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Superseding AIR4742

Display Characteristics of FDI Head-Up Guidance System as Approved for the B-727 Airplane

RATIONALE

This document has been determined to contain basic and stable technology which is not dynamic in nature.

STABILIZED NOTICE

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1. SCOPE:

The scope of this document is limited to descriptions of the display characteristics of the Flight Dynamics, Inc. (FDI) Model 1000WS Head up Guidance System (HGS) as installed on the Boeing 727 airplane and certified by the Federal Aviation Administration for use in Category III landing operations. The symbology depicted in this document is referenced to the particular pilot task(s) for which it was designed. Also included are descriptions of operational features of the particular symbol along with any associated criteria regarding symbology constraints, source data, or position error.

2. APPLICABLE DOCUMENTS:

The following publications form a part of this document to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order. In the event of conflict between the text of this document and references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

2.1 FAA Publications:

Available from Federal Aviation Administration, 800 Independence Avenue, SW, Washington, DC 20591.

Federal Aviation Administration Advisory Circular 120-28C, “Criteria for Approval of Category III Landing Weather Minima”

3. OBJECTIVES:

This is primarily a historical document. It was developed with the objective of preserving the identity of the criteria applied to the civil certification as well as the description and characteristics of the symbology used in the FDI Model 1000WS HGS.

PREPARED BY SAE SUBCOMMITTEE G-10H, HEAD-UP DISPLAY
OF COMMITTEE G-10, AEROSPACE BEHAVIORAL ENGINEERING TECHNOLOGY (ABET)

STABILIZED BY SAE COMMITTEE G-10, AEROSPACE BEHAVIORAL ENGINEERING TECHNOLOGY (ABET)
STEERING GROUP

SYMBOL

BORESIGHT

PHASE OF FLIGHT

ALL PHASES

PILOT TASK

Determine relation of related symbology to position of boresight symbol. This is a major portion of information used to maintain awareness of absolute attitude.

REQUIRED PILOT PERFORMANCE

Historical training concepts have pilot rotating aircraft to absolute boresight attitudes for takeoff and go-around maneuvers.

CONSTRAINTS

Positioning constraints in that boresight should not interfere with other dynamic symbol elements. Since the Boresight symbol is used in conjunction with Pitch Ladder to represent actual aircraft attitude, the flight path group can wander up into and interfere with Boresight at low angles of attack. Past attempts to mask Boresight and overwrite with Flight Path have had objectionable results.

SYMBOLOGY IMPLEMENTATION(S)

In modes where pilot task is to attain absolute pitch attitude, Boresight symbol has taken on an enhanced shape upon detection of that mode. One example of this enhancement is an extension of the width of the symbol as follows:

SYMBOL FAMILY TASK

This symbol represents direction aircraft is pointing. Symbol position may be critical if other performance related symbology is present (e.g., flight path). The symbol is also used as center indication for HSI CDI mimic. However, the necessity for the symbol in all implementations is controversial.

ELEMENT TASK

A static element useful for guaging variations in other dynamic symbol elements.

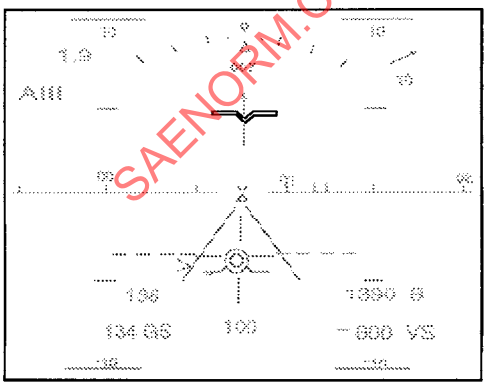
SOURCE DATA

None: fixed symbology. Generally taken to be fuselage pointing direction.

POSITION OR POSITION ERROR

Position of boresight is believed to be non-critical, but it should be absolutely static. Boresight should roughly correspond with head down pitch attitude reference; three degrees difference has been found to be acceptable in the past, but judged to be about the maximum deviation allowable.

SYMBOLOGY



OPERATIONAL FEATURES

The Boresight symbol (sometimes referred to as the Aircraft Reference symbol) represents the boresight of the aircraft in pitch, roll and heading. It is similar in operation to the aircraft symbol on a conventional ADI except that it is also conformal with the outside world. For instance, if the Boresight symbol is aligned with the Horizon symbol, aircraft attitude is level (zero pitch).

FIGURE 1 - Boresight

SYMBOL

PITCH LADDER

PHASE OF FLIGHT

CLIMB, GO-AROUND

PILOT TASK

Always have a sense of context of aircraft attitude in relation to the outside world.

REQUIRED PILOT PERFORMANCE

Somewhat airplane dependent. Most demanding case would require pilot to be able to determine at quick glance absolute attitude within 1 degree.

CONSTRAINTS

Scaling should be commensurate with pilot performance; 2.5 degree minor marks, 10 degree major marks, with scale markings. Ladder should not interfere with other dynamic symbology.

SYMBOLOGY IMPLEMENTATION(S)

Implementations includes ladders that are fixed in left/right sense as well as ladders that are tied to aircraft heading.

Some implemtations have used minor marks approximately 0.5 degrees wide and major marks approaimately 1 degree wide.

SYMBOL FAMILY TASK

Aids pilot in awareness of absolute attitude, in conjunction with horizon line.

ELEMENT TASK

Provides scale marks to judge pitch attitude of aircraft, angle of flight path in relation to horizontal.

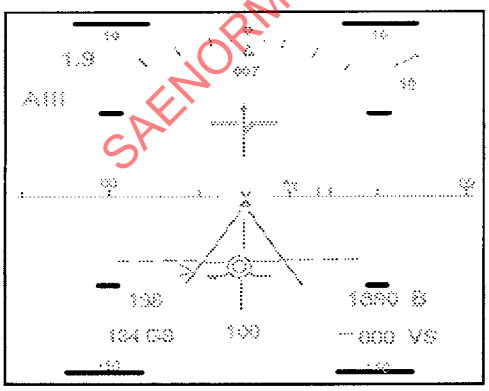
SOURCE DATA

Same as horizon line.

POSITION OR POSITION ERROR

Same as horizon line.

SYMBOLOGY



OPERATIONAL FEATURES

The Pitch Ladder (sometimes referred to as Pitch Scale) consists of a set of horizontal pitch lines which appear in increments of 5 degrees above and below the Horizon Line Like the Boresight and the Horizon Line symbols (except when vertical display compression is in effect) it is in scale with the outside world as viewed through the display. A set of pitch lines is positioned laterally every 15 degrees on the display.

FIGURE 2 - Pitch Ladder

SYMBOL

FLIGHT PATH

PHASE OF FLIGHT

LEVEL FLIGHT, DESCENT, APPROACH & TOGA

PILOT TASK

Maintain awareness of aircraft velocity vector. Symbol may be used for altitude hold in conjunction with horizon line, angle tracking for approach, and as part of command guidance symbol set.

REQUIRED PILOT PERFORMANCE

About horizon line, sufficient accuracy to maintain zero rate of climb with low workload. With other flight guidance symbology, ease of placement of flight path symbol to obtain desired attitude with low workload. When used with Flight Director symbol, pilot should not show any tendency to reverse commanded control directions.

CONSTRAINTS

Previous "air mass" types have been deemed inferior to those obtaining true conformality of velocity vector by incorporating inertial speeds. The implication is that conformality is very important for both pitch and lateral axes for HUD use in terminal area operations. Dynamic correction for c.g. of sensors is important, as flight path will be used as an aircraft control parameter. Update rate must be consistent with possible symbol motion, on the order of 10 Hz.

SYMBOLOGY IMPLEMENTATION(S)

This symbol has been implemented with angled legs referenced to thirty degrees and a horizontal leg segment which is referenced for related speed error scale and flight path acceleration.

SYMBOL FAMILY TASK

Represent velocity vector, conformal to outside world. Central element of "flight path group," comprised of flight path symbol, speed/acceleration symbology, altitude and flight director symbol. This group moves dynamically as flight path varies, but elements within the group maintain same relative position to each other (except for Guidance Cue).

ELEMENT TASK

Represent velocity vector, conformal to outside world.

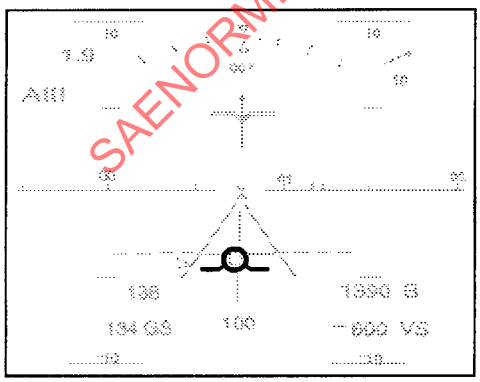
SOURCE DATA

Normally positioned by groundspeed divided by vertical speed, related to horizon line (pitch) and boresight (lateral) axes. "Air mass" flight path positioned without knowledge of inertial speeds, only alpha and beta (wind effects ignored). Dynamic correction using g for c.g. placement of sensors.

POSITION OR POSITION ERROR

Conformality: Pitch, +/- 1/4 degree; Lateral, +/- 1 degree
Relation to other symbols:
Horizon: +/- 1/10 degree
Guidance Symbols: +/- 1/10 degree
Boresight (0 wind, 0 beta): +/- 1/10 degree
Lateral (heading) errors greater than 1/2 degree are noticeable and objectionable when visually pointing at a runway more than 1 mile away.

SYMBOLOGY



OPERATIONAL FEATURES

Flight path symbolizes a new and unique type of flight information made available by electronic displays. Instead of replicating a single type of head-down instrument, the Flight Path symbol actually represents the sum total of all the conventional flight instruments. With actual flight path represented by the center of the Flight Path symbol 's circle, this symbol provides an instantaneous and continually updated indication of where the aircraft is going through space, as opposed to the conventional aircraft reference symbol which only gives pitch information. Because flight path is derived from inertial sensors, the pilot can maneuver the aircraft and "fly" the symbol to keep the flight path aimed at a desired point ahead.

FIGURE 3 - Flight Path

SYMBOL

SPEED ERROR

PHASE OF FLIGHT

ALL FLIGHT PHASES

PILOT TASK

Maintain sense of deviation from selected/desired speed.

REQUIRED PILOT PERFORMANCE

Humans are sensitive to indications about the zero index; therefore, placement in reference to zero is very important. Scaling and linearity are less important.

CONSTRAINTS

Excessive speed error has not been constrained on the display; pilot opinion suggests that normal modes with excessive speed error present (takeoff) are objectionable and maximum length constraints should be implemented. Speed select facility should be same as the one used for autopilot/flight director speed selection. Speed select should be accessible to the pilot without substantial movement of the eyes out of the HUD eyebox.

SYMBOLOGY IMPLEMENTATION(S)

Vertical bar of variable length representing speed error. Scaled about 1 degree per 10 knots. Width approximately 1/4 degree. Zero reference is the left horizontal leg of Flight Path symbol. Speed Error symbol moves dynamically with flight path group.

SYMBOL FAMILY TASK

In conjunction with other speed and flight path related symbology, give pilot information to recognize aircraft control inputs required (direction and proportional amount) to achieve desired attitude/energy state.

ELEMENT TASK

Analog representation of deviation of selected speed.

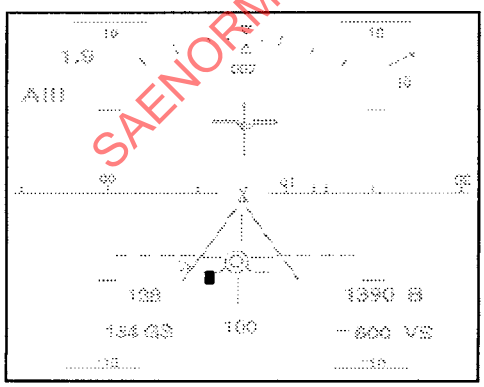
SOURCE DATA

Air data, selected speed control, or VNAV performance speed computation.

POSITION OR POSITION ERROR

Relationship to speed zero reference: +/- 1/10 degree. Scaling error may not be important: +/- 20%.

SYMBOLOGY



OPERATIONAL FEATURES

The Speed Error symbol (or sometimes referred to as Speed Error Tape) displays the difference between the actual airspeed (from the #1 air data computer) and the reference or "bug" speed selected by the pilot. If air speed is faster than the "bug" speed, the speed error tape rises from the left "wing" of the Flight Path symbol. If it is slower, it falls below the Flight Path symbol "wing." Each one degree of Speed Error symbol (tape) appearing represents approximately four knots of airspeed.

FIGURE 4 - Speed Error

SYMBOL

FLIGHT PATH ACCELERATION

PHASE OF FLIGHT

ALL FLIGHT PHASES

PILOT TASK

Maintain awareness of energy rate.

SYMBOL FAMILY TASK

In conjunction with other members of flight path group, represent aircraft total energy rate of increase or decrease.

REQUIRED PILOT PERFORMANCE

Symbol should be naturally usable in manual control of the aircraft to maintain desired energy rates via thrust of attitude control. Natural use of Flight Path Acceleration symbol is as a "throttle director."

ELEMENT TASK

Represent instantaneous inertial acceleration component along axis of flight path velocity vector. Scaling should be such that a flight path angle matching the instantaneous acceleration would result in zero accel. Zero reference should be horizontal leg of Flight Path symbol; same as speed error zero reference.

CONSTRAINTS

A changing air mass can induce accelerations in opposite direction to speed error increase. Without air data correction to long term inertial acceleration it has been necessary to hide ("pull") the Flight Path Acceleration symbol whenever the air data rate and acceleration have opposite signs and their absolute difference is greater than "X" knots/second or "Y" g.

SOURCE DATA

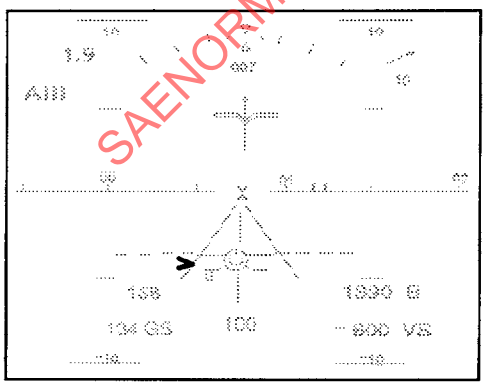
Accelerometer, IRS/stable platform. Algorithms have been derived that use air data to correct long-term components of acceleration due to moving air mass.

POSITION OR POSITION ERROR

Relation to zero reference: +/- 1/10 degree.
Scaling - absolute value: +/- 1/10 degree.

SYMBOLOGY IMPLEMENTATION(S)

SYMBOLOGY



OPERATIONAL FEATURES

Flight path acceleration, like the flight path symbol, is derived from inertial sensors. It indicates the acceleration (or deceleration) of the aircraft along the flight path. When the Flight Path Acceleration symbol is above the Flight Path symbol, the aircraft is accelerating. When it is below the Flight Path symbol, the aircraft is decelerating. When the Flight Path and Flight Path Acceleration symbols are aligned horizontally, the aircraft is in a steady state, neither accelerating nor decelerating.

It is important to remember that thrust will affect flight path acceleration. However, the symbol actually represents the total acceleration forces acting on the aircraft. Therefore, it should not be thought of as a throttle indicator or command.

FIGURE 5 - Flight Path Acceleration

SYMBOL

PRESENT HEADING POINTER

PHASE OF FLIGHT

ALL PHASES OF FLIGHT

PILOT TASK

Maintain awareness of present heading, manifested by heading the aircraft is pointing.

REQUIRED PILOT PERFORMANCE

CONSTRAINTS

Since this is part of symbology grouping that gets concentrated in the center of the screen for certain flight modes, care has to be taken so that the heading symbol does not lead to unseparable clutter.

SYMBOLOGY IMPLEMENTATION(S)

Small inverted caret placed on horizon line, vertically positioned under boresight symbol.

SYMBOL FAMILY TASK

Represent heading in a way compatible with other directional related symbology.

ELEMENT TASK

If the Boresight symbol is present, aircraft heading is represented by vertical projection of Boresight onto the Horizon Line. In cases where the vertical distance between these two symbols is large, it becomes necessary to aid the pilot's visualization of heading by adding a mark on the Horizon Line symbolic of present heading.

SOURCE DATA

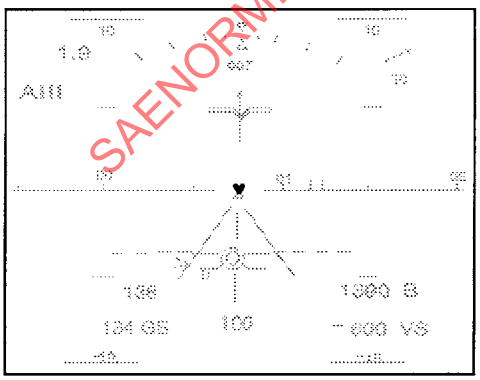
Aircraft heading.

POSITION OR POSITION ERROR

Visual perception of error in positioning the symbol drives error requirements tighter than required knowledge of absolute heading.

+/- 1/8 degree horizontal positioning
+/- 1 linewidth vertical positioning against Horizon Line

SYMBOLOGY



OPERATIONAL FEATURES

The Present Heading Pointer (or sometimes referred to as Heading Index symbol) indicates the actual heading of the aircraft along the horizon is positioned directly below the Boresight symbol.

FIGURE 6 - Present Heading Pointer

SYMBOL	*PHASE OF FLIGHT*
BANK ANGLE SCALE	**ALL PHASES OF FLIGHT**

PILOT TASK

Maintain awareness of instantaneous bank angle.

REQUIRED PILOT PERFORMANCE

Pilot should be able to resolve within +/- 1/4 degree when bank angle is near zero. Pilot can probably normally resolve within 0.1 degree.

CONSTRAINTS

None in particular. Some controversy surrounds the question of bank scale removal for phases of flight where presence may not be critical.

SYMBOLOGY IMPLEMENTATION(S)

Scale markings placed at 10 degree intervals, over a 60 degree arc segment, thirty degrees either side of zero; markings placed on imaginary arc centered on boresight symbol.

SYMBOL FAMILY TASK

Offer an analog representation of bank angle that is not obtrusive, but still provides clear perception of present bank angle. Useful only in conjunction with bank angle pointer (sky pointer).

ELEMENT TASK

Unobtrusive scale markings representing bank angle.

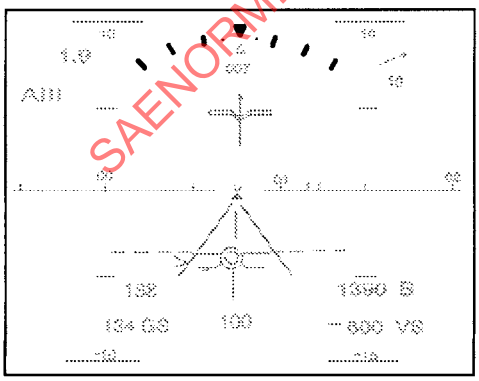
SOURCE DATA

Fixed symbology.

POSITION OR POSITION ERROR

Error of position of scale is not critical. Position of scale in reference to pointer should be +/- 1/4 degree.

SYMBOLOGY	*OPERATIONAL FEATURES*



The Bank Angle Scale symbol (sometimes referred to as Roll Scale symbol) is similar to the "sky pointer" bank angle scale at the top of a conventional ADI, except that it is in scale with the outside world. The "tick" marks indicate 10 degrees of bank, and the "dots" indicate 5 degrees. The Bank Angle scale is fixed relative to the Boresight symbol

FIGURE 7 - Bank Angle Scale

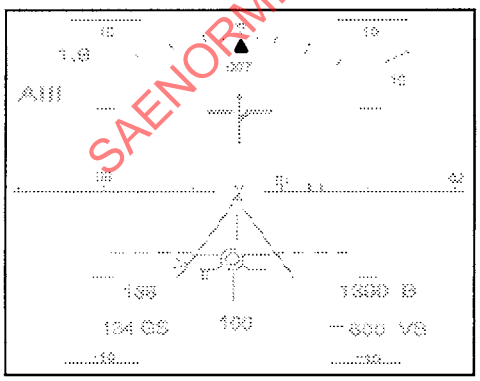
SYMBOL **BANK ANGLE POINTER**	***PHASE OF FLIGHT*** **ALL PHASES OF FLIGHT**
PILOT TASK Maintaining awareness of instantaneous bank angle.	***SYMBOL FAMILY TASK*** Offer an analog representation of bank angle that is not obtrusive, but still offers clear perception of present bank angle. Useful only in conjunction with bank angle scale.
REQUIRED PILOT PERFORMANCE Pilot should be able to resolve within +/- 0.25 degree when bank angle is near zero. Pilot can probably normally resolve within 0.1 degree.	***ELEMENT TASK*** Point to position on bank angle scale that is representative of current instantaneous bank angle.
CONSTRAINTS None in particular. Some controversy surrounds the question of bank scale removal for phases of flight where presence may not be critical.	***SOURCE DATA*** Inertial Reference System or vertical gyro.
SYMBOLOGY IMPLEMENTATION(S)	***POSITION OR POSITION ERROR*** Position of pointer in reference to scale should be +/- 0.25 degree when near zero bank angle. Beyond 10 degrees bank angle position within +/- 1.0 degree.
SYMBOLOGY	***OPERATIONAL FEATURES***
	Used in conjunction with the Bank Angle Scale, indicates the instantaneous bank angle of the aircraft.

FIGURE 8 - Bank Angle Pointer

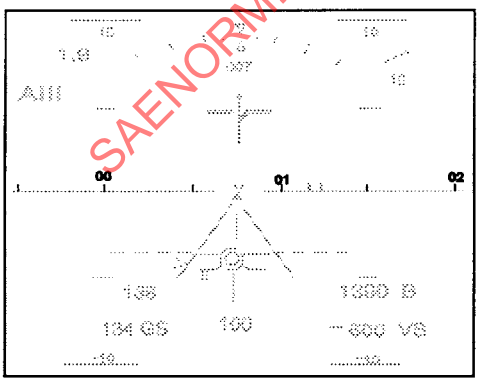
SYMBOL	***PHASE OF FLIGHT***
HEADING SCALE	**ALL FLIGHT PHASES**
PILOT TASK	***SYMBOL FAMILY TASK***
Maintain awareness of present aircraft heading.	In conjunction with Present Heading Pointer projected vertically from Boresight symbol, gives conformal representation of absolute aircraft heading.
REQUIRED PILOT PERFORMANCE	***ELEMENT TASK***
Pilot should be able to resolve within 0.5 degree. Resolution within 0.1 degree is probable when present heading is aligned with scale marks.	Scale marks unobtrusively give conformal sense of aircraft heading.
CONSTRAINTS	***SOURCE DATA***
Need to be unobtrussive, but be visible enough to be resolvable to above requirement.	Inertial Reference System, Directional Gyro referenced to North via flux sensor, or Attitude Heading Reference System (AHRS).
SYMBOLOGY IMPLEMENTATION(S)	***POSITION OR POSITION ERROR***
Short vertical scale marks placed each 10 degrees on (above) the Horizon Line. Digital readout of heading inscribed immediately above the scale mark.	Position error: +/- 1.0 degree in relation to true heading reference system (magnetic or true North).
SYMBOLOGY	***OPERATIONAL FEATURES***
	The Heading Scale marks represent actual magnetic headings in five degree increments. The Heading Scale is conformal to the outside world.

FIGURE 9 - Heading Scale

SYMBOL

SELECTED HEADING POINTER or MARKER

PHASE OF FLIGHT

ALL FLIGHT PHASES

PILOT TASK

Maintain awareness of difference between present heading and selected heading or heading reference.

REQUIRED PILOT PERFORMANCE

Pilot can probably resolve 0.1 degree when positioning marker to be coincident with scale mark. Otherwise, pilot should be able to resolve to 1.0 degree.

CONSTRAINTS

Heading select facility (knob) should be visible to the pilot without moving the head substantially out of the eyebox. The position error requirements are constraints on selected control hysteresis as well as absolute positioning accuracy.

SYMBOLOGY IMPLEMENTATION(S)

Double vertical short marks that lie on the horizon line, and move laterally with selected heading.

SYMBOL FAMILY TASK

Indicate the present value of the heading selector.

ELEMENT TASK

A marker that lies conformally on the heading scale in the position representing the present value of the heading selector. If selected heading does not fall within the field of view then symbol is not displayed.

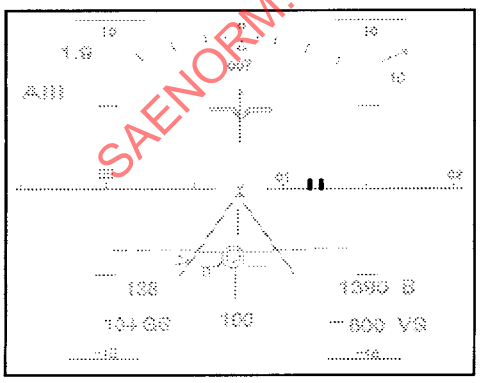
SOURCE DATA

Heading select facility: if aircraft has existing autopilot or flight director heading selector, then same facility should also serve the HUD. Source accuracy should allow selecting cardinal (scale) headings within 0.1 degree.

POSITION OR POSITION ERROR

Position error:
When value coincides with scale mark, +/- 0.1 degree;
In the region between scale marks, +/- 1.0 degree.

SYMBOLOGY



OPERATIONAL FEATURES

The Selected Heading Pointer or Marker (sometimes referred to as Heading Reference) indicates the location on the horizon of the heading selected by the pilot for use as a heading reminder during flight maneuvers associated with ATC vectoring, missed approach executions and other navigation procedures.

FIGURE 10 - Selected Heading Pointer or Marker

SYMBOL

VERTICAL SPEED

PHASE OF FLIGHT

ALL FLIGHT PHASES

PILOT TASK

Awareness of vertical speed.

REQUIRED PILOT PERFORMANCE

Not critical.

CONSTRAINTS

None, other than position with relation to altitude.

SYMBOLOGY IMPLEMENTATION(S)

Digital readout, 50 fpm resolution.

SYMBOL FAMILY TASK

Digital readout of vertical speed, feet per minute. Symbol use is controversial. In initial FAA experiments, vertical speed was severely missed by half of participating pilots if it was not present in the display. Other half seemed to not care, and performance did not seem to suffer. Since such a large fraction of pilots feel their performance is degraded, vertical speed representation will be necessary.

ELEMENT TASK

Convey awareness of vertical speed. Vertical displacement of flight path symbol is insufficient.

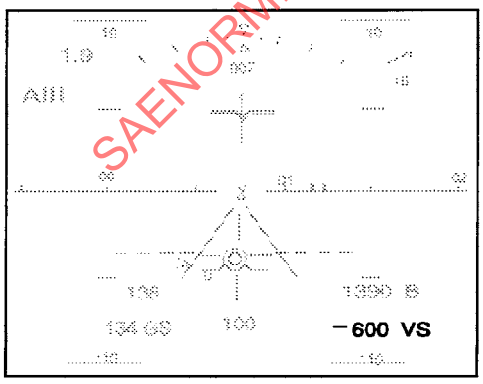
SOURCE DATA

Aircraft air data. Resolution of 50 feet per minute has been shown to be adequate.

POSITION OR POSITION ERROR

Position on display must be below any representation of altitude. Any other relationship with altitude has been shown to be subject to being reversed with altitude.

SYMBOLOGY



OPERATIONAL FEATURES

The Vertical Speed symbol is a digital display of the inertial rate of climb or descent. It is displayed in feet-per-minute to the nearest fifty feet-per-minute. A minus sign indicates descent.

FIGURE 11 - Vertical Speed

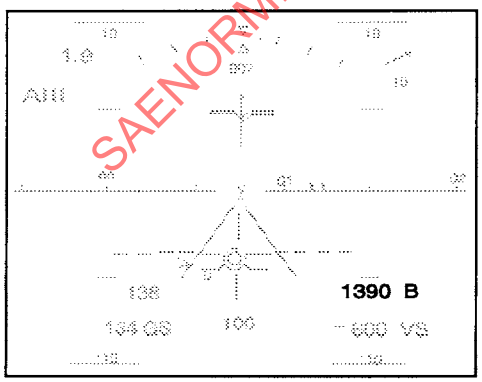
SYMBOL	*PHASE OF FLIGHT*
BAROMETRIC ALTITUDE	**ALL FLIGHT PHASES**
PILOT TASK	***SYMBOL FAMILY TASK***
Maintain awareness of present barometric altitude.	Offers means of awareness of present altitude. Controversial, in that digital altitude readout by itself has been shown to not be optimum. The overall altitude awareness task is closely related to determination of differences between present altitude, altitude rate, and selected altitude target for leveloff maneuver.
REQUIRED PILOT PERFORMANCE	***ELEMENT TASK***
Altitude tracking (altitude hold) should be accomplished using the Flight Path symbol by itself. Awareness of altitude within 10 feet should be possible.	Altitude symbology should be useful to the pilot in accomplishing leveloffs at target (selected) altitudes.
CONSTRAINTS	***SOURCE DATA***
Position constrained to right side of flight path.	Aircraft air data. Display resolution to nearest 10 feet. Source resolution should be to nearest 1 foot. Related altitude TSO requires 20 foot markings.
SYMBOLOGY IMPLEMENTATION(S)	***POSITION OR POSITION ERROR***
Digital readout of altitude to nearest 10 feet, located to right of and below Flight Path symbol.	Right side of flight path group. Part of flight path conformal group that moves as a unit.
SYMBOLOGY	***OPERATIONAL FEATURES***
	The Barometric Altitude symbol is a digital display of barometric altitude from the #1 barometric altimeter.

FIGURE 12 - Barometric Altitude

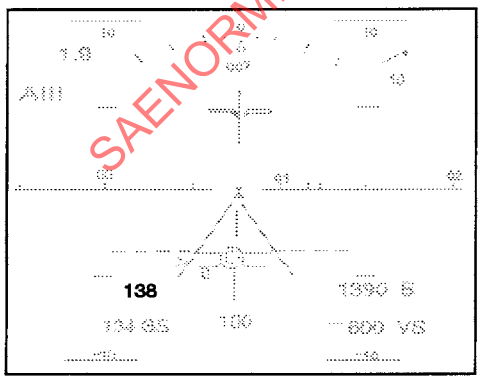
SYMBOL **INDICATED AIRSPEED**	***PHASE OF FLIGHT*** **RUNWAY TRANSITION AND ALL FLIGHT PHASES**
PILOT TASK Maintain awareness of absolute value of indicated airspeed.	***SYMBOL FAMILY TASK*** Offer means for awareness of absolute value of indicated airspeed. Separate function from that of Speed Error symbol.
REQUIRED PILOT PERFORMANCE Pilot should be able to easily resolve present indicated airspeed within 1 knot and control airspeed to within 1 knot.	***ELEMENT TASK*** Same as above.
CONSTRAINTS Position constrained to left side of Flight Path symbol.	***SOURCE DATA*** Aircraft air data. Displayed resolution 1 knot. Source data resolution should be 1 knot or less. Source accuracy is constrained by FAR. Normally is within two knots.
SYMBOLOGY IMPLEMENTATION(S) Digital readout of indicated airspeed from air data system with a resolution of 1 knot.	***POSITION OR POSITION ERROR*** Left side of flight path group. Part of flight path conformal group that a moves as a unit.
SYMBOLOGY	***OPERATIONAL FEATURES***
	The Indicated Airspeed symbol is a digital display of the indicated airspeed from the air data computer.

FIGURE 13 - Indicated Airspeed

SYMBOL

PRIMARY CDI RAW DATA

PHASE OF FLIGHT

PHASES INVOLVING ILS, VOR OR AREA NAV.

PILOT TASK

Awareness of deviation from selected course. This symbol group is used by pilot (in conjunction with flight director elements) to control aircraft to course centerline.

REQUIRED PILOT PERFORMANCE

Pilot can probably perceive error to within 0.1 degree.

CONSTRAINTS

Positioning accuracy can obviously be no better than the data source. Positioning constraints and total accuracy is dependent on phase of flight. This symbol is not shown if localizer data is invalid or not available from the reciever.

SYMBOLOGY IMPLEMENTATION(S)

Vertical bar approximately 10 degrees high, highlighted (double stroked) to stand out.

The HSI CDI mimic placed against the Boresight symbol is intended to compensate for the pilots' expectation identified under Symbol Family Task above.

SYMBOL FAMILY TASK

Provide means for awareness of deviation from selected course, either VOR or ILS Localizer. Symbol operates in conjunction with Selected Course pointer that is placed on Horizon Line at Heading Scale value corresponding to selected course. Symbol operation is controversial in that when off course but on intercept heading by large amounts, symbol grouping does not conformally overlie the actual runway extended centerline or represent the desired track. Many pilots try to infer some conformal meaning to symbology that is not there.

ELEMENT TASK

Its normal operation is to be the same as the Head Down Course Deviation Indicator. Symbol is positioned so as to indicate error with respect to the selected course pointer.

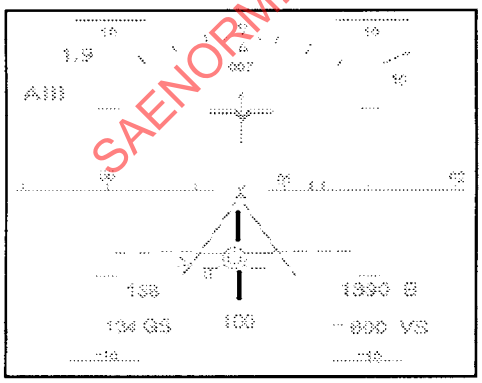
SOURCE DATA

VOR or ILS Localizer receiver: source could also be deviation information from an Area Navigation computer.

POSITION OR POSITION ERROR

Position error: +/- .2 degree. (Needs verification.)

SYMBOLOGY



OPERATIONAL FEATURES

The Primary CDI Raw Data symbol (sometimes referred to as the Localizer symbol) is a raw data display of the aircraft's horizontal orientation (left or right) relative to the selected course, either VOR or ILS Localizer. When on track, the symbol will line up with the Selected Course symbol. It is always perpendicular to the horizon and moves horizontally on the display.

FIGURE 14 - Primary CDI Raw Data

SYMBOL

PRIMARY GLIDE SLOPE RAW DATA

PHASE OF FLIGHT

LANDING APPROACH

PILOT TASK

Awareness of deviation from selected glide slope. This symbol group is used by pilot (in conjunction with flight director elements) to control aircraft to glide slope centerline.

REQUIRED PILOT PERFORMANCE

Pilot can probably perceive error to within 0.1 degree.

CONSTRAINTS

Normally displayed in conjunction with localizer CDI. Special considerations for low attitude where Glide Slope data customarily has low accuracy (< 65 feet).

SYMBOLOGY IMPLEMENTATION(S)

Horizontal bar approximately 5 degrees wide, highlighted (double stroked) to stand out.

SYMBOL FAMILY TASK

Provide means for awareness of deviation from selected glide slope, normally from the ILS. Symbol operates in conjunction with Selected Glide Slope reference (horizontal dashed line) that is placed vertically on pitch scale in conformal position.

ELEMENT TASK

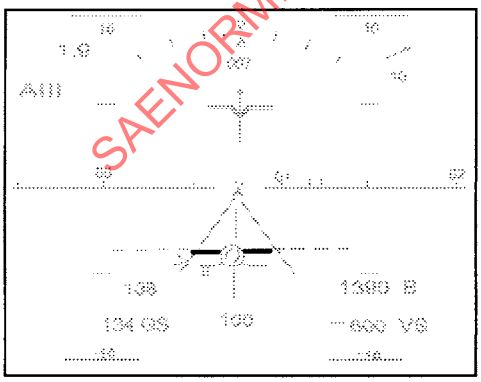
Vertical angular deviation is represented by distance of Glide Slope raw data line from the Selected Glide Slope reference line.

SOURCE DATA

ILS glide slope receiver; information could also be generated by Area Navigation Computer.

POSITION OR POSITION ERROR

SYMBOLOGY



OPERATIONAL FEATURES

The Primary Glide Slope Raw Data symbol (sometimes referred to as Glide Slope symbol) is a raw data display of the aircraft's vertical deviation from the selected glide slope. It is displayed only in the IMC mode. When the aircraft is tracking the glideslope, the Primary Glide Slope Raw Data symbol will be aligned with the Glide Slope Reference symbol.

FIGURE 15 - Primary Glide Slope Raw Data