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Airbus
A318/A319/A320/A321

ATA 34
Navigation

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- The LTT production process ensures that the Training Manual contains a complete set of all necessary pages in the latest finalized revision.

ATA 34 NAVIGATION

34-00 NAVIGATION - GENERAL

SYSTEM PRESENTATION

The aircraft navigation systems provide the crew with the data required for flight within the most appropriate safety requirements.

This data is divided into four groups:

- AIR DATA/INERTIAL REFERENCE SYSTEM (ADIRS),
- LANDING AND TAXIING AIDS,
- INDEPENDENT POSITION DETERMINING,
- DEPENDENT POSITION DETERMINING.

ADIRS

The ADIRS is an integrated Air Data System and an Inertial Reference System. One part called Air Data Reference mainly computes speed and altitude information from air parameters. The other part called Inertial Reference mainly computes heading, attitude and position from gyros and accelerometers. The ADIRS is composed of three Air Data/Inertial Reference Units (ADIRUs).

Besides the ADIRUs, there are still standby instruments:

- Altimeter and Airspeed indicators directly supplied by pressure lines,
- Standby Compass,
- Standby Horizon.

LANDING AND TAXIING AIDS

The Head-Up Display (HUD) is used as a piloting aids system for roll out, take-off and landing (optional). The Instrument Landing System (ILS), is used to obtain the optimum aircraft position during an approach and landing phase. The Marker (MKR) system is used to indicate the distance to the runway threshold during an ILS descent.

The aircraft is equipped with:

- 1 HUD (optional),
- 2 ILS,
- 1 MARKER (Included in the VOR receiver).

Frequency Control is achieved either automatically or manually (through the MCDU) by the Flight Management and Guidance Computers (FMGCs) or manually through the Radio Management Panels (RMPs).

INDEPENDENT POSITION DETERMINING SYSTEMS

This part of the navigation systems, called independent system, provides information regarding the safety of the aircraft without taking reference from any ground station.

This part of the Navigation system includes:

- 1 Weather Radar / Predictive Windshear (WR/PWS) (the second is optional),
- 2 Radio Altimeter (RA),
- 1 Traffic Collision Avoidance System (TCAS) or Traffic and Terrain Collision Avoidance system (T2CAS),
- 1 Enhanced Ground Proximity Warning System (EGPWS).

DEPENDENT POSITION DETERMINING SYSTEMS

This part of the navigation system, called dependent system, provides various means of navigation through data exchange with ground installations or satellites.

This part of the Navigation includes:

- 2 DME,
- 2 ATC,
- 1 ADF (the second is optional),
- 2 VOR,
- 2 GPS.

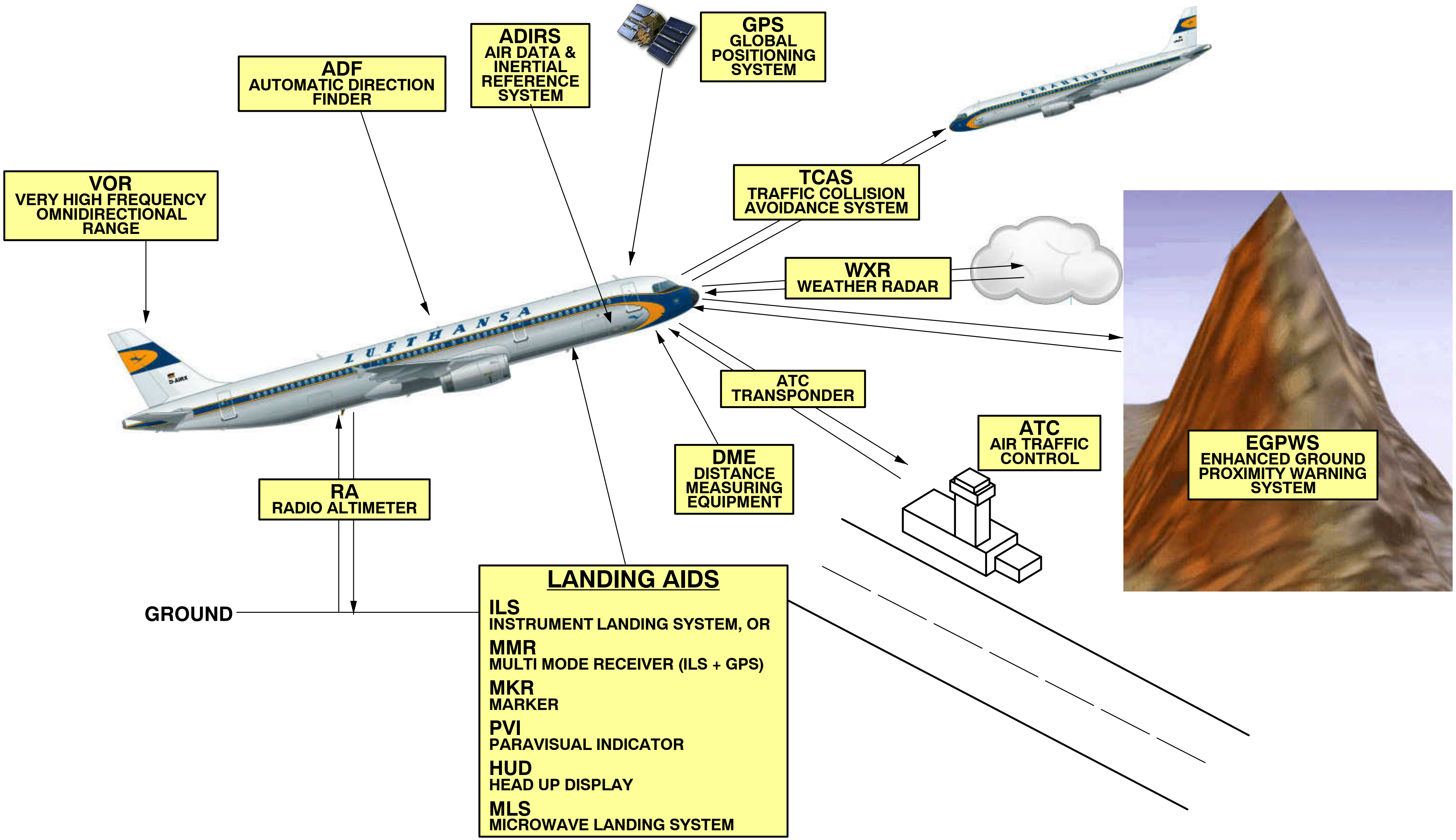


Figure 1 Radio Navigation - General

34–36 ILS (MMR)

ILS (MMR) GENERAL

The primary function of the Multi–Mode Receiver (MMR) is to receive and process Instrument Landing System (ILS) and Global Positioning System (GPS) signals.

The MMR is a navigation sensor with two internal receivers:

- **ILS Receiver**

  The function of the ILS is to provide the crew and airborne system users with lateral (LOC) and vertical (G/S) deviation signals, with respect to the approach ILS radio beam transmitted by a ground station.

  The localizer operates in a frequency band which ranges from 108.1 MHz to 111.95 MHz and the glide uses the band from 329.15 MHz to 335 MHz.

ILS Principle

The function of the ILS is to provide the crew and airborne system users with signals transmitted by a ground station. A descent axis is determined by the intersection of a Localizer beam (LOC) and a Glide Slope beam (G/S) created by this ground station at known frequencies. The ILS allows measurement and display of angular deviations and receives the Morse audio signal, which identifies the ILS ground station.

- **GPS Receiver**

  The GPS is a radio aid to worldwide navigation which provides:

  - the crew with a readout of accurate navigation information, e.g. position, track and speed.
  - the Flight Management and Guidance Computer (FMGC) with position information, after hybridization in the Air Data/Inertial Reference Unit (ADIRU) with inertial parameters, for accurate position fixing.

GPS Principle

The NAV System Time And Ranging (STAR) GPS is a worldwide navigation radio aid which uses satellite signals to provide accurate navigation information.

The principle of GPS position computation is based on the measurement of transmission time of the GPS signals broadcast by at least four satellites. This segment is constituted by the GPS receiver and allows:

- signal acquisition,
- distance calculation,
- navigation computation (Satellite choice, positioning, propagation corrections),
- detection and isolation of failed satellites.

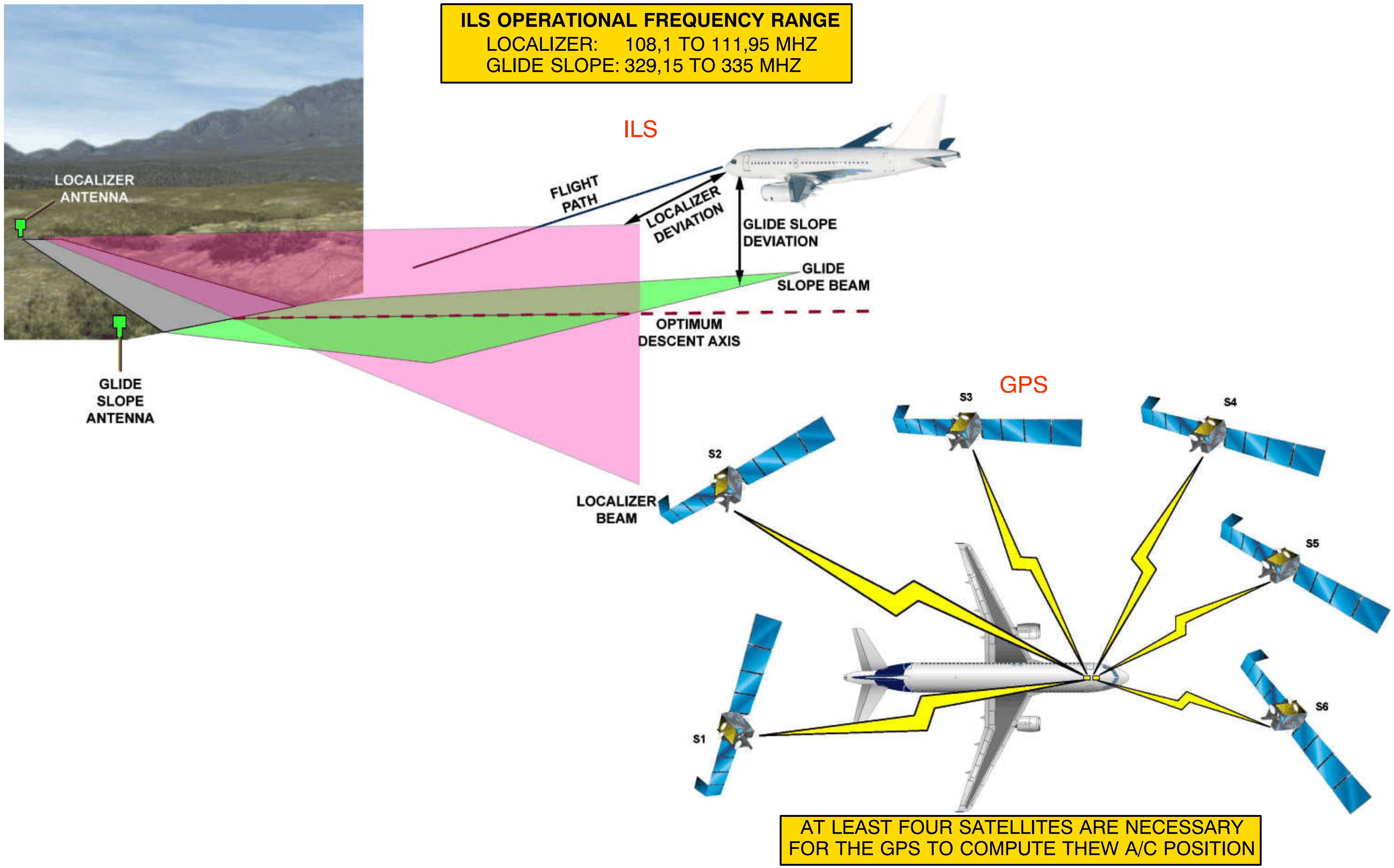


Figure 2 MMR - Principle

Components

The components are two ILS antennas, two GPS antennas and two MMR units. The MMR system interfaces with:

- PFDs and NDs for display,
- EFIS control unit for display and ILS control,
- Flight Management and Guidance Computers (FMGCs), for ILS auto-tuning and GPS position,
- MCDUs for ILS manual tuning,
- CAPT and F/O Radio Management Panels (RMPs) for ILS back-up tuning,
- Audio Control Panels (ACPs) for ILS audio signal,
- Air Data/Inertial Reference Units (ADIRUs) for GP-IRS hybrid position computation.

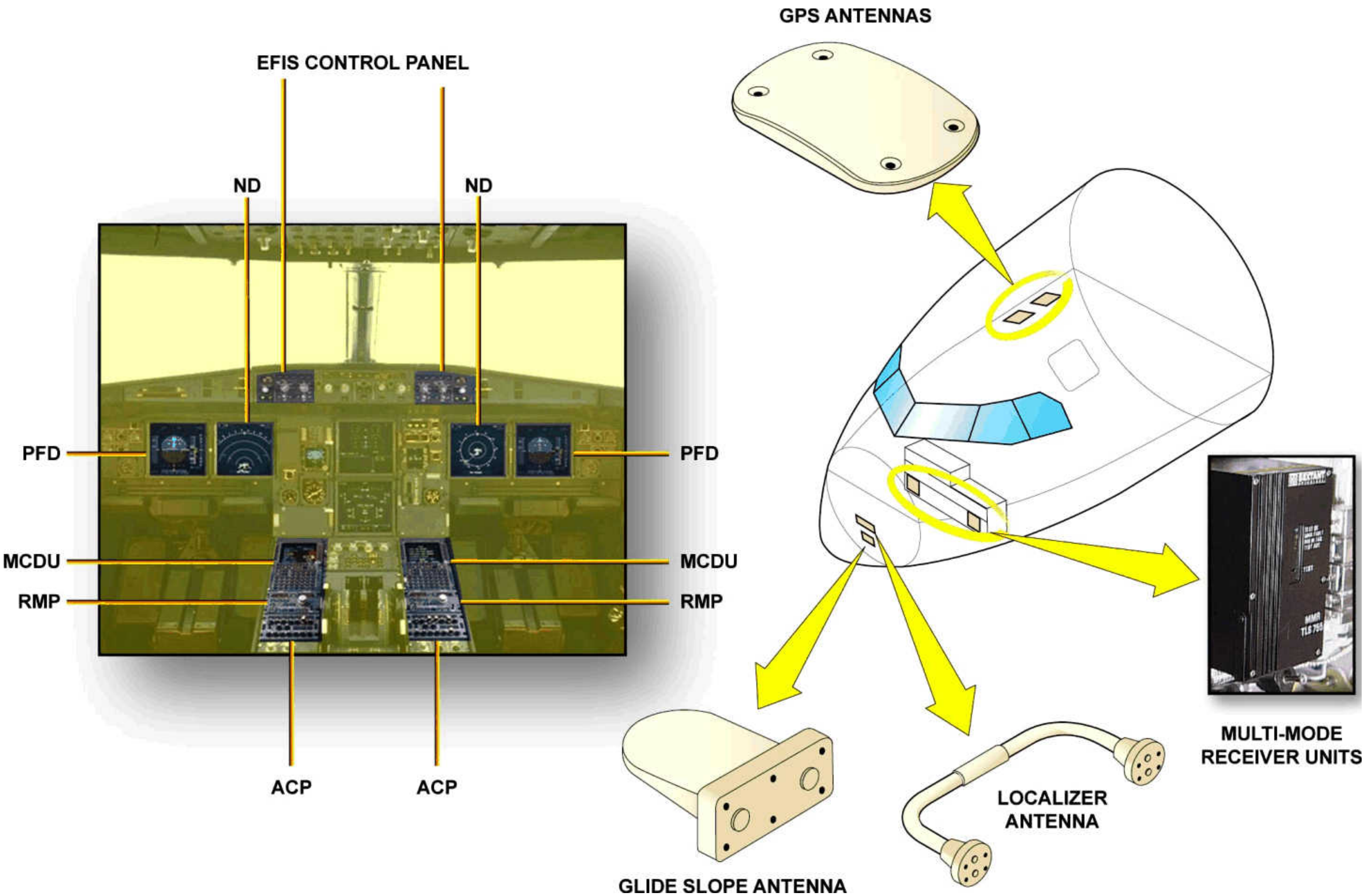


Figure 3 MMR - Components

MMR INDICATION

ILS INDICATION

Indication on PFD

If the ILS pushbutton is pressed and a ILS frequency is sent to the receiver (flight plane insertion on auto tuning, MCDU or RMP insertion on manual tuning), the white ILS deviation scales appear.

The magenta deviation indexes appear, when the Localizer or Glide Slope signals are valid.

When the deviation is out of range, the index is against one stop and only its outer half remains in view.

The scale and the index flash, when the deviation is excessive (ILS deviation warning).

The magenta course cursor or dagger shows the ILS course against the heading scale.

When the course is out of range, the numeric value is shown on the left or right corner of the heading scale.

The magenta ILS information shows:

- ILS identifier, if decoded by the ILS receiver.
- ILS frequency
- ILS DME distance, if there is a ILS/DME.

Indication on ND

- ND in Rose ILS Mode

  The white ILS deviation scales appear. The magenta course cursor or dagger shows the ILS course (runway heading) against the heading scale.

  The magenta LOC deviation bar appears, when the Localizer signal is valid. It moves perpendicular to the course cursor. When the deviation is out of range, the bar moves against one stop. The scale and the bar flash, when the deviation is excessive (ILS deviation warning).

  The magenta G/S deviation index appears, when the glide slope signal is valid. When the deviation is out of range, the index moves against one stop and only its outer half remains in view.

  The scale and the index flash, when the deviation is excessive (ILS deviation warning).

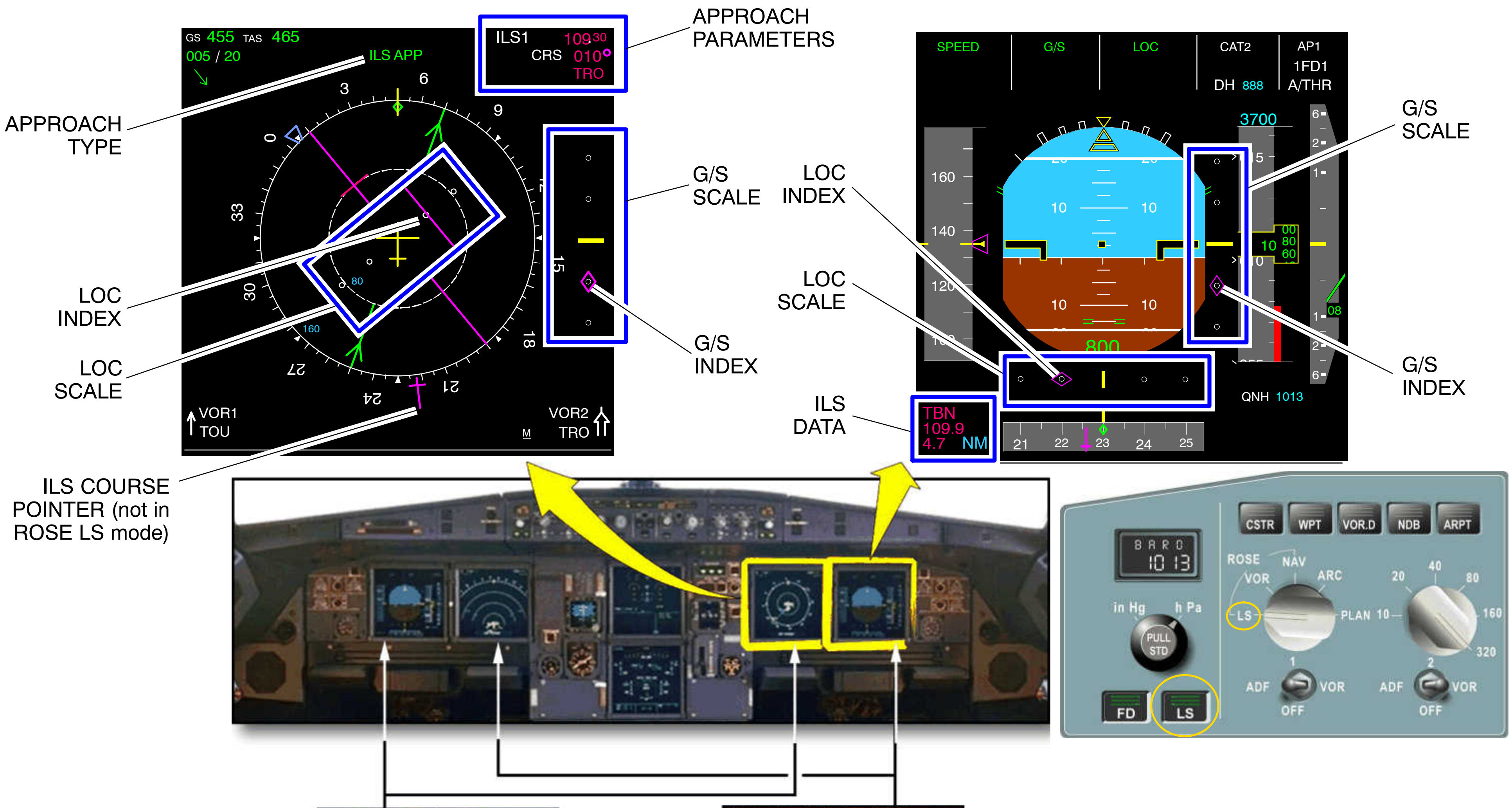
  The magenta ILS information shows:

  - ILS system and frequency,
  - ILS course,
  - ILS identifier, if decoded by the ILS receiver.

- ND in Rose NAV or ARC Mode

  If the ILS pushbutton on the EFIS control panel is pressed, the magenta course cursor or dagger shows the ILS course (runway heading) against the heading scale.

The ND shows the ILS APP message in its center top section when the pilot has selected the ILS approach on the MCDU.



LEGEND:
ILS: INSTRUMENT LAND
GPS: GLOBAL POSITIONING SYSTEM
G/S: GLIDESLOPE
LOC: LOCALIZER

Figure 4 ILS - Indication

GPS INDICATION

The GPS data is displayed on the MCDUs and on the NDs.

MCDU GPS Monitor Page

The GPS data are displayed on the GPS MONITOR page of the MCDU.

To get the GPS MONITOR page, push the DATA key on the MCDU, then the line key adjacent to the GPS MONITOR indication.

The upper part is dedicated to GPS 1 data, the lower part to GPS 2 data.

The following data are displayed:

- GPS position (lat/long),
- true track,
- GPS altitude,
- figure of merit (in meters),
- ground speed,
- number of satellites tracked,
- mode.

GPS PRIMARY in white or GPS PRIMARY LOST in amber show on the MCDU scratchpad.

ND GPS PRIMARY white message

The GPS is used by the FMGC for navigation.

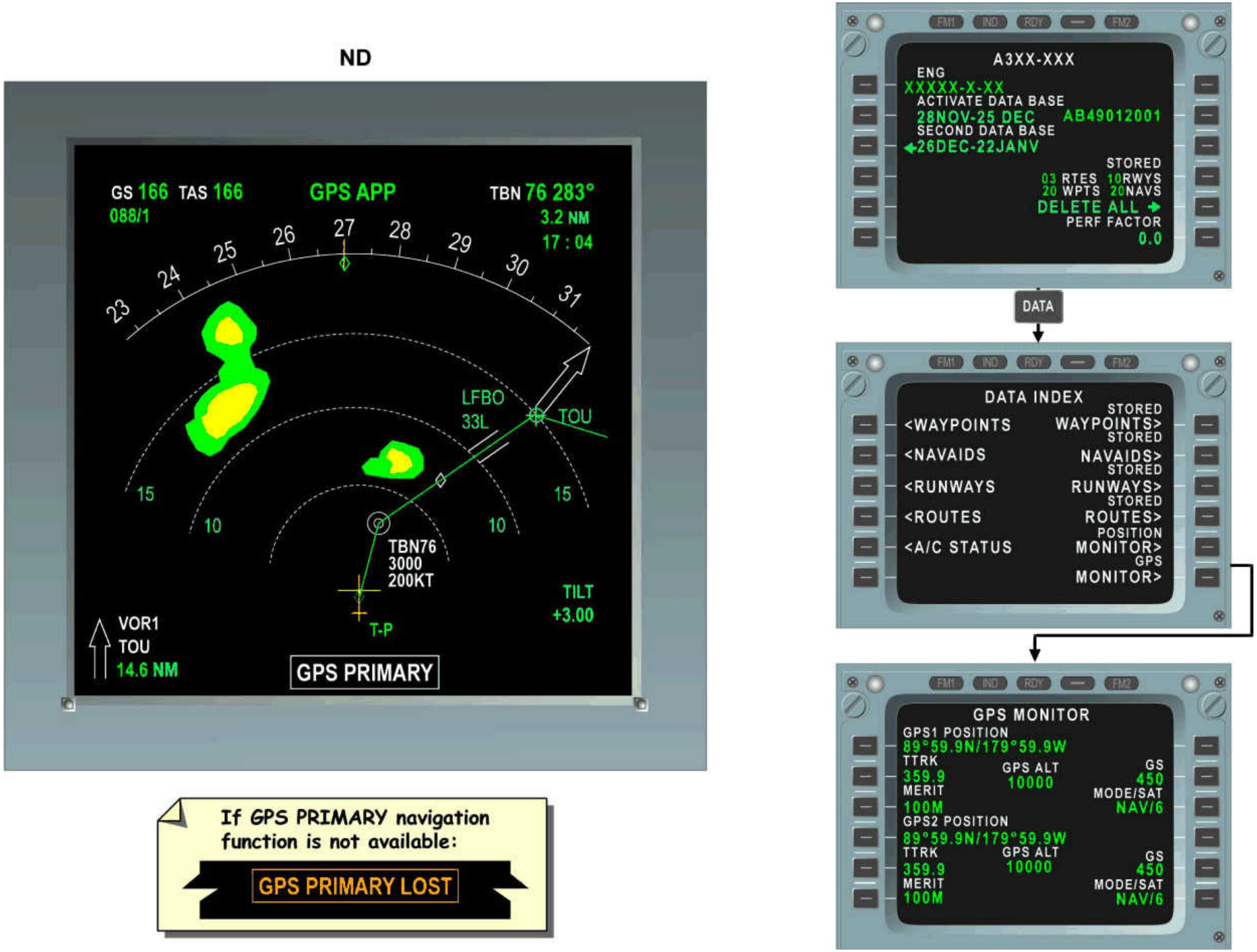


Figure 5 GPS - Indication

MMR GENERAL SYSTEM DESCRIPTION

MMR GENERAL

The A/C comprises two independent MMRs, 40RT1 and 40RT2, linked to:

- a common localizer antenna 3RT,
- a common glide/slope antenna 4RT,
- a GPS active antenna 43RT1 (linked to MMR1),
- a GPS active antenna 43RT2 (linked to MMR2).

ILS OPERATION

The equipment given below can control the ILS operation:

- the Multipurpose Control and Display Units (MCDU) and the Flight Management and Guidance Computers (FMGC) for frequency/course selection in normal operating mode.
- the Radio Management Panels (RMPs) for frequency/course selection in back-up mode.

The ILS data are shown on the EFIS displays:

- the CAPT Primary Flight Display (PFD) and F/O Navigation Display (ND) show the deviations from the ILS1.
- the F/O PFD and CAPT ND show the deviations from the ILS2.

The Morse-coded audio identification signals are sent to the Audio Management Unit (AMU). These signals can be heard in the boomset and on the loudspeaker according to the selection by the crew on the Audio Control Panel (ACP).

ILS Antennas

The dual G/S and dual LOC antennas are common to both MMR units. Each antenna has two independent connectors, for each MMR units.

NOTE: The Antennas are not monitored by the system BITE.

GPS OPERATION

In normal operation, the GPS 1 data are used by the ADIRUs 1 and 3; the GPS 2 data by the ADIRU 2.

NOTE: In order to reduce GPS initialization time, the GPS 1(2) receives init data from the ADIRU 1(2).

The Inertial Reference (IR) portion of the ADIRUs provides the FMGCs with:

- pure IR data
- pure GPS data (in this case the ADIRU operates as a relay)
- hybrid GPIR data.

  The hybrid GPIR 1(2) data are used by the FMGC 1(2) for position fixing purposes. The pure GPS data are used for display on the MCDU 1 and 2.

In case of one GPS failure, the three ADIRUs automatically select the only operative GPS to compute hybrid GPIR data.

In case of ADIRU 1 failure, the FMGC 1 uses ADIRU 3/GPS 1 data.

In case of ADIRU 2 failure, the FMGC 2 uses ADIRU 3/GPS 2 data.

In case of failure of two ADIRUs, the two FMGCs use only the operative ADIRU. This ADIRU receives data from its own side GPS (e.g. ADIRU 1 - GPS 1).

GPS Landing System (GLS) Function

The GLS function uses the ground stations and the GPS to compute the approach data (LOC and G/S) for the landing system. The GLS ground station data are transmitted to the localizer antenna, and the GPS data are transmitted to the GPS antennas.

GPS Antennas

The GPS antenna is an L-band active antenna, with an integrated preamplifier and filter, providing an omni-directional upper hemispheric coverage.

The GPS antenna operates at a frequency of 1575.42 MHz called L1. A second frequency of 1227.6 MHz, called L2, is used to estimate the propagation error of L1 and to suppress it.

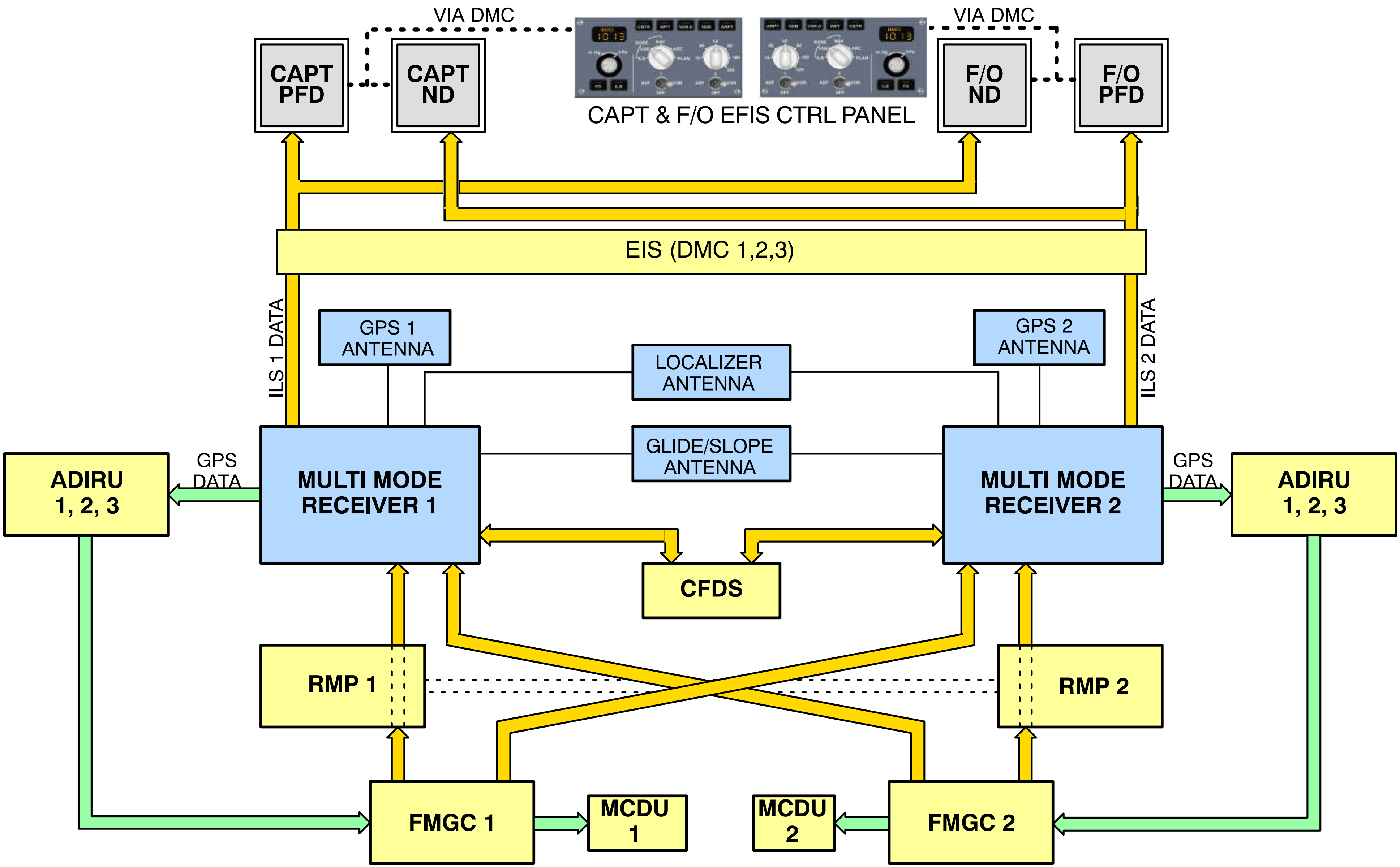


Figure 6 MMR - Schematic

ILS OPERATION

Normal operation

Each MMR is connected to one Radio Management Panel (RMP). The MMR 1 is connected to the RMP 1 (the MMR 2 to the RMP 2). The MMR 1 receives management bus from the FMGC 1 through the RMP 1 (the MMR 2 from the FMGC 2 through the RMP 2).

In normal operation, the FMGC 1(2) tunes the MMR 1(2) either automatically or manually by means of the MCDU. In this case the RMP 1(2) operates as a relay which sends the frequency information from the FMGC 1(2) to the receiver 1(2).

Via a second port, the MMR 1(2) receives a second management bus (ILS FREQ + RWY HDG) directly from the FMGC 2(1).

The receiver selects one of the two input ports according to the FREQ / FUNCT DATA SOURCE SEL discrete signal, which is received from the FMGC 1(2) through the RMP 1(2).

Operation in case of failure

With failure of one FMGC, the second FMGC, can control the two MMRs, the off side directly, the on side through its RMP.

With failure of the RMP 1(2) or two RMPs, the RMP concerned is transparent to data and discrete from FMGC.

Reconfiguration switching

In normal utilization, the ILS 1 data are shown on the CAPT PFD and the F/O ND; the ILS 2 data on the F/O PFD and the CAPT ND.
The DMC 1 supplies data to the CAPT PFD and ND; the DMC 2 to the F/O PFD and ND.

Failure of DMC

With failure of the DMC 1(2) it is possible to switch over to the DMC 3 with the EIS DMC selector switch located on the center pedestal.
In this case, the DMC 3 totally replaces the DMC 1(2) through the stage of the output switching relay of the failed DMC.

Failure of PFD

With failure of the PFD, there is an automatic transfer of the PFD image onto the ND.

Failure of ND

With failure of the CAPT (F/O) ND, you obtain the transfer of the ND image onto the CAPT (F/O) PFD when you push the PFD/ND XFR pushbutton switch.

When you set the PFD potentiometer to OFF this causes:

- deactivation of the CAPT (F/O) PFD
- transfer of the PFD image onto the CAPT (F/O) ND.

Audio control

The MMR applies its audio output to the audio integrating system. This system controls and directs the output to the headsets and / or the loudspeakers.

The Audio Management Unit (AMU) controls the audio level through the ACP. On the ACP, the pilot must push the ILS pushbutton switch and adjust the related potentiometer to the correct audio level.

With ILS / DME collocated stations, the DME identification morse code can be listened in sequence with the ILS audio signal when you push the ILS pushbutton switch on the ACP and the ILS pushbutton switch on the FCU.

ADIRU

To reduce initialization time, MMR unit 1 and 2 receive position data (latitude, longitude), time and date from the associated ADIRU. In case of failure of ADIRU 2 the primary source of ADIRU 3 being GPS 1, it is necessary to select the second input port of ADIRU 3 (GPS 2) by means of the ATTitude/HeaDinG selector knob on the SWITCHING panel to preserve the side 1/side 2 segregation:

- MMR 1 provides data to FMGC 1 through ADIRU 1,
- MMR 2 provides data to FMGC 2 through ADIRU 3.

Landing Gear Control and Interface Unit

Each LGCIU sends a ground/flight discrete signal, which is used by the receiver BITE module to count the MMR internal flight legs.

Users

The MMR data is sent to the FMGCs for aircraft guidance during take off, approach and landing phases. The MMR data is also sent to the ECAM for warnings. The MMR 1 data is send to the Enhanced Ground Proximity Warning System (EGPWS) for mode 5 computation (descent below G/S).

NOTE: A discrete signal sent by the FMGC inhibits any frequency change in the MMR unit when LAND mode is armed below 700ft.

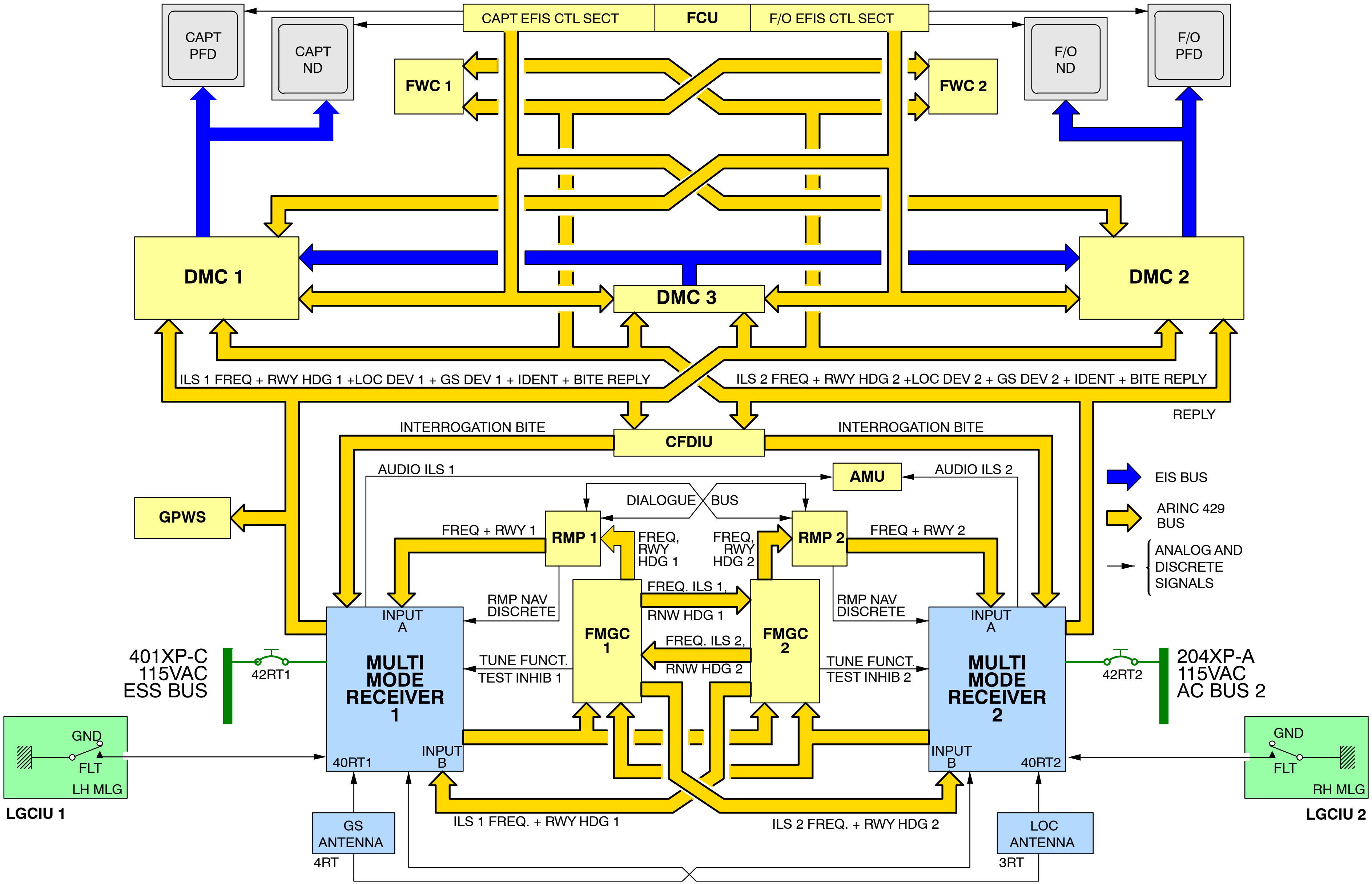


Figure 7 ILS Interface Diagram

GPS OPERATION

NORMAL OPERATION

To reduce initialization time, the MMR 1(2) receives position data, LAT/LONG from the ADIRU 1(2) and SET LAT, SET LONG UTC/Date from the FMGC 1(2) through the ADIRU 1(2).

Each MMR receives the GPS satellite RF signals from the active antenna to compute and provide the three ADIRUs with:

- UTC, date,
- position, altitude,
- ground speed, track angle,
- N/S speed, E/W speed, vertical speed,
- horizontal and vertical dilution of precision, figure of merit,
- satellite position,
- satellite measurement (pseudo-range, delta range, range rate, UTC measurement time),
- GPS measurement status, sensor status,
- real time and predictive integrity data.

Within each ADIRU an hybridization function performs the following:

- monitoring of the MMR using GPS status word and ADIRU BITE,
- generation of failure message for ECAM display,
- use of pseudo-range/delta range data to compute GPS position,
- use of inertial data to smooth GPS position/velocity,
- use of a Kalman filter to estimate and minimize errors,
- use of IR data to improve the robustness of the MMR RAIM algorithm,
- transmission of GPS and GPIR data to the FMGC for position fixing and display purposes.

GPS primary navigation function principle in the FMGC

A navigation mode with the least error is chosen based upon the mixed IR position and the best GPIR or radio position available.

NOTE: The GPIR position used by the FMGC to determine the aircraft position is computed in the GPIR partition of the ADIRU (hybrid solution).

The FMS mode of navigation is selected according to the following hierarchy:

- GPIR/Inertial,
- DME/DME/Inertial,
- DME/VOR/Inertial,
- Inertial only.

The GPIR/INERTIAL mode is selected as long as the following conditions are satisfied:

- GPIR position is available and with an estimated accuracy consistent with the intended operation.
- GPIR integrity is available and compatible with the applicable phase of flight requirement.

As long as the GPS/INERTIAL mode is active, no DME/DME or VOR/DME radio updating is allowed. However, LOC updating can apply to GPS/INERTIAL position. In this navigation mode, N IR/GPS indication is displayed on the POSITION MONITOR page with N being the number of IRs used to compute mixed IR position.

The selected hybrid GPIRS position is displayed on the POSITION MONITOR page in place of the radio position.

The mixed IR position and the IR deviations displayed on the POSITION MONITOR page do not change and are still computed using pure IR inputs.

Aircraft position is generated by a series of filters which use inertial position, GPIR position or radio position, and aircraft velocity as input.

A position bias is computed once every second through the position bias filter. This position bias is computed as the difference between the GPIR position (or radio position) and the inertial position.

The aircraft position is finally computed every 200 ms based on the corrected inertial position and the aircraft velocity using the aircraft position filter.

The GPS/INERTIAL mode can be manually inhibited by pushing the line key adjacent to the DESELECT GPS indication on the SELECTED NAVAIDS page.

FMGC computed integrity:

When the GPIR position is available in the FMGC but the GPIR integrity is not delivered by the ADIRS, the FMGC is capable of computing an equivalent integrity called AIM (Alternate Integrity Monitoring), using IR data, during a limited period of time. The goal of this FMGC functionality is to improve the availability of the GPS Primary function in the cockpit.

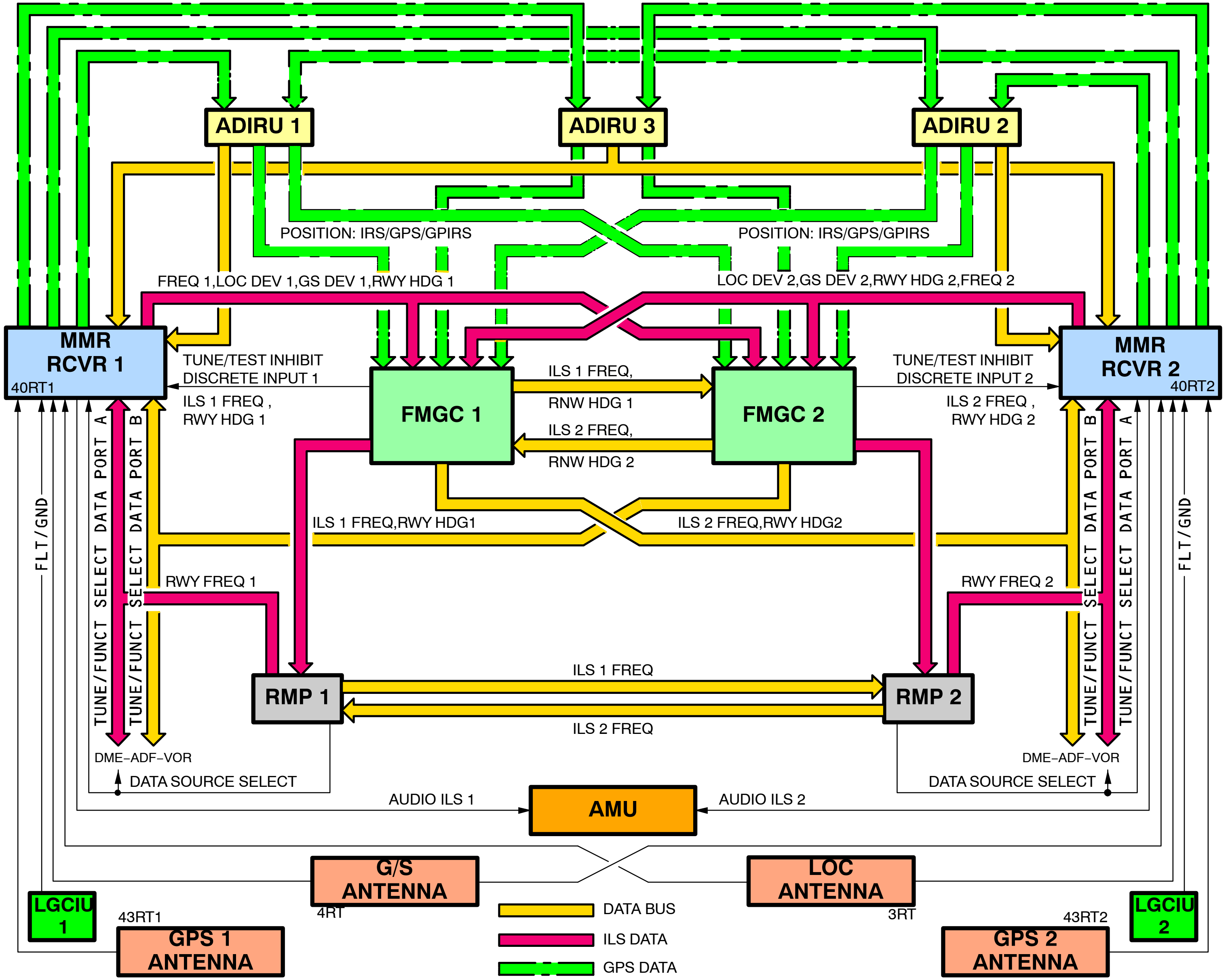


Figure 8 MMR Interface Schematic

ILS TUNING FUNCTION

Auto Tuning

The MMR 1 is connected to the RMP 1 (the MMR 2 to the RMP 2).

The MMR 1 receives management bus from the FMGC 1 through the RMP 1 (the MMR 2 from the FMGC 2 through the RMP 2).

In normal operation, the FMGC 1(2) tunes the MMR 1(2) automatically. The departure and destination runway is entered by the crew into the flight plan, the FMGC gets the related ILS frequency from the navigation database.

In this case the RMP 1(2) operates as a relay which sends the frequency information from the FMGC 1(2) to the receiver 1(2).

Operation in case of FMGC failure

With failure of one FMGC, the second FMGC, can control the two MMRs, the off side directly, the on side through its RMP.

Manual Tuning by MCDU

A frequency selection is done at the RAD/NAV page via the Alpha–Numeric Keys on the MCDU.

- ILS–TUNING

  On the RAD/NAV page it is possible to enter a ILS identifier or a frequency and a course. The course will be automatically cleared, if a new ILS station is entered.

  - After insertion of a new identifier, the FMGC uses the NAV DATA BASE to search for the new frequency and sends it to the receiver.
  - After insertion of a new frequency, the FMEC uses the NAV DATA BASE to search for the new identifier to display the data on the MCDU screen.

Radio Navigation Back Up Tuning

If both FMGC fail, each MMR must be tuned directly from the onside RMP.

The RMPs can be used to tune the radio navigation systems:

- RMP 1 for VOR 1, DME 1, ILS 1 and ADF 1
- RMP 2 for VOR 2, DME 2, ILS 2 and ADF 2

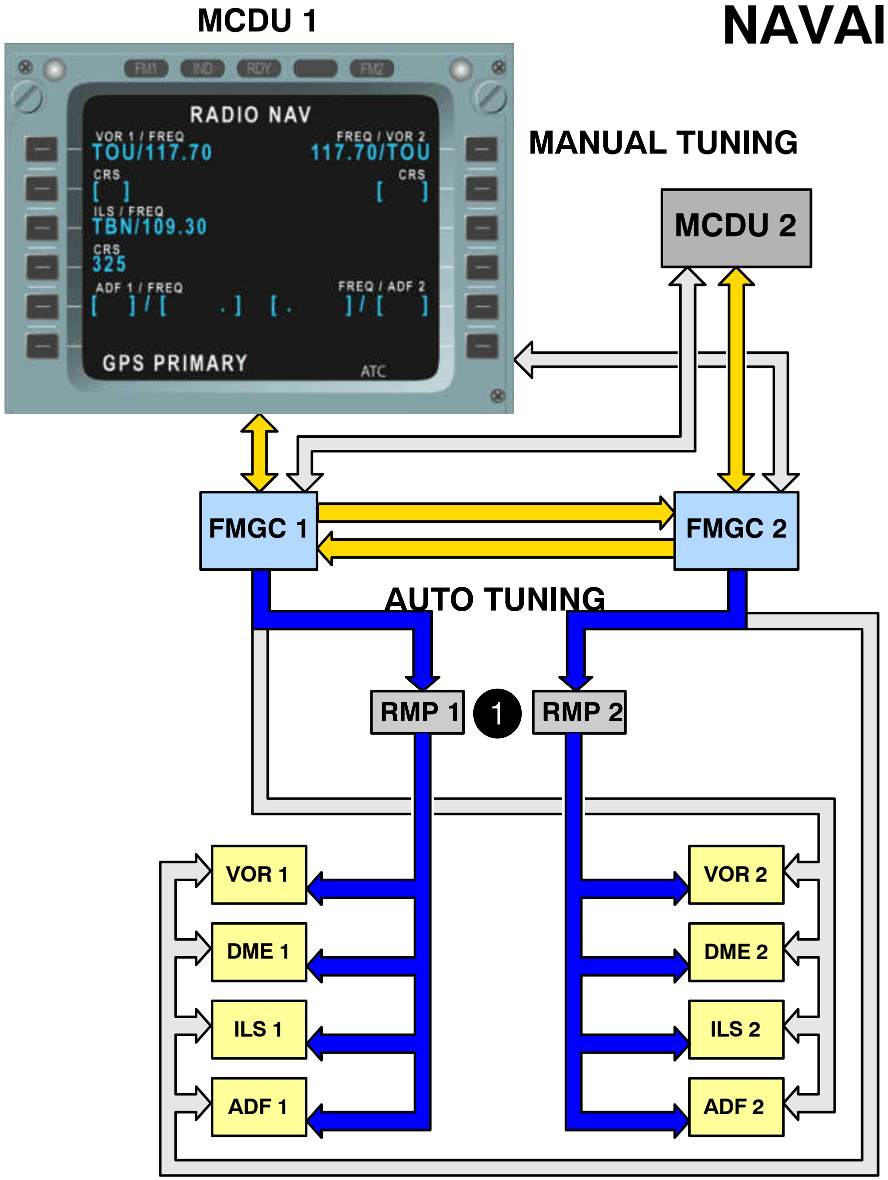
To do so, the guarded NAV pushbutton must be pressed to switch the RMP in the radio navigation back up mode (green NAV LED on).

All navigation systems associated to that RMP now uses the last stored RMP NAV frequencies.

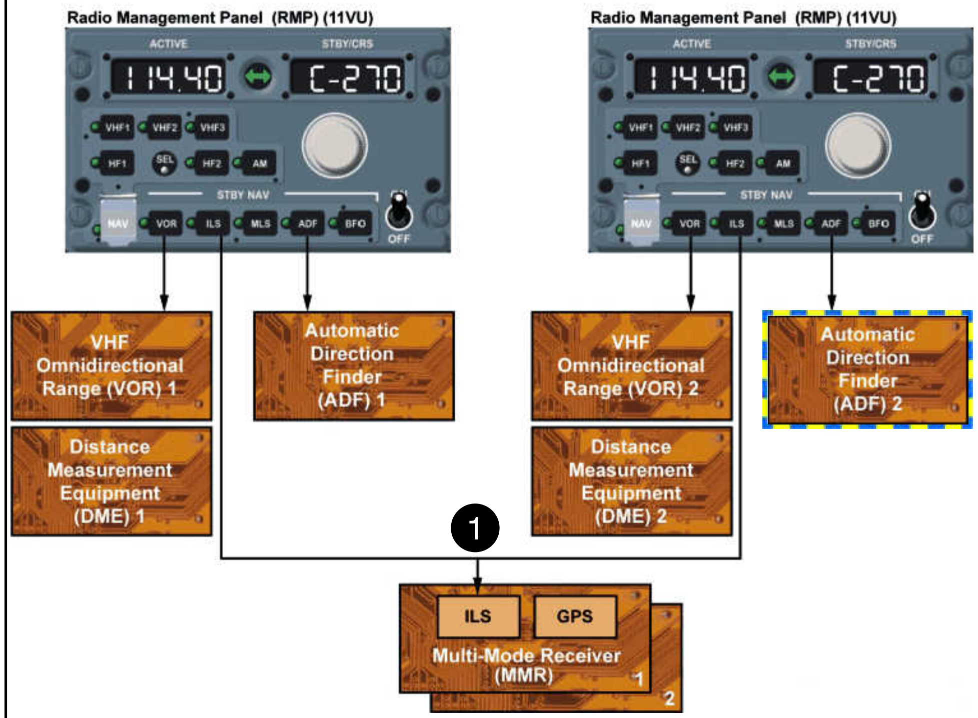
After selection of the NAV system via the pushbuttons, a new frequency and a new course can be entered by using rotary knob and the transfer switch.

NOTE: The Tuning Function is the same for VOR (DME), ADF.

NAVAIDS TUNING



BACKUP (STBY NAV) TUNING



1 NOTE: IN STBY NAV MODE THE ILS FREQUENCY AND COURSE IS SYNCHRONIZED BETWEEN THE RMP 1 & 2 TO ENSURE THAT BOTH ILS ARE TUNED TO THE SAME RUNWAY.

OPTIONAL

Figure 9 NAVAIDS Tuning

MMR COMPONENT DESCRIPTION

MMR

The face of the MMR is fitted with a handle, two attaching parts, a TEST pushbutton switch and four Light Emitting Diodes (LEDs).

The four LEDs have the following name, color and function:

- TEST OK (green) indicates that no fault is detected during the initiated (by pushbutton switch or by MCDU) self–test or during the power–up test.
- MMR FAULT (red) indicates that an internal fault is detected by the MMR itself.
- BUS IN FAIL (red) indicates that no control input is available.
- TEST ANT (red) indicates that a failed antenna (or coaxial cable) is detected.

The back of the MMR is equipped with one ARINC 600 size one connector, which includes three plugs:

- Top Plug (TP): connection with the GPS antenna
- Middle Plug (MP): service interconnection
- Bottom Plug (BP): connection with the power supply circuit, and the LOC and G/S coaxial interconnections.

GPS ANTENNA

Two L–Band Antennas are mounted on the top of the fuselage, at the centerline, to receive signals from the GPS satellites.

The GPS antenna is an active antenna with an integrated preamplifier and filter. It receives GPS signals at 1575.42 MHz and matches to a 50 –ohms coaxial cable at the input to the MMR. The antenna has a right–hand circular polarized and omnidirectional radiation pattern.

The power supply of the preamplifier is provided by the MMR through the coaxial cable.

NOTE: The antenna connectors have a hole to install a lockwire and safety the coaxial cable.

LOCALIZER ANTENNA

The localizer antenna is an airborne antenna used to receive LOC signals in the 108–112MHz range. It is a folded half–loop type driven by capacitive coupling. The antenna has two independent RF connectors used to feed two independent ILS receivers. Connector separation is provided by a hybrid junction in the antenna.

GLIDE SLOPE ANTENNA

The glide slope antenna is an airborne antenna used to receive GLIDE signals in the 329–335MHz range. It is a folded half–loop type driven by capacitive coupling. The antenna has two independent RF connectors used to feed two independent ILS receivers. Connector separation is provided by a hybrid junction in the antenna.

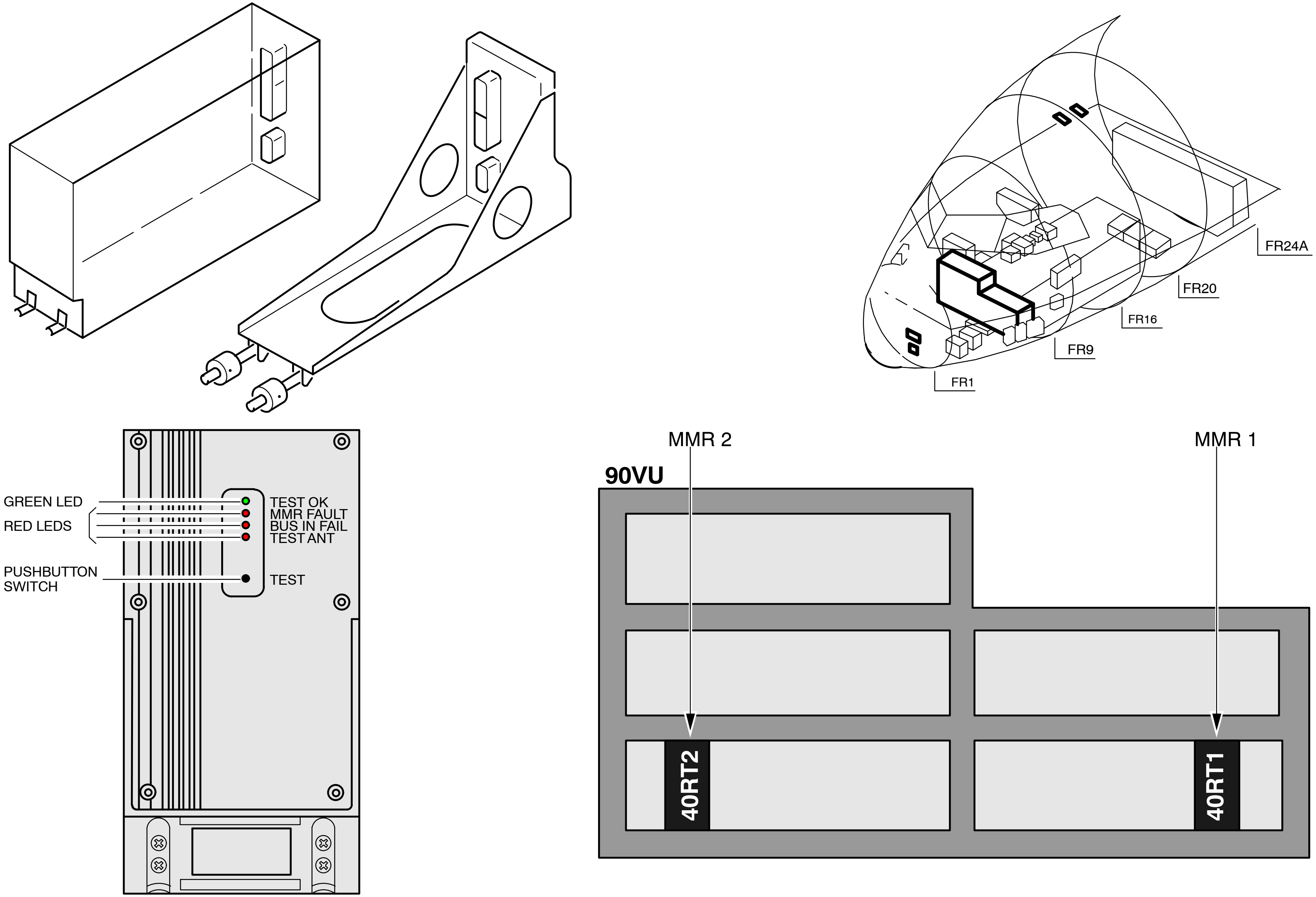


Figure 10 Multi Mode Receiver

ILS (MMR) FLAGS DESCRIPTION

ILS FLAGS

Flags on PFD

If the ILS pushbutton is pressed and the ILS receiver fails (LOC or GS) a red ILS message is displayed instead of ILS information in the left bottom corner. Frequency and identifier disappear.

With LOC failure, a red LOC flag (flashing 9s, then steady) comes into view in the middle of the LOC scale and the LOC deviation bar goes out of view.

With LOC data not available (NCD), the LOC deviation index goes out of view.

With G/S failure, a red G/S flag (flashing 9s, then steady) comes into view in the middle of the G/S scale and the G/S deviation bar goes out of view.

With G/S data not available (NCD), the G/S deviation index goes out of view.

If course input is not available (fail or NCD), the course cursor disappears.

The last used frequency will be locked, if the frequency information becomes NCD or fail.

Flags on ND

If the ILS receiver fails (LOC or GS) a red ILS message is displayed instead of ILS Information in the right top corner. Frequency and identifier disappear.

With LOC failure, a red LOC flag (flashing 9s, then steady) comes into view in the middle of the LOC scale and the LOC deviation bar goes out of view.

With LOC data not available (NCD), the LOC deviation bar goes out of view.

With G/S failure, a red G/S flag (flashing 9s, then steady) comes into view in the middle of the G/S scale and the G/S deviation bar goes out of view.

With G/S data not available (NCD), the G/S deviation index goes out of view.

If the course input fails, a vertical red dagger and a red course flag (CRS XXX) are shown.

If the course information is NCD, a course of 0° is displayed and the LOC deviation bar goes out of view.

GPS FLAGS

ND GPS PRIMARY LOST amber message

This message is displayed at the bottom of the image in all the ND modes when the GPS primary is lost.

In this case, the GPS is not used for navigation (accuracy and integrity for the intended operation can still be met by the use of alternate navigation means).

GPS failure

The GPSs are monitored by the both FWCs using a status word sent by each GPS.

In case of GPS failure, the NAV GPS 1(2) FAULT message is displayed in the lower part of the upper ECAM DU.

This message is accompanied by:

- activation of the MASTER CAUT lights on the glareshield
- aural warning: Single Chime (SC).

PFD

ND (ROSE/ILS MODE)

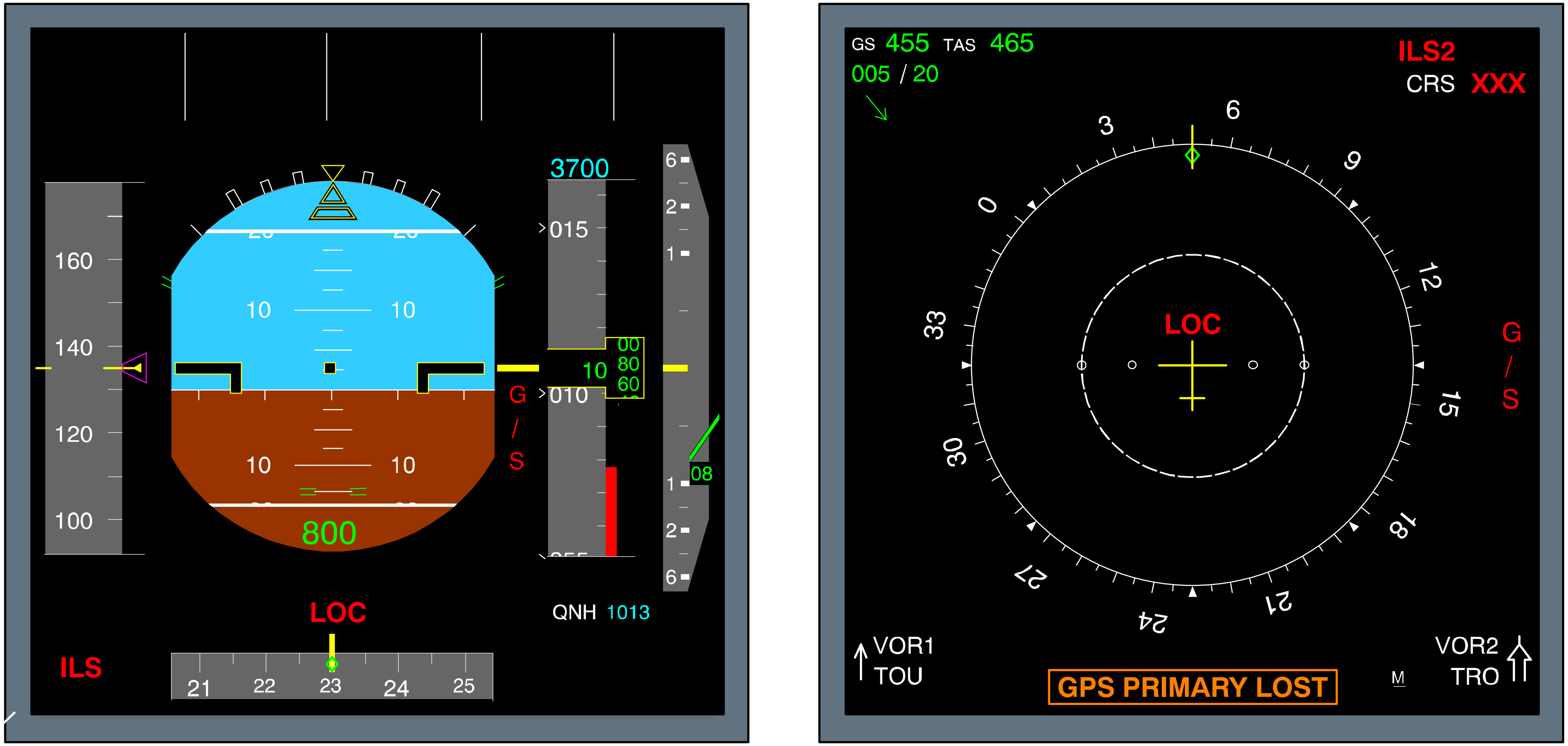


Figure 11 MMR Flags

34−55 VOR/MARKER

VOR/MAKRER INTRODUCTION

VOR PRINCIPLE

The VOR system is a medium−range radio navigation aid. The VOR system receives, decodes and processes bearing information from the omni−directional ground station, working in the frequency range of 108 MHz to 117.95 MHz.

The ground VOR station generates a reference phase signal and a variable phase signal. The phase difference between these signals, called bearing, is function of the aircraft position with respect to the ground station.

The bearing is the angle between the magnetic north and the ground station/aircraft axis. Furthermore, the VOR station provides a Morse identification, which identifies the station.

These signals are processed and conditioned to provide the crew with:

- identification of a selected ground station,
- indication of the aircraft position with respect to the station (bearing information),
- indication of the aircraft angular deviation from a selected course.

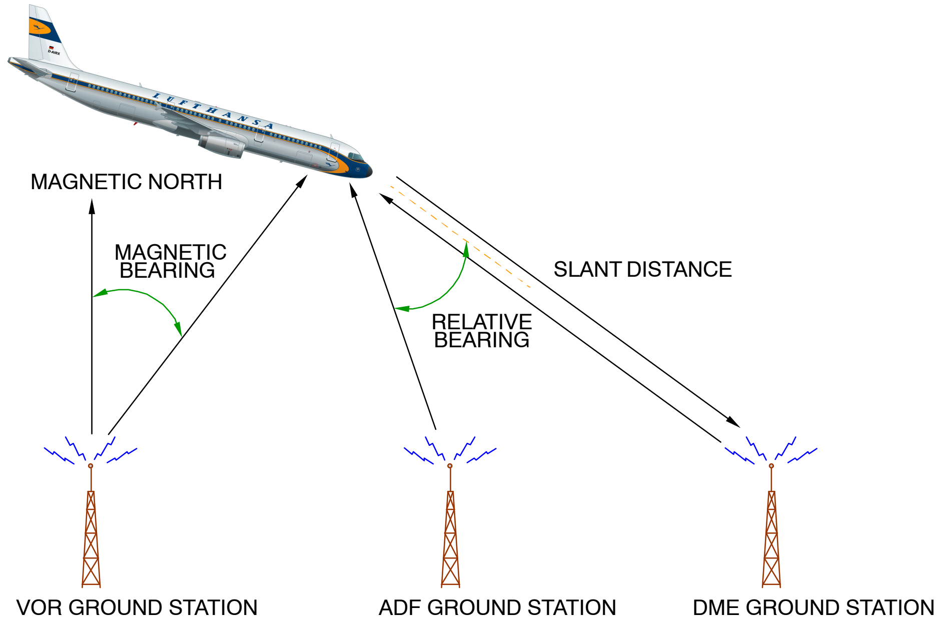


Figure 12 Dependent Position Determining

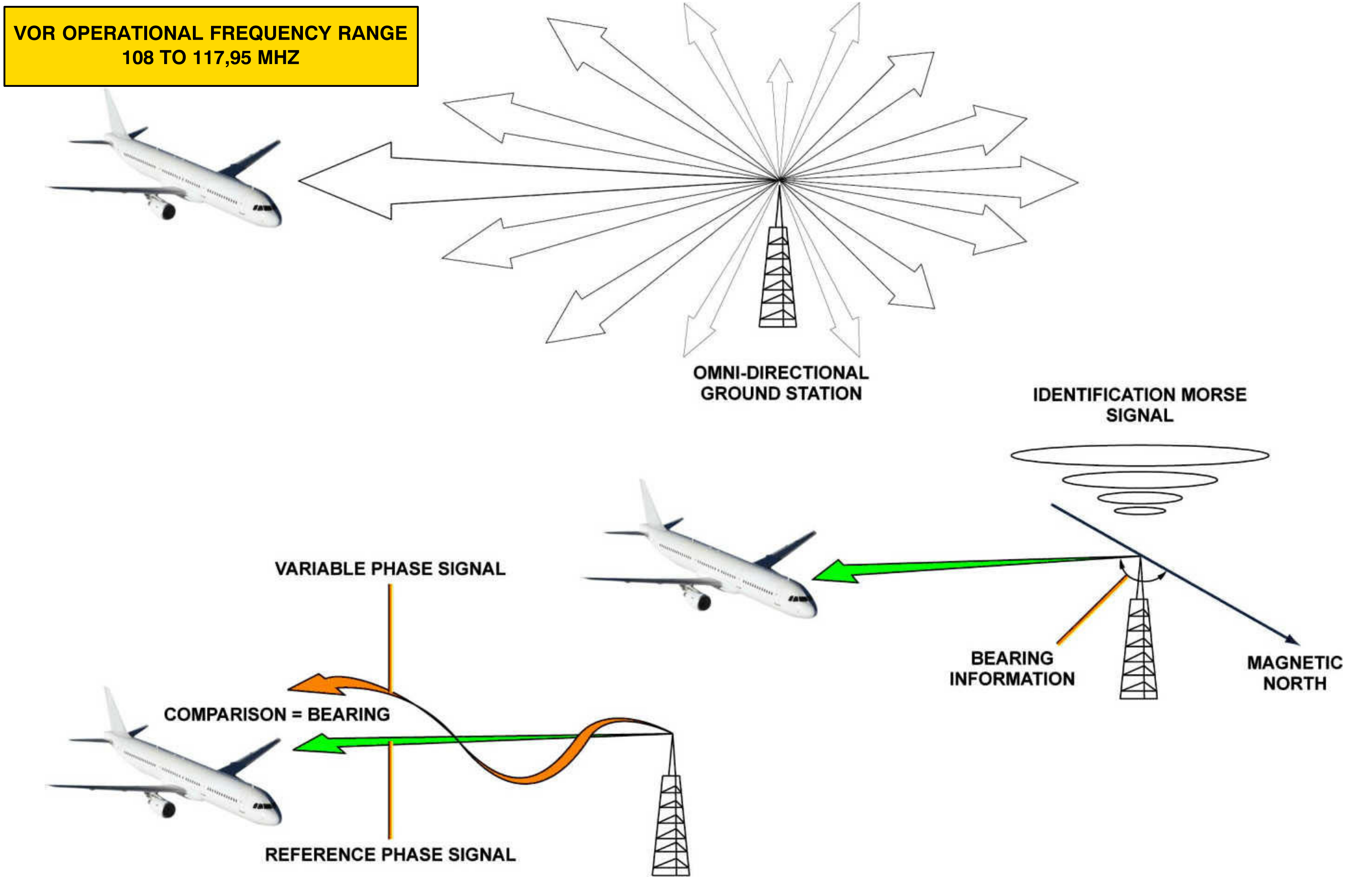


Figure 13 VOR Princible

MARKER PRINCIPLE

The marker system is a radio navigation aid. It is normally used together with the Instrument Landing System (ILS) portion of the Multi−Mode Receiver (MMR) during an ILS approach.

The system determines the distance between the aircraft and the runway threshold. The marker system also marks particular airway and holding points.

The system provides visual and aural indications of the passage of the aircraft over the marker transmitters located on the ground.

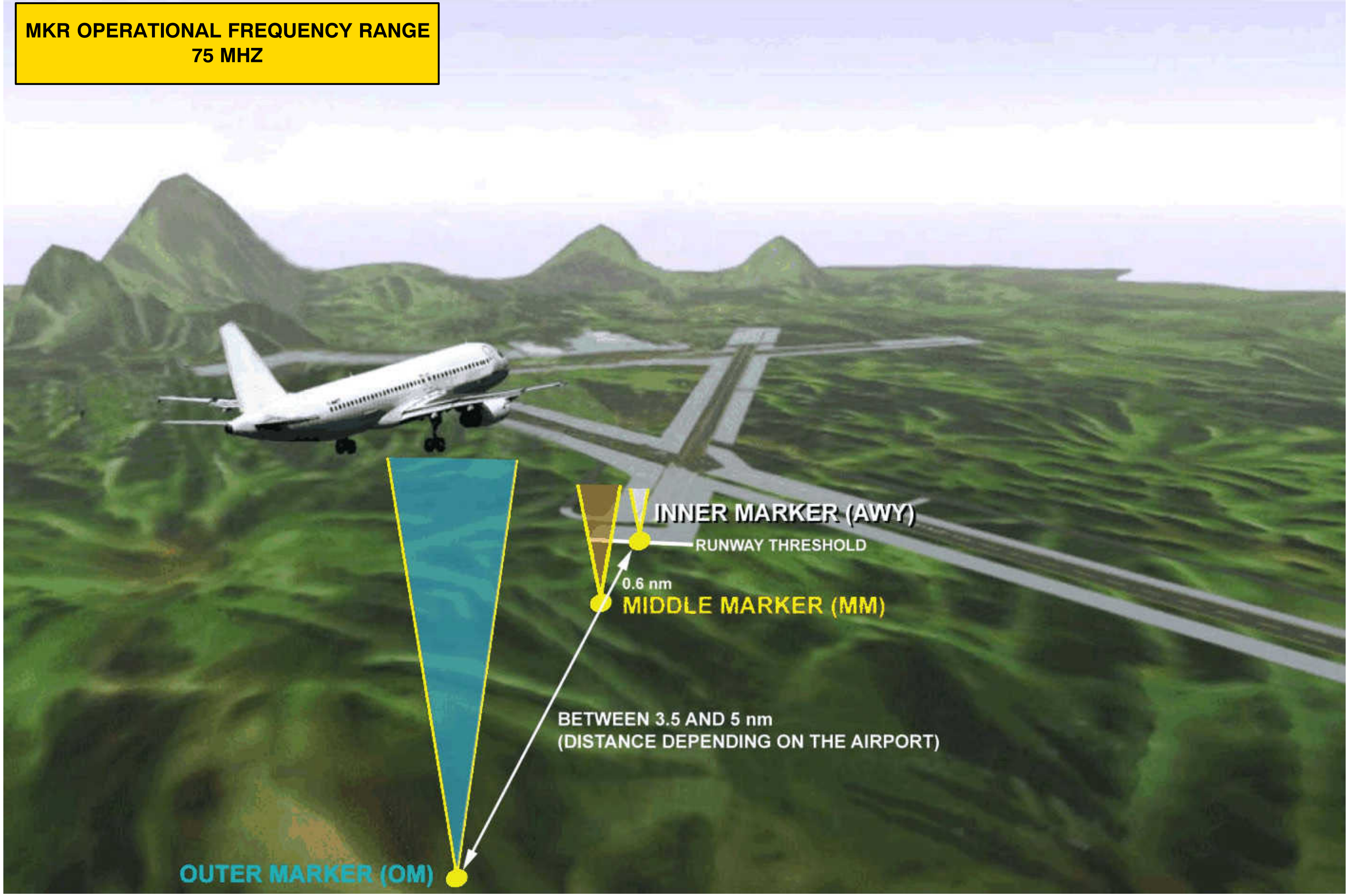
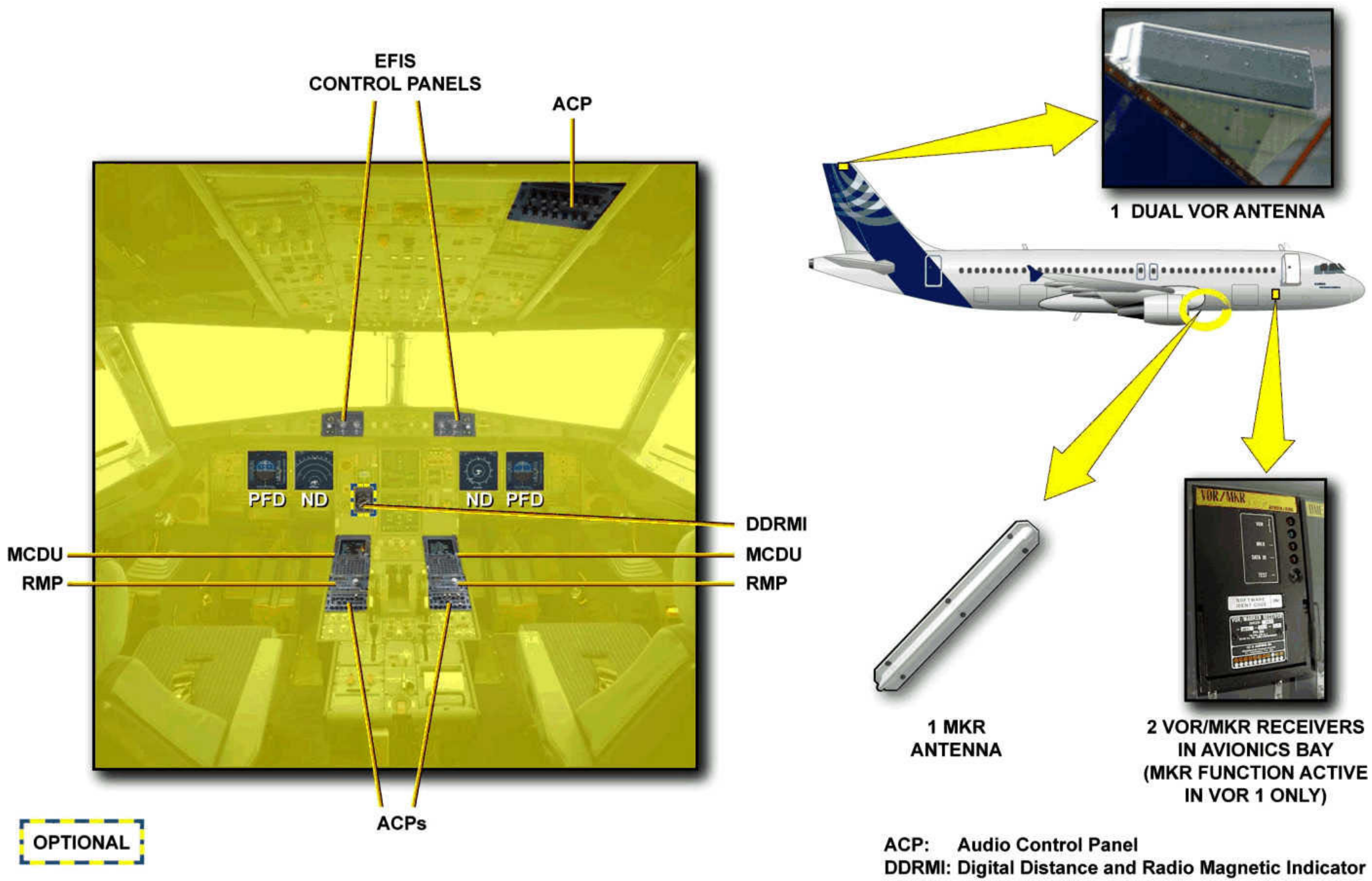


Figure 14 Marker Principle

SYSTEM COMPONENTS

The VOR and MKR systems are composed of two receivers, one MKR antenna and one dual VOR antenna. The VOR/MKR system is also connected to:

- NDs, PFDs and Digital Distance and Radio Magnetic Indicator (DDRMI) for display,
- EFIS control panels for control display,
- Flight Management and Guidance Computers (FMGCs) for auto-tuning,
- MCDU for manual tuning,
- CAPT and F/O Radio Management Panels (RMPs) for back-up tuning,
- Audio Control Panels (ACPs) for VOR/MKR audio signal.



ACP: Audio Control Panel
DDRMI: Digital Distance and Radio Magnetic Indicator
RMP: Radio Management Panel

Figure 15 VOR/Marker System Components

VOR/MARKER INDICATION

VOR INDICATION ON ND

- ND in ROSE VOR Mode

  The white VOR deviation scale appears.

  The cyan course cursor or dagger shows the preselected course PSC (Pre-Selected Course) in relation to the heading rose.

  The cyan deviation bar appears, when the VOR signal is valid. It moves perpendicular to the course cursor (1 dot = 5°). When the deviation is out of range, the bar moves against one stop. The arrow shows the direction to the station (TO/FROM).

  The VOR information (white) shows:

  – VOR system and frequency,
  – VOR course (PSC),
  – VOR identifier, when decoded by the VOR receiver,
  – Tuning mode.

- **ND in ROSE NAV or ARC Mode**

  When the VOR.D pushbutton on the EFIS control panel is pressed, all VOR/DME stations contained in the FMGCs NAV DATA BASE are displayed on the ND, depending on the selected range:

  “O“ for DME “+“ for VOR

- **ND in ROSE VOR,ROSE ILS, ROSE NAV or ARC Mode**

  When the VOR/ADF selector is switched to VOR and the VOR signal is valid, the white VOR pointer appears and shows the bearing to the VOR station. The VOR station characteristics is displayed in the left or right lower corner of the ND and shows:

  – VOR system,
  – Pointer symbol,
  – VOR/DME frequency or identifier, if decoded by the VOR receiver,
  – Tuning mode.

VOR Indication on DDRMI (Optional)

The pointer shows VOR ground station bearing on the heading dial.

Audio Control

The VOR/MKR receivers apply their VOR audio output to the audio integrating system. This system controls and directs the output to the headsets and/or the loudspeakers. The AMU controls the audio level through the ACP. On the ACP, the pilot must push the VOR 1 (2) pushbutton switch and adjust the related potentiometer to the correct audio level.

In case of ATIS message transmission by the VOR station:

- it is necessary to push the ON VOICE pushbutton switch on one ACP in order to hear clearly this information without Morse signal.

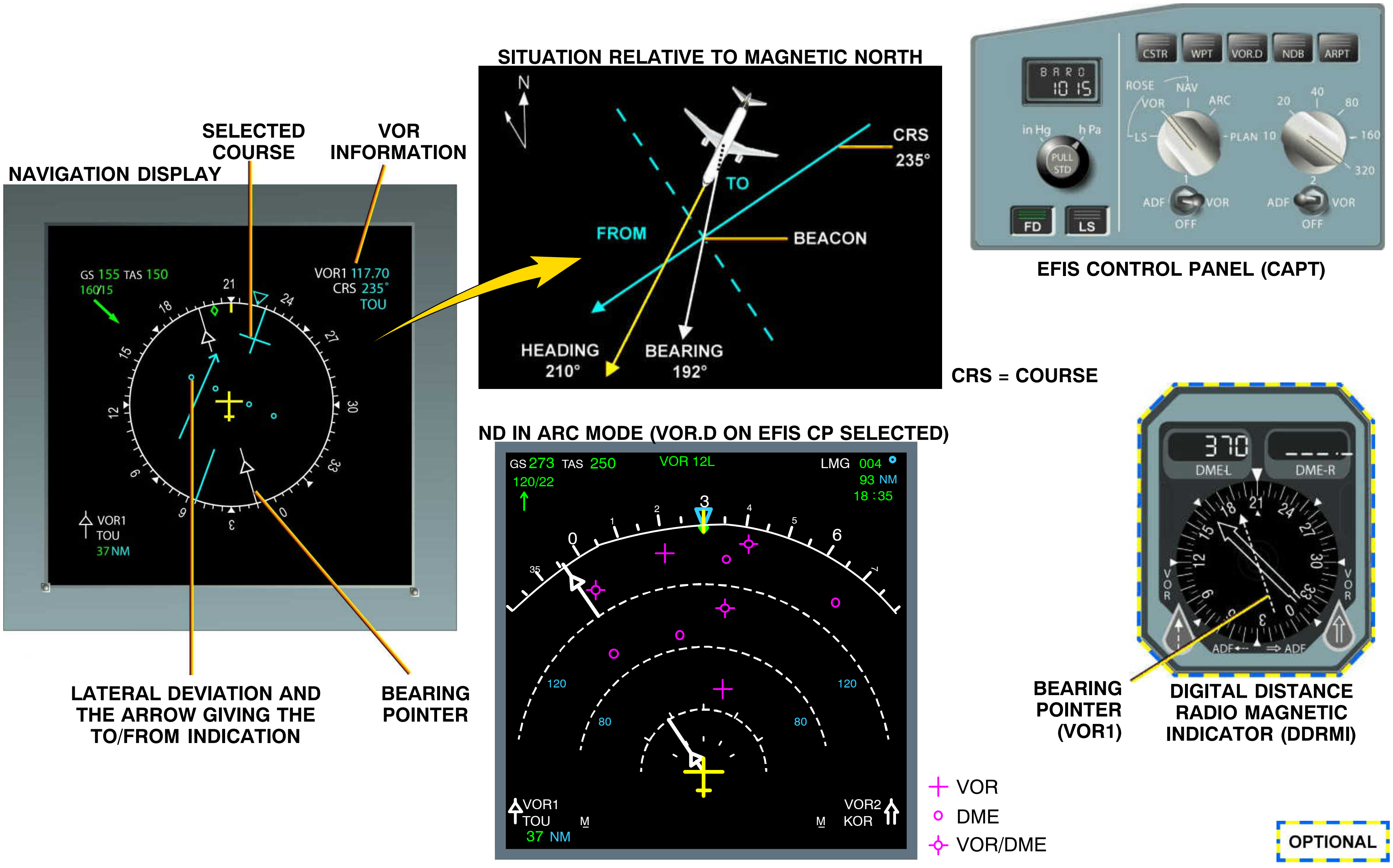


Figure 16 VOR Indications

MARKER INDICATION ON PFD

At the intersection of the LOC and G/S scale on the PFD the following Marker indication appears:

- **AWY** (Airways Marker) in white or
- **OM** (Outer Marker) in cyan or
- **MM** (Middle Marker) in amber.

Marker audio signals are processed by the receiver and sent to the AMU.

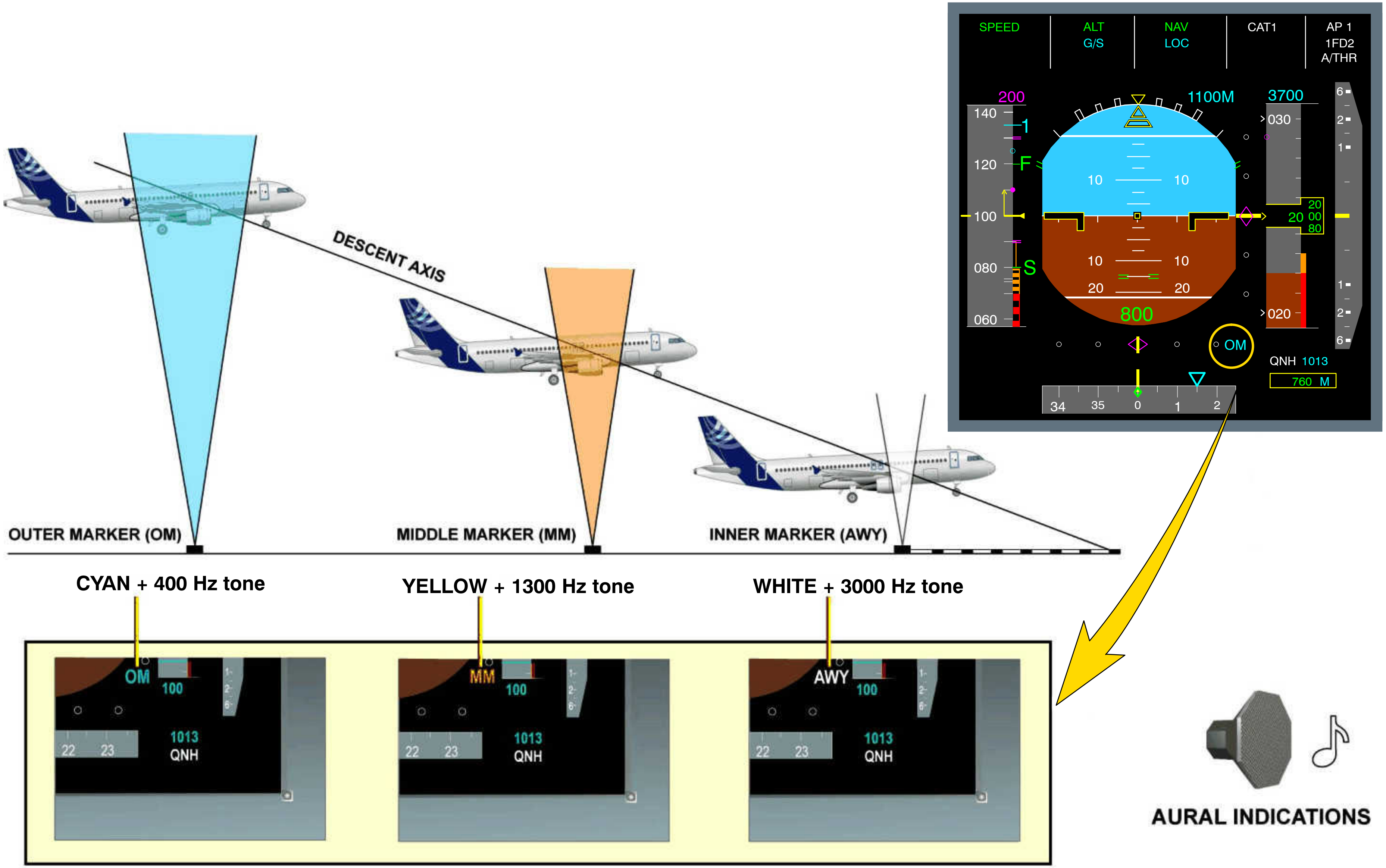
Audio Control

The VOR/MKR receiver 1 applies its marker audio output to the audio integrating system.

- A **400 Hz** tone for the outer Marker,
- a **1300 Hz** tone for the middle Marker,
- and a **3000 Hz** tone for the inner Marker.

This system controls and directs the output to the headsets and/or the loudspeakers. The AMU controls the audio level through the ACP.

On the ACP, the pilot must push the MKR pushbutton switch and adjust the related potentiometer to the correct audio level.



OVERFLY MARKER INDICATIONS WITH CORRESPONDING COLORS

Figure 17 Marker Indications

VOR/MARKER DESCRIPTION

General

The VOR/MARKER comprises two independent systems in a same receiver:

- a VOR system for the radio navigation phase,
- a MARKER (MKR) system for the landing approach phase.

The two VOR/MKR receivers are interchangeable but only one marker system is installed on the aircraft.

VOR System

The principle of the VOR navigation is a comparison between a reference phase signal and a variable phase signal. The ground station generates these two signals. The phase difference between the reference and the variable phase is a function of the position of the aircraft with respect to the ground station.

Furthermore, the ground station provides a Morse identification.

The VOR system is a radio aid to medium–range navigation.

The aircraft is equipped with two VOR systems which can accept ground station signals in the frequency range of 108 MHz to 117.95 MHz.

These signals are processed and conditioned to provide the crew with:

- identification of a selected ground station,
- indication of the aircraft position with respect to the station (bearing information),
- indication of the aircraft angular deviation from a selected course.

MARKER System

The marker system is a radio navigation aid. It is normally used together with the Instrument Landing System (ILS) portion of the Multi–Mode Receiver (MMR) during an ILS approach. The system determines the distance between the aircraft and the runway threshold. The marker system also marks particular airway and holding points. There are three marker transmitters positioned on the ground at known distances from the runway threshold:

- the outer marker at approx. 4 N miles,
- the middle marker at 0.6 N miles,
- the inner marker at the runway threshold.

The markers transmit a modulated 75 MHz signal to provide a marker position.

When the aircraft passes through the beam of a marker, the modulating frequency is detected. Then, the system provides aural and visual indications to the flight crew.

System Architecture

The VOR system comprises two independent systems.

Each system consists of:

- one VOR/MKR receiver 1(2),
- one VOR 1/2 antenna,
- one VOR/DME Radio Magnetic Indicator (VOR/DME RMI).

NOTE: The VOR antenna is common for both receivers (dual antenna).

The components given after control the VOR system:

- the CAPT (F/O) Audio Control Panel (ACP) and the Audio Management Unit (AMU) for audio control,
- the Multipurpose Control and Display Unit 1(2) (MCDU), the Radio Management Panel 1(2) (RMP) and the Flight Management and Guidance Computer 1(2) (FMGC) for frequency/course selection,
- the MCDU 1(2) and the Centralized Fault–Display Interface–Unit (CFDIU) for test purposes.

The Marker system consists of one system only. The receiver is part of the VOR/MKR receiver 1.

The system comprises:

- one VOR/MKR receiver 1,
- one marker antenna.

Indication

VOR 1 data are sent to the Capt and F/O ND and the RMI.

VOR 2 data are sent to the F/O and Capt ND and the RMI.

MKR (1) data are sent to Capt and F/O PFD.

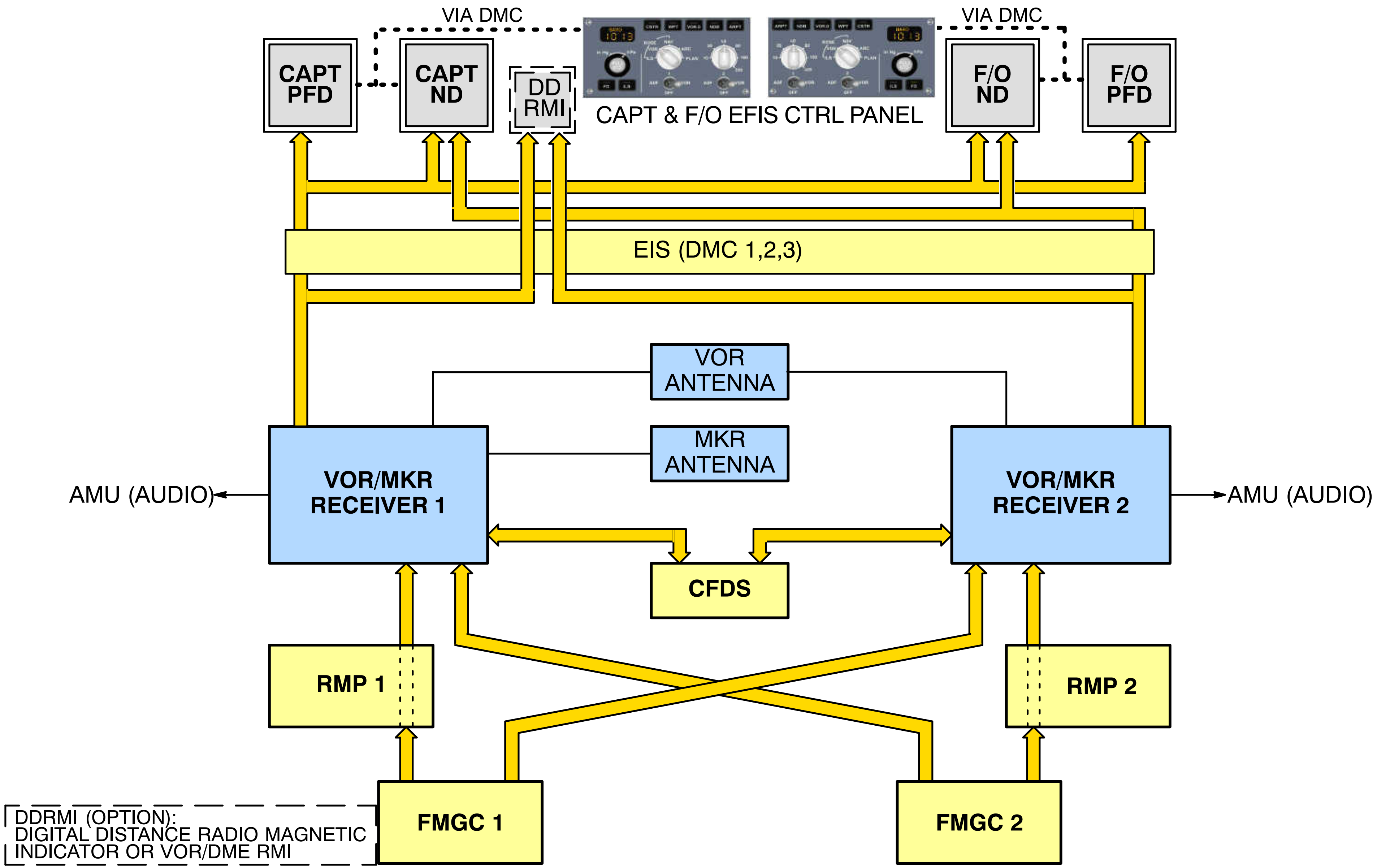


Figure 18 VOR/MKR - Schematic

VOR/MKR OPERATION

Tuning

- **Auto Tuning**

  In normal operation the VOR receiver 1 (2) is automatically tuned by the onside FMGC 1 (2) through the associated RMP 1 (2). In this case, the RMP is only used to transmit the frequency and course information from the FMGCs to the frequency input port A of the receiver.

- **Manual Tuning**

  Frequency and course data can by manually entered on the RAD/NAV page of the MCDUs. The FMGCs sent this information to the receivers in the same way like in the auto−tuning mode.

- **FM Switching**

  If a FMGC fails, a discrete is sent to the receiver (via the RMP) to activate the frequency input port B. This port receives information direct from the opposite FMGC. In this case, one FMGC tunes both VOR receivers.

- **NAV Back Up Tuning**

  If both FMGC fail, each VOR receiver must be tuned directly from the onside RMP. To do so, press the NAV and the VOR pushbutton on both RMPs. The RMP now uses manually entered data and not the data coming from the FMGC. A discrete reselects the frequency input port A, which is directly supplied from the associated RMP. A second discrete inhibits the data display on the RAD/NAV page of the MCDUs to indicate that no FMGC tuning is possible.

Antenna

The VOR antenna is common to both receivers. The antenna has two independent connectors, used to feed the two VOR receivers.

VOR1 receiver is connected to the Marker antenna.

Inputs

Each LGCIU sends discrete signals to the VOR receiver for internal BITE purposes.

Indication

All DMCs receive VOR data from both receivers such as VOR bearing, frequency, VOR course, VOR deviation and VOR identifier. Data of both systems are shown on Capts and F/Os ND.

Only in ROSE VOR mode, the specific VOR 1 data (characteristics, course, deviation) is shown on Capts ND and specific VOR 2 data on F/Os ND.

All DMCs receive Marker data (OM, MM, AM) from VOR1 receiver to display it on both PFDs.

The DDRMI receive VOR bearing from both VOR receivers to show the VOR bearing.

Warnings and Flags

A faulty VOR system results in the following cockpit effects:

- Flags on PFD and ND
- Flags on DDRMI

Audio control

- **VOR system:**

  The VOR/MKR receivers apply their VOR audio output to the audio integrating system. This system controls and directs the output to the headsets and/or the loudspeakers. The AMU controls the audio level through the ACP. On the ACP, the pilot must push the VOR 1 (2) pushbutton switch and adjust the related potentiometer to the correct audio level.

  In case of ATIS message transmission by the VOR station it is necessary to push the ON VOICE pushbutton switch on one ACP in order to hear clearly this information without Morse signal.

- **Marker system:**

  The VOR/MKR receiver 1 applies its marker audio output to the audio integrating system. This system controls and directs the output to the headsets and/or the loudspeakers. The AMU controls the audio level through the ACP. On the ACP, the pilot must push the MKR pushbutton switch and adjust the related potentiometer to the correct audio level.

Users

The FMGCs receives the VOR Data for navigation purpose during various flight phases.

The CFDIU is used to communicate with the internal BITE functions of the VOR receivers (tests only available on ground).

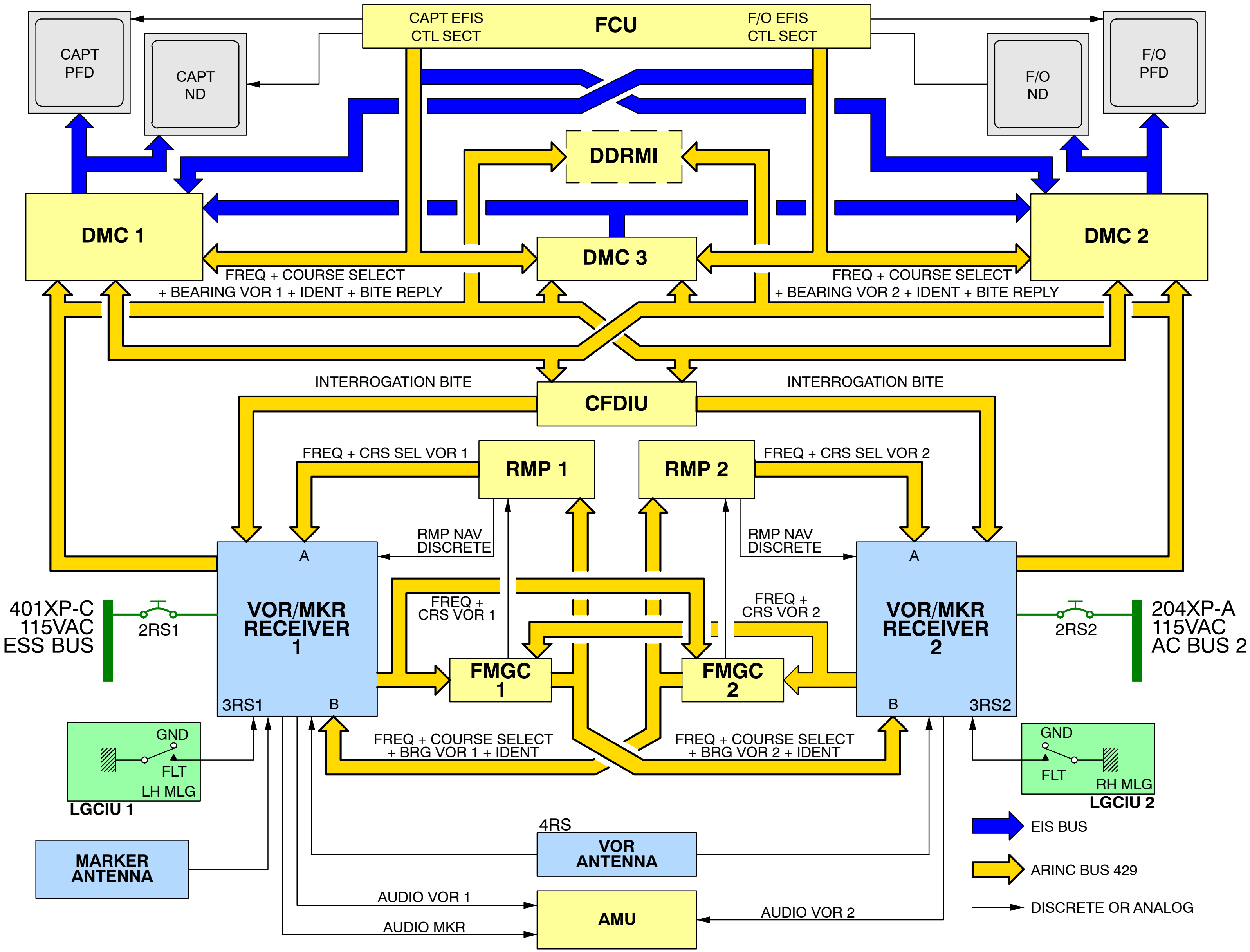


Figure 19 VOR/MKR Interface Diagram

VOR/MKR COMPONENT DESCRIPTION

VOR/MARKER Receiver (Bendix)

The front panel test can be activated in ground condition only by pushing the TEST pushbutton switch on the face of the receiver.

- During the first 3 seconds, all LEDs on the face of the receiver are on.
- During the next 3 seconds, all LEDs go off.
- During the last 3 seconds (or until the TEST pushbutton switch is released) the green VOR LED is on (except if a fault has been detected during the test).

The name, color and function of the three LEDs are as follows:

- VOR (red) indicates that an internal fault is detected of the VOR Receiver
- VOR (green) indicates that no internal fault is detected of the VOR Receiver
- MKR (red) indicates that a internal fault is detected of the MKR receiver
- DATA IN (red) indicates that no control input is available (frequency).

VOR/MARKER Receiver (Collins)

The face of the receiver is fitted with a handle, two lugs, a TEST pushbutton switch and test LEDs.

The name, color and function of the LEDs are as follows:

- CONTROL FAIL (red) indicates that the control input data are faulty,
- LRU STATUS (green) indicates that no faults are detected during the self-test sequence,
- LRU STATUS (red) indicates that a fault is detected during the self-test sequence.

The back of the VOR /MKR receiver contains an ARINC 600, shell size connector to provide electrical connections to the aircraft wiring via mount.

ANTENNAS

MARKER antenna:

- A low-drag, lightweight antenna, located in the longitudinal axis of the aircraft below the fuselage, is provided for the reception of the 75 MHz marker signals. The dielectric, foam-filled, white polyester fiberglass housing, fitted with a metal leading edge, protects against moisture and erosion. The antenna is horizontally polarized, has an impedance of 50 ohms.

VOR antenna:

- The VOR antenna is an airborne antenna sunk into the fin and used to receive VOR signals in the 108-118 MHz range. It is a small-sized half-wave folded dipole type.
- The antenna has two independent RF connectors used to feed two items of equipment. The antenna is horizontally polarized, has an impedance of 50 ohms.

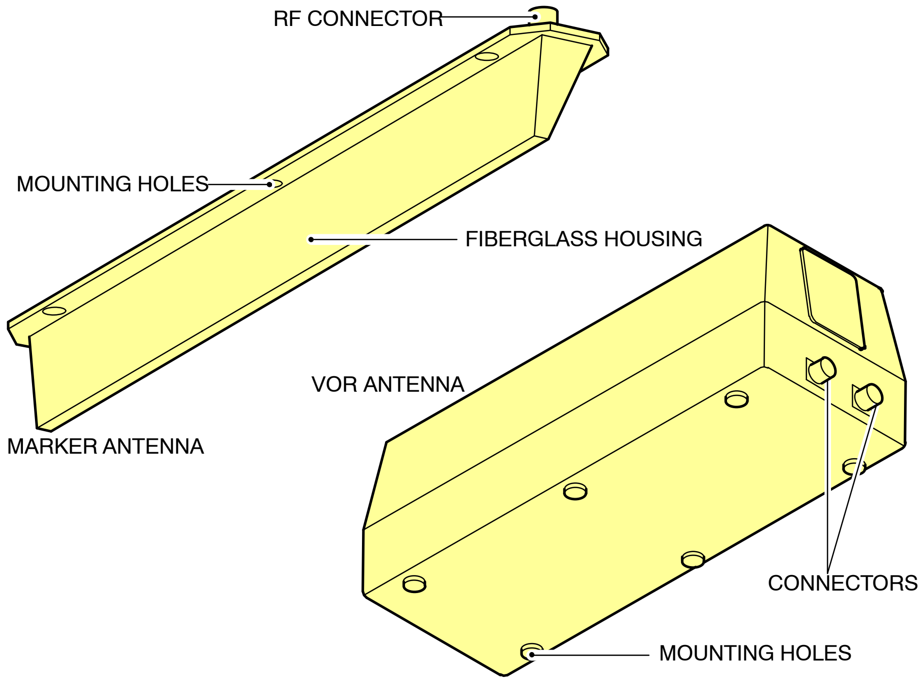


Figure 20 MKR & VOR Antenna

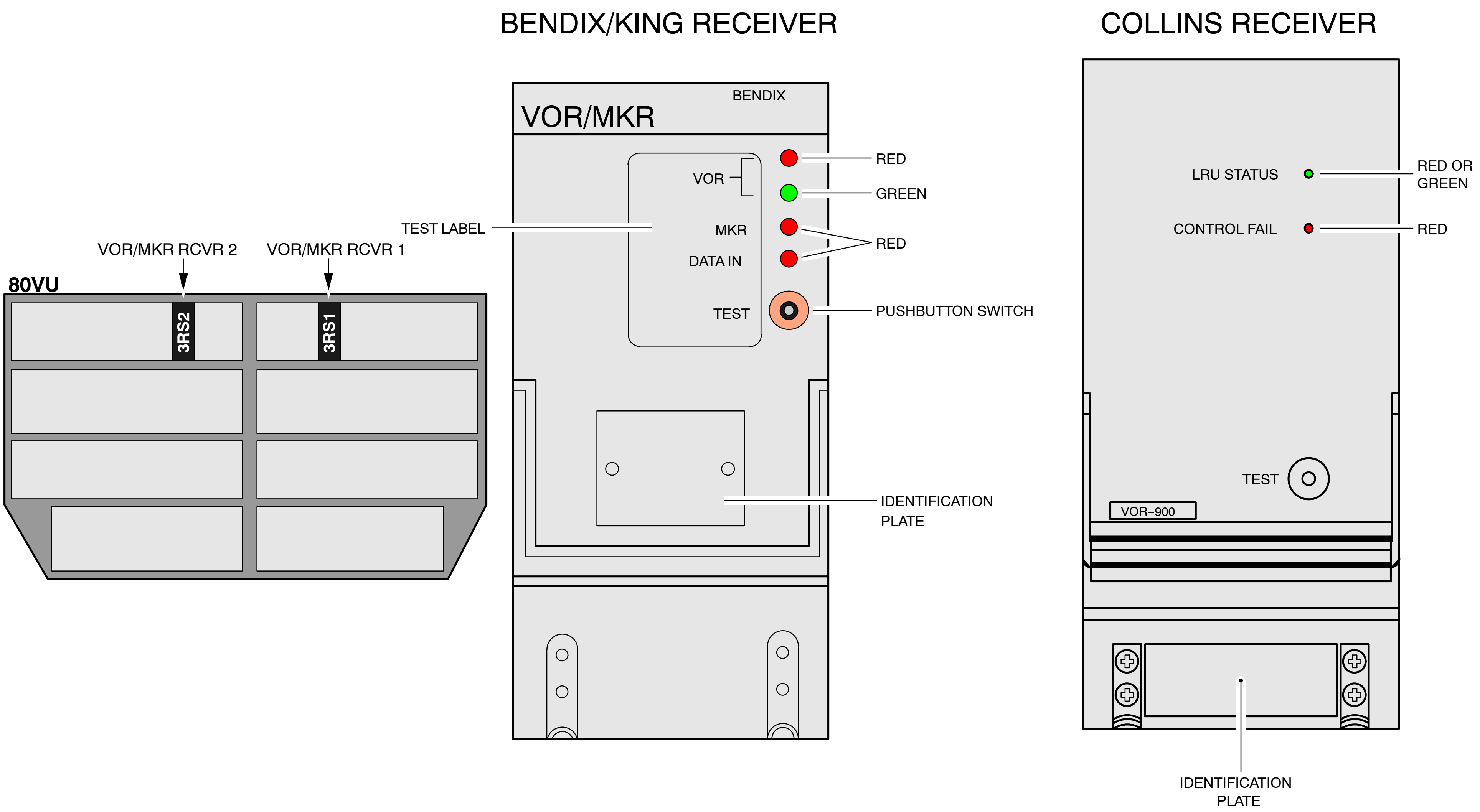


Figure 21 VOR/MKR - Receiver

VOR/MKR FLAGS DESCRIPTION

VOR FLAGS

NOTE: In case of a Marker system fault there is no Marker Flag on the Primary Flight Display Unit.

NOTE: In case of a VOR/MKR system fault there is no ECAM message.

Flags on ND

In case of VOR system fault, all the corresponding data go out of view and the VOR indication turns to red.

ND in ROSE VOR Mode and VOR/ADF Selector in position VOR:

1. If the VOR course fails, a red CRSXXX flag appears. If there is non-computed data (NCD), a blue CRS – – – indication appears.
2. In ROSE VOR mode, when the VOR bearing is not valid, this flag flashes for 9 seconds, then remains steady.
3. If a VOR/MKR receiver fails, the VOR Ident flag flashes for 9 seconds, then remains steady.

ND in ROSE VOR, ROSE ILS, ROSE NAV or ARC Mode and VOR/ADF Selector in position VOR:

- If the VOR receiver fails, a red VOR1 (2) flag (flashing 9s, then steady) comes into view instead of VOR characteristics and the VOR bearing pointer goes out of view.
- In case of NCD, the VOR bearing pointer goes out of view and on VOR characteristics, the VOR identifier is replaced by the frequency.
- If the frequency information is fail or NCD, the VOR bearing pointer goes out of view. Identifier and frequency data are sent by the DME interrogator.

Flags on DDRMI

The indicators display these flags if:

the VOR or ADF receiver fails (VOR/ADF selector position indicates the failed receiver),

the DDRMI has an internal failure,

the heading signal from ADIRS is not valid,

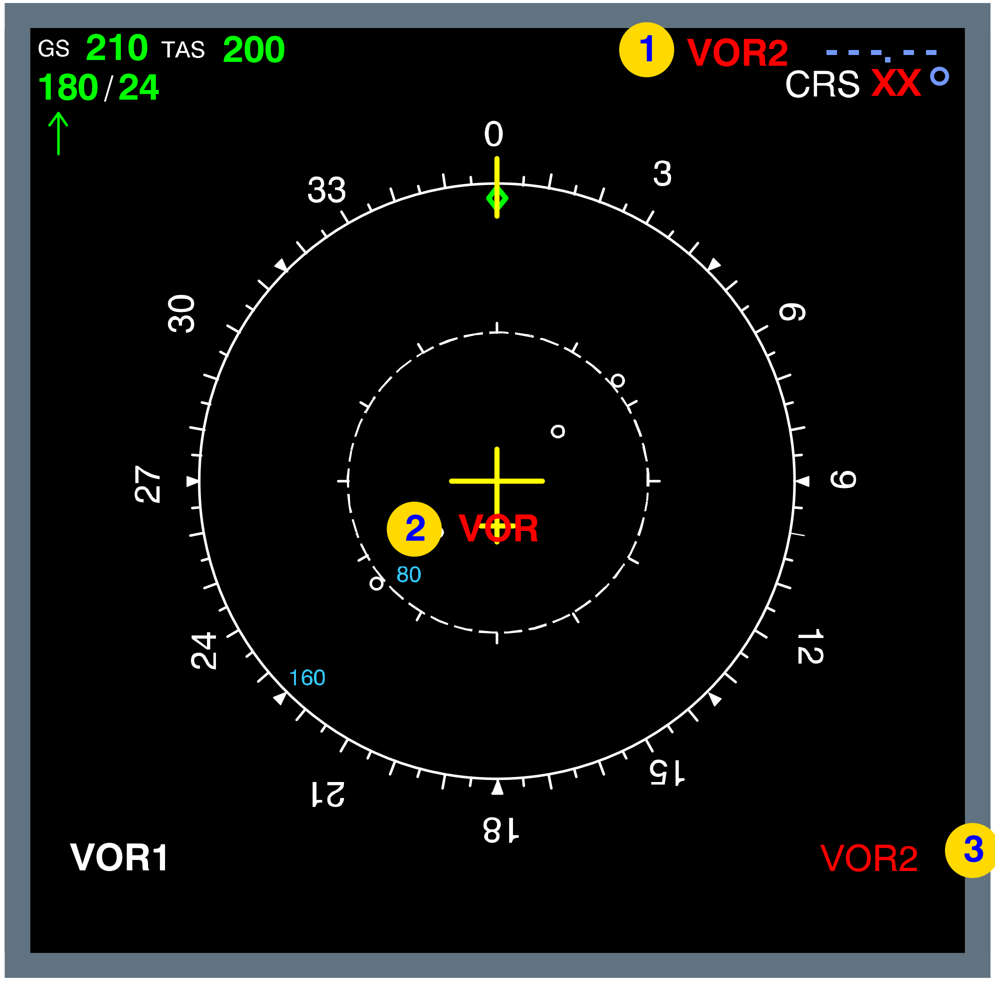
the power supply fails.

As long as the flag shows, the relevant pointer moves into horizontal 3 o'clock position.

If DME is is still valid the distance to the station is still shown.

NOTE: There is no ECAM message in case of a VOR System Fault.

VOR FLAGS ON ND



VOR FLAGS ON DDRMI

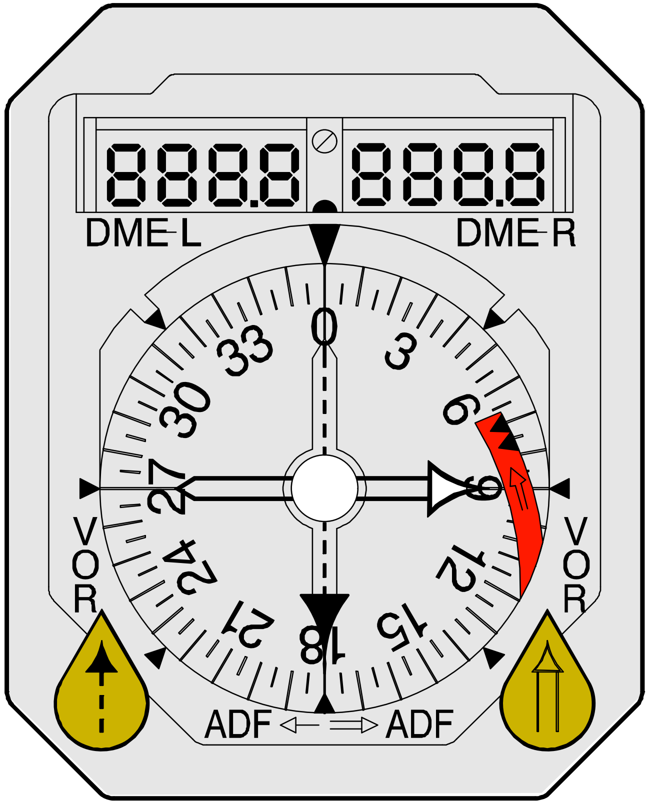


Figure 22 VOR Flags on ND and DDRMI

34–51 DISTANCE MEASURING EQUIPMENT

DME INTRODUCTION

DME PRINCIPLE

The Distance Measuring Equipment (DME) provides digital readout of the aircraft slant range distance from a selected ground station. The system generates interrogation pulses from an onboard interrogator and sends them to a selected ground station.

After a 50 microseconds delay, the ground station replies. The interrogator determines the distance in nautical miles between the station and the aircraft. The interrogator detects the Morse audio signal, which identifies the ground station.

The Distance Measuring Equipment (DME) is a radio aid to medium range navigation which provides the crew with:

- a digital readout of the slant range distance of the aircraft from a selected ground station,
- audio signals which identify the selected ground station.

The DME uses the frequency band from 962 MHz to 1213 MHz for reception and transmission.

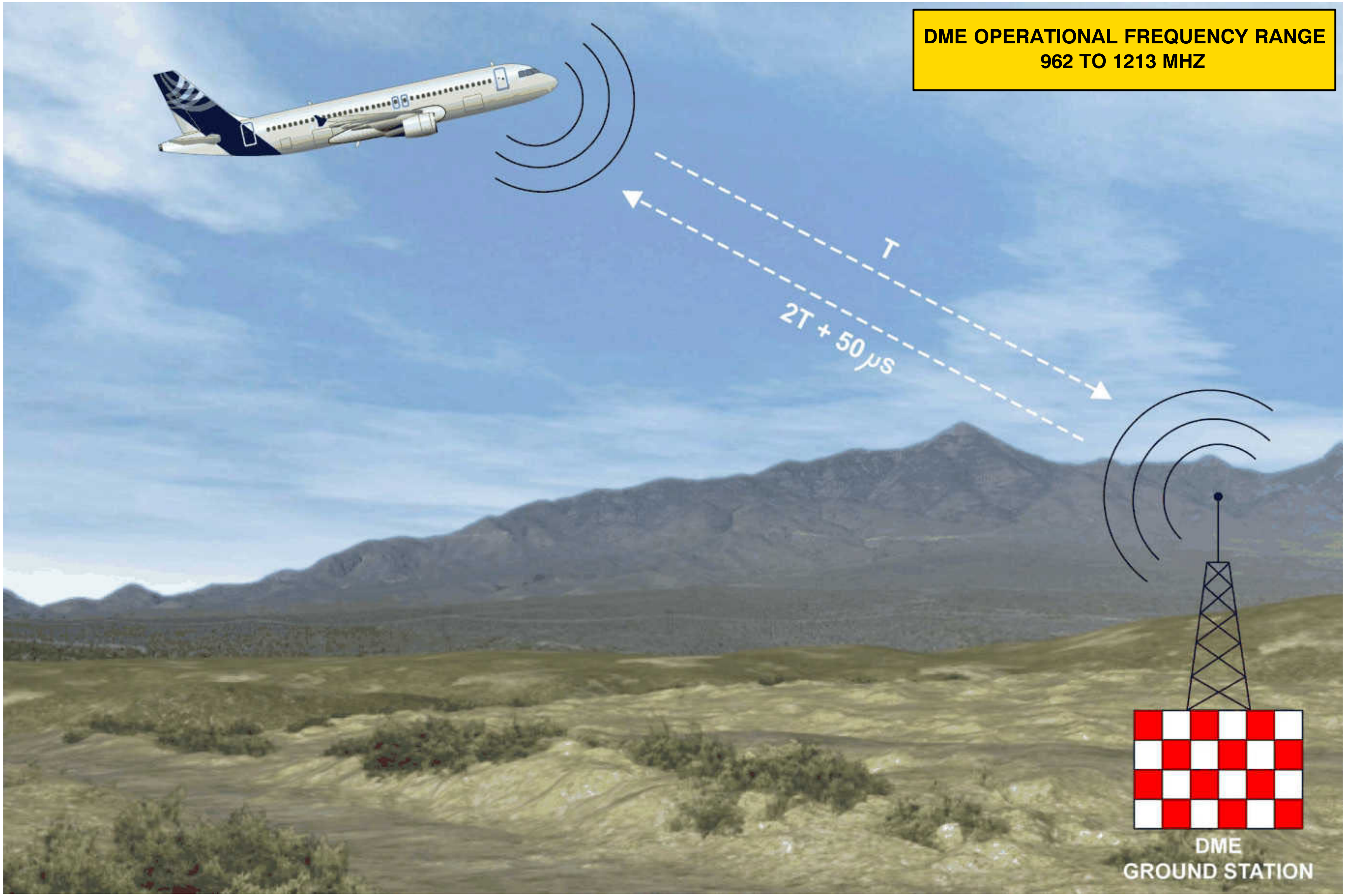
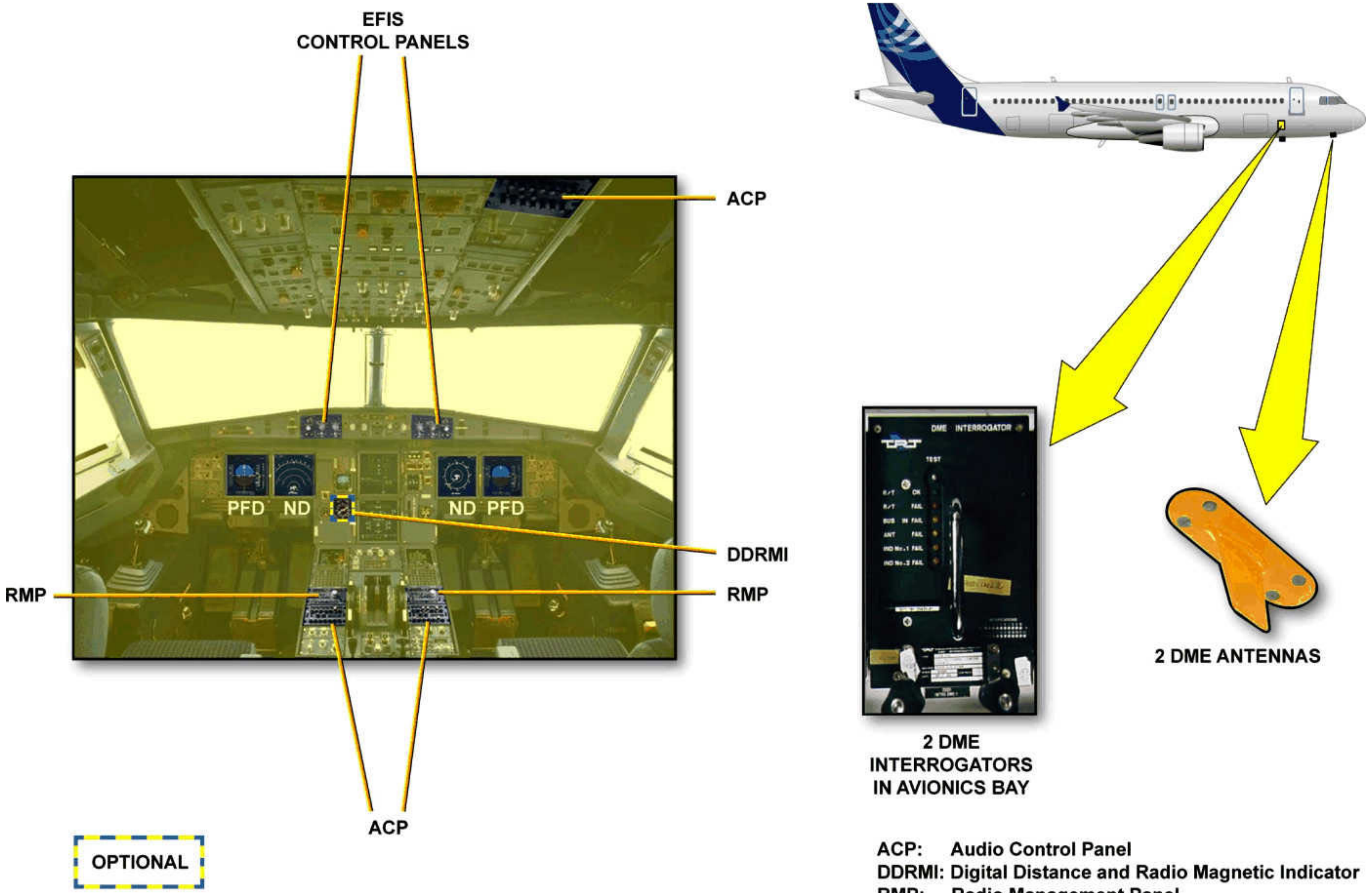


Figure 23 DME Principle

DME COMPONENTS

The components are two antennas and two interrogators. The DME system is also connected to:

- PFDs, NDs and optional Digital Distance and Radio Magnetic Indicator (DDRMI) for display,
- EFIS control panels for display control,
- Flight Management and Guidance Computers (FMGCs) for automatic and manual tuning,
- CAPT and F/O Radio Management Panels (RMPs) for back–up tuning and,
- Audio Control Panels (ACPs) for DME audio signal.



ACP: Audio Control Panel
DDRMI: Digital Distance and Radio Magnetic Indicator
RMP: Radio Management Panel

Figure 24 DME System Components

DME INDICATION

Normal Indication on PFD

If the ILS pushbutton on the EFIS control panel is pressed, on the lower left corner of the PFD the ILS DME distance is shown (if a ILS/DME station is available). On Capts PFD ILS/DME1 distance is displayed, on F/Os PFD, ILS/DME 2 is displayed.

If no ILS/DME station is available, the display is blank.

Normal Indication on ND

- ND in ROSE ILS, ROSE VOR, ROSE NAV or ARC Mode

  When the VOR/ADF selector is switched to VOR, the DME distance is displayed in green under the associated VOR characteristics in the lower left or right corner.
- ND in ROSE NAV or ARC Mode

  When the VOR.D pushbutton on the EFIS control panel is pressed, all VOR/DME stations around the aircraft and contained in the FMGCs NAV DATA BASE are displayed on the ND, depending on the selected range.

  No Ground Station Signal

  When the VOR ground station is not equipped with a DME the indication on the ND is “- - -“.

Normal Indication on DDRMI

The Digital Distance Radio Magnetic Indicator shows DME1 and DME2 distance in the upper left and right corner.

When the VOR ground station is not equipped with a DME the indication on the DDRMI is “- - -“.

NOTE: The DDRMI is also named VOR/DME RMI or VOR/ADF/DME RMI in the AMM, depending if ADF indication is available or not.

Figure 25 DME Indication on DDRMI

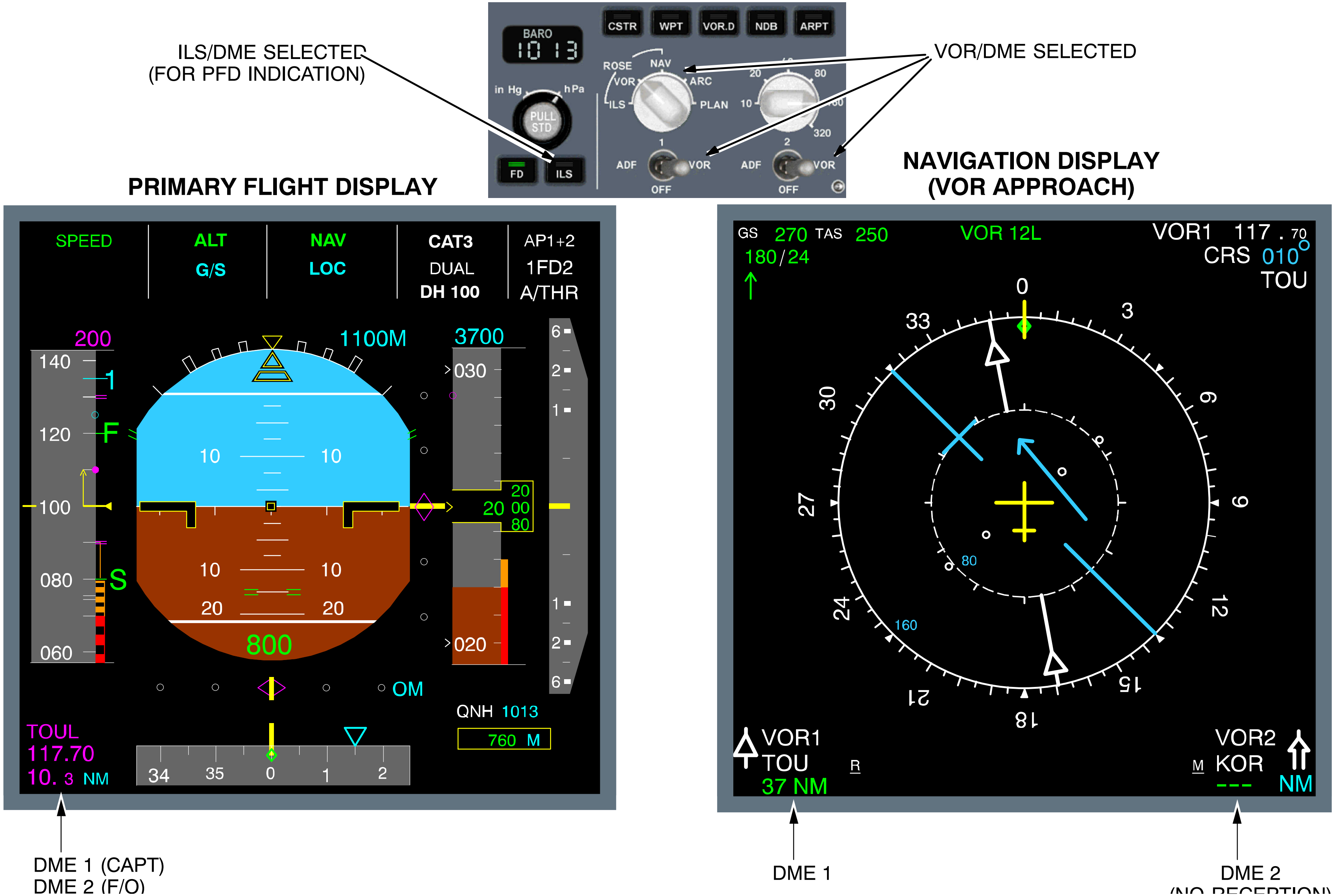


Figure 26 DME Indication on EFIS Screens

DME DESCRIPTION

General

The Distance Measuring Equipment (DME) is a radio aid to medium range navigation which provides the crew with:

- a digital readout of the slant range distance of the aircraft from a selected ground station
- audio signals which identify the selected ground station.

The DME uses the frequency band from 962 MHz to 1213 MHz for reception and transmission.

Principle

The principle of the DME navigation is based on the measurement of the transmission time. Paired interrogation pulses go from an onboard interrogator to a selected ground station. After 50 microseconds, the station transmits the reply pulses to the aircraft. The measurement of time between transmitting the interrogation pulses and receiving the reply pulses is a function of the slant range distance of the aircraft to the ground station.The measurement value is converted into nautical miles and shown to the crew.

The interrogation frequencies vary from 1041 to 1150 MHz. The reply frequencies vary from 962 to 1213 MHz.

Furthermore, the ground station provides a Morse identification.

System Architecture

The DME comprises two independent systems. Each system consists of:

- one DME interrogator
- one DME antenna
- one dual VOR/DME Radio Magnetic Indicator (VOR/DME RMI).

The components given after can control the DME system:

- the CAPT (F/O) ACP and the AMU for audio controls
- the MCDU 1(2), the RMP 1(2), and the FMGC 1(2) for frequency/course selection
- The MCDU and the CFDIU for test causes.

The DME data are shown on:

- the CAPT and F/O Primary Flight Displays (PFD)
- the CAPT and F/O Navigation Displays (ND)
- the VOR/DME RMI
- the MCDU(s) (maintenance data).

UTILIZATION TECHNICAL DATA

Data display on the PFDs:

With ILS/DME collocated stations, the ILS/DME distance is shown in magenta in the L lower corner of the PFD. These data come into view when you push the ILS pushbutton switch located on the EFIS control section of the Flight Control Unit (FCU).

Data display on the NDs:

The VOR/DME distance is shown in green in the L lower corner of the ND for DME system 1, and in the R lower corner of the ND for DME system 2 when:

- you set the mode selector switch on the EFIS control section of the FCU to ROSE (ILS, VOR, NAV) or ARC
- you set the ADF/VOR/OFF switch to VOR.

In addition, when you push the VOR−D pushbutton switch on the EFIS control section of the FCU, this causes:
Display of the VOR/DME and DME ground stations which are not already included in the flight plan, with the mode selector switch in ROSE NAV and ARC positions:

- a circle for the DME station
- circle plus cross symbol for the VOR/DME station.

Indication on the VOR/DME RMI:

Two windows are available for indication of both distances from the DME 1 and DME 2 when the VOR/DME stations are collocated.

Audio control:

The DME interrogator applies its audio output to the audio integrating system. The pilot can control the DME audio signals by pressing the VOR pushbutton switch on the ACP and adjusting the related potentiometer to the correct audio level. In case of collocated ILS/DME ground stations and when the ILS pushbutton switch is pressed on the EFIS control section of the FCU, the pilot can control the DME audio signal through the ILS pushbutton switch on the ACP.

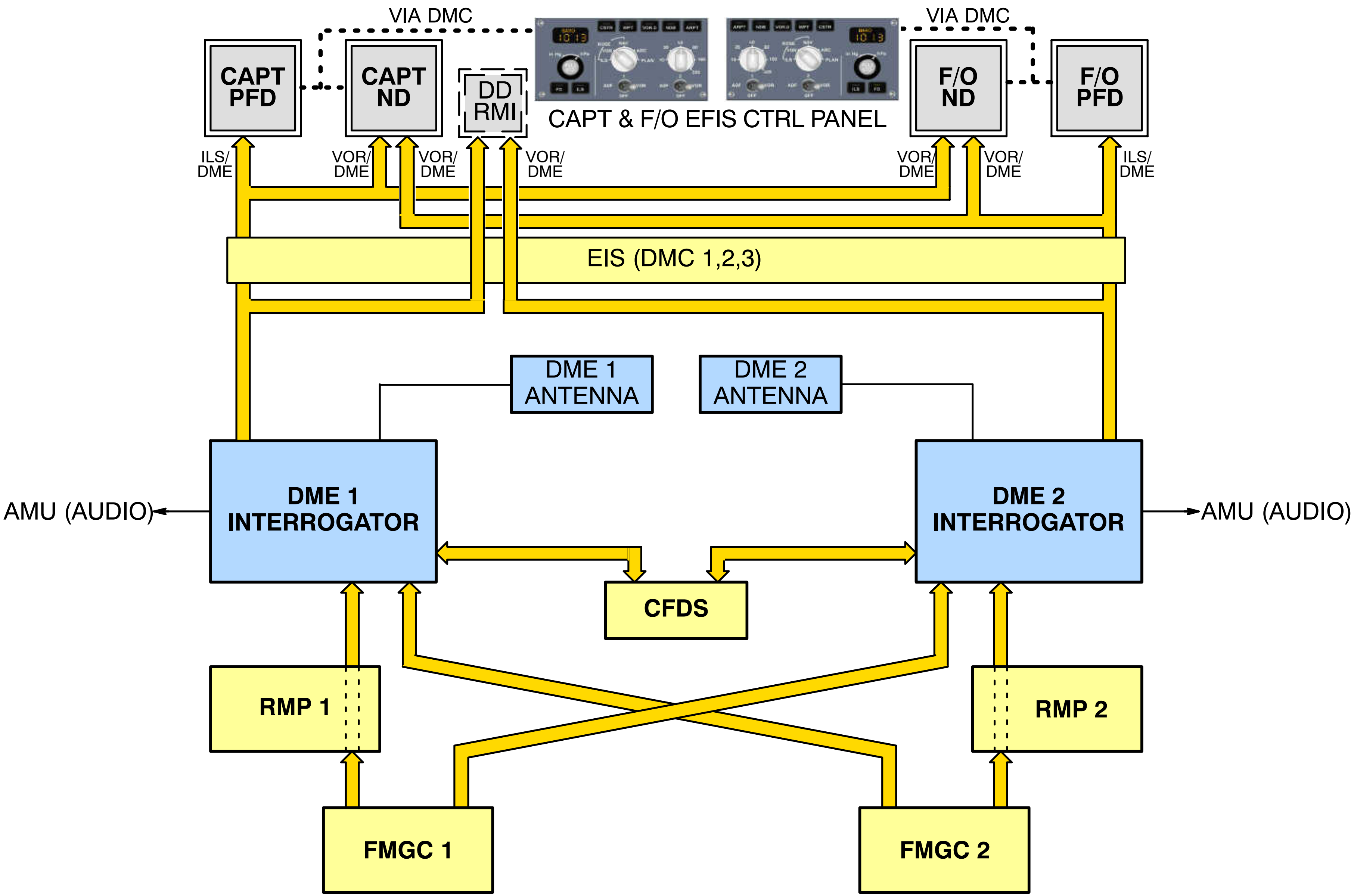


Figure 27 DME - Schematic

DME OPERATION

Control

- **Auto Tuning**

  In normal operation the DME interrogator 1 (2) is automatically tuned by the onside FMGC 1 (2) through the associated RMP 1 (2). In this case, the RMP is only used to transmit the frequency and course information from the FMGCs to the frequency input port A of the receiver. VOR/DME and ILS/DME distance can be calculated and displayed simultaneously.
- **Manual Tuning**

  Frequency and course data can by manually entered on the RAD/NAV page of the MCDUs. The FMGCs sent this information to the receivers in the same way like in the auto−tuning mode.
- **FM Switching**

  If a FMGC fails, a discrete is sent to the interrogator (via the RMP) to activate the frequency input port B. This port receives information direct from the opposite FMGC. In this case, one FMGC tunes both DME interrogators.
- **NAV Back Up Tuning**

  If both FMGC fail, each DME Interrogator must be tuned directly from the onside RMP. To do so, press the NAV and the VOR pushbutton on both RMPs. The RMP now uses manually entered data and not the data coming from the FMGC. A discrete reselects the frequency input port A, which is directly supplied from the associated RMP. A second discrete inhibits the data display on the RAD/NAV page of the MCDUs to indicate that no FMGC tuning is possible. No ILS/DME indication is possible.

Antenna

Each DME interrogator uses its own DME antenna for radio transmission and reception. A suppression signal is transmitted by the DME interrogator each time when in transmission mode to inhibit other systems working in same frequency range (ATC, TCAS) and to prevent simultaneous transmission.

Inputs

Each LGCIU sends discrete signals to the DME interrogator for internal BITE purposes.

Indication

All DMCs receive DME data from both interrogators such as DME distance, frequency and identifier. Data of both systems are shown on Capts and F/Os ND. ILS DME information is only shown on the associated PFD.

The DDRMI receive DME data from both DME interrogators to show the DME distance in the upper left and right corner.

Audio

The DME audio signal is processed by the Interrogator and sent to the AMU and can be heard by the crew on headphones or cockpit loudspeaker in parallel to the VOR audio signal.

Users

The FMGCs receive DME Data (5 stations max.) for navigation purpose during various flight phases.

The CFDIU is used to communicate with the internal BITE functions of the DME Interrogators (tests only available on ground).

Warnings and Flags

A faulty DME system results in the following cockpit effects:

- Flags on PFD and ND
- blank display in DDRMI

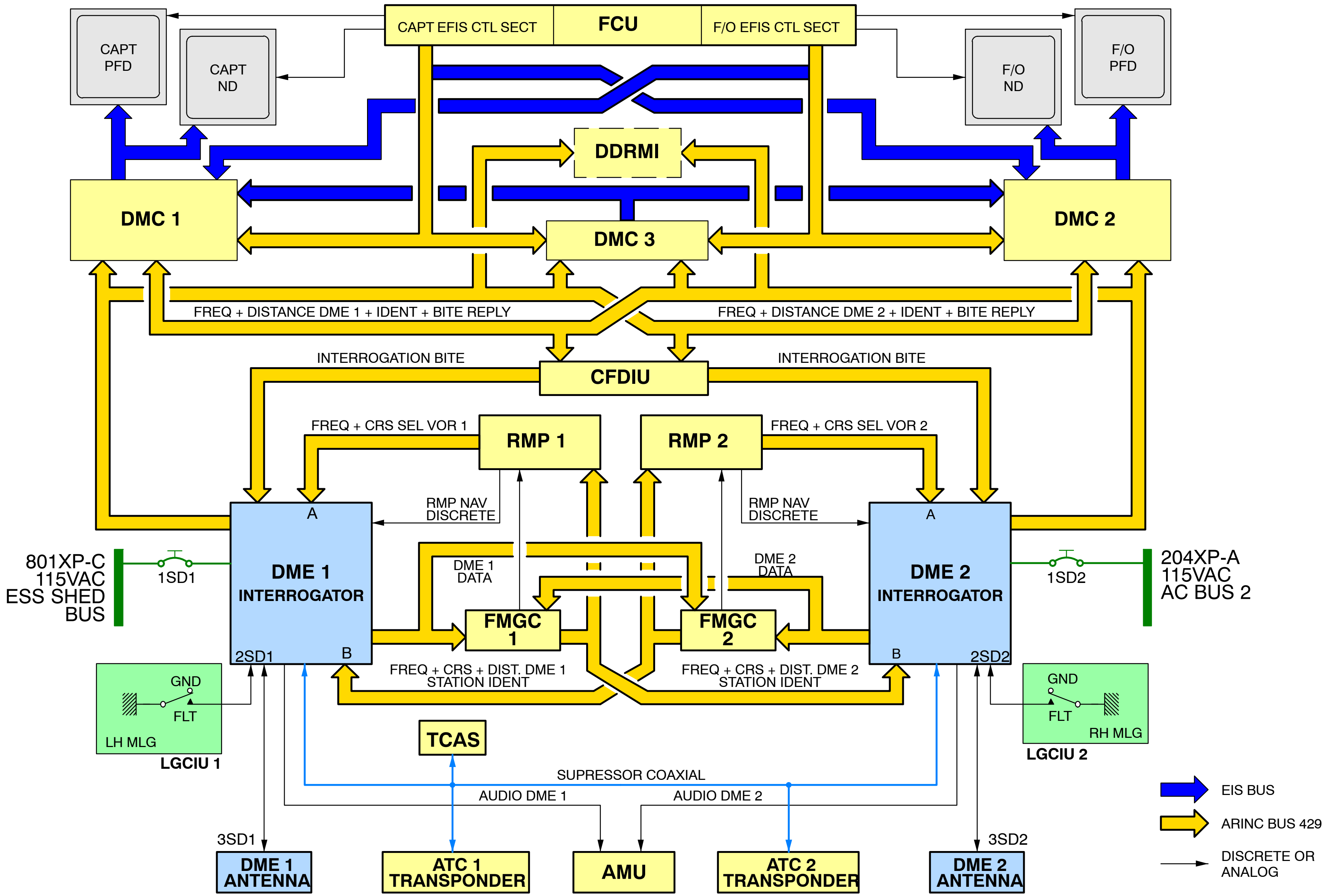


Figure 28 DME Interface Diagram

DME COMPONENT DESCRIPTION

1 DME Interrogator (Collins)

The face of the interrogator is fitted with a handle, two attaching parts, a TEST pushbutton switch and three LEDs.

The name, color and function of the three LEDs are as follows:

- CONTROL INPUT FAIL (red) indicates the status of the ARINC 429 input control word when the TEST pushbutton switch is pressed.
- LRU STATUS/PASS (green) indicates that no faults are detected during the self–test sequence.
- LRU STATUS/FAIL (red) indicates that a fault is detected during the self–test sequence.

The microprocessor based interrogator consists of various assemblies interconnected through a motherboard and housed in a case which conforms to the ARINC 600 form factor 4 MCU.

The assemblies include:

- a chassis on which the motherboard, the rear connector, the circulator and a low–pass filter are fitted. The circulator isolates the transmitter signals from the receiver signals. The low–pass filter reduces transmission harmonics.
- a power supply module which converts the aircraft 115VAC to +5, −12, +12, +15, −28, +36, +50 and +86 VDC for the various internal circuits.
- a synthesizer which contains a Voltage Controlled Oscillator (VCO) which generates the L–band frequency, and a Stabilized Master Oscillator (SMO) which produces the tuning voltage for the voltage controlled oscillator.
- a driver which contains a 3–stage amplifier and a modulator.
- a receiver which operates in the 962 to 1213 MHz frequency band.
- a video processor which determines the range measurement timing and produces the audio identification signal.
- a range processor which contains a CPU, memory units, a self–test generator and a range counter.
- The CPU controls the interrogator functions, signal processing, circuit monitoring and fault analysis.
- a monitor which detects faults within the interrogator

2 DME Interrogator (Collins New)

The face of the interrogator is fitted with a handle, two lugs, a TEST pushbutton switch and two LEDs.

The name, color and function of the two LEDs are as follows:

CONTROL FAIL (red) indicates invalid frequency input tuning words

LRU STATUS (green) indicates that no faults are detected during the test sequence

LRU STATUS (red) indicates that a fault is detected during the test sequence.

DME Antenna

The L–band antenna is an airborne antenna for the DME interrogator. It is a blade type with a radiating cavity driven by capacitive coupling.

This antenna is designed for installation on fast aircraft and operation within the L–band from 960 to 1250 MHz.

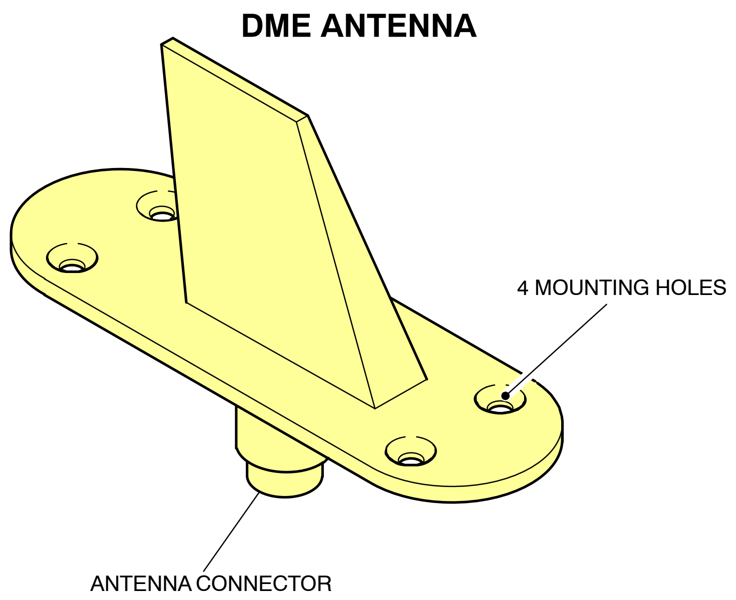


Figure 29 DME Antenna

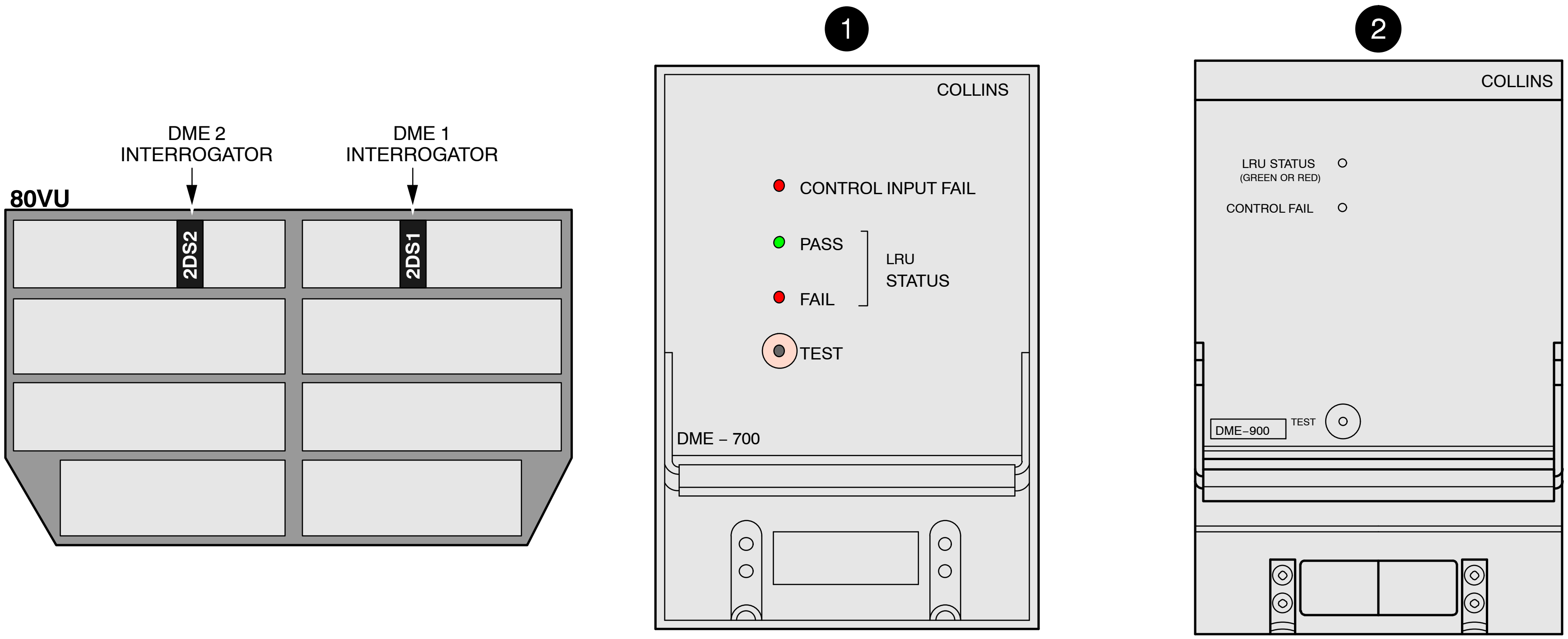


Figure 30 DME Interrogator

DME FLAGS DESCRIPTION

DME FLAGS

NOTE: In case of a DME 1 or 2 system fault there is no ECAM message.

Flags or NCD Indication on PFD

If the DME interrogator fails and the ILS pushbutton on the EFIS control panel is pressed, a red DME1 (2) flag (flashing 9s, then steady) comes into view instead of the DME distance.

With No Computed Data and ILS pushbutton pressed, dashes are displayed.

If the frequency information is fail or NCD, the DME indication is blank.

Flags or NCD Indication on ND

Flags or DME NCD indication are only displayed on ND, when in ROSE or ARC mode and the VOR/ADF selector is switched to VOR.

If the DME interrogator fails, a red DME1 (2) flag (flashing 9s, then steady) comes into view instead of DME distance.

In case of NCD, dashes are shown.

Flags or NCD Indication on DDRMI

If the DME interrogator fails, the DME1 (2) window is blanked. There is no DME flag.

In case of NCD, dashes are shown.

Figure 31 DME Fault and NCD Indication on DDRMI

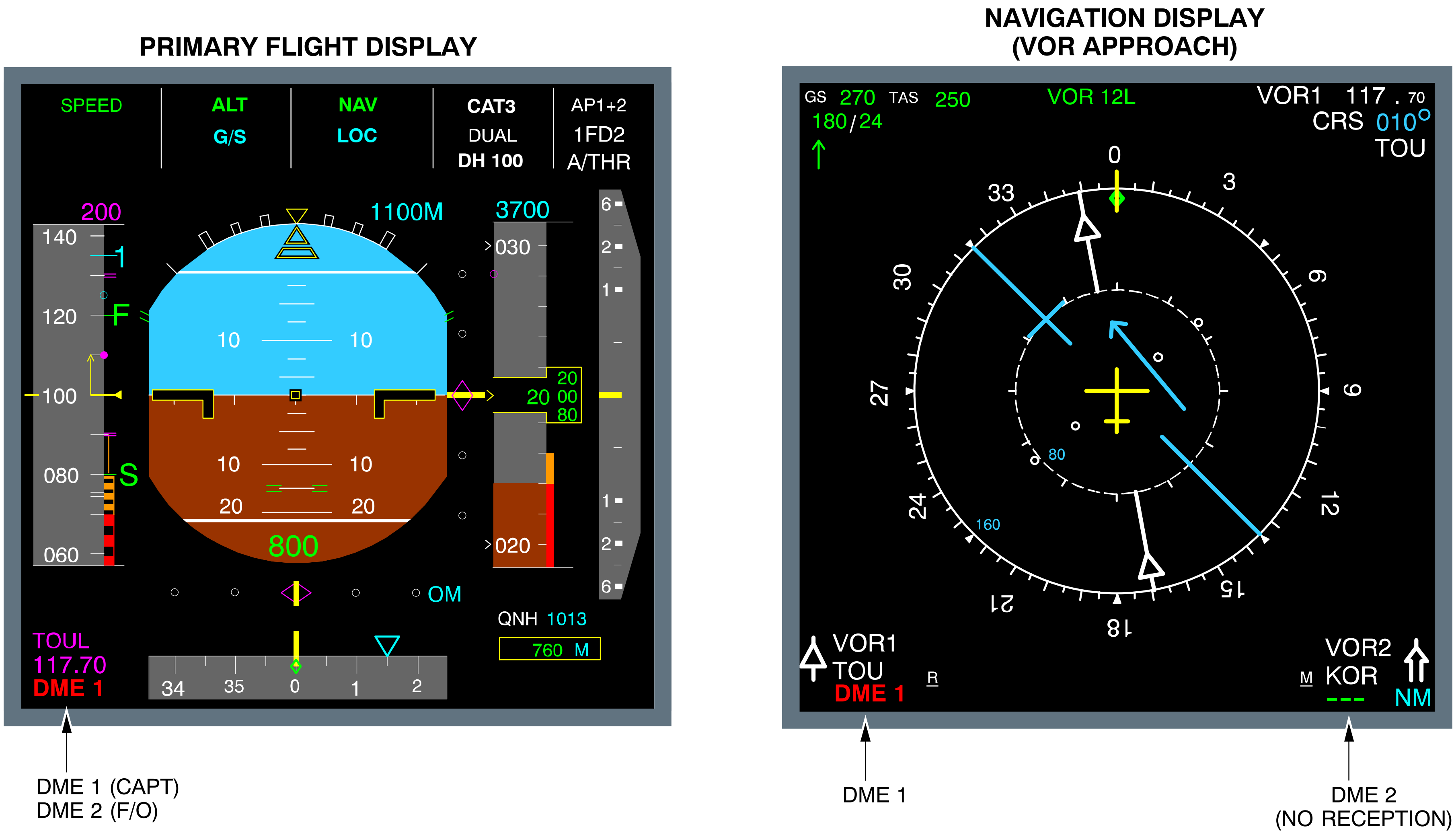


Figure 32 DME Flags on EFIS Displays

35–53 AUTOMATIC DIRECTION FINDER

ADF INTRODUCTION

ADF PRINCIPLE

The ADF is a radio navigation aid. It provides:

- the relative bearing of the aircraft to a selected ground station called Non−Directional Beacon (NDB),
- an aural identification of the ground station.

The relative bearing is the angle between the aircraft heading and the aircraft/ground station axis.

The combination of signals, received from two loop antennas and from one omni−directional sense antenna, provides bearing information.

The ground stations operate in a frequency range of 190 kHz to 1.750 kHz. An additional Morse signal is provided to identify the selected ground station.

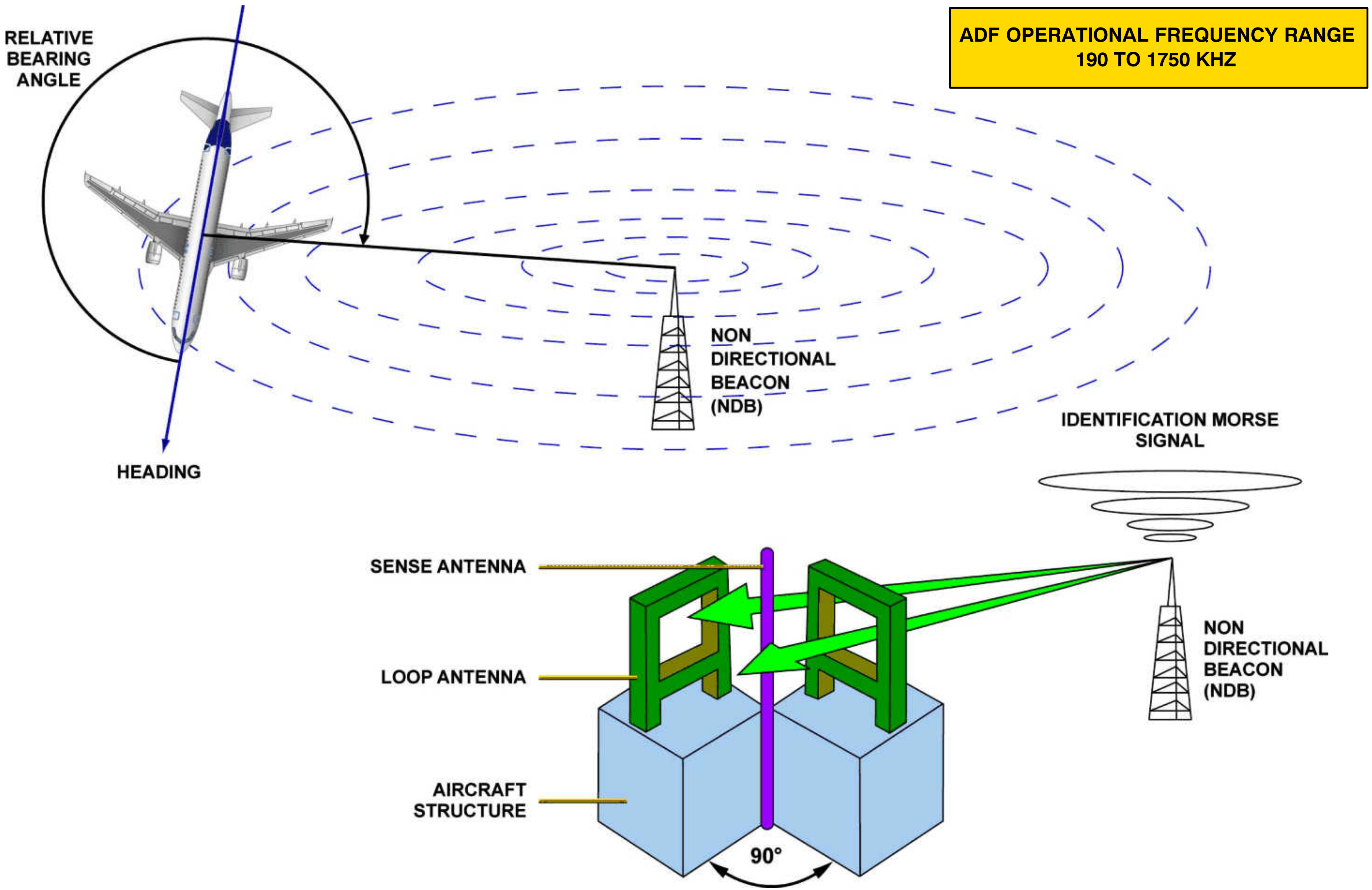


Figure 33 ADF Principle

ADF COMPONENTS

The ADF system is composed of two receivers and two antennas.

The ADF system is also connected to:

- NDs and optional Digital Distance and Radio Magnetic Indicator (DDRMI) for display,
- EFIS control panels for control display,
- Flight Management and Guidance Computers (FMGCs) for auto-tuning, - MCDUs for manual tuning,
- CAPT and F/O Radio Management Panels (RMPs) for back-up tuning and,
- Audio Management Unit (AMU) for listening to the ADF audio signal.

NOTE: ADF 2 system is optional.

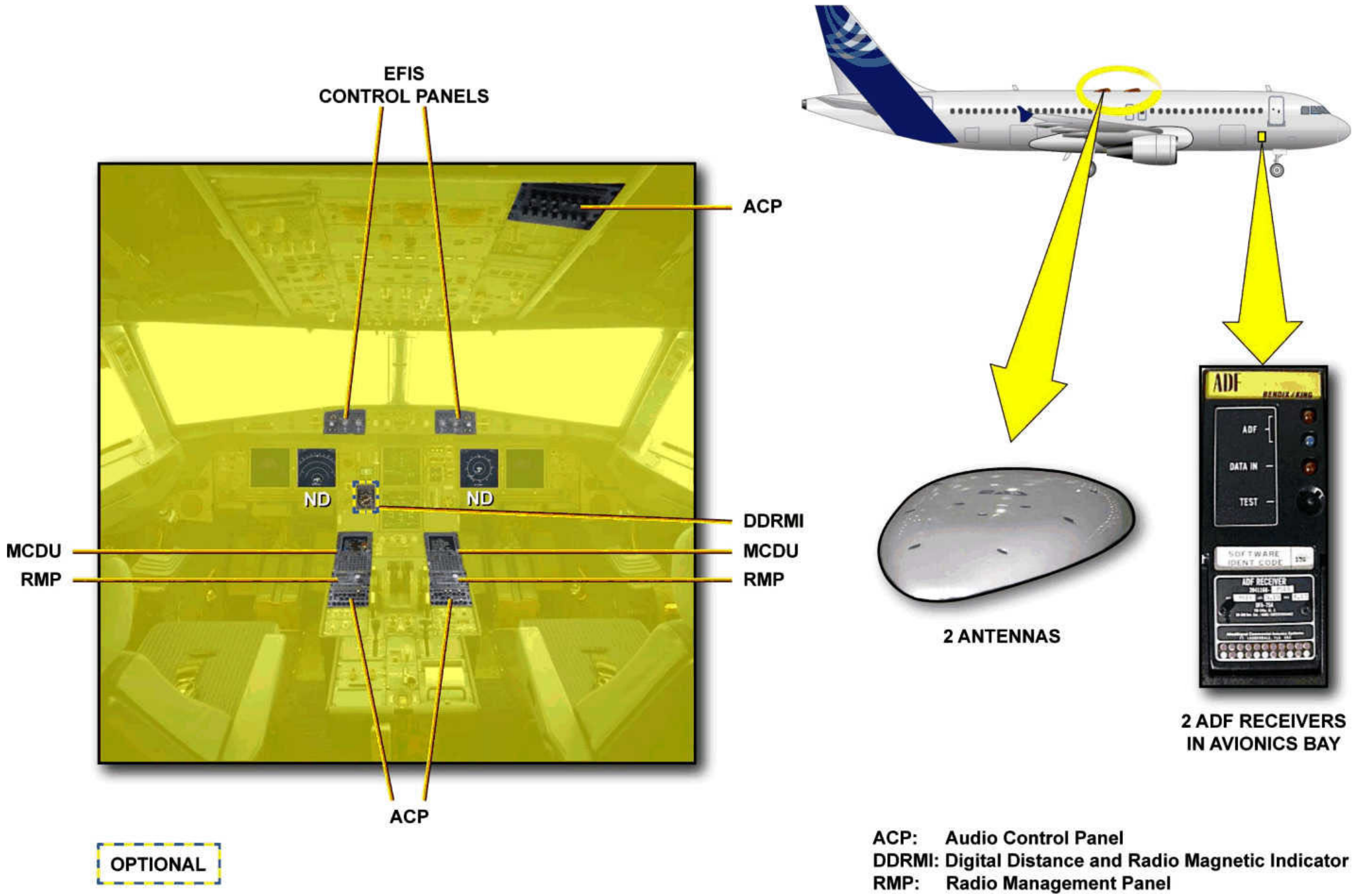


Figure 34 ADF System Components

ADF INDICATION

Normal Indication on ND

- ND in ROSE VOR,ROSE ILS, ROSE NAV or ARC Mode

  When the ADF/VOR selector is switched to ADF and the ADF signal is valid, the green ADF pointer appears and shows the bearing to the ADF station. The ADF station characteristics is displayed in the left or right lower corner of the ND and shows:

  - ADF system
  - Pointer symbol
  - ADF frequency or identifier, if decoded by the ADF receiver
  - Tuning mode
- ND in ROSE NAV or ARC Mode

  When the NDB pushbutton on the EFIS Control Panel is pressed, all ADF stations contained in the FMGC’s NAV DATA BASE are displayed on the ND, depending on the selected range.

NOTE: If only one ADF system is installed, the ADF 2 pointer will show to the station tuned with ADF 1.

Normal Indication on the DDRMI (Option)

If you set the VOR/ADF selector switches to ADF, the RMI indicates the ADF bearings:

- a single pointer indicates the ADF 1 bearing
- a double pointer indicates the ADF 2 bearing

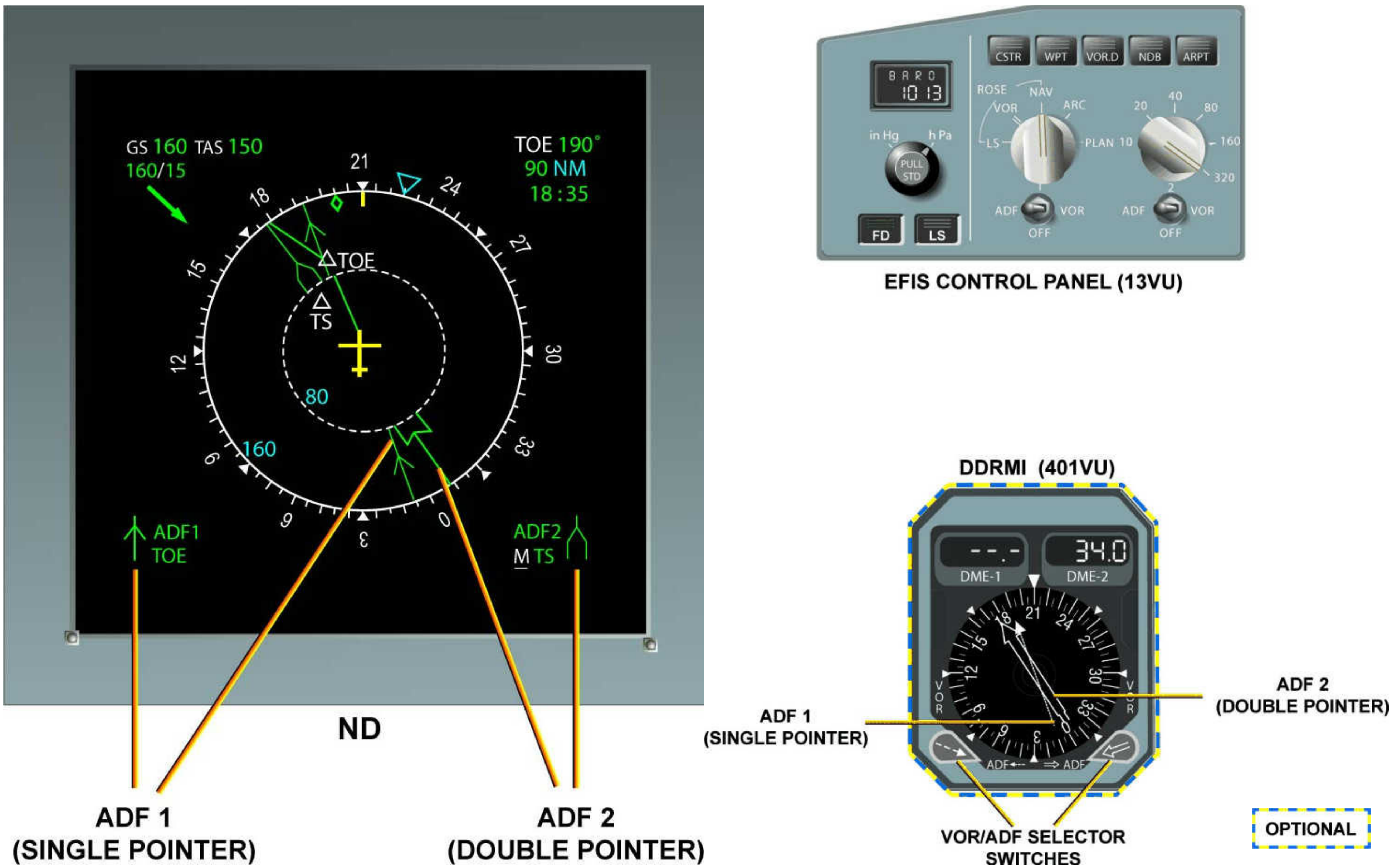


Figure 35 ADF Indication

ADF DESCRIPTION

General

The Automatic Direction Finder (ADF) is a radio navigation aid which provides:

- an indication of the relative bearing of the aircraft to a selected ground station (150 to 1799 KHz)
- aural identification of the ground station.

The frequency range includes:

- the standard commercial broadcast AM stations (550 to 1610 KHz) located at known co–ordinates around the world
- the Non–Directional Beacons (NDB) (190 to 550 KHz).

The principle of the ADF navigation is to determine the relative bearing of a selected ground station.

This is obtained by the combination of:

- the signals from two loop and sense antennas positioned 90 deg. apart with,
- the signal from an omni–directional sense antenna.

  This signal is not affected by the relative bearing.

An additional Morse signal is provided to identify the selected ground station.

System Architecture

The ADF comprises two independent systems. Each system consists of:

- one receiver,
- one loop and sense antenna.

In addition, the components given after control the system:

- the Radio Management Panel 1(2) (RMP),
- the Multipurpose Control and Display Unit 1(2) (MCDU),
- the Flight Management and Guidance Computer 1(2) (FMGC),
- the Centralized Fault–Display Interface–Unit (CFDIU),
- the Audio Management Unit (AMU).

The Navigation Displays (ND) show the ADF1 and ADF2 data.

Utilisation Technical Data

Data Display in ROSE and ARC modes:

If you set the ADF/VOR/OFF switches on the EFIS control section of the FCU to ADF, this causes : display of the characteristics of the ADF 1 and/or 2 stations in the L and/or R lower corner of the ND:

- type of station
- shape of the associated bearing display
- station identification or frequency
- tuning mode (M = manually tuned, R = tuned by the RMP).

A single pointer on the heading dial shows the bearing of the ADF 1, a double pointer that of the ADF 2.

All these data are shown in green except the tuning mode which is shown in white.

If you push the NDB pushbutton switch on the EFIS control section of the FCU in ROSE and ARC modes, triangle symbols show the ADF stations.

To get the ND indication, on the EFIS Control panel the VOR/ADF selector switches must be switched to ADF.

NOTE: Even if a DDRMI is installed it is an option that ADF may be shown on this instrument.

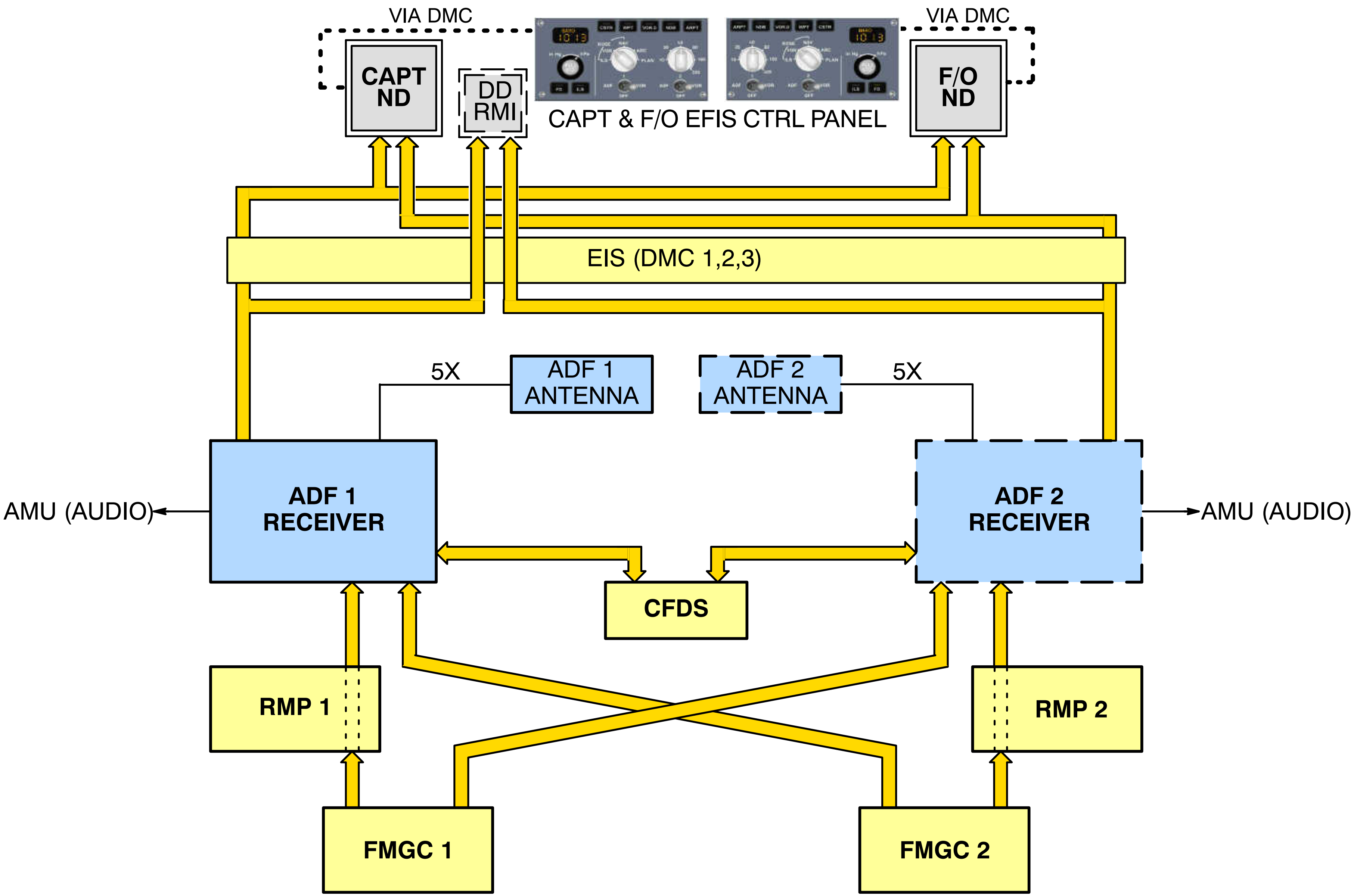


Figure 36 ADF - Schematic

ADF OPERATION

General

The two ADF systems are independent. The operating mode is identical for ADF 1 and ADF 2.

The FMGC 1 sends a management bus to the ADF receiver 1 through the RMP1.

In normal operation, the FMGC 1 tunes the ADF receiver 1 either automatically or manually by means of the MCDU. In this case, the RMP 1 operates as a relay which sends the frequency information from the FMGC 1 to the ADF receiver 1.

By a second port, the ADF receiver 1 receives a second management bus directly from the FMGC 2. The FMGC 2 becomes active when the ADF receiver 1 receives a failure signal from the FMGC 1.

With RMP 1 internal failures the RMP 1 is transparent to data and discrete from the FMGC 1.

In emergency configuration (failure of the FMGC 1 and 2), the RMP 1 can control the ADF receiver 1 after ON NAV mode selection.

In emergency configuration (failure of the FMGC 1 and 2), the RMP 2 can control the ADF receiver 2 after ON NAV mode selection.

Tuning

- Auto Tuning

  In normal operation the ADF receiver 1 (2) is automatically tuned by the onside FMGC 1 (2) through the associated RMP 1 (2). In this case, the RMP is only used to transmit the frequency and course information from the FMGCs to the frequency input port A of the receiver.
- Manual Tuning

  Frequency and course data can be manually entered on the RAD/NAV page of the MCDUs. The FMGCs sent this information to the receivers in the same way like in the auto-tuning mode.
- FM Switching

  If a FMGC fails, a discrete is sent to the receiver (via the RMP) to activate the frequency input port B. This port receives information direct from the opposite FMGC. In this case, one FMGC tunes both ADF receivers.
- NAV Back Up Tuning

  If both FMGC fail, each ADF receiver must be tuned directly from the onside RMP. To do so, press the NAV and the ADF pushbuttons on both RMPs. The RMP now uses manually entered data and not the data coming from the FMGC. A discrete reselects the frequency input port A, which is directly supplied from the associated RMP. A second discrete inhibits the data display on the RAD/NAV page of the MCDUs to indicate that no FMGC tuning is possible.

Antenna

Each ADF receiver is connected to its own ADF antenna. The ADF antenna consists of one sense antenna and two loop antenna elements, which are pre-amplified by integrated amplifiers.

A test loop input is not used.

Inputs

Each LGCIU sends discrete signals to the ADF receiver for internal BITE purposes.

Indication

All DMCs receive ADF data from both receivers such as ADF bearing, frequency and ADF identifier. Data of both systems are shown on Capts and F/Os ND.

Audio

The ADF audio signal is processed by the receiver and sent to the AMU and can be heard by the crew on headphones or cockpit loudspeaker.

Users

The CFDIU is used to communicate with the internal BITE functions of the ADF receivers (tests only available on ground).

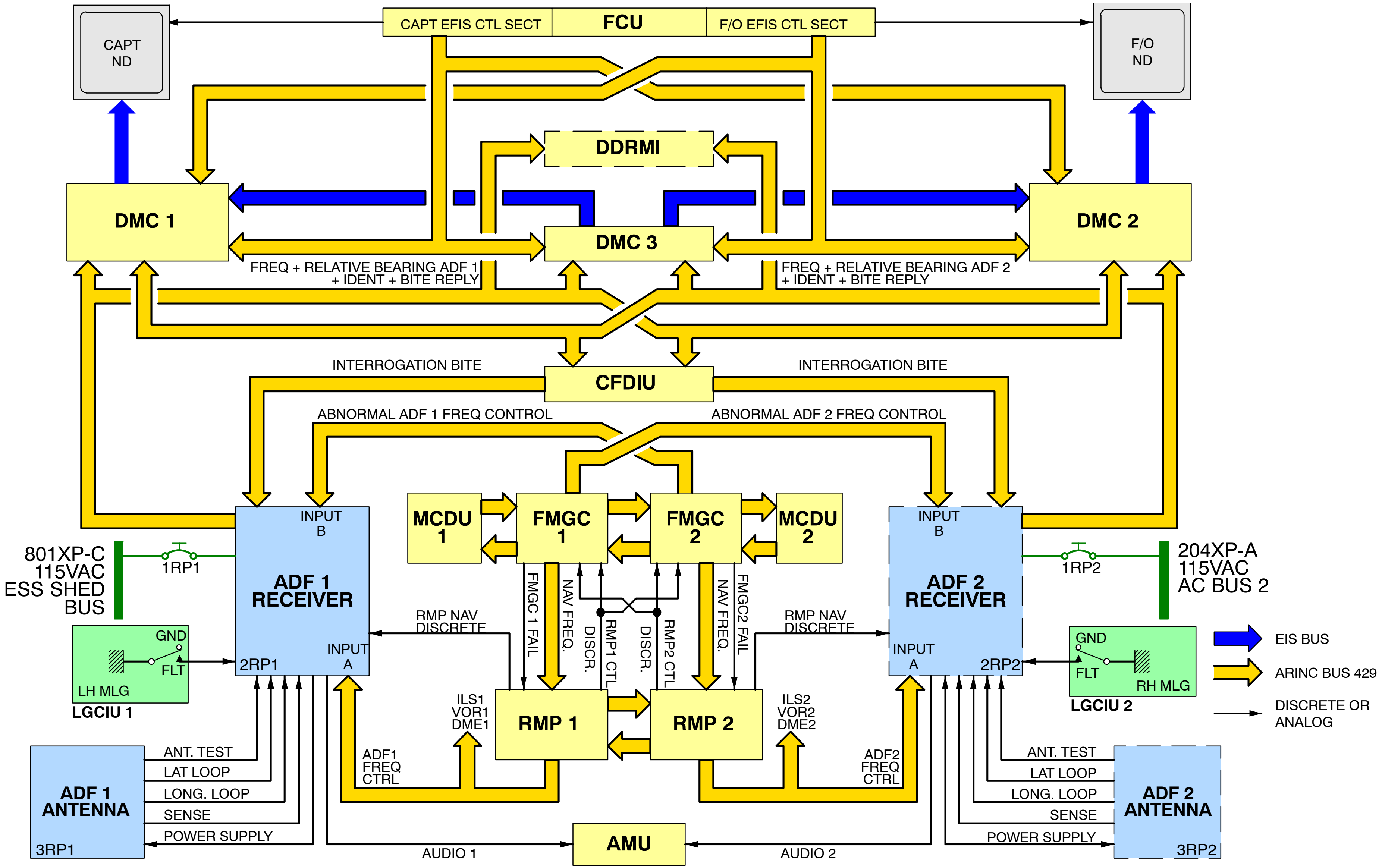


Figure 37 ADF Interface Diagram

ADF COMPONENT DESCRIPTION

ADF RECEIVER

Characteristics

- Frequency range : 190 to 1799 KHz in 0.5 KHz steps
- Electrical power supply: 115VAC, 400 Hz, 45 VA
- Tuning accuracy: selected frequency plus or minus 250 Hz
- ADF accuracy: plus or minus 2 deg.
- Sensivity: 30 % modulation
- ADF mode: 50 microV/m field strength at 400 Hz for 6 dB signal to noise ratio.

1 Receiver Face

The face of the receiver is fitted with a handle, one lug, a TEST pushbutton switch and two LEDs.

The name, color and function of the two LEDs are as follows:

- LRU STATUS (red): indicates that a malfunction is detected during the self test of the ADF receiver.
- LRU STATUS (green): indicates that no faults are detected during the self test of the ADF receiver.
- CONTROL FAIL (red): indicates that an ARINC input data is faulty.

2 Receiver Face

The face of the receiver is fitted with a handle, one attaching part, a TEST pushbutton switch and three LEDs.

The name, color and function of the three LEDs are as follows:

- ADF (red) indicates that a malfunction is detected during the self test of the ADF receiver.
- ADF (green) indicates that no faults are detected during the self test of the ADF receiver.
- DATA IN (red) indicates that an input data is faulty.

3 Receiver Face

The face of the receiver is fitted with a handle, one attaching part, a TEST pushbutton switch and three LEDs.

The name, color and function of the three LEDs are as follows:

- CONTROL INPUT/FAIL (red) indicates that the receiver is not receiving any information at the input ports, during self−test
- LRU STATUS/PASS (green) indicates that no faults are detected during the self−test sequence
- LRU STATUS/FAIL (red) indicates that a fault is detected during the self−test sequence.

4 Receiver face

The face of the receiver is fitted with a handle, two attaching parts, two momentary pushbutton switches and a front panel Liquid Crystal Display (LCD).

The LCD is used as a fault display and as an operator interface during certain modes. The front panel display also provides user interfaces for test and troubleshooting.

The front panel contains two momentary pushbutton switches for interfacing with the LCD pages.

An RS−232 maintenace access port is provided on the front panel. This port is compatible with RS−232 serial ports on Personal Computers (PC).

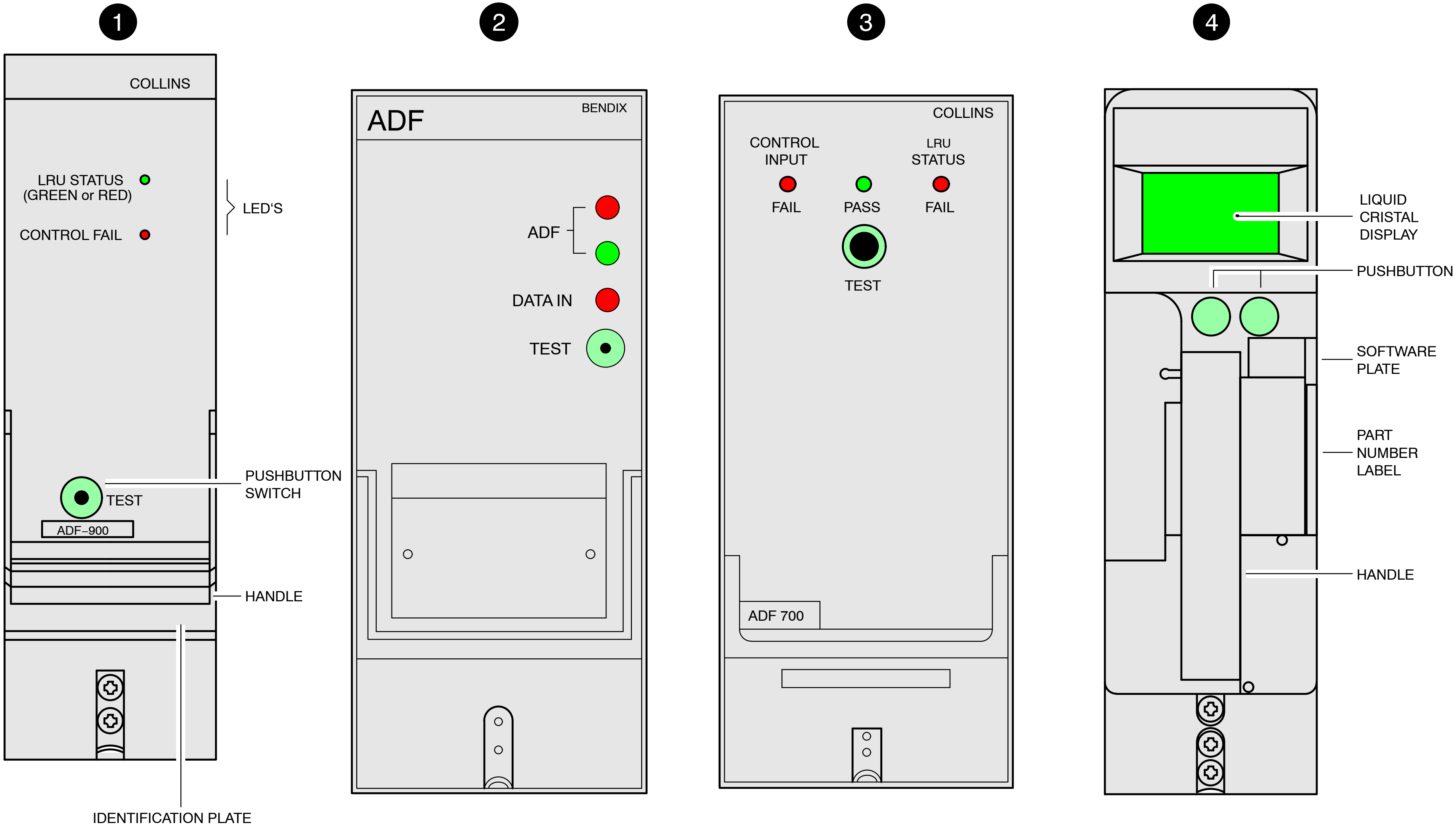


Figure 38 ADF Receiver

ADF Receiver Internal Description

The receiver determines the relative bearing to any selected transmitter operating between 190 and 1750 kHz. This bearing data is converted into ARINC 429 format and transmitted through ARINC buses to the DMCs. In addition the AM modulation of the carrier wave is detected and applied to the audio integrating system. The receiver is housed in an ARINC 2MCU case and consists of the following interconnected modules:

- A receiver module combines the sense and loop signals from the antenna and provides data bearing and audio outputs.
- A synthesizer module generates fixed and variable oscillations to tune the receiver.
- A coherent demodulator module detects bearing data from the composite input signal.
- The signal processor module converts the bearing data from the coherent demodulator into a digital ARINC word format which is then transmitted to the DMCs.
- A power supply module converts the 115VAC aircraft supply into the various voltages used by the internal circuits of the receiver.
- A BITE module controls functional and automatic self-tests in the receiver.

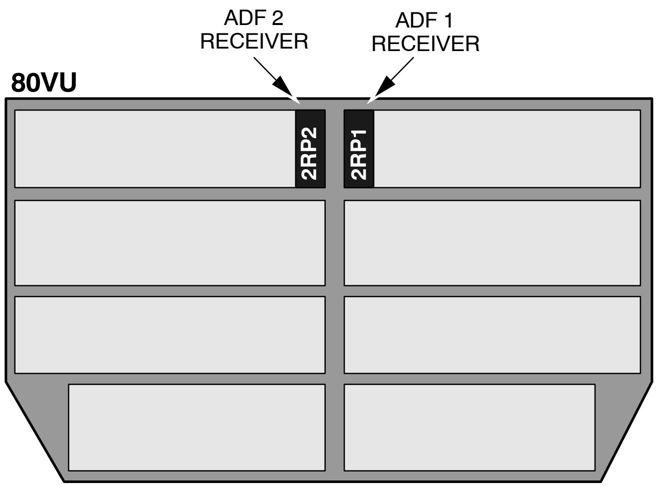


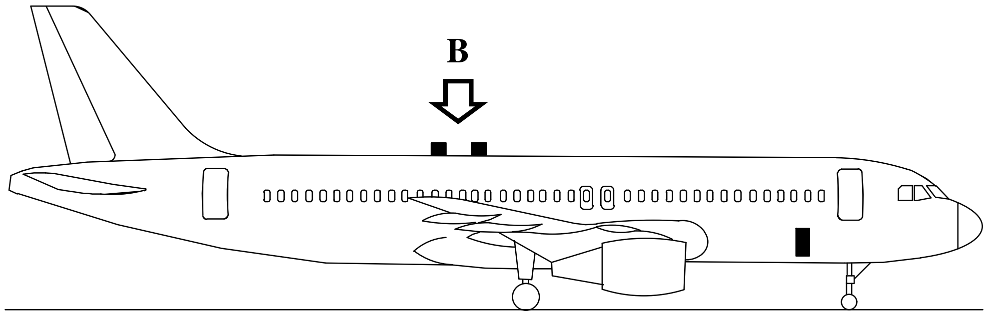
Figure 39 ADF Receiver Location

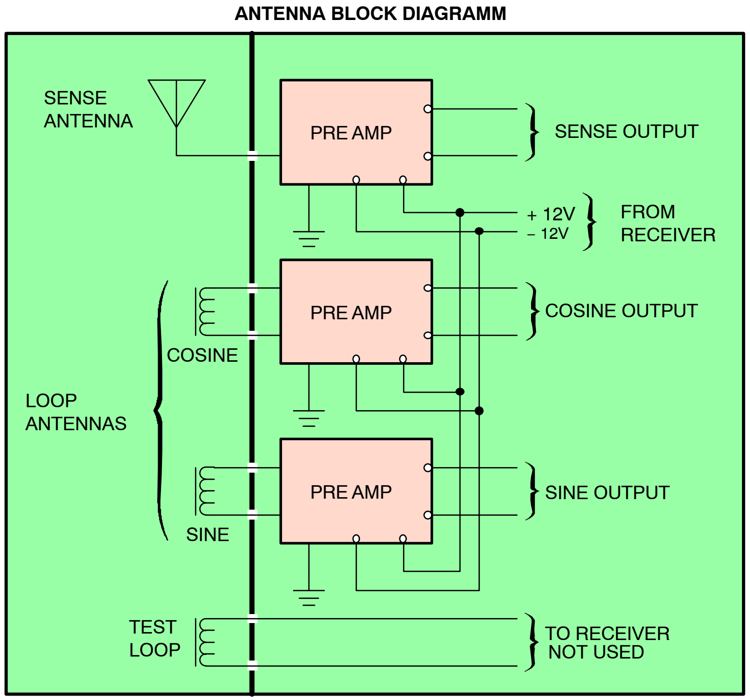
Loop and Sense Antenna

The combined loop and sense antenna operates in the 190 to 1750 kHz frequency range and consists of the following components enclosed in a fiberglass housing:

- a vertically polarized sense antenna which is omnidirectional in the horizontal plane,
- two horizontally polarized loop antennas which are directional in the horizontal plane,
- a test loop which enables a self-test of the antenna (not used),
- a printed circuit board which contains three pre-amplifiers used to amplify the loop and sense antennas signals. The pre-amplifiers are energized by plus or minus 12VDC from the ADF receiver.

The output impedance of the antenna is 78 Ohm and the Voltage Standing Wave Ratio 1.2 : 1 (VSWR).





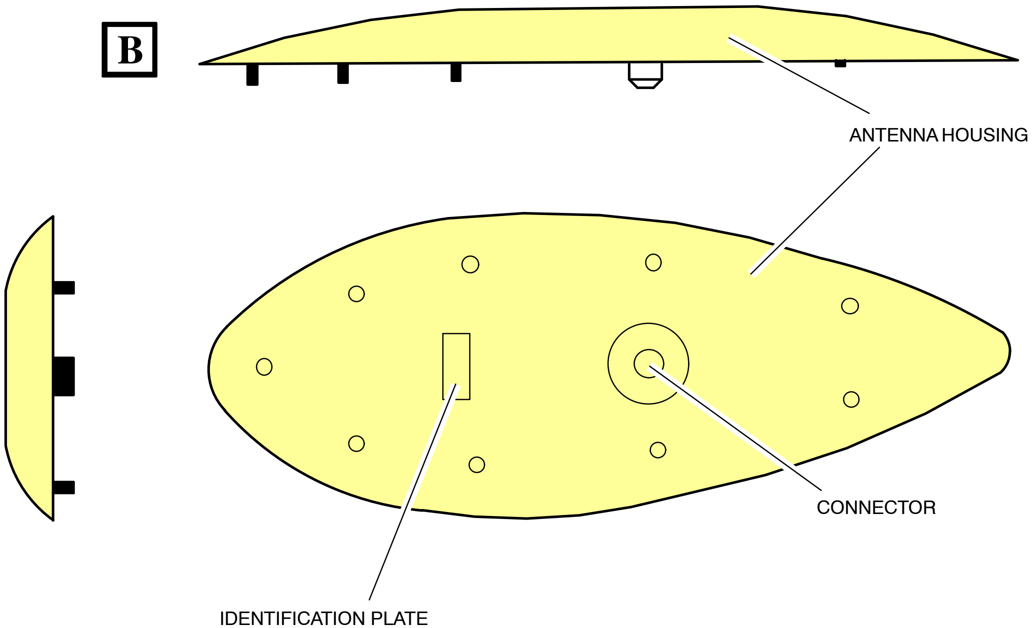


Figure 40 ADF Antenna

ADF FLAGS DESCRIPTION

ADF FLAGS

Flags or NCD Indication on ND

Flags or NCD indication are only displayed on ND, when in ROSE or ARC mode and the VOR/ADF selector is switched to ADF. If the ADF receiver fails, a red ADF1 (2) flag (flashing 9s, then steady) comes into view instead of ADF characteristics and the ADF bearing pointer goes out of view.

In case of NCD, the ADF bearing pointer goes out of view. On the ADF characteristics, the ADF identifier is replaced by the frequency.

If the frequency information is fail or NCD, the ADF bearing pointer, the frequency or the identifier goes out of view.

Flags or NCD Indication on DDRMI

A warning flag comes into view to indicate system malfunction.

In this case, the related pointer is at the last valid position.

If No Computed Data (NCD), the and the related pointer moves to the 3 o‘clock position.

NOTE: There is no ECAM message in case of an ADF System Fault.

ADF FLAGS ON ND

ADF FLAGS ON DDRMI

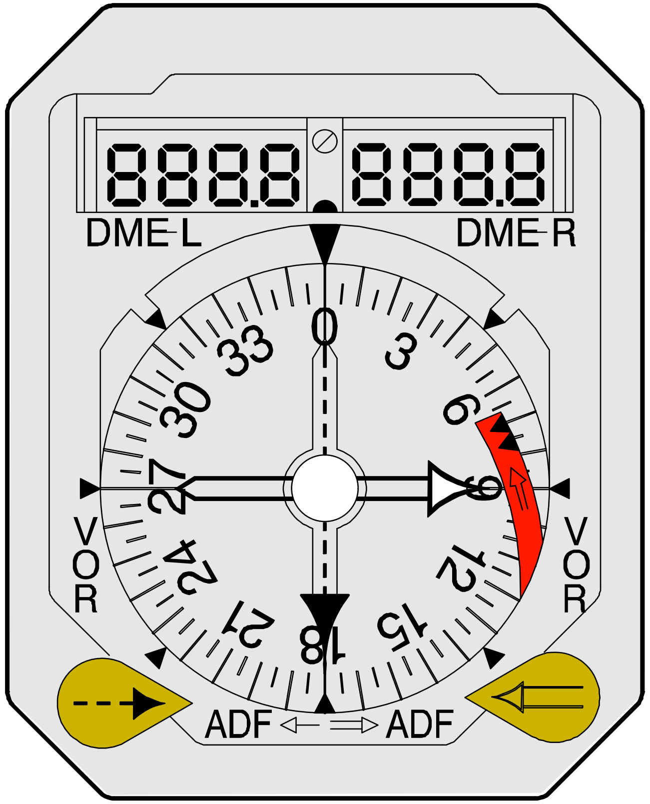


Figure 41 ADF Flags on ND and DDRMI

34–57 RADIO MAGNETIC INFORMATION – SWITCHING AND INDICATING

DDRMI COMPONENT DESCRIPTION

DIGITAL DISTANCE RADIO MAGNETIC INDICATOR

Compass card

ADIRU 1 normally supplies the signal that positions the compass card. ADIRU3 supplies it when selected by the ATT HDG SWITCHING selector.

Bearings pointers

Indicate the magnetic bearing to the station received by VOR 1 or ADF 1 (dashed pointer) and, VOR 2 or ADF 2 (double pointer).

NOTE: Depending on the quality of the VOR beacon signal, and mainly at distances greater than 25 NM from the station, the processing of the signal, on aircraft equipped with COLLINS or BENDIX VOR may lead to bearing pointer oscillations.

NOTE: The indication of ADF is an option.

VOR/ADF Flags

The indicators display these flags if:

- the VOR or ADF receiver fails (VOR/ADF selector position indicates the failed receiver),
- the RMI has an internal failure,
- the heading signal from ADIRS is not valid,
- the power supply fails.

As long as the flag shows, the relevant pointer remains at the last valid position.

HDG flag

Appears, associated with VOR/ADF flags display, when:

- The heading signal from the supplying ADIRS is not valid,
- the RMI has an internal failure,
- the power supply fails.

DME 1(2) counters

The counters indicate distances in NM and 1/10th at less than 20 NM. At less than 1 NM, 0 is shown.

Two windows are available for indication of both distances from the DME 1 and DME 2 when the VOR/DME stations are collocated.

When the DME or RMI monitoring circuits detect a fault, the corresponding display window is blanked.

In case of No Computed Data (NCD) (out–of–range station) the windows show white horizontal dashed lines.

VOR/ADF Selector

VOR 1 or ADF 1 on the dashed pointer.

VOR 2 or ADF 2 (or ADF 1 if ADF 2 is not installed).

Nomenclature

In the documentation there are different names used for the DDRMI:

- VOR/DME RMI
  for DDRMI with VOR and DME indication
- VOR/ADF/DME RMI
  for DDRMI with VOR, ADF and DME indication
- RMI
  for DDRMI ADF indication only.

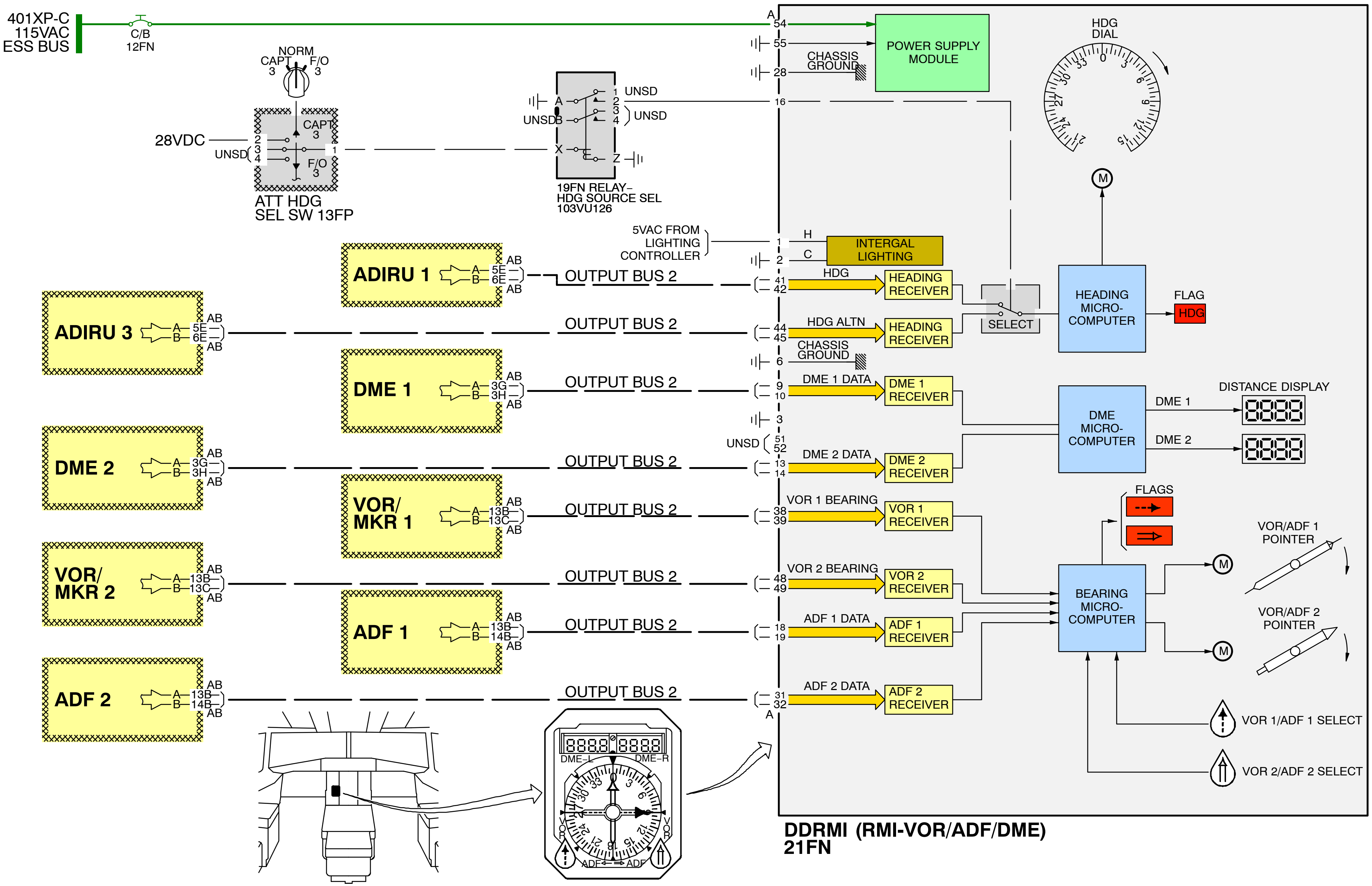


Figure 42 DDRMI Interface Diagram

34−52 ATC/MODE S

AIR TRAFFIC CONTROL SYSTEM INTRODUCTION

ATC PRINCIPLE

The Air Traffic Control (ATC) transponder is an integral part of the Air Traffic Control Radar Beacon (ATCRB) system. The transponder is interrogated by radar pulses received from the ground station. It automatically replies by a series of pulses.

These reply pulses are coded to supply:

- aircraft identification (Mode A),
- automatic altitude reporting (Mode C) and,
- selective calling and transmission of flight data of the aircraft on the ground controller’s radar scope.

These replies enable the controller to distinguish the aircraft and to maintain effective ground surveillance of the air traffic. The ATC transponder (Mode S) also responds to interrogations from aircraft equipped with a Traffic Alert and Collision Avoidance System (TCAS).

ATC System General

The Air Traffic Control (ATC) system is based on the replies provided by the airborne transponders in response to interrogations from the ATC Secondary Surveillance Radar (SSR).

The ground ATC secondary radar uses technics which provide the air traffic control with information that cannot be acquired by the primary radar.

This system serves to distinguish between aircraft and to maintain effective ground surveillance of the air traffic.

The system provides the air traffic controllers with:

- **Mode A:** transmission of aircraft identification (code number)
- **Mode C:** transmission of aircraft barometric altitude
- **Mode S:** aircraft selective calling and transmission of flight data for the ground surveillance.

The mode S is fully compatible with the other modes, A and C.

The mode S has been designed as an evolutionary addition to the ATC system to provide the enhanced surveillance and communication capability required for air traffic control automation.

Each (ATC Mode S−equipped) aircraft has its own Mode S address. This address (24−bit) is included in all Mode S transmissions, so that every interrogation can be directed to a specific aircraft, preventing multiple replies.

Also, answers are unequivocal from only one specific aircraft. If the discrete address is included in an interrogation, the discrete address is also a part of the reply. This is especially important for use in conjunction with TCAS.

For SSR interrogations, the transponder transmits the selectable code number (Mode A) or the barometric altitude (Mode C) if required.

For SSR/Mode S all call interrogations, the transponder transmits the same information.

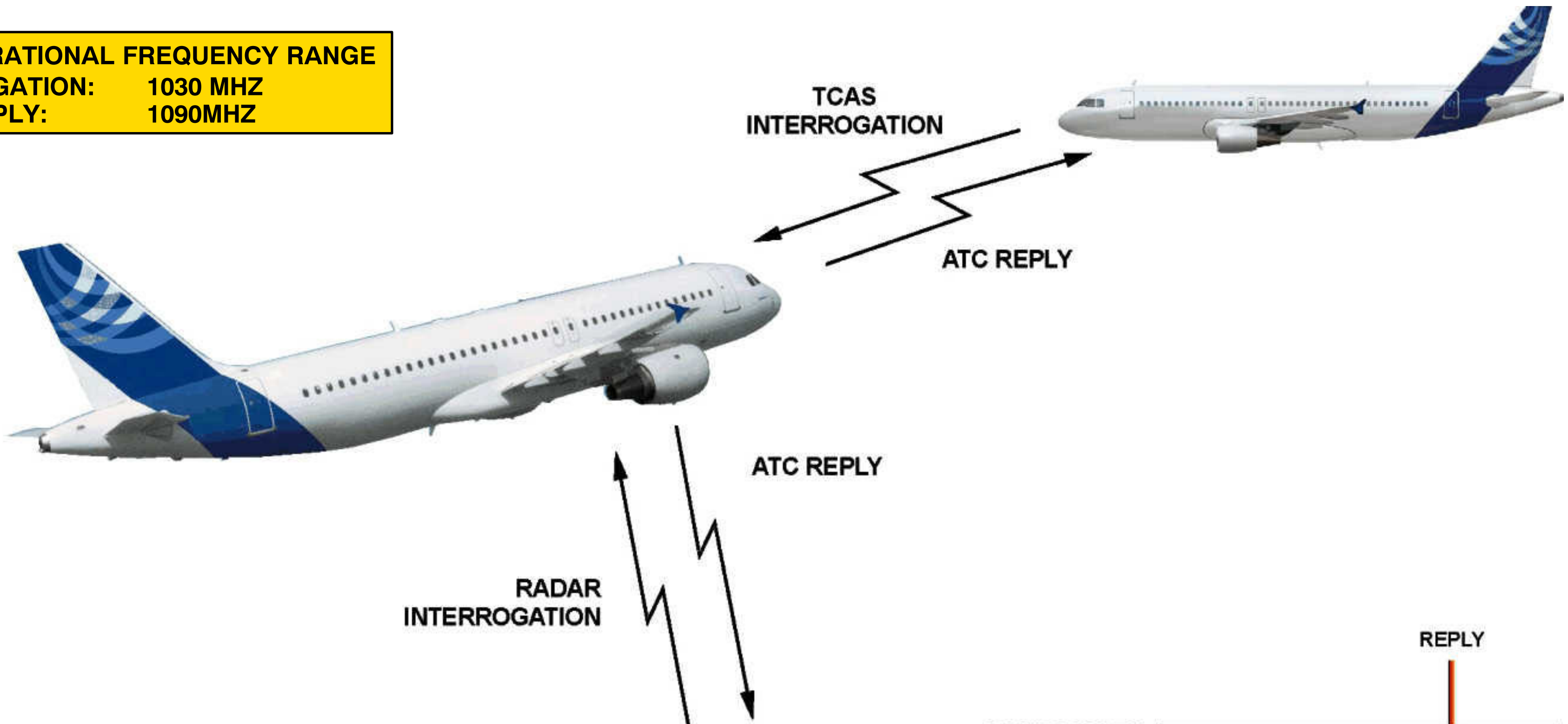
In addition, new functionalities are required for ATC/Mode S transponders:

- elementary surveillance (mandatory in Europe after March 31, 2003),
- enhanced surveillance (mandatory in Europe after March 31, 2005).
- com A/B: capability to receive ground to air data uplink (com A) and to transmit air to ground data downlink (com B) in addition to bidirectional data exchange
- com C: capability to receive Extended Length Messages (ELM)
- It also incorporates the following improvements:
- it has interface characteristics in compliance with ARINC 718A.
- as a Mark IV transponder, this transponder needs additional wiring to perform enhanced surveillance and extended squitters functions.

  If this wiring is not installed, the transponder will operate as a Mark III transponder. In this case, neither enhanced surveillance parameters nor extended squitters are available.
- its software is fully loadable.

The transponder is a level 3 transponder since it is capable of processing com A/B/C/ data link messages.

ATC OPERATIONAL FREQUENCY RANGE
INTERROGATION: 1030 MHZ
XPNDR RPLY: 1090MHZ



ATC MODE	INFORMATION ABOUT THE A/C
A	IDENTIFICATION
C	ALTITUDE
S	SELECTIVE CALL, FLIGHT DATA

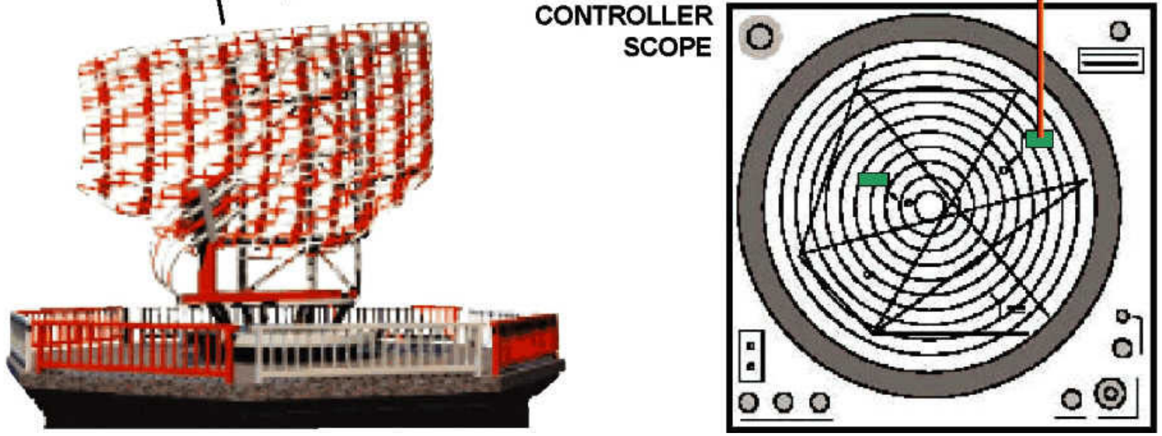


Figure 43 ATC Principle

29|–52|ATC Intro|L1

ATC SYSTEM COMPONENTS

The components are:

- two transponders,
- four antennas and,
- one ATC/TCAS control panel.

HI JACK P/B

In case of hijack, two P/B SWs are optionally installed near the captain and first officer locations in order to activate emergency functions.

Optionally aural and lighted warnings are also activated in cabin to notify the cabin crew that the cockpit crew will be threatened.

NOTE: The ATC/TCAS control panel shown here after is given as example. It may differ according to the aircraft configuration.

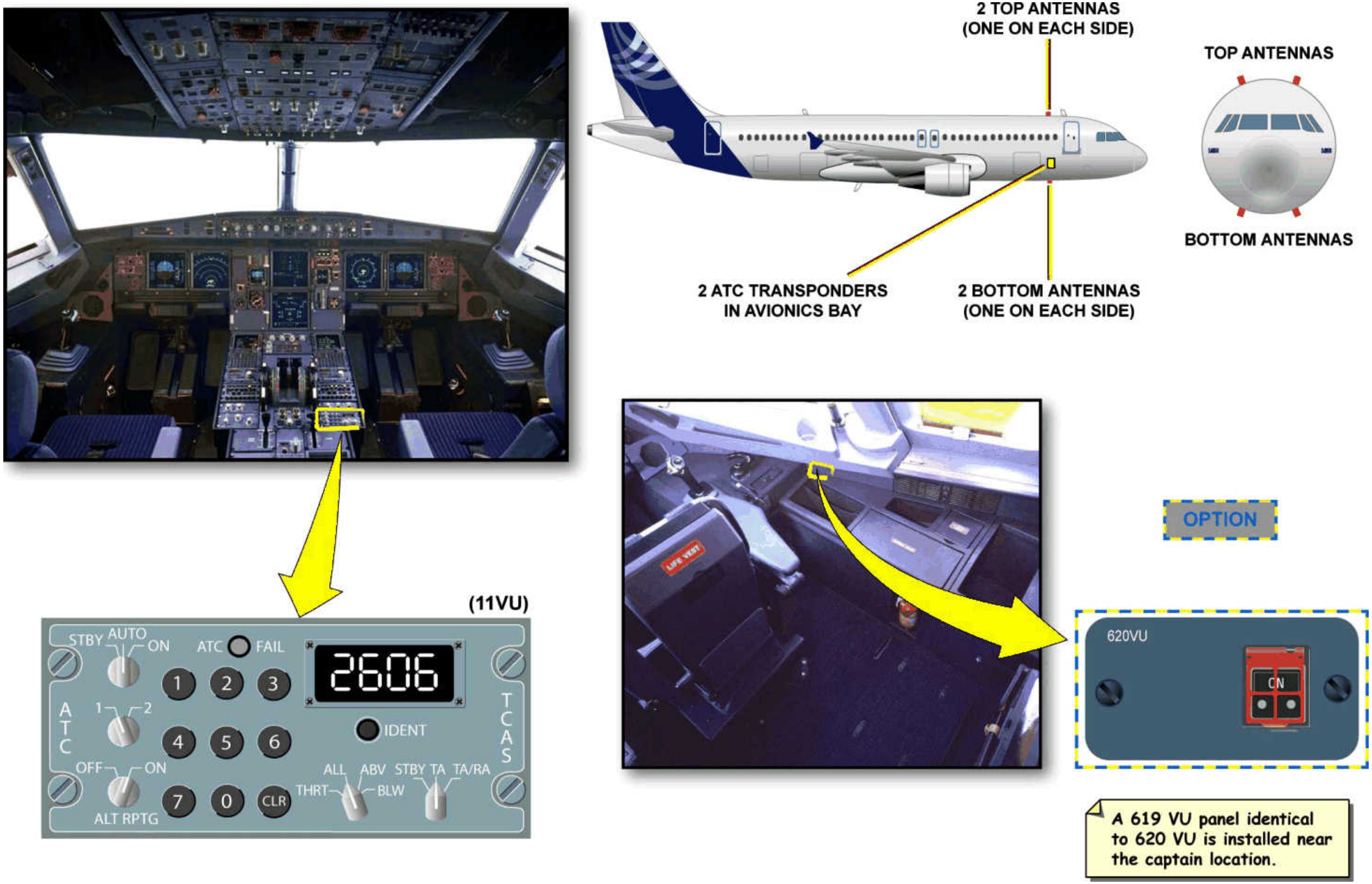


Figure 44 ATC System Components

ATC SYSTEM DESCRIPTION

GENERAL

The Air Traffic Control (ATC) system includes:

- 1 ATC/Traffic Alert and Collision Avoidance System (TCAS) control panel (common to both systems),
- 2 transponders,
- 4 antennas.

CONTROL PANEL

A single ATC/TCAS control panel enables system selection. It provides the selected transponder with code and function data and, in return, receives status data. The ATC/TCAS control panel converts selected mode and selected code data into digital data and transmits this data in ARINC 429 format to the selected transponder. The Landing Gear Control and Interface Units (LGCIUs) provide a ground/flight discrete signal to the ATC transponder via the ATC/TCAS control panel for BITE purposes.

TRANSPONDER

In normal operation, one ATC transponder operates and the other is in standby mode. The operating mode (A, C or S) of the transponder is determined by the decoding of the time between the interrogation pulses.

The main function of the mode S transponder is surveillance. Each transponder has its own and unique address coded on 24 bits so that every interrogation can be directed to a specific aircraft preventing multiple replies. The mode S is also used in collision avoidance (TCAS).

NOTE: The links between the ATC and the Air Traffic Service Unit (ATSU), the Flight Control Unit (FCU), the Muti Mode Receiver (MMR) and the Inertial Reference (IR) part of the Air Data/Inertial Reference Unit (ADIRU) are optionally installed for enhanced surveillance/extended squitters.

ANTENNA

The ATC antennas transmit replies to interrogations from the ATC ground station. Top and bottom antennas provide the antenna diversity features that allow a better radar coverage. The antenna operates in the 960 MHz to 1.220 MHz frequency band with an interrogation frequency of 1.030 MHz and a reply frequency of 1.090 MHz.

ADIRU

ADIRU 1 and ADIRU 2 provide barometric altitude to associated transponders for mode C. In case of failure of ADIRU 1 or 2, the pilot can switch to ADIRU 3 through the AIR DATA selector switch.

FMGC

The Flight Management and Guidance Computers (FMGCs) provide the flight number. This data will be transmitted to an ATC ground station after a mode S interrogation.

CFDIU

The Centralized Fault Display Interface Unit (CFDIU) allows testing and trouble-shooting of the ATC system through the MCDUs. The tests are only available on ground.

TCAS

The TCAS allows individual communications with each TCAS equipped aircraft through the Mode S transponder. This enables a coordination of avoidance maneuvers by acquisition, at regular intervals, of the relative altitude and the separation range.

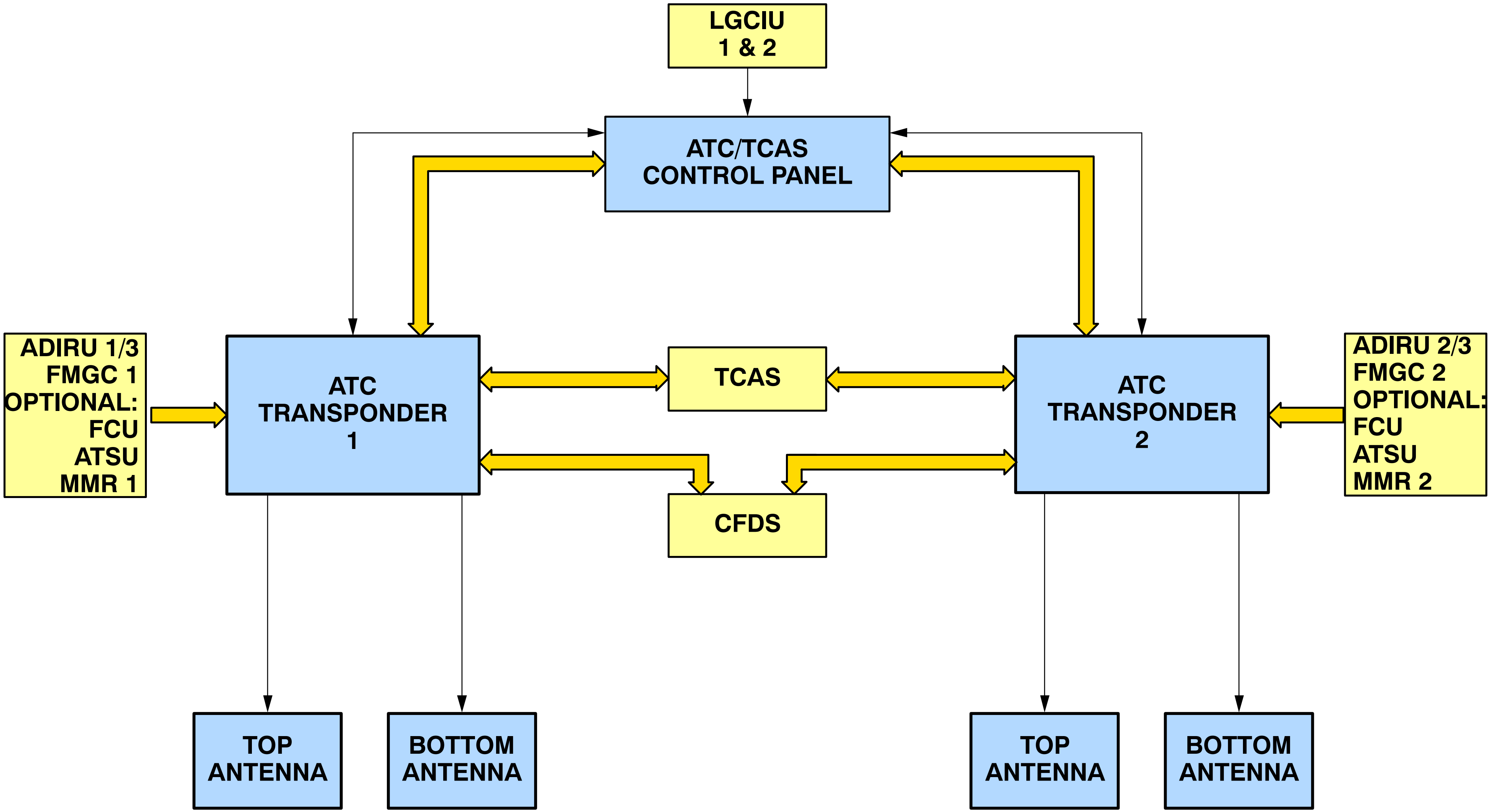


Figure 45 ATC System Schematic

ATC/TCAS Control Unit

The processor-based unit conforms to the ARINC 718 specification.

The front panel is integrally lit by clear 5V lamps and features:

- a **liquid crystal display** window in which the identification code is displayed
  - Upon energization of the aircraft or modification of system selection, the last ATC code selected is displayed before the new code selection. This code comes into view on the display window of the control unit.
- an **ATC FAIL** indicator light which indicates a transponder failure
- a **IDENT** pushbutton switch
  - When you push the IDENT pushbutton switch (ON configuration), this generates an additional identification pulse in the reply signal.
- an **ALT RPTG/ON/OFF** switch which controls the transmission of altitude data from the transponder to the ATC ground control stations
  - When you set the ALT RPTG/ON/OFF switch to ON, the altitude information transmission of the selected transponder is enabled.
- a **keyboard** to select the four-digit transmit code (from 0000 to 7777)
- a **1/2 selector** switch which enables the operation of the ATC system 1 or 2
  - In normal operation, you select the ATC 1(2) through the 1/2 switch on the control unit in either position 1 or 2.
- a **STBY/AUTO/ON** selector switch which enables the ATC operating modes
  - in STBY position: the two transponders are electrically supplied but do not operate
  - in AUTO position: the selected transponder operates in flight but operates only in mode S on ground
  - in ON position: the selected transponder operates when the aircraft is in flight or on ground.
- a TCAS mode selector switch (STBY/TA/TA-RA) which enables the ATC/TCAS operating modes (Ref. 34-43 for more details).
- a THRT/ALL/ABV/BLW selector switch which controls the type of traffic to be displayed as well as the above and below vertical altitude for traffic advisory.

Figure 46 ATC - ATC/TCAS Control Unit

ATC SYSTEM OPERATION

ATC INTERFACES

The ARINC 429 signals provide a two−way interface between the transponder and other aircraft systems. The ARINC 429 signals consist of 32−bit data words. The first 8 bits of the word make up a label which specifies the type of information contained in that word.

The ARINC 429 buses provide the interfaces with:

- the Traffic Collision Avoidance System (TCAS) computer,
- the Air Data and Inertial Reference Units (ADIRUs, ADC and IRS),
- the Centralized Fault Display Interface Unit (CFDIU),
- the Flight Management and Guidance Computer (FMGC),
- the ATC/TCAS Control Panel.

NOTE: MMR/ATC link, ATSU/ATC link, FCU/ATC link and ADIRU (IR part)/ATC link are installed if the optional wiring provisions for enhanced surveillance/extended squitters are validated.

Power Supply

Energization of each system is through:

- 115VAC ESS BUS SHEDDABLE via circuit breaker 5SH1 for system 1.
- 115VAC BUS 2 via circuit breaker 5SH2 for system 2.

Suppressor Coaxial

The ATC, the DME and the TCAS operate in the same frequency range.

A suppressor signal is transmitted, via a coaxial, by the operating system to inhibit the other systems and to prevent simultaneous transmission.

Reconfiguration Switching

In normal configuration, each ATC receives the altitude information from its corresponding Air Data/Inertial Reference Unit (ATC1 from ADIRU1, ATC2 from ADIRU2).

With failure of the ADIRU corresponding to the serviceable transponder, the pilot can select the altitude information from the ADIRU 3. This selection is through the AIR DATA selector switch installed on panel 8VU on the center pedestal.

Principle of Operation

Each ground interrogator transmits its interrogations at the frequency of 1030 MHz in the form of a series of two pulses.

Depending on the pulse intervals and numbers, they define three different interrogation modes. After receiving these pulses, the transponder identifies and decodes the interrogations. Depending on the detected interrogation mode, the transponder transmits either the identification of the aircraft or its barometric altitude or flight data.

The transmission of the replies takes place on a carrier frequency of 1090 Mhz. If the interrogation is sent by the side lobe of the radar, a characteristic signal is sent allowing the transponder to disregard the interrogation.

DATA TRANSMISSION

The specific data related to the elementary surveillance are the following:

- 24 bits A/C address, flight number, transponder capability report, altitude/ground reporting, flight status, RA report, Surveillance Identifier (SI/Squawk).

The specific parameters related to the ENHANCED SURVEILLANCE are:

- selected altitude, barometric pressure setting, roll angle, track angle rate, true track angle, ground speed, true air speed, magnetic heading, indicated airspeed, mach number, barometric altitude rate, inertial vertical velocity.

Data transmitted in extended squitters (if the optional wiring provisions for enhanced surveillance/extended squitters are validated):

- altitude, longitude, latitude, movement, ground track, flight number, E/W velocity, N/S velocity, vertical rate.

Warning

The warning related to the ATC is only the FAULT or FAIL indicator light of the ATC control unit. When the system is faulty, the amber FAULT or FAIL indicator light comes on.

NOTE: There is **no ECAM message** in case of an ATC system Fault.

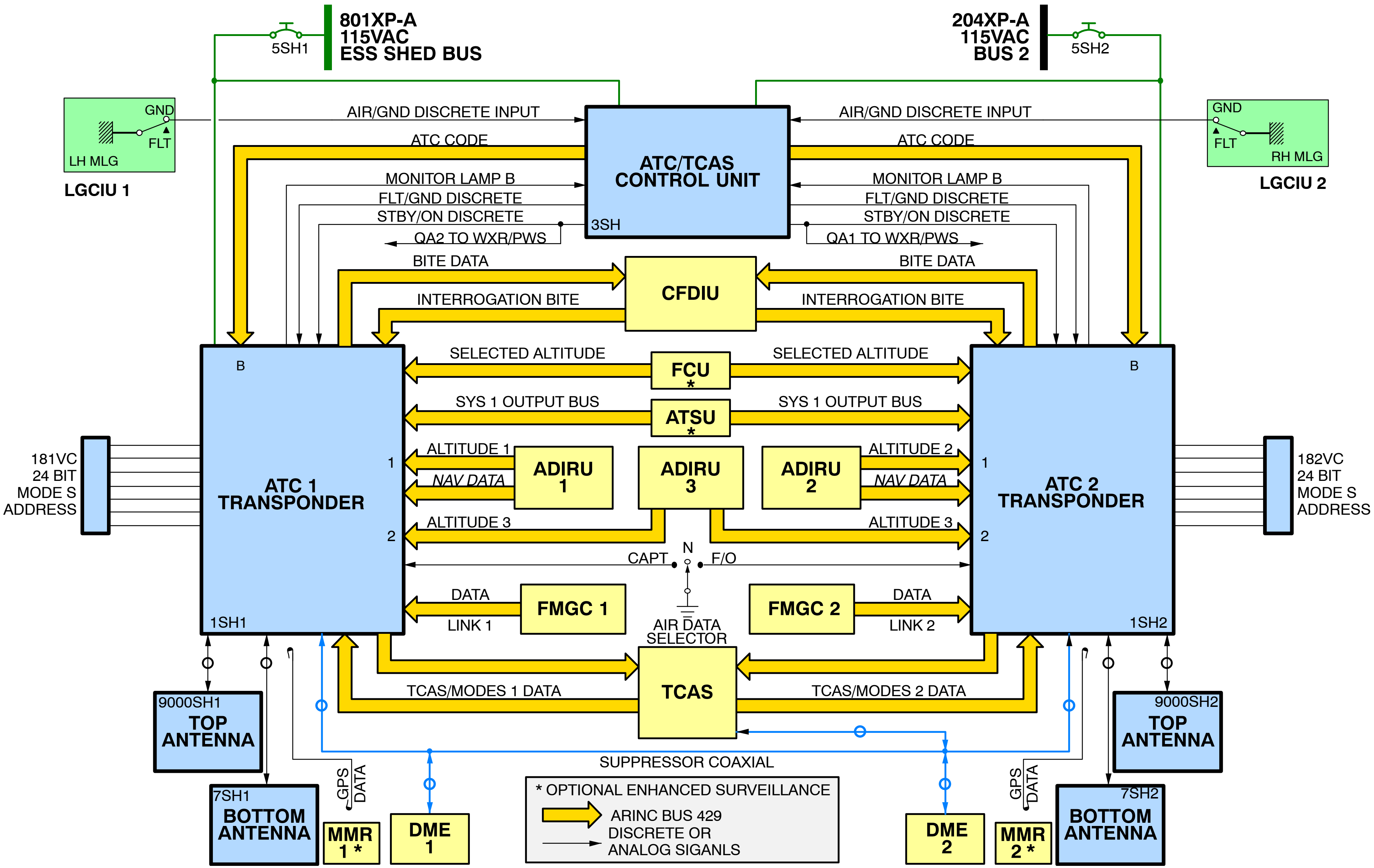


Figure 47 ATC Interface Diagram

ATC COMPONENT DESCRIPTION

ATC TRANSPONDER

1 Receiver face

The face of the transponder is fitted with a handle, two attaching parts, a TEST pushbutton switch and five LEDs.

The TEST pushbutton switch is used to initiate the BITE self-test. During the self-test, the transponder performs the following functions:

- **With TEST pushbutton switch pressed for less than 5 seconds:**
  - stops normal processing, performs test of full-time ROM checksum status, performs RAM tests, stimulates receiver noise sources and monitors results,
  - checks antenna integrity,
  - injects simulated ATCRBS/Mode S all-call into top and bottom receivers,
  - samples transmitter monitor, following transmission , and verifies reply is correct,
  - samples power supply monitor,
  - performs test on non-active serial buses (TCAS, COM A/B and C/D),
  - updates maintenance portion of nonvolatile memory,
  - returns unit to normal operation,
  - performs receiver test:
    - All LEDs come on red for 2 seconds. Then the LRU status LED becomes green and the other LEDs remain red for 2 seconds. Then all LEDs go off for 2 seconds, then the test results are displayed for 30 seconds:
  - LRU status - green for LRU with no fault, red for LRU fault; all other LEDs are off for no fault, red for fault.

2 Receiver Face

The face of the transponder is fitted with a handle, two attaching parts, a TEST pushbutton switch and six LEDs.

The name, color and function of the six LEDs are as follows:

- **TPR PASS** (green) indicates that no faults are detected during the reply.
- **TPR FAIL** (red) indicates fault of ATC function.
- **UPPER ANT** (red) indicates that the upper antennas are incorrectly connected or are failed.
- **LOWER ANT** (red) indicates that the lower antennas are incorrectly connected or are failed.
- **ALT** (red) indicates that the altitude is not in correct format.
- **CTL** (red) indicates that the control input is not in correct format.

3 Receiver Face

The face of the transponder is fitted with a handle, two attaching parts, a TEST pushbutton switch and ten LEDs.

The TEST pushbutton switch initiates the LED test and transponder self-test. When pressed and held, it initiates the LED test: - three seconds on and three seconds off. After the LED test, the LEDs indicate unit operational status and any current major malfunctions.

The functions of the LEDs are indicated on the table below:

- **TPR** (green), on after test indicates normal operation,
- **TPR** (red), on after test indicates malfunction,
- **ALT** (red), on after test indicates abnormal input from ALT data system bus, or associated circuitry,
- **DATA IN** (red), on after test indicates abnormal input of 429 word data from control unit, or associated circuitry.
- **TOP or BOT** (red), on after test indicates malfunctioning top/bottom transponder antenna or associated circuitry.
- **TCAS** (red), on after test indicates abnormal input of 429 word data from the TCAS unit or associated circuitry.
- **MAINTENANCE** (red), on after test indicates abnormal input from maintenance data system bus, or associated circuitry.

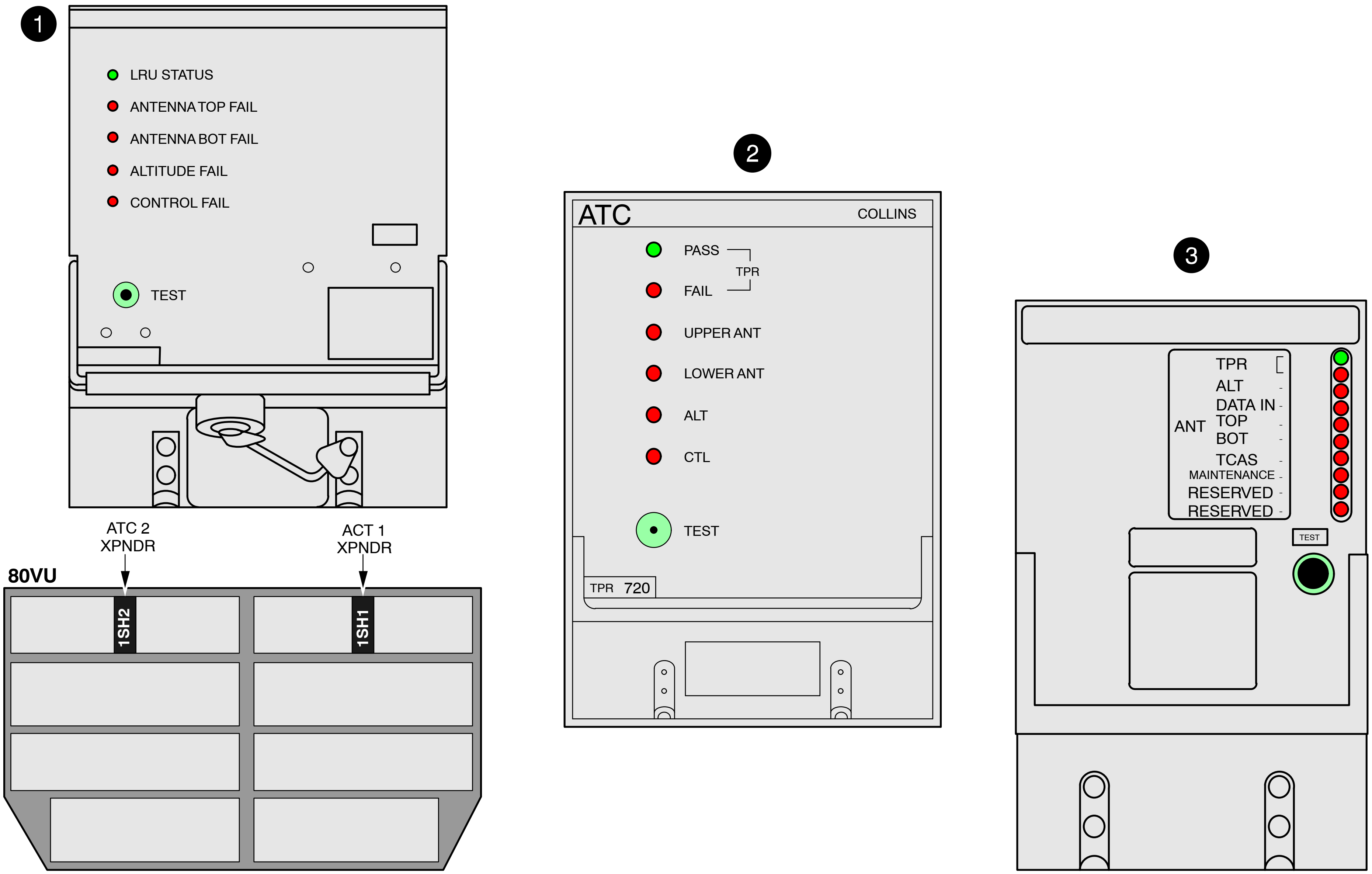


Figure 48 ATC Transponder

ATC ANTENNA DESCRIPTION

The L−band antenna is a short stub, all aluminum blade type which is completely sealed to prevent failure from moisture incursion.

- It is vertically polarized,
- has an impedance of 50 ohms,
- a Voltage Standing Wave Ratio (VSWR) of 1,5 : 1
- and operates in the 960 MHz to 1220 MHz frequency band.
- Lightning protection is provided to prevent damage to the antenna and the transponder.

Four antennas must be provided on the aircraft.

The desire for improved upper hemisphere coverage usually leads to a choice of upper and lower mounting locations for the transponder antennas on the aircraft.

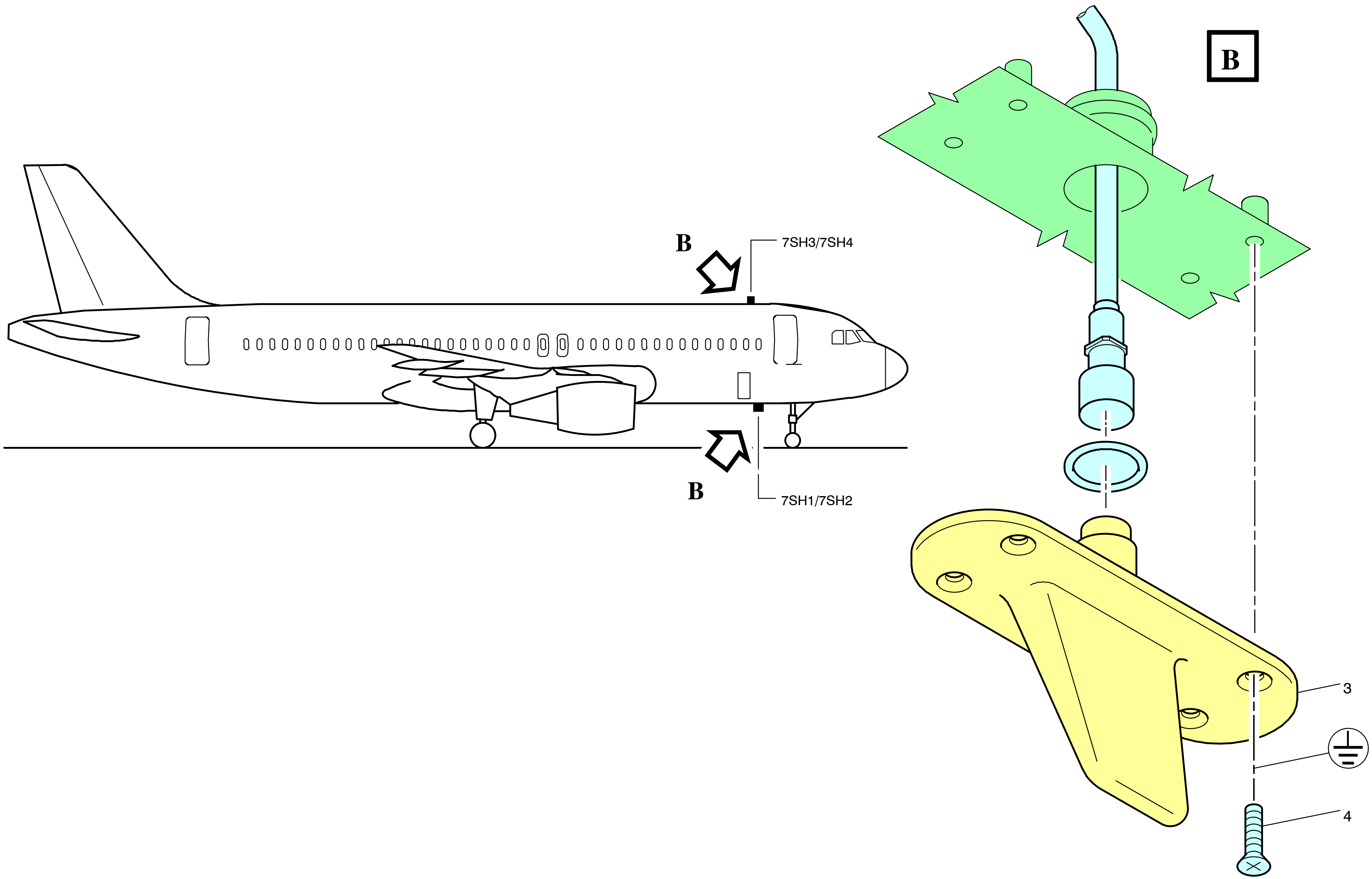


Figure 49 ATC Antenna

AUTOMATIC DEPENDANT SURVEILLANCE (ADS)

ELEMENTARY SURVEILLANCE (ELS)

The Elementary Surveillance (ELS) sends to the ATC Center:

- aircraft identification,
- flight level.

The specific parameters related to the enhanced surveillance are:

- selected altitude,
- barometric pressure setting,
- roll angle,
- track angle rate,
- true track angle,
- ground speed,
- true air speed,
- magnetic heading,
- indicated airspeed,
- mach,
- barometric altitude rate,
- inertial vertical velocity.

The communication is made through modes S transponder.

The ADS gives more data to the ATC Center, for example:

- aircraft position,
- GPS altitude,
- aircraft speed,
- aircraft ground speed.

ENHANCED SURVEILLANCE TO AUTOMATIC DEPENDANT SURVEILLANCE

The ADS also sends to the ATC center more parameters than those of Enhanced Surveillance (EHS), but the communication is done differently.

ADS-B AND ADS-C

There are two types of ADS: ADS-Broadcast (ADS-B) and ADS-Contract (ADS-C). These two types of ADS are very different, because they do not use the same system.

The ADS-B is an application of the Mode S transponder. Thus, this application is hosted by the transponder. ADS-B broadcasts extended squitters to report data. A Mode S receiver is necessary to collect broadcasted data. No data link is necessary. Because ADS-B uses the transponder aerial, the range limit is 120NM. All units (ground or airborne) that have an ADS-B receiver can pick up broadcasted data.

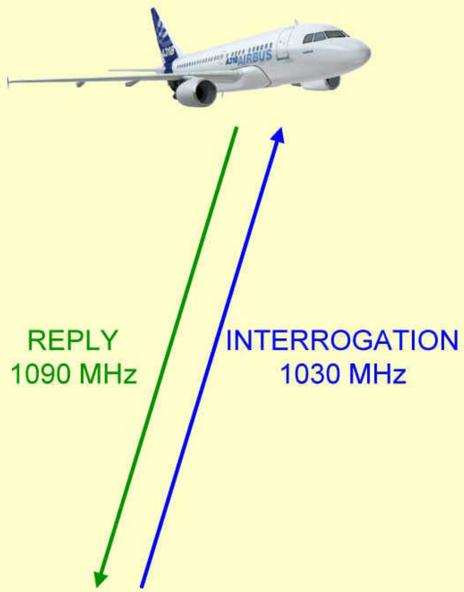
The specific parameters related to the extended squitters are:

- altitude,
- longitude,
- latitude,
- movement,
- ground track,
- flight number,
- E/W velocity,
- N/S velocity,
- vertical rate.

NOTE: This data is also send on ground when the ATC selector is set to AUTO position!

The ADS-C application is hosted by the ATSU and reports data requested in a contract made between the airborne system and the ATC ground system. ADS-C is an end-to-end application. ADS-C uses the almost worldwide data link range and can track aircraft out of SSR coverage.

ELEMENTARY/ENHANCED SURVEILLANCE
TRANSPONDER MODES A, C, S



SECONDARY SURVEILLANCE RADAR

AUTOMATIC DEPENDANT SURVEILLANCE-BROADCAST (ADS-B)
MODE S TRANSPONDER (NO ROUTING FROM ATSU)

NO INTERROGATION

ACTIVE ON GND IN AUTO MODE

ADS-B :

Automatic : No action necessary from flight crew
Dependant : Aircraft position given by aircraft
Surveillance
Broadcast : Transmission of data without solicitation

ADS-B sends aircraft parameters :
- when the aircraft is in flight
- when the aircraft is on ground

Figure 50 ADS-B Operation

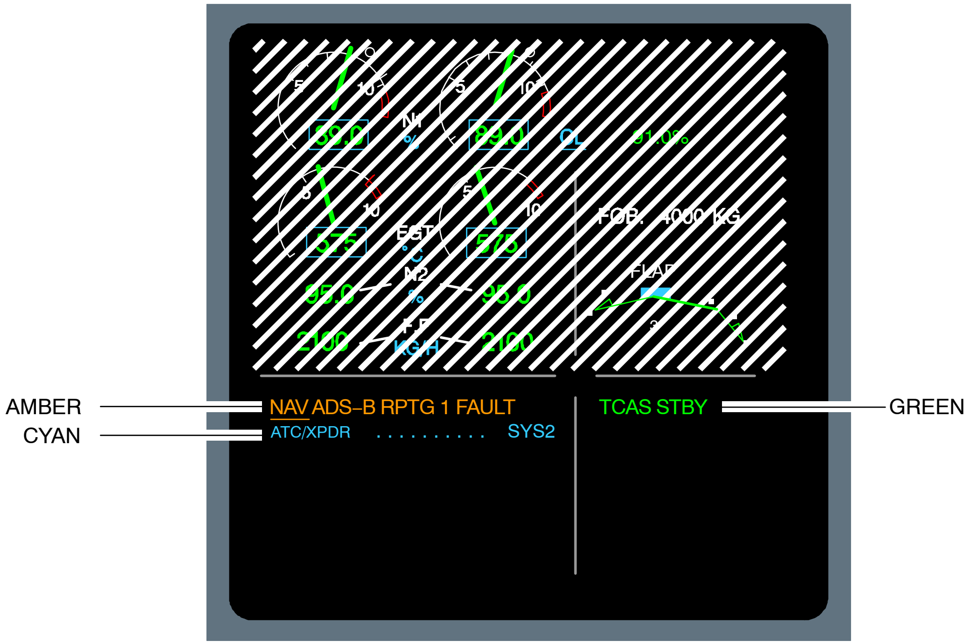
ADS-B OPERATION

The transponder provides Mode S transponder functions, including Elementary Surveillance (ELS), Enhanced Surveillance (EHS) and Automatic Dependant Surveillance –Broadcast (ADS–B OUT)

With the ADS–B OUT capability, the Mode S transponders automatically and continuously transmit surveillance data, without preliminary interrogation.

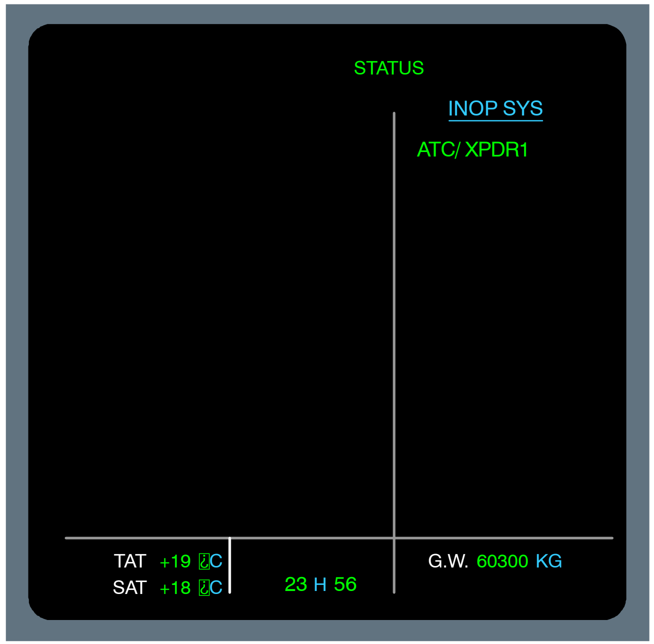
		A/C ON THE GROUND	A/C IN FLIGHT (OR IN SIMULATED FLIGHT CONDITION)
ATC/TCAS CONTROL UNIT	AUTO POSITION	THE TRANSPONDER: – DOES NOT REPLY TO MODE A OR MODE C INTERROGATIONS. – DOES NOT REPLY TO MODE S ALL–CALL INTERROGATIONS. – DOES NOT TRANSMIT THE ACQUISITION SQUITTER (DF11). – TRANSMITS THE EXTENDED SQUITTER (DF17). – IS NOT INTERROGATED BY THE TCAS OF OTHER AIRCRAFT (BECAUSE IT IS ”SEEN” ON THE GROUND). IN THIS CASE, THE AIRCRAFT WILL APPEAR ON THE TRAFFIC CONTROLLER’S SCREEN, BUT WILL NOT BE DISPLAYED/TRACKED BY THE TCAS OF THE OTHER AIRCRAFT.	THE TRANSPONDER: – REPLIES TO MODE A OR MODE C INTERROGATIONS. – REPLIES TO MODE S ALL–CALL INTERROGATIONS. – TRANSMITS THE ACQUISITION SQUITTER (DF11) AND EXTENDED – IS INTERROGATED BY THE TCAS OF OTHER AIRCRAFT.
ATC/TCAS CONTROL UNIT	ON POSITION	THE TRANSPONDER: – REPLIES TO MODE A OR MODE C INTERROGATIONS, – REPLIES TO MODE S ALL–CALL INTERROGATIONS, – TRANSMITS THE ACQUISITION SQUITTER (DF11) AND EXTENDED. SQUITTER (DF17), – IS NOT INTERROGATED BY THE TCAS OF OTHER AIRCRAFT (BECAUSE IT IS ”SEEN” ON THE GROUND). IN THIS CASE, THE AIRCRAFT AND THE ALTITUDE OF THE AIRPORT WILL APPEAR ON THE TRAFFIC CONTROLLER’S SCREEN, BUT THE AIRCRAFT WILL NOT BE DISPLAYED/TRACKED BY THE TCAS OF THE AIRCRAFT IN APPROACH OR DEPARTURE.	SAME OPERATION AS IN AUTO MODE, AIRCRAFT INFLIGHT THE TRANSPONDER: – REPLIES TO MODE A OR MODE C INTERROGATIONS, – REPLIES TO MODE S ALL–CALL INTERROGATIONS, – TRANSMITS THE ACQUISITION SQUITTER (DF11) AND EXTENDED SQUITTER (DF17), – IS INTERROGATED BY THE TCAS OF OTHER AIRCRAFT.

Figure 51 Transmission on Ground and in FLight



MESSAGES DISPLAYED ON
UPPER ECAM DU (ENGINE/
WARNING DISPLAY)

TYPICAL



MESSAGES DISPLAYED ON
LOWER ECAM DU (SYSTEM/
STATUS DISPLAY)

TYPICAL

Figure 52 ADS-B Fault Indication

OPTIONAL REMOTE CONTROL BOX - FUNCTIONAL OPERATION

General

The anti hijack ATC mode can be activated from the anti hijack pushbutton switches (9SH1 & 2) which are located on the CAPT and F/O side consoles 619VU and 620VU. They can not be used to deactivate the anti hijack mode. Therefore they are covered with a protective cover.

The Remote ATC Control (RACT) box (8SH) is able to supply power for the ATC/Mode S Transponder (XPNDR) 1, even if the circuit breaker 5SH1 is pulled. Furthermore the RACT box can send the hijack ATC squawk code to the ATC XPNDR 1.

The ATC control unit in the cockpit is no more directly connected to the ATC XPNDR 1. In normal configuration the RACT box will send the Control Unit Inputs to the ATC XPNDR 1.

The ATC control unit is still connected to the ATC XPNDR 2 except the STBY/ON discrete which is controlled by the RACT box. This ensures that the ATC 2 system may be deactivated by the RACT box in case of hijack mode activation, which is only possible with ATC system 1.

Power Supply

Energization of each system is through:

- 115VAC ESS BUS SHEDDABLE 801XP via circuit breaker 5SH1 for system 1.
- 115VAC BUS 2 204XP via circuit breaker 5SH2 for system 2.
- 115VAC ESS BUS SHEDDABLE 801XP via circuit breaker 10SH for system 1 in hijack mode.
- 28VDC ESS BUS 801PP via circuit breaker 11SH for remote ATC control box.

Energization of the ATC control unit is done through the two circuit breakers 5SH1 and 5SH2.

System operation

If one of the two anti hijack pushbutton switches (P/B SW) is pressed the RACT Box will take over control of the ATC system.

ATC 2 system will by deactivated if it was active before. ATC 1 system will be energized by the RACT Box 115VAC power output. This makes sure that the system is energized even if the ATC 1 circuit breaker 5SH1 was pulled in the cockpit. The circuit breakers for the remote anti hijack function are located on the circuit breaker panels 106VU and105VU which are located in the left and right avionic compartment, which is not accessable from the cockpit.

Once activated the anti hijack system will continuously send the hijack squawk code via ATC XPNDR 1 to the ground. The ATC/TCAS control unit in the cockpit provides no more control over the system, so it can not be deactivated from the cockpit again. Only a system reset will deactivate the anti hijack function. This is done by a new power up of the ATC system.

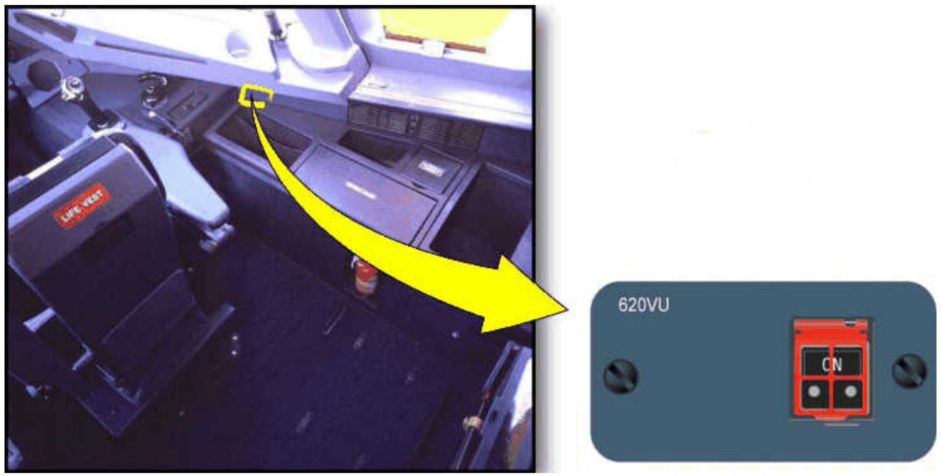


Figure 53 Anti Hijack P/B SW

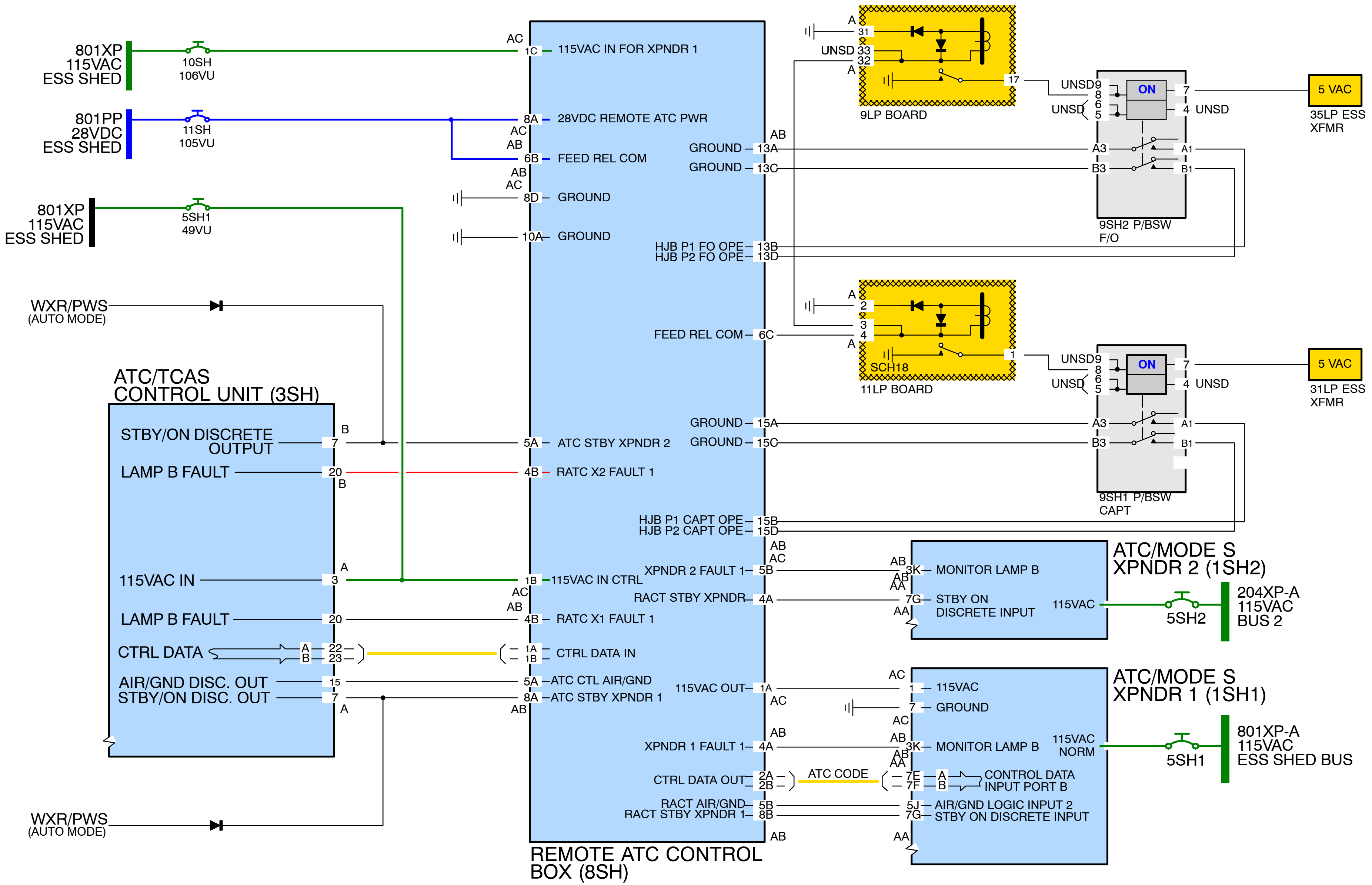


Figure 54 ATC Remote Box System (Option)

34–43 TRAFFIC COLLISION AVOIDANCE SYSTEM

TCAS INTRODUCTION

TCAS PRINCIPLE

The Traffic and Collision Avoidance System (TCAS) is a system whose function is to detect and display aircrafts in the immediate vicinity and to provide the flight crew with indications to avoid these intruders. The Traffic and Terrain Collision Avoidance System (T2CAS) is an optional system, which ensures the same functions as the TCAS.

NOTE: The TCAS II provides indications to avoid these intruders by changing the flight path in the vertical plane only.

The TCAS detects the Air Traffic Control (ATC) system or TCAS equipped aircraft and maintains surveillance within a range determined by its sensivity. To evaluate threat potential of other aircraft the system divides the space around aircraft into 4 volumes.

Other Traffic Volume

The other traffic volume is the first volume providing the presence and the progress of an intruder. The aircraft detected in this zone does not represent a collision threat.

Proximate Traffic Volume

The proximate traffic volume is defined by a given volume around the TCAS equipped aircraft. The aircraft detected in this zone does not represent a collision threat, but is declared in vicinity.

TA Volume

When the intruder is relatively near but does not represent an immediate threat, the TCAS (or T2CAS) provides aural and visual information known as Traffic Advisory (TA). The TCAS aural messages can be inhibited depending on higher priority aural messages.

RA Volume

When the intruder represents a collision threat, the TCAS triggers an aural and visual alarm known as Resolution Advisory (RA), which informs the crew about avoidance maneuvers.

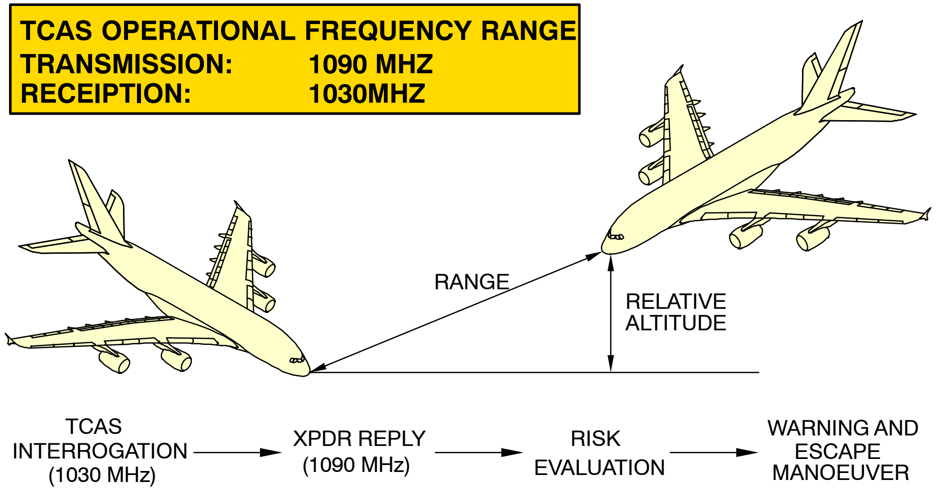
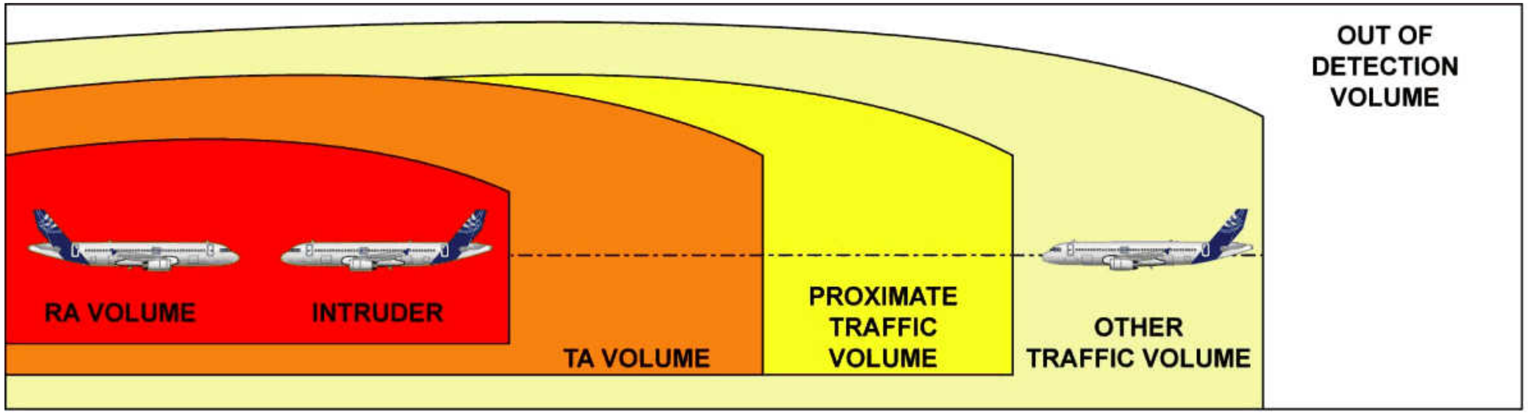


Figure 55 TCAS Principle



INTRUDER LOCATION / INTRUDER EQUIPMENT	RESOLUTION ADVISORY (RA) VOLUME	TRAFFIC ADVISORY (TA) VOLUME	PROXIMATE TRAFFIC VOLUME	OTHER TRAFFIC VOLUME	OUT OF DETECTION VOLUME
WITHOUT OPERATIVE ATC	NO DETECTION	NO DETECTION	NO DETECTION	NO DETECTION	NO DETECTION
WITH ATC MODE A	TA WITHOUT INTRUDER RELATIVE ALTITUDE	TA WITHOUT INTRUDER RELATIVE ALTITUDE	TRAFFIC INFORMATION WITHOUT INTRUDER RELATIVE ALTITUDE	TRAFFIC INFORMATION WITHOUT RELATIVE ALTITUDE	
WITH ATC MODE C OR S	RA WITHOUT A/C MANEUVER COORDINATION	TA WITH INTRUDER RELATIVE ALTITUDE	TRAFFIC INFORMATION WITH INTRUDER RELATIVE ALTITUDE	TRAFFIC INFORMATION WITH INTRUDER RELATIVE ALTITUDE	
WITH TCAS II or T2CAS if installed	RA WITH A/C MANEUVER COORDINATION				

ATC: Air Traffic Control

TCAS: Traffic alert and Collision Avoidance System

T2CAS: Traffic and Terrain Collision Avoidance System

Figure 56 TCAS Detection Principle

TCAS PRESENTATION

The TCAS II (Traffic Collision Avoidance System) is a system whose function is to detect and display aircraft in the immediate vicinity and to provide the flight crew with indications to avoid these intruders by changing the flight path in the vertical plane only.

The TCAS periodically interrogates their transponders, computes their trajectories and constantly determines their potential threat. The acquisition of their signals is achieved by means of two transmit/receive antennas, one located on the underside of the fuselage and the other on the top.

The system can establish individualized communications with each aircraft through ATC/Mode S transponders, thus permitting operation in dense traffic areas while avoiding an overload of radio-electric transmissions that would result from a general all-intruder response.

The TCAS II system is designed to provide the air traffic control system with an additional possibility. It usually operates independently but may be controlled from ground stations.

The TCAS has the capability to communicate with ATCRBS (Air Traffic Control Radar Beacon System) ground stations equipped with the Mode S system to indicate to them the vertical maneuver orders presented to the aircraft pilot. This information can facilitate the task of the ground station controller who, in turn, can modify the TCAS operating mode and cancel the avoidance orders if it deems it necessary for safety.

The system maintains surveillance within a sphere determined by the transmit power and receiver sensitivity of the TCAS computer. The area in which a threat is imminent depends on the speed and path of the own A/C and the threat A/C.

There is an area defined as TAU within the surveillance arc which represents the minimum time the flight crew needs to discern a collision threat and take evasive action.

The TCAS detection capability covers an area of 35-40 NM in range and plus or minus 9900 ft in altitude but display range is authorized up to plus or minus 2700 ft in altitude.

TCAS COMPONENTS

The TCAS (or T2CAS) components are two antennas, one TCAS II computer (or T2CAS computer) and one TCAS/ATC control panel.

NOTE: The TCAS/ATC control panel shown here after is given as example. It may differ according to the aircraft configuration.

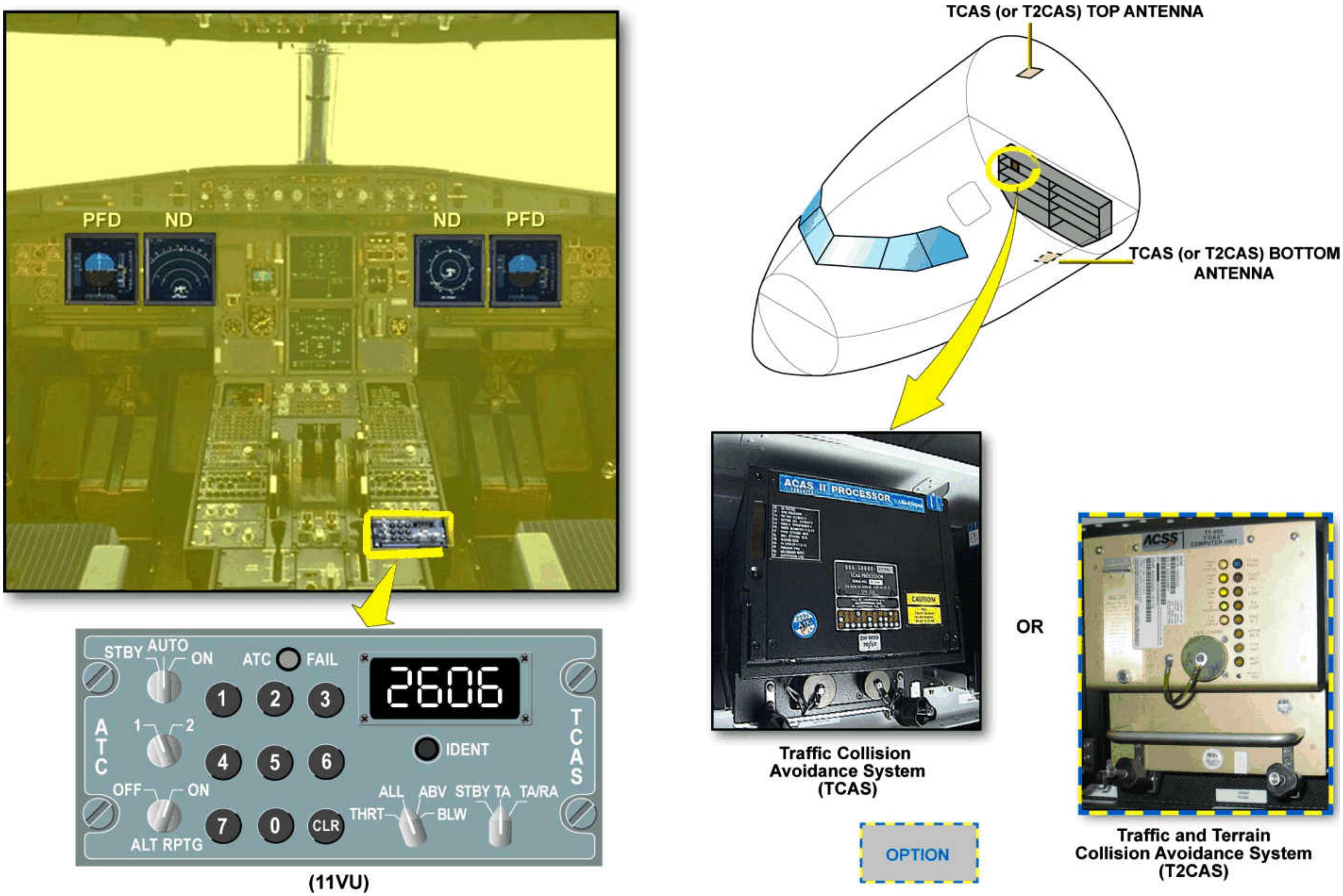


Figure 57 TCAS Components

TCAS INDICATION

NORMAL INDICATION ON PFD

A TCAS indication appears on PFD only in case of a resolution advisory (RA). So the system must be active and switched to TA/RA mode.

If a RA is initiated, red and/or green sectors are shown on the vertical speed scale of the PFD. There are two different types of RAs:

- **Preventive advisory**

  In this case, the advisory instructs the pilot to avoid certain deviations from current vertical speed rate to avoid a risk of collision. On the PFD vertical speed scales the forbidden values are indicated by red sectors.

- **Corrective advisory**

  In this case, the advisory instructs the pilot to change current flightpath (vertical plan only) to avoid a collision. On the vertical speed scale of the PFD, colored sectors indicate avoidance maneuvers to be performed:

  - red sector -> forbidden vertical speed (v/s)
  - green "fly to" sector -> a v/s range to be respected

NORMAL INDICATION ON ND

A TCAS indication on ND appears, when:

- the TCAS mode switch is in TA or TA/RA mode, and
- the ALT RPTG switch is ON, and
- the ATC transponder is not in STBY, and
- a ROSE or the ARC mode is selected on EFIS control panel.

DEFINITION OF TARGET AIRCRAFT

Target aircraft are divided into four categories:

- OTHER,
- PROXIMATE,
- TRAFFIC ADVISORY (TA),
- RESOLUTION ADVISORY (RA).

Other Traffic (Indication Optional)

Aircraft detected by the TCAS are defined as OTHER traffic if:

they are within + or - 2700 ft vertically of own aircraft

and if they do not enter in the PROXIMATE, TA or RA categories.

These targets are represented by a white diamond, outline only, on the ND.

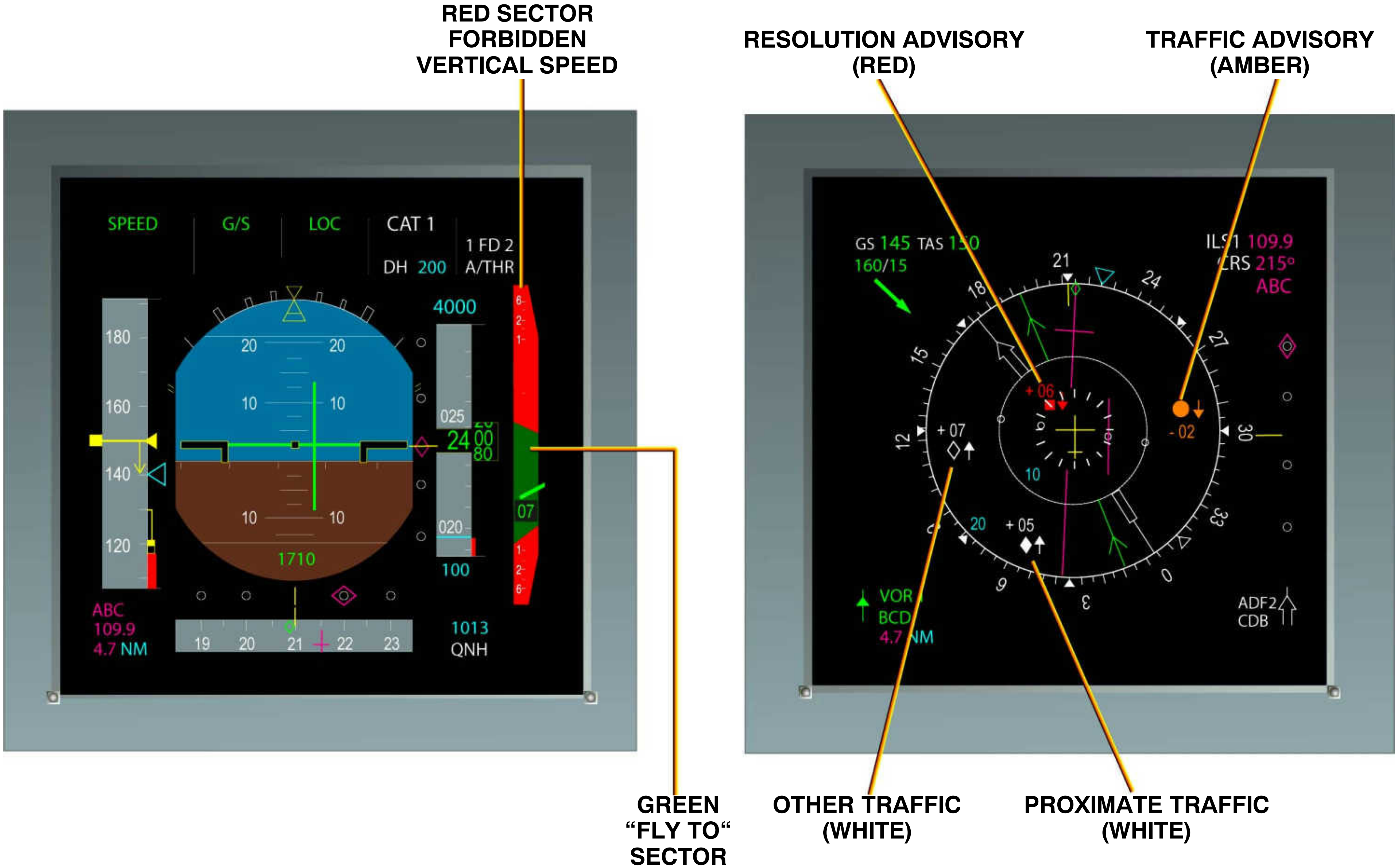


Figure 58 TCAS Indications General

TCAS INDICATION DESCRIPTION

NORMAL INDICATION ON PFD

A TCAS indication appears on PFD only in case of a resolution advisory (RA). So the system must be active and switched to TA/RA mode.

If a RA is initiated, red and/or green sectors are shown on the vertical speed scale of the PFD. There are two different types of RAs:

- **Preventive advisory**

  In this case, the advisory instructs the pilot to avoid certain deviations from current vertical speed rate to avoid a risk of collision. On the PFD vertical speed scales the forbidden values are indicated by red sectors.
- **Corrective advisory**

  In this case, the advisory instructs the pilot to change current flightpath (vertical plan only) to avoid a collision. On the vertical speed scale of the PFD, colored sectors indicate avoidance maneuvers to be performed:
  - red sector −> forbidden vertical speed (v/s)
  - green ”fly to” sector −> a v/s range to be respected

Aural Alerts

Trajectory correction or holding visual orders are accompanied by synthesized voice announcements whose level cannot be adjusted by the pilot. These announcements are generated by the TCAS computer and broadcast via the cockpit loud speakers.

These messages and their meanings are described below:

- ”**CLIMB, CLIMB**“**,**

  Climb at the rate shown by the green sector on the PFD (1500 ft/min).
- ”**CLIMB, CROSSING CLIMB, CLIMB, CROSSING CLIMB**”**,**

  As above except that it further indicates that own flight path will cross through that of the intruder.
- **”INCREASE CLIMB, INCREASE CLIMB**”,

  Follows a ”climb” advisory. The vertical speed of the aircraft should be increased (2500 ft/min).
- ”**CLIMB, CLIMB NOW, CLIMB, CLIMB NOW**”,

  Follows a ”descend” advisory when a reversal in sense is required to achieve safe vertical separation from a maneuvering intruder.
- **”DESCEND, DESCEND**”,

  Descend at the rate indicated by the green sector on the PFD(−1500 ft/min).
- ”**DESCEND, CROSSING DESCEND, DESCEND, CROSSING DESCEND**”**,**

  As above except that it further indicates that own flight path will cross through that of the intruder.
- **”INCREASE DESCENT, INCREASE DESCENT**”,

  Follows a ”descend” advisory. The vertical speed of the descent should be increased (−2500 ft/min).
- ”**DESCEND, DESCEND NOW, DESCEND, DESCEND NOW**”,

  Follows a ”climb” advisory when a reversal in sense is required to achieve safe vertical separation from a maneuvering intruder.
- ”**ADJUST VERTICAL SPEED, ADJUST**”,

  Reduce vertical speed to that shown by the green sector on the PFD. It can correspond to a corrective reduce climb or reduce descent. It can also represent a weakening of corrective RA.

Four other aural advisories are also generated:

- **‘‘MONITOR VERTICAL SPEED**”,

  Indicates that a forbidden vertical speed range exists (red sector) and that pilot must monitor vertical speed so as not to enter this range (Preventive Advisory).
- ”**MAINTAIN VERTICAL SPEED, MAINTAIN**”,

  Indicates a non−crossing advisory type, maintains rate RA’s (corrective).
- ”**MAINTAIN VERTICAL SPEED, CROSSING MAINTAIN**”,

  Indicates an altitude crossing advisory type, maintains rate RA’s (corrective). These messages are spoken only once if softening from a previous corrective advisory,
- ”**CLEAR OF CONFLICT**”

  Indicates that separation has been achieved and range has started to increase.

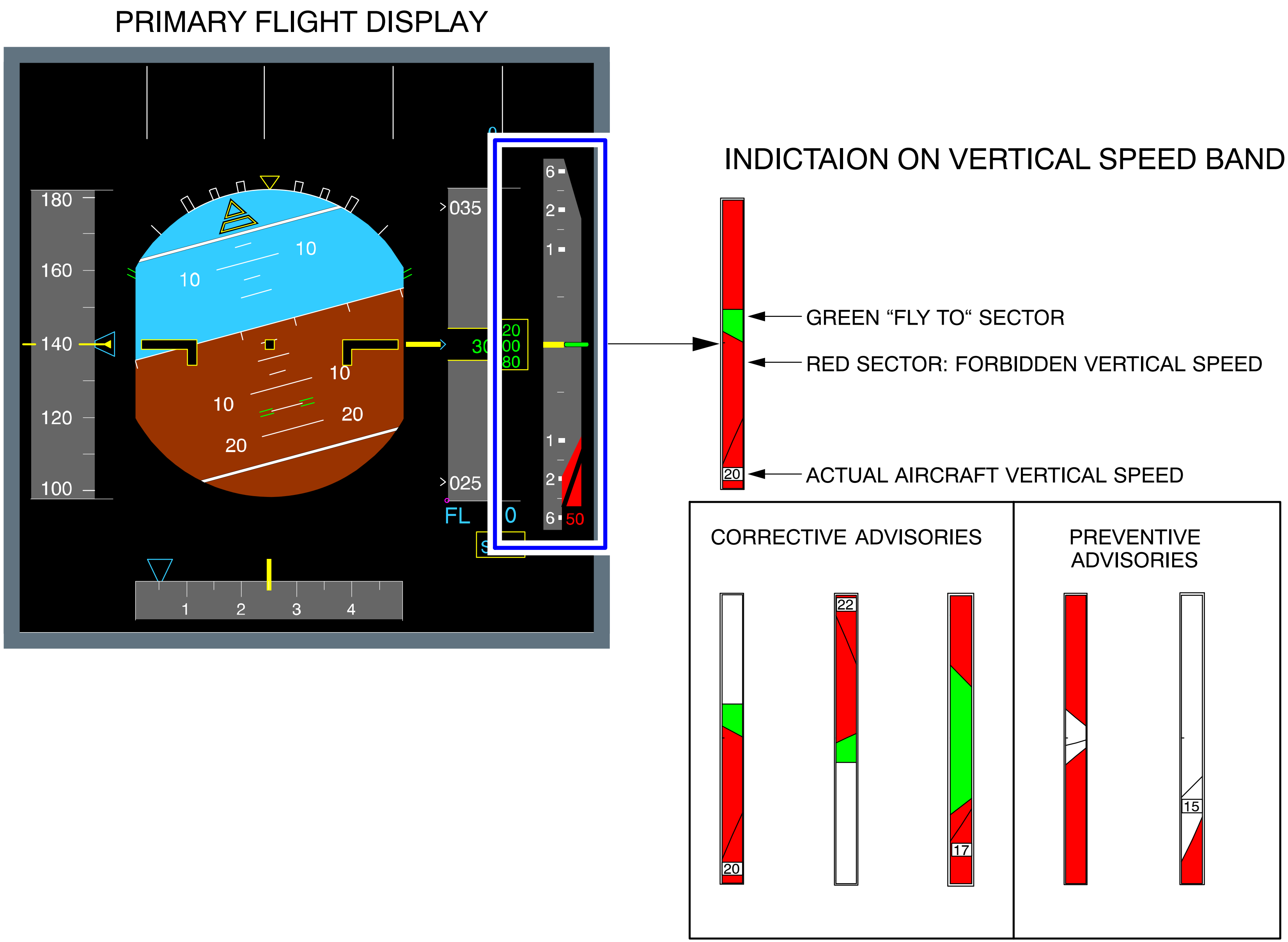


Figure 59 TCAS Indication on PFD

NORMAL INDICATION ON ND

A TCAS indication on ND appears, when:

- the TCAS mode switch is in TA or TA/RA mode, and
- the ALT RPTG switch is ON, and
- the ATC transponder is not in STBY, and
- a ROSE or the ARC mode is selected on EFIS control panel.

DEFINITION OF TARGET AIRCRAFT

Target aircraft are divided into four categories:

- OTHER, PROXIMATE, TRAFFIC ADVISORY (TA), RESOLUTION ADVISORY (RA).

Other Traffic (Indication Optional)

Aircraft detected by the TCAS are defined as OTHER traffic if:

they are within + or – 2700 ft vertically of own aircraft

and if they do not enter in the PROXIMATE, TA or RA categories.

These targets are represented by a white diamond, outline only, on the ND.

Proximate Aircraft

Targets are defined as proximate traffic if the difference between their altitude and that of the TCAS aircraft is less than 1200 ft and if their range is within 6 NM. Their presentation on the ND is conditioned by the presence of another TA or RA intruder. Generally aircraft not in the immediate vicinity enter into this category. Depending on their trajectory, they may:

- conserve this status and move away without an advisory being declared.

  In this case the pilot is informed of their presence on the ND by a white filled diamond symbol and can monitor their progress, or
- have a trajectory liable to lead to a conflict situation and in this case they require a traffic advisory and their symbol changes.

Traffic Advisory Aircraft (TA)

When an intruder is relatively near but does not represent an immediate threat the TCAS issues a traffic advisory. Its presence is displayed on the ND by an amber filled circle. Its display is accompanied by an aural alert ”Traffic Traffic”. The pilot is therefore aware of its presence and knows its range and relative bearing. Its display is linked to vertical separation and time TAU before CPA values. Depending on its trajectory, an intruder may conserve this status and move away, or it may become a collision threat. In this case avoidance maneuvers are suggested to the pilot via a resolution advisory.

Resolution Advisory Aircraft

In resolution displays, the intruder is represented on the ND by a red filled square and corrective orders are issued on the vertical speed scale of the PFD. Crossing into resolution advisory occurs for a TAU time threshold 10 to 15 seconds lower than a traffic advisory threshold.

Vertical separation between the two aircraft is also taken into account for this category. There are two types of resolution advisory, in function of the vertical separation value:

- Preventive Advisories
- Corrective Advisories.

The symbols are positioned on the ND so as to depict their relative bearing and range. Data tags are associated with intruders. These tags consist of:

- two digits indicating their relative altitude in hundreds of feet
- a symbol indicating whether the intruder is above (+) or below (–) the aircraft.
- an arrow to the right of the symbol indicates the vertical trend of the aircraft (v/s > ±500ft/min).

These indications are only present for the 10, 20 and 40 NM range selection. If a TA or RA type intruder is detected at wrong range or mode selection, messages come into view on the ND.

If the range is 20 or 10 NM, a white range ring with markings at each of the twelve clock positions is placed around the own aircraft symbol at a radius of 2.5 NM.

Only the 8 most threatening intruders are displayed.

NOTE: Since the Display Management Computers (DMC) do not sort the OTHER intruders, the latter are not presented on the NDs. Their presentation is optional. It is activated by pin programming and replacement of ATC/TCAS control unit (ALL TRAFFIC configuration).

Status messages

- If the TCAS is in TA mode, the “TA ONLY“ message comes into view at the bottom of the ND to indicate, that no RA are possible.

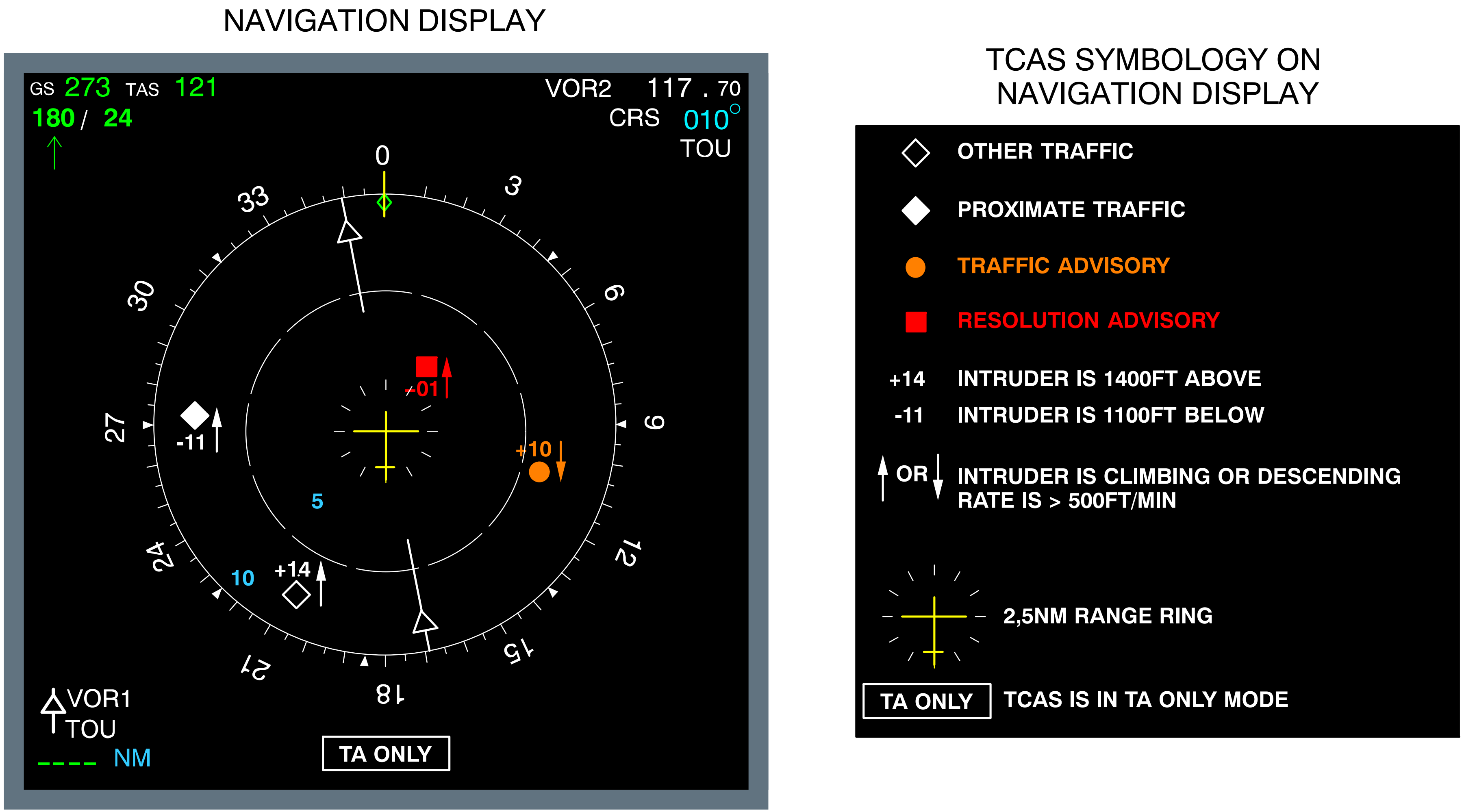


Figure 60 TCAS Indication on ND

TCAS SYSTEM DESCRIPTION

System Description

The TCAS environment is composed of items closely associated with its operation, such as the transponders and the EFIS display units and peripherals supplying parameters or with maintenance functions.

The TCAS computer is the heart of the TCAS II system.

It ensures two main functions:

- a radio-electric transmission reception function in the L-band frequency for intruder acquisition,
- a processing function ensuring total operation control: digital, discrete and analog-type interfaces, intruder trajectory computation and tracking, visual and aural alert commands.

Display

Advisories are displayed by the Electronic Instrument System (EIS) by high speed transmission of ARINC 429 messages on the buses linking the TCAS to the DMCs 1 on one hand and to the DMC 2 on the other hand. Depending on the EFIS DMC selection, the DMC 3 receives either the TA/RA display bus 1 (CAPT3/NORM positions) or the TA/RA display bus 2 (FO3 position). The FWCs connected in parallel on these buses monitor the validity of the information.

The NDs provide indications on the location of intruders in the traffic area. The PFDs provide the flight crew with vertical speed correction information to avoid them.

The ECAM system also presents warning messages.

Directional Antennas

The TCAS has two antennas, one located on the top of the aircraft and the other on the underside of the fuselage. These antennas, of the transmit/receive type, provide azimuth information on aircraft located within the TCAS surveillance range. They consist of four independent elements. In reception, the amplitude of the signals received by each element depends on the direction of the signal source, which permits the relative bearing of the transmitting aircraft to be determined.

ATC/TCAS Control Unit

The ATC/TCAS control unit common to the ATC transponders and the TCAS, enables the operating modes of these two items of equipment to be selected. Information intended for the TCAS is transmitted via an ARINC 429 bus to the transponders which in turn transmit it to the TCAS computer.

ATC/Mode S Transponders

Two ATC/Mode S transponders, one active and the other on standby, are used with their antennas. Each transponder is ARINC 429 linked to the TCAS. Apart from the specific transponder functions (response to ATC ground station interrogations) they permit communication between the TCAS and a TCAS-equipped detected aircraft.

Peripherals

The TCAS receives information from the following equipment:

- Radio Altimeter (permits modulation of system sensitivity and triggering of inhibit orders).
- Air data system (fulfils the same functions as radio altitude information but for the range over 2500 ft).
- Inertial reference system (magnetic heading and pitch and roll attitude information)
- Landing Gear Control and Interface Unit (ground/flight & landing gear extended signal).
- Centralized Fault Display Interface Unit (BITE).
- Data Loader (load software data into the TCAS).
- Flight Data Interface Unit (receives TCAS data from the DMC).
- Various discrete signals (advisory inhibit by windshear, stall and ground proximity warning).
- Pin programming

  (used to set the audio level output, intruders are only displayed if a TA or RA is presented, aircraft is on the ground TA mode only, maximum number of intruders = 8, 48,000 ft aircraft altitude limit inhibits climb orders).

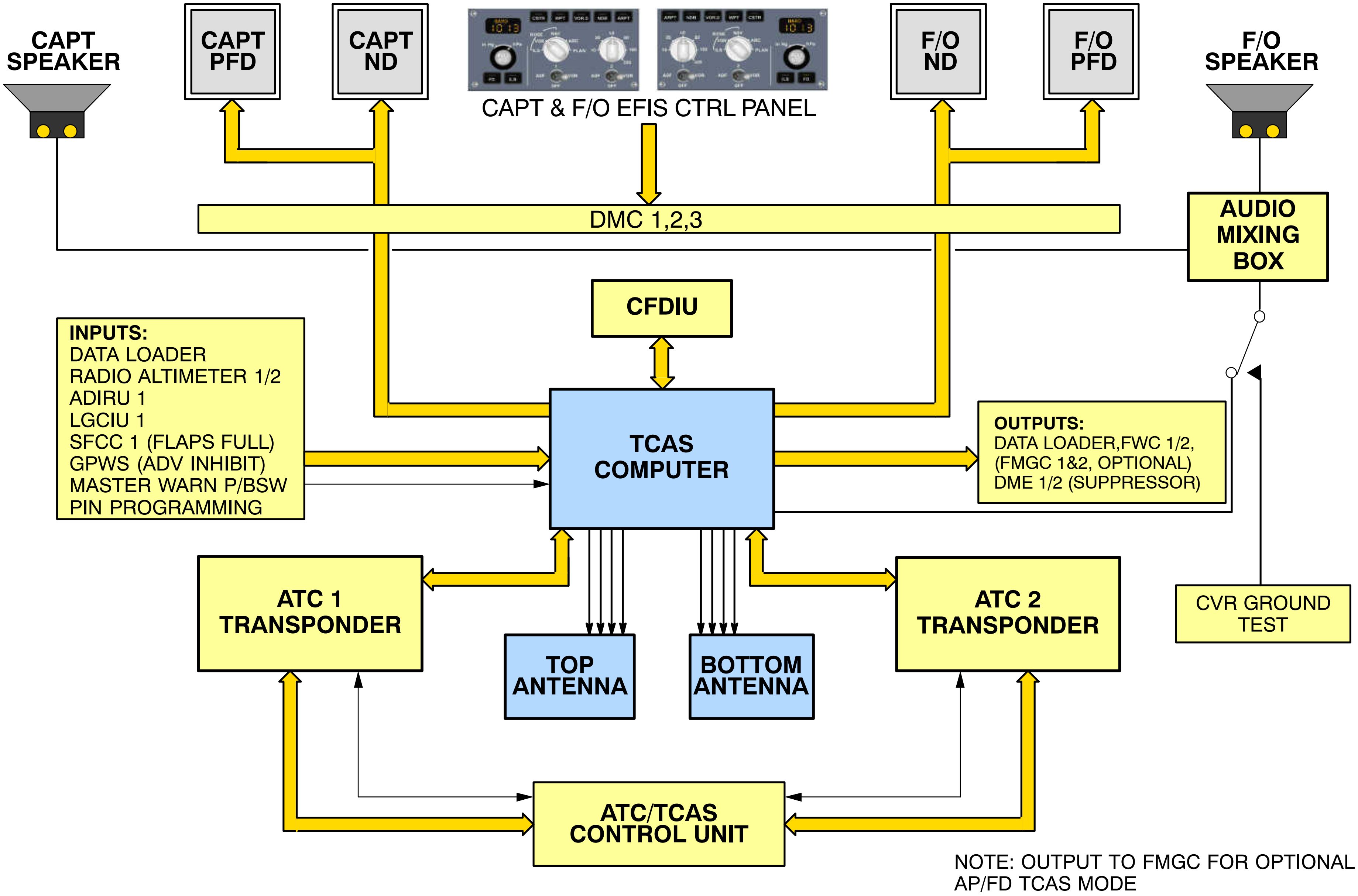


Figure 61 TCAS Schematic

ATC/TCAS CONTROL UNIT DESCRIPTION

1 TCAS modes of indication

- **THRT mode**

  Proximate and other intruders are displayed on the ND only, if a TA (Traffic Advisory) or RA (Resolution Advisory) is present, and they are within 2700 feet above and 2700 feet below the aircraft.
- **ALL mode:**

  This selection enables display of all intruders without any conditions.

  The altitude range is -2700 feet to +2700 feet.
- **ABV and BLW modes:**

  This selection controls the above and below vertical altitude for traffic advisory:
  - **ABV:** altitude range is set to 9900 ft above the aircraft and 2700 ft below.
  - **BLW:** altitude range is set to 9900 ft below the aircraft and 2700 ft above.

2 TCAS modes of operation

- **STBY mode**

  In the Standby Mode, the advisory generation and surveillance functions are inhibited. No TCAS information can be displayed on the PFDs and NDs. The aircraft symbol and the range ring remain on the ND and vertical speed information is not displayed on the PFD.

  The green **TCAS STBY** message is displayed in the memo section of the upper ECAM DU.
- **TA mode:**

  In this mode, intruders are displayed on the ND according to their position in the airspace. The RA type intruder symbols are converted into TA type symbols. The TCAS performs surveillance functions but does not generate any vertical orders (Resolution Advisories).

  The boxed TA ONLY message is displayed in white on the ND at the bottom.
- **TA/RA mode (Normal Position):**

  The TCAS performs all TA mode functions and also issues preventive or corrective resolution advisories, represented in the form of colored sectors along the vertical speed scale on the PFD.

  The sensitivity level is determined automatically in function of altitude.

NAVIGATION DISPLAY

ATC/TCAS CONTROL UNIT (3SH)
TA/RA SELECTED

NAVIGATION DISPLAY

ATC/TCAS CONTROL UNIT (3SH)
TA SELECTED

Figure 62 TCAS Modes of Operation

TCAS OPERATION

GENERAL

The Traffic alert and Collision Avoidance System (TCAS) includes:

- one control unit common with Air Traffic Control (ATC) system,
- one TCAS computer,
- two antennas (1 top and 1 bottom).

NOTE: As an option, the Traffic alert and Collision Avoidance System (TCAS) part of the Traffic and Terrain Collision Avoidance System (T2CAS) can replace the TCAS.

ANTENNA

The TCAS directional antennas provide azimuth information on aircraft located within the TCAS surveillance range. They transmit at 1.030 MHz and receive at 1.090 MHz. The phase and amplitude of the received signal depend on the direction of the signal source, which permits the relative bearing of the transmitting aircraft to be determined.

SUPPRESSOR

The TCAS , ATC, and the Distance Measurement Equipment (DME) operate in the same frequency range. A suppressor signal is transmitted, via a coaxial, by the operating system to inhibit the other systems and to prevent simultaneous transmission.

CONTROL PANEL

The operating modes of the TCAS are selected on a common ATC/TCAS control panel. The TCAS information is transmitted to the TCAS computer via the ATC transponder.

AIR TRAFFIC CONTROL SYSTEM

The operative ATC mode S transponder transmits response to ATC ground station interrogations and data to the TCAS: Barometric altitude, TCAS mode from control panel, TCAS broadcast messages. The Mode S transponder permits communication between the TCAS and a TCAS equipped and detected aircraft through the communication link function for exchanging coordination messages.

RADIO ALTIMETER

The RA transceivers provide radio height used as reference to determine the computation sensitivity level and trigger the inhibit orders. The radio height is used in the 0 to 2.500 ft range.

ADIRU

The Air Data System (ADR) part of the Air Data/Inertial Reference Unit (ADIRU) provides barometric altitude information fulfils the same functions as radio altitude information but for the range over 2500 ft. The ADIRU, which is not directly linked to the TCAS computer, transmits this information to the computer across the transponders via the ARINC 429 buses.

The Inertial Reference (IR) part of the ADIRU provides the magnetic heading and the pitch and roll attitude information to the TCAS computer.

NOTE: The barometric altitude is transmitted via the ATC transponder.

LANDING GEAR CONTROL & INTERFACE UNIT

The Landing Gear Control and Interface Unit (LGCIU) provides a flight/ground signal used by the BITE module for flight leg counting. It provides also a landing gear extended signal for TCAS operation.

PIN PROGRAMMING

Some pin programs define the operating mode of the TCAS.

Discrete pin program inputs are used:

- audio level to set the audio level of the synthetic voice output,
- all traffic/threat traffic display at Threat Traffic indicates that intruders are only displayed if a TA or RA is presented,
- ground display mode: specifies that the display mode, when the aircraft is on the ground, is the TA mode only,
- display intruder limit: indicates the maximum number of intruders that can be displayed (max 8)
- aircraft altitude limit, configured at 48,000 ft informs the TCAS computer that it must inhibit climb orders above this altitude.

DATA LOADER

It will be possible to load software data into the TCAS computer by means of a data loader. When the A/C is equipped with a Mulitpurpose Disc Drive Unit (MDDU) there is a connection to the Data Loading Routing Box and software loading with a Portable Data Loader is needless.

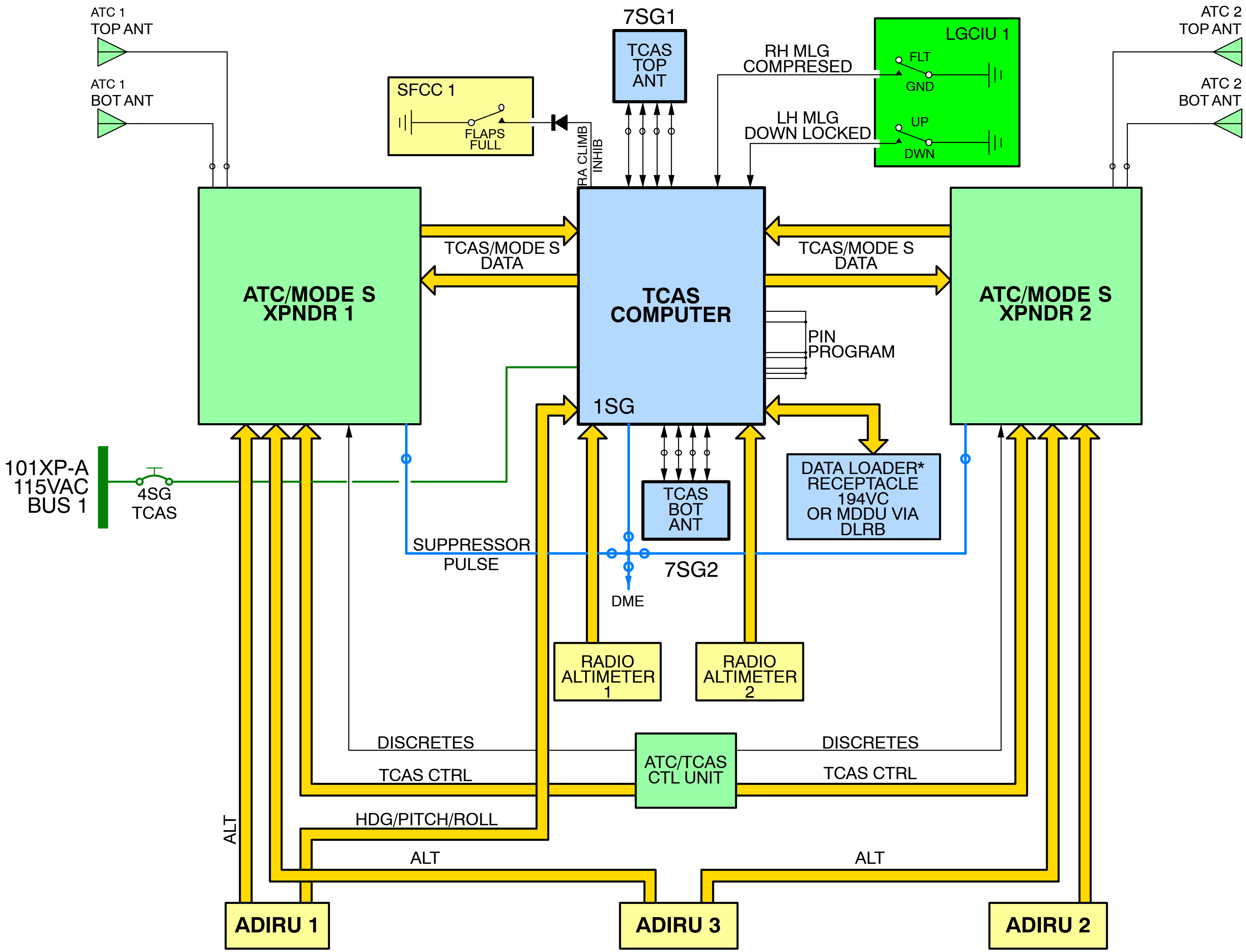


Figure 63 TCAS Data Acquisition Schematic

TCAS OPERATION (CONTINUED)

TCAS COMPUTER

The TCAS computer ensures two main functions:

- a transmission/reception function for intruder acquisition,
- a processing function for operation control: Digital, discrete and analog types interfaces, intruder trajectory computation and tracking, visual and aural alert commands.

POWER SUPPLY

The TCAS is supplied with 115VAC, 100 watt power rating. The ATC/TCAS control unit, common to the transponders and the TCAS, is also supplied with 115VAC:

- the 115VAC BUS1 101XP supplies the TCAS via circuit breaker 4SG
- the 115VAC SHED ESS BUS 801XP supplies the ATC1 system via circuit breaker 5SH1
- the 115VAC BUS2 204XP supplies the ATC2 system via circuit breaker 5SH2.
- ATC/TCAS control unit is energized through the two circuit breakers 5SH1 and 5SH2.

INDICATING

Visual indications are presented on the NDs and PFDs. The NDs present the location of intruders in the traffic area. The PFDs present the avoidance maneuver indications on the vertical speed scale. The Flight Warning Computers (FWCs) monitor the validity of the information.

Synthesized voice announcements generated by the TCAS computer and broadcast by the loudspeakers accompany the visual indications.

AUDIO MIXING BOX

An audio mixing box mixes the predictive windshear warning synthetic voice with the CVR test (on ground only) or the TCAS voice. The purpose of the audio mixing box is to sum low-frequency audio signals after level and independance matching.

FLIGHT DATA INTERFACE UNIT (FDIU)

The FDIU receives TCAS data from the DMC.

The following parameters are recorded by the FDIU:

- RA related information:
  - advisory rate to maintain,
  - combined control,
  - vertical control,
  - up advisory,
  - down advisory.
- manual sensitivity level (SL),
- TA issued or not.

INHIBITION

Various discrete signals are used for inhibition by equipment with higher priority than the TCAS. These priorities are:

- Stall,
- WindShear,
- Predictive WindShear (PWS),
- Enhanced Ground Proximity Warning System (EGPWS) messages.

CFDIU

The Centralized Fault Display Interface Unit (CFDIU) allows testing and trouble-shooting of the TCAS through the MCDU. The tests are only available on ground.

FMGC (OPTIONAL)

The new AP/FD TCAS mode completes the existing TCAS functionality by implementing a TCAS vertical guidance feature into the Auto Flight computer. This new mode controls the Vertical Speed (V/S) of the aircraft on a vertical speed target - acquired from TCAS - adapted to each RA.

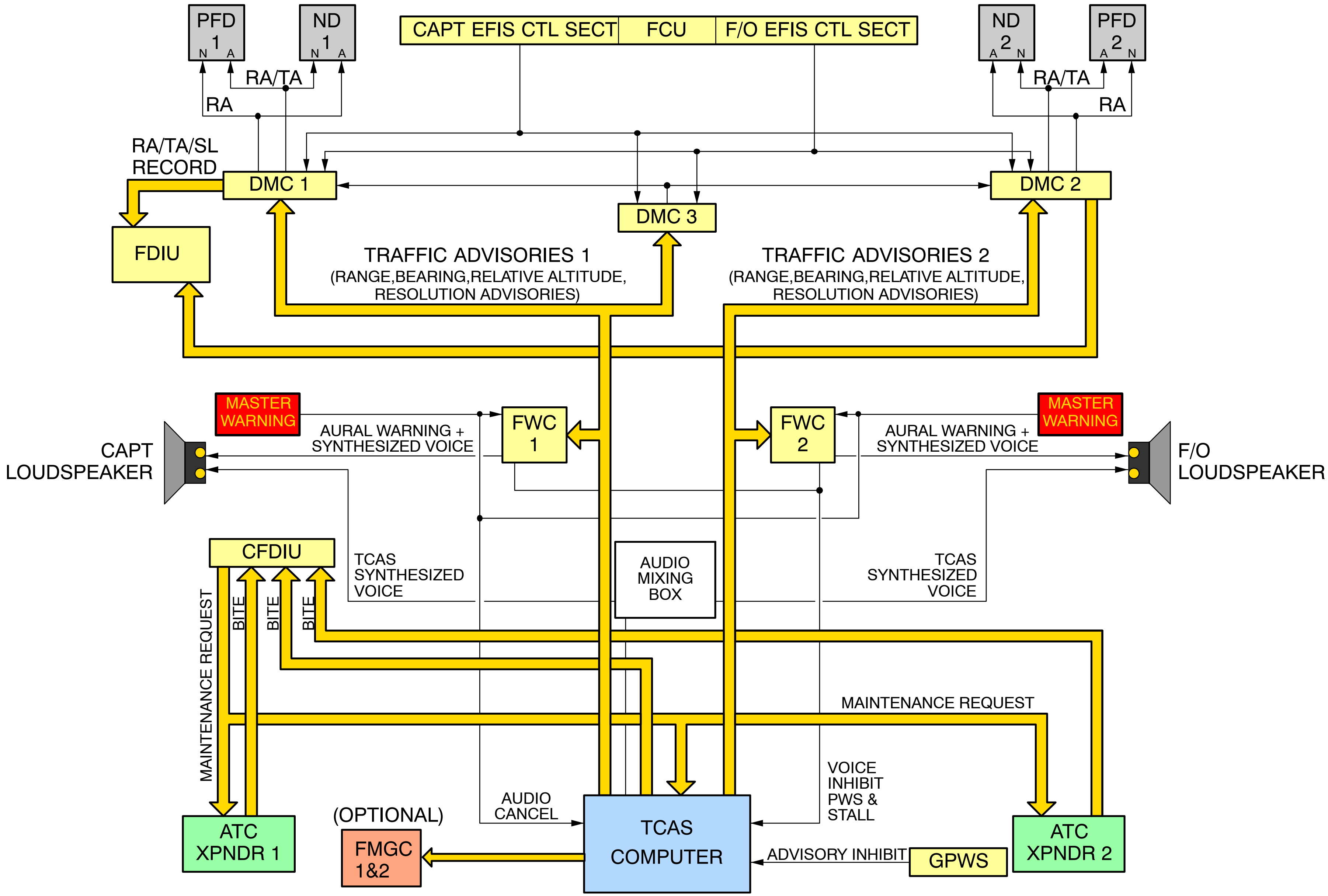


Figure 64 TCAS BITE, Warnings and Indication Schematic

TCAS SENSITIVITY LEVELS DESCRIPTION

ADVISORY INHIBIT CONDITIONS

In certain particular conditions, certain advisories are not generated as they could lead to the pilot adopting flight conditions that are hazardous or outside the aircraft's performance capability.

Low Altitude Inhibitions

Ground proximity leads to the inhibition of those advisories liable to cause a hazardous situation at this level. In decreasing altitude, these are:

- below 1550 +/− 100 ft above ground level (AGL) inhibition of "Increase Descend" resolution advisories (RA),
- below 1100 +/− 100 ft AGL, inhibition of "Descend" resolution advisories (RA),
- below 1000 ft +/− 100 ft AGL, TCAS automatic switching to TA Only mode (inhibition of all resolution advisories),
- below 500 +/− 100 ft AGL (600 ft in climb, 400 ft in descent), inhibition of all resolution advisories (RA) and of aural traffic advisories (TA).

High Altitude Inhibition

Above 48,000 ft, further climb orders are inapplicable as the aircraft performance capability does not permit them to be taken into account.

"Climb" advisories are therefore inhibited above this altitude.

Advisory Inhibit Discretes

Three discretes are used to manage priority between:

- windshear/stall,
- GPWS − G/S,
- and the TCAS computer.

The environmental alert priorities are: windshear/stall, GPWS − G/S and then TCAS II.

When TCAS II is inhibited, the TA ONLY mode is selected and the voice announcements are cancelled.

Rejection of Signals from Aircraft on Ground

Aircraft on the ground may reply to TCAS interrogations, producing an unnecessary overload in the processing and display of information. The ground logic "aircraft declared on the ground" is enabled when the own aircraft descends below 1650 ft AGL and when it climbs up to 1750 ft AGL.

All on−ground intruders are displayed as non−threat traffic white unfilled diamond.

Intruders are declared to be on−ground if they are within 380 ft from the ground when descending, and if they are within 400 ft from the ground when climbing. Intruders declared to be on−ground can never cause proximate, traffic or resolution advisory.

But, as the altitude transmitted by the intruder is a barometric altitude with respect to sea level, the TCAS shall process this value to convert it into height above ground level in order to compare it with the 380 ft (plus or minus 20 ft) threshold.

Rejection of Non Altitude Reporting Aircraft by The Own Aircraft

The TCAS does not display "non altitude reporting aircraft" above 15,500 ft MSL.

SENSITIVITY LEVEL

The notion of sensitivity level is very important in the TCAS as many of the operating modes depend on it.

The TCAS separates the surrounding airspace into altitude layers. A different Sensitivity Level (SL) threshold for issuing advisories is applied to each altitude layer.

The sensitivity level is decreased at low altitude to prevent unnecessary advisories in higher traffic densities such as terminal areas.

Generally, the level is determined automatically by the TCAS in function of:

- altitude values from the radio altimeter up to 2500 ft AGL,
- barometric altitude values in the 2500 ft to 48,000 ft range.

  TAU values corresponding to each sensitivity level indicate the TA and RA thresholds. The vertical separation thresholds at CPA also vary in function of the sensitivity level for the different types of advisory.

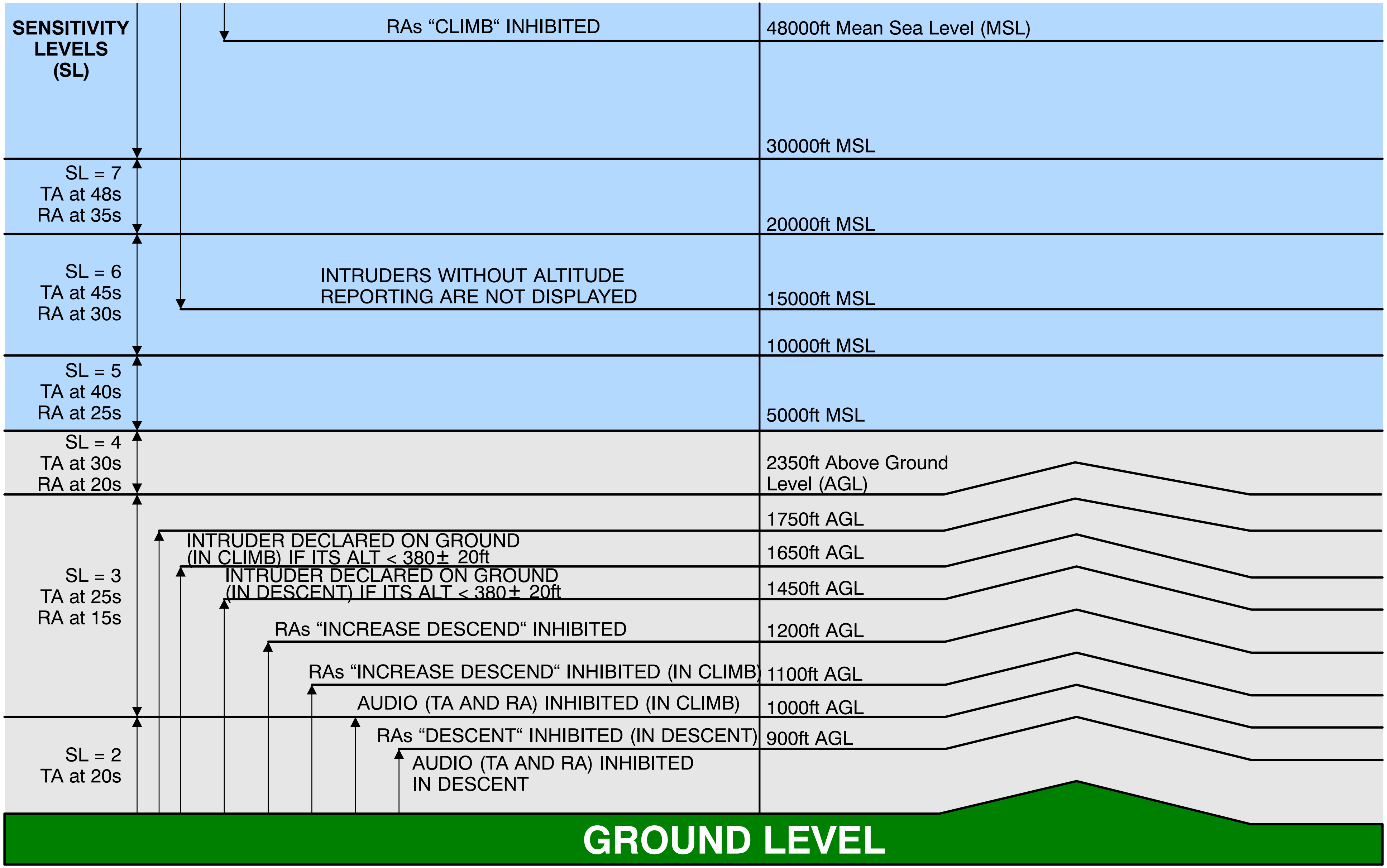


Figure 65 TCAS Sensitivity Levels

TCAS COMPONENT DESCRIPTION

TCAS COMPUTER

The TCAS computer is the heart of the TCAS II system.

It complies with the dimensional standard in ARINC 600 for 6 MCU form factor.

It is compatible with ARINC 600 forced air cooling.

It ensures two main functions:

- a radio–electric transmission reception function in the L–band frequency for intruder acquisition
- a processing function ensuring total operation control: digital, discrete and analog–type interfaces, intruder trajectory computation and tracking, visual and aural alert commands.

Self Test

A quick check of the correct operation of the TCAS installation can be performed by activating the TEST function:

- either by pressing the pushbutton switch on the front of the TCAS computer,
- or through the CFDIU by applying the procedure TCAS functional test on the MCDU.

The self–test sequence checks the main functions of the computer and transmits to the displays:

- resolution advisory characteristics (0 ft/mn advisory, up corrective advisory, don't descend, don't climb > 2000 ft/mn, rate to maintain),
- data for each of the four intruders according to the following table:

INTRUDER	TYPE	RANGE	REL ALT (NM)	BEAR-ING	VERTICAL RATE
1	RA	2.00	+200	+90	NONE
2	TA	2.00	-200	-90	CLIMBING
3	PROX	3.625	–1000	+33.75	DESCENDING
4	OTHER	3.625	+1000	-33.75	NONE

DIRECTIONAL ANTENNAS

The TCAS has two antennas, one located on the top of the aircraft and the other on the underside of the fuselage. These antennas, of the transmit/receive type, provide azimuth information on aircraft located within the TCAS surveillance range.

They consist of four independent elements. In reception, the amplitude of the signals received by each element depends on the direction of the signal source, which permits the relative bearing of the transmitting aircraft to be determined.

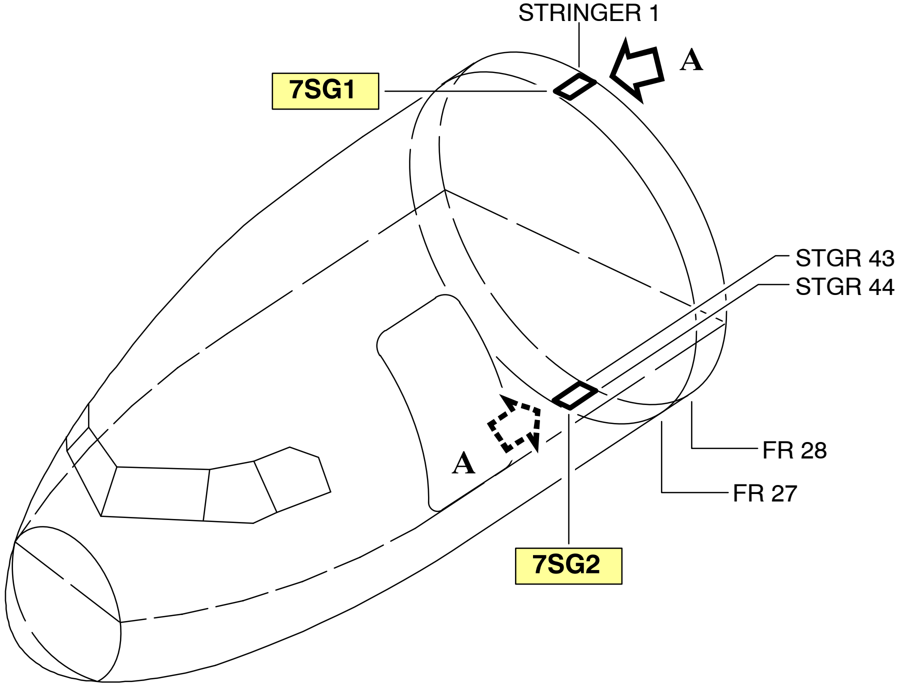


Figure 66 TCAS Antenna Location

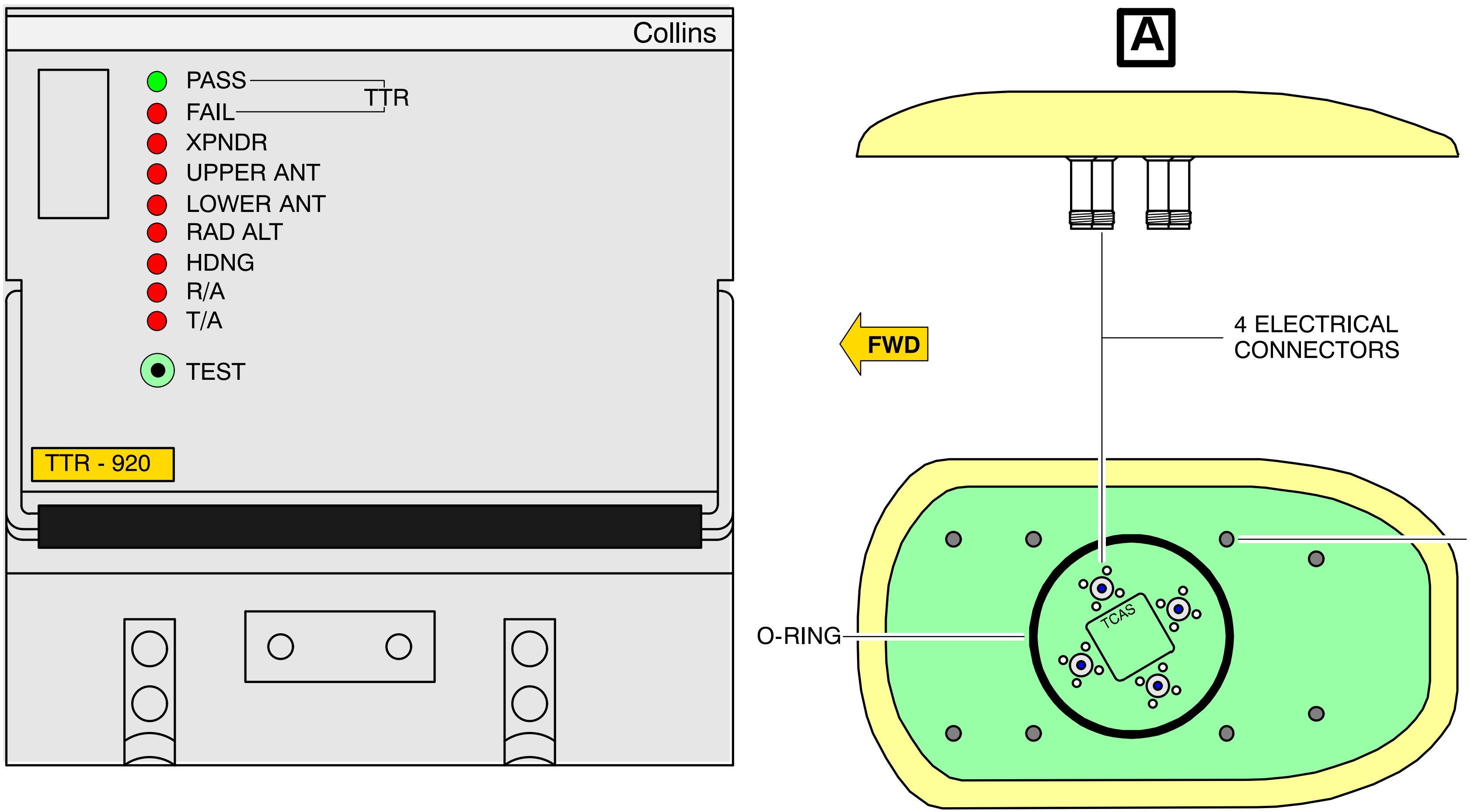


Figure 67 TCAS Computer & Antenna

TCAS FLAGS DESCRIPTION

TCAS MESSAGES ON PFD

The TCAS flag on the PFD appears in red, when TCAS cannot deliver RA data, or in case of TCAS internal failure.

TCAS MESSAGES ON ND

As well as intruder information, the ND also displays operating mode messages or fault data. This information is presented in the lower section of the ND (message zone):

TA ONLY in white for the TA mode (automatic or manual switching)

TCAS in red to indicate a TCAS computer failure.

Mode and Range Messages on the ND

Following messages can be displayed to draw pilots attention:

- **TCAS: REDUCE (CHANGE) RANGE:**
  - displayed when a TA or RA is detected and **ND range above 40 NM**.
- **TCAS: CHANGE MODE:**
  - displayed when a TA or RA is detected and ND mode is PLAN.

These messages are displayed in amber or red depending on the advisory level (TA or RA). They will flash 9 seconds then remain steady.

TCAS MESSAGES ON THE UPPER ECAM DU

If a TCAS fault is detected, the amber caution message NAV TCAS FAULT is displayed on the upper ECAM DU.

Selection of the TCAS STBY mode on the ATC/TCAS control unit results in the display of the TCAS STBY message (green) in the memo section of the upper ECAM DU.

These messages are generated by the Flight Warning Computer (FWC).

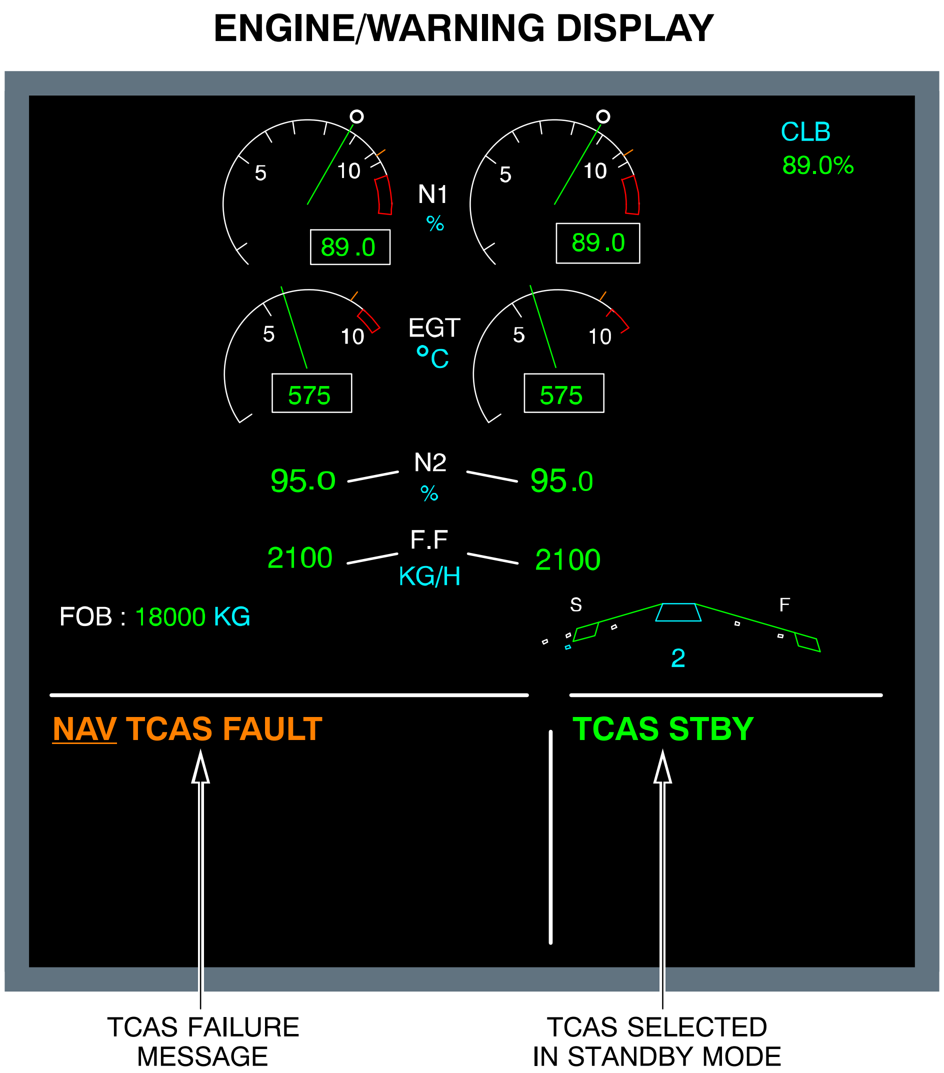


Figure 68 TCAS Messages on E/WD

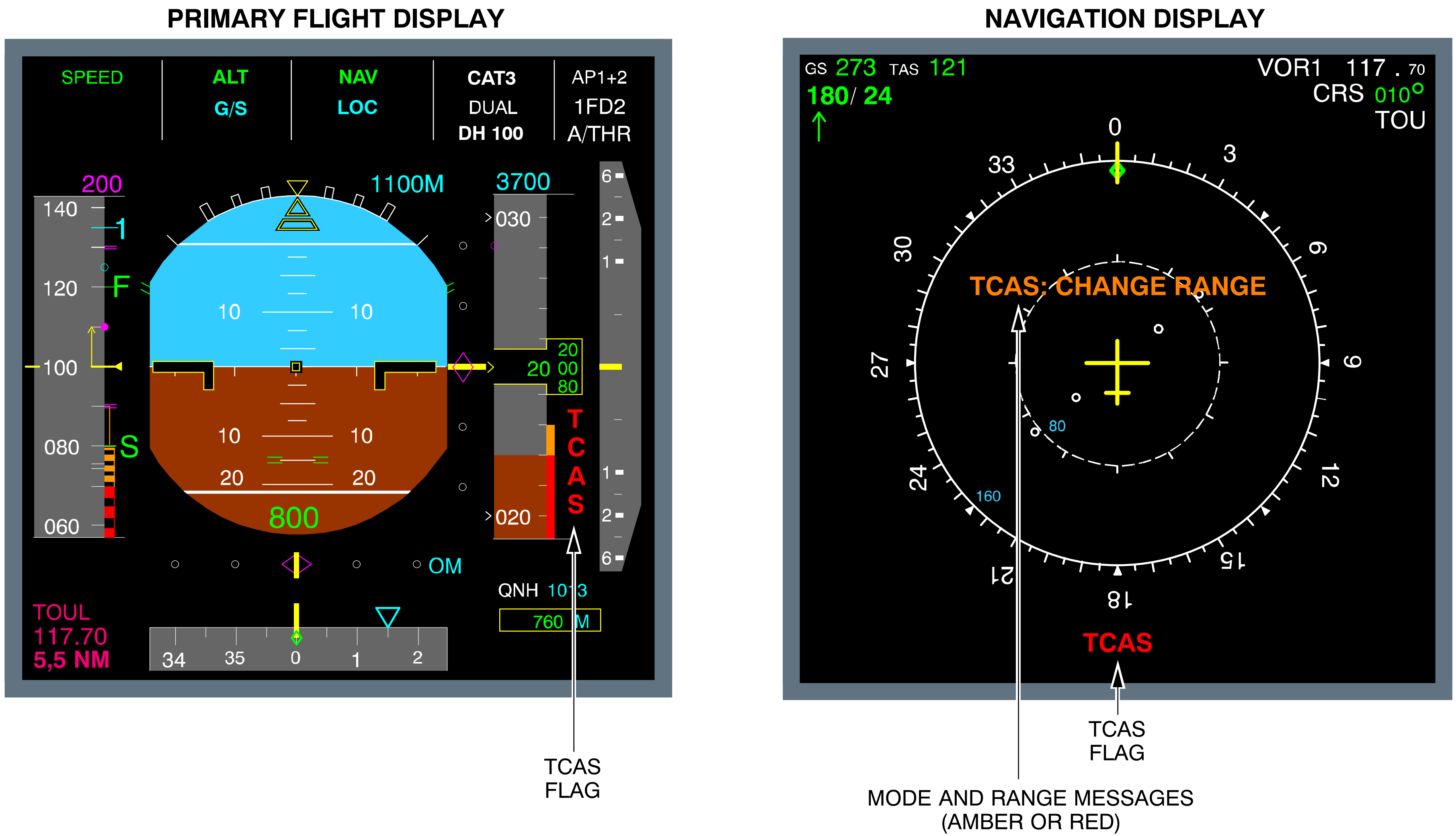


Figure 69 TCAS Messages on PFD & ND

34–50 DEPENDENT POSITION DETERMINING

COMPONENT LOCATION

AVIONICS RACK 80VU

The following system units are installed in the aft avionics compartment in the rack 80VU:

- VOR/Marker receivers 1 & 2,
- DME Interrogators 1 & 2,
- ADF receivers 1 & 2,
- ATC transponders 1 & 2,
- TCAS or T2CAS computer.

AVIONICS RACK 90VU

The following system units are installed in the forward avionics compartment in the rack 90VU:

- Multi Mode or ILS receivers 1 & 2.

FUSELAGE

The following radio navigation system antennas are installed on the upper fuselage:

- MMR 1 & 2 GPS antennas,
- VOR 1 & 2 antenna unit (vertical stabilizer),
- ADF 1 & 2 antennas,
- ATC 1 & 2 top antennas,
- TCAS top antenna.

The following radio navigation system antennas are installed on the lower fuselage:

- VOR 1 Marker antenna,
- DME 1 & 2 antennas,
- ATC 1 & 2 bottom antennas,
- TCAS bottom antenna,

The following radio navigation system antennas are installed in the radome:

- MMR or ILS 1 & 2 Localizer & Glide Slope antennas.

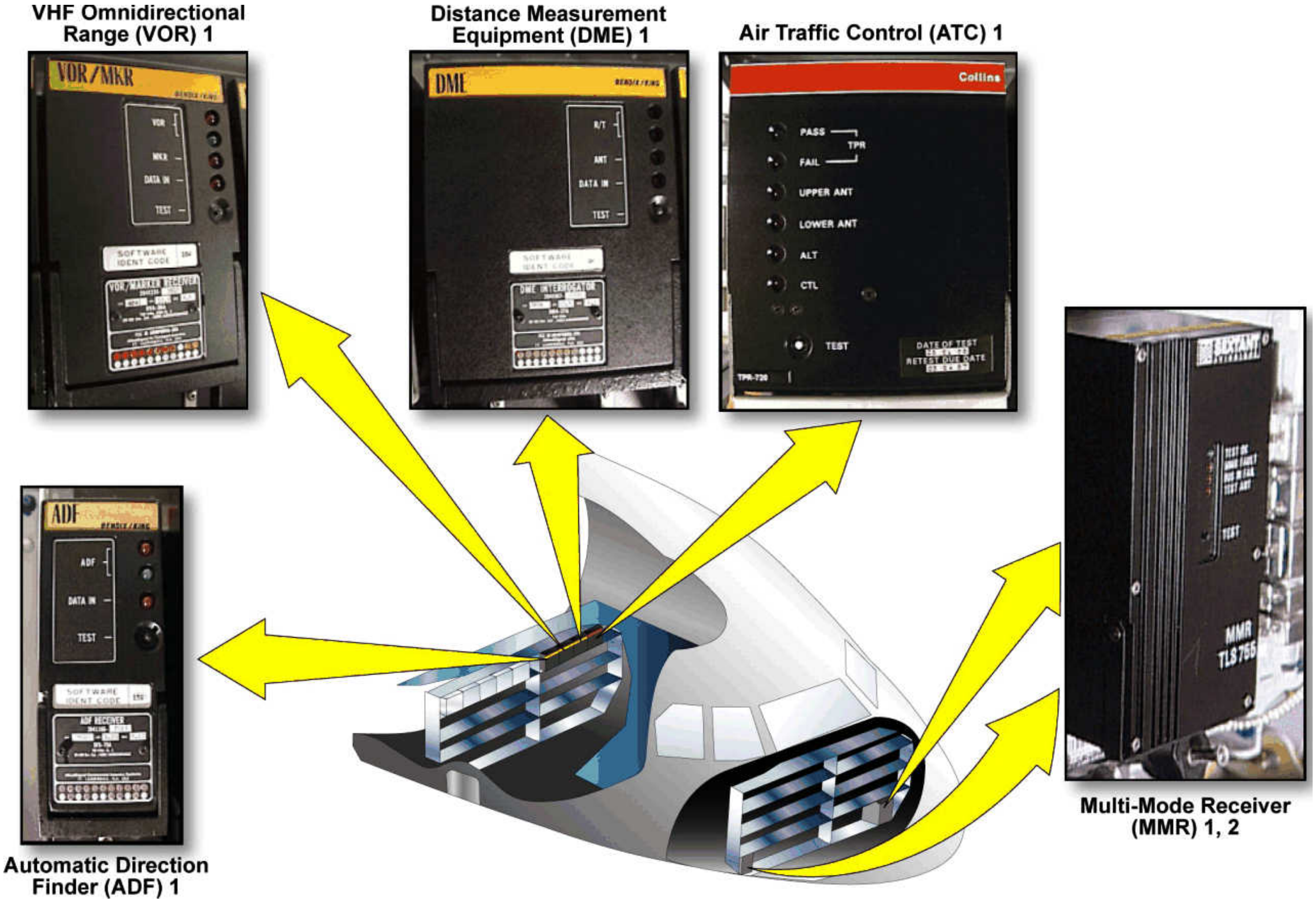


Figure 70 Radio Navigation Receivers Location

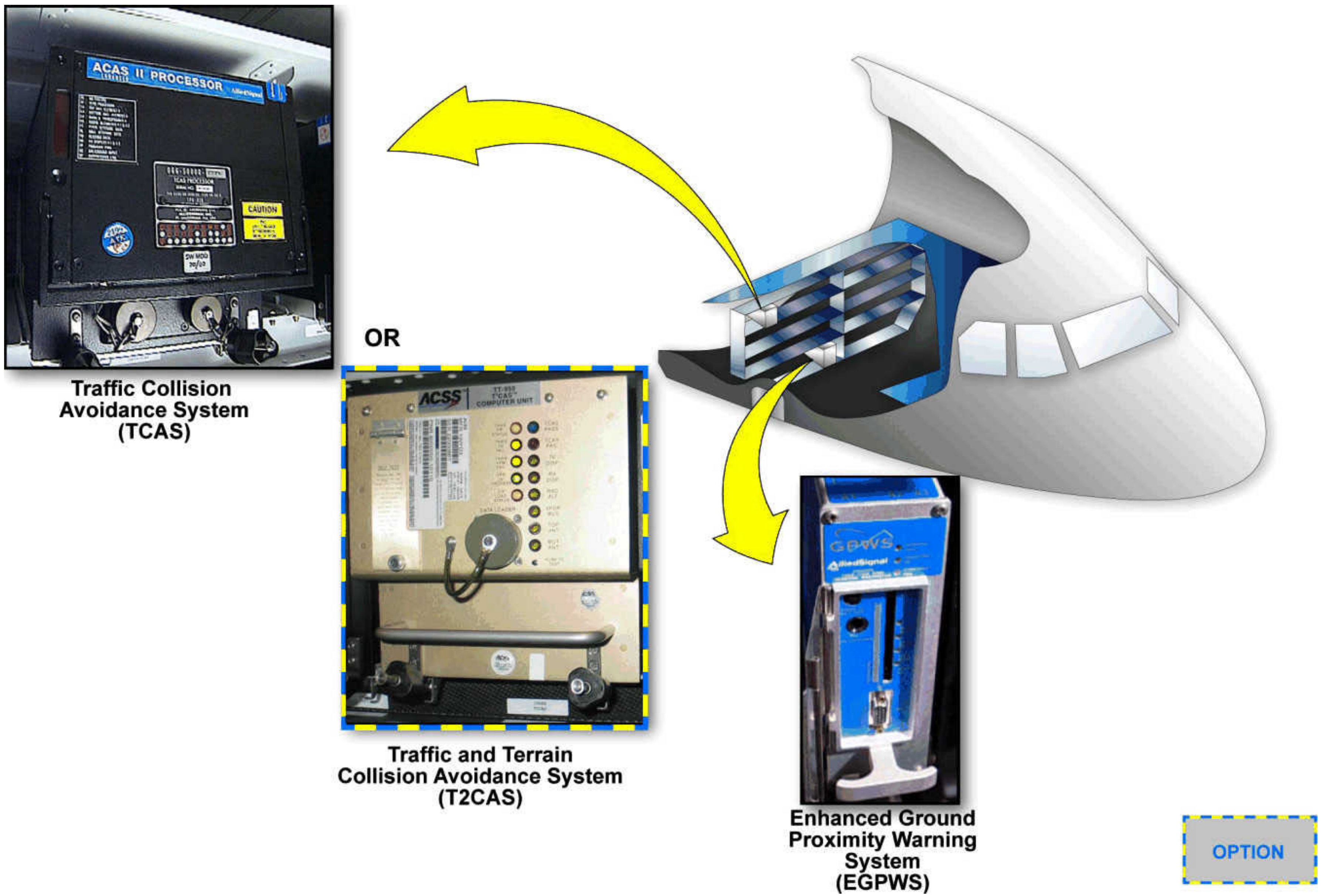


Figure 71 T(2)CAS Computer Location

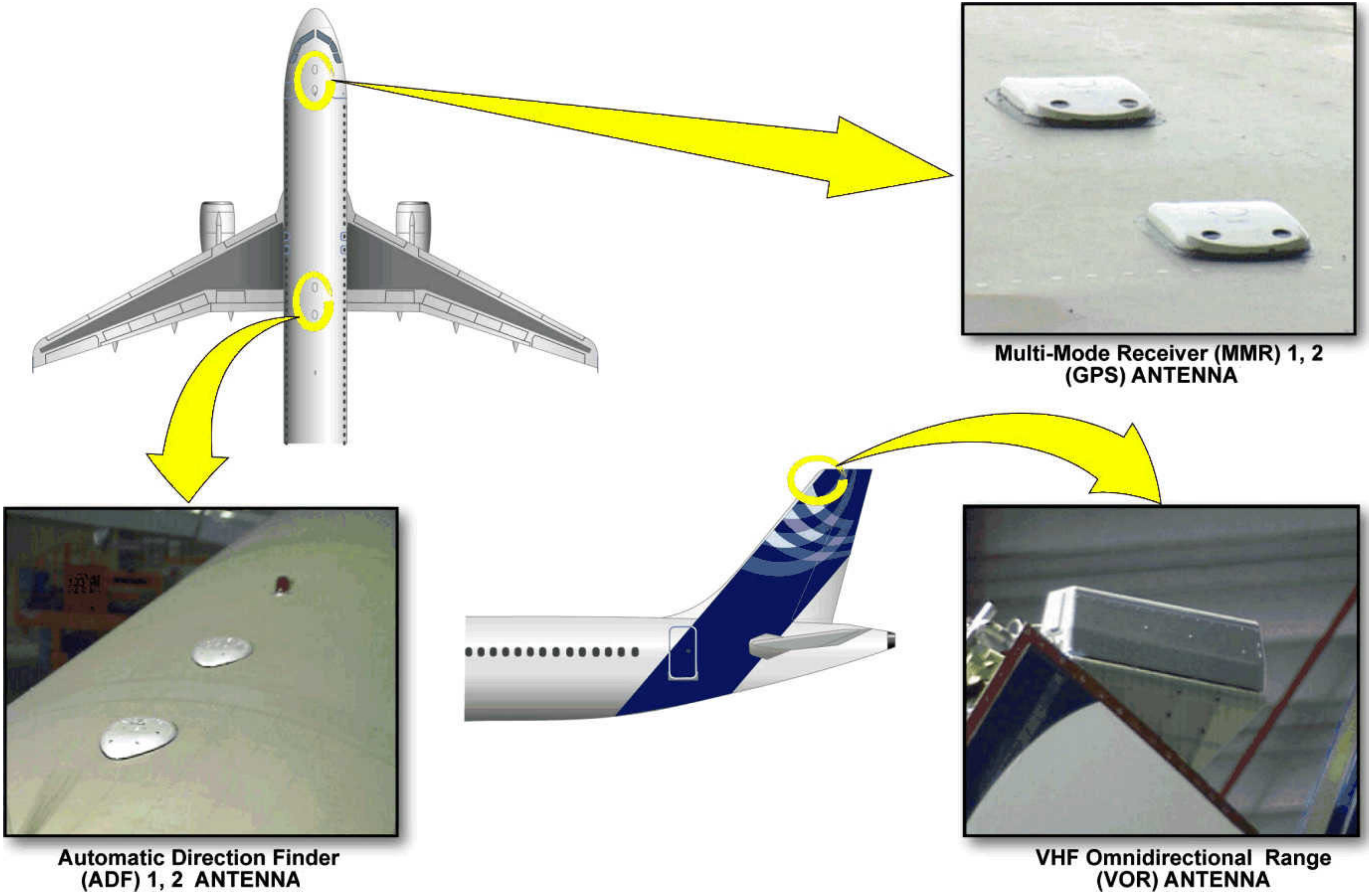


Figure 72 Antennas on Upper Fuselage

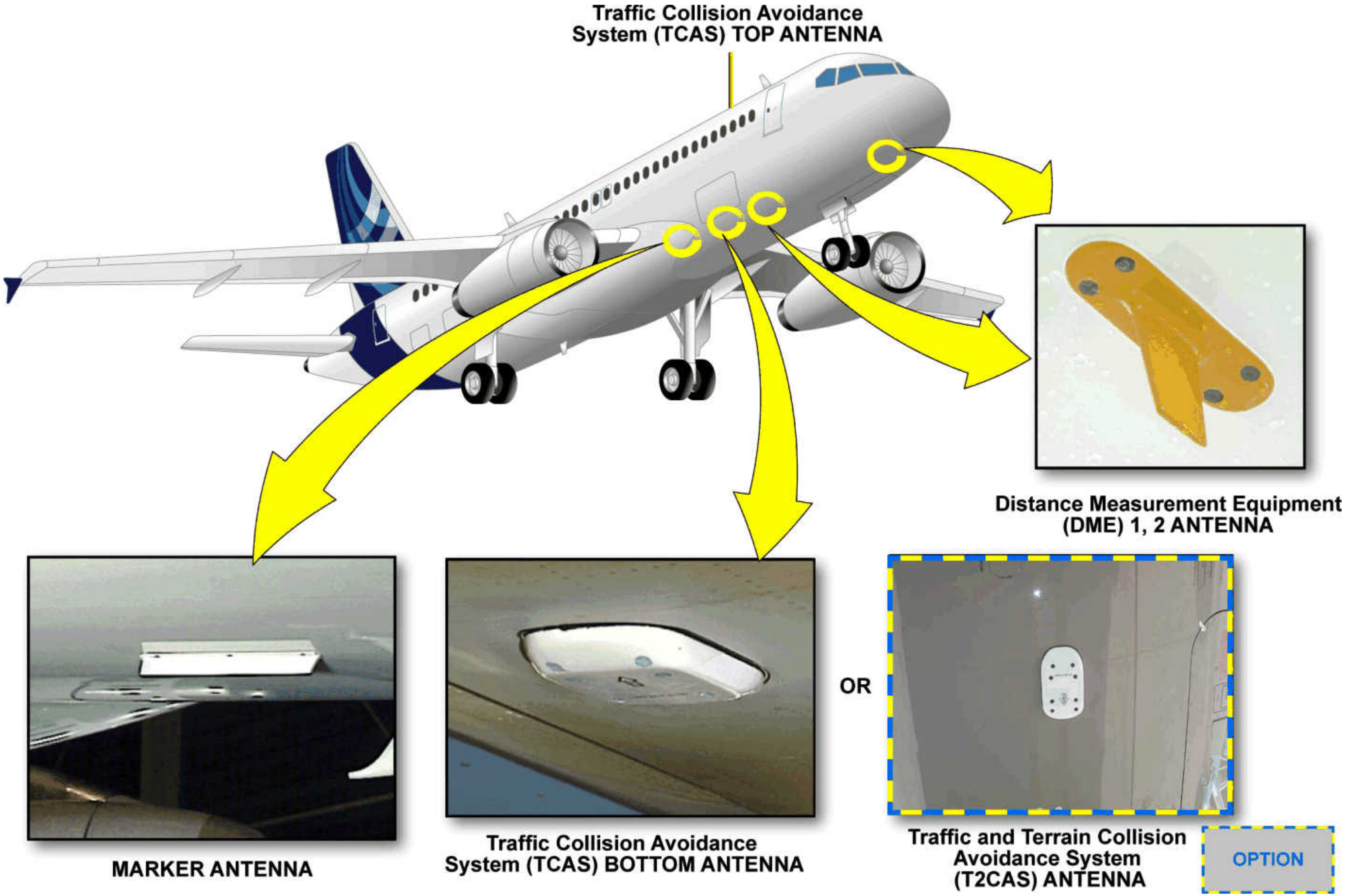


Figure 73 Antennas on Lower Fuselage

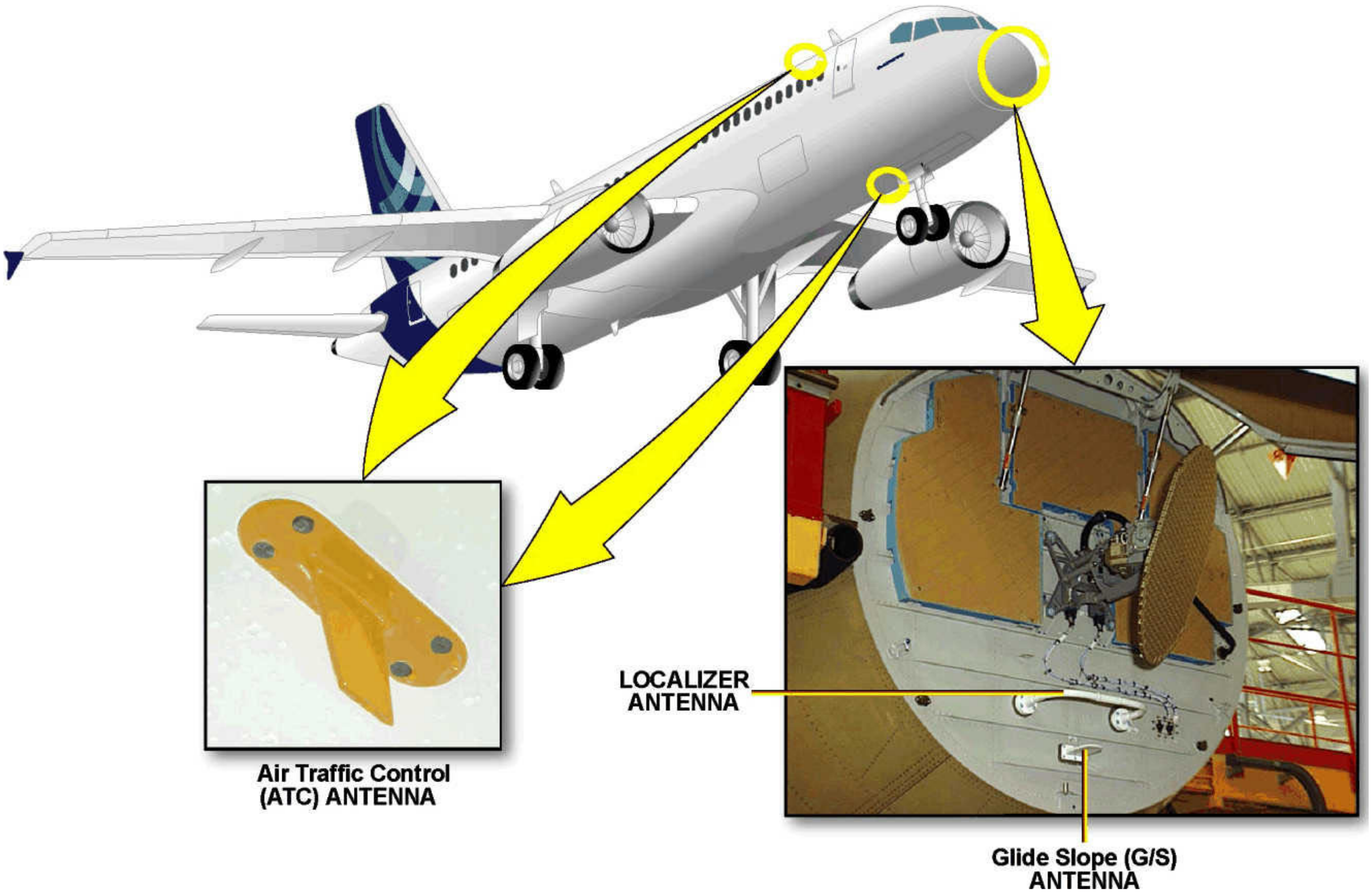


Figure 74 ATC and ILS Antennas Location

34−41 WEATHER RADAR SYSTEM

WEATHER RADAR SYSTEM INTRODUCTION

WEATHER RADAR PRINCIPLE

The airborne Weather Radar (WXR) and Predictive WindShear system (PWS) detects and localizes atmospheric wet disturbances and windshear events in the area scanned by the antenna.

The WXR helps the pilots to avoid these areas and the associated turbulences by determining their range and bearing. It can also be used for ground mapping. The radar emits microwave pulses through a directive antenna, which picks up the return signals.

The distance is determined by the time taken for the echo to return. The azimuth is given by the antenna position when the echo is received.

General

The aircraft is equipped with a single or dual X−band dual Collins WXR−2100 Multiscan Radar transceiver with Predictive Windshear System (PWS). This system is compatible with Electronic Instrument System 1 and 2 (EIS1 and EIS2).

Multiscan is a radar function that displays all significant weather at all ranges, at all aircraft altitudes, and at all times on a display that is essentially clutter−free, without the need for pilots to input tilt or gain settings. Multiscan reduces pilot workload while enhancing weather detection capability.

Two antenna scans are performed, each scan is optimized for a particular region in front of the aircraft. The upper beam detects medium−range weather and the lower beam detects short and long−range weather by automatically adjusting tilt and gain. The information is then stored in a temporary database. When the captain or the first officer selects a range, the weather radar transceiver retrieves the appropriate portions of the desired information, merges the data and then eliminates ground clutter. The result is an optimized weather display and the flight crew selects the range scale required.

In the following text, the abbreviation WXR/PWS is used.

The WXR/PWS enables:

- detection and localization of the atmospheric disturbances in the area defined by the antenna scanning: plus or minus 90 deg. of aircraft centerline and up to 320NM in front of the aircraft,
- detection of turbulence areas caused by the presence of precipitations up to a distance of 40NM,
- presentation of terrain mapping information by the combination of the orientation of the radar beam and of the receiver gain,
- detection of a microburst windshear event in the area defined by the antenna scanning: plus or minus 60 deg,
- presentation of windshear events within an area plus or minus 30 deg. of aircraft centerline and up to 5NM in front of the aircraft.

NOTE: A microburst is a cool shaft of air, like a cylinder, between 1000 and 3000 ft. When it encounters the ground (airflow velocity from 40 to 110 kts) the downward moving airflow is translated to a horizontal flow (from 80 to 220 kts), at the base of the air shaft. Two types of microburst exist, wet and dry.

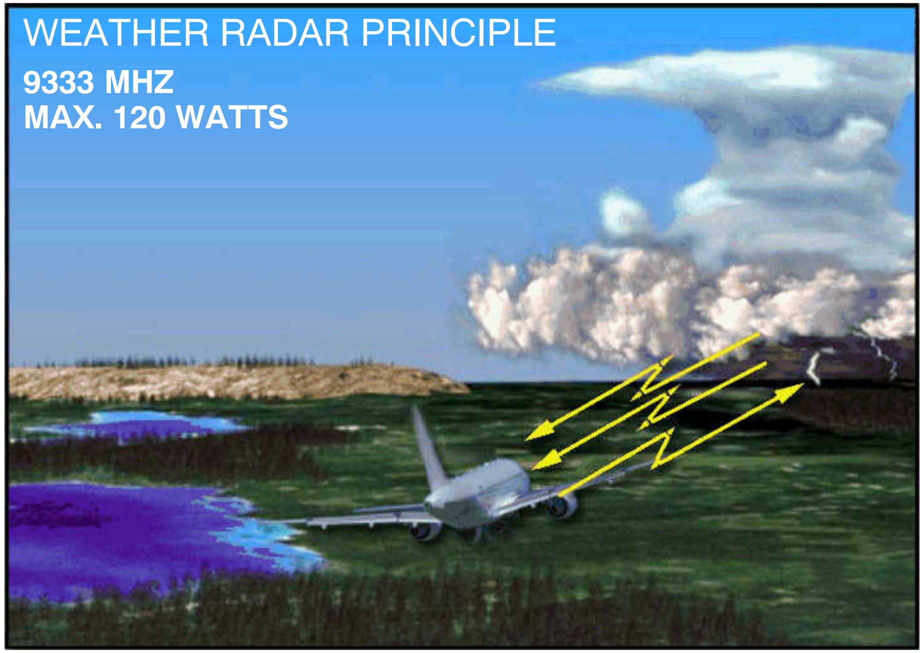
Five color displays are used to show precipitations, turbulence and ground mapping to the crew.

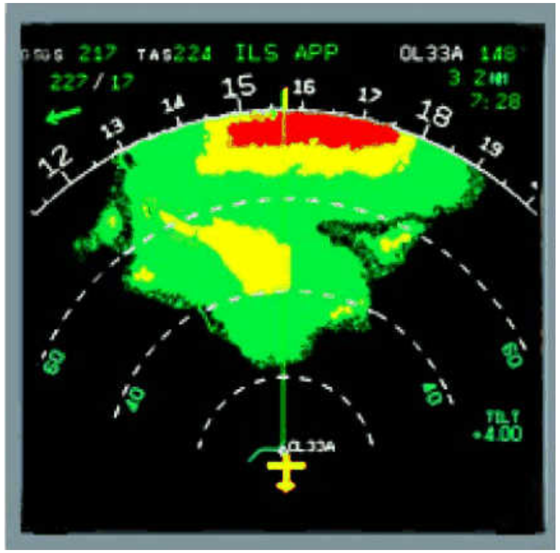
The location of the windshear events is indicated by an icon (symbol consisting of alternating red and black arcs).

PREDICTIVE WINDSHEAR (PWS) PRINCIPLE

A windshear event is a sudden change of wind speed and/or direction over a small distance due to downwards and/or upwards movement of the air.

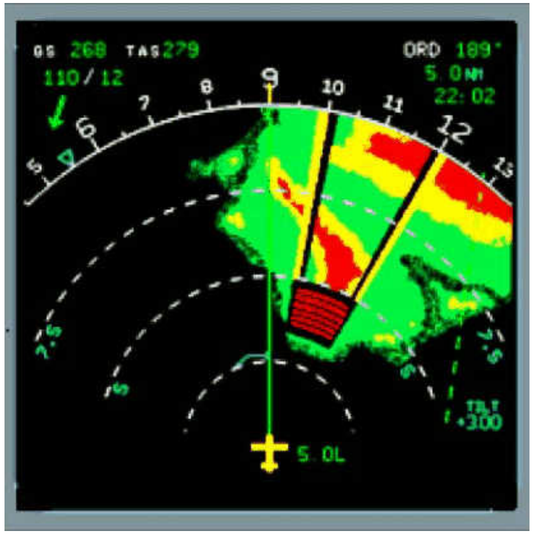
The most critical moment for the aircraft is near the ground level during the approach or in take−off.





WEATHER IMAGE ON ND

PREDICTIVE WINDSHEAR IMAGE ON ND



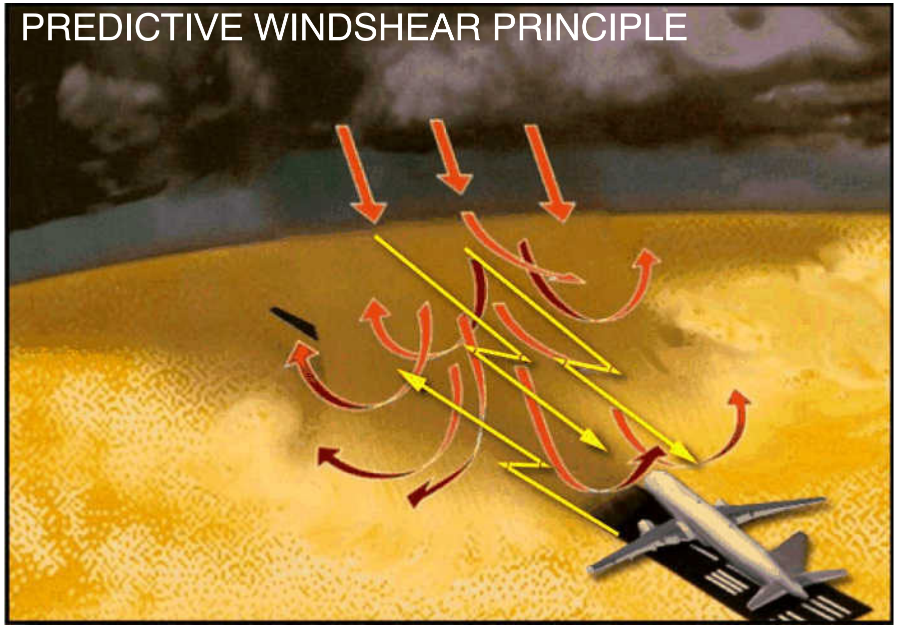


Figure 75 WXR & PWS Principle

MULTISCAN RADAR FUNCTION

The key to MultiScan operation is the radar's ability to look down, towards the bottom reflective portion of a thunderstorm, and then eliminate the ground clutter with advanced digital signal processing. The system combines multiple radar scans at preselected tilt angles in order to detect short−, mid− and long−range weather. The result is superior weather detection.

The MultiScan Radar's ability to eliminate ground clutter with advanced algorithms allows it to skim the radar horizon and provide pilots with true strategic weather out to 320 nautical miles (NM). The system also provides OverFlight Protection, allowing crews to avoid inadvertent thunderstorm top penetrations, which today account for a significant portion of aircraft turbulence encounters. OverFlight Protection ensures that any thunderstorm that is a threat to the aircraft will remain on the radar display until it no longer poses a danger to passengers and crew.

The Multiscan function optimizes weather detection and minimizes ground clutter. This function determines the optimum tilt angle for the radar through monitoring of:

- the aircraft altitude above the terrain (RA and ADR information),
- the aircraft position (IR information),
- the terrain conditions in the area (information located in an interval ”Reference table”).

1 The Ideal Radar Beam

Understanding thunderstorm reflectivity and the effect that radar tilt angle has on it allows us to envision a hypothetical ideal radar beam for weather threat detection. The ideal radar beam would look directly below the aircraft to detect building thunderstorms and then follow the curvature of the earth out to the radar's maximum range. Thus, the ideal beam would keep the reflective part of all significant weather in view at all times, from right in front of the aircraft out to 320 nm.

2 Multiscan Emulation Of the Ideal Radar Beam

The Collins MultiScan Radar emulates an ideal radar beam by taking information from different radar scans and merging the information into a total weather picture. Rockwell Collins patented ground clutter suppression algorithms are then used to eliminate ground clutter.

The result is the ability for flight crews to view all significant weather from 0 − 320 nm on a single display that is essentially clutter free.

3 Conventional Weather Radar Image

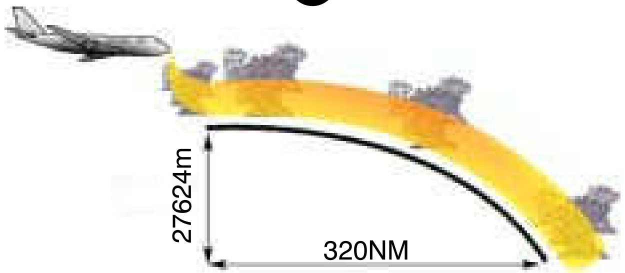
The first picture below shows a radar display typical of today's manual systems. Weather returns are mixed with ground returns making the weather, except that very close to the aircraft, almost indistinguishable. Pilots have to manually manipulate gain, tilt and range to in an attempt to separate ground returns from actual weather.

4 MultiScan Ground Clutter Suppression

The second picture shows the same weather presentation during MultiScan Hazard Detection Weather Radar System automatic operation. As is illustrated the MultiScan ground clutter suppression techniques clearly enable the display of weather that was previously hidden in the ground returns of the thunderstorms. Previously, pilots had to manually manipulate gain, tilt and range to in an attempt to separate ground returns from actual weather.

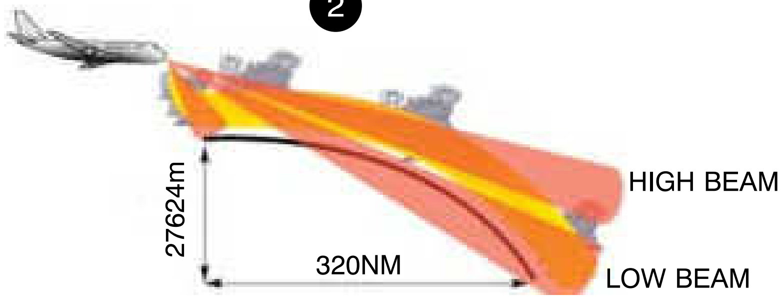
The patented MultiScan ground clutter suppression (GCS) algorithms replace these manual pilot inputs allowing the radar to display weather returns that were normally hidden by ground clutter. By allowing the radar to operate at lower tilt angles looking down into the most reflective portion of the storm, without displaying ground clutter, pilots now have better information on which to base their deviation decisions. To better understand the fundamentals behind Rockwell Collins GCS, a short explanation of thunderstorm reflectivity, radar beam characteristics and radar beam tilt control is in order.

1



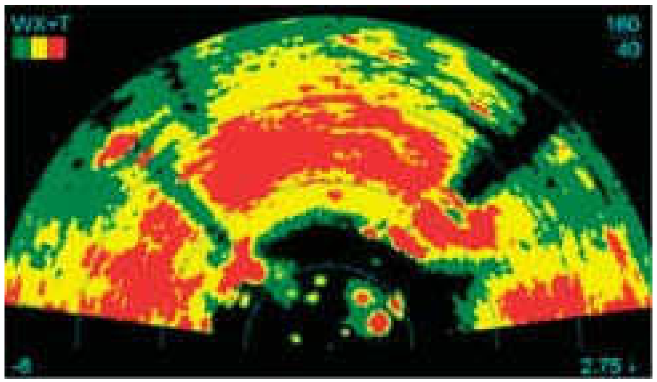
Ideal radar beam (hypothetical)
(note earth's curvature causes a drop of
approximately 27624m over a distance of 320 nm).

2



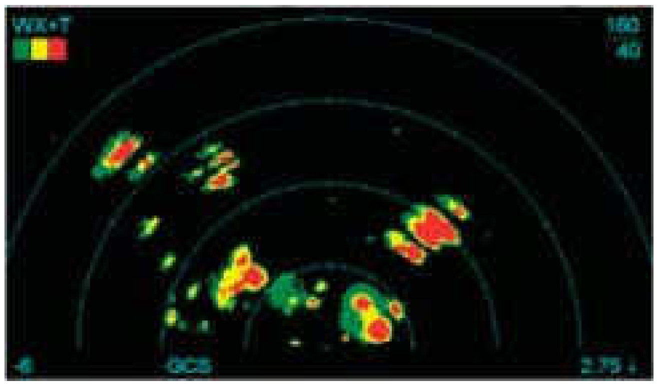
MultiScan emulation of ideal beam.

3



MultiScan is able to look down into ground clutter
to detect the reflective portion of thunderstorms.
The picture above shows the radar picture with
the ground clutter suppression turned off.
Weather is masked by the ground clutter.

4



When Ground Clutter Suppression (GCS) is activated,
all significant weather (in this case from right in front of
the aircraft out to 160 NM) is visible on a single,
essentially clutter free, display.

Figure 76 Multiscan Radar Principle

WXR SYSTEM COMPONENTS

The main components are an antenna, a wave−guide, a WXR transceiver (XCVR) dual mounting tray with an optional second XCVR, and a control unit. The WXR/PWS system is also connected to the NDs via the Display Management Computers (DMCs) for display.

NOTE: There are many different weather radar systems installed in the history of the A320 family.

These different systems are:

- a pure weather radar (WXR) system,
- WXR + Turbulence Detection system (TURB),
- WXR + TURB + Predictive Windshear system (PWS),
- WXR + TURB + PWS + Multiscan System.

In the cockpit these systems can be distinguished by the weather radar control unit.

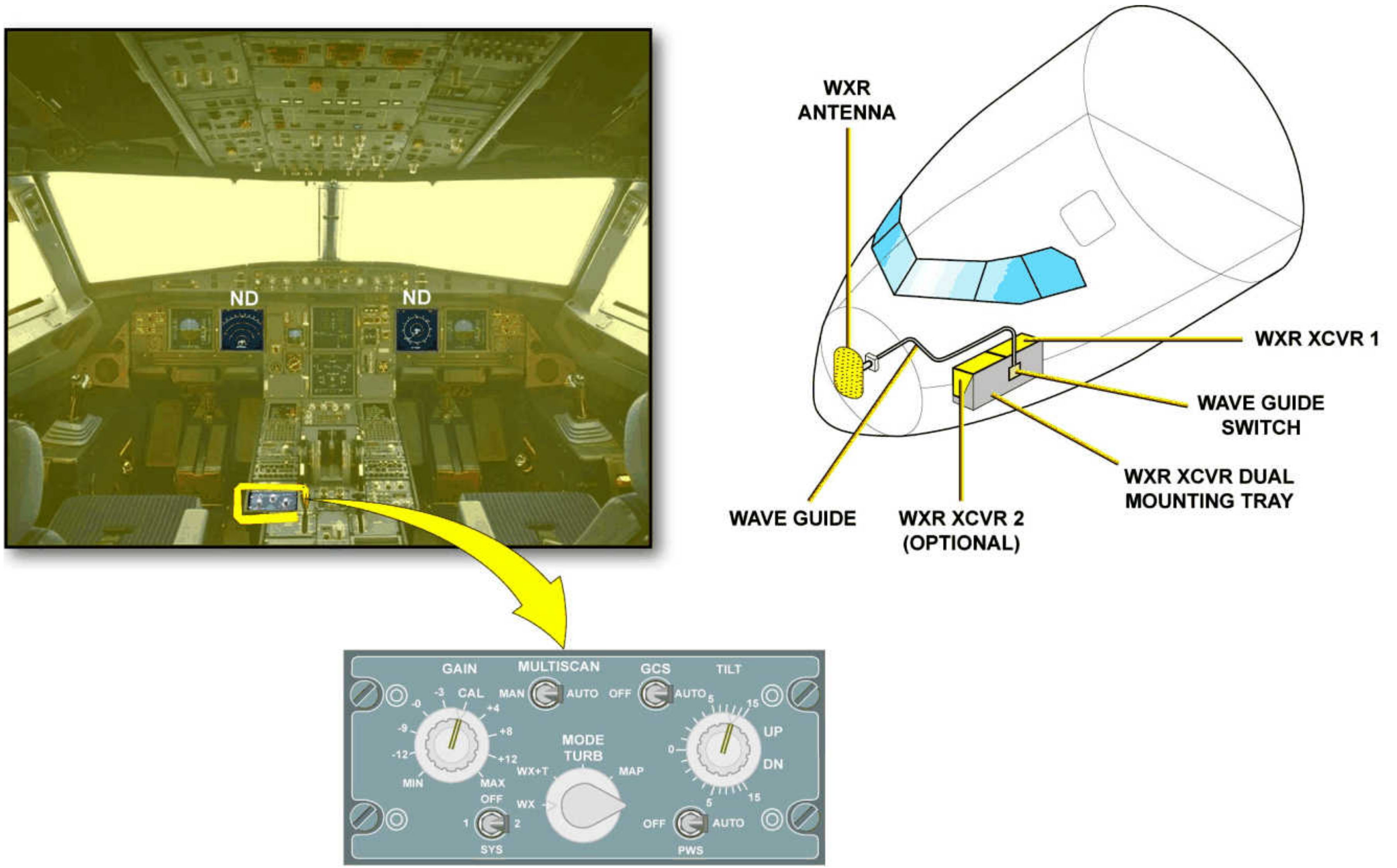
WXR OPERATION

The weather radar system uses the principle of radio echoing. It works at a normal frequency of 9333 MHz. The peak power emitted is 120 W approx.

The weather radar transceiver generates microwave energy in the form of electromagnetic pulses via an X−band wave guide to the antenna. When these pulses intercept an appropriate target, part of the energy is reflected back to the weather radar antenna then to the transceiver. For each case, the system uses a different mode of operation which allows to vary the scanning of the antenna, the timing of the pulses and the processing of the weather radar returns and of the predictive windshear events (if the function is activated).

The electronics circuits of the transceiver measure the elapsed time between the transmission of the wave and the reception of the echo to determine the target distance (it takes around 12.36 microseconds for the electromagnetic wave to travel out and back for each nautical mile of target range).

The angular position of the target is detected by the angular position of the antenna in its scanning in azimuth. As the quantity of energy reflected to the antenna is proportional to the target density, the different levels of atmospheric disturbances are shown on the displays by different colors. The detection of the turbulence areas are based on the Doppler phenomenon.



WXR/PWS PANEL
with MULTISCAN function

XCVR: Transceiver
WXR: Weather Radar

Figure 77 WXR Components

WEATHER RADAR INDICATION DESCRIPTION

WXR INDICATION

General

The various system controls are grouped on the weather radar control unit and on the EFIS control sections of the FCU.

Radar image control on the NDs is achieved through the scale selector switches located on the Captain and First Officer EFIS control sections of the FCU.

Weather Radar Indication on the PFD

The Primary Flight Display (PFD) it provides all visual alerts for caution or warning alert.

Only a WXR system equipped with PWS can display a WINDSHEAR AHEAD warning on the PFD. This message is displayed, when the predictive windshear system has detected windshear ahead of the aircraft.

The message is in amber or red, depending on the alert level.

NOTE: The red WIND SHEAR warning message is displayed when windshear is detected (reactive windshear warning) by the FAC. This warning has NOTHING to do with the PWS.

Weather Radar Data Displayed on the NDs

The Navigation Display (ND) it provides the following indications:

- weather radar image,
- windshear events location for advisory, caution or warning alert,
- WXR failures,
- PWS messages.

CAPT and F/O lighting/LOUDSPEAKER control panels 301VU and 500VU which are connected to CAPT and F/O NDs, include ND concentric potentiometers for adjusting the brightness of the image displayed on the NDs. The outer knob of each potentiometer controls the brightness of the radar image only.

When the radar is operating, and when the ND is not in PLAN mode, the ND displays the weather radar picture. The FDIU records the windshear alert and failure.

Messages inform the crew of the tilt angle and gain selected on the weather radar control unit. Other messages indicate the failures which affect the operation of the radar system. All these messages are displayed in the R lower corner of each ND whenever a radar image is selected.

The value of the tilt angle is in degrees, and quarters of a degree. It appears in blue in the lower right–hand corner of the screen. This angle is the angle between the horizon and the radar beam axis.

“MAN“ appears in white, when the manual gain mode is selected.

The radar images are displayed on the NDs in four colors (black, green, yellow, red); their intensity corresponds to the strength of the return signal.

Turbulence detection is limited to the first 40 NM regardless of the weather radar range selected and displayed. Turbulence areas are displayed on the NDs in magenta.

Windshear indications

The location of a windshear phenomenon is indicated to the crew by means of an icon superimposed on the radar image.

This icon consists of alternating red and black arcs. For 10 NM range selection and above, yellow radial lines appear at the edges and start beyond the windshear event. These lines, superimposed on the radar image, continue to the edge of the display area to provide directional information for the event.

WARNING: THE WINDSHEAR DATA ARE ALWAYS DISPLAYED EVEN IF THE SYSTEM SELECTOR SWITCH ON THE RADAR CONTROL UNIT IS SET TO OFF.

The windshear switch on the radar control unit has to be set to AUTO. When on the radar control unit, the weather radar system selector switch is set to OFF and the windshear mode selector switch is set to AUTO, the green ”PWS SCAN” indication is displayed on the bottom right–hand corner of the NDs instead of the tilt indication to inform the crew that the weather radar operates in windshear mode only.

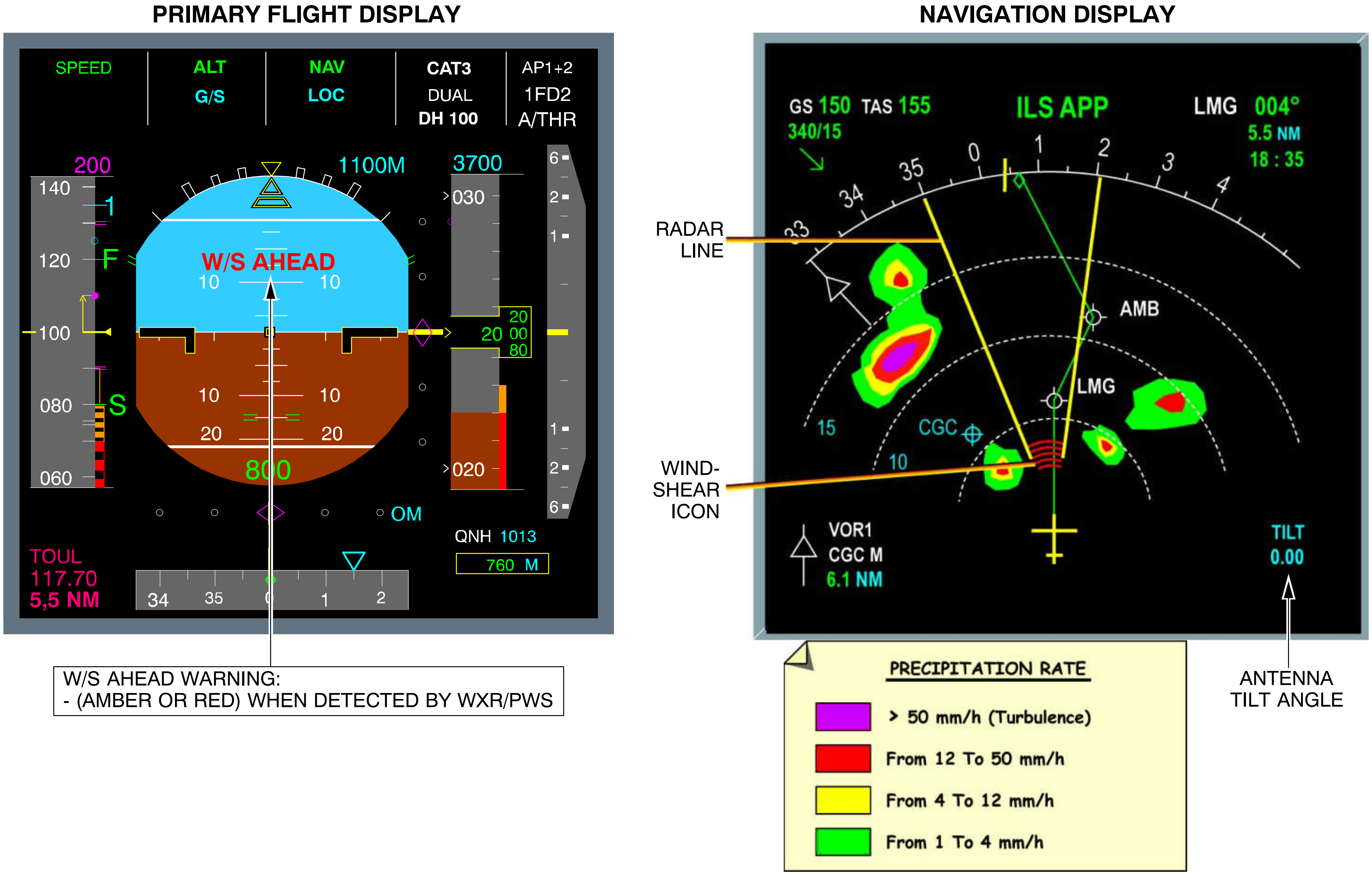


Figure 78 WXR/PWS Indication on EFIS Screens

WEATHER RADAR SYSTEM DESCRIPTION

GENERAL

The main components are an antenna, antenna drive, a wave−guide with a switch, a WXR transceiver (XCVR) dual mounting tray for an optional second XCVR and a control unit.

The weather radar image is shown on the CAPT and F/O Navigation Displays (ND). The NDs are connected to the three Display Management Computers (DMC) and to the CAPT and F/O EFIS control panels of the FCU.

NOTE: If the Enhanced GPWS is operative, the WR image is replaced by the terrain image, on the Captain and First Officer NDs, during a terrain alert or a crew action. More explanations are given in ATA 34−48.

The Predictive Windshear Warning message is shown on the PFD, aural warnings are transmitted via the Audio Mixing Box to the cockpit loudspeakers.

The ADIRUs give data information to the weather radar system. These data ensure the radar antenna stabilization and the computations of the windshear function.

The Radio Altimeter provides altitude information, this data is used for automatic activation of the windshear function.

Weather Radar Transceiver

The receiver−transmitter is the heart of the WR/PWS system, the additional necessary wiring and interfaces enable the weather radar transceiver to operate as a PWS (WR/PWS) and autotilt.

The receiver−transmitter ensures the following functions:

- generation of the very short intense pulses of microwave energy via an X−band wave guide to the antenna, and the processing of their echoes (radio frequency signals) to obtain the desired information,
- the receiver signal is formatted into 1600−bit ARINC 453 words and sent to the Display Management Computers (DMCs),
- acquisition of data from Radio Altimeters (RA1 and RA2) and other specific interfaces,
- windshear event detection and generation of the appropriate signal,
- BITE function of the system.

Weather Radar Control Unit

The control unit generates a 32−bit (label 270) serial control word which describes the selected operating modes (1/OFF/2, WX, WX + T, TURB, MAP, PWS, GCS, MULTISCAN, GAIN TILT).

The WR/PWS receives one ARINC 429 bus coming from the control unit. Moreover, the predictive windshear function can be de−activated if the PWS does not operate correctly.

Antenna Drive

The WXR/PWS has one antenna drive which is the interface between the WXR XCVR and the antenna to control and monitor the azimuth and elevation of the antenna.

Weather Radar Antenna

The antenna is used for transmitting and receiving radar radio frequency signals.

Transceiver Mounting tray with a Wave Guide

It allows to install the transceiver on the aircraft rack and connects the transceiver to the wave guide.

General Technical Characteristics

The WR/PWS system is mainly used to detect and localize various types of atmospheric disturbances and windshear events in the area scanned by the antenna. The system shows the disturbance intensity through the use of colors which vary with the atmospheric precipitation rate.

The disturbances are shown to the crew members on the NDs with different colors. The system can show the location of the windshear events via the NDs.

Audio Mixing Box (if predictive windshear function is activated)

An analog audio output allows to transmit the aural alert windshear (synthetic voice message) to an audio mixing box connected to loud speakers.

Pin Programming

This programs the audio level of the synthetic voice for windshear aural alert, the Ident of the XCVR (1 or 2), if the system shall communicate with the CFDIU, if the MONITOR RADAR DISPLAY synthetic voice is generated instead of the chime and the activation of the windshear function.

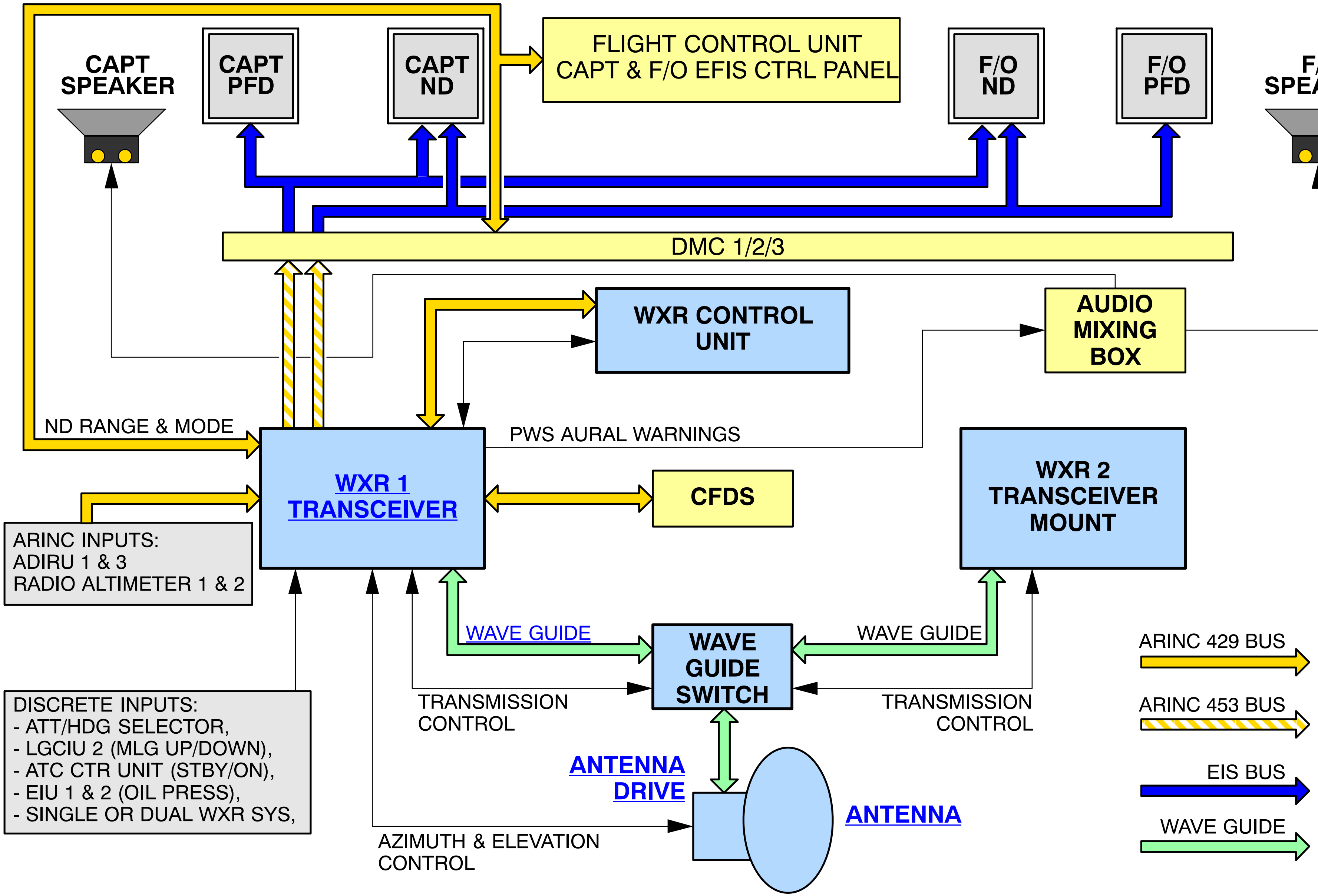


Figure 79 Weather Radar System Schematic

WEATHER RADAR CONTROL UNIT

Part of weather radar controls is grouped on the control unit (TILT control, system GAIN control, MODE selection control, MULTISCAN MAN/AUTO mode).

These data are digitized and monitored by a CPU to generate a control word which is sent to the transceiver through a control bus line.

The windshear function enable signal provided by the weather radar control unit through switch AUTO/OFF enables the windshear function. This discrete signal is also transmitted to the DMCs which use it for the logic of windshear messages displayed.

WXR Controls

The face of the weather radar control unit includes the following controls:

- A mode selector switch, which enables the selection of the WX, WX+T, TURB or MAP function.
- A TILT selector switch, which enables the control of the antenna elevation.

  Antenna position is read in degrees, opposite the notch on the switch:
  - either from 0 to 15 deg. upwards (UP),
  - or from 0 to −15 deg. downwards (DN).
- A GAIN potentiometer, which enables the manual adjustment of the transceiver gain.
- A switch, with three stable positions 1/OFF/2, which enables the selection of the transceiver 1 or 2 and the deactivation of the transceivers.
- A PWS/OFF/AUTO switch, which enables the selection of the windshear function independently from the 1/OFF/2 switch.
- A GCS switch, with a Ground Clutter Suppression (GCS) function which is activated in Multiscan AUTOMATIC mode (this is the default position). In manual mode, the GCS is never activated.
- A Multiscan switch, which enables the selection between MANUAL mode and Multiscan AUTOMATIC mode.

The face of the control unit is provided with integral lighting. The INTEG LT potentiometer enables lighting adjustment. The potentiometer is located on the panel 111VU, at the left aft section of the center pedestal 100VU.

NOTE: Depending on the version and the vendor of the weather radar system there are many different control units available.

WEATHER RADAR CONTROL UNITS FOR SYSTEMS EQUIPPED WITH:

WXR & MAP MODE

WXR , TURBULENCE, MAP & PREDICTIVE WINDSHEAR MODE

WXR, TURBULENCE & MAP MODE

WXR , TURBULENCE, MAP, PWS & MULTISCAN MODE

Figure 80 WXR Control Unit Variations

WEATHER RADAR EFIS CONTROL

In this part, the controls related to the selection of WX and W/S functions are described.

1 Mode Selector Switch

This mode selector switch enables the image display on the corresponding ND whenever the ARC or ROSE mode is selected and the transceiver is supplied. In that case, the radar image is displayed in the background of the navigation image. If neither ROSE or ARC mode is selected, the message W/S CHANGE MODE is shown on both NDs, if there is a windshear alert. The pilot is advised to select ARC or ROSE mode to see the W/S icon. The color depends on the W/S alert level.

NOTE: There is no WXR or PWS image available in the PLAN mode.

2 Scale Selector Switch

This selector switch enables the display of the range selected for an optimum use of the radar image on the corresponding ND. For each of the following ranges: 10, 20, 40, 80, 160 and 320, four concentric range arcs are displayed respectively spaced 2.5, 5, 10, 20, 40 and 80 NM, when the mode selector switch is in the ARC position. Only 2 range arcs are displayed in the ROSE mode.

Windshear information is presented in the 10 NM range only. If a windshear alert is generated but the selected range is greater than 10 NM, the message W/S: SET RNG 10 NM is shown on the NDs. In this case, the pilot is advised to select the 10 NM range. The color depends on the W/S alert level.

3 Radar Image Brightness Control

The ND potentiometer enables the adjustment of brightness and contrast of radar echoes in relation to the navigation image, which is superimposed.

However, the adjustment range does not allow total extinction of the image. The OFF position of the potentiometer corresponds to the minimum brightness. The BRT position corresponds to the maximum brightness.

A photoelectric cell associated with each ND also adjusts image brightness as a function of ambient light variations.

NOTE: In the ARC or ROSE mode, if the CAPT or the F/O switches to the OFF mode FM, the offside weather image will also be transferred on the ND. Only one scale selector switch can then control the weather radar image display

Utilization of Controls and Indicating

Special precautions to be taken.

Before selecting a radar mode on the control unit, make sure that:

- no one is within a distance less than 1.50 m from the antenna in movement within an arc of plus or minus 135 deg. on either side of the aircraft centerline
- the aircraft is not directed towards any large metallic obstacle, such as a hangar, which is within 5 m in an arc of plus or minus 90 deg. on either side of the aircraft centerline.

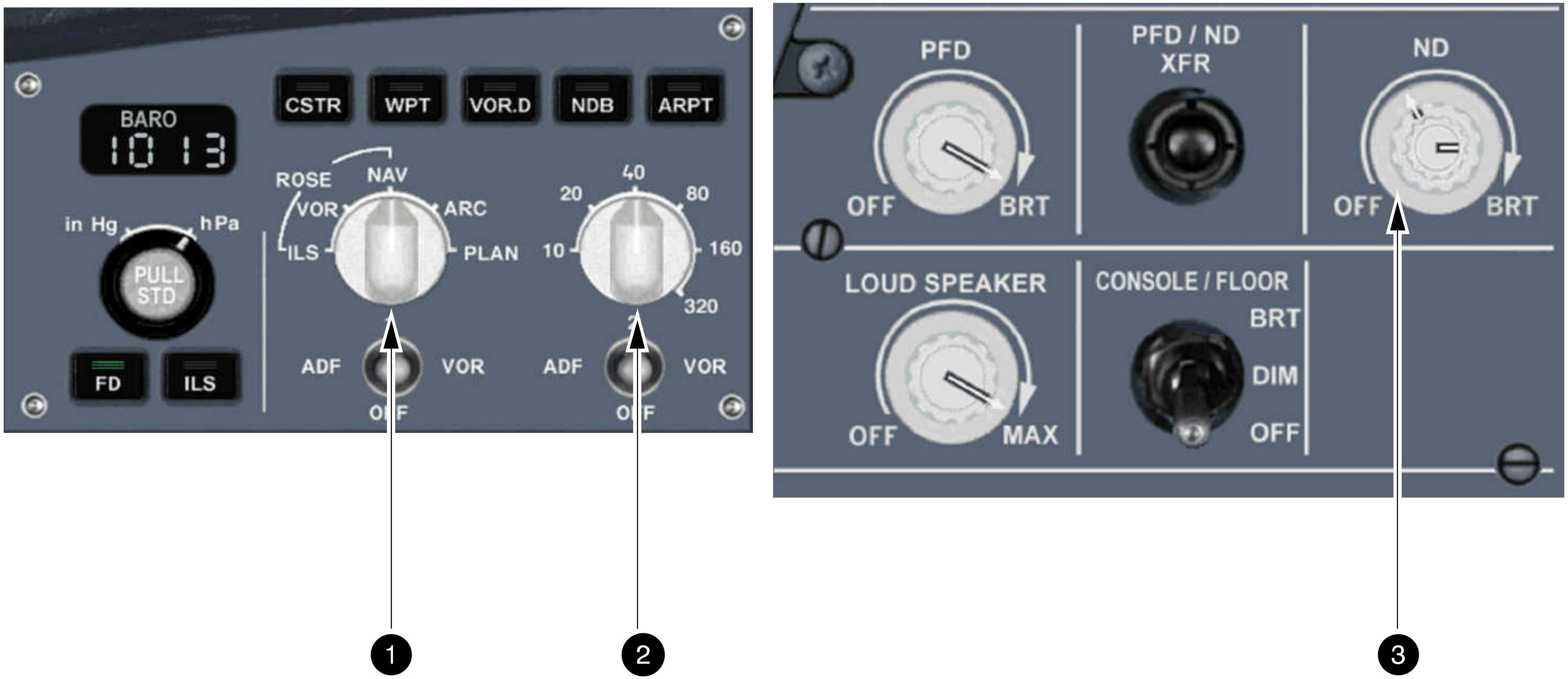


Figure 81 WXR EFIS Controls

WXR SYSTEM OPERATION

WXR GENERAL

The Weather Radar (WXR) and Predictive WindShear (PWS) System is composed of:

- 1 control panel,
- 1 or 2 WXR transceiver (XCVR),
- 1 antenna assembly,
- 1 wave−guide,
- 1 wave−guide switch.

Control Unit

The control unit gives the modes of operation, antenna tilt and gain of the receiver digitized information, via an ARINC 429 bus. An ON/OFF discrete fulfils the energization of the transceiver, which in turn supplies the control unit and the antenna assembly.

WXR Transceiver

The WXR XCVR uses the principle of radio echoing to detect the level of precipitation, the ground map, and the principle of Doppler effect to detect the turbulence areas. The transceiver operates in X−Band frequency at 9345 MHz. It digitizes the video signals on two ARINC 453 data buses connected to the Display Management Computers (DMCs) for display on the NDs. The PWS function also uses the principle of Doppler effect to detect windshear events.

Horizontal and vertical wind velocity and aircraft true airspeed are the different windshear components for the determination of the windshear threshold.

Antenna Assembly

The WXR antenna is energized and controlled in azimuth and elevation by the WXR XCVR. The radio frequency signals are exchanged between the transceiver and the antenna, via a wave−guide. The antenna scans a 180 degrees sector in azimuth and has a tilt coverage of + or − 15 DEG.

An internal circuit of the transceiver fulfils the antenna stabilization. The stabilization data is: Pitch and roll angles, selected tilt, antenna azimuth and elevation angle.

As an option of weather radar, the auto−tilt function allows optimization of the weather detection to minimize ground clutter, and optimization of data correlation with radars returns to maximize ground clutter contrast.

Indicating

The WXR XCVR is connected to the DMCs by means of two ARINC 453 buses. Each data bus wiring is terminated at one end by a low inductance resistor (68 ohms) to avoid a signal return. The WXR image is shown on the CAPT and F/O NDs when ROSE or ARC mode is selected on the EFIS control panel. The windshear events are shown on the CAPT and F/O NDs and all visual alerts on the CAPT and F/O PFDs for caution or warning alert (Advisory is only shown on NDs).

NOTE: When both EFIS control panels are in PLAN mode, the WXR/PWS transceiver is de−energized, because there is no WXR indication in the PLAN mode.

Audio Inhibit Signals

These discretes are used to indicate whether the aural alert output has to be active or not.

- PWS aural alerts (discrete input) are inhibited by the reactive windshear and stall warning from the Flight Warning Computers (FWCs),
- PWS discrete output is used to inhibit aural alerts generated by TCAS or Enhanced Ground Proximity Warning System (EGPWS) or other FWC warnings.

SYSTEM INTERFACES

Centralized Fault Interface Display Unit (CFDIU)

The MCDUs let the system be tested via the CFDIU. The test is only available on ground. During the test, the antenna carries out an elevation and an azimuth scanning sequence.

Enhanced Ground Proximity Warning System (EGPWS)

The EGPWS receives PWS alerts from the radar hazard bus to determine the priorities. Alert priorities are:

- WXR/PWS warning,
- WXR/PWS caution,
- Ground Proximity Warning System (GPWS) terrain warning,
- GPWS terrain caution.

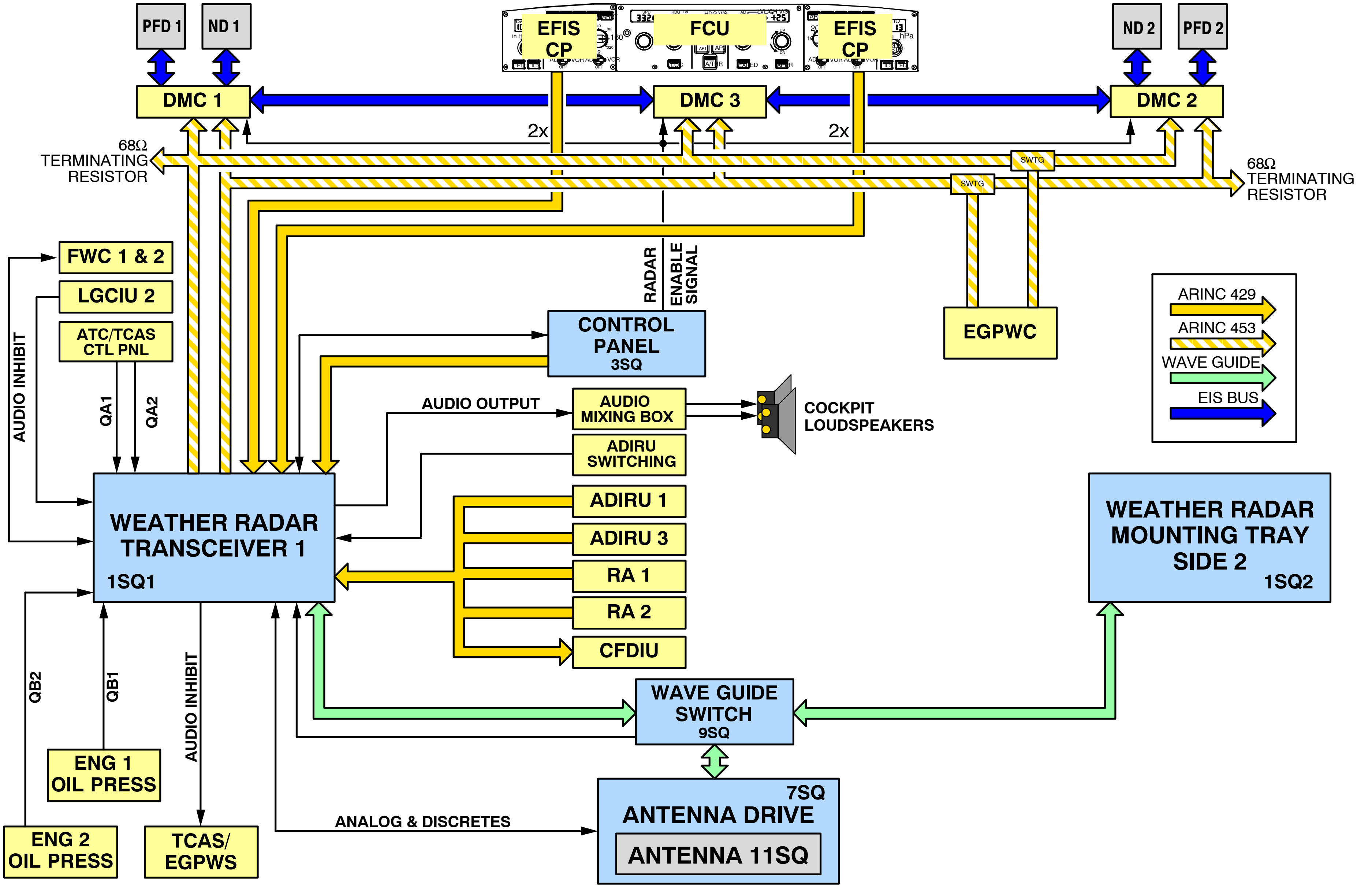


Figure 82 WXR Interface Diagram (Single System)

Landing Gear Control & Interface Unit (LGCIU)

The LGCIU sends ground/flight and landing gear extended information to the transceiver. This discrete signal is used by the receiver BITE module to count the flight legs. The landing gear extended signal is used to determine if the A/C is taking-off or landing to generate the aural warning message:

- GO AROUND, WINDSHEAR AHEAD in approach,
- or WINDSHEAR AHEAD, WINDSHEAR AHEAD at take-off.

Radio Altimeter (IF PWS is Installed)

The RA gives the altitude information through an ARINC 429 bus.

This data is used for automatic activation, together with the two (A & B) qualifiers, of the windshear function.

QUALIFIERS A AND B SIGNALS (IF PWS IS INSTALLED)

Version 1 (Qualifiers A & B Signals)

Two types of qualifier inputs are required to enable automatic activation of the predictive windshear function.

Qualifier type A:

- 2 qualifiers are used (QA1 and QA2).

  Provided by the Air Traffic Control (ATC)/Traffic Collision Avoidance System (TCAS) control unit, which indicates the position of the AUTO/ON/STBY switch. Qualifier A is valid when AUTO or ON is selected.

Qualifier type B:

- 2 qualifiers are used (QB1 and QB2).

  Provided by the engine low oil pressure switches 1 and 2, which indicate a normal engine oil pressure. Qualifier B is valid when the engine is running (high oil pressure).

  T<u>he windshear function is automatically activated below 2300 ft RA and one of each qualifier A and one of each qualifier B have to be valid.</u>

Version 2 (Qualifiers B, C, D signals (Qualifier A: ATC is no more used)

Two types of qualifier inputs are used to control automatic activation of the windshear function (B and C or B and D):

- qualifiers B: two qualifiers B inputs are used like version 1.
- Qualifiers C: two qualifiers C inputs are used.

  Qualifier C1: ground speed (IR bus from IR1) (valid when GS > 30Kts).
  Qualifier C2: ground speed (IR bus from IR3) (valid when GS > 30Kts).
- **Qualifiers D:** two qualifiers D inputs are used.

  Qualifier D1: body longitudinal acceleration (IR1, valid when Nx > 0.07g for at least 0.5 seconds). Qualifier D2: body longitudinal acceleration (IR3, valid when Nx > 0.07g for at least 0.5 seconds).

For the second transceiver, C1 and D1 information is provided by IR2.

<u>To automatically activate the windshear function, one of the qualifiers B and one of the qualifiers C or D have to be valid.</u>

NOTE: The automatic activation of the PWS function is independent from the WXR ON/OFF selector on the WXR Control Unit.

Audio Mixing Box

An analog audio output transmits the aural alert windshear to an audio mixing box connected to loudspeakers.

Air Data Inertial Reference Unit (ADIRU)

The WXR receives, from Air Data/Inertial Reference Units (ADIRUs) 1or 3, pitch and roll data, for the stabilization and control of the antenna, and ground speed for Doppler mode correction. The ADIRU, which provides data, is selected by means of the ATTittude/HeaDinG selector switch. The PWS function receives data from ADIRU 1or 3 for velocity calculations:

- true airspeed, altitude (or corrected altitude), east/west and north/south velocity ground speeds, longitudinal acceleration, track angle, true heading, and magnetic heading.

Flight Data Interface Management Unit (FDIMU)

One ARINC 429 high speed bus (hazard) provides radar data to be recorded on FDIMU.

Power Supply

Energization of the system is through a 115VAC/400 Hz bus:

- 1XP via the sub-busbar 101 XP for transceiver 1,
- 2XP via the sub-busbar 202 XP for transceiver 2 (if installed).

Energization of the weather radar control unit and of the WR antenna drive is through the transceiver. Consumption of the transceiver is 145 Watts maximum.

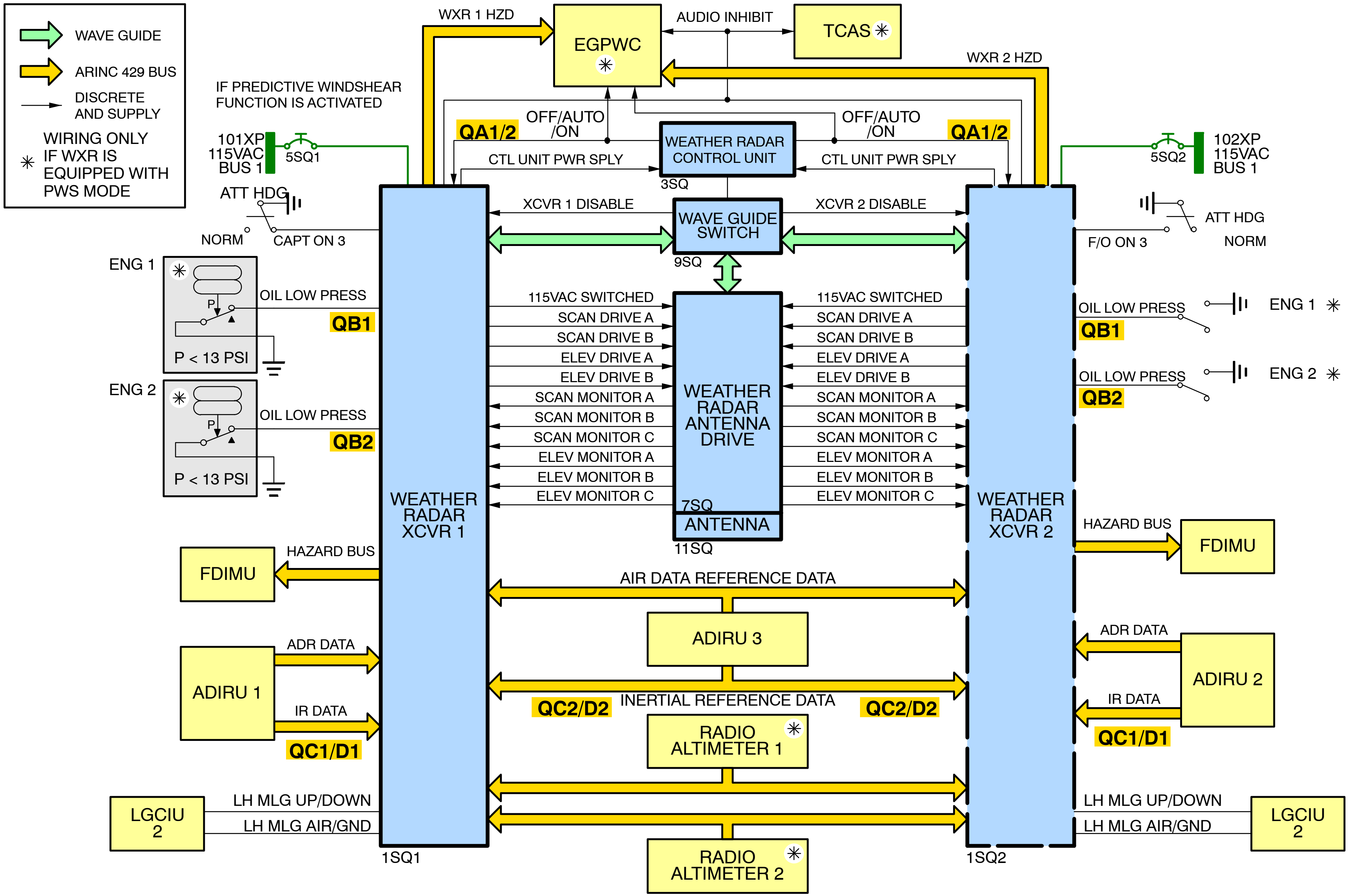


Figure 83 WXR System Data Acquisition (Dual System)

WEATHER RADAR WAVE GUIDE AND WAVE GUIDE SWITCH

wave guide assembly ensures the RF connection between the WR antenna drive and the WR transceiver mounting tray (connected to the wave guide switch).

The wave guide assembly is made up of rigid and flexible parts which have a standard rectangular section (1 in. x 0.5 in.).

The wave guide switch is integral with the mounting tray. It ensures switching of the RF signal from the antenna to the transceiver. Moreover control circuits recopy the wave guide switch position to avoid transmission on a closed wave guide.

TERRAIN OR WEATHER RADAR IMAGE SWITCHING

The Enhanced GPWS is configured to automatically de−select the weather display and pop−up a display of the terrain threats when they occur. The logic used provides an external input for predictive windshear alerts that can override a terrain display and revert to the weather display with the corresponding windshear data (if WR/PWS installed).

The Enhanced GPWS provides two external display outputs, each with independent range−scaling control in the same fashion as a weather radar on both NDs. Changes of range scaling to one ND do not affect the other display. Each of these two independent outputs may be used to drive more than one display.

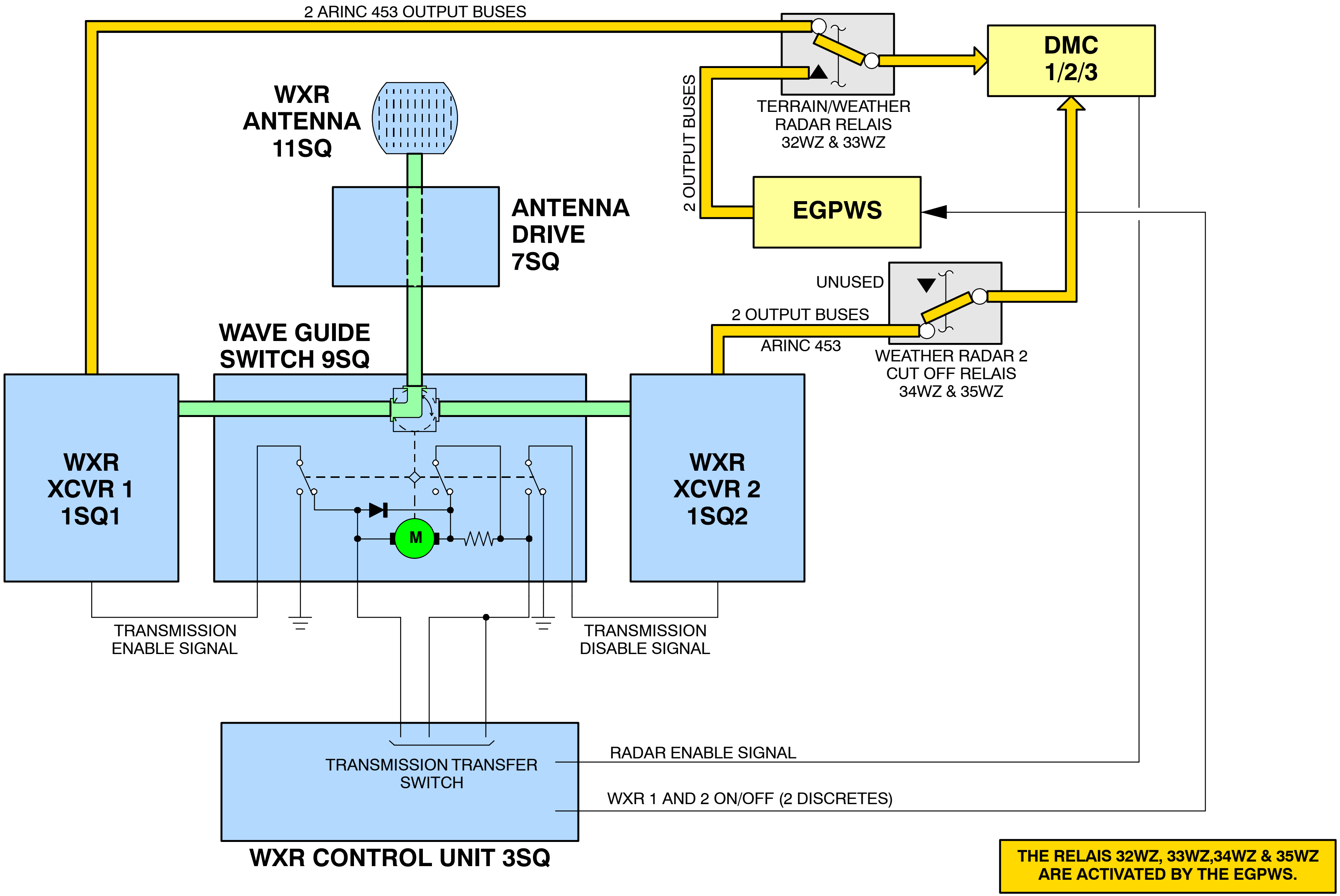


Figure 84 WXR Switch and Display Switching Scxhematic

WINDSHEAR ALERT FUNCTIONAL OPERATION

ALERT LEVELS

There are three alert levels defined in function of event seriousness and distance from the aircraft. The weather radar provides the crew with visual and aural warnings which vary in function of the level detected.

Windshear Warning Alert (Level 3)

This alert corresponds to the most dangerous phenomenons. It is generated for windshear events detected within +/– 0.25 NM from the longitudinal axis of the aircraft and within +/– 30 deg. scan of the aircraft heading.

On the ground, the maximum range is 3 NM. In flight, the maximum range is reduced to 1.5 NM.

During takeoff, level 3 covers ranges from 0 to 1.5 NM, from 50 to 1200 ft Above Ground Level (AGL). During landing, this coverage is from 1.5 to 0.5 NM, from 370 to 50 ft.

Range reduction is a linear function of altitude: at 370 ft, range is equal to 1.5 NM and reaches 0.5 NM at 50 ft.

During takeoff, this warning is inhibited from the time the aircraft attains 100 kts and until it reaches 50 ft AGL.

Level 3 warning is inhibited below 50 ft (in approach phase) and above 1200 ft. The windshear warning alert is announced by:

- an aural warning message: GO AROUND WINDSHEAR AHEAD in approach or WINDSHEAR AHEAD, WINDSHEAR AHEAD at takeoff, generated by the radar synthesized voice,
- a visual warning: red W/S AHEAD message on the PFD.

Display priority on PFD is given to level 3. The computer has to determine whether the aircraft is taking–off or landing to generate the aural warning message ”GO AROUND, WINDSHEAR AHEAD” or ”WINDSHEAR AHEAD, WINDSHEAR AHEAD”.

Transition between the GO AROUND, WINDSHEAR AHEAD and WINDSHEAR AHEAD, WINDSHEAR AHEAD aural warning messages is controlled by the GEAR UP discrete input.

Windshear Caution Alert (Level 2)

This level covers the events detected in a region from 0 to 3 NM, within +/– 30 deg. of the aircraft heading but outside the windshear warning alert region (level 3). This caution alert is inhibited:

- during takeoff, from the time the aircraft attains 100 kts and until it reaches 50 ft AGL,
- during landing, below 50 ft AGL.

There should be no windshear caution alert (level 2) above 1200 ft.

The windshear caution alert is announced by:

- an aural warning: MONITOR RADAR DISPLAY,
- a visual warning: amber W/S AHEAD message on the PFD.

Windshear Advisory Alert (Level 1)

This level covers the events located within 5 NM from the aircraft, within +/– 30 deg. of the aircraft heading but outside the windshear warning and caution alert regions (levels 2 and 3).

There should be no windshear advisory alert (level 1) above 1500 ft. No aural or visual warnings are provided for this advisory alert: only the windshear icon is superimposed on the radar image.

The weather radar transmits the windshear alerts following their detection order. A maximum of 8 events can be transmitted. Therefore, alerts of different levels can be generated simultaneously.

ALERTS	PFD	ND	AURAL WARNING
Advisory	N/A	Windshear Icon	N/A
Advisory in windshear mode only	N/A	PWS SCAN (GREEN)	N/A
Caution	W/S AHEAD (AMBER)	Windshear Icon	MONITOR RADAR DISPLAY
Warning	W/S AHEAD (RED)	Windshear Icon	During Take Off: WINDSHEAR AHEAD WINDSHEAR AHEAD During Landing: GO AROUND WINDSHEAR AHEAD

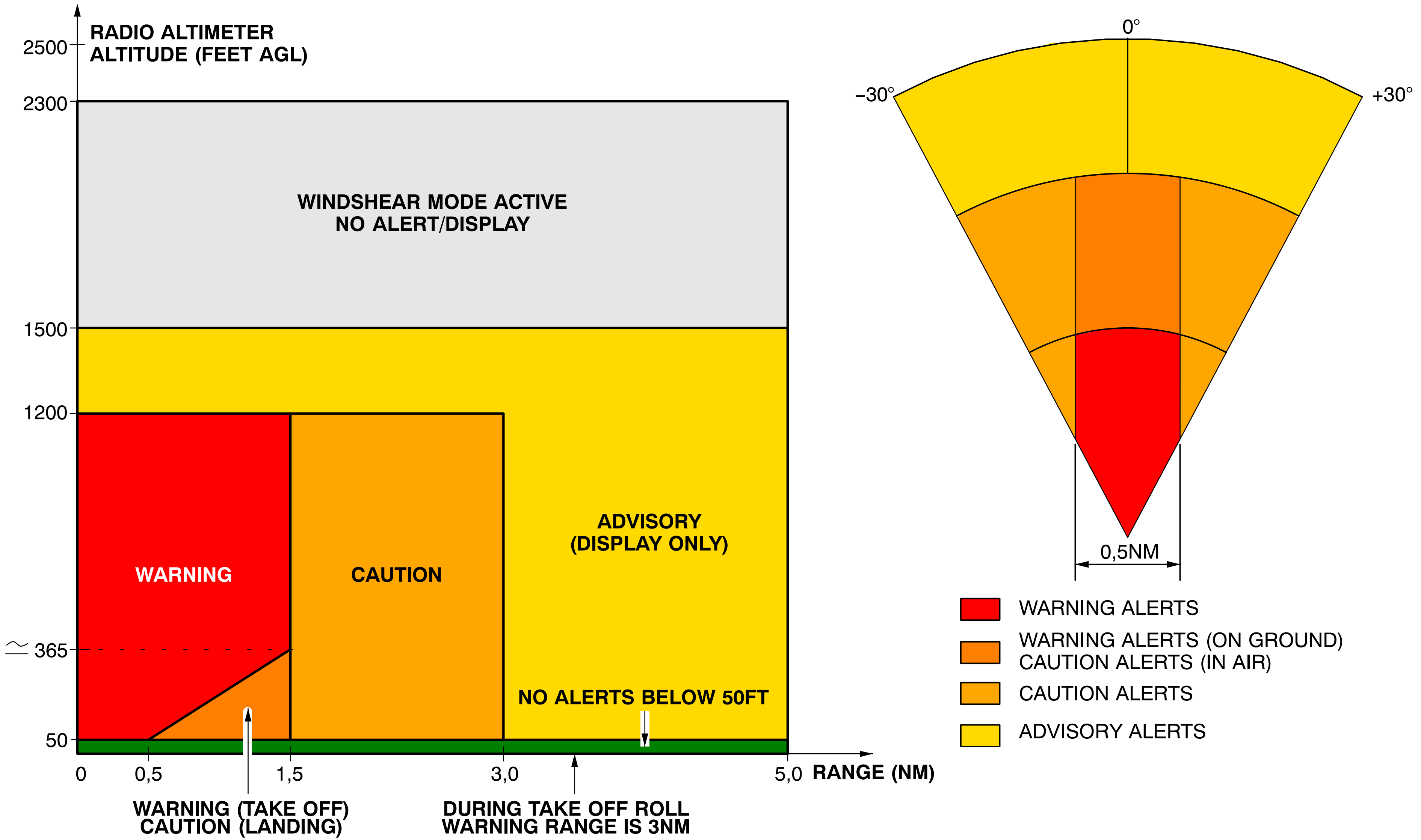


Figure 85 Windshear Alert Levels

WEATHER RADAR COMPONENT DESCRIPTION

WXR TRANSCEIVER

The weather radar transceiver with PWS is a completely solid–state airborne unit. It contains:

- A power amplifier.

  A single 777.77 MHz multiplier drive signal is developed by the power amplifier. The power amplification of the transmit section is accomplished by splitting the power amplifier drive before recombining the signals into a single multiplier drive signal.
- A power multiplier.

  The power multiplier produces the 9333.24 MHz transmitter output signal from the single multiplier drive signal (from the power amplifier).

  The multiplier drive signal is multiplied by 3 to produce a 2333.31 MHz signal. The 2333.31 MHz signal is their quadrupled to produce the 9333.24 MHz transmitter output signal.
- A duplexer/monitor.

  The transmitter output is coupled through a duplexer/monitor to the waveguide antenna feed through a 4–port circulator. Incorporated in the duplexer operation are monitor circuits to monitor the output power level and develop a frequency loop error signal for the correction of frequency chirp.

  The monitor circuit also accepts a test signal which causes a portion of the reference signal to be injected into the receiver for test calibration. The 4–port circulator also couples the RF return from the waveguide antenna feed through the preamplifier to the receiver portion of the transceiver.
- A preamplifier.

  The preamplifier assembly perform the waveguide limiter functions (protects the mixer diodes from all high power pulses), contains a noise diode circuit and contains a 2–stage RF amplifier which provides +18dB of RF gain.
- A mixer.

  The mixer circuit processes the detected RF return signal by mixing it with the First local oscillator signal and amplifying the resultant Intermediate Frequency (IF) signal in the First IF amplifier. The first IF amplifier provides 25dB amplification before the First IF signal is applied to the second IF amplifier.
- A sampler.

  The sampler commands and controls the receive and transmit functions within the receiver–transmitter. A digital signal processor is used to control transmitter timing and receiver normalizer.
- A digital signal processsor.

  The digital signal processor circuit card performs the weather processing, clutter identification, clutter filtering, velocity extraction and editing, hazard computation and hazard recognition algorithms. Command and control information is passed from the digital signal processor to the sampler through a dual port RAM.
- A central processing unit

  Control of internal functions, antenna servo controls, monitoring of system operation and formatting the processed data is accomplished by the central processing unit. It uses a microprocessor and a stored program to execute the major routines that control the transceiver and system operations.
- An input/output unit.

  All interface functions between the microprocessor of the central processing unit and the rest of the transceiver and units in the system are provided by the input/output unit. Control word buses, digital and analog attitude buses, radio altitude inputs and discrete buses are all connected to the multiplexer and shift register of the input/output unit. In addition, the input/output unit contains speech circuits for windshear hazard annunciation, the synchro–to–digital conversion circuits, discrete warning annunciation outputs, aural warning outputs and remote turn–on circuits.
- A BITE/monitor.

  The BITE/monitor provides the BITE power supply voltages to BITE functions and circuits, a power monitor for the detected transmitter output and an interconnect for various signals used throughout the transceiver.

WXR ANTENNA

The weather radar antenna is controlled in azimuth and elevation by the transceiver CPU. The binary control data are decoded and activate the antenna scan and elevation stepper motors through corresponding power circuits. The indication of these positions is sent to the CPU for comparison. The RF signal (transmitted or received) is conveyed by a wave guide between the antenna and the transceiver.

Energization of the antenna is 115VAC/400 Hz through the transceiver.

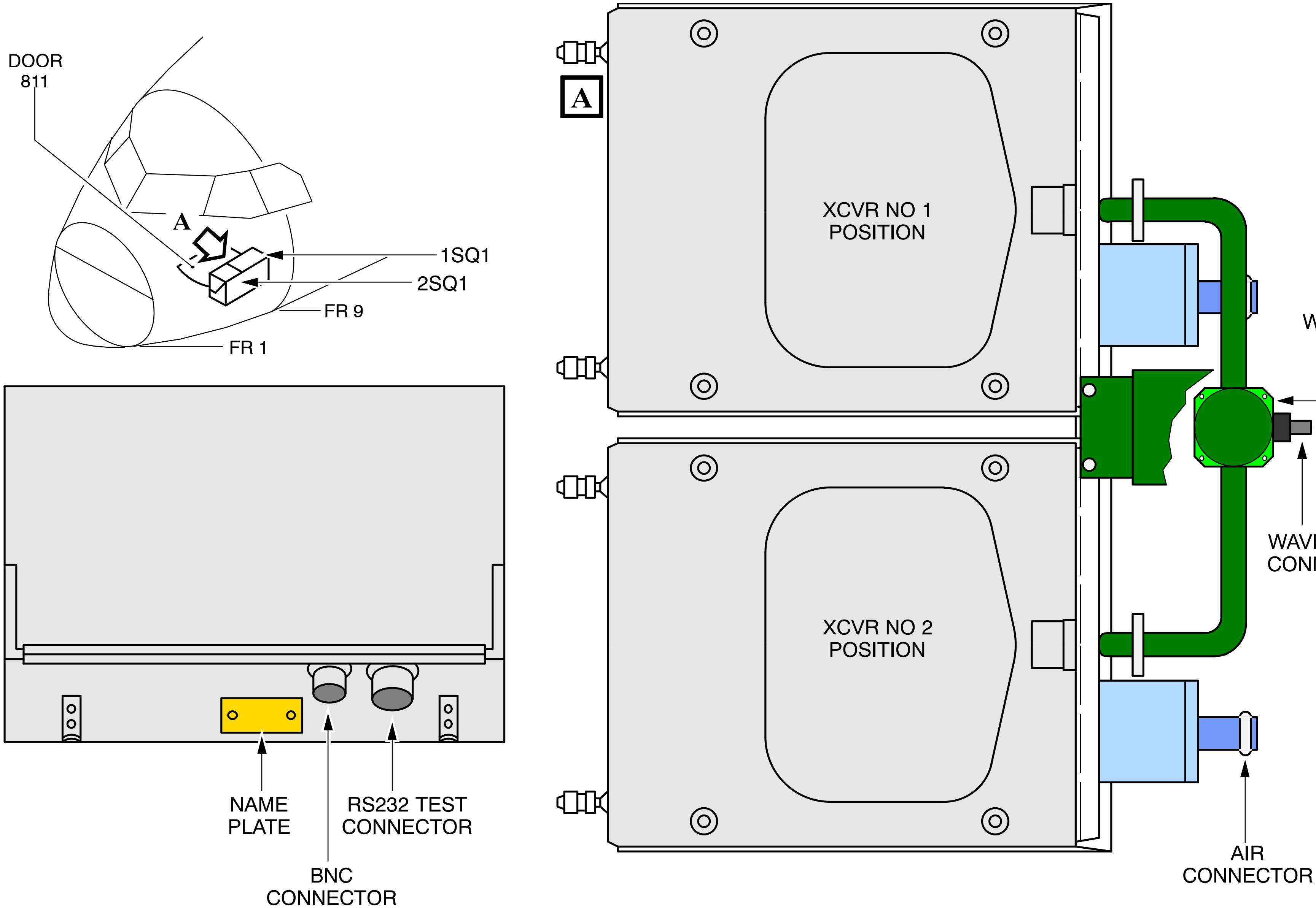


Figure 86 WXR Transceiver

LOGIC OF SCANNING MODE

The antenna scan pattern varies depending on the mode of operation.

Weather Radar Scan Pattern

In weather radar mode, the antenna scans a 180 deg. in azimuth and has tilt (pitch) coverage of plus or minus 15 deg.

Stabilization limits are plus or minus 25 deg. in the pitch axis and plus or minus 40 deg. in the roll axis.

An antenna scanning is performed in 4 seconds, this causes the transmission of 760 data words at each antenna scanning.

The weather radar system features a 4−second constant refresh rate of the WX image whatever the ranges selected on the CAPT and F/O EFIS control sections of the FCU.

Weather and Windshear Scan Pattern (No Detected Windshear Event)

When the system is placed into alternate weather/windshear scan pattern and no windshear event is detected, the antenna scan pattern is as follows:

- clockwise weather scan with plus or minus 90 deg. of azimuth coverage and processing for weather
- counterclockwise windshear scan with full plus or minus 90 deg. of azimuth coverage, but with windshear processing limited to the plus or minus 45 deg. sector.

However, the WR/PWS have to update the refresh rate of the WX image to 12 seconds due to sharing of processing between windshear and radar.

Weather and Windshear Scan Pattern (With Windshear Event Detected)

When the system is placed into alternate weather/windshear scan pattern and the system detects a windshear event, the antenna scan pattern is as follows:

- clockwise weather scan, from minus 90 deg. to plus 90 deg.,

The sequence is repeated as long as windshear event is detected. If a windshear event is not detected, the system reverts to the alternating weather/windshear scan pattern described above.

The refresh rate of the WX image is minimum 16 sesonds due to sharing processing between radar and windshear event detection.

Windshear Scan Pattern

When the system operates in windshear mode only, the scan pattern is plus or minus 45 deg. azimuth coverage on both the clockwise and counterclockwise scans.

This mode occurs if the operator has placed the weather radar to OFF mode. Windshear data are processed during both directions of antenna scanning. In this case the windshear mode works transparent to the flight crew until a windshear event is detected. The refresh rate of the display is 8 seconds.

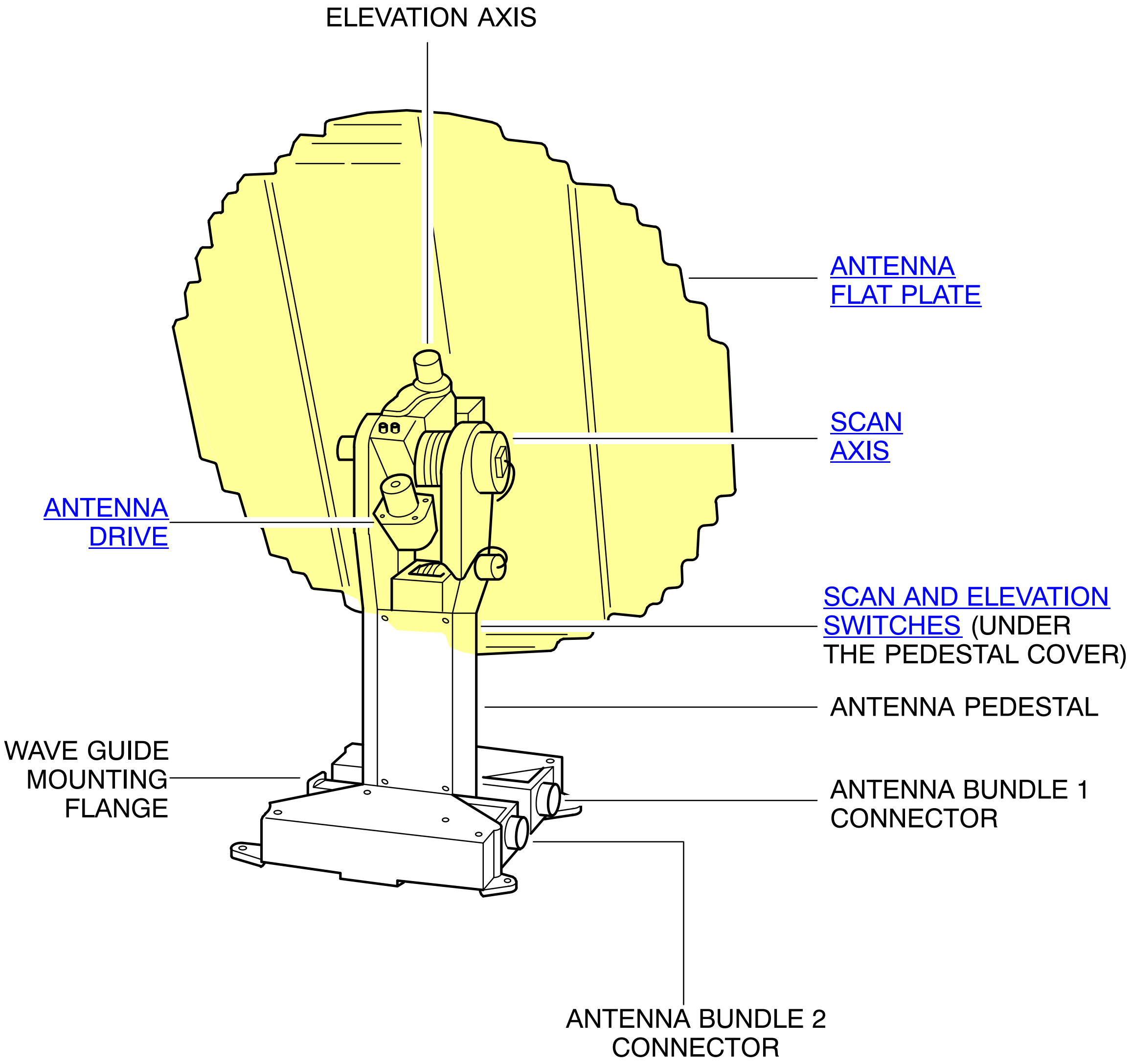
RADAR MULTISCAN MODE

The Multiscan mode manages the antenna beam tilts automatically. The antenna tilts are controlled for optimum weather detection during each phase of flight. This mode uses a low and high beam to examine short and long range, even while on the ground. Data for display is automatically selected from the upper beam, lower beam or both depending on the flight regime, clutter situation and optimum weather detection requirements.

At each initial flight of the Multiscan radar transceiver, the transceiver needs to be calibrated (each transceiver must be turned on for approximately four minutes) during a short period in stable flight conditions. Before the initial calibration step, it is possible that the weather image shows an excessive ground clutter. If the initial calibration step is not performed or is uncompleted, the Multiscan radar transceiver will calibrate itself during the next flights.

Weather Mode Scan Pattern

When Multiscan operates in the weather mode only two radar scans are utilized. One four−second sweep is utilized for the high beam and one four−second sweep is utilized for the low beam. Therefore, the total cycle time is 8 seconds.



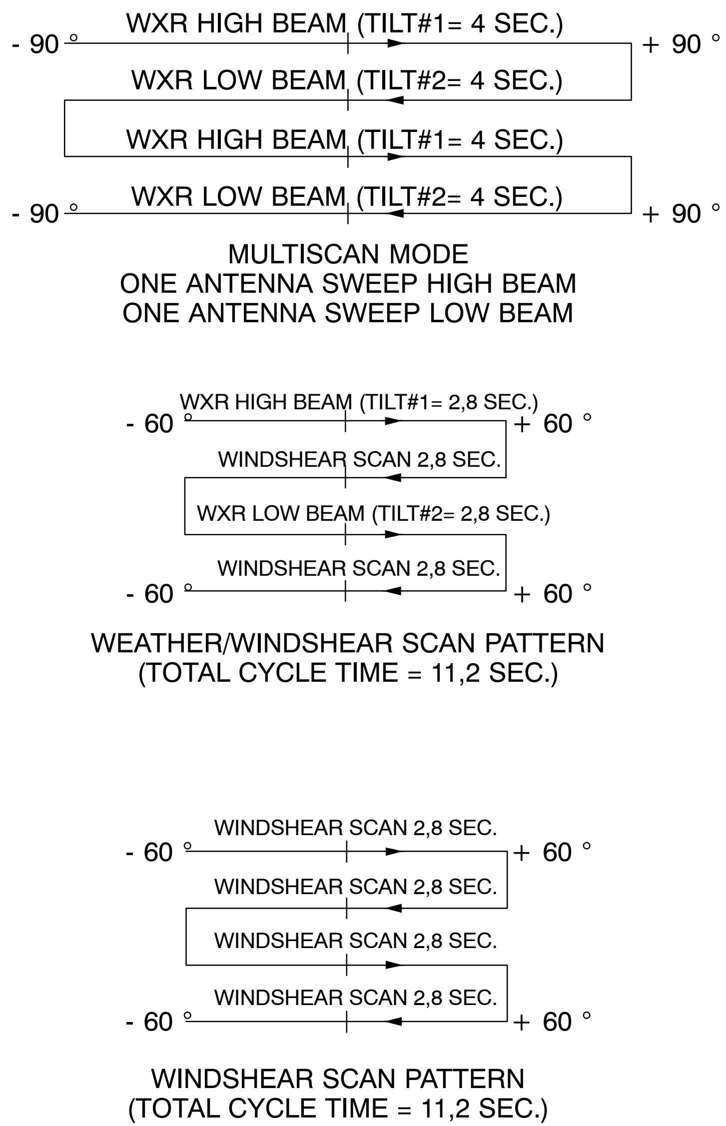


Figure 87 WXR Antenna & Scan Patterns

WXR SYSTEM FLAGS AND WARNINGS DESCRIPTION

WXR MESSAGES ON THE ND

Messages inform the crew of the tilt angle and gain selected on the weather radar control unit. Other messages indicate the failures which affect the operation of the radar system. All these messages are displayed in the R lower corner of each ND whenever a radar image is selected.

It information and gain selection are displayed on the ND when no failure warning message is generated, or when the TEST mode is not selected.

The various failures which can affect the radar image are listed in decreasing order of importance. If several failures occur, only the most important one is displayed. Two types of failures can affect the radar system.

Failures which Result in the Loss of the Radar Image

The corresponding messages are displayed in red:

- **WXR WEAK:**
  Indicates the loss of the transceiver calibration.
- **WXR DU:**
  Indicates an overheating of the Display Unit (DU).
- **WXR R/T:**
  Indicates a failure of the weather radar transceiver.
- **WXR ANT:**
  Indicates a failure of the weather radar antenna.
- **WXR CTL:**
  Indicates a failure of the weather radar control unit.
- **WXR RNG:**
- Indicates an error of comparison between the range from the EFIS control section and the copy data received on the DMC via the radar data bus.

Failures which do not affect the Radar Image

The corresponding messages are displayed in amber:

- **PRED W/S:**
  Indicates a failure of the windshear function.
- **WXR ATT:**
  Indicates an attitude failure from the ADIRU,
- **NO AUTOTILT:**
  Indicates a failure of the Multiscan function.
- **WXR STAB:**
  Indicates the loss of the radar antenna stabilization.
- **WXR TEST:**
  Indicates the selection of the radar TEST mode.

Operational Message that does not affect the Radar Image

The following message is displayed in green instead of the TILT value:

- **PWS SCAN:**
  Indicates that the weather radar operates in windshear mode only (weather radar system selector switch set to OFF and windshear mode selector switch set to AUTO on weather radar control unit).
  On ground the qualifier logic has to be satisfied.

Windshear Flags on NDs

When a windshear fault occurs, an amber PRED W/S message comes into view. The radar image remains available if this fault does not affect the radar modes or detection function.

A detected fault is displayed when:

- the aircraft is on the ground or the flap and slat control lever is in a position different from 0.
- the windshear AUTO/OFF switch on the radar control unit is set to AUTO (the fault message is not displayed when the switch is set to OFF).

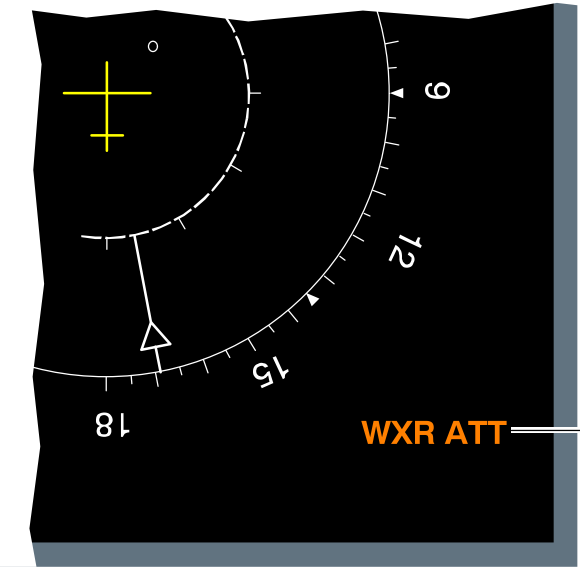
Windshear Failure Display on Upper ECAM Display Unit

A detected windshear fault is indicated by the following amber messages:

- **NAV: PRED. W/S DET FAULT** on EWD,
- **PRED. W/S DET** on SD INOP SYSTEM area.

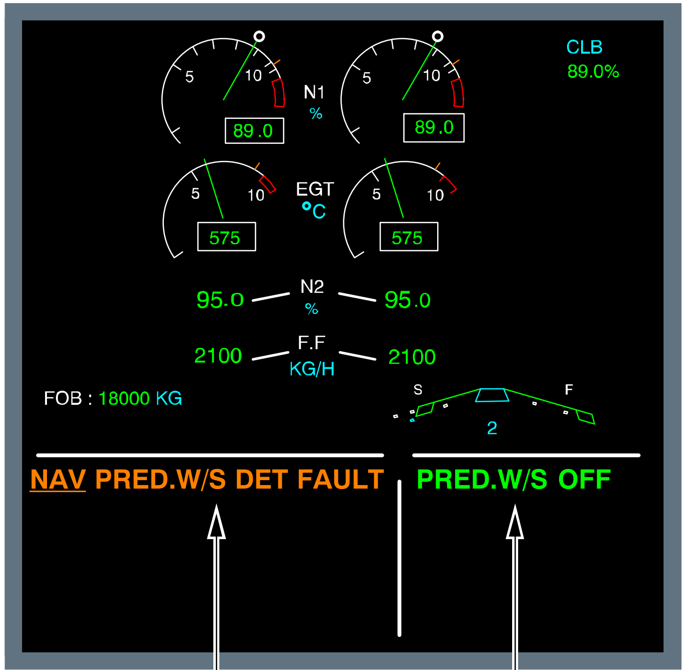
This message is associated to the indications presented on the NDs.

When the windshear AUTO/OFF switch is set to OFF on the weather radar control unit, a green or amber PRED W/S OFF memo message is presented to the crew. The color of this message depends on the flight phases.



MESSAGES DISPLAYED ON ND

MESSAGE	COLOR	CAUSE	CONSE-QUENCE
WXR DU	RED	DU OVERHEATING	LOSS OF IMAGE
WXR R/T	RED	XCVR FAILURE	
WXR ANT	RED	ANTENNA FAILURE	
WXR CTL	RED	CONTROL UNIT FAILURE	
WXR RNG	RED	INCOORECT RANGE COMPARISON	
WXR WEAK	AMBER	INCORRECT CALIBRATION	IMAGE NOT LOST
WXR ATT	AMBER	ATTITUDE FAILURE	
WXR STAB	AMBER	LOSS OF ANTENNA STABILIZATION	
WXR TEST	AMBER	TEST MODE	TEST IMAGE
PWS SCAN	GREEN	PREDICTIVE WINDSHEAR MODE ONLY	NORMAL OPERATION



AMBER PWS FAILURE MESSAGE

GREEN OR AMBER MEMO MESSAGE

(PWS SELECTED OFF ON CTRL UNIT)

Figure 88 WXR & PWS Failure Messages on E/WD & ND

WEATHER RADAR RDR-4000 GENERAL DESCRIPTION

GENERAL

The general purpose of the **RDR-4000** weather radar system is to alert the crew from weather hazards encountered by aircraft on its potential flight path.

Those may be:

- Adverse Weather conditions,
- Windshear,
- Turbulence.

Compared to the previous generation WXR (RDR4B), RDR-4000 main improvements/modifications are:

- use of a 3D buffer to collect weather information, Navigation Display (ND) is no more correlated with antenna scan
- independent display selection for CAPT and F/O automatic display of ”on path” and ”off path” weather cells
- constant elevation display mode replaces manual tilt mode
- enhanced turbulence detection
- autonomous” reduction of ground clutter by using an embedded terrain database
- refine windshear (W/S) automatic activation logic.

System description

The RDR-4000 weather radar is composed of items closely associated with its operation, such as peripherals supplying parameters, EFIS display units or maintenance functions.

NOTE: The weather radar image is shown independently on the CAPT and F/O Navigation Displays (ND).

The weather radar system, which complies with ARINC Characteristics 708A, consists of:

- a weather radar transceiver (or Radar Processor) 1SQ1
- a weather transceiver mounting tray 9SQ1
- a dual weather radar control unit 3SQ
- a single weather antenna drive 7SQ
- a weather radar antenna 11SQ
- a weather radar transmitter/receiver 13SQ1.

Weather radar transceiver (or Radar Processor)

The Honeywell RDR–4000 is an airborne X–Band weather radar system. Its function is to increase the flight crew’s awareness by detecting and annunciating weather conditions that could disturb the correct development of the flight, primarily heavy precipitation, turbulence, and windshear. By providing automatic features, RDR–4000 allows to reduce crew workload.

Source: HONEYWELL

Figure 89 RDR 4000 components

WEATHER RADAR OUTPUTS

The weather radar processor provides the following outputs:

Displays

The RDR-4000 weather radar is connected to the DMCs by an ARINC 453 bus to transmit the weather radar data. All the weather and windshear data received by the DMCs are processed and displayed on CAPT and F/O NDs and PFD for caution and warning alert.

The Navigation Display (ND) provides the following indications:

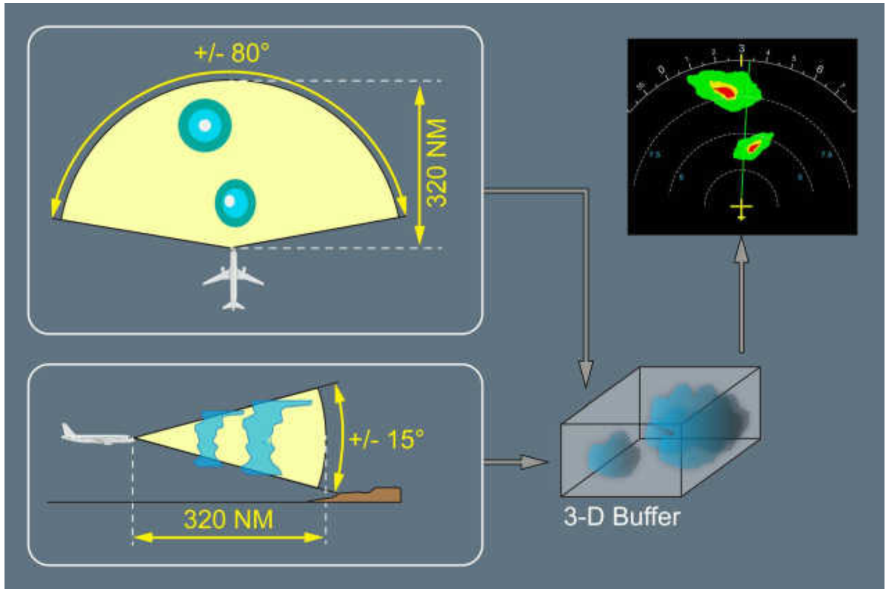
- weather radar image
- windshear events location in case of PWS alert
- mode messages reflecting mode CAPT and F/O selection on control panel (CAPT mode selection is indicated on CAPT ND, F/O selection is indicated on F/O ND).

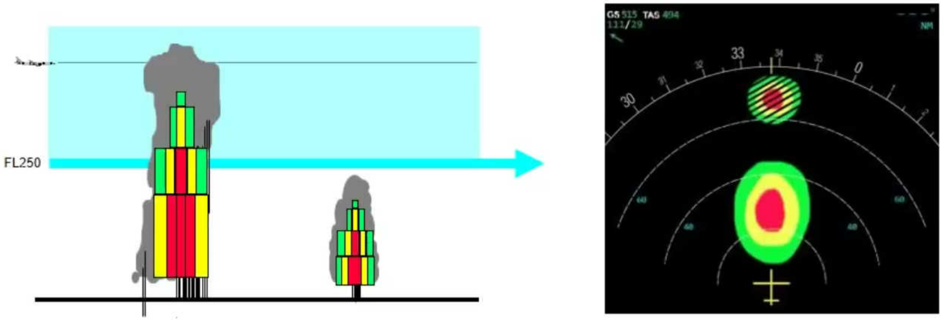
The WEATHER AHEAD message is displayed in the TCAS zone of the ND and can also be displayed during a TCAS alert.

The **Primary Flight Display** (PFD) indicates windshear visual alert in case of caution or warning alert.

The Flight Warning Computers (FWC) and the FDIU receive RDR-4000 weather radar data through the DMCs. These data are used by the FWCs to display windshear function failure and windshear function de-activation.

The **FDIU** records the windshear alert and failure.





Aircraft above FL250

- **Display maximum level of relevant weather from FL250 up to +4000' feet above the aircraft**
- **Display secondary weather in cross-hatch pattern**

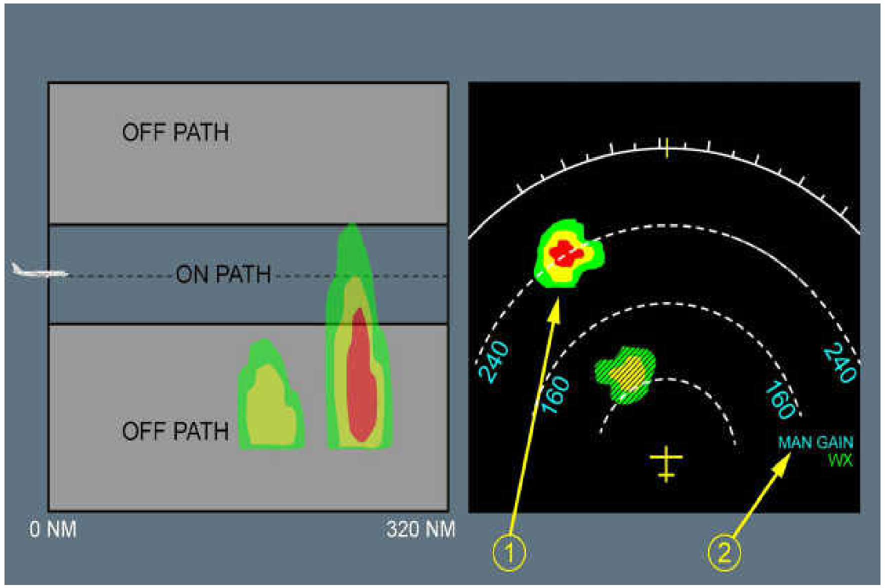


Figure 90 Weather radar indication

RADAR PERIPHERICALS DESCRIPTION

DIGITAL SERIAL DATA INPUTS:

The weather radar transceiver receives digital serial data inputs from the following components:

Radio altimeter:

The radio altimeter provides altitude information over two redundant ARINC 429 bus inputs to the RDR–4000 weather radar. This data is used in the predictive windshear function.

Air data reference

Two redundant ARINC 429 low–speed buses provide

- airspeed data used for volumetric buffer processing and Predictive Windshear System (PWS) function
- altitude data used in elevation mode.

Inertial reference

Two redundant ARINC 429 high–speed buses provide:

- pitch roll and drift angle data for the stabilization and control of the antenna
- hybrid position and altitude, speed, track/heading angle for volumetric buffer processing.

Centralized Fault Display Interface Unit (CFDIU)

The RDR–4000 weather radar communicates with the CFDIU Low–speed ARINC 429 bus for maintenance purpose.

EFIS control section

Two ARINC 429 buses provide the CAPT and F/O range selection and barometric reference selection (for selected altitude display in elevation mode).

The receiver/transmitter receives one bus from the CAPT EFIS control section and another one from the F/O EFIS control section.

General Technical Characteristics

The RDR–4000 weather radar system is mainly used to detect and localize various types of atmospheric disturbances and windshear events in the area scanned by the antenna. The system shows the disturbance intensity through the use of colors which vary with the atmospheric precipitation rate.

The disturbances are shown to the crew members on the NDs with different colors:

- black, green, yellow, red to quantify the precipitation rates
- magenta to represent the turbulence areas up to 40 NM.

The system can show the location of the windshear events via the NDs: alternating black and red arcs depict the windshear event.

As the minimum display range is 10 NM, two yellow radials appear at the edges and start beyond the windshear (W/S) event.

Power Supply

Energization of the system is through a 115VAC/400 Hz bus:

- 1XP via the busbar 101 XP–C for weather radar transceiver 1.
- The weather radar transceiver supplies power to the other units of the system:

  Control unit, transmitter/receiver unit and antenna drive.
- Consumption of the radar transceiver (and so the whole system) is 120 W maximum.

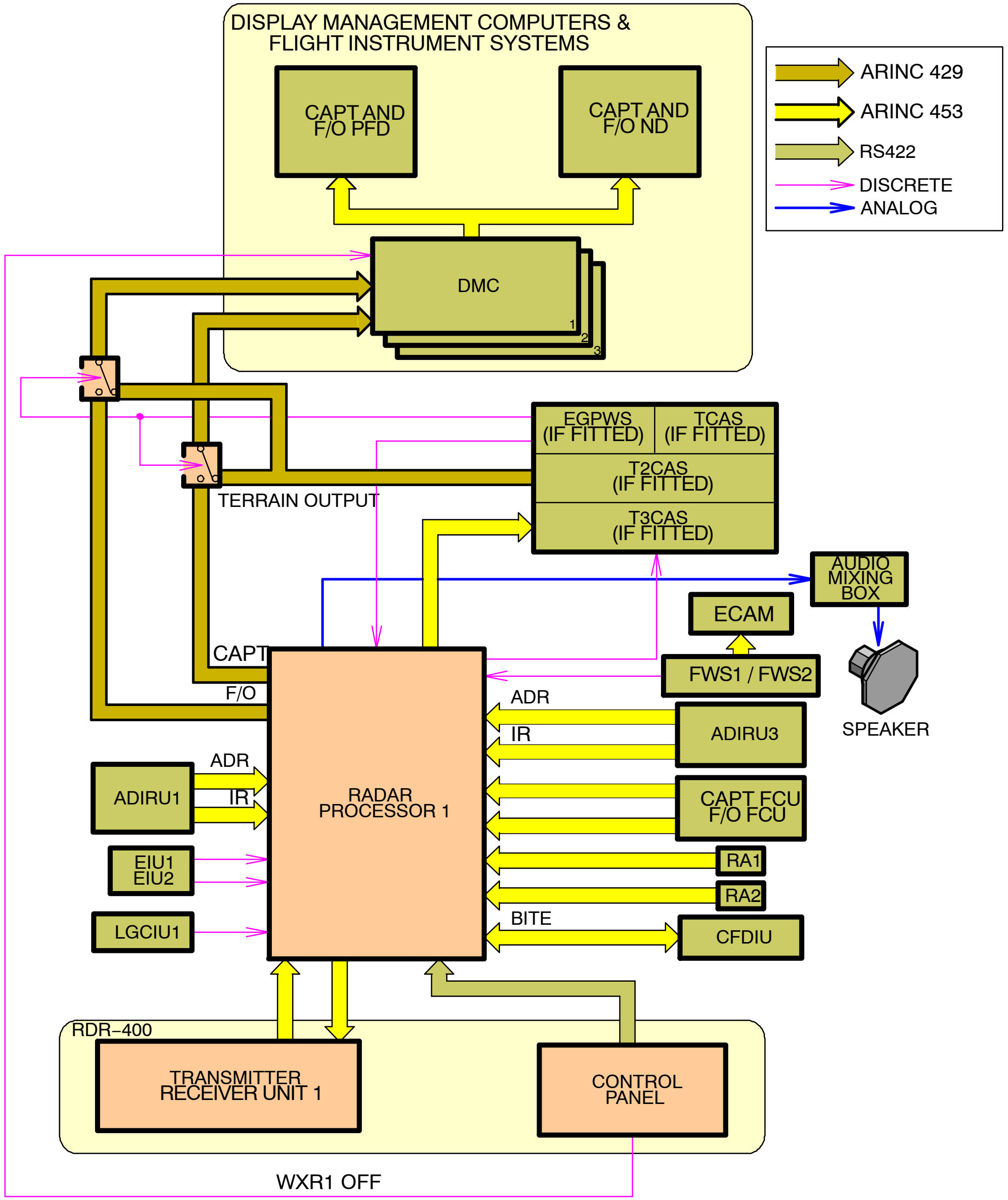


Figure 91 Weather radar block diagram

DISPLAY MODES DESCRIPTION

RDR-4000 introduces **3D-Buffer technology**, antenna scanning is no more correlated with ND display. The system will continuously scan the atmosphere in front of the aircraft from **0 to 60000 ft**.

That is the main difference compared to previous generation weather radar with which antenna scanning was limited to one tilt setting defined either automatically by the system or manually by the pilot and weather radar echoes detected over the plan defined by the antenna tilt position were synchronously displayed on ND.

In automatic mode, RDR-4000 provides to the ND all detected weather cells. Cells situated outside of aircraft vertical flight path (called OFF PATH weather

Operational behavior/antenna scanning

Activation of WX/TURB and PWS function is made through one single switch.

System behavior regarding activation of WX or W/S detection depends on control panel selection and Air/Ground or qualifier status:

- If system switch is set to OFF, system is supplied, BITE interactive mode is available but the system will not scan, whatever the position of other control knobs.
- If one system is selected with system switch then operational state of the system depends on Ground/Air condition and control knobs position:

On ground

- When both CAPT and F/O display mode selectors are set to OFF then the system will not scan ("standby" state) until qualifier logic becomes valid (Automatic activation). Once qualifier became valid the system will scan for WX (including TURB) and W/S detection.
- If CAPT or F/O display mode selector is set to a mode different than OFF, then WX (including TURB) and W/S detections are activated and system will scan (Manual activation).

In air

- System always scans for WX (including TURB) detection and for W/S in the PWS activation area.

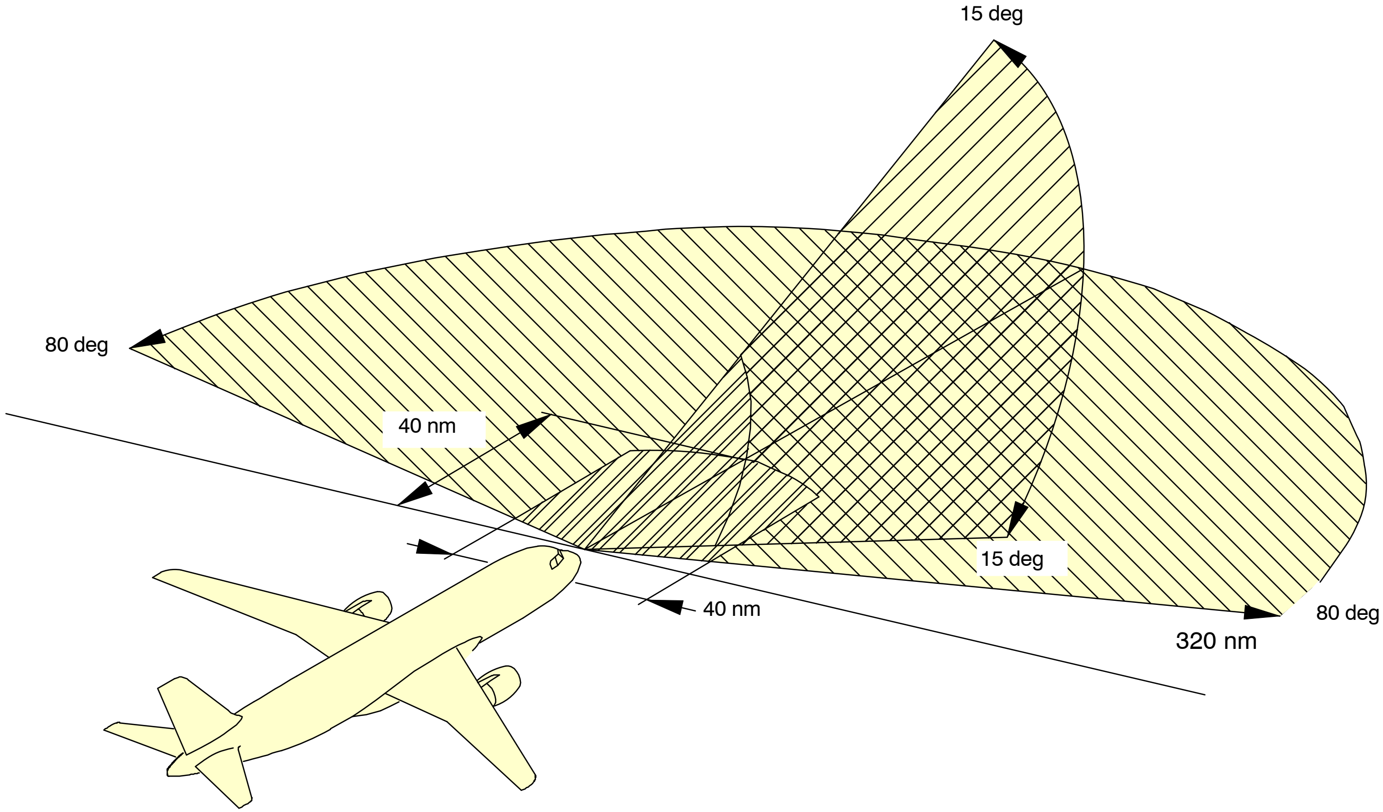
WINDSHEAR MODE

The WXR/PWS, by a Doppler mode, determines the wind field ahead of the aircraft. By a mathematical treatment, the system determines the hazard factor (so called F-factor) related to the danger of a windshear event. An hazard factor exceeding a value of 0.13 and within 5 NM ahead of the aircraft is considered as the presence of a dangerous event and a corresponding windshear alert is generated. The display of windshear hazard consists of an icon of red and black bands superimposed on the radar returns. These events are dangerous during takeoff and landing maneuvers. So when weather system is activated (one system selected through 1/OFF/2 selector switch on control panel), PWS function is automatically activated with a dedicated logic called qualifier logic. Contrarily to WX function that requires around 30 seconds after start of antenna scanning, PWS operation is "real beam" and therefore PWS detection is available as soon as antenna starts scanning.

Qualifiers also permit to prevent undesired radar emission on ground and to protect personal.

Turbulence detction

The turbulence detection has been improved with the new pulse waveforms and digital signal processing. The radar system detects moderate and severe turbulence from the blind range (less than 1 NM) to 40 NM from the aircraft and 20 NM laterally on either side from the aircraft centerline.



NOTE:

TURBULENCE DETECTION RANGE

WEATHER DETECTION RANGE

Figure 92 Radar coverage

WEATHER RADAR CONTROL UNIT DESCRIPTION

The weather radar control unit includes the following controls:

- A **WXR/PWS** control switch, item 1, with three stable positions 1/OFF/2, which enables the activation of system 1 or 2 when installed.
- A **TURB** control switch, item 2, with two stable positions AUTO/OFF.
- A **GAIN** knob, item 3, which allows to adjust the intensity of weather displayed colors around automatic position for weather cell reflectivity analysis.
- A **CAPT DISPLAY** or **F/O DISPLAY** selector switch, item 4.

  Each crew member can choose between the following modes :

  – **OFF :** in this mode, PWS function is active in the activation zone (during take-off and landing), no weather echo is displayed except when a windshear alert is triggered.
  On ground, both display mode switches have to be set to OFF in order to prevent any radar emission. If one crew member selects a display mode different than OFF when one system is selected, then antenna is scanning and emitting.
  As soon as system detects the Air state, system will automatically scan and update the 3D-buffer but no weather radar echo will be displayed until pilots change display mode.
  – **ALL:** in this mode, ON PATH and OFF PATH weather data are displayed, windshear and turbulence detections are enabled
  – **ON PATH:** in this mode, only ON PATH weather is displayed, windshear and turbulence detections are enabled.
  – **ELEVN:** in this mode, each crewmember can display the weather data at the altitude selected with ELEVN rotary knob. The windshear detection is enabled but turbulence presentation is not available.
  – **MAP:** in this mode, only ground echoes are displayed on ND, windshear detection is still enabled.
- An **ELEVN knob**, item 5
  – When the ELEVN display mode is selected, item 4, each crew member can control the weather altitude layer to be displayed on ND.

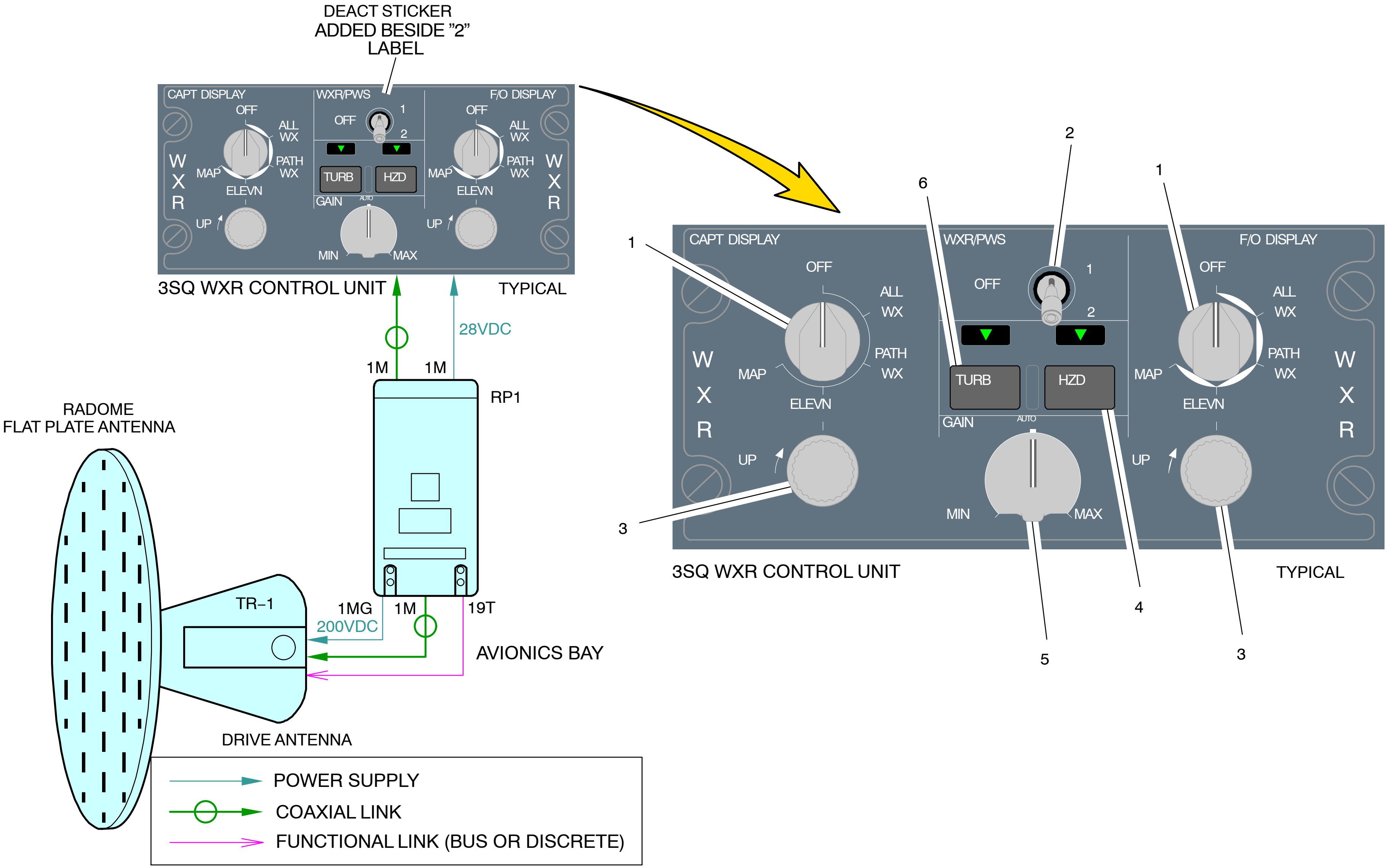


Figure 93 Weather radar control panel

COMPONENT DESCRIPTION

WEATHER RADAR TRANSMITTER/RECEIVER UNIT

The weather radar transmitter/receiver unit provides the means for:

- generating and transmitting a nonlinear, frequency modulated (FM) waveform
- receiving return echoes that then will be processed by the radar transceiver.
- The Transmitter/Receiver contains the electronics necessary to transmit, receive, and process the radar pulses used to detect turbulence, windshear, weather, and terrain targets. It also contains the system integrity monitoring and self test electronics.
- The TR–1 is located in the radome in the base of the antenna drive.

TRANSCEIVER (RADAR PROCESSOR

The RDR-4000 radar transceiver (or Radar Processor) converts the receiver output signal from the transmitter/receiver unit to an usable output for display. It provides positioning data to the antenna drive and mode control data to the transmitter receiver unit.

RADAR OPERATION

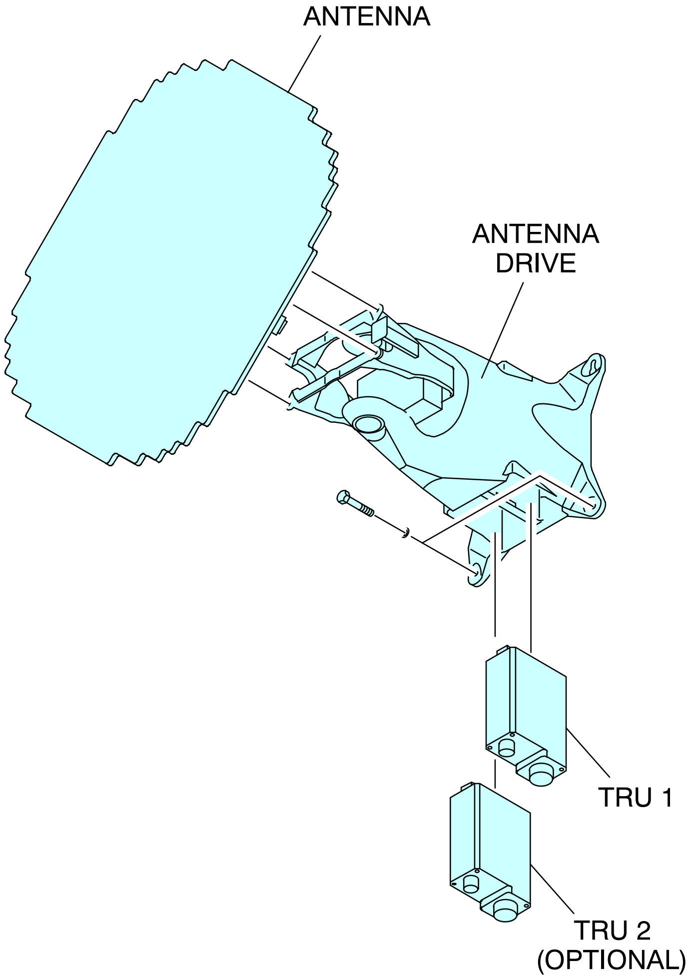
The weather radar system uses the principle of radio echoing. It works at a normal frequency of 9345 MHz. The transmitter/receiver unit generates a microwave energy in the form of electromagnetic pulses via X-band wave guide to the antenna. When these pulses intercept an appropriate target, part of the energy is reflected back to the weather radar antenna then to the transmitter/receiver. Then signal is outputted from transmit/receiver unit to radar transceiver through a coaxial link and processed by the radar transceiver in order to convert it in a displayable data.

The elapsed time between the transmission of the wave and the reception of the echo allows determining the target distance (it takes around 12.36 microseconds for the electromagnetic wave to travel out and back for each nautical mile of target range). The azimuth and elevation position of the target is detected by the position of the antenna. As the quantity of energy reflected to the antenna is proportional to the target density, the different levels of atmospheric disturbances are shown on the displays by different colors. The detection of the turbulence areas is based on the Doppler Phenomenon.

3D BUFFER

The RDR-4000 radar antenna continuously scans the volume ahead of the aircraft (from 0 to 60000 ft) and stores weather returns in a 3D buffer. The weather information stored in the 3D buffer is used for display on ND. So with the 3D buffer, the weather display is no more correlated with the radar antenna position like for conventional weather radar.

Use of a volumetric display buffer which stores swaths of data that can be retrieved in either horizontal slices or in vertical slices allows to improve weather detection by reducing ground clutter and providing multiple views of the reflectivity data.



TRU: TRANSMITTER/RECEIVER UNIT

TRANSCEIVER/RECEIVER UNIT

RADAR PROCESSOR

Figure 94 Radar Components

MAINTENANCE PRACTICES

SPECIAL PRECAUTIONS

Some special precautions must be taken before using the Weather Radar (WXR) system on ground in MAP, WX or WINDSHEAR mode.

- The dangerous zone forward of the aircraft must be free of metallic obstacles such as hangars or aircraft, within 5 meters in an arc of + or − 90° on either side of the aircraft centerline.
- Make sure that nobody is within a distance of 1.5 m from the antenna, in an arc of + or − 135° on either side of the aircraft centerline.
- The system must not be operated during the refueling of the aircraft or during any refueling operation within 100 m.

NOTE: Although the power radiated by the system is low, the above written safety precautions should be observed for obvious routine reasons (behavior with respect to other types of radar systems).

To avoid radiating danger, and nuisance aural alerts the WINDSHEAR AUTO/OFF selector switch must be selected OFF independently of the radar selector switch.

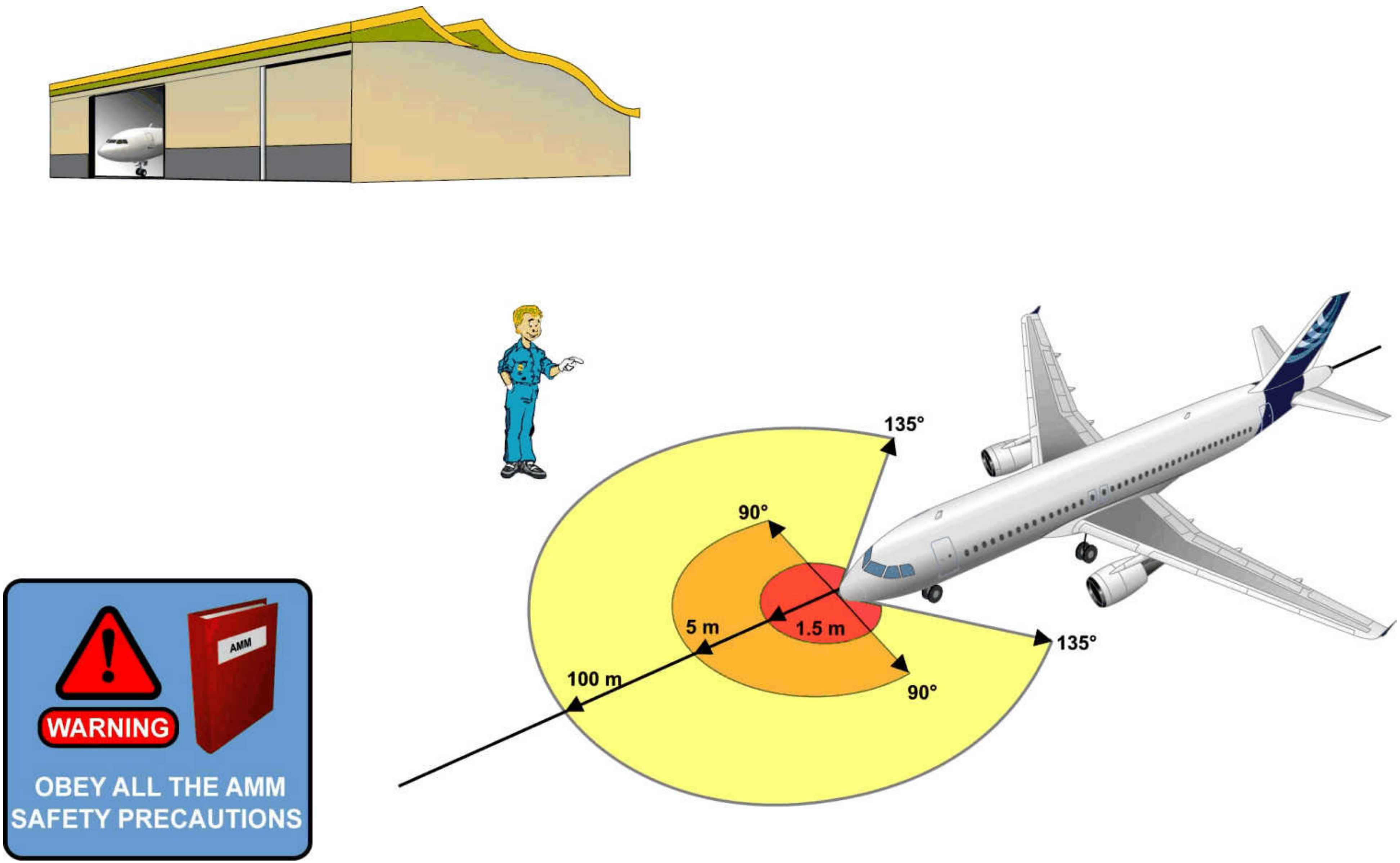


Figure 95 WXR Special Precautions

34−42 RADIO ALTIMETER

RADIO ALTIMETER INTRODUCTION

RADIO ALTIMETER PRINCIPLE

The RAs supply accurate measurement of the A/C height above the ground during initial climb, landing and approach phases.

The RA system determines the height of the aircraft above the terrain during initial climb, approach and landing phases. The RA can therefore operate over non−flat ground surface.

The principle of the RA is to transmit a frequency−modulated signal from the aircraft to the ground, and to receive the ground reflected signal after a certain delay.

The time between the transmission and the reception of the RA signal is proportional to the A/C height.

The principle of the radio altimeter is to:

- transmit a frequency modulated signal from the aircraft to the ground,
- receive the ground reflected signal after a certain delay.

The time between the transmitted frequency and the received frequency is proportional to the aircraft height. The height of the aircraft is calculated by determining the difference between the frequency of the reflected signal and the signal being transmitted at the instant the reflected signal is received. This difference frequency is directly proportional to the time required for the reflected signal to traverse the distance from the aircraft to the ground and back to the aircraft. The difference frequency is measured and converted to distance by a microprocessor in the altitude processor which also transmits the measured distance to user equipment over the ARINC 429 bus.

The reflected signal is fed from a dedicated receive antenna to the receiver where it is mixed with a portion of the transmitted signal now being radiated at the transmit antenna to develop a beat frequency (Fb). The beat frequency is processed by the IF system and is sent to the altitude and monitor processors.

Two independent samples of transmitted RF are fed to two reference signal generators. Each generator produces an output (Fr) corresponding to the delay time that represents a 300−foot altitude. Fr1 is the reference signal for the altitude processor, Fr2 is the reference signal for the monitor processor.

The altitude processor samples the beat frequency input signal (Fb) and the reference frequency signal (Fr1) and converts each to digital form.

The ratio of the measured frequency input signal (Fb) to the output of the 300−foot reference channel is calculated and multiplied by 300 to produce the total radio altitude. The total radio altitude is further modified by the AID and internal box delays to produce the actual aircraft altitude above terrain.

The following figure shows the principle of the RA operation:

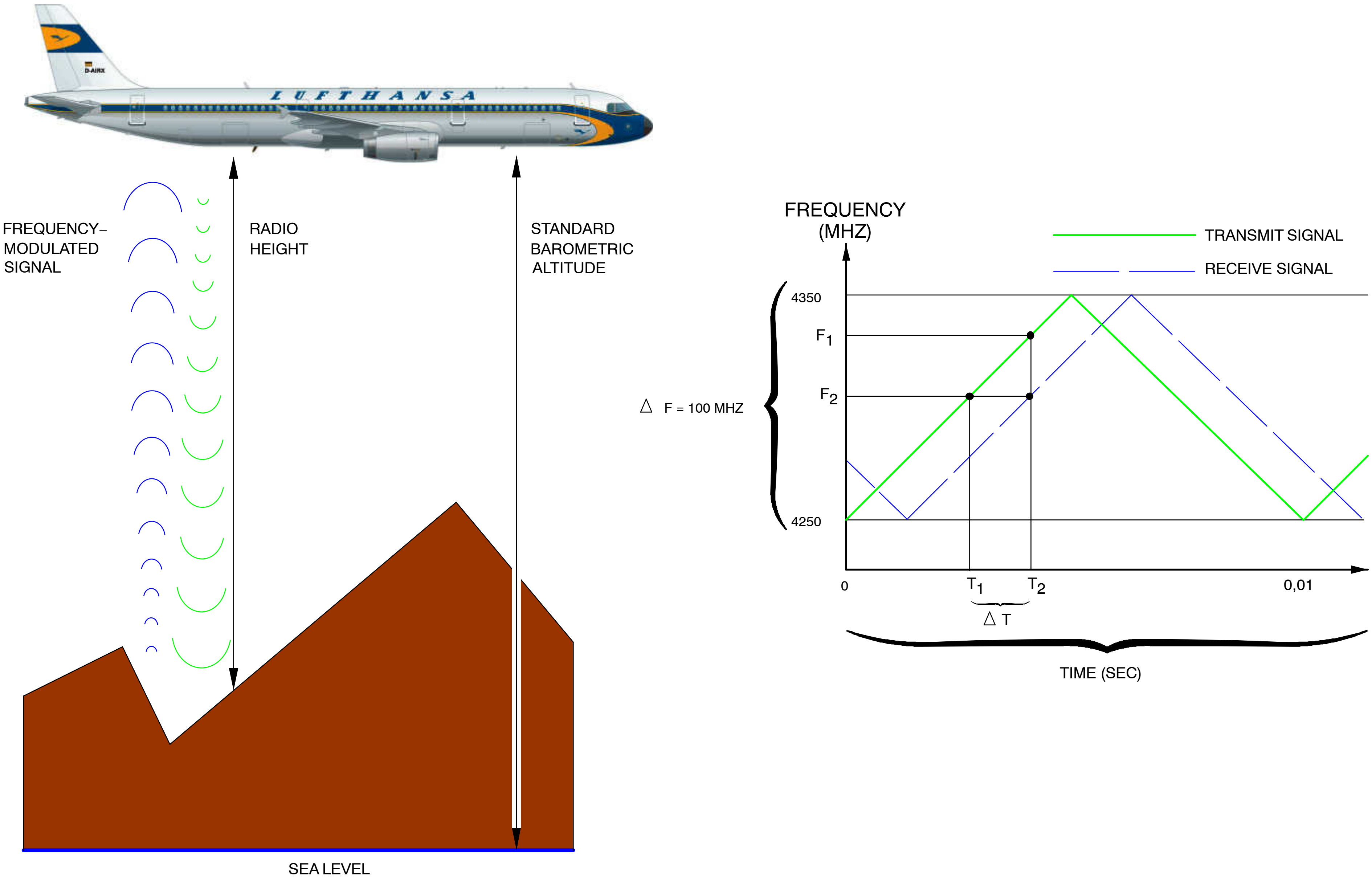


Figure 96 Radio Altimeter Principle

RADIO ALTIMETER COMPONENTS

The radio altimeter comprises two independent systems.

Each system consists of:

- one transceiver,
- one transmission antenna,
- one reception antenna,
- one fan 3SA1.

In addition, the Centralized Fault-Display Interface-Unit (CFDIU) controls the system through the Multipurpose Control and Display Unit 1 (2) (MCDU) for test purposes.

The radio height data is shown on the Primary Flight Display (PFD). In normal operation, system 1 provides information to the CAPT PFD and system 2 to the F/O PFD.

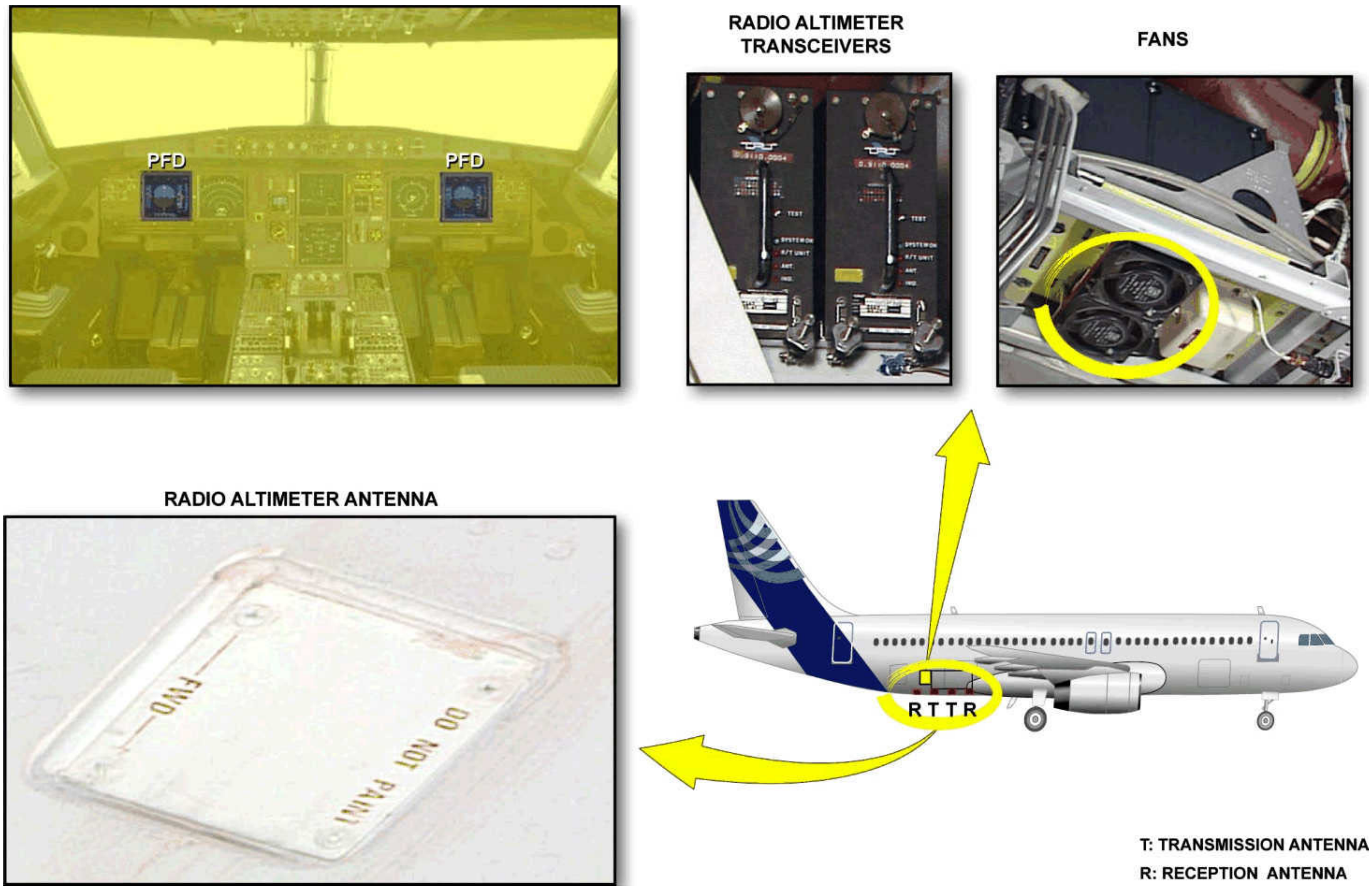


Figure 97 Radio Altimeter System Components

RADIO ALTIMETER INDICATION

The A/C height data is displayed on the PFDs for heights less than or equal to 2.500 ft.

The altitude is also shown by means of:

- a red ribbon next to the altitude scale (below 500 ft),
- a ground line rising on to the pitch down area (below 300 ft).

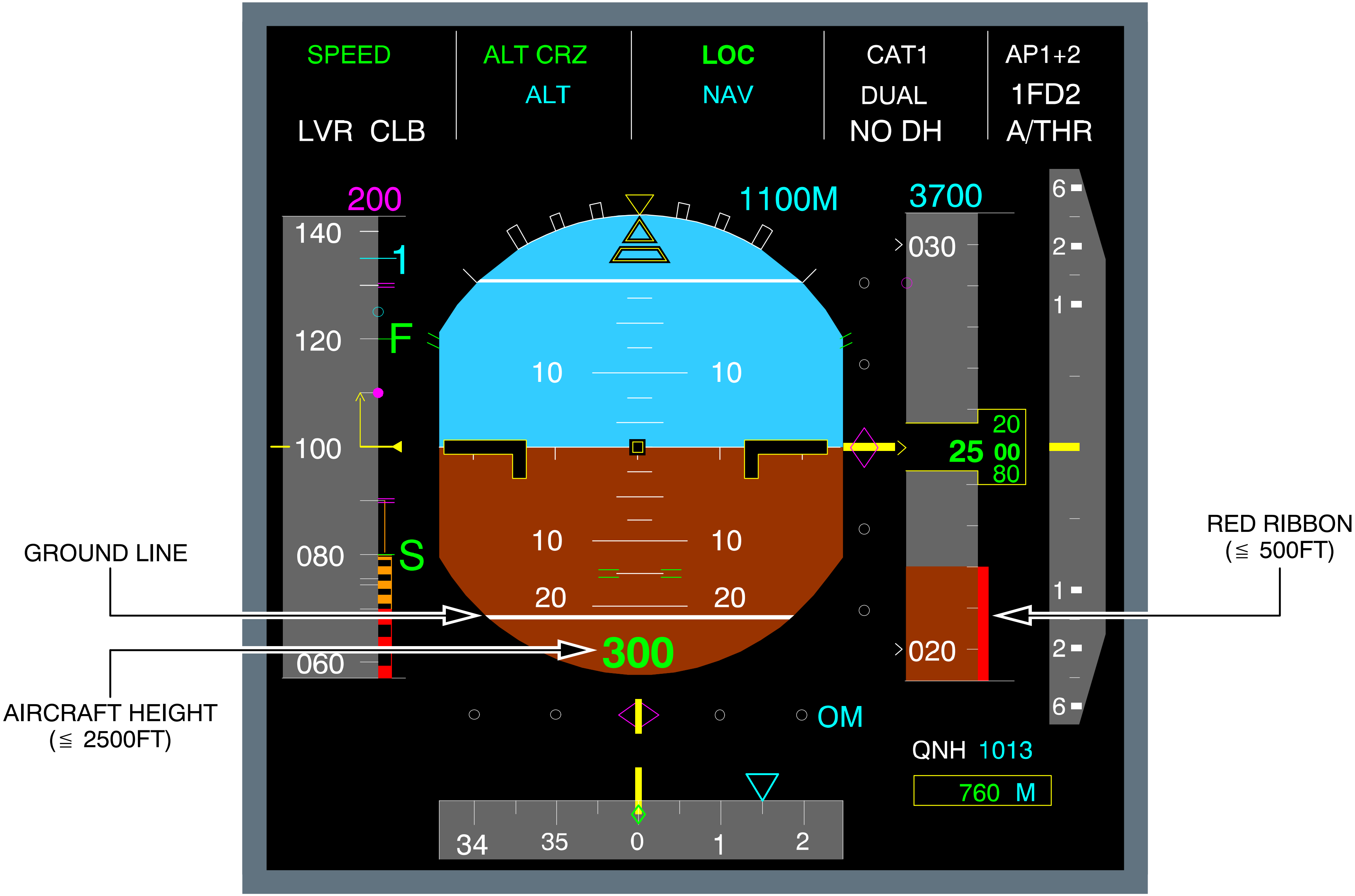


Figure 98 RA Indications on PFD

RADIO ALTIMETER INDICATION DESCRIPTION

HEIGHT DATA DISPLAY

The aircraft height data with respect to the ground is shown in the lower part of the PFD. This indication is at the bottom of the attitude sphere, for height less than or equal to 2500 ft.

The dimension and color of the digits change in relation to the height (H) and decision height (DH) as follows:

H more than or equal to 400 ft:	3 mm green digits
400 ft. > H > DH + 100 ft:	4 mm green digits
H < DH + 100 ft:	4 mm amber digits

The sensitivity of the digits is also a function of the height:

H > 50 ft:	10 ft increments
50 ft > or = to H and H > or = to 5 ft:	5 ft increments
H < 5 ft:	1 ft increments

When the aircraft is below 500 ft. height above the terrain a red ribbon comes into view on the bottom of the altitude scale and moves up with this scale as the aircraft is in the descent phase.

When the aircraft has touched down the ground the top of this ribbon is at the middle of the altitude window.

Below 300 ft., the height is shown by the distance between the horizon line and the limit of the sector 2. The limit of the sector 2 moves up as the aircraft is in the descent phase.

The distance between these two lines is proportional to the ground height (sensitivity 5 ft./mm). As it moves up, the limit line erases the graduations on the pitch scale.

DECISION HEIGHT DISPLAY (DH)

The pilot sets the DH on the MCDU. The DH data are shown on the R top corner of the PFD (3 mm high digits) as soon as the radio altimeter operates.

When the height is lower than the DH, a DH amber warning message comes into view at the bottom of the attitude sphere.

SOURCE OF INDICATION

Normally the CAPT PFD displays the RA1 height and the F/O PFD displays the RA2 height. If either radio altimeter fails, both PFDs display the height from the remaining one.

AUTOMATIC CALL OUT BY FLIGHT WARNING COMPUTER

The FWC generates synthetic voice for radio height announcement below 2500 feet. These announcements come through the cockpit loudspeakers even if the speakers are turned off. The call out are pin programmed at the FWC.

The altitude call out uses the following predetermined threshold:

Height (FT)	Call Out
2500	TWO THOUSAND FIVE HUNDRED OR TWENTY FIVE HUNDRED
2000	TWO THOUSAND
1000	ONE THOUSAND
500	FIVE HUNDRED
400	FOUR HUNDRED
300	THREE HUNDRED
200	TWO HUNDRED
100	ONE HUNDRED
50	FIFTY
40	FORTY
30	THIRTY
20	TWENTY
10	TEN
5	FIVE
DH + 100	HUNDRED ABOVE
DH	MINIMUM

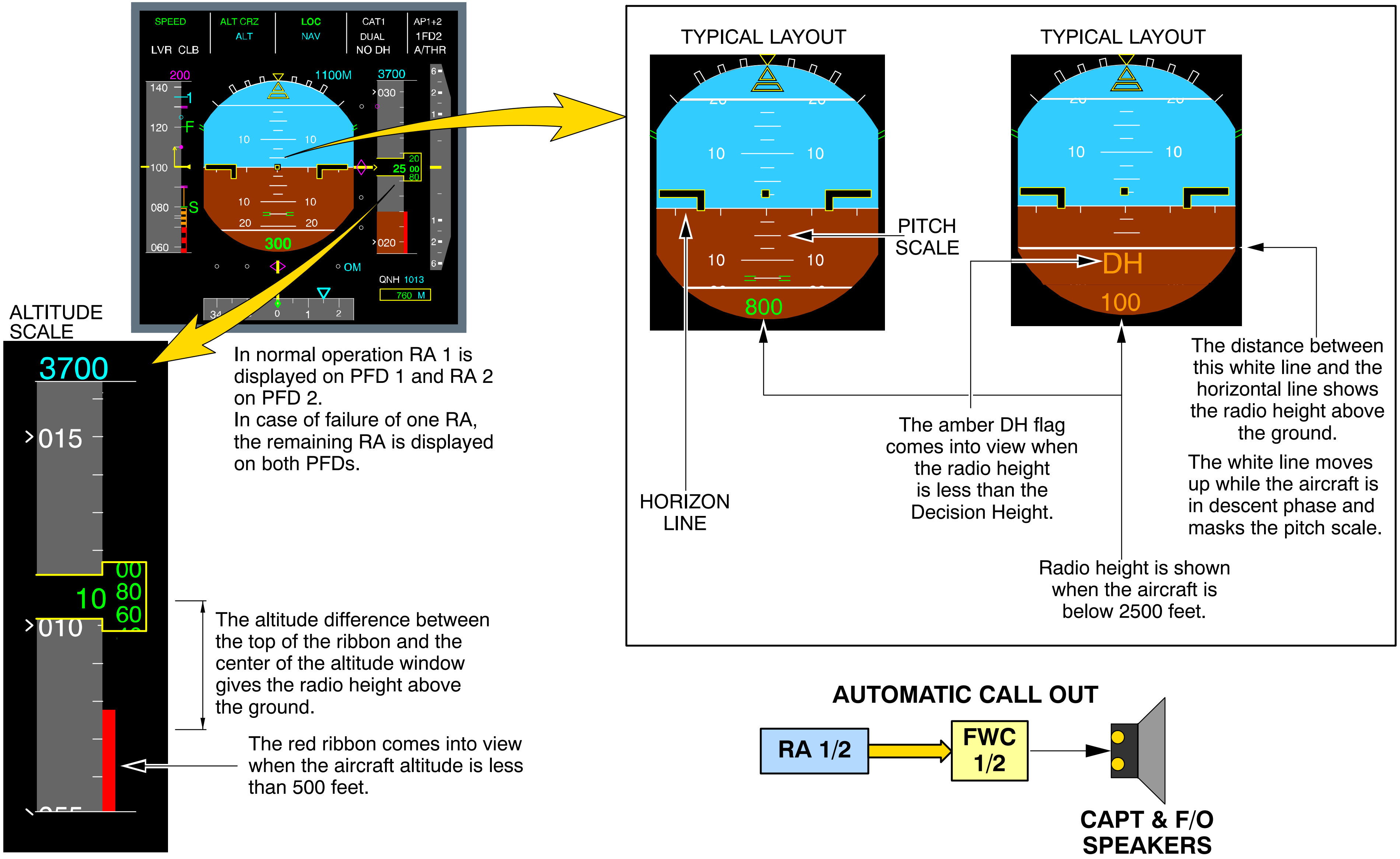


Figure 99 RA Indication Description

RADIO ALTIMETER SYSTEM DESCRIPTION

GENERAL

The RA system is made of two independent systems and has:

- two transceivers with associated mounts and fans,
- two transmission antennas,
- two reception antennas.

In normal operation, system 1 automatically provides the height data for the CAPT PFD and system 2 for the F/O PFD. With failure of one system, the valid system is automatically switched to both CAPT and F/O PFDs.

With failure of the two systems, the digits go out of view from the PFD. In place of the digits, a red RA warning message flashes during three seconds then remains on.

For information the pilot sets the DH on the MCDU approach performance page of the FMGC. The Flight Warning Computer (FWC) generates the DH warning message. With loss of DH information, the DH data are not shown.

Transceiver

The RA transceiver measures the radio height of the aircraft in relation to the ground. The transceiver operates in a frequency range of 4.200 to 4.400 MHz.

Antenna

The RA system includes two identical transmission and reception antennas. The operating range of the antenna according to the aircraft attitude is limited to + or − 30° for pitch and roll.

Fan

Each RA transceiver is cooled by an associated fan, attached under the transceiver mount. Interference is suppressed by a capacitor mounted on the fan case.

Indicating

In normal operation, RA 1 provides the radio height to the CAPT PFD and RA 2 to the F/O PFD through the Display Management Computers (DMCs). In case of one transceiver failure the DMC automatically switches to the other one.

The radio height information appears on the PFDs when less than or equal to 2.500 ft.

Auto Call Out

The FWC generates a synthetic voice for radio height announcement below 2500 feet. These announcements come through the cockpit loudspeakers, even if the speakers are turned off.

Pin programming enables Operators to select the required callouts.

If the aircraft remains at a height that is in the detection zone for a height callout, the corresponding message is repeated at regular intervals.

Users

The RA information is sent to various systems through ARINC 429 buses.

The system users are:

- Enhanced Ground Proximity Warning System (EGPWS) for terrain warnings,
- Flight Management and Guidance Computers (FMGCs) for processing data,
- Flight Warning Computers (FWCs) for call out indications and warnings,
- ELevator Aileron Computers (ELACs) for integration into various flight parameters.

Engine Interface Unit

The EIU 1 (2) sends a ground discrete to the RA 1 (2) to inhibit the test on ground when the associated engine N2 rating (high−pressure compressor rotational speed) is greater than minimum idle rating.

Landing Gear Control and Interface Unit

The LGCIU provides the flight/ground information, which is used by the transceiver BITE module to count the flight legs.

Centralized Fault Display Interface Unit

The MCDUs allow the systems to be tested via the CFDIU. The tests are only available on ground.

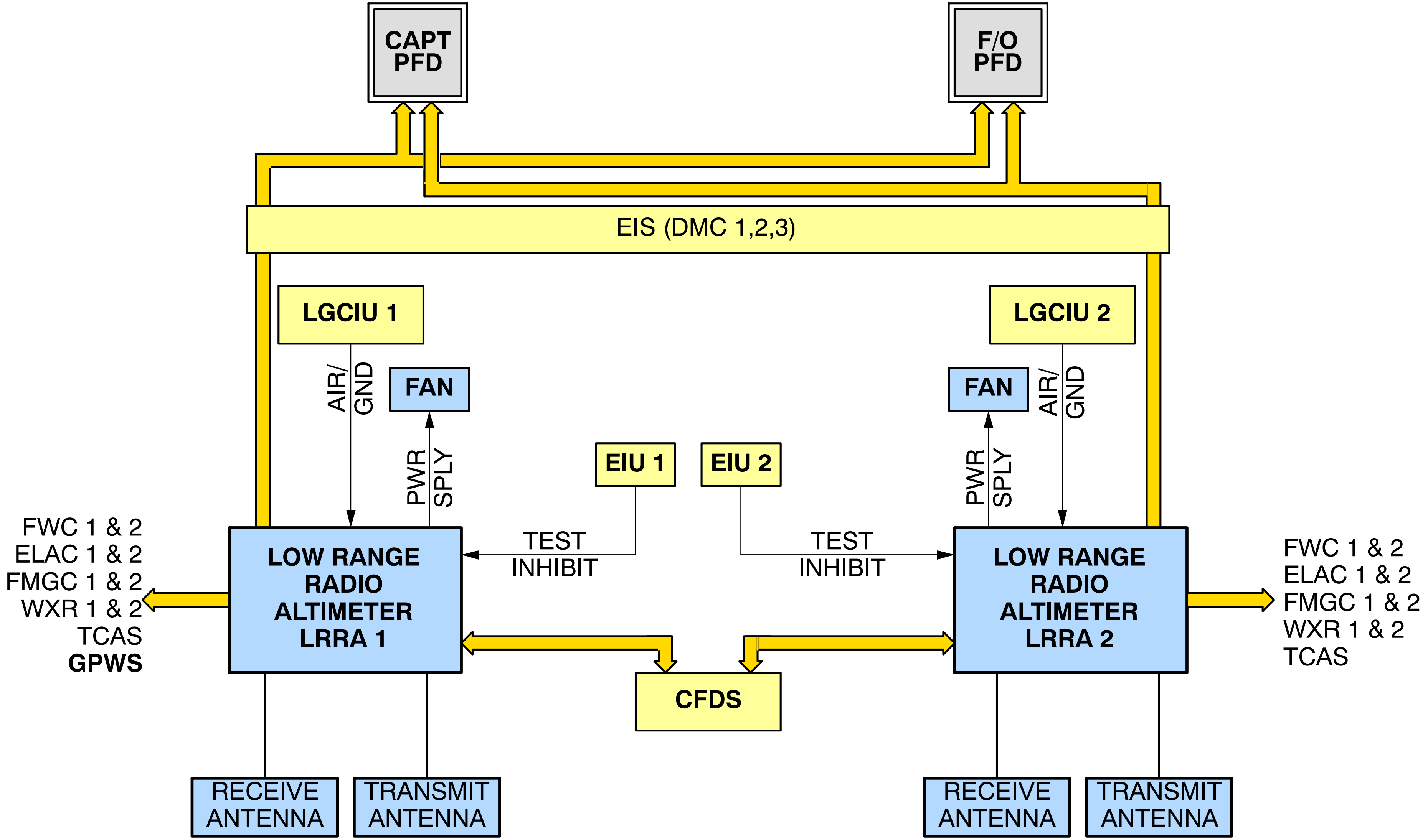


Figure 100 Radio Altimeter Schematic

RA SYSTEM OPERATION

Reconfiguration Switching

In normal utilization, the radio altimeter data are shown on the CAPT PFD and F/O PFD through the Display Management Computers 1 and 2 (DMC).

With failure of the radio altimeter transceiver 1, the DMC 1 and 3 automatically switch over to the transceiver 2.

With failure of the DMC 1 (2), it is possible to switch over to the DMC 3 with the EIS DMC selector switch.

This selector switch is located on panel 8VU on the center pedestal.

In this case the DMC 3 totally replaces the DMC 1 (2) through the stage of the output switching relay of the failed DMC.

With failure of the PFD, there is an automatic transfer of the PFD image onto the Navigation Display (ND).

When you set the PFD potentiometer to OFF on panel 301VU (500VU), this causes:

- deactivation of the PFD,
- transfer of the PFD image onto the ND.

RA Interfaces

The Radio Altimeter has interfaces to the following system computers:

- ELAC 1 & 2,
- FMGC 1 & 2,
- TCAS Computer,
- GPWC (RA 1 ONLY),
- FWC 1 & 2,
- CFDIU,
- WXR (if equipped with PWS),
- EIU 1 & 2.

Power Supply

Energization of each system is through 115VAC, 400 Hz normal buses:

- 115VAC BUS1 101XP via circuit breaker 1SA1 for system 1,
- 115VAC BUS2 202XP via circuit breaker 1SA2 for system 2.

The RA Fans are energized by the transceivers.

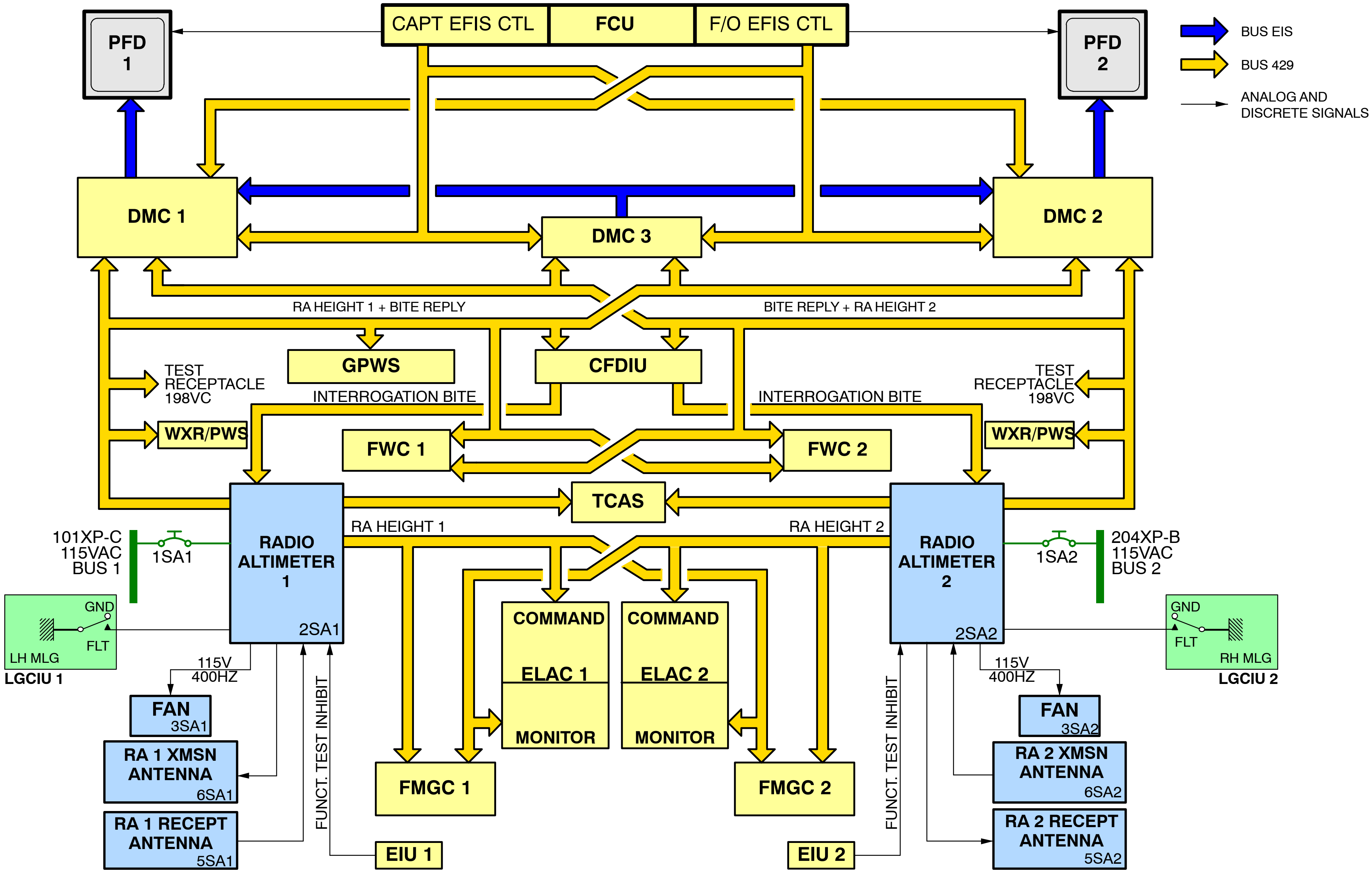


Figure 101 RA Interface Diagram

RA SYSTEM COMPONENT DESCRIPTION

RADIO ALTIMETER TRANSCEIVER

1 Version 1

The face of the transceiver is fitted with a handle, two attaching parts, a TEST pushbutton switch, a connector (TEST CONN) to connect test set for system test and four LEDs.

The name, color and function of the four LEDs are as follows:

- **SYSTEM OK** (green) indicates no fault,
- **R/T UNIT** (red) indicates a fault in the reception-transmission circuit,
- **ANT** (red) indicates a fault in the antenna circuit,
- **IND** (red) indicates a fault in the indicating circuit.

RAMP TEST (via CFDS)

The RAMP TEST function can be activated from the MCDU by pressing the line key adjacent to the SYSTEM REPORT/TEST indication on the CFDS menu then selecting the LRRA 1 (LRRA2) on the NAV menu and then selecting the RAMP TEST page. On the RAMP TEST page select:

- START ALT: 0 ft,
- STOP ALT: 2500 ft,
- SLOPE: 25 ft/s,

  Push the line key adjacent to the TRIGGER indication.

  On the PFD:

  - the ramp test starts, it moves up to 2500 ft. it stops after approximately 1 minute 40 seconds,
  - when the altitude is between 0 and 160 ft. the horizon line moves down. The elevation scale comes into view,
  - when the altitude is between 0 and 570 ft. the red ribbon adjacent to the altitude scale moves down and then it goes out of view,
- on the MCDU, at the altitude 2500 ft. the RAMP TEST STOPPED page comes into view.

2 Version 2

The face of the transceiver is fitted with a handle, two attaching parts, a TEST pushbutton switch, a connector (TEST CONN) to connect test set for system test and three LEDs.

The name, color and function of the three LEDs are as follows:

- **LRU STATUS:** green indicates no fault detected during the self-test sequence and red indicates that a fault is detected during the self-test sequence,
- **XMIT ANT FAIL:** red indicates a fault in the antenna circuit,
- **REC ANT FAIL:** red indicates a fault in the antenna circuit.

RAMP TEST (via CFDS)

The RAMP TEST function can be activated from the MCDU by pressing the line key adjacent to the SYSTEM REPORT/TEST indication on the CFDS menu then selecting the RA1 (RA2) on the NAV menu and then selecting the RAMP TEST page.

The RA then begins simulating a ramp starting from 500 ft. down to 0 ft. (with a slope of 11 ft/s from 500 ft. to 50 ft. and approximately 3 ft/s from 50 ft. to 0 ft.).

There is nothing to select manually.

RA ANTENNAS

The transmission and reception antennas are identical. The small - thickness antenna is installed on the skin of the aircraft.

Each antenna is supplied through a coaxial connector linked to the transceiver. The operating range of the antenna according to the attitude of the aircraft is limited to + or - 30° for roll and pitch.

RA FANS

The six-blade fan is integral with a removable base plate attached under the transceiver mount. It is contained in a square aluminum alloy case.

It is supplied with 115VAC through a connector and associated wiring connecting it to the transceiver. Interference is suppressed by a capacitor mounted on the fan case.

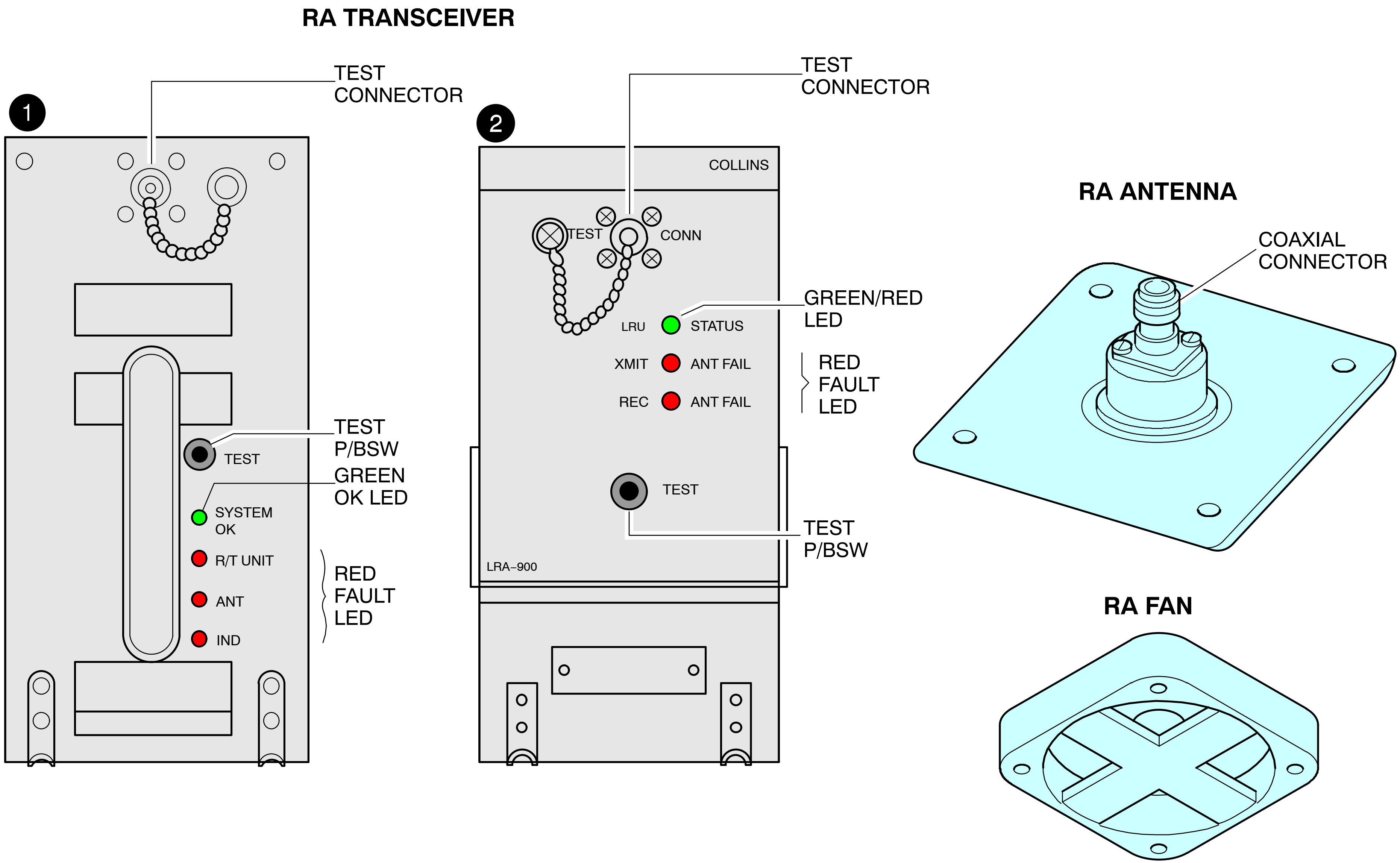


Figure 102 RA System Components

RA SYSTEM FLAGS AND WARNINGS DESCRIPTION

RA FLAGS

With failure of both radio altimeters, a red RA warning message is shown in place of the radio height information.

Depending on aircraft version this RA flag is shown in slats extented configuration only.

Red Ribbon

The message flashes during 3 seconds then remains on.

With failure of both radio altimeters, the red ribbon beside the altitude scale goes out of view.

Radio Height Line

The distance between these two lines is proportional to the ground height (sensitivity 5 ft./mm).

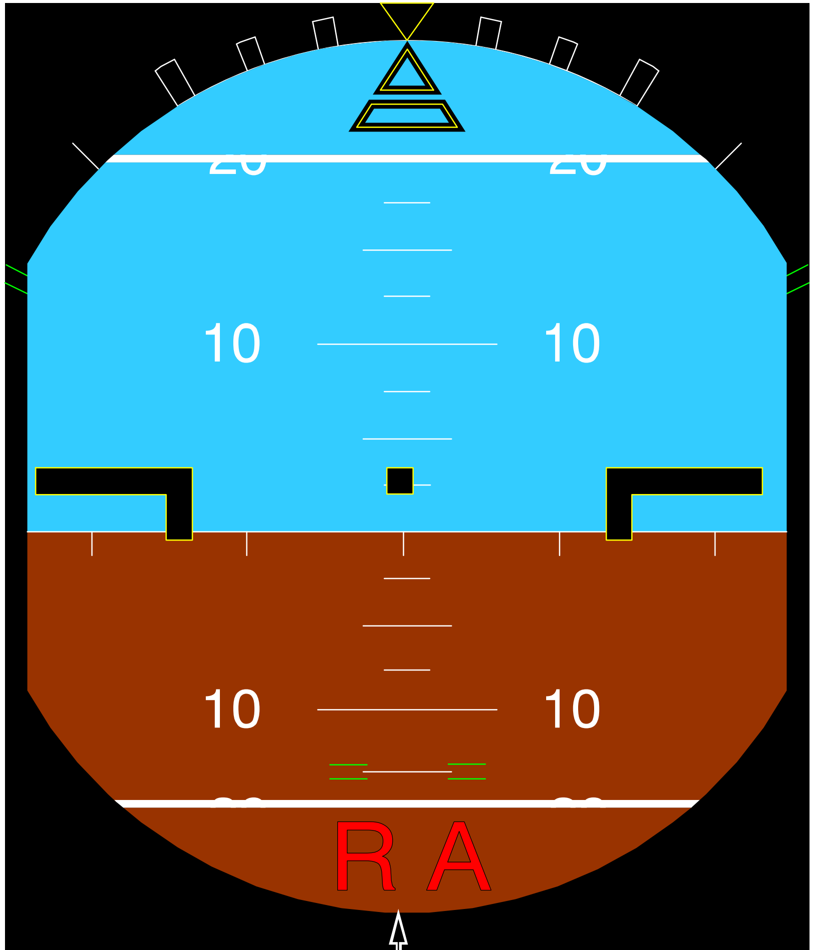
As it moves up, the limit line erases the graduations on the pitch scale.

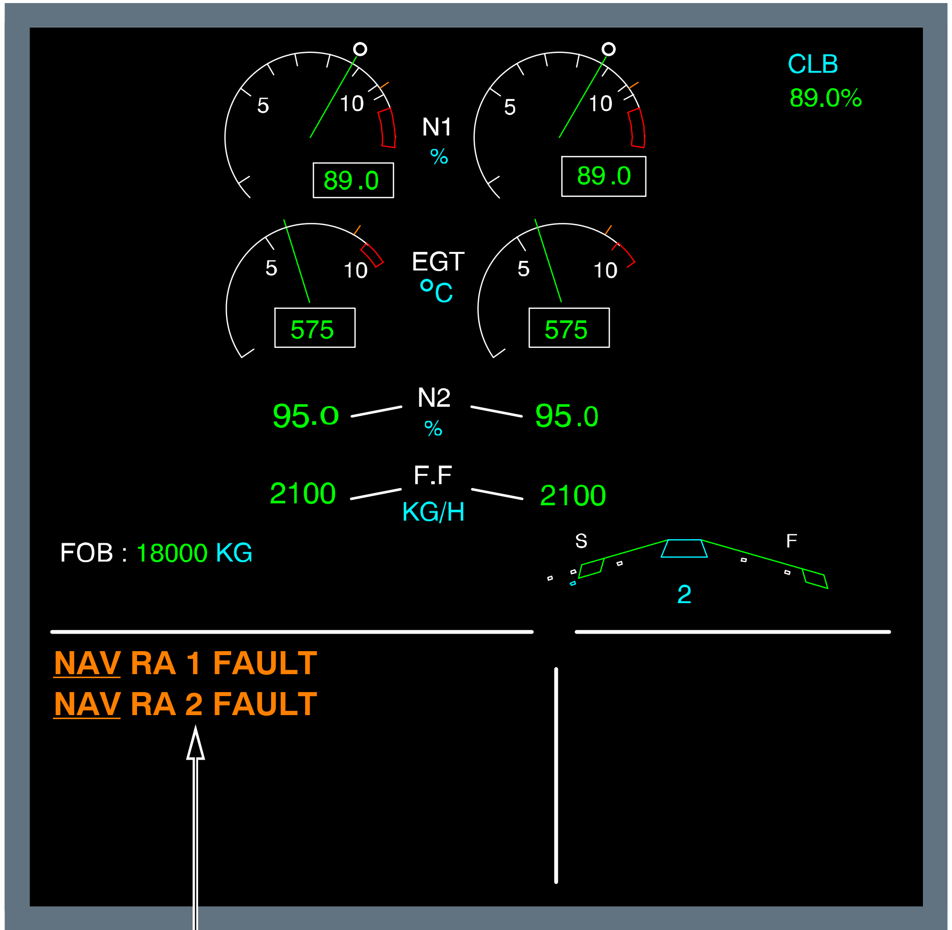
With failure of both radio altimeters, this indication goes out of view.

WARNINGS

The warnings related to the radio altimeter are:

- local warning on the instruments that use the radio altimeter data,
- MASTER CAUT lights on the CAPT and F/O glareshield panels,
- aural warning: single chime,
- warning message shown on the upper ECAM display unit.





THE RED RA FLAG COMES INTO VIEW ON THE PFD 1 & 2:

- VERSION 1
  - WHEN BOTH RADIO HEIGHTS ARE NOT AVAILABLE
- VERSION 2
  - WHEN BOTH RADIO HEIGHTS ARE NOT AVAILABLE AND THE SLAT/FLAP LEVER IS NOT IN 0 POSITION.

AMBER CAUTIONS ON E/WD GENERATED BY THE FWC

Figure 103 RA Flags and Warnings

34–48 GROUND PROXIMITY WARNING SYSTEM

ENHANCED GROUND PROXIMITY WARNING SYSTEM INTRODUCTION

EGPWS PRINCIPLE

The purpose of the EGPWS (Enhanced Ground Proximity Warning System) is to generate aural and visual warnings if the A/C adopts a potentially hazardous configuration of Controlled Flight Into Terrain (CFIT).

This system has five basic EGPWS modes and has 2 TERRAIN modes called TERRAIN Clearance Function (TCF) and the TERRAIN Awareness and Display (TAD).

When boundaries of any alerting envelope are exceeded; aural alert messages, visual annunciations and displays are generated.

The basic GPWS modes generate aural and visual warnings corresponding to an aircraft behavior when the alert envelope is penetrated.

The basic GPWS modes are:

- **Mode 1 – Excessive rate of descent,**
- **Mode 2 – Excessive closure rate with terrain,**
- **Mode 3 – Descent after takeoff and minimum terrain clearance,**
- **Mode 4 – Unsafe terrain clearance,**
- **Mode 5 – Descent below glide slope.**

The basic GPWS functions (Modes 1 to 5), mainly based on Radio Altitude, Landing Gear and Flap position.

The ”ENHANCED” features complete the basic GPWS modes:

- **Terrain Clearance Floor (TCF):**

  Increase the terrain clearance envelope around the airport runway.
- **Terrain Awareness alerting and Display (TAD):**

  Incorporation of a terrain database to predict conflict between flight path and terrain and to display the conflicting terrain.

  Optionally the EGPWS also incorporates an obstacle database in which are recorded the man made obstacles. They are treated as terrain.

As an option, the T2CAS can replace the EGPWS.

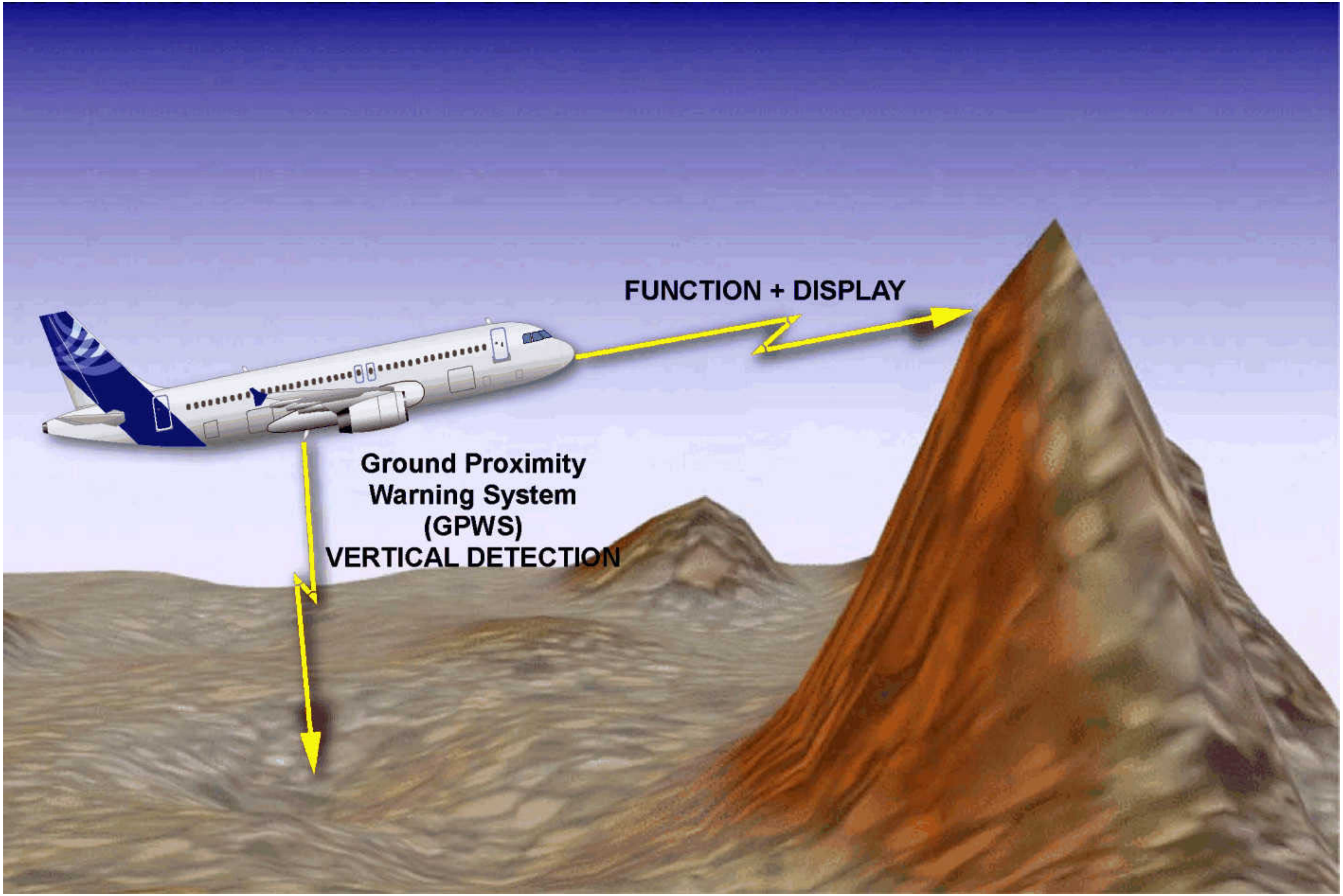


Figure 104 EGPWS Principle

EGPWS COMPONENTS

The system comprises an Enhanced Ground Proximity Warning Computer (EGPWC) (or T2CAS), a GPWS control panel, two warning lights and two TERRain ON ND mode P/BSWs.

The EGPWS (T2CAS-TAWS) is connected to various navigation systems like Radio Altimeter, Instruments Landing System, Air Data Inertiel Reference System, Flight Management System ect.

It processes the navigation data and generates alarms.

The T2CAS is made of a single Line Replaceable Unit (LRU).

The controls of the T2CAS are similar to the EGPWS ones.

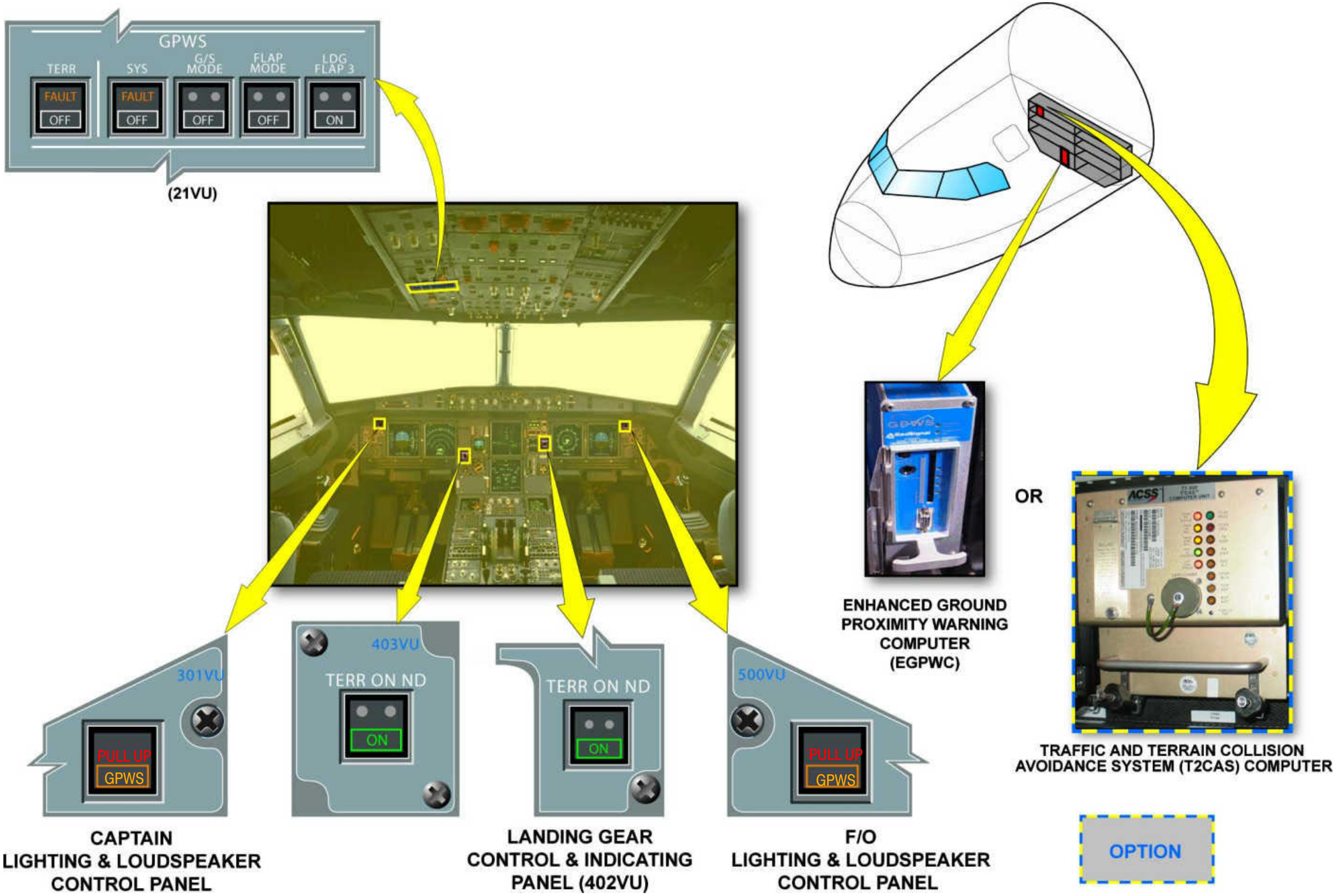


Figure 105 EGPWS Components

EGPWS INDICATION

EGPWS Terrain Picture

The ND displays the EGPWS terrain picture, when the TERR ON ND switch is selected ON, and the ND is not in PLAN mode. The terrain picture replaces the weather radar image. Terrain data is displayed independently of the aircraft relative altitude. There are two different background Terrain Awareness display mode: Standard and Peaks. For both modes the background display is computed from the aircraft altitude with respect to the terrain data in the digital elevation matrix overlays.

The terrain appears in different colors and densities, according to its relative height:

- **Solid Red:**
  - Warning terrain (approximately 30 seconds from impact).
- **Solid Yellow:**
  - Caution terrain (approximately 60 seconds from impact).
- **High Density Red:**
  - Terrain that is more than 2000 ft above aircraft altitude).
- **High Density Yellow:**
  - Terrain that is between 1000 ft and 2000 ft above aircraft altitude.
- **Medium Density Yellow:**
  - Terrain that is 500 ft (250 ft with gear down) below to 1000 ft above aircraft altitude.
- **Solid Green:**
  - (Peaks only) Highest terrain not within 500 ft 250 ft with gear down) of aircraft altitude. Mainly appears with dotted yellow terrain when the aircraft altitude is within 500 ft (250 ft with gear down) of terrain.
- **High Density Green Dots:**
  - Terrain that is 500 ft (250 ft with gear down) below to 1000 ft below aircraft altitude. (Peaks only) Terrain that is the middle elevation band when there are no red or yellow terrain areas within range on the display.
- **Black**
  - No close terrain.
- **Low Density Cyan Dots:**
  - (Peaks only) Terrain elevation equal to 0 ft. MSL.
- **Light Density Magenta:**
  - Unknown terrain.

EGPWS Background Display

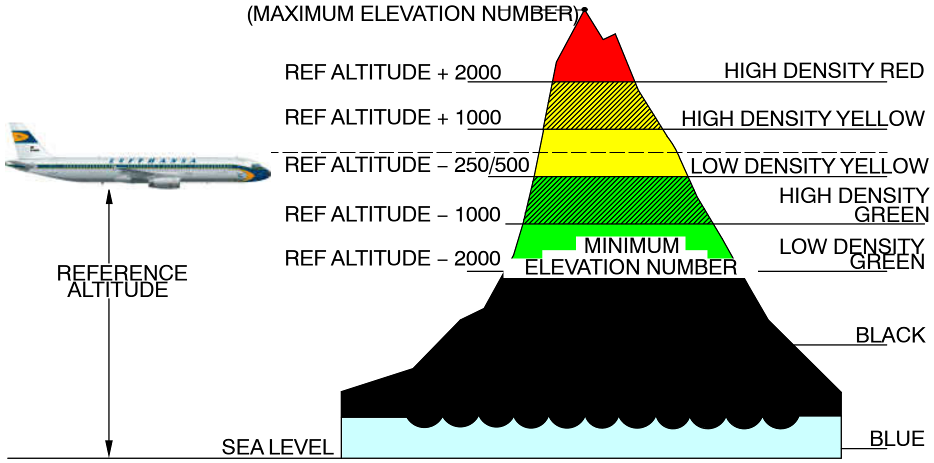
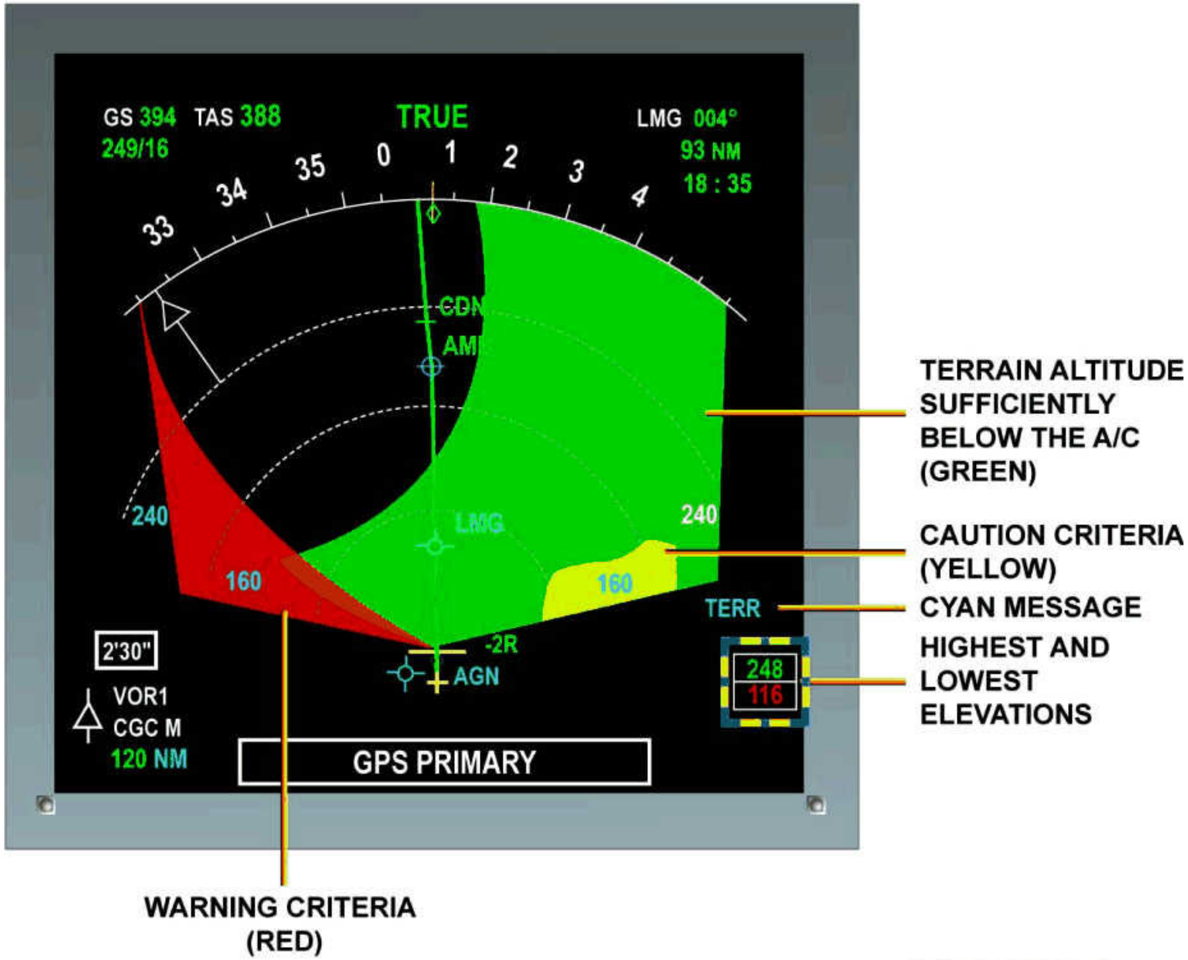
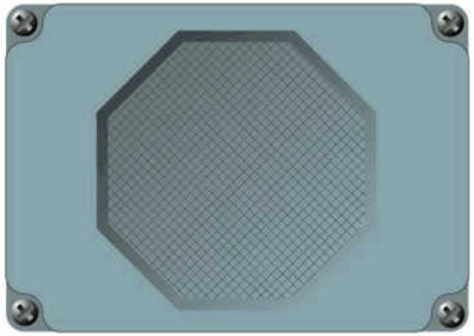


Figure 106 EGPWS Display Colours

CAPTAIN & F/O
LIGHTING & LOUDSPEAKER
CONTROL PANEL

NAVIGATION DISPLAY (ND)





CAPT & F/O LOUDSPEAKER (2 & 6VU)

OPTIONAL

Figure 107 EGPWS Indication

EGPWS MODES PRESENTATION

EGPWS MODES GENERAL

The Enhanced Ground Proximity Warning System (EGPWS) computes and compares the aircraft behavior with a predetermined envelope.

WARNING MODES

When the warning envelope is penetrated, visual and aural warnings are generated. The aural messages are broadcast through the cockpit loudspeakers and visual warnings are indicated by the PULL UP Ground Proximity Warning System P/B SWs lights.

A terrain image is displayed on the NDs. A number of airports through the world have approaches or departures, which are not entirely compatible with the standard GPWS operation.

These airports are identified in the database, the GPWS recognizes them and modifies the profile and triggers the warning in accordance.

The Ground Proximity Warning System (GPWS) generates aural and visual warnings, when one of the following conditions occurs between radio altitudes 30 and 2450 feet:

- **Mode 1 : Excessive rate of descent,**
- **Mode 2 : Excessive terrain closure rate,**
- **Mode 3 : Altitude loss after takeoff, or go-around,**
- **Mode 4 : Unsafe terrain clearance when not in landing configuration,**
- **Mode 5 : Too far below glideslope.**

In addition to the basic GPWS functions, the GPWS has an enhanced function (EGPWS) which provides, based on a worldwide terrain database:

- A **Terrain Awareness Display (TAD)**, which predicts the terrain conflict, and displays the terrain on the ND.
- A **Terrain Clearance Floor (TCF)**, which improves the low terrain warning during landing.

The cockpit loudspeakers broadcast, even if turned off, the aural warning or caution messages associated with each mode. The audio volume of these messages is not controlled by the loudspeaker volume knobs. (These knobs only allow volume adjustment for radio communication).

PULL UP or GPWS lights, on the Captain and First Officer instrument panels, come on to give a visual warning depending on the engaged GPWS mode.

AUDIO OUTPUT

Alert outputs result in an audio voice warning unless inputs are invalid or one of the audio suppression discretes is active. The actual output message, or intended message during audio suppression, is sent to the warning lamp logic for proper output activation.

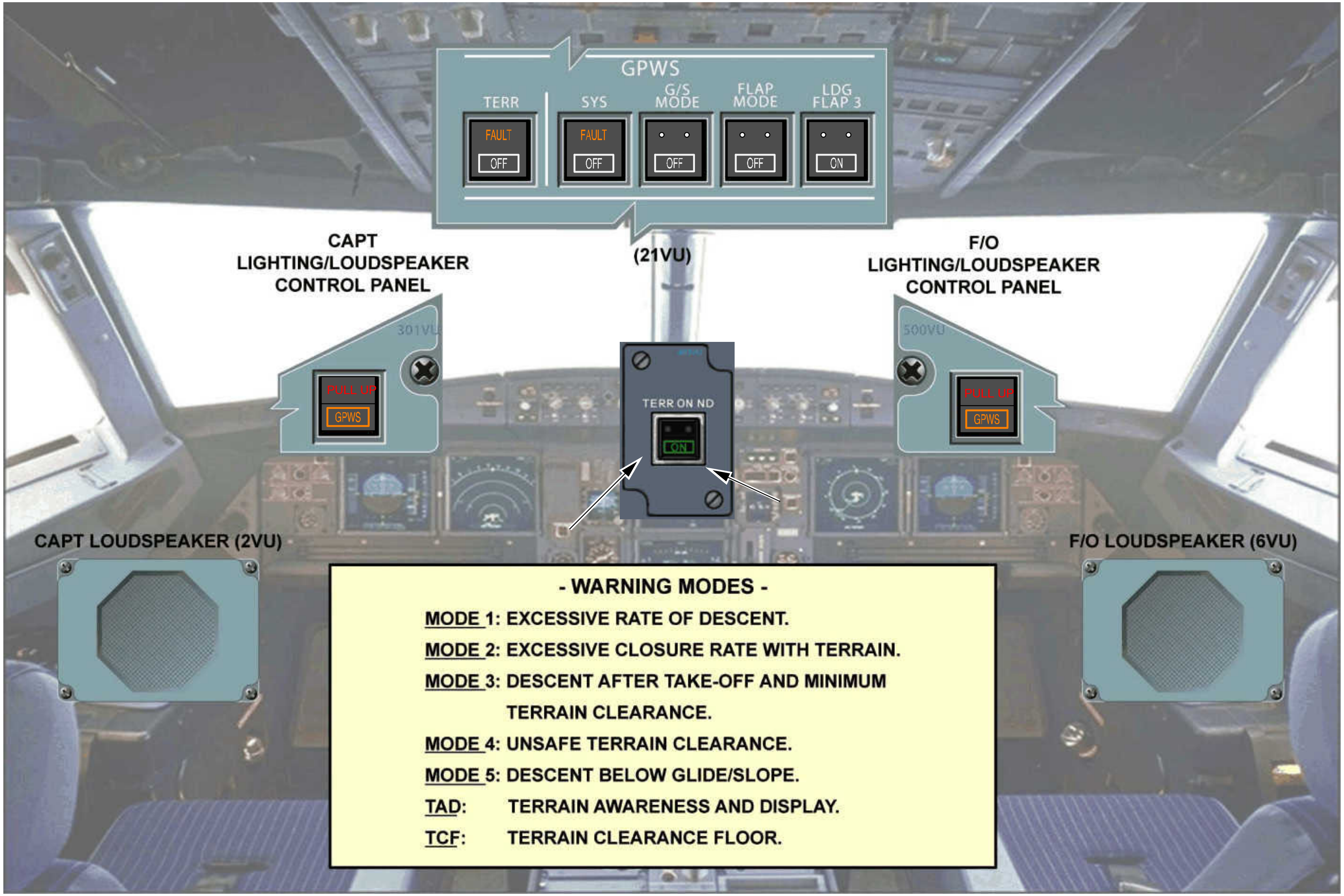


Figure 108 EGPWS Warning Modes

EGPWS MODE 1 - EXCESSIVE RATE OF DESCENT

Mode 1 provides an alert warning for high descent rates into terrain and for rapidly increasing sink rates near the runway when landing.

Mode 1 has two boundaries. Penetration of the first boundary generates a repeated ”SINK RATE” aural alert and causes both GPWS lights to come on.

Penetration of the second boundary generates a repetitive ”PULL UP” aural alert and causes both PULL UP lights to come on.

The upper cut-off limit is 2450 feet radio altitude.

The lower cut-off limit is 50 or 10 feet radio altitude.

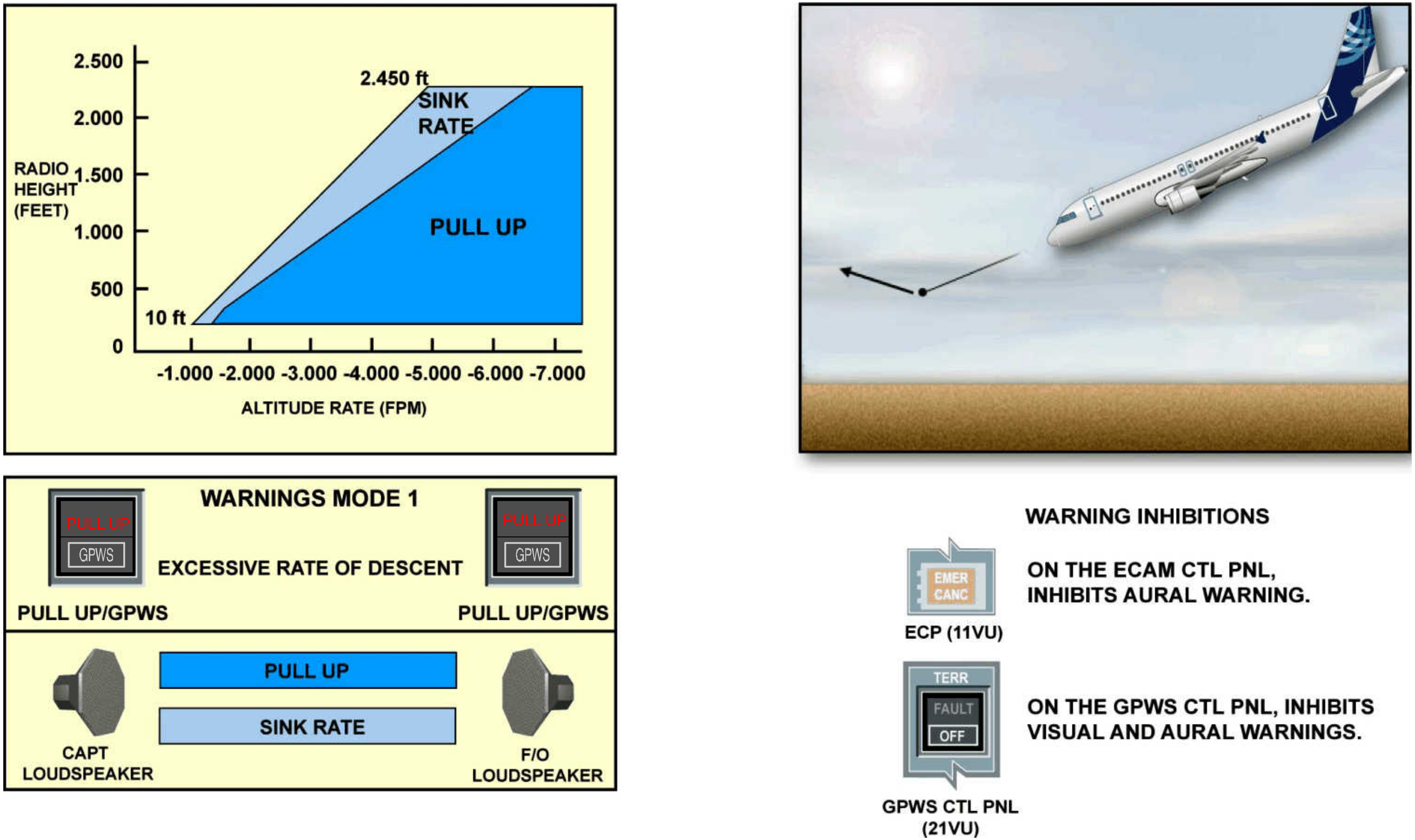


Figure 109 EGPWS Mode 1 Excessive Rate of Descent

EGPWS MODE 2 - EXCESSIVE TERRAIN CLOSURE RATE

Mode 2 provides a warning based on the radio height and on how rapidly the radio height decreases.

It has two areas of application known as mode 2A and 2B.

Mode 2A

Flaps not in landing configuration, and aircraft not on the glide slope beam.

Penetration of the boundary causes the GPWS lights to come on, and generates the repeated aural alert: ”TERRAIN”.

After ”TERRAIN” has sounded twice, the warning switches to ”PULL UP”, repeated continually until the aircraft leaves the warning envelope. In addition, the PULL UP lights come on.

After the aircraft leaves the boundary, the PULL UP lights stay on and the ”TERRAIN” aural message persists. These alerts stop when the aircraft increases either the barometric or inertial altitude by 300 feet.

Mode 2B

Flaps in landing configuration.

Lowering the flaps to the landing position automatically switches GPWS to mode 2B. In this case lower boundary varies between 200 feet and 600 feet depending on altitude rate. In ILS approach (glide slope deviation < ∓2 dots) the lower boundary is fixed at 30 feet.

When the aircraft enters the envelope, the alert is the same as for mode 2A. When gear and flaps are in the landing configuration, the aural message is ”TERRAIN” only and is not followed by ”PULL UP” if the aircraft remains in the envelope.

When the enhanced GPWS functions and the optional geometric altitude function are of high integrity, the upper operational limit is reduced.

Upper cut–off limit varies from 1650 feet to 2450 feet radio altitude, depending on speed (between 220 knots to 310 knots). At certain airports, the upper boundary may be lowered down to 1250 feet to reduce the warning sensitivity and minimize the nuisance warnings.

The new enhanced operational upper limit is reduced to 1250 feet and to 789 feet in final approach, when the enhanced functions and the Geometric Altitude are of high integrity.

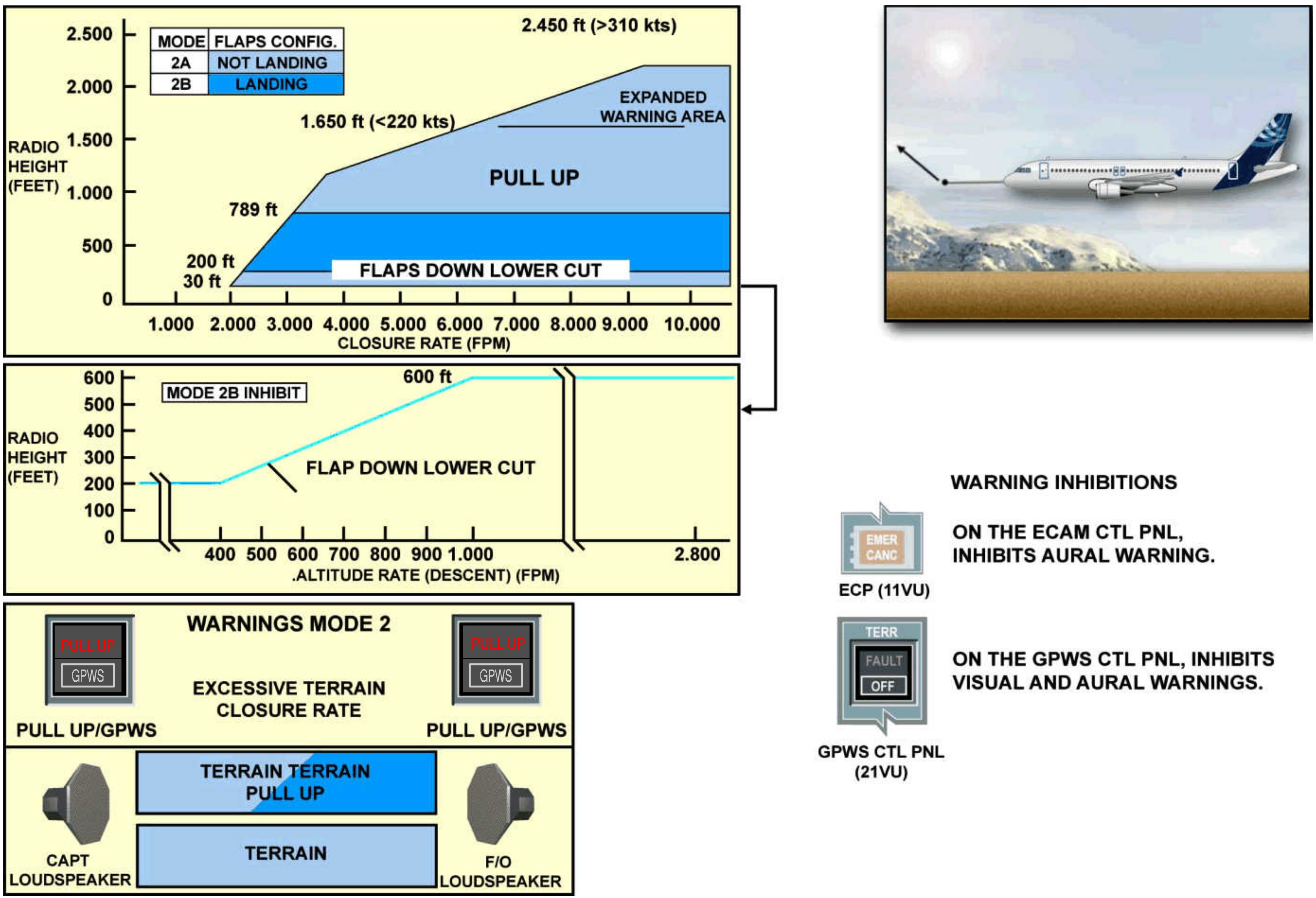


Figure 110 EGPWS Mode 2– Excessive Terrain Closure Rate

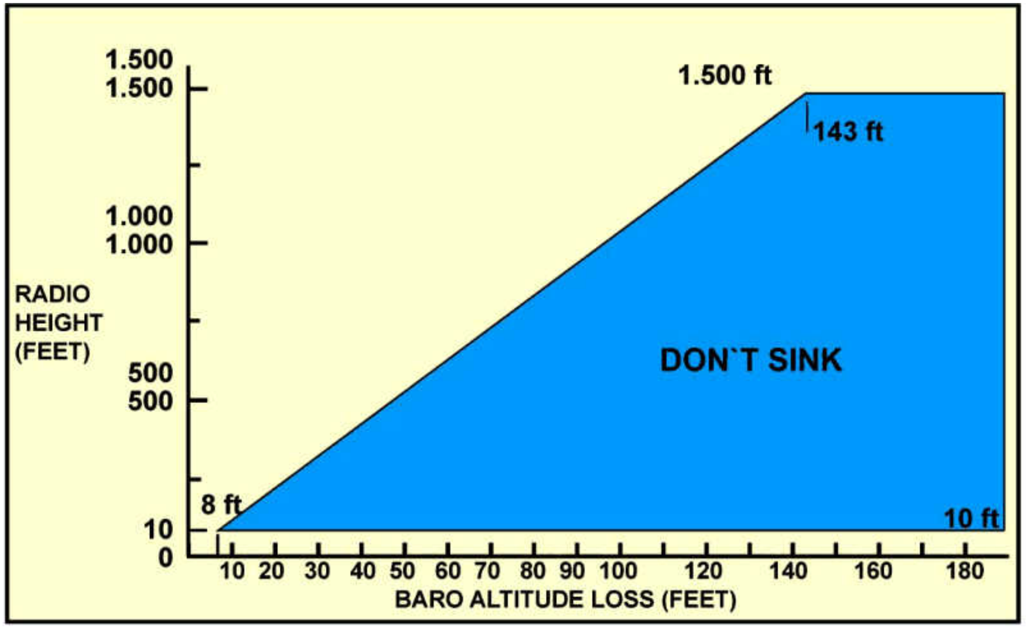
EGPWS MODE 3 - ALTITUDE LOSS AFTER TAKE OFF

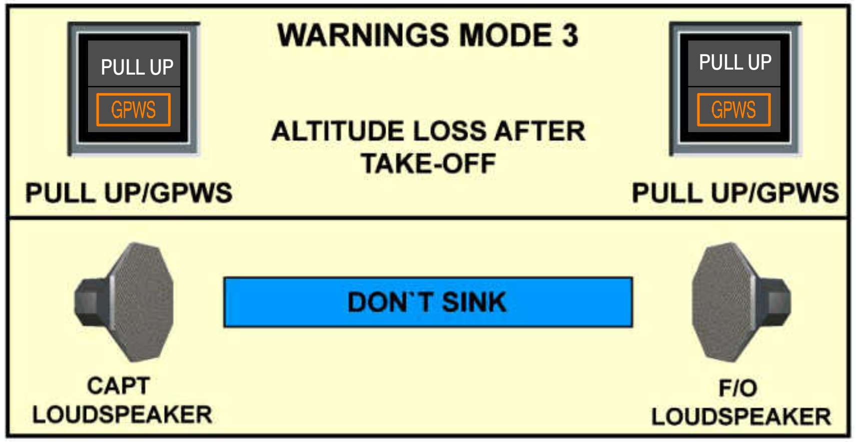
Mode 3 provides a warning for excessive altitude loss after take−off, climb or during a go−around. GPWS lights come on and the ”DON'T SINK” aural alert sounds repeatedly.

This mode is based on radio height, altitude (inertial, barometric or computed altitude) and altitude rate (Inertial Vertical Speed (IVS) computed altitude rate or barometric altitude rate).

The upper cut−off limit varies between 667 feet and 1333 feet radio altitude depending on airspeed.

The lower cut−off limit is 30 feet radio altitude.





WARNING INHIBITIONS

ECP (11VU)

ON THE ECAM CTL PNL, INHIBITS AURAL WARNING.

GPWS CTL PNL (21VU)

ON THE GPWS CTL PNL, INHIBITS VISUAL AND AURAL WARNINGS.

Figure 111 EGPWS Mode 3 - Altitude Loss After Take Off

EGPWS MODE 4 - UNSAFE TERRAIN CLEARANCE WHEN NOT IN LANDING CONFIGURATION

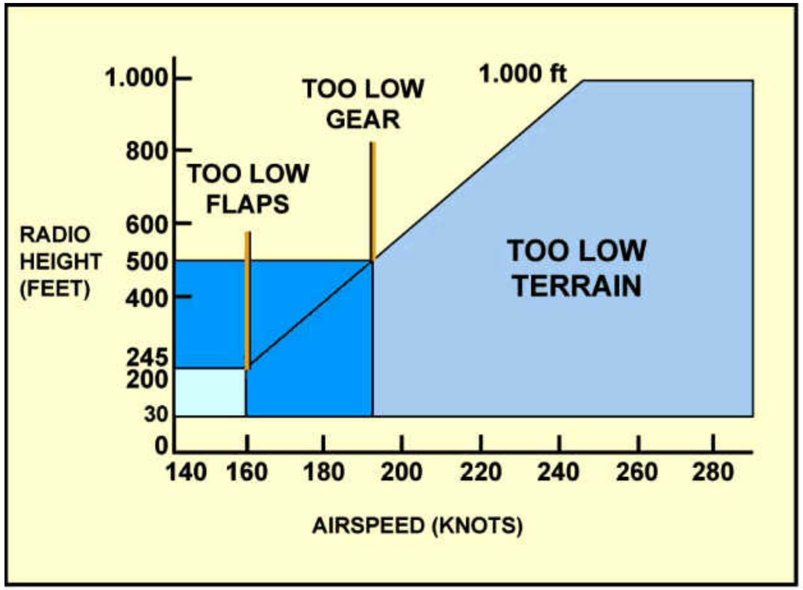
Mode 4 generates three type of voice warnings based on the radio height, computed airspeed and aircraft configuration.

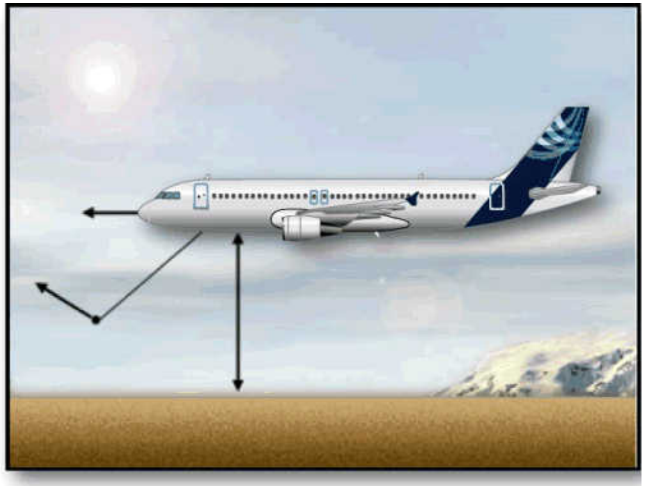
”TOO LOW TERRAIN” is broadcast when the aircraft is below 1.000 ft with landing gear retracted and/or flaps not in landing configuration. ”TOO LOW GEAR or TOO LOW FLAPS” are broadcast depending on the aircraft configuration:

- gear up or down,
- flaps extended or retracted,
- aircraft speed in relation to the radio height.

NOTE: The ”TOO LOW GEAR” message has priority over the ”TOO LOW FLAPS” message.

When the enhanced GPWS functions and the optional geometric altitude function are of high integrity, the upper operational limit is reduced.

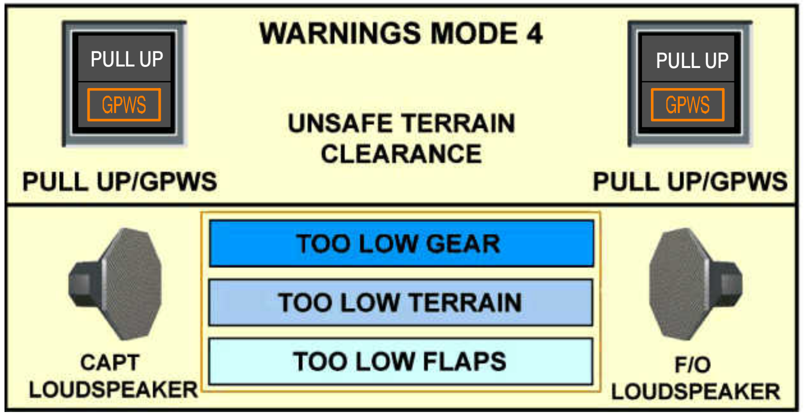




MODE 4A: GEAR AND FLAPS UP

MODE 4B: GEAR OR FLAPS DOWN

MODE 4C: GEAR OR FLAPS UP (DURING TAKE-OFF)



WARNING INHIBITIONS

ECP (11VU)

ON THE ECAM CTL PNL, INHIBITS AURAL WARNING.

GPWS CTL PNL
(21VU)

ON THE GPWS CTL PNL, INHIBITS VISUAL AND AURAL WARNINGS.

ON THE GPWS CTL PNL, INHIBITS THE AURAL "TOO LOW FLAP" AND VISUAL WARNINGS.

Figure 112 EGPWS Mode 4 - Unsafe Terrain Clearance

EGPWS MODE 5 - DESCENT BELOW GLIDESLOPE

Mode 5 provides warnings when the aircraft flight path descends below the G/S beam during ILS approaches.

The loudness of the ”GLIDE SLOPE” voice message and the repetition rate are increased when closing to the ground.

The mode is armed, when ILS 1 receives a valid signal.

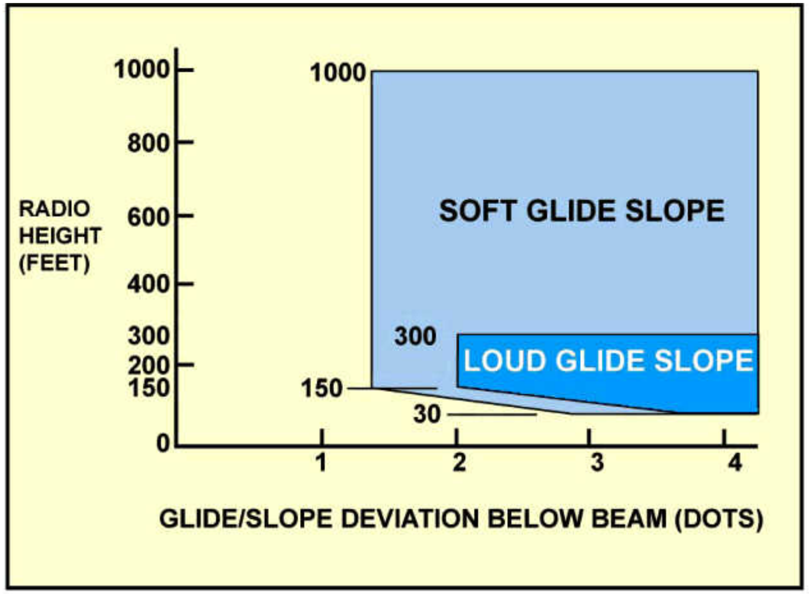
Pressing the GPWS pushbutton cancels the warning. This is temporary ; the mode is automatically reactivated for a new envelope.

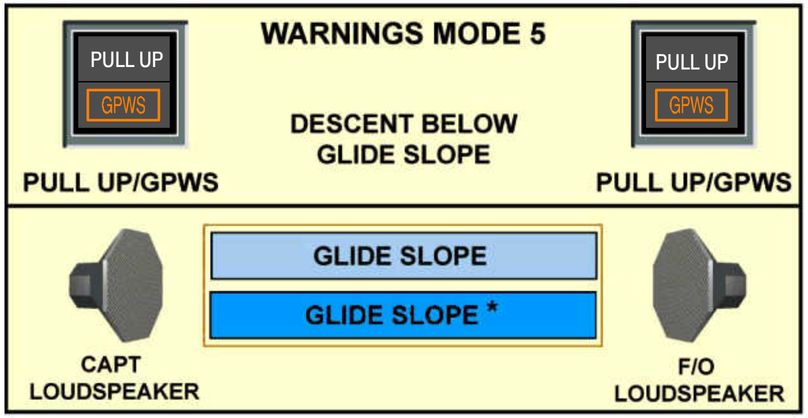
Pressing the G/S OFF P/BSW deactivates mode 5 completely.

The upper cut–off limit is 1000 feet radio altitude.

The lower cut–off limit is 30 feet radio altitude.

NOTE: The basic GPWS modes 6 & 7 are not active on Airbus 320 family aircraft types.





WARNING INHIBITIONS

ECP (11VU) — ON THE ECAM CTL PNL, INHIBITS AURAL WARNING.

GPWS CTL PNL (21VU) — ON THE GPWS CTL PNL, INHIBITS VISUAL AND AURAL WARNINGS.

GPWS CTL PNL (21VU) — ON THE GPWS CTL PNL, INHIBITS THE AURAL AND VISUAL WARNINGS.

LIGHTING/ LOUDSPEAKER CTL PNL (301 & 500VU) — ON THE LIGHTING/LOUDSPEAKER CONTROL PANEL, INHIBITS THE AURAL AND VISUAL WARNINGS.

* VOICE MESSAGE INCREASES

Figure 113 EGPWS Mode 5 - Descent Below Glideslope

TERRAIN AWARENESS AND DISPLAY (TAD)

When a terrain threat forward of the aircraft path is detected, with respect to the aircraft position and the local terrain database, caution and warning alerts are triggered.

When the envelope boundaries are met the following alerts are generated:

- terrain caution alert: ”TERRAIN AHEAD” is broadcast for Joint Aviation Authorities (JAA) regulations or ”CAUTION TERRAIN, CAUTION TERRAIN” for Federal Aviation Administration (FAA) regulations,
- terrain warning alert: ”TERRAIN AHEAD, PULL UP” is broadcast for JAA regulations or ”TERRAIN, TERRAIN, PULL UP” for FAA regulations.

When the optional obstacle function is activated the EGPWS can also generate the following alerts:

- obstacle caution alert: ”OBSTACLE AHEAD” is broadcast for JAA regulations or ”CAUTION OBSTACLE” for FAA regulations,
- obstacle warning alert: ”OBSTACLE AHEAD, PULL UP” is broadcast for JAA regulations or ”OBSTACLE, OBSTACLE, PULL UP” for FAA regulations.

These alerts are completed by a terrain image on the NDs:

- red area for warnings,
- yellow area for cautions.

As an option, the peaks function allows the display of the absolute terrain with the highest and lowest elevations.

When the TERR ON ND pushbutton is selected ON, and ARC or ROSE mode is selected, the terrain is displayed on the ND. The terrain is displayed in various densities of green, yellow, red, or magenta, depending on the threat.

If an alert is generated (caution or warning) when TERR ON ND is not selected, the terrain will be automatically displayed and the ON light of the TERR ON ND pushbutton will come on.

When TERR ON ND is selected, the weather radar image is not displayed.

The relative height of the aircraft is computed using the Captain‘s baro setting.

Thus, the Terrain Awareness Display (TAD) does not protect against baro setting errors.

The TAD and Terrain Clearance Floor (TCF) functions operate using the FMS 1 position. Thus, the system does not protect against FMS 1 position error.

If the FMGS detects low navigation accuracy, then the enhanced modes of the EGPWS are automatically deactivated. The EGPWS modes 1-5 remain active.

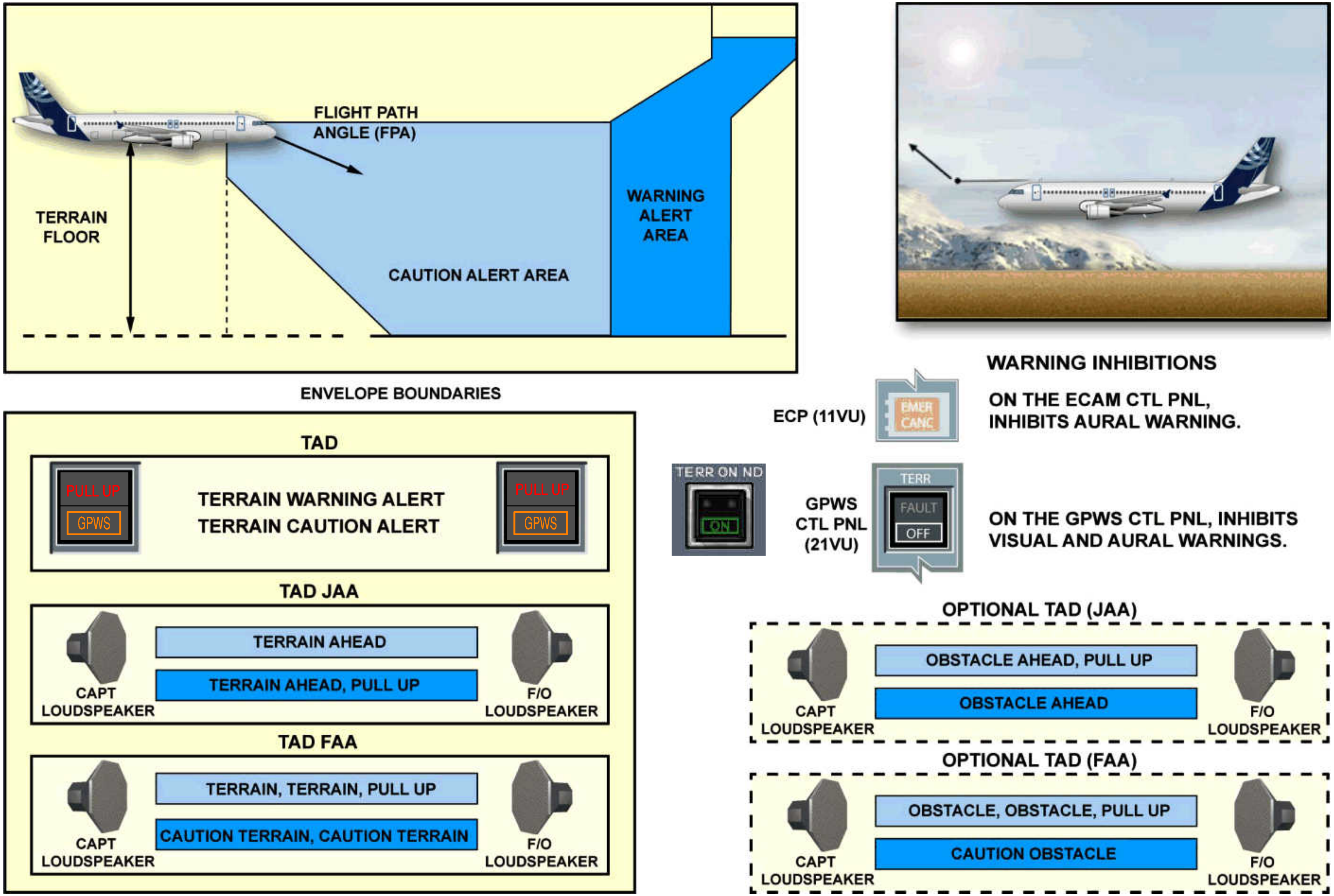


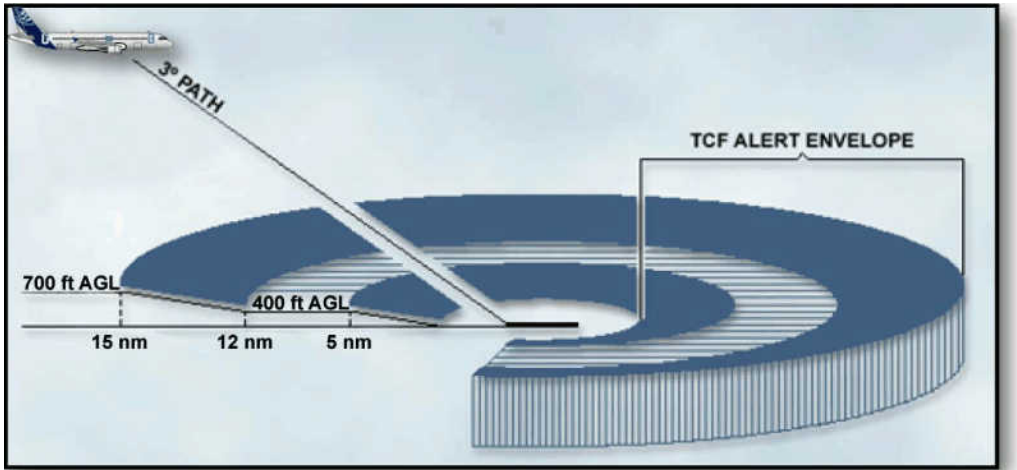
Figure 114 Terrain Awareness and Display Mode

TERRAIN CLEARANCE FLOOR (TCF)

The Terrain Clearance Floor (TCF) is an increasing terrain clearance envelope around the airport runway to provide protection against Controlled Flight Into Terrain (CFIT).

The TCF alert function complements the existing Mode 4. When TCF alert envelope is penetrated "TOO LOW TERRAIN" is broadcast. It is based on current aircraft position, nearest runway center point position and RA.

A terrain clearance floor envelope is stored in the database for each runway for which terrain data exist. The Terrain Clearance Floor (TCF) function warns a premature descent below this floor, regardless of aircraft configuration.



TCF ALERT ENVELOPE

WARNING INHIBITIONS

ECP (11VU)

ON THE ECAM CTL PNL, INHIBITS AURAL WARNING.

GPWS CTL PNL (21VU)

ON THE GPWS CTL PNL, INHIBITS VISUAL AND AURAL WARNINGS.

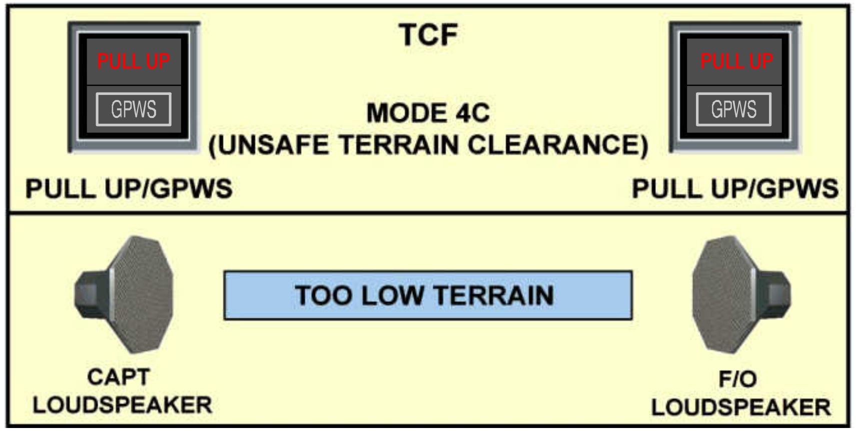


Figure 115 Terrain Clearance Floor Mode

RUNWAY AWARENESS AND ADVISORY SYSTEM (OPTIONAL)

The Runway Awareness and Advisory System (RAAS) enhances the flight crew's awareness of the aircraft position on ground.

The RAAS uses the EGPWS to trigger aural alerts in the three following cases:

- **Approaching the runway:**
  - When the aircraft is within a specific distance from the runway, e.g. "Approaching three four left".

    If the aircraft is within a specific distance from more than one runway, the "Approaching runways" aural alert is triggered.
- **On the runway:**
  - When the aircraft enters a runway and the aircraft heading aligns with the runway direction, e.g. "On runway three four left".
- **Takeoff from the taxiway:**
  - When the aircraft speed exceeds 40 knots, while the aircraft is not on a runway, the "On taxiway ! On taxiway !" aural alert is triggered.

The Runway Awareness and Advisory System (RAAS) is an optional software enhancement hosted in the EGPWS Unit.

The RAAS uses GPS position data and the EGPWS Database to provide aural advisories for flight crew awareness during ground operations and on approach to landing to avoid runway incursions or collisions.

The RAAS operates automatically without any action required from the flight crew. An EGPWS self test can verify the availability of this function.

RAAS aural advisory priority:

- Approaching Runway In Air (Opt),
- Approaching Short Runway In Air (Opt),
- On Runway (std),
- Insufficient Runway Length On Ground (Opt),
- Approaching Runway On Ground (Std),
- Taxiway Take Off (opt),
- Extended Holding (Opt),
- Runway End (Opt).

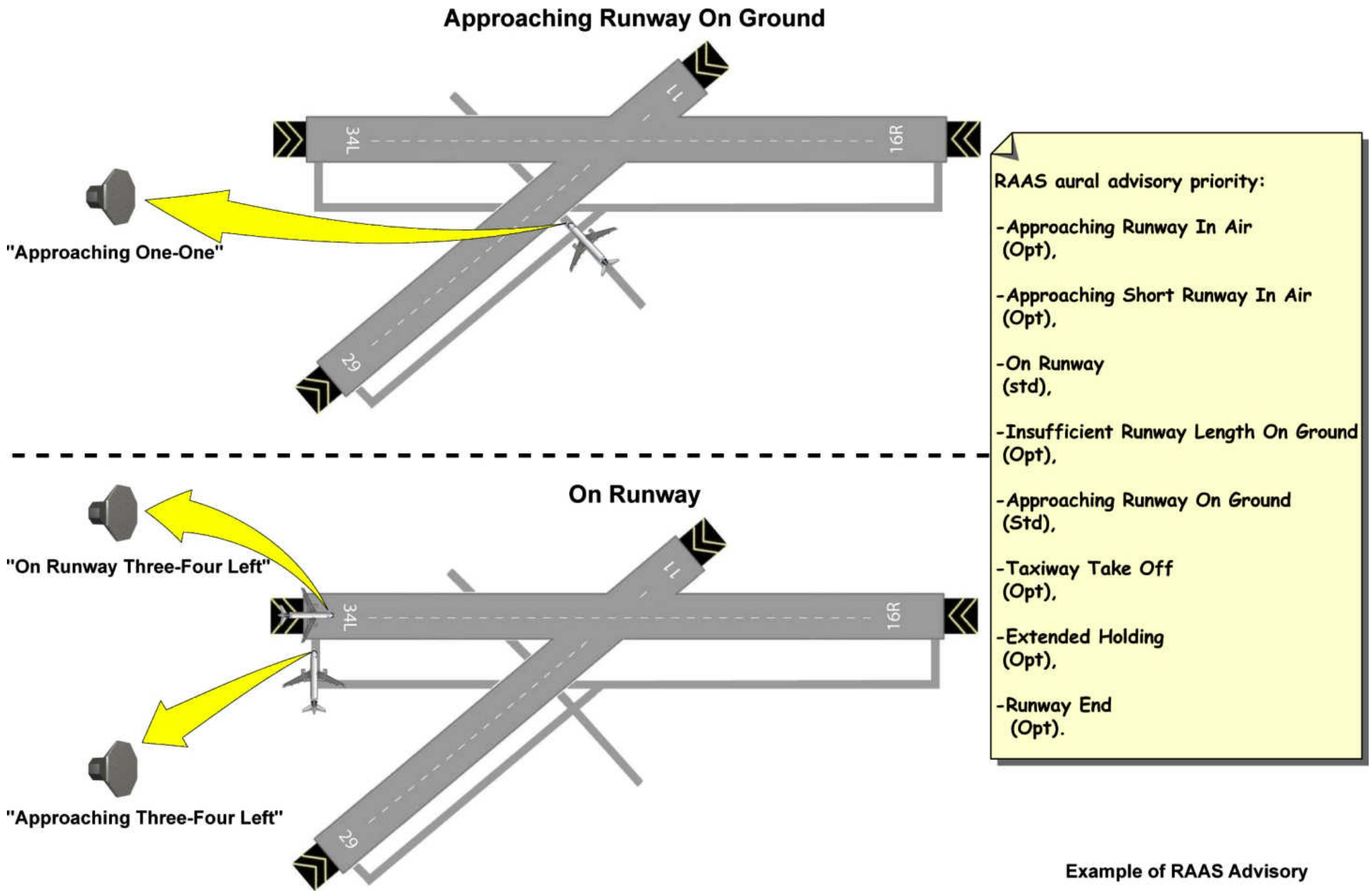


Figure 116 Runway Awareness and Advisory System

EGPWS DESCRIPTION

GENERAL

The purpose of the Enhanced Ground Proximity Warning System is to alert the flight crew of potentially hazardous conditions with respect to the terrain.

The system achieves this objective by accepting a variety of aircraft parameters as inputs, applying alerting algorithms, and providing the flight crew with aural alert messages and visual annunciations and displays in the event that the boundaries of any alerting envelope are exceeded.

The Enhanced GPWC, will be able to use preferably GPS position when available on board and to activate peaks and/or obstacle functions with EFIS/EIS1/EIS2 display.

Two architectures will be available to receive GPS data. The first one using the ADIRS connection as GPS data are transmitted via the IRS bus, and the second one will be a direct connection between Enhanced GPWS and GPS sensor (MMR or GPSSU) if ADIRS is not able to transmit GPS data.

Enhanced features have been added to existing basic Ground Proximity Warning Modes 1 to 5 which are the backbone of the system. The primary design objective has been to maintain the integrity of these modes independent of the other functions. For example, loss of the Terrain Awareness Display (TAD) function does not affect the operation of the basic GPWS modes. Also, loss of basic GPWS modes does not affect TAD function.

When EGPWS is pin programmed to use GPS position, then geometric altitude is also activated.

SYSTEM DESCRIPTION

The Enhanced GPWS monitors data inputs from the navigation sensors. This information is used to provide suitable aural and visual warnings to alert the crew of a hazardous situation with respect to the terrain.

GPWS/LDG FLAP 3 Pushbutton Switch

To avoid nuisance warnings during approach, the Enhanced GPWC needs to know at which flap position the crew intends to land. This pushbutton switch, when pressed in (white ON legend on), indicates to the Enhanced GPWC that the pilot intends to land in flap 3 position. When released out, the pushbutton switch indicates to the Enhanced GPWC that the pilot intends to land in flap FULL position. The GPWS FLAP message is permanently displayed in green on the MEMO of the ECAM display unit if no warning is in progress.

GPWS/FLAP MODE Pushbutton Switch

This pushbutton switch, when pressed (white OFF legend on), overrides flap abnormal condition input and generates the GPWS FLAP MODE OFF message (green) in the memo area of the upper ECAM display unit.

GPWS/G/S MODE Pushbutton Switch

This pushbutton switch, when pressed (white OFF legend on), inhibits the glide slope mode.

GPWS/SYS Pushbutton Switch

When this pushbutton switch is pressed (white OFF legend on), all ground proximity alerts (Mode 1 to 5) are inhibited (visual and audio) and no Enhanced GPWC self−test is possible. This pushbutton switch provides a FAULT warning on the ECAM indicating that a failure in Modes 1 to 5 has been detected by the Enhanced GPWC.

GPWS/TERR Pushbutton Switch

When this pushbutton switch is pressed (white OFF legend on), the TAD and TCF functions are inhibited (visual display and audio inhibition). The pushbutton switch provides a FAULT warning on the ECAM indicating that a failure of TAD and/or TCF functions has been detected by the Enhanced GPWC.

CAPT and F/O PULL UP/GPWS Pushbutton Switches

These pushbutton switches have two functions. When pressed (in) they cancel the glide slope alert, or they initiate the self−test sequence if the aircraft is on ground.

CAPT and F/O TERR ON ND Pushbutton Switches

These pushbutton switches allow the crew to select or deselect terrain display on ND. The ON legends indicate that terrain data is displayed on ND (following manual or automatic pop up selection).

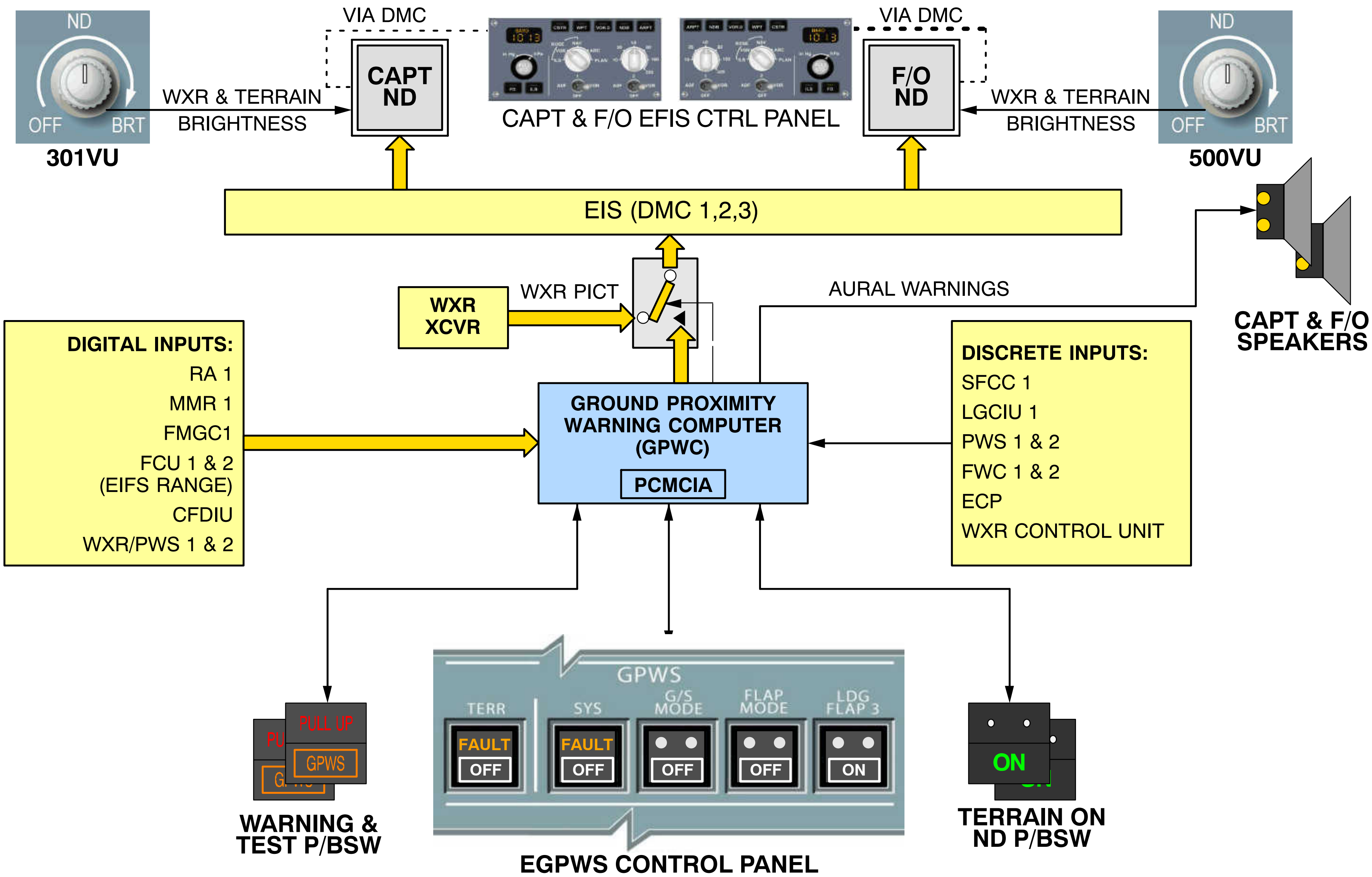


Figure 117 EGPWS Schematic

EGPWS OPERATION

GENERAL

The Enhanced GPWS monitors data inputs from the navigation sensors. This information is used to provide suitable aural and visual warnings to alert the crew of a hazardous situation with respect to the terrain.

Warnings are generated by the Enhanced GPWC Aural warnings are broadcast from the cockpit loud speakers.

DIGITAL DATA INPUTS/OUTPUTS

The Enhanced GPWC receives serial digital data inputs from:

- Radio Altimeter transceiver 1 (radio altitude),
- Air Data/Inertial Reference Unit 1 (ADIRU),
  - ADR portion (SAT, barometric altitude, barometric altitude rate, computed airspeed),
  - IR portion (latitude, longitude, magnetic heading, GPS parameters if ADIRU is in hybrid configuration),
- Multi-Mode Receiver 1 (MMR) (glide slope deviation, localizer deviation, selected runway heading and GPS parameters if ADIRU is in autonomous configuration),
- Flight Management and Guidance Computer (FMGC) (latitude, longitude, track, navigation modes),
- Centralized Fault Display Interface Unit (CFDIU) (command word, date, flight number, UTC),
- Flight Control Unit (FCU) 1 and 2 (CAPT and F/O ranges),
- Weather Radar 1 and 2 (hazard busses).

The bus output is used by the Aircraft Integrated Data System (AIDS), Data Management Unit (DMU) and by the Centralized Fault Display Interface Unit (CFDIU) for test purposes.

DISCRETE DATA INPUTS

Discrete data inputs are received from the following:

- Slat Flap Control Computer 1 (SFCC) (3 and FULL flap position),
- Flight Warning Computer 1 and 2 (FWC) (all audio inhibition),
- Landing Gear Control and Interface Unit (LGCIU) (main landing gear retracted or extended),
- ECAM control panel (audio suppression),
- GPWS/FLAP MODE pushbutton switch which, when pressed (in) (white OFF legend on), overrides a flap abnormal condition input,
- GPWS/SYS pushbutton switch which, when pressed (in) (white OFF legend on), inhibits Modes 1 to 5 warnings,
- GPWS/G/S MODE pushbutton switch which, when pressed (in) (white OFF legend on), overrides the glide slope mode,
- PULL UP/GPWS pushbutton switch which, when pressed (in), enables the Enhanced GPWC to perform test,
- GPWS/TERR pusbutton switch which, when pressed (in) (white OFF legend on), inhibits TAD and TCF functions,
- TERR ON ND (CAPT or F/O) pushbutton switches allow the crew to select or deselect terrain display on ND's,
- Weather Radar control unit,
- Weather Radar with Predictive Windshear System (WR/PWS), inhibition of Enhanced GPWS aural and/or visual alerts each time there are PWS aural and/or visual alerts.

Monitor Outputs

There are three monitor outputs:

- GPWS monitor output controls the FAULT legend of the SYS pushbutton switch and indicates a failure of Modes 1 to 5,
- TERR monitor output controls the FAULT legend of the TERR pushbutton switch and indicates a failure of TAD and TCF functions.
- TERR NOT AVAIL output allows FWC to generate a TERR STBY ECAM memo. This output is triggered when EGPWS is valid but the TAD/TCF function cannot be temporarily computed.

Audio Output

The audio output is used by the cockpit loud speakers for aural warning messages.

Power Supply

The Enhanced GPWC power supply circuits receive 115VAC, 400 Hz, single phase (22 W max.) and 28VDC supply from the aircraft AC power.

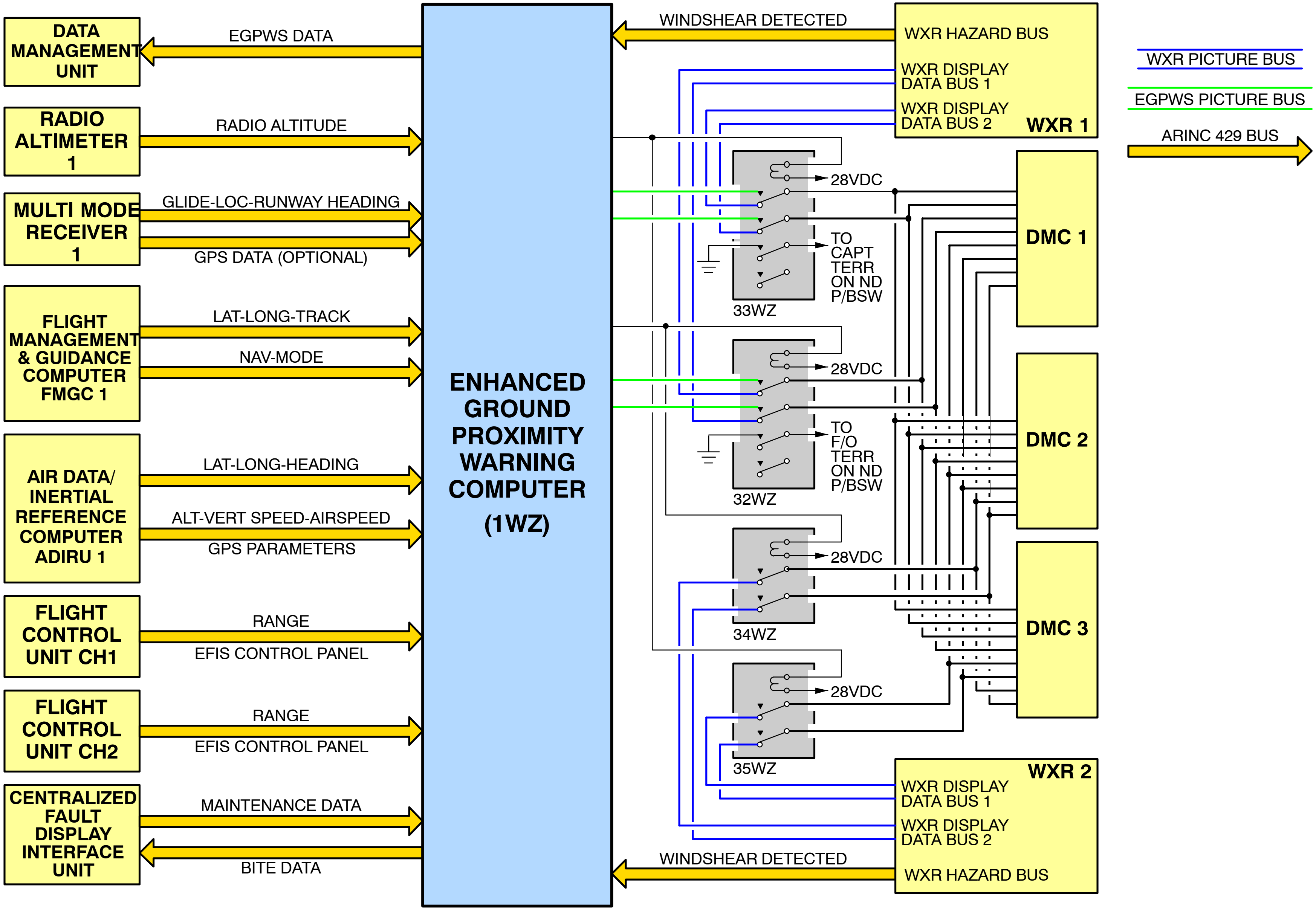


Figure 118 EGPWS Digital Interfaces

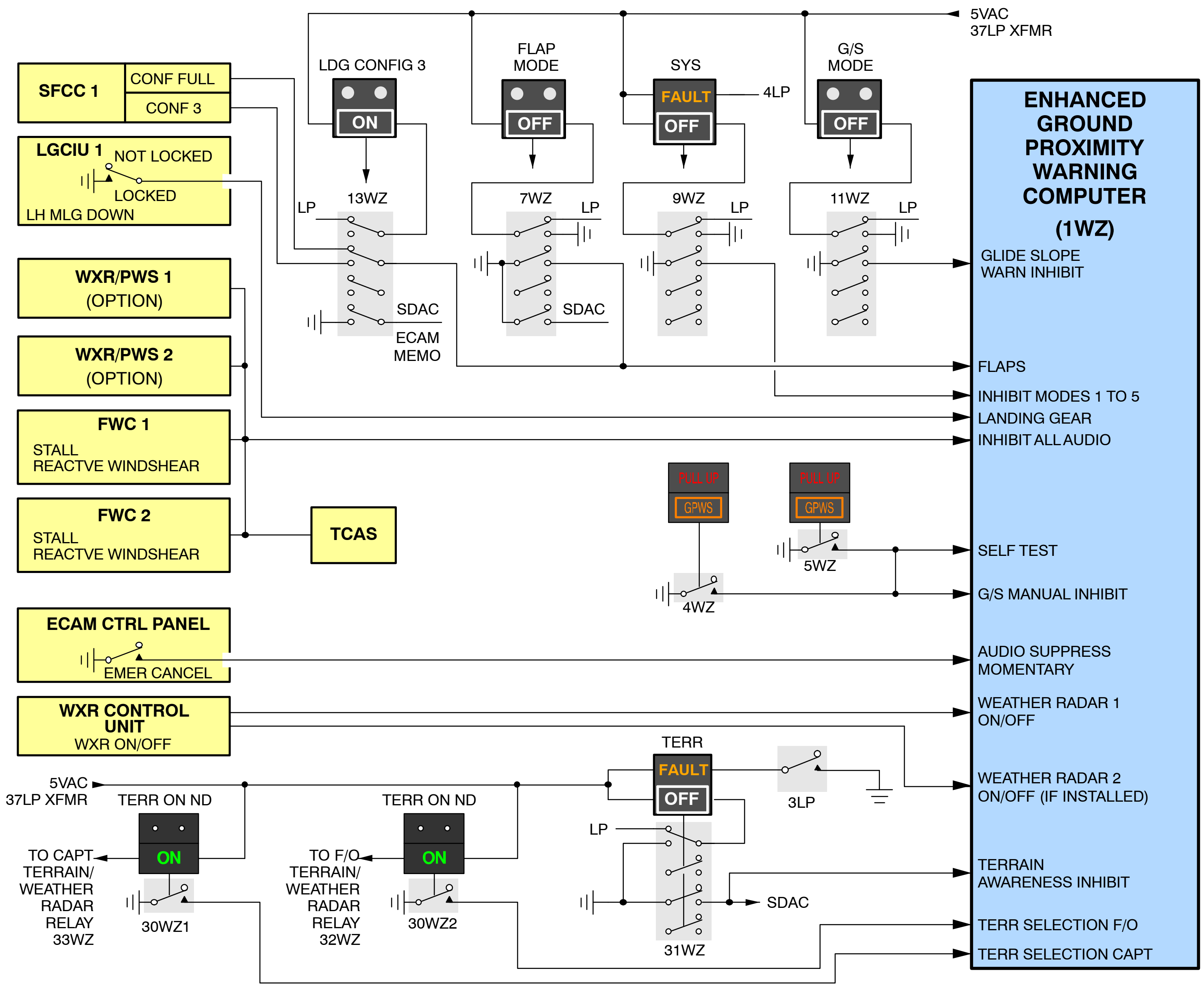


Figure 119 EGPWC Discrete Inputs

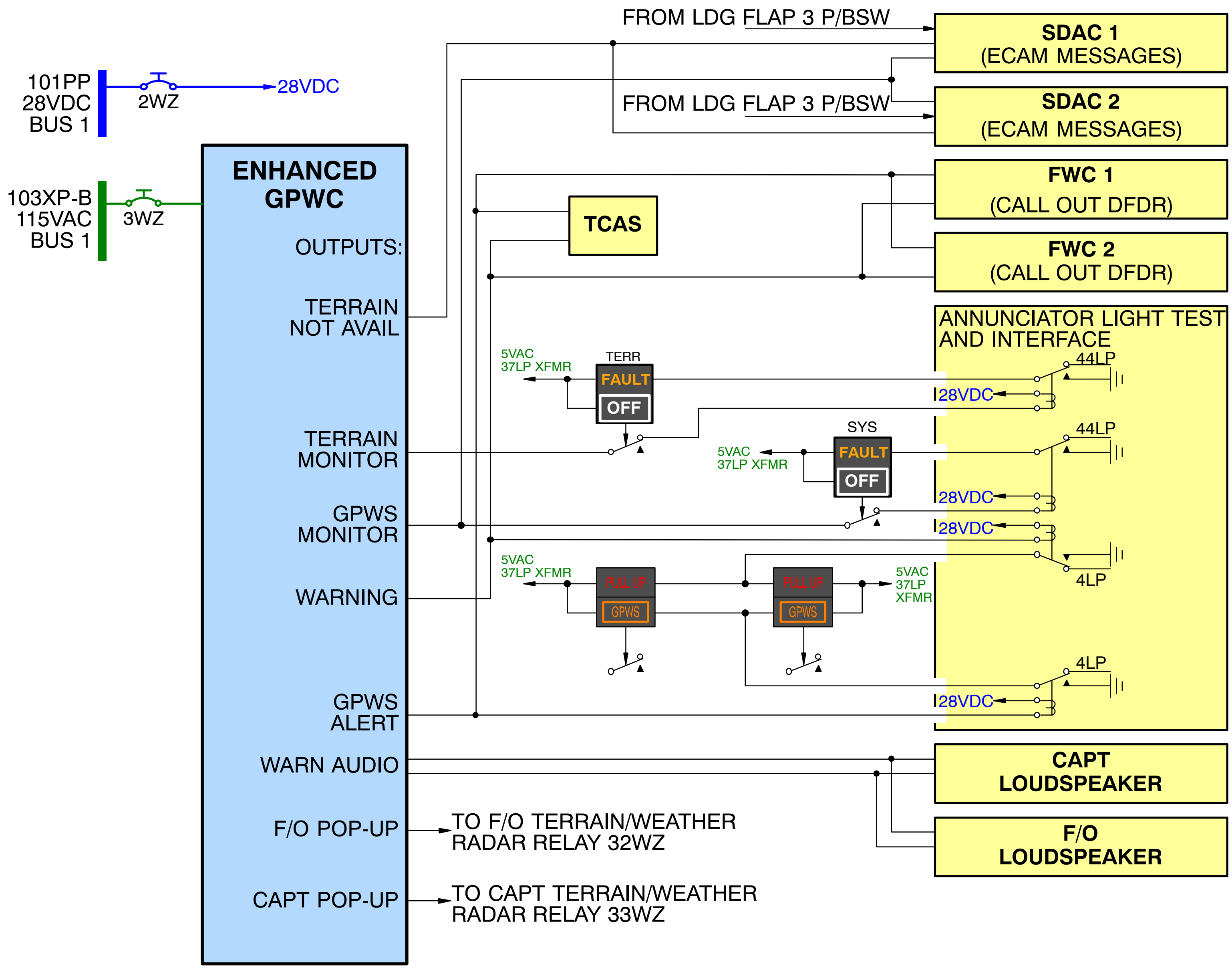


Figure 120 EGPWC Discrete Outputs

EGPWS SELF-TEST FUNCTION

GENERAL

On the ground only, the Enhanced GPWC provides self-test capability, both in flight and on ground, providing an indication of the ability of the Enhanced GPWC to perform its intended function.

The Enhanced GPWC self-test is initiated by pressing PULL UP/GPWS pushbutton switches or via the MCDU on the ground.

When activated by pressing the PULL UP/GPWS pushbutton switches, the self-test is enunciated, via the same audio system as the Enhanced GPWS alerts. This self-test can also be accessed via the headphone jack on the front panel of the Enhanced GPWC. The self-test is divided into six different levels to help with Enhanced GPWC testing and troubleshooting.

Level 1 (Short Test)

Level 1 (functional testing) provides an overview of the current operational functions selected and provides an indication of their operational status. The short self-test is initiated by momentarily pressing PULL UP/GPWS pushbutton switches for a short time.

Level 1 self-test sequence:

- the FAULT legend of the GPWS/SYS pushbutton switch comes on,
- the FAULT legend of the GPWS/TERR pushbutton switch comes on,
- the GPWS legends of both PULL UP/GPWS pushbutton switches come on,
- the GLIDE SLOPE audio phase is broadcast,
- the GPWS legends of both PULL UP/GPWS pushbutton switches go off,
- the PULL UP legends of both PULL UP/GPWS pushbutton switches come on,
- the PULL UP audio phase is broadcast,
- the TERRAIN AHEAD PULL UP audio phase is broadcast,
- the PULL UP legends of both PULL UP/GPWS pushbutton switches go off,
- the ON legends of both TERR ON ND pushbutton switches come on,
- the terrain self-test pattern is displayed on both NDs.

The uppers area is colored in cyan if peaks option is activated, black otherwise.

Level 1 (Long Test)

A long level 1 self-test sequence is initiated when the PULL UP/GPWS pushbutton switch is not released while self-test voices start. It should be hold until the fourth call out is heard (aproximately 5 seconds).

Additional sequence when long self-test initiated:

- SINK RATE; PULL UP; TERRAIN; PULL UP; DON'T SINK; DON'T SINK; TOO LOW TERRAIN; TOO LOW GEAR; TOO LOW FLAPS; TOO LOW TERRAIN; GLIDE SLOPE; TOO LOW TERRAIN; TERRAIN AHEAD; TERRAIN AHEAD; TERRAIN AHEAD PULL UP; OBSTACLE AHEAD; OBSTACLE AHEAD; OBSTACLE AHEAD PULL UP,
- the terrain self-test pattern disappears,
- the ON legends of both TERR ON ND pushbutton switches and the images displayed on both NDs revert to the configuration selected before the test,
- the FAULT legend of the GPWS/SYS pushbutton switch goes off,
- the FAULT legend of the GPWS/TERR pushbutton switch goes off.

  If the aircraft is fitted with EIS2 and if the Peaks display option is selected, then the Peaks elevations are provided to the displays as follows:

  - XXX (amber),
  - XXX (amber) for 5 seconds and then:
  - 290 (Red) High altitude
  - 13 (Green) Low altitude

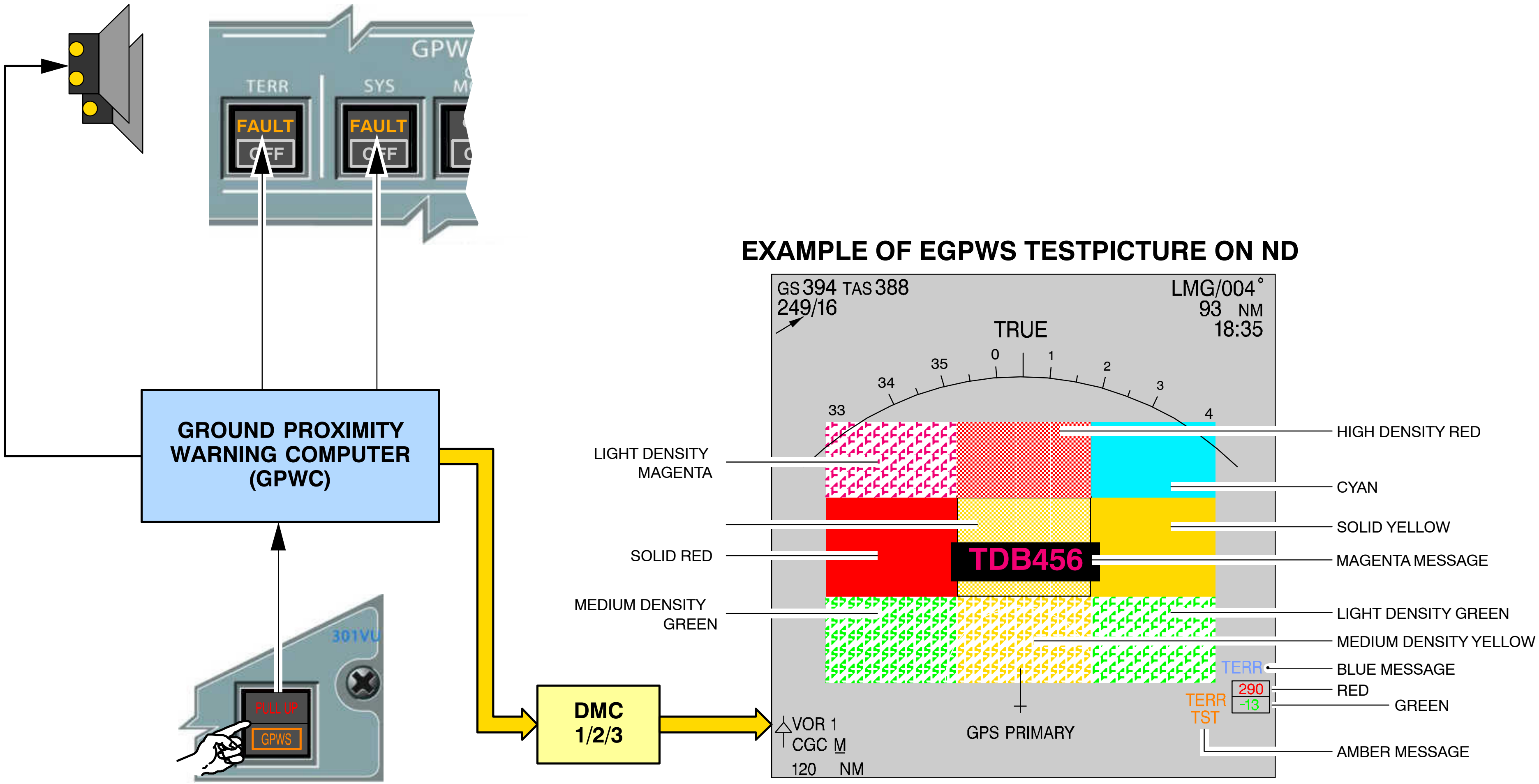
Level 2 - 6

Level 2 self-test (current faults) is initiated by pressing the PULL UP/GPWS pushbutton switch within 3 seconds after the end of level 1 self-test.

Level 3 (Enhanced GPWS configuration) is initiated by pressing the PULL UP/GPWS pushbutton switch when the PRESS TO CONTINUE message is enunciated.

Level 4 (fault history), Level 5 (warning history), Level 6 (discrete test) are initiated by pressing the PULL UP/GPWS pushbutton switch when the PRESS TO CONTINUE message is enunciated.

To speed up the navigation of self-test levels and information, two types of cancel sequences are supported. Pressing and holding the PULL UP/GPWS pushbutton switch for less than 2 seconds is considered to be a short cancel. Pressing and holding the PULL UP/GPWS pushbutton switch for more than 2 seconds is considered to be a long cancel.



SHORT TEST:
- PRESS SHORTLY

FULL TEST:
- PRESS APPROX. 5 SEC.

NOTE:
- The full test is not possible with the T2CAS!

NOTE:
- The test picture varies depending on Software Version

Figure 121 EGPWS Ground Self Test Function

GPWC COMPONENT DESCRIPTION

GPWC INTERNAL DESCRIPTION

The hardware consists of three main circuit card assemblies:

- the controller card,
- the accessory card,
- the analog acquisition card.

The controller card contains the main processor (microprocessor 486DX4), the Digital Information Transfer System (DITS) handler microcontroller and the image generator DSP.

The accessory card contains the power supply and the voice generator DSP.

The analog acquisition card contains the analog acquisition microcontroller.

FRONT PANEL ASSEMBLY

The front panel assembly contains identification and modification status labels, status LEDs, a latched door for access to a SELF−TEST pushbutton switch, a HEADPHONE jack, a RS232 test connector (P1), and a Personal Computing Memory Card Interface Adapter (PCMCIA) interface and status LEDs.

There is also a handle for ease of carrying and installation/removal, and a hold−down hook for securing at installation.

PCMCIA INTERFACE

The standard Type II PCMCIA interface provided at the front panel allows for both the uploading and downloading of internal Enhanced GPWC information. Control of the upload/download process is accomplished by insertion of the PCMCIA card into the front panel access. Four LEDs are provided for PCMCIA interface operation.

The PCMCIA card does not remain installed during normal Enhanced GPWC operation, and is not intended as an on−line/inflight storage medium.

FRONT CONNECTOR

A 15−pin (double density, D−Sub) test connector is located on the front panel, which provides for connection to either a CRT terminal or a PC.

This connector provides the following interfaces:

- Three−wire serial interface, compatible with RS232.

  This port can be used to access internal data from the Enhanced GPWC for both bench simulation and aircraft testing. Unit configuration and flight history can also be accessed. This port can also be used to upload software and data bases.
- ARINC 429/422/423 data loader interface.

  This port can be used to upload software and data bases. System power is provided on two of the pins for data loader use.

UPLOADING OF THE ENHANCED GPWC DATABASE PROCEDURE

NOTE: Before you load the software make sure that the version of the terrain data base is correct.

- Make sure that the COMPUTER OK LED on the face of the Enhanced GPWC, is on.
- Open the door on the face of the Enhanced GPWC.
- Put the PCMCIA card into the PCMCIA card slot.
- During software loading, the IN PROG LED stays on and the COMPUTER OK LED is off.
- When the loading is completed, the XFER COMP LED comes on.
- Remove the PCMCIA card from the Enhanced GPWC.
- After approximately 15 seconds, the COMPUTER OK LED comes on to tell the operator that the loading of the PCMCIA card contents is completed.
- On the label on the front panel door of the Enhanced GPWC, write the number of the database that you loaded.
- Close the door on the face of the Enhanced GPWC.
- Do the BITE Test of the Enhanced GPWC.

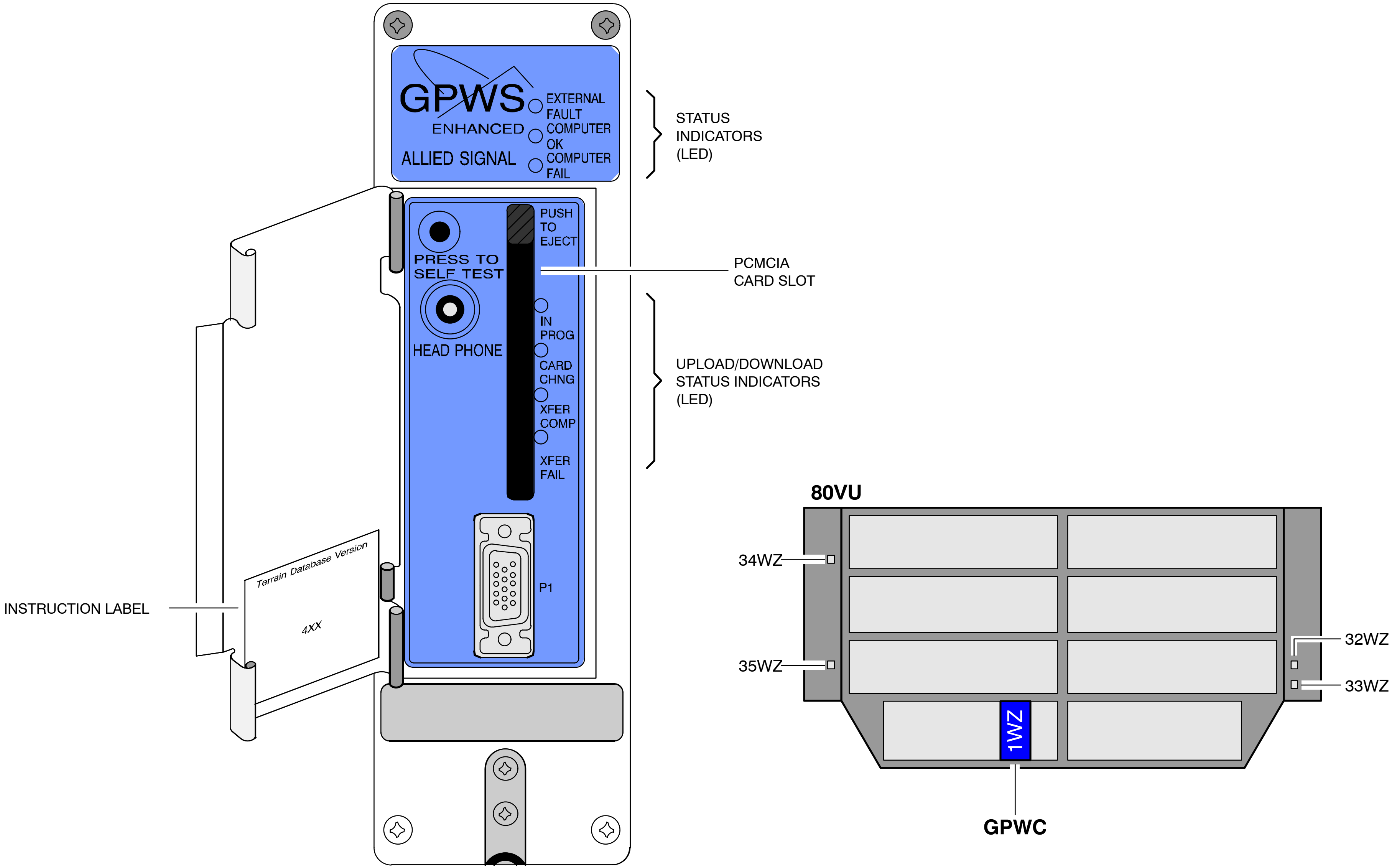


Figure 122 Grond Proximity Warning Computer

GPWS FAILURE DESCRIPTION

FAULT Light on GPWS/SYS Pushbutton Switch

When the FAULT legend comes on, the following messages are displayed:

- on the upper ECAM display unit if they are not inhibited by the FWC:
  - NAV – GPWS FAULT (amber),
  - GPWS ....OFF (cyan),

    (associated with action requested)
- in the INOP SYS item, on the STATUS page of the lower ECAM display unit:
  - GPWS (amber).

A fault message is sent to the CFDIU.

FAULT Light on GPWS/TERR Pushbutton Switch

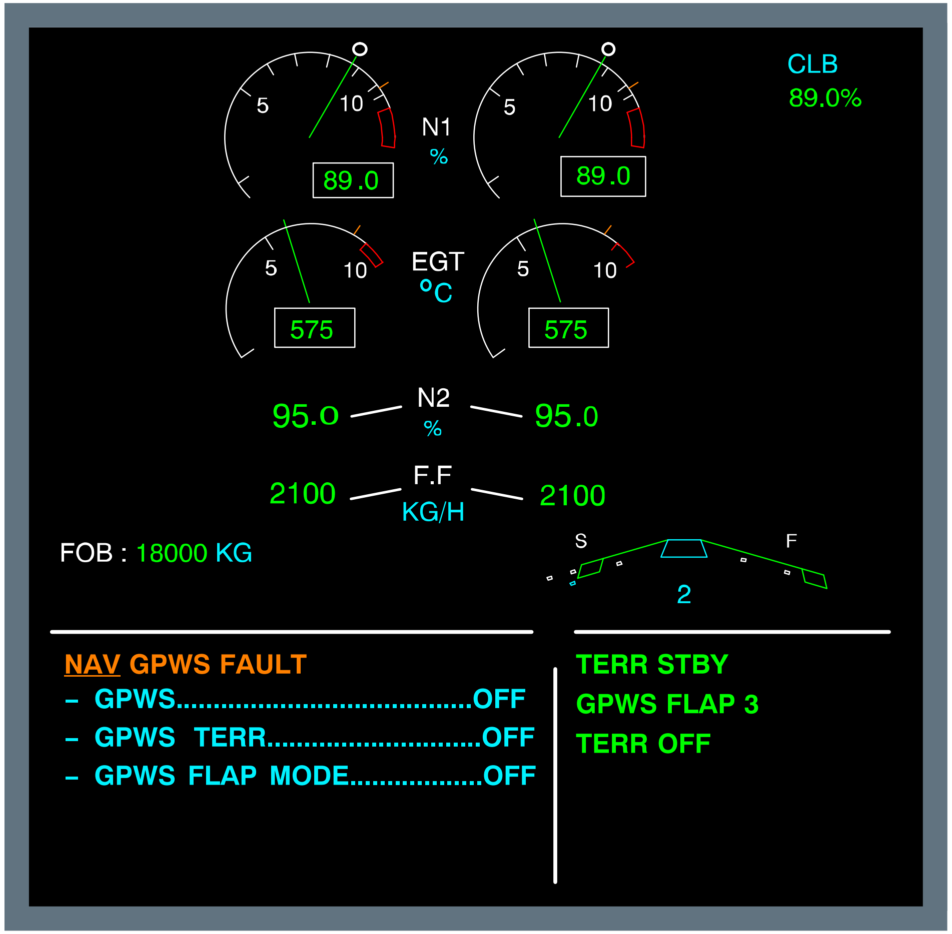
The pushbutton switch provides a FAULT warning indicating that a failure of TAD and/or TCF functions has been detected by the Enhanced GPWC.

When the FAULT legend comes on, the following messages are displayed:

- on the upper ECAM display unit if they are not inhibited by the FWC:
  - TERR OFF (green or amber),
  - GPWS TERR......OFF (cyan),
- in the INOP SYS item, on the STATUS page of the lower ECAM display unit
  - GPWS TERR (amber)

A fault message is sent to the CFDIU.

GPWS FAILURE MESSAGES ON E/WD



GPWS FAILURE MESSAGES ON STS PAGE

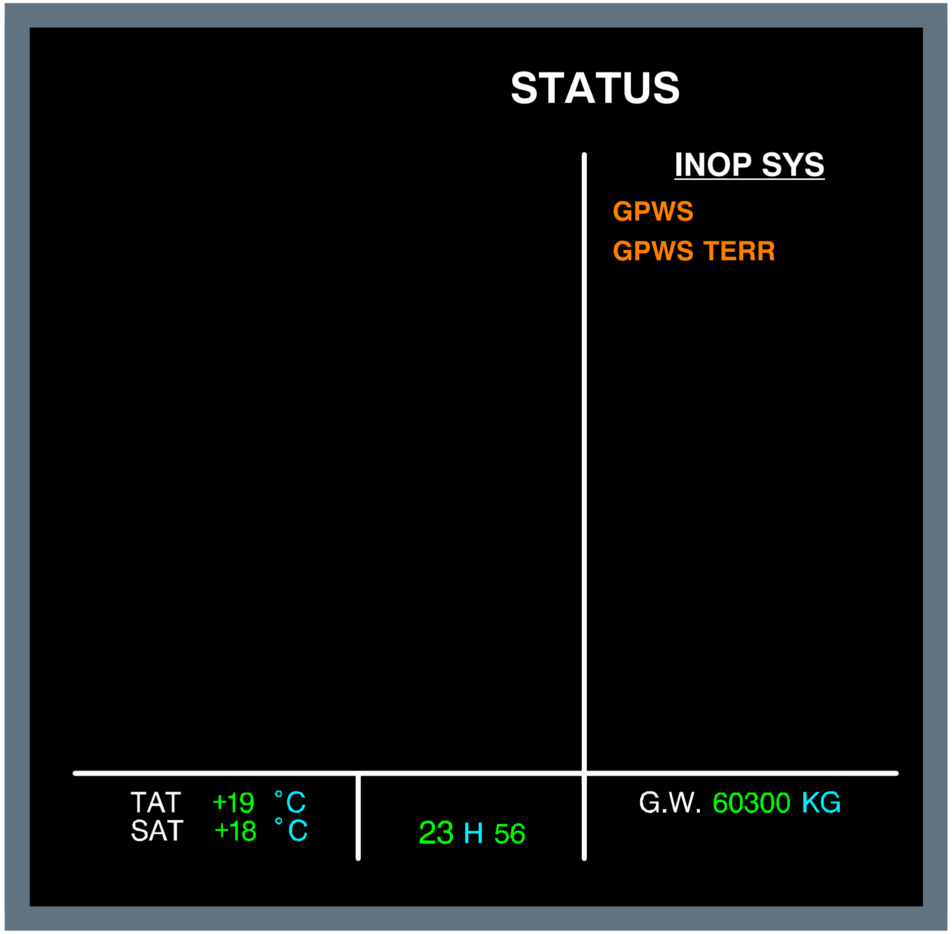


Figure 123 EGPWS ECAM Messages

EGPWS/T2CAS DIFFERENCES DESCRIPTION

GENERAL

The Terrain and Traffic Collision Avoidance System (T2CAS) is a combination of two functions in a single Line Replaceable Unit (LRU). These functions are the TCAS (TCAS II Change 7) and the Terrain Awareness and Warning System (TAWS).

The general purpose of the T2CAS is to alert the crew of two kinds of hazards which are:

- Collision with terrain (Controlled Flight Into Terrain).
- Collision with surrounding traffic.

The T2CAS:

- Detects the hazards
- Alerts the crew if the hazard is imminent
- Informs the crew of the aircraft environment
- When possible, proposes escape maneuvers.

To do this, the system receives different aircraft parameters, applies alerting algorithms and provides the flight crew with aural and visual alerts and displays. In this document, "T2CAS-TCAS" is used to define the TCAS function and "T2CAS-TAWS" is used to define the TAWS function.

All cockpit hardware interfaces (lights, push-buttons switches) for the T2CAS-TAWS remain identical to the Enhanced Ground Proximity Warning System (Enhanced GPWS). Only the audio messages and Navigation Display (ND) interface are different. All EGPWS inputs/outputs (I/O) are conveyed to the T2CAS as well as a few dedicated T2CAS-TAWS inputs (slat/flap control lever position from Slat Flap Control Computer 1 (SFCC1) and engine out information from the Flight Management Guidance Computer 1 (FMGC1).

There has been no change on the TAWS peripheral systems (in particular the Flight Warning Computer (FWC), Display Management Computer (DMC), Centralized Fault Display Interface Unit (CFDIU) and Flight Data Interface and Management Unit (FDIMU)).

EGPWS/T2CAS DIFFERENCES

The EGPWS and T2CAS have different philosophies.

The EGPWS keeps all modes active but desensitizes nuisance prone modes function of the predictive mode (TAD) integrity and aircraft location (through envelope modulation).

The T2CAS inhibits mode 2 when the Collision Prediction and Alerting (CPA) is in normal operation and the CPA altitude crosscheck is correct.

The EGPWS sensor includes a vertical margin (terrain floor) function of Vz and Runway proximity. This margin is directly applied on the terrain cells for T2CAS.

The EGPWS and T2CAS both use a caution and a warning sensors projected in a terrain database. EGPWS assumed that the A/C could climb 6° all the time.

The T2CAS takes into account real time aircraft climb capability to give an alert with guaranteed safety margins. If this safety margins is not sufficient, the AVOID TERRAIN alert is triggered to indicate to the pilot that a turn maneuver is recommended in addition to the PULL UP warning.

The EGPWS and the T2CAS have very similar display principles (same layer colorations). Both systems have an anticipated background display in descent (approximately 30 sec).

The T2CAS has one specific feature, which is the AVOID TERRAIN display.

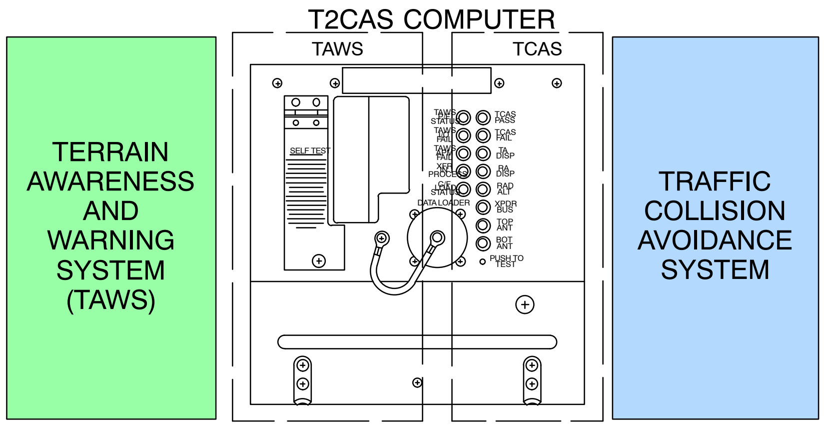


Figure 124 T2CAS System

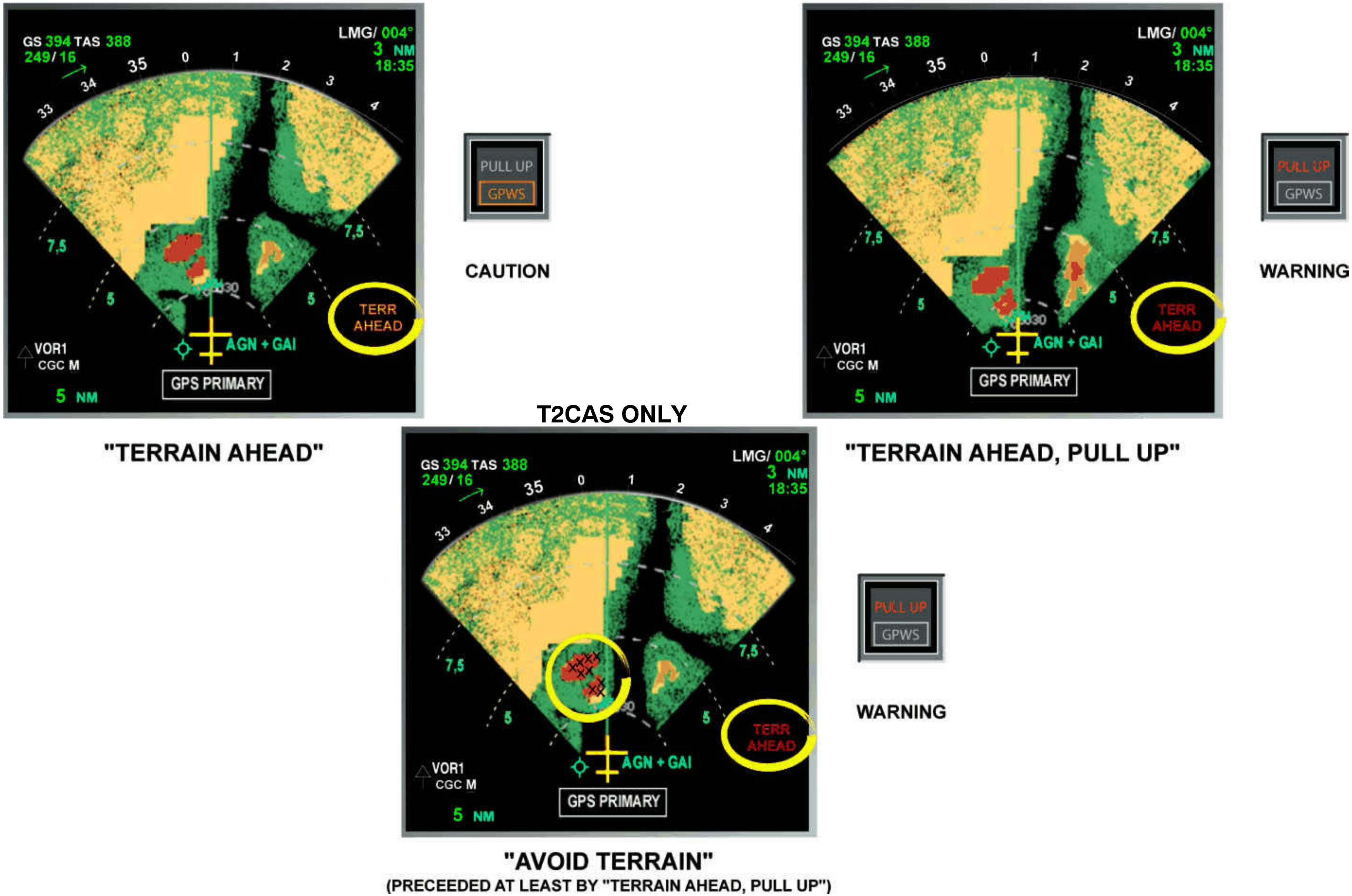


Figure 125 EGPWS/T2CAS Differences

34−40 INDEPENDENT POSITION DETERMINING

COMPONENT LOCATION

WEATHER RADAR SYSTEM

The units of the weather radar system are located in the aircraft as follows:

FIN	COMPONENT	PANEL	ZONE	ACESS DOOR
1SQ1	XCVR−WEATHER RADAR, 1	109VU	121	811
1SQ2	XCVR−WEATHER RADAR, 2	109VU	121	811
3SQ	CTL UNIT−WEATHER RADAR	11VU	210	831
7SQ	DRIVE−WR ANTENNA	NIL	110	110AL
9SQ	MTG TRAY−WR XCVR	109VU	121	811
11SQ	ANTENNA−WEATHER RADAR	NIL	110	110AL

RADIO ALTIMETER

The units of the radio altimeter system are located in the aircraft as follows:

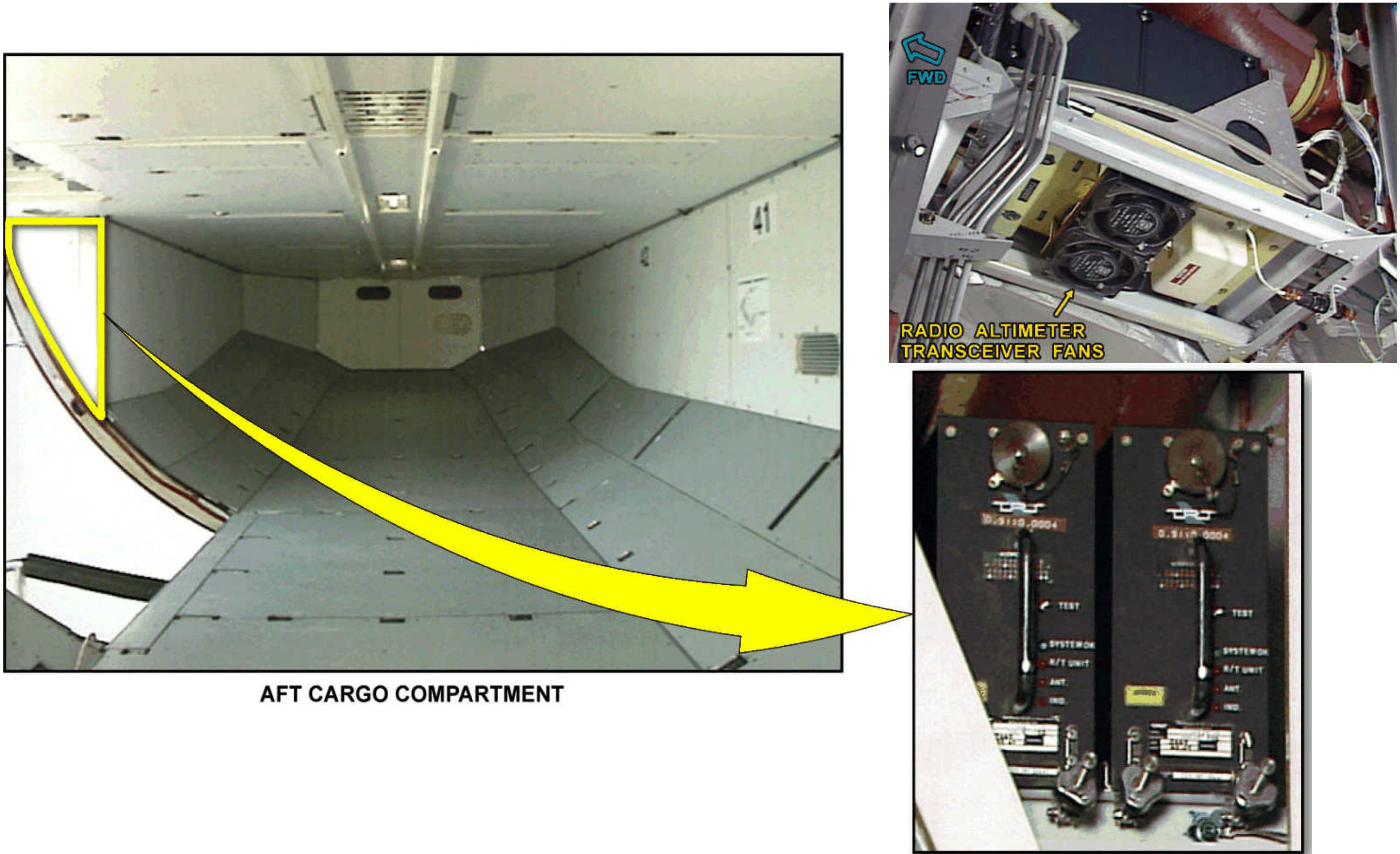
FIN	COMPONENT	ZONE	ACESS DOOR
2SA1	XCVR-RA, 1	152	826
2SA2	XCVR-RA, 2	152	826
3SA1	FAN−RA XCVR 1	152	826
3SA2	FAN−RA XCVR 2	152	826
5SA1	ANTENNA−RA RCPTN, 1	153	NIL
5SA2	ANTENNA−RA RCPTN, 2	153	NIL
6SA1	ANTENNA−RA XMSN, 1	153	NIL
6SA2	ANTENNA−RA XMSN, 2	153	NIL

ENHANCED GROUND PROXIMITY WARNING SYSTEM

The units of the EGPWS are located in the aircraft as follows:

FIN	COMPONENT	PANEL	ZONE	ACESS DOOR
1WZ	GPWC	88VU	128	824
100SG	OR CMPTR - T2CAS	82VU	128	824
4WZ	P/BSW−PULL UP/GPWS	500VU	212	831
5WZ	P/BSW−PULL UP/GPWS	301VU	211	831
7WZ	P/BSW−GPWS/FLAP MODE	21VU	211	831
9WZ	P/BSW−GPWS/SYS	21VU	211	831
11WZ	P/BSW−GPWS/G/S MODE	21VU	211	831
13WZ	P/BSW−GPWS/LDG FLAP 3	21VU	211	831
30WZ1	P/BSW−TERR ON ND,CAPT	403VU	211	831
30WZ2	P/BSW−TERR ON ND,F/O	402VU	212	831
31WZ	P/BSW−GPWS/TERR	21VU	211	831
32WZ	RELAY−TERR/WXR RADAR 1	187VU	127	824
33WZ	RELAY−TERR/WXR RADAR 1	187VU	127	824
34WZ	RELAY−TERR/WXR RADAR 2	188VU	128	824
35WZ	RELAY−TERR/WXR RADAR 2	188VU	128	824

Figure 126 WXR XCVR, T2CAS & GPWC Location



AFT CARGO COMPARTMENT

Radio Altimeter (RA) 1, 2

Figure 127 Radio Altimeter Location

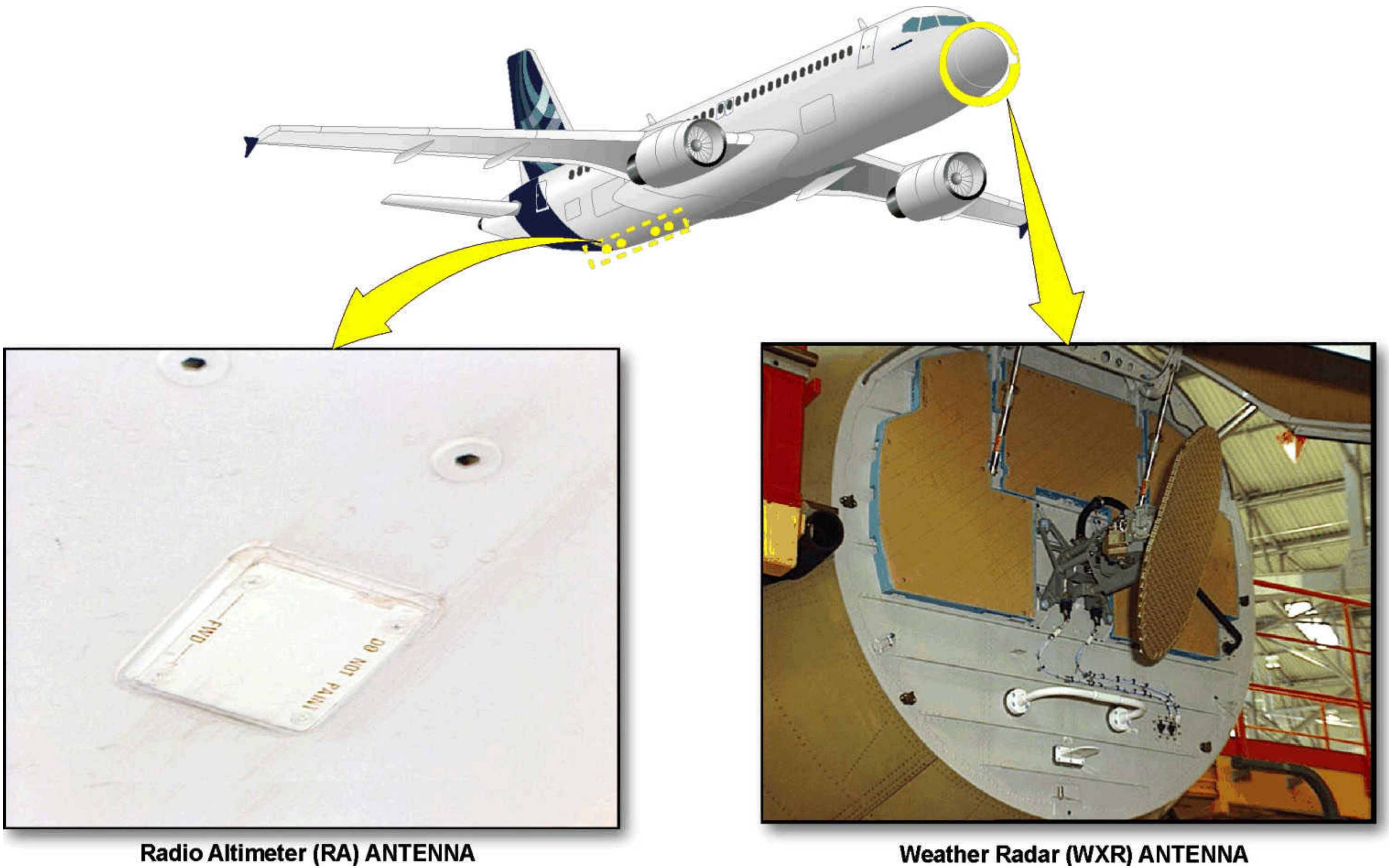


Figure 128 RA and WXR Antenna Location

34–34 PARAVISUAL INDICATING (PVI)

PARAVISUAL INDICATING (PVI) DESCRIPTION

PVI GENERAL

The paravisual indicator (PVI) is a system which serves as a piloting aid for roll out on runway (take off and landing) in reduced visibility conditions.

This indicator is proposed for certification of CAT3 automatic landing without DH with reduced runway visual ranges.

The PVI, installed on the glareshield, Captain's side, generates a paravisual image for the Captain.

This image provides "head up" display of parameters needed for manual guidance of the aircraft during roll out in reduced visibility conditions.

Furthermore, the AUTO LAND warning light is integral to the indicator.

The warning light displays AUTO LAND inscription. This black inscription flashes on a red background. Warning light illumination is controlled by the FWCs.

LOCATION

The PVI is installed in the cockpit at level of glareshield panel.

SYSTEM DESCRIPTION

The PVI receives an ARINC 429 HS bus from the DMC1 which can be switched to the DMC3 by Captain to generate images.

The AUTO LAND warning light is controlled by the FWCs independently from the image generation system. The Test of the AUTO LAND warning light and the self–test of the PVI are controlled by means of a pushbutton switch located on the PVI face.

As concerns image generation, the PVI can be switched on or off by means of a switch located on the PVI face.

AUTO LAND WARNING LIGHT

The AUTO LAND warning light is supplied with 5VDC when bright and 3VDC when dim.

The brightness of this warning light depends on the control voltage level.

FUNCTIONAL DESCRIPTION

The PVI comprises two distinct sections:

- the AUTO LAND warning
- the roll out piloting aid system.

AUTO LAND Warning

The AUTO LAND warning consists of a warning light directly controlled by the FWCs. The warning light goes off and comes on when the FWCs transmit a ground signal.

Each computer controls two lamps (warning light has four) installed in parallel. When the TEST pushbutton switch, located on the PVI face, is pushed, it controls the transmission of a discrete signal to the two FWCs so as to test warning.

Roll Out Piloting Aid System

Operation of this system has been designed around a digital CPU which controls:

- ARINC 429 bus reception interface,
- display control module.

Temperature of display is monitored to guarantee a segment response time compatible with roll out function whatever the temperature.

A self–monitoring circuit serves to permanently check the PVI operation.

TEST FUNCTION

Located on the PVI face, a TEST pushbutton switch serves to test the AUTO LAND warning light. The same pushbutton switch is used to test PVI assembly and the display.

POWER SUPPLY

The PVI operates on 115V/400Hz voltage provided by the normal busbar 1XP via the sub busbar 103XP and the circuit breaker 2FW. This circuit breaker is located on the panel 121VU. The 115V/400Hz is protected against lightning.

Integral lighting (TEST, ON, OFF labels and display window) is supplied by the VAC network whose peak value is 5VAC. This voltage is delivered by the general lighting circuit for all the cockpit panels.

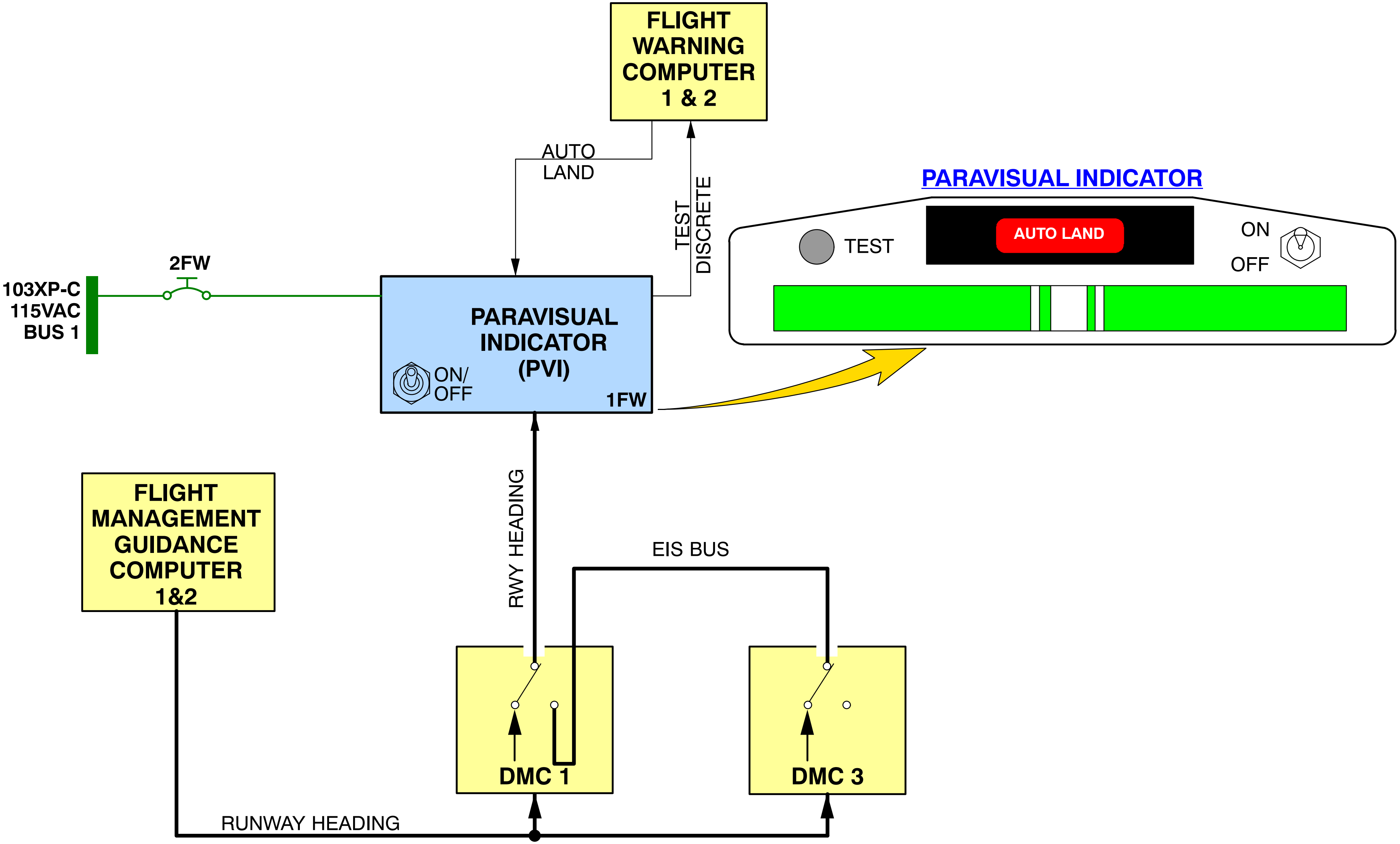


Figure 129 PVI Schematic

34–35 HEAD UP DISPLAY

HEAD–UP DISPLAY (HUD) DESCRIPTION

GENERAL

The HUD is an optional flying aid system, which gives to the pilot an image superimposed on the outside world in his field of view. This aid is based on the principle of symbol projection on an external combiner, mainly composed of a flat sheet of glass.

The objectives of the HUD are:

- to supply guidance information on the ground, at take–off and landing in conditions of reduced visibility,
- to give information to the pilot for visual approach on airfields without Instrument Landing System (ILS),
- to monitor the automatic approach operations.

The HUD system is composed of one HUD set (giving head–up data for the CAPT).

HEAD–UP DISPLAY COMPONENTS

The HUD is composed of one Head–Up Computer (HUDC), one Head–Up Projection Unit (HPU), one Head–Up Combiner Unit (HCU), one Personalization Memory Module (PMM) and one HUD Control Panel.

The HUDC is located in the avionics bay 82VU. It is used:

- to centralize the source data from the aircraft systems,
- to send the necessary data to the HPU.

The HPU is located inside the cockpit above the Captain. It is used to generate the image to project towards the HCU. The generated image is sent to the HCU by the HPU optical lenses. The HCU is located inside the cockpit in front of the Captain forward field of view.

It is used to reflect the image projected by the HPU towards the pilot while the forward field of view remains visible through the combiner. The HCU can take two positions (operational or retracted) by means of a declutching handle, located on its right (left) hand side.

The PMM is a memory module used to store the HPU installation adjustment (Contains data specific to the A/C particular installation, eg correction of error in X/Y positioning).

One HUD Control Panel on 131VU in the cockpit left hand side is composed of:

- a HUD potentiometer used to switch ON/OFF the HUD,
- a DECLUTTER pushbutton switch used to change the display,
- and an X WIND switch also used to change the display.

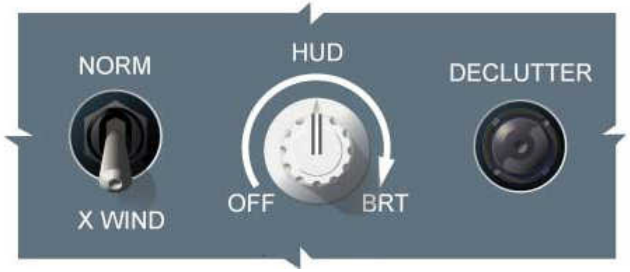
HEAD–UP COMBINER UNIT DISPLAY

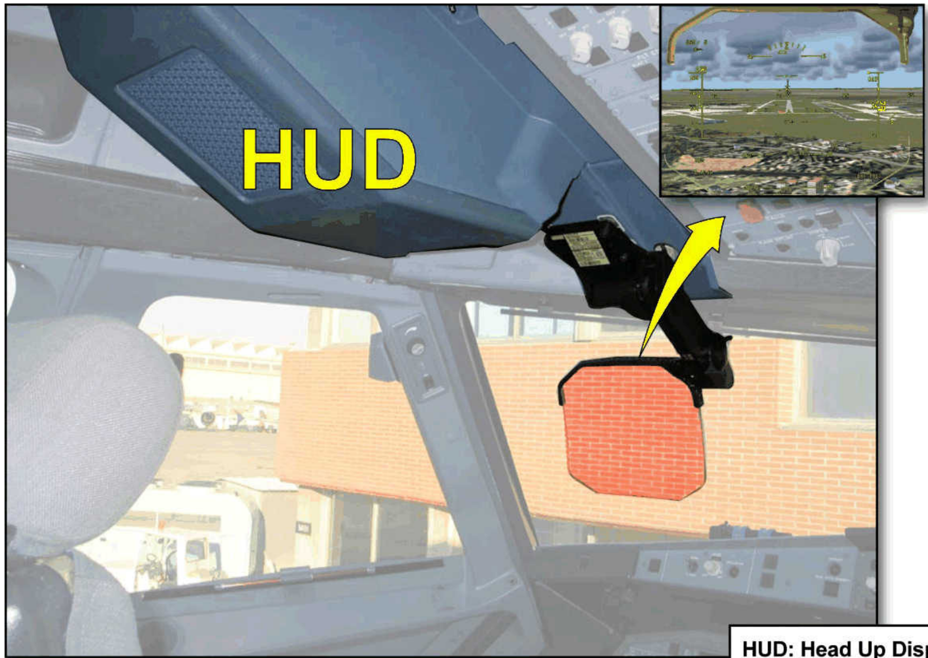
According to the flight configuration, different displays can be shown to the pilot.

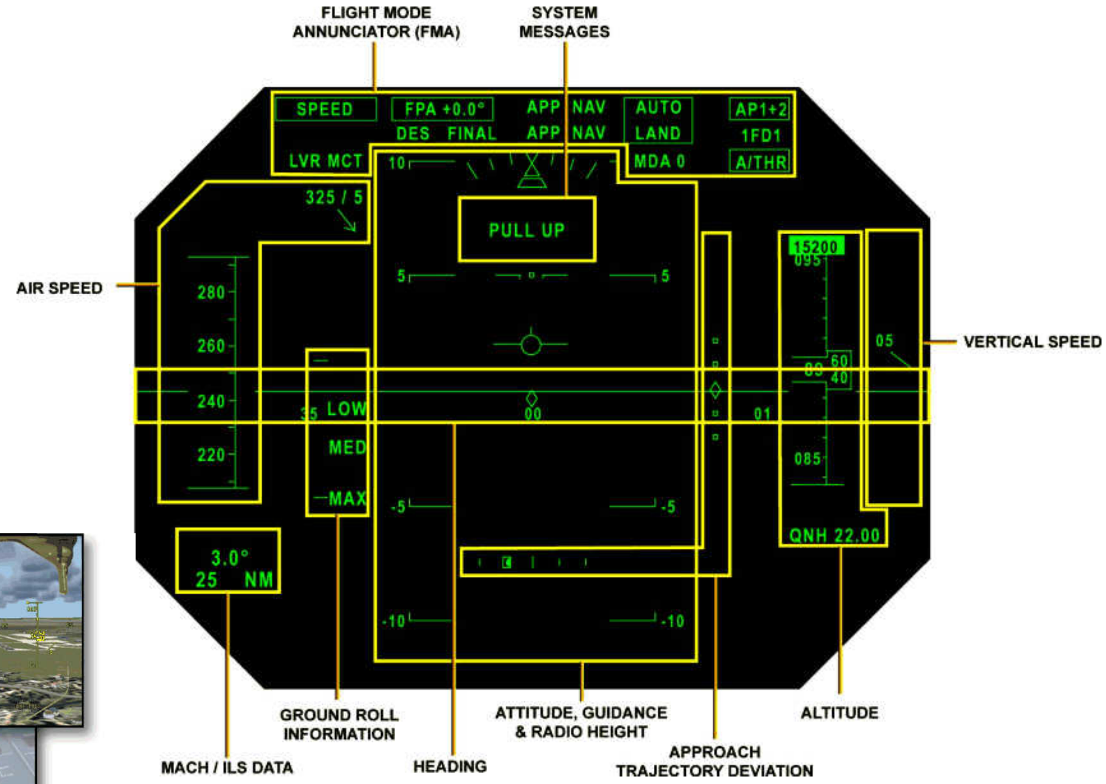
The HUD image is divided into ten areas, which show indications related to:

- attitude, guidance and radio height,
- heading,
- ground roll information,
- mach/ILS data,
- air speed,
- Flight Mode Annunciator (FMA),
- system messages,
- vertical speed,
- altitude,
- approach trajectory deviation.

CAPT HUD CONTROL PANEL (131VU)







HUD: Head Up Display

Figure 130 HUD Indication

HEAD UP DISPLAY SYSTEM OPERATION

HEAD-UP DISPLAY COMPUTER (HUDC)

The HUDC is interfaced with the remaining part of the avionics systems to obtain the needed data. Then, it computes and generates the symbols to display according to the manual or/and automatic selections and flight phases. It also has a monitoring function to make sure that no misleading information will be displayed to the pilot.

The HUDC implements two fully segregated logical channels, a Command channel (COM) and a Monitor Channel (MON).

The COM channel is used to select, validate the appropriate avionics system data, and display computation, symbol generation and self-test processing.

The MON channel is used to:

- monitor all critical data (feedback monitoring), and
- manage the HUD system BITE.

The HUDC carries out the control functions coming from the HUD control panel:

- brightness of the displayed symbology / HPU OFF and declutter.

HEAD-UP PROJECTION UNIT (HPU)

The HPU is located inside the cockpit above the Captain head. It contains an image generation device based on LCD technology, drive circuitry and the optical relay lenses.

The HPU has the following functions:

- to acquire video from HUDC (via optical fiber),
- to transform the video flow into a green image,
- to project the image onto the HCU glass (ensuring superimposition on the outside view),
- to adapt the image luminance according to orders received from HUDC,
- to acquire and transfer to the HUDC the value of brightness potentiometers (located in the front panel),
- to acquire and transfer to the HUDC the value of one luminance sensor (located on the HCU),
- to transfer to HUDC internal parameters (temperature, status) via discrete signals
- to give the BITE to the HUDC and control functionalities (via RS422 link).

PERSONALIZATION MEMORY MODULE (PMM)

The PMM is a memory module. To obtain the necessary accuracy for the HUD installation, two types of adjustment are necessary. The mechanical adjustment and the electronic adjustment (done with the PMM).

During A/C manufacturing, the HCU and HPU are precisely attached to the upper fuselage frames. After the bore-sighting process, electronic corrections are introduced into the HUDS and stored in the PMM to compensate aircraft residual errors in X/Y positioning. Therefore, the PMM is linked to the aircraft and non-interchangeable. This is necessary in order to reach the accuracy for correct symbols positioning. The electronic bore-sighting process is only done once at the first HUD equipment installation on the A/C. There is no necessity to do this process again due to the memorization of electronic corrections in the PMM equipment.

HUD CONTROL PANEL

The HUD Control Panel on 1411VU in the cockpit on the left hand side comprises:

- a HUD potentiometer, which is used to switch ON/OFF the HUD and to adjust HUD symbols brightness,
- a DECLUTTER pushbutton switch which is used to change the display format on the HCU from normal mode to simplified mode (two levels of de-clutter are defined), and
- a X WIND switch which is used to change the format of the speed and altitude scales (from large scales to small scale).

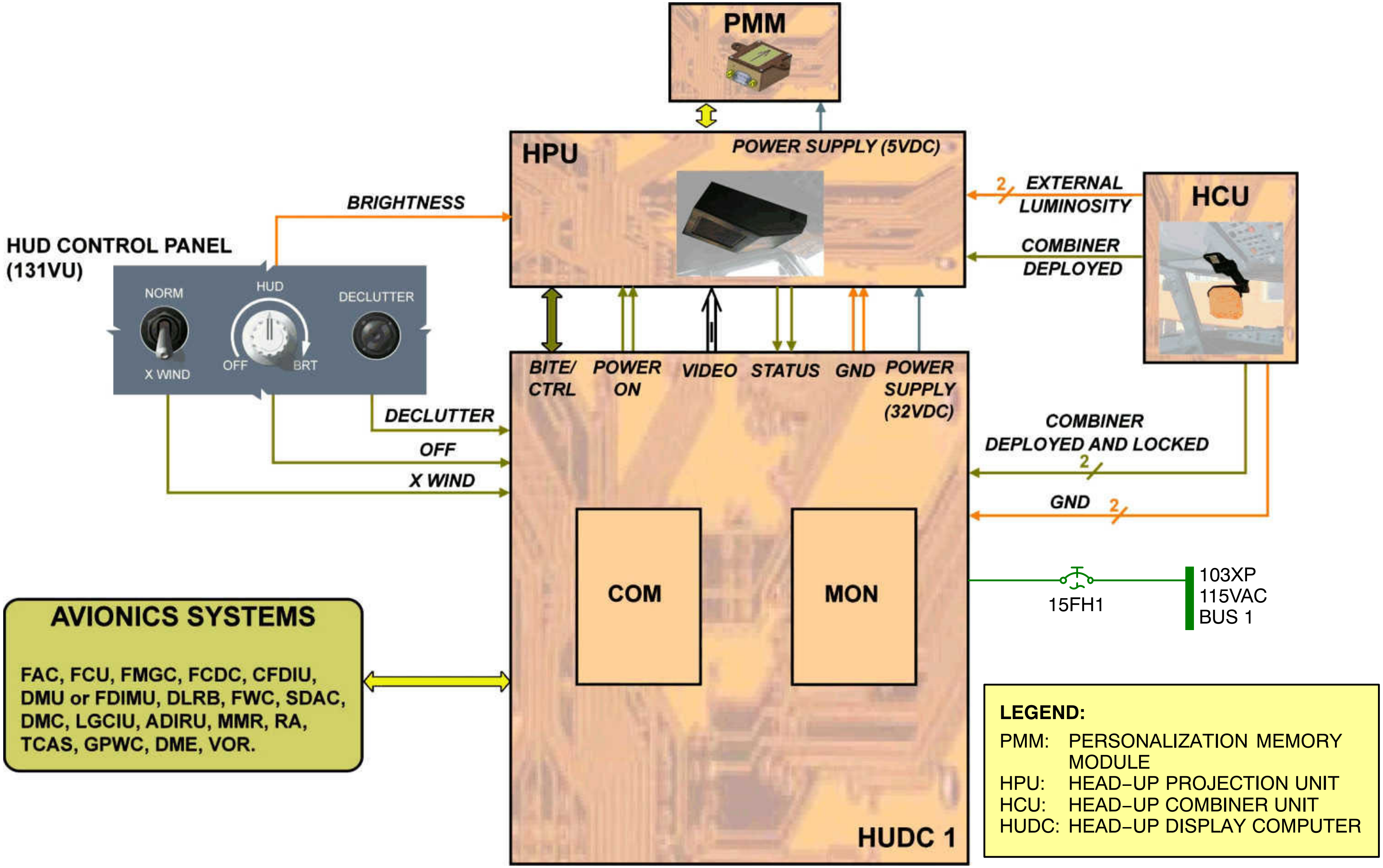


Figure 131 HUD System Schematic

HEAD−UP COMBINER UNIT (HCU)

The HCU is composed of:

- a transparent glass covered with a wavelength selective coating, and
- a mechanical subassembly.

The Combiner is also doted of sensors in order to do the auto−brightness control.

The HPU receives from the HCU some data related to:

- the position of the HCU,
- the automatic brightness control function.

  the HCU integrates an external luminosity sensor that is used to measure the external world lighting conditions. This measurement is then used by the HUDC to automatically adjust the image brightness lighting changes around the control value adjusted by the pilot. Those data are then forwarded by the HPU to the HUDC through the RS422 bus.

The HCU has three positions:

- operational (HCU deployed and locked),

  HCU in position in front of the pilot with display of operational symbols,
- stowed (keeping through a locking mechanism),

  HCU in up position with cleared display,
- breakaway (to prevent head strike in case of strong deceleration of 6−8g).

  HCU in position for crash conditions or shock.

The declutching handle is used to lock and deploy the HCU.

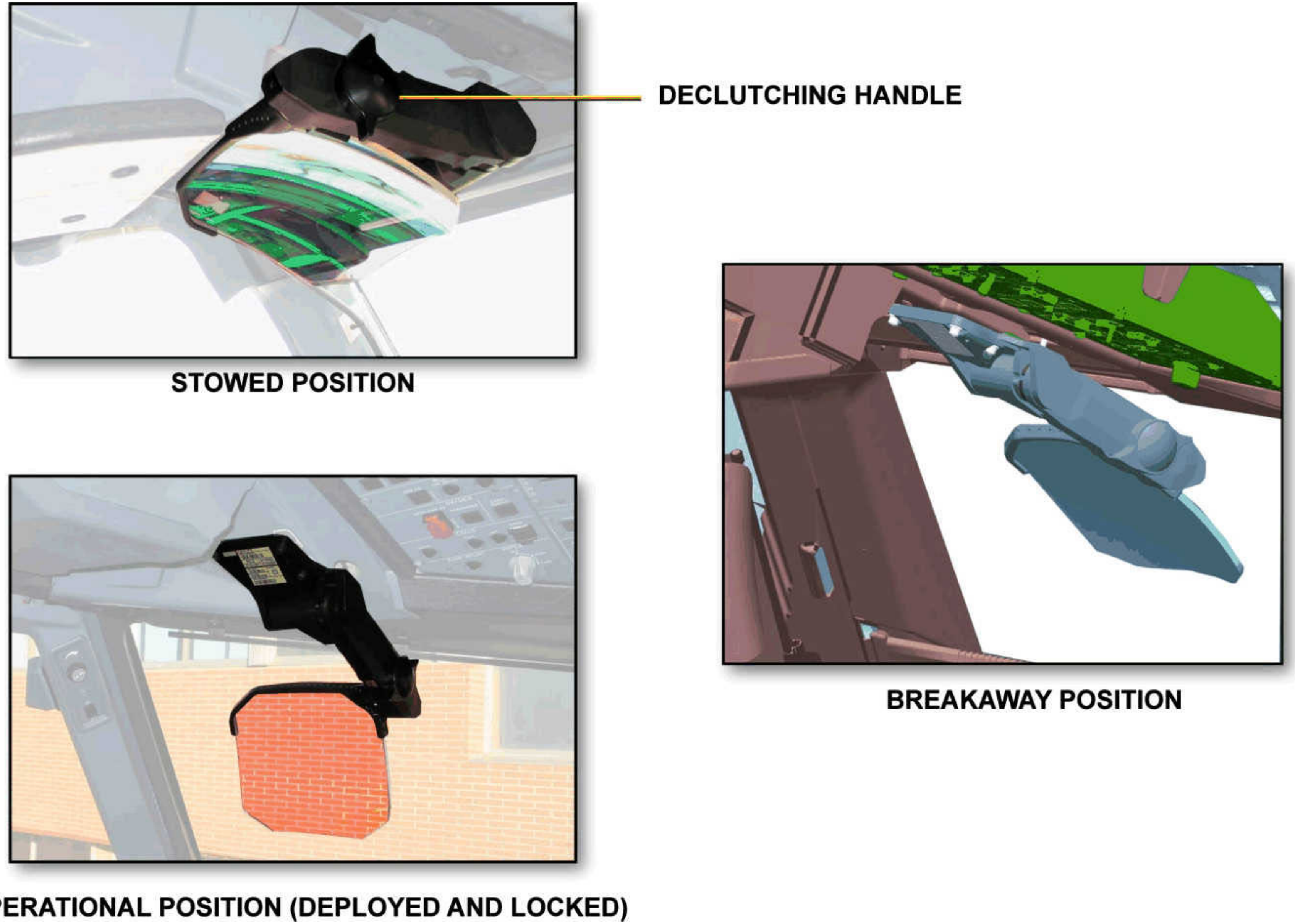


Figure 132 Head-Up Combiner Unit Positions

34–00 NAVIGATION GENERAL

RADIO NAVIGATION SYSTEM CFDS CONNECTIONS

GENERAL

All NAvigation Systems can be tested via the CFDS.

They are all BITE Type 1 systems.

The following system BITE do not monitor the system Antennas:

- DME 1,
- DME 2,
- VOR 1,
- VOR 2,
- ADF 1,
- ADF 2,

The following system BITE monitors the system Antennas:

- RA 1,
- RA 2,
- RADAR 1,
- RADAR 2,
- ATC 1,
- ATC 2,
- TCAS

NOTE: The MMR BITE only monitors the GPS antennas.

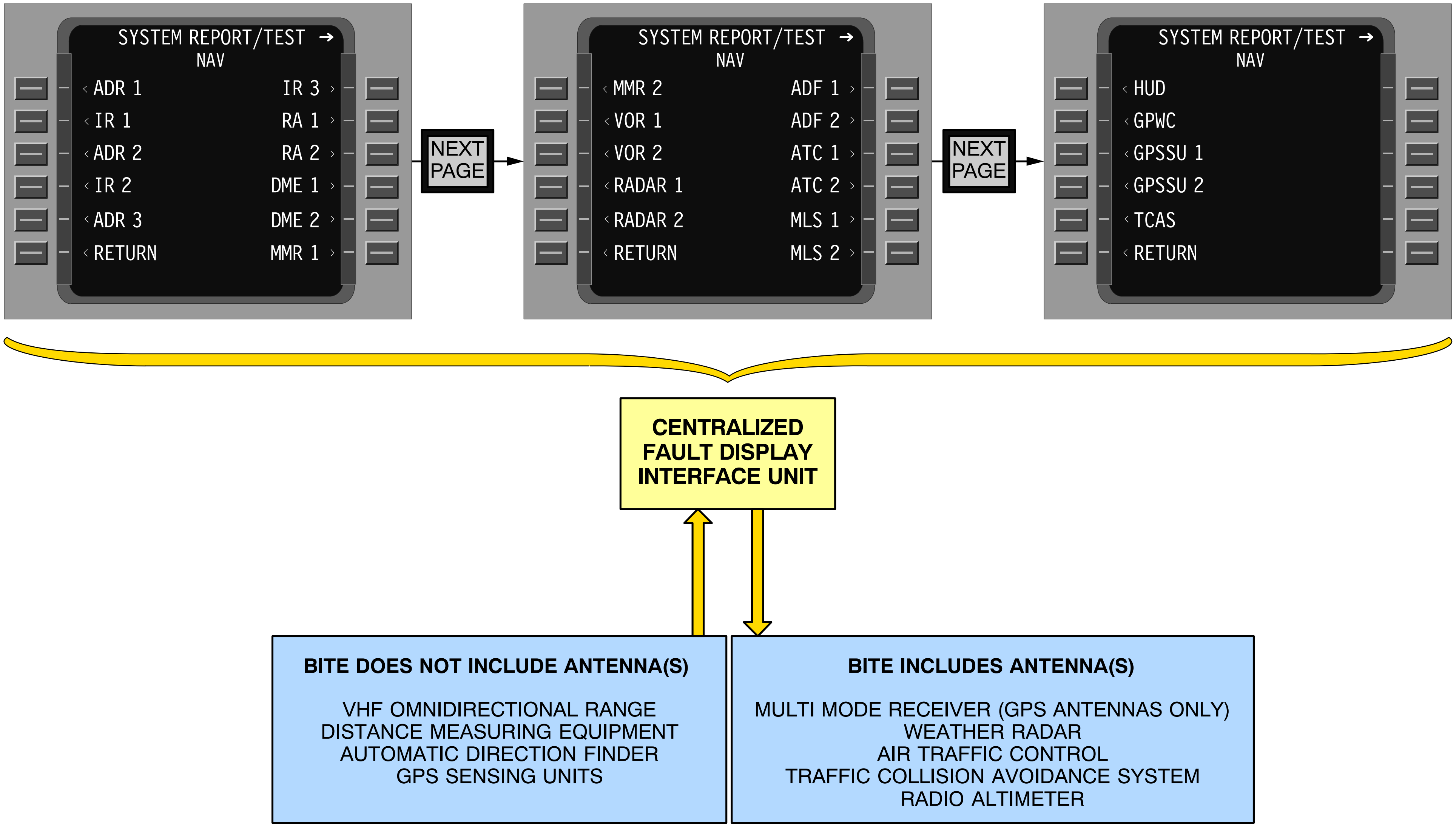


Figure 133 Radio Navigation Systems CFDS Connection

RADIO NAVIGATION SYSTEM WARNINGS

GENERAL

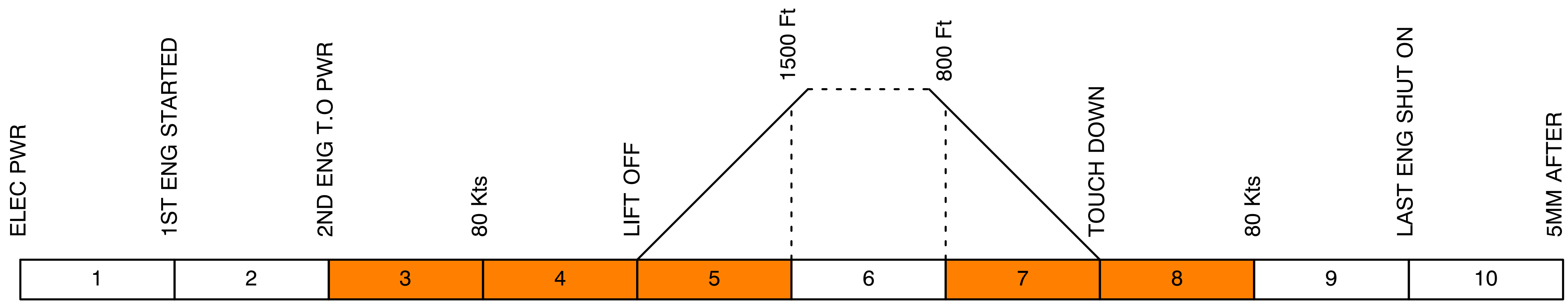
The following system faults will result in an ECAM caution message:

- ILS 1 (2) Fault,
- GPS 1 (2) Fault,
- TCAS Fault,
- Predictive Windshear Detection Fault,
- RA 1 (2) Fault,
- GPWS Fault,
- GPWS Terrain Detection Fault,
- Flight Management/GPS Position Disagree.

The following system faults will NOT lead in an ECAM caution message:

- VOR 1 (2) Fault,
- Marker Fault,
- DME 1 (2) Fault,
- ADF 1 (2) Fault,
- ATC 1 (2) Fault,
- Weather Radar 1 (2) Fault.

NOTE: A Fault in these systems will only lead to a ND Flag or, in case of an ATC Fault, only to a local warning on the control panel.



E/WD FAILURE MESSAGE	AURAL WARNING	MASTER LIGHT	SD PAGE CALLED	LOCAL WARNINGS	FLIGHT PHASE INHIBIT
NAV ILS 1 (2) FAULT	SINGLE CHIME	MASTER CAUT	NIL	NIL	3,4,5
NAV GPS 1 (2) FAULT					3,4,5,7,8
NAV TCAS FAULT				PFD & ND RED MESSAGES	3,4,5,7
NAV PRED W/S DET FAULT				ND AMBER MESSAGE	3,4,5,8
NAV RA 1 (2) FAULT				PFD RED MESSAGE	
NAV GPWS FAULT				GPWS SYS P/BSW FAULT	1,3,4,5,8,10
NAV GPWS TERR DET FAULT				GPWS TERR P/BSW FAULT	1,3,4,10
NAV FM/GPS POS DISAGREE				NIL	3,4,5,7,8

Figure 134 Radio Navigation Systems - ECAM Messages

RADIO NAVIGATION SYSTEMS POWER SUPPLY PRESENTATION

MMR

Each MMR system is energized through 115VAC busbars as follows:

- 401XP for system 1
- 204XP for system 2.

VOR/Marker

Energization of each system is through 115VAC 400Hz buses:

- 115VAC ESS BUS 401XP via circuit breaker 2RS1 for system 1
- 115VAC BUS 2 204XP via circuit breaker 2RS2 for system 2.

DME

Energization of each system is through 115VAC 400 Hz buses:

- 115VAC SHED ESS BUS 801XP via circuit breaker 1SD1 for system 1
- 115VAC BUS2 BUS 204XP via circuit breaker 1SD2 for system 2.

ADF

Energization of the system is through 115VAC 400 Hz buses:

- 115VAC SHED ESS BUS 801XP via circuit breaker 1RP1
- 115VAC BUS 2 202XP via circuit breaker 1RP2

DDRMI

The 115VAC ESS BUS 401XP energizes the VOR/DME RMI via circuit breaker 12FN.

Radio Altimeter

Energization of each system is through 115VAC, 400 Hz normal buses:

- 115VAC BUS1 101XP via circuit breaker 1SA1 for system 1
- 115VAC BUS2 202XP via circuit breaker 1SA2 for system 2.

ATC

Energization of each system is through:

- 115VAC ESS BUS SHED 801XP via circuit breaker 5SH1 for system 1.
- 115VAC BUS 2 204XP via circuit breaker 5SH2 for system 2.

Energization of the ATC control unit is through the two circuit breakers 5SH1 and 5SH2.

TCAS

The TCAS is supplied with 115VAC, 100 watt power rating. The ATC/TCAS control unit, common to the transponders and the TCAS, is also supplied with 115VAC:

- the 115VAC BUS1 101XP supplies the TCAS via circuit breaker 4SG.

WXR

Energization of the transceiver 1 is through 115VAC, 400 Hz normal bus:

- 115VAC BUS 1 1XP via sub−busbar 101XP−C and circuit breaker 5SQ1
- 115VAC BUS 2 2XP via sub−busbar 102XP−A and circuit breaker 5SQ2.

Radio Altimeter

Energization of each system is through 115VAC, 400 Hz normal buses:

- 115VAC BUS1 101XP via circuit breaker 1SA1 for system 1
- 115VAC BUS2 202XP via circuit breaker 1SA2 for system 2.

GPWS

The Enhanced GPWC power supply circuits receive 115VAC, 400 Hz, single phase (22 W max.) and 28VDC supply from the aircraft AC power.

- 28VDC 101PP BUS 1 via circuit breaker 2WZ
- 115VAC 103XP BUS1 via circuit breaker 3WZ

PVI

The PVI operates on 115V/400Hz voltage provided by the normal busbar 1XP via the sub busbar 103XP and the circuit breaker 2FW. This circuit breaker is located on the panel 121VU. The 115V/400Hz is protected against lightning.

HUDC

The HUDC is supplied with 115VAC from the normal busbar 1XP via sub−busbar 103XP.

This component is supplied through these circuit breakers:

- 121VU/HUD/15FH1/P01

BUS EQUIPMENT LIST

		NORM		EMER ELEC		
		AC	DC	AC ESS	DC ESS	HOT
NAVAIDS	ILS 1 OR MMR 1			X		
	ILS 2 OR MMR 2	AC BUS 2				
	VOR 1			X		
	VOR 2	AC BUS 2				
	DME 1			SHED		
	DME 2	AC BUS 2				
	ADF 1	AC BUS 1				
	ADF 2	AC BUS 2				
	DDRMI			X		
AIR TRAFFIC CONTROL	ATC 1			SHED		
	ATC 2	AC BUS 2				
TRAFFIC COLLISION AVOIDANCE SYSTEM	TCAS COMPUTER	AC BUS 1				
WEATHER RADAR	WXR 1	AC BUS 1				
	WXR 2	AC BUS 2				
RADIO ALTIMETER	RA 1	AC BUS 1				
	RA 2	AC BUS 2				
ENHANCED GROUND PROXIMITY WARNING SYSTEM	GPWC	AC BUS 1				
PARAVISUAL INDICATOR	PVI	AC BUS 1				
HEAD-UP DISPLAY	HUDC	AC BUS 1				

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