GENERAL

The navigation systems calculate and display the attitude, altitude and position of the aircraft, based on data from other aircraft systems, ground stations, and sensed environmental conditions around the aircraft. The displayed information includes aircraft movement, distance, speed and direction of travel about all three axes. The present position and computed future positions can also be displayed.

This chapter will cover:

- Inertial reference system (IRS)
- Weather radar system
- Terrain awareness warning system (TAWS)
- VHF navigation system
- Distance measuring equipment (DME) system
- Automatic direction finder (ADF) system
- ATC transponder
- Traffic alert and collision avoidance system (TCAS II)
- Global positioning system (GPS)
- Flight management system (FMS)

INERTIAL REFERENCE SYSTEM (IRS)

Description

The Honeywell Laseref V micro inertial reference system (IRS) uses digital ring laser gyros to compute attitude, heading, angular rates, linear accelerations, vertical velocity and present position information. The IRS interfaces with the following aircraft systems:

- Electronic flight instrumentation system (EFIS);
- Weather radar;
- Automatic flight control system (AFCS);
- Flight data recorder (FDR);
- Terrain awareness warning system (TAWS);
- Traffic alert and collision avoidance system (TCAS);
- Stall protection system (SPS);
- Aircraft fuel system; and
- Flight management system (FMS).

Alignment

The IRS requires an initialization process that establishes the relationship between the aircraft body frame and the local geographic reference. Thus, a valid input of initial latitude and longitude is necessary in order to achieve this initialization process or alignment.

If GPS position is available, the IRSs will start aligning automatically using GPS position. No crew action is required. If GPS is not available, initial position (LAT/LONG) must be entered manually in the POS INIT page of the FMS CDU.

During IRS initialization on ground, the IRS ALIGNING/DO NOT TAXI message appears on the PFDs. The aircraft should be stationary. Excessive aircraft movement may extend the time needed to successfully align the IRS.

INERTIAL REFERENCE SYSTEM (IRS) (CONT'D)

After successful alignment, the message on the PFD is removed, and the IRS automatically sequences into navigation mode.

IRS Standard Alignment Time

5.0 minutes	At 0.0° latitude
10.0 minutes	At ±60.0° latitude
10.0 minutes	At ±60.0° < latitude < ±70.24°
17.0 minutes	At ±70.24° < latitude < ±78.25°

In-Flight Alignment

If a power interruption or a transient system fault occurs in-flight, and a GPS signal is valid, the IRS system will have the capability for re-alignment. During in-flight re-alignment, the IRS ALIGNING message appears on the PFDs.

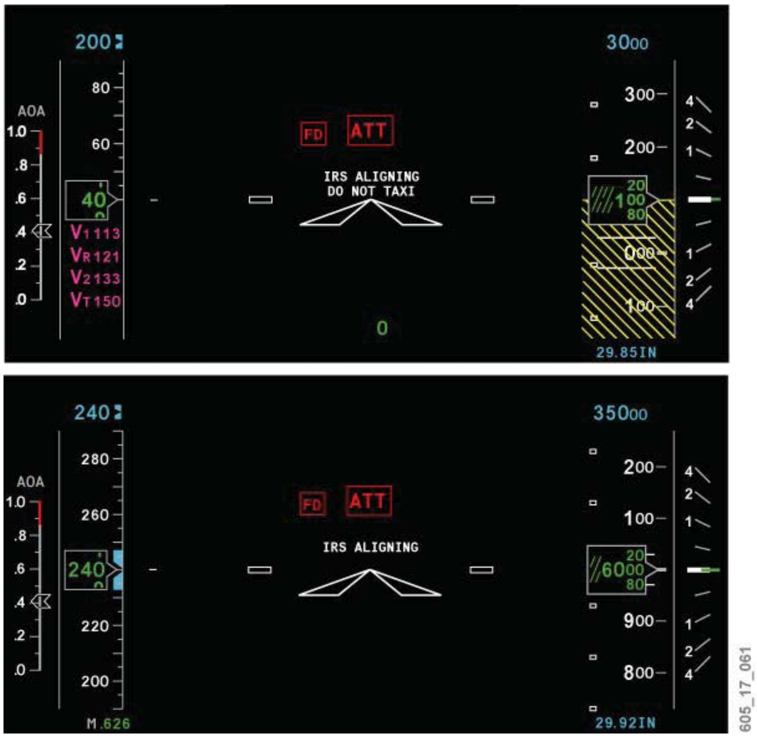
The FMS will prompt the crew with the SET IRS HDG amber message on the FMS CDU scratchpad (required for FMS navigation – IRS will align without this action). If the crew enters a heading, the IRS will work as a DG until it transitions to the ATT mode, at which point it starts calculating its own HDG.

Typically, the time required for a full alignment in navigation mode is between 10 to 20 minutes. At the beginning of the alignment process, it is recommended that the aircraft maintain a straight and level flight attitude (see Note 1).

NOTE

1. Aircraft maneuvers involving changes in heading increase the alignment time.
2. The alignment time increases as a function of latitude, with the minimum time occurring at the equator, and the maximum time occurring at the poles.

INERTIAL REFERENCE SYSTEM (IRS) (CONT'D)



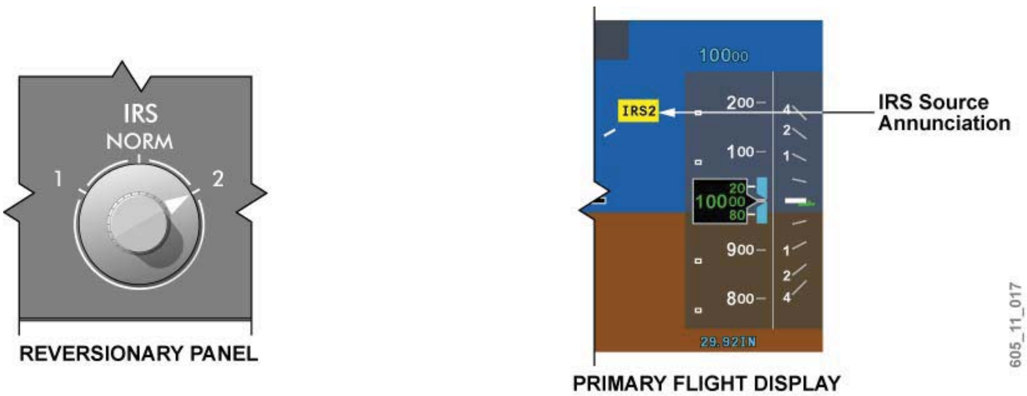
PFD IRS Aligning Annunciations
Figure 17–10–1

IRS Reversionary Function (Dual IRS Configuration)

When NORM is selected, the pilot and copilot electronic flight displays receive data from their individual onside IRS.

When 1 is selected, the pilot and copilot electronic flight displays receive data from IRS 1 only. A yellow source message is displayed on the PFD and/or MFD.

When 2 is selected, the pilot and copilot electronic flight displays receive data from IRS 2 only. A yellow source message is displayed on the PFD and/or MFD.



IRS Reversionary Annunciation (Dual IRS Configuration)
Figure 17–10–2

INERTIAL REFERENCE SYSTEM (IRS) (CONT'D)

IRS Reversionary Function (Triple IRS Configuration)

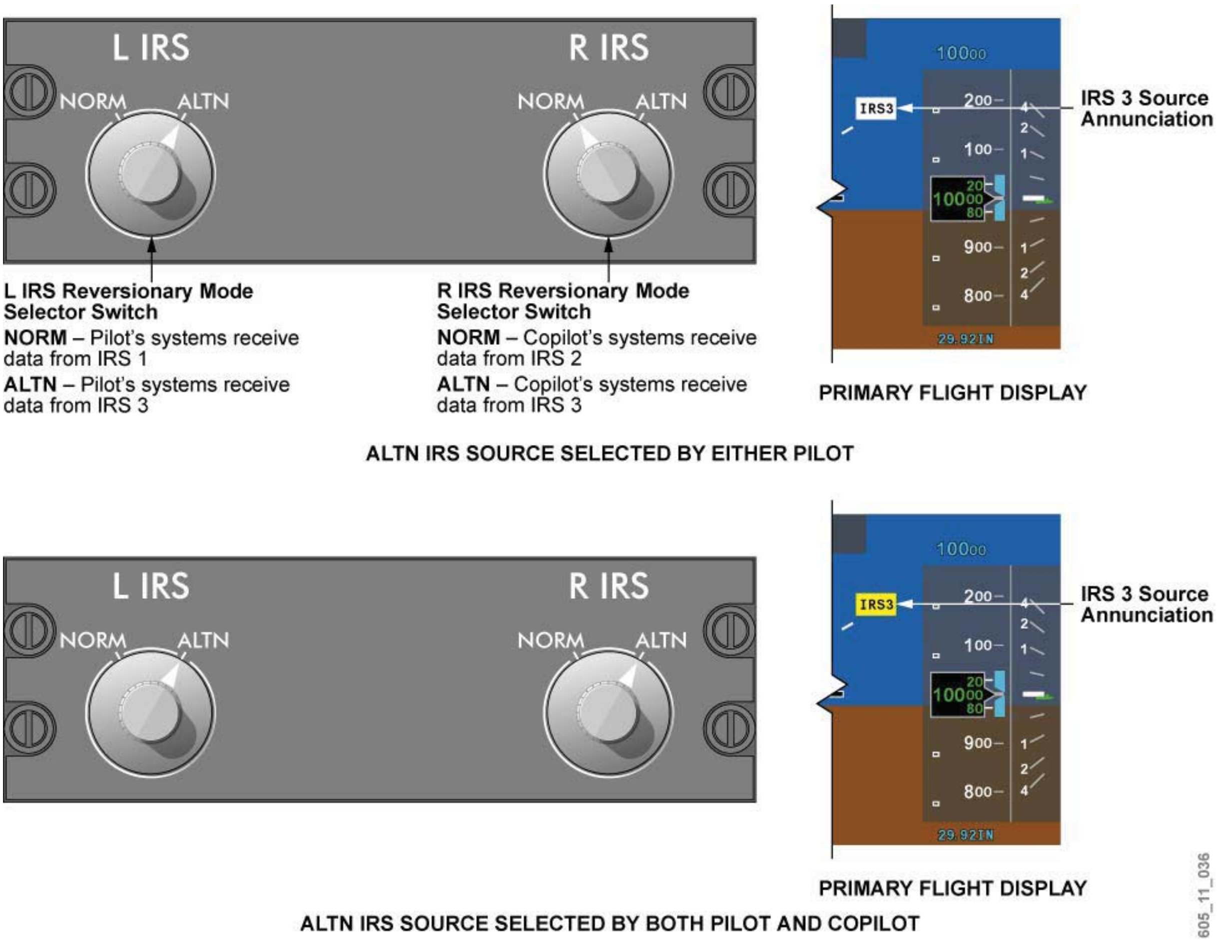
An optional third IRS may be installed to supply an auxiliary source of inertial data, to increase dispatch and enroute reliability. Thus, an alternate sensor reversion panel (IRS/FMS reversionary panel) is also installed in the center pedestal.

When both L and R IRS rotary switches are selected to NORM, the pilot and copilot electronic flight displays receive data from their individual onside IRS sensor.

When the L IRS switch is selected to ALTN, the pilot electronic flight displays receive data from IRS 3 only. An IRS 3 annunciation is displayed on the left PFD, left of the altimeter tape.

When the R IRS switch is selected to ALTN, the copilot electronic flight displays receive data from IRS 3 only. An IRS 3 annunciation is displayed on the right PFD, left of the altimeter tape.

When ALTN IRS is selected by both the pilot and copilot, a yellow IRS 3 annunciation is displayed on both L and R PFDs.



IRS Reversionary Annunciation (Triple IRS Configuration)
Figure 17–10–3

INERTIAL REFERENCE SYSTEM (IRS) (CONT'D)

EICAS Messages

MESSAGE	MEANING
IRS 3 ALIGNING	IRS 3 is in align mode or ATT mode with no IRS 3 INOP status message.
IRS 1 (2) (3) POWER FAULT	Indicates the respective IRS DC power supply failed.
IRS 1 (2) (3) IN ATT	Indicates the respective IRS is operating in attitude mode.
IRS 3 INOP	Indicates a failure of IRS 3.

WEATHER RADAR SYSTEM

Description

The Collins WXR–854 is a solid-state, low-power, X-band weather radar system. The radar detects wet precipitation and precipitation-related turbulence along the flight path of the aircraft. A ground mapping function is incorporated to assist with navigation. In addition, a target alert function (TGT) allows the radar to automatically search for heavy rainfall returns and provide an alert to the pilot.

An optional lightning detection system may be installed, and is presented on the weather radar displays.

The weather and map information can be overlaid on ROSE and PPOS navigation formats of either or both PFDs and MFDs.

Receiver Transmitter Antenna (RTA)

The receiver transmitter antenna is an integrated unit with a 14-inch flat-plate antenna. The radar scan is ±60 degrees of the aircraft heading, and the selectable antenna tilt angle is ±15 degrees above and below the horizontal.

The RTA is powered by DC bus 1.

Weather Radar Controls

Weather radar controls are provided by the DCPs. These controls are:

- Radar menu (RDR MENU) pushbutton
- RADAR pushbutton
- RANGE/TILT/PUSH AUTO TILT button
    - RANGE knob
    - TILT knob
    - PUSH/AUTO/TILT button

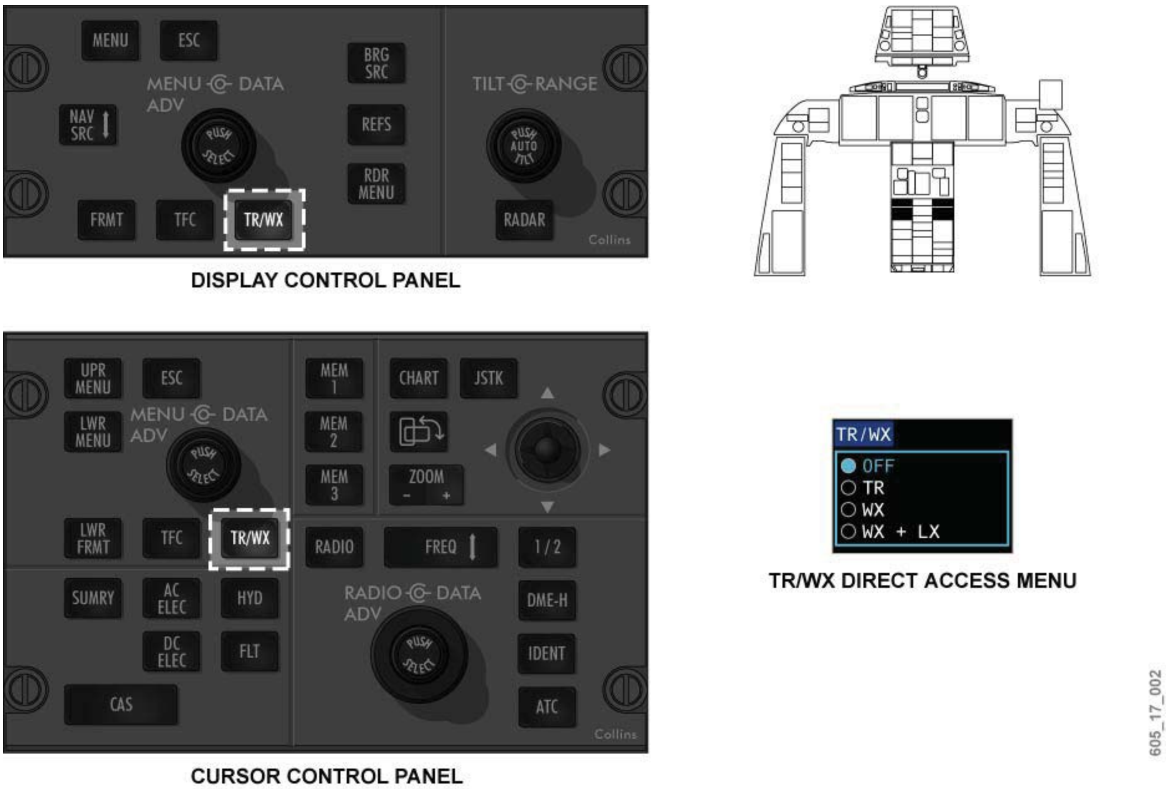
WEATHER RADAR SYSTEM (CONT'D)

Display Control Panel (DCP) – Weather Radar Controls
Figure 17–10–4

Each pilot and copilot PFD/MFD radar display is controlled by the on-side DCP, and is updated on alternate sweeps of the antenna. With two DCPs, the radar operates as two independent systems.

Overlay Controls

A dedicated multiple press TR/WX pushbutton is provided on both the DCP and CCP, to allow direct access to the list of radar and lightning overlays for display on the PFD/MFD navigation formats. The first press of the TR/WX pushbutton selects the next overlay available on the PFD. A subsequent press selects the next overlay available within the menu.

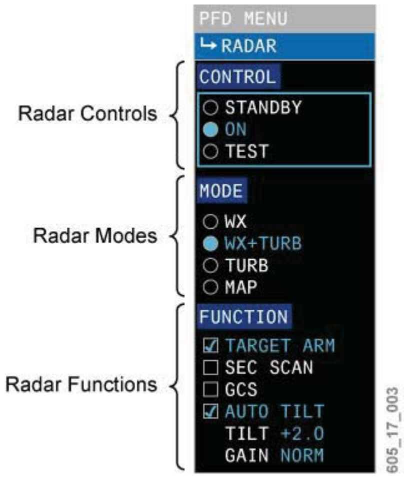


DCP & CCP TR/WX Direct Access Pushbuttons Menu
Figure 17–10–5

WEATHER RADAR SYSTEM (CONT'D)

RDR MENU Pushbutton

The RDR MENU pushbutton selects or deselects the RADAR menu on the PFD. The RADAR menu provides control, mode and function selections of the weather radar system. The items on the RADAR menu change using the MENU ADV/DATA/PUSH SELECT knob on the DCP (selection box method). The menu automatically times out after 20 seconds of inactivity.



PFD Weather Radar Menu
Figure 17–10–6

RADAR Pushbutton

This pushbutton turns the radar from STANDBY to ON, and from TEST or ON to STANDBY.

RANGE/TILT/PUSH AUTO TILT Knob

RANGE Knob

The RANGE inner knob decreases or increases the PFD and MFD navigation display range. The outer range ring of the navigation format (PPOS) is numbered with the selected range. The middle range ring of ROSE and PPOS formats indicates half the selected range. The available ranges are 5, 10, 25, 50, 100, 200 and 300 NM when weather radar is in use.

The pilot should keep in mind the blanked range area of the radar display in which weather targets are not shown. When potential weather is present and one of the longer ranges is selected, it is possible for weather targets to position within the blanked range area, and therefore not show on the display. The size of the blanked range area equals one eighth of the selected range.

SELECTED RANGE, NMI	HALF-RANGE ARC ANNUNCIATION	FULL-RANGE ARC ANNUNCIATION	BLANKED RANGE, NMI
5	2.5	5	0.6
10	5	10	1.2
25	12.5	25	3.1
50	25	50	6.3
100	50	100	12.5

WEATHER RADAR SYSTEM (CONT'D)

SELECTED RANGE, NMI	HALF-RANGE ARC ANNUNCIATION	FULL-RANGE ARC ANNUNCIATION	BLANKED RANGE, NMI
200	100	200	25.0
300	150	300	37.5

TILT Knob

The knob adjusts the pitch attitude of the weather radar antenna from +15° (full up) to –15° (full down).

The weather radar antenna tilt arc is 30 degrees above and below the horizon. Fifteen degrees is for manual tilt selection, and the remaining 15 degrees is for automatic stabilization. The system automatically adjusts the antenna tilt in response to aircraft pitch and roll attitude changes.

The selected tilt angle (–15° to +15°) is displayed on the weather radar mode line of the navigation display.

PUSH AUTO TILT Button

Pushing the PUSH AUTO TILT button in the center of the TILT/RANGE knob alternately selects or deselects automatic tilt. When selected, the antenna tilt is adjusted to maintain a constant tilt/range ratio as radar range selection is changed. The tilt angle readout, on the status line, is appended by “A” to indicate that automatic tilt is enabled. The antenna tilt is automatically adjusted when aircraft altitude or radar range is changed, which keeps a ground return at the same relative position on the display.

For example, if a ground return was indicated at 40 miles on a 50-mile range setting, it would show at 80 miles (4/5 of the display) if the range setting were changed to 100 miles.

RADAR Modes

As previously mentioned, the radar modes are selectable from the PFD weather radar menu (see Figure 17–10–6). Available modes are:

- STANDBY (from control section);
- TEST (from control section);
- WX;
- WX + TURB;
- TURB; and
- MAP.

STANDBY Mode

In STANDBY mode, the antenna stops transmitting and ceases to sweep.

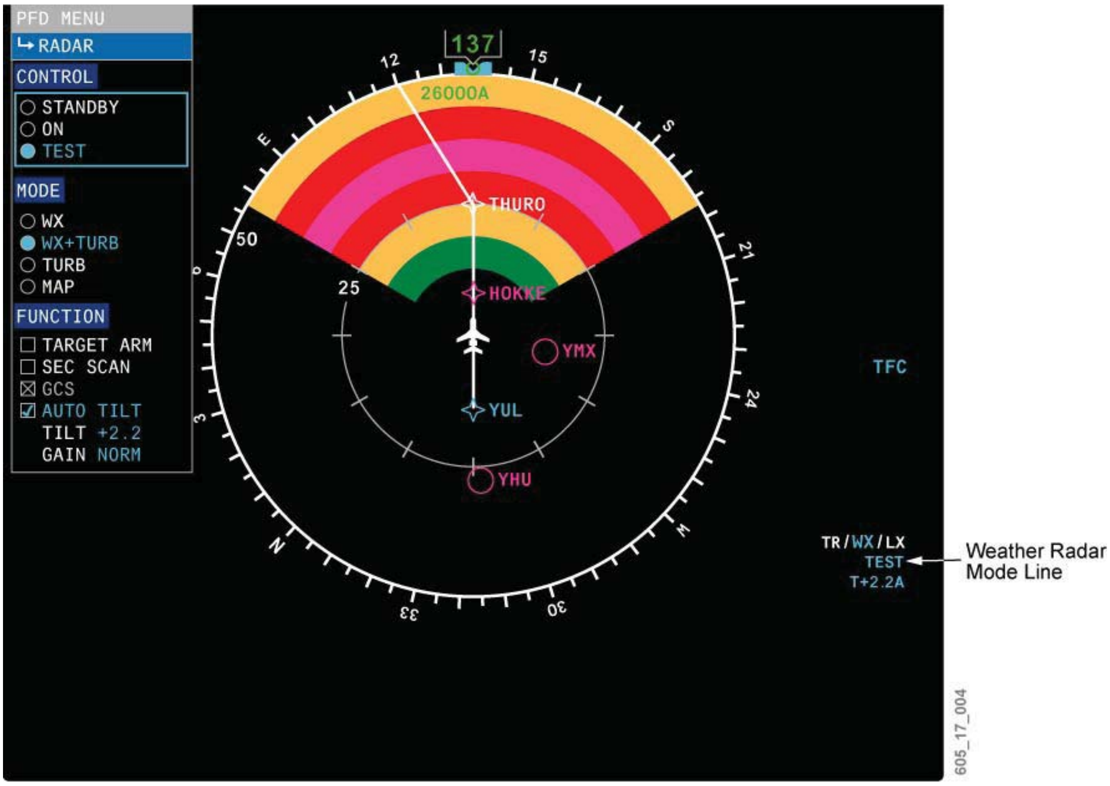
TEST Mode

In TEST mode, the weather radar system verifies that the display is capable of depicting the proper radar color palette.

Six colored arcs show on the display in TEST. The fifth arc changes between red and magenta on alternate sweeps.

WEATHER RADAR SYSTEM (CONT'D)

The transmitter is disabled in TEST mode, but antenna scan and tilt functions remain operational.



Weather Radar Test Display
Figure 17–10–7

WARNING

THE AREA WITHIN THE SCAN ARC, AND WITHIN TWO FEET OF AN OPERATING WEATHER RADAR SYSTEM, CONSTITUTES A HAZARDOUS AREA. DO NOT OPERATE THE SYSTEM IN ANY MODE OTHER THAN TEST WHEN THE ANTENNA MIGHT SCAN OVER PERSONNEL. DO NOT OPERATE THE RADAR INSIDE A HANGAR.

WX Mode

WX is the normal mode of weather detection. Detectable weather appears in different colors. The color code map of the weather returns is dependent on the precipitation rate and its reflectivity levels. Detectable weather appears as one of four colors: green yellow, red or magenta. The highest precipitation rates are represented in magenta.

WEATHER RADAR SYSTEM (CONT'D)

COLOR AND LEVEL	RAINFALL RATE	
	mm/hr	inches/hr
6	Turbulence	
5	PAC (Path Attenuation Correction)	
4 (Intense)	>51	>2.0
3 (Strong)	>12.7 - 51	>0.5 - 2.0
2 (Moderate)	>3.8 - 12.7	>0.15 - 0.5
1 (Weak)	>0.76 - 3.8	>0.03 - 0.15
0	>0.15 - 0.76	>0.006 - 0.03

Weak Storm - light to moderate turbulence, lightning possible
Moderate Storm - light to moderate turbulence
Strong Storm - severe turbulence, lightning possible
Intense Storm - severe turbulence, lightning, wind gusts, hail

605_17_WX

Weather Radar Display Levels
Figure 17–10–8

WX + TURB Mode

In WX + TURB mode, weather and turbulence detection are combined, so that return signals can be received for precipitation and precipitation-related turbulence.

The highest precipitation rates and turbulence show in magenta.

WX + TURB is operational for ranges less than or equal to 40 NM. When ranges greater than 50 NM are selected in WX + TURB mode, the weather radar reverts to WX mode.

TURB Mode

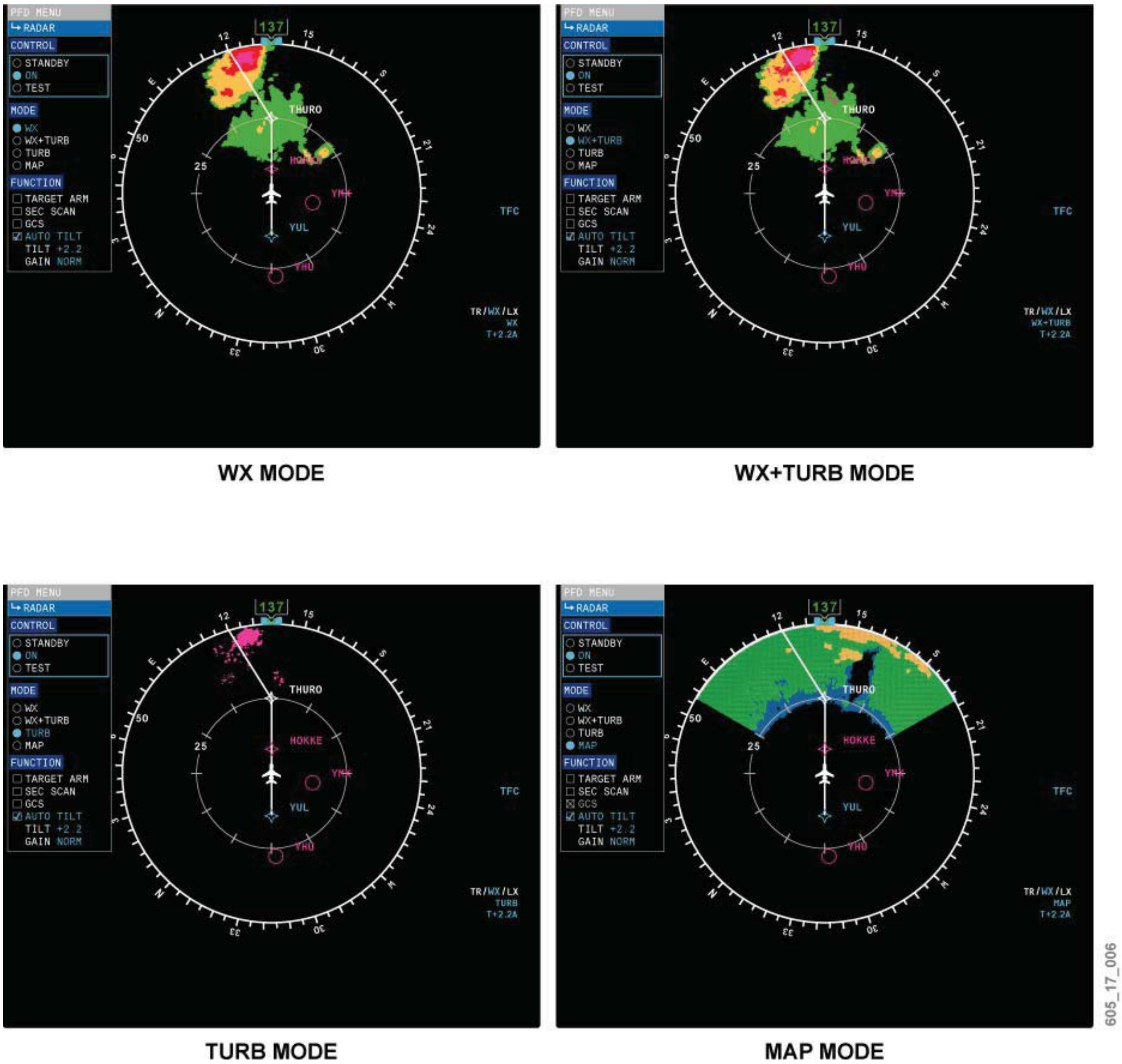
In TURB mode, only the detection of the precipitation-related turbulence is displayed. With this mode, the pilot can look up for areas of concern that have been identified using the WX + TURB mode.

When radar ranges are greater than 50 NM, the TURB mode is inoperative.

MAP Mode

In MAP mode, the radar system receives ground returns for terrain mapping. Ground targets are displayed in cyan, green, yellow or magenta (least to most reflective) on the navigation formats.

WEATHER RADAR SYSTEM (CONT'D)



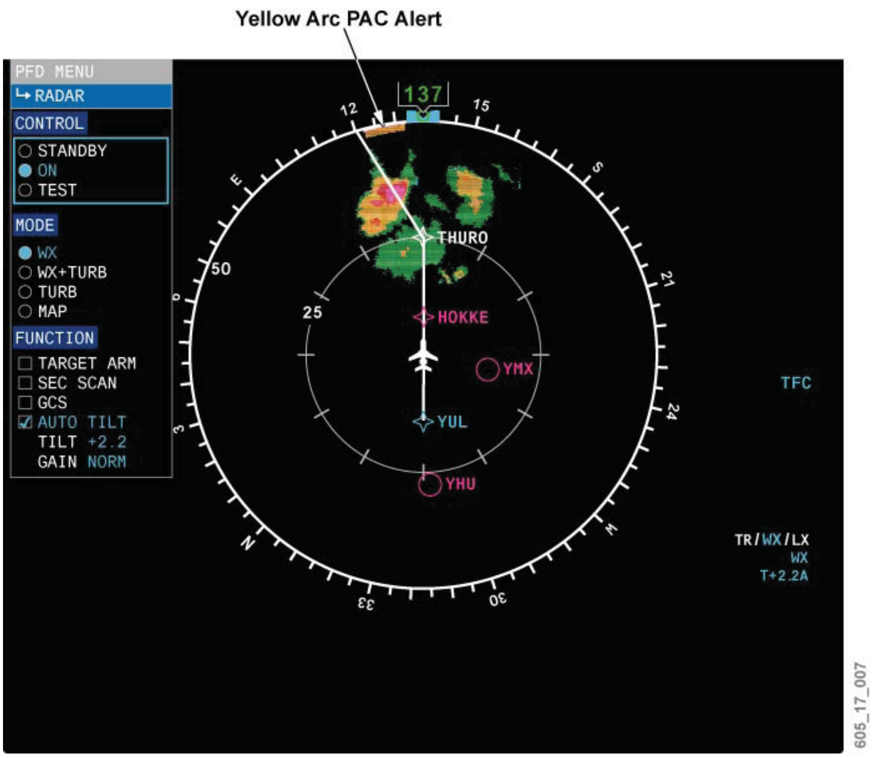
Weather Radar Operational Modes
Figure 17–10–9

Path Attenuation Correction (PAC) Alert Indication

In WX and WX + TURB modes, the PAC feature compensates for the radar energy that is absorbed as the beam penetrates a precipitation cell. When the radar detects weather formations that could cause energy to be absorbed and possibly give a false return, the radar sensitivity is corrected.

If the precipitation cell is of sufficient dimensions to use the full range of attenuation correction, a condition known as PAC alert occurs. The yellow PAC alert arc informs the pilot that the radar beam is being severely attenuated, and that the area of shadow behind the intervening rainfall may contain hidden, and possibly significant, precipitation. Avoid flight into the area between the displayed weather and the yellow PAC alert.

WEATHER RADAR SYSTEM (CONT'D)



Weather Radar PAC Alert
Figure 17–10–10

Target/Turbulence Alert Function

Target and turbulence alert function (TGT/TRB) allows the radar to detect weather targets and alert the crew, without the targets themselves showing on the display. It is used as a background feature when other data is being displayed on the navigation format. Therefore, a TGT or TRB alert advises the pilot of areas of important precipitation or turbulence (red or magenta weather targets).

When TARGET ARM is selected in the FUNCTION section of the PFD RADAR menu*, the radar automatically evaluates a target window of ±15° of aircraft heading from 7 to 200 NM range, regardless of the range selected on the DCP. A cyan TGT is displayed below the radar tilt status line, to indicate the TARGET ARM selection.

* In order to have target function active, the following conditions must be met:

- Radar mode must be ON; and
- The onside PFD and MFD radar overlays are selected off.

When a significant turbulence target is detected within the alert window, a flashing yellow TGT is displayed in place of cyan TGT.

When a significant precipitation target is detected, a flashing yellow TRB is displayed left of TGT annunciation.

WEATHER RADAR SYSTEM (CONT'D)

Sector Scan Function

When SEC SCAN is selected in the FUNCTION section of the PFD RADAR menu, the radar scans ±30° from aircraft heading, therefore the display update rate is increased. When deselected, normal ±60° scan resumes.

Ground Clutter Suppression Function

To permit a better definition of precipitation, the ground clutter suppression decreases the intensity of ground returns when operating in WX mode.

GCS is activated by selecting GCS in the FUNCTION section of the PFD RADAR menu. Ground return intensity decreases, and the cyan GCS annunciation is displayed on the radar mode line.

After 30 seconds, the ground return reverts to normal intensity, and the GCS annunciation is removed.

Gain Function

The GAIN function is used for manual gain control of the radar receiver, and is selectable from the FUNCTION section of the PFD RADAR menu.

When set to NORM, the gain is preset to a specified value. Each setting from NORM changes the sensitivity one color level.

Lower gain settings are useful for evaluating intense weather targets, while higher gain settings are useful for evaluating light precipitation.

Weather Radar Automatic Stabilization

The stabilization feature automatically stabilizes the radar antenna with attitude input data from the IRS system. This provides a constant antenna scan attitude regardless of the aircraft pitch and roll attitudes.

If an IRS input failure occurs, the attitude input data is removed from the antenna, however, the radar system remains operational. On the radar status line, a yellow USTB annunciation flashes for 5 seconds, then remains displayed.

When USTB is displayed and the tilt angle is changed, the USTB will be replaced by the tilt annunciation. The tilt annunciation remains displayed for 5 seconds after the tilt setting has stopped changing, and then reverts to the USTB annunciation.

Lightning Detection System (LDS) (Optional)

The lightning detection system maps electrical discharge activity (lightning) 360 degrees around the aircraft, to a distance of 100 nautical miles. Three levels of electrical activity intensity are identified. Level one represents the lowest rate of electrical discharge, and level three the highest.

The system transmits the location of up to 63 thunderstorm cells to the displays. The data set is updated every two seconds. Electrical discharge activity is presented as thunderbolts on the display in yellow, red, and magenta, with yellow signifying level one, and magenta signifying level three activity.

The lightning detection system is selected by the TR/WX button on the display control panel (DCP) or cursor control panel (CCP).

WEATHER RADAR SYSTEM (CONT'D)

Radar Fault Annunciations

RADAR FAULT ANNUNCIATION	DESCRIPTION
WX FAIL	When no radar operating mode is being received by the PFD or MFD from the RTA, the WX FAIL annunciation flashes for 5 seconds, then remains displayed on the navigation display, and the radar mode is removed.
WX FAULT	When the weather radar system detects an internal fault, the WX FAULT annunciation flashes for 5 seconds, and then remains displayed to replace the Tilt/Stabilization annunciation on the radar status line 2.
LX FAIL	When the LDS is selected for display and is reporting a fault, the LX FAIL annunciation flashes for 5 seconds, then remains displayed on the navigation display, and the lightning icons are removed.

Overlay Fault Field

The overlay fault field is a single line of text, located above the PFD and MFD navigation display.

OVERLAY FAULT FIELD	DESCRIPTION
RADAR ON	The annunciation flashes for 5 seconds, then remains displayed to indicate that the radar is transmitting on the ground.
RADAR RANGE XXX NM	The annunciation is displayed when the radar range and the on-side navigation display range differ for more than 5 seconds. XXX represents the actual range the radar is currently reporting (i.e. 10, 25, etc.).

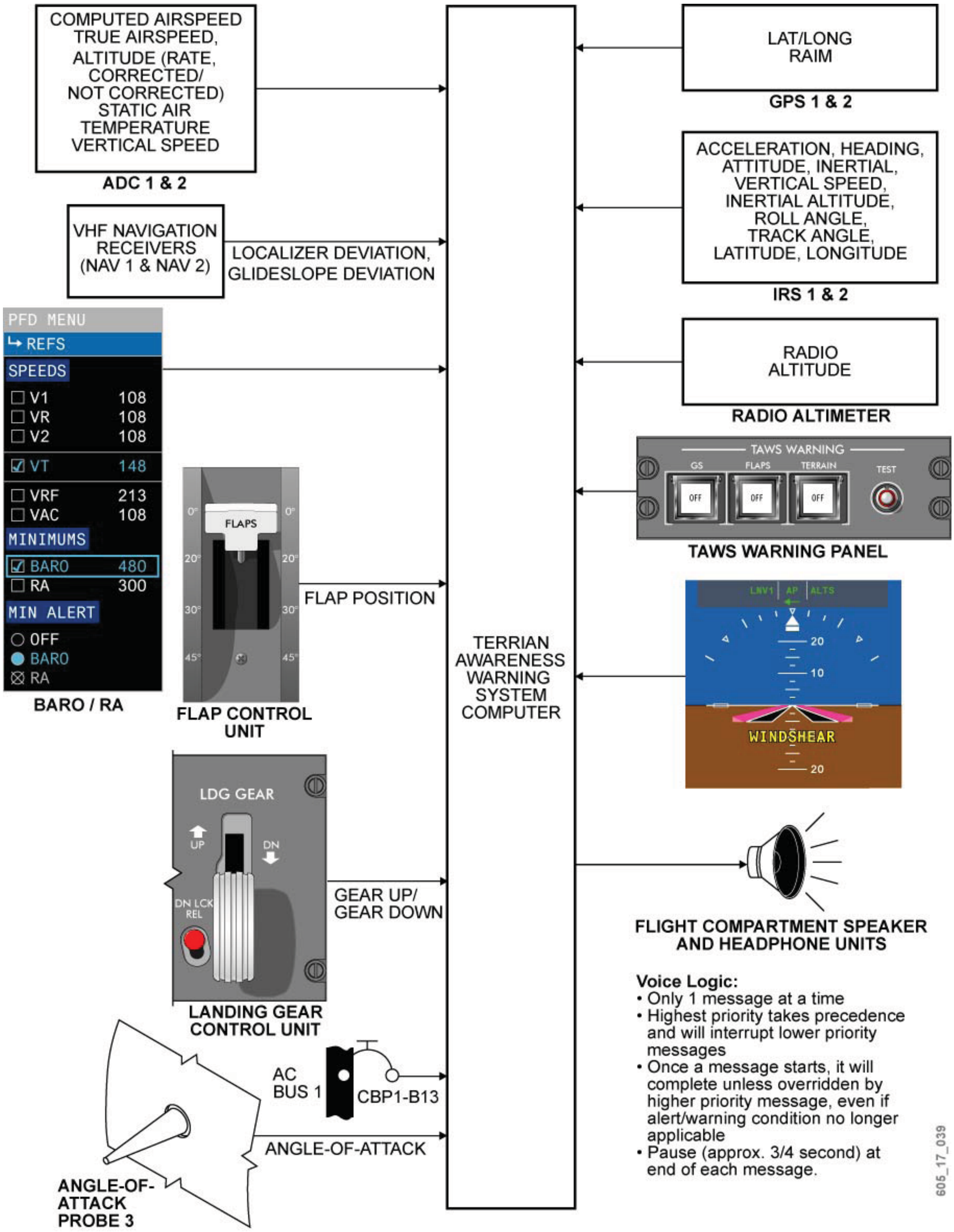
TERRAIN AWARENESS WARNING SYSTEM (TAWS)

Description

The TAWS alerts and warns the flight crew when the airplane's flight path and position, relative to terrain, requires immediate crew attention and action. TAWS alerts the flight crew when predetermined thresholds are exceeded using the following modes:

- Mode 1 – Excessive descent rate
- Mode 2 – Excessive terrain closure rate
- Mode 3 – Altitude loss after takeoff or go-around
- Mode 4 – Unsafe terrain clearance when not in a landing configuration
- Mode 5 – Below glideslope deviation alert
- Mode 6 – Callouts
- Mode 7 – Windshear detection and alerting
- Terrain/obstacle awareness alerting and display (TAAD)
- Terrain clearance floor (TCF)

TERRAIN AWARENESS WARNING SYSTEM (TAWS) (CONT'D)



TAWS Functional Schematic
Figure 17–10–11

TERRAIN AWARENESS WARNING SYSTEM (TAWS) (CONT'D)

Components and Operation

TAWS Computer

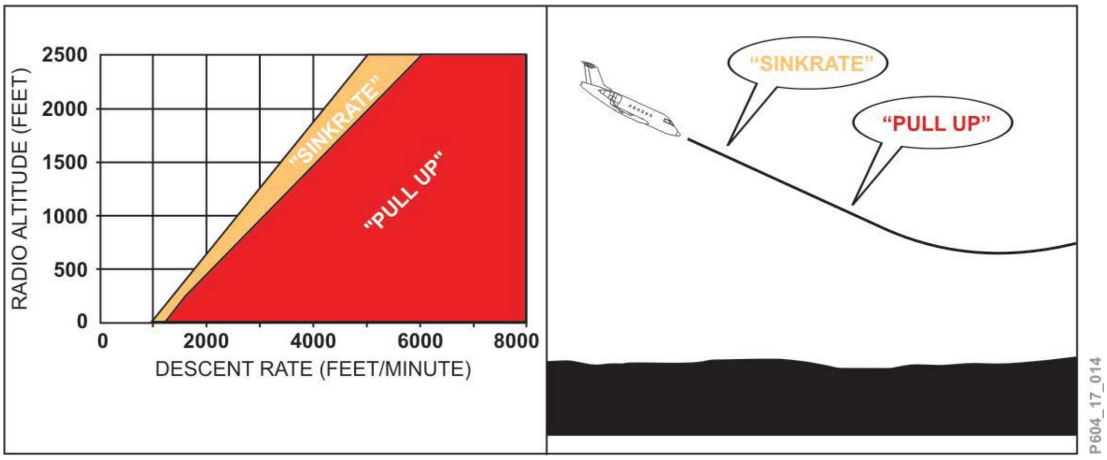
The TAWS receives inputs from the air data system, radio altimeters, VHF navigation receivers, GPS, IRS, angle-of-attack vanes, gear and flap selector levers and TAWS panel switch/lights. These inputs are used to compute potential terrain conflicts.

Mode 1 – Excessive Descent Rate

Mode 1 provides aural and visual alerts and warnings, in the event that the TAWS computer determines that the rate of descent is excessive with respect to airplane altitude. The mode is active when the airplane is less than 2,500 feet AGL. Mode 1 requires radio altitude and rate of descent data.

The annunciation envelope consists of two areas: alert and warning.

- Penetration of the alert area will display GND PROX on the PFDs, and generate an aural “SINKRATE SINKRATE”. The aural alert will be annunciated once, and will be repeated only if conditions degrade by more than 20% based on computed time to impact. The visual alert will remain until the condition is rectified.
- Penetration of the warning area will display PULL UP on the PFDs, and generate an aural “WHOOP, WHOOP, PULL UP” warning. The aural warning is annunciated continuously until the condition is rectified



TAWS Mode 1
Figure 17–10–12

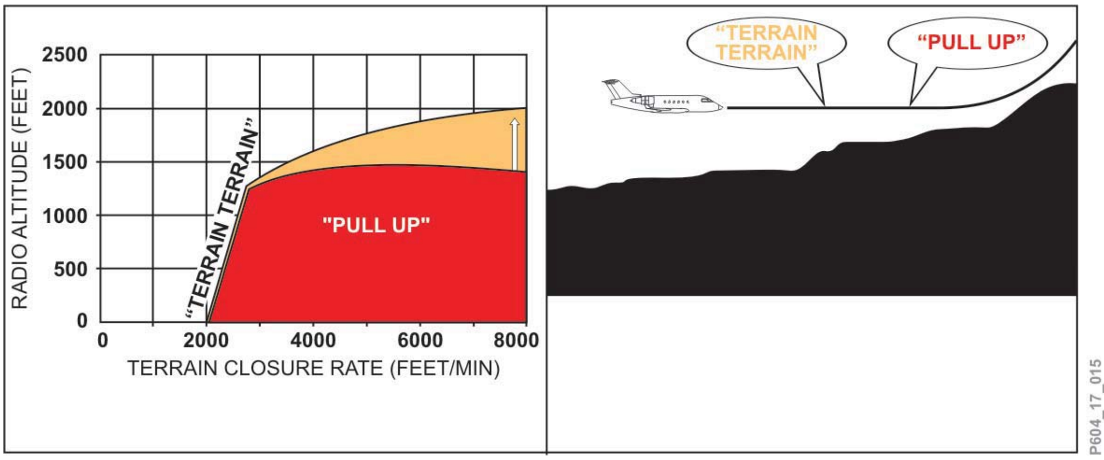
Mode 2 – Excessive Terrain Closure Rate

Mode 2 provides alerts and warnings when the TAWS computer detects that the closure rate between the airplane and terrain is excessive. The airplane need not be in descent, rising terrain may be encountered in level flight, or the terrain may be rising at a rate greater than the airplane rate of climb. Mode 2 uses radio altitude, vertical speed and aircraft configuration inputs.

TERRAIN AWARENESS WARNING SYSTEM (TAWS) (CONT'D)

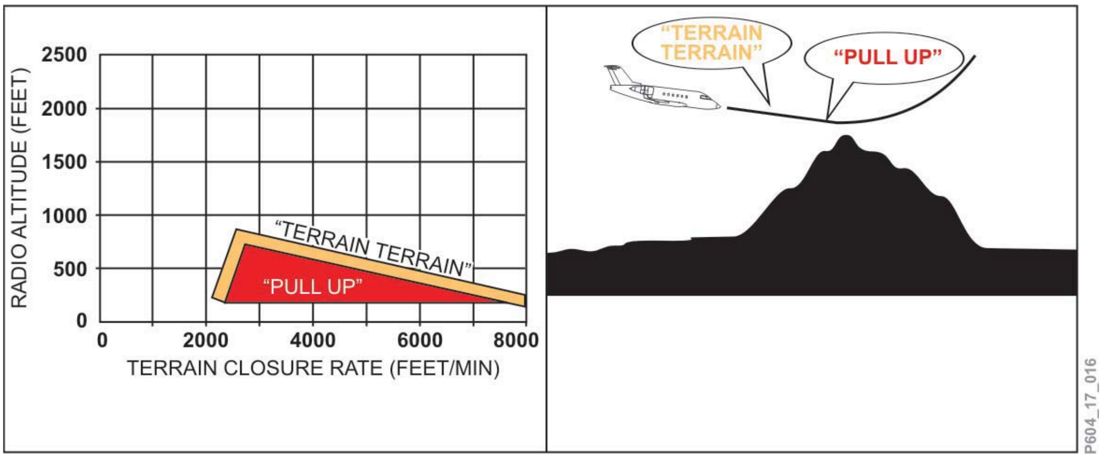
Mode 2 has two submodes: Mode 2A and Mode 2B.

- Mode 2A – Activated when flaps are not in the landing position, and the aircraft is not in the GS beam. Penetration of the alert area will display GND PROX on the PFDs, and generate an aural “TERRAIN, TERRAIN”. The aural is annunciated once, and the visual alert will remain displayed until the condition is rectified. Penetration of the warning area will display PULL UP on the PFDs, and generate an aural “PULL UP” warning. The aural and visual warnings are annunciated continuously until the condition is rectified.



TAWS Mode 2A
Figure 17–10–13

- Mode 2B – Activated when flaps are in the landing configuration, or in the event the flaps are up and the airplane is on an ILS approach, and the glideslope and localizer deviations are less than ±2 dots and for 60 seconds after takeoff. Penetration of the alert area will display GND PROX on the PFDs, and enable an aural “TERRAIN, TERRAIN”. The aural and the visual alerts are annunciated continuously, and will remain until the condition is rectified. Penetration of the warning area will display PULL UP on the PFDs, and generate an aural “PULL UP” warning. The aural and visual warnings are annunciated continuously until the condition is rectified.



TAWS Mode 2B
Figure 17–10–14

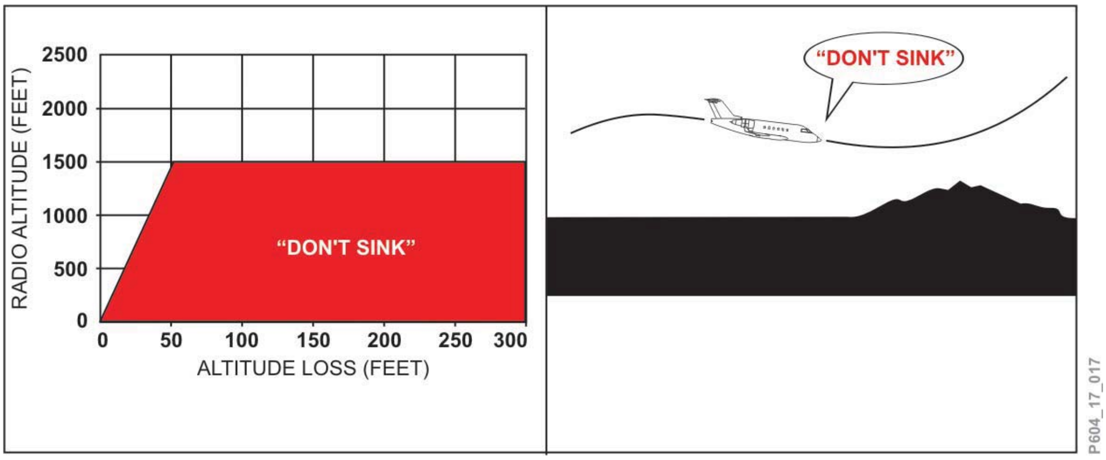
TERRAIN AWARENESS WARNING SYSTEM (TAWS) (CONT'D)

Mode 3 – Altitude Loss after Takeoff

Mode 3 provides warnings when the TAWS computer detects that a significant amount of altitude is lost immediately after takeoff, or during a go-around. Mode 3 uses radio altitude, barometric altitude and altitude rate.

If a descent is initiated following takeoff or go-around, the TAWS computer stores the altitude value at which the descent began, and compares successive altitude data to the stored value. Activation of the warning is induced when the minimum terrain clearance, as a function of altitude lost, is exceeded.

Penetration of the alert area will display GND PROX on the PFDs, and generate an aural “DON’T SINK, DON’T SINK” warning. The aural warning is annunciated only once, unless the altitude value degrades by more than 20% from the initially stored value, and again at each additional 20% degradation from the initially stored value. This condition will remain until the airplane regains the initial altitude value. Mode 3 is inhibited for radio altitude in excess of 1,500 feet.



TAWS Mode 3
Figure 17–10–15

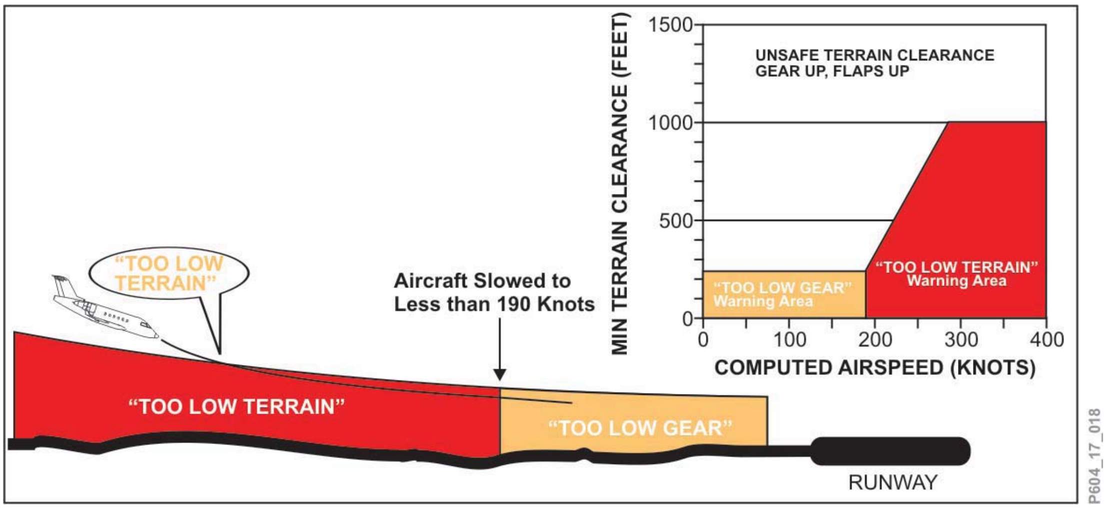
Mode 4 – Unsafe Terrain Clearance

Mode 4 provides alerts and warnings for insufficient terrain clearance, based on airplane phase of flight and airspeed. Mode 4 requires radio altitude, computed airspeed, gear position and flap position inputs. The alert and warning envelopes are based on minimum allowable terrain clearance, as a function of computed airspeed.

Mode 4 is divided into 3 submodes: Mode 4A, Mode 4B and Mode 4C.

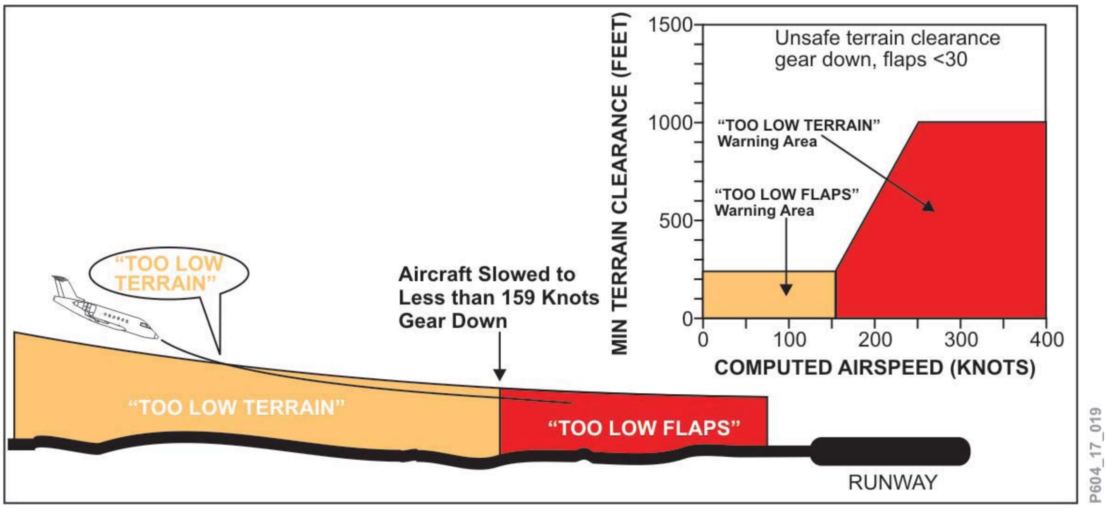
- Mode 4A – Active when the airplane is in cruise or approach phase of flight, and the landing gear is not in the landing position. The alert envelope for Mode 4A begins at 30 feet AGL, and extends vertically to an altitude of 500 feet AGL. Penetration of the alert area, above 190 knots (the upper boundary increases with airspeed to a maximum of 1,000 feet radio altitude at 250 knots or more) will display GND PROX on the PFDs, and generate an aural “TOO LOW TERRAIN” warning. Penetration of the alert area, below 190 knots, will display GND PROX on the PFDs, and generate an aural “TOO LOW GEAR” warning. The aural and visual warnings remain until the airplane exits the envelope.

TERRAIN AWARENESS WARNING SYSTEM (TAWS) (CONT'D)



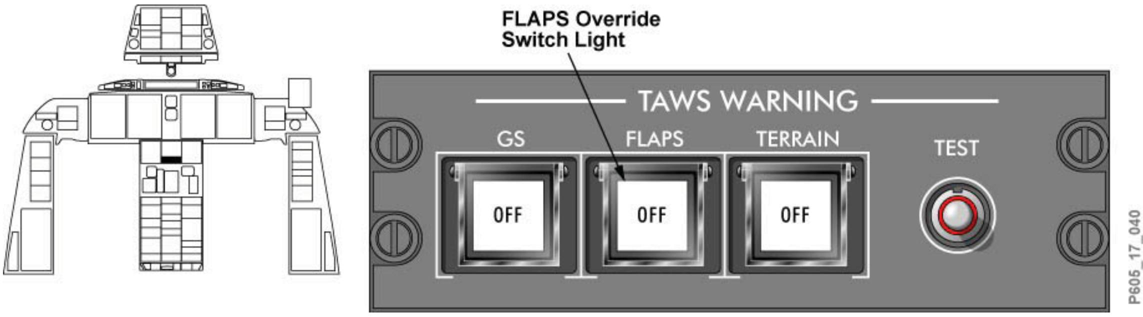
TAWS Mode 4A
Figure 17–10–16

- Mode 4B – Active when the airplane is in cruise or approach phase of flight, and the landing gear is in the landing position, with flaps not in the landing configuration. The alert envelope for Mode 4B extends vertically to an altitude of 245 feet AGL. Penetration of the alert area, above 159 knots, will display GND PROX on the PFDs, and generate a continuous aural "TOO LOW TERRAIN" warning. The aural and visual warnings remain until the airplane exits the envelope. Penetration of the alert area, below 159 knots, will display GND PROX on the PFDs, and generate an aural "TOO LOW FLAP" warning. These alerts can be deactivated by pressing the FLAPS OFF switch/light on the TAWS WARNING panel.



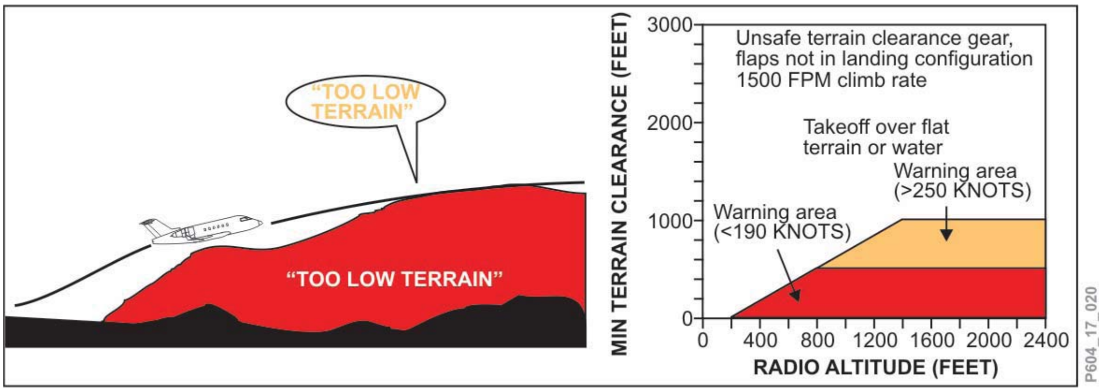
TAWS Mode 4B
Figure 17–10–17

TERRAIN AWARENESS WARNING SYSTEM (TAWS) (CONT'D)



TAWS WARNING Panel & Locator
Figure 17–10–18

- Mode 4C is based on a minimum terrain clearance, or floor, that increases with radio altitude during takeoff. At takeoff, the minimum terrain clearance (MTC) is at zero feet. As the aircraft ascends, the MTC is increased to 75% of the aircraft's current (average of the previous 15 seconds) radio altitude. This value is limited to 500 feet AGL for airspeeds less than or equal to 190 knots. If the airspeed is greater than 190 knots, the MTC increases linearly with increasing airspeed up to 250 knots. Beyond 250 knots, the MTC is limited to 1,000 feet AGL. Any decrease in altitude below minimum terrain clearance will display GND PROX on the PFDs, and generate an aural "TOO LOW TERRAIN" warning.
- It is activated after takeoff when the gear or flaps are not in the landing configuration. It is also active during a low altitude go-around, if the aircraft has descended below 245 feet AGL.



TAWS Mode 4C
Figure 17–10–19

Mode 5 – Descent Below Glideslope

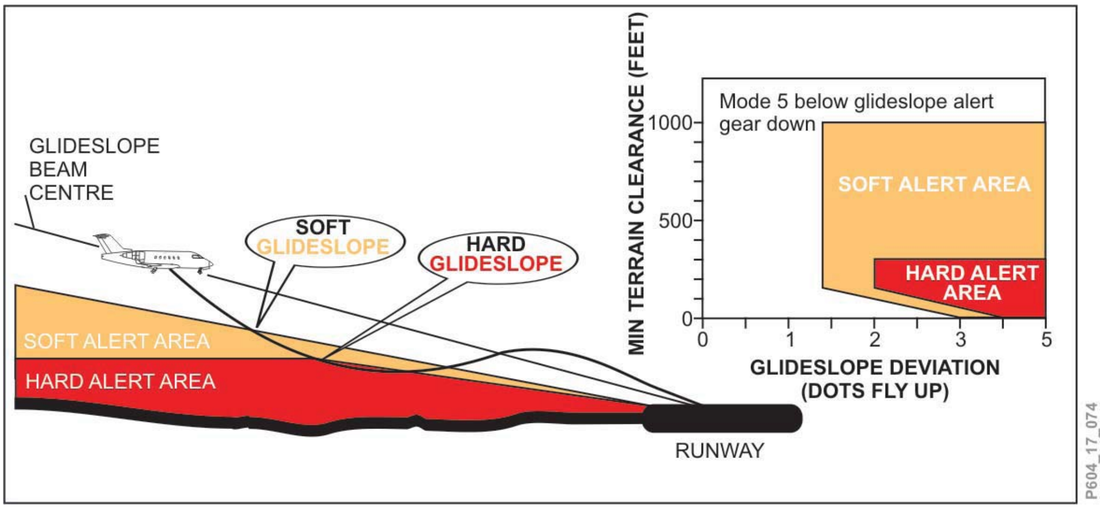
Mode 5 provides two levels of alerting if the aircraft flight path descends below the glideslope. The first alert occurs whenever the aircraft is more than 1.3 dots below the beam, and is called a "soft alert" because the volume level is reduced. A second alert occurs below 300 feet radio altitude with greater than 2 dots' deviation, and is called a "hard alert" because the volume is louder.

TERRAIN AWARENESS WARNING SYSTEM (TAWS) (CONT'D)

To avoid unwanted glideslope alerts when capturing the localizer between 500 and 1,000 feet AGL, the upper limit of the alert envelope is varied in the following ways:

- Glideslope alerts are only enabled if the localizer is within ±2 dots. This allows a lateral capture of the localizer.
- The upper altitude limit for the glideslope alert is modulated with vertical speed. For normal descent rates above 500 FPM, the upper limit is set to the normal 1,000 feet AGL. For descent rates lower than 500 FPM, the upper limit is desensitized to allow a level flight capture of the localizer.

The above requirements are overridden when the aircraft descends below 500 feet AGL.



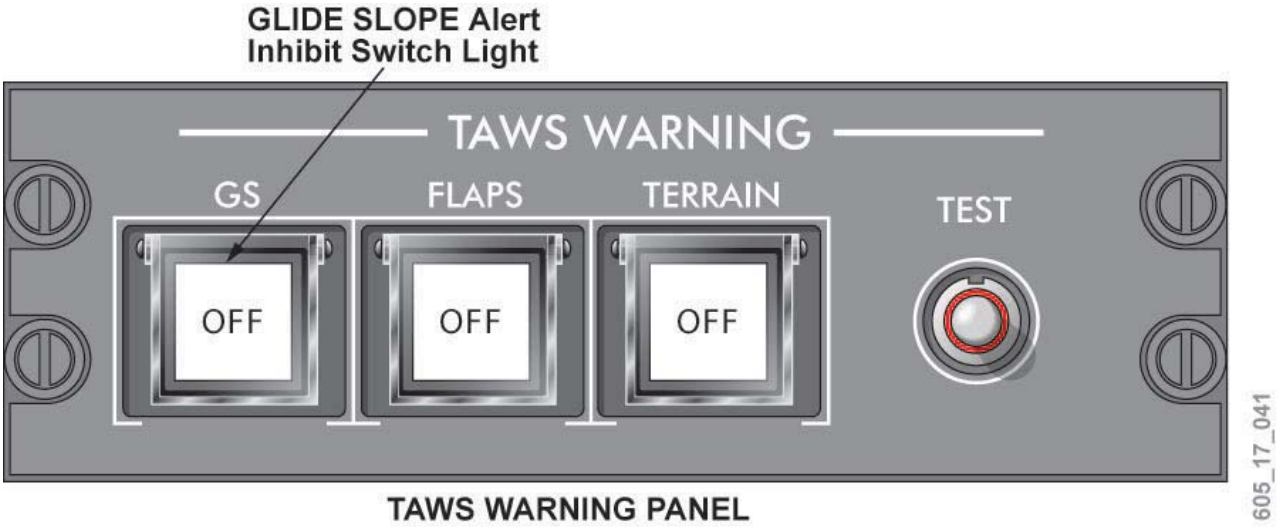
TAWS Mode 5
Figure 17–10–20

Alerts for Mode 5 display GND PROX on the PFDs, and generate an aural “GLIDESLOPE” warning. Only two “GLIDESLOPE” warnings are given while in the Mode 5 outer “soft” envelope. If the conditions worsen, two more “GLIDESLOPE” aural messages annunciate at a faster rate. This pattern continues until the inner “louder” area is penetrated (2 dots or greater deviation, below 300 feet AGL), at which time the “GLIDESLOPE” aural message will become louder and continuous.

Below 150 feet AGL, glideslope alerting is desensitized to reduce the possibility of nuisance alerts.

To permit maneuvering on final approach with an unreliable glideslope, the Mode 5 alert can be inhibited by pressing the GS switch/light on the TAWS WARNING panel. The GS switch/light can be engaged below 2,000 feet AGL, and is automatically reset before the next approach, provided the aircraft has descended below 30 feet or climbs above 2,000 feet.

TERRAIN AWARENESS WARNING SYSTEM (TAWS) (CONT'D)



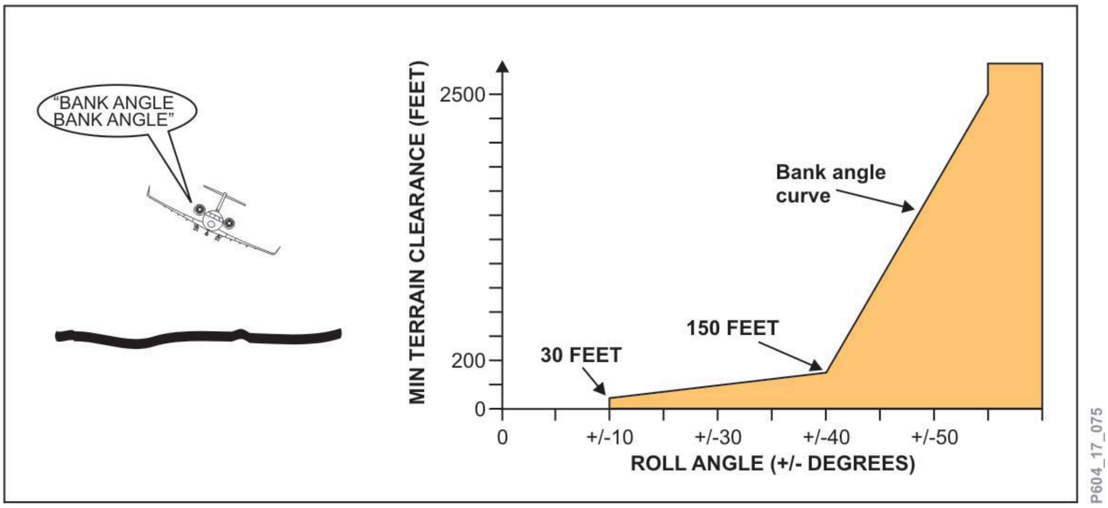
TAWS WARNING Panel
Figure 17–10–21

Mode 6 – Callouts

Mode 6 provides the following advisory alerts:

- **Approach minimums:** One hundred feet above the RA, the “APPROACHING MINIMUMS” alert will sound. The “MINIMUMS” callout occurs as the aircraft descends through the selected minimums (RA or BARO).
- **Altitude callouts:** Specific callouts are program-pin selectable. Typical installation includes: 1,000, 500, 50, 40, 30, 20, 10.
- **Excessive bank angle:** The excessive bank angle alert is a function of the roll angle with respect to altitude above ground level. The alert envelope varies linearly from a 10° bank at 30 feet AGL, to 40° of bank at 150 feet AGL, to 55° of bank at 2,450 feet AGL. This will generate an aural “BANK ANGLE, BANK ANGLE” alert. The alert is annunciated once, and will repeat if the bank angle increases by 20%. The alert will be annunciated continuously if the bank angle is increased to 55°. The alert will be annunciated until the bank angle is decreased below threshold value.

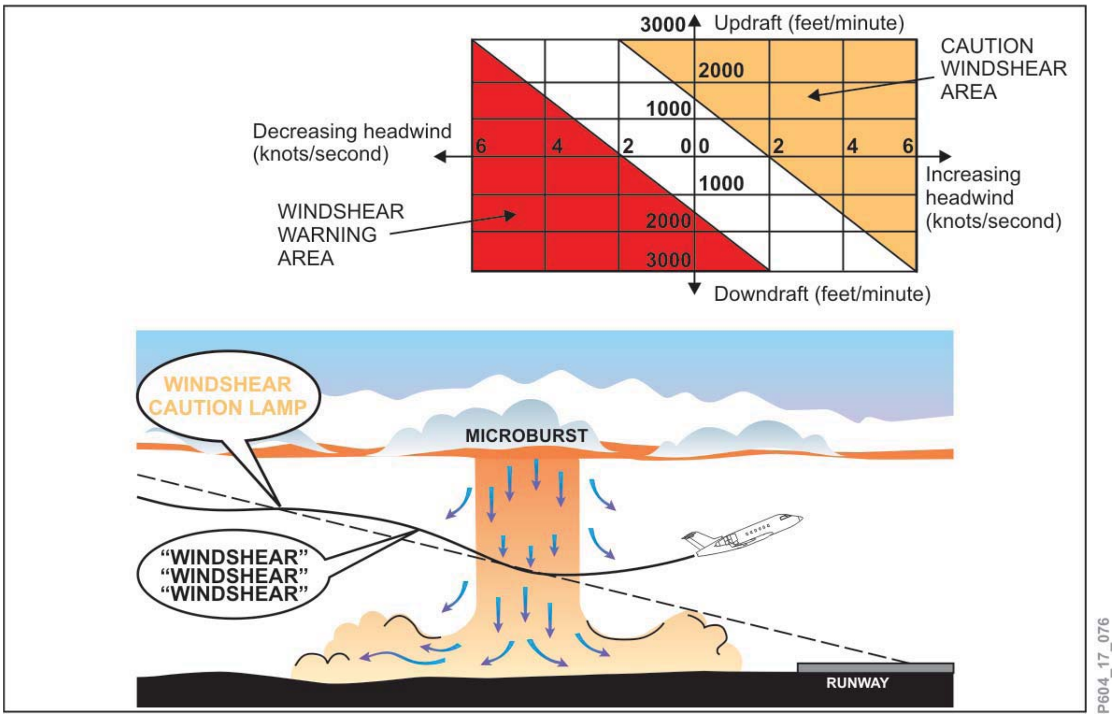
TERRAIN AWARENESS WARNING SYSTEM (TAWS) (CONT'D)



TAWS Mode 6 Bank Angle
Figure 17–10–22

Mode 7 – Windshear Detection and Alerting

Mode 7 provides alerts and warnings in the event that significant windshear is detected by the TAWS computer. Mode 7 is active during takeoff and landing phases of flight only, between 10 and 1,500 feet AGL.

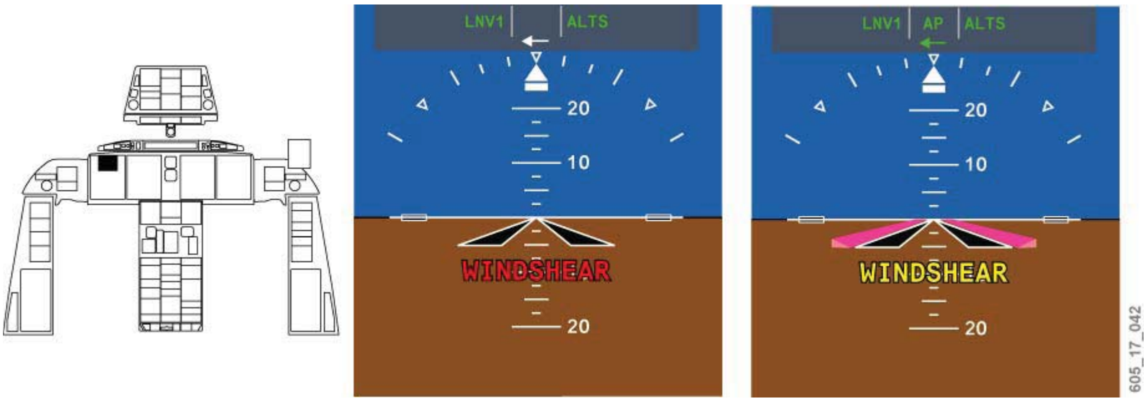


TAWS Mode 7 Windshear Thresholds
Figure 17–10–23

TERRAIN AWARENESS WARNING SYSTEM (TAWS) (CONT'D)

There are two types of windshear warnings: increasing performance (updraft/headwind), and decreasing performance (downdraft/tailwind).

- For an increasing performance shear (updraft/headwind), an amber WINDSHEAR message is annunciated on the PFD and flashes for 5 seconds, then remains steady. No aural message is given.
- For a decreasing performance shear (downdraft/tailwind), a red WINDSHEAR message is annunciated on the PFD and flashes for 5 seconds, then remains steady, and an aural siren and “WINDSHEAR, WINDSHEAR, WINDSHEAR” warning are activated. Two seconds after a windshear warning is issued, the autopilot, if engaged, is disconnected and the flight director bars are removed. No escape guidance is provided.



PFD Windshear Display
Figure 17–10–24

Terrain Clearance Floor (TCF)

The TCF function of the TAWS provides an additional terrain clearance alert envelope around airports. This alert mode complements the existing Mode 4 protection, by providing an alert based on insufficient terrain clearance even when in landing configuration.

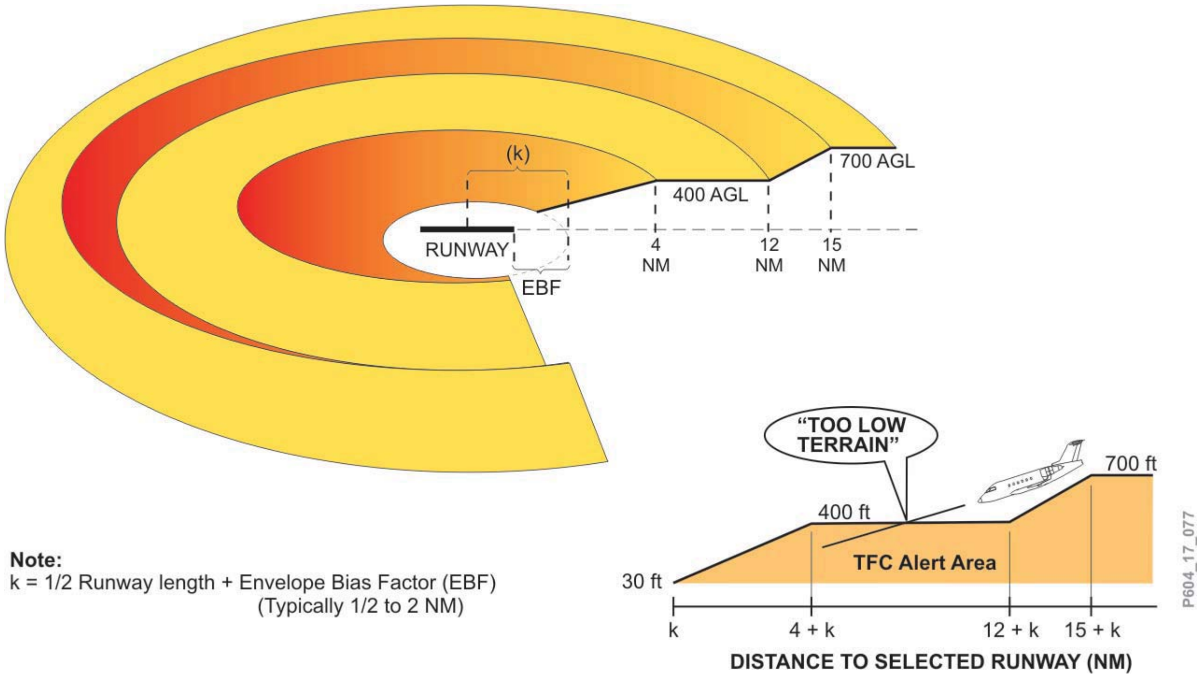
TCF creates an increasing terrain clearance envelope around the intended airport runway, directly related to the distance from the runway. TCF alerts are based on current airplane location, nearest runway center point position and radio altitude, with an integral TCF airport database.

Penetration of the alert envelope will display GND PROX on the PFDs, and generate an aural “TOO LOW TERRAIN” alert. The aural alert is repeated twice, and again thereafter if the radio altitude value decreases by more than 20% from the altitude at which the initial warning was issued. The aural and visual alerts operate until the airplane exits the alert envelope.

Terrain Clearance Floor Database

The TCF database is integral to the TAWS computer, and includes worldwide coverage of all airports with hard-surfaced runways longer than 3,500 feet in length.

TERRAIN AWARENESS WARNING SYSTEM (TAWS) (CONT'D)



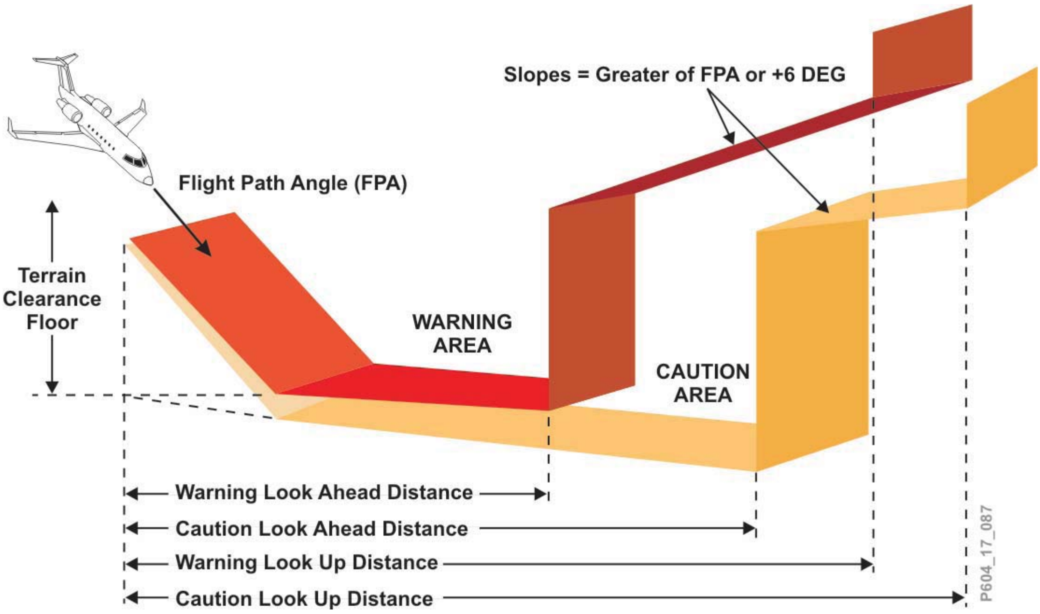
Terrain Clearance Floor (TCF)
Figure 17–10–25

Terrain/Obstacle Awareness Alerting and Display (TAAD)

A feature of the TAWS is the incorporation of the terrain/obstacle awareness alerting and display function. This function uses aircraft geographic position, aircraft altitude, and a terrain and obstacle database, to predict potential conflicts between the aircraft flight path and the terrain or obstacle, and to provide terrain display overlay of the conflicting terrain or obstacles.

The terrain awareness alerting algorithms continuously compute terrain clearance envelopes ahead of the aircraft, as a function of ground speed, flight path angle and track. If the boundaries of these envelopes conflict with terrain elevation data in the terrain database, alerts are issued. Two envelopes are computed, one corresponding to a terrain caution alert level and the other to a terrain warning alert level.

TERRAIN AWARENESS WARNING SYSTEM (TAWS) (CONT'D)



TAAD Caution and Warning Alert Envelopes
Figure 17–10–26

TAWS Position and Altitude Determination

The TAWS computer determines aircraft position and altitude using GPS sensor data primarily. The computer monitors RAIM status, and applies geometric altitude algorithms to ensure the required level of precision is maintained laterally and vertically. If GPS is not available, the computer applies barometric altitude calculations for vertical position determination, and uses the FMS integrated navigation solution for lateral position determination.

Terrain/Obstacle Awareness Alerting and Display (TAAD) Database

The TAAD database is comprised of a terrain database and an obstacle database integral to the TAWS computer. The terrain database includes worldwide coverage of the earth's surface, divided into grid sets referenced to the WGS–84 datum.

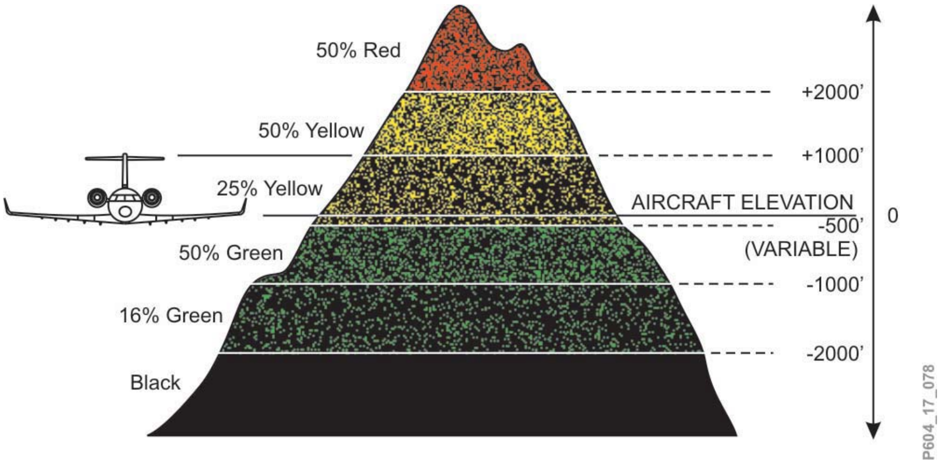
The obstacle database contains known man-made obstacles that are higher than 100 feet AGL. This database covers the USA, Canada, the Caribbean, Europe, Australia, and portions of the Middle East and Far East. A complete obstacle database map is available at www.egpws.com

Terrain Awareness Display

The terrain awareness display displays an image of surrounding terrain in varying density dot patterns of green, yellow, and red. The display is generated from the aircraft altitude compared to terrain data in the TAWS computer. These dot patterns represent specific terrain separation with respect to the aircraft. Terrain more than 2,000 feet below the aircraft is not displayed. Areas with no terrain data available are shown as a low-density magenta color.

The obstacle data included is depicted on the terrain display in the same fashion as terrain.

TERRAIN AWARENESS WARNING SYSTEM (TAWS) (CONT'D)

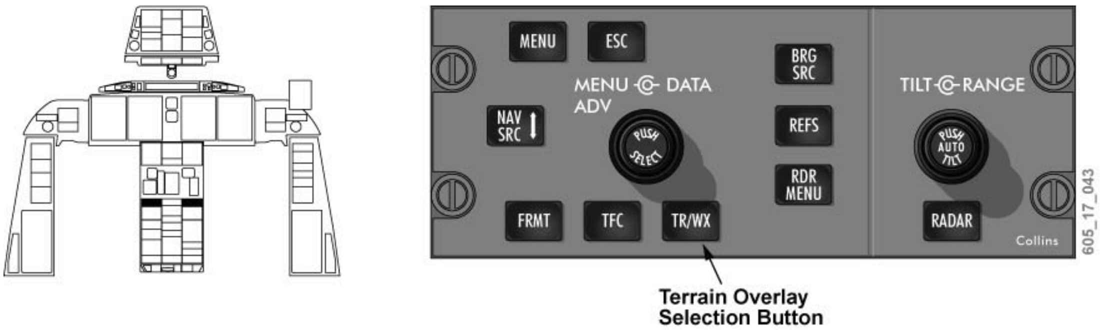


Terrain/Obstacle Awareness Display Color Patterns
Figure 17–10–27

The crew may independently select the terrain display on either PFD or MFD by selecting the function on the appropriate menus. The terrain display can be overlaid on any PFD/MFD format that supports weather radar overlay. A cyan TERRAIN annunciation appears on the bottom right corner of the displays to inform the flight crew that the terrain overlay has been selected. Weather radar and terrain cannot be displayed simultaneously on the same display.

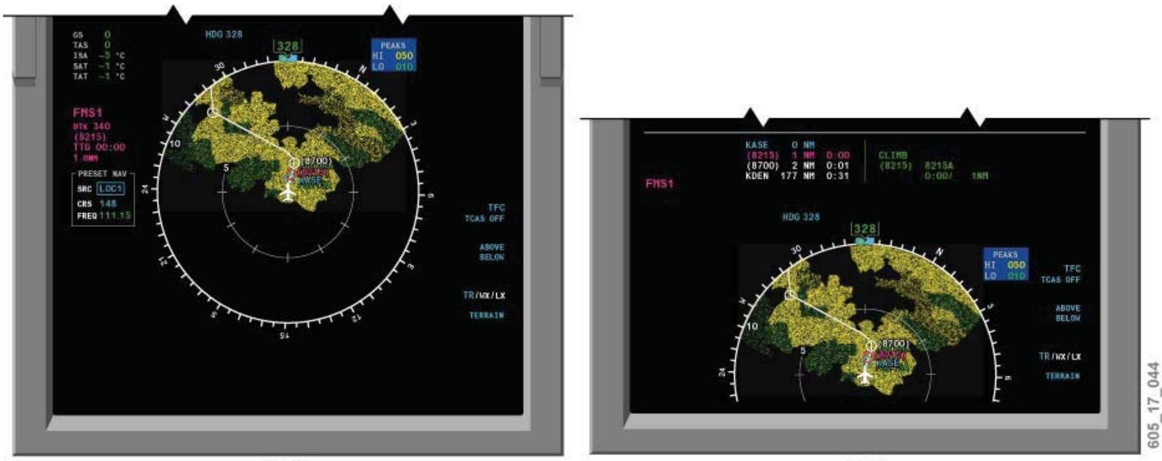
Auto Pop-Up

When a terrain awareness caution or a terrain awareness warning are detected, the terrain overlay automatically pops up on both PFDs, and the format and range automatically change to PPOS MAP and 10 NM.



Display Control Panel– Terrain Button
Figure 17–10–28

TERRAIN AWARENESS WARNING SYSTEM (TAWS) (CONT'D)



PFD MFD

PFD/MFD Terrain Awareness Display
Figure 17–10–29

NOTE

Navigation must not be predicated upon the use of the terrain awareness display.

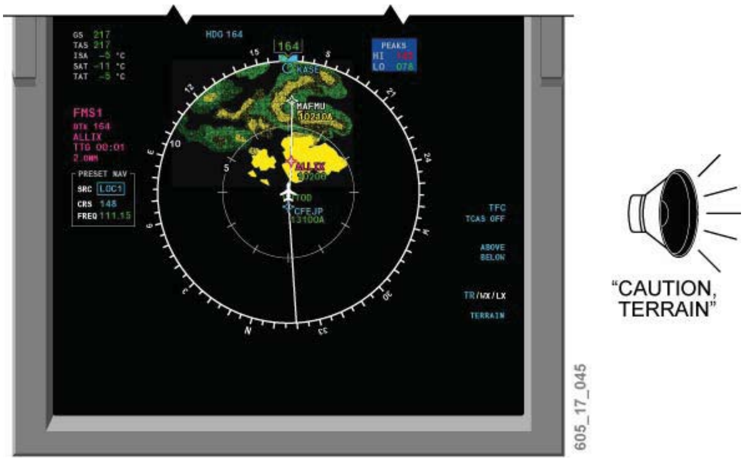
If a terrain display fault condition is present when the terrain is being displayed, one of the following yellow messages will be presented in the bottom right corner of the PFD and MFD (i.e., in the weather radar fault message field): “TERRAIN FAIL”, “TERRAIN CONTROL FAULT”, “TERRAIN NOT AVAIL”. All terrain messages, except the normal condition “TERRAIN”, flash for 10 seconds when they are posted.

Terrain/Obstacle Awareness Caution Alert

If the aircraft penetrates the caution envelope boundary, the aural message “CAUTION TERRAIN” or “CAUTION OBSTACLE” is generated, and the amber GND PROX message flashes. Simultaneously, terrain/obstacle areas which conflict with the caution criteria are shown in solid yellow color on the terrain awareness display.

The caution alert is typically given 60 seconds ahead of a terrain/obstacle conflict.

TERRAIN AWARENESS WARNING SYSTEM (TAWS) (CONT'D)

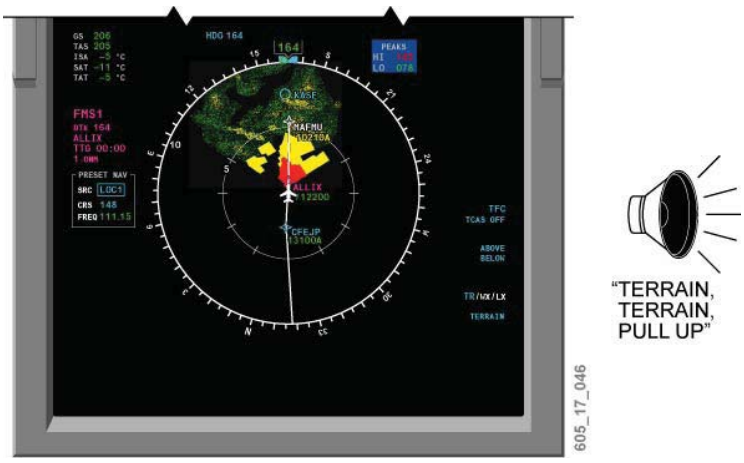


Terrain/Obstacle Awareness Caution Alert
Figure 17–10–30

Terrain/Obstacle Awareness Warning Alert

If the aircraft penetrates the warning envelope boundary, the aural message “TERRAIN TERRAIN, PULL UP” or “OBSTACLE, OBSTACLE, PULL UP” is generated, and the red “PULL UP” message flashes. Simultaneously, terrain/obstacle areas which conflict with the warning criteria are shown in solid red color on the terrain awareness display.

The warning alert is typically given 30 seconds ahead of a terrain/obstacle conflict.



Terrain/Obstacle Awareness Warning Alert
Figure 17–10–31

TAWS WARNING Panel

The TAWS WARNING panel is installed on the center pedestal, below the landing gear handle. The panel has three switch/lights and one TEST toggle switch.

The GS switch/light inhibits Mode 5, glideslope alert.

The FLAPS switch/light inhibits Mode 4B, flaps not in landing configuration with gear extended alert.

TERRAIN AWARENESS WARNING SYSTEM (TAWS) (CONT'D)

The TERRAIN switch/light inhibits the TCF and TAAD terrain functions. Modes 1 to 7 remain operational.

The TEST toggle switch initiates the TAWS self-test when on ground (TAWS self-test is inhibited in flight).

If the terrain is selected for display while the terrain functions have been inhibited by the crew, a cyan “TERRAIN OFF” message replaces the “TERRAIN” message in the bottom right corner of the PFD or MFD, and the TERRAIN switch/light illuminates white.

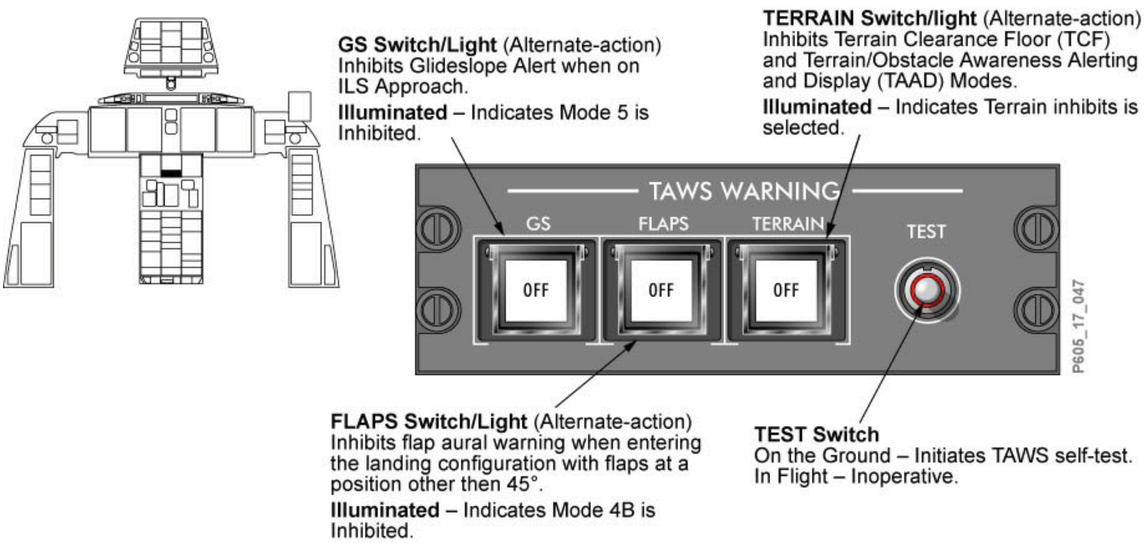
The TAWS WARNING panel TERRAIN switchlight should be selected before flight if the airport is not in the TAWS database, or if GPS is not available during QFE operations.

It should also be selected during descent, within 15 NM of approach, if any of the following conditions applies:

- Runway is less than 3,500 feet in length, or
- Airport is not in the TAWS database, or
- Intended approach is not compatible with TAWS terrain awareness alerting, or
- QFE operation with no GPS available.

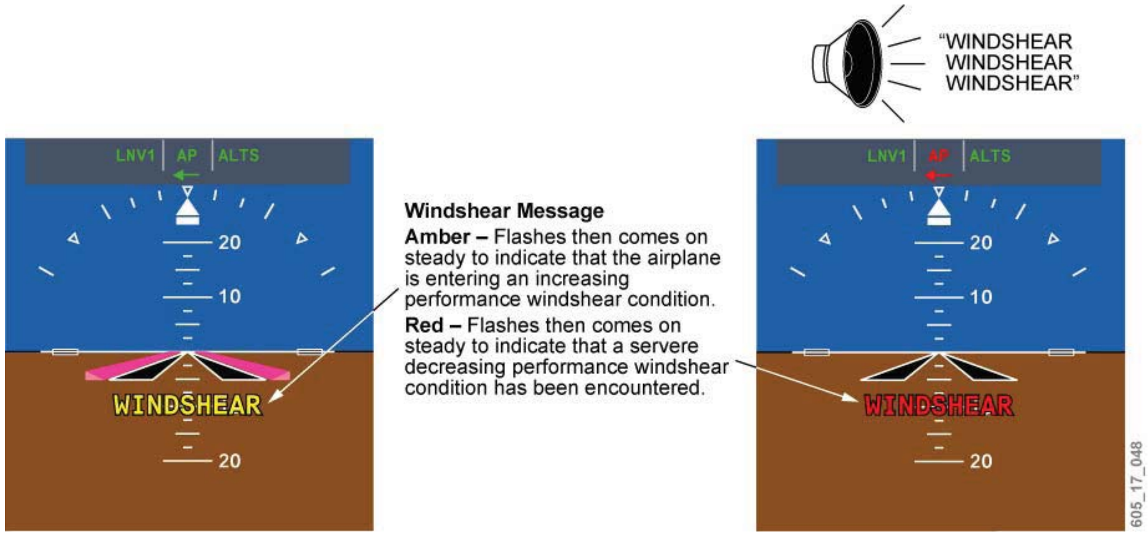
TAWS WARNING Panel
Figure 17–10–32

Controls and Indicators

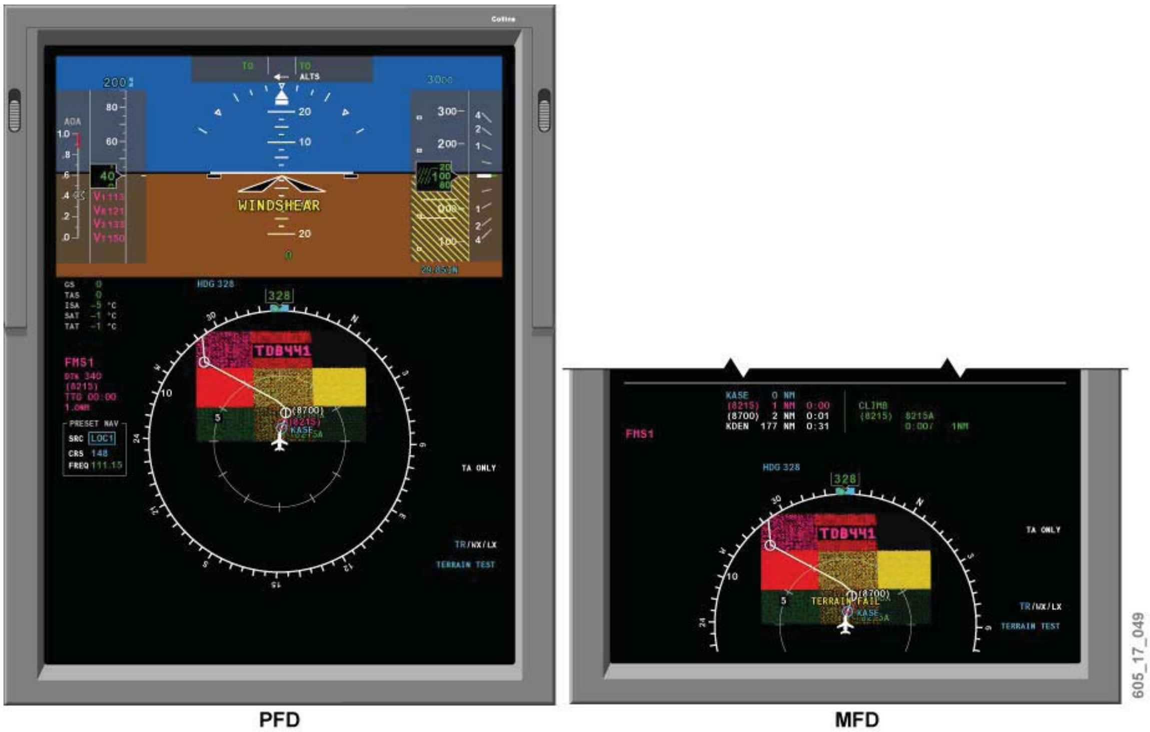


TAWS Controls and Indicators
Figure 17–10–33

TERRAIN AWARENESS WARNING SYSTEM (TAWS) (CONT'D)



PFD Indications
Figure 17–10–34



TAWS Self-Test – Terrain Test Pattern
Figure 17–10–35

TERRAIN AWARENESS WARNING SYSTEM (TAWS) (CONT'D)

TAWS Abnormal Annunciation

TAWS ABNORMAL ANNUNCIATION	DESCRIPTION
TERRAIN FAIL	The TAAD is inoperative due to an TAWS internal fault or due to the failure of a required input.
TERRAIN NOT AVAIL	The TAAD and the TCF have been temporarily inhibited by the TAWS computer because the estimated navigation accuracy from both the GPS and the FMS is insufficient.
TERRAIN RANGE XXX NM	Indicates the selected display range does not agree with TAWS transmitted range.
TERRAIN OFF	The terrain overlay is selected off.

MFD Terrain Abnormal Annunciations
Figure 17–10–36

EICAS Messages

The following white EICAS status messages are provided to inform the crew when TAWS functions are inoperative:

MESSAGE	MEANING
TAWS FAIL	All TAWS functions have failed.
TAWS WINDSHEAR FAIL	The windshear detection has failed.
TAWS TERR NOT AVAIL	Terrain database not available for current location.
TAWS TERR FAIL	The terrain awareness alerting and display functions and the terrain clearance floor function are inoperative due to a fault condition.
TAWS BASIC FAIL	TAWS Modes 1–6 are failed.

The following table lists a summary of the TAWS modes and associated indications:

TERRAIN AWARENESS WARNING SYSTEM (TAWS) (CONT'D)

TAWS Aural and Visual Alerts

MODE	CONDITION	AURAL WARNING LEVEL 1	VISUAL WARNING LEVEL 1	AURAL WARNING LEVEL 2	VISUAL WARNING LEVEL 2
1	Excessive descent rate	"SINK RATE"	GND PROX	"PULL UP"	PULL UP
2A	Excessive terrain closure rate (Flaps **not** extended)	"TERRAIN TERRAIN"	GND PROX	"PULL UP"	PULL UP
2B	Excessive terrain closure rate (Flaps **fully** extended)	"TERRAIN TERRAIN"	GND PROX	"PULL UP"	PULL UP
3	Altitude loss after takeoff or go-around	"DON'T SINK DON'T SINK"	GND PROX	None	None
4A	On approach with gear and flaps up	"TOO LOW TERRAIN"	GND PROX	"TOO LOW GEAR"	GND PROX
4B	On approach with gear down and flaps not in landing configuration	"TOO LOW TERRAIN"	GND PROX	"TOO LOW FLAPS"	GND PROX
4C	Takeoff or go-around unsafe terrain clearance	"TOO LOW TERRAIN"	GND PROX	None	None
5	Descent below glideslope	"GLIDESLOPE GLIDESLOPE" (Soft alert)	GND PROX	"GLIDESLOPE GLIDESLOPE" (Hard alert)	GND PROX
6	Approaching minimums	"APPROACHING MINIMUMS"	None	None	None
6	Minimums	"MINIMUM"	None	None	None
6	Altitude callouts	1000, 500, 50, 40, 30, 20, 10 feet RA	None	None	None
6	Excessive bank angle	"BANK ANGLE"	None	None	None
7	Windshear alerting caution (increasing performance) warning (decreasing performance)	None	Amber WINDSHEAR	"WINDSHEAR, WINDSHEAR, WINDSHEAR"	Red WINDSHEAR
	Terrain look ahead	"CAUTION TERRAIN CAUTION TERRAIN"	GND PROX	"TERRAIN, TERRAIN PULL UP"	PULL UP

TERRAIN AWARENESS WARNING SYSTEM (TAWS) (CONT'D)

MODE	CONDITION	AURAL WARNING LEVEL 1	VISUAL WARNING LEVEL 1	AURAL WARNING LEVEL 2	VISUAL WARNING LEVEL 2
	Obstacle detection	“CAUTION OBSTACLE CAUTION OBSTACLE”	GND PROX	“OBSTACLE, OBSTACLE PULL UP”	PULL UP
	Terrain clearance floor	“TOO LOW TERRAIN”	GND PROX	None	None

VHF NAVIGATION SYSTEM

Description

The aircraft is equipped with two digital VHF navigation (VHF NAV) receivers, which receive and process data from ground stations for en route navigation, precision approach and landing.

Components and Operation

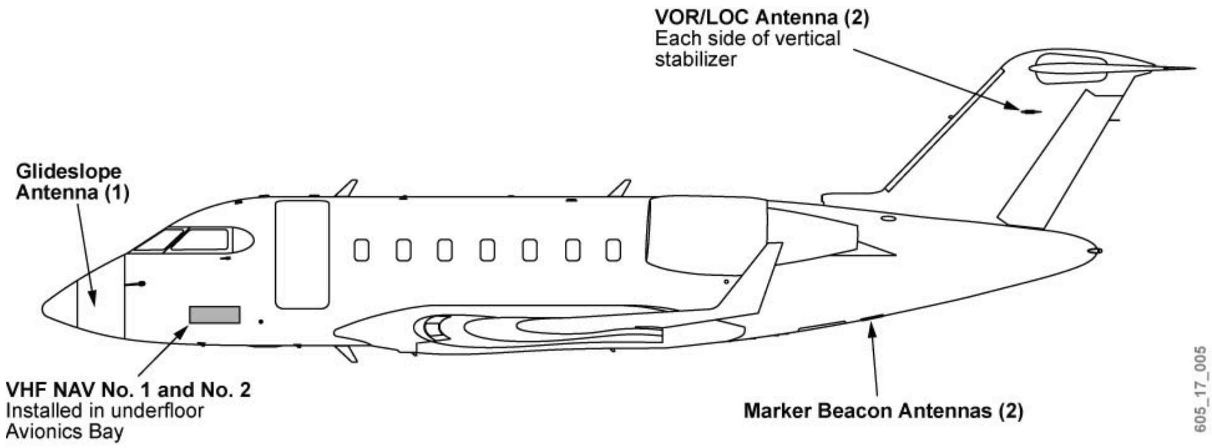
Two VOR/LOC antennas are installed on the left and right sides of the vertical stabilizer. An antenna coupler, installed within the vertical stabilizer, balances the signal input from both antennas, and routes it to the VHF Nav receivers.

A single glideslope (GS) antenna is installed behind the radome, below the weather radar receiver/transmitter and antenna assembly. The GS antenna provides output to both VHF Nav receivers.

The two marker beacon antennas are installed on the bottom of the aft fuselage.

The VHF Nav receivers include fully integrated circuitry for receiving and processing of VOR, ILS (localizer, glideslope), marker beacon and ADF signals. The ADF is independent of the other Nav receiver functions, and is covered later in this chapter.

The VHF Nav receivers route navigation data to the IAPS for distribution to user systems, including the flight director, flight displays and the FMS. Station audio is provided to the aircraft’s audio integrating system.



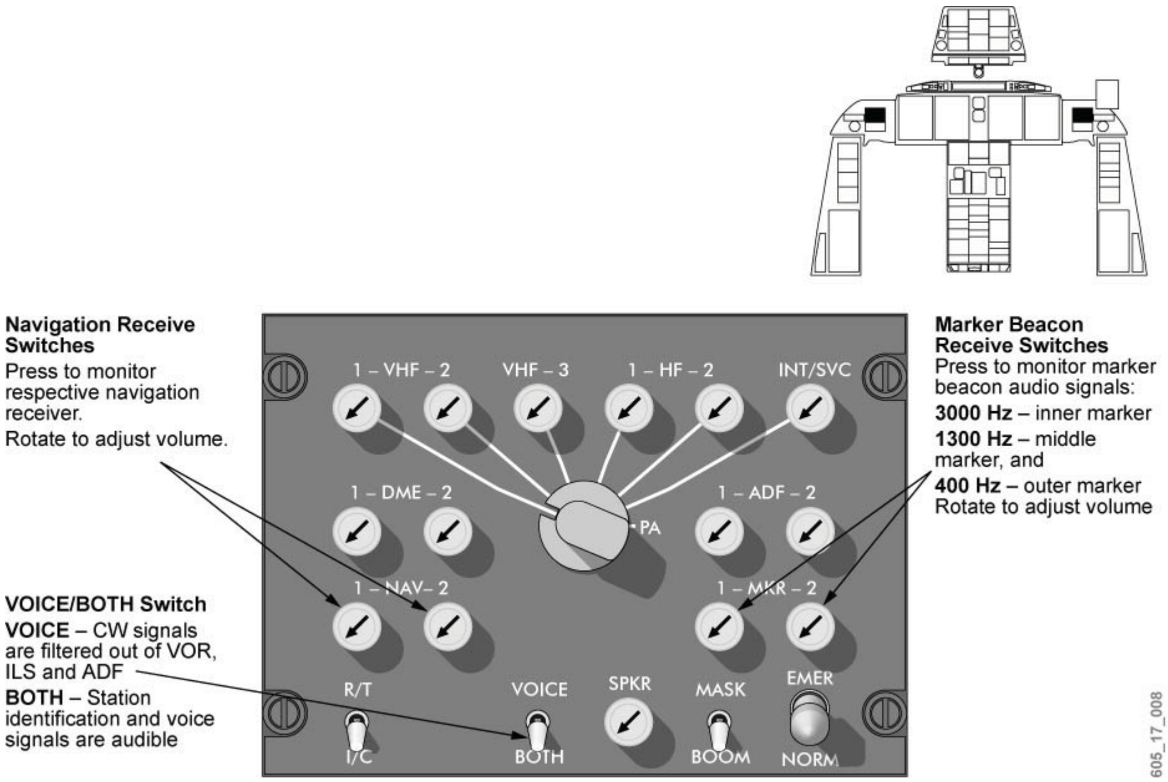
VHF Navigation System Components
Figure 17–10–37

VHF NAVIGATION SYSTEM (CONT'D)

VHF Navigation Radio Audio

The NAV 1 and NAV 2 controls on the audio control panel are used to turn ON or OFF, and adjust the audio volume of, the navigation radios. The VOICE/BOTH switch filters the tone from the NAV ground station beacons when the VOICE position is selected.

Marker beacon audio may also be monitored through the MKR 1 and MK 2 switches. The outer marker provides a 400 Hz tone, the middle marker provides a 1300 Hz tone, and the inner marker provides a 3000 Hz tone.



VHF Navigation Radio Audio Control
Figure 17–10–38

VHF Navigation Radio Tuning

Tuning of the VHF Nav radios may be carried out using the control display units (CDUs) associated with the flight management system (FMS). Alternatively, the cursor control panels (CCPs) may be used to control a tuning menu presented on the MFDs.

The VHF Nav radios may also be automatically tuned by the FMS. The radios include circuitry that automatically identifies navigation ground stations. This makes it possible for the FMS to query its navigation database, and automatically tune the navigation radios.

All tuning input is provided directly to the associated navigation radio, as well as to the integrated avionics processing system (IAPS). The IAPS echoes the display of radio tuning information on all MFDs and CDUs, regardless of the tuning method used.

VHF NAVIGATION SYSTEM (CONT'D)

CDU Tuning

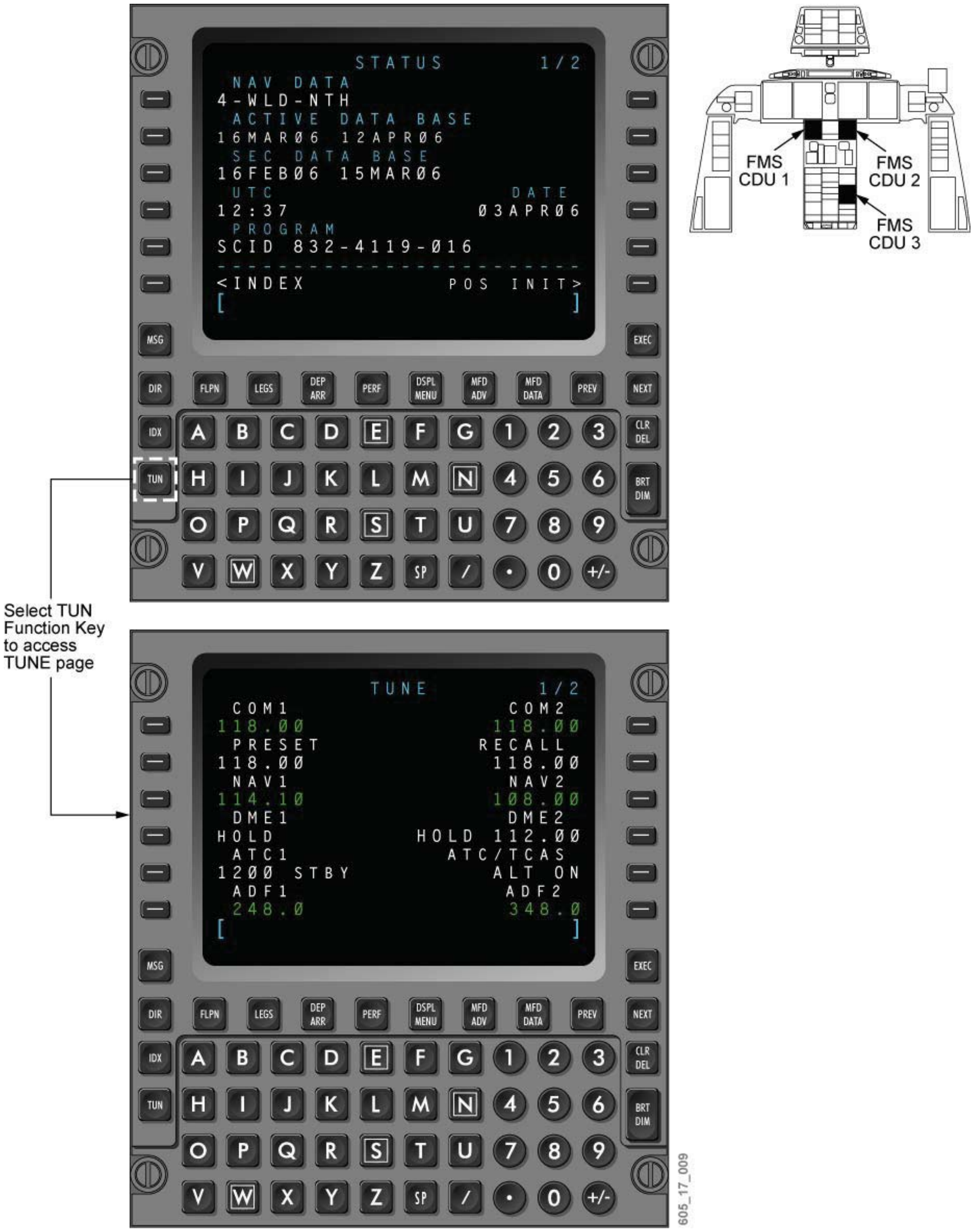
Tuning and control of the VHF Nav radios may be carried out from the CDU TUNE page. The page is accessed by selection of the TUN function key on the CDU. The TUNE page provides primary control of all installed radios, including the VHF navigation radios.

VHF navigation radio titles, NAV1 and NAV2, are shown on page 1 of the TUNE page. Active frequencies appear in green on the data line directly below the corresponding radio title. There is no recall frequency line key on the CDU for the VHF Nav radios.

A new frequency may be entered by direct tuning, selecting a numbered preset frequency, or by permitting the FMS to carry out automatic tuning.

Direct tuning from the CDU is carried out by first keying in the desired frequency on the scratchpad, followed by pushing the radio’s line key. This moves the scratchpad frequency to the active frequency line.

VHF NAVIGATION SYSTEM (CONT'D)



CDU TUNE Page
Figure 17–10–39

VHF NAVIGATION SYSTEM (CONT'D)

NAV CONTROL Page

The VHF Nav radio's CONTROL page (NAV 1, 2 CONTROL) is accessed from the TUNE page by pressing the key adjacent to the radio title.

The control page provides access to the following functions:

- Active frequency selection;
- Preset frequency selection;
- Test;
- Nav autotune enable;
- DME hold; and
- Marker beacon sensitivity.

Preset frequencies are shown at the bottom of the control page. Up to 20 preset frequencies may be stored for the VHF Nav radios. Changing a preset frequency is possible by keying in a new frequency on the scratchpad, then selecting a line key to place it on the preset list. A preset frequency can be made active by selecting a preset line key (with the scratchpad empty). As a result, the selected preset frequency is moved to the active frequency line.

Pushing the TEST line key causes the VHF Nav and DME radios to simultaneously perform a self-test. The test lasts for 10 seconds, during which the TEST annunciator enlarges, and the following indications are shown on the flight displays:

- If VOR frequency tuned – bearing shows 0°;
- If LOC/GS frequency tuned – fly left and fly up indications;
- Marker beacon – 400 Hz audio tone is enabled on the audio system;
- DME shows 100 NM;
- Time to Go (TTG) shows 60 minutes;
- Station ID shows 'AOK'; and
- Ground speed (GS) shows 100 kt.

A cyan AUTO annunciation is displayed when FMS autotune is enabled. Autotuning allows the navigation receiver and DME to be automatically tuned by the FMS. This function is disabled should the pilot manually tune the associated navigation radio, or if DME hold is selected.

The DME hold function allows the DME transceiver to remain at the current frequency while the VHF Nav radio is tuned to a new frequency. HOLD is shown in cyan on the TUNE and CONTROL pages when the DME hold function is enabled.

The crew can adjust the sensitivity of the marker beacon receiver function via a LO/HI selection on the CONTROL page.

VHF NAVIGATION SYSTEM (CONT'D)

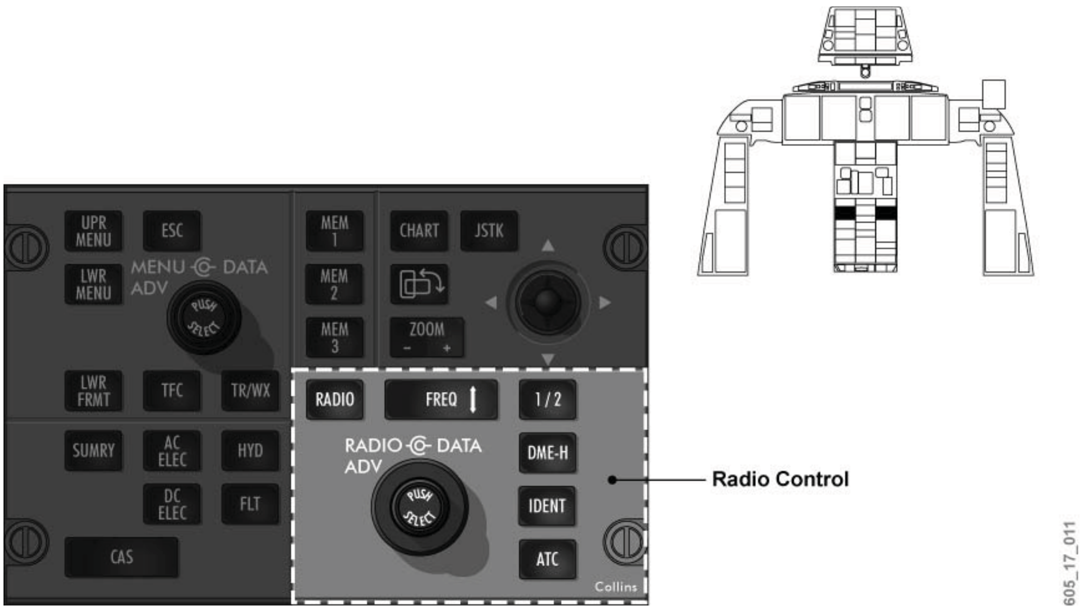
VHF Nav Radio CONTROL Page
Figure 17–10–40

VHF NAVIGATION SYSTEM (CONT'D)

MFD Tuning

The cursor control panel (CCP) and MFD provide single point control of both on-side and cross-side VHF Nav radios. The following controls on each CCP are used for tuning and functional control:

- RADIO ADV/DATA selector/PUSH SELECT knob – used for tuning and operational selections;
- RADIO button – shows the VHF Nav radio submenu;
- FREQ button – swaps the active/recall frequency for the highlighted radio;
- 1/2 button – enables cross-side tuning. When pressed, the on-side MFD shows tuning data from the opposite MFD; and
- DME-H – holds the last DME frequency when pushed.



Cursor Control Panel – ATC Control
Figure 17–10–41

MFD Radio Tuning Window

The VHF Nav radio block is located on the left side of the tuning window, next to the communications block. The active frequency is shown in green, while the recall frequency is shown in white.

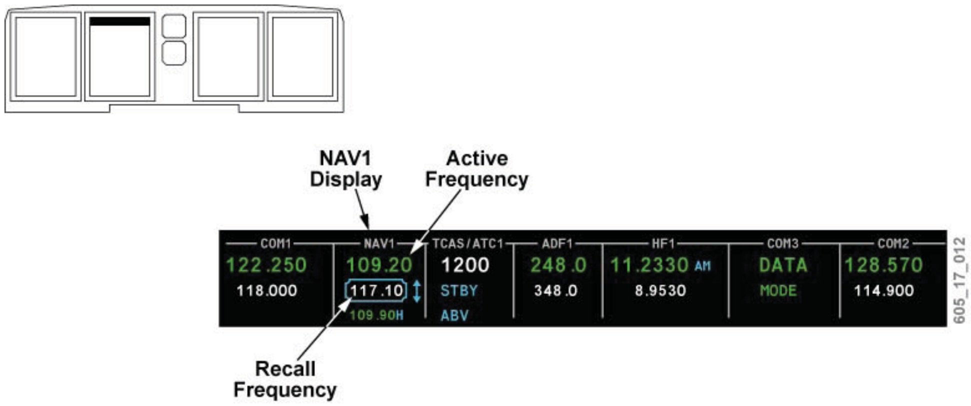
The tuning box is positioned over the recall frequency by rotating the RADIO ADV selector on the CCP. Direct tuning changes can only be made when the PUSH SELECT button is pressed.

When the tune box is made active, the box is split in two. Coarse tuning is carried out by the RADIO ADV selector, while fine tuning is carried out by the DATA selector. Pressing the transfer button on the CCP switches the active and recall frequencies.

Selecting the 1/2 button on the CCP causes the VHF Nav radio block to show tuning information from the opposite VHF navigation radio. The NAV legend at the top of the data block is shown in yellow, indicating that cross-side data is being displayed.

VHF NAVIGATION SYSTEM (CONT'D)

If the DME hold (DME-H) button on the CCP is pushed, the hold frequency is shown below the recall frequency. It is shown in green to indicate that the frequency remains active for DME operations.



MFD Radio Tuning Block
Figure 17–10–42

MFD Radio Tuning Control Page Navigation

The VHF Nav radio’s CONTROL menu is accessed by positioning the tune box over the VHF Nav radio, then pressing the RADIO button on the cursor control panel. The RADIO ADV/DATA selector and center PUSH SELECT button are used to move and make selections in the submenu.

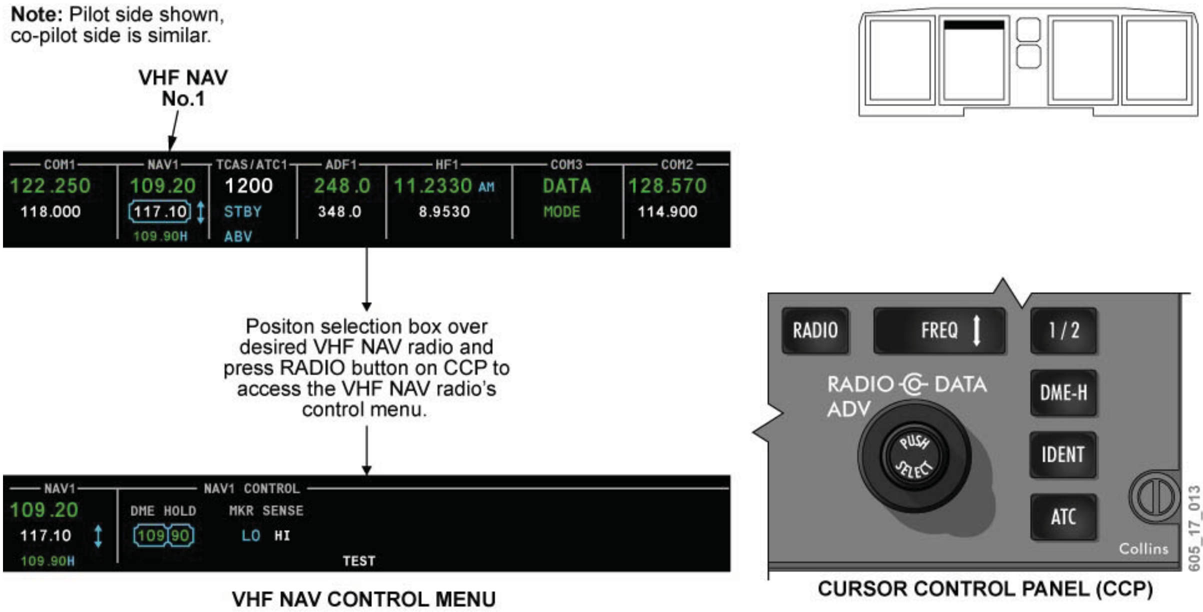
AUTO is displayed in cyan below the recall frequency, if navigation autotune has been enabled from the FMS CDU.

The NAV 1 (2) CONTROL submenu provides control of the following:

- Active/Recall frequency;
- DME hold frequency;
- Marker beacon sensitivity; and
- Test.

The cyan transfer symbol is shown on the Main and Control menu when valid frequencies are available. The FREQ button on the CCP is used to swap the frequencies.

VHF NAVIGATION SYSTEM (CONT'D)



VHF Nav Sub-Menu Control
Figure 17–10–43

VHF Navigation Indications

Description

The following VHF navigation information may be presented on the flight displays:

- Active and preset source information;
- Course selector;
- To/From indicator;
- Course or localizer deviation;
- Glideslope deviation;
- Marker beacon; and
- Bearing indications.

Active and Preset Source Indications

Active and preset NAV source data is presented on the left side of the PFD's Nav display, in all formats. An upper block shows active NAV source information, while a lower block displays preset NAV source data.

Selection of a VHF NAV source in the active block is carried out by accessing the PFD MENU, selecting NAV-SRC, and rotating the inner DATA knob on the DCP to the desired navigation source.

VHF navigation data may be set as the preset navigation source by rotating the DCP DATA knob until VOR or LOC is displayed, and the PUSH SELECT button is pushed. The preset navigation source data may be moved to the active block by pressing the NAV SRC button on the DCP. The previous active data is moved to the preset block.

VHF NAVIGATION SYSTEM (CONT'D)

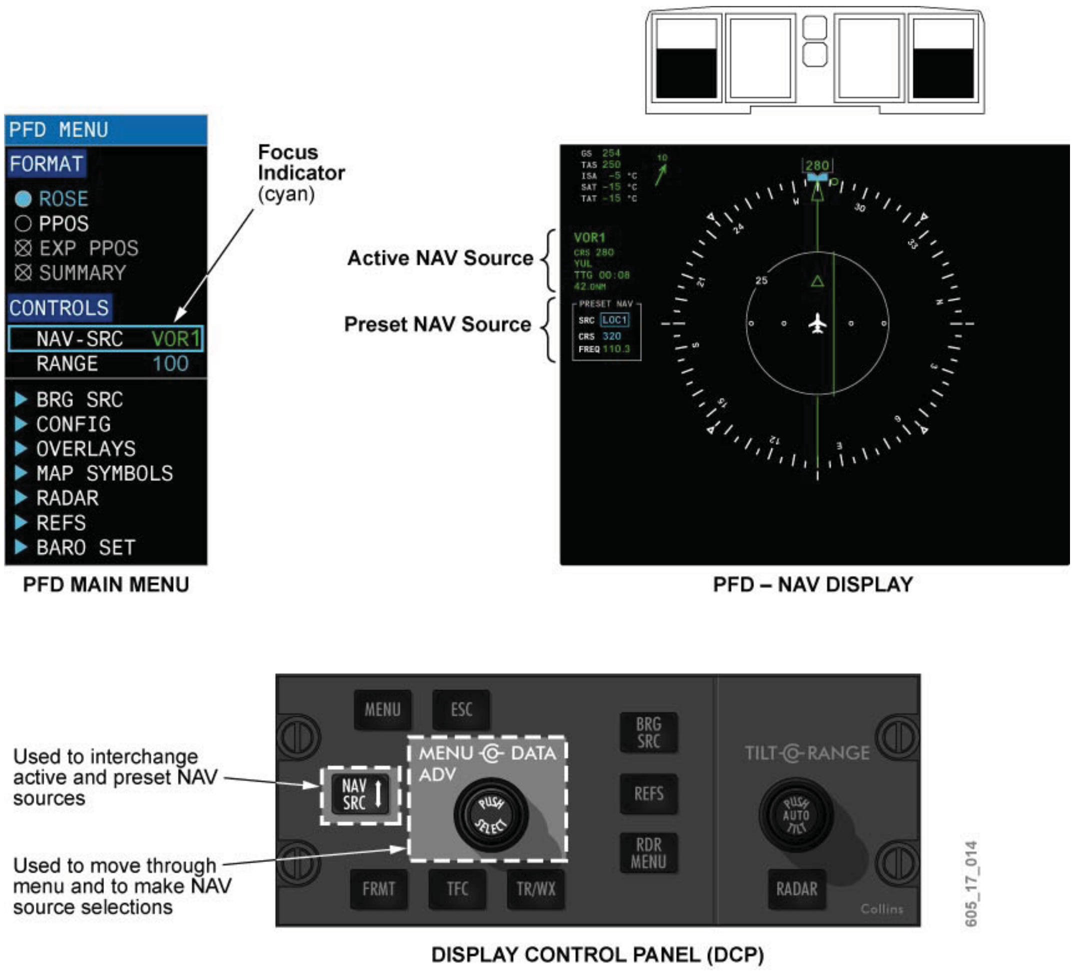
When VOR/LOC is selected as the active source, the active block displays:

- Active navigation source title;
- Course readout;
- Station identification;
- Time-to-go – from DME; and
- Distance display – to VOR station, or distance to runway (LOC).

Text color in the active block is also dependent on the navigation source selected. On-side VOR/LOC data is green, while cross-side data is shown in yellow.

When VOR/LOC is selected in the preset navigation (PRESET NAV) block, the following data is presented:

- Navigation source (SRC): VOR or LOC, shown in cyan;
- Preset course (CRS): shown in cyan; and
- Preset frequency (FREQ): shown in green.



VHF Navigation Source Indications
Figure 17–10–44

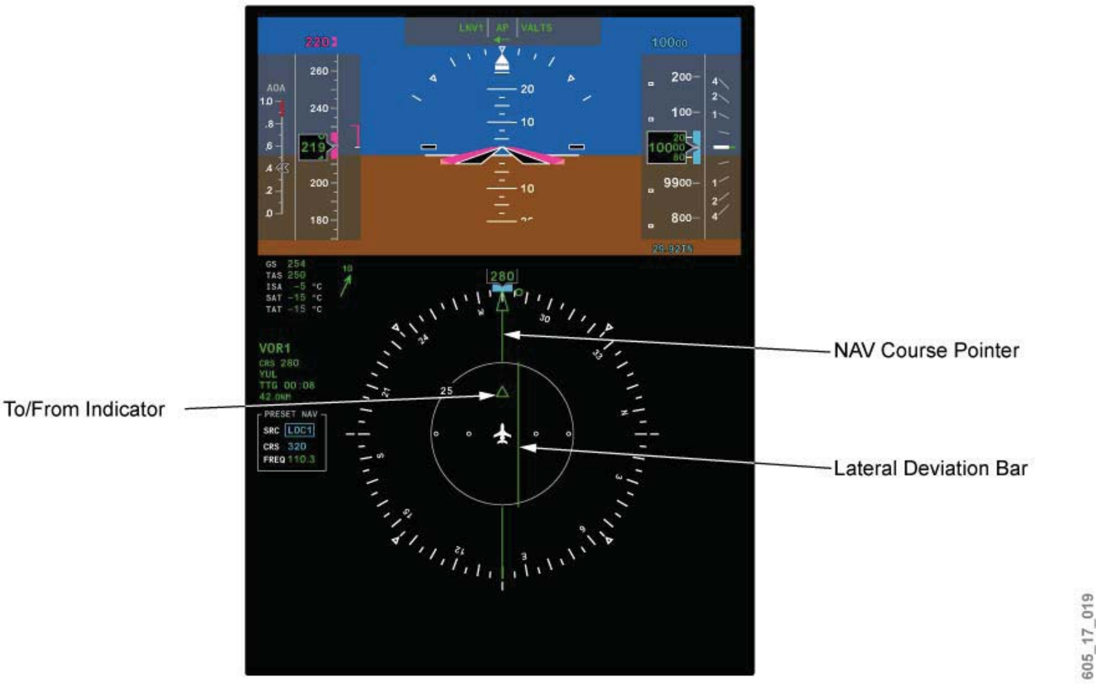
VHF NAVIGATION SYSTEM (CONT'D)

Course Selection and Tracking

The flight control panel (FCP) course knobs (CRS 1, CRS 2) are used to set the course selector when VOR or LOC is the active navigation source. Selection of the PUSH DIRECT button, located in the center of each CRS knob, sets the course direct to the tuned VOR station.

The lateral deviation bar forms the center of the course pointer, and moves along a white deviation scale, shown perpendicular to the course pointer.

The course pointer, deviation bar and To/From indicator are shown in green when on-side VOR/LOC data is displayed, or in yellow when cross-side data is selected.



L-PFD

VHF NAV Display
Figure 17–10–45

VHF NAVIGATION SYSTEM (CONT'D)

LOC/GS Deviation

A lateral deviation scale is shown above the compass rose when a localizer (including back course) is selected as the preselect or active VHF navigation source. LOC deviation is displayed as a diamond-shaped pointer against the deviation scale. The pointer is removed from view when LOC is no longer the active NAV source.

A vertical deviation scale is shown on the right side of the attitude display when localizer is the preselect or active VHF navigation source. GS vertical deviation is displayed as a diamond-shaped pointer against the analog scale. The deviation pointer is removed from view when back course approach is selected.

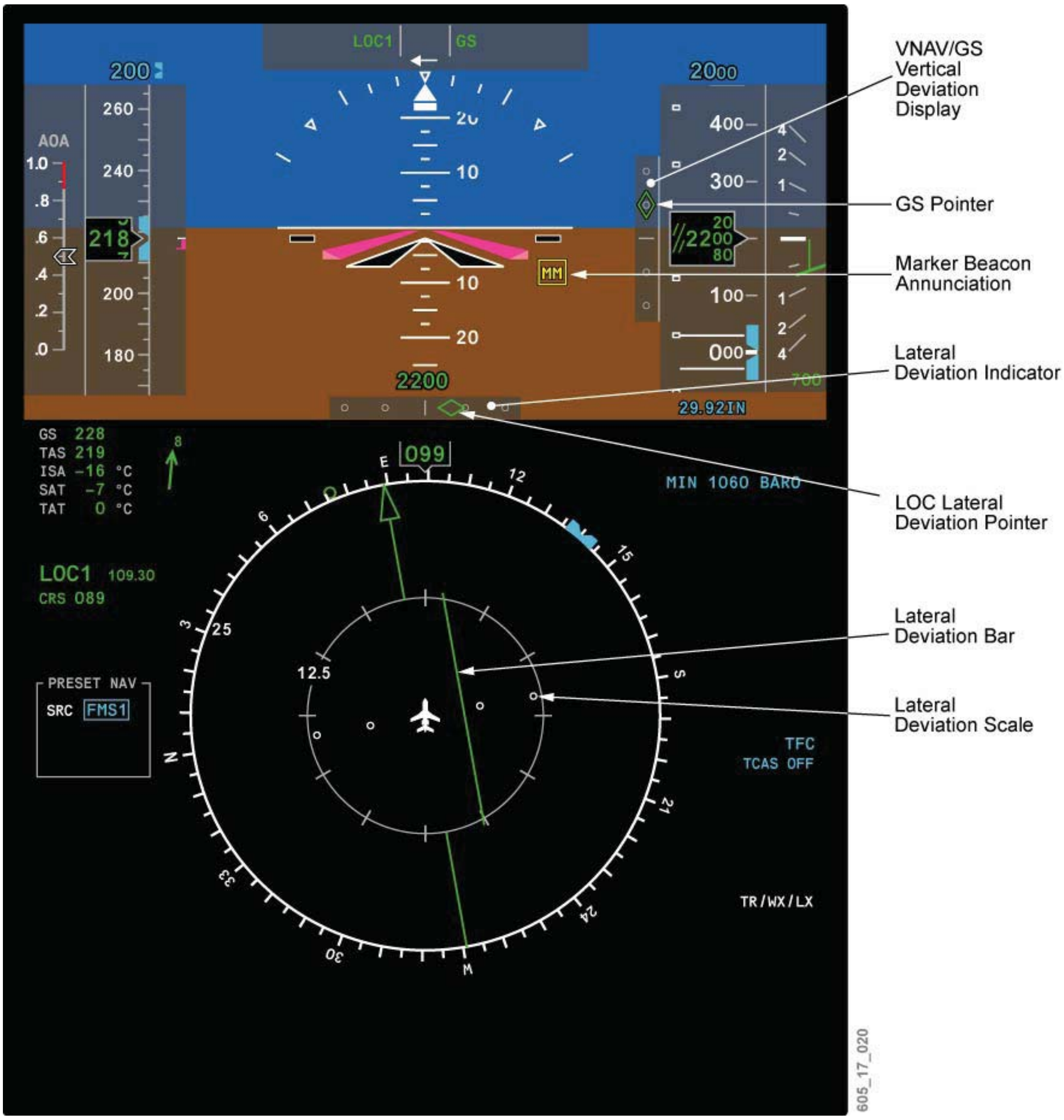
Marker Beacon

The VHF navigation radios process marker beacon signals. the outer, middle and inner beacon positions are indicated by visual cues and aural tones. Visual indications are provided as boxed, color-coded abbreviations, located at the bottom of the PFD’s attitude indicator. Aural tones are also selectable from the audio control panel. The HI/LO sensitivity of the marker beacon function can be adjusted from the VHF navigation tuning windows.

As the aircraft passes over each marker beacon position, the following events occur:

- Outer – cyan OM legend, accompanied by a series of dashes, modulated at 400 Hz.
- Middle – yellow MM legend, accompanied by a series of dots and dashes, modulated at 1300 Hz.
- Airway/Inner – white IM legend, accompanied by a series of dots, modulated at 3000 Hz.

VHF NAVIGATION SYSTEM (CONT'D)



LOC/GS and Marker Beacon Indications
Figure 17–10–46

LOC/GS Failure Indications

In the event of a LOC or GS failure, the associated diamond pointer is removed, and a red-boxed LOC or GS indication is displayed next to the deviation scale.

VHF NAVIGATION SYSTEM (CONT'D)

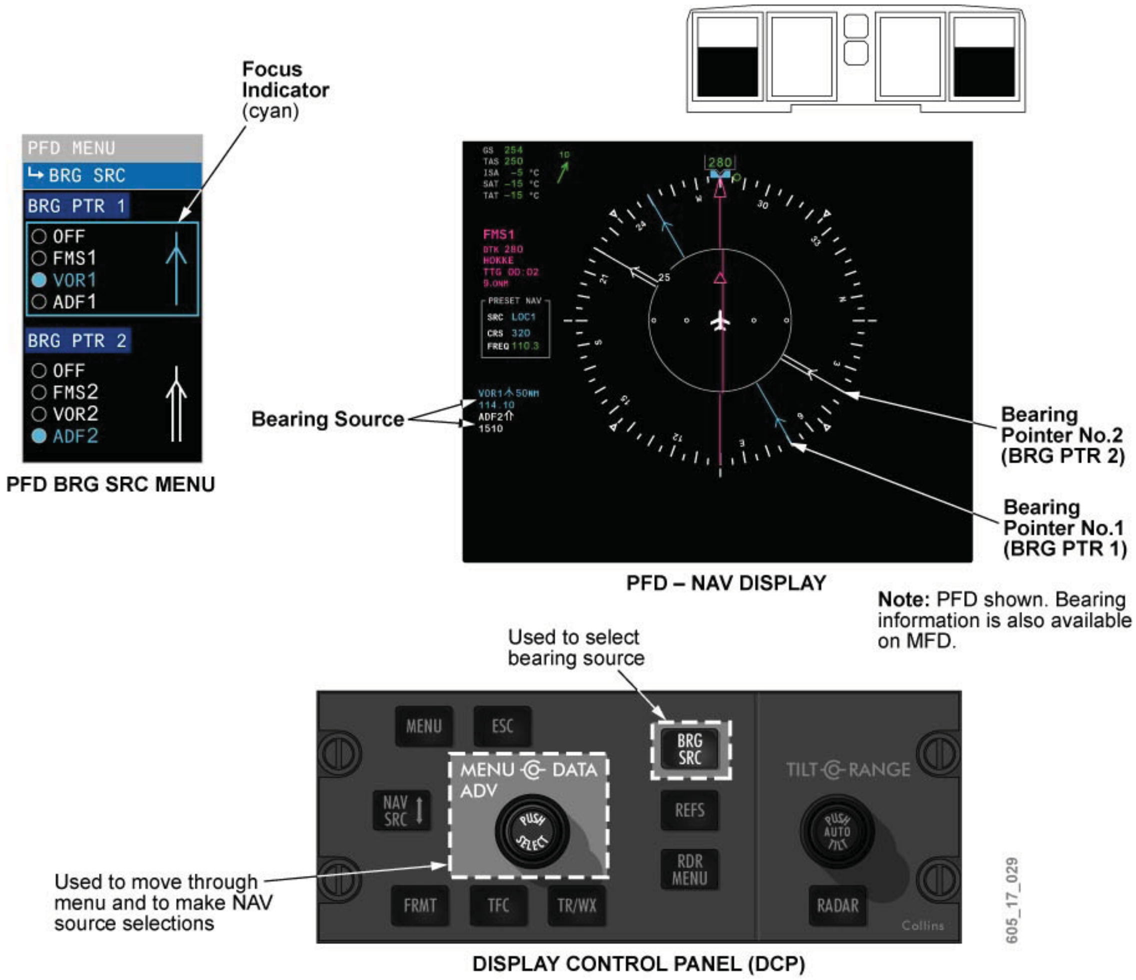
LOC/GS Failure Indications
Figure 17–10–47

VHF NAV Bearing Pointer

The bearing pointers may be selected from the PFD Main Menu, BRG SRC submenu. Actuating the BRG SRC button on the display control panel (DCP) provides direct access to the bearing source submenu. The submenu includes a VOR selection, which allows bearing data and pointers to be presented on the ROSE and PPOS formats on the PFDs and MFDs.

Bearing indications are accompanied by VOR station identification, as well as aircraft distance to bearing source. Bearing distance and station identification are not displayed if the bearing source is also the active NAV source. Bearing distance is removed if DME hold is selected, or if the VHF Nav radio is tuned to a localizer frequency.

VHF NAVIGATION SYSTEM (CONT'D)



VHF NAV Bearing Pointer Selection
Figure 17–10–48

DISTANCE MEASURING EQUIPMENT (DME) SYSTEM

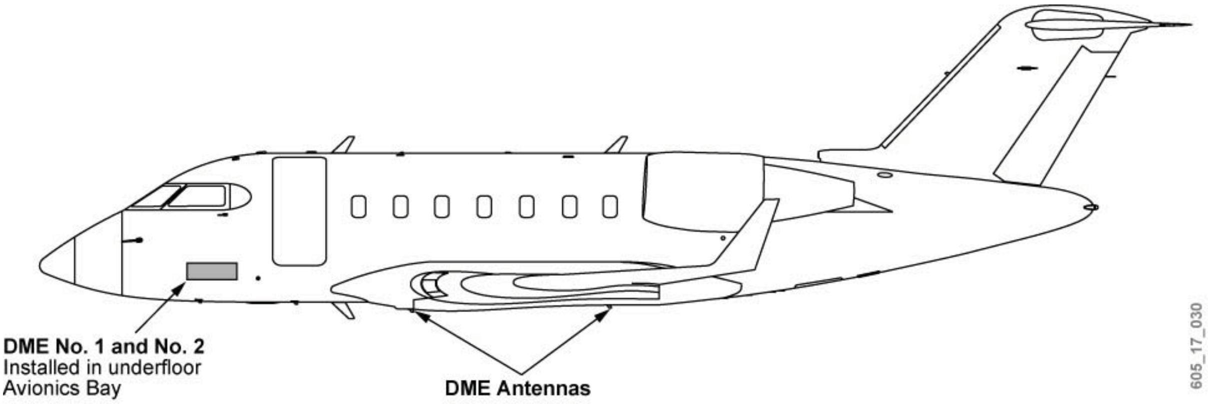
Description

The aircraft is equipped with two DME systems. Each DME system provides calculations of slant range from the aircraft to the DME ground stations. The information is used for position fixing, enroute separation, approach to an airport, holding a given position, and determining ground speed.

Components and Operation

Each DME system includes a DME transceiver, located in the avionics compartment, and a DME antenna, located on the bottom of the fuselage.

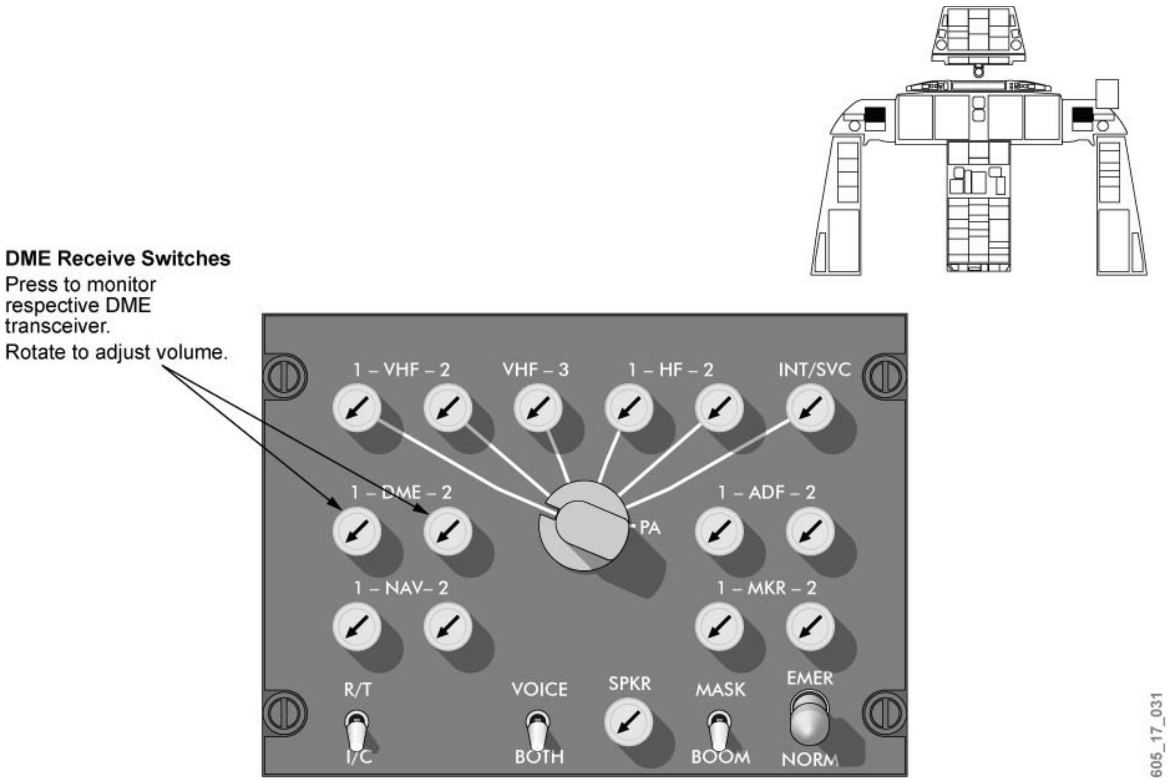
DISTANCE MEASURING EQUIPMENT (DME) SYSTEM (CONT'D)



DME System Components
Figure 17–10–49

DME Audio

The DME 1 and DME 2 controls on the audio control panel are used to turn ON or OFF, and adjust the volume of, the DME transceiver audio. The DME morse code identifier is supplied to the audio integrating system. When listening to the NAV idents simultaneously, the DME is recognizable by its higher pitch.



DME Audio Control
Figure 17–10–50

DISTANCE MEASURING EQUIPMENT (DME) SYSTEM (CONT'D)

DME Tuning and Control

DME operating frequencies are paired and tuned with the VHF Nav frequencies. Each DME can continuously scan up to three channels. One channel is manually tuned, and provides data to the flight displays, while the remaining two channels may be automatically tuned by the FMS, and are used for multisensor navigation.

DME Hold

A DME hold function allows the crew to maintain a DME tuned to one frequency, while tuning the VHF Nav to a new frequency. This function is enabled via the CDU TUNE page, by pressing the line key adjacent to the DME legend. The HOLD text enlarges when selected, and the frquency being ’held’ is shown next to it.

The Hold function may also be selected by pressing the DME-H button on the cursor control panel (CCP). When pressed, the focus indicator on the MFD moves to the NAV recall frequency, allowing the VHF Nav to be tuned to a new frequency.

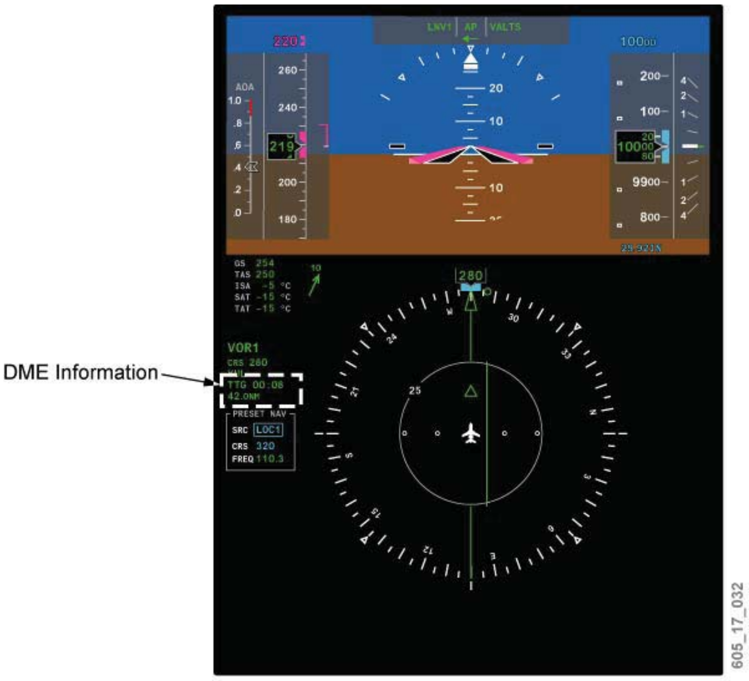
Independent DME Tuning

Independent tuning of the DME may also be carried out via the FMS CDU. This feature allows for a separate DME frequency to be tuned without having to select HOLD. This is done by entering a DME frequency onto the CDU scratchpad, followed by selecting the desired DME line key. Independent tuning in this manner cannot be carried out from the MFD tuning window.

DME Display

DME information is displayed on the PFDs and MFDs. The information is listed on the active navigation source data block on the PFDs. The DME distance includes the abbreviation “NM” (nautical miles) when DME tuning is coupled with the VHF Nav frequency. The abbreviation “NM” is removed and replaced with “H” when DME hold is selected. DME information is also presented in the same color as the navigation source. DME and related indications, such as time-to-go, are also provided at the top of the MFD. The color of the DME data presented on the MFD also corresponds with the navigation source.

DISTANCE MEASURING EQUIPMENT (DME) SYSTEM (CONT'D)



DME Indications
Figure 17–10–51

AUTOMATIC DIRECTION FINDING SYSTEM

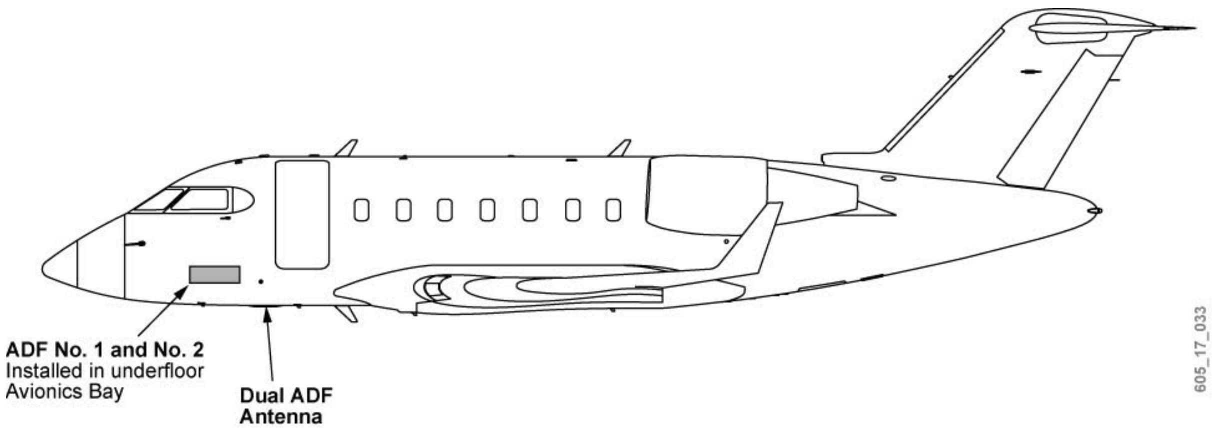
Description

The aircraft is equipped with two automatic direction finding (ADF) systems. The ADF supplies aircraft bearing to station, and audio outputs to the navigation and audio systems.

Components and Operation

The ADF receivers are an integral and functional part of the VHF navigation receivers. A dual ADF antenna is located on the bottom of the fuselage, forward of the wing root.

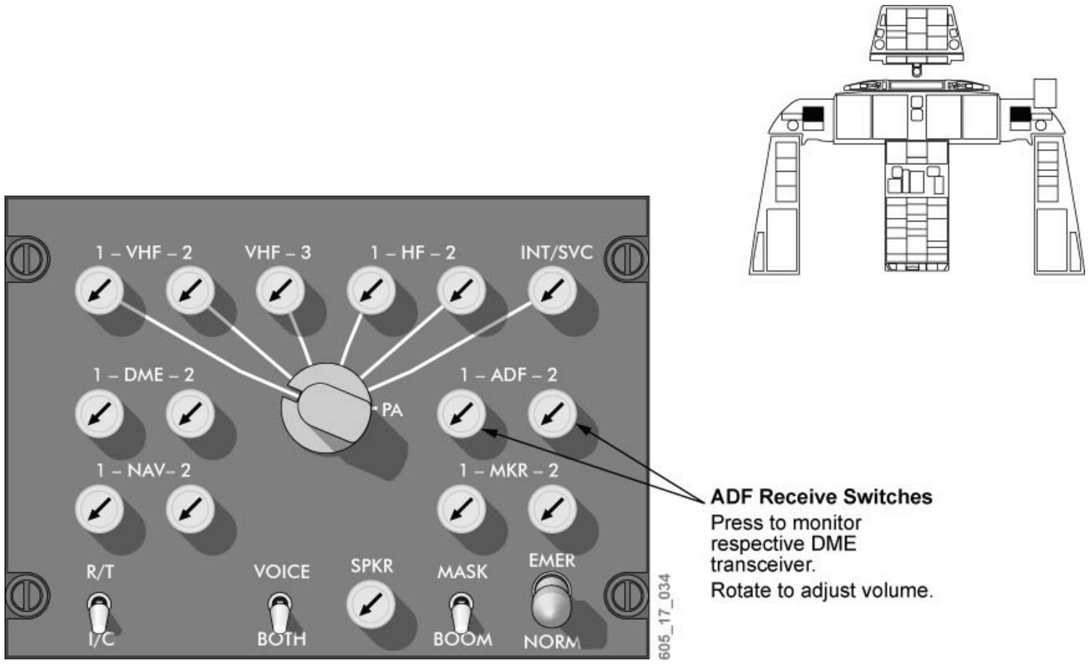
AUTOMATIC DIRECTION FINDING SYSTEM (CONT'D)



ADF System Components
Figure 17–10–52

ADF Audio

The ADF 1 and ADF 2 audio controls, on the audio control panel, are used to turn ON or OFF, and adjust the volume of, the ADF receiver audio.



ADF Audio Control
Figure 17–10–53

Tuning and Control

ADF functions are tuned and controlled via the CDUs, or through the MFD tuning windows.

AUTOMATIC DIRECTION FINDING SYSTEM (CONT'D)

CDU Tuning

Tuning of the ADF may be carried out from the TUNE page displayed on the CDUs. ADF receiver titles, ADF 1 and ADF 2, are shown on page 1 of the TUNE page. Active frequencies appear in green on the data line directly below the corresponding radio title. There is no recall frequency line key for the ADFs.

Direct tuning from the CDU is carried out by first keying in the desired frequency on the scratchpad, followed by pushing the ADF (1 or 2) line key. This moves the scratchpad frequency to the ADF frequency line.

ADF Control Page

Selecting an ADF (1 or 2) line key with the scratchpad empty provides access to the ADF (1 or 2) CONTROL page. The ADF CONTROL page provides control display of the following:

- ADF test;
- Mode selection (ADF/ANT);
- BFO (ON/OFF); and
- ADF presets.

Selection of ADF test causes the word “TEST” to enlarge and show in cyan. The ADF bearing on the flight displays rotates clockwise 90 degrees. Test duration is approximately 10 seconds.

In the ADF mode, the ADF receiver provides bearing-to-station output to the flight displays. In the ANT mode, the ADF sensitivity is increased. It receives station signals at long range, but does not provide bearing information to the flight displays.

NOTE

When HF communications is required and the microphone is keyed, the ADF pointers will freeze during HF transmissions.

The beat frequency oscillation (BFO) function adds a 1020 Hz audio tone to the normal audio output. Depending on the method of transmission used by the ground station, BFO operation aids in making the station’s identifier signal more audible. When BFO is selected, the BFO text enlarges, and is shown in cyan.

Up to 20 preset frequencies for the ADF systems may be entered on the ADF CONTROL page. Preset frequencies are entered on the scratchpad, then selected to a preselect key. A preselect frequency is made active by first selecting the desired frequency to the scratchpad, followed by selecting the active ADF frequency.

AUTOMATIC DIRECTION FINDING SYSTEM (CONT'D)

ADF CONTROL Page
Figure 17–10–54

AUTOMATIC DIRECTION FINDING SYSTEM (CONT'D)

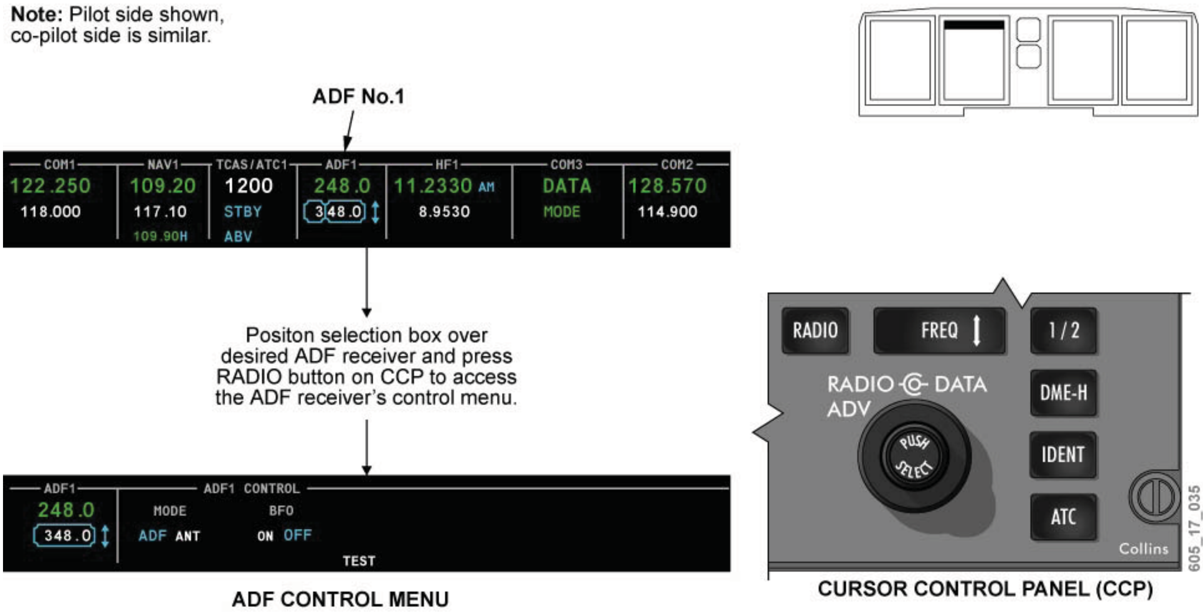
MFD Tuning

ADF tuning and control may also be carried out from the MFD tuning window. Active frequencies appear in green on the data line directly below the corresponding radio title. There is no recall frequency line key for the ADFs.

The ADF submenu on the MFD provides control display of the following:

- ADF test;
- Mode selection (ADF/ANT); and
- BFO (ON/OFF).

The cyan transfer symbol is shown on the Main and Control menu when valid frequencies are available. The FREQ button on the CCP is used to swap the frequencies.

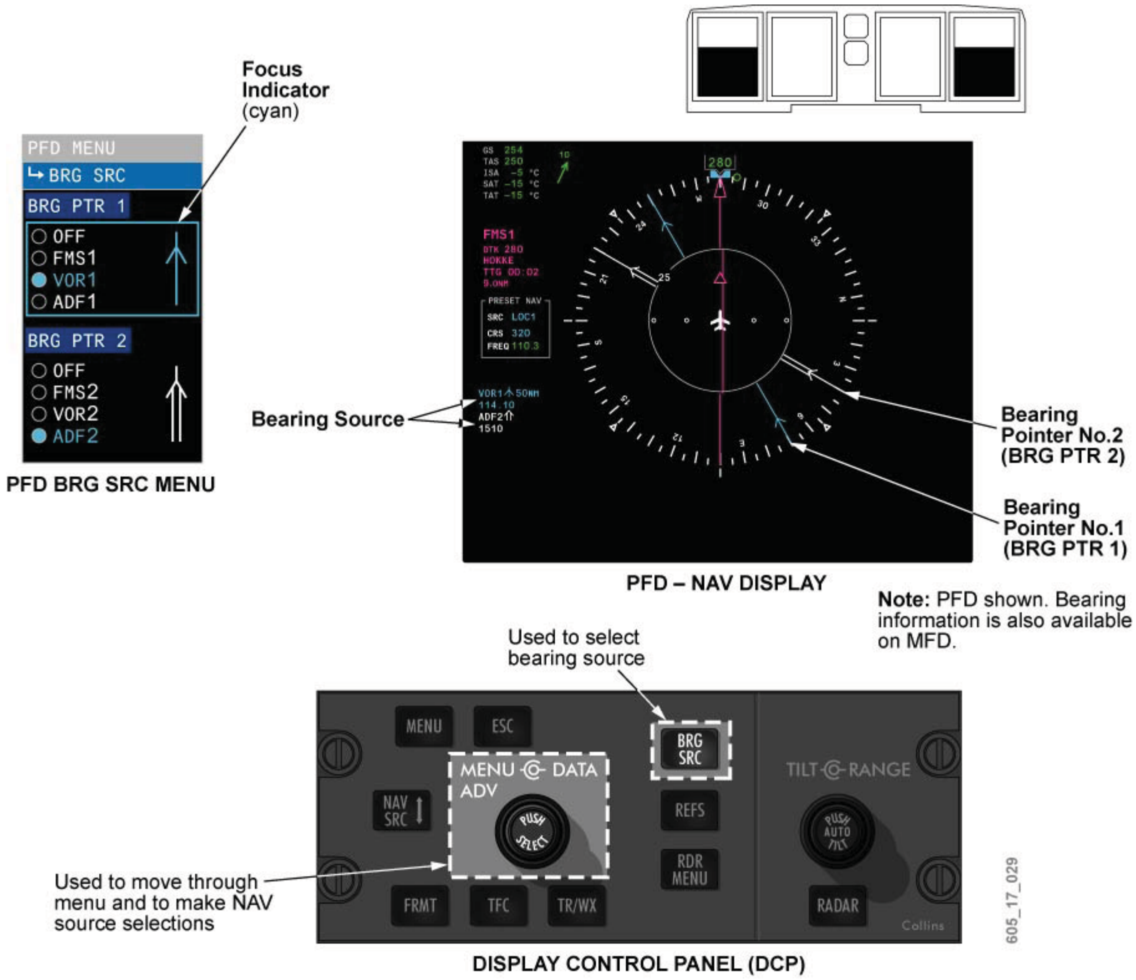


ADF Tuning and Control
Figure 17–10–55

ADF Display

ADF data is available as a source for the flight display bearing pointers. The ADF bearing pointers are selected from the BRG SRC button on the DCPs, or via the BRG SRC submenu. The ADF bearing data is available for presentation on the ROSE and PPOS format on the PFDs and MFDs. The bearing pointer is automatically removed should the associated ADF receiver fail.

AUTOMATIC DIRECTION FINDING SYSTEM (CONT'D)



ADF Bearing Indications
Figure 17–10–56

AIR TRAFFIC CONTROL (ATC) TRANSPONDER SYSTEM

Description

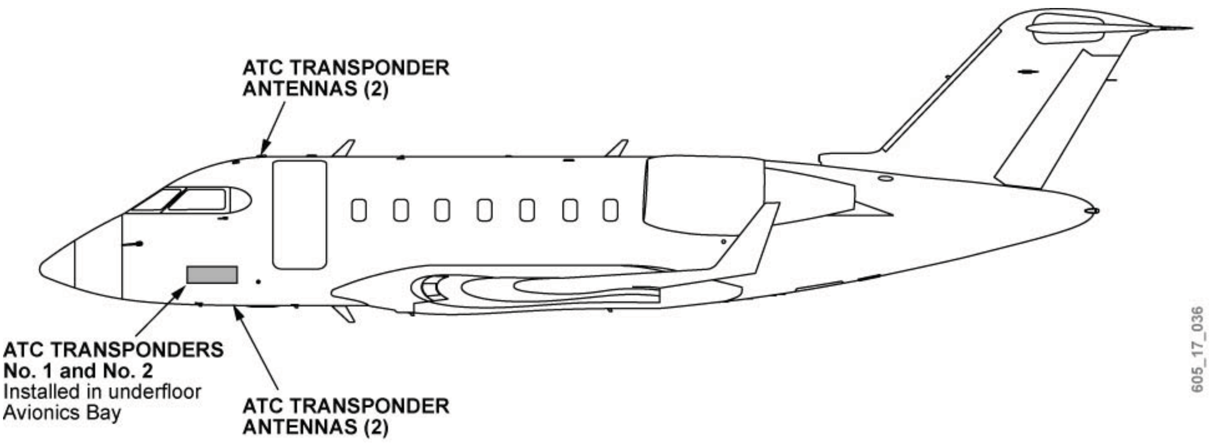
The two ATC transponders operate as an air traffic control radar beacon system, which automatically responds to interrogations. The ATC transponder system includes the following reply modes:

- Mode A – Provides a reply that includes an identification code.
- Mode C – Provides a reply containing the aircraft's encoded pressure altitude.
- Mode S – Provides a reply containing an ICAO address code that is unique to the aircraft, and includes expanded data communication capabilities.

Components and Operation

Each ATC system includes two paired antennas, located on the top and bottom of the fuselage, and two transponders installed in the avionics compartment.

AIR TRAFFIC CONTROL (ATC) TRANSPONDER SYSTEM (CONT'D)



ATC System Components
Figure 17–10–57

ATC Transponder Control

Control of the ATC transponders may be carried out using the control display units associated with the flight management system. Alternatively, the cursor control panels may be used to control an ATC/TCAS control menu presented on the MFDs.

ATC Transponder Control – CDU

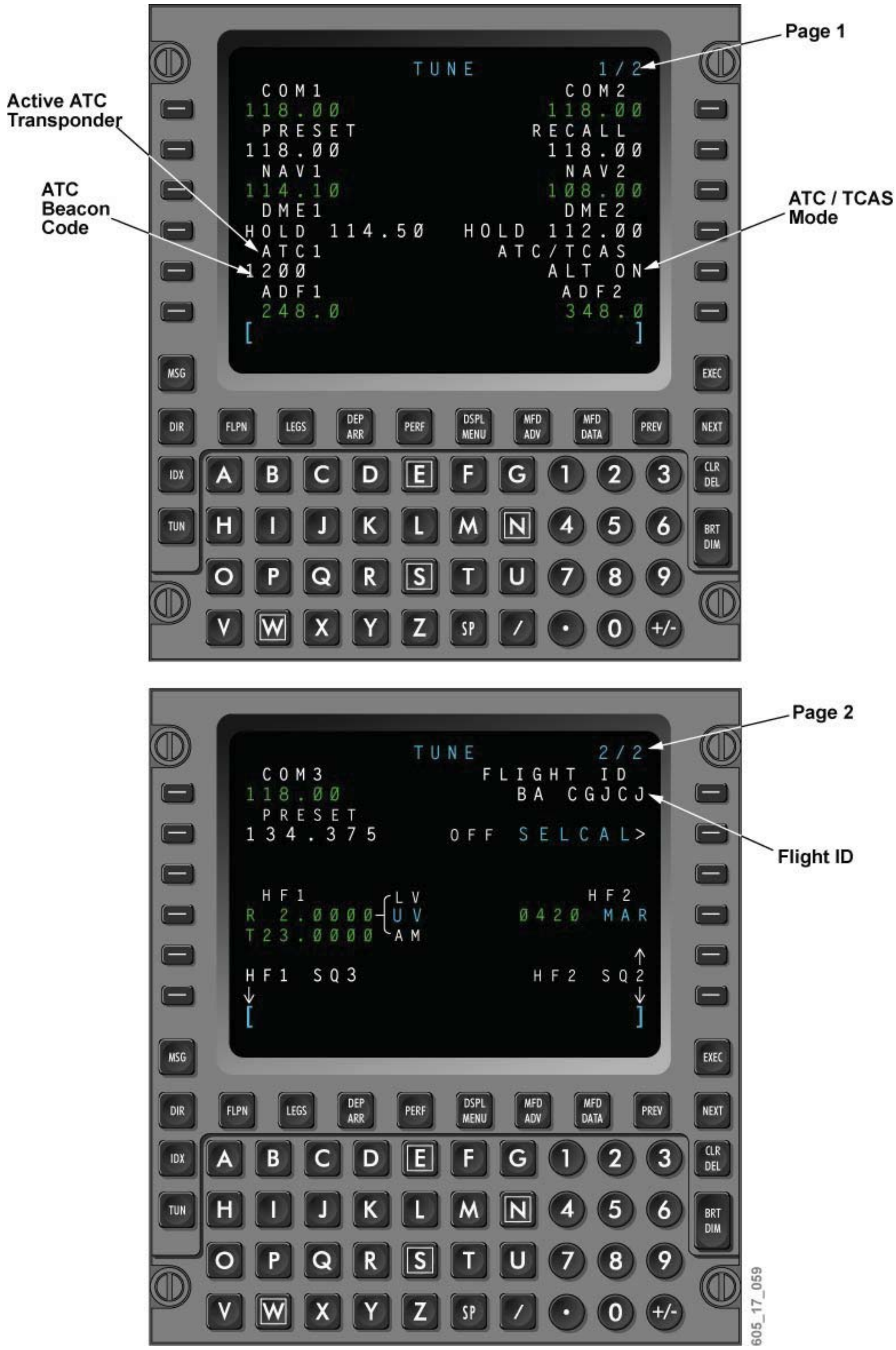
TUNE Page

The first TUNE page includes two line keys which input to the ATC system, one on each side of the display. The left line key is used to enter the ATC code. The four digit code (0000 to 7777) is first entered on the scratchpad, and transferred to the ATC via the line key adjacent to the ATC title.

The right line key is a mode selection line key providing input to ATC and TCAS. It allows the crew to select from the following modes: STBY, TA/RA, TA ONLY, ALT ON and ALT OFF. The ATC transponder is fully functional in all modes except for STBY (standby). The altitude reporting function of the ATC is off when ALT OFF is selected. See the TCAS section in this chapter for additional information on the remaining operating modes.

The second TUNE page, accessed by selection of the NEXT function key, includes a line key for entering the aircraft FLIGHT ID. The FLIGHT ID is first entered on the scratchpad, then transferred to the FLIGHT ID line by the line key adjacent to the ID space.

AIR TRAFFIC CONTROL (ATC) TRANSPONDER SYSTEM (CONT'D)



CDU TUNE Pages 1 and 2
Figure 17–10–58

AIR TRAFFIC CONTROL (ATC) TRANSPONDER SYSTEM (CONT'D)

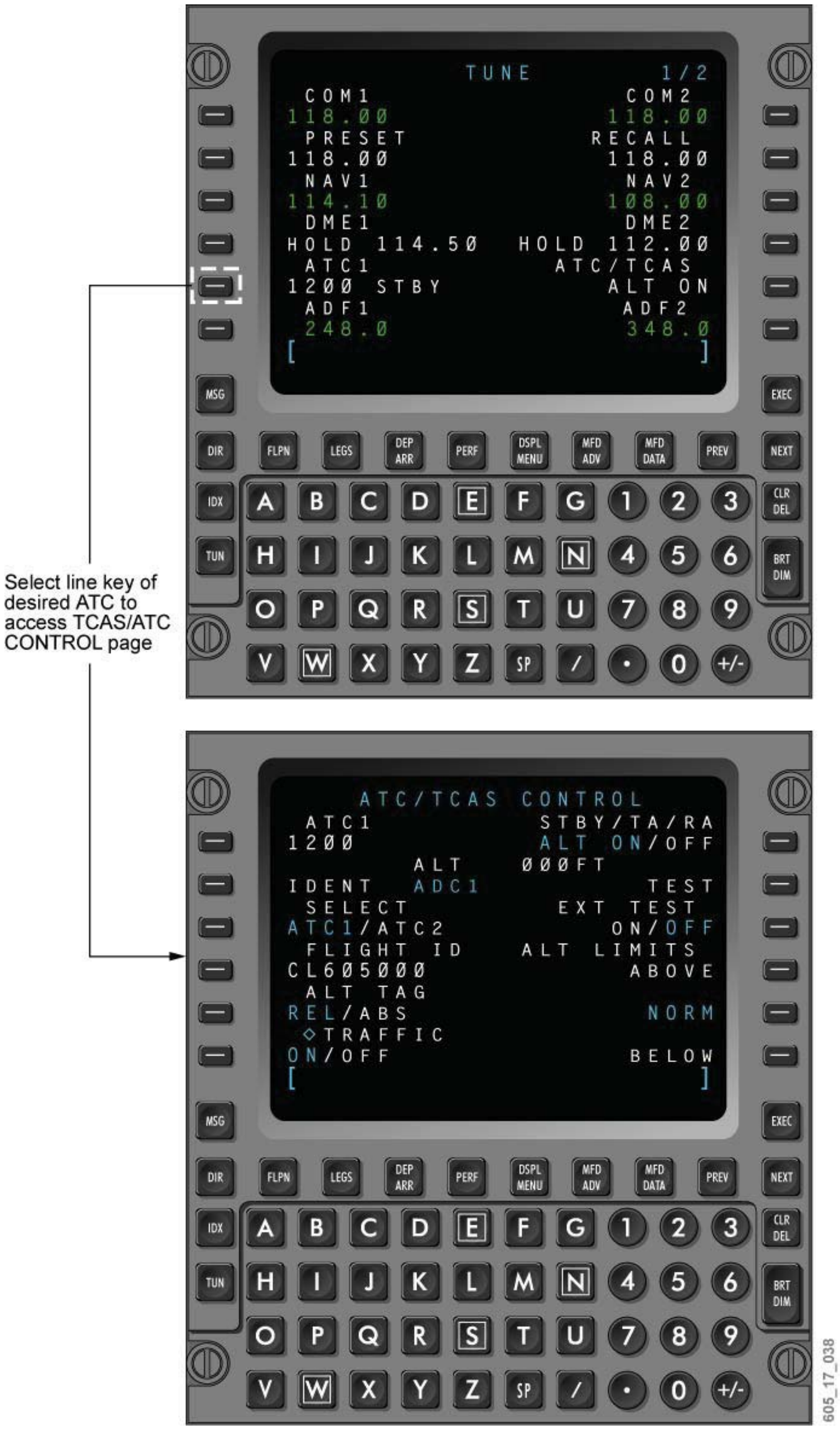
ATC/TCAS CONTROL Page

The ATC/TCAS CONTROL page is accessed from the TUNE page by selection of the line key adjacent to the ATC title. The ATC/TCAS CONTROL page includes six line keys, which provide input to the ATC system as follows:

- ATC 1 (2) – Used to set the active ATC code (similar to TUNE page). RPLY annunciation, shown in cyan next to ATC code, indicates ATC is responding to an interrogation.
- IDENT – Used to select the squawk ident function of the active transponder.
- SELECT – Used to select the active ATC transceiver (ATC 1 or ATC 2).
- FLIGHT ID – Used to set the active flight identification (similar to TUNE page).
- STBY/TA/RA/ALT ON/ALT OFF – Used for mode selection (similar to TUNE page). ATC is functional in all modes except for STBY. Altitude reporting of ATC is off when ALT OFF is selected.
- TEST – Enables a simultaneous test of both the ATC and TCAS systems. The ATC transponder test is an internal functional test. When active, the TEST text enlarges for approximately 10 seconds.

The page also indicates which ADC source is being used by the ATC. The source ADC is indicated in cyan next to the IDENT text. In keeping with RVSM requirements, the flight director/autopilot and ATC transponder must use the same pressure altitude source. Should the crew select a flight control computer (FCC) transfer (XFR) from the flight control panel (FCP), the ATC automatically switches ADCs in order to use the same altitude source as the active FCC.

AIR TRAFFIC CONTROL (ATC) TRANSPONDER SYSTEM (CONT'D)



ATC/TCAS CONTROL Page
Figure 17–10–59

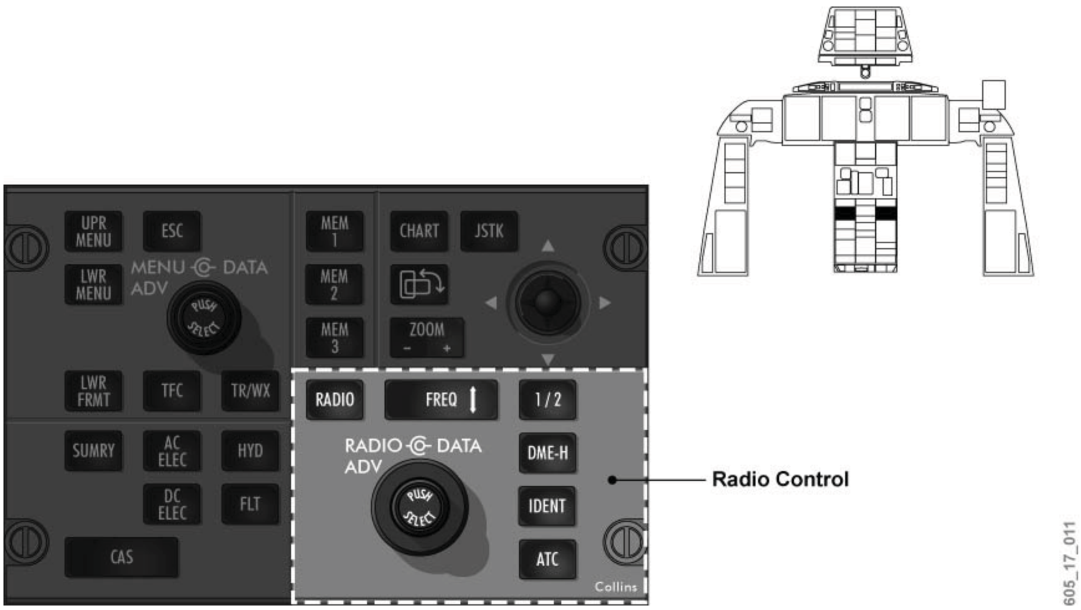
AIR TRAFFIC CONTROL (ATC) TRANSPONDER SYSTEM (CONT'D)

ATC Transponder Control – MFD Tuning Block

ATC control may also be carried out from the MFD tuning window. The top level TCAS/ATC 1 (2) menu of the MFD tune display includes selections for the active ATC code, mode selection, and altitude limits selection (TCAS only). A combined ATC/TCAS submenu is also available, providing similar functions as found on the CDU ATC/TCAS control page.

The cursor control panel includes several buttons providing input to the ATC system, and controlling the focus indicator on the MFD tuning window.

- RADIO button – Used to access the ATC submenu on the MFD tuning window.
- FREQ – Used to position the focus indicator around the active ATC code when it is located within the TCAS/ATC block, but does not surround the active code.
- 1/2 button – Enables cross-side control of the opposite ATC transponder.
- IDENT button – Used to select transponder ident for the active transponder.
- ATC button – Used to change the transponder/TCAS from standby to RA/TA, and from any state to standby.
- RADIO/DATA/ADV knob – Used to navigate through the displayed ATC submenu.



Cursor Control Panel – ATC Control
Figure 17–10–60

ATC Transponder Control – TCAS/ATC Submenu

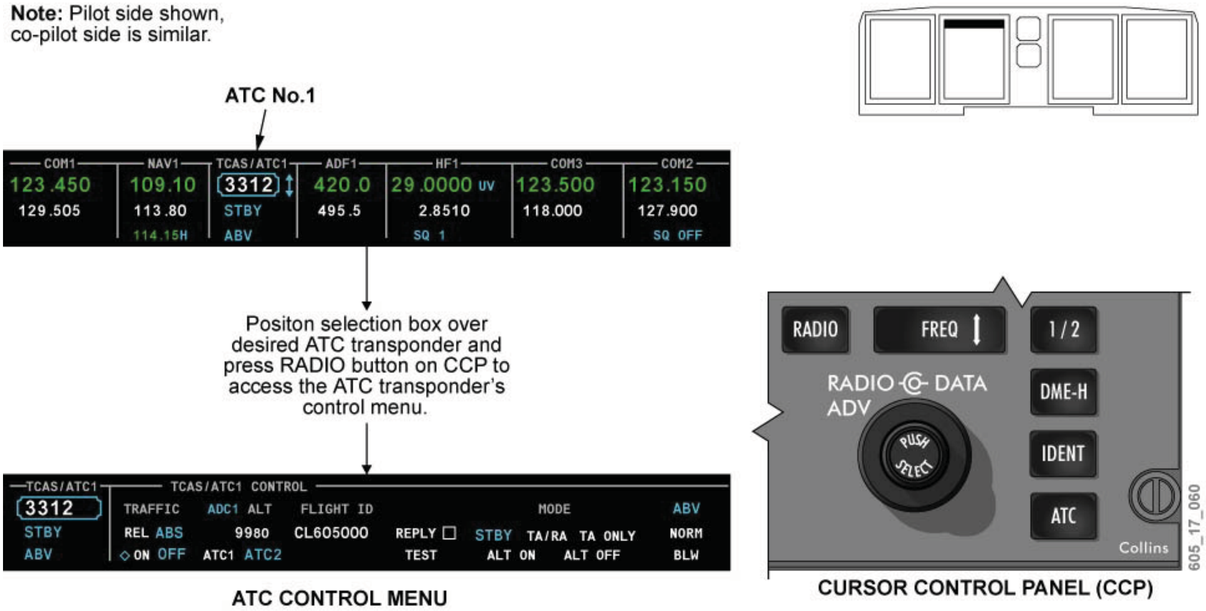
The combined TCAS/ATC 1 (2) control submenu is accessed using the RADIO ADV/DATA and RADIO button on the cursor control panel. Active mode selections on the submenu are indicated by enlarged cyan text.

From the submenu, the crew can carry out the following ATC functions:

- Set the ATC code.
- Identify the ATC altitude source (ADC 1 or ADC 2).
- Select the active ATC (1 or 2).

AIR TRAFFIC CONTROL (ATC) TRANSPONDER SYSTEM (CONT'D)

- Set the Flight ID.
- Select the TCAS/ATC mode.
- Enable the combined TCAS/ATC test.



ATC Transponder Control
Figure 17–10–61

TRAFFIC ALERT AND COLLISION AVOIDANCE SYSTEM (TCAS)

Description

The TCAS is an airborne system that interrogates other aircraft's ATC transponders to identify and display potential collision threats. The system protects a volume of airspace around the aircraft, and provides aural and visual advisories when intruding aircraft penetrate that protected airspace.

TCAS monitors a radius of approximately 5 to 40 NM around the aircraft. The TCAS transceiver transmits mode-C and mode-S transponder interrogation signals, and monitors all replies. Internal processing determines the range, bearing, and altitude of each transponder-equipped aircraft within range. When a conflict exists, the TCAS generates traffic advisory (intruder alert), resolution advisory (recommended vertical escape maneuver), and/or synthesized-voice audio outputs.

When an intruder aircraft is also equipped with a functioning mode-S transponder, the TCAS uses the transponder to transmit collision avoidance data to that aircraft. This mode-S link allows the two TCAS systems to coordinate conflict resolution between aircraft.

TCAS Transmitter/Receiver

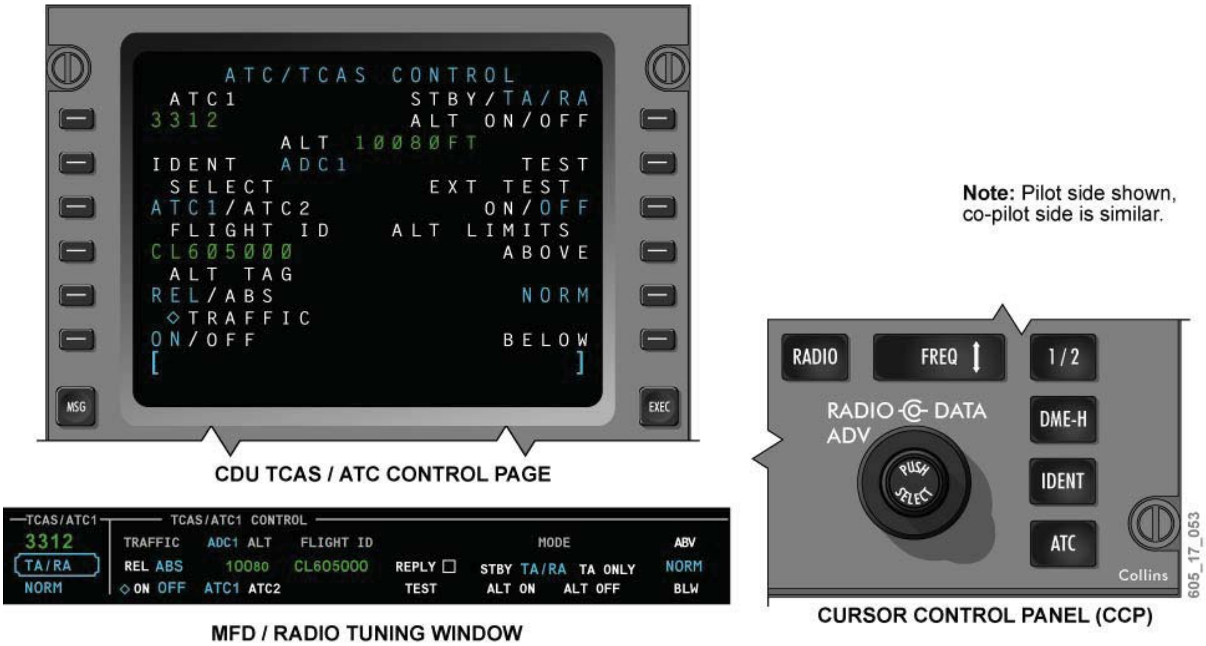
The TCAS transmitter/receiver contains the TCAS computer, and is installed in the underfloor avionics compartment. It selectively transmits interrogation signals, receives and analyzes the responses, determines if potential conflicts exist, generates collision avoidance solutions, and formats the data to visually and/or aurally present that information to the pilots.

TRAFFIC ALERT AND COLLISION AVOIDANCE SYSTEM (TCAS) (CONT'D)

The TCAS transmitter/receiver receives bearing information from the TCAS directional antenna on the top of the fuselage, and receives altitude information from the TCAS omnidirectional antenna, located on the underside of the fuselage. Power for the TCAS transmitter/receiver is supplied by the AC essential bus.

TCAS Controls

TCAS controls and mode selections are done on the FMS control display unit (CDU), or on the CCP/MFD radio tuning window. The displays and controls of the TCAS and ATC radio are combined.



TCAS/ATC Controls
Figure 17–10–62

CDU – ATC/TCAS Control Page

On the CDU TUNE page, the left line select key 5 provides access to the ATC/TCAS CONTROL page. The TCAS control is associated with right line select key 5 of the TUNE page, and right line select key 1 of the ATC/TCAS CONTROL page.

The ATC/TCAS CONTROL page provides control display of the following:

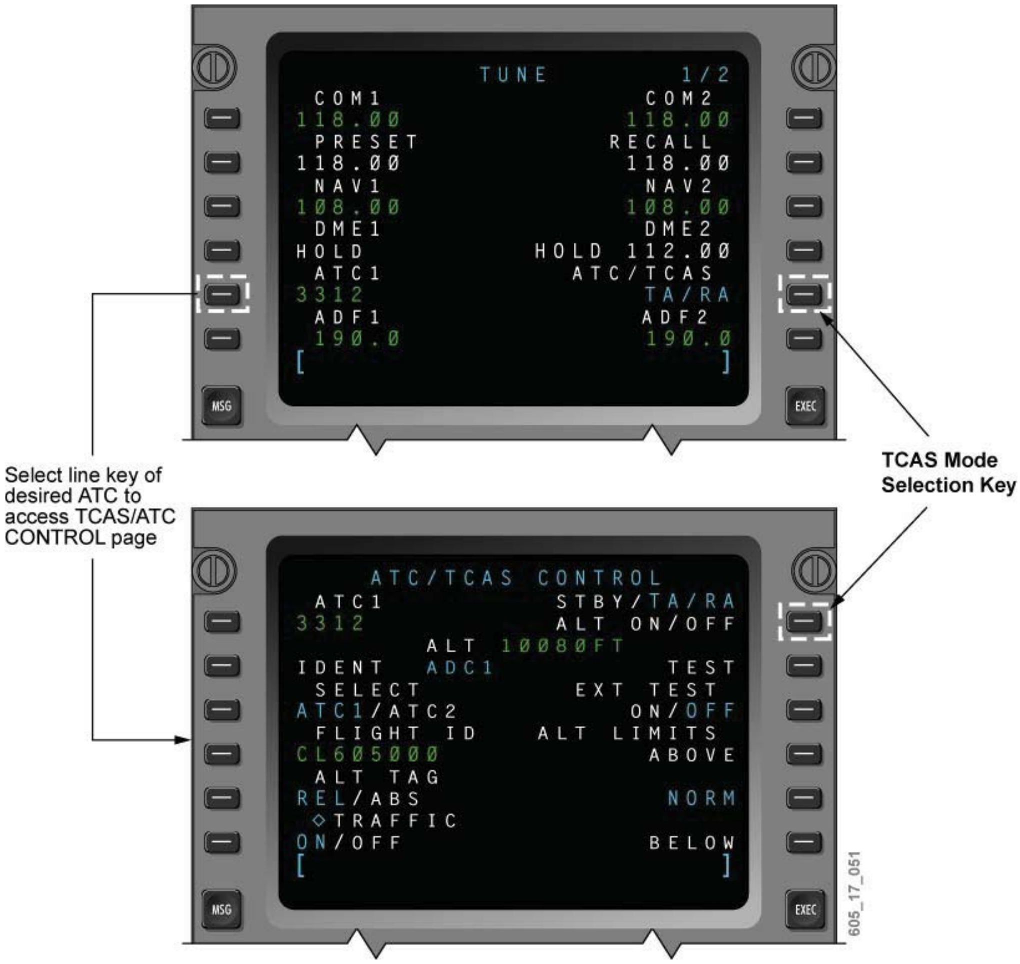
TCAS Controls

- Traffic selection (ON/OFF);
- Altitude tag selection (REL/ABS);
- TCAS test function, simultaneous with ATC test; and
- Altitude limits selection (ABOVE/NORM/BELOW).

TRAFFIC ALERT AND COLLISION AVOIDANCE SYSTEM (TCAS) (CONT'D)

ATC Controls

- TCAS test function, simultaneous with TCAS test;
- Combined ATC/TCAS mode selection;
- IDENT and REPLY;
- Reporting altitude; and
- ATC selection.



CDU – Tune and ATC/TCAS Control Pages
Figure 17–10–63

TCAS – MFD Radio Tuning Window

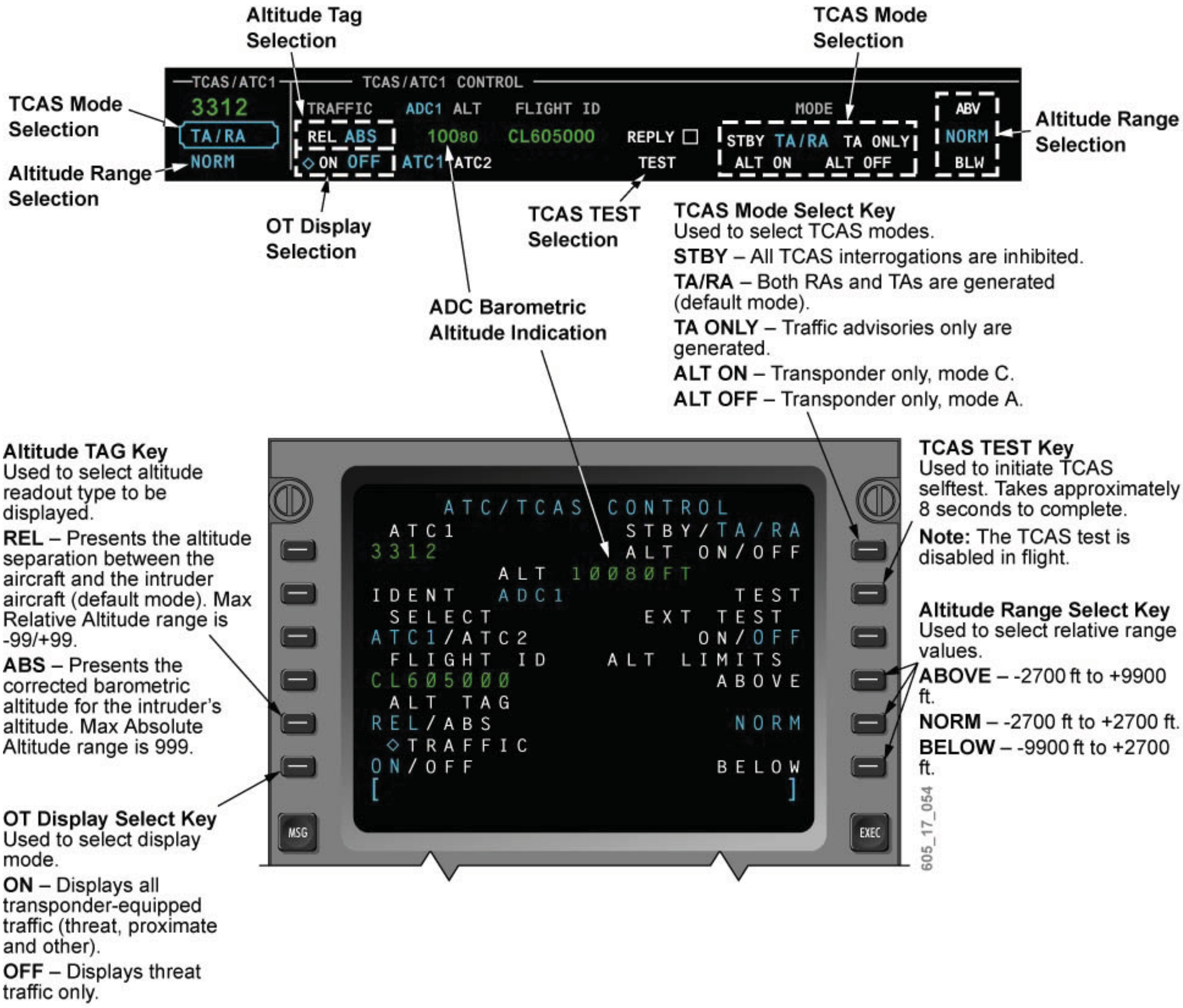
The TCAS/ATC radios are tuned in the same manner as described in both the ATC transponder section in this chapter, and in Chapter 6, Communications.

The TCAS/ATC submenu of the radio tuning window provides control display of the following:

- TCAS altitude display selection (Relative/Absolute);
- Traffic selection (ON/OFF);
- Reporting altitude;

TRAFFIC ALERT AND COLLISION AVOIDANCE SYSTEM (TCAS) (CONT'D)

- Reporting altitude source;
- ATC radio selection;
- Flight ID code setting;
- Reply annunciation;
- Test function;
- Mode selection; and
- Altitude limits selection (Above/Normal/Below).



TCAS Controls Indications
Figure 17–10–64

TRAFFIC ALERT AND COLLISION AVOIDANCE SYSTEM (TCAS) (CONT'D)

Overlay Controls

TFC (Traffic) Pushbutton – DCP

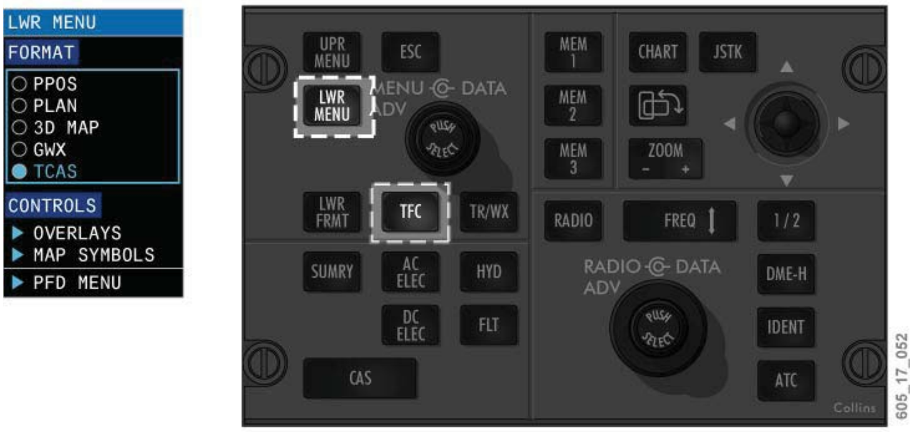
When no TCAS Traffic Alert is active, pressing the pushbutton selects or deselects a TCAS overlay on the PFD navigation format presented (ROSE or PPOS).

TFC (Traffic) Pushbutton – CCP

The TFC pushbutton selects or deselects a traffic display overlay on the current MFD format. If traffic is selected for display and the current format/range is not compatible, the MFD will automatically display TRAFFIC ONLY, and change the range to 10NM.

Also, the TCAS format can be presented on the MFD by using the LWR MENU/FORMAT TCAS selection.

DISPLAY CONTROL PANEL



CURSOR CONTROL PANEL

DCP and CCP TFC Pushbuttons
Figure 17–10–65

TCAS Traffic Symbology

Four different TCAS symbols are used to represent TCAS targets. Indicators that represent the intruder's vertical speed and relative altitude data accompany each TCAS symbol.

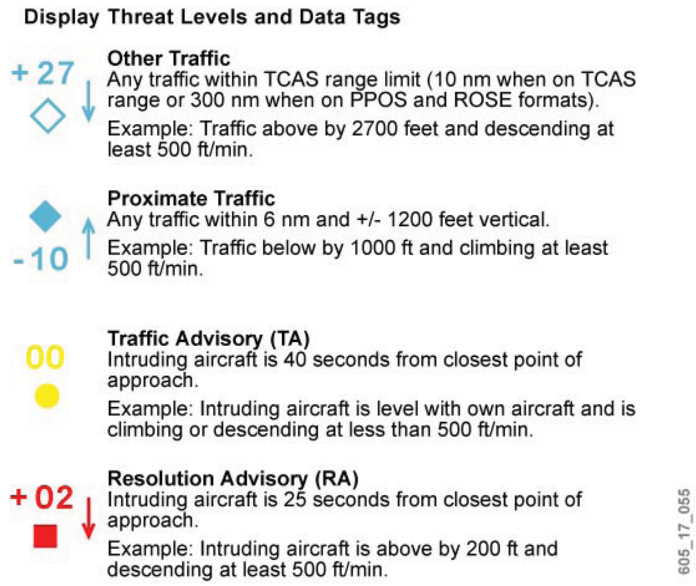
An arrow is used to indicate the vertical speed of the target aircraft. The arrow appears only when the target aircraft is climbing or descending at more than 500 fpm. An up arrow indicates climbing, and a down arrow indicates a descending intruder.

TRAFFIC ALERT AND COLLISION AVOIDANCE SYSTEM (TCAS) (CONT'D)

Plus or minus signs, along with a number, symbolize the relative altitude of the threat airplane (plus = above, minus = below).

The TCAS computer classifies nearby aircraft into one of four types:

- Other traffic (OT)
- Proximate traffic (PT)
- Traffic alert (TA)
- Resolution advisory (RA)



TCAS Symbols
Figure 17–10–66

Other Traffic (OT)

With TCAS overlaid on the PPOS or ROSE formats, other traffic (OT) is defined as any non-threat aircraft traffic within a maximum detection range of 300 NM. With the TCAS-only format selected, 10 NM is the maximum detection range. There are no aural alerts associated with OT.

The display of OT symbols may be set to on or off. The control for this function is located on both the ATC/TCAS control page of the CDU, and on the TCAS – MFD radio tuning window.

Proximate Traffic (PT)

Proximate traffic (PT) is any aircraft within six NM and ±1,200 feet vertical separation, and is not deemed a threat.

PT cannot be deselected, and is always shown on the traffic display as an aid to the pilots when visually acquiring TAs and RAs. There are no aural alerts associated with PT.

TRAFFIC ALERT AND COLLISION AVOIDANCE SYSTEM (TCAS) (CONT'D)

Traffic Alert (TA)

The traffic alert (TA) is issued when an intruding aircraft penetrates the 35 second TCAS surveillance area, and is considered by the TCAS computer to be a possible threat. The TA provides the flight crew with an opportunity to use the TCAS display on the navigation display (PFD/MFD), in order to assist in visually locating the intruding aircraft.

The traffic alerts (TAs) consist of the following:

- Aural advisory “TRAFFIC, TRAFFIC” is sounded;
- Yellow word TRAFFIC is displayed below the ADI on the PFD; and
- Yellow TAs are shown on the navigation display of the PFD/MFD as a solid yellow circle.

The TAs are displayed when TA ONLY or TA/RA mode is active. These modes are selected on the ATC/TCAS control page of the CDU, or on the TCAS – MFD radio tuning window.

Resolution Advisory (RA)

When the intruder penetrates the 25-second surveillance area and is considered a threat, the TCAS initiates a resolution advisory. There are two types of RAs: corrective and preventive.

Preventive RA

To avoid a conflict in the vertical plane, the preventive RA will advise the pilot not to fly in a certain direction.

Corrective RA

The corrective RA advises the pilot to alter the current flight path in the vertical plane.

The corrective RAs are given to the pilots as voice messages, and on the PFD vertical speed instrument as avoidance guidance instructions.

Aural alerts, in the form of voice messages, are listed in the TCAS Aural Alerts table. The TCAS resolution advisory aural alerts are based on the pilot promptly initiating the correct RA maneuver. If an additional corrective RA is issued, the tone of the voice message increases in urgency.

The maneuver should be initiated within 2.5 seconds.

TCAS Aural Alerts

ADVISORY	VOICE MESSAGE	PROPER PILOT RESPONSE
Clear	“Clear of Conflict”	Resume normal flight, apparent conflict of airspace has been resolved.
Traffic	“Traffic, Traffic”	Gain visual contact with traffic. Check TCAS display for traffic bearing and range, if necessary. Assess the threat, and prepare to execute the evasive maneuver that TCAS issues.
Preventive RA	“Monitor Vertical Speed”	Be alert for approaching traffic. Make sure that the VSI needle does not enter the red area of the TCAS VSI display.
Preventive RA	“Maintain Vertical Speed Maintain”	Maintain current vertical speed and direction. Make sure that the VSI needle does not enter the red area of the TCAS VSI display.

TRAFFIC ALERT AND COLLISION AVOIDANCE SYSTEM (TCAS) (CONT'D)

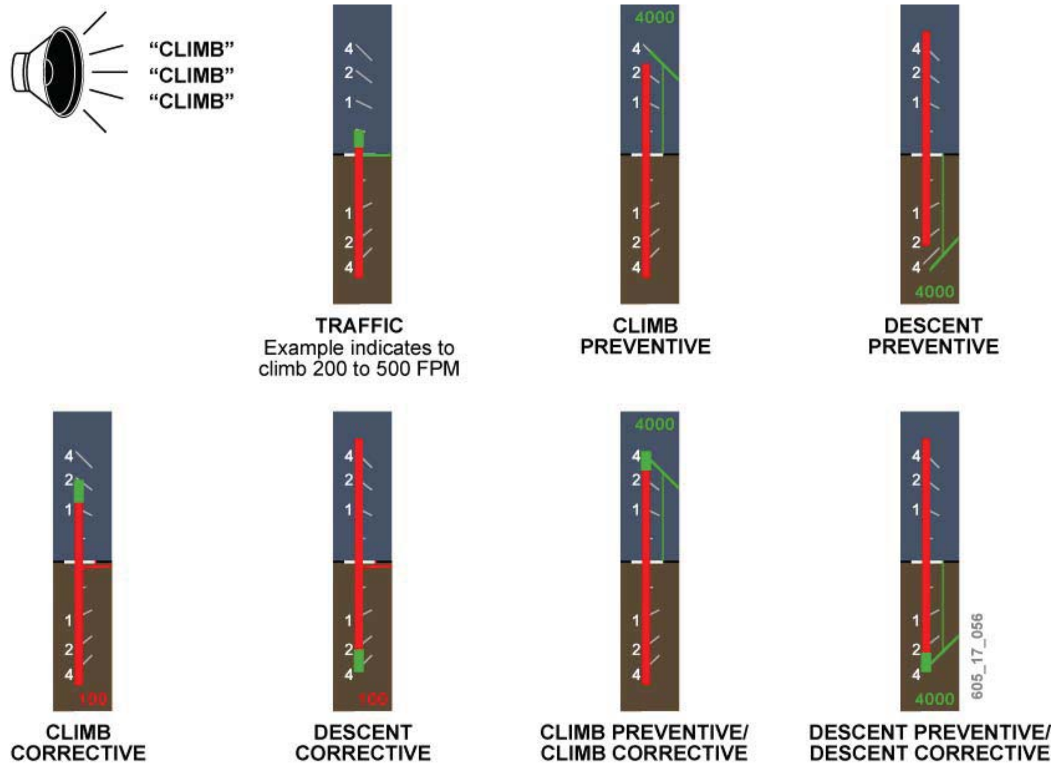
ADVISORY	VOICE MESSAGE	PROPER PILOT RESPONSE
Preventive RA	“Maintain Vertical Speed Crossing Maintain”	A flight path crossing is predicted, but is being monitored by TCAS. Maintain current vertical speed and direction. Make sure that the VSI needle does not enter the red area of the TCAS VSI display.
Preventive RA	“Adjust Vertical Speed Adjust”	Indicates a weakening of the RA. Pilot should initiate a return to the assigned altitude.
Corrective RA	“Climb, Climb”	Change vertical speed to 1,500 FPM climb, or as indicated on the TCAS VSI display.
Corrective RA	“Climb, Crossing Climb Climb, Crossing Climb”	Same as CLIMB, except that it indicates that the flight paths will cross at some altitude.
Corrective RA	“Descend, Descend”	Change vertical speed to 1,500 FPM descent, or as indicated on the TCAS VSI display.
Corrective RA	“Descend, Crossing Descend, Descend, Crossing Descend”	Same as DESCEND, except that it indicates that the flight paths will cross at some altitude.
Corrective RA	“Adjust Vertical Speed Adjust”	Reduce vertical climb speed to that shown on the TCAS VSI display.
Corrective RA	“Increase Climb Increase Climb”	Follows a CLIMB advisory. Increase the vertical climb speed as shown on the TCAS VSI display (typically 2,500 FPM).
Corrective RA	“Increase Descent Increase Descent”	Follows a DESCEND advisory. Increase the vertical descent speed as shown on the TCAS VSI display (typically 2,500 FPM).
Corrective RA	“Climb, Climb Now Climb, Climb Now”	Follows a DESCEND advisory to indicate a change in vertical direction is needed. Initiate an immediate climb from the current descent to provide adequate separation.
Corrective RA	“Descend, Descend Now Descend, Descend Now”	Follows a CLIMB advisory to indicate a change in vertical direction is needed. Initiate an immediate descent from the current climb to provide adequate separation.

RA Communication and Coordination

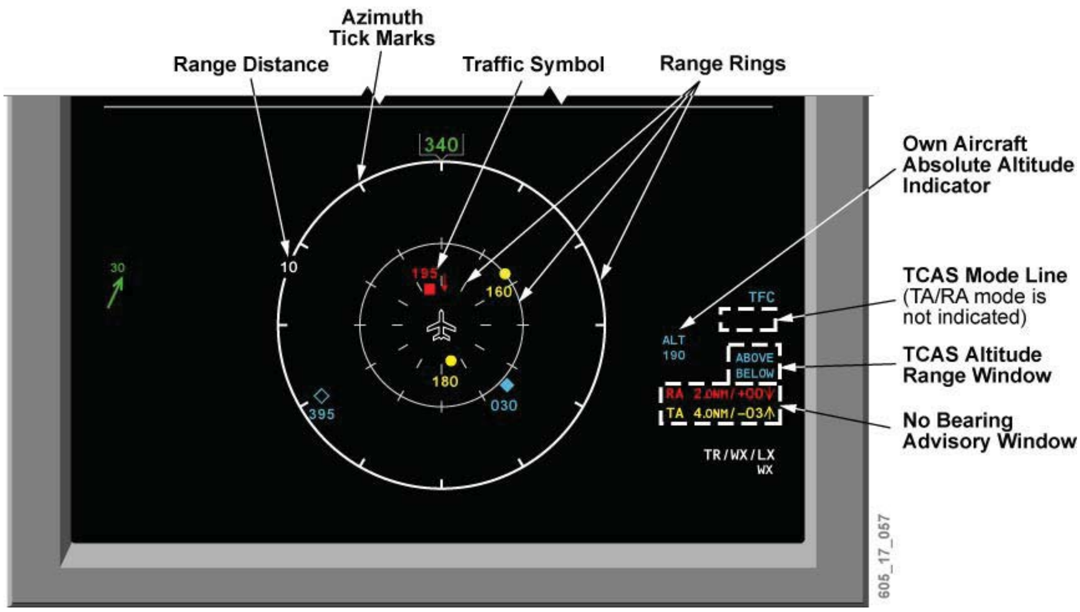
In a case where both aircraft are TCAS equipped, the TCAS communicates with the other aircraft to coordinate evasive strategies. This coordination may occur before an advisory is issued, and is calculated for optimum safe separation using the least disruptive maneuver possible. For example, if one aircraft is in a particular vertical speed (VS) profile, it may be advantageous for that aircraft to increase or decrease its VS, as opposed to the other assuming an evasive VS. Whatever maneuver is selected, this information is communicated to other aircraft and ground facilities.

If the other aircraft is not TCAS equipped, the corrective or preventive maneuver responsibility is assumed by the TCAS-equipped aircraft, and only the ground facility communication is possible.

TRAFFIC ALERT AND COLLISION AVOIDANCE SYSTEM (TCAS) (CONT'D)



TCAS Vertical Speed Advisories
Figure 17–10–67



Navigation Display TCAS Indications
Figure 17–10–68

TRAFFIC ALERT AND COLLISION AVOIDANCE SYSTEM (TCAS) (CONT'D)

TCAS Resolution Advisory (RA) Inhibits

TCAS RAs and some aural alerts are inhibited below certain radio altitudes. Radio altitudes and the associated RA status are as follows:

TCAS RA Inhibits (Limits)

ADVISORY OR MODE	LIMITS
Increase Descent RA	Prevented below 1,550 feet AGL during a climb and 1,450 feet AGL during a descent.
Descend RA	Prevented below 1,000 feet AGL during a descent and 1,200 feet AGL during a climb.
Resolution Advisories (RAs)	Prevented below 1,100 feet AGL during a climb and 900 feet AGL during a descent (TCAS automatically changes to the TA or TA ONLY mode).

Self-Test

The TCAS self-test is initiated from the ATC/TCAS control page by pushing the TEST line select key, or selecting TEST in the MFD/TCAS tuning window. The following indications should be displayed during the test:

- TCAS TEST is presented on the TCAS mode line of the PFD/MFD navigation display.
- Each PFD displays flashing red TRAFFIC right of the heading and vertical traffic resolution cue on the VSI (red/green).
- TCAS format traffic display shows the TCAS self-test pictorial representation. The display shows four intruder symbols.

TRAFFIC ALERT AND COLLISION AVOIDANCE SYSTEM (TCAS) (CONT'D)

TCAS Test Indications
Figure 17–10–69

GLOBAL POSITIONING SYSTEM (GPS)

Description

The GPS is a space-based navigation system that provides highly accurate three-dimensional position, velocity and time information to ground or aircraft receivers.

The GPS is a sensor used by the flight management system to compute an accurate position. All GPS data is accessed through the FMS CDU.

The GPS has three main segments:

- Space segment;
- Control segment (ground); and
- User segment.

GLOBAL POSITIONING SYSTEM (GPS) (CONT'D)

Space Segment

The space segment of the GPS is made up of 24 NAVSTAR satellites. There are 21 operational satellites at all times, and three are spares. The satellites:

- Are in a 10,900-mile-high orbit;
- Are in six orbital planes, with four satellites in each plane;
- Have a 12-hour orbit;
- Are spaced to provide a minimum of 4 satellites in view at all times; and
- Have atomic clocks, and transmit on two coded frequencies.

Control Segment

The control segment monitors the space segment, and adjusts the orbits when operationally required. It includes five ground stations around the world. One is the master control station and the others are monitor stations.

The monitor stations passively track all satellites in view and acquire range data from them. This data is forwarded to the master control station. The master control station uses the data from the monitor stations to estimate satellite orbit and clock data. This information is transmitted to the satellites and down to the users as a navigation message.

User Segment

The FMS uses the signal from the GPS satellites as a navigation sensor to upgrade its own position. A minimum of three satellites is required for two-dimensional calculations, and four satellites are required for three-dimensional calculations.

Components and Operation

GPS Receivers

Dual GPS receivers are installed in the Challenger 605 (GPS 1 and GPS 2). The GPS receivers process signals from the orbiting constellation of GPS satellites to determine geographic position. Each of the GPS receivers is capable of receiving up to 12 satellites. Tuning is fully automatic, and does not require any pilot input/action.

GPS 1 is powered by the battery bus, and GPS 2 is powered by DC bus 2.

GPS Sensors and Navigation

The flight management system (FMS) is the interface between the GPS receivers and the aircraft navigation systems. GPS position information is supplied to each FMS by the on-side GPS receiver (GPS 1 supplies FMS 1, and GPS 2 supplies FMS 2). The FMS then calculates the integrated navigation solution (FMS position) using a combination of GPS, DME/DME, VOR/DME, and IRS sensor information.

In the event that on-side GPS information is not available, the FMS will automatically use cross-side information, and display the GPS REVERTED message on the FMS CDU.

GLOBAL POSITIONING SYSTEM (GPS) (CONT'D)

GPS RAIM

GPS Receiver Autonomous Integrity Monitoring (RAIM) is used to assure that the GPS position information meet the required accuracy:

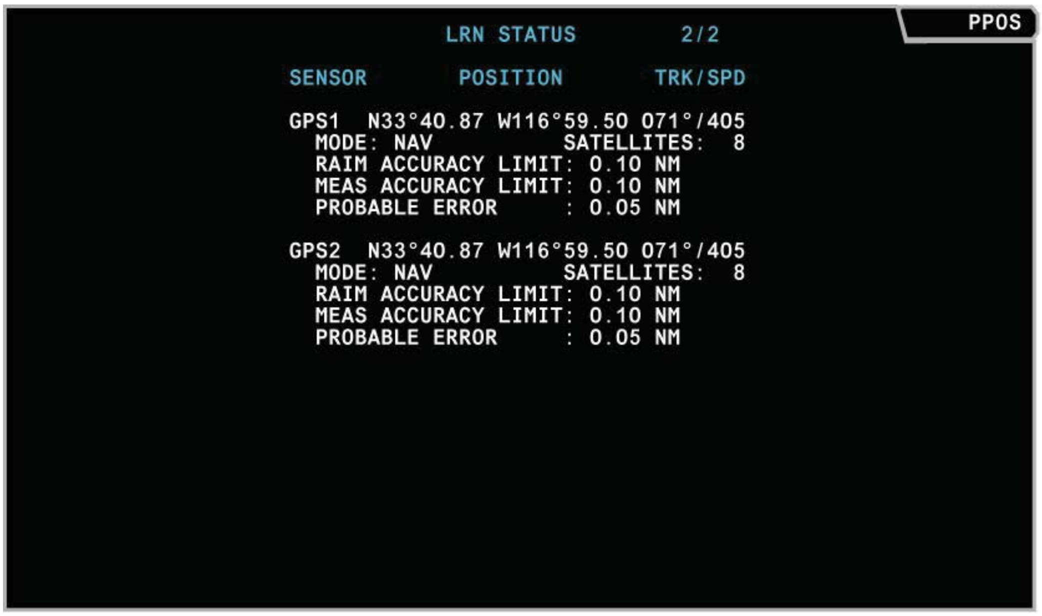
- 4 NM oceanic/remote;
- 2 NM en route;
- 1 NM terminal; and
- 0.3 NM final approach.

The current RAIM accuracy limit and measured accuracy limit are displayed on the MFD LRN STATUS page 2/2. The measured accuracy limit indicates the maximum estimated error based on measurement inconsistency. Unless an error is detected by RAIM, this value is always less than the RAIM accuracy limit.

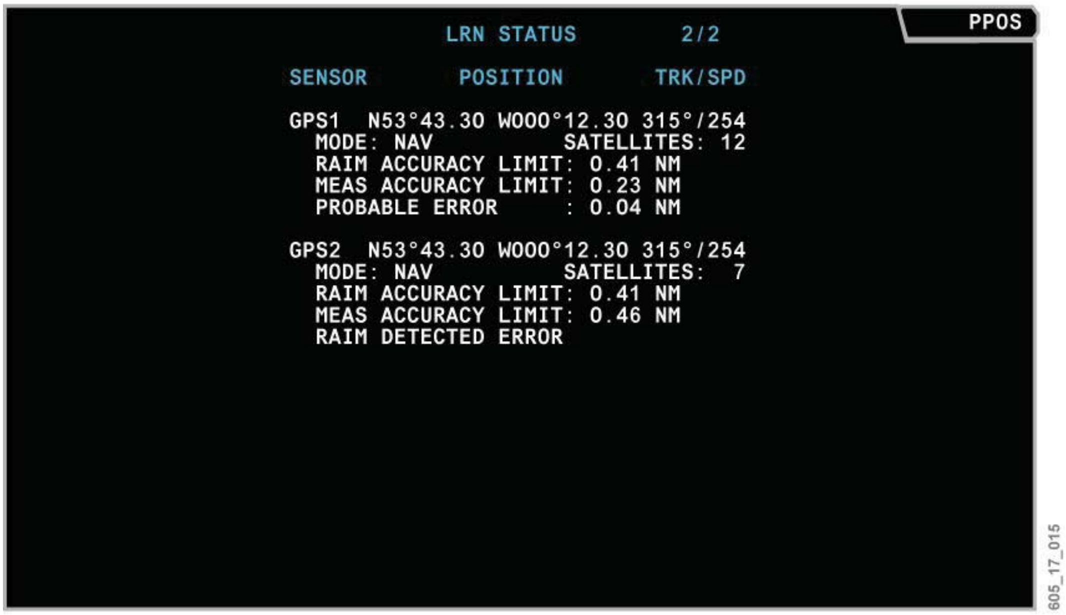
When an error is detected, it is annunciated on the MFD LRN STATUS page 2/2. If the detected error cannot be predicted to be less than the required integrity threshold, GPS is removed from the navigation solution.

If no error is detected by RAIM, the probable GPS error is shown. This is a statistical number based on normal satellite error characteristics.

GLOBAL POSITIONING SYSTEM (GPS) (CONT'D)



NORMAL RAIM INDICATIONS



RAIM DETECTED ERROR ON GPS 2

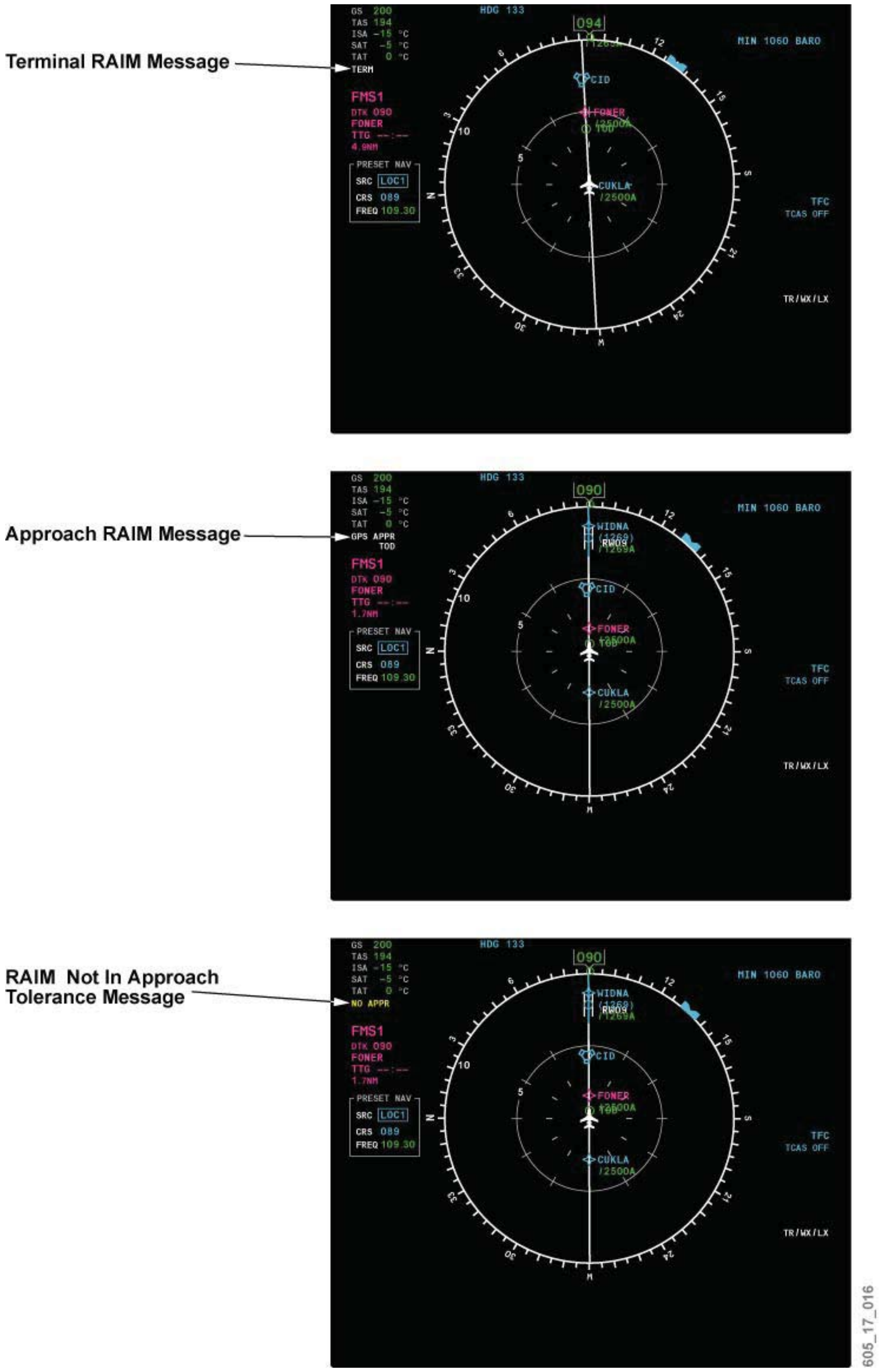
MFD LRN STATUS
Figure 17–10–70

In the terminal environment (30NM from airport reference point), RAIM accuracy is indicated by the white TERM message above the NAV SOURCE display of the PFD.

On final approach, RAIM accuracy is indicated by the white GPS APPR message above the NAV SOURCE display of the PFD.

GLOBAL POSITIONING SYSTEM (GPS) (CONT'D)

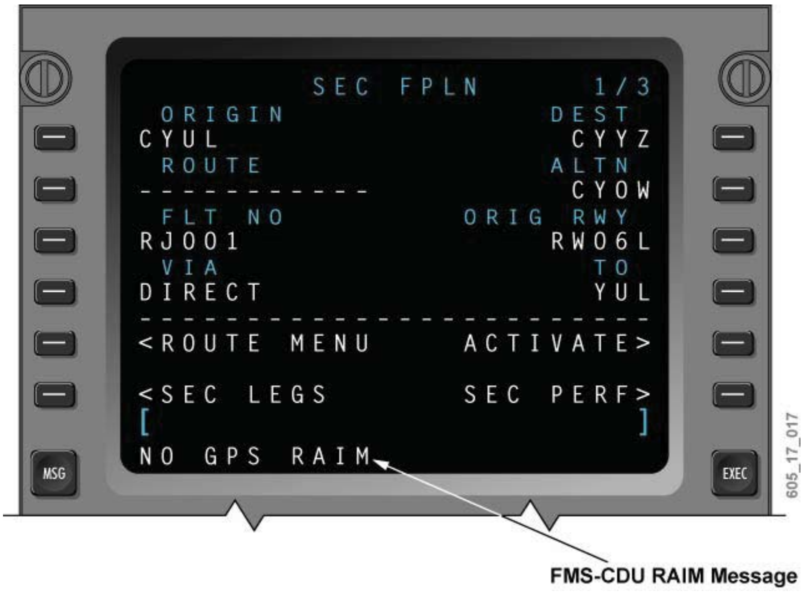
If RAIM accuracy does not reach final approach tolerances, the yellow NO APPR message is displayed above the NAV SOURCE display of the PFD.



PFD RAIM Indications
Figure 17–10–71

GLOBAL POSITIONING SYSTEM (GPS) (CONT'D)

For a complete listing of GPS and RAIM messages, see the “Collins FMS-6000 for the Challenger 605” Pilot’s Guide.



FMS CDU RAIM Message
Figure 17–10–72

Controls and Indicators

FMS-GPS Control Page

The GPS control page allows the pilot to monitor the FMS aircraft position in relation to the GPS. The position differential (POS DIFF) is shown in direction and magnitude from the FMS position.

To alternately enable or disable use of a specific GPS sensor, push the left side line-select key of that sensor. Enabled sensors show in large green font, and disabled sensors show in small white font.

The DEST and ETA entries are those of the active flight plan. The flight crew can manually enter changes to see if RAIM is available for other destinations and/or arrival times.

Satellite Deselect

Individual satellites can be deselected from use by entering the identifier for the satellite in the FMS. This function would be used if the satellite is NOTAMed under test. When deselected, the FMS ignores the data from the satellite. Deselected satellites are not included in the predicted RAIM computations.

GLOBAL POSITIONING SYSTEM (GPS) (CONT'D)

FMS GPS Control Page
Figure 17–10–73

FLIGHT MANAGEMENT SYSTEM (FMS)

Description

A dual flight management system (FMS) provides integrated cockpit and flight management functions. Each flight management system (FMS 1 and FMS 2) is composed of a control display unit (CDU) in the cockpit, and a flight management computer (FMC) in the underfloor avionics equipment bay. A single data base unit (DBU) allows data to be uploaded or downloaded to all of the FMCs. A third flight management system (FMS 3) may be installed as a customer option.

The FMS cockpit management functions include:

- Navigation sensor control;
- Radio tuning;
- Multifunction display (MFD) control menus;
- Navigation database management;
- Control and management of the data loader; and
- Management of the data interface with external systems (AFIS).

Flight management functions include:

- Continuous calculation of the integrated navigation solution;
- Flight plan inputs by the crew;
- Lateral flight plan point-to-point navigation;
- Vertical navigation;
- Performance calculation; and
- Lateral/vertical steering commands to the flight control system.

The third FMS, if installed, is defined as a “hot spare”, and is fully functional when selected.

FLIGHT MANAGEMENT SYSTEM (FMS) (CONT'D)

For a comprehensive description of FMS functions and operation, refer to the “Collins FMS-6000 for the Challenger 605” Pilot’s Guide.

Components and Operation

FMS Control Display Units (CDUs)

The FMS CDU is the cockpit interface of the flight management system. It allows the flight crew to input, modify, and execute flight plans, as well as calculate aircraft performance. It also acts as a radio tuning interface through a dedicated TUNE page, and is the primary means of control for most navigation sensors. The CDU controls certain information displays on the MFDs, and advises the flight crew of FMS system status through a variety of message formats.

Power Supplies

- The No. 1 (left) CDU is powered by BATT bus.
- The No. 2 (right) CDU is powered by DC bus 2.
- The No. 3 CDU is powered by the DC essential bus.

Scratchpad and Line-Select Keys

The FMS CDU is arranged so that all flight crew inputs are conducted through a “scratchpad”, which allows easy data input and retrieval. An alphanumeric keypad permits entry of all relevant data to the scratchpad, and line-select keys are used to insert the data in the appropriate area of the display page. Most information contained on the display page can similarly be “line-selected”, and is then transferred to the scratchpad for reference or modification.

Execute Key

Most entries made into the flight plan or performance calculations are considered modifications to the active flight plan, and must be executed using the EXEC function key before they become active components of the flight plan. This permits the flight crew to cross-check any modifications prior to committing them to the active flight plan.

Function Keys

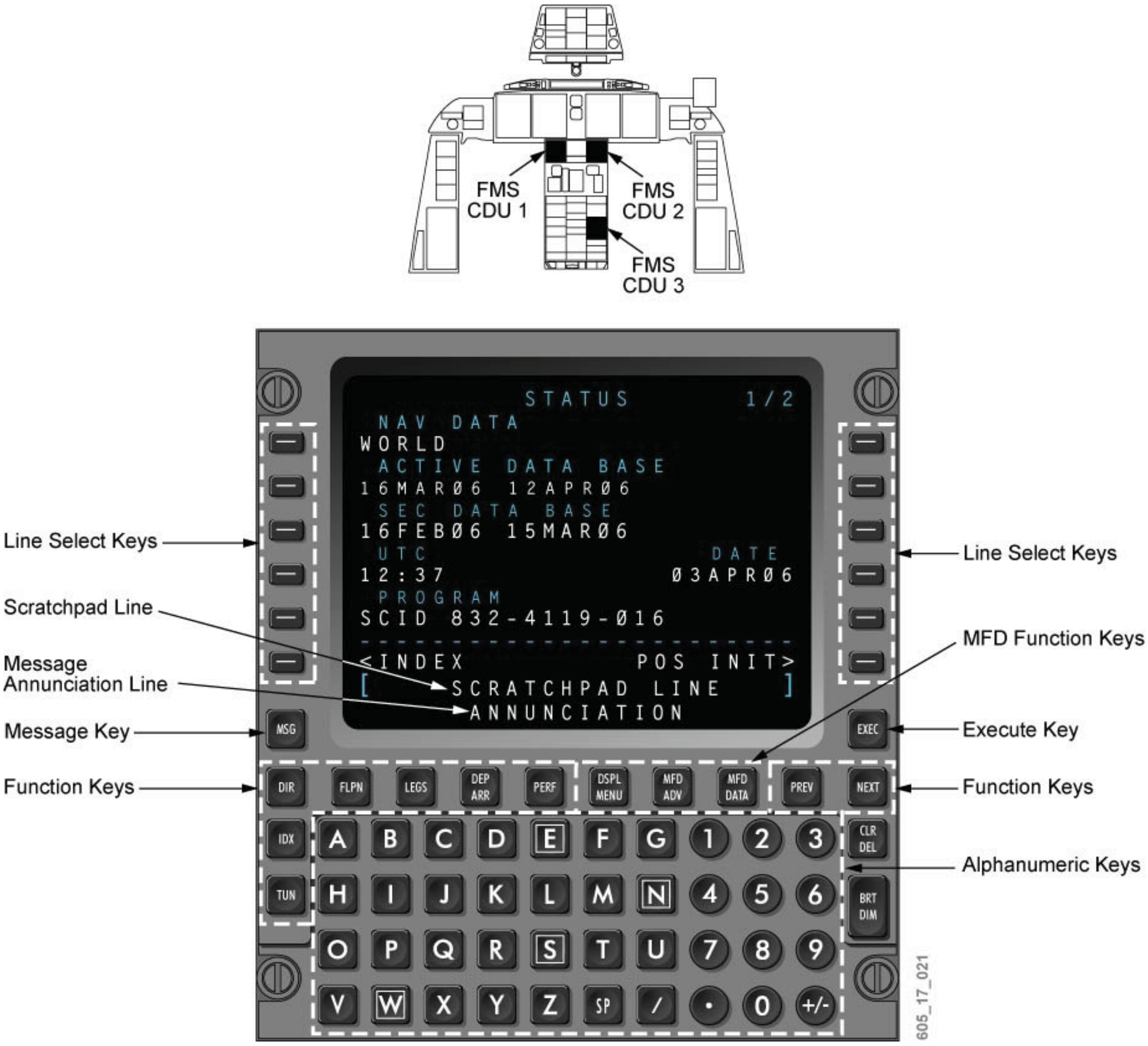
Dedicated function keys allow direct access to certain flight management or cockpit management features of the FMS.

Certain CDU displays have multiple pages, as indicated in the top right corner of the display screen. Access to the other pages is achieved using the PREV and NEXT function keys.

MFD Function Keys

Three function keys relate specifically to MFD displays. The MFD DATA and MFD MENU keys control the type of information available on the MFD. The MFD ADV key allows access to multiple pages of MFD information. When the PLAN MAP format of the MFD is in use, the MFD ADV key allows the flight crew to view the waypoints of their flight plan.

FLIGHT MANAGEMENT SYSTEM (FMS) (CONT'D)



FMS Control Display Unit (CDU)
Figure 17–10–74

Flight Management Computers (FMCs)

The flight management computers are installed in the integrated avionics processing system (IAPS). The FMCs receive flight crew inputs from the CDU, and perform all the flight management and cockpit management functions. Each FMC contains a navigation database, which it uses to execute the active flight plan.

Integrated Navigation Solution

The integrated navigation solution is the FMS-calculated position of the aircraft, in latitude and longitude. The FMCs receive data from all aircraft navigation sensors, and continuously calculate the integrated navigation solution. GPS is normally the highest priority sensor used in this position calculation, but a combination of DME/DME, VOR/DME, and IRS information is also used, according to predetermined blending algorithms. The FMC rejects sensor data that is not valid, and advises the flight crew of position determination errors through the CDU message system.

FLIGHT MANAGEMENT SYSTEM (FMS) (CONT'D)

Flight Plan Tracking

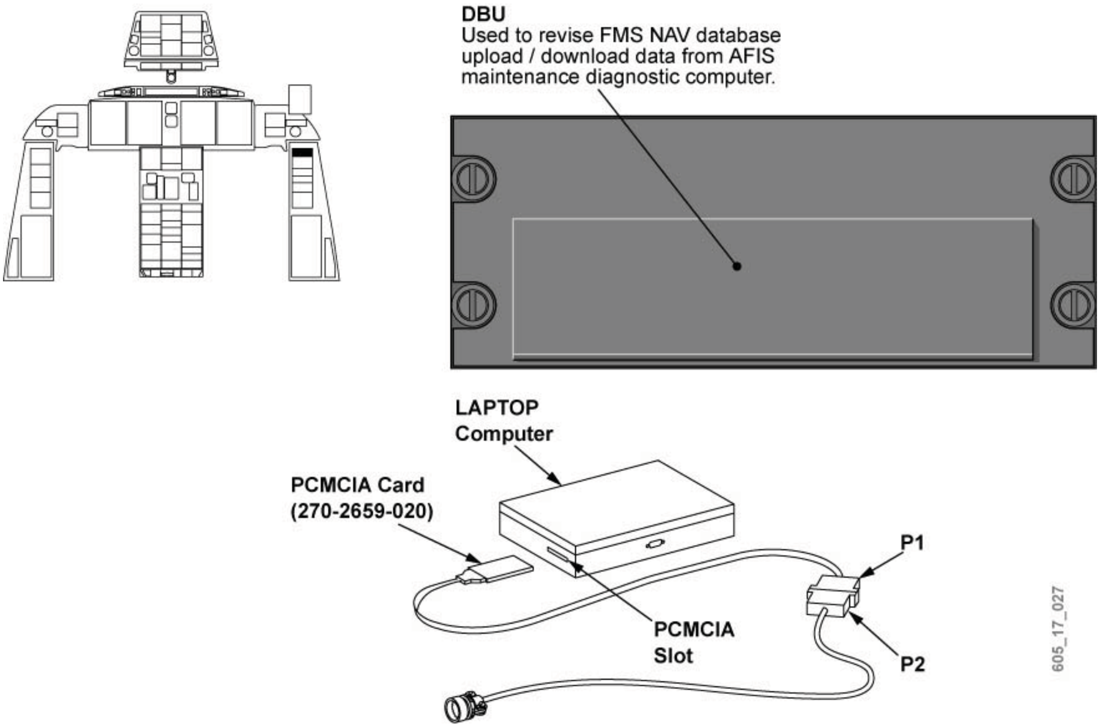
By comparing the integrated navigation solution to the navigation database and the active flight plan, the FMC calculates and displays the aircraft's position relative to the flight plan routing, and issues steering commands to the flight control computers to track the lateral and vertical components of the active flight plan.

Data Base Unit (DBU)

The data base unit (DBU) is a panel-mounting data loader with a disk drive, that is used with the FMS system and the maintenance diagnostic computer. The FMS system uses the DBU to load database updates from diskettes into the FMS computers. The integrated avionics processing system (IAPS) maintenance diagnostic computer uses the DBU to upload maintenance tables from diskette, or download maintenance data files to diskette. High-density and double-density 3-1/2 inch diskettes are acceptable. The unit has a “drive in-use” indicator and a disk eject button.

The navigation database is loaded into each FMC individually through the DBU. Flight plans and waypoints may also be loaded or stored on disk through the DBU.

An optional database loading kit (PCD-3000) is available. This kit allows simultaneous database loading of up to three FMSs.



Data Base Unit
Figure 17–10–75

FLIGHT MANAGEMENT SYSTEM (FMS) (CONT'D)

Synchronized/Independent Operation

Dual-FMS system have provisions for operation in synchronized (SYNC) or independent (INDEP) modes. By default, dual-FMS airplanes power up in SYNC, and triple-FMS airplanes power up in INDEP mode.

In the triple-FMS configuration, the flight crew decides which two FMSs to synchronize. FMS 3 is selected using the FMS reversionary selector switch (see Figure 17–10–77). SYNC/INDEP mode selections are made on the FMS CONTROL page of the CDU.

When two FMSs are synchronized, they share the following parameters:

- Flight plan edits;
- Performance initialization;
- Leg sequencing (based on NAV source selection);
- Active database selection;
- Fix entries on FIX INFO page;
- Deselection of navaids;
- Performance mode selection, fuel flow and ground speed entered on FUEL MGMT page;
- MAG/TRU display mode;
- Thrust management;
- Direct-to edits;
- Holding pattern data; and
- Enabling/disabling of VOR/DME from the navigation solution.

Parameters that are not synchronized include:

- FMC position initialization; and
- Selection and tuning of on-side sensors.

When the FMSs are operated in INDEP mode, all parameters must be manually entered in each FMS.

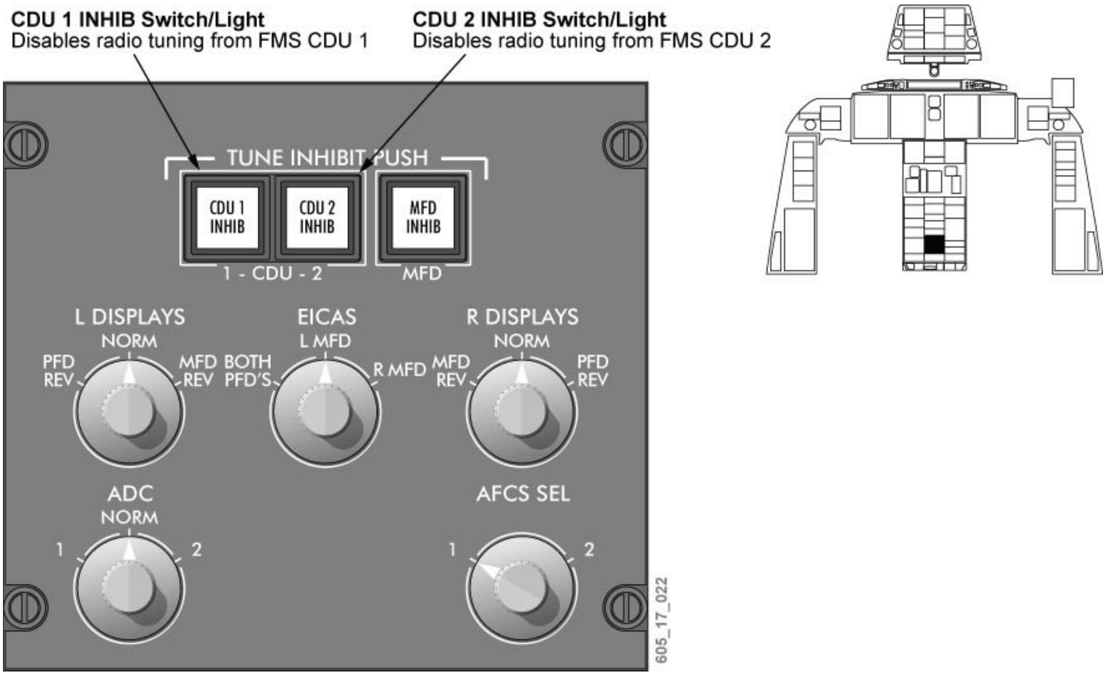
For additional information about SYNC/INDEP operation, see the “Collins FMS-6000 for the Challenger 605” Pilot’s Guide.

Controls and Indicators

FMS CDU Tune Inhibit

The FMS CDUs may be inhibited from tuning the radios by selection of the CDU 1 INHIB or CDU 2 INHIB switch/light, located on the reversionary panel. The lights illuminate when CDU auto tuning inhibit is selected.

FLIGHT MANAGEMENT SYSTEM (FMS) (CONT'D)



FMS TUNE INHIB Switch/Light
Figure 17–10–76

FMS 3 Reversionary Selector

FMS 3 may be selected using the FMS 3 reversionary selector switch on the center pedestal. FMS 3 replaces FMS 1 or FMS 2 when the rotary selector switch is moved to position 1 or 2 respectively.

FMS 3 Reversionary Selector
Figure 17–10–77

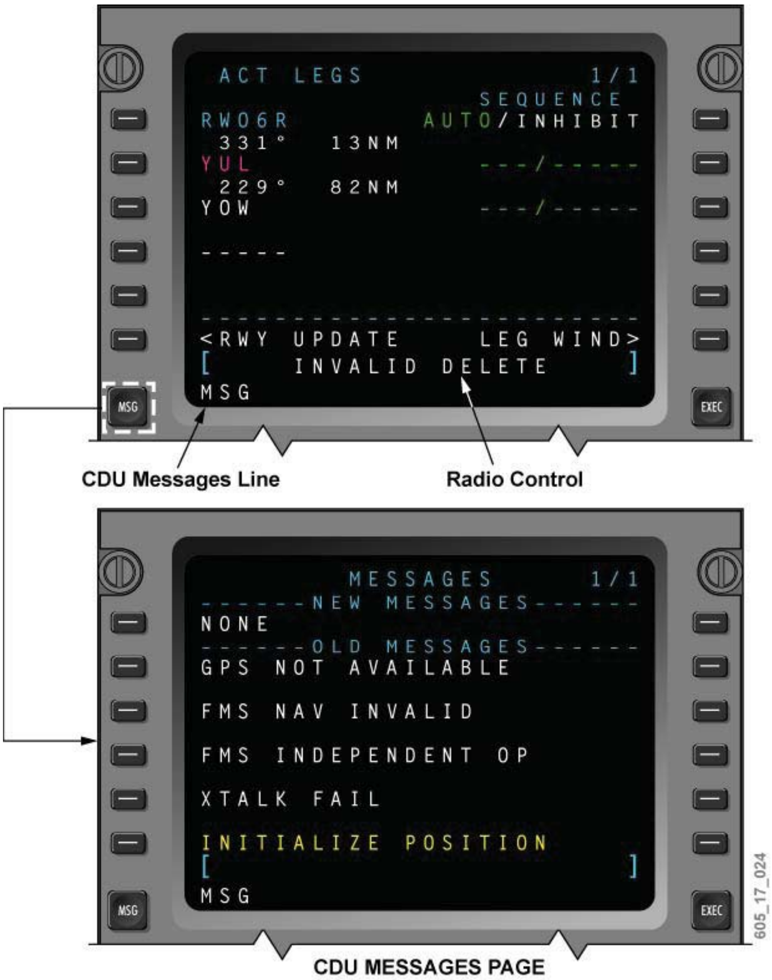
FMS Message Displays

The FMS messages are displayed in several locations. Typically, a message remains displayed as long as the condition that generated the message persists. For a complete description of messages and message categories, see the “Collins FMS-6000 for the Challenger 605” Pilot’s Guide.

FLIGHT MANAGEMENT SYSTEM (FMS) (CONT'D)

CDU Messages

Messages may appear in the scratchpad, or in the message line immediately below the scratchpad. Selection of the MSG function key cycles the CDU display to a dedicated message page, where new and old messages may be reviewed.

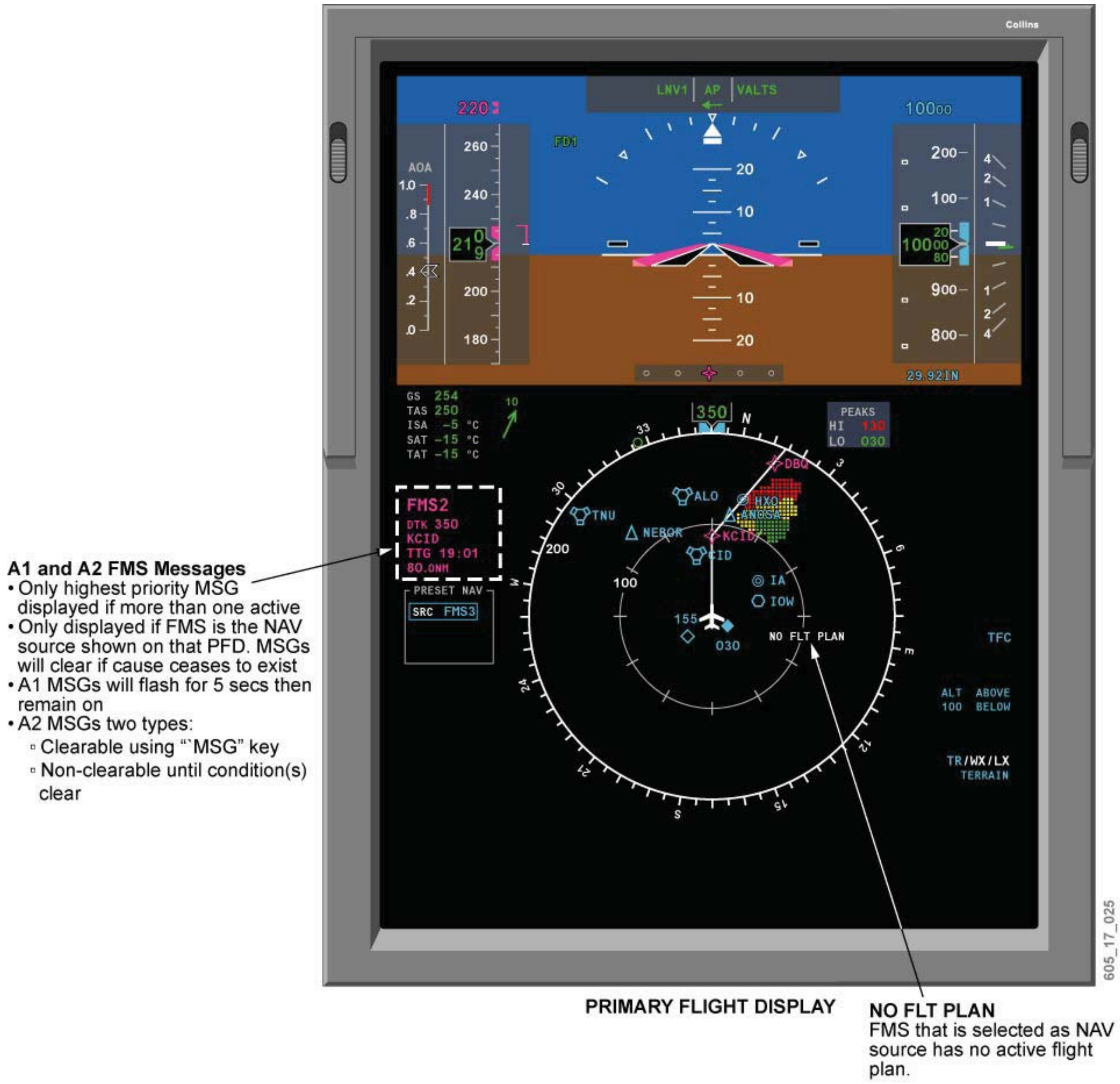


CDU Message Display
Figure 17–10–78

PFD Messages

FMS messages also appear on the PFD (when FMS is the NAV SOURCE). Additionally, certain PFD messages may be displayed on the navigation information section of the PFD.

FLIGHT MANAGEMENT SYSTEM (FMS) (CONT'D)

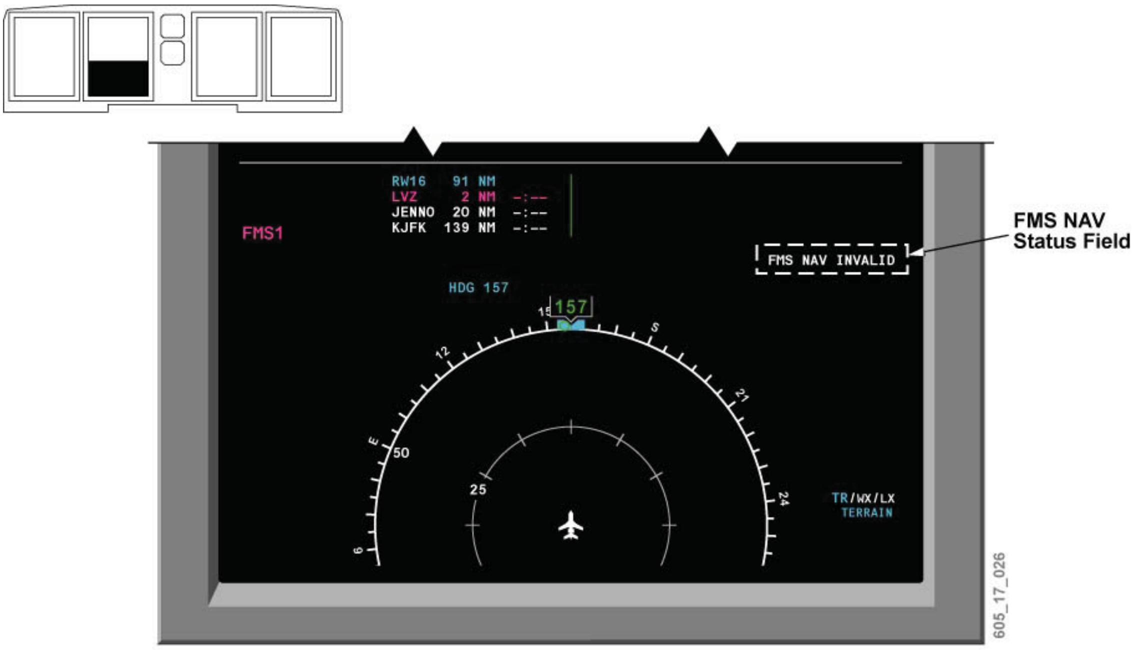


PFD Message Display
Figure 17–10–79

MFD Messages

FMS messages may be displayed in the FMS NAV status field, located in the lower window of the MFD display area.

FLIGHT MANAGEMENT SYSTEM (FMS) (CONT'D)



MFD Message Display
Figure 17–10–80

FMS Color Conventions

The FMS color conventions are outlined in the following table. The EFIS FMS colors have been included for reference only.

FMS Color Conventions Table

COLOR	FMS CDU USE	EFIS USE (REFERENCE ONLY)
RED	Not used.	Warnings.
AMBER	Cautions usually requiring timely pilot intervention.	Cautions, cross-side NAV source, and active leg “to waypoint”.
GREEN	Active selections, VNAV data on LEGS page, availability status.	Safe/normal operation altitudes on map.
CYAN	Secondary information (e.g. from waypoint, page titles).	Legends, pilot-selected values, secondary map data.
MAGENTA	Active leg (“to waypoint”).	Fly-to-references, flight director, airspeed bug, preselect altitude, on-side data, active leg “to waypoint”.
WHITE	Primary information (e.g. flight plan data, down track waypoints, and FPLN and LEGS MOD state).	Reference symbols, scales, NAV map, alternate-source sensor, on-side FMS, AFDS armed modes.

POWER SUPPLY AND CIRCUIT BREAKER SUMMARY

SYSTEM	SUB-SYSTEM	CB NAME	BUS BAR	CB PANEL	CB LOCATION	NOTES
Navigation Systems	Navigation Receiver	VHF NAV 1	DC ESS	4	D13	
		VHF NAV 2	DC BUS 2	2	H15	
	Distance Measuring Equipment	DME 1	DC BUS 1	1	H12	
		DME 2	DC BUS 2	2	H12	
	Transponder	XPDR 1	DC ESS	4	D4	
		XPDR 2	DC BUS 2	2	H4	
	FMS	FMS CDU 1	DC BATT	1	M3	
		FMS CDU 2	DC BUS 2	2	H9	
		FMS CDU 3	DC ESS	4	D9	
		FMS DATA LOAD	DC BUS 1	1	H10	
	GPS	GPS 1	DC BATT	1	N3	
		GPS 2	DC BUS 2	2	H11	
	Inertial Reference System	IRU 1	DC ESS	4	D11	
		IRU 1 SEC	DC BATT	1	Q8	
		IRU 2	DC BUS 2	2	H10	
		IRU 2 SEC	BATT BUS	1	Q9	
		IRU 3	DC BATT	1	H13	
		IRU 3 SEC	DC BATT	1	Q10	
	Radio Altimeter	RAD ALT 1	DC BUS 1	1	H14	
		RAD ALT 2	DC BUS 2	2	H14	
	Lightning Sensor	LDS	DC BUS 2	2	H6	
	Weather Radar	WEATHER RDR R/T	DC BUS 1	1	K1	
	Traffic Collision Avoidance System	TCAS	AC ESS	3	C5	
	Terrain Collision Avoidance System	TAWS	AC BUS 1	1	B13	