2A-34-10: General

The navigation system provides the flight crew with indications of position in three dimensions and vector information for management of the flight environment, supplemented with aural and visual alerts to prevent Controlled Flight into Terrain (CFIT) and collision with other airborne traffic.

Flight environment data, aircraft attitude and direction are integrated with the SPZ-8000 (or SPZ-8400) Digital Automatic Flight Control System (DAFCS) and the Integrated Automatic Tuning System (Collins RTU-4200 Series Radio Tuning Unit (RTU)). The DAFCS is described in Honeywell's SPZ-8000 (or SPZ-8400) Digital Automatic Flight Control System Pilot's Manual for the Gulfstream IV. The Integrated Automatic Tuning System (Collins RTU-4200 Series Radio Tuning Unit (RTU)) is described in Section 2A-23-40, Integrated Automatic Tuning System and Collins' RTU-4200 Series Pilot's Guide. This section details the sensor systems used to determine airspeed and altitude, the integration functions of the Digital Air Data Computers that supply sensor data to the DAFCS and the onboard systems that provide alerts and warnings to prevent hazardous flight conditions.

The Enhanced Ground Proximity Warning System (EGPWS) is a terrain awareness and warning system incorporating alerting and display functions. The system uses aircraft geographic position, altitude, climb and descent rate, and a terrain database to determine potential conflicts between the aircraft flight path and terrain, and provide aural alerts and visual depictions (in conjunction with the DAFCS) of hazardous terrain clearance. (Visual cues generated by the TERRAIN DISPLAY feature of the EGPWS are shown and described in Honeywell's SPZ-8000 (or SPZ-8400) Digital Automatic Flight Control System Pilot's Manual for the Gulfstream IV.

The Traffic Collision Avoidance System / Aircraft Collision Avoidance System (TCAS / ACAS) uses transponder signal information to detect and plot the tracks of other airborne traffic and formulate flight guidance for maneuvers to avoid potential collisions.

The navigation system is divided into the following subsystems:

- 2A-34-20: Flight Environment Data System
- 2A-34-30: Attitude and Direction System
- 2A-34-40: Radio Altimeter System
- 2A-34-50: Enhanced Ground Proximity Warning System (EGPWS)
- 2A-34-60: Traffic / Aircraft Alert and Collision Avoidance System (TCAS / ACAS)

2A-34-20: Flight Environment Data System

1. **General Description:**

   The flight environment data systems incorporate navigational sensors that sample environmental conditions to determine airplane attitude, speed and direction.

   The systems include the following components:

   - Pitot-Static System
   - Standby Airspeed Indicator
   - Standby Altimeter
   - Static Air Temperature / Total Air Temperature (SAT / TAT) System
   - Digital Air Data Computer System

2. **Description of Subsystems, Units and Components:**

   A. **Pitot-Static System:**

The pitot-static system samples the atmospheric environment to provide indications of airplane airspeed and altitude. (See the illustration in Figure 3 for a depiction of the system.) Three pitot tubes are mounted on the exterior of the airplane and aligned forward to sense dynamic air pressure generated proportional to airplane velocity. As the airplane moves through the atmosphere, more air molecules are encountered than if the airplane were stationary. The increase is proportional to speed, and is sensed as pressure. The hollow pitot tube heads, positioned into the airplane slipstream, direct the increased pressure into the pitot system for measurement by the airspeed indicators. The metal heads of the tubes are heated electrically to prevent blockage by frozen precipitation. Internally, the pitot tubes are plumbed with nylon tubing. The increased dynamic air pressure in pitot tubes is compared with static air pressure sensed by other tubes attached to static ports mounted flush on the airplane fuselage. (The static ports are essentially vents, since they are not aligned into the slipstream.) By measuring the difference between static air pressure and the increased dynamic air pressure, an accurate determination of airspeed can be made.

There are four static air pressure tubes and ports: three are paired with and plumbed to the associated pitot tube (pilot to DADC #1, copilot to DADC #2, and standby to the standby airspeed and altimeter). The fourth static tube and port is connected to the cabin pressure indicator and controller. Cabin pressure is measured and controlled within structural limits by comparing the air pressure within the airplane to the atmospheric pressure outside the cabin (for the cabin differential pressure). Unlike the pitot tubes, the static tubes have dual connections, with each tube plumbed to a static port on either side of the airplane. Dual ports are necessary in order to obtain an accurate static pressure sampling. If a static tube were not connected to a port on either side of the airplane, any untrimmed flight condition around the vertical axis, such as a skid or slip, would induce an increase in the sampled static pressure due to the port being slightly aligned into the airplane slipstream.

NOTE:

On some airplanes the customer has chosen to install an optional secondary cabin pressure indicator. For those airplanes, a switch on the aft portion of the copilot side console, labelled NON-ESSENTIAL PITOT/STATIC CONTROL, is used to isolate the secondary cabin pressure indicator from the primary indicator. When the secondary indicator is isolated with the switch, an independent verification of cabin altitude is available.

   B. **Standby Airspeed Indicator:**

The standby airspeed indicator provides an emergency source of airspeed information in the event of failure or malfunction of the primary flight displays. The standby indicator displays current airspeed, maximum airspeed for altitude (V_{MO}) and Mach number. On airplanes Serial Number

(SN) 1000 to 1059 (except SN 1001 and 1034) not having Aircraft Service Change (ASC) 66, airspeed is indicated with a white pointer that rotates clockwise around the face of the instrument proportional to airplane speed and V_{MO} by a “barber pole” striped pointer. Pitot/static connections provide the input for airspeed information. Although the indicator has a drum-type readout of Mach number in the upper center of the instrument, the ARINC 429 connections necessary to derive Mach speed information from the DADC are not installed. The OFF flag covering Mach readout will be displayed at all times on the instrument, indicating that this feature is not available.

On airplanes SN 1060 and subsequent, and prior airplanes having ASC 66, the standby airspeed indicator is not powered (except for lighting circuits) and obtains speed information directly from the pitot/static system. On these airplanes, airspeed is indicated by a rotating white pointer, Mach number is read on an additional scale positioned on the outside perimeter of the airspeed scale and V_{MO} / M_{MO} is denoted with a red band on both the airspeed and Mach number scales. A knob on the lower face of the instrument is provided to set a movable airspeed reference bug (V_{REF}). See the illustration in Figure 1.

On all airplanes, the indicator is illuminated internally using 5V DC power from normal cockpit lighting circuits.

C. Standby Altimeter:

The standby altimeter provides an indication of airplane pressure altitude in event of primary flight display failure or malfunction. Altitude is indicated in twenty (20) foot increments within a range of one thousand (1,000) feet by a pointer that moves in front of the circular scale on the face of the instrument, making one revolution for every 1,000 feet. A drum-type counter in the center of the instrument provides graphic indications of altitude in hundred (100) and 1,000 foot increments. The local barometric pressure in inches of mercury (Hg) or millibars (Mb) is set with the knob on the lower corner of the instrument and displayed in windows in the instrument face. See the illustration in Figure 1.

Like the standby airspeed indicator, the ARINC 429 connections necessary to derive altitude information from the DADCs are not installed. A yellow flag, labeled PNUE, is displayed at all times on the instrument, indicating that this feature is not available.

The standby altimeter is powered by 28V DC from the Essential DC bus, and uses only pitot/static input for altitude determination. It is internally illuminated and has an electrically driven vibrator to smooth pointer movement. If electric power is lost, a VIB flag is displayed on the instrument and while indications will be valid, pointer movement may be intermittent, requiring occasional manual tapping on the face of the instrument during climb and descent.

D. Static Air Temperature / Total Air Temperature (SAT / TAT) System:

A heated Total Air Temperature probe is installed on the lower right forward fuselage to provide actual air temperature to the DADCs. See Figure 2 for a depiction of the probe. On the ground with electrical power and bleed air available, the probe is aspirated by bleed air through a dedicated line controlled by a solenoid operated valve that routes air into the probe housing, venting the air through holes in the probe to induce outside air flow over the temperature sensing element. Air flow through the probe gives a more accurate reading of ambient conditions and avoids temperature increases associated with the heating effects of sunlight. Bleed air aspiration is controlled by the nutcracker (squat) switch system and requires 28V DC from the Right Main DC bus. The TAT probe is electrically heated when the airplane is airborne to prevent icing.

E. Digital Air Data Computer System (DADC):

Dual Honeywell AZ-810 Digital Air Data Computers (DADCs) are installed in the forward avionics racks. The DADCs are connected to the pitot/static system, with the pilot side pitot/static probe and ports connected to DADC #1 and the copilot side pitot/static sensors connected to DADC #2. Both DADCs are connected to the TAT probe for temperature data. The DADCs use the pneumatic and temperature data to compute correct airspeed, altitude, vertical speed, static source error correction (SSEC) and to send a signal to the audible tone generator initiating the overspeed “cricket” warning when airspeed reaches V_{MO}/M_{MO}. Other inputs used by the DADCs are Angle of Attack (AOA), flap handle position, barometric setting and pre-selected altitude. The DADCs formulate digital signals for elements of the airplane avionics system. The DADCs communicate data to the following:

- Electronic Display System
- Transponders
- Flight Recorder
- Flight Guidance Computer
- Fault Warning Computer
- Inertial Reference System
- Flight Management System
- Cabin Pressurization System
- Stall Barrier System
- Engine Pressure Ratio (EPR) Sensor
- Traffic / Aircraft Collision Avoidance System (TCAS / ACAS)

In order to maintain a continual crosscheck of system accuracy, it is recommended that the pilot select DADC #1 as a data source, and the copilot select DADC #2. Data source selection is made on the SENSOR page of the Display Controller. In this configuration, each pilot has an independent source for altitude, airspeed, AOA, vertical speed, SAT and TAS on their respective PFDs and navigation displays. If both pilots select the same DADC as data source, an amber annunciation is displayed on both PFDs. (If the pilot PFD is selected to DADC 2, both PFDs would display DADC 2 in amber in the upper right of the PFDs.)

Data source selection for the guidance panel altitude pre-select is a function of the PFD command button (PFD-CMD). When the button indicates L, the data source is DADC #1, when R is displayed, data comes from DADC #2.

Most subsystems with dual installations normally source DADC data according to a standard coupling arrangement: the left (L), #1 or pilot side sourced to the #1 DADC, and the right (R), #2 or copilot side connected to the #2 DADC. For some, but not all installations, the data source is selectable to provide redundancy in case of DADC failure. Transponders (ATC) #1 and #2 are normally sourced to their respective DADC, but may be selected to the alternate DADC. Angle of Attack (AOA) indicators are referenced to the DADC selected to the respective PFD. EPR sensors are normally paired with engine #1 to DADC #1, engine #2 to DADC #2, but failure of a DADC will prompt an automatic switch to the remaining DADC for EPR computation. The DADC source for cabin pressure control is selectable on the cockpit overhead panel.

DADC Failure Modes (Flagged, Unflagged)

(1) A "flagged" DADC failure is one where the failure is readily apparent, because of the blue DADC 1 (or 2) FAIL advisory CAS message, and red "X's" through all four air data scales (airspeed, altitude, AOA, and vertical speed) of the PFD using the failed DADC as its air data source, as selected on the display controllers. Other confirmation of failure is as follows:

- Transponder indications
- AOA indexer failure
- Automatic cabin pressurization control problems and faulty guidance panel indications (if operating on the failed DADC)
- EICAS message indicating that EPR is receiving pressure information from the opposite DADC (EPR 1 - DADC 2, or EPR 2 -DADC 1)

The solution is to select the opposite (good) DADC as the air data source, on display controllers, guidance panel, cabin pressure control panel, etc.

(2) An “unflagged” DADC failure will produce a blue DADC MISCOMPARE advisory CAS message, and the failure may not be readily apparent. The autopilot and yaw damper will disconnect and will not re-engage until the faulty DADC has been identified and isolated by pulling its circuit breaker. Pitch trim will remain operative. The flight crew may be able to identify the faulty DADC by looking for an amber IAS and / or ALT comparator warning annunciation to left of the horizon in each PFD. The IAS indication means a split of 20 or more knots exists between air data systems; the ALT indication means a split of 200 feet or more exists between systems. To determine which system is correct requires reference to an independent data source, in this case standby flight instrumentation. Since the standby flight instruments show large errors because they are uncorrected for static source error, it is recommended that standby altimeter be set so as to read the same as the cruising flight level. Once stable cruise speed is attained, the settable airspeed bug should be aligned with the standby airspeed pointer. Thus, reference can be made to the standby altimeter and airspeed indications, as “voters” in helping to determine which DADC outputs are more nearly correct. Then, check the other DADC outputs, the pressurization system, AOA indexers and transponders, for indications of faulty operation. If observation leads to a determination of which DADC is faulty, select the “good” DADC to both PFDs, guidance panel, transponders, and the cabin pressurization system. Then isolate the faulty DADC by pulling its circuit breaker, and after at least a one minute wait, re-engage the autopilot.

3. Controls and Indications:

(See Figure 1.)

NOTE:

A description of the SPZ-8000 (or SPZ-8400) Digital Automatic Flight Control System (DAFCS) can be found in Honeywell’s SPZ-8000 (or SPZ-8400) Digital Automatic Flight Control System Pilot’s Manual for the Gulfstream IV. A description of the Integrated Automatic Tuning System (Collins RTU-4200 Series Radio Tuning Unit (RTU)) can be found in Section 2A-23-40, Integrated Automatic Tuning System and Collins’ RTU-4200 Series Pilot’s Guide.

A. Circuit Breakers (CBs):

Circuit Breaker Name	CB Panel	Location	Power Source
TOTAL TEMP PROBE HTR	CP	L-10	MAIN 115V AC ϕB
TOTAL TEMP VALVE	CP	M-10	R MAIN 28V DC
L PITOT HT PWR	CP	L-11	ESS 115V AC ϕA
R PITOT HT PWR	CP	M-11	MAIN 115V AC ϕA
L PITOT HT CONT	CP	L-12	ESS 28V DC
R PITOT HT CONT	CP	M-12	MAIN 28V DC

Circuit Breaker Name	CB Panel	Location	Power Source
STBY PITOT HT CONT	CP	L-13	ESS 28V DC
STBY PITOT HT PWR	CP	M-13	ESS 115V AC ϕA
AOA PRB HTR #1	CP	L-14	ESS 28V DC
AOA PRB HTR #2	CP	M-14	MAIN 28V DC
DADC #1	CP	F-3	ESS 28V DC
DADC #2	CP	G-3	MAIN 28V DC
STBY AIR SPD IND	CP	H-4 **(1)**	EMER 28V DC
DUAL MODE ALTM VIB	CP	H-3 **(1)**	EMER 28V DC
STBY ALTM VIB	CP	H-3 **(2)**	EMER 28V DC
DUAL MODE ALTM	CP	H-4 **(3)**	ESS 28V DC
STBY ALTM VIB	CP	H-4 **(4)**	EMER 28V DC

NOTE(S):

(1) SN 1000 -1059 (except 1001 and 1034) not having ASC 66

(2) SN 1000, 1002-1122 (except 1034) having ASC 66, SN 1001, and 1060 - 1167

(3) SN 1000, 1002 - 1059 (except 1034) not having ASC 66

(4) SN 1034, 1168 and subs

B. Caution (Amber) CAS Messages:

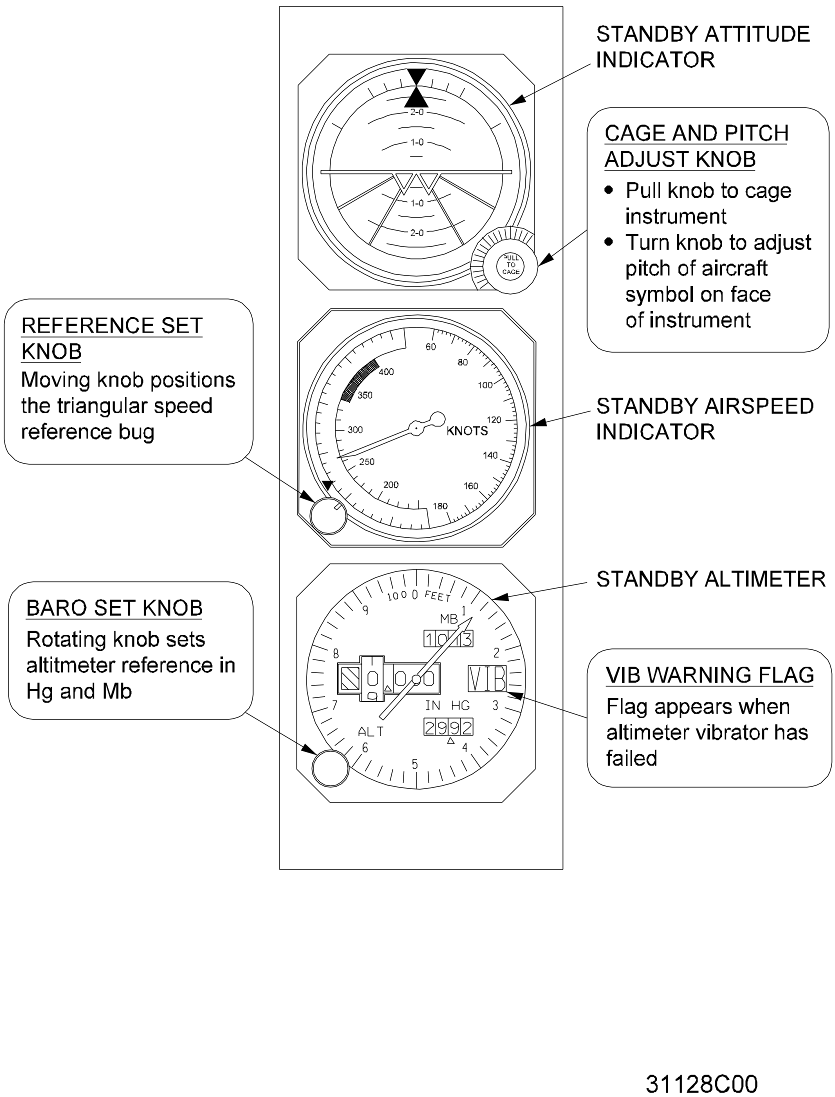
CAS Message	Cause or Meaning
AOA HEAT 1-2 FAIL	Angle of attack probe heater failed
L-R PITOT HT FAIL	Indicated pitot tube heater elements not energized
SSEC DISABLED	Static source error correction to DADC has been disabled
STBY PITOT HT FAIL	Standby pitot heater elements not energized
TAT PROBE HT FAIL	TAT probe heater has failed

C. Advisory (Blue) CAS Messages:

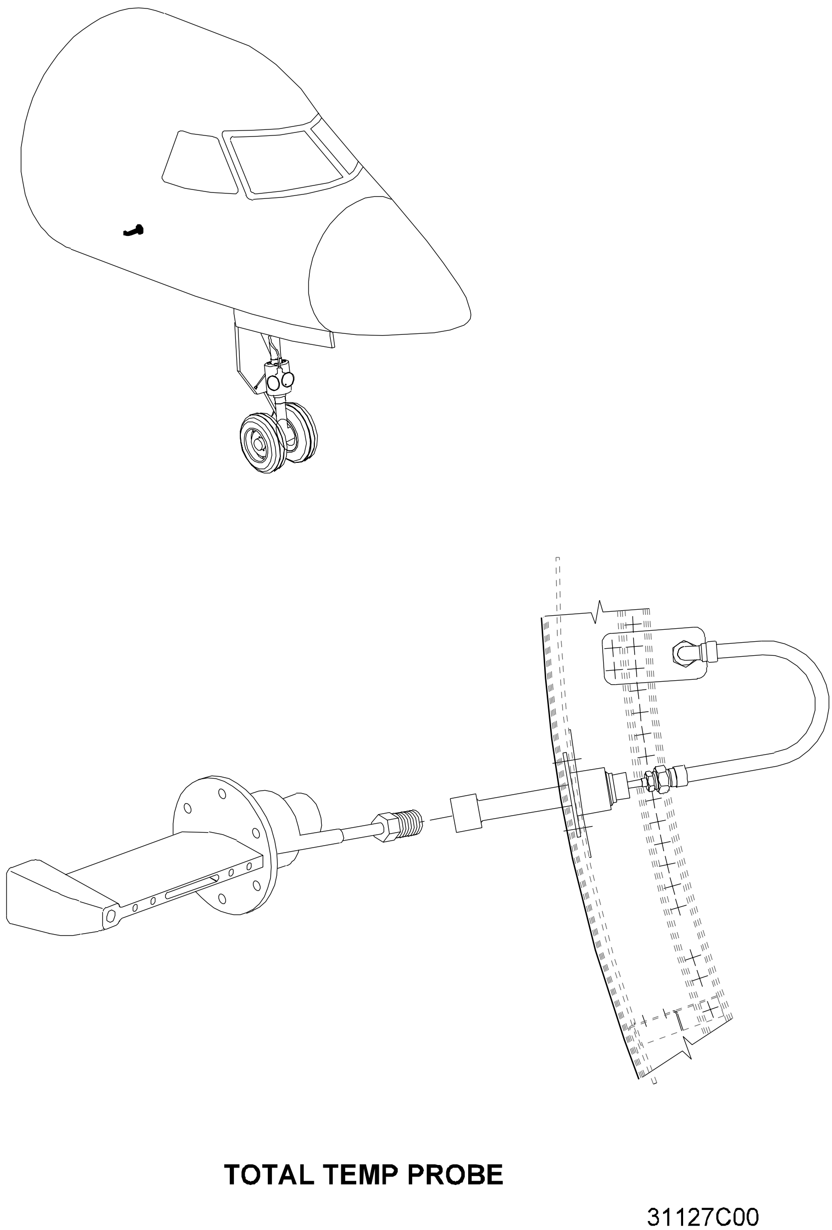
CAS Message	Cause or Meaning
DADC 1-2 FAIL	A DADC has failed
DADC MISCOMPARE	The priority FGC has detected an unflagged miscompare between DADC 1 and DADC 2
EPR 1 - DADC 2 EPR 2 - DADC 1	DADC malfunction has caused remaining DADC to supply information to both EPR systems

4. Limitations:

There are no limitations to this system at the time of this revision.

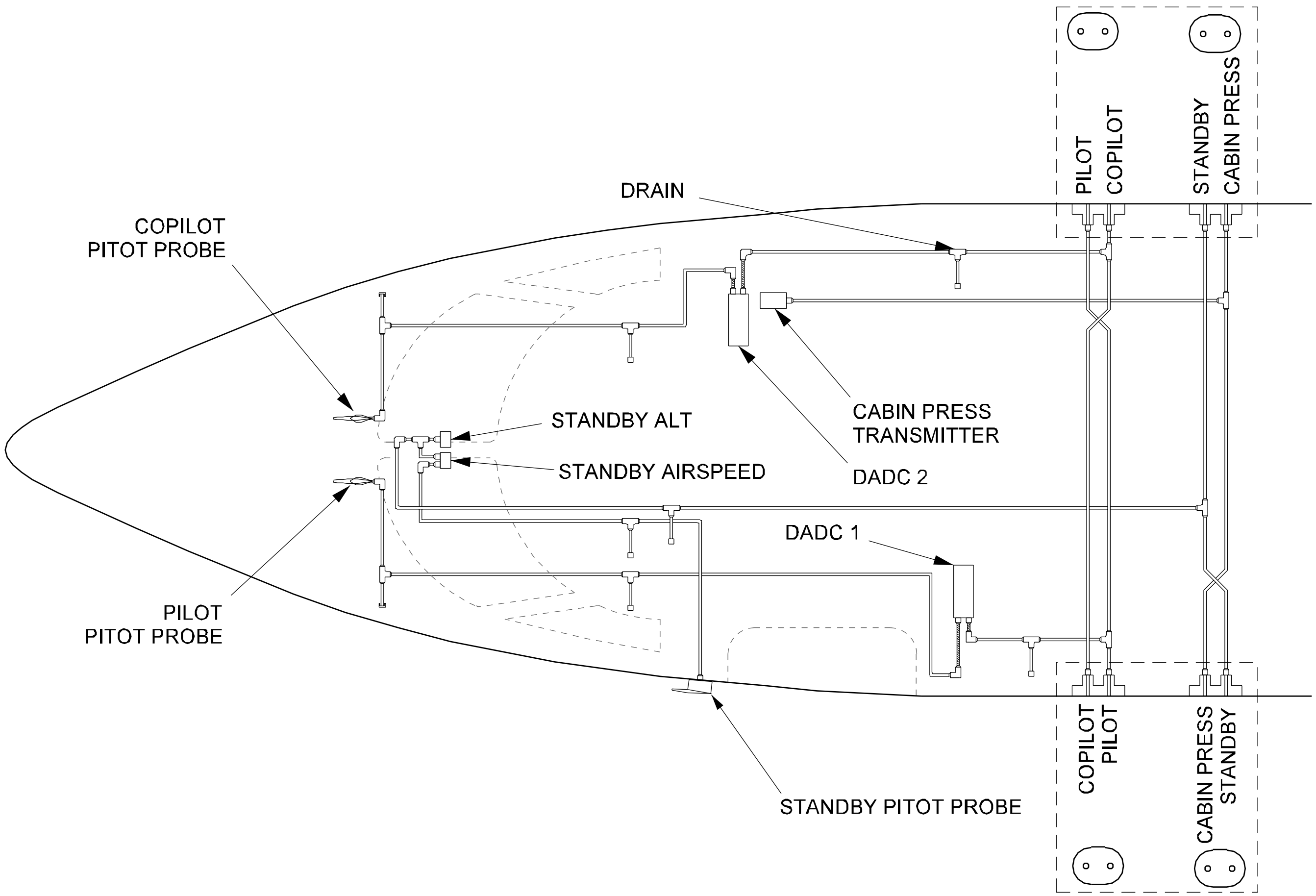


Standby Flight Instruments
Figure 1



SAT / TAT Probe
Figure 2

THIS PAGE IS INTENTIONALLY LEFT BLANK.



Pitot / Static System
Schematic
Figure 3

2A-34-30: Attitude and Direction System

1. **General Description**

   The standby attitude and direction systems provide references for steering the airplane in the desired direction using basic instruments that remain powered during instances of failure / malfunction of the Primary Flight Displays (PFDs) and / or the Flight Management System (FMS). The following subsystems, units and components are included:

   - Standby Attitude Indicator
   - Standby Directional System

2. **Description of Subsystems, Units and Components:**

   A. **Standby Attitude Indicator:**

   The standby attitude indicator (shown in Figure 1) is a gyroscopically driven artificial horizon that provides a backup indication of airplane pitch and roll in the event of a failure or malfunction of PFDs, FMS or IRS systems. The indicator contains a sphere divided into hemispheres painted blue and brown (or black) representing sky and earth. Markings on the hemispheres denote pitch attitude in five degree (5°) increments from level up or down to eighty degrees (80°). When the airplane is initially powered, the indicator will power-up and self-erect once the internal gyroscope reaches operating speed. To immediately erect the indicator, use the cage knob on the face of the instrument, orienting the sphere upright and leveling the horizon (where the sky and earth representations meet). The airplane symbol on the face of the instrument is adjusted to match the airplane pitch attitude by rotating the cage knob.

   At the top of the instrument is a triangular pointer that indicates airplane bank angle against the semicircular scale surrounding the artificial horizon. The scale is marked in ten degree (10°) increments up to thirty degrees (30°) of bank, and additional marks at forty-five degrees (45°) (for Serial Number (SN) 1330 and subsequent only), sixty degrees (60°) and ninety degrees (90°).

   The standby attitude indicator is powered by the Emergency DC bus. If power to the instrument is interrupted, a red warning flag is displayed on the face of the instrument (the flag is also displayed when the indicator is caged). If Emergency DC bus power to the indicator is lost (battery depleted - warning flag displayed) the rate of spin of the gyro may be sufficient to supply attitude information for several minutes before becoming unreliable.

   On airplanes SN 1330 and subsequent, the standby attitude indicator has pointers for glideslope and localizer signals, providing guidance for an ILS approach. ILS information is supplied by VHF NAV #1 over an ARINC 429 data bus. A knob on the lower left corner of the attitude indicator is used to select signal input to the glideslope and localizer pointers. The knob has three (3) positions: OFF, ILS and B/C (for a back course approach). Both the glideslope and localizer pointers have a warning flag to indicate power off or lack of signal reception.

   B. **Digital Bearing and Distance Indicator (DBDI):**

   The dual DBDI (pilot and copilot) indicators provide a standby display of heading, bearing, and distance to a selected navigation source independent of the Primary Flight Display (PFD). The indicators have dual power supplies, each powered by the Essential or Emergency DC bus, with only basic heading information available when operating on Emergency DC bus power. The DBDI is illustrated in Figure 4.

During normal operation with all electrical sources available, the DBDIs are powered through the Essential DC bus and display the following information:

- Airplane heading beneath the lubber line at the top of the compass card, sourced from the IRS system in use (pilot on #1, copilot on #2).
- Pointer #1 (single shaft arrow) pointing to the currently tuned navigational radio transmitter (VOR / VORTAC or ADF) selected with the pointer switch on the lower left of the instrument. The pointer will be positioned to the three o'clock position and a flag displayed if no navigation radio is tuned or the signal is out of range for the transmitter type selected.
- Pointer #2 (double shaft arrow) pointing to the currently tuned navigational radio transmitter (VOR / VORTAC or ADF) selected with the pointer switch on the lower right of the instrument. The pointer will be positioned to the three o'clock and a flag displayed if no nave radio is tuned or the signal is out of range for the transmitter type selected.
- Digital DME distance readout is displayed in the window in the top of the instrument for both (1 and 2) currently tuned VORTACs (only dashes are displayed if no VORTAC is currently tuned). Distance is indicated in one-tenth mile (0.1) increments up to 99.9 nautical miles and one mile increments from 100 to 999 nautical miles.
- Digital display of the frequency of the currently tuned VORTAC if the NAV selector is placed in HOLD mode, with the frequency preceded by an H to indicate that HOLD has been selected. In normal NAV mode, only dashes are displayed in the frequency space.

A failure of the heading information source (IRS #1 and IRS #2) prompts the DBDI to automatically switch to an alternate heading source if one is installed (typically AHRS or IRS #3). The use of an alternate heading source is annunciated on the face of the instrument by the illumination of a green AHDG light in the upper right corner of the instrument.

A more severe failure that involves the loss of primary and alternate heading reference sources would automatically switch the DBDI to standby mode, annunciated by the illumination of the amber STBY light in the upper right of the indicator. In standby mode, the heading reference source is the dual flux detector installation in the airplane wing tips. The flux detectors act as magnetic compasses, sensing the horizontal component of the magnetic field surrounding the earth. The magnetic direction sensed by the flux detectors is corrected for errors (induced by the metallic structure of the airplane) by a magnetic compensator before it is sourced to the DBDI for use as the heading reference in standby mode.

Should there be a failure of the standby / flux detector system, a red STBY light illuminates in the upper right corner of the instrument. The red STBY will illuminate with a standby system failure even if the DBDI is operating in the normal (IRS) mode.

The DBDI indicators annunciate system degradation and/or subcomponent failure with the following displays:

- OFF flag in the upper left of the instrument indicates loss of instrument power
- HDG flag at the lubber line at the top of the instrument indicates an invalid compass signal
- Single shaft arrow flag on the left of the instrument indicates invalid signal to the #1 pointer
- Double shaft arrow flag on the right of the instrument indicates invalid signal to the #2 pointer

All of the mode annunciations and system / subcomponent failure annunciations may be tested on the ground during preflight with the ST/R switch (momentary) on the upper right of the heading display. This test feature is wired through the nutcracker (squat) switch system to operate in the ST or self-test mode on the ground and the R or reset mode in the air. Pressing the ST/R button in the air will reset the heading indicator, recapturing a primary or alternate heading source if one is available. Pressing the ST/R button during a ground preflight will illuminate the mode annunciations, display warning flags and indicate a DBDI malfunction by a five (5) second flashing red STBY light followed by continuous illumination of the light.

On airplanes having Aircraft Service Change (ASC) 217, DBDI MANUAL STBY switches are installed on the outboard side of the pilot and copilot forward instrument panels, one for each DBDI. The installation is shown in Figure 5. (A switch that enables manual selection of the standby mode is located on the face of the DBDI electronic module in the radio rack on airplanes not having ASC 217). This switch allows the crew to manually select the standby (STBY) heading mode in flight to crosscheck inertial (IRS) heading information, compensate for faulty IRS information, or to select a heading source during realignment of the IRSs.

3. **Controls and Indications:**

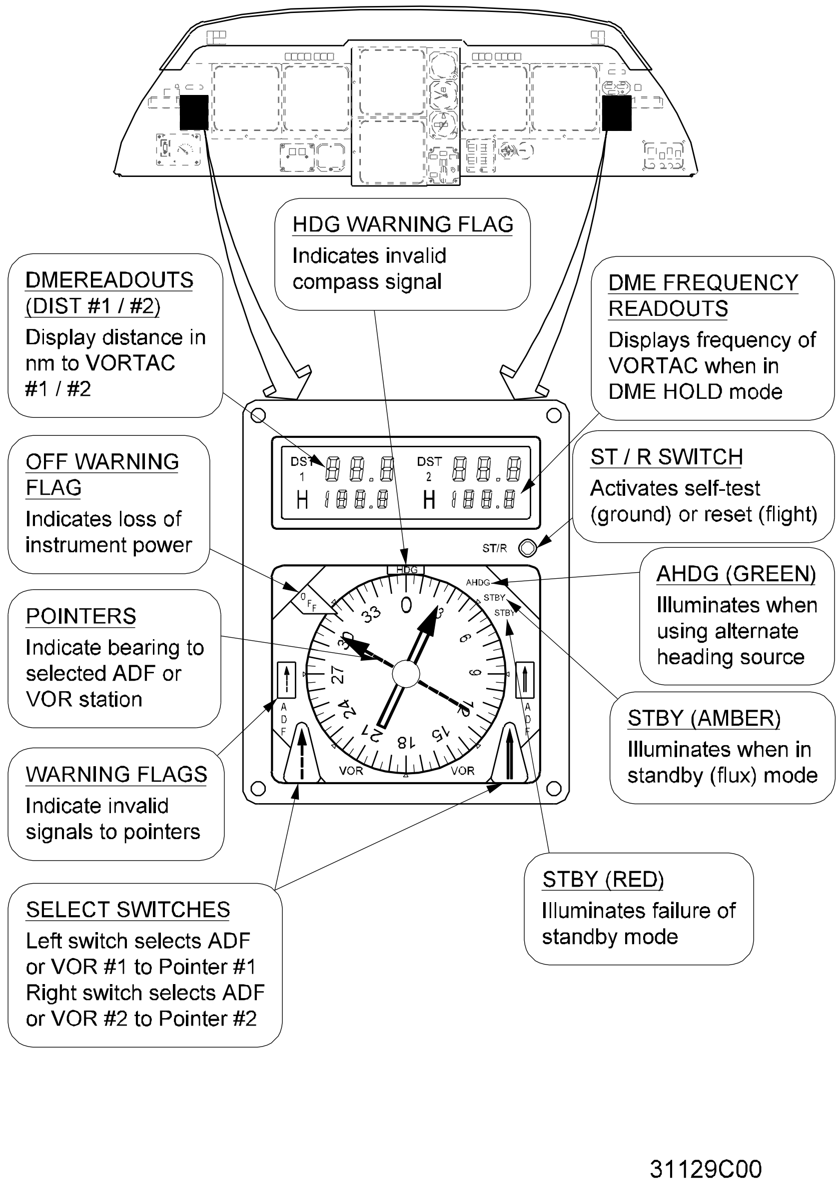
(See Figure 4 and Figure 5.)

A. **Circuit Breakers (CBs):**

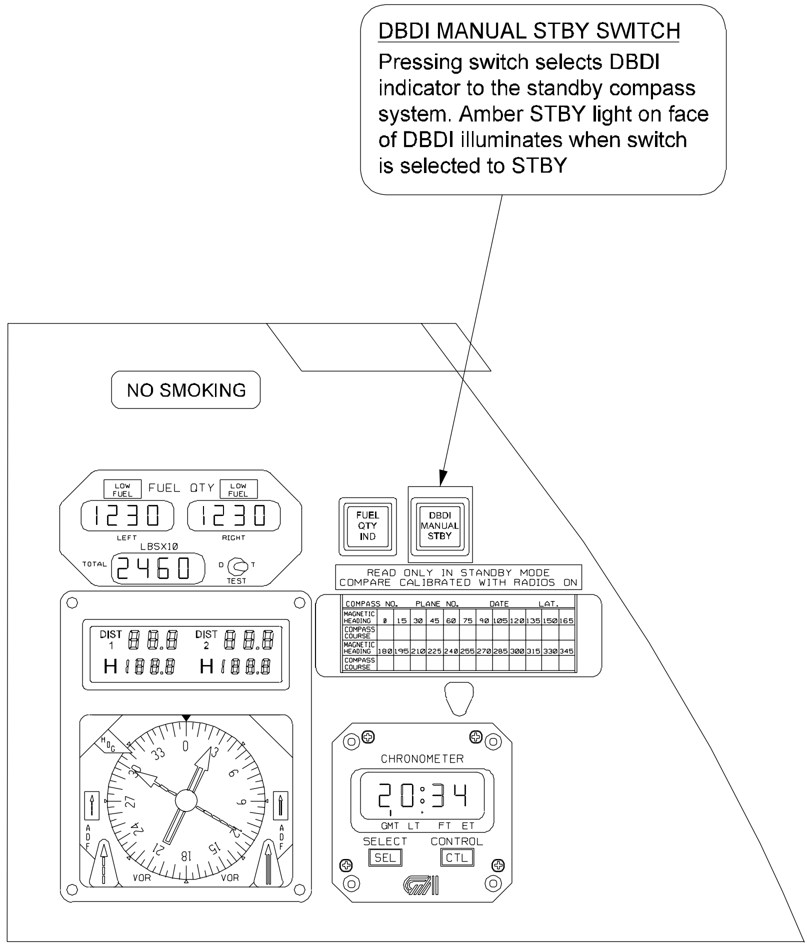
Circuit Breaker Name	CB Panel	Location	Power Source
STBY HORZN	CP	E-4	EMER 28V DC
DBDI #1 (SN 1212 & subs) (DDRMI #1 on SN 1000-1211)	CP	F-4	ESS 28V DC
DBDI #2 (SN 1212 & subs) (DDRMI #2 on SN 1000-1211)	CP	G-4	ESS 28V DC
E DBDI #1 (SN 1212 & subs) (E DDRMI #1 on SN 1000-1211)	CP	H-5	EMERG 28V DC 1C
E DBDI #2 (SN 1212 & subs) (E DDRMI #2 on SN 1000-1211)	CP	I-5	EMERG 28V DC 2B

4. **Limitations:**

There are no limitations for this system at the time of this revision.



Digital Bearing and Distance Indicator
Figure 4



31130C00

DBDI MANUAL STBY Switch Installation
Figure 5

2A-34-40: Radio Altimeter System

1. General Description:

The GIV is equipped with two independent AA-300 radio altimeters. Each has a dedicated Receiver / Transmitter (R/T) unit, transmitting antenna and receiving antenna. (Antenna location is shown in Figure 27.) There are no off / on controls (switches) or separate displays for the radio altimeters. The radio altimeters operate continuously when the airplane Main DC buses are powered, using high resolution, short pulse radar signals that are accurate over wide variations of terrain, target reflectivity, weather and airplane altitude.

The radio altimeters provide a continuous readout of airplane altitude above ground level in the operating range of zero to twenty-five hundred (0-2,500) feet. Accuracy of the altitude readout varies with height above ground, with readings between zero and one hundred (0 and 100) feet accurate to within three (3) feet, readings between one hundred and five hundred (100-500) feet have an accuracy within three percent (3%), and readings between five hundred and twenty-five hundred (500-2,500) feet accurate within four percent (4%). Above twenty-five hundred (2,500) feet, the radio altimeters continue to operate, however the radio altitude information is no longer displayed because of the increase in error margin at higher altitudes.

2. System Operation:

Radio altimeter data is sent to the Data Acquisition Units (DAUs) to be digitized and then forwarded over the Avionics Standard Communications Bus (ASCB) to the symbol generators for display on the Primary Flight Display (PFD). A discrete signal is also provided to the landing gear indication system to provide the altitude warning at twelve hundred (1,200) feet if the landing gear is not down and locked (see the discussion in Section 2A-32-30, Extension and Retraction System of this manual).

The PFD displays of radio altitude differ slightly between airplanes with SPZ-8000 and SPZ-8400 Digital Automatic Flight Control Systems (DAFCS). See Figure 6 and Figure 7 for illustrations of the radio altitude display formats.

A. SPZ-8000 Radio Altimeter Display:

The display of radio altitude on the PFD is selected using the SENSOR function on the Display Controller (DC). When SENSOR is selected, a menu appears on the screen of the DC with the available data display options. Pushing the appropriate Line Select Key (LSK) adjacent to the menu item will select that sensor data for display on the PFD. When Radio Altitude (RAD ALT) is displayed, it is shown in digital format just outside the lower right corner of the attitude display. The white digital readout is in ten (10) foot increments between twenty-five hundred (2,500) feet and two hundred (200) feet, and five (5) foot increments below two hundred (200) feet.

If the dual radio altimeters are paired on-side (pilot selected to radio altimeter #1 and copilot selected to radio altimeter #2) the source of the altimeter data is not shown. If the pilot and copilot have selected off-side radio altimeters (pilot to #2 and copilot to #1) the letters RA, and the numbers 1 or 2 as appropriate, are shown in white immediately to the right of the digital readout. If both pilot and copilot are selected to the same radio altimeter, the RA is shown in amber. (The pilot and copilot can select radio altimeter data source with options on the DC.)

A reference set option on the DC allows entering a radio altitude reference for use as a visual indication of Decision Height (DH) during precision approaches predicated on radio altitude data. Pushing the FLT REF button on the DC displays the menu containing RAD ALT. A value for radio altitude DH is entered with the rotary set knob and selected for display with the LSK. The selected DH is displayed on the PFD just above the readout of current radio altitude. As the airplane descends to the selected DH, a flashing white box is displayed around the current radio altitude when it is equal to the selected DH. The white box flashes for five (5) seconds after reaching DH, and remains displayed as long as airplane radio altitude is less than the DH.

When a valid ILS frequency is received for an approach and the airplane descends below two hundred (200) feet radio altitude, a yellow runway symbol is displayed on the PFD, rising from the bottom of the attitude display up to meet the airplane symbol on runway contact at landing. The symbol also moves laterally to indicate displacement from localizer centerline.

An additional reminder of airplane altitude is shown on the altitude tape on the right side of the PFD. As the airplane descends below six hundred (600) feet radio altitude, the color of the altitude tape changes to brown, indicating proximity the ground. The brown altitude tape extends from six hundred (600) feet down to zero (0) feet radio altitude.

NOTE:

> This altitude reminder should not be confused with the radio altitude display. The brown portion of the altitude tape corresponds to airplane terrain clearance at a given height above mean sea level (with barometric altimeter set to QNH). For instance, if the airplane is landing on a runway with an elevation of one thousand twenty (1,020) feet MSL, the altitude tape color will change from blue to brown as the airplane descends through one thousand six hundred twenty (1,620) feet MSL.

If there is a system malfunction that causes a loss of valid radio altimeter data, the white digital radio altitude readout is replaced by amber dashes (“- - - - “). If the yellow runway symbol is displayed at the time of the failure, the symbol is removed from the PFD.

B. SPZ-8400 Radio Altitude Display:

The display of radio altitude on the PFD is selected using the SENSOR function on the Display Controller (DC). When the SENSOR button is selected, a menu appears on the screen of the DC with the available data display options. Pushing the appropriate Line Select Key (LSK) adjacent to the menu item will select that sensor data for display on the PFD. When radio altitude (RAD ALT) is displayed, it is shown in digital format at the bottom of the attitude display. The digital readout is in green, indicated in ten (10) foot increments between twenty-five hundred (2,500) feet and two hundred (200) feet, and five (5) foot increments below two hundred (200) feet.

If the dual radio altimeters are paired on-side (pilot selected to radio altimeter #1 and copilot selected to radio altimeter #2) the source of the altimeter data is not shown. If the pilot and copilot have selected off-side radio altimeters (pilot to #2 and copilot to #1) the letters RA, and the numbers 1 or 2 as appropriate, are shown in white immediately to the right of the digital readout. If both pilot and copilot are selected to the same radio altimeter, the RA is shown in amber. (The pilot and copilot can select radio altimeter data source with options on the DC.)

A reference set option on the DC allows entering a radio altitude reference for use as a visual indication of Decision Height (DH) during precision approaches predicated on radio altitude data. A DH must be entered when the airplane is one hundred (100) feet or more above the desired DH. Pushing the FLT REF button on the DC displays the menu containing RAD ALT. A value for radio altitude DH is entered with the rotary set knob and selected for display with the LSK. The selected DH is displayed on the PFD outside the lower right corner of the attitude indicator. As the airplane descends to the selected DH, an empty box symbol is displayed in the upper right corner of the attitude display when the airplane is within one hundred (100) feet of the selected DH. When the airplane descends to the set DH, an amber DH annunciation is displayed in the box. The DH symbol flashes for five (5) seconds, then remains displayed whenever the airplane is below DH. The readout of actual radio altitude (displayed at the bottom of the attitude indicator) changes color from green to amber when the airplane is one hundred (100) feet or less above the selected DH.

When a valid ILS frequency is received for an approach and the airplane descends below two hundred (200) feet radio altitude, a yellow runway symbol is displayed on the PFD, rising from the bottom of the attitude display up to meet the airplane symbol on runway contact at landing. The symbol also moves laterally to indicate displacement from localizer centerline.

An additional reminder of airplane altitude is shown on the altitude tape on the right side of the PFD. As the airplane descends below six hundred (600) feet radio altitude, the color of the altitude tape changes to brown, indicating proximity the ground. The brown altitude tape extends from six hundred (600) feet down to zero (0) feet radio altitude. A yellow line appears at the top of the brown portion of the tape. The line flashes for the first ten (10) seconds after the brown tape is displayed or until the airplane descends to four hundred (400) feet radio altitude, whichever occurs first. The yellow line rides in front of the brown altitude tape display, indicating height above touchdown.

NOTE:

This altitude reminder should not be confused with the radio altitude display. The brown portion of the altitude tape corresponds to airplane terrain clearance at a given height above mean sea level (with barometric altimeter set to QNH). For instance, if the airplane is landing on a runway with an elevation of one thousand twenty (1,020) feet MSL, the altitude tape color will change from gray to brown as the airplane descends through one thousand six hundred twenty (1,620) feet MSL.

If there is a system malfunction that causes a loss of valid radio altimeter data, the white digital radio altitude readout (and DH setting if selected) is replaced by amber dashes (“- - - - “). If the yellow runway symbol is displayed at the time of the failure, the symbol is removed from the PFD.

3. Controls and Indications:

There are no separate controls or indicators for the radio altimeter system. All cockpit interface with the system is through the DCs and the EFIS (PFD) display system. When the airplane is on the ground with full electrical power, the normal radio altitude readout is -5 (minus five) feet ± 5 feet.

A radio altimeter self-test may be initiated (on-side test only: pilot tests RAD ALT #1, copilot tests RAD ALT #2) using the LSK labeled RAD ALT on the TEST menu of the DC. When the test is in progress, a radio altitude of one hundred (100) feet should be displayed on the PFD:

- Preflight: Entering a DH of 50 feet prior to performing the radio altimeter self-test will test the DH display on the PFD.
- In-Flight Test: Entering a DH of 200 feet prior to performing the radio altimeter self-test will test the DH display on the PFD.

NOTE:

The radio altimeter self-test is inhibited with the AFCS engaged. The self-test is also inhibited by the fault warning computer during certain flight director modes.

A. Circuit Breakers (CBs):

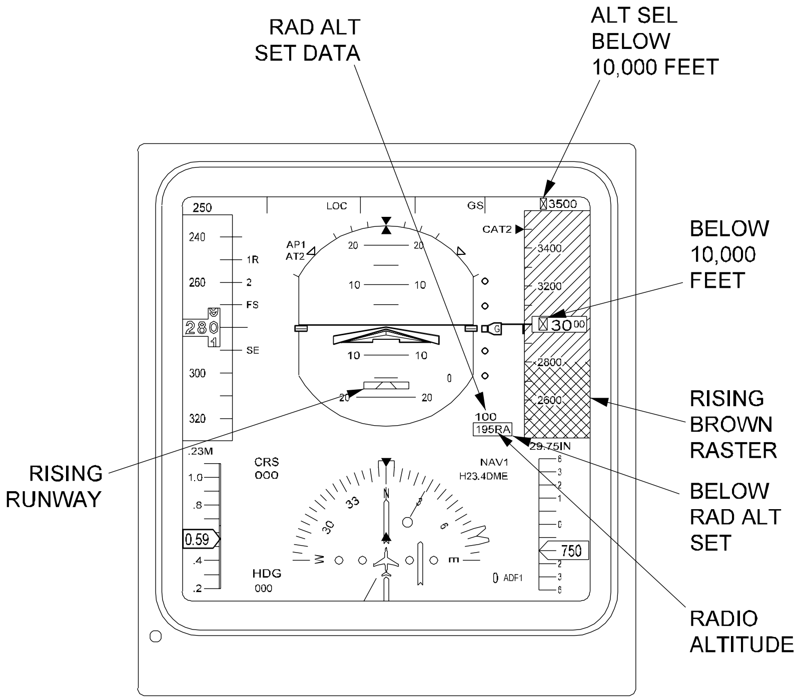
Circuit Breaker Name	CB Panel	Location	Power Source
RADIO ALT #1	CPO	I - 4	L MAIN 28V DC
RADIO ALT #2	CPO	J - 4	R MAIN 28V DC

B. Advisory (Blue) CAS Messages:

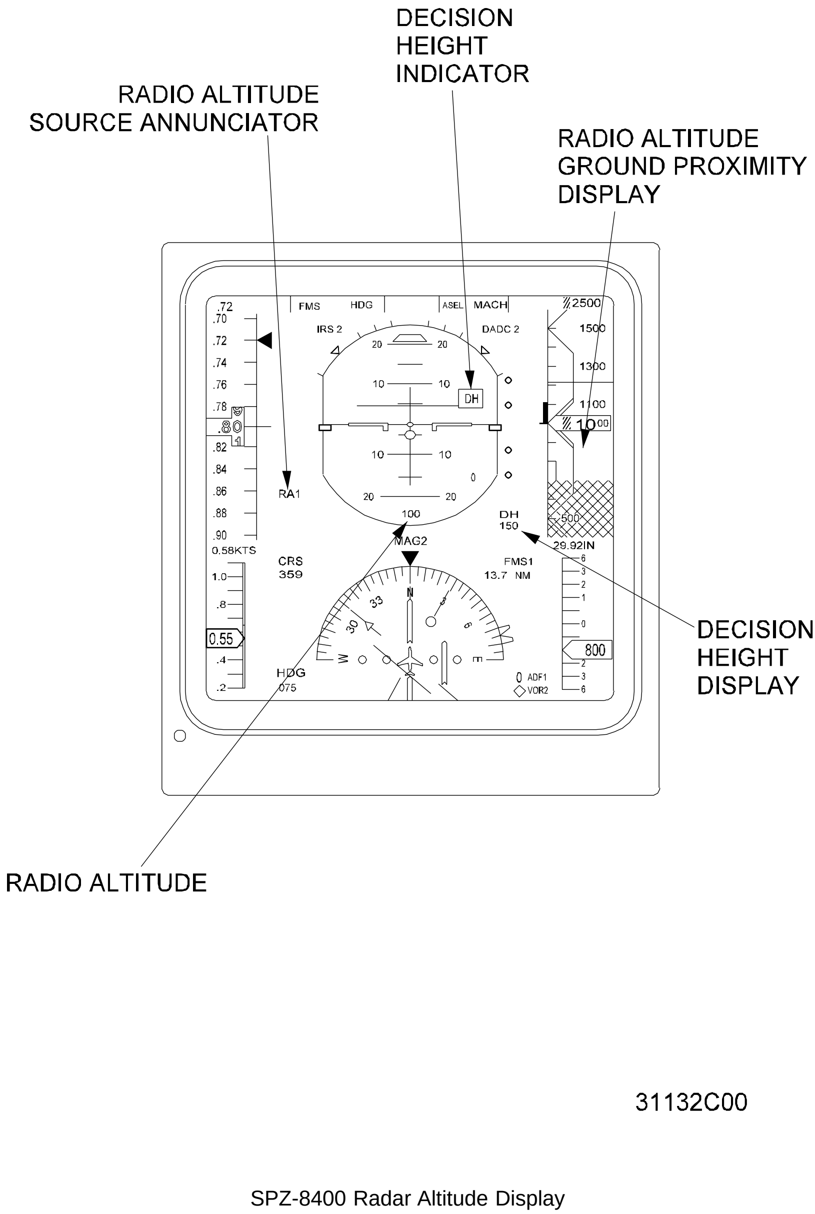
CAS Message	Cause or Meaning
RAD ALT 1 - 2 FAIL	Indicated radio altimeter(s) has failed

4. Limitations:

There are no limitations associated with this system at the time of this revision.



SPZ-8000 Radar Altitude Display
Figure 6



SPZ-8400 Radar Altitude Display
Figure 7

2A-34-50: Enhanced Ground Proximity Warning System (EGPWS)

1. General Description:

The Enhanced Ground Proximity Warning System (EGPWS) is installed during production beginning with airplanes Serial Number (SN) 1390 and subsequent. (The following system description is applicable to the production installed system only. Operators with systems installed by completion outfitters should consult the documentation supplied by the outfitter.) EGPWS provides aural and visual alerts to prevent Controlled Flight Into Terrain (CFIT). Alerts are generated in conditions of terrain clearance danger, severe windshear and excessive deviation below an Instrument Landing System (ILS) glideslope. EGPWS also provides aural notification of excessive bank angles and provides height above runway callouts, including approach minimums, during final approach.

2. Subsystems, Units and Components:

The EGPWS consists of a computer and geographical database interfaced with the SPZ-8400 DAFCS and airplane subsystems over ARINC 429 busses and discrete connections for data sensing and display presentation. See the system diagram in Figure 8. The system uses inputs from the DADCs, radio altimeter, FMS/GPS/IRS, angle of attack (AOA), landing gear and flap position, navigation data and a manually entered approach decision height. This information is integrated with the database in the computer to produce the aural and visual alert messages and the Terrain Awareness Display (TAD) graphic on the cockpit EFIS displays. (The TAD is usually selected to the NAV display, however, the Display Controller has an EGPWS option that allows selection of the TAD to the PFD, with the TAD shown on the HSI similar to the radar display.) Aural alerts and warnings are transmitted over cockpit speakers and through the cockpit interphone system, while alert and warning text messages are displayed on the Primary Flight Display (PFD). EGPWS aural alerts and warnings, except the windshear alert / warning can be inhibited with the GPWS VOICE O-RIDE switch on the O-RIDES panel on the center pedestal, shown in Figure 9 (location may vary).

The computer is located in the right electronic equipment rack and is powered from ϕC of the Left Main 115V AC bus and the Left Main 28V DC bus. The system operates in seven (7) distinct modes:

- Mode 1 - Excessive descent rate.
- Mode 2 - Excessive terrain closure rate
- Mode 3 - Altitude loss after takeoff
- Mode 4 - Unsafe terrain clearance
- Mode 5 - Excessive deviation below glideslope
- Mode 6 - Advisory callouts
- Mode 7 - Windshear alerting

The basic seven modes of operation are available in earlier model GPWS systems, with the alerts and warnings formulated using only airplane sensor data (airspeed, radio altitude, etc.). With the EGPWS, the ability to compare present airplane position, and predicted flight path vectors with data in the geographical database provides expanded warning envelopes and display options that increase situational awareness.

System enhancements improve the basic modes of operation and offer features not previously available. A Terrain Awareness Display (TAD) feature provides a graphic of terrain ahead of the airplane's current flight path. The TAD graphic is in multicolor and can be selected for continuous view on the NAV display (or PFD in the HSI position). If not selected for continuous view, the TAD will automatically “pop up” on the NAV display when the EGPWS computer detects terrain conflicts. Terrain displayed is within the range selected. The display range is adjusted with the same control as the weather radar, however if the TAD is not selected for continuous display and subsequently “pops up” the default range is ten (10) nautical miles - the range may then be adjusted from the default value. On the TAD, the color red is used to indicate the highest and most hazardous terrain areas, yellow (in varied intensity) identifies less dangerous terrain at elevations equal to or higher than airplane altitude, and green (in varied intensity) denotes areas equal to or below airplane altitude.

NOTE:

The TERR INHIB switch on the O-RIDES panel on the center pedestal, shown in Figure 9, will prevent the “pop up” of the TAD. If TERR INHIB is selected, the basic EGPWS modes 1 - 7 will continue to provide terrain clearance / windshear alerts, but indications will be limited to aural alerts over speakers and interphone and visual text alerts on the PFD.

Features of the Terrain Awareness Display include the following:

- Obstacles are displayed on the TAD when the airplane’s flight path will conflict with any of the known obstacles in the EGPWS database. (The database does not include temporary man-made obstacles covered in NOTAMS).
- A Terrain Peaks feature enhances situational awareness with a digital readout of elevations of the highest and lowest terrain and additional color gradations to further define terrain.
- A Terrain Clearance Floor (TCF) feature alerts the crew of a premature descent based upon current airplane position relative to the nearest runway. The TCF feature is useful in non-precision approaches and is enabled with TAD.
- On airplanes with EGPWS software build -210 -210 (SN 1426 and subsequent), a Runway Field Clearance Floor (RFCF) feature based on airplane position and height above destination runway using a computed Geometric Altitude (GA) provides improved safety margins at locations where the runway is higher than surrounding terrain.
- Geometric Altitude is computed blend of altitude information including GPS data, and at lower altitudes enhanced with Radio Altitude, to reduce or eliminate altimeter errors induced by non standard atmospheric conditions or reference setting errors.
- A EGPWS Envelope Modulation feature is incorporated that compensates for terrain and obstacles at some airports that have historically generated nuisance alerts, or that have environmental characteristics that inhibit needed alerts.

3. **Basic Mode Functions:**

NOTE:

Basic modes 1 - 6 require radio altimeter information to function. If radio altimeter information is not available, the TAD will continue to provide terrain awareness using Geometric Altitude (GA) inputs (see the discussion of GA in the following text).

A. **Mode 1: Excessive Descent Rate:**

Excessive descent rate alerts and warnings are generated when the descent is too steep for the margin of altitude below the airplane. The alert / warning envelope upper boundary is approximately 2,500’ radio altitude, and within the envelope, the alert / warning logic is biased for the amount of recovery time for the hazardous condition. See Figure 10. At 2,500’ a descent of approximately 4500 feet per minute (FPM) would initiate a “SINK RATE, SINK RATE” aural alert annunciation, and a descent of approximately 7000 FPM would prompt a “WHOOP, WHOOP, PULL UP” aural warning and the text PULL UP in red is displayed on the PFD. At lower radio altitudes, corresponding lower rates of descent will initiate alerts and warnings, and the envelope margin between alerts and warnings narrows.

If a valid Instrument Landing System (ILS) front course signal has been tuned and received, and the airplane is descending to capture the glideslope from above, the margin of the SINK RATE alert envelope is desensitized to prevent unwanted alerts when the airplane is in a safe position to capture (or recapture) the glideslope.

B. **Mode 2: Excessive Terrain Closure Rate:**

Mode 2 is the inverse of Mode 1 in that in this instance the airplane is in level flight, but is in danger of impacting rapidly rising terrain. Mode 2 is also based on radio altitude and the alert / warning envelope predicated upon closure rates and time remaining for evasive maneuvers. Mode 2 is split into two sub-modes with different parameters depending upon airplane configuration.

Sub-mode 2A is operable during climbout, cruise and initial approach (defined as flaps not in landing configuration and airplane not on ILS centerline). See the envelope shown in Figure 11. In these circumstances, if the airplane approaches rising terrain at a speed such that avoidance time is limited, initially an aural “TERRAIN, TERRAIN” alert message is prompted, and an amber TERRAIN text message is displayed on the PFD. If conditions deteriorate such that ground contact is imminent, an aural “WHOOP, WHOOP, PULL UP, PULL UP” warning is heard over cockpit speakers and headsets, and a red PULL UP text message is displayed on the PFD. The aural and text annunciations will continue until terrain clearance is sufficient that the warning envelope is cleared. If terrain clearance does not continue to increase, the TERRAIN aural and text alerts will continue. In all instances, the visual text alert will continue to be displayed on the PFD until the airplane has gained 300 feet of altitude, forty-five (45) seconds have elapsed, landing flaps have been selected or the flap override switch has been activated.

Sub-mode 2B is a desensitized alert and warning envelope that is automatically activated when landing flaps are selected (or flap override activated), or when within two (2) dots of the centerline of glideslope and localizer during an ILS approach. See Figure 12. This mode is also active during the first sixty (60) seconds after takeoff. The alerts and warnings in sub-mode 2B are the same as those in sub-mode 2A, with additional provisions that if the airplane enters the boundaries of the warning envelope without gear or flaps in the landing configuration, the aural “TERRAIN, TERRAIN” alert will sound with the accompanying text message on the PFD. Further penetration of the envelope will result in “PULL UP” aural warnings and text message until the airplane exits the envelope or the airplane configuration is corrected. If the airplane configuration is correct for landing (gear and flaps down), and a hazardous terrain closure rate exists, the “PULL UP” aural and text warnings are suppressed, and the “TERRAIN” aural and text alerts are prompted until the airplane exits the sub-mode 2B envelope.

C. Mode 3: Altitude Loss after Takeoff:

This mode provides an aural alert for any significant altitude loss after takeoff or when performing a go-around at an altitude of less than two hundred forty-five feet (245’) radio altitude with the gear and flaps not in the landing configuration. The alert envelope, shown in Figure 13, is predicated upon the amount of terrain clearance available below the airplane versus sink rate. Any significant loss of altitude prompts an aural alert of “DON’T SINK, DON’T SINK”. The aural alert is sounded twice only, unless there is a continued loss of altitude clearance.

D. Mode 4: Unsafe Terrain Clearance:

Mode 4 is subdivided into three sub-modes to address specific phases of flight, airplane configurations and airspeeds. The sub-modes 4A, 4B and 4C are active in circumstances similar to those that prompt alerts and warnings under Mode 2 and Mode 3, but provide increased situational awareness when hazardous conditions are not as immediate.

Sub-mode 4A is active during cruise and approach with gear and flaps up, with the alerting envelope predicated on speed and altitude. See Figure 14. (This envelope also provides additional protection against a gear-up landing). Flying in altitude and airspeeds from 1000 feet radio altitude at a speed of 250 knots down to an altitude of 500 feet and a speed of 190 knots prompts an aural “TOO LOW TERRAIN” alert over speakers and headsets and an amber text message TERRAIN on the PFD. If the airplane is still in the clean configuration below 500 feet and at less than 190 knots, the aural alert changes to “TOO LOW GEAR”. Either of these aural alerts is sounded only once, unless there is further decrease of altitude / airspeed of twenty percent (20%) or more.

Sub-mode 4B operates during cruise and approach with the landing gear down, but with the flaps not in landing configuration. See the envelope depicted in Figure 14. Below 1000 feet at 250 knots down to 245 feet at 159 knots with the flaps not fully extended prompts a “TOO LOW TERRAIN” aural alert and the display of an amber TERRAIN on the PFD. Below 245 feet and less than 159 knots, the aural alert changes to “TOO LOW FLAPS”. The aural alerts are sounded only once unless there is a further twenty percent (20%) degradation of clearance.

Sub-mode 4C operates during climbout toward rising terrain that produces a decrease in vertical clearance, but is not severe enough to prompt activation of mode 2. See the alert envelope shown in Figure 15. After takeoff or a go-around below 245 feet, and the gear and flaps not in landing configuration, the airplane must continue to gain terrain clearance at a rate that is equal to or exceeds 75% of the radio altitude averaged over the previous fifteen (15) seconds, with no decrease. This envelope is upwardly limited at 500 feet radio altitude at airspeeds less than 190 knots, and expands linearly to 1000 feet at 250 knots. If airplane climb does not meet the envelope gradients, an aural alert “TOO LOW TERRAIN” is heard and the TERRAIN text alert is displayed on the PFD.

E. Mode 5: Excessive Deviation Below Glideslope:

Mode 5 provides terrain clearance alerts during ILS approaches. The alerts are triggered at two different levels, depending upon how closely the airplane is aligned with the glideslope and the terrain clearance available below the airplane. The alerting envelope is shown in Figure 15. For glideslope alerts to be operative, the airplane must be within two (2) dots of localizer centerline, gear and flaps in the landing configuration and a valid front course ILS signal received. As the airplane descends below 1000 feet radio altitude on the localizer, any deviation below glideslope center that exceeds 1.3 dots prompts an aural “GLIDESLOPE” alert and illumination of the BELOW G/S lights below the cockpit glareshield. This aural alert is sounded at only half of the volume of normal aural alerts, and is called a “soft” alert. If the airplane deviates twenty percent (20%) further from the 1.3 dot displacement, the “soft” alert is repeated at increasingly faster rates.

The BELOW G/S light is a dual function switchlight installation. The top half of the switchlight is labelled BELOW G/S and illuminates amber when the airplane deviates outside of the glideslope alerting envelope. The bottom half of the light is labelled G/S INHIBIT. Pushing the switchlight will inhibit further glideslope alerts. When the inhibit function is selected by pushing the switchlight, the legend G/S INHIBIT illuminates blue. The inhibit switchlight may be used to cancel Mode 5 alerts at any time the airplane is below 2000 feet radio altitude. Once cancelled, Mode 5 alerting is reset when the airplane descends below 30 feet, climbs above 2000 feet or the ILS frequency is deselected then retuned. Mode 5 would then be available for a subsequent approach in the event of a go-around

As the airplane descends to 300 feet and lower during the ILS approach, a deviation from glideslope center of two (2) dots or more prompts aural alerts “GLIDESLOPE” at normal (louder) volume. The aural alert is sounded every three (3) seconds until the airplane returns to within 1.3 dots of glideslope center.

Both the 1.3 dot “soft” alert and the 2 dot normal aural alerts are desensitized below 150 feet radio altitude to allow for glideslope beam variations and to reduce the possibility of nuisance (unwarranted) alerts.

If the airplane is maneuvering at low altitude to capture the localizer for an ILS approach, the upper altitude limit of the glideslope deviation alert envelope is reduced to 500 feet radio altitude if the airplane is descending at less than 500 FPM.

.

F. Mode 6: Advisory Callouts:

The mode 6 advisory callouts are aural notifications of specific altitudes and excessive bank angle. There are no visual text messages or displays associated with mode 6. The specific altitudes announced over the cockpit speakers and interphone system are selected upon installation of the EGPWS system, as are the optional instrument approach minimum altitude and excessive bank angle callouts. The following altitude callouts are most commonly selected, but others may be selected by individual operators. Different selections should be noted by system placards in the cockpit (if confirmation of selected altitudes is required, note the callouts during EGPWS self-test):

- “ONE THOUSAND”
- “FIVE HUNDRED”
- “FOUR HUNDRED”
- “THREE HUNDRED”
- “TWO HUNDRED”
- “ONE HUNDRED”
- “FIFTY”
- “FORTY”
- “THIRTY”
- “TWENTY”
- “TEN”

The above listed aural callouts are sounded by the EGPWS when the radio altitude associated with the callout is reached. In addition to these standardized callouts, aural notification of descent within one hundred feet (100’) of instrument approach minimum altitude and reaching approach minimum altitude will take place if the crew has manually entered the minimum altitude (MDA or DH). The callouts are “APPROACHING MINIMUMS” and “MINIMUMS” and are sounded only once during the approach. (Other aural notification options may be selected and programmed during system installation - monitor the callouts during self-test for verification). If altitude callouts are not desired, selecting the RAD ALT VOICE O/R switch on the O-RIDES panel (shown in Figure 9) will inhibit the annunciation of callouts.

An aural notification of excessive bank angle is a standard option (others are available for operator customizing). The business airplane bank angle limits are set at forty degrees (40°) above 150 feet radio altitude. See Figure 16. Below 150 feet, the bank angle limit is proportionally decreased with altitude, down to ten degrees (10°) at thirty (30) feet. The feature is inhibited below five (5) feet of altitude. If the airplane exceeds the bank angle limit for altitude, an aural notification of “BANK ANGLE, BANK ANGLE” is heard. If the bank limit is exceeded, the airplane must return to a bank angle of thirty degrees (30°) or less to reset the excessive bank callout.

G. Mode 7: Windshear Alerting:

If the airplane encounters environmental conditions often associated with a windshear at lower altitudes, aural and visual caution and warning alerts are provided to the crew by mode 7 of the EGPWS. The operating envelope for the windshear alert is shown in Figure 17.

Windshear alerting is computed using inputs from air data sensors for pitot/ static information, and accelerometers for sensing forces on the airplane. The computer interfaces with the IRSs and DADCs for attitude and TAT information, and with discretes for flap position and nutcracker switch data. The computer generates windshear cautions and warnings that are communicated via ARINC 429 bus inputs to the Symbol Generators for display on the PFDs.

Mode 7 is operable between ten (10) and fifteen hundred (1500) feet radio altitude during takeoff, approach or go-around. The Windshear Computer detects suddenly changing headwinds and tailwinds, excessive updrafts and downdrafts, and other factors indicating an impending microburst. Moderate conditions of increasing headwind and updraft that do not immediately hazard the airplane result in the aural message “CAUTION, WINDSHEAR” over cockpit speakers and interphone, and the amber text message WINDSHEAR displayed on the PFD. More severe conditions (decreasing headwinds and downdrafts) prompt windshear warnings. The aural warning “WINDSHEAR, WINDSHEAR, WINDSHEAR” is sounded, and the red text warning WINDSHEAR is displayed on the PFD.

For both cautions and warnings, the aural message is repeated only once, but the text message on the PFD remains in view until the airplane exits the windshear conditions. The parameters that prompt the windshear cautions / warnings are adjusted as a function of available climb performance, flight path angle, airspeeds that significantly vary from normal takeoff / approach / go-around speeds, and unusual fluctuations in Static Air Temperature (SAT) often associated with microbursts.

4. **Enhanced Mode Functions:**

With the ability to compare accurate airplane position from FMS / IRS / GPS systems with the terrain database stored within the computer, EGPWS is able to improve the function of the seven basic modes of operation and provide the flight crew with additional features.

A. **Envelope Modulation:**

EGPWS modifies the alert envelopes of some basic modes at specific geographical locations where there are terrain features that are known to cause nuisance alerts or to inhibit needed alerts. The alert envelope for basic modes 4 (unsafe terrain clearance), 5 (excessive glideslope deviation) and 6 (advisory callouts) is expanded at some locations that are known to require additional terrain clearance, while at other locations modes 1 (excessive descent rate), 2 (excessive terrain closure rate) and 4 (unsafe terrain clearance) are desensitized to avoid nuisance alerts generated by known non-hazardous terrain.

B. **Terrain Clearance Floor:**

In conjunction with the Terrain Awareness Display (TAD), the Terrain Clearance Floor (TCF) function alerts the flight crew at any time the airplane descends below the TCF defined altitude regardless of airplane configuration. The alert envelope is depicted in Figure 18. A descent below the TCF will trigger the aural alert “TOO LOW TERRAIN” and the amber text message TERRAIN on the PFD. This feature is operational at all times unless the TAD is inhibited. The floor is defined as seven hundred feet (700') above terrain for all areas except within fifteen (15) miles of airport with a runway of 3500 feet or longer that is in the EGPWS database. As the airplane approaches a database airport, the floor drops to four hundred feet (400') between twelve (12) miles and four (4) miles of the center of the runway. On airplanes with EGPWS software version -210 -210 and higher (SN 1426 and subsequent), the inner alert floor is lowered to two hundred forty-five feet (245') and positioned closer to the center of the runway (typically 1/3 NM to 1 NM) due to the higher resolution of airplane position relative to the terrain database. For SN 1426 and subsequent, this software version also provides an identification logic that determines the most likely destination runway based on airplane position and navigation information.

C. Runway Clearance Floor:

The Runway Clearance Floor (RCF) is very similar to the TCF, and is available on -210 -210 software (SN 1426 and subsequent) equipped airplanes. The RCF uses a computed Geometric Altitude (see the description of Geometric Altitude in the following sections) in lieu of radio altitude. RCF provides improved terrain alerting in locations where the runway is located at a much higher altitude than the surrounding terrain, or where an approach to the runway transits a steep decrease in terrain clearance. If the airplane enters the RCF alert envelope, an aural "TOO LOW TERRAIN" alert is sounded and the amber TERRAIN text message is displayed on the PFD. The aural alert is not repeated unless there is a further twenty percent (20%) decrease in terrain clearance. The amber TERRAIN text message remains displayed on the PFD until the RCF alert envelope is exited.

D. Look Ahead Terrain Alerting:

The EGPWS is able to anticipate potential hazards to the airplane by using the terrain database and algorithms based on airplane position, flight path vertical component (climb or descent), and airplane track and speed relative to the terrain database. See Figure 19. The EGPWS projects a terrain alert envelope ahead of the airplane, above and below the projected flight path and laterally within ¼ mile and out to within ± three degrees (3°) of track (or more if the airplane is turning). If the system algorithms predict that the airplane will encounter hazardous terrain within sixty (60) seconds, an aural "TERRAIN, TERRAIN" caution is sounded and the amber TERRAIN text message is displayed on the PFD. The aural caution is repeated every seven (7) seconds while the airplane is in the caution alert envelope, and the text TERRAIN remains displayed until the airplane clears the terrain caution envelope. If the airplane is projected to encounter a terrain hazard within thirty (30) seconds, an aural "TERRAIN, TERRAIN" followed by a "PULL UP, PULL UP" warning is sounded, and a red text message PULL UP is displayed on the PFD. The aural warnings are repeated continuously and the red PULL UP is displayed until the airplane exits the terrain warning alert envelope.

E. Terrain Awareness Display (TAD):

The Terrain Awareness Display (TAD) is graphic representation of the terrain within two thousand feet (2000') above or below the airplane, usually selected to the NAV / RADAR cockpit EFIS display by the EGPWS options on the Display Controller. (The TAD may be selected for view on the PFD, in which case the display is similar to the weather radar display mode in HSI format.) The terrain display defined altitudes are shown in Figure 20. The TAD as it appears on cockpit EFIS displays is seen in Figure 21. This display will automatically appear on the NAV display if a terrain conflict is detected. The automatic display function is initiated by the EGPWS computer that switches the Display Controller to the TAD mode. If desired by the crew, the automatic TAD function may be inhibited with the TERR INHIB switch on the O-RIDES panel located on the center pedestal.

CAUTION

THE TERRAIN AWARENESS DISPLAY (TAD) IS INTENDED FOR USE ONLY AS AN ADVISORY OF POTENTIALLY THREATENING TERRAIN AHEAD. IN NO WAY SHOULD THE FLIGHT CREW USE THE DISPLAY FOR NAVIGATION OF THE AIRPLANE OR FOR GUIDANCE IN STEERING THE AIRPLANE CLEAR OF TERRAIN.

The TAD offers a plan view image of surrounding terrain in patterns of green, yellow and red in varying densities. Each specific color and intensity represents terrain and / or obstacles above, level with or below the airplane’s altitude based upon airplane position relative to the geographic database. If the airplane is in an area not covered by the database (typically near the poles) the display is low density magenta. Terrain that is more than two thousand feet (2000’) below the airplane is not displayed, nor is terrain within four hundred vertical feet (400’) of the elevation of the nearest airport runway. See the table at the end of this topic for a full description of the significance of the colors and densities of the TAD function.

With the incorporation of the Peaks function, the TAD presents a digital readout of the elevations of the highest and lowest terrain and / or obstacle currently displayed. The numerical values of the readout are in hundreds of feet above mean sea level (MSL), thus a display of 125 equals (=) 12,500 feet MSL. The elevation values are displayed in the same color as the terrain of that elevation. The elevation of the highest terrain indicated in red, the lowest in green. If there is no significant variation in terrain elevation, for instance over flat terrain, only the highest elevation is indicated numerically. The numerical elevation values are no longer displayed when the airplane is five hundred feet (500’) or less above the terrain (250’ if the landing gear is extended).

When the image is initially presented, the ten (10) mile range is the default value - other range values must be manually selected. When potential terrain conflicts prompt caution or warning alerts, the terrain and / or obstacle is depicted in solid yellow for cautions and solid red for warnings. Additionally, during alerts the image scale of the area immediately surrounding the hazard is enlarged to better identify a small obstacle or terrain feature.

Color	Indication
Solid Red	Terrain / Obstacle Threat Area - Warning
Solid Yellow	Terrain / Obstacle Threat Area - Caution
50 % Red Fill	Terrain / Obstacle that is more than 2000 feet above airplane altitude
50 % Yellow Fill	Terrain / Obstacle that is between 1000 feet and 2000 feet above airplane altitude
25 % Yellow Fill	Terrain / Obstacle that is 500 feet (250 feet with landing gear extended) below to 1000 feet above airplane altitude
Solid Green (Peaks display)	Shown only when no Red or Yellow Terrain / Obstacles are within range of the display. The highest Terrain / Obstacle is not within 500 feet (250 feet with landing gear extended) of airplane altitude
50 % Green Fill	Terrain / Obstacle that is between 500 feet (250 feet with landing gear extended) and 1000 feet below airplane altitude
50 % Green Fill (Peaks display)	Terrain / Obstacle that is in the middle elevation band when there is no Red or Yellow Terrain / Obstacle within range on the display
16 % Green Fill	Terrain / Obstacle that is between 1000 feet an 2000 feet below airplane altitude
16 % Green Fill (Peaks display)	Terrain / Obstacle that is in the lower elevation band when there is no Red or Yellow Terrain / Obstacle within range on the display
Black	No significant Terrain / Obstacle
16 % Cyan Fill (Peaks display)	Water at mean sea level elevation (0 feet MSL)
Magenta Fill	Unknown terrain. No terrain data in the database for the magenta area shown

F. Geographic Altitude:

The alerts and displays generated by the EGPWS are most accurate when airplane altitude can be determined with a high degree of certainty. To obtain the highest accuracy in measuring airplane altitude, the EGPWS computes a Geographic Altitude (GA). GA is a blended altitude derived from all altimeter data sources available, and includes:

- Non-corrected standard altitude
- Runway calibrated altitude computed during takeoff
- GPS calibrated altitude
- Radio altitude calibrated during approach
- Barometric altitude, corrected for local conditions if available

For each of these readings, a Vertical Figure of Merit (VFOM) is determined in order to calculate the importance of the individual reading in blending the final GA computation. The final computed GA value is more accurate than the value of individual sensor readings and allows a more precise determination of separation between the airplane and the terrain in the EGPWS database.

NOTE:

A terrain awareness display with degraded accuracy remains available if radio altitude information is lost. A GA is formulated from the available altitude data sources for computing the terrain display. A display generated without radio altitude should be used only as a general cue for terrain awareness, and should not be relied upon for navigational purposes.

5. Controls and Indications:

A. Circuit Breakers (CBs):

Circuit Breaker Name:	CB Panel:	Location:	Power Source:
EGPWS AC	CPO	D-10	L MAIN 115V AV ϕC
EGPWS DC	CPO	E-10	L MAIN 28V DC

B. Advisory (Blue) CAS Messages:

CAS Message:	Cause of Meaning:
GPWS FAIL	Ground Proximity Warning System (GPWS) has failed.
WINDSHEAR FAIL	Failure of essential input data from one or more of the following: AOA, Stall Warning System or IRS accelerometers.
TERRAIN INHIBITED	Terrain inhibit switch selected ON.
TERRAIN NOT AVAIL	Airplane position cannot be determined due to failure / malfunction in GPS and / or IRS systems.

C. System Test:

The GPWS switch on the TEST panel, located on the cockpit center console (location varies) initiates an EGPWS system self-test. Prior to initiating a self-test, determine that the following conditions are met:

- Normal airplane power is available and EGPWS is ON
- No O-RIDE switches are selected (TERR INHIB, RAD ALT VOICE O/R or GPWS VOICE O/R)
- No GPWS inoperative annunciations are displayed on CAS

Pressing the GPWS TEST switch will result in the following indications if the system is functioning normally:

- CAS messages GPWS FAIL, WINDSHEAR FAIL, TERRAIN INHIBITED and TERRAIN NOT AVAIL displayed
- Amber caution light BELOW G/S on
- “GLIDESLOPE” annunciation over cockpit speakers and interphone
- Amber BELOW G/S light extinguishes
- Blue G/S INHIBIT light on
- Blue G/S INHIBIT light extinguishes
- Red PULL UP text warning displayed on PFD
- “PULL UP” aural annunciation over cockpit speakers and interphone

- Red PULL UP text warning clears
- Red WINDSHEAR text warning displayed on PFD
- “WINDSHEAR, WINDSHEAR, WINDSHEAR” aural annunciation over cockpit speakers and interphone
- Red WINDSHEAR text warning clears
- Amber WINDSHEAR text caution displayed on PFD
- Amber WINDSHEAR text caution clears
- Red PULL UP text warning displayed on PFD
- “TERRAIN, TERRAIN” aural warning followed by “PULL UP, PULL UP” aural warning annunciated over cockpit speakers and interphone
- Terrain test pattern shown on cockpit displays
- Red PULL UP text warning clears
- CAS messages GPWS FAIL, WINDSHEAR FAIL, TERRAIN INHIBITED and TERRAIN NOT AVAIL clear
- Terrain test pattern clears on cockpit displays

6. Limitations:

A. Flight Manual Limitations:

(1) Pilot’s Manuals:

The Honeywell Enhanced Ground Proximity Warning System Pilot’s Guide, Publication Number 060-4241-000, Revision D, dated March 2000 (or later approved revision appropriate to the software version below) shall be immediately available to the pilots for -208 -208 (SN 1390 through 1425) or -210 -210 (SN 1426 and subsequent).

(2) Clearance:

Pilots are authorized to deviate from their current Air Traffic Control (ATC) clearance to the extent necessary to comply with an EGPWS warning.

(3) Navigation:

Navigation is not to be predicated upon the use of the Terrain Display.

(4) Database:

The EGPWS database, displays and alerting algorithms currently account for man-made obstructions.

(5) Terrain Display:

The Terrain Display is intended to serve as a situational awareness tool only, and may not provide the accuracy and / or fidelity on which to solely base terrain avoidance maneuvering.

Terrain Display shall be selected OFF when within 15 NM of landing at an airport when:

- The airport has no published instrument approach procedure (-104 -104 software version only).
- The longest runway is less than 3500 ft in length.
- The airport is not in the EGPWS database.

(6) TAWS:

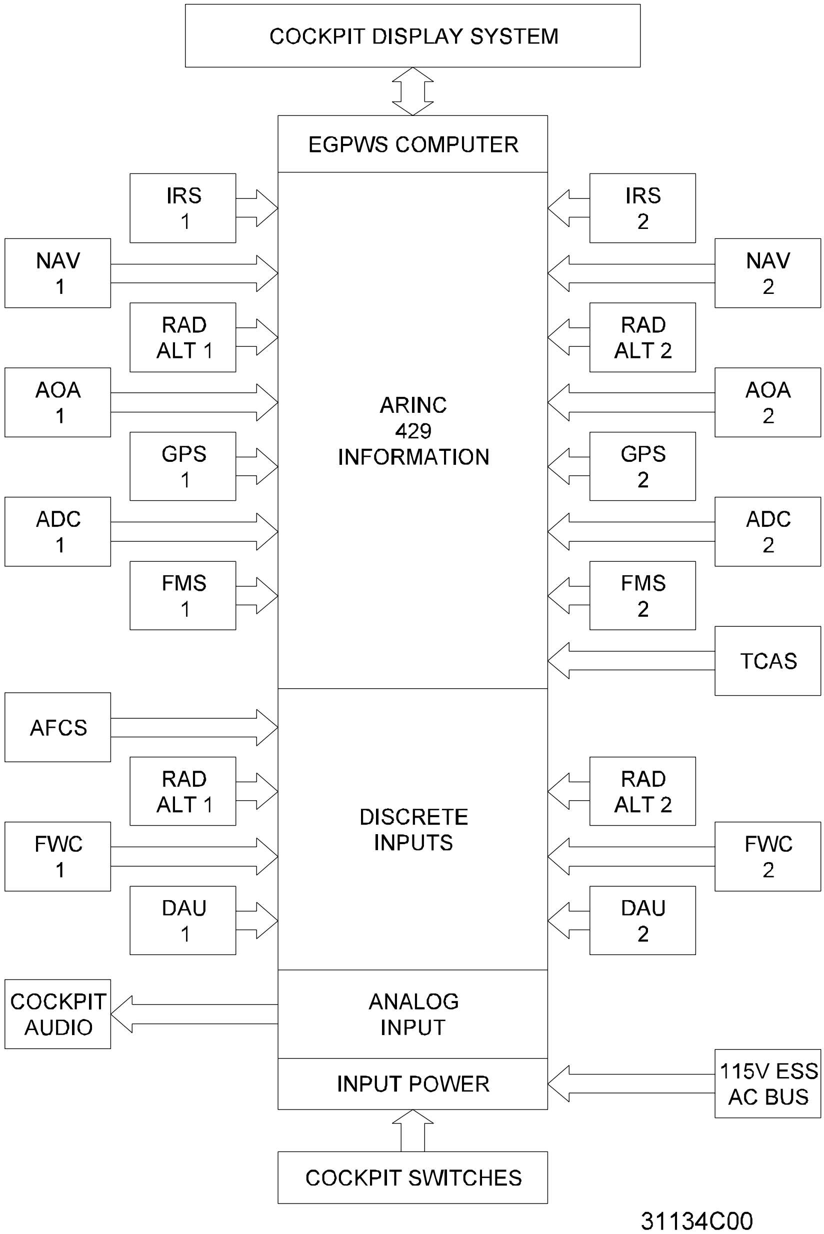
The production EGPWS installation meets the requirements for Class A TAWS as defined in Advisory Circular AC 25-23.

7. System Notes:

The EGPWS database consists of three (3) smaller databases:

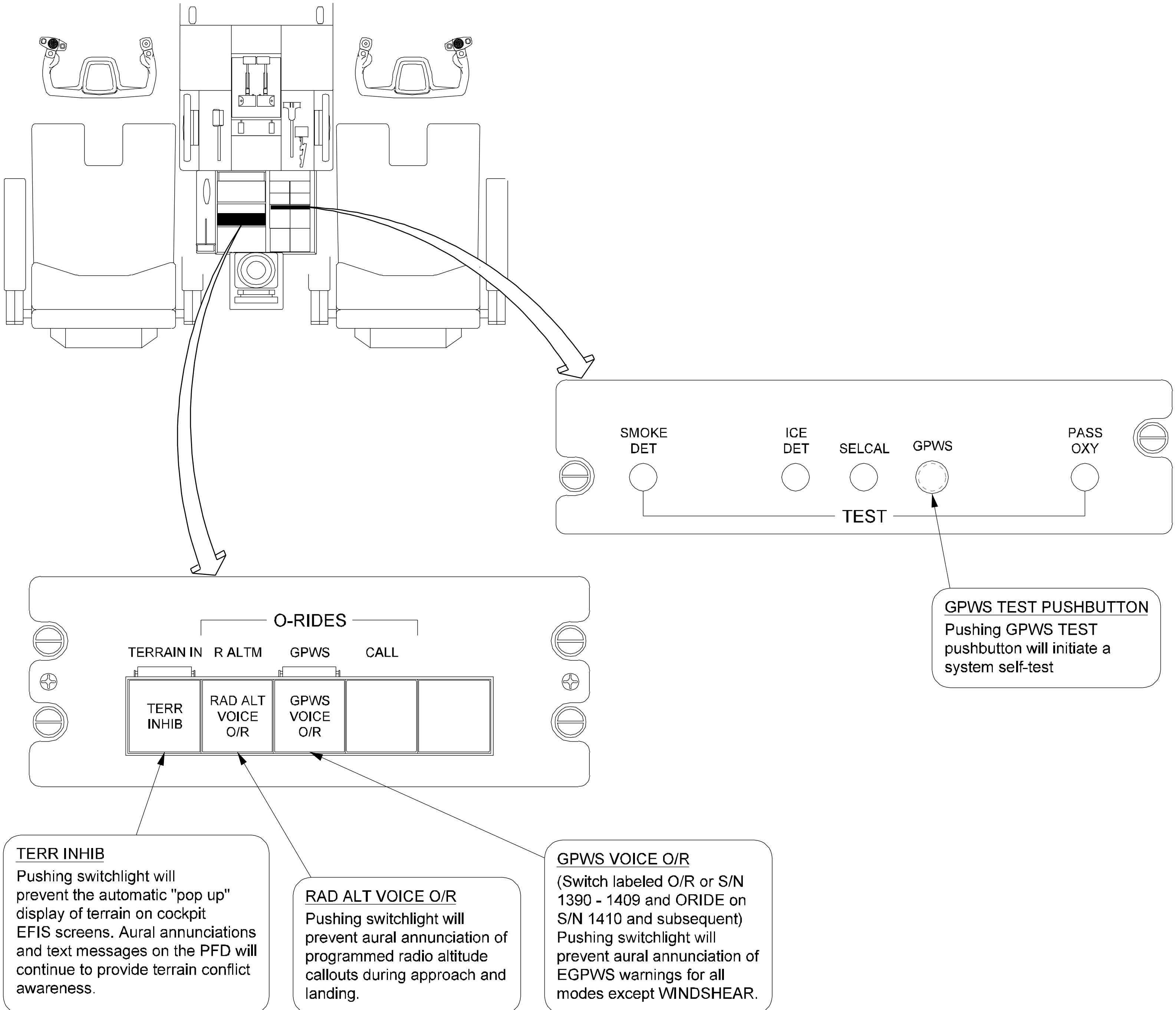
- Terrain database that covers most of the earth
- Obstacles database that covers all charted obstacles in North America and slightly beyond
- Runway database that covers all runways at least 3,500 feet in length

The database is updated when significant changes occur. The database updates are on a PCMCIA card available from Honeywell. The number of the latest database version is listed on the Honeywell website http://www.egpws.com/ or by calling the EGPWS hotline at (800) 813-2099.



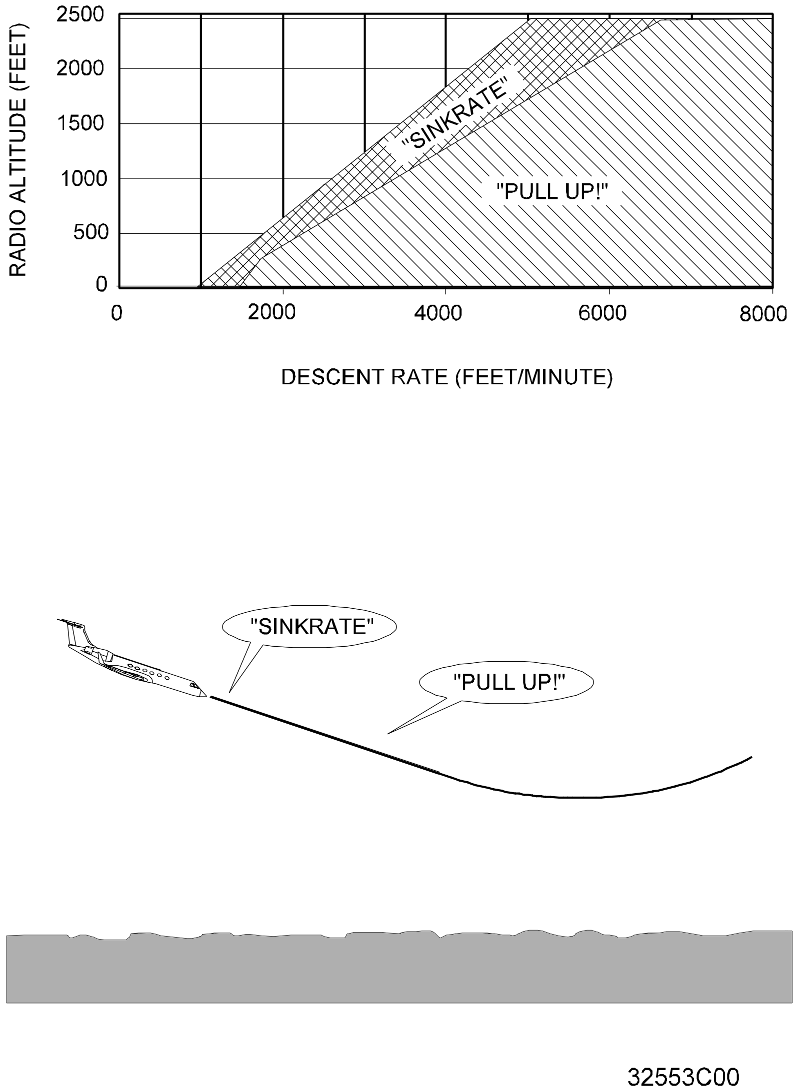
EGPWS System Diagram
Figure 8

THIS PAGE IS INTENTIONALLY LEFT BLANK.

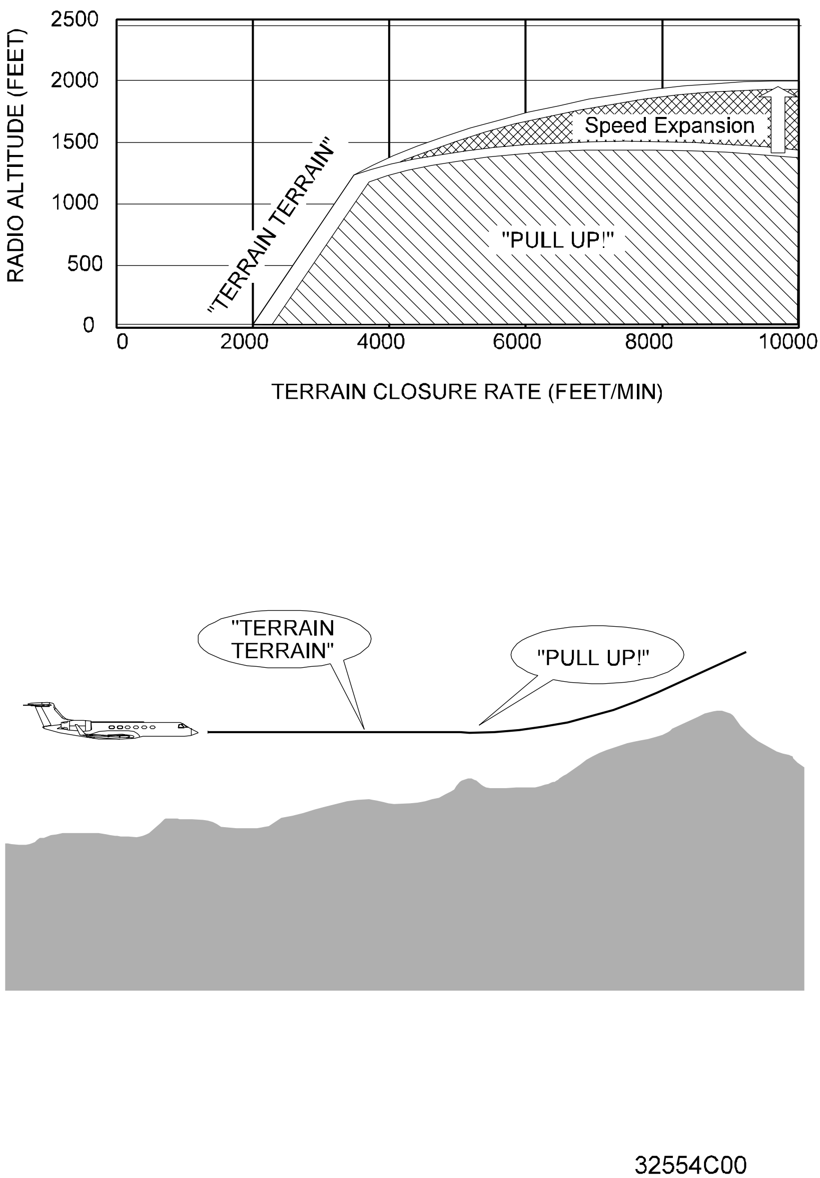


31137C00

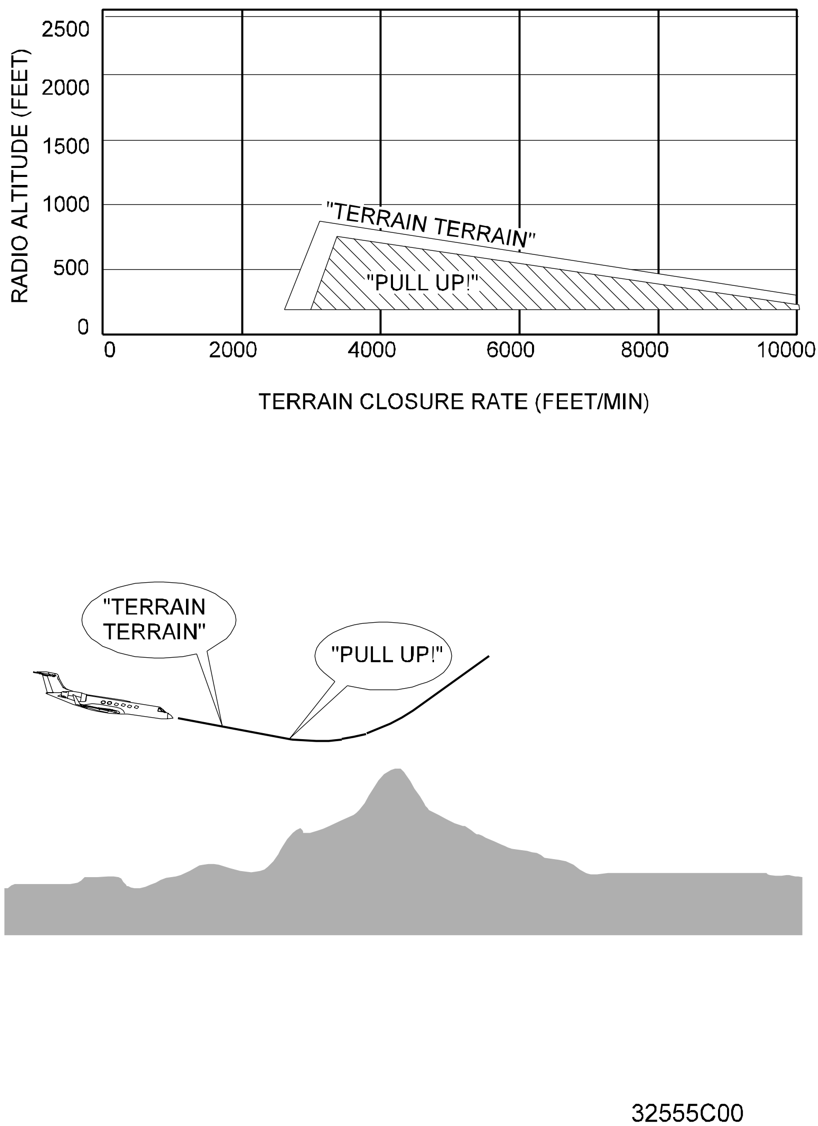
O-RIDES / TEST Panels
on Center Pedestal
Figure 9



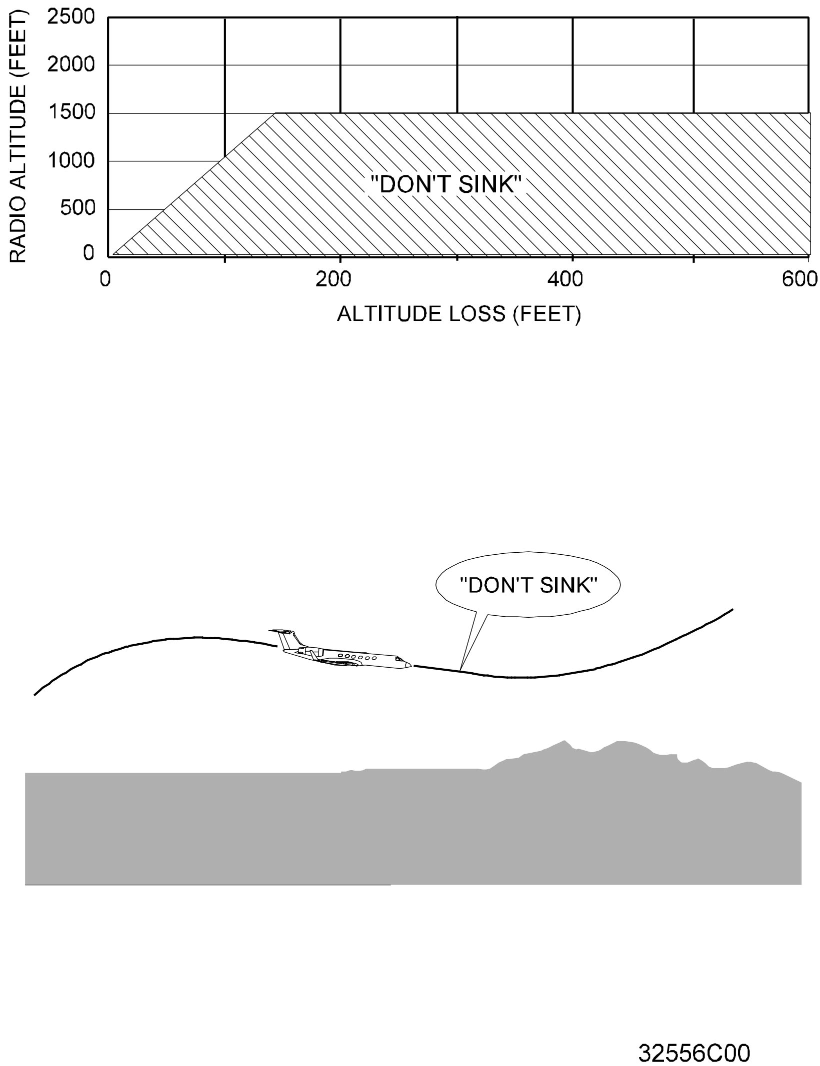
Excessive Descent Rate Envelope - Mode 1
Figure 10



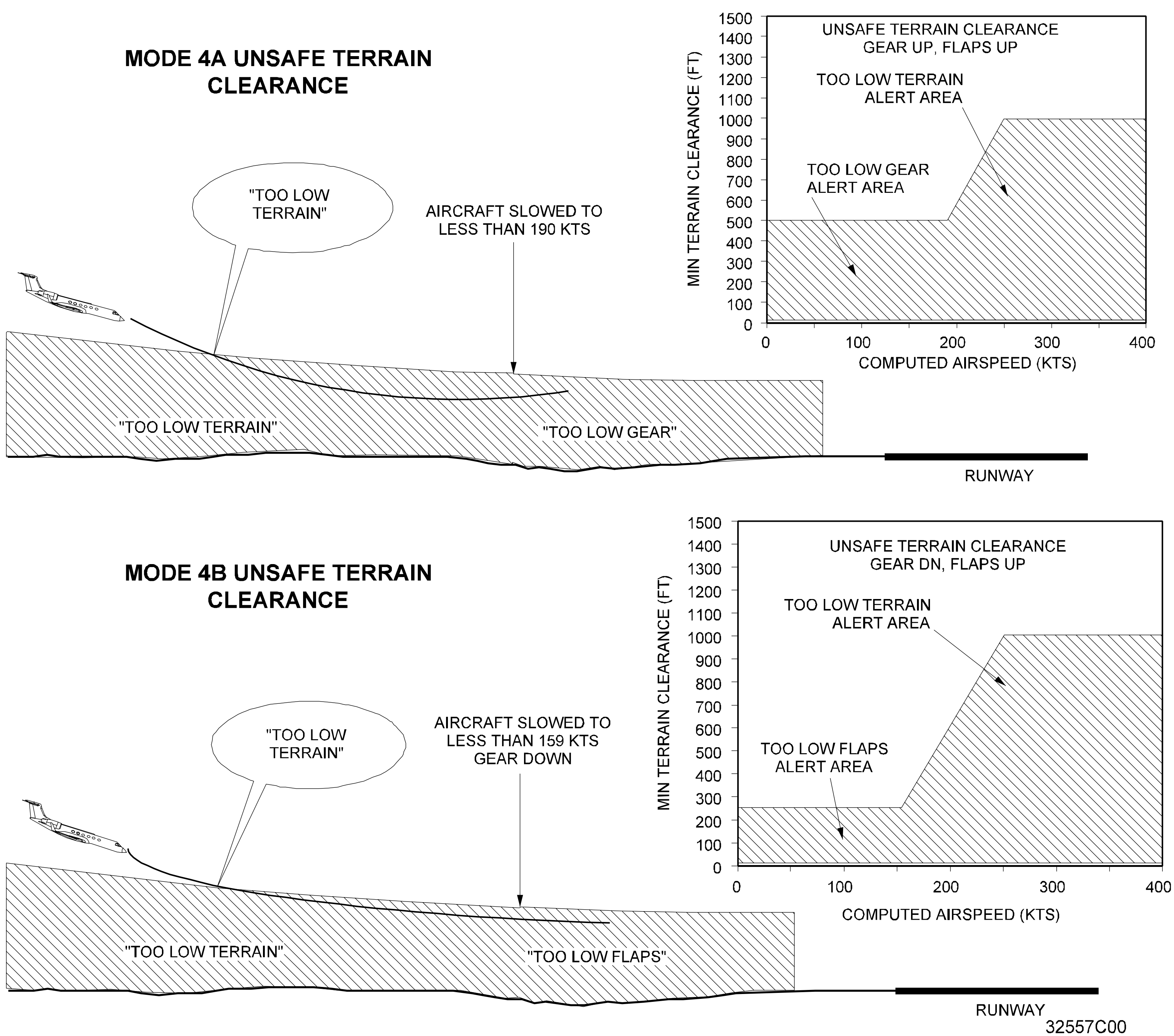
Excessive Terrain Closure Envelope - Mode 2A
Figure 11



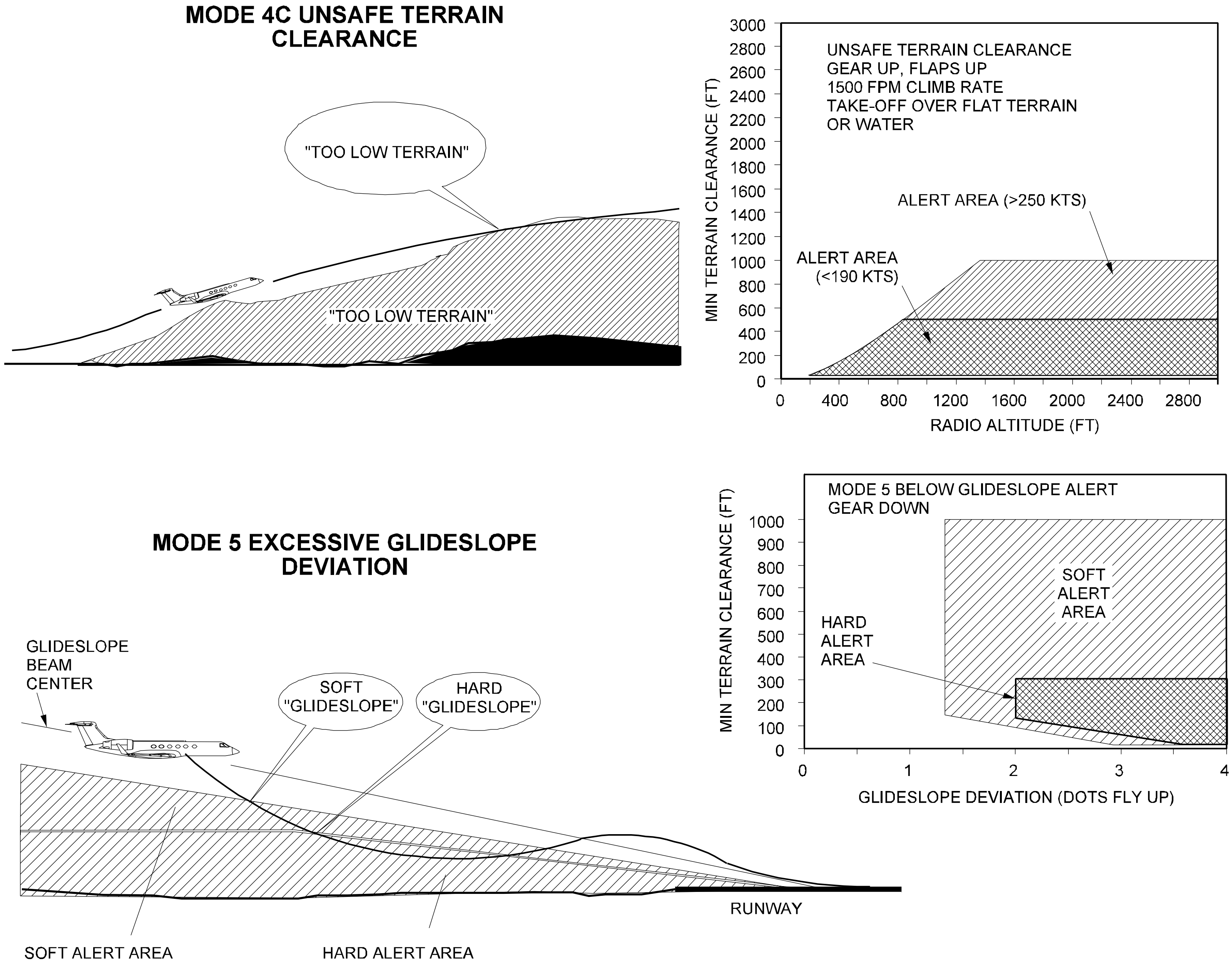
Excessive Terrain Closure Envelope - Mode 2B
Figure 12



Altitude Loss After Takeoff Envelope - Mode 3
Figure 13

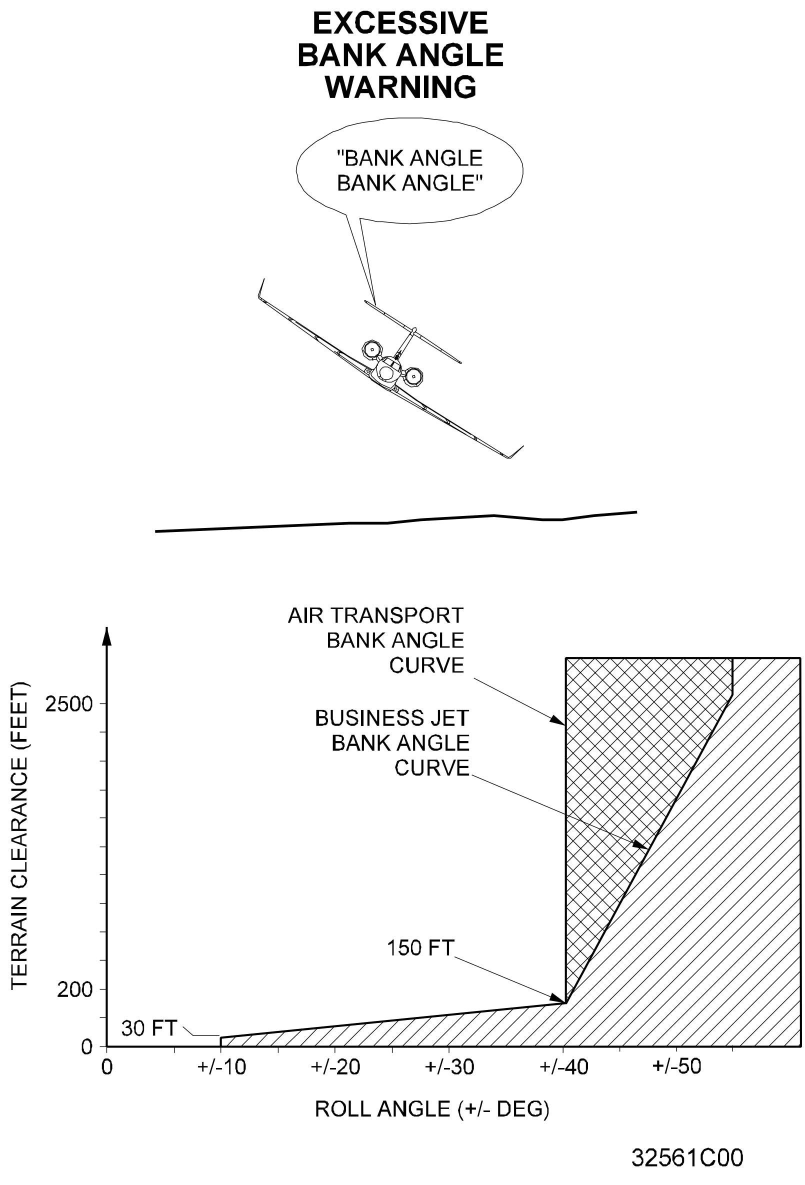


Unsafe Terrain Clearance Envelope - Mode 4A and Mode 4B
Figure 14



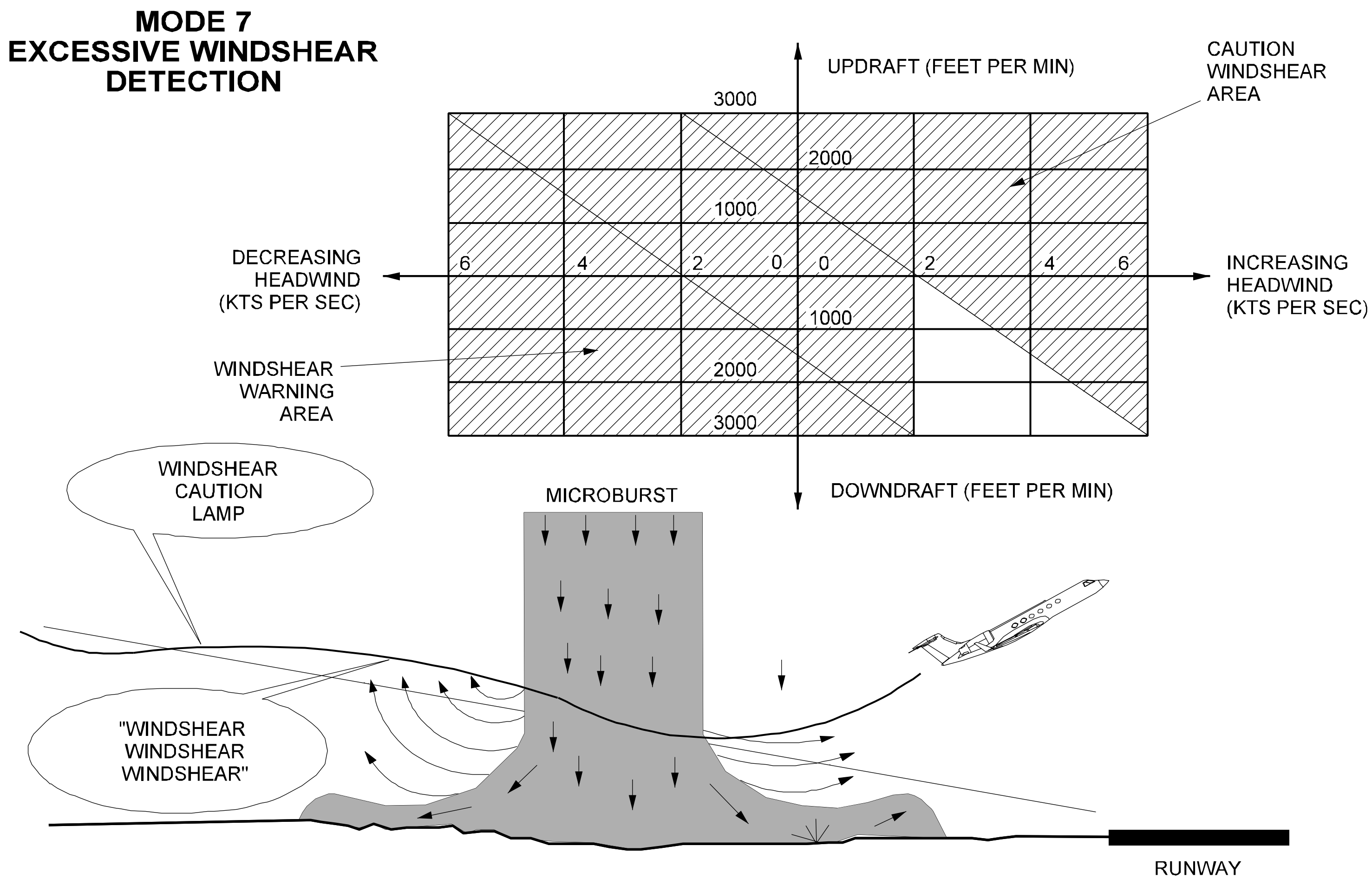
32559C00

Unsafe Terrain Clearance
Envelope - Mode 4C and
Excessive Glide Slope
Deviation - Mode 5
Figure 15

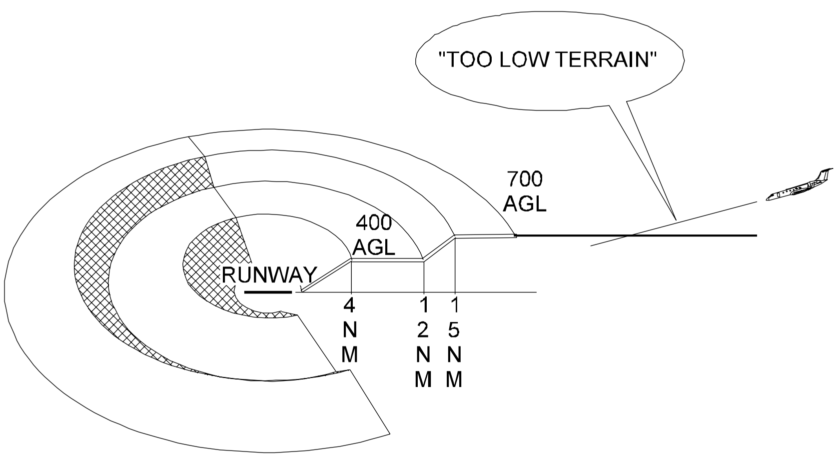


Excessive Bank Angle Envelope - Mode 6
Figure 16

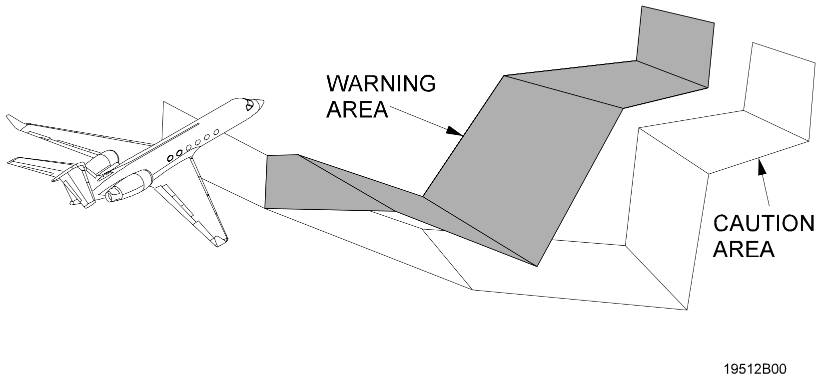
THIS PAGE IS INTENTIONALLY LEFT BLANK.



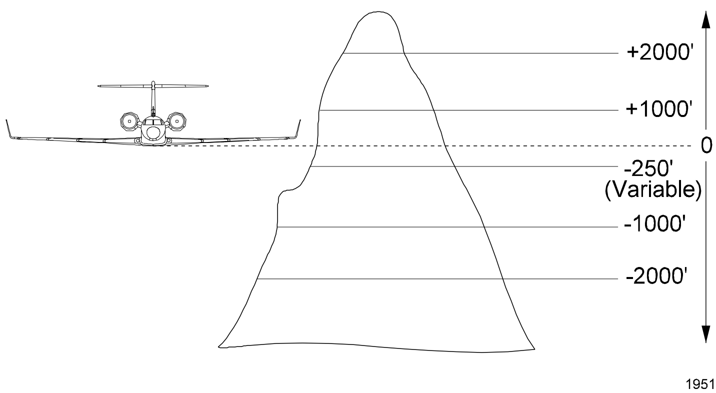
Windshear Alerting
Envelope - Mode 7
Figure 17



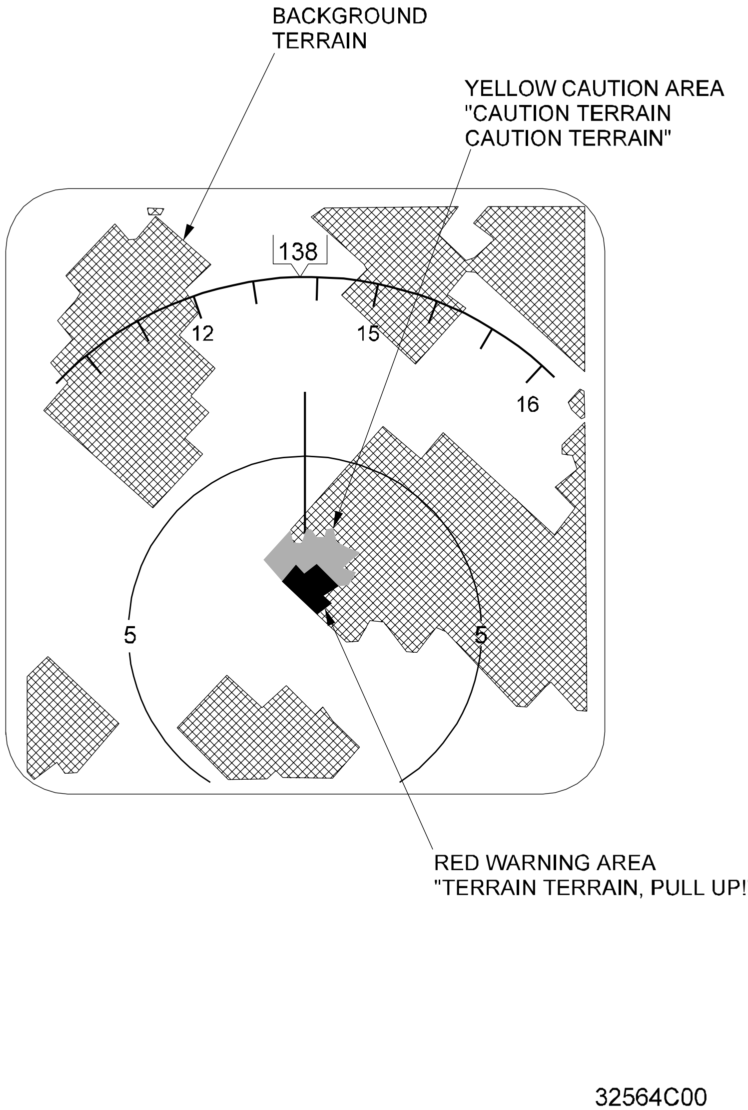
Terrain Clearance Floor Envelope
Figure 18



Forward Looking Terrain Alerting Areas
Figure 19



Terrain Awareness Display Altitudes
Figure 20



Terrain Awareness Display
Figure 21

2A-34-60: Traffic / Aircraft Alert and Collision Avoidance System (TCAS / ACAS)

1. General Description:

The Honeywell Traffic / Aircraft Alert and Collision Avoidance System (TCAS-2000 / ACAS) is production installed on GIV Serial Number (SN) 1390 and subsequent. Airplanes SN 1390 to 1433 were originally programmed with TCAS software version 6.04 and SN 1434 and subsequent with ACAS software version 7.0. Software version 7.0 is required for operation within European airspace. It is expected that all TCAS equipped airplanes will be equipped with version 7.0. This system description presumes the installation of software version 7.0.

TCAS/ACAS provides the flight crew with notifications of the presence of other transponder equipped traffic in the vicinity that may present a collision hazard. TCAS/ACAS can track up to fifty (50) airplanes simultaneously. The system provides aural alerts to the presence of traffic, visual plots on cockpit displays of the relative location of other airplanes, and aural and visual cues for evasive maneuvers if collision is imminent. If both converging airplanes are equipped with TCAS/ACAS and Mode S transponders, the systems mutually coordinate evasive maneuvers to ensure diverging flight paths.

The system functions as a low-powered airborne equivalent of the ground-based ATC system, interrogating and receiving replies from the transponders of other airplanes. Transponder replies are used to plot the position of traffic, and for traffic with Mode C and Mode S transponders, the altitude of the target is also determined.

TCAS / ACAS consists of the following subsystems / components as shown in the simplified block diagram in Figure 22:

- Two antennas, one on the top and one on the bottom of the airplane, each located on airplane centerline forward of the main cabin door.
- System computer
- Cockpit displays
- Radio Tuning Unit (RTU) and Mode S ATC Transponder

The directional antennas interrogate and receive the transponder signals of other airplanes and also continuously transmit a high speed data code (squitter) to TCAS / ACAS equipped airplanes. Transponder responses from other airplanes are processed in the TCAS / ACAS computer to determine relative closure vectors for traffic within the defined alerting envelope. The alerting envelope has altitude limit values that may be modified with selections made on the RTU.

The TCAS / ACAS computer communicates traffic information to the Display Controllers (DCs) and Symbol Generators (SGs) for subsequent display on the cockpit EFIS units. The TCAS / ACAS display is automatically selected to the NAV display on airplane power up. The flight crew may deselect the TCAS / ACAS display by using the Line Select Keys (LSKs) on the MAP menu of the DCs. The TCAS / ACAS traffic display may also be shown on the CAS screen (DU #4) by selecting TCAS / ACAS on the SYSTEMS menu on either DC. The TCAS / ACAS traffic display will automatically “pop up” on DU #4 whenever conflicting traffic penetrates the TCAS / ACAS alert envelope. Although the system tracks up to fifty (50) airplanes, only fifteen (15) airplane targets may be displayed at one time due to the limitations of the SGs.

The TCAS / ACAS computer has an internal synthetic voice component that annunciates the presence of traffic over cockpit speakers and interphone. If the computer determines that an airplane presents an imminent collision hazard, the synthetic voice directs the flight crew to make changes in the vertical speed of the airplane to avoid the conflict. Any evasive maneuver directed by the TCAS / ACAS computer is shown on the Primary Flight Display (PFD) in a cue format that guides the flight crew to a safe separation distance.

NOTE:

TCAS / ACAS displays and alert messages are tools to increase flight crew situational awareness. Other tools include windshear and other EGPWS alerts. Displays and annunciations are prioritized so that any Windshear alert will override a EGPWS or TCAS / ACAS alert, and any EGPWS alert will override a TCAS / ACAS alert. In instances where TCAS / ACAS alerts are overridden, only Traffic Advisories are displayed and aural messages are temporarily inhibited.

2. Subsystems, Units and Components:

A. TCAS / ACAS Antennas:

Two antennas (upper and lower) antennas are installed. The antennas (shown in Figure 27) are directional receivers and omni-directional transmitters operating in the L-Band of the radio spectrum. A signal strength algorithm in the computer determines which antenna is used for best system operation. Using the directional features of the antennas and the elapsed time between interrogation and reply, the system computer determines bearing and distance to the other airplane transponder. If the received transponder signal is from an airplane with Mode C or Mode S, the altitude encoded in the signal is used to locate the airplane in three dimensions. Since TCAS / ACAS transmits and receives on the same frequency as the ATC system, a pulse suppression circuit is incorporated to prevent the TCAS / ACAS antennas from transmitting simultaneously with the onboard transponder.

B. TCAS / ACAS Computer:

The TCAS / ACAS computer is installed in the right radio rack, and is powered by ϕC of the Left Main 115V AC bus. The computer uses transponder replies received from other airplanes to monitor flight path tracks and determine potential conflicts. Conflicts are detected by comparing airplane range versus range closure rate and airplane altitude versus altitude closure rate. TCAS / ACAS can exchange data with other airplanes having Mode S transponders at a range of forty nautical miles (40 NM) and can detect (but not communicate with) Mode S airplane targets up to one hundred twenty miles (120 NM). For airplane targets with Mode A or Mode C transponders, the range is twenty nautical miles (20 NM).

A TCAS / ACAS alerting envelope is formulated based upon the amount of time available to the flight crew for evasive maneuvers at computed closure rates. The alerting envelope is a three-dimensional space surrounding the airplane that varies in size and sensitivity with altitude. Sensitivity levels determine the alarm time, size of the protected area and the vertical threshold for alerts. At higher altitudes the sensitivity level is expanded to provide a larger protected area since traffic density is lower (and travelling at higher speeds). A protected area is defined by closure rate to a Closest Point of Approach (CPA). The protected area is expanded at close range to compensate for low closure rates, for example when two airplanes are on similar flight tracks at similar speeds, but the tracks differ sufficiently for the airplane tracks to converge at some point at a low closure rate. The vertical threshold of the protected area is expanded slightly at higher altitudes corresponding with higher sensitivity levels. TCAS / ACAS software version 7.0 is compliant with RVSM (Reduced Vertical Separation Minimums), therefore the envelope size is predicated on vertical separations of 1,000 feet below FL 420 and vertical separation of 2,000 feet above FL 420. For more specific information, consult the Honeywell Traffic Alert and Collision Avoidance System (TCAS) Pilot's Guide, publication number C28-3841-005-00, dated September 1999 (or later approved revision).

If TCAS / ACAS determines that another airplane's track will close within the defined caution envelope, a Traffic Advisory in the format of an aural message of “TRAFFIC, TRAFFIC” is annunciated over cockpit speakers and interphones. Concurrently with the aural alert, the TCAS / ACAS display will automatically “pop up” on DU #4 (the systems CAS display) with conflicting traffic represented as a solid amber circle on the TCAS / ACAS display. If traffic continues to close to within the warning envelope, the traffic is displayed as a solid red square on the TCAS / ACAS display accompanied by an aural message instructing the flight crew to take evasive action. Visual cues are presented on the Primary Flight Display (PFD) directing a change or restriction in vertical speed to avoid collision. The aural instructions and PFD cues are termed Resolution Alerts (RAs). After completion of the avoidance maneuver and traffic separation distances increase beyond the alerting envelope, an aural message “CLEAR OF TRAFFIC” is sounded, signalling the flight crew that they may return to the previously assigned flight parameters. Traffic Advisories and Resolution Alerts with accompanying display characteristics are discussed in the Cockpit Displays and Aural Messages section below.

WARNING

DO NOT RELY SOLELY ON TCAS / ACAS OR AIR TRAFFIC CONTROL FOR COLLISION AVOIDANCE:

- **TCAS / ACAS CANNOT DETECT AIRPLANES WITH INOPERATIVE OR NON-ICAO COMPLIANT TRANSPONDERS**
- **TCAS / ACAS REQUIRES A VALID ON-BOARD MODE S TRANSPONDER, A VALID BAROMETRIC ALTIMETER SOURCE AND A VALID RADIO ALTIMETER SOURCE**
- **TCAS / ACAS CAN PROVIDE RESOLUTION ALERTS ONLY FOR AIRPLANES WITH OPERATING ICAO COMPLIANT TRANSPONDERS WITH ALTITUDE REPORTING FUNCTIONS**
- **FOR AIRPLANES WITH ICAO TRANSPONDERS**

WITHOUT ALTITUDE REPORTING FUNCTIONS, TCAS / ACAS CAN ONLY PROVIDE TRAFFIC ADVISORIES

WARNING

TCAS / ACAS MAY NOT ALWAYS INHIBIT RESOLUTION ALERT MANEUVER COMMANDS IN FLIGHT REGIMES THAT MAY SIGNIFICANTLY REDUCE STALL MARGINS. EXAMPLES ARE:

- **BANK ANGLES EXCEEDING 15°**
- **ENGINE OUT (CREW SHOULD SELECT TRAFFIC ADVISORIES ONLY ON DISPLAYS)**
- **ABNORMAL CONFIGURATIONS - SUCH AS GEAR UN-RETRACTED WHICH WOULD LIMIT AIRPLANE PERFORMANCE**
- **OPERATION AT TEMPERATURES BEYOND ISA STANDARDS - ± 27.8°C (50°F)**
- **SPEEDS BELOW NORMAL OPERATING SPEEDS**
- **AT BUFFET MARGINS LESS THAN 0.3 “G”**
- **DURING A TCAS / ACAS TO TCAS / ACAS SENSE REVERSAL**

C. Cockpit Displays and Aural Messages:

The TCAS / ACAS display on Display Unit (DU) #4 (CAS) is a map view with a range of five (5) miles. At the center of the display is an airplane icon surrounded by a ring of twelve (12) dots at a range of two (2) miles. The dots represent clock positions and are shown as an aid in sighting detected traffic. See the illustration in Figure 23.

When selected to the cockpit NAV displays, TCAS / ACAS is in MAP mode and the range may by adjusted with the weather radar range controls on the DCs. A typical display is shown in Figure 24. If TCAS / ACAS is tracking a target that is outside of the selected display range, the target will be shown at the perimeter of the display with only half (½) of the appropriate symbol visible. Although the maximum traffic detection range for TCAS / ACAS is 120 NM in front of the airplane and 15 NM behind the airplane, a smaller range setting offers better traffic discrimination in high density airspace.

TCAS / ACAS symbology is the same on both the DU #4 and NAV displays. Traffic is represented in different icon shapes and colors corresponding to the potential threat of collision:

- ■ - a red square represents a Resolution Alert (RA) for conflicting traffic that poses a collision danger within 15 to 35 seconds
- ● - an amber circle represents a Traffic Alert (TA) for conflicting traffic that poses a collision danger within 20 to 48 seconds
- ◆ - a cyan (blue) diamond represents proximate traffic that is within ± 1200 feet of airplane altitude, but whose projected track does not pose a collision danger

- ◇ - a hollow cyan diamond represents other traffic more than ± 1200 feet from airplane altitude that does not hazard the airplane

When the detected traffic is equipped with a functioning Mode C or Mode S transponder, a two digit display of the altitude of the traffic in hundreds (100's) of feet accompanies the symbol. If the traffic is above airplane altitude, the two digits are shown above the symbol and preceded by a plus (+) sign, and if the traffic is below the airplane the digits are placed below the symbol and preceded by a minus (−) sign. For example, ◆$^{+13}$ represents proximate traffic 1300 feet above the airplane, while ◆$_{-08}$symbolizes proximate traffic 800 feet below the airplane. If the detected traffic is climbing or descending more than 500 feet per minute (FPM), an arrow is placed to the right of the symbol pointing in the direction of altitude change. Examples are ◆↓$^{+13}$ and ◆↑$_{-08}$.

If TCAS / ACAS is unable to determine the bearing of a target, the appropriate color coded symbol will be shown at the lower center of the display with altitude information if available. Failure to determine target bearing is most likely due to high bank angles masking antenna functions. Bearing information is usually available as soon as bank angle is moderated.

The flight crew may choose to have the traffic altitude displayed in absolute altitude rather than as a relative altitude difference from the airplane. If absolute altitude is selected, the traffic symbol is accompanied by the altitude readout reported by the ATC transponder. Absolute altitude reverts to relative altitude after 10 seconds.

The altitude range for TCAS / ACAS traffic surveillance is normally limited to ±2700 feet of airplane altitude (NORM on the RTU TCAS / ACAS control page). The altitude envelope may be expanded above and below the normal range with selections on the RTU. If ABOVE is selected, the envelope is set between −2700 feet and +7000 feet. If BELOW is selected, the envelope is set between +2700 feet and −7000 feet.

If the closest point of approach of any traffic is near enough to generate a RA, avoidance maneuver cues will automatically be displayed on both PFDs accompanied by aural instructions. An RA as presented on the PFD is shown in Figure 25. The Flight Director command bars are removed from view and the PFD will display climb or descent rates to avoid in the format of a red outlined trapezoid above, below or above and below the airplane symbol on the PFDs. The trapezoid enclosed areas represent vertical speeds that lead to a potential collision. A fly-to target in the form of a rectangular box outlined in green is displayed representing the desired airplane vertical speed for collision avoidance. The airplane should be maneuvered so that the airplane symbol on the PFD is within the green fly-to box. A RA that does not require modification of present vertical speed is termed a “preventative” RA, and in this case a green fly-to box is not shown, only the red vertical speed avoidance cues are presented.

The airplane symbol on the PFD is normally yellow, however during a RA display, the airplane symbol will be red if the airplane is flown in the vertical speed area(s) outlined in the red trapezoid(s), and colored green if the airplane is flown within the vertical speeds defined by the green fly-to box.

The RA vertical speed commands are programmed to be within the airplane performance capability and should usually only require altitude changes of 300 to 500 feet and loads of ¼ ″G″ or less.

The display of RA guidance on the PFD and the MAP mode depiction of RA traffic on the NAV / CAS displays are accompanied with aural commands to emphasize the evasive maneuver. The TCAS / ACAS aural commands are tabulated below:

Aural Command	Meaning
“MONITOR VERTICAL SPEED - MONITOR VERTICAL SPEED”	Keep vertical speed outside of the ranges defined by the red trapezoid(s) on the PFD.
“CLIMB - CLIMB”	Promptly establish a rate of climb of 1500 FPM or more.
“CLIMB, CROSSING CLIMB - CLIMB, CROSSING CLIMB”	Promptly establish a rate of climb of 1500 FPM or more for a climb that will cross the flight path of conflicting traffic.
“DESCEND - DESCEND”	Promptly establish a rate of descent of 1500 FPM or more.
“DESCEND, CROSSING DESCEND - DESCEND, CROSSING DESCEND”	Promptly establish a rate of descent of 1500 FPM or more for a descent that will cross the flight path of conflicting traffic.
“REDUCE DESCENT - REDUCE DESCENT”	Promptly reduce descent rate to match the rate shown in the green outlined rectangle on the PFD.
“REDUCE CLIMB - REDUCE CLIMB”	Promptly reduce climb rate to match the rate shown in the green outlined rectangle on the PFD.
“CLIMB, CLIMB NOW - CLIMB, CLIMB NOW”	(Following a DESCEND advisory when circumstances require a reversal of direction.) Promptly establish a rate of climb of 1500 FPM or more.
“DESCEND, DESCEND NOW - DESCEND, DESCEND NOW”	(Following a CLIMB advisory when circumstances require a reversal of direction.) Promptly establish a rate of descent of 1500 FPM or more.
“INCREASE CLIMB - INCREASE CLIMB”	Promptly increase rate of climb to 2500 FPM or more.
“INCREASE DESCENT - INCREASE DESCENT”	Promptly increase rate of descent to 2500 FPM or more.
“ADJUST VERTICAL SPEED, ADJUST”	Adjust vertical speed to the range displayed on the PFD.
“MAINTAIN VERTICAL SPEED, MAINTAIN”	Maintain current climb or descent rate as shown on PFD to ensure traffic separation.
“MAINTAIN VERTICAL SPEED, CROSSING MAINTAIN”	Maintain current climb or descent rate as shown on PFD to ensure traffic separation - maneuver requires crossing flight path of conflicting traffic.
“CLEAR OF CONFLICT”	Promptly return to and / or maintain last assigned flight profile.

NOTE:

TCAS / ACAS visual and aural alerts are restricted in certain areas of the airplane operating envelope:

- No CLIMB commands are issued when the airplane cannot maintain a climb rate of 1,500

FPM.

- No INCREASE CLIMB commands are issued when the airplane cannot achieve a climb rate of 2,500 FPM.
- No INCREASE DESCENT commands are issued at altitudes less than 1,450 feet AGL (radio altitude).
- No DESCEND commands are issued when climbing at altitudes less than 1,200 feet AGL or descending at less than 1,000 feet AGL (radio altitude).
- No Resolution Advisories are issued when climbing at altitudes less than 1,100 feet AGL or descending at less than 900 feet AGL (radio altitude).
- No Aural Traffic Advisories are issued at altitudes less than 500 feet AGL (radio altitude).
- No Visual Traffic Advisories are issued for traffic with a transponder altitude readout of less than 380 feet AGL.
- In high density traffic areas, TCAS / ACAS reduces transponder interrogation power in order to limit interference with the ATC system. As a result, some targets at the outer perimeter of system surveillance range will not be shown on cockpit displays.

D. Radio Tuning Unit (RTU) and Mode S ATC Transponder:

Two Collins RTU-4220 Radio Tuning Units (RTUs) are installed in the cockpit center console, one for each crew position. TCAS / ACAS selections are made by pressing the Line Select Key (LSK) adjacent to the TCAS / ACAS section of the main display page. Pressing the LSK twice will access the TCAS / ACAS sub-display. See Figure 26 for an illustration of the TCAS / ACAS sub-display on the RTU. On the sub-display page, menu items may be selected with LSK entries. Available options are:

- Mode selections for Traffic Advisories and Resolution Alerts (TA / RA), Traffic Advisories only (T / A) or Standby (STBY)
- Display of absolute altitude (ABS) or relative altitude (REL) for TCAS / ACAS targets with Mode C or Mode S transponders (the ABS reverts to REL after 10 seconds)
- TRAFFIC selection to display other traffic that is determined not to be a collision hazard
- Selection of envelope altitude parameters for monitoring TCAS / ACAS traffic. ABOVE sets the envelope from 2,700 feet below the airplane to 7,000 feet above, BELOW sets monitoring between 2,700 feet above to 7,000 feet below the airplane, and NORMAL sets the envelope between 2,700 feet above and 2,700 feet below the airplane.
- TEST will initiate an eight (8) second system self-test that may be accomplished in the air or on the ground. If the airplane is on the

ground and the TEST LSK is pushed and held in, a longer maintenance test will be initiated. Either the short or long test will also check the ATC transponder system.

Dual Collins TDR-94D Mode S transponders are installed in the nose of the airplane within the radome. Two transponder antennas are located on the bottom of the fuselage as shown in Figure 27. The transponders are controlled with LSK selections (on the ATC main display page) and the rotary knob on the RTU. Only one transponder is active at a time. LSK selections designate the active transponder and assigned ATC codes are entered with the rotary knob. An IDENT button on the upper right of the RTU is used to respond to identification requests from ATC. LSKs may also be used to turn off the altitude reporting feature of the transponder, and initiate a system test for both the transponders and TCAS / ACAS system from the RTU ATC main display page.

Annunciations presented on the ATC main display page include:

- RPLY shown in cyan (blue) when the transponder is replying to an interrogation signal
- XPDR FAIL shown in amber (yellow) when the selected active transponder has failed
- TYPE S is shown identifying that the transponder is compatible for TCAS / ACAS operation
- ID is displayed when the IDENT button has been pushed

3. Controls and Indications:

A. Circuit Breakers (CBs):

Circuit Breaker Name	CB Panel	Location	Power Source
TCAS	CP	D - 11	L MAIN 115V AC ϕC
XPNDR #1	CP	H - 11	EMER 28V DC 1A
XPNDR #2	CP	I - 11	R MAIN 28V DC

B. Advisory (Blue) CAS Messages:

CAS Message	Cause or Meaning
TCAS FAIL	TCAS / ACAS system has failed

C. TCAS / ACAS Self-Test:

Prior to initiating the eight (8) second self-test, turn on all displays with the NAV displays in MAP mode, select TA ONLY or TA / RA on the TCAS main page of the RTU display, select TCAS on the systems display of DU #4 (CAS) and select ATC transponder #1 altitude reporting ON with the transponder in standby.

Press the ATC 1 transponder TEST button until the aural annunciation “TCAS TEST” is heard. The following indications are shown on the NAV and / or CAS displays:

- A solid blue diamond ◆↓ (proximate traffic) positioned at one o’clock with an arrow pointing down and a relative altitude below the symbol of -10 (indicates 1,000 feet below TCAS / ACAS test airplane)
- A hollow blue diamond ◇ (other traffic) positioned at eleven o’clock

with no arrow and a relative altitude above the symbol of +10 (indicates 1,000 feet above TCAS / ACAS test airplane)

- A solid red square ■ (RA) at three o'clock with no arrow and a relative altitude above the symbol of +02 (indicates 200 feet above TCAS / ACAS test airplane)
- A solid amber circle ● (TA) positioned at nine o'clock with an upward pointing arrow and a relative altitude of - 02 (indicates 200 feet below TCAS / ACAS test airplane)
- TCAS FAIL message shown in blue on the CAS display for the duration of the test
- After eight seconds, an aural annunciation of "TCAS TEST PASS" or "TCAS TEST FAIL"

NOTE:

ATC transponder #2 may be used for the self-test if transponder #1 is turned OFF.

CAUTION

ACTIVATING THE SELF-TEST WHILE AIRBORNE WILL BLOCK ALL TRAFFIC INFORMATION DISPLAY AND ANNUNCIATIONS FOR THE EIGHT SECOND DURATION OF THE TEST.

4. Limitations:

A. Flight Manual Limitations:

(1) **Pilot's Manuals:**

The Honeywell Traffic Alert and Collision Avoidance System (TCAS) Pilot's Guide, publication number C28-3841-005-00, dated September 1999 (or later approved revision) shall be immediately available to the pilots. The Honeywell SPZ-8400 Digital Automatic Flight Control System Pilot's Manual for the Gulfstream IV, publication number A28-1146-097-02, Revision 2, dated October 1999 (or later approved revision) shall be immediately available to the pilots. This applies to airplanes SN 1390 and subsequent.

(2) **TCAS Operating Constraints:**

With 6.04A software installed, all Resolution Advisory (RA) and Traffic Advisory (TA) aural messages are inhibited at a radio altitude less than 1,100 feet climbing and 900 feet descending.

With 7.0 software installed (SN 1434 and subsequent), all RA and TA aural messages are inhibited at a radio altitude less than 500 feet ±100 feet.

(3) **Clearance:**

The pilot is authorized to deviate from ATC to the extent necessary to comply with a Resolution Advisory (RA).

(4) **Traffic Advisories:**

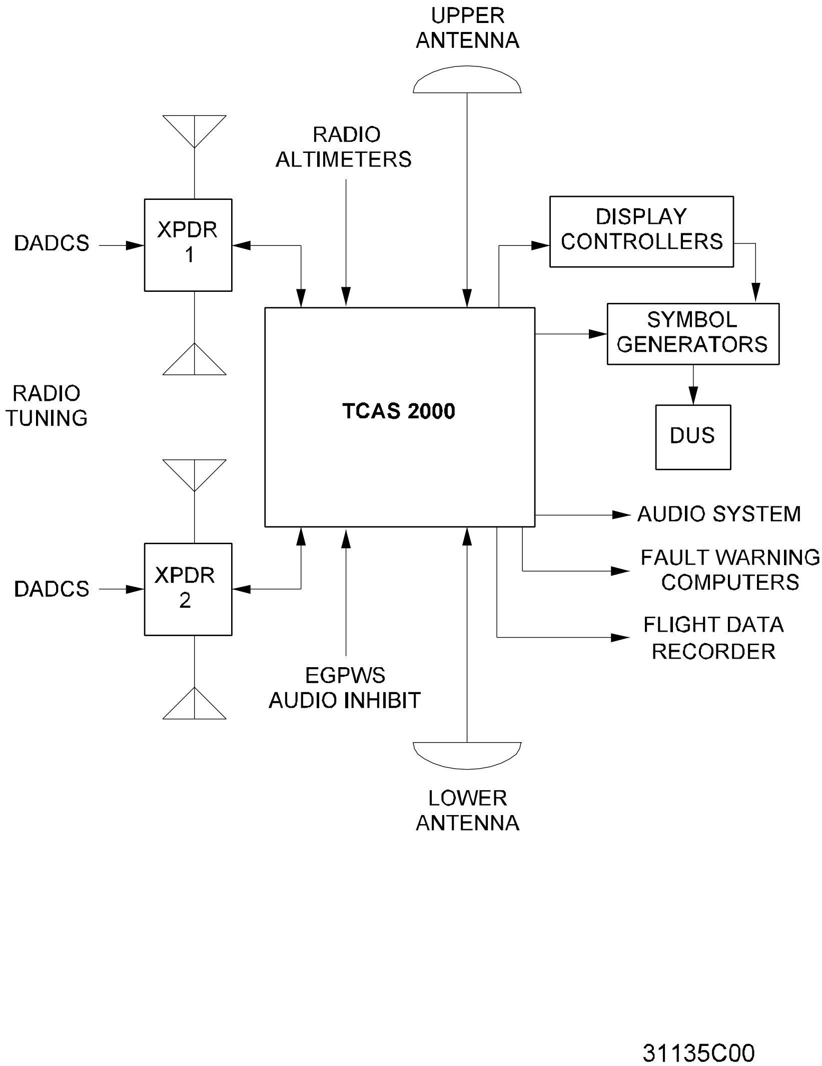
The pilot must not initiate evasive maneuvers based solely on information from a Traffic Advisory (TA). Traffic Advisory information should be used only as an aid to visual acquisition of traffic.

(5) **Resolution Advisories:**

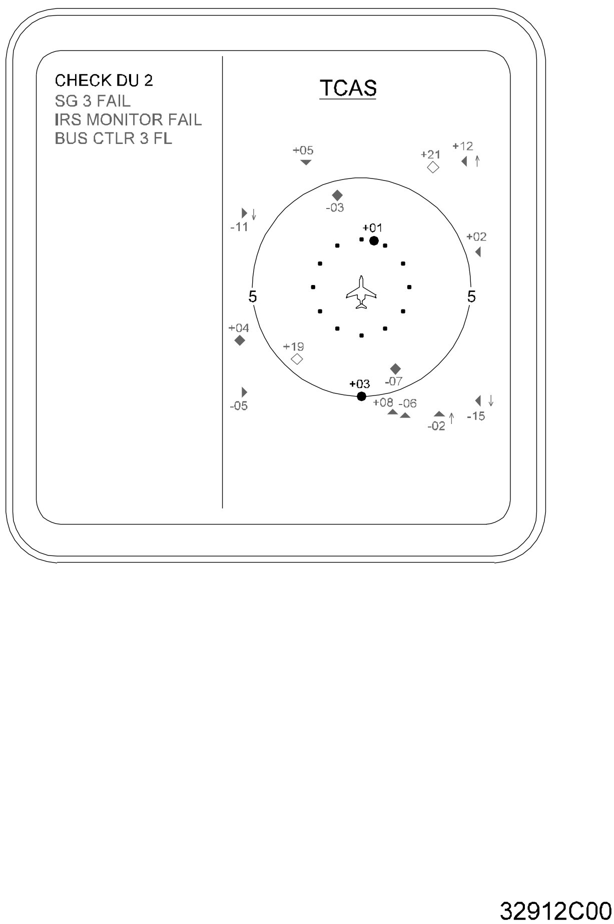
Compliance with TCAS Resolution Advisories (RA) is required unless the pilot considers it unsafe to do so. Maneuvers which are in the opposite direction of an RA are extremely hazardous and are prohibited unless it is visually determined to be the only means to assure safe separation.

(6) **Clear Of Conflict:**

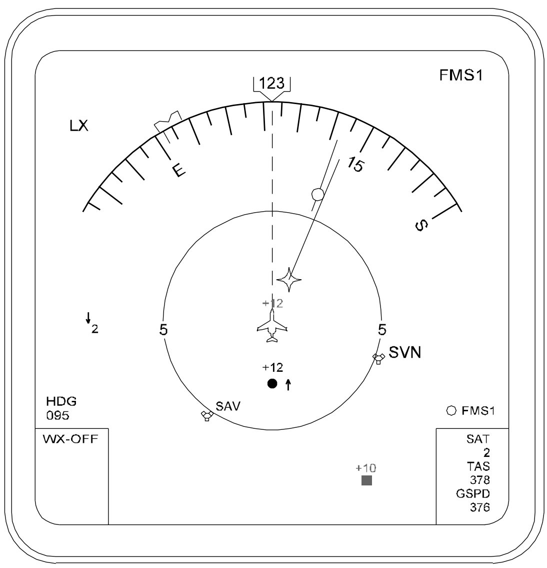
Prompt return to the ATC cleared altitude must be accomplished when “CLEAR OF CONFLICT” is announced.



TCAS / ACAS System Simplified Block Diagram
Figure 22

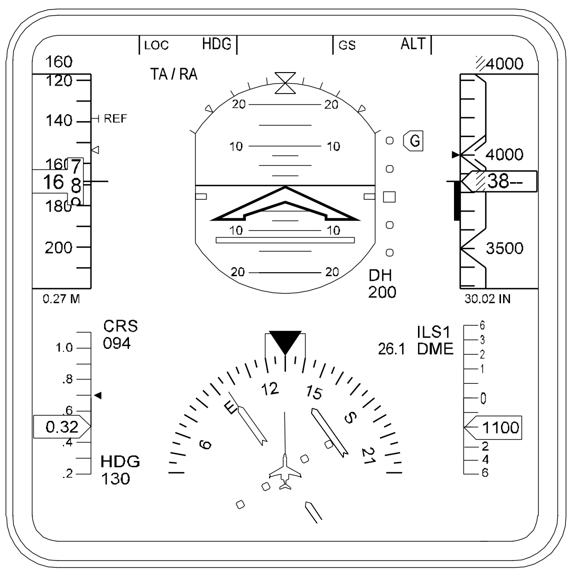


TCAS / ACAS Display on DU #4
Figure 23



32911C00

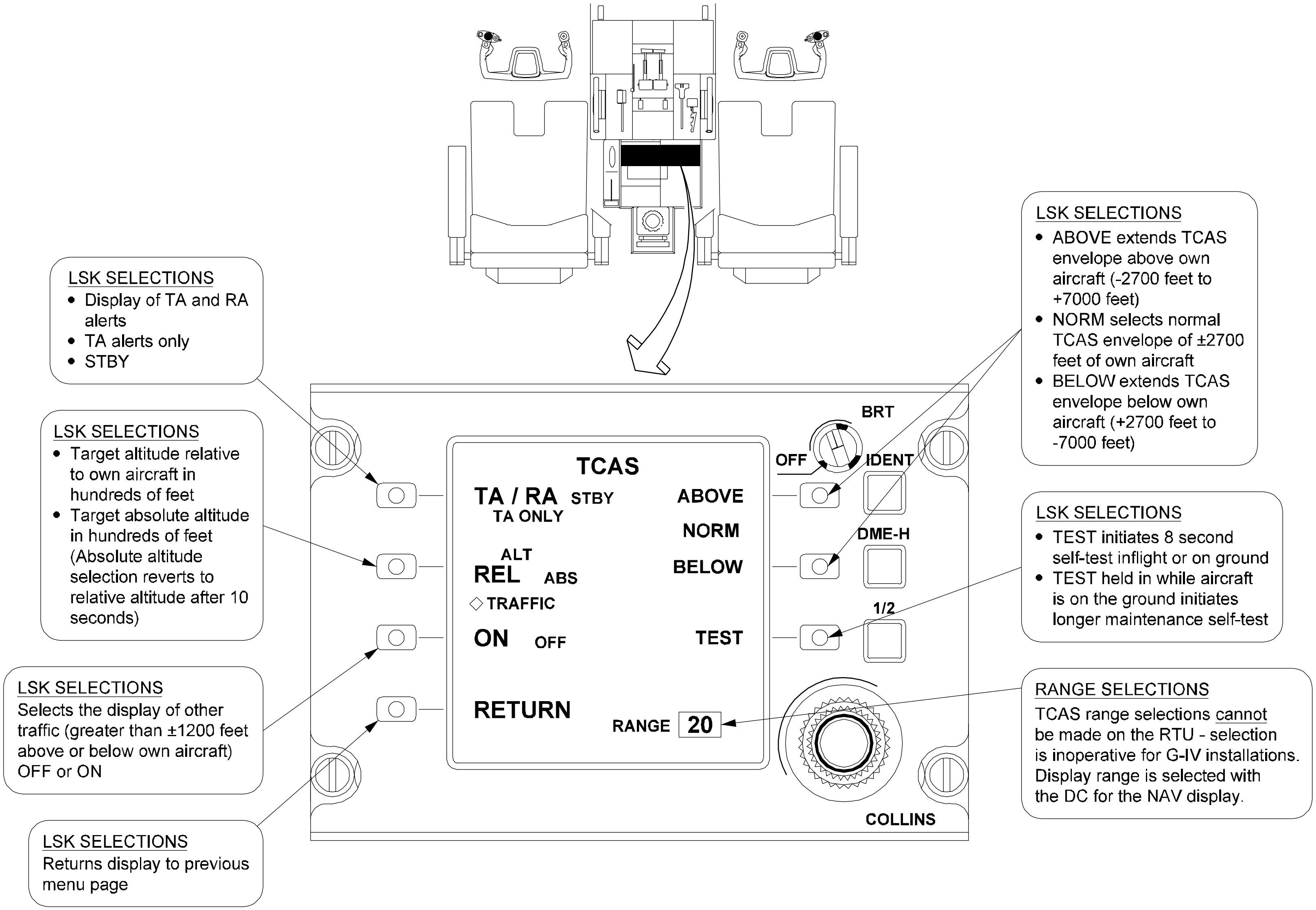
TCAS / ACAS Display in MAP Mode
Figure 24



32910C00

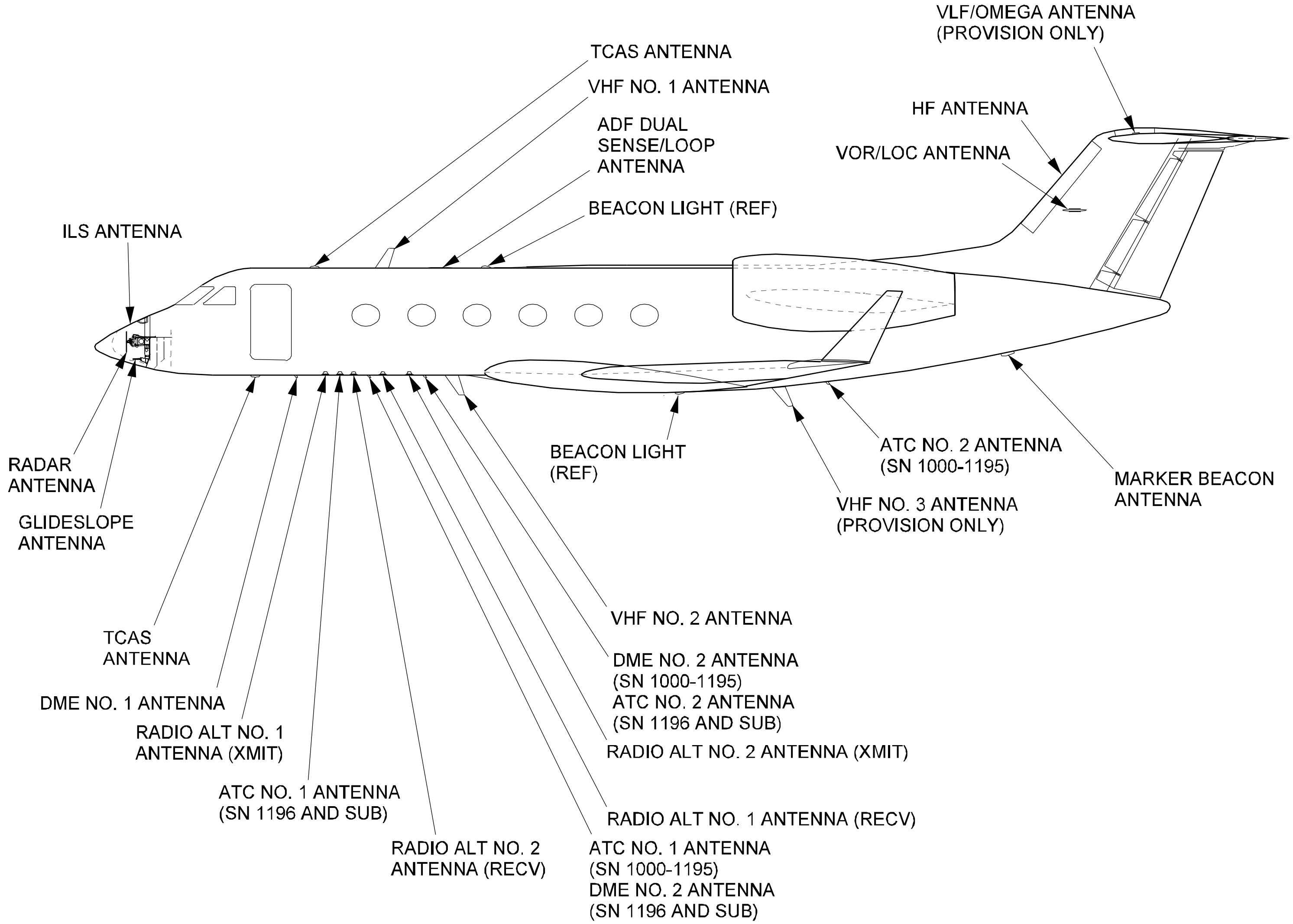
TCAS / ACAS RA Display on the PFD
Figure 25

THIS PAGE IS INTENTIONALLY LEFT BLANK.



31136C00

Radio Tuning Unit (RTU)
Figure 26



TCAS / ACAS
Transponder Antenna
Locations
Figure 27