1. GENERAL.

The Engine Indicating and Crew Alerting System (EICAS) provides:

- Engine Indications
- Aircraft systems indications
- Aural and visual warnings and cautions
- Engine and a/c system data to the Maintenance Diagnostic Computer (MDC) for calculating engine exceedances, a/c systems exceedances and engine/APU trends
- Stall warning functions (see chapter 17/5)
- Data acquisition for the flight data recorder.

2. SYSTEM DESCRIPTION.

The EICAS includes:

- Two Data Concentrator Units
- Two EICAS displays
- One EICAS Control Panel
- One EICAS Brightness control
- One Lamp Driver Unit
- Two Annunciator Power Supplies for the annunciator lights.

Data Concentrator Units, DCU.

The DCU is the interface between the EICAS and the different aircraft systems. There are two DCUs installed in the avionic rack, both providing identical functions for redundancy purposes.

The DCUs receive analog signals, discrete signals, and digital bus data from the engines and the aircraft systems.The DCU provides conversion and concentration of engine and aircraft system data for the EICAS displays. The DCU also provides the logic for the crew alerting messages and the visual and aural annunciations. The data are sent through the ARINC-busses to the following equipment:

- Lamp Driver Unit (LDU)
- EICAS displays
- The other DCU
- Solid State Digital Flight Data Recorder (SSFDR)
- Integrated Avionics Processor System (IAPS)
- Maintenance Diagnostic System (MDS).

EICAS displays.

The EICAS displays are 7.25 by 7.25 inch color CRTs and are installed in the center of the instrument panel.

Each CRT is provided with a BRT knob for individual EICAS display brightness. A main display intensity control is also provided on the glareshield panel. The displays are supplied with cool air from a brushless DC fan under each display. The fan function is not monitored but the display temperature is, and if the temperature exceeds 110°C a "DISPLAY TEMP" message is displayed. If the temperature continues to increase the display automatically shuts down at 115°C.

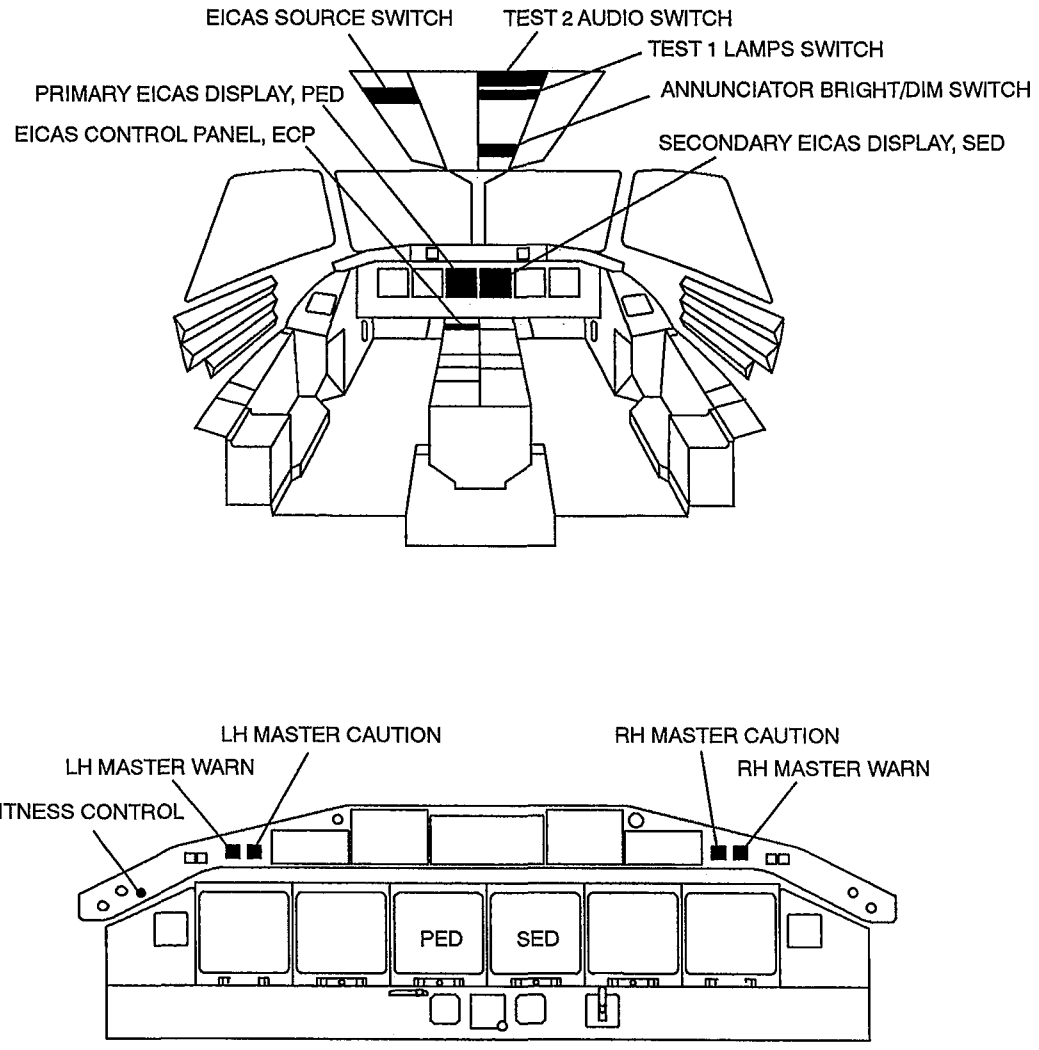


FIG.1. EICAS controls.

Warnings/Cautions.

Master Warnings and Master Cautions are indicated by lights (illuminated pushbuttons) on the glareshield panel and by messages (CAS) on the Primary EICAS Display, PED. Lamps will also illuminate in the associated pushbuttons to the failing system (when applicable).

A Warning condition requiring immediate action is indicated by:

- the red Master Warning lights flashing
- an aural triple chime sounding
- a red warning message on the PED.

A Caution condition not requiring immediate action is indicated by:

- the amber Master Caution lights flashing.
- an aural single chime sounding
- an amber caution message on the PED
- illuminating pushbutton of the failing system (when applicable).

The aural alerts and the Master Warning/Master Caution lights can normally be reset by pressing the MASTER WARNING or MASTER CAUTION pushbutton respectively. There are also a number of non-resetable audio alerts that can only be cancelled by removing the warning condition.

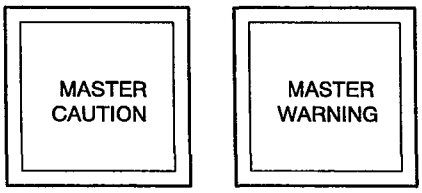


FIG.2 Master Warning and Master Caution illuminated pushbuttons.
B4729

The LH display is normally used as the Primary EICAS Display, PED and the RH display is normally used as the Secondary EICAS Display, SED.

The PED normally shows the primary, PRIM page that includes:

- Primary engine indications provided by the Full Authority Digital Engine Controls, FADEC's
- Crew Alerting System, CAS warnings and cautions
- Fuel information
- Trim indications
- Flap position
- Gear information
- Oil Pressure and Temp information.

The SED normally shows one of the following manually selected secondary EICAS data pages:

- Status, STAT page (default page during power up)
- Electrical, ELEC DC page
- Electrical, ELEC AC page
- Fuel, FUEL page
- Hydraulics, HYD page
- Air conditioning, AIR page
- Anti-ice, de-ice, ICE page
- Engine, ENG page
- Menu, MENU page
- Flight controls, FCS page.

The SED can also show the primary, PRIM page if selected.

If one of the EICAS displays is unserviceable, all EICAS information can still be accessed on the remaining EICAS display. In such case the remaining display automatically reverts to the condensed primary page. In this mode APU and Cabin Pressure information are added to the primary page but the various secondary pages can still be selected as before, however the display will automatically return to condensed PRIM page if any new red CAS message occurs. If both EICAS displays should fail, either of the Navigation Displays, ND can be switched manually to show the Primary or secondary EICAS pages.

MAINTENANCE CAUTION (amber) and MAINTENANCE STATUS (white).

Maintenance Caution (amber) ARE INDICATED on PED and Maintenance Status on SED (white):

- A **Maintenance Caution** (PED) will come on only above 10 000 ft and will remain on during the next takeoff as long as the fault remains. ("Old" Maintenance Caution is not inhibited during takeoff). If a maintenance Caution is stored below 10 000 ft it will be displayed either when climbing above 10 000 ft or after landing (40 KIAS).
- Maintenance Status (SED) is inhibited during flight but will come on after landing (40 KIAS).

MAINTENANCE DIAGNOSTIC SYSTEM (MDS).

- MDS is installed to give more information to maintenance and flight crew, to facilitate actions in case of failure.
- For aircraft with the optional enhanced MDS (Mod 5906) the failure information is displayed in plain language. "Maintenance Messages", in addition to the "FAULT BIT system".
- Maintenance Messages are available in flight above 10 000 ft if Mod 5915 is installed.
- For a/c without the enhanced MDS the Fault BIT system apply.

"Maintenance Messages" are triggered and stored by following:

- Warnings (aircraft system related failures only).
- Cautions (aircraft system related failures only).
- Maintenance Cautions (e.g. ENG MAINT).
- Maintenance Status.

NOTE
Other information like ENG TREND – ENGINE EXCEEDANCE – SYSTEM EXCEEDANCE – etc. are also stored but is not designated as "Maintenance messages".

- "Maintenance messages" is information **about failures** in the aircraft systems.
- "Maintenance Messages" can be selected on L/R ND above 10 000 ft and after landing at speed (<40 KIAS).
- To check if a message or exceedance has been stored the procedure calls for the TAKE OFF INH (OVHD) sw to be selected to OFF and check for a "MAINT INFO" on SED. This check can be performed during all phases of flight, however, what type of "Maintenance Message" that is stored can only be checked above 10 000 ft or after landing.
- **"MAINT INFO"** is reset after Maintenance Message or exceedance has been checked on ground.
- Two hundred (200) Maintenance Messages can be stored (50 per leg). If more than 200 the oldest will be kicked out and a new message will replace that one.
- The Maintenance Message comprises either one message or two messages. If the failure consists of a failure in a system which is the only system in the aircraft, there is just a "Failure Message". If the failure consists of a failure where different systems or components can create the same failure (e.g. L FADEC A or L FADEC B) there is also a "Source Message", which is normally indicated above the "Failure Message".
- A "Failure Message" starts with the ATA number.
- Each "Failure Message" is stored together with time (TIME), date (DT) and Flight Leg number (LEG).

NOTE
If a special "Source" has been used for a previous failure and another failure triggers the same "Source", that specific "Failure" will be indicated above the "Source".

MDS operation.

CAUTION
Although there is a possibility to use the system at altitudes well below 10 000 ft AGL, if high terrain elevation, the purpose of the 10 000 ft is to avoid possible increased pilot work load when operating at lower altitudes. The system should be used only at altitudes above 10 000 ft AGL. The system should never be used below 10 000 ft AGL after takeoff, and never during the approach or during landing phase of flight.

NOTE
Operational limitations of the MDS system, during flight, remains with national aviation regulation.

For more information about system operation, see QRH and MELPG.

ENGINE TREND – ENGINE EXCEEDENCE – SYSTEM EXCEEDENCES.

Engine Trend is automatically stored each flight; CRZ mode >18 000 ft – ENG A–I normal – AIR COND normal – and stabilized flight > 2 minutes. A manual engine trend shot can also be initiated by FDR p/b at any time. Engine Trend data is only available on ground.

Engine exceedance and **System exceedance** is automatically stored in case of triggering values are exceeded.

ENGINE MAINT page:

– Select T/O INHIBIT to OFF.
– Push ENG p/b twice. The first page is the Engine SED page and the second page coming up is the ENG MAINT page.

EICAS Control Panel.

The EICAS Control Panel, ECP is installed in the center pedestal.

The ECP provides the control for selecting the different pages on the EICAS displays. The control panel is a single channel microprocessor controlled unit.
The panel contains 16 momentary contact push buttons for selection of the different displays. Four push buttons have direct discrete outputs, PRIM, STAT, CAS and STEP, so that their function is retained in the event of power loss to the ECP.

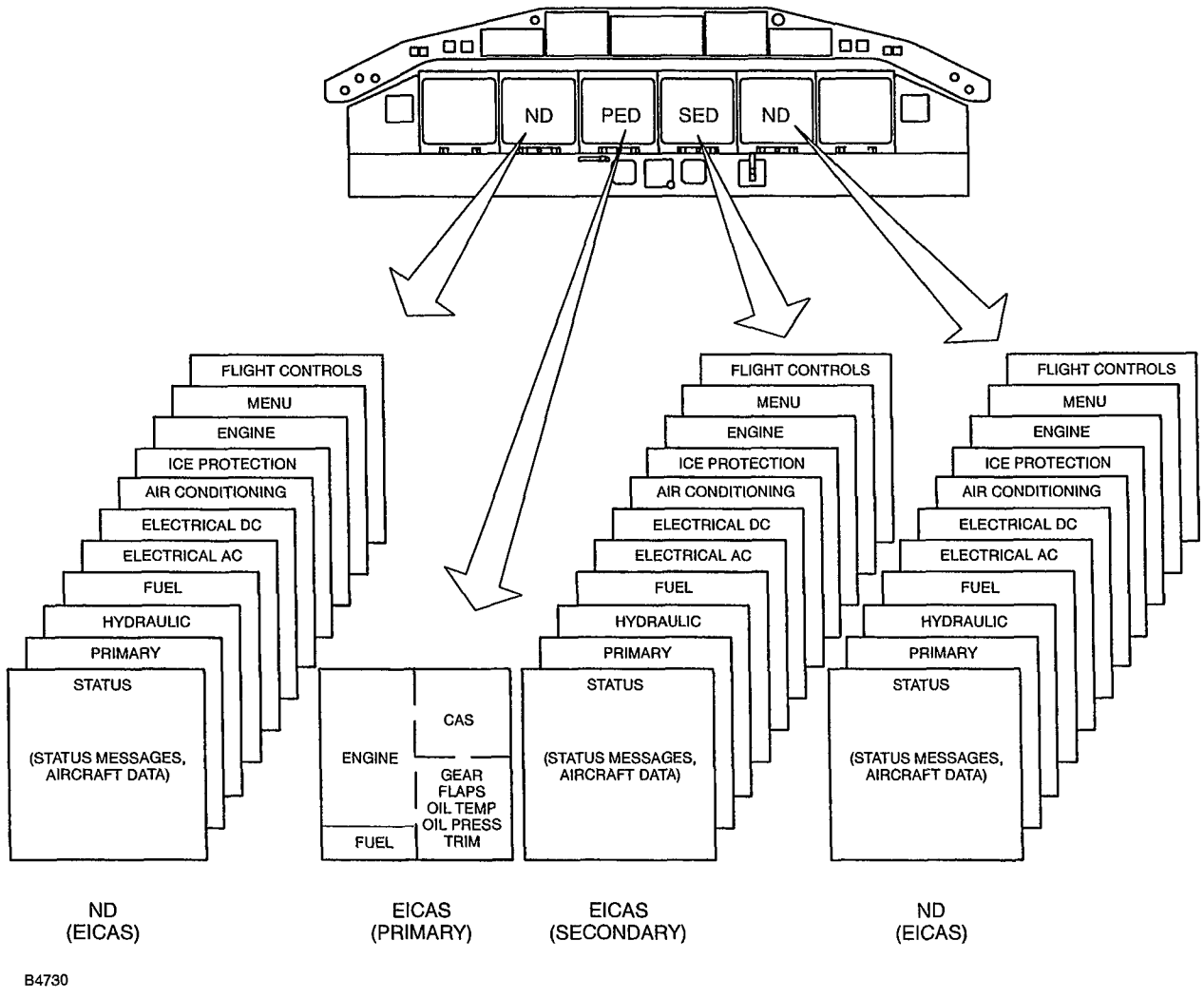
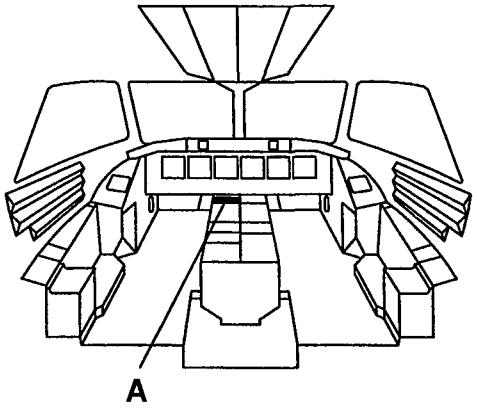
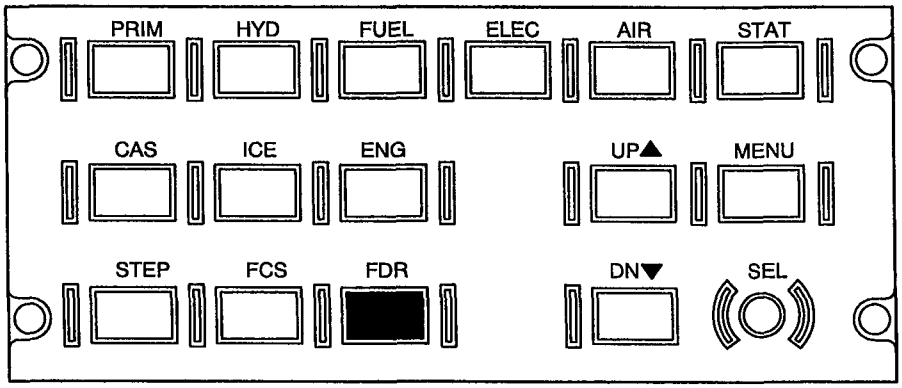


FIG.3. EICAS pages (condensed Primary page not shown).



A EICAS CONTROL PANEL, ECP



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PRIM button	– selects the primary page
STAT button	– selects the status page and can be used to page messages when having more messages than what can be displayed on one page
ENG button	– selects the engine page
ELEC button	– selects the electrical pages. The first push on the button selects the AC electrical and the second push selects the DC electrical page
HYD button	– selects the hydraulic page
FUEL button	– selects the fuel page
AIR button	– selects the air page
ICE button	– selects the ice page
FCS button	– selects the flight control system page
CAS button	– used for paging CAS messages when having more data than what can be displayed in the CAS window
STEP button	– used for paging of EICAS display pages
MENU button	– selects the menu page
UP and DN buttons	– used for moving the cursor up or down and changing the value of selected parameters on the MENU page.
SEL button	– selects the function the cursor is positioned at
FDR button	– creates an event mark on the Flight Data Recorder recording

FIG.4. EICAS control panel, ECP.

Audio Alerts.

The DCU provides the audio alert signals.

There are four levels of audio alerts:
- Specific warning tones
- General warning tones (triple chime)
- Specific caution tones
- General caution tones (single chime).

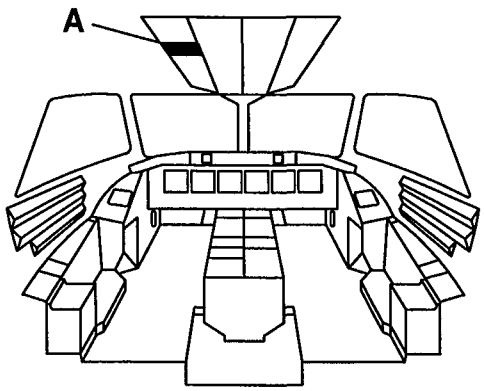
When more than one audio alert occurs at the same time, the alert with the highest priority is given first. When that alert stops, the next level alert is given.

When more than one alert is given within the same priority level, they are given in a preset order. A specific warning and a general warning can be given simultaneously. A general warning has priority over a specific caution and a general caution. A specific caution and a general caution can be given simultaneously.

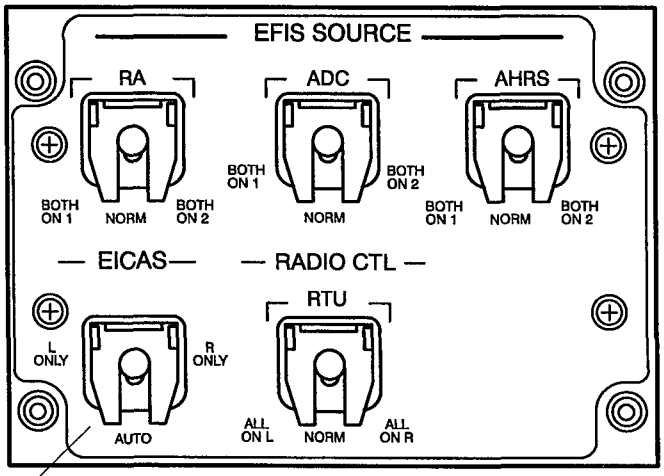
The Specific Audio Alerts.

Some warnings and cautions have their own specific audio alerts. These are listed below in priority order.

PRIORITY LEVEL	FUNCTION	AUDIO ALERT
WARNING	Stall warning	Continuous Clacker
WARNING	Autopilot disconnect	Cavalry charge
WARNING	Engine Fire warning	Fire bell
WARNING	Configuration alert	Intermittent horn
CAUTION	Altitude alert	C–chord
CAUTION	Overspeed	Continuous horn
CAUTION	SELCAL	Double chime



A EFIS SOURCE PANEL



EICAS L ONLY / AUTO / R ONLY switch

AUTO

If the primary EICAS display fails the secondary EICAS display will automatically change to display the condensed PRIM page.

L ONLY R ONLY

Used to select the single operation of the LH or the RH EICAS display if one of the displays should fail. When the switch is set to L ONLY or R ONLY the deselected display is powered down and the active display reverts to show the condensed PRIM page.

B4732

FIG.5. EICAS source switch.

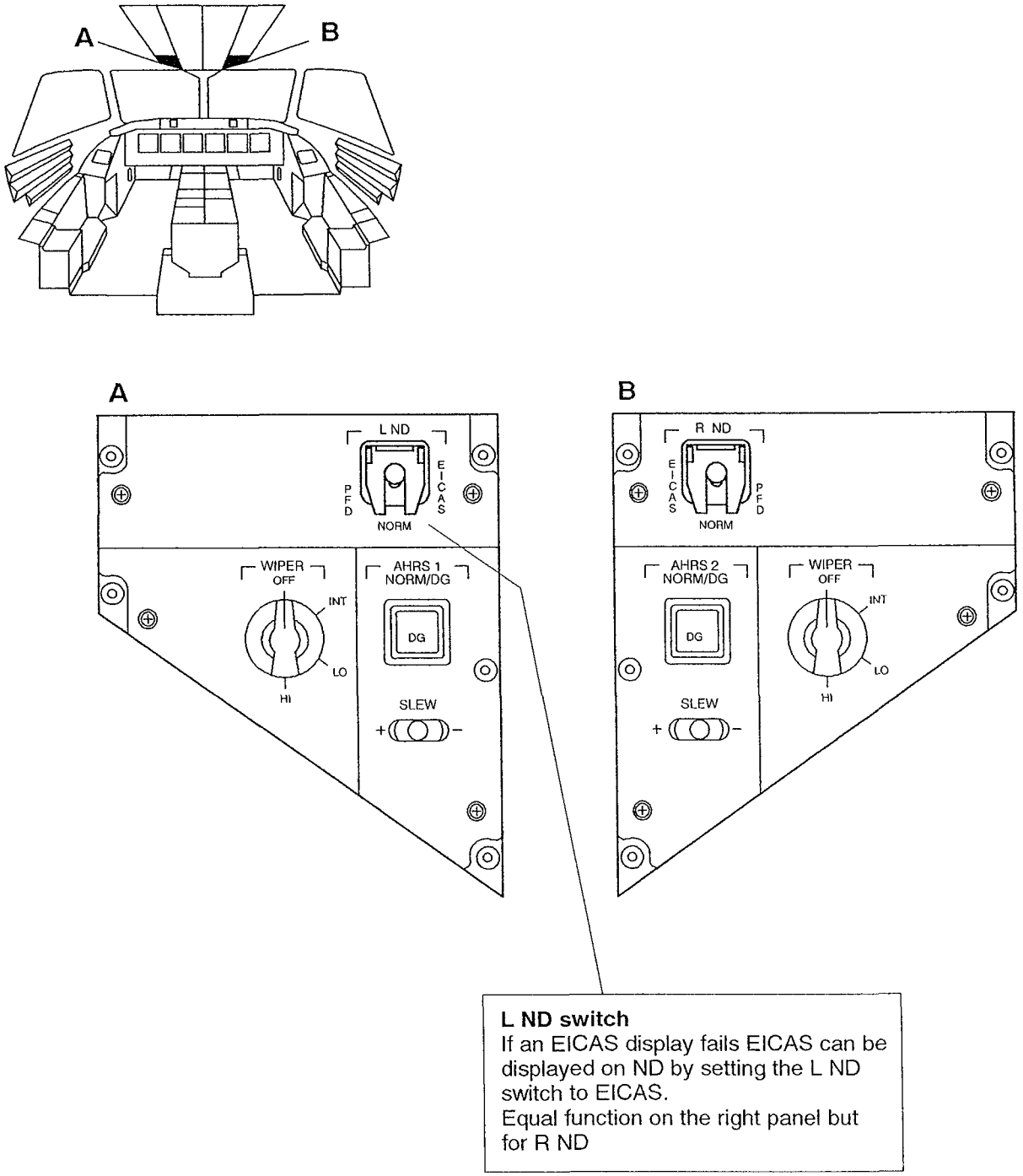
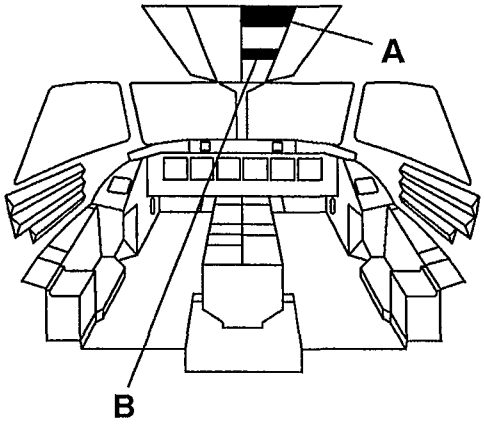
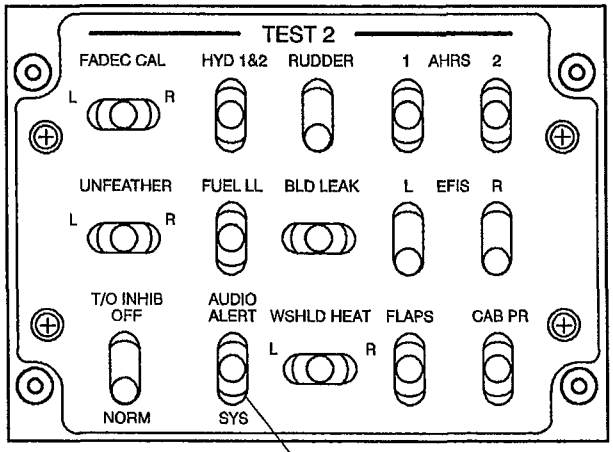


FIG 6 Reversionary switches.

Lamp Driver Unit.
The Lamp Driver Unit, LDU, receives logic signals from the DCUs. It uses these signals to provide discrete outputs to drive the illuminated annunciator-pushbuttons mainly located in the overhead panel. BRIGHT/DIM function is also provided. The annunciators contain two lamps which are tested with the LAMPS switch.



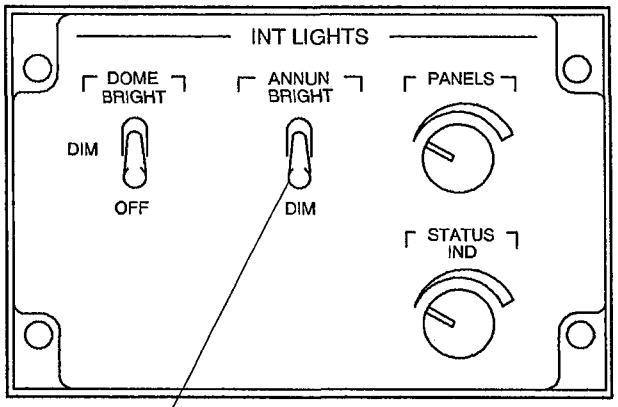
A TEST PANEL



AUDIO ALERT test switch

Performs test of all audio alert messages (maintenance only)

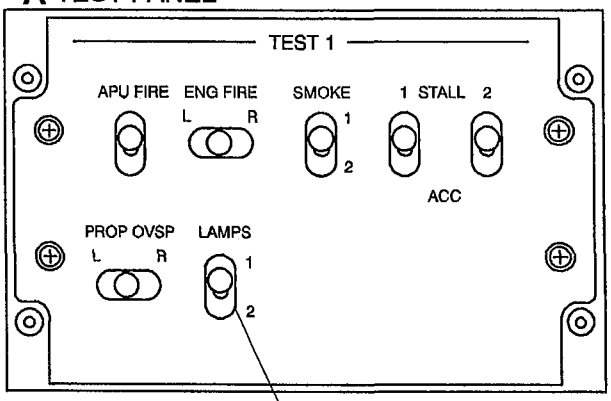
B



ANNUN

Annunciator BRIGHT DIM selection

A TEST PANEL



LAMPS tests switch

1 for testing the half part of the annunciator pushbutton lamps and 2 the other part.

B4733

FIG.7. Light intensity and test switches.

3. ELECTRICAL POWER SUPPLY.

			— EICAS —
L DCU standby power	L HOT BAT BUS	K–23	L DCU STBY
R DCU standby power	R HOT BAT BUS	S–23	R DCU STBY
PED and Cooling Fan	Main power supply by L BAT BUS via CB K–19 L SYS MAIN Standby power supply by R BAT BUS via CB S–18 L SYS STBY	K–20	PED
L DCU and Cooling Fan		K–21	L DCU
LDU channel A		K–22	LDU A
L Annunciator Power Supply		K–24	L ANNUN
ECP		G–23	ECP
SED and Cooling Fan	R BAT BUS	S–20	SED PWR
R DCU and Cooling Fan	R MAIN BUS	S–21	R DCU
R Annunciator Power Supply	R MAIN BUS	S–24	R ANNUN
LDU channel B	R MAIN BUS	S–22	LDU B
SED control	R MAIN BUS	S–19	SED CTL

1. GENERAL.

The Ground Proximity Warning System, GPWS, receives the following inputs:

– Radio Altitude ARINC bus from the radio altimeter systems 1 and 2. (System 2 optional.)

– Computed Airspeed, Barometric Altitude Rate, Uncorrected Baro Altitude, Corrected Baro Altitude ARINC bus from the air data system.

– Glideslope deviation, Localizer deviation ARINC bus from VOR/ILS/MB systems 1 and 2.

– A 28 V DC signal from the flap system when the flaps are in landing position.

– Selected course, Decision Height, FMS latitude and longitude, PFD Mode Select Word#1 from IAPS.

– A signal from the landing gear system when the landing gear is locked down.

– Magnetic Heading, Attitude Mode, Roll Angle, Pitch Angle, Body Normal Acceleration, Body Longitudinal Acceleration on a bus from the AHRS or IRS.

– A signal from the stall warning system when a stall warning is triggered is a customer option which may be required depending on national regulations.

– Signals from the optional Steep Approach system.

The GPWS computer processes these inputs and determines if any warning envelopes are being penetrated. If the aircraft deviates into a dangerous condition (warning envelope penetrated) visual and aural warnings are generated as shown in Table 1.

Mode	Visual warning	Aural warning
1 – Excessive sink rate	TERRAIN lights	– SINK RATE – WHOOP WHOOP PULL UP
2 – Excessive Terrain closure rate	TERRAIN lights	– TERRAIN TERRAIN – WHOOP WHOOP PULL UP
3 – Altitude loss after takeoff	TERRAIN lights	– DON'T SINK
4A– Terrain clearance (gear up)	TERRAIN lights	– TOO LOW TERRAIN – TOO LOW GEAR
4B– Terrain clearance (gear down, flaps up)	TERRAIN lights	– TOO LOW TERRAIN – TOO LOW FLAPS
4C– Minimum Terrain clearance during takeoff	TERRAIN lights	– TOO LOW TERRAIN
5 – Inadvertent descent below glideslope	BELOW G/S lights	– GLIDESLOPE or – GLIDESLOPE with increased level
6 – Descent below selected decision height	–	– MINIMUMS MINIMUMS – As options, various Altitude Callouts, MINIMUMS and BANK ANGLE BANK ANGLE

Table 1. Visual and Aural Warnings.

2. MAIN COMPONENTS AND SUBSYSTEMS.

2. 1. Visual Warnings.

The TERRAIN lights and the BELOW G/S lights are illuminated pushbuttons activated by the GPWS computer.

2. 2. Aural Warnings.

The aural warning messages are digitally synthesized and stored in the read only memories (ROM) in the GPWS computer. When a warning is generated, the information stored in the appropriate ROM is retrieved and converted to an audio signal. The audio signal is routed to the audio integrating system where it is amplified and supplied to both pilots' cockpit speakers and headsets.

If more than one mode warning envelope is penetrated at the same time requiring conflicting aural warnings, the warnings are generated according to the table below.

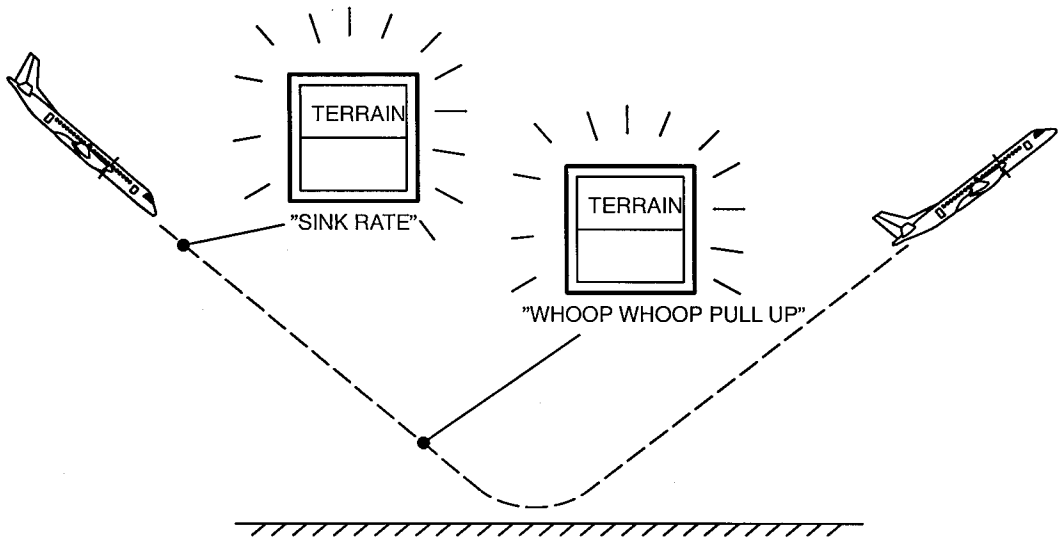
The highest priority message is always provided. If a higher priority warning occurs, the higher priority is immediately generated. When a warning ceases, the message is completed before switching to a warning of lower priority.

Priority	Message	Mode
1	WHOOP WHOOP PULL UP	1 and 2
2	TERRAIN TERRAIN	2
3	MINIMUMS MINIMUMS (as an option, MINIMUMS)	6
4	TOO LOW TERRAIN	4A, 4B and 4C
5	Altitude Callouts	6 (optional)
6	TOO LOW GEAR	4A
7	TOO LOW FLAPS	4B
8	SINK RATE	1
9	DON'T SINK	3
10	GLIDESLOPE	5
11	BANK ANGLE BANK ANGLE	6 (optional)

Table 2. Warning message priority.

MODE 1 EXCESSIVE SINK RATE

The mode 1 warning is generated if the aircraft vertical speed is excessive with respect to the height above terrain. The mode has two warning envelopes that provide warning of excessive rate of descent at a given altitude. On penetration of the outer envelope the TERRAIN lights come on flashing and the aural warning "SINK RATE" sounds and is repeated twice at 0.75 seconds interval. It will remain silent until a 20 % degradation in time to impact is computed then an additional two messages are given and the cycle repeats. However the lamps will be flashing all the time. If the descent rate is not corrected and the inner envelope is penetrated, a harder aural warning "WHOOP WHOOP PULL UP" sounds. The mode is independent of aircraft configuration.



B4754

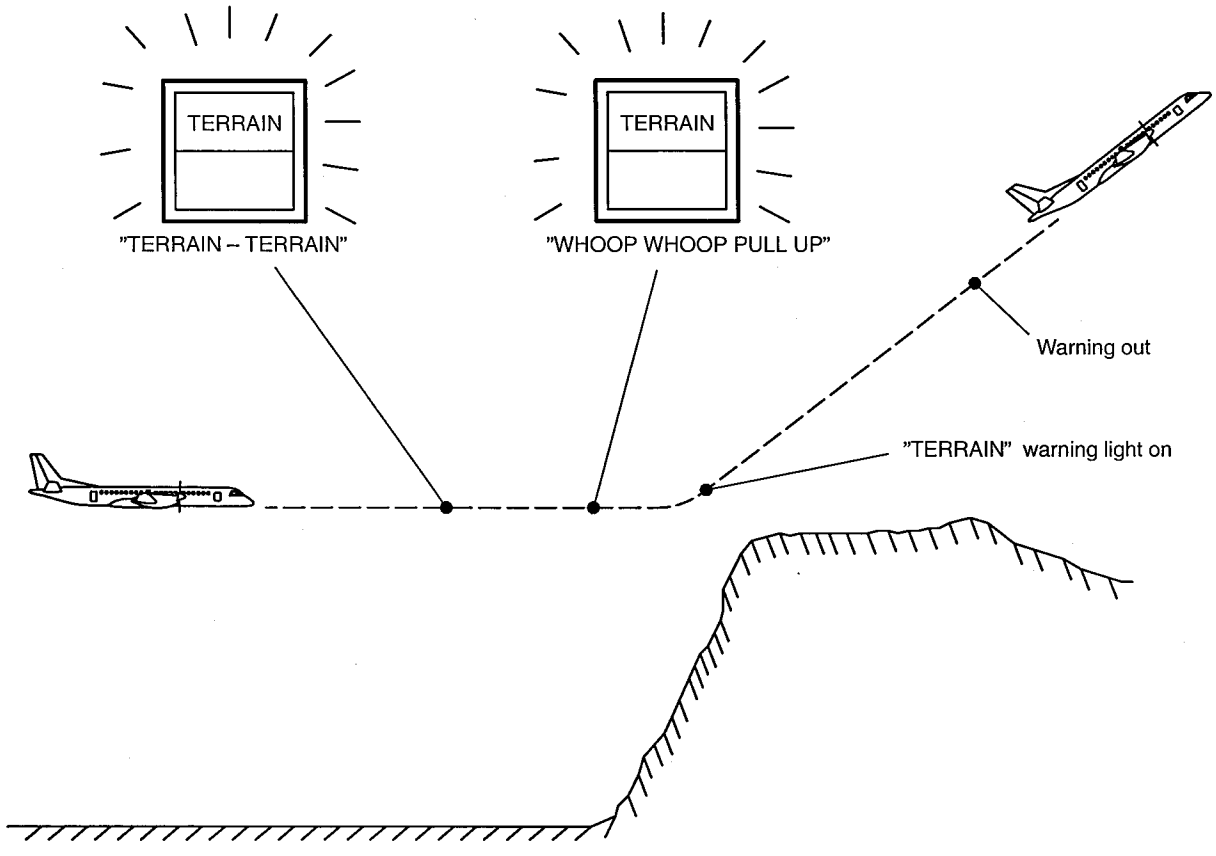
FIG. 1. Excessive sink rate.

MODE 2 EXCESSIVE TERRAIN CLOSURE RATE

Mode 2 warns for level flight or too shallow climb rate towards rising terrain with respect to the height above ground. On penetration of the envelope the TERRAIN warning lights come on flashing and the repeated aural warning "TERRAIN TERRAIN" sounds. If the closure rate remains within the warning envelope for about one second the warning changes to "WHOOP WHOOP PULL UP" which will be repeated every 0.75 seconds continuously until corrective action is taken. When corrective action has been taken, the TERRAIN lights will remain on untill the aircraft gains 300 feet of barometric altitude, or in addition and as an option, until 45 seconds have elapsed since the last warning.

The warning envelope is expanded by airspeed (IAS) when the aircraft is above 1650 feet RALT to provide the earliest possible warning.

With both gear and flaps in landing position the "WHOOP WHOOP PULL UP" warning is inhibited and only the "TERRAIN TERRAIN" warning is activated.



B4753

FIG 2. Excessive terrain closure rate.

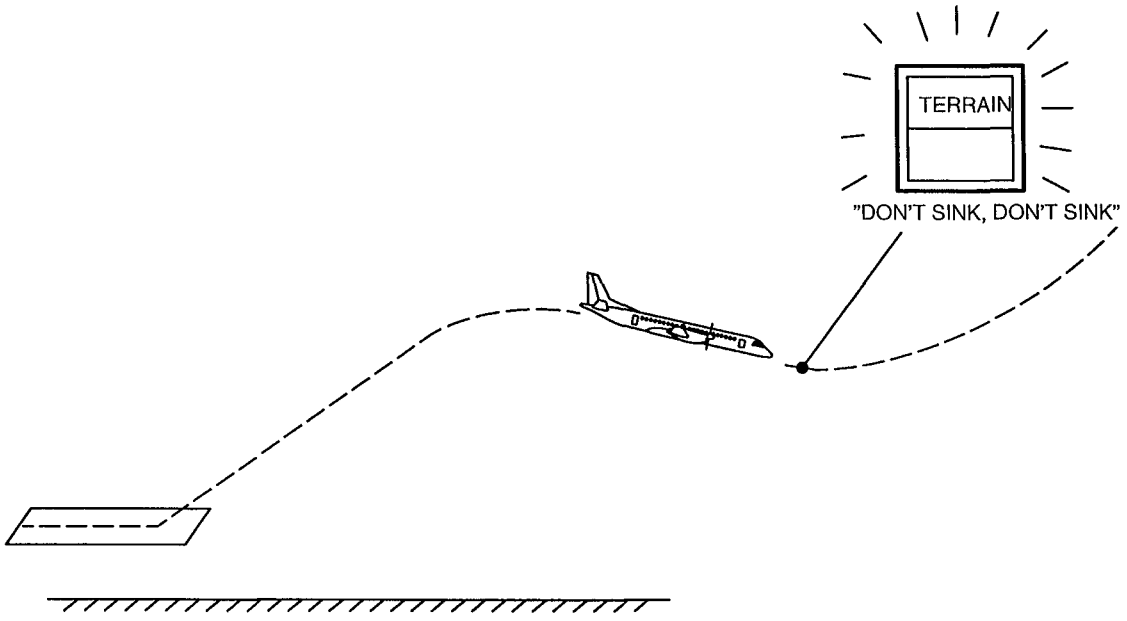
MODE 3 ALTITUDE LOSS AFTER TAKEOFF

Mode 3 warns for unintentional loss of barometric altitude after takeoff or go–around.

The mode is enabled between 10 and 1500 feet RALT after takeoff. The altitude loss required to trigger a mode 3 warning varies with the height above terrain when the inadvertent descent occurs. When the warning envelope is penetrated, the TERRAIN lamps flash and an aural warning "DONT SINK" is repeated twice with 0.75 second intervals. If the radio altitude decreases 20 % two additional messages are given. This continues until the original altitude is recovered.

The TERRAIN lights will flash until the altitude has increased above the altitude which the aircraft had when the warning was generated.

However, if loss of altitude occurs again within the envelope, another warning will be generated based on the lost altitude from the first warning.



B4755

FIG. 3. Altitude loss after takeoff.

MODE 4A TERRAIN CLEARANCE WITH GEAR UP

Mode 4A warns either for inadvertent proximity to terrain outside the approach area or aircraft not being in landing configuration (gear down) during approach. Mode 4A becomes enabled when the gear is not locked down and the radio altitude has decreased below 1000 feet. At penetration of the envelope with speed above 190 KIAS, the TERRAIN lights come on flashing and the aural warning "TOO LOW TERRAIN" sounds. If the radio altitude decreases 20 % further an additional message is given. This continues until corrective action is taken. At speeds below 190 KIAS and below 500 feet RALT the aural warning will change to "TOO LOW GEAR".

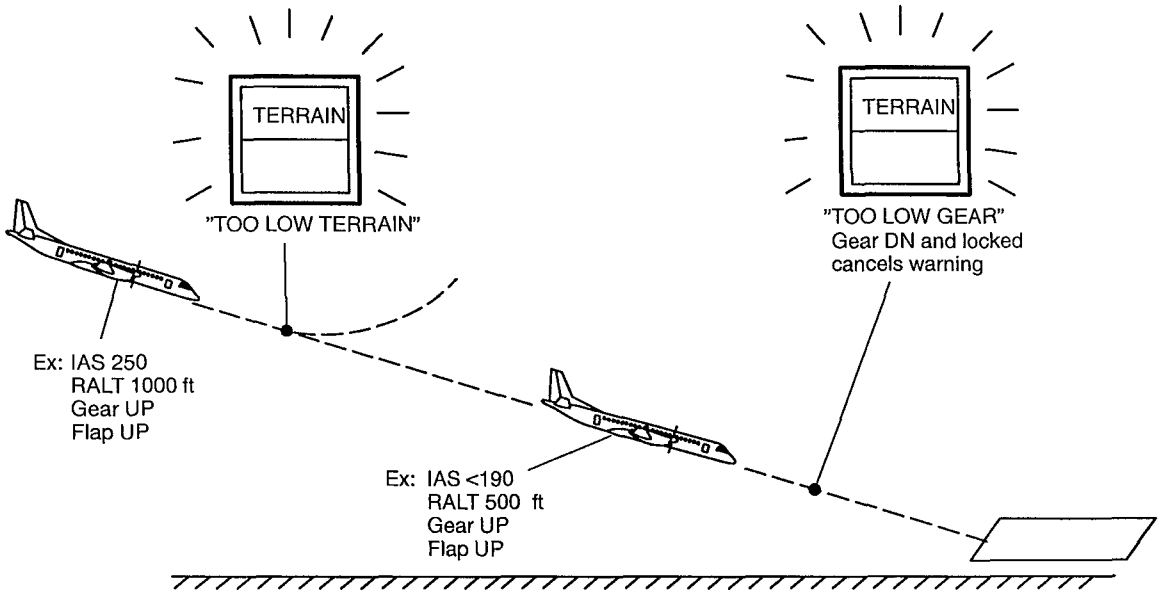
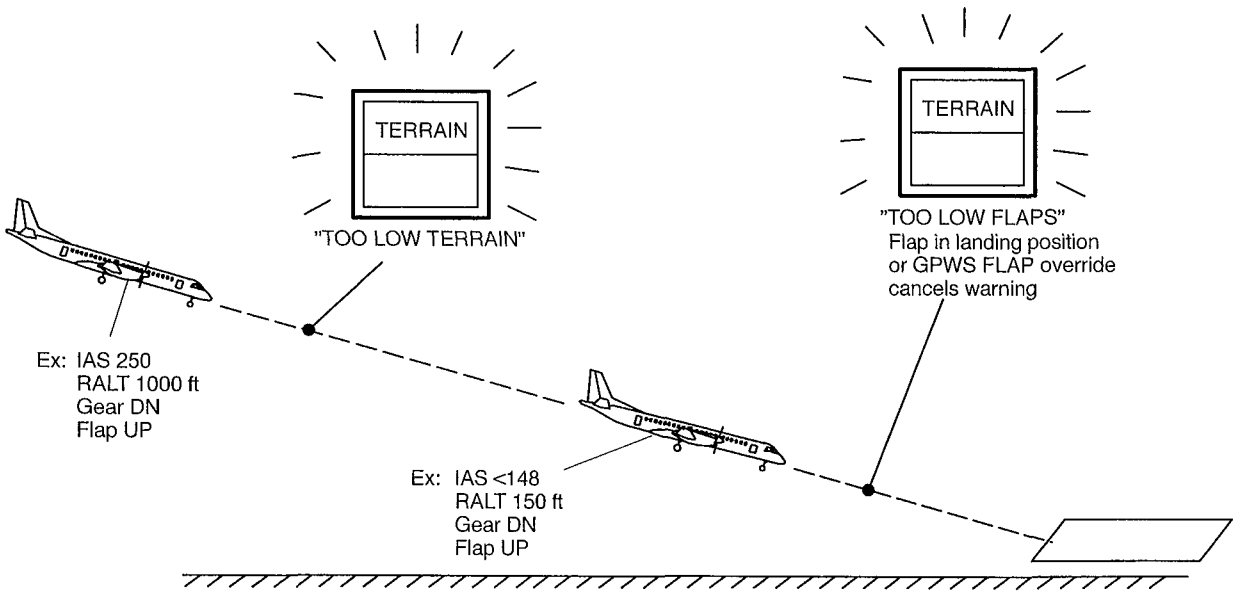


FIG. 4. Terrain clearance – gear up.

MODE 4B TERRAIN CLEARANCE WITH GEAR DOWN AND FLAPS UP

Mode 4B warns either for inadvertent proximity to terrain outside approach area or flaps not being in landing position during approach. Mode 4B becomes enabled when the gear is locked down and the flaps are up. At penetration of the envelope with speeds above 148 KIAS and below 1000 feet RALT, the TERRAIN lights come on flashing and the aural warning "TOO LOW TERRAIN" sounds. If the radio altitude decreases 20 % further an additional message is given. This continues until corrective action is taken. At speeds below 148 KIAS and below 150 feet RALT, the aural warning will change to "TOO LOW FLAPS". The "TOO LOW FLAPS" warning can be overridden at a decided landing without landing flap with the GPWS FLAP button on the center pedestal, which simulates flaps down for the GPWS. When selected, the white message GPWS FLAP OVRD will be displayed on EICAS SED.



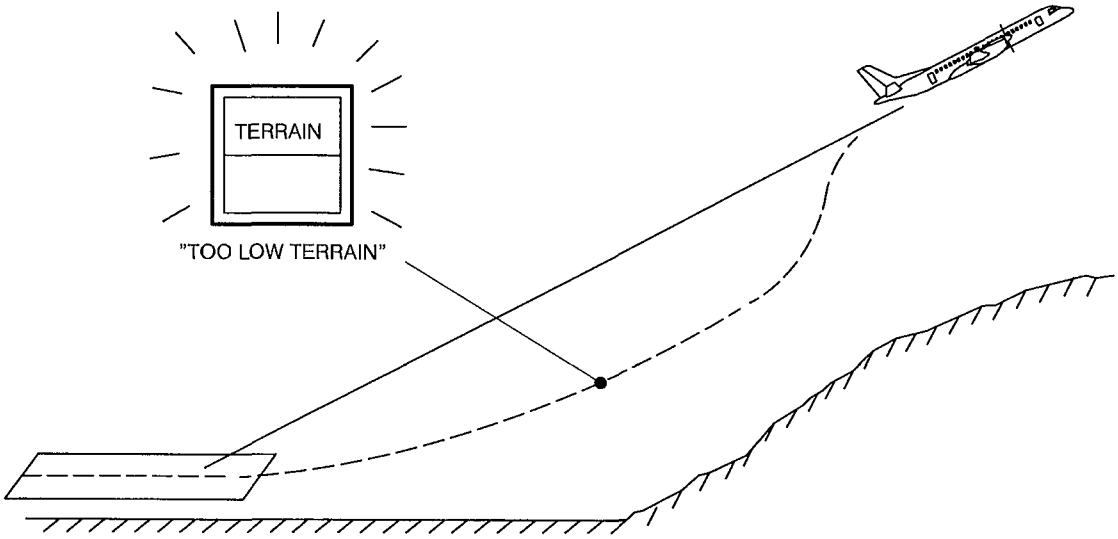
B4757

FIG. 5. Terrain clearance – gear down and flaps up.

MODE 4C TERRAIN CLEARANCE DURING TAKEOFF

Mode 4C warns for inadvertent descent or too shallow climb towards rising terrain in the takeoff area.

Mode 4C provides a warning based on minimum radio altitude clearance during takeoff. Mode 4C is based on a minimum terrain clearance that increases with radio altitude during takeoff. A value equal to 75 % of the current radio altitude is accumulated in a long term filter that is only allowed to increase in value. If the radio altitude should later decrease, the filter will store its maximum attained value. Further decrease of radio altitude below the stored filter value with Gear or Flaps up will cause the TERRAIN lights to come on flashing and the aural warning "TOO LOW TERRAIN" sounds. If the radio altitude decreases 20 % further an additional message is given. This continues until corrective action is taken.



B4758

FIG. 6. Terrain clearance during takeoff.

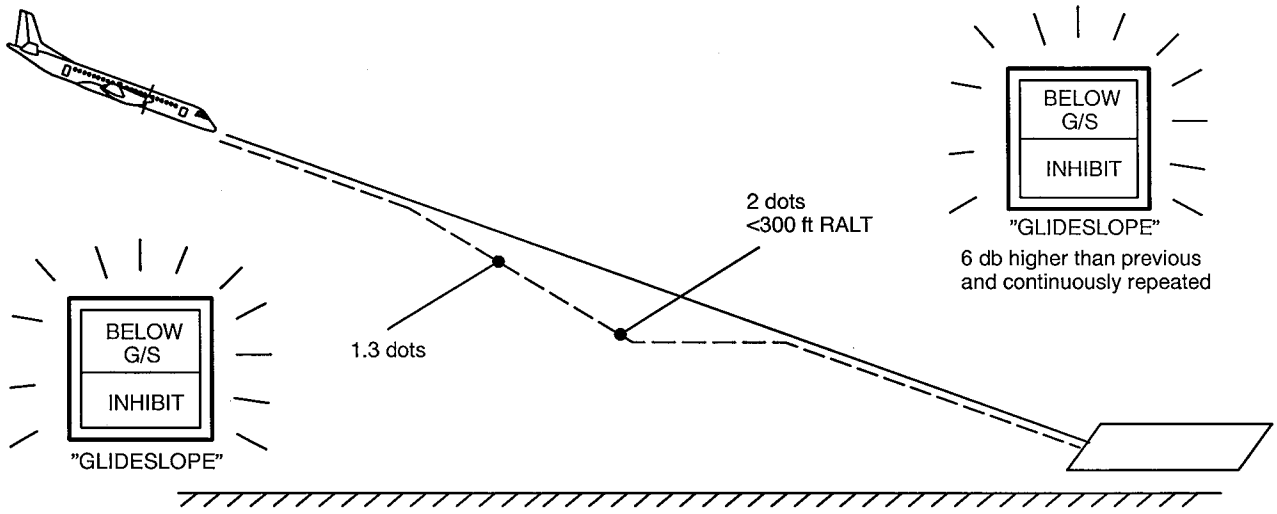
MODE 5 INADVERTENT DESCENT BELOW GLIDESLOPE

Mode 5 warns for inadvertent descent below the ILS glideslope.

Mode 5 is enabled when an ILS frequency is selected, the gear is down and the aircraft is between 30 feet and 1000 feet RALT.
As an option and to reduce nuisance warnings caused by a level flight before glideslope capture above 500 feet RALT, the localizer deviation must be within 2 dots to enable the mode. Additionally to enable mode 5, this option requires the rate of descend above 500 feet RALT to be greater than a sinkrate that allows the aircraft to reach 500 feet RALT within one minute.

The warning envelope consists of two envelopes. At penetration of the outer envelope, below 1.3 dots, the BELOW G/S INHIBIT lights come on flashing and the aural warning "GLIDESLOPE" sounds once with a soft (alert) volume. If no corrective action is taken and the deviation is increased with 20 %, "GLIDESLOPE" will be repeated. If still no corrective action is taken and if the deviation exceeds 2 dots when the aircraft is below 300 feet RALT, the volume of the aural "GLIDESLOPE" warning will increase by 6 dB (hard alert) and the message will be reapeated continuously. The amount of glideslope deviation necessary to produce a warning is increased below 150 ft, to eliminate any nuisance warnings by large deviation signals when the aircraft is close to the glideslope transmitter.

To allow the pilot to purposely descend below the glideslope, the mode 5 warning can be inhibited below 1000 feet by pressing the BELOW G/S INHIBIT button light. Mode 5 is automatically reset at climb above 1000 feet RALT.



B4759

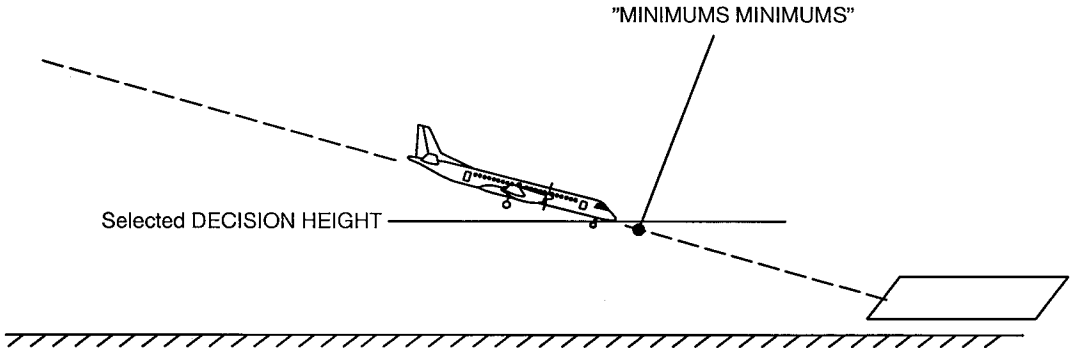
FIG. 7. Inadvertent descent below glideslope.

MODE 6 ALTITUDE CALLOUTS

Below 1000 ft RALT, mode 6 provides an aural alert when the aircraft descends below the selected decision height. The aural alert is "MINIMUMS MINIMUMS" and sounds once. Further alerts are inhibited until radio altitude becomes greater than 1000 feet RALT or until next flight.

Mode 6 is also available with two diffrent options that provide additional aural callouts. Regarding the first option, at 2500 feet RALT the callout is "RADIO ALTIMETER" and at 1000, 100, 50, 30, 20 and 10 feet RALT, the callout is made with the respective RALT value. The second option is used together with the Head–up Display system and provides callouts at 1000, 500, 400, 300, 200, 100, 50, 40, 30, 20 and 10 feet RALT with the respective RALT value.

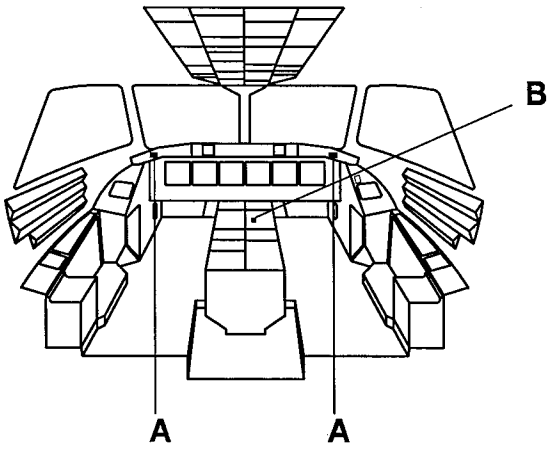
For both options, a Bank Angle aural alert is provided at any altitude for inadvertent over–banking. The alert is "BANK ANGLE BANK ANGLE". Also, the aural alert given for descent below selected decision height is changed to "MINIMUMS".

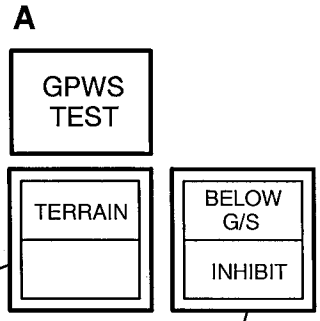


B6408

FIG. 8. Descent below selected Decision Height.

3. CONTROLS AND INDICATORS.





TERRAIN warning button light (flashing red).

Comes on together with aural warning if any of modes 1–4 becomes activated.

GPWS test:

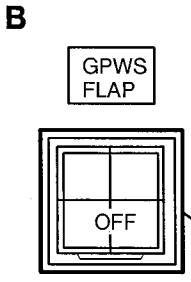
Press the TERRAIN button to activate the GPWS synthetic voice generator and to test the TERRAIN and BELOW G/S INHIBIT lights.

BELOW G/S INHIBIT caution button light (flashing amber).

Comes on together with aural warning if aircraft descends more than 1.3 dots below glideslope.

For planned descent below glideslope:

Press button light below 1000 feet RALT to inhibit the Descent below glideslope mode. The mode is automatically reset after climbing above 1000 ft radio height.



GPWS FLAP button.

Lift cover and push button to simulate flap down position and to eliminate the "TOO LOW FLAPS" warning at landings without landing flap selected. The white message GPWS FLAP OVRD willl be displayed on EICAS SED.

B2075

FIG. 9. GPWS FLAP switch and button lights.

4. ELECTRICAL POWER SUPPLY.

GPWS	L INV 115V AC BUS	F–20	GPWS PWR
GPWS flap override	L BAT BUS	F–19	GPWS FLAP OVRD

CONFIG–warnings.

The EICAS includes the logic to produce four different types of CONFIGURATION warnings, three Takeoff and one landing CONFIG–warning, as shown in the table below.
The warnings will, if initiated, cause the Master Warning to flash, an intermittent horn to sound and a CAS–text to be displayed on the PED.
The warnings are non–resettable until the conditions are corrected.

Mode/CAS–text	Description	Warnings conditions
CONFIG TRIM	Warning initiated if takeoff is attempted with incorrect trimsetting in Pitch, Roll, Yaw or if Rudder Test is not completed.	– Weight on wheels left and right. and – Power lever angle left and right > 60 deg. and – Gas generator speed (Ng) left and right > 56%. and – Incorrect trimsetting for takeoff (Pitch, Roll or Yaw) or rudder test active or not passed.
CONFIG FLAP	Warning initiated if takeoff is attempted with incorrect flap setting.	– Weight on wheels left and right. and – Power lever angle left and right > 60 deg. and – Gas generator speed (Ng) left and right > 56%. and – Flap position 7, 20 or 35 deg.
CONFIG PWR	Warning initiated if takeoff is attempted with incorrect power setting (not TOGA mode and not FLX mode selected on PMU).	– Weight on wheels left and right. and – Power lever angle left and right > 60 deg. and – Gas generator speed (Ng) left and right > 56%. and – Selected Power mode is CLB, CRZ or MCP on any engine. and – APR not selected.
CONFIG GEAR	Warning initiated if a landing is attempted with any landing gear not extended and locked.	– Any of the landing gears not extended and locked. and – Flap position 20 or 35 deg. or – Flap position > 17 and L + R pwr < min Climb pwr or – Flap position 15 and L + R pwr < max Appr pwr and Radio Height < 500ft. or – Flap position 35 and Flap system fault and Left + Right pwr < max Approach pwr and Radio Height < 500 ft or – Left + Right power < min Takeoff pwr and Radio Height < 300 ft.

Without AFR system.

CONFIG–warnings.

The EICAS includes the logic to produce four different types of CONFIGURATION warnings, three Takeoff and one landing CONFIG–warning, as shown in the table below.
The warnings will, if initiated, cause the Master Warning to flash, an intermittent horn to sound and a CAS–text to be displayed on the PED.
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Mode/CAS–text	Description	Warnings conditions
CONFIG TRIM	Warning initiated if takeoff is attempted with incorrect trimsetting in Pitch, Roll, Yaw or if Rudder Test is not completed.	– Weight on wheels left and right. and – Power lever angle left and right > 60 deg. and – Gas generator speed (Ng) left and right > 56%. and – Incorrect trimsetting for takeoff (Pitch, Roll or Yaw) or rudder test active or not passed.
CONFIG FLAP	Warning initiated if takeoff is attempted with incorrect flap setting.	– Weight on wheels left and right. and – Power lever angle left and right > 60 deg. and – Gas generator speed (Ng) left and right > 56%. and – Flap position 7, 20 or 35 deg. or – Flap handle >18 deg and flaps at 15.
CONFIG PWR	Warning initiated if takeoff is attempted with incorrect power setting (not TOGA mode and not FLX mode selected on PMU).	– Weight on wheels left and right. and – Power lever angle left and right > 60 deg. and – Gas generator speed (Ng) left and right > 56%. and – Selected Power mode is CLB, CRZ or MCP on any engine. and – APR not selected.
CONFIG GEAR	Warning initiated if a landing is attempted with any landing gear not extended and locked.	– Any of the landing gears not extended and locked. and – Flap position 20 or 35 deg. or – Flap position > 17 and L + R pwr < min Climb pwr or – Flap position 15 and L + R pwr < max Appr pwr and Radio Height < 500ft. or – Flap position 35 and Flap system fault and Left + Right pwr < max Approach pwr and Radio Height < 500 ft or – Left + Right power < min Takeoff pwr and Radio Height < 300 ft.

With AFR system.

1. GENERAL.

An aural overspeed warning is provided in the form of a continuous horn. The warning comes on if V_{MO}/M_{MO} should be exceeded.

The two Air Data Computers (ADC) output the overspeed signals to EICAS which generates the aural overspeed warning. No backup is required since the ADCs' output two independent overspeed signals.

1. GENERAL.

A dual channel stall warning system provides the flight crew with distinctive warnings of an impending stall:

- –The stickshaker provides a physical warning in the form of vibrations in each control column for the respective channel.
- –The aural warning is a sharp continuous clacker.
- – Autopilot disengage.
- –The stickpusher provides a firm forward movement of the control columns giving the aircraft a slight pitch down attitude if sufficient corrective action is not taken after stickshaker and aural warning.

The system consists of two independent stall warning computers which are part of EICAS, a left and a right angle of attack (AOA) sensor. There are also two stickshakers, one on each control column. A stickpusher actuator is also connected to the control columns. The stickpusher can be disabled by the crew. The stall warning system can be tested by two switches in the overhead panel. System fault indications are also provided on EICAS.

NOTE
False stall warnings (of short duration) may occur during low speed in turbulent weather.

2. MAIN COMPONENTS AND SUBSYSTEMS.

2. 1. Stall warning computer.

Stall warning and stall identification is based on angle of attack, information which is sensed by the AOA sensors.

The AOA signal is compared with activation levels for stall warning and stall identification (stick push). These activation levels are adjusted based on flap position and deicing system operation. When the activation levels are exceeded the corresponding stall warning and stall identification signals activate the stick shakers, the aural stall warning and stick pusher actuator. The signals are combined in such a way that stall warning is given to both pilots when either AOA sensor signal exceeds the stall warning threshold, while a stick push command requires that stall warning is given on both sides and that the stall identification limit is exceeded on one or both sides. The stick shaker activation also disengages the autopilot, if in use.

Both the stall warning and the stall ident functions are inhibited on ground.

Monitoring circuits are included which will give Master Caution and failure indications on EICAS.

2. 2. Angle of attack (AOA) sensor.

There is one swept vane type of AOA sensor mounted on each side of the forward part of the fuselage. The sensors measure the direction of the airflow relative to the fuselage, thus the angle of attack, and transfers the information to the stall warning computer. The sensors are electrically heated.

2. 3. Pusher actuator.

At pusher activation the pusher applies approximately 80 lbs force moving the control column forward. The "< 0.5 g"–switch will prevent the actuator from forcing the aircraft into an unacceptable nose down maneuver. The actuator is a DC torque motor with a slip clutch and an electronic interface to the stall warning computers. The electronic circuit requires push command signals from the stall warning computers for activation of the slip clutch and the DC torque motor. The torque motor force is transferred to the left elevator control system via a quadrant wheel and a pushrod. Connection with the right elevator control system is by the elevator interconnect unit.

Each pilot can disable the pusher actuator by pressing and releasing the center pedestal mounted PUSHER button. The pusher can be reset by pressing the PUSHER button a second time. The stick pusher is inhibited for 7 seconds after liftoff (not weight on wheel) and if the a/c load factor is less than 0.5 g.

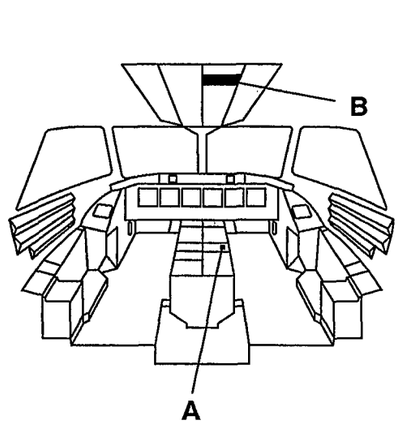
2. 4. Stickshaker.

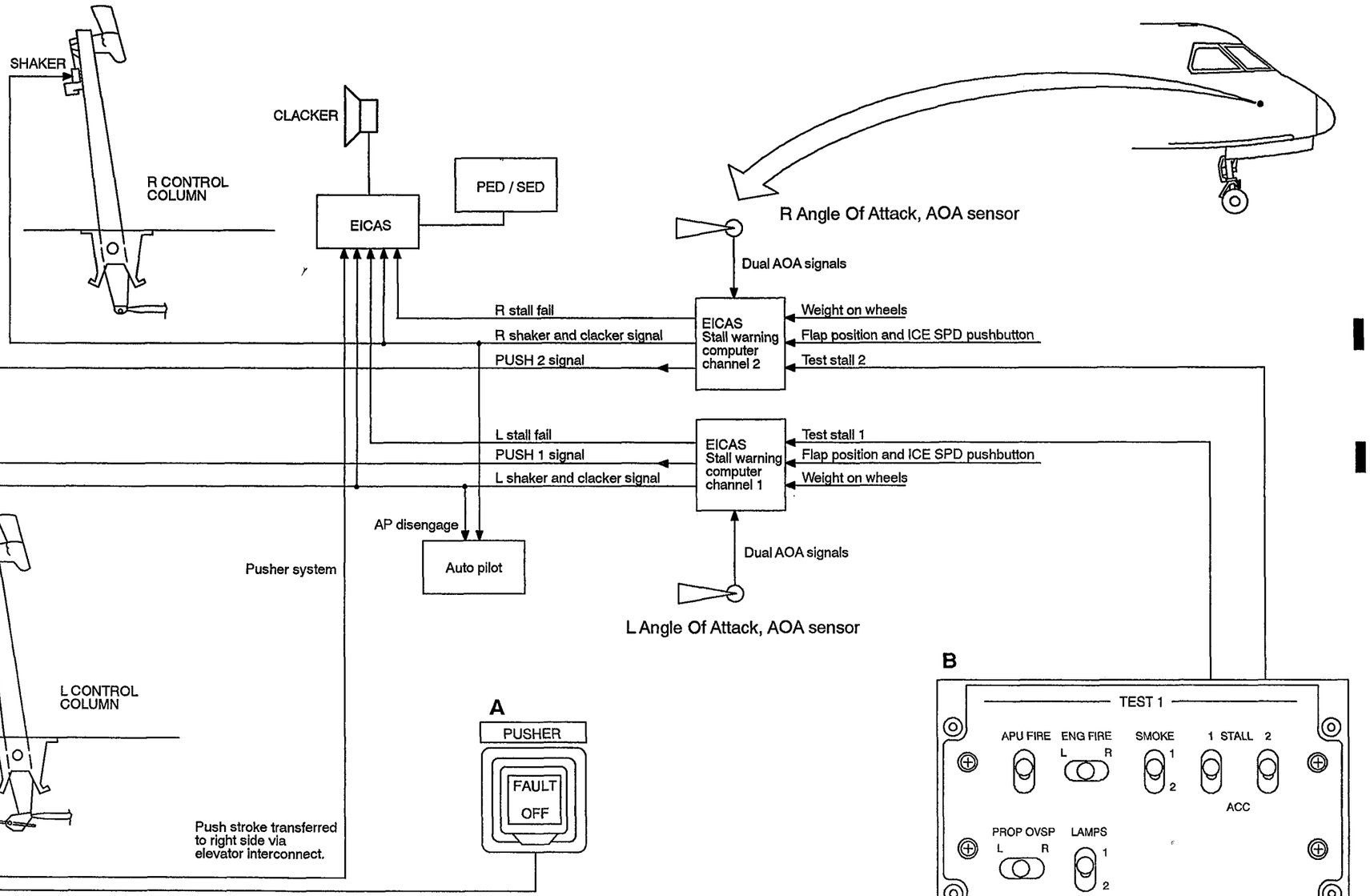
The stick shaker consists of a rotating unbalanced weight driven by a DC motor via a gearing, giving a

vibration of approximately 20 Hz. One stick shaker is mounted on each control column and is activated by the stall warning computer channel 1 and/or channel 2.

2. 5. Stall warning test.

Test of the stall warning system is also provided by the two STALL 1 and 2 switches on TEST 1 panel, see chapter 23/17.5 for operation of test.





B4680

NOTE
BOTH PUSH 1 AND PUSH 2 SIGNALS REQUIRED FOR ACTIVATION OF PUSHER ACTUATOR.

3. ELECTRICAL POWER SUPPLY.

Stall warning channel 1	L BAT BUS	E–10	STALL WARN CHAN 1
Stall warning channel 2	R BAT BUS	L–10	STALL WARN CHAN 2
Stick pusher actuator	R BAT BUS	L–9	STICK PUSHER

1. GENERAL.

The TCAS II system is an on–board collision avoidance and traffic situation system which monitors a radius of at least 14 nautical miles about the aircraft and, by interrogating any "intruding" aircraft's transponder, determines if a potential airspace conflict exists. This is done by computing the range, altitude, bearing and closure rate of other transponder–equipped aircraft, with respect to the TCAS–equipped aircraft.

The ACAS II system complies with TCAS II Change 7.0. There are no operational differences between ACAS II and TCAS II Change 7.0. When TCAS is mentioned in this section ACAS is also applicable. When TCAS II is mentioned in this manual it applies both to change 6.04A and 7.0, unless otherwise stated.

2. MAIN COMPONENTS AND SUBSYSTEM.

2.1. TCAS II system equipment.

The TCAS II system consists of the following:

Qty	Description
1	TCAS II Transmitter–Receiver
2	Directional Antennas (one top, one bottom)

The TCAS II requires the following equipment to be functional and operating:

- Mode S transponder
- Air Data Computer
- Radio Altimeter

The TCAS II system provides two levels of threat advisories:

- If the traffic gets within approximately 45 seconds of projected Closest Point of Approach (CPA), it is then considered an intruder, and an aural and visual Traffic Advisory (TA) is issued. This level calls attention to a developing collision threat using the TCAS II traffic/advisory indications on the PFD/ND indicators and the voice message, "TRAFFIC TRAFFIC". It permits mental and physical preparation for a possible maneuver to follow, and assists the pilot in achieving visual acquisition of the threat aircraft.
- If the intruder gets within approximately 30 seconds of CPA, it is considered a threat and an aural and visual Resolution Advisory (RA) is issued. This level provides a recommended vertical maneuver using the RA bars on the VSI indicator on the PFD and voice messages to provide adequate vertical separation from the threat aircraft, or prevents initiation of a maneuver that would place the TCAS II aircraft in jeopardy.

2.2. Mode S transponder system equipment.

The Mode S transponder system consists of the following equipment:

Qty	Description
2	Mode S transponders
4	L–Band Omni–directional Antennas (two top, two bottom)

The ATC/MODE S transponder is a solid–state, airborne, air traffic control (ATC) transponder that responds to ATCRBS (Air Traffic Control Radar Beacon System) MODE A, MODE C and MODE SELECT (MODE S) interrogations. The MODE S function is capable of being discretely addressed (so that interrogation can be directed to a specific aircraft as required by TCAS II) and for receiving and sending data link messages. It is also capable of receiving and transmitting from two antennas (for use in diversity operations for improving air–to–air surveillance and communications).

The TCAS II system will resolve multiple aircraft encounters. The TCAS II is considered a backup system to the "SEE–AND–AVOID" concept and the ATC radar environment.

2.3. Standard TCAS II definitions.

a. ACAS II/TCAS II – An ACAS (Airborne Collision Avoidance System) or TCAS (Traffic alert and Collision Avoidance System) that utilizes interrogation of, and replies from airborne radar beacon transponders and provides Traffic Advisories (TA) and Resolution Advisories (RA) in the vertical plane.

b. Other Traffic – is defined as any other traffic within the range of the display and within +/– 2700 feet vertically.

c. Proximate Traffic – is defined to be any traffic not generating an RA or TA but which is within six nautical miles (NM) slant range and within +/– 1200 feet vertically.

d. Traffic Advisory (TA) – Information given to the pilot pertaining to the position of intruding aircraft in the immediate vicinity. The information contains no suggested maneuver.

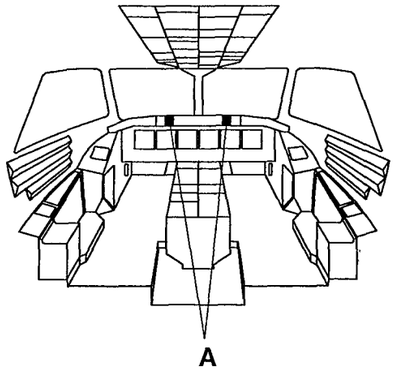
e. Threat – Traffic that has satisfied the threat detection logic and requires a Resolution Advisory (RA).

f. Resolution Advisory (RA) – A display indication given to the pilot recommending a maneuver to increase vertical separation relative to an intruding (threat) aircraft.

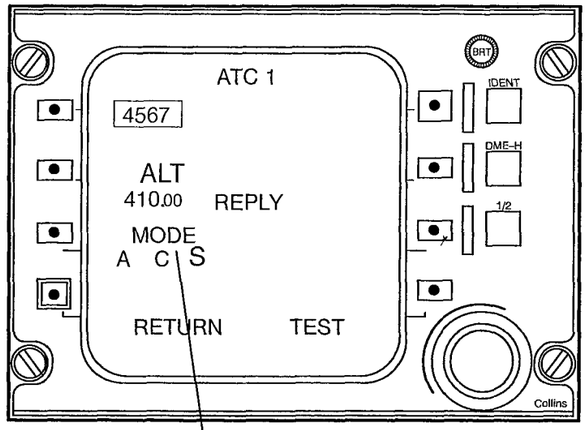
(1) Corrective Advisory – A Resolution Advisory that instructs the pilot to deviate from current vertical rate.

(2) Preventive Advisory – A Resolution Advisory that instructs the pilot to avoid certain deviations from current vertical rate.

3. CONTROLS.



Transponder PAGE

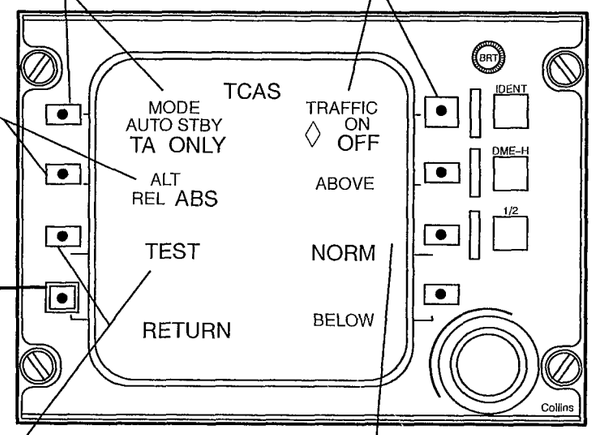


Transponder Mode.
Mode S for TCAS use.

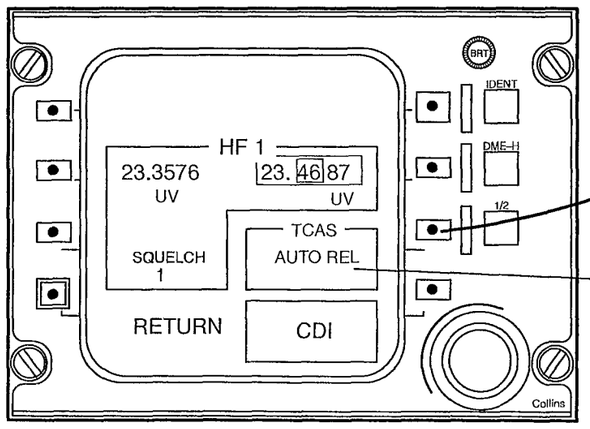
TCAS Mode.
Pressing the line select pushbutton selects the operational mode of the TCAS. The three possible modes are standby (STBY), automatic or on (AUTO), and TA ONLY, which causes the TCAS to display only Traffic Advisory targets. Repeated pressing of this line select pushbutton cycles through the active modes. The AUTO mode is the default.

Traffic.
The line select pushbutton toggles between traffic display ON and OFF. Traffic ON causes the TCAS to display all traffic on its display (ND).

Altitude Type.
Pressing the line select pushbutton toggles between the absolute (ABS) and relative (REL) altitude type which is shown on the TCAS display (ND).



A RTU



TCAS PAGE selected

"RETURN".
The MAIN page may be re–entered from the TCAS PAGE by pressing the select pushbutton.

The TCAS PAGE controls both the TCAS system modes and the display modes.

TCAS window.
The selected TCAS sensitivity and altitude tag. Changes to the TCAS parameters cannot be made from this window.

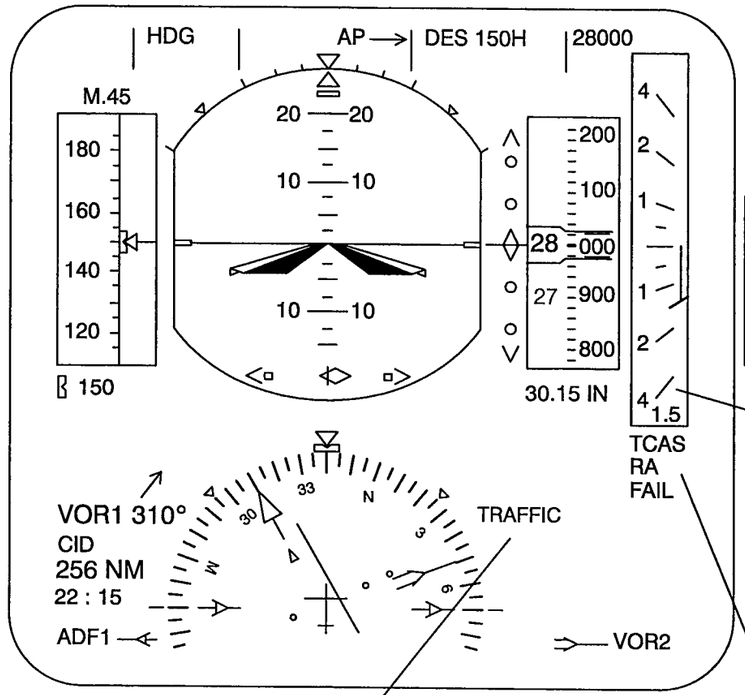
TEST
Provides TCAS self–test.

TCAS Altitude Range.
Pressing a select button selects the altitude range of the traffic to be shown on the TCAS display (ND). The choices are normal (NORM), above (ABOVE) and below (BELOW). "NORM" selects an altitude range of +/– 2700 ft of the aircraft altitude, "ABOVE" selects 2700 ft below to 9900 ft above the aircraft altitude, "BELOW" selects 9900 ft below to 2700 ft above the aircraft altitude. Selecting both "ABOVE" and "BELOW" gives an altitude range of +/– 9900 ft of the aircraft altitude.
The default state is "NORM".

For description about RTU controls see chapter 4/2 RTU and Radios.

B1845

FIG. 1. TCAS and Transponder controls.



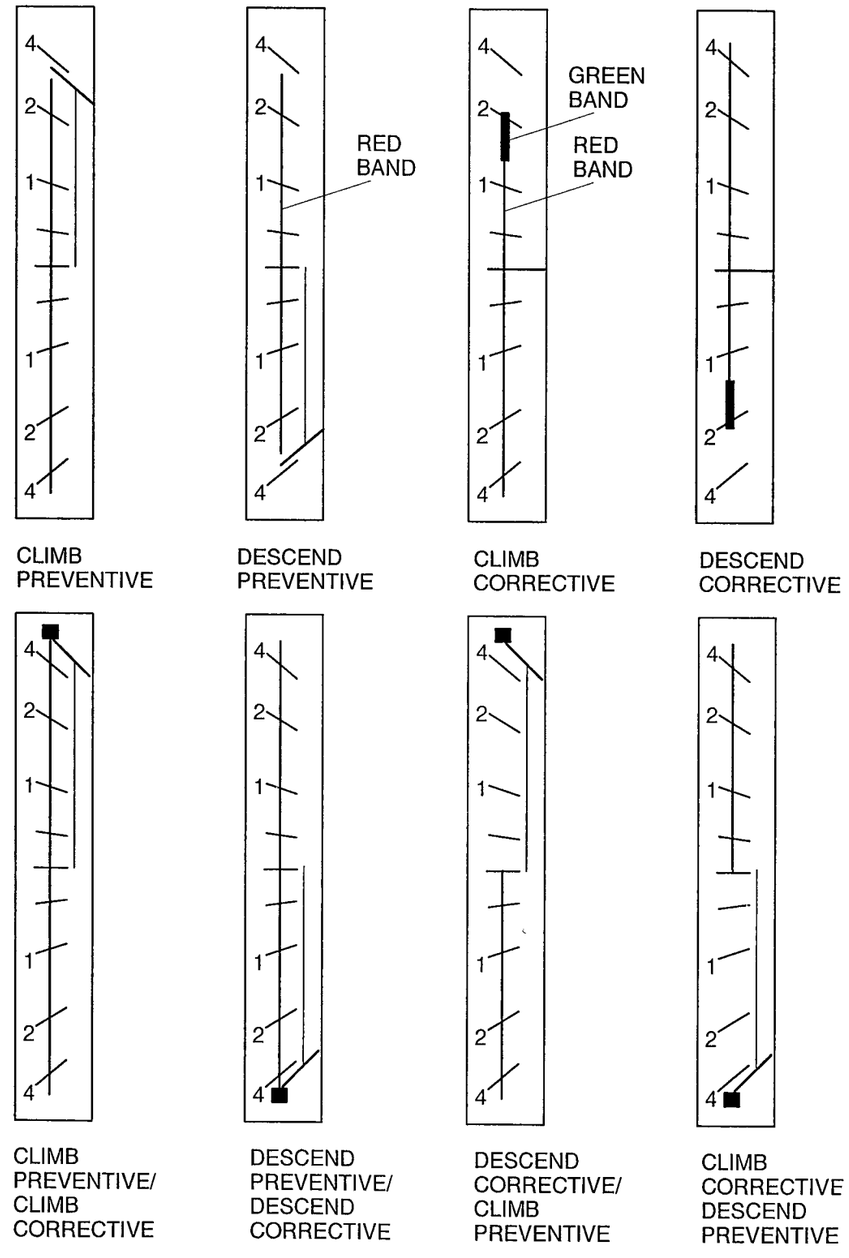
TCAS Resolution Advisories.

The resolution advisories are displayed on the Vertical Speed Indicator. The advisories are displayed as red and green bands showing the commanded vertical speed ranges and limits.

The TCAS "TRAFFIC" annunciation is displayed when valid RA or TA intruder data is received from the TCAS system. The annunciation is red for RA intruders and yellow for TA intruders.

The TCAS annunciations that show the status of TCAS operation are displayed in the same place on the PFD and consist of the following listed in order of priority:

- "TCAS RA FAIL" is displayed in yellow if the PFD is unable to display Resolution Advisories.
- "TCAS FAIL" is displayed in yellow if the TCAS system has failed and the PFD is able to display Resolution Advisories.
- "TCAS TEST" is displayed in white if TCAS system is under test and the TCAS system is not failed and the PFD is able to display Resolution Advisories.
- "TCAS OFF" is displayed in white if the TCAS system is in STANDBY / or on ground.
- "TA ONLY" is displayed when the TCAS system is in the TA ONLY mode. "TA ONLY" is displayed in yellow if TA intruders are present, otherwise displayed in white.



B1732

FIG. 2. TCAS vertical speed advisories.

TCAS status.

TCAS status annunciations consist of "TCAS FAIL", "TCAS TD FAIL" and "TCAS TEST". "TCAS TEST" is displayed whenever the TCAS system is placed in the test mode. "TCAS FAIL" is displayed whenever the TCAS system reports a failure. "TCAS TD FAIL" (Traffic Display Failure) is displayed whenever the display is unable to display TCAS data, e.g. a bus failure.

TCAS Intruder Display.

TCAS traffic symbols are positioned using TCAS computer data. The symbols are displayed with the selectable relative or absolute altitude complete with a climb/descend arrow.

An out–of–range symbol is displayed at the maximum selected range with only half of the symbol in view.

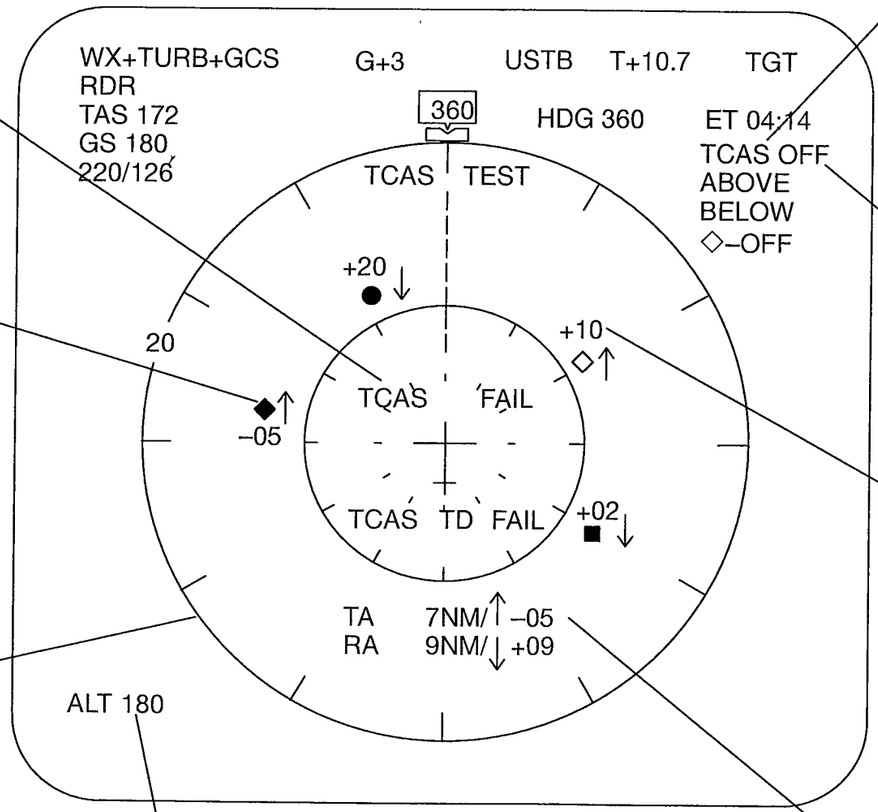
Resolution Advisory symbols are solid red squares. Traffic Advisory symbols are solid yellow circles. Proximate traffic symbols are filled cyan diamonds. Other traffic symbols are open cyan diamonds.

TCAS Range Ring Symbology.

A half–intensity white, three mile range ring composed of 12 small tick marks is displayed around the aircraft symbol for range values of 5, 10, 20 and 40 nautical miles. For range values greater than 20 nautical miles, the three mile range ring is not displayed. The tick marks represent the 12 cardinal clock positions.

A full circle white range ring with 12 tick marks is displayed at the full scale selected range. Range is selected on the DCP.

If a range greater than 5 miles is selected an additional full circle half–intensity white range ring is displayed at half the full scale selected range.



TCAS mode.

The TCAS mode annunciation consists of "TCAS OFF" and "TA ONLY". "TCAS OFF" is displayed in white. "TA ONLY" is displayed in yellow if TA intruders are present and white if TA intruders are not present.

TCAS Altitude Range.

The altitude range for display of OTHER (NO THREAT) intruders is selectable from the ABOVE/BELOW/NORMAL menu on the RTU. Each menu item will be displayed in white. Power–up default is "NORMAL".

Type	Altitude Range
Normal	–2700 to +2700 ft
Above	–2700 to +9900 ft
Below	–9900 to +2700 ft
Above + Below	–9900 to +9900 ft

TCAS Altitude Type.

The relative altitude is displayed as a sign (+ or –) and two (2) digits with a resolution of 100 ft. The range is from –99 to +99. If the relative altitude is zero, no plus or minus sign is displayed. Leading zeroes are displayed.

Absolute altitude is displayed as three (3) digits with a resolution of 100 ft. When absolute altitude is negative, "XXX" is displayed. The range is from 000 to 999. Leading zeroes are displayed.

The altitude information is displayed in white.

The TCAS Display mode will display TCAS Traffic and Resolution Advisories in a 360 degree coverage area around the present position of the aircraft. Weather data can be superimposed on the TCAS Traffic display.

Present altitude, own aircraft.

TCAS No Bearing Table.

TCAS advisories are received from the TCAS computer in priority order. The first two TA or RA intruders with no valid bearing information are placed in a textual NO BEARING TABLE. If no TA and RA intruders are received without bearing information, the NO BEARING TABLE is blank. A slash separates the range from the altitude, which is displayed the same as for the symbols on the TCAS traffic display.

The color of the NO BEARING TABLE entry is red for RA intruders, and yellow for TA intruders.

B7979

FIG. 3. TCAS traffic display.

4. ELECTRICAL POWER SUPPLY

TCAS	R AVIONICS BUS	L–23	TCAS

1. GENERAL.

The Terrain Awareness Warning System (TAWS), provides unique visual and aural warnings to prevent the aircraft from approaching the ground inadvertently. The TAWS is based on the Honeywell EGPWS MkV system which is an enhancement of the standard Ground Proximity Warning System (GPWS). In this description the system will be referd to as "TAWS" even though the Honeywell designation is "EGPWS". The TAWS contains additional "look ahead" features to improve crew situational awareness and provide advanced warnings and alerts of hazardous proximity to terrain with significantly increased margins compared to the standard GPWS. The TAWS continuously compares the projected aircraft ground track (horizontal and vertical position) with a safe altitude "floor" based on known terrain features, extracted from an internal terrain database. Accurate aircraft position data are derived from the GPS system.

The TAWS computer monitors interfacing system inputs to determine if any alert/warning envelope is being penetrated. When aircraft operation deviates into an alert/warning condition, visual warning and aural messages are generated as shown in Table 1.

Mode	Visual Warning/Alert	Aural Warning/Alert
1 – Excessive descent rate	TERRAIN / BELOW G/S lights TERRAIN lights	– SINK RATE – PULL UP
2 – Terrain closure rate	TERRAIN / BELOW G/S lights TERRAIN lights	– TERRAIN TERRAIN – PULL UP
3 – Altitude loss after take off	TERRAIN / BELOW G/S lights	– DON'T SINK
4A– Terrain clearance (gear up)	TERRAIN / BELOW G/S lights	– TOO LOW GEAR – TOO LOW TERRAIN
4B– Terrain clearance (gear down, flaps up)	TERRAIN / BELOW G/S lights	– TOO LOW FLAPS – TOO LOW TERRAIN
4C– Minimum Terrain clearance during takeoff.	TERRAIN / BELOW G/S lights	– TOO LOW TERRAIN
5 – Inadvertent descent below glideslope	TERRAIN / BELOW G/S lights	– GLIDESLOPE or – GLIDESLOPE with increased level
6 – Alerts (altitude callout, basic) (altitude callout, optional and HUD/CAT III) (excessive bank angle)		– 500, MINIMUMS–MINIMUMS at DH – 1000, 500, 400, 300, 200, 100, 50, 40, 30, 20, 10 and MINIMUMS at DH – BANK ANGLE–BANK ANGLE
TCF – Pre–mature Descent	TERRAIN / BELOW G/S lights	– TOO LOW TERRAIN
FLTA – Terrain/Obstacle Caution	TERRAIN / BELOW G/S lights	– TERRAIN/OBSTACLE AHEAD
FLTA – Terrain/Obstacle Warning	TERRAIN lights	– TERRAIN/OBSTACLE AHEAD – PULL UP

Table 1. Visual and Aural Warnings/Alerts.

TCF: Terrain Clearance Floor.

FLTA: Forward Looking Terrain Avoidance

2. MAIN COMPONENTS AND SUBSYSTEMS.

2. 1. Aural Warnings.

The aural messages are digitally synthesized and stored in read only memories in the TAWS. When an alert/warning is generated, the information stored in the appropriate read only memories is retrieved and converted to an audio signal. The audio signal is routed to the audio integrating system where it is amplified and supplied to both pilots' cockpit speakers and headsets.

2. 2. Visual Warnings.

The amber TERRAIN/BELOW G/S and red TERRAIN lamps are illuminated pushbutton activated by the TAWS.

If more than one warning mode envelope is penetrated at the same time requiring conflicting aural warnings, the warnings are generated according to the priority order in Table 2.

The highest priority message is always provided. If a higher priority warning occurs, the higher priority warning is immediately generated. When a warning ceases, the message is completed before switching to a warning of lower priority.

2. 3. Terrain Database.

The terrain database divides the earth's surface into grid sets referenced horizontally on the geographic coordinate system of the WGS–84. Higher resolution grids are used around airports.

2. 4. Obstacle Database.

Obstacle database is a separate file from the terrain database, containing man made obstacles with a height exceeding 100 feet. The obstacle data is processed and displayed on the ND's in the same fashion as terrain is presented on the display, it also causes the same visual indications of warning and caution alerts as the terrain data.

Some areas may not be included in the obstacle database. The operator should check the availability of obstacle database for his area of operation.

2. 5. Geometric Altitude.

Geometric altitude is a computed aircraft altitude designed to ensure optimal operation of the terrain awareness function through all phases of flight and atmospheric conditions. Geometric altitude uses a pressure altitude calculation, GPS altitude, radio altitude, terrain and runway elevation data to reduce or eliminate errors potentially induced in correct barometric altitude by temperature extremes, non standard altitude conditions and altimeter miss–sets. Geometric altitude allows TAWS operations in QFE environments without special procedures by the flight crew.

2. 6. Terrain Awareness Display.

The TAWC outputs terrain data to the left and right ND via left and right WXR/terrain display switching relays. Display of terrain is selected by pressing left and/or right terrain awareness display pushbuttons on the glareshield panel. This energizes the WXR/Terrain display relays and outputs terrain data to left and right ND. RDR must be selected on the DCP in order to display terrain since the terrain display uses the weather radar display input. The range of the terrain image is selected with the range select knob on the DCP.
The terrain display is selectable also when the WXR system is selected to OFF.

The TAWS is configured for automatic pop–up of the terrain image, once a terrain alert/warning is generated. This means that the terrain image will be displayed automatically in conjunction with the terrain awareness aural alert, with the range as selected on the DCP. A condition for automatic pop–up is that RDR is selected on the DCP prior to the terrain alert.

To distinguish the terrain image from the ordinary WXR image, the terrain display includes two elevation numbers displayed on the ND, together with the terrain image. "DISP" will also be displayed in green in the lower field on the left and right terrain awareness pushbuttons on the glareshield panel. The WXR modes "WX" and "TILT 0.0" will be displayed in cyan on the ND as soon as the terrain display is active.

The selected WXR modes and selections, including XRNG (single WXP) and XCTL (dual WXP), will be displayed whenever the WXR is displayed.

It is possible to monitor weather on left ND and terrain on right ND and vice versa. Auto range function is not availabe.

The terrain image is depicted as variable density dot patterns in green, yellow or red (see Table 3). The density and color being a function of how close the terrain or obstacle is relative to aircraft altitude.

Solid yellow or red colors indicate terrain near or above the current altitude of the aircraft. When an alert is active yellow or red colors indicates caution and warning areas relative to the flight path of the aircraft.
At altitudes safely above all terrain for the range chosen, the terrain is displayed independent of aircraft altitude emphasizing the highest and lowest elevations to provide increased situational awareness. A solid green level indicates the highest, non–threatening terrain. The lower density green display pattern indicate mid and upper terrain in the display area as well as terrain that is within 2000 feet of the aircraft. See Fig. 1.

There are two elevation numbers indicating that the highest and lowest terrain currently being displayed are overlaid on the display. The elevation numbers indicate terrain in hundreds of feet above sea level (MSL). The terrain numbers are displayed with the "highest" terrain number on the top and the "lowest" terrain number beneath it. A single elevation number is displayed when the screen is black as a result of flying over water or relatively flat terrain.

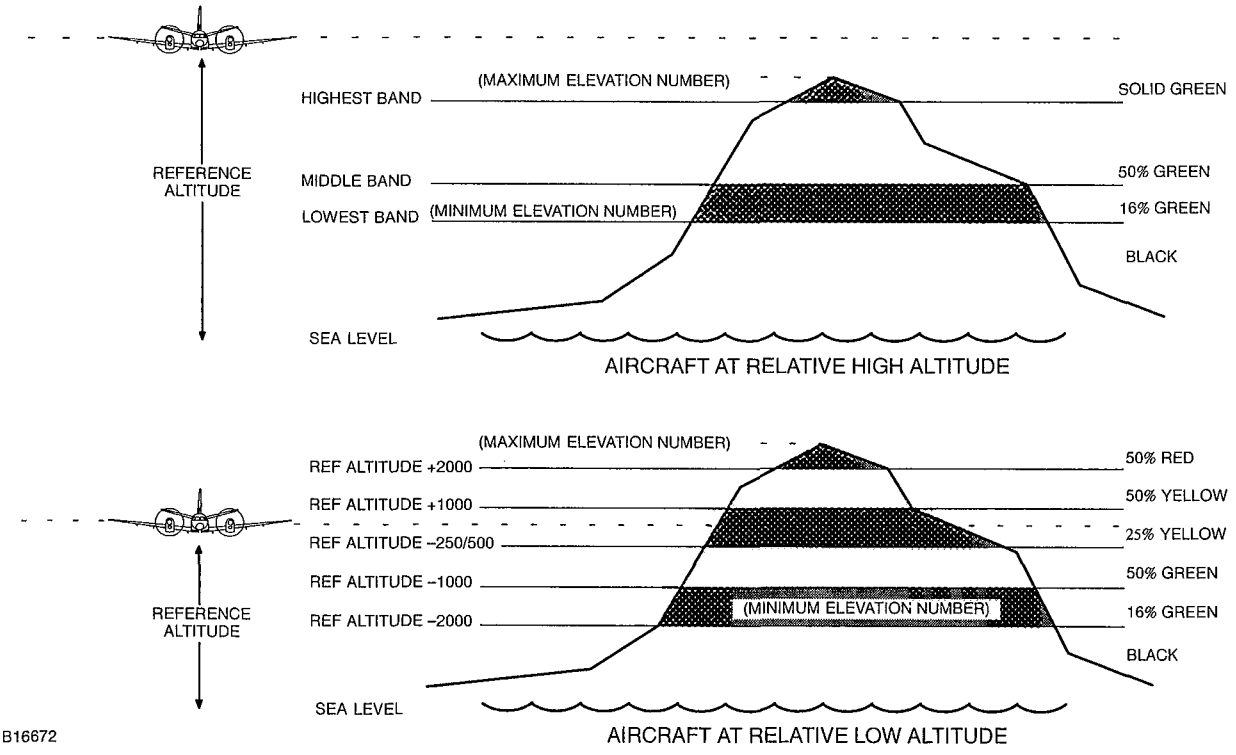


Fig.1. Display colors – schematic.

Priority	Message	Mode
1	WHOOP WHOOP PULL UP	1
2	TERRAIN TERRAIN	2 preface
3	WHOOP WHOOP PULL UP	2 pull–up
4	TERRAIN AHEAD PULL UP	FLTA, Terrain awareness warning
5	OBSTACLE AHEAD PULL UP	FLTA, Obst. awareness warning [1)]
6	TERRAIN	2 Terrain
7	MINIMUMS	6
8	TERRAIN AHEAD	FLTA, Terrain awareness caution
9	OBSTACLE AHEAD	FLTA, Obst. awareness caution [1)]
10	TOO LOW TERRAIN	4
11	TOO LOW TERRAIN	TCF, Pre–mature decent
12	Altitude Callouts	6
13	TOO LOW GEAR	4
14	TOO LOW FLAPS	4
15	SINK RATE	1
16	DON'T SINK	3
17	GLIDESLOPE	5
18	BANK ANGLE – BANK ANGLE	6

Table 2. Warning message priority.

Note:
[1)] Alerts/warnings for man made obstacles will not be given if such obstacle data is not included in the database.

Color	Terrain Elevation.
Solid Red	Terrain Threat Area – Warning.
Solid Yellow	Terrain Threat Area – Caution.
50% Red	Terrain that is more than 2000 feet above aircraft altitude.
50% Yellow Dots	Terrain that is between 1000 and 2000 feet above aircraft altitude.
25% Yellow Dots	Terrain that is 500 (250 with gear down) below to 1000 feet above aircraft altitude.
Solid Green	Shown only when no Red or Yellow terrain areas are within range on the display. Highest terrain not within 500 (250 with gear down) feet of aircraft altitude.
50% Green Dots	Terrain that is 500 (250 with gear down) feet below to 1000 below aircraft altitude, or Terrain that is middle elevation band when there are no Red or Yellow terrain areas within range on the display.
16% Green Dots	Terrain that is 1000 to 2000 feet below aircraft altitude, or terrain that is the lower elevation band when there are no Red or Yellow terrain areas within range of the display.
Black	No significant terrain, outside coverage of regional terrain database or unknown.

Table 3. Display colors and patterns

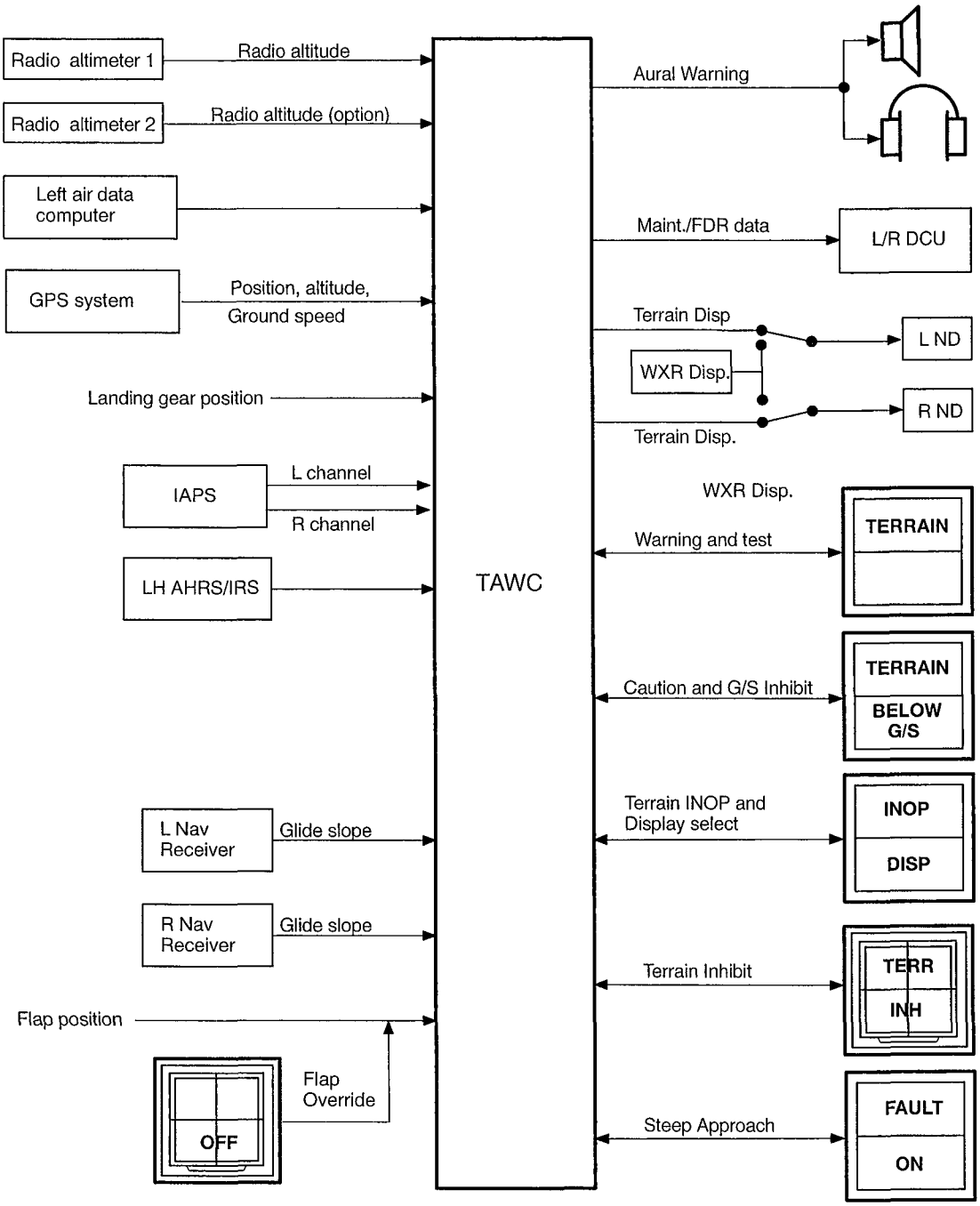
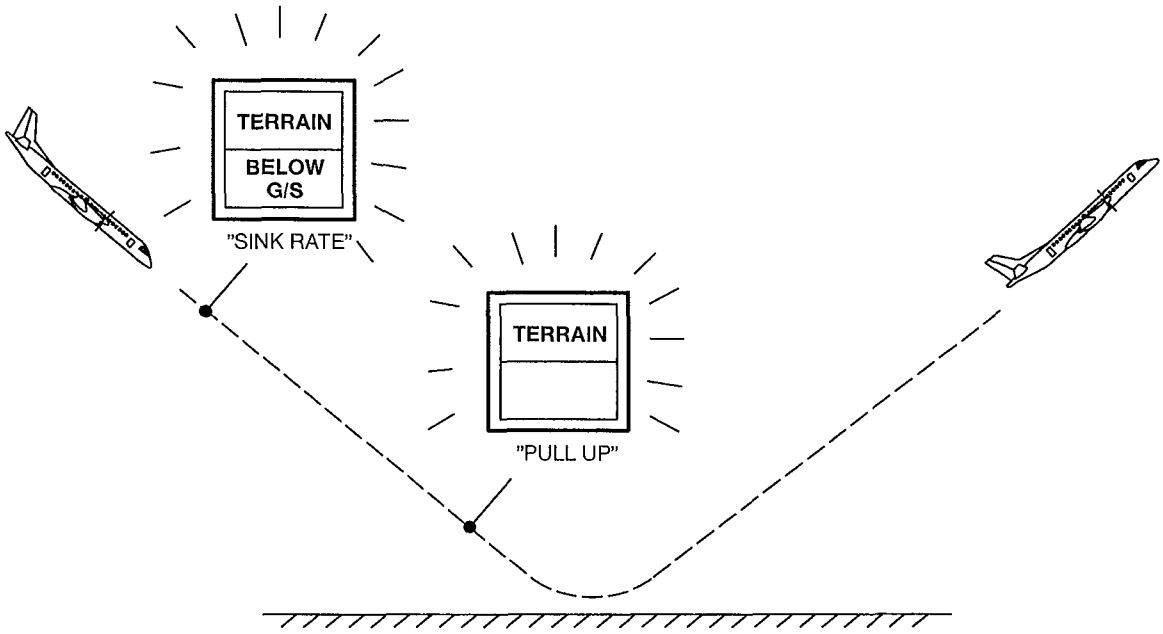


Fig.2. TAWS – schematic.

MODE 1 – EXCESSIVE DESCENT RATE.

The mode 1 warning is generated if the aircraft barometric descent rate is excessive with respect to the height above terrain. The mode has two warning envelopes that provides warning of excessive rate of descent at a given altitude. At penetration of the outer envelope the TERRAIN / BELOW G/S lights come on flashing and the aural warning "SINK RATE" is repeated twice. It will then remain silent until the excessive decent rate condition degrades by approximately 20 %. The lamps however will be flashing continuously. This cycle will be repeated until the aircraft rate of descent is corrected. If the descent rate is not corrected and the inner envelope is penetrated, the aural warning "PULL UP" will be repeated continuously and the TERRAIN lights will start flash until the descent rate is corrected. The mode is independent of aircraft configuration.



B16337

Fig.3. Excessive descent rate–schematic.

MODE 2A – EXCESSIVE TERRAIN CLOSURE RATE FLAPS UP .

Mode 2A warning is generated if the aircraft closure rate (radio altitude) is excessive against terrain with respect to the height (radio altitude). When the warning envelope is penetrated the TERRAIN BELOW G/S lights flashes and the aural warning "TERRAIN TERRAIN" sounds. If the closure rate remains within the warning envelope fore about one second the aural warning " PULL UP" sounds and the terrain lights flashes. This is repeated continuously until the closure rate is corrected. If the aircraft remains within the warning envelope for more than 3 seconds, an altitude gain function is started. Even though the closure rate has been corrected the terrain lights will remain illuminated until the aircraft has gained 300 feet barometric altitude or 45 seconds have been elapsed, from when the aircraft exited the PULL UP envelope.

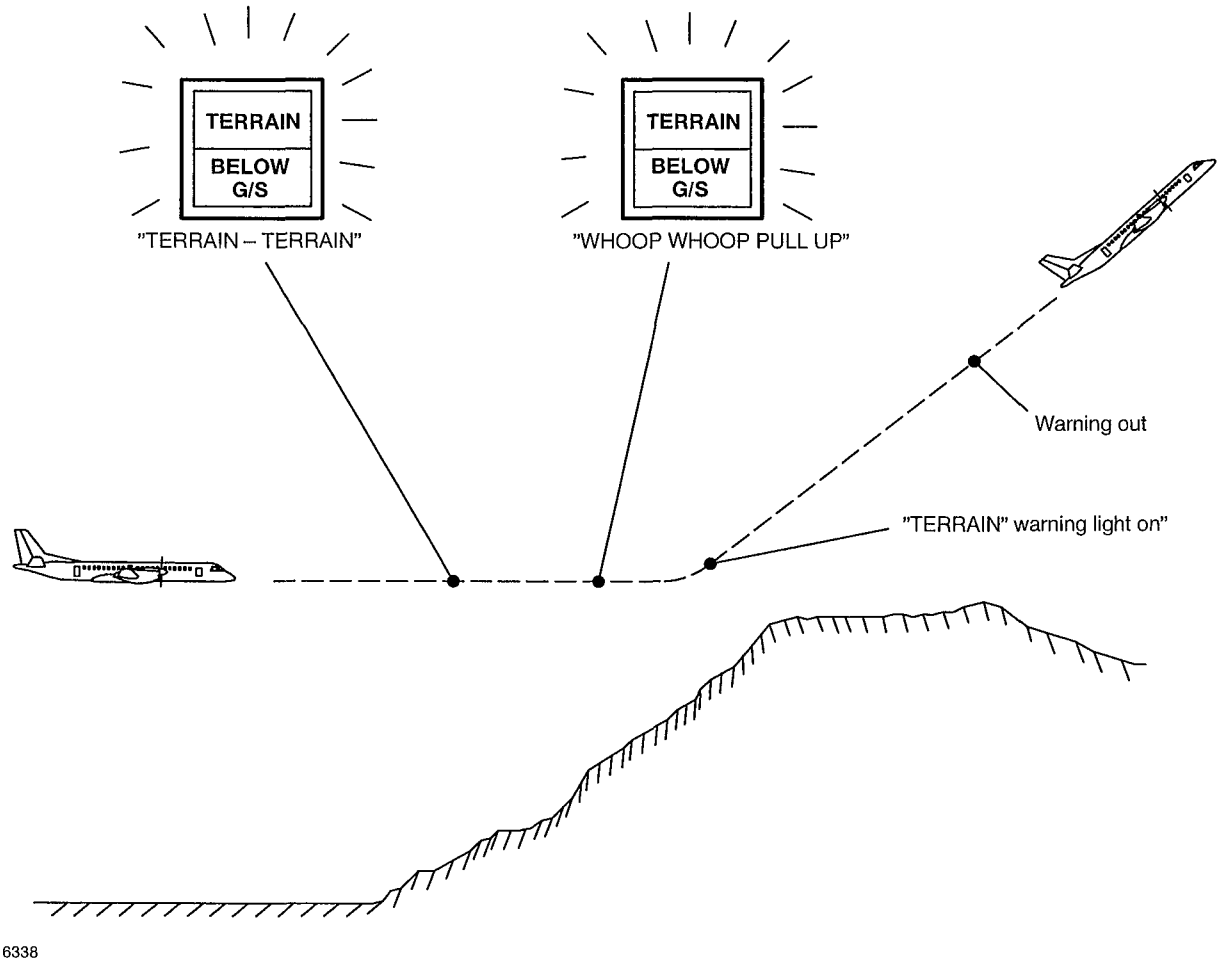


Fig.4. Excessive terrain closure rate – schematic.

MODE 2B – EXCESSIVE TERRAIN CLOSURE RATE FLAPS IN LANDING CONFIGURATION .

When the flaps are in the landing configuration, the aircraft is on ILS approach within ±2 dots of the Glideslope centerline or for the first 60 seconds after take–of the TAWS switches to mode 2B and the warning envelope is modified.

When the envelope boundary conditions for mode 2B is violated, the TERRAIN /BELOW G/S and TERRAIN lights come on. The voice message is repeated until boundary is exited. If the gears or flaps are up, the aural message will be"TERRAIN TERRAIN", followed by "PULL UP" if the condition persists. If both gear and flaps are in landing configuration the aural message will be "TERRAIN TERRAIN", and only the TERRAIN / BELOW G/S lights will come on.

To avoid nuisance mode 2A alerts due to erroneous radio altitude tracking during take–off climb, mode 2B is automatically selected during the first 60 seconds after take–off.

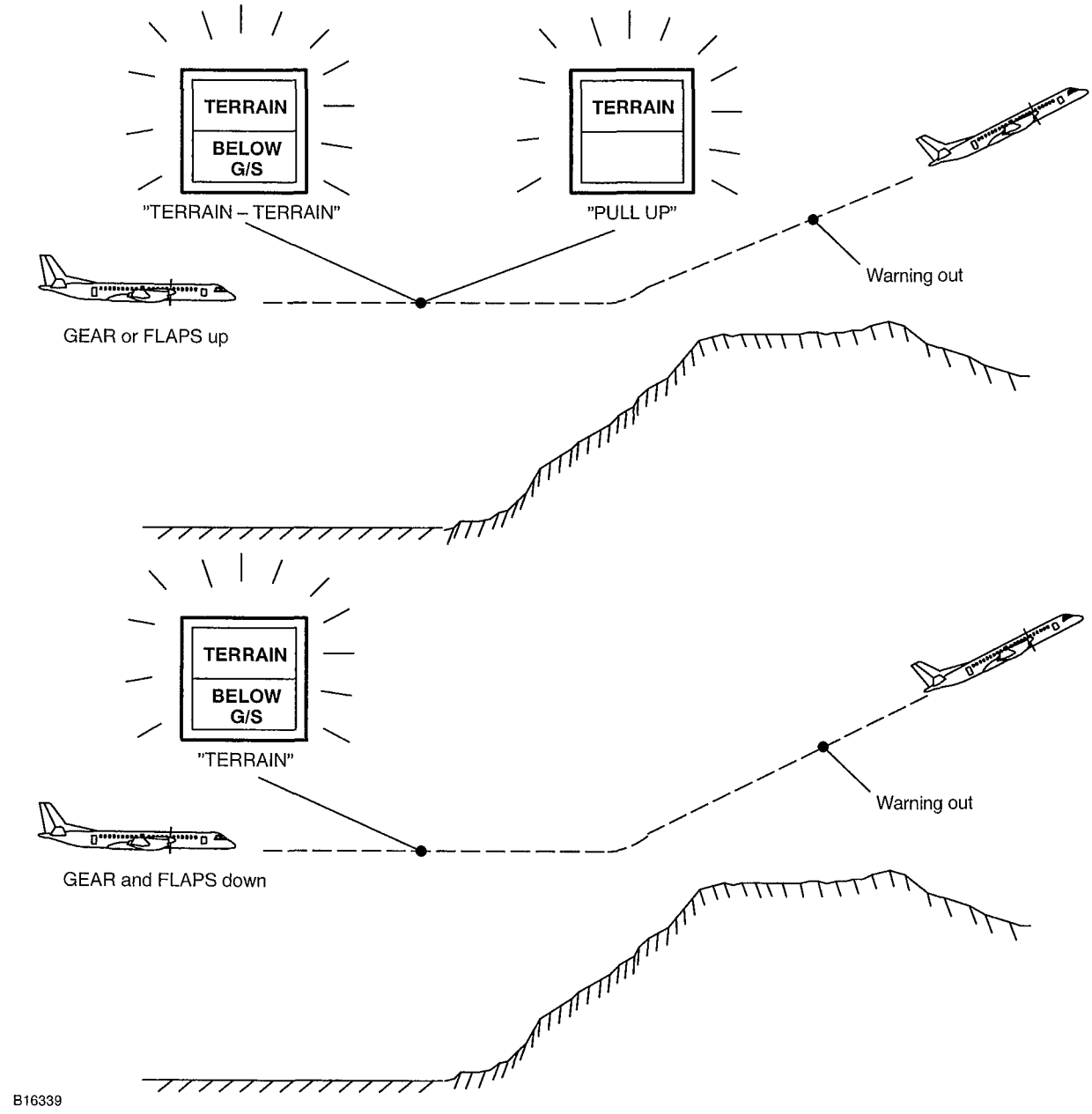


Fig.5. Excessive terrain closure rate – schematic.

MODE 3 – LOSS OF ALTITUDE AFTER TAKEOFF.

This mode warns for unintentional loss of barometric altitude after take off and is enabled between 30 and 1500 feet. The loss of altitude required to trigger this mode varies with height above terrain. When the warning envelope is penetrated, the TERRAIN BELOW G/S lights flashes and an aural warning "DON'T SINK" is given.

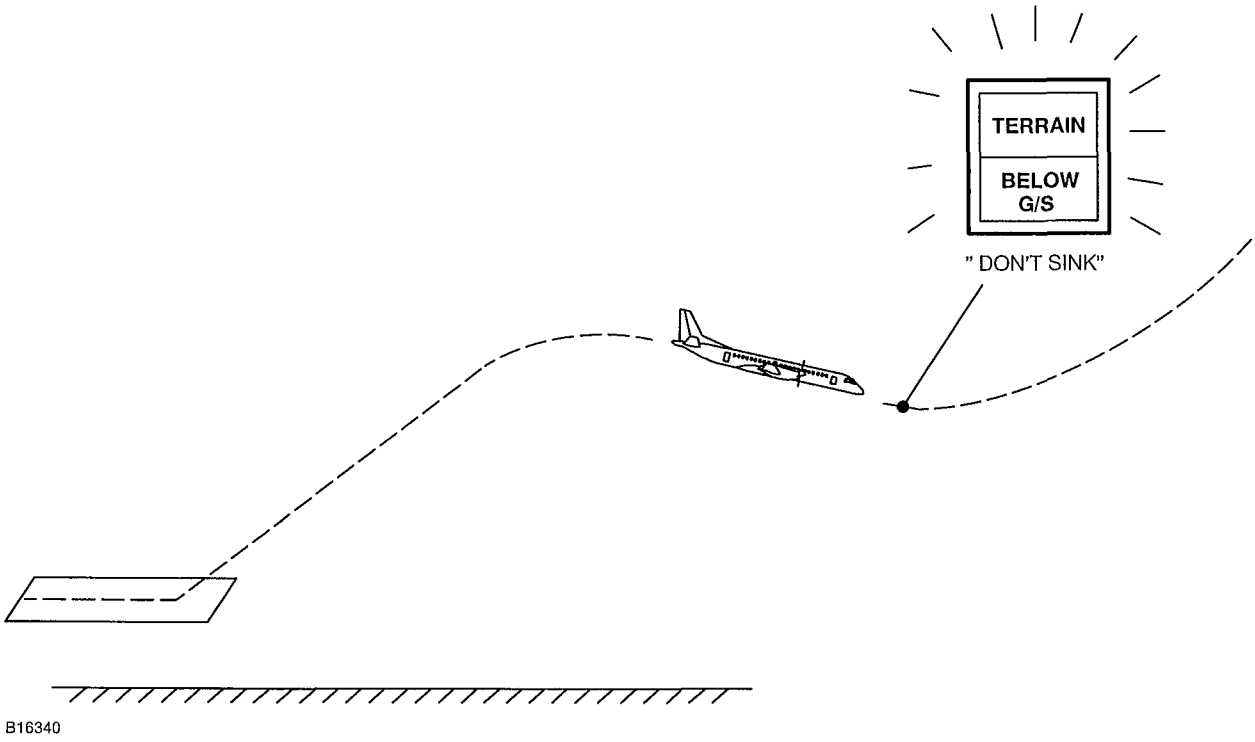


Fig.6. Loss of altitude after takeoff – schematic.

MODE 4A – UNSAFE TERRAIN CLEARANCE WITH GEAR UP.

The warning for unsafe terrain clearance is generated if the aircraft descends below a pre–determined altitude with the landing gear not down and locked. With a speed below 190 knots and below 500 feet the TERRAIN / BELOW G/S lights flashes and the aural warning "TOO LOW GEAR" sounds. Further warnings are held until additional 20% radio altitude are lost. If the speed is above 190 knots the aural warning "TOO LOW TERRAIN" sounds. In this condition the warning threshold increases linearly with airspeed to a maximum of 1000 feet above terrain at 250 knots. The warning is cancelled when the warning conditions are corrected by extending the landing gear.

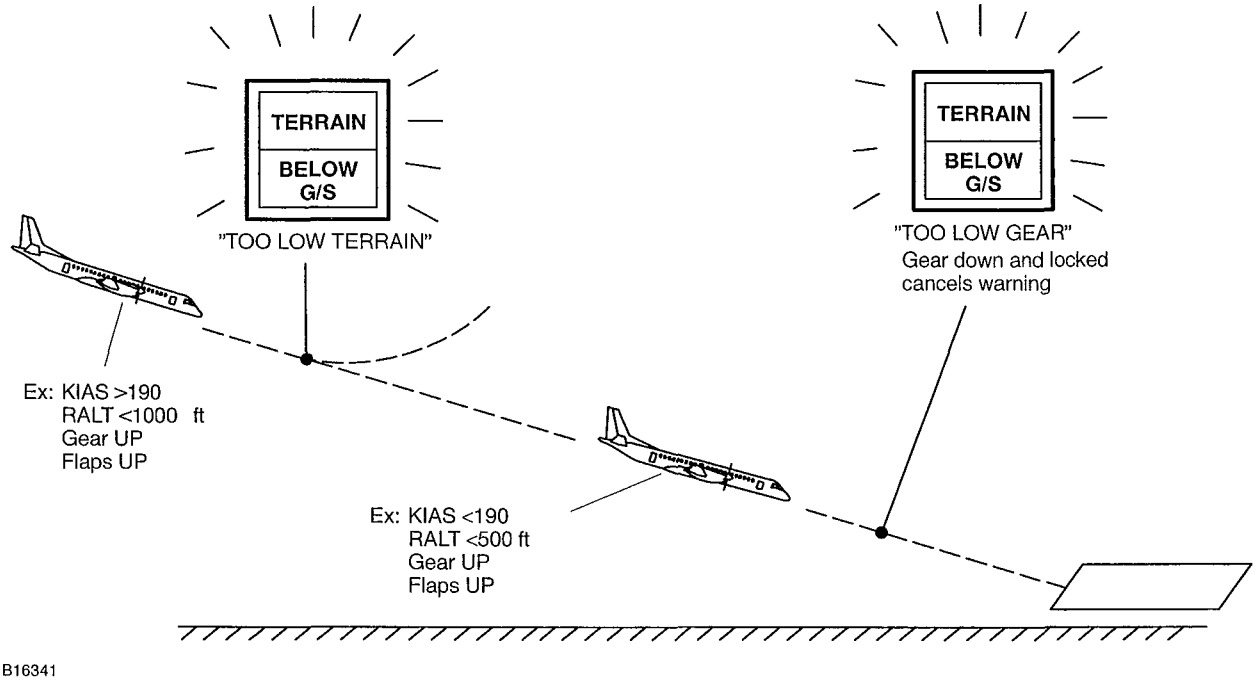


Fig.7. Unsafe terrain clearance with gear up – schematic.

MODE 4B – INADVERTENT PROXIMITY TO TERRAIN WITH GEAR DOWN AND FLAPS UP.

This mode warns either for proximity to terrain outside the approach area or flaps not being in landing position during approach. The mode becomes enabled when the gear is locked down and the flaps are up. With a speed below 148 knots and when aircraft descends below 150 feet, the TERRAIN / BELOW G/S LIGHTS flashes and an aural warning "TOO LOW FLAPS" sounds. Further warnings are held until additional 20% radio altitude is lost. At speeds above 148 knots the aural warning is changed to "TOO LOW TERRAIN" and the warning threshold increases linearly with airspeed to a maximum at 1000 feet above terrain at 250 knots. If landing with flaps not in landing position has been decided, selecting GPWS FLAP pushbutton to OFF will exit the warning envelope.

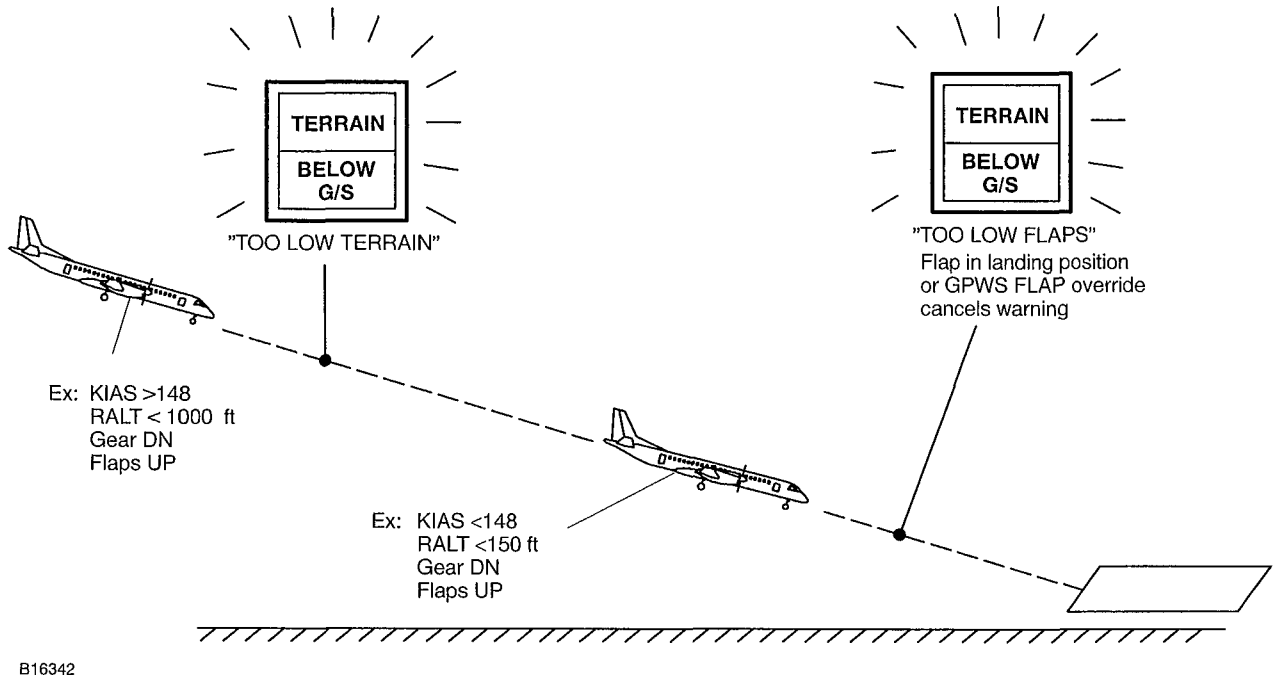


Fig.8. Inadvertent proximity to terrain with gear down and flaps up – schematic.

MODE 4C TERRAIN CLEARANCE DURING TAKEOFF

Mode 4C warns for inadvertent descend or too shallow climb towards rising terrain in the takeoff area.

Mode 4C provides a warning based on minimum radio altitude clearance during takeoff. Mode 4C is based on a minimum terrain clearance that increases with radio altitude during takeoff. A value equal to 75% of the current radio altitude is accumulated in a long term filter that is only allowed to increase in value. If the radio altitude should later decrease, the filter will store its maximum attained value. Further decrease of radio altitude below the stored filter value with Gear or Flaps up will cause the TERRAIN / BELOW G/S lights to come on flashing and the aural warning "TOO LOW TERRAIN" sounds. Further aural warning are held until additional 20% radio altitude is lost. This continues until corrective action is taken.

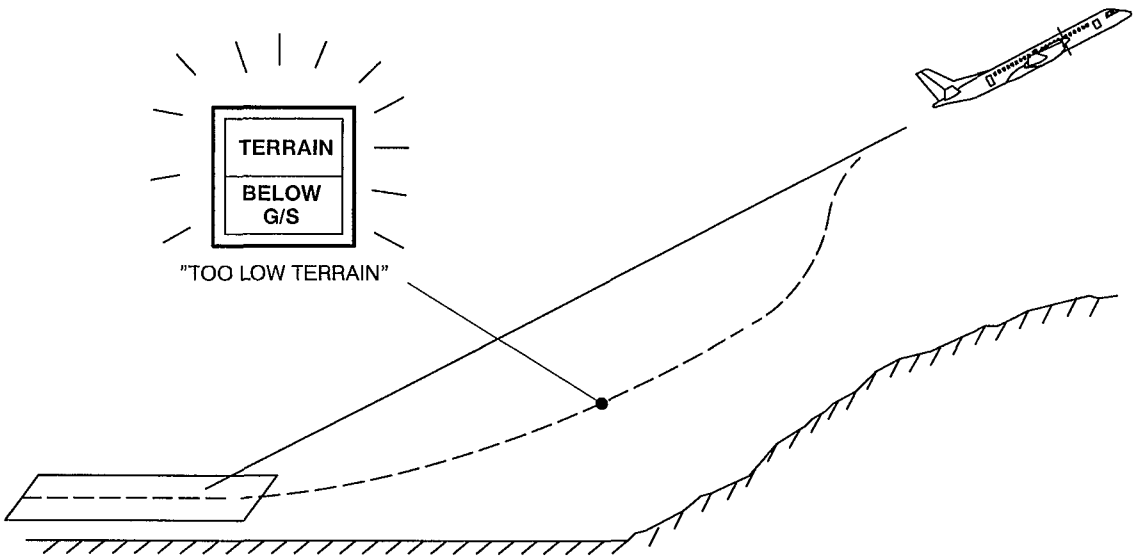


Fig.9. Terrain clearance during takeoff – schematic.

MODE 5 – DESCENT BELOW GLIDESLOPE.

This mode warns for unintentional deviation below the ILS glideslope. The mode becomes enabled when an ILS frequency is selected, the gear is down and between 30 and 1000 feet RALT

The warning envelope consists of two envelopes. On penetration of the outer envelope, below 1.3 dots, the TERRAIN / BELOW G/S caution light illuminate and the aural warning "GLIDESLOPE" is given once with a soft volume. If aircraft descends lower on the glideslope beam by approximately 20% (dots of deviation) , an additional message is given. The amount of glideslope deviation necessary to initiate an alert is increased below 150 feet to eliminate nuisance alerts caused by large deviation signals when the aircraft is close to the ILS transmitter. If no corrective action is taken and the inner envelope is penetrated (the deviation has exceeded 2 dots and the aircraft is below 300 feet RALT), the volume of the aural "GLIDESLOPE" warning will increase with 6dB and the message is continuously repeated.

To allow descend below glideslope, Mode 5 can be inhibited when radio altitude is below 1000 feet by pressing the pilot's or co–pilot's TERRAIN / BELOW G/S switch. Climb to a height above 1000 feet reactivates mode 5 again, even if it has been inhibited.

Mode 5 is inhibited in following cases:
- ILS frequency not selected.
- Landing gear not extended and locked.
- Glideslope validity signal not present.
- Aircraft not between 30 and 1000 feet.
- Inappropriate descent rate compared to altitude between 500–1000 feet when ILS is captured.
- The TERRAIN / BELOW G/S switch pressed between 30 and 1000 feet.

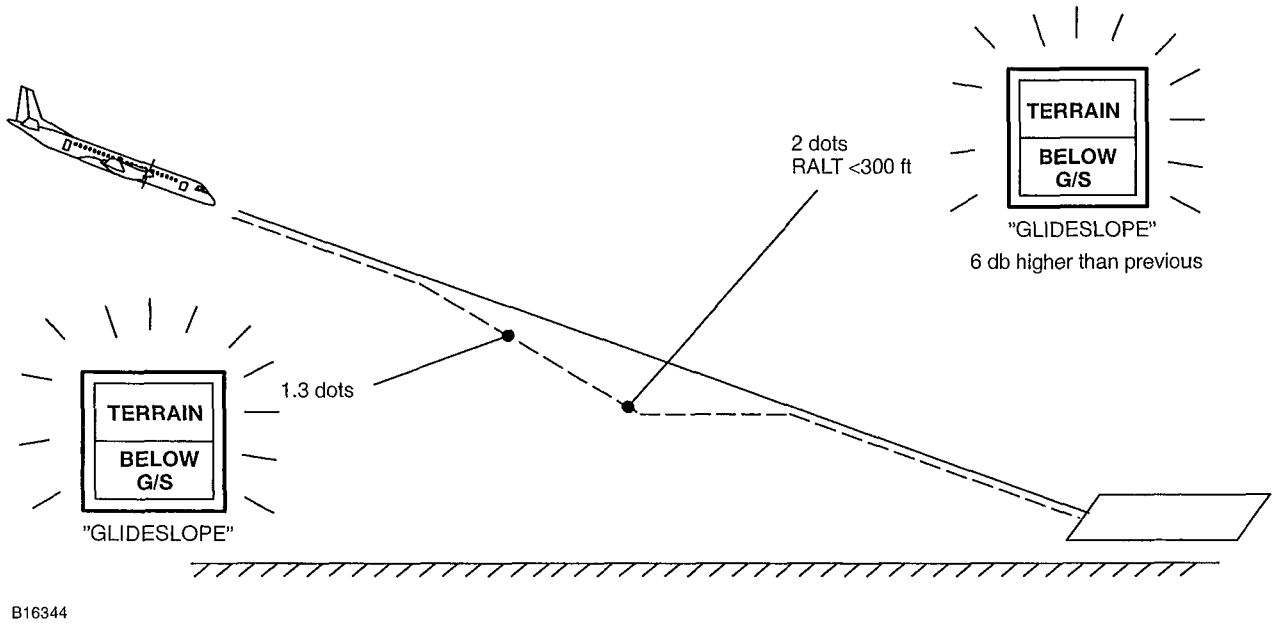


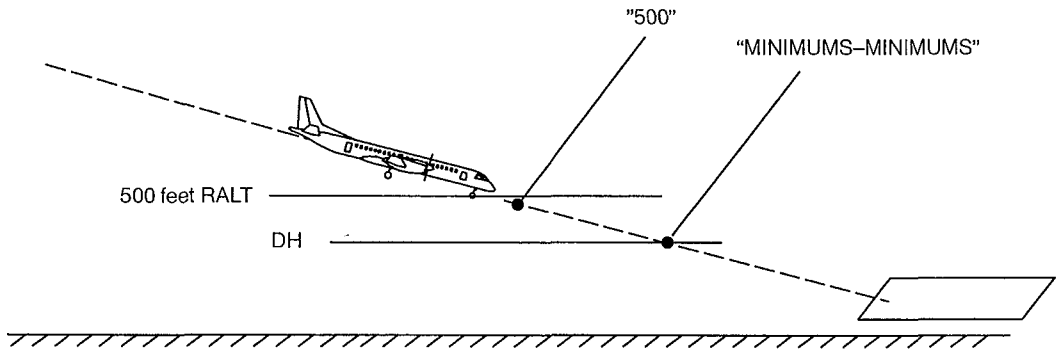
Fig.10. Descent below glideslope – schematic.

MODE 6 – ALERTS (ALTITUDE CALLOUT)

For the basic altitude callouts an aural callout is given when the aircraft descends below 500 feet radio altitude. At decision height the aural alert "MINIMUMS–MINIMUMS" is given. There are no visual alerts accompanied with this altitude callout.

For the optional and HUD/CAT III altitude callouts an aural callout is given when the aircraft descends below 1000, 500, 400, 300, 200, 100, 50, 40, 30, 20 and 10 feet radio altitude. At decision height the aural alert "MINIMUMS" is given. There are no visual alerts accompanied with this altitude callout.

Basic altitude callouts



HUD/CAT III altitude callouts

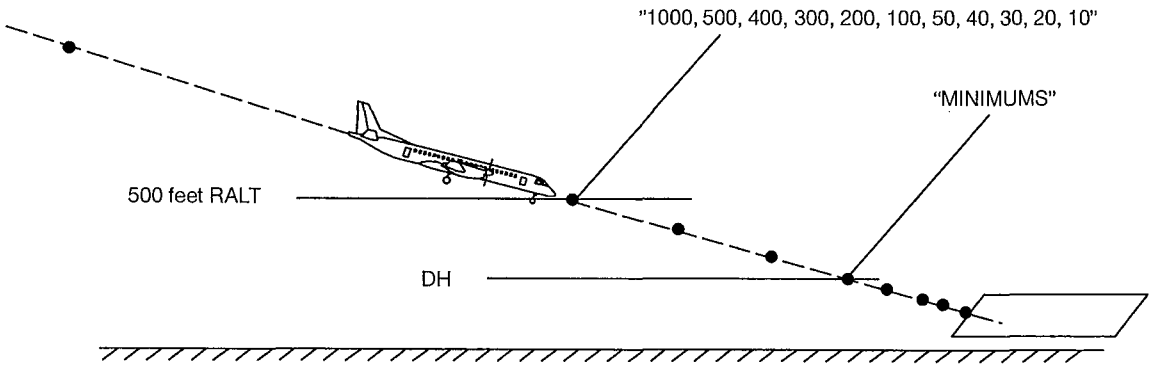


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Fig.11. Altitude callout – schematic

MODE 6 – ALERTS (BANK ANGLE ALERT)

An alert logic for excessive bank angles provides protection during maneuvring on approach or climbout. The roll angle limit for the bank angle alert varies linearly from 10 degrees at 30 feet to 40 degrees at 150 feet. From 150 feet the roll limit remains 40 degrees.
When the aircraft roll limit exceeds the envelope limit, two voice messages "BANK ANGLE" is given. If the roll angle increases by an additional 20% the message will be repeated twice. Should the roll angle exceed 44% of the initial threshold, the messages will be repeated every three seconds. There are no visual alerts accompanied with the bank angle alerts.

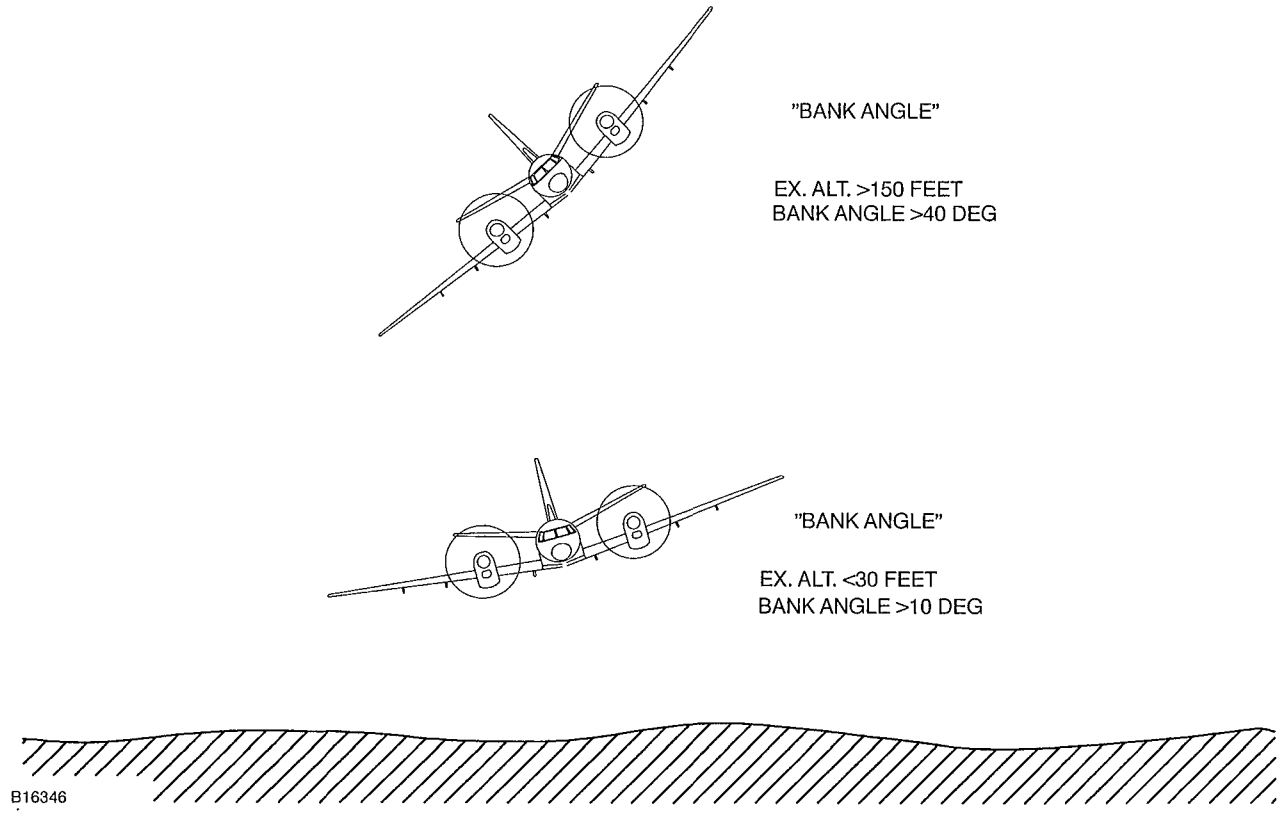

Fig.12. Alerts (Bank Angle Alert).

PREMATURE DESCENDS WARNING

The Premature descends warning provides warning for insufficient terrain clearance even with the aircraft in landing configuration. The alert envelope is based on a Terrain Clearance Floor (TCF) which is a circular band centered over the runway. Close to the runway the envelope is 0 and expands up to 700 feet at around 15 nautical miles plus position error from the selected runway. Close to the runway there is an improved alert envelope, with increased protection if the aircraft has a large deviation from runway centerline. When it is determined that the aircraft is to the side of the runway, the TCF curve is limited to a minimum value of 245 feet. The TCF alert envelope also provides protection for cases when runway is at high elevation, compared with the terrain below the approach path. In this case the radio altitude show larger margin than the aircraft actually has compared with runway elevation.

When the aircraft penetrates the alert envelope, the aural message "TOO LOW TERRAIN" is given and the TERRAIN / BELOW G/S lights flashes. For each 20% degradation in radio altitude from the initial penetration, an additional aural message will be given. The TERRAIN lights will be activated until alert envelope is exited.

The database includes all runways in the world greater than or equal to 3500 feet in length.

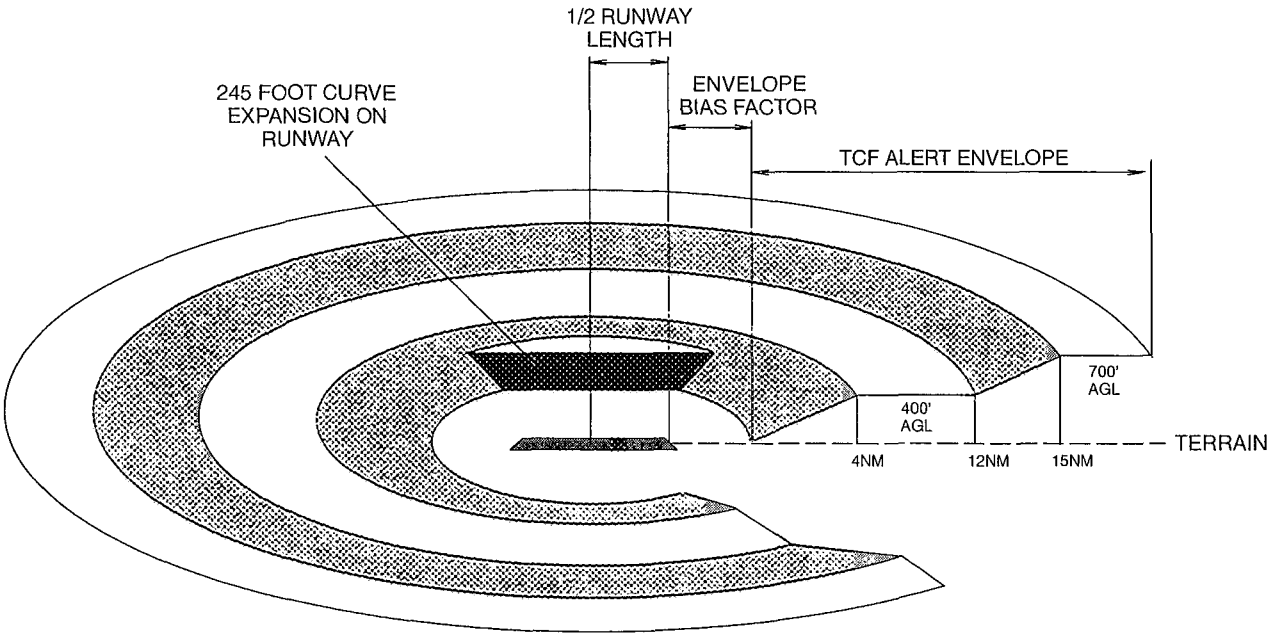

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Fig.13. TCF Alert Envelope – Schematic.

FORWARD LOOK–AHEAD WARNING

The forward look–ahead algorithm is used to predict any potential conflict between the aircraft's intended ground track and terrain or obstacle. Terrain or obstacle threats are recognized and annunciated when terrain or obstacles violates specific computed envelope boundaries forward the aircraft path. When the TAWS detects a terrain or obstacle threat in conflict with the flight path, an aural message "TERRAIN AHEAD" or "OBSTACLE AHEAD" is given twice minimum 40 seconds before predicted impact. This message is repeated after 7 seconds, if the terrain or obstacle is still in conflict with the flight path. This message is accompanied by flashing TERRAIN / BELOW G/S lights and terrain or obstacle threat image on the ND in solid amber areas. When corrective action is taken and no threat is present, the TERRAIN / BELOW G/S lights extinguish and the presentation of the amber solid areas on the terrain image goes away.

Minimum 15 seconds before predicted impact and if corrective action is not taken, an aural "TERRAIN AHEAD PULL UP" or "OBSTACLE AHEAD PULL UP" message is generated. The TERRAIN lights start flashing and a display of the terrain or obstacle threat on the ND in red solid areas. The "PULL UP" message is repeated until corrective action is taken.

> NOTE
> Alerts/warnings for man made obstacles will not be given if such obstacle data is not included in the database.

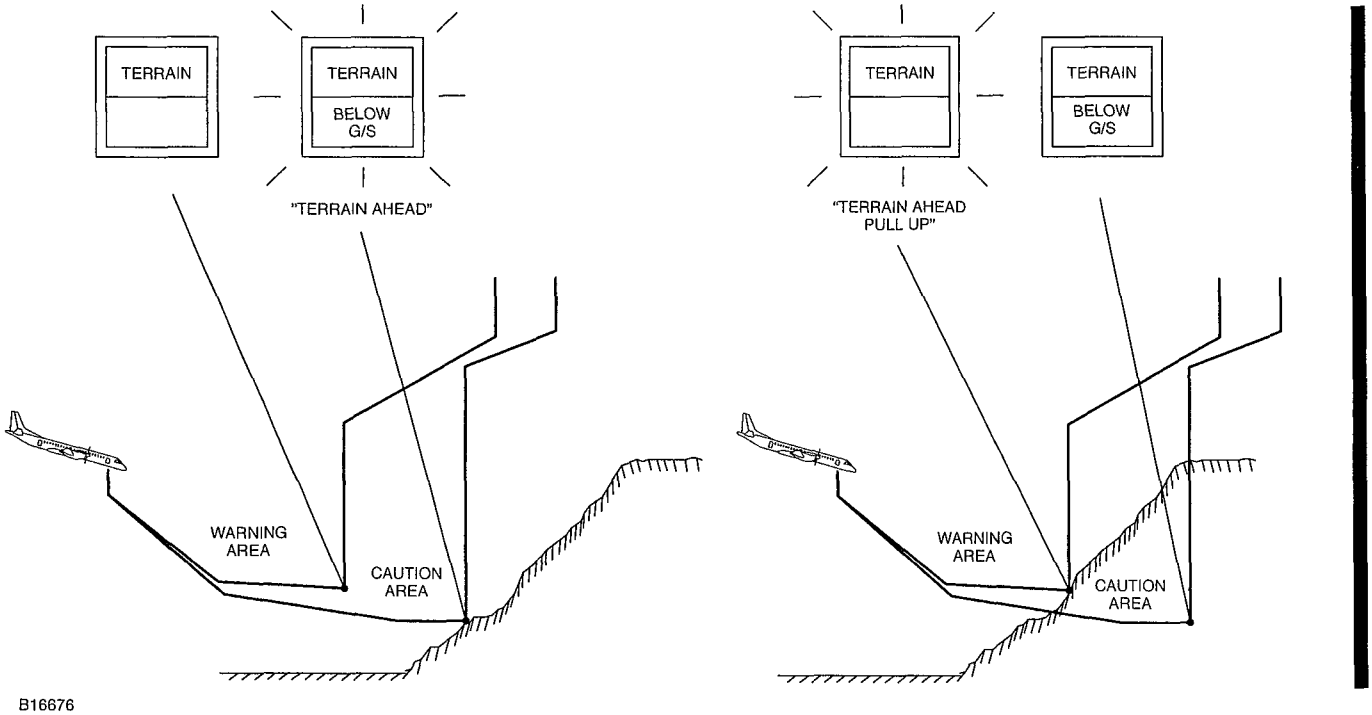

Fig.14. Forward Look–Ahead Warning – Schematic.

3. CONTROLS AND INDICATORS.

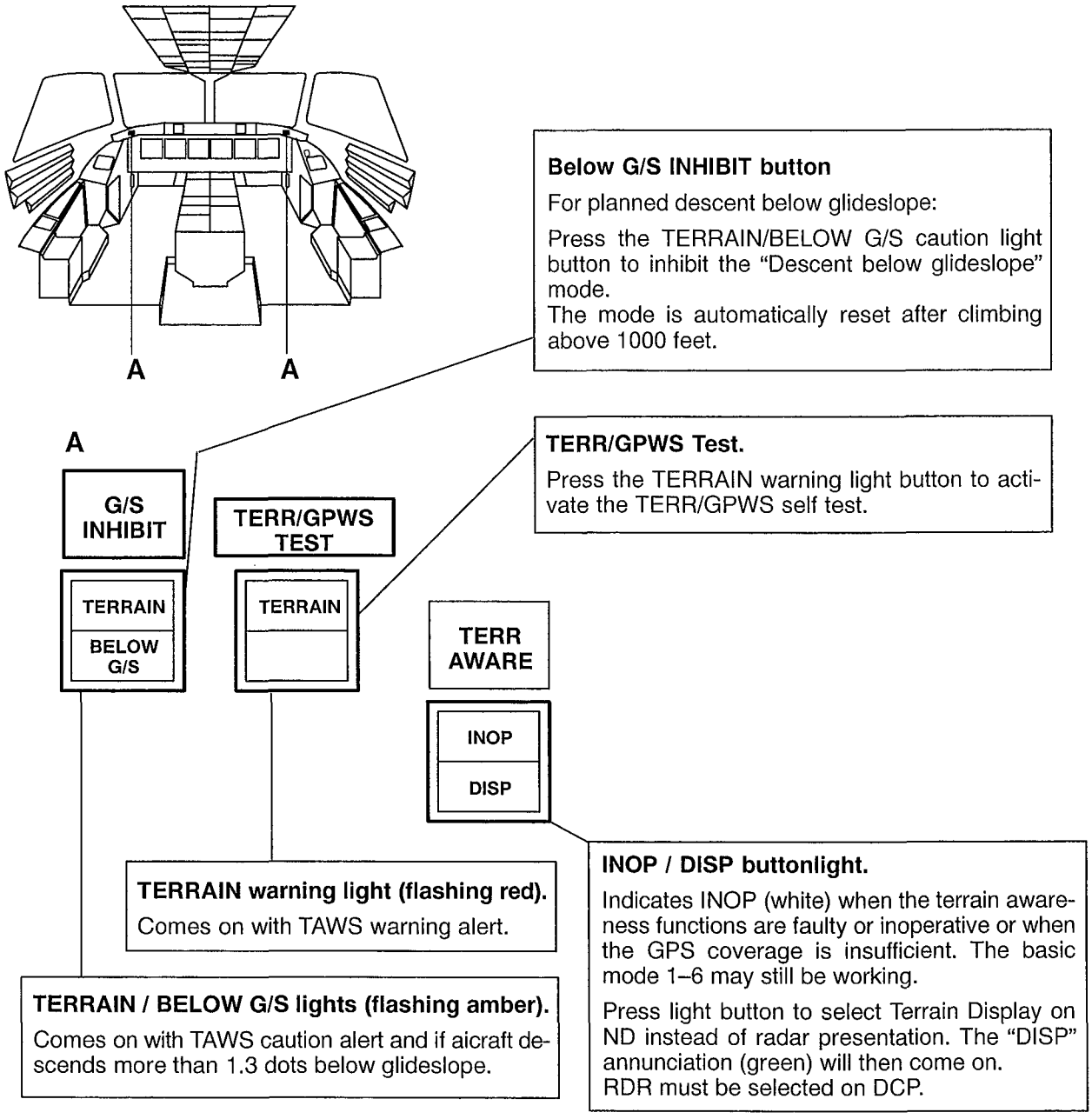

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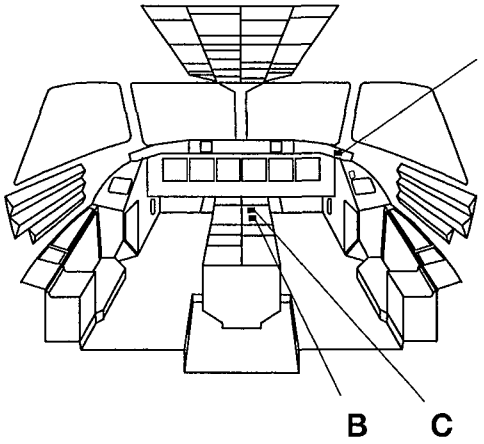
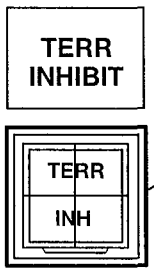
Fig.15. TAWS indications and buttonlights.



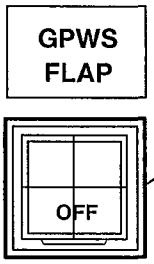
A



TERRAIN INHIBIT buttonlight (guarded).

Press the Terrain Inhibit to inhibit the terrain awareness functions at areas not covered by the terrain database.

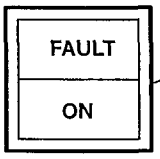
B



GPWS FLAP buttonlight (guarded).

Lift cover and push button to simulate flap down position and to eliminate the "TOO LOW FLAPS" warning at landings without landing flap selected. The white message GPWS FLAP OVRD willl be displayed on EICAS SED.

C



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Steep Approach pushbutton.

Select to arm the steep approach function. This adjusts the SINK RATE warning level. On will be displayed in white and STEEP APPROACH ON will also be presented on SED.

FAULT will be displayed in amber if the steep approach function is inoperative. An amber caution message STEEP APPROACH FAIL will also be presented on PED.

Fig.16. TERR INHIBIT, GPWS FLAP and Steep Approach buttonlights.

4. ELECTRICAL POWER SUPPLY.

TAWS power	L AVIONIC BUS	F–20	TERR/GPWS PWR
Terrain display and flap override	L BAT BUS	F–19	TERR/GPWS DISP/FLAP