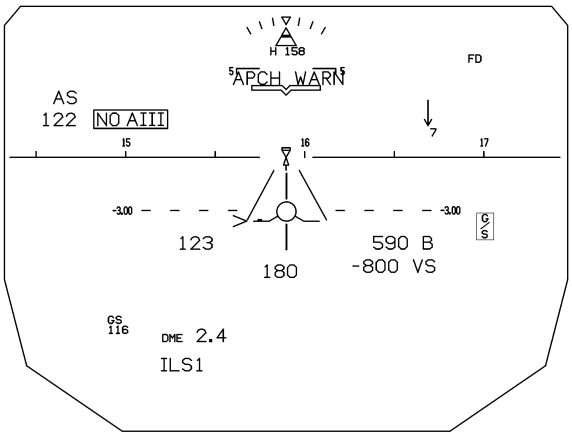
Once the AIII mode is active, any sensor or equipment condition that results in a loss of AIII capability will cause a boxed "NO AIII" status to be displayed on the Combiner (flashing for five seconds) and on the HCP MODE line (example E below). The F/O's AIII annunciation is also extinguished. This "NO AIII" annunciation will remain until another mode is selected or until the AIII capability is regained.

Also, below 500 feet AGL, if either the AIII capability is lost ("NO AIII" status) or the aircraft approach or flare performance does not ensure a safe touchdown within the required touchdown zone (out of tolerances), then the HGS will provide an "APCH WARN" (Approach Warning) annunciation on the Combiner and on the F/O's HGS Annunciator Panel. An approach out of tolerance condition by itself will result in the "APCH WARN" annunciations, but will not cause the loss of the AIII status. Any "APCH WARN" in instrument conditions should result in the execution of a missed approach.

Refer to the Appendix for additional AIII status and System Monitoring information.

NO AIII
IMC
286FT
-3.00°

HCP DISPLAY (example E)



HGS LOSS OF AIII AND APPROACH WARNING (example)

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

IMC APPROACH MODE

The IMC mode is an alternate approach mode primarily intended for Autopilot Flight Director approaches. Like the Primary mode, the IMC mode Guidance Cue utilizes DFCS derived 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 can be displayed the same as in the PRIMARY mode.

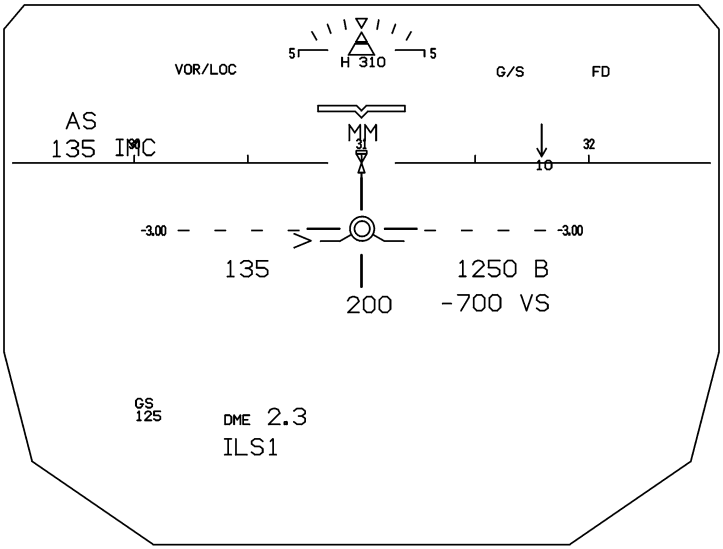
VMC APPROACH MODE

The VMC mode 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.). In a VMC mode approach, Flight Path is used to control the approach to the runway visually. This is particularly beneficial during night-time approaches or approaches with poor visual cues.

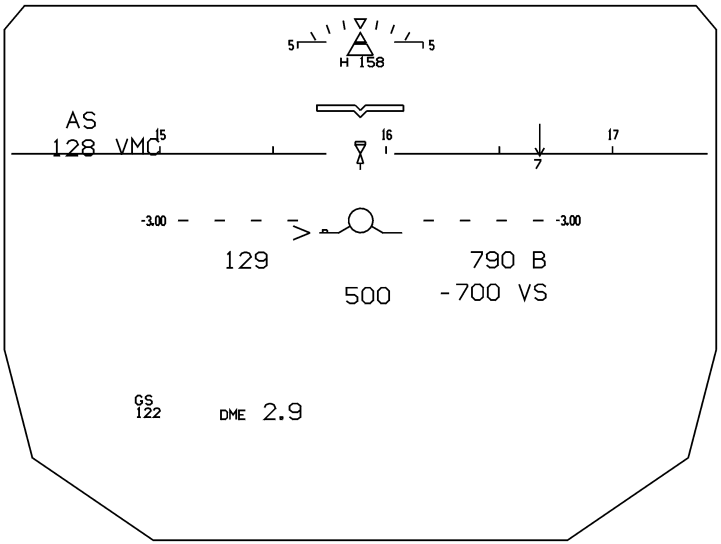
The VMC mode provides approach symbology in the same format as the AIII and IMC modes. However, navigation data is not displayed.

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 approach will be completed visually. The proper mechanical alignment of the HGS Combiner is very critical during visual operations. The Combiner's operating position is monitored by a Combiner Alignment Detector (CAD) to determine if the Combiner is within allowable position tolerances while in the IMC or VMC mode. If its position is out of tolerance, an "ALIGN HUD" message is displayed on the Combiner. Elimination of the message is generally accomplished by pushing the Combiner in the breakaway direction (slightly) and releasing the Combiner allowing it to spring back and position itself. Smaller adjustments can also be made by applying pressure in either direction on the Combiner to eliminate the message. Once positioned within tolerances ("ALIGN HUD" not displayed) the Combiner should retain this position reliably.



HGS "IMC" APPROACH MODE SYMBOLOGY (typical)

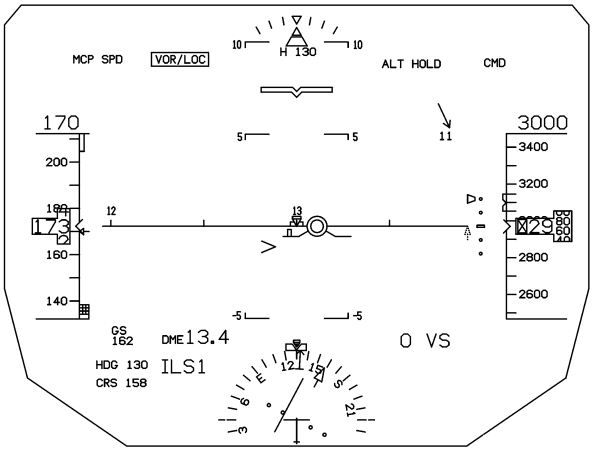


HGS "VMC" APPROACH MODE SYMBOLOGY (typical)

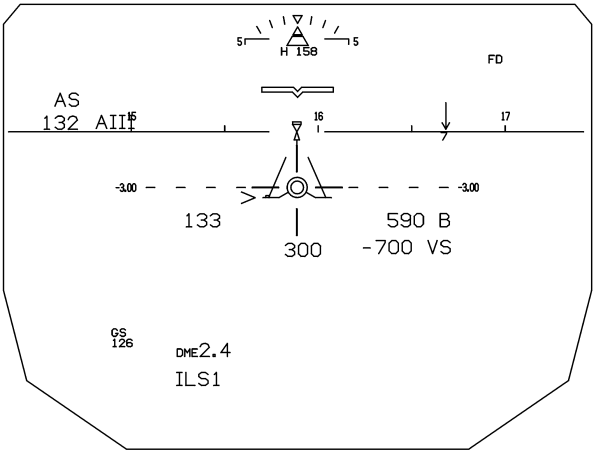
Symbology

HGS symbology, including Flight Path and Flight Path acceleration, is presented in the two basic display formats shown below. The Primary mode display can be used from takeoff through landing, and provides information in a conventional format similar to an EFIS Primary Flight Display (PFD). The Approach mode displays (AIII, IMC, VMC) are optimized to enhance aircraft control, situational awareness, and energy management during final approach, flare, and touchdown.

HGS display elements and their interrelationships are described in the following pages.



PRIMARY MODE SYMBOLOGY (typical)



AIII APPROACH AND LANDING MODE SYMBOLOGY (typical)

AIRCRAFT REFERENCE

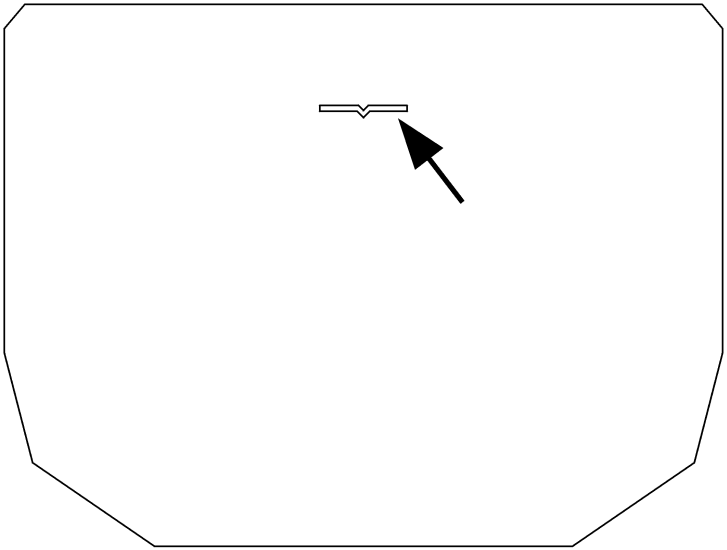
The Aircraft Reference symbol, commonly referred to as the Boresight symbol, represents the projected centerline of the aircraft (boresight). The top center point of the symbol (the point of the top V) is the actual boresight point.

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.

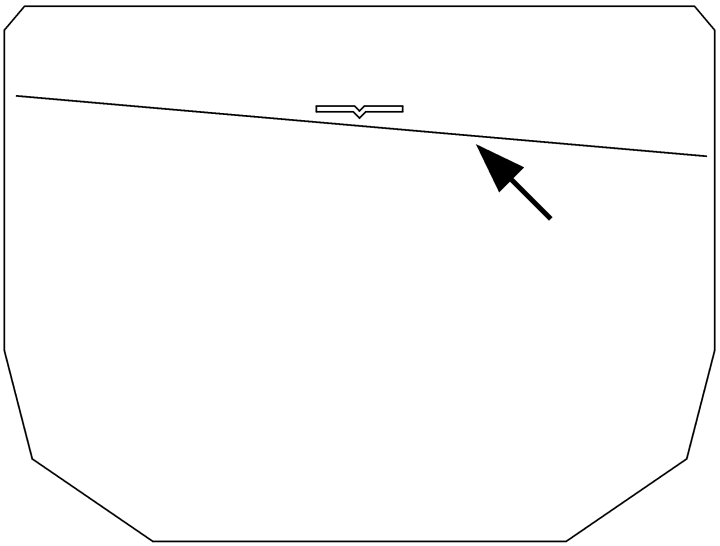
HORIZON LINE

The Horizon Line is displayed relative to the Aircraft Reference symbol and is positioned based on the current aircraft pitch and roll attitude. The vertical position of the Horizon Line relative to Boresight is the pitch attitude. When the Horizon Line and Boresight (apex of upper center point) overlay, 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 Boresight 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.

NOTE: The HGS displayed horizon line represents the aircraft's "local level" attitude meaning that the horizon line always indicates a 0° pitch attitude relative to the earth. Being that the Horizon Line symbol is on a flat plane viewed from the pilot's eye, the curvature of the earth is evident by the HGS Horizon Line being positioned above the real world horizon at altitude. The difference between the HGS horizon and the earth horizon is directly proportional to the aircraft's height (1-2° is not uncommon at cruising altitudes) and should not be interpreted as an error in display positioning.



AIRCRAFT REFERENCE SYMBOL



HORIZON LINE

PITCH SCALE

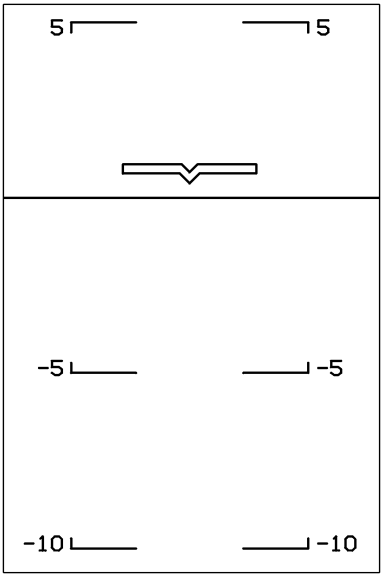
A Pitch Scale is displayed above and below the horizon line. It is scaled in five degree increments from -20° to +25° and every ten degrees between ±30° and ±90°. At the ends of each pitch line is a vertical tic mark "pointing" in the direction of the horizon line and labeled with its corresponding pitch value. The pitch attitude is read against the Pitch Scale by the Aircraft Reference symbol.

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

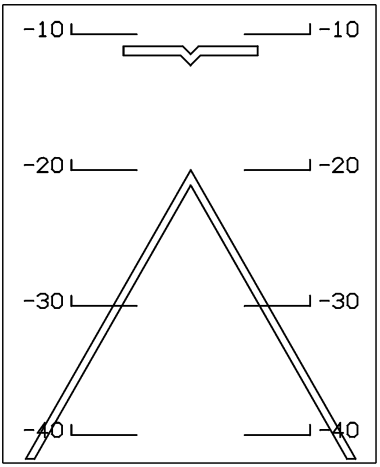
Chevrons are included on the Pitch Scale to enhance interpretation of attitude while in unusual attitude situations. A downward pointing chevron is placed with the tip on the 30° pitch line and an upward pointing chevron is placed with the tip on the -20° pitch line.

ROLL SCALE AND POINTER

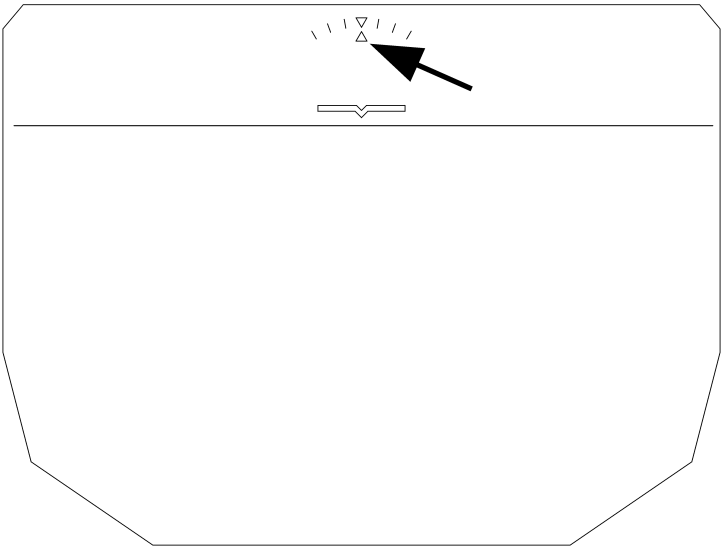
The Roll Scale and Pointer is positioned above the Aircraft Reference symbol. The scale has tic marks for each 10° between 0° and ±30°. Tic marks at ±45° and ±60° are also added to the Roll Scale when the aircraft exceeds ±35° and ±50° respectively. The Roll Scale is similar to the "Sky Pointer" on a conventional ADI. The pointer points to the corresponding roll attitude on the scale.



PITCH SCALE



PITCH SCALE COMPRESSED



ROLL SCALE AND POINTER

HEADING SYMBOLOGY

Magnetic Heading, represented in 5° increments (tic marks) and labeled every 10°, is displayed on the Horizon Line. The 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 Magnetic Heading of the aircraft (where the nose is pointing) and is positioned either directly below (or above) the Aircraft Reference symbol.

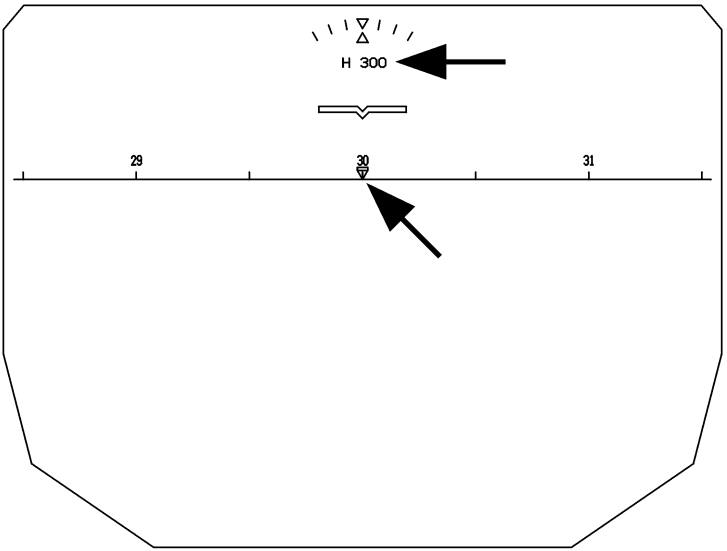
The aircraft's current Magnetic Heading is also displayed as a digital value preceded by an "H" directly below the Roll Scale Pointer. The digital value is expressed to the nearest one degree with a heading of 0 (or 360) being displayed as "H 000".

HSI

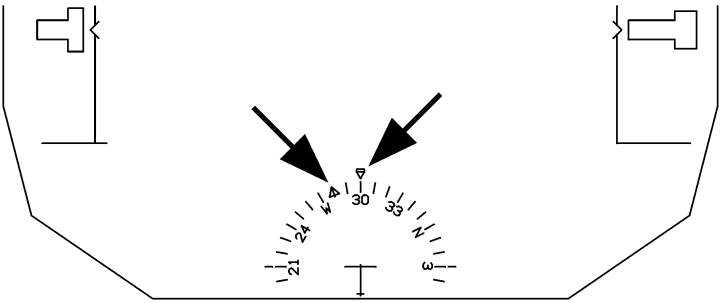
A conventional sectored HSI is positioned in the bottom center portion of the display in the Primary mode in flight. This HSI display consists of a partial compass rose spanning 210° with tic marks every 10°. Each 30° tic mark is labeled with its corresponding value in tens of degrees (e.g., label 13 is 130°). Cardinal headings are labeled with the characters "N", "S", "E", and "W" instead of the numerical values as is displayed on the Horizon Line. 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 magnetic track.

The HSI is displayed in full 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 is "pushed" down until only a small portion of the HSI is visible. 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. This movement of the HSI symbology allows the Horizon Line and Flight Path symbol to be positioned where the HSI is normally displayed without overlaying symbology.



HORIZON HEADING SCALE



HSI – with DRIFT ANGLE POINTER

GROUND ROLL REFERENCE

The Ground Roll Reference symbol provides a reference for the Ground Roll Guidance Cue during Low Visibility Takeoff operations. 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.

FLIGHT PATH

The Flight Path symbol is unique information not normally available on conventional head-down displays. The Flight Path symbol 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. 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 priority over all other symbols except the guidance cue and flare command symbology. 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. 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.

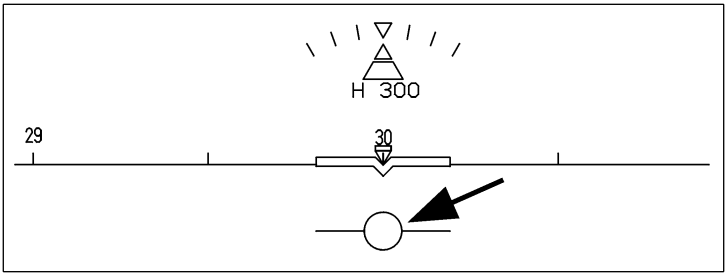
FLIGHT PATH ACCELERATION

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

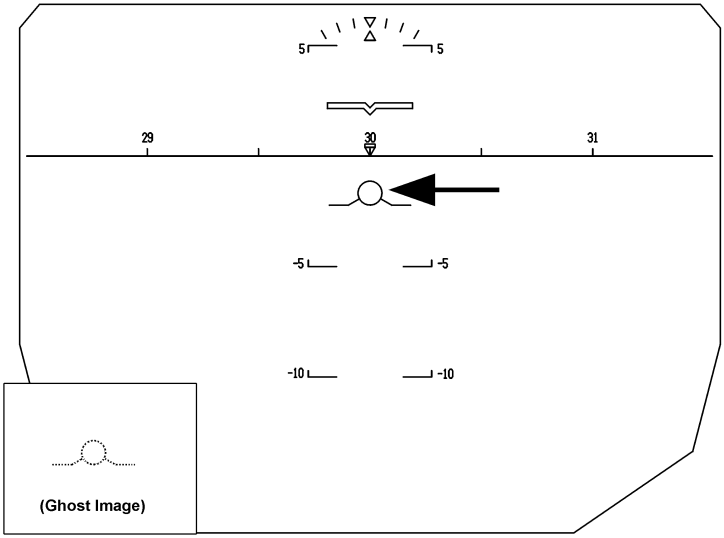
It is positioned, in flight, to the left of the Flight Path symbol. When Flight Path Acceleration is above the wing of the Flight Path symbol, the aircraft is accelerating. When it is below the Flight Path wing, the aircraft is decelerating. To maintain a steady state (neither accelerating or decelerating), 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 referenced to the Aircraft Reference symbol.

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.

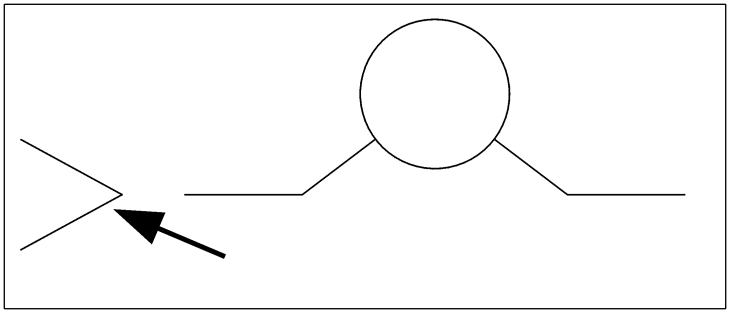
To avoid confusion in controlling aircraft thrust, the Flight Path Acceleration symbol is removed from the display when the HGS detects a low level decreasing performance wind shear below 400 feet AGL.



GROUND ROLL REFERENCE



FLIGHT PATH SYMBOL



FLIGHT PATH ACCELERATION

AOA LIMIT

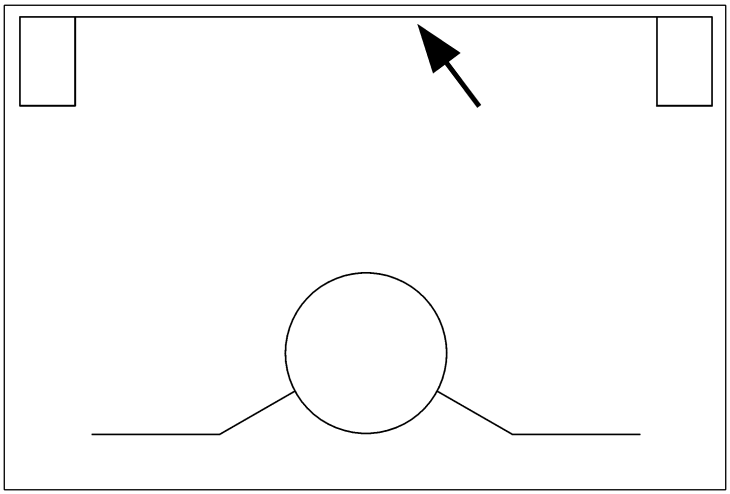
The aircraft's Angle-Of-Attack (AOA) relative to stick shaker is indicated by the AOA Limit symbol. The distance between the AOA Limit symbol and the Flight Path symbol represents the aircraft's angle-of-attack to stick shaker. When the AOA Limit symbol is positioned on the Flight Path symbol (boxed ends set on the Flight Path wings) the aircraft is at the stick shaker angle-of-attack.

The AOA Limit symbol is displayed whenever the aircraft's angle-of-attack is within 5° of stick shaker, any time stick shaker is active, or whenever the Windshear Guidance Cue is displayed.

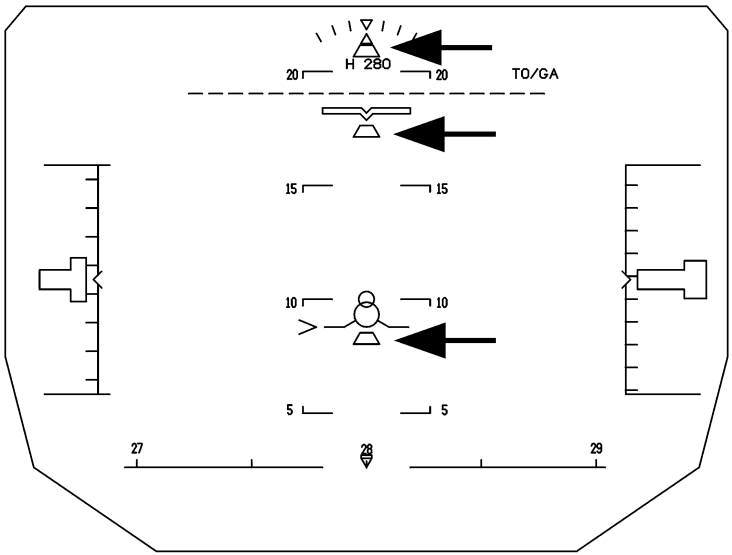
SLIP/SKID INDICATORS

The aircraft's slip/skid is indicated by the Slip/Skid indicator located on the display as part of the Roll Scale Pointer. The bottom portion of the Roll Scale Pointer moves laterally with respect to the top triangle portion of the pointer and is dependent on the lateral acceleration of the aircraft. The Slip/Skid indicator functions like a conventional Slip/Skid indicator in that positioning the Slip/Skid symbol directly under the symbol, by applying the appropriate rudder input, nulls the lateral acceleration.

Additional Slip/Skid indicators are displayed relative to the Aircraft Reference and Flight Path symbols. These are displayed anytime a takeoff is determined or the DFCS TO/GA mode is engaged for takeoff and will remain displayed until 1500 feet AGL. They are also displayed if on approach and the DFCS TO/GA mode is engaged below 1000 feet and remain until 1500 feet. The gain of all three of the Slip/Skid symbols is increased by about 2.5 times (over the normal roll scale only slip-skid indicator) during these same operations. These symbols are primarily intended to enhance lateral control in the event of an engine out operation by providing the lateral acceleration indication in proximity to the place where the pilot is concentrating his attention.



AOA LIMIT



SLIP/SKID INDICATORS

SPEED ERROR TAPE

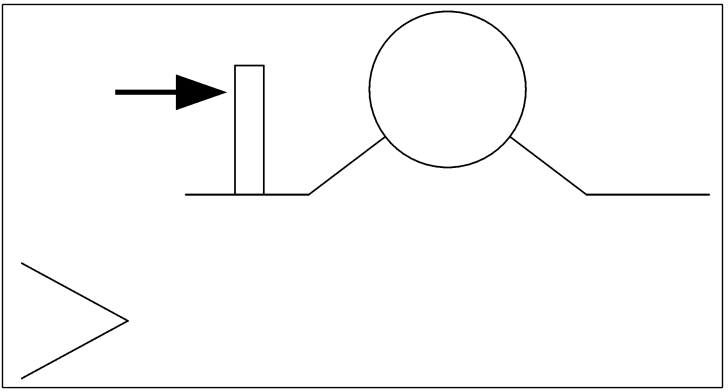
The Speed Error Tape displays the difference between the indicated airspeed and the reference or "bug" speed selected on the DFCS Mode Control Panel (MCP).

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 (about the diameter of the Flight Path circle) represents approximately five knots of airspeed error. The tape length is limited to 15 knots of error. The Speed Error Tape is displayed in all modes.

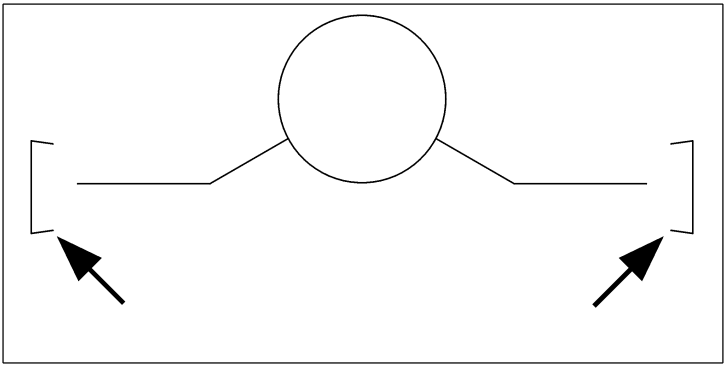
BANK WARNING

The Bank Warning symbols give an indication that a potentially dangerous bank angle condition exists during low altitude operation. The symbols are displayed anytime Radio Altitude is less than 100 feet and the aircraft's roll angle exceeds 5° and remains displayed until the roll angle is reduced to less than 3°.

The symbols are positioned and formed to be used relative to the wings of the Flight Path symbol such that when the Flight Path is aligned in roll with opposing ends of the two brackets, the roll attitude is +/- 8°.



SPEED TAPE ERROR



BANK WARNING

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 "PRI" mode, and when configured for a Low Visibility Takeoff, 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 the Low Visibility Takeoff roll 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.

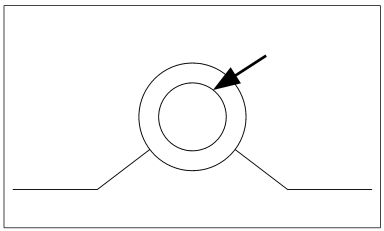
Whenever In-flight in either the "PRI" or "IMC" mode, and when the left seat pilot's pitch and roll Flight Director commands are in view (head-down), the Guidance Cue is driven by pitch and roll command signals from the Digital Flight Control System (DFCS). Whenever the HGS "AIII" approach mode is active, 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 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 "PRI" or "IMC" and "AIII", the Guidance Cue will switch between sources (DFCS or HGS) and will continue to display without change to the symbol itself, but a slight change in its position might be observed.

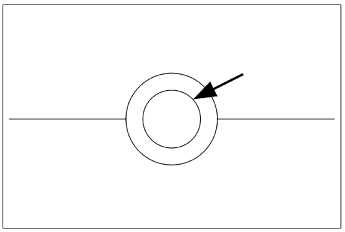
TO/GA PITCH TARGET LINE

Above 65 knots and whenever the DFCS TO/GA mode is active and a valid pitch command input of greater than 10° is received, a TO/GA Pitch Target Line is displayed. During the takeoff roll, the TO/GA Pitch Target Line is displayed as a horizontal dash line initially positioned fixed at the top of the display. 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 DFCS. 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.

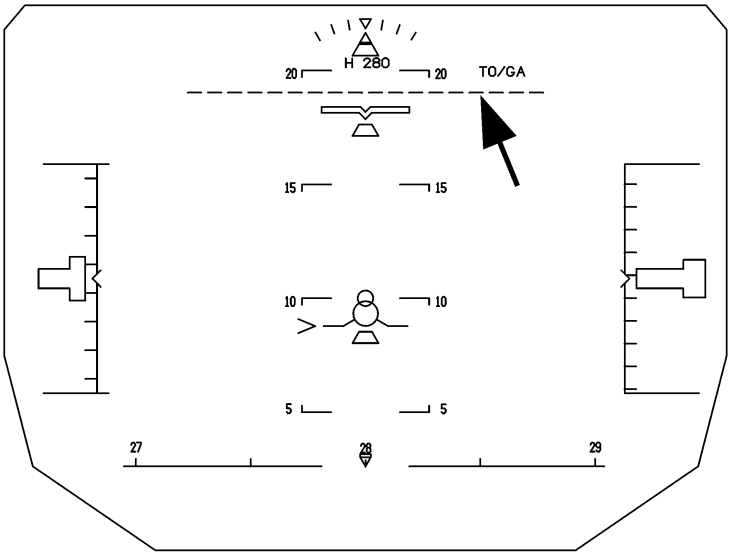
Once in flight, when the DFCS Flight Director Guidance Cue is displayed the spacing between the TO/GA Pitch Target Line and the Aircraft Reference symbol is equal to the difference between the Guidance Cue and Flight Path symbols. The TO/GA Pitch Target Line is displayed until the DFCS TO/GA mode is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



GUIDANCE CUE W/FLIGHT PATH



GROUND ROLL GUIDANCE CUE



TO/GA PITCH TARGET LINE

AIII FLARE COMMAND

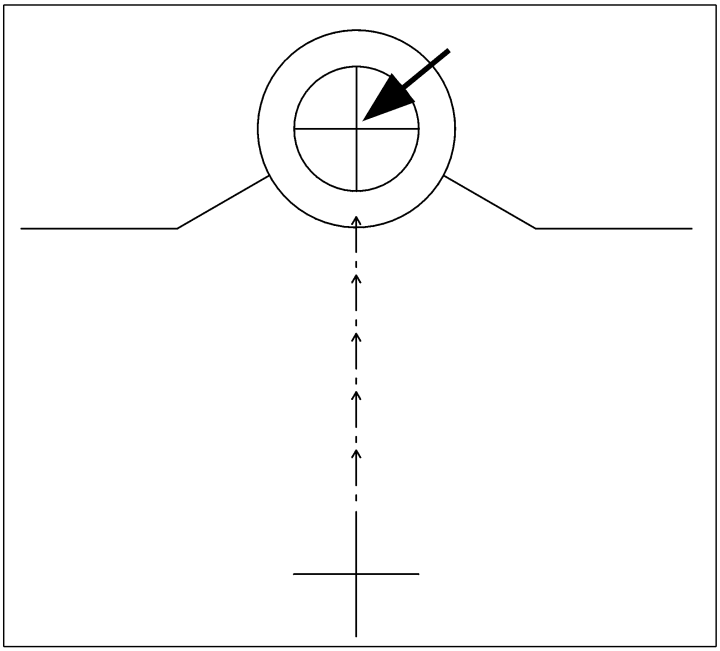
In the AIII mode, an HGS AIII Flare Command is displayed. This consists of a plus symbol (" + ") initially positioned 2-3° directly below the Guidance Cue as the aircraft descends through 105 feet above the runway elevation. The AIII Flare Command symbol initially flashes for 1 second. The symbol rises 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 to command the flare maneuver, continuing until touch-down. The displayed symbol provides the indication that the HGS AIII flare guidance is being executed and that the pilot should perform the flare maneuver by following the Guidance Cue upward on the display. Any condition resulting in the inability of the HGS to provide the AIII flare guidance, results in the loss of the AIII status and an approach warning ("APCH WARN").

FLARE CUES

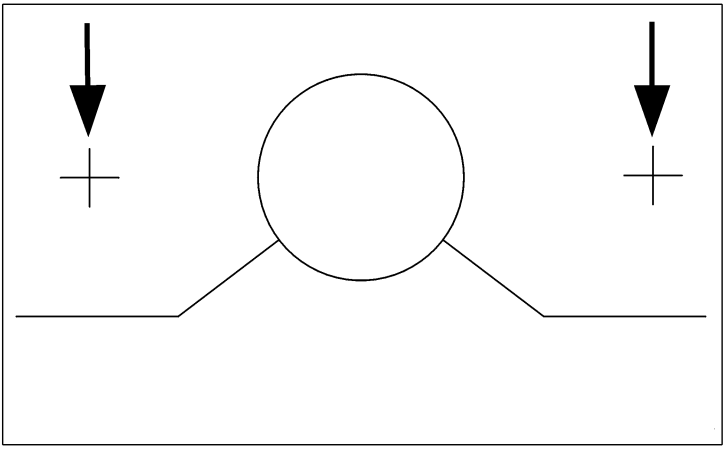
Flare Cue symbols are provided to indicate to the pilot he must flare the aircraft. The display of the Flare Cue symbol is also dependent on the mode of operation.

In all modes except "AIII", the Flare Cue is displayed as a pair of " + " (plus symbols) positioned one on each side and directly above the wings of the Flight Path symbol. These Flare Cue symbols are displayed flashing as the aircraft descends through 55 feet Radio Altitude, continuing until the aircraft descends through 10 feet.

NOTE: The above Flare Cue symbols are fixed to the Flight Path symbol and are 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.



AIII FLARE COMMAND



FLARE CUES

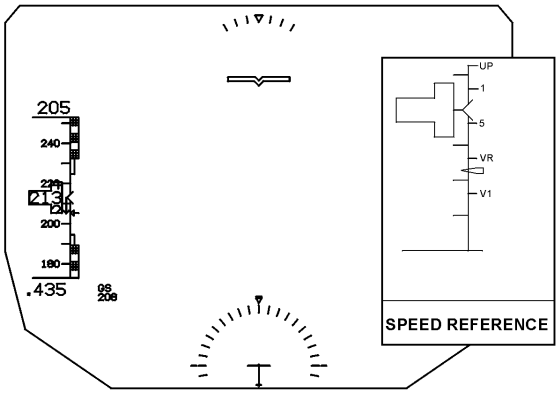
AIRSPEED DISPLAYS

Airspeed data is displayed in both analog and digital forms, depending on the mode of operation. In the "PRI" mode, the displayed airspeed information is comprised of the following:

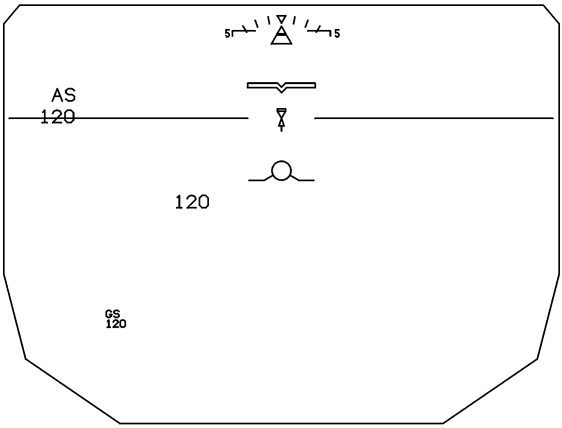
- **Computed Airspeed (CAS)** – from the Air Data Inertial Reference Unit (ADIRU) is shown relative to a vertical scale along the left edge of the display and as a digital value within an airspeed odometer window. The airspeed scale displays a ±40 knot range with an airspeed index (" < ") at its center. The overall range of the airspeed scale is 30 to 450 knots with tic marks every 10 knots, labeled every 20 knots.
- **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 45 knots.
- **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.
- **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.
- **Minimum Operating Speed** - is indicated by a "⌉" symbol placed alongside the lower portion of the airspeed tape. The upper edge indicates the minimum maneuvering speed.
- **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.
- **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 scale.
- **VR Speed** - is indicated by a tic mark labeled "VR" when the VR speed is within the airspeed scale.
- **Flap Maneuver Speeds -** are indicated by tic marks labeled with the flap position “UP”, “1”, “2”, “5”, “10”, “15”, “25” along the airspeed scale when the Flap Maneuver Speeds are within the airspeed scale.
- **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.
- **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.
- **Takeoff Speed Bug** – positioned at 80 or 100 knots based on CDS option selected.
- **Climb-out Speed Indicator** – positioned at selected A/S +15 knots during T/O until first flap retraction.
- **Manual Bug 5 Speed Indicator** – positioned by selecting position 5 on EFIS Control Panel Reference Speed select knob.

- **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.
- **VREF +15 Bug** – positioned 15 knots above REF bug when REF bug is displayed.
- **Selected Airspeed** - is displayed in all modes as a digital value directly above the airspeed scale and, as pointed to by the selected airspeed mark "←", positioned along the airspeed scale when within the scale's range. The selected airspeed value is selected on the DFCS Mode Control Panel (MCP).

In any mode other than Primary mode, the airspeed scale and associated symbols are replaced with a digital readout of Computed Airspeed. CAS is positioned relative to the Flight Path symbol when it is 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.



AIRSPEED TAPE SYBOLOGY – PRIMARY MODE



DIGITAL AIRSPEED SYMBOLOGY

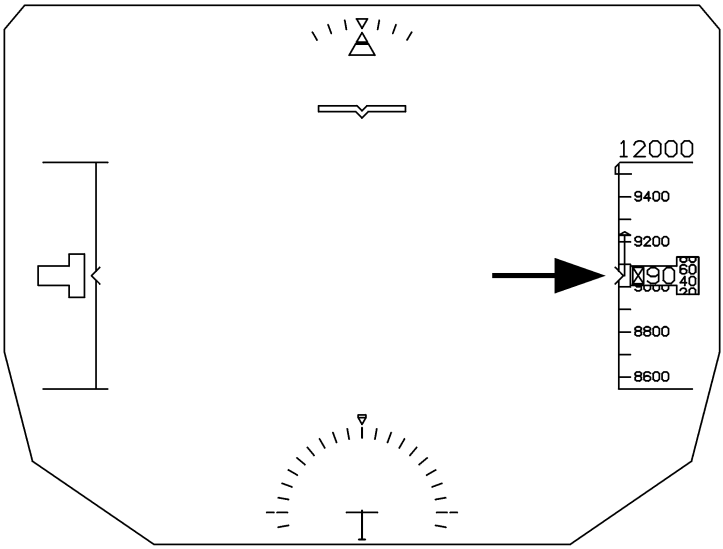
ALTITUDE DISPLAYS

Altitude data is displayed in both analog and digital forms, depending on the mode of operation.

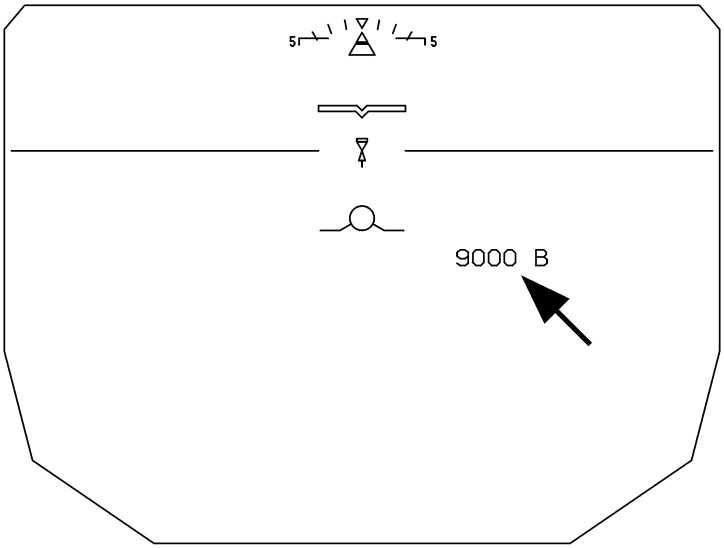
In the "PRI" mode, the displayed altitude information is comprised of the following:

- **Barometric (Baro) Altitude** - from the Air Data Inertial Reference Unit (ADIRU-ADR) is displayed relative to a vertical scale along the right edge of the display and as a digital value within an altitude odometer window in 20 foot increments. An "X" is used to show the absence of the most significant digit when the altitude is less than 10,000 feet. The altitude scale displays a ±500 foot range with an altitude index (" > ") at its center. The overall range of the altitude scale is -2000 to 50,000 feet with tic marks every 100 feet, labeled every 200 feet.
- **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.
- **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).

In any mode other than Primary mode, the altitude scale and associated symbols are replaced with a digital readout of Baro Altitude. Baro Altitude is positioned relative to the Flight Path symbol when it is displayed, and relative to the Aircraft Reference symbol if Flight Path is not displayed. Baro Altitude is displayed in ten-foot increments just below and to the right of Flight Path or the Aircraft Reference and is only displayed in flight.



ALTITUDE TAPE SYMBOLOGY – PRIMARY MODE



DIGITAL ALTITUDE SYMBOLOGY

WIND SPEED AND DIRECTION

The current Wind Speed and Direction obtained from the FMCS (primary) or ADIRU (reversionary) is displayed in the upper right portion of the display. Backup information is obtained from the ADIRU-ADR in the case of invalid data from the FMCS.

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

The Wind Direction is referenced to the aircraft's magnetic heading. 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 are displayed when the aircraft is in flight and the Wind Speed exceeds 6 knots. They are both removed when the Wind Speed drops below 4 knots.

WINDSHEAR WARNING

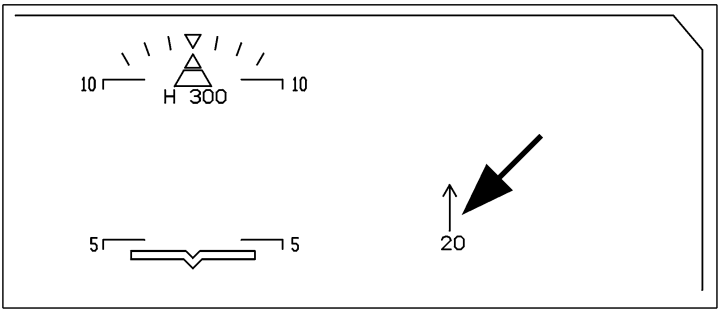
A Windshear Warning message ("WINDSHEAR") is displayed just above the Aircraft Reference symbol whenever the Ground Proximity Warning System (GPWS) detects and provides a warning annunciation signal, or the WXR Predictive Windshear is active and no Ground Proximity Warning is displayed. The Windshear Warning continues to display until the signal is no longer provided.

WINDSHEAR GUIDANCE CUE

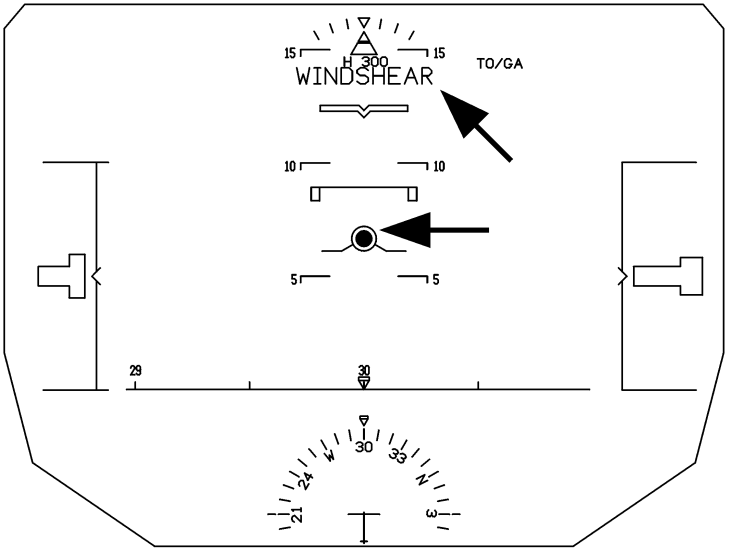
During a Windshear Warning, when the pilot selects the DFCS TO/GA mode, the PRIMARY mode is automatically selected and the Guidance Cue becomes a Windshear Guidance Cue by being displayed as a solid circle. In this case, the DFCS provides the windshear recovery guidance and is to be followed to exit the windshear condition. The Windshear Guidance Cue is provided until the GPWS Windshear Warning is no longer active, in which case the cue is again displayed normally.

GROUND PROXIMITY WARNING

A Ground Proximity Warning (“PULL UP”) is displayed above the aircraft reference symbol when GPWS indicates a Ground Proximity Warning.



WIND SPEED AND DIRECTION



WINDSHEAR WARNING AND GUIDANCE CUE

RADIO ALTITUDE

A digital Radio Altitude is displayed directly below the Flight Path symbol. The Radio Altitude value is removed from the display at 1500 feet when ascending and is again displayed at 1400 feet when descending. If the Flight Path symbol is not displayed, the Radio Altitude is displayed relative to the Aircraft Reference symbol.

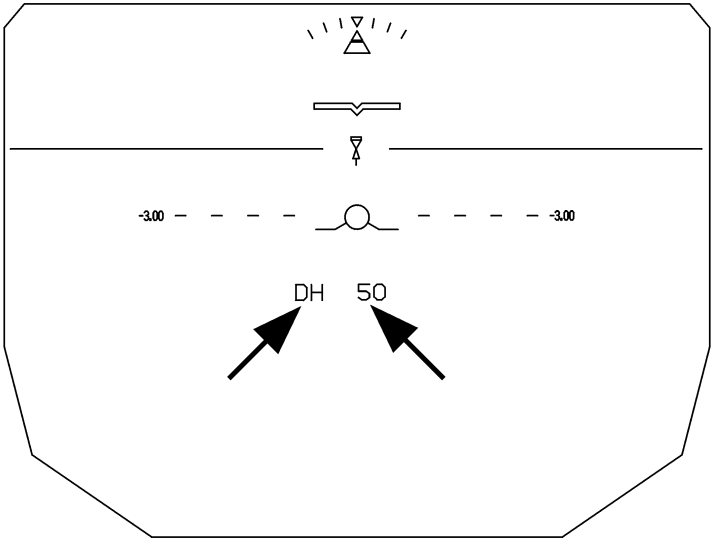
The digital value is displayed in flight in ten-foot increments between 50 and 1500 feet, five-foot increments between 10 and 50 feet and one-foot increments between -20 and 10 feet. Radio Altitude is not displayed on the ground.

DECISION HEIGHT MESSAGE

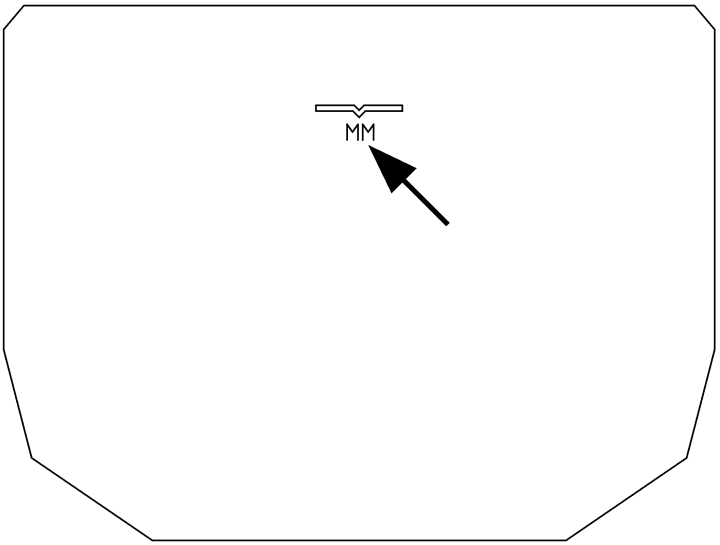
A Decision Height annunciation "DH" is displayed to the left of the digital Radio Altitude when the selected decision height altitude has been reached. Selection is made on the Captain's EFIS Control Panel (EFCP). When tripped, "DH" flashes for 3 seconds and then remains steady. "DH" is removed from the display if the EFCP Reset switch is pressed, or if Radio Altitude becomes more than 75 feet greater than the Decision Height altitude, or the aircraft is no longer in flight. Decision Height is not displayed if Radio Altitude is not displayed.

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.



RADIO ALTITUDE AND DECISION HEIGHT



MARKER BEACON

DIGITAL VERTICAL SPEED

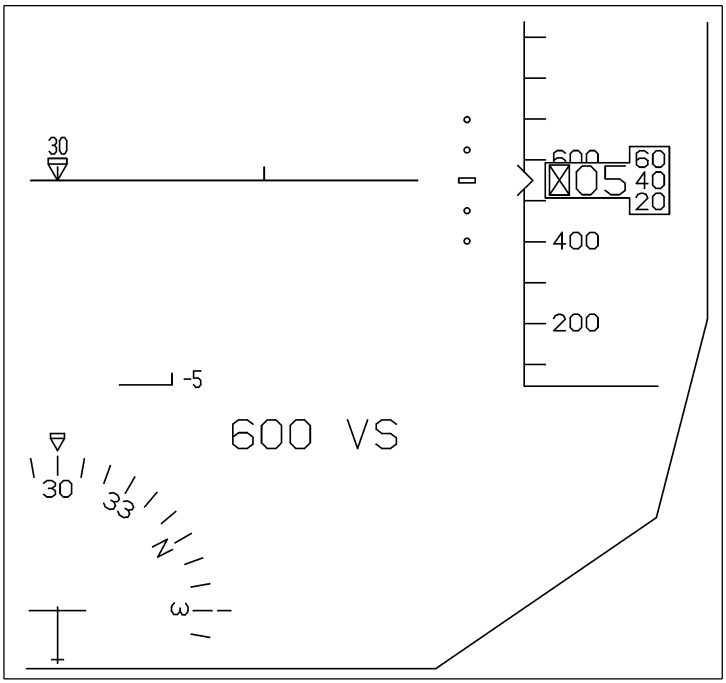
In the Primary mode, Digital Vertical Speed is displayed in a fixed location in the lower right portion of the display. In all other modes, Digital Vertical Speed is displayed below and to the right of the Flight Path symbol. In all modes, the Digital Vertical Speed value is expressed in 50 feet/minute increments and is identified by the characters "VS" immediately to the right of the vertical speed value. Digital Vertical Speed is not displayed on the ground.

DIGITAL DISTANCE (DME)

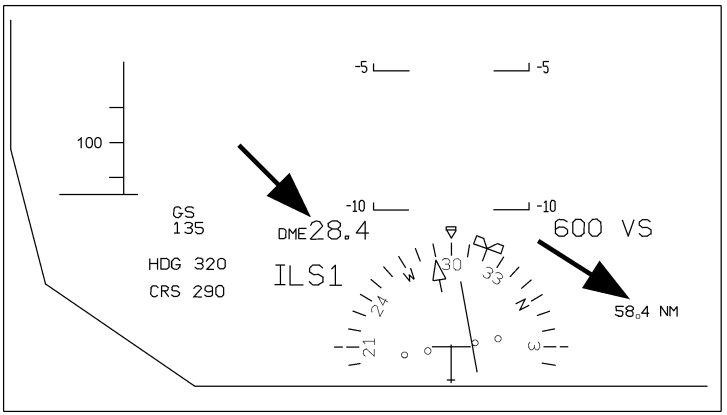
DME Distance is displayed as a digital value preceded by "DME" in the lower left portion of the display. The DME Distance is displayed in 0.1 nautical mile increments between 0 and 99.9 miles and in one nautical mile increments 100 miles and above when valid. Digital Distance is not displayed on the 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 when valid. Distance To Go is not displayed on the ground.



DIGITAL VERTICAL SPEED – PRIMARY MODE



DIGITAL DISTANCE

SELECTED COURSE

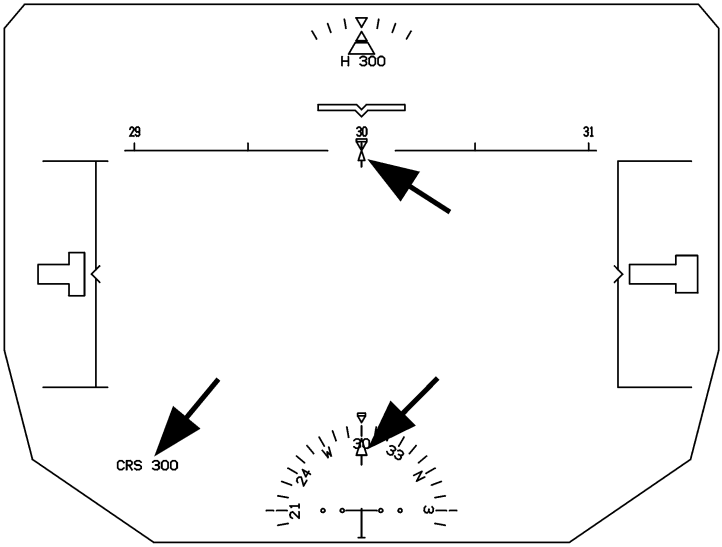
Selected Course is displayed on the HSI, Horizon Line, and as a digital value.

- 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, then the Selected Course mark is ghosted to the side closest to the Selected Course.
- Digital Selected Course is displayed in the lower left portion of the display preceded by the characters "CRS". It is displayed full time in the Primary mode and for five seconds after selection in the IMC, VMC or AIII modes. It is displayed in one degree increments as selected on the DFCS Mode Control Panel (MCP). A zero degree selection is displayed as "000".

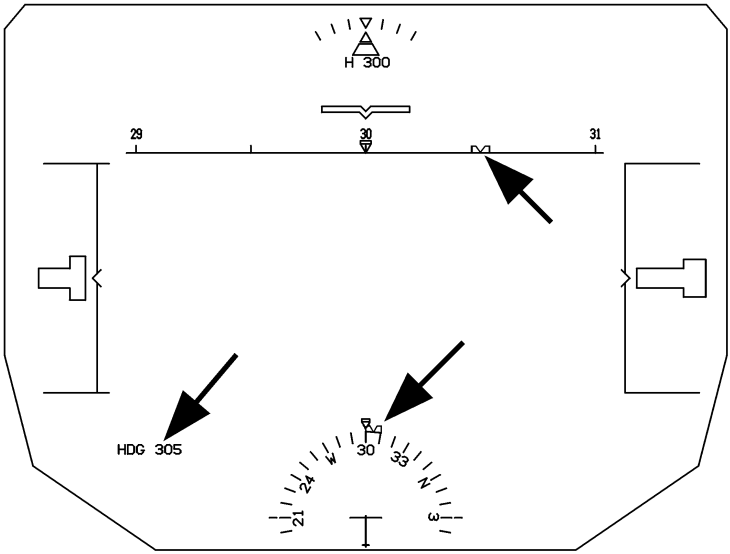
SELECTED HEADING

Selected Heading is displayed on the HSI, Horizon Line, and as a digital value.

- In the Primary mode, a Selected Heading mark is displayed on the HSI pointing to the corresponding Selected Heading value. If the Selected Heading value 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 pointing to the corresponding Selected Heading value. If the Selected Heading value 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 displayed full time in the Primary mode and for five seconds after selection in the IMC, VMC or AIII modes. It is displayed in one degree increments as selected on DFCS Mode Control Panel (MCP). A zero degree selection is displayed as "000".



SELECTED COURSE



SELECTED HEADING

NAVIGATION SOURCE ANNUNCIATIONS

The source of the navigation information being displayed is indicated by the Navigation Source Annunciation. These annunciations are displayed in a fixed location in the lower left portion of the display. The possible Navigation Source Annunciations are:

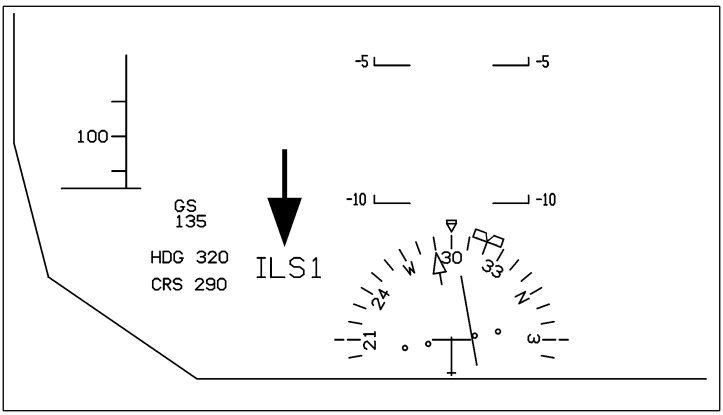
- **ILS1 -** indicates that the source for the localizer and glideslope deviation displayed is Nav Receiver #1 (Nav transfer switch in "NORMAL" or "BOTH ON 1") and an ILS frequency is tuned.
- **ILS2 -** indicates that the source for the localizer and glideslope deviation displayed is Nav Receiver #2 (Nav transfer switch in "BOTH ON 2" position only) and an ILS frequency is tuned.
- **VOR1 -** indicates that the source for the VOR lateral deviation and TO/FROM information displayed is Nav Receiver #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 Nav Receiver #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 ILS receivers.

All Navigation Source Annunciations are displayed in all modes except VMC.

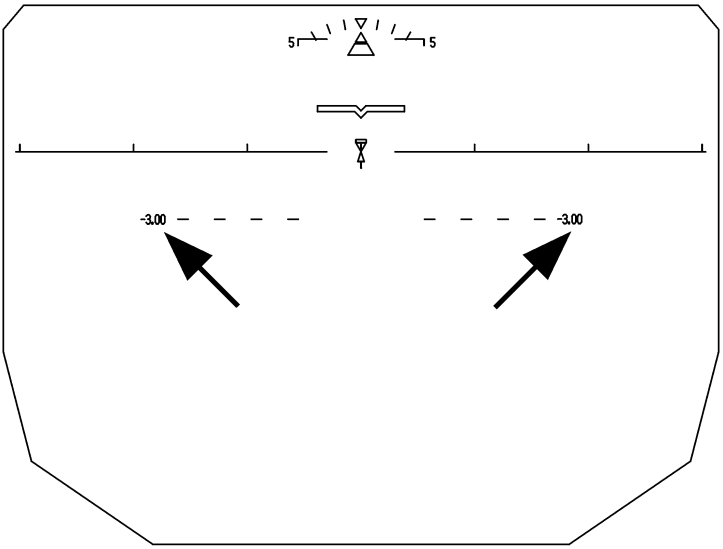
GLIDESLOPE REFERENCE LINE

The Glideslope Reference Line symbol 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. If a -3.00 degree angle is entered, then the Glideslope Reference line is positioned 3 degrees below the Horizon Line and laterally centered on the display. At the outside ends of the Glideslope Reference Line is a digital value corresponding to the selected value. The Reference Glideslope Line is not displayed in the Primary Mode.

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



NAVIGATION SOURCE ANNUNCIATION



GLIDESLOPE REFERENCE LINE

LATERAL DEVIATION - PRIMARY MODE

In the Primary mode, Lateral Deviation is displayed on the HSI as a conventional CDI. Displacement of the CDI with respect to its null position at the center of the ±2 dot scale is the indication of the current lateral deviation during ILS, or VOR operations.

When the DFCS detects excessive localizer deviation during an ILS approach, the CDI will flash 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.

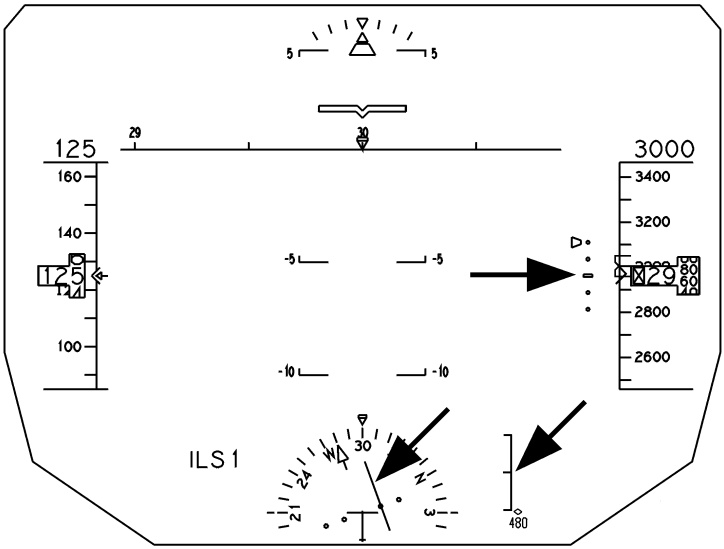
GLIDESLOPE DEVIATION - PRIMARY MODE

In the Primary mode, during ILS operations, Glideslope Deviation is displayed as a pointer against a vertical scale on the right side of the display just inside and centered on the Altitude Scale. The scale replicates a conventional Glideslope scale with ±1 and 2 dots.

When the DFCS detects excessive glideslope deviation during an ILS approach, the glideslope deviation pointer will flash until the excessive deviation is no longer present. If the Glideslope date is not computed, the Glideslope pointer is removed from the scale. Failure of the ILS Receiver (or MMR) will result in removal of the pointer and scale and display the Glideslope fault annunciation (boxed G/S).

VERTICAL DEVIATION - PRIMARY MODE

In the Primary and IMC mode when the Flight Director Mode indicates "VNAV ALT", "VNAV SPD", or "VNAV PTH", of if the Vertical Deviation is valid and EFIS display mode is “MAP” or “PLAN”, the Vertical Deviation Scale and Index will be in view in the lower right hand area of the display. The Vertical Deviation scale with a diamond shaped index is derived from the FMCS. Full scale represents 400 feet of vertical deviation and the pointer is limited at ±440 feet. When limited, the digital value for the vertical deviation is displayed at the appropriate end of the scale.



DEVIATION – PRIMARY MODE

LATERAL DEVIATION - AIII OR IMC MODES

In the "AIII" or "IMC" modes, Lateral Deviation is displayed as vertical bars referenced to the Selected Course mark.

Lateral Deviation is indicated by the displacement of the symbol, left or right of the Selected Course mark during ILS, or VOR operations. The source and gain of the Lateral Deviation is dependent 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. As a measure of scale, this results in a 1/5th of a dot (on the HSI) deviation error when the localizer deviation line is displaced to either edge of the Horizon Line around the Selected Course break.

In the IMC mode, the localizer line will flash, similar to the CDI in the Primary mode, when the DFCS detects an excessive localizer deviation. Loss of valid Localizer or VOR deviation causes the Lateral Deviation symbol to be removed. Failure of the tuned source will result in a boxed VOR or LOC failure message.

GLIDESLOPE DEVIATION - AIII OR IMC MODES

In the "AIII" or "IMC" modes, the Glideslope Deviation is displayed as two horizontal bars referenced to the Glideslope Reference Line.

Glideslope Deviation is indicated by the displacement of the symbol above or below the Glideslope Reference Line during ILS 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 symbol is removed from the display below 70 feet AGL.

Loss of valid Glideslope causes the Glideslope symbol to be removed. In the IMC mode, the glideslope line will flash, similar to the glideslope pointer in the PRIMARY mode, when the DFCS detects an excessive glideslope deviation. Failure of the ILS will result in a boxed G/S.

VERTICAL DEVIATION - IMC MODE

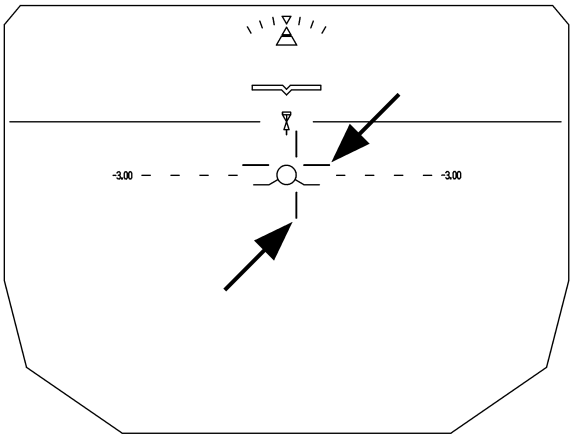
In the "IMC" mode, when the EFIS display mode is “MAP” or “PLAN” or VNAV guidance is active, the Vertical Deviation is displayed the same as Vertical Deviation in the PRIMARY mode.

GROUND LOCALIZER LINE - PRIMARY, AIII AND IMC MODES

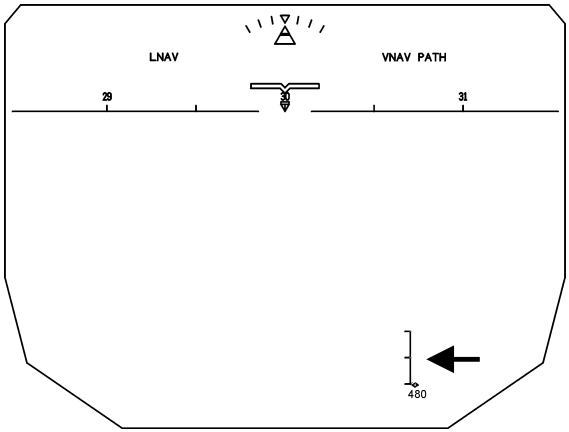
The Ground Localizer Line is displayed in either the PRIMARY, AIII or IMC modes if the Captain's VHF Nav Receiver is tuned to an ILS frequency and localizer is valid while on the ground. The Ground Localizer Line displays Localizer Deviation relative to the Selected Course mark under the HGS Horizon Line.

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 (see Definitions).

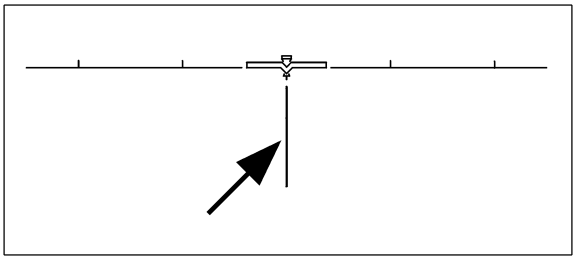
In the AIII mode, the Ground Localizer Line is displayed at Aircraft Touchdown.



DEVIATION – AIII OR IMC MODE



VERTICAL DEVIATION – IMC MODE



GROUND LOCALIZER LINE

BEARING POINTERS

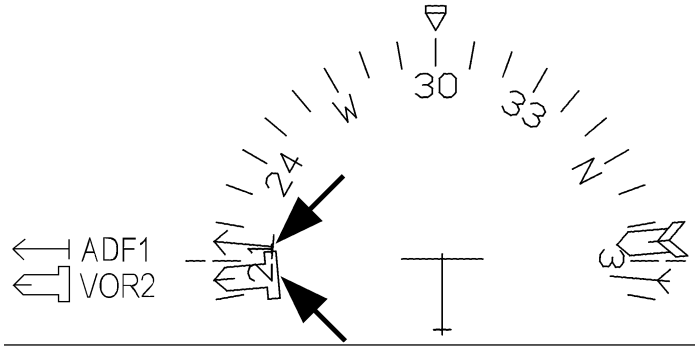
Bearing Pointer #1 and #2 are displayed when selected on the EFIS control panel and data is valid. Pointer can be VOR or ADF bearings.

VOR TO/FROM

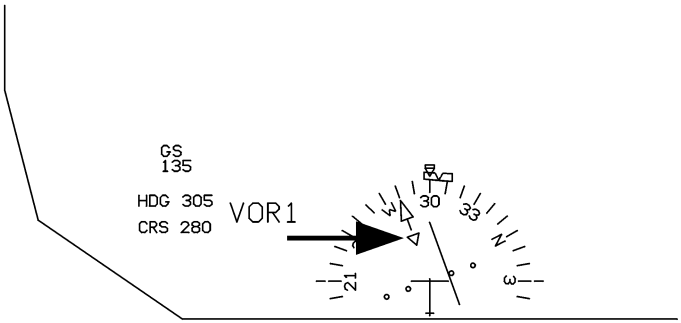
In the Primary mode, VOR To/From is displayed as a triangle on the CDI, just inside the Selected Course mark. A triangle pointing in the same direction as Selected Course indicates a "TO" condition. Pointing away from Selected Course indicates a "FROM" condition. The TO/FROM indicator is only displayed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

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

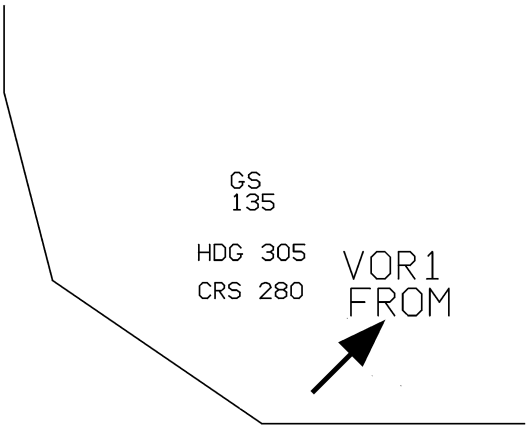
NOTE: This is also true in the AIII mode, but only if the Captain's Nav Receiver is tuned to a VOR frequency after the AIII mode is entered. This will also result in the loss of the AIII status ("NO AIII").



BEARING POINTERS 1 & 2



TO/FROM INDICATION



TO/FROM ANNUNCIATION

DIGITAL RUNWAY ELEVATION

The Digital Runway Elevation is displayed in the lower right portion of the display for a period of five seconds after either of the following conditions:

1. The "AIII" mode is selected, or;

2. The Runway Elevation value is changed during an AIII mode operation.

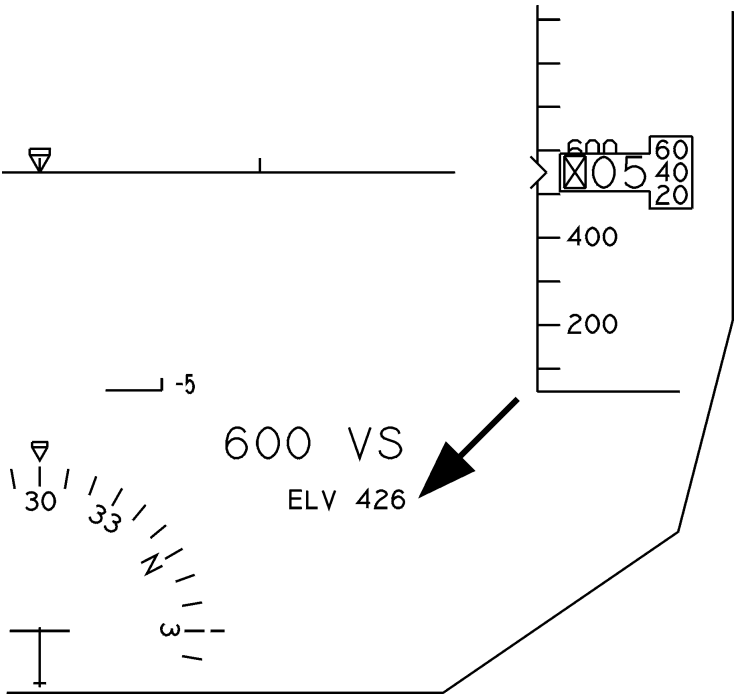
The display consists of the characters "ELV" followed by the runway elevation value entered through the HGS HCP.

RUNWAY EDGELINES

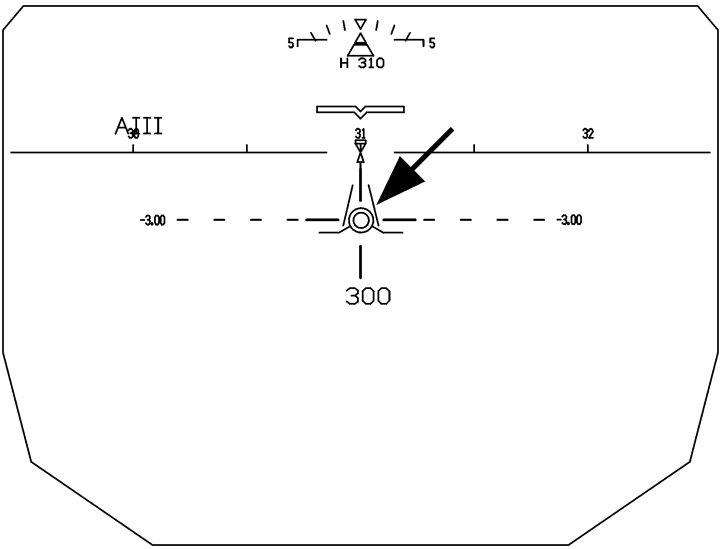
During an "AIII" approach, Runway Edgeline symbols are displayed between 300 and 60 feet Above runway elevation. The runway symbol consists of an outline of the two sides of the runway scaled to a width of 200 feet and a length of 8000 feet. Tic marks are displayed at the touchdown aimpoint representing 1050 feet from the runway threshold.

The aircraft's orientation to the runway is depicted 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, Reference Glideslope and HCP Elevation.

NOTE: Conformity of the symbolic runway to the real world runway is dependent on all of the above input signals but is most predominantly effected by heading errors. Heading errors can be attributed to the errors in the published approach course, real runway heading, IRS magnetic heading data and selected course errors, all affected by the natural deviation in the local magnetic variation over time or Inertial errors. All are potential causes for the symbolic runway not aligning to the real world runway perfectly. 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 IIIa approach and landing). When being flown 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.



DIGITAL RUNWAY ELEVATION



RUNWAY EDGELINES

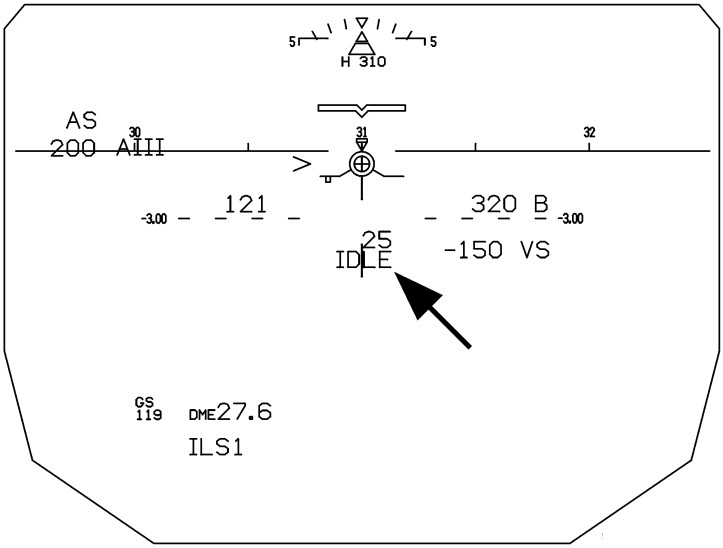
"IDLE" MESSAGE

During an "AIII" approach, part of the flare guidance includes a command for the pilot to reduce the aircraft thrust to idle for touchdown. This is indicated by the characters "IDLE" being displayed directly below the Flight Path and Digital Radio Altitude symbology.

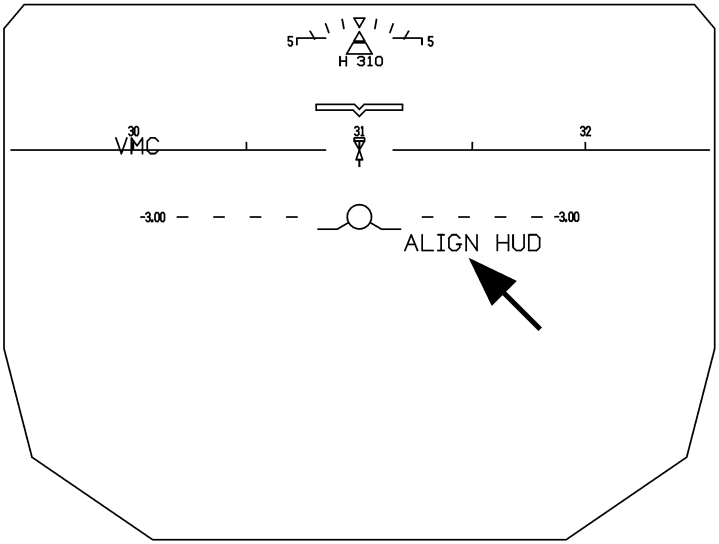
The IDLE message is displayed beginning at a Radio Altitude between 25 and 5 feet, determined by the aircraft's airspeed relative to the selected airspeed, continuing until touchdown. If the airspeed is greater than or equal to the selected airspeed, then the IDLE message is displayed at 25 feet. If the airspeed is less than the selected airspeed, then the altitude is decreased 2 feet for every 1 knot of airspeed below the selected airspeed to a minimum of 5 feet.

"ALIGN HUD" MESSAGE

An "ALIGN HUD" message is displayed to indicate that the HGS Combiner is not properly aligned when operating in the IMC or VMC approach modes. For additional information, refer to the VMC Mode in the Modes of Operation section.



“IDLE” MESSAGE



“ALIGN HUD” MESSAGE

AUTOTHROTTLE MODE ANNUNCIATIONS (If Activated)

Autothrottle (A/T) Mode annunciations, similar to the A/T mode annunciations on the DFCS Flight Mode Annunciator (FMA), are displayed in the upper left corner of the display. The following table lists the Autothrottle Mode annunciations displayed:

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 highlighting the newly engaged mode.

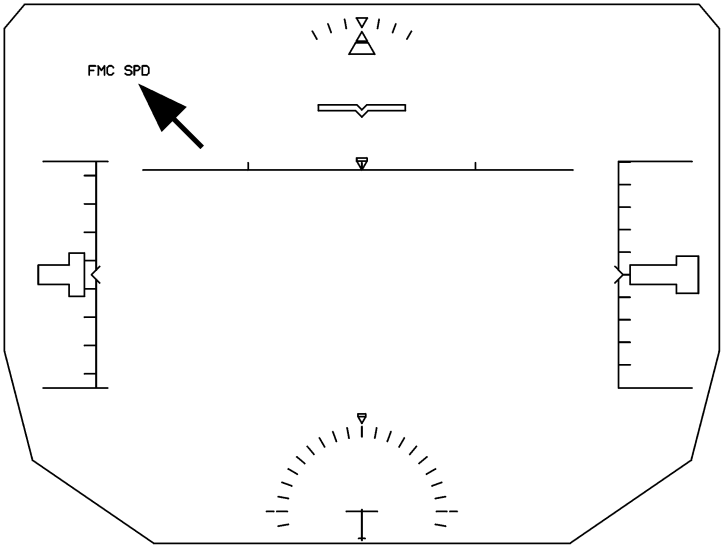
FLIGHT DIRECTOR MODE ANNUNCIATIONS

Flight Director (F/D) Mode annunciations are located at the top center portion of the display with the vertical modes on the right and the lateral modes on the left, similar to the F/D mode annunciations on the DFCS Flight Mode Annunciator (FMA). Only engaged modes (not armed) are annunciated on the display. The following table lists the lateral and vertical Flight Director Mode annunciations displayed:

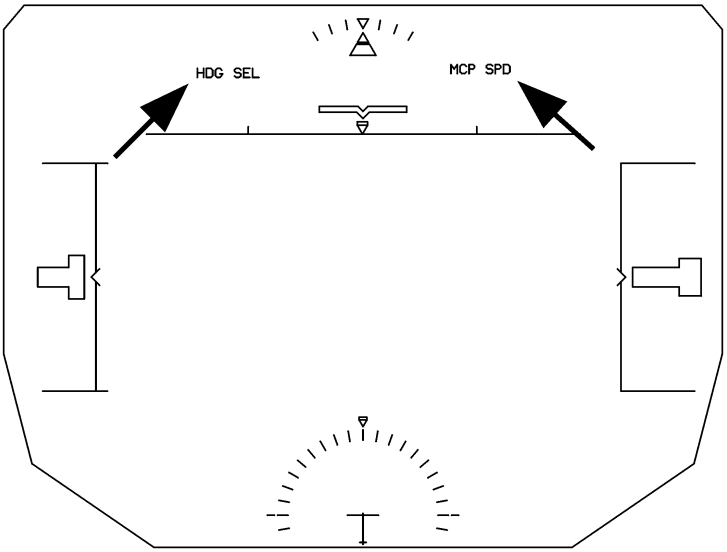
A mode change or engagement causes the corresponding mode annunciation to be boxed for ten seconds highlighting the newly engaged mode.

F/D LATERAL MODES		F/D VERTICAL MODES	
Mode Annunciation	**Engaged Mode Name**	**Mode Annunciation**	**Engaged Mode Name**
"HDG SEL"	Heading Select	"TO/GA"	Takeoff/Go-Around
"VOR/LOC"	VOR or Localizer	"V/S"	Vertical Speed Hold
"LNAV"	Lateral Navigation *	"ALT ACQ"	Altitude Acquire
"ALT HOLD"	Altitude Hold	"VNAV SPD"	Vertical Nav Speed *
		"VNAV PTH"	Vertical Nav Path *
		"MCP SPD"	Level Change to MCP Selected Altitude
		"G/S"	Glideslope

* if operational



AUTOTHROTTLE MODE ANNUNCIATIONS



FLIGHT DIRECTOR MODE ANNUNCIATIONS

AUTOPILOT MODE/STATUS ANNUNCIATIONS

An indication of the current Autopilot (A/P) status is displayed in the upper right portion of the display, 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:

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.
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.
"SINGLE CH"	The A/P detects localizer capture with only one channel engaged.

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

HGS MODE/STATUS

In the "IMC" or "VMC" modes, the mode is indicated in the upper left portion of the display just to the right of the Selected Airspeed. The Primary mode is not indicated as it is uniquely identifiable by the Airspeed and Altitude tapes being displayed.

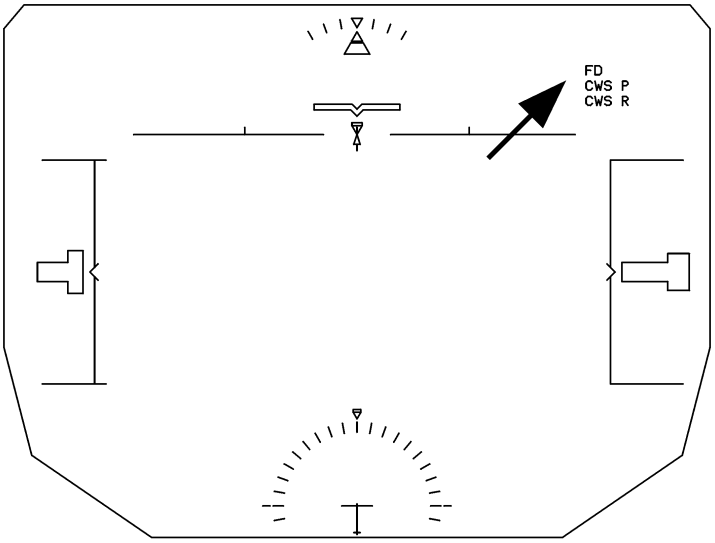
In the PRIMARY mode, with all requirements satisfied for an AIII approach at approach capture (AOC), the availability of the AIII mode is indicated by a flashing "AIII" in the upper left portion of the display (just above where the current HGS mode would be displayed). The flashing "AIII" is not displayed in either the IMC or VMC modes. Once the AIII mode is selected on the HCP, the "AIII" or "NO AIII" status is displayed in the same position as the other HGS modes directly to the right of the Selected Airspeed.

APPROACH WARNING

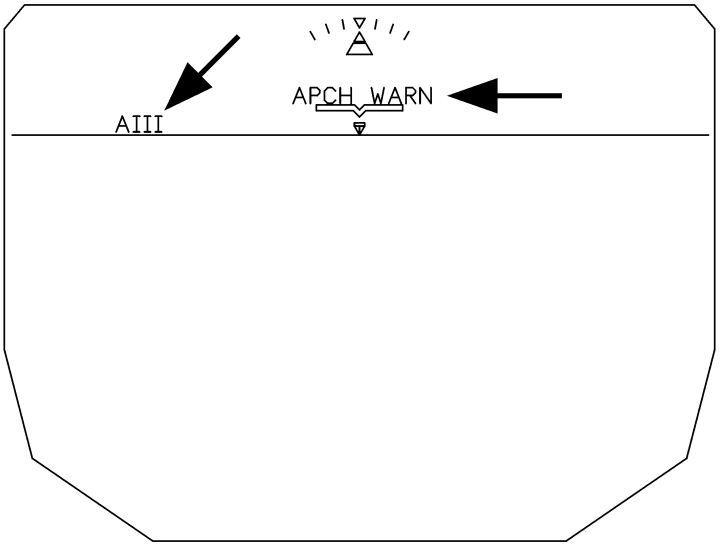
During AIII approaches below 500 feet, an "APCH WARN" message may be displayed in the top center portion of the display just above the Aircraft Reference symbol. This message is displayed if any of the following conditions exist:s

1. Approach monitoring tolerances are exceeded;
2. The AIII capability is lost ("NO AIII").

See Modes of Operation or the Appendix for more information.



AUTOPILOT STATUS ANNUNCIATIONS



HGS MODE/STATUS ANNUNCIATIONS

TCAS RESOLUTION ADVISORY DISPLAY

The HGS provides TCAS Resolution Advisories from the TCAS computer. The advisories are displayed in all modes in the form of Preventive and Corrective Advisory symbologies 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 also, but in this case either the top or 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.

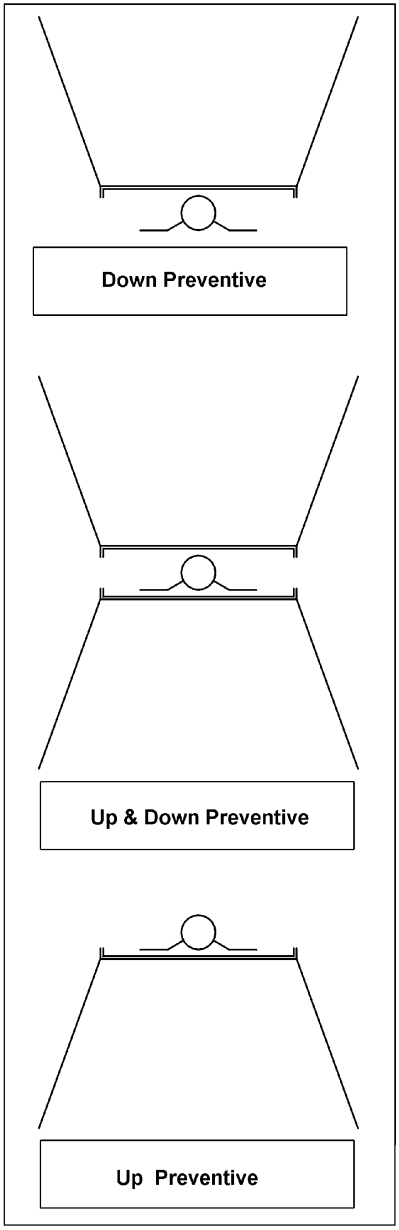
The lateral center of the bracket or box is fixed at the position of the aircraft's current track. Whenever the Flight Path is in the unsafe zone, between the angled lines, then the angled lines flash on and off. Flight Path should be repositioned within the safe zone.

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).

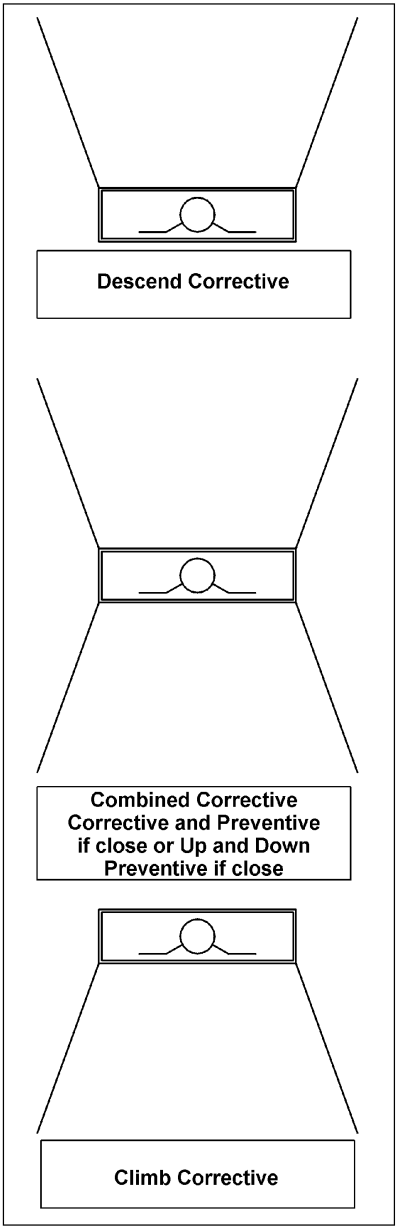
Navigation data will continue to be displayed as well as the Guidance Cue, but the vertical component of the guidance is to be ignored in favor of the TCAS Resolution Advisory.

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).



TCAS PREVENTIVE



TCAS CORRECTIVE

FAILURE FLAGS AND DATA SOURCE INDICATIONS

Failure Flags are displayed for invalid sensor statuses and miscompares between certain similar parameters. 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.

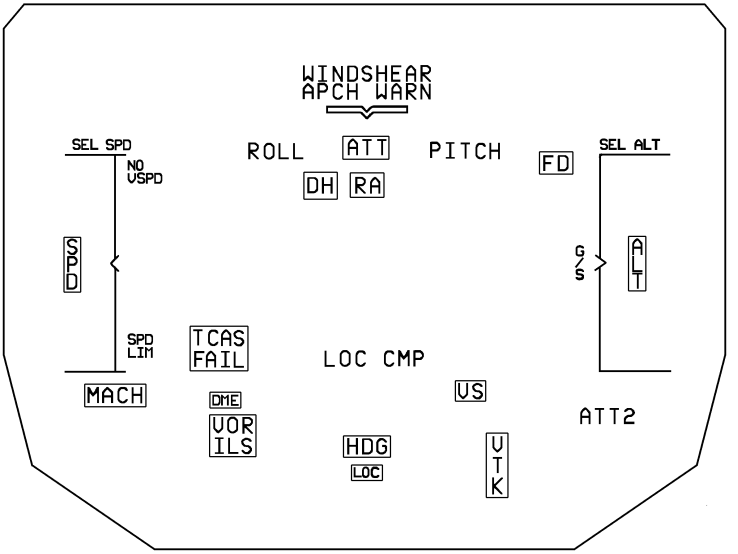
Flags associated with a miscompare of similar data results in the display of a flag without the removal of the related symbols. In this case, the flag indicates that the applicable data should be verified by crosschecks with other cockpit displays.

Data source flags 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:

- ADIRU-IR 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.
- ADIRU-IR 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.
- ADIRU-IR Heading is No Computed Data (NCD) - is indicated by heading data being removed from the horizon line and HSI heading scales (scales remain) and digital heading is replaced with dashes "H - - -". No heading flag is displayed.
- Airspeed failure – failure of the ADIRU-IR 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.
- ADIRU-ADR Airspeed is Not Valid - PRIMARY mode - is indicated by airspeed data being removed (scale remains) and no failure flag is displayed. AIII, IMC or VMC mode - same as airspeed failure above.
- Altitude failure - failure of the ADIRU-IR 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.
- ADIRU-ADR Altitude is Not Valid - PRIMARY mode - is indicated by altitude data being removed (scale remains) and no failure flag is displayed. AIII, IMC or VMC mode - same as altitude failure above.
- 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 bottom of the airspeed scale and the removal of the appropriate data.

- Mach failure - is indicated by the boxed characters "MACH" replacing the mach data unless NCD where the numerics are replaced with dashes "--".
- Ground Speed failure - is indicated by removing the Ground Speed data or if NCD replacing the numerics with dashes "---".
- Vertical Speed failure - is indicated by the boxed characters "VS" replacing the Vertical Speed data. The boxed "VS" is also displayed if Vertical Speed is NCD in the AIII, IMC or VMC modes. In the PRIMARY mode only, if NCD the numerics are replaced with dashes "- - - VS".
- Selected Altitude failure - is indicated by the characters "SEL ALT" replacing the Digital Selected Altitude data, or if NCD, the removal of the Selected Altitude data with no flag displayed.
- 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 with no flag displayed.
- Radio Altitude failure - is indicated by the boxed characters "RA" replacing the digital Radio Altitude data.
- 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 - 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, or if NCD the vertical deviation pointer is removed with the scale remaining.
- DME failure - is indicated by the boxed characters "DME", or if NCD, the digital data is replaced by dashes "DME - - -".
- Distance to waypoint failure is indicated by the removal of the Distance to Waypoint digital data or if NCD, the data is replaced by dashes "- - - NM".
- Flight Director failure- is indicated by the boxed characters "FD" positioned in the top right portion of the display and the removal of the DFCS 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 all IRS information used or displayed by the HGS (specifically pitch, roll and heading) is being sourced from the #2 IRS.
- When a NAV DATA source cannot be determined due to a conflict between the VOR and ILS a boxed VOR/ILS annunciation appears.
- ILS failure is indicated by the boxed characters G/S or LOC.
- Failure of the VOR is indicated by a boxed VOR.



FAILURE FLAGS AND DATA SOURCE INDICATIONS

HGS MODE/SYMBOLOGY MATRIX

Symbol	Primary Mode		"AIII" Mode		"IMC" Mode	"VMC" Mode
	In-Flight	Ground	Approach	Rollout		
Aircraft Attitude Symbology						
Attitude Fault Annunciation	●	●	●	●	●	●
Attitude Source Annunciation	●	●	●	●	●	●
Bank Warning Indicator	●		●		●	●
Horizon Line	●	●	●	●	●	●
Pitch Miscompare Annunciation	●	●	●	●	●	●
Pitch Reference Scale	●		●		●	●
Roll Miscompare Annunciation	●	●	●	●	●	●
Roll Scale and Index	●	●	●	●	●	●
TO/GA Reference Line (5)	●					
Aircraft Flight Path Symbology						
Flight Path	●		●		●	●
Flight Path Acceleration	●	●	●	●	●	●
Glideslope Reference Line			●		●	●
Aircraft Angle of Attack Symbology						
AOA Limit	●		●		●	●
Aircraft Heading and Track Symbology						
ADF/VOR Bearing Indicator #1 (4)	●					
ADF/VOR Bearing Indicator #2 (4)	●					
Bearing Source #1 Annunciation	●	●				
Bearing Source #2 Annunciation	●	●				
Conformal Heading Scale and Index	●	●	●	●	●	●
Conformal Selected Course Mark	●	●	●	●	●	●
Conformal Selected Heading Mark	●	●	●	●	●	●
Digital Heading	●	●	●	●	●	●

Symbol	Primary Mode		"AIII" Mode		"IMC" Mode	"VMC" Mode
	In-Flight	Ground	Approach	Rollout		
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	•	•				
Slip/Skid Symbology						
Additional Slip/Skid Indicator (2)	•		•		•	•
Roll Scale 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	•	•				
Maximum Operating Speed Tape	•					

Symbol	Primary Mode		"AIII" Mode		"IMC" Mode	"VMC" Mode
	In-Flight	Ground	Approach	Rollout		
Minimum Operating Speed Tape	•	•				
Reference Speed (VREF) Indicator	•	•				
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		•				
Wind Speed and Direction Indicators	•		•		•	•
Altitude Symbology						
Altitude Trend Vector	•					
Baro. Altitude Scale and Index	•	•				
Barometric Altitude Fault Annunciation	•	•	•	•	•	•
Digital Altitude Odometer	•	•				
Digital Barometric Altitude			•	•	•	•
Digital Radio Altitude	•		•		•	•
Digital Selected Altitude	•	•				
Digital Vertical Speed	•		•		•	•
Radio Altitude Fault Annunciation	•	•	•	•	•	•
Selected Altitude Fault Annunciation	•	•				
Selected Altitude Mark	•	•				
Vertical Speed Fault Annunciation	•	•	•	•	•	•

Symbol	Primary Mode		"AIII" Mode		"IMC" Mode	"VMC" Mode
	In-Flight	Ground	Approach	Rollout		
Navigation Symbology						
Course Deviation Scale and Index	•					
Distance To Waypoint	•				•	
DME Distance	•		•		•	•
DME Fault Annunciation	•	•	•	•	•	•
FMC NAV Source Annunciation	•				•	
Glideslope Deviation Fault Annunciation	•		•		•	
Glideslope Deviation Line			•		•	
Glideslope Deviation Scale and Index	•					
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						
Combiner Alignment Message					•	•
Decision Height Annunciation	•		•		•	
Decision Height Fault Annunciation	•		•		•	
Flare Cue	•				•	•
Ground Proximity Warning Message	•		•		•	•
HGS Approach Capability Annunciation	•					

Symbol	Primary Mode		"AIII" Mode		"IMC" Mode	"VMC" Mode
	In-Flight	Ground	Approach	Rollout		
HGS Mode Annunciation			•	•	•	•
Windshear Warning Message (3)	•		•		•	•
Category III Symbology						
Approach Warning Message			•			
Idle Message			•			
Digital Runway Elevation (1)			•			
Flare Command			•			
Ground Roll Guidance Cue (6)		•				
Ground Roll Reference (6)		•				
HGS Guidance Cue			•			
Runway Lines			•			
Flight Director/Autopilot Symbology						
Autopilot Status Annunciation	•	•	•	•	•	•
Autothrottle Mode Annunciation	•	•	•	•	•	•
F/D Lateral Mode Annunciations	•	•			•	
F/D Vertical Mode Annunciation	•	•			•	
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. Only if #2 ADF is installed.
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.

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Operations

This section provides information and recommended procedures for HGS operations.

Approved operating procedures for the 737 with an HGS are the responsibility of the operator and the appropriate regulatory agency (e.g., the FAA) 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 IIIa approach and landing operations. Once authorized, all operations must be conducted in accordance with the operators approved operating procedures.

GENERAL

The HGS is approved for use throughout the full flight regime. Specifically, the HGS equipped Boeing 737 has been shown to meet the applicable airworthiness performance criteria of FAA Advisory Circular (AC) 20-57A (Category I and II, and III), and operational criteria of AC 120-29 (Category I and II) and AC 120-28C (Category III). The HGS has also been shown to meet applicable airworthiness and performance criteria for takeoff operations in low visibility conditions in accordance with the Joint Aviation Authorities (JAA) Joint Aviation Requirements - All Weather Operations (JAR-AWO) Subpart 4, Directional Control for Takeoff in Low Visibility.

Airborne equipment required for these low weather operations is defined in the Aircraft Flight Manual supplement:

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.

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

Allow the HGS to warm-up for up to 2 - 5 minutes depending on the ambient temperature (generally, once an image is displayed on the Combiner the system is capable of normal operation).

HGS COMBINER ..... SET

Lower the Combiner to its operating position and check to verify that symbology is displayed (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 "FAULT" and/or "CLR" (clear) annunciators on the HCP are extinguished and, if so, check the Combiner HUD BRT control. 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 (Optional - refer to HCP Display Test in the Appendix).

Runway Length and Elevation ..... SET

Enter the published runway length 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 expected runway).

Mode ..... SET

Select or verify the Primary (PRI) mode on the HCP.

HGS ANUNCIATOR PANEL ..... CHECK

Verification of the F/O's HGS annunciations is accomplished during a cockpit master lamp test. Selecting the test position for the Master Dim and Test switch should illuminate all the HGS annunciations. Another means to cause all the HGS annunciations to illuminate is to select TEST on the HCP. This causes the annunciators to come on for 2 - 5 seconds then extinguish. Select TEST again to exit the Test mode.

For illustrations of HGS symbology associated with the following normal procedures, refer to the TYPICAL FLIGHT PROFILE section.

TAKEOFF

To maintain proficiency, it is recommended that the HGS Low Visibility Takeoff procedures be used for takeoffs where conditions allow. This is generally anytime the departing runway has a localizer available and system/time constraints allow for the proper execution of the procedure. The following table identifies the procedures for an HGS Low Visibility Takeoff that are in addition to standard operating procedures:

CAPTAIN (PF)	FIRST OFFICER (PNF)
Before Taking runway: - Set both VHF Nav's 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 PRI mode.	- Standard procedures.
Cleared for Takeoff:	
- Taxi aircraft into position straddling 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 course mark and Ground Localizer Deviation symbols with the runway centerline. - Verify display of Ground Roll Guidance Cue. - Use the minimum display intensity necessary so as to be able to view both the runway markings and the symbology. - Call out "HGS SET".	- Verify Localizer deviation display is centered.
- Initiate takeoff using standard procedures. - Use standard call outs.	- Standard procedures. - Use standard call outs.
- Track runway centerline visually, augmenting with HGS guidance.	- Monitor head-down instruments. - Monitor localizer deviation. - Call out "CENTERLINE STEER LEFT/RIGHT" as necessary.
- At VR, rotate smoothly 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.

A particular advantage during operations in the vicinity of 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 on 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 “HUD BRT” as desired, considering the current and expected ambient and runway lighting conditions.

HCP ELEVATION ..... PNF/P F.....ENTER/VERIFY

Input on the HCP the Touch Down Zone Elevation for the landing runway. If the TDZE is not available, use the closest airport elevation given.

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

Input on the HCP the glideslope angle for the approach.

HGS MODE ..... SET

Select the desired mode. It is anticipated that the PRI mode will continue to be utilized for the approach intercept.

The approach briefing prior to an HGS AIII approach should include a review of the approach procedure and a reminder that the Captain will be head-up throughout the approach and 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 the call outs, particularly with respect to approach minimums, in addition to other standard approach briefing items.

APPROACH & 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 PRI mode. Flight Director guidance is displayed in either the PRI or IMC mode through standard MCP settings. Refer to Supplemental Procedures for Flight Director (PRI or IMC), Visual (VMC), and right seat or Autopilot flown monitored approach operations.

On ILS approaches, it is recommended that whenever possible, the HGS AIII mode, and procedures be utilized to maintain proficiency. This helps to re-enforce 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:

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 (refer to AIII STATUS in the Appendix). Establish a stable landing configuration as early as possible on final approach.	
- Intercept localizer and glideslope. - Monitor display for flashing "AIII" annunciation (AIII available).	- Monitor localizer and glideslope capture. - Call out "LOCALIZER ALIVE", "GLIDESLOPE ALIVE" and "AIII AVAILABLE" when appropriate.
- Select or direct to select the AIII mode (must be selected prior to 500 feet) - Observe "AIII" on Combiner. Call out "AIII" when displayed.	- Select/Verify AIII mode. Call out "AIII ON THE RIGHT" (on HGS Annunciator Panel) when displayed.
- Track ILS with HGS guidance. - Establish target airspeed prior to 500 feet. - Monitor for "NO AIII" annunciation and flags.	- Monitor ILS tracking on head-down displays. - Monitor for loss of "AIII" annunciation and flags. Call out "NO AIII" when appropriate.
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" and/or "APCH WARN" annunciations and flags. - Perform go-around if "APCH WARN" is displayed. Call out "GO-AROUND, MAX POWER" when go-around is initiated	- Monitor approach parameters relative to approach tolerances (see following table). Call out any deficiencies as indicated. - Monitor for loss of "AIII" and "APCH WARN" annunciations. Call out "APCH WARN" 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".

CAPTAIN (PF)	FIRST OFFICER (PNF)
At altitude where 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: - Judge 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.
DH to touchdown: - Shift focus to visual cues and perform flare and landing using visual cues (primary) and HGS guidance (secondary). - 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 HGS 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 eliminate long landing monitor). - Rollout using visual cues and HGS Ground Localizer symbology. - use normal procedures to decelerate to taxi speed.	- Monitor localizer deviation head-down throughout rollout or assume head-up posture after touchdown as desired or directed.

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.

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"

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

First Officer's 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.

SUPPLEMENTAL PROCEDURES

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

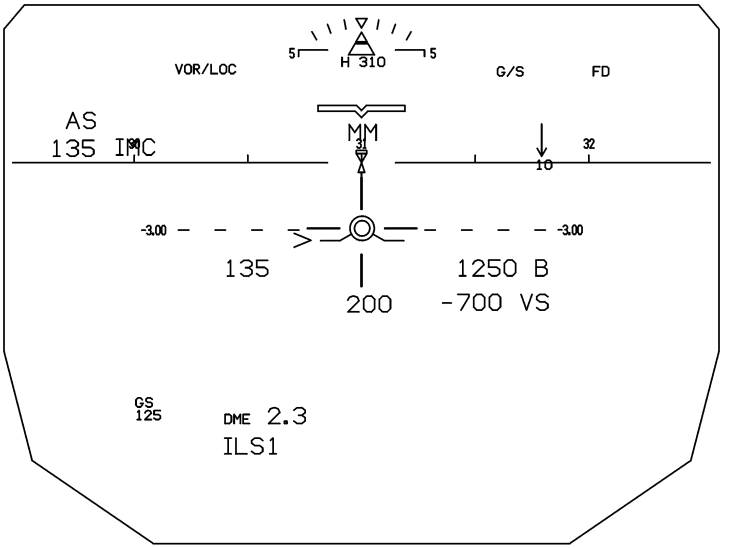
TAKEOFF (NORMAL W/O STEERING GUIDANCE)

When performing a takeoff using other than Low Visibility Takeoff procedures, utilize the HGS Primary mode using 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, utilize the HGS Primary or IMC mode and follow standard operating procedures. No HGS unique procedures are required.

It is recommended that the PRI mode be utilized prior to and during the approach capture phase with the IMC mode selected following final course capture. In either the PRI or IMC modes, Flight Director guidance is displayed based on MCP/FCC operation. The following illustration depicts an IMC approach.



IMC APPROACH

The IMC mode allows DFCS 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:

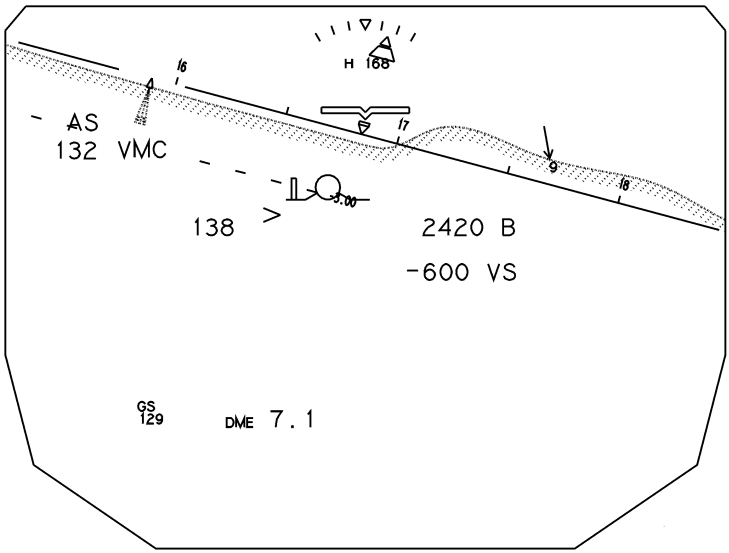
- The guidance cue is derived from the DFCS and is removed from the display at 50 feet by the DFCS;
- Flight Director modes are displayed;
- The IMC mode is annunciated;
- No approach monitoring or flare guidance is provided by the HGS. However, flare cues (" + + ") are displayed for the visual flare.

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

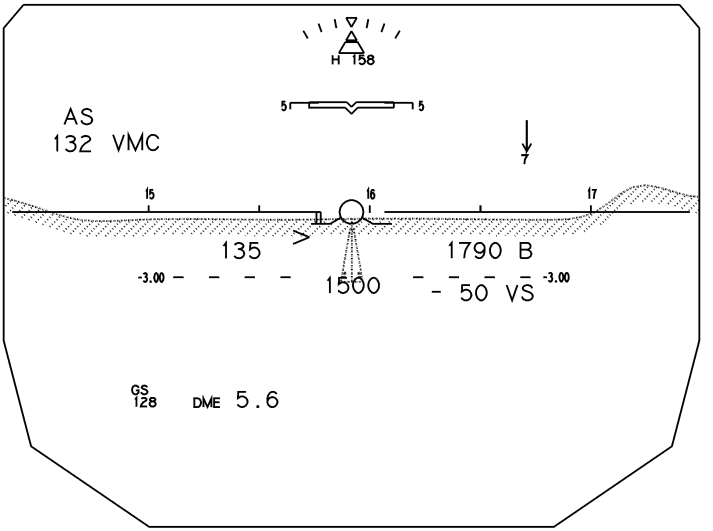
The HGS VMC mode is used to enhance situational awareness, increase approach precision, and improve energy management when operating in visual conditions. This is particularly useful during visual approaches into airports without visual approach aids like a VASI. The principle benefit from the HGS when 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 display of Reference Glideslope, when positioned relative to the real world runway touchdown point and flown using Flight Path, 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.



VMC APPROACH – LATERIAL ALIGNMENT

In the illustration above, 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 Reference Glideslope positioned short of (below) the runway touchdown zone.

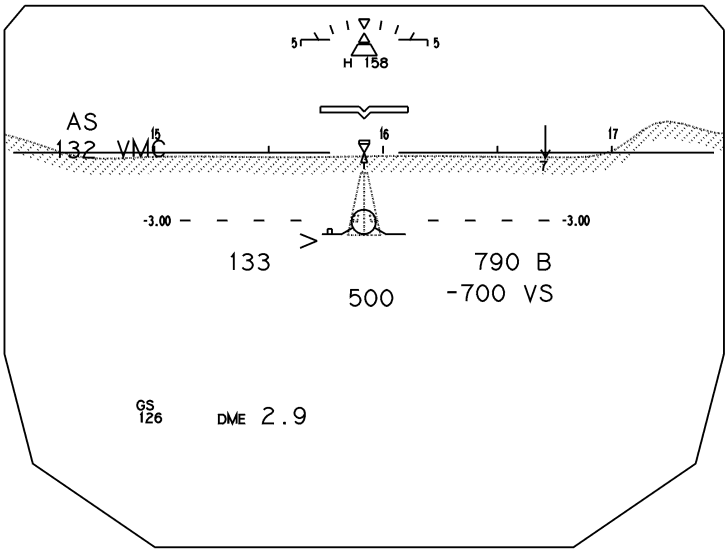


VMC APPROACH – VERTICAL ALIGNMENT

In the illustration above, 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 symbol (dash line) intersects the touchdown zone (TDZ) on the runway (as shown). If the dash line is short of the TDZ, then the pilot must maintain a higher flight path angle until they intersect. If the dash 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.

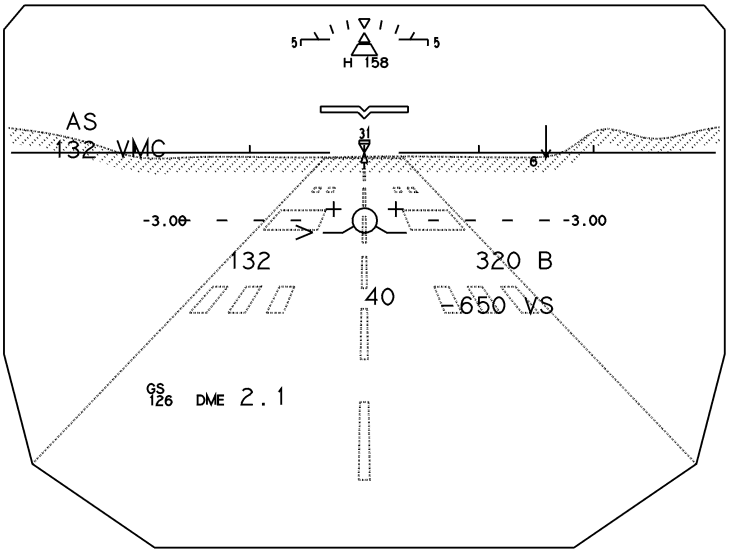
Once the reference glideslope angle is established on the runway, then the proper glidepath is maintained by keeping Flight Path on the TDZ and Glideslope Reference and making small corrections as necessary.

One consideration when using the VMC (or IMC) mode is that the Combiner must be properly positioned in order to conformally display the symbolic image. An "ALIGN HUD" message is displayed on the Combiner if a misalignment exists in the Combiner mechanics. If this occurs, push the Combiner forward slightly out of its operating position and allow the Combiner to return on its own (this allows it to find its own position) to eliminate the error. Another means is to apply pressure either fore or aft on the Combiner until the "ALIGN HUD" message is removed. If the message can not be eliminated, then the VMC mode should not be used.



VMC APPROACH – ON GLIDESLOPE

This illustration depicts the proper relationship of the VMC symbology and the runway for an on glideslope position at 500 feet. Airspeed control is maintained the same as in other approach operations.



VMC APPROACH - FLARE

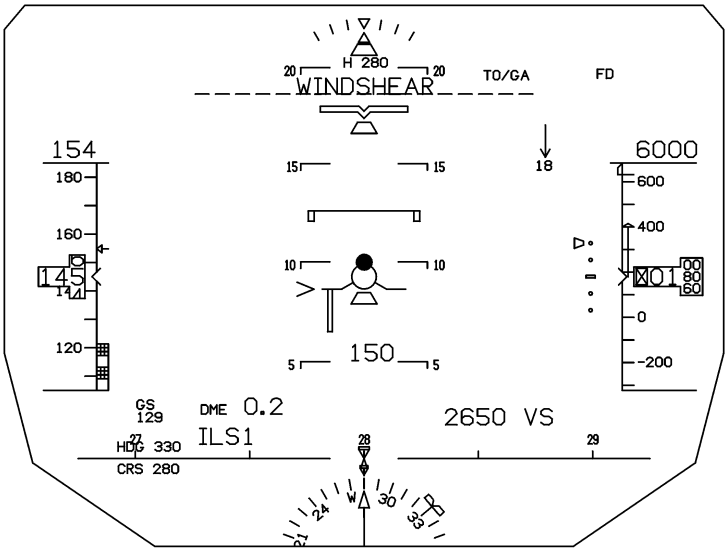
Flare and landing in the VMC mode is accomplished using normal visual procedures. Between 55 feet and 10 feet, flare cue symbols consisting of two " + " (plus) are displayed above the Flight Path symbol wings. These are not guidance but only annunciations to the fact that the pilot must flare the aircraft.

WINDSHEAR

In the event a windshear is encountered while the HGS is in use, the HGS displays a "WINDSHEAR" message as directed by the GPWS (see illustration on next page). If the DFCS TO/GA mode is selected, Flight Director guidance can be used to exit the shear (assumes windshear guidance is available). Also, whenever WINDSHEAR is indicated, the aircraft's margin to stick shaker is indicated by the display of the AOA bracket (refer to the following illustration).

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. First of all, the 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 are early indicators of a potentially shearing atmosphere.

NOTE: Upon selection of TO/GA, the HGS system will revert to the Primary mode.



HGS WINDSHEAR DISPLAY

In addition, 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.

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.

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

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 (see Failure Flags and Data Source Indications in the Symbology section).

Sensor miscompare

The HGS monitors certain sensor parameters for validation based on a comparison with the offside sensor. For normal display purposes, IRS pitch and roll parameters are monitored. Any miscompare between ADIRU-IR's #1 and 2 of greater than 5° causes the appropriate data (either pitch and/or roll) to be removed from the display. Consequently, since pitch and roll data is essential to the positioning of much of the displayed data, including Flight Path and its related symbols, the loss of pitch or roll data also results in the removal of these affected symbols.

For determination of the AIII approach capability, additional comparisons are performed. These are discussed in the degraded capability section that follows.

HGS failure

The HGS itself contains an extensive self-monitoring capability. This Built-In Test (BITE) capability monitors the overall health of the HGS components and if a fault is detected that affects its ability to accurately display symbology, the entire display is turned off. Concurrent to the display being blanked, or a result of any BITE detected failure, 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 eliminates the use of the HGS for a specific purpose (e.g., a Low Visibility Takeoff, AIII approach, or a VMC (or IMC) visual approach). This can be as a result of a degraded display condition described above, some additional sensor fault or miscompare cases, 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:

- The aircraft on the ground,
- The HGS PRIMARY mode is selected,
- Both VHF Navs tuned to the departing runway ILS frequency.

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 the Takeoff (the total requirements are identified in the Ground Roll Guidance Cue Requirements Table in the Appendix). The additional aircraft configuration requirements include:

- IRS and NAV transfer switches are in the "NORMAL".
- IRS #1 is in the NAV mode,
- The difference between the Captain's Selected Course and the aircraft's Magnetic Heading (from IRS #1) 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 between 7,500' and 13,500'.

These configuration requirements and the validity of all required sensor and HGS inputs will result in the display of the Low Visibility Takeoff Guidance symbology (Refer to the Low Visibility Takeoff Guidance section in the Appendix). 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 can not be met prior to or while positioning on the runway, then the HGS Low Visibility Takeoff can not be performed.

AIII approach:

The AIII capability is unique in that at any given time the AIII capability is determined and an AIII status is indicated based on the assessment of certain requirements (requirements are dependent on the current operation phase, refer to the AIII STATUS portion of the Appendix). The loss of the AIII status is indicated as follows:

- Loss of the AIII capability prior to Aircraft On Course (AOC - see definitions) 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 (replaced by the next available mode, e.g., IMC if the current mode is PRI) and the elimination of the flashing "AIII" on the Combiner (no longer AIII mode available). 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, on the HCP MODE display line, and the "AIII" on the First Officer's HGS Annunciator Panel being extinguished. If this occurs below 500 feet (above the TDZE), it also results in the "APCH WARN" annunciations on the Combiner and HGS Annunciator Panel. The AIII capability will again be indicated if the capability is again acquired (independent of AOC or altitude).

An AIII approach capability may 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. These are identified in the AIII Requirements Table in the Appendix. The aircraft configuration requirements for an AIII status at or following AOC are:

- Both IRSs 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, and;
- The Reference Glideslope on the HCP must be set between 2.51° and 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, 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.

VMC (or IMC) visual approach:

If it is not possible to obtain or retain a Combiner operating position that eliminates the "ALIGN HUD" message from being displayed on the Combiner, then the HGS VMC (or IMC) mode must not be used for a visual approach.

Use of the HGS for other flight operations (e.g., Flight Director approaches using the PRI or IMC mode) is dependent on the available information presented on the Combiner.

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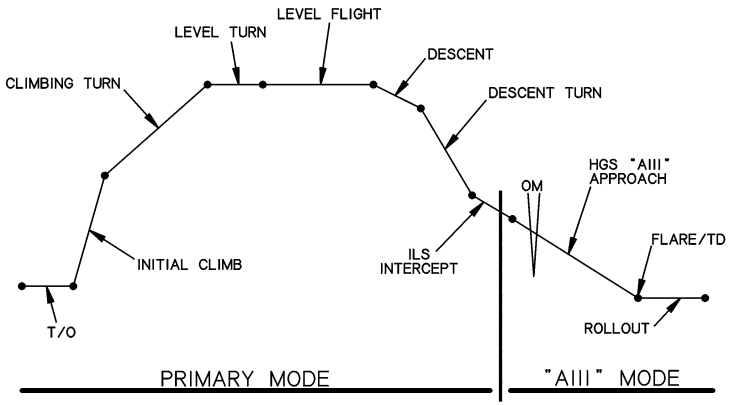
Typical Flight Profile

A typical flight using the HGS might be performed as follows:

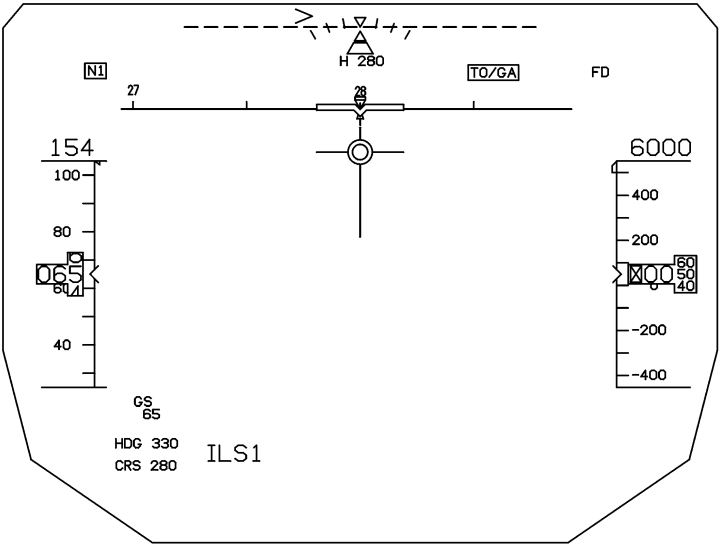
- The HGS is used during a conventional or a Low Visibility takeoff in the Primary mode.
- The HGS is used in the Primary mode during the climb to the assigned cruising altitude. The HGS allows the pilot to optimize aircraft performance with Flight Path and Flight Path Acceleration while simultaneously monitoring the flight's progress and monitoring for other traffic.
- The HGS is used in the Primary mode enroute for navigation.
- The HGS is used in the Primary mode for the descent, utilizing Flight Path to establish the proper glide path and airspeed control. Again, the HGS can be used while monitoring for other traffic and to perform normal terminal area maneuvering.
- Once established on the ILS approach (ILS captured), the AIII mode is engaged for precise manually flown approach and landing guidance capable of operations to CAT IIIa minimums.

The following HGS symbology illustrations and text depict a hypothetical flight profile as depicted above.

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.



TYPICAL FLIGHT PROFILE

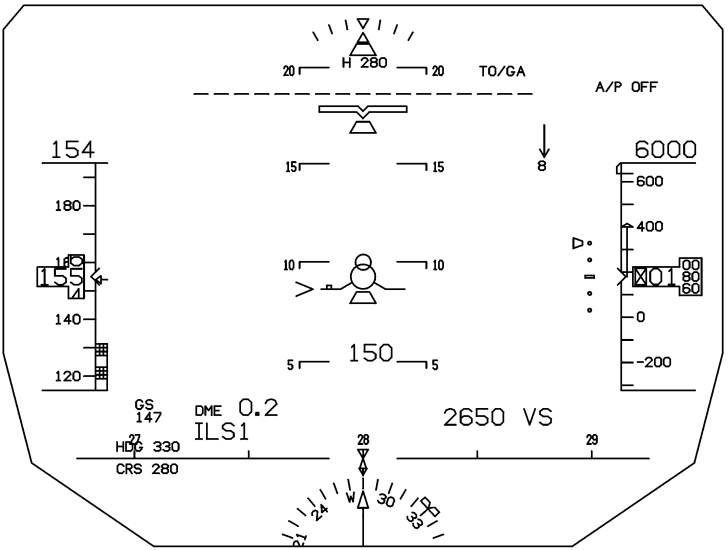


TAKEOFF GROUND ROLL

For takeoff, the HGS PRIMARY mode is selected.

For a Low Visibility Takeoff, the general operating procedure is to taxi the aircraft into takeoff position over the runway centerline. Readjust the selected course as necessary to overlay the Selected Course and Ground Localizer Line symbols on the actual runway centerline. Given that all requirements for the display of the HGS Guidance Cue are present, the Guidance Cue will display in the center of the Ground Roll Reference symbol. Advance power and using normal control inputs, visually track the centerline while monitoring the Guidance Cue and Ground Localizer Symbols. These can be especially beneficial in the event of an engine failure during the takeoff roll in assisting in maintaining lateral control and successfully aborting or continuing the takeoff.

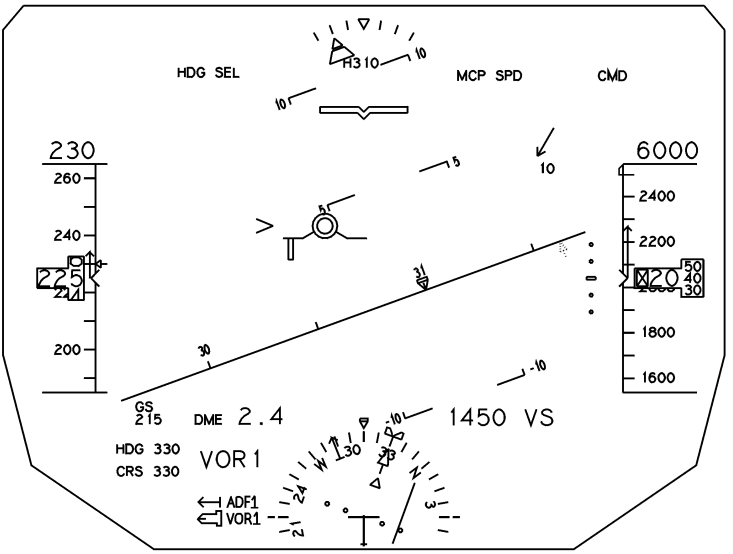
The illustration above indicates a Low Visibility Takeoff, accelerating through 65 knots with the Guidance Cue centered within the Ground Roll Reference symbol and the localizer centered under the Selected Course on runway 28. Target airspeed of 154 knots is set for the initial climb, 6000 feet for the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



INITIAL CLIMB

At rotation, a number of changes take place on the display. Flight Path is displayed, with Flight Path Acceleration now positioned relative to Flight Path. This is particularly useful in determining a positive climb gradient and in optimizing climb performance. With power set as desired and the appropriate 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 DFCS 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, however the amount of HSI visible is dependent on the display compression as a result of the pitch attitude.

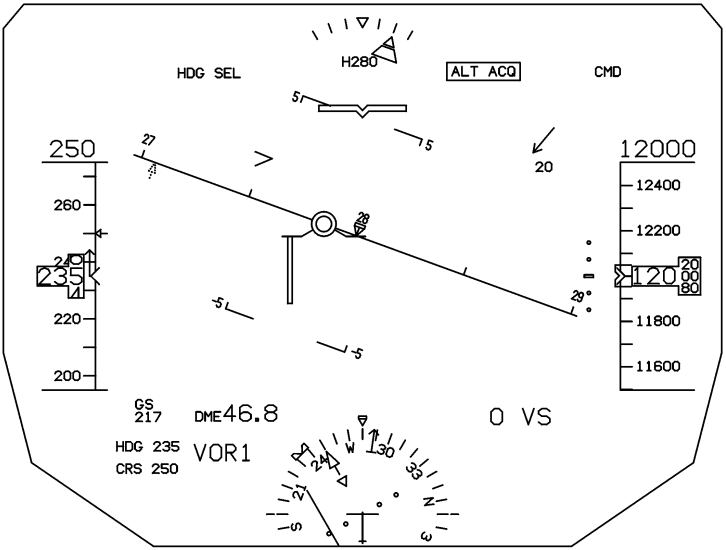
In the illustration above, the aircraft pitch attitude is approximately 17° and the climb angle is approximately 9°. Flight Path is just below the guidance cue, likewise, the Aircraft Reference symbol is just below the TO/GA Target Pitch Line, indicating that the pilot needs to pitch up slightly to capture the Flight Director engaged in the Takeoff/Go-Around 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.



CLIMBING TURN

In this illustration, 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.

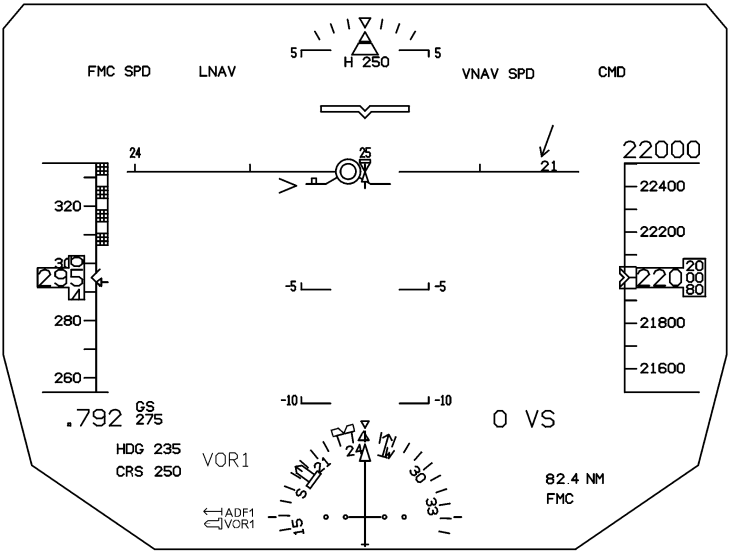
The aircraft is climbing through 2040 feet to the assigned altitude of 6000 feet and is accelerating slightly through 225 knots to the target speed of 230 knots. The autopilot has also been engaged.



LEVEL TURN

In a level turn, the pilot needs only to maintain the Flight Path symbol centered on the horizon to maintain altitude. In a level 30° bank turn, the angled portion of the Flight Path symbol will overlay the horizon line. The target altitude is also maintained by holding the selected altitude pointer inside the altitude scale index " > ".

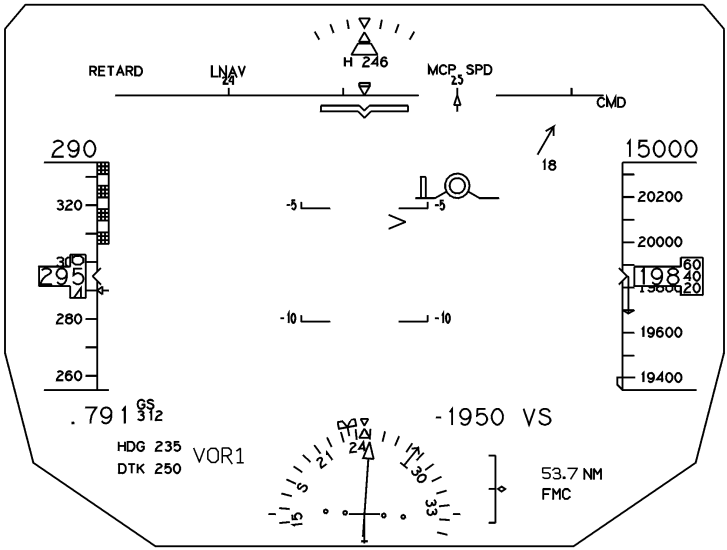
In this illustration, the autopilot recently acquired the assigned altitude and the aircraft is in a level left turn of 20°. The aircraft is currently turning through a heading of 280° toward the selected heading of 235° to intercept the 250° radial FROM the VOR station. The aircraft is accelerating 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's a right quartering headwind resulting in a groundspeed of 217 knots.



LEVEL FLIGHT

Straight and level unaccelerated flight 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.

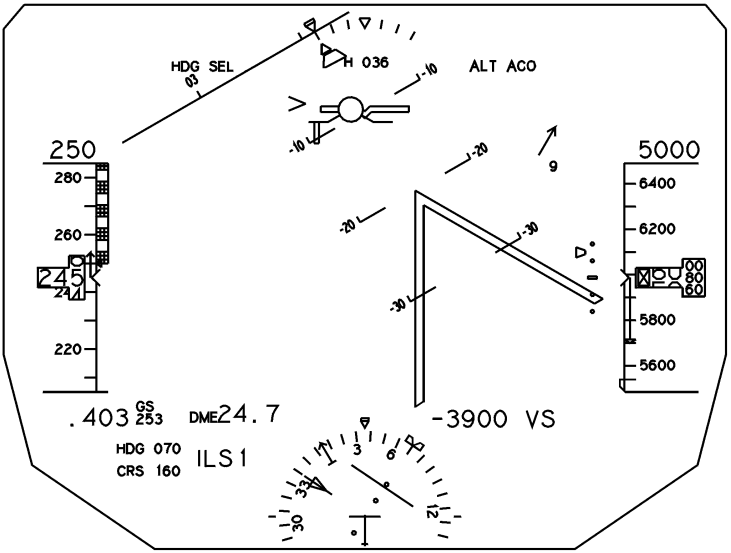
In this illustration, the aircraft is level at 22,000 feet, 295 knots and Mach .792. Ground Speed is now 275 knots as a result of the 21-knot right quartering headwind indicated by the wind arrow. The aircraft is being flown by the autopilot (CMD) with LNAV and VNAV modes selected and is 82.4 nautical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



DESCENT

Here 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 positioning the Flight Path symbol in pitch. 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 having to be 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.

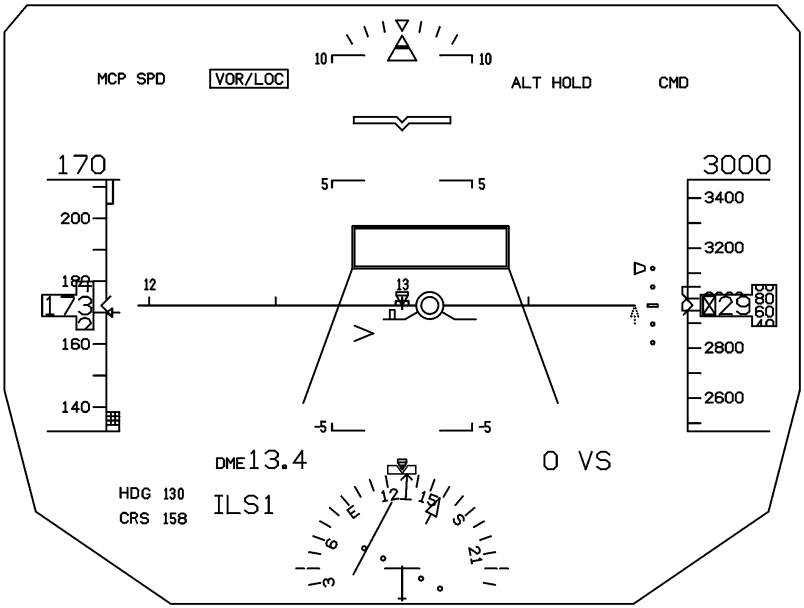


DESCENDING TURN

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

In this illustration, 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 lines 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. At positive pitch attitudes, the chevron is displayed with the point on the 30° pitch line. This is to enhance pitch awareness.



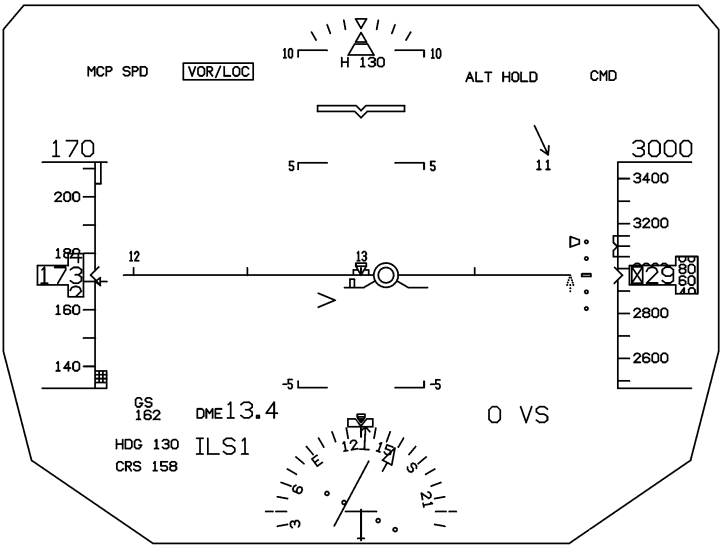
TCAS RESOLUTION ADVISORY

TCAS Resolution Advisories 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 (illustrated above) 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 the example above, 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.

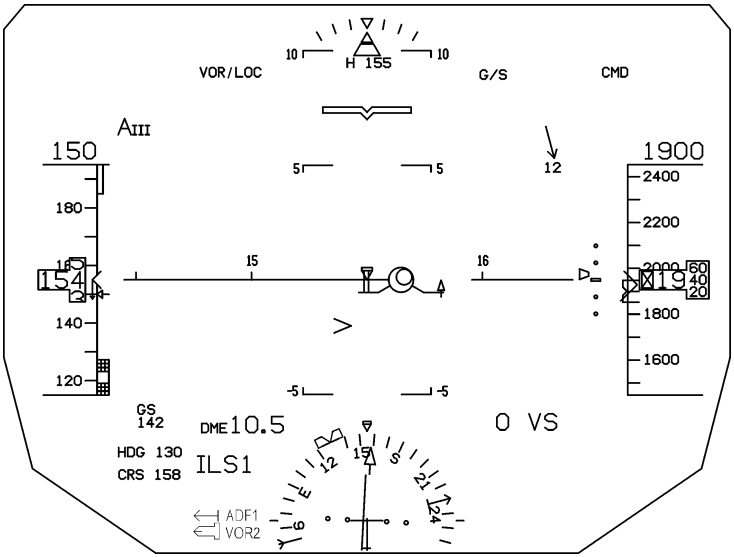


ILS INTERCEPT

The Primary (PRI) mode is the principle mode of operation for enroute navigation. The other HGS modes are predominantly used for approach. Any of the modes can be selected at any time as desired however, with the exception of "AIII" which is intended for CAT II or IIIa approaches and is only selectable after ILS capture.

In the PRI 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 the illustration above, 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 and the closest direction to turn to it. The aircraft is level at about 3000 feet (2970) 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.

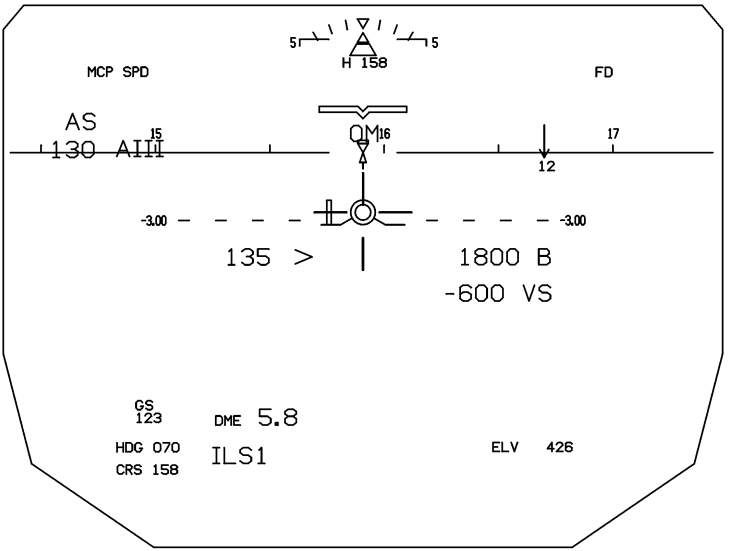


ILS CAPTURE

In the illustration above, the aircraft is just completing the turn to the final approach course and has captured the localizer and glideslope. This has caused the flashing "AIII" to be displayed.

Prior to an ILS capture, the capability of the HGS to perform an AIII approach is indicated on the HCP by displaying, on the right half of the STBY display line, an "AIII". At ILS capture, if Aircraft On Course (AOC) logic is satisfied and all required systems are operating properly (AIII capable), the HGS will automatically annunciate on the Combiner (in the PRIMARY mode only) and HCP that the AIII mode is available for selection. This is indicated by "AIII" flashing on the Combiner in the upper left portion of the display and "AIII" displayed on the left half of the HCP STBY line. At this point the pilot has the following options:

- If desired, the AIII mode can be selected by pressing the "MODE" key.
- The pilot can delay the AIII mode selection, but it must be selected prior to 500 feet above the TDZE. If not selected prior to 500 feet above the TDZE, and no other changes are made, the "AIII" on the HCP and the flashing "AIII" on the Combiner is eliminated making the AIII mode inaccessible.
- If AIII is not desired, pressing the "STBY" key on the HCP will position the IMC mode in standby and display "AIII" on the right and extinguish the flashing "AIII". Additional presses of the STBY key will cycle through the standby modes including AIII, any of which can be selected by pressing the MODE key.

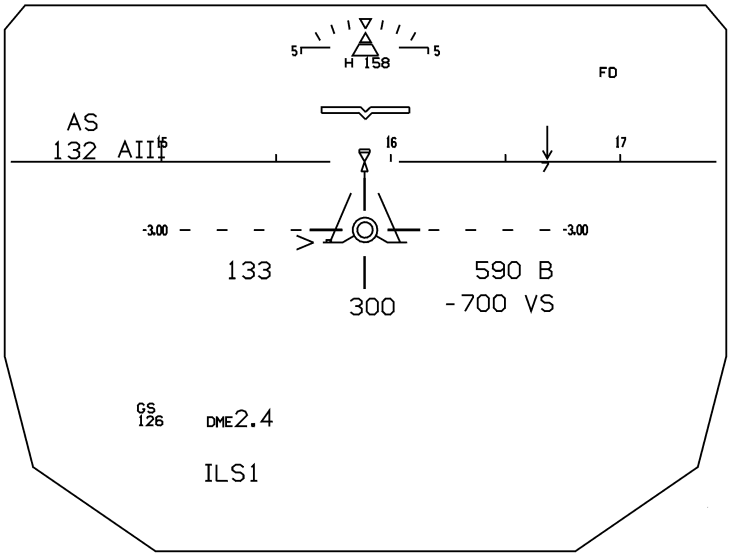


AIII APPROACH

In this illustration, with the aircraft established on the ILS approach, the AIII mode has been selected on the HCP. The aircraft is on the localizer and slightly below the glideslope. The position of the Flight Path and centered Guidance Cue slightly above the -3.00° Reference Glideslope 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. The digital Elevation data is only displayed for five seconds after the AIII mode is selected or whenever the value is changed.

Localizer deviation is now displayed as vertical bars laterally positioned relative to the Selected Course pointer. Glideslope deviation is now displayed as horizontal bars vertically positioned relative to the Reference Glideslope line. When centered, these create a cross in the center of the display with the Flight Path and Guidance Cue in the middle. It is important to note here that the Guidance Cue in the AIII mode is providing pitch and roll commands derived by the HGS. The Guidance Cue is now independent of the DFCS Flight Director and will provide guidance all the way to touchdown.

The AIII mode incorporates an Approach Monitor function active from 500 feet to touchdown. This monitor triggers the "APCH WARN" annunciation as a result of a system fault (i.e., sensor, equipment or HGS failure) or a performance monitor limit being exceeded. 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.

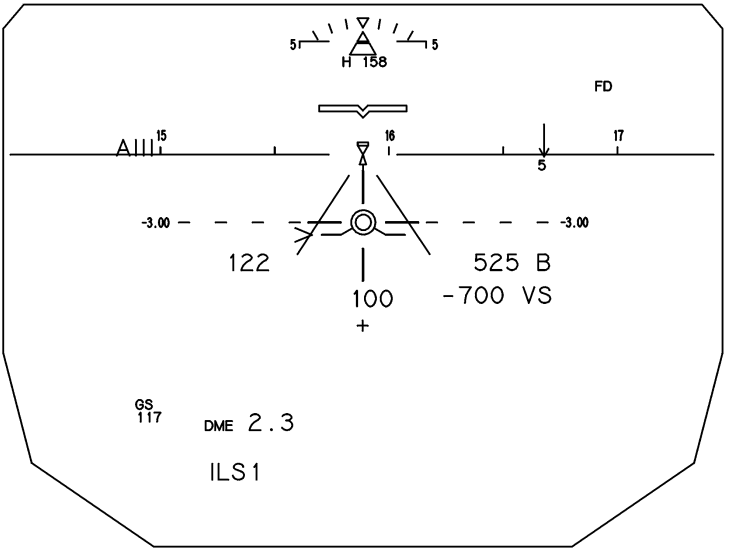


AIII APPROACH - 300 FEET

In the illustration above, the aircraft is descending through 300 feet Radio Altitude, on speed and track. The two runway edge lines symbolically represent the runway. These are drawn referenced to the Selected Course pointer on the horizon so that if the real world runway were visible, the two would closely overlay.

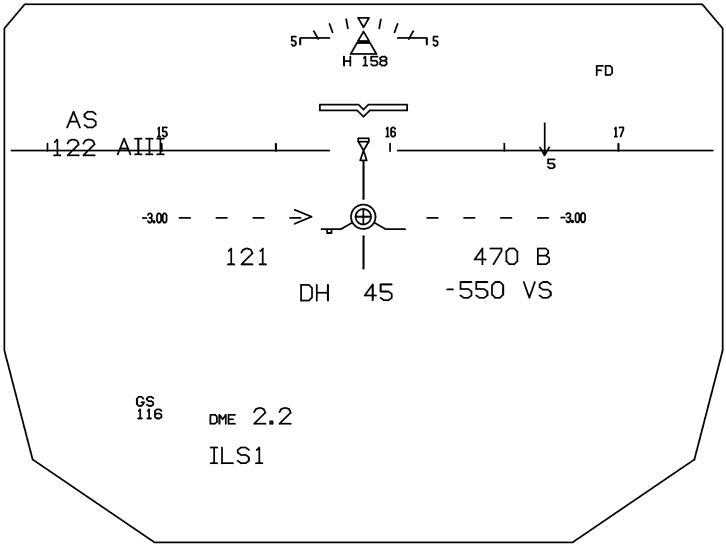
During operations in nominal CAT IIIa conditions (generally environmentally stable), the symbology is very stable and benign. Tracking the HGS Guidance Cue, and subsequently the ILS, amounts to centering and maintaining the Flight Path symbol over the cue. Monitoring localizer and glideslope raw data 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 deviations 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 approach status. As long as all required parameters and conditions are valid for a CAT IIIa 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 IIIa operations procedures would require a go-around anytime either of these occur below 500 feet.



AIII APPROACH - 100 FEET

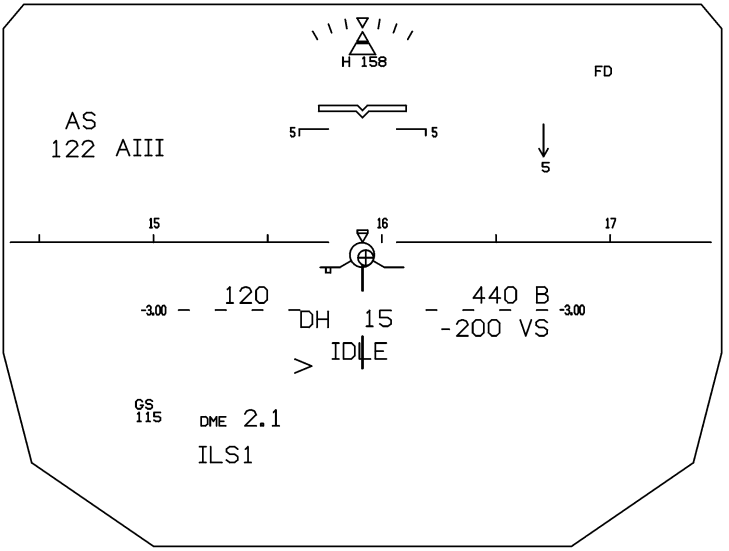
In this illustration, the aircraft is descending through 100 feet Radio Altitude, still on speed and track. At 105 feet AGL the AIII Flare Command symbol comes into view, displayed as a flashing " + " (plus) symbol, 2-3° below Flight Path. The symbol then starts moving up towards the Flight path symbol and now 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.



AIII APPROACH - 45 FEET

In this illustration, 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). This also coincides with the illumination of the "FLARE" annunciation on the F/O's HGS Annunciator Panel. The AIII Flare Command and Guidance Cue (now tied together) then command the Flight Path up through the flare maneuver, continuing until touchdown.

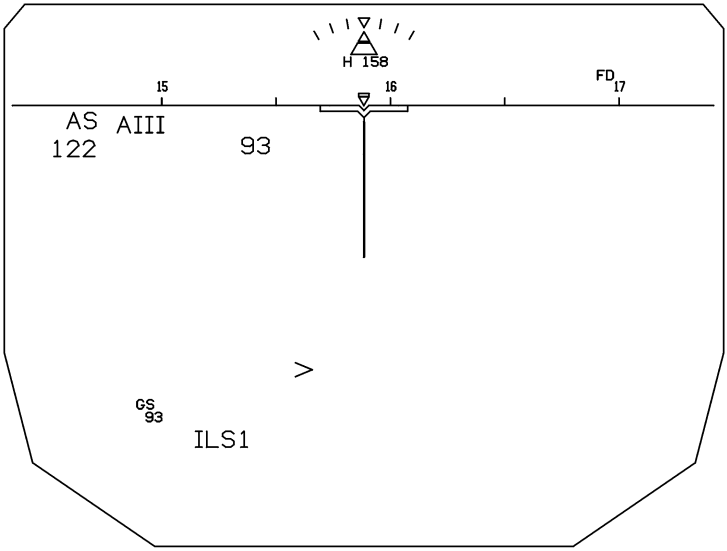
Airspeed is on target with only a one knot airspeed error. The runway edge lines are no longer displayed (below 60 feet) because the actual runway must be in view by decision height. Glideslope deviation raw data is also no longer displayed (below 70 feet) because the glideslope deviation data becomes 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 to assist in assessing approach performance. The right seat pilot continues to monitor the approach head down through touchdown.



AIII APPROACH - FLARE/TOUCHDOWN

In this illustration, 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 IIIa 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.



AIII ROLLOUT

Following touch down, the display changes to remove unnecessary symbology to assist with the landing rollout. This includes changing the localizer symbol to the Ground Localizer Line. The centerline and localizer are tracked while the aircraft is decelerated to exit the runway.

NOTE: The Ground Localizer Line is displayed in either the AIII, IMC or PRI modes while the aircraft is on the ground and the selected Nav source is an ILS. The illustration above is also representative of the IMC mode, except for the mode annunciation.

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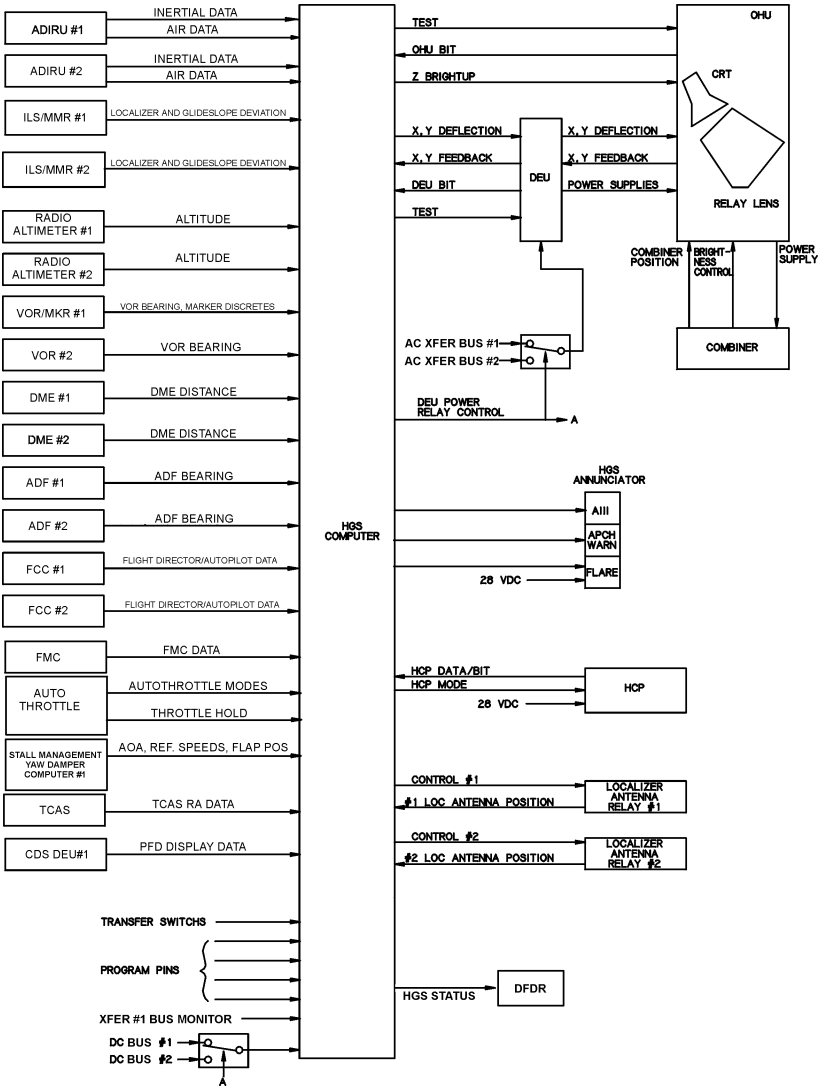
Appendix

This section supplies supplemental information.

HGS INTERFACE

The HGS interface block diagram is illustrated below.



HGS INTERFACE BLOCK DIAGRAM

SENSOR AND EQUIPMENT INPUTS

In order for the HGS to meet the requirements of a fail passive CAT IIIa approach and landing system, the HGS requires inputs from redundant sensor and equipment systems. The HGS receives these inputs through dual independent input/output subsystems contained within the HGS Computer. These inputs consist of digital data and associated discrete signals from the following sensors and equipment:

- Dual Air Data Inertial Reference Systems (ADIRU's) for primary attitudes, heading, body accelerations, body rates, vertical speed, ground speed, environmental data, and for barometric altitude and airspeed data,
- Dual ILS or Multi-Mode Receivers, including control panels, for ILS data
- Dual Radar Altimeter Systems for altitude above ground data
- Dual Flight Control Computers (DFCS - FCC) for Flight Director command signals, mode control, status annunciations, and expanded localizer control
- DFCS Mode Control Panel (MCP via FCC's), for selected course, heading, airspeed, and altitude
- Autothrottle Computer (A/T) for A/T modes (optional)
- Distance measuring Equipment (DME) for station slant range distance
- Single or Dual Automatic Direction Finding (ADF) for Bearing to Station
- Traffic Alert and Collision Avoidance System (TCAS) for Resolution Advisories
- Ground Proximity Warning System (GPWS) for Windshear Warning
- Flight Management Computer System (FMCS) for LNAV and VNAV data (optional)
- Stall Management/Yaw Damper Computer (SMYDC) for AOA and Reference speed data

In addition to the sensor and equipment inputs, a number of program pin and discrete inputs are required to identify the type of aircraft in which the HGS system is installed, aircraft configuration inputs, and the source of data to be used by the system. These include:

- Dual or single FMC installed,
- Dual or single ADF receivers,
- AIII mode enabled/disabled,
- Localizer antenna selection inputs,
- IRS, FMC (If dual Flight Management Computers are installed) and Navigation data transfer relay state inputs.

Manual selection of certain parameters used or displayed by the HGS are provided by the following:

- DFCS modes, F/D, A/T and A/P selection and Selected Course, Heading, Airspeed and Altitude that are displayed on the HGS are selected on the Mode Control Panel (MCP) or power lever GA switches.
- Decision Height used by the HGS is entered on the Captain's EFIS Control Panel.

HGS INTERCONNECT

The interface between HGS LRUs consists of:

- Video drive and video feedback signals between the HGS Computer, DEU and OHU;
- Bi-directional communication between the HGS Computer and the HCP;
- DEU, OHU and Combiner BITE status information to the HGS Computer;
- Combiner position monitoring, brightness control and ambient light sensor information between the OHU and Combiner;
- Power voltages for the OHU and Combiner supplied from the DEU,
- HGS Computer outputs to drive the HGS annunciators, Localizer antenna switching, and Computer/DEU power switching relays.

LOCALIZER ANTENNA POSITION MONITORING AND SWITCHING

The Boeing 737 ILS Receiver antenna inputs are required to be switched to forward mounted antennas during Low-visibility takeoffs and ILS approaches. This is normally controlled by the selection of the Approach mode switch on the MCP. In order for the HGS to perform a Low Visibility Takeoff or an AIII approach independent of the MCP approach modes, the HGS Computer commands the antenna switching relays to be in the forward position when configured for a Low Visibility Takeoff or upon selection of the AIII mode. This position is then monitored by the HGS Computer throughout the Takeoff or AIII approach. If either the #1 or #2 antenna are not sensed as forward, the Ground Roll Guidance is removed for the Low Visibility Takeoff or the AIII status is lost ("NO AIII") and, if below 500 feet, an "APCH WARN" is indicated on an AIII approach.

HGS POWER

The primary source of power for the HGS is the No. 1 AC and DC Transfer Buses (115vac and 28vdc). The DEU operates from 115vac and the HGS Computer and HCP operate from 28vdc. The OHU and Combiner do not require their own source of power as these are both powered by the DEU. The HGS Annunciator Panel receives its power from the aircraft Master Bright/Dim and Test lighting circuit.

In the event of a power loss on the No. 1 AC Transfer Bus, an automatic power transfer takes place restoring power to the affected bus. However, an intentional delay in the aircraft power transfer system would cause a momentary power loss to the DEU and HGS Computer, blanking the display momentarily (3-4 seconds). In order to eliminate this possibility, the HGS Computer monitors the No. 1 AC Transfer Bus and if a failure is detected, the HGS Computer controls dedicated DEU and HGS Computer power transfer relays. These are designed to switch power sources well before the HGS Computer will shut down. The DEU transfer relay switches power for the DEU from the No. 1 AC Transfer Bus to the No. 2 AC Transfer Bus. The HGS Computer transfer relay switches power for the HGS Computer from the No. 1 DC Transfer Bus to the No. 2 DC Transfer Bus. Shortly after power is restored to the #1 system, the power is switched back to the #1 source.

This HGS power switching is transparent in the normal operation of the system.
Head-Up Guidance Circuit Breakers consist of two Head-Up Guidance Computer breakers (#1 and alternate), two DEU breakers (#1 and alternate), an HCP breaker and an Head-Up Guidance Power Monitor breaker. These are located together in the P18-2 Circuit Breaker Panel.

HGS COOLING REQUIREMENTS

The HGS Computer and the DEU are both supplied aircraft cooling air from the Aircraft's avionics cooling system. This forced air-cooling is necessary to maintain acceptable operating temperatures and reliability. None of the other HGS LRU's require aircraft cooling and use natural convection cooling.

AIII STATUS

The ability of the HGS to perform an AIII approach is dependent on the availability (status) of the HGS and the other aircraft systems necessary for a CAT IIIa ILS approach. The status indication that the HGS has the ability to perform an AIII approach is indicated by:

- "AIII" displayed on the right side of the HCP STBY line prior to Aircraft On Course (AOC), or;
- "AIII" displayed on the STBY line as an available mode after AOC, or;
- The annunciated "AIII" after AIII mode selection.

Operational conditions also determine the requirements for the AIII status.

- Aircraft on ground (see Definitions);
- Aircraft in flight (see Definitions) prior to AOC;
- Approach on course;
- AIII mode selected.

Following AOC, additional requirements and tighter comparison tolerances are imposed in order to meet all HGS display and guidance requirements for the AIII approach and landing.

The following conditions must be met in order to achieve the AIII capability at AOC:

- Both IRSs must be in the NAV mode.
- All instrument transfer switches must be in "NORMAL";
- Both ILS/MMRs must be tuned to an 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 and;
- The Reference Glideslope on the HCP must be set between 2.51° and 3.00°.

SYSTEM MONITORING

Contained within the HGS Computer is an independent processor, called the System Monitor. The System Monitor determines the status of the required systems for an AIII approach. The System Monitor is also programmed to ensure that HGS symbology is positioned accurately (Critical Symbol Monitor, see Built-In Tests this section) and that the approach is flown successfully (Approach Monitor). If the System Monitor detects a system failure within the HGS or in any required input, it will cause the loss of the AIII status (see AIII Status this section). The Approach Monitoring is only active when below 500 feet above the TDZE and the HGS is providing approach guidance during an AIII approach. If a loss of the AIII status exists or the System Monitor detects an out of tolerance approach condition when below 500 feet, an Approach Warning ("APCH WARN") is annunciated.

Approach Monitoring is functionally divided into a tracking monitor and a flare monitor.

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

- Airspeed error;
- Localizer deviation;
- Glideslope deviation, and;
- Crosstrack rate.

The flare monitor evaluates:

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

The System Monitor automatically initiates a functional test of the Approach Monitor when the system is AIII capable and Aircraft On Course (AOC) logic is satisfied. A failure of this test will result in the loss of the AIII status.

LOW VISIBILITY TAKEOFF MONITORING

During a Low Visibility Takeoff, monitoring is performed between the #1 and #2 localizer deviations. Below 40 knots, a failure of the #2 localizer or if a miscompare between the #1 and the #2 is detected, then the Ground Roll Guidance Cue will not be displayed and a localizer comparison flag ("LOC CMP") is displayed. A failure of the #1 localizer causes the localizer deviation and the Ground Roll Guidance Cue to be removed from the display but the flag ("LOC CMP") is not displayed. Above 40 knots, the above remains true except a failure of the #2 localizer will not result in the localizer comparison flag. Once the "LOC CMP" flag is displayed, it remains displayed until the cause is corrected or the aircraft is in flight.

LOW VISIBILITY TAKEOFF GUIDANCE

The HGS derived Ground Roll Guidance Cue provides lateral guidance relative to the Ground Roll Reference for tracking the localizer during a Low Visibility Takeoff. The ability of the HGS to provide the Ground Roll Guidance Cue is dependent on the aircraft being configured for a Low Visibility Takeoff and the availability of inputs required for the processing of the Ground Roll Guidance Cue.

When preparing for a Low Visibility Takeoff, the display of the Ground Roll Reference symbology is dependent on following conditions:

- The HGS PRIMARY mode is selected,
- The aircraft is on the ground,
- The Nav Receivers are tuned to a localizer frequency.

During Low Visibility Takeoff operations, the HGS Guidance Cue gain (sensitivity) is varied dependent on the distance to the localizer antenna. The entered runway length and ground speed provide the system with the information necessary to know the approximate distance to the antenna at any point during the takeoff roll. By compensating for the increased sensitivity as the aircraft accelerates toward the localizer antenna, the Ground Roll Guidance Cue effectively maintains a constant sensitivity throughout the takeoff roll.

BUILT-IN TESTS

The HGS contains extensive self test hardware and software which continuously determines the operational status of the HGS.

Tests performed as a function of Built-In Test (BITE) include:

- Critical Symbol Monitor - verifies that certain critical symbols are positioned properly by comparing the display output back to expected aircraft sensor input values.
- Window Comparator Test - verifies video deflection signals against references as another form of deflection position monitoring.
- Power Supply Monitors - verifies required power supply voltages.
- CRT Deflection Circuitry - monitors CRT operation.
- Input Converters - verifies HGS Computer and HCP input converters.
- Processors - verifies basic arithmetic and logical functions of each processor and its activity.
- Processor Memory - verifies all processor RAM and program memory.
- Program Execution - verifies proper execution of the software programs.
- Combiner Alignment - determines the proper alignment of the Combiner glass when in the operating position.

BITE functions are continuously performed on a background basis to normal display and guidance calculations. During a system power up and an operator initiated test (see HGS TEST), all tests are performed in approximately two seconds.

A BITE detected fault in portions of the HGS Computer, the DEU or the OHU, will cause the display to be blanked so that no misleading information can be displayed on the Combiner. As an additional indication that a BITE detected fault is occurring, the HCP "FAULT" annunciator will be illuminated. When TEST is selected on the HCP, any existing faults are displayed in a fault code form. If more than one fault is detected, the fault codes are cycled on the HCP display. These fault codes are grouped by LRU and indicated as illustrated below.

HGS LRU	FAULT CODES
HGS COMPUTER	HC10 thru HC57
OVERHEAD UNIT (OHU)	OHU60 thru OHU66
DRIVE ELECTRONICS UNIT (DEU)	DEU70 thru DEU77
HGS CONTROL PANEL (HCP)	HCP90 thru HCP97
HGS SYSTEM	HGS 80,81
COMBINER	ALIGN HUD

NOTE: The Combiner position fault is not displayed as a fault code but is displayed to match the message presented on the Combiner "ALIGN HUD".

HGS TEST

An HGS Test capability is provided to assist in performing system tests and troubleshooting. The HGS Test is specifically designed for maintenance activities and there is no requirement to perform an HGS Test during normal operations. However, since the test functions are performed and are accessible from the cockpit, the following description is provided for information.

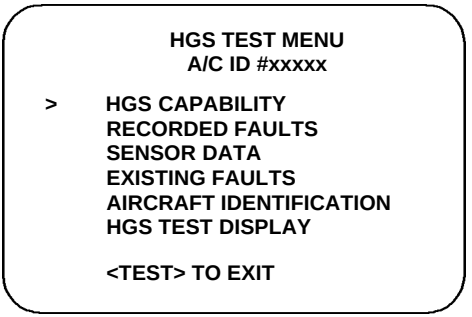
NOTE: In some cases, an operator initiated test could cause a fault to be cleared (due to the HGS being reset) returning the system to normal operation.

The HCP TEST function key is used to initiate HGS internal tests, enter the HGS TEST display functions and perform an HCP Display Test.

The HGS Test function is available for selection while the aircraft is on the ground. Selection is made by depressing the TEST key in the keypad, illuminating the dot annunciator in the upper left corner of the TEST key. If a Runway or Glideslope data entry operation, or the Clear function is active when TEST is selected, these functions are automatically exited.

Initially, all HGS BITE functions are performed. This results in the Combiner display being blanked and the fault annunciator on the HCP illuminating until all tests are passed (approximately two seconds if normal). If any fault is detected, then the fault annunciator will remain illuminated and a fault code will display on the HCP STBY display line. Depending on the fault, the Combiner display could also remain blank. If more than one fault is detected, all fault codes are displayed in two second intervals, repeating until the fault is cleared. This fault code information should be observed and noted for any maintenance action.

Following the successful BITE, "TEST" replaces the current mode on the MODE display line, and a "HGS TEST MENU" is displayed on the Combiner (see below) replacing normal flight symbology.



A cursor " > " indicates the current selection and is controlled with the BRT+ and DIM- keys on the HCP. Once positioned as desired, pressing the ENTER key makes the selection. In data displays, an arrow is also used to indicate that additional data is available for viewing. These are positioned pointing up and/or down alongside the data fields displayed. The BRT+ and DIM- keys are again used to scroll the displays accordingly. Manually exiting the Test function is accomplished by again pressing the TEST key.

A brief explanation of each of the options follows.

HGS CAPABILITY

The HGS Capability option is intended to provide a quick method of determining whether the HGS is AIII capable, and if not, what is causing the inability. The same AIII mode/status logic used in normal operation is used for displaying the AIII capability status, and the cause for any inability detected, indicated on the HGS Capability page.

An example of the HGS Capability page is shown below.

HGS CAPABILITY FAULTS

CAPABILITY	FAULT	
AIII INCAP	ADIRU1-IR	INVALID
AIII INCAP	ADIRU2-ADR	INVALID
AIII INCAP	FCC1	INVALID

3 FAULTS

In the example given, three faults are detected disallowing an AIII capability; ADIRU1-IR is invalid, ADIRU2-ADR is invalid and FCC1 is invalid. Eliminating these conditions would result in an AIII capability. Viewing the Sensor Data page for these faults will provide specific signal and status information to troubleshoot these conditions (see SENSOR DATA).

If the HGS determines the system is capable of an AIII approach, "AIII" is displayed in the capability column, and "NO CAPABILITY FAULTS DETECTED" is displayed in place of the number of faults beneath the table.

RECORDED FAULTS

The HGS Computer is designed to record faults related to aircraft equipment and sensors, and HGS faults detected by BITE, and store these in non-volatile memory. Faults are recorded only when ground speed is greater than 40 knots and only those associated with an HGS fault code, a loss of AIII capability, or a "NO AIII" or "APCH WARN" indication (a flight deck effect). These faults are then available for review from the Recorded Faults menu option.

The HGS non-volatile memory is capable of storing at least 128 flight legs each containing a maximum of 80 faults. Once the memory is filled, the oldest data is written over with the latest data.

Selecting "RECORDED FAULTS" from the HGS Test Menu causes the Combiner display to be changed to the Recorded Fault Display. Faults are tagged for each flight leg, a leg starting at 40 knots on takeoff and ending at 40 knots on landing. The Recorded Fault Display when selected displays flight leg #1 as the last flight leg flown. If viewed in flight, the current flight leg is not shown and the display will be for the previous flight.

The display provides access to all fault recorded data stored in the HGS Computer and includes the following information as illustrated below:

1. LEG# - The flight legs are numbered from the most recent (#1) to the oldest still available from non-volatile memory.
2. A/C ID# - The aircraft ID # displayed represents the unique aircraft identification number used by the HGS Computer to tag the flight recorded data to the specific aircraft the faults occurred on. This ID number is entered from the AIRCRAFT IDENTIFICATION option from the HGS Test Menu.
3. xxx LEGS - identifies the number of flight legs that are currently stored in the fault recording non-volatile memory.
4. EFFECT - The approach Flight Deck Effect resulting from the fault.
5. FAULT - indicates the LRU and type of fault detected.
6. xxx FAULTS - indicates the total number of unique faults stored in the fault recording non-volatile memory for the flight leg currently being displayed.

LEG #1		A/C ID # 700	
ENTER LEG #		10 LEGS	
EFFECT	FAULT		
APCH WARN		LOC	EXCEED
APCH WARN		NO AIII	
NO AIII	RALT2		INVALID
APCH WARN		GLIDESLP	EXCEED
AIII INCAP	ADIRU - IR	PITCH	COMP
9 FAULTS			

In this example, the last recorded fault on the most recent flight leg (#1) for aircraft ID # 700 was the localizer deviation limit being exceeded, a radio altimeter fault caused a loss of AIII and APCH WARN (must have occurred below 500 feet to get approach warning), a glideslope deviation limit was exceeded which also caused an approach warning, and at some point prior to AOC, an ADIRU #1 & #2 pitch miscompare was detected resulting in the loss of AIII capability. Four additional faults are recorded for this leg and could be observed by scrolling the display up using the "DIM-" key. Ten other flight legs are recorded.

SENSOR DATA

Selecting "SENSOR DATA" from the HGS Test Menu enables Sensor Data pages to be displayed on the Combiner. The Sensor Data displays provide the current value and status of each signal being received from each of the sensors and equipment that interface with the HGS Computer. The initial display page consists of another menu as illustrated below.

SENSOR MENU		
>	ADIRU - IR	FCC / AT
	ADIRU - ADR	FMC
	RAD ALT	SMYDC
	ILS	CDS / GPWS
	VOR / MKR	TCAS
	DME / ADF	DISCRETES

The cursor " > " indicates the current sensor selection and is controlled with the BRT+ and DIM- keys on the HCP. Once positioned as desired, pressing the ENTER key makes the selection and the display is changed to the appropriate sensor data page.

An example of an IRU data page is illustrated below.

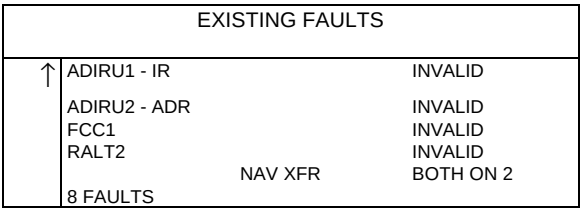
ADIRU - IR DATA				
SIGNAL	1		2	
PITCH	0.19	NORM	0.21	NORM
ROLL	-0.24	NORM	-0.26	NORM
MAG HDG	183.89	NORM	184.23	NORM
MAG TRACK	0.00	NCD	0.00	NCD
TRUE HDG	162.89	NORM	163.23	NORM
TRUE TRACK	0.00	NCD	0.00	NCD
GROUND SPD	0.00	NORM	0.00	NORM
VERT SPD	0.00	NORM	0.00	NORM

The left column indicates the signal data displayed for that row of data. The data is provided under column #1 if the data is from the #1 sensor and under column #2 if the data is from the #2 sensor. A data value and status is indicated for each signal based on the current signal being received.

An arrow is also used to indicate that additional data is available for viewing. These are positioned pointing up and/or down alongside the signal data field displayed. The BRT+ and DIM- keys are used to scroll the displays accordingly.

EXISTING FAULTS

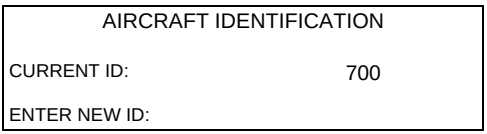
Selecting "EXISTING FAULTS" from the HGS Test Menu enables the Existing Faults page to be displayed on the Combiner. The Existing Faults display provides a list of the faults that are currently detected. An example is illustrated below.



The information provided includes the LRU identified as the source, the signal and the type of failure detected, and the total number of existing faults indicated at the bottom. To assist in viewing intermittent faults, a fault that clears will remain displayed for two seconds before being removed from the display. Faults are displayed in the order detected with the most recent on top. If no faults are detected, "NO DETECTED FAULTS" is displayed.

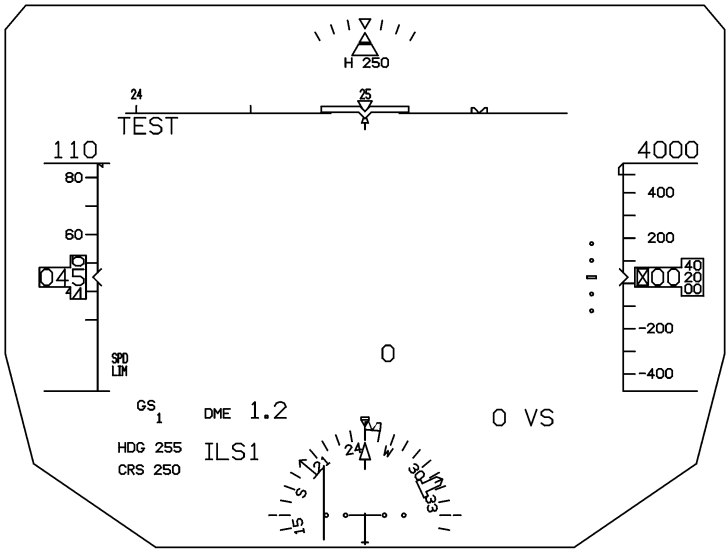
AIRCRAFT IDENTIFICATION

Selecting "AIRCRAFT IDENTIFICATION" from the HGS Test Menu enables the Aircraft Identification page to be displayed on the Combiner. This option allows the operator to enter a unique aircraft identification number (up to four digits) for HGS Fault Recording data. A number is entered using the numeric keypad on the HCP in the same manor as other numeric inputs and is followed by pressing the ENTER key to accept. The number should represent the specific aircraft in which the HGS Computer is currently installed. Each flight leg is then tagged with the corresponding aircraft ID number to distinguish the aircraft the faults occurred on. This allows the HGS Computer to be moved from aircraft to aircraft, or removed from service, without losing track of the stored fault information and its relative source. An illustration of the Aircraft Identification page is shown below.



HGS TEST DISPLAY

The "HGS TEST DISPLAY" option is only available on the ground. Selection of this option from the HGS Test Menu provides a symbology test display that includes all symbology that would be displayed in the Primary Mode in the air. An example is illustrated below. This is a real time display and includes all symbols whose corresponding inputs have a valid or test status. "TEST" is indicated on the symbology display as the active mode while the HGS Test Display is selected.



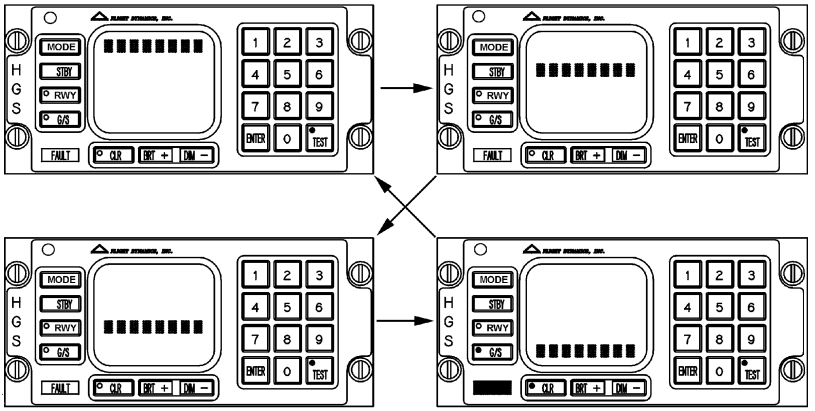
HGS TEST DISPLAY

HCP DISPLAY TEST

Another function of the TEST function key allows the verification of all HCP displays and annunciations. This test function is performed independent of the HGS Test function. Available only while on the ground, by pressing and holding the TEST key for four seconds, the HCP Display Test, illustrated below, is entered with the following sequence.

- Initially, all HCP display lines and annunciators will blank except the TEST dot annunciator, which remains illuminated during any test operation.
- The display line adjacent to the MODE key is completely illuminated first for approximately two seconds.
- The MODE display line is extinguished and the STBY display line is completely illuminated for another two seconds.
- The STBY display line is extinguished and the RWY display line and dot annunciator is illuminated for another two seconds.
- The RWY display line and dot annunciator is extinguished and the G/S display line, dot annunciator, CLR dot annunciator and FAULT annunciator are all illuminated.
- The cycle repeats until TEST is deselected.

Verification of all HCP keys is accomplished through normal operation of the HCP modes and functions.



HCP DISPLAY TEST

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 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*.

Aircraft on Course (AOC)- for purposes of the HGS, AOC is defined to occur when :

- Both VHF Nav's are tuned to an ILS frequency;
- Either #1 or #2 Glideslope and Localizer are captured;
- Track error is less than 15°;

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.

Aircraft Touchdown - for purposes of the HGS, Aircraft Touchdown is defined to occur when one of the following conditions exists:

- Wheel Height is less than 6 feet and Wheel Touch is true followed by a negative pitch rate, or,
- Radio Altitude is less than 4 feet and (Pitch Attitude is less than 2.3°) for 1.5 seconds, or,
- CAS #1 & #2 are less than 77.5 knots and Radio Altitude is less than 5 feet.

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

Category IIIa (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* and 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.

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 A_{III} - ..... Approach III (CAT IIIa approach mode or status)
ALT - ..... Altitude
ALTN - ..... Alternate
AOA - ..... Angle Of Attack
AOC - ..... Aircraft 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
BC - ..... Back Course
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
DEU - ..... Display 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
FPV - ..... Flight Path Vector
Ft - ..... Feet

FT - ..... Functional Test
GA - .....Go-Around
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
HERF - .....High Intensity Radiation Field
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 Authorities
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
PDU - ..... Pilot Display Units (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 Omnidirectional Range
VS or V/S - ..... Vertical Speed
XTK - ..... Crosstrack deviation
µA - ..... Microamp
° - ..... degrees
> - ..... greater than or cursor
< - ..... less than
Δ - ..... Delta - the difference between

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