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A318/A319/A320/A321

ATA 22
Auto Flight

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ATA 22 AUTO FLIGHT

22–00 AUTO FLIGHT SYSTEM - GENERAL

AFS INTRODUCTION

This module highlights the new concept of the **A**uto **F**light **S**ystem (AFS) and presents the relationship with the Electrical Flight Control Systems and the Full Authority Digital Engine Control (FADEC).

Introduction

The purpose of this module is to explain basic system design aspects included in a modern Auto Flight System. This module is not an introduction of all the functions of the system.

General Concept

The Auto Flight System (AFS) is divided into four main parts:

- Flight Management (FM),
- Flight Guidance (FG),
- Flight Augmentation,
- Fault Isolation and Detection System (FIDS).

The first two functions are accomplished by the Flight Management and Guidance Computers (FMGCs). The other two functions are accomplished by the Flight Augmentation Computers (FACs).

The AFS calculates the position of the aircraft using several aircraft sensors. In addition, the system has the capability of storing flight plans in its memory, which are predetermined by the airline.

The Auto Flight System calculates orders to automatically control the flight controls and the engines. The system computes orders only. These orders are not executed by actuators (except FAC for Rudder Control) belonging to AFS but by systems which usually control the surfaces and the engines when the AFS is not active i.e. the side sticks and thrust levers.

Navigation

A fundamental function of Auto Flight System is to calculate the position of the aircraft. When computing A/C position, the system uses several aircraft sensors giving useful information for this purpose.

Flight Plan

The system has several flight plans in its memory. These are predetermined by the airline. A flight plan describes a complete flight from departure to arrival, it includes vertical information and all intermediate waypoints. The flight plan can be displayed on the display units. The flight plan navigation data base must be updated every 28 days.

Operation

There are several ways to use the Auto Flight System. The normal and recommended way to use the AFS is to use it to follow the flight plan. Knowing the position of the aircraft and the desired flight plan (chosen by the pilot), the system is able to compute the orders sent to the surfaces and engines so that the aircraft follows the flight plan. The pilot has an important monitoring role.

NOTE: During AFS operation, side sticks and thrust levers **do not move** automatically.

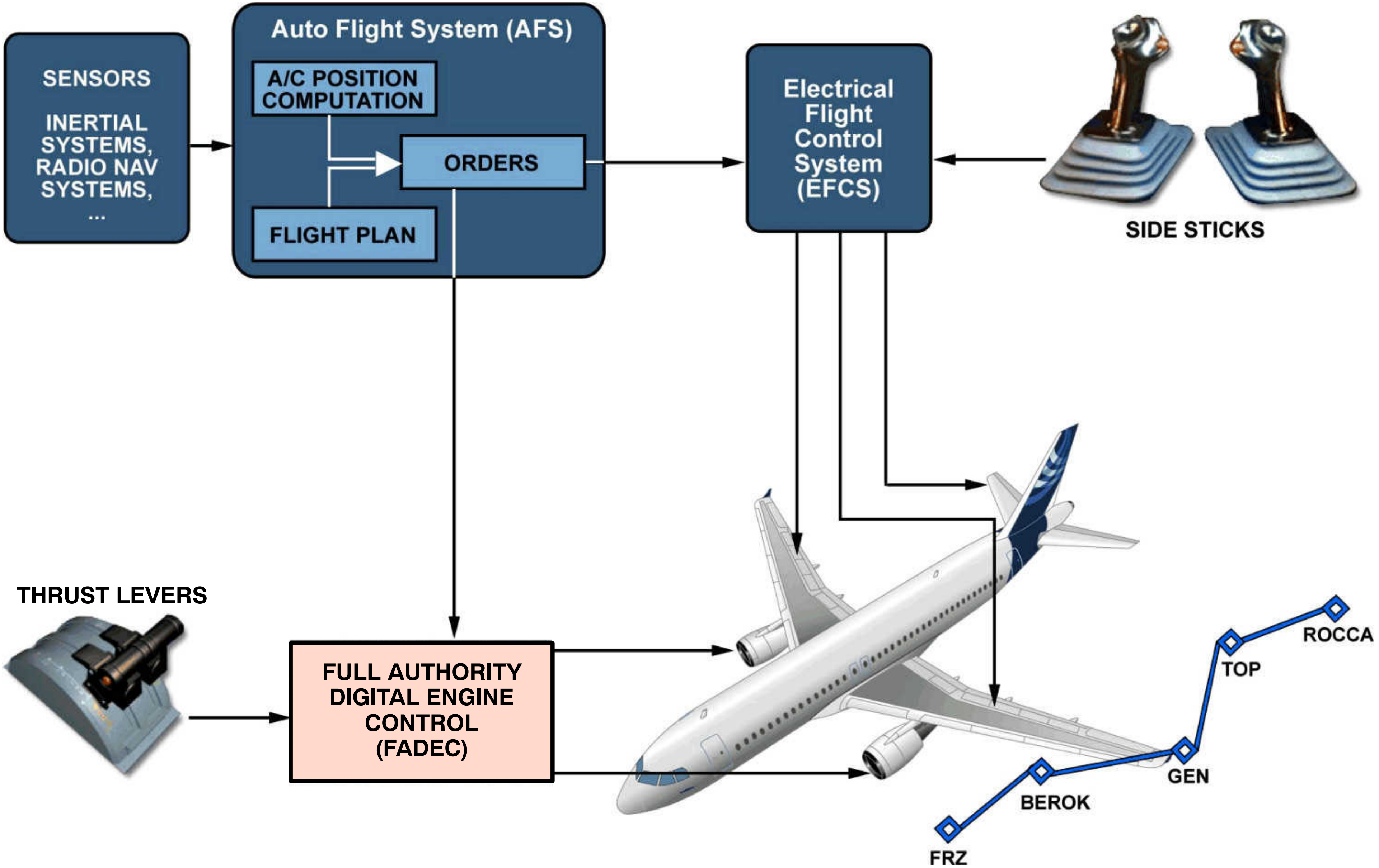


Figure 1 Auto Flight System - General

AFS GENERAL LAYOUT

FLIGHT MANAGEMENT AND GUIDANCE COMPUTER (FMGC)

The Flight Management and Guidance Computer (FMGC) is a digital computer to 8 MCU (**M**odular **C**oncept **U**nit) in conformity with ARINC Specification 600.

It is to be noted that some boards in the computer are equipped with a memory module. The access to these modules is from the outside of the unit. The computer consists of two separate parts: a command channel and a monitoring channel.

The command channel ensures two functions:

- the management of the flight and the guidance.

The monitoring channel only ensures the guidance function.

The two channels are physically separate:

- each channel has its own power supply unit.
- the electronic boards assigned to each channel are located in different zones in the computer unit.
- the electrical routings are separate.
- the pin connections at the output connectors are duplicated and separate.

In terms of software, the programming languages of the command and monitoring channels are different.

For the GUIDANCE function, the engage logic of the AP, FD and A/THR systems in command and monitoring channels is achieved in hard−wired circuitry.

FLIGHT AUGMENTATION COMPUTER (FAC)

The FAC performs the functions given below:

- yaw damper,
- rudder trim (manual and automatic),
- rudder travel limiting,
- monitoring of the flight envelope and computations of maneuvering speed,
- achievement of yaw autopilot order using power loops of yaw damper and rudder trim.

In addition the **FAC 1** performs the BITE function of the AFS.

AFS/Fly by Wire

The control wheel steering mode which existed in previous Auto Flight System is now ensured by the manual fly by wire mode of the Electrical Flight Control System. On conventional aircraft the Control Wheel Steering (CWS) mode consists in maintaining the A/C attitude once the control wheel is released.

In any case, when the automatic control of surfaces is active, if the pilot moves the sidestick or the rudder pedals (hydraulic pressure available), it will disengage.

System Design

To meet the necessary reliability, the Auto Flight System is built around four computers. Two Flight Management and Guidance Computers (FMGC 1 and FMGC 2) and two Flight Augmentation Computers (FAC 1 and FAC 2).

Each FMGC and each FAC has a command part and a monitor part. Therfore it is a fail passive computer.

In Approach or Go Around the AFS is automatically fail operative, if both APs are engaged.

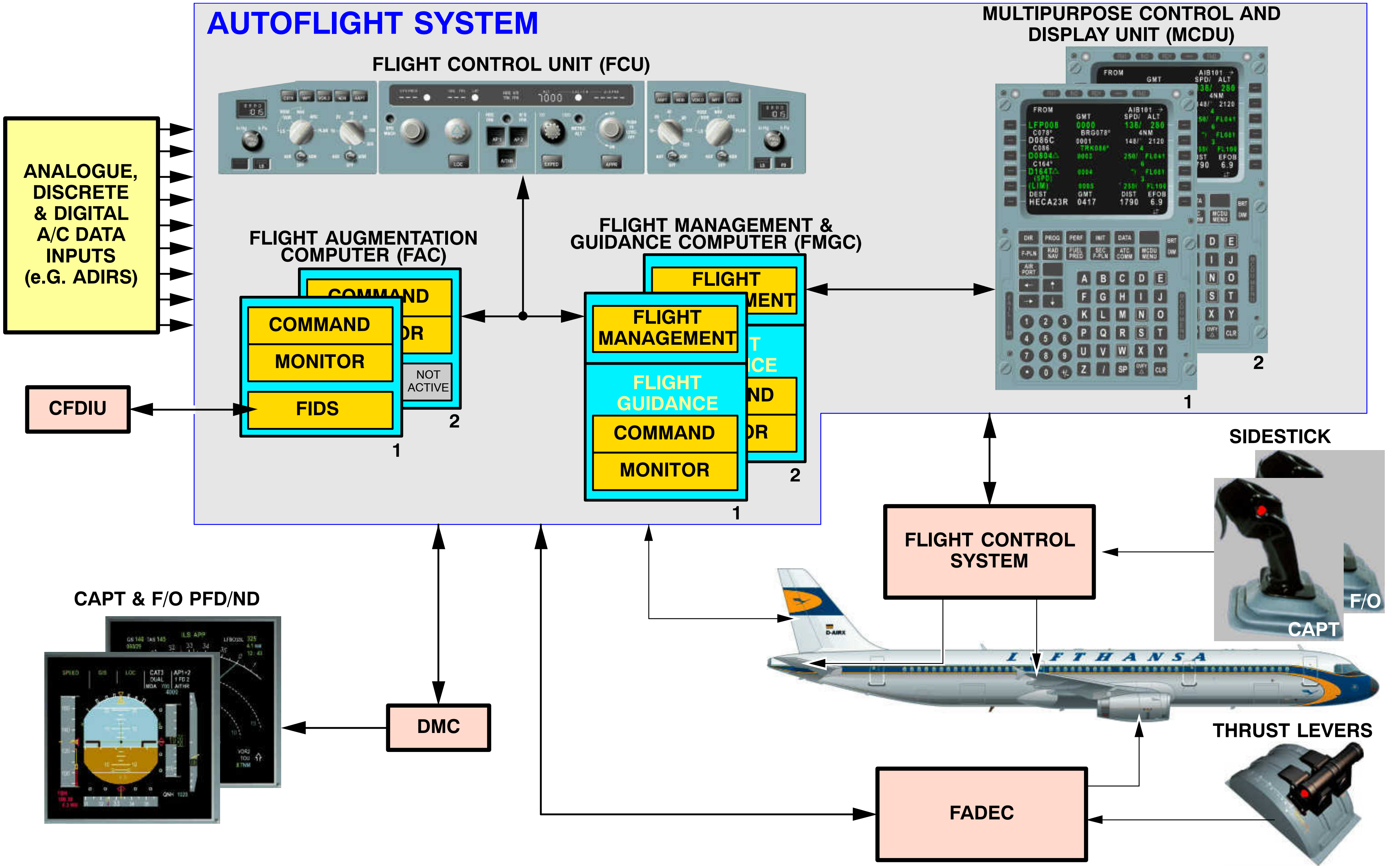


Figure 2 Auto Flight System Design Philosophy

CONTROLS AND INDICATING

CONTROLS

The auto flight system is composed of the following cockpit controls:

- Flight Control Unit (FCU) on the glareshield (3CA),
- FAC pushbutton switches on FLT CTL panels 23VU and 24VU (12CC1/2),
- Takeover and priority pushbutton switches (47CE1/2),
- Rudder trim control switch (9CC) and indictaor (17CC),
- Rudder trim/reset pushbutton switch (8CC),
- Multipurpose Control and Display Units (MCDUs) (3CA1/2),
- A/THR instinctive disconnect pushbutton switches (7CA1/2).

INDICATING AND WARNINGS

The auto flight system generates indications on the following components:

- Primary Flight Display (CAPT and F/O PFDs),
- Navigation Display (CAPT and F/O NDs),
- Upper and lower display units of the ECAM system,
- Rudder trim indicator on the RUD TRIM panel on the center pedestal,
- MASTER WARN, MASTER CAUT and AUTO LAND lights.

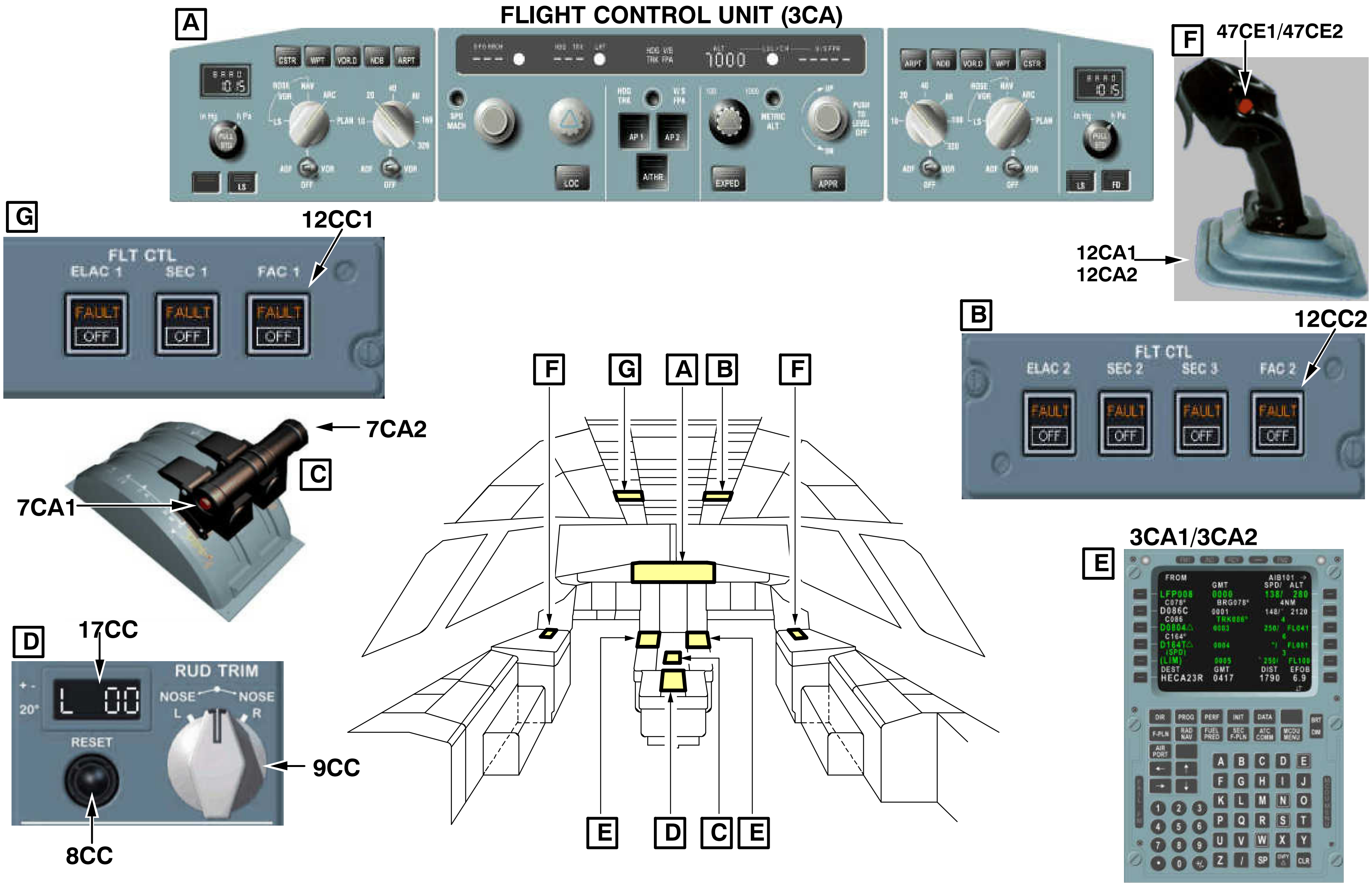


Figure 3 Autoflight System Controls

LOCATION

LOCATION OF THE FMGCs AND FACs

The AFS/FMS includes four computers: two FACs and two FMGCs (8 **M**odular **C**oncept **U**nit each) located in the aft electronics rack 80VU.

FIN	DESIGNATION	PANEL	ZONE	ACCESS DOOR	ATA REF.
1CA1	FMCG 1	83VU	127	824	22−83−34
1CA2	FMCG 2	84VU	128	824	22−83−34
1CC1	FAC 1	83VU	127	824	22−66−34
1CC2	FAC 2	84VU	128	824	22−66−34

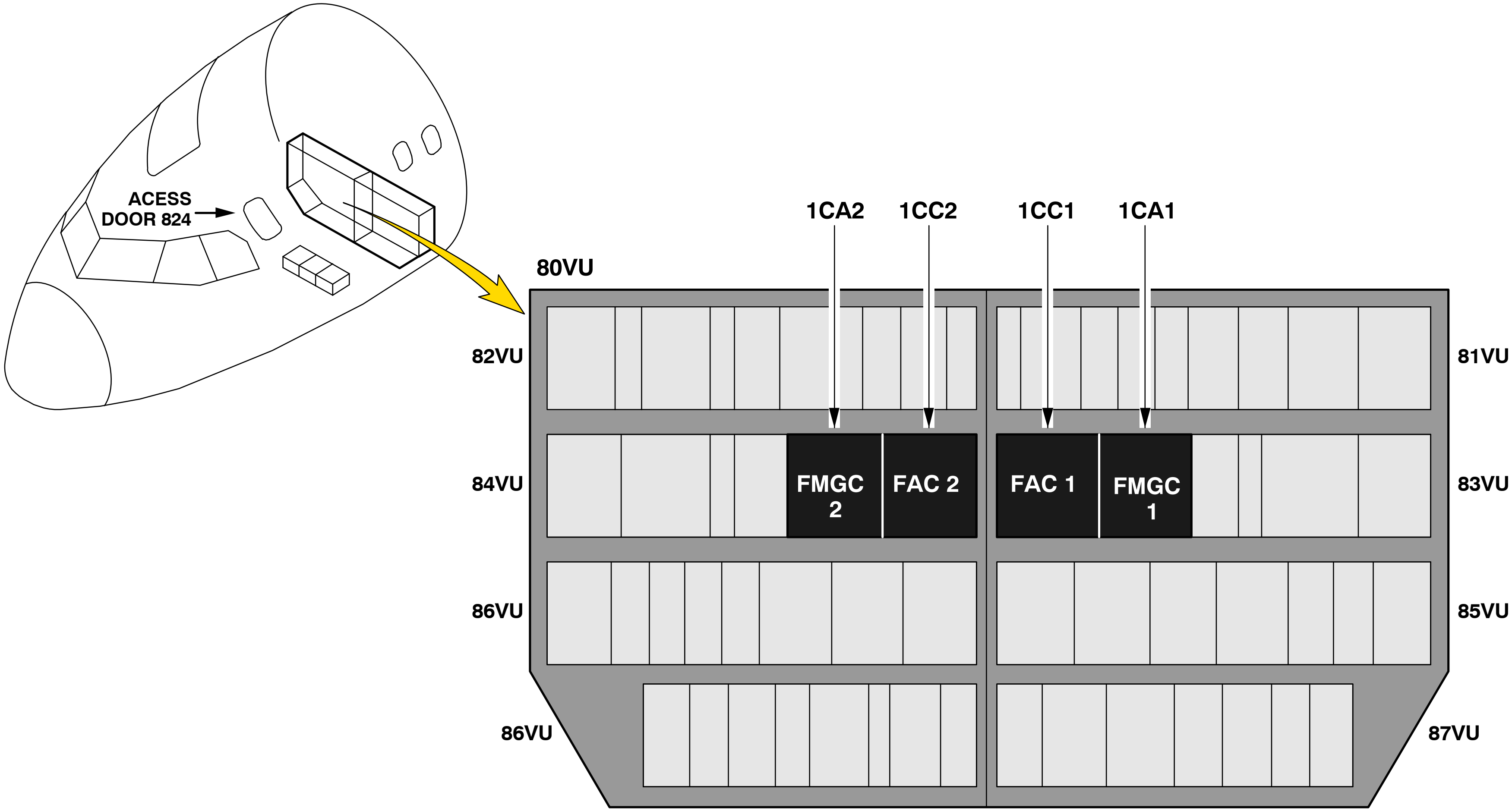


Figure 4 FMGC & FAC Location

FLIGHT MANAGEMENT, GUIDANCE & AUGMENTATION SYSTEM PRESENTATION

FLIGHT MANAGEMENT

The FM part has several functions linked to the flight plan such as lateral and vertical guidance associated with performance computation.

The **F**light **M**anagement (FM) part controls the following functions:

- navigation:
  - computation of **P**resent **POS**ition (PPOS),
  - evaluation of position accuracy,
  - radio navigation tuning,
  - alignment of Inertial Reference System.
- management of flight planning,
- prediction and optimization of performance (e.g. fuel and flight time),
- management of displays (MCDU, PFD and ND indications).

FLIGHT GUIDANCE

The FG part has 3 functions:

- Autopilot (AP),
- Flight Director (FD),
- Autothrust (A/THR).

The FMGC functions, FM and FG are controlled from the MCDUs and the Flight Control Unit (FCU).

Basically, the MCDUs provide the long term interface between the crew and the FMGCs (e.g. flight plan selection and modification) while the FCU provides the short term interface (e.g. engagement of the autopilot, flight director and A/THR functions).

Besides the MCDUs and the FCU, the main displays presenting Flight Management and Guidance information are the EFIS displays.

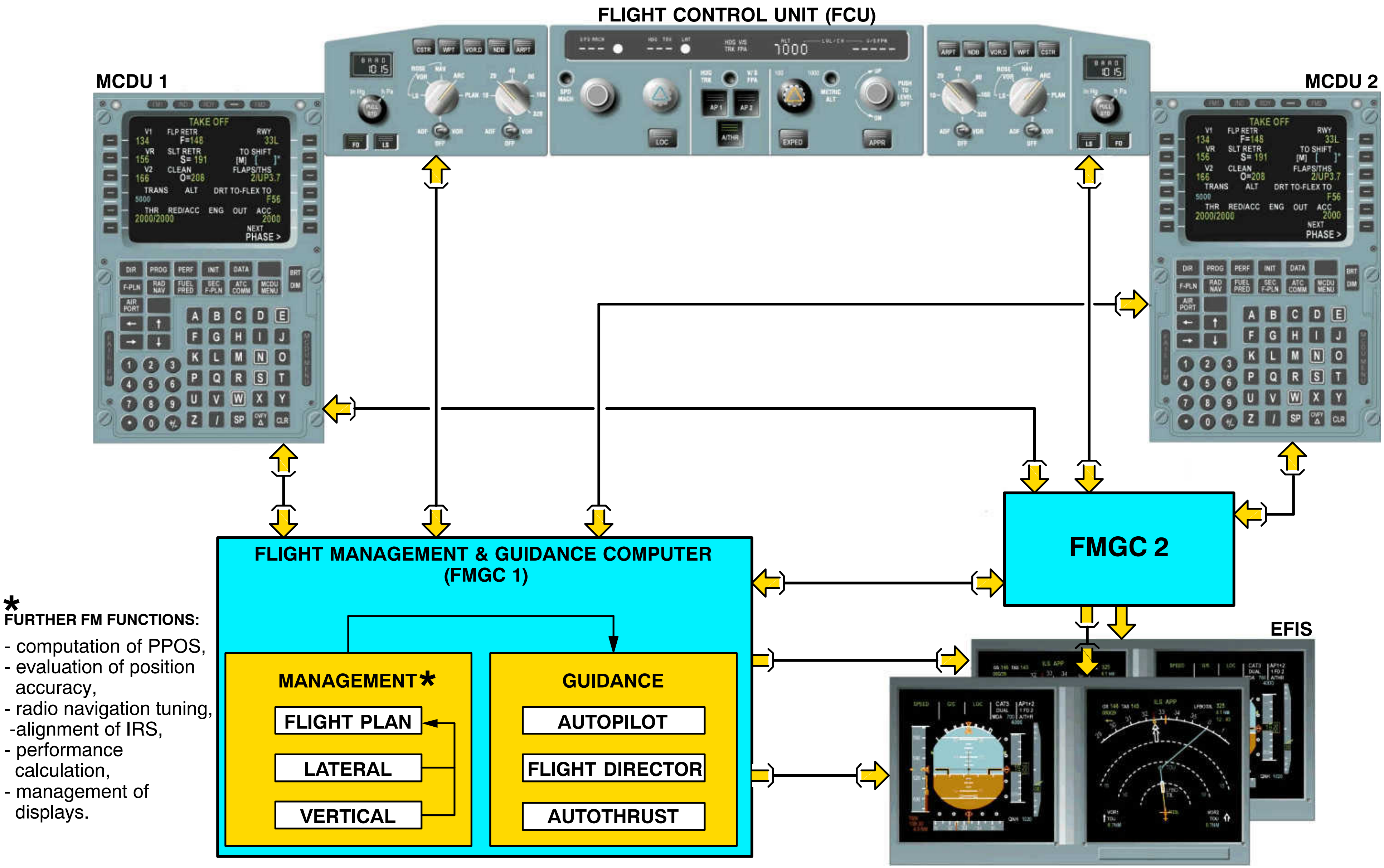


Figure 5 Flight Management & Guidance

AUTOPILOT/FLIGHT DIRECTOR SYSTEM PRESENTATION

AUTOPILOT/FLIGHT DIRECTOR

The main AP and FD functions are:

- stabilization of the aircraft around its center of gravity when the AP/FD system holds vertical speed or flight path angle and heading or track,
- acquisition and holding of a flight path,
- guidance of the aircraft after take off,
- automatic landing and go around.

The AP function gives orders to control:

- the position of the control surfaces on the three axes (pitch, roll and yaw),
- the nose wheel steering.

The FD function generates optimum guidance orders used in manual controls. The FD is also used to monitor the AP when it is engaged.

The FD symbols are displayed on the PFDs.

FLIGHT AUGMENTATION

General

The FAC performs the functions given below:

- yaw damper,
- rudder trim (manual and automatic),
- rudder travel limiting,
- monitoring of the flight envelope and computations of maneuvering speed,
- achievement of yaw autopilot order using power loops of yaw damper and rudder trim.

In addition the FAC 1 performs the BITE function of the AFS. The FAC is a dual−dual type system for yaw damper, rudder trim and rudder travel functions. FACs 1 and 2 can be engaged at the same time through FAC 1 and FAC 2 pushbutton switches on the overhead panel. Only one system is active at a time. FAC 1 has priority, FAC 2 being in standby and synchronized on FAC 1 orders. An automatic changeover occurs on FAC 2 in case of disengagement or failure of FAC 1. Partial changeover function per function (yaw damper, rudder trim, RTL) is possible. When the aircraft electrical network is energized, the functions that follow will operate independently of the FAC pushbutton switches:

- monitoring of the flight envelope,
- computation of maneuvering speed.

The FMGCs and the PFDs receive these information signals as follow:

- FMGC 1 and Capt PFD normally use data from FAC 1,
- FMGC 2 and F/O PFD normally use data from FAC 2.

In the event of failure, the FMGCs and the PFDs use the data from the active FAC.

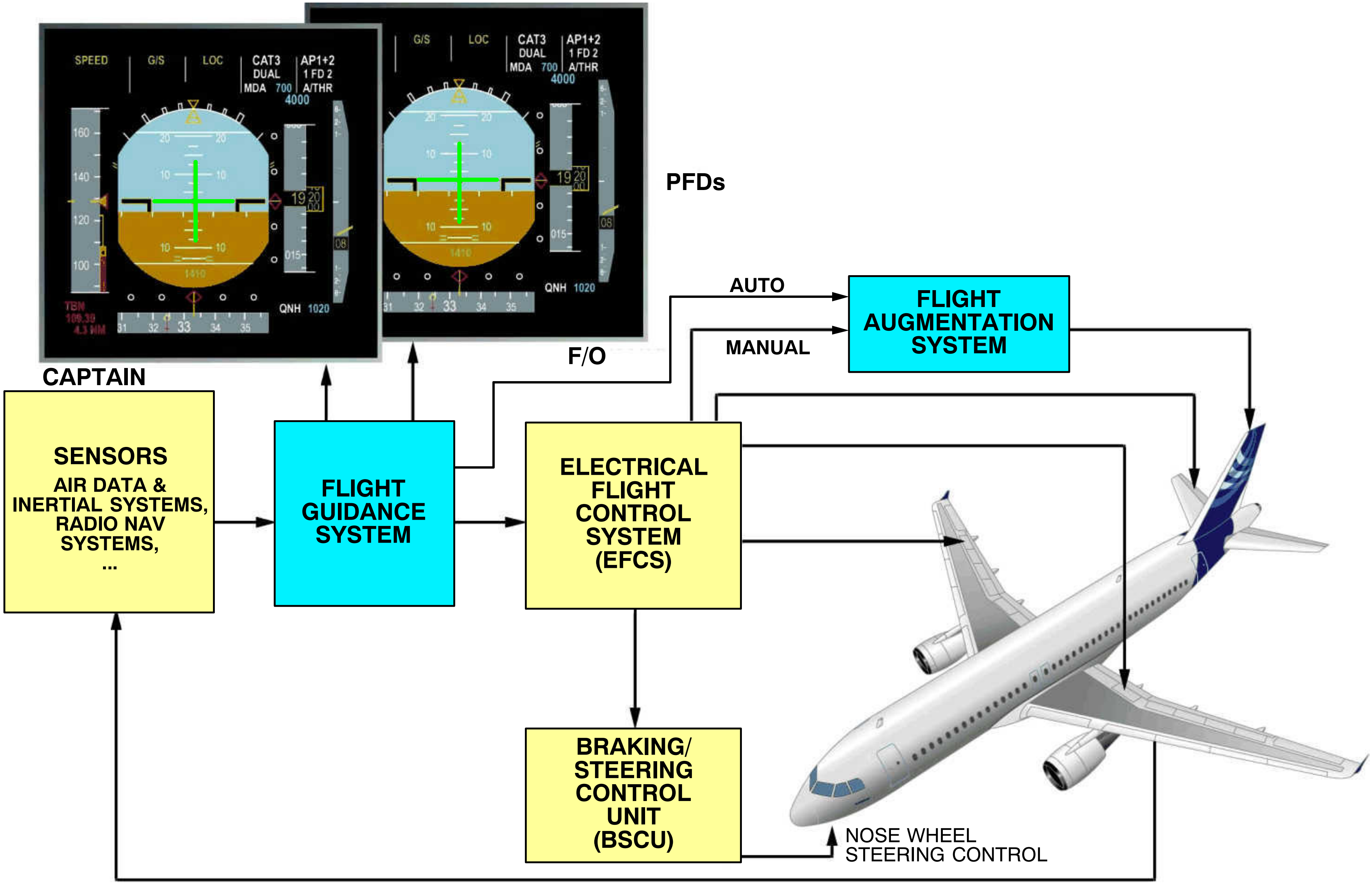


Figure 6 Flight Guidance - Autopilot/Flight Director

AUTOTHRUST SYSTEM PRESENTATION

AUTOTHRUST GENERAL

The A/THR system ensures the functions below through the control of the thrust:

- speed or mach hold (either FMGCs computed or from thrust levers position),
- thrust hold (either FMGS computed or from thrust lever position),
- thrust reduction during descent and during flare in final approach,
- protection against insufficient speed linked to excessive angle of attack.

To fulfill the A/THR functions, the FMGCs communicate with the Full Authority Digital Engine Control (FADEC) via the FCU and the Engine Interface Units (EIUs).

The A/THR is integrated in the Flight Management and Guidance System (FMGS).

The Engine Interface Units (EIUs) and the Electronic Control Units (ECUs)/ Electronic Engine Control (EECs) ensure the link between the FMGS and the engines.

The use of digital engine control units simplify the autothrust system through:

- the deletion of the autothrottle actuator (use of a digital link between the FMGC and the ECUs/EECs)
- the deletion of the limit thrust computation (already performed by the ECUs/EECs)
- the deletion of the limit thrust panel (the ECUs/EECs make this selection automatically depending on the position of the thrust control levers)
- the deletion of the TO/GA levers (the engagement of these modes is made through push action on the thrust control levers).

AUTOTHRUST ENGAGEMENT

The A/THR function can be engaged in three different ways:

- When the A/THR pushbutton switch on the FCU is pushed in, with aircraft on the ground and engines stopped or in flight at an altitude higher than 100 feet (except in LAND TRACK phase)
- Automatically further to the engagement of the AP/FD TAKE OFF or GO AROUND modes
- Automatically if the ALPHA FLOOR condition elaborated in the FAC is present and if the altitude is higher than 100 feet.

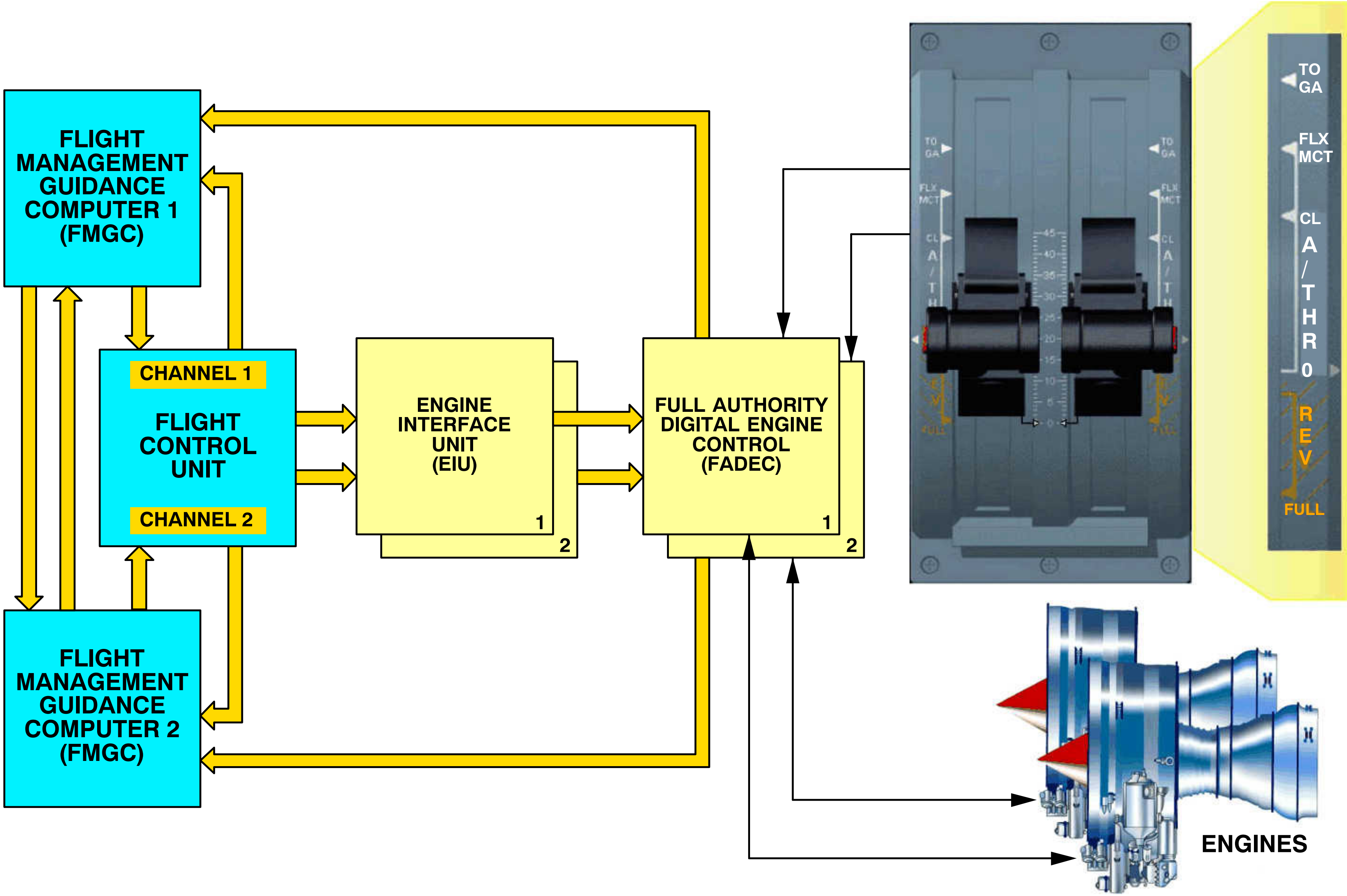


Figure 7 Flight Guidance - Autothrust

FLIGHT AUGMENTATION SYSTEM PRESENTATION

Yaw Damper

The yaw damper function provides:

- manual yaw stabilization.

  The ELACs compute the corresponding data and transmit them to the rudder surface via the servo loop of the yaw damper (FAC):
- alternate law for Dutch roll damping when the ELAC no longer computes normal yaw stabilization,
- Dutch roll damping (including turn coordination) when the autopilot is engaged in cruise only,
- engine failure recovery when the autopilot is engaged (the ELACs provide this function in manual flight).

Rudder Trim

The rudder trim function provides:

- manual control via a rudder trim control switch located on the center pedestal.

  In addition the ELACs compute a command signal for rudder deflection (normal yaw damping law including recovery of engine failure) performed by the trim sub−system in manual flight. Reset of the rudder trim position is possible using a pushbutton switch located on the center pedestal.
- automatic control when the autopilot is engaged which provides the accomplishment of yaw autopilot command and the recovery of engine failure.

Rudder Travel Limitation

This function provides the limitation of the rudder travel by displacement of a stop as a function of the speed.

Flight Envelope Functions

Flight envelope functions are:

- **Computation of maneuvering speed.**

  Monitoring of flight envelope and computation of maneuvering speed provides the PFD with data to be displayed on the speed scale, e.g. stall warning speed (VSW), maximum speed (V MAX), airspeed tendency (VC TREND) and more.
- **Reactive windshear detection (optional).**

  The windshear is a sudden change in wind direction and/or speed over a relatively short distance in the atmosphere. This can have an effect on aircraft performance during takeoff and landing phases. In windshear conditions, the principle is to reduce the detection threshold according to the detected windshear in order to get the possibility of performing a go around maneuver sooner.
- **Low energy detection.**

  The Low Energy Function is to prevent the A/C from entering a low energy situation by alerting the pilot through an audio warning: ”SPEED...SPEED...SPEED”.
- **Computation of Alpha Floor Protection.**

  This function permits:
  - To protect the aircraft against excessive Angle−Of−Attack.

    To do this, a comparison is made between the aircraft Angle−Of−Attack and predetermined thresholds function of configuration. Beyond the thresholds, the FAC transmits a command signal to the autothrust which will apply full thrust.
  - To protect the aircraft against longitudinal wind variations in approach by determining a wind acceleration (deduced from the difference between ground acceleration and air acceleration).

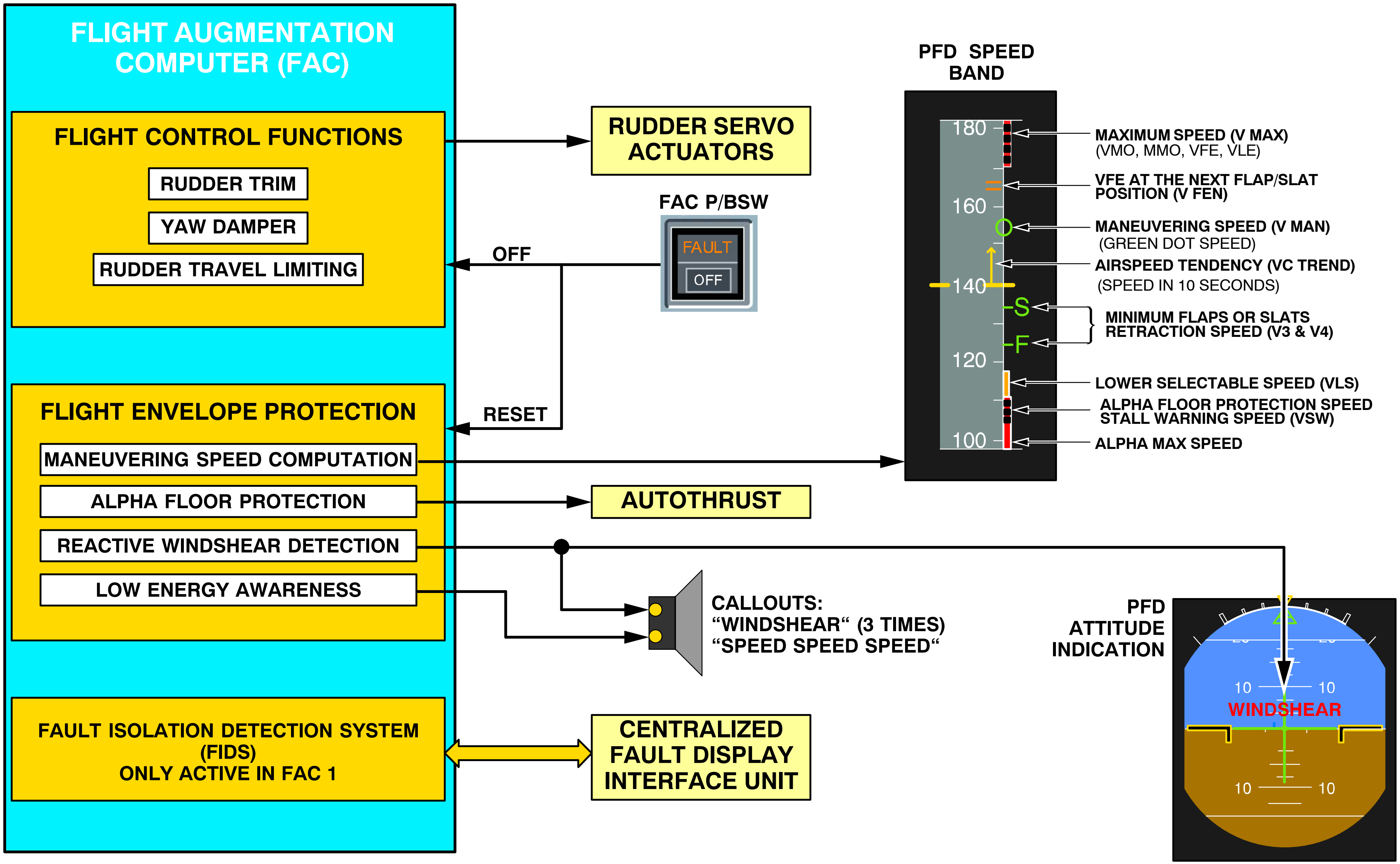


Figure 8 Flight Augmentation

AUTO FLIGHT SYSTEM OPERATION

GENERAL

The AFS/FMS includes four computers:

- two FACs and two FMGCs located in the aft electronics rack 80VU.

The actuators associated with the FAC are directly connected to the flight controls.

All the controls and displays are in the cockpit on the glareshield, overhead panel, maintenance panel and center pedestal.

The system buses which transfer the digital information of the ARINC specification 429 perform:

- interconnections between the computers,
- connections between the computers, control units and sensors.

Architecture of AFS

The AFS comprises two sub-systems:

- Flight Augmentation Computer system,
- Flight Management and Guidance Computer system.

These sub-systems include the computers, actuators, control units and associated peripherals.

There are no servo actuators for the autopilot and the autothrust functions. The system (FMGS) sends the surface deflection commands for the autopilot function to:

- ELAC 1 and ELAC 2 for pitch and roll commands (**EL**evator and **A**ileron **C**omputer),
- FAC 1 and FAC 2 for yaw commands.

The system (FMGS) sends the thrust command for the autothrust function to:

- ECU 1 /EEC 1 (to set the thrust command on the engine 1),
- ECU 2 /EEC 2 (to set the thrust command on the engine 2).

  (ECU: **E**lectronic **C**ontrol **U**nit - CFM Engine; EEC: **E**lectronic **E**ngine **C**ontrol - IAE V2500 Engine)

The side stick controllers and the thrust control levers do not move when the autopilot and the A/THR are engaged.

INTERCONNECTION WITH PERIPHERALS

The interconnection between the FACs, the FMGCs and the peripherals makes sure that a single failure of a peripheral has no effect on the AFS/FMS functions.

INTERCONNECTION WITH FLIGHT CONTROLS

FMGC

Pitch and roll axes:

- The FMGC 1 and 2 send autopilot orders through output buses to the ELACs. The ELACs then transmit deflection commands to the surfaces on the pitch and roll axis. The ELACs use the buses from the FMGC 1 or FMGC 2 according to the autopilot engaged (AP1 has priority when both APs are engaged in ILS approach).

Yaw axis:

- The FMGC 1 and 2 send autopilot orders to the FACs which control both yaw damper servo actuators (transient commands) and rudder trim actuator (permanent commands). The FACs use the same priority logic as the ELACs.

FAC

The FACs send yaw damper commands to two hydraulic servo actuators (one per FAC). They also send commands to four electrical actuators for rudder trim and rudder travel limiting (one per FAC and per function). All the servomotors operate using the automatic changeover.

INTERCONNECTION WITH ENGINE CONTROLS

The FMGCs compute and transmit data to the engines through the FCU, EIU and ECU/EEC using ARINC Specification 429 bus. To consolidate engine data, the priority FMGC compares the output parameters from the FCU with its own available data by means of associated logic.

Each FMGC receives four ARINC buses for computation. Two buses associated with the own side, two others associated with the opposite side.

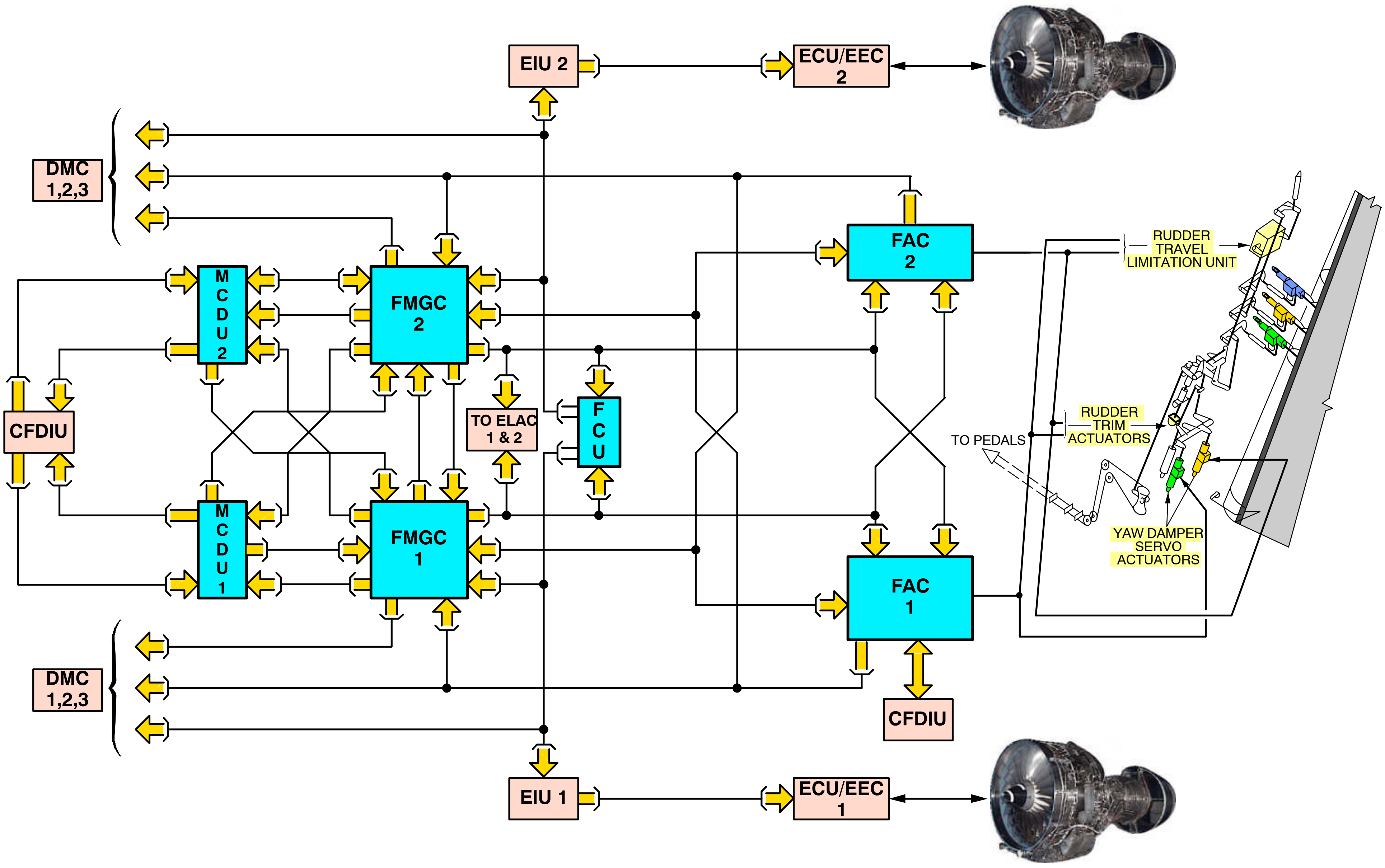
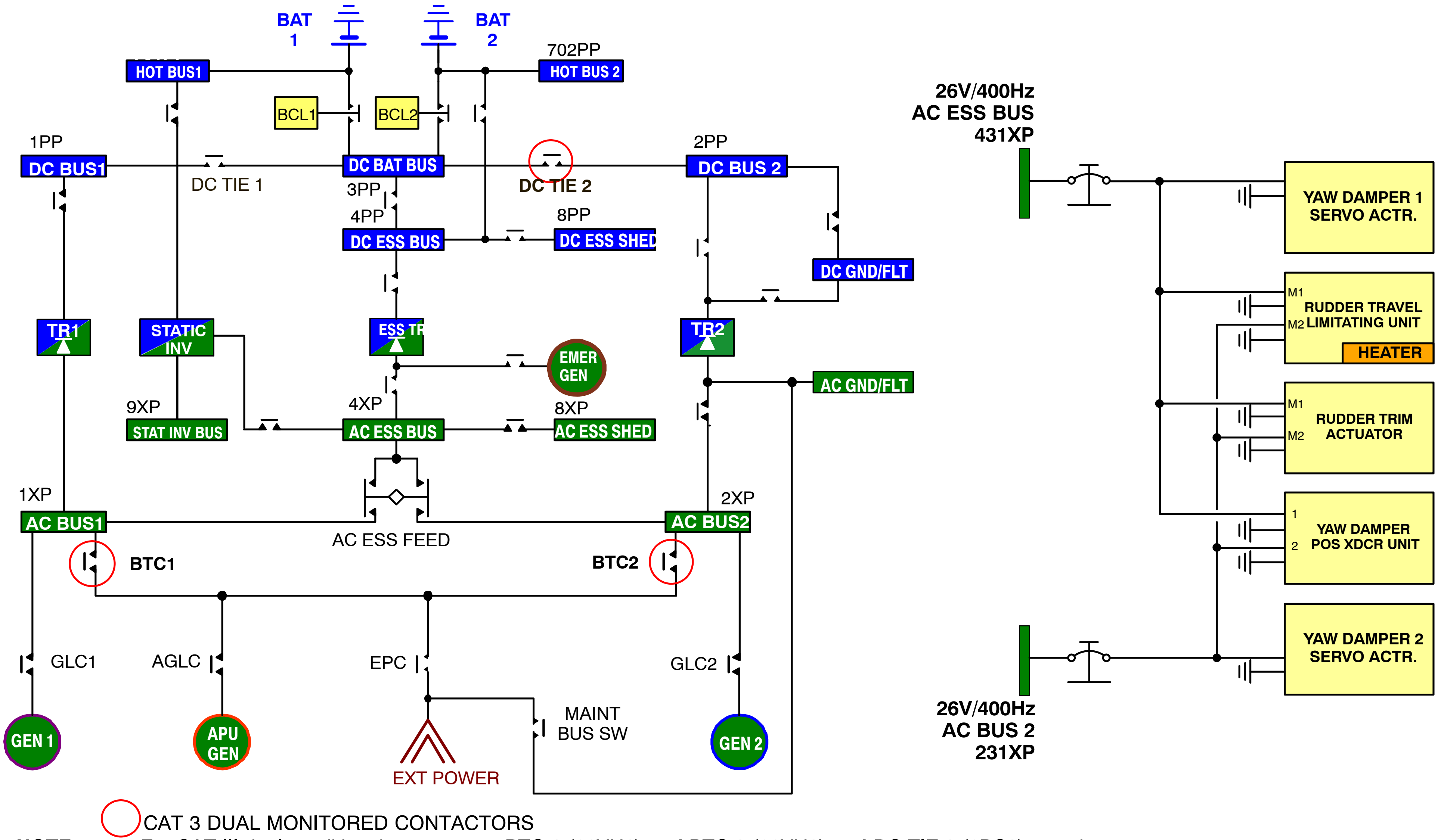


Figure 9 AFS Architecture

AFS POWER SUPPLY BUS EQUIPMENT LIST

		NORM		EMER ELEC		
		AC	DC	AC ESS	DC ESS	HOT
FMGC	1				SHED	
	2		DC 2			
MCDU	1			SHED		
	2	AC BUS 2				
FCU	1				ESS	
	2		DC 2			
FAC	1				SHED	
FAC	2		DC 2			
RUDDER TRIM	MOTOR 1				ESS	
RUDDER TRIM	MOTOR 2		DC 2			
RUDDER TRAVEL LIMITER	MOTOR 1				ESS	
RUDDER TRAVEL LIMITER	MOTOR 2		DC 2			



CAT 3 DUAL MONITORED CONTACTORS

NOTE: For CAT III dual condition the contactors BTC 1 (11XU1) **and** BTC 2 (11XU2) **and** DC TIE 2 (1PC2) must be open.
The APU–generator is **not** accepted for "CAT 3 DUAL" operation.

Figure 10 AFS Power Supply

22−70 FLIGHT MANAGEMENT SYSTEM (FMS)

FMS PRESENTATION

GENERAL

The Flight Management System (FMS) gives various functions to help the crew in the management of the flight. These functions are all constructed from a lateral and a vertical flight plan. The pilot can select this flight plan from a data base stored in the system and he can modify it at any time.

In the lateral plan, the FMS gives:

- navigation computation (aircraft position),
- radio navigation aids selection (automatically or by pilot selection),
- lateral guidance to keep the aircraft along the flight plan from the take−off to the approach.

In the vertical plan, it computes:

- an optimum speed at each point,
- other characteristic speeds,
- the aircraft predicted weight and center of gravity,
- predicted wind at each point.

Then it computes predictions along the flight plan based on these speeds and weight. It performs vertical guidance referenced to these predictions.

The crew can insert different data or can select function modes through two Multipurpose Control and Display Units (MCDU) linked to two Flight Management and Guidance Computers (FMGCs).

The FMS also uses the two MCDUs, both Navigation Displays (NDs) and for some parameters the Primary Flight Displays (PFDs), to display data related to the above mentioned functions.

System Description

It has to be noted that the navigation data base must be loaded every 28 days. The navigation data base can be loaded from one FMGC to the other FMGC through the intersystem bus. This function is called ”Nav data base crossload”.

The MCDUs are also shared between other systems: CFDIU, AIDS, ATIMS. However, the FMS has priority. This means that when the power is set up after a long−term interrupt, the MCDUs are linked to the FMS automatically.

The displayed page is the A/C STATUS page which gives the FMS configuration. A specific procedure allows access to the other systems.

If the MCDUs are already working when the FMGCs are powered, the display is not modified. The crew has then to press any page key (except MCDU MENU) to be coupled to the FMGC. The initialization will be briefly described in next section.

Operation

Due to the type of the various functions the system is performing during the flight, the crew is required to initialize the system by inserting some data via the MCDU. To do so, the pilot must ensure that the MCDUs are correctly coupled to the FMGCs. The first page displayed by the FMGC, at power−up on the ground or after access through the MCDU MENU page, is the A/C status page which allows the crew to be aware of the status of the FMS. Then by selecting the INIT page, the pilot has the possibility to initialize the FMS.

The initialization consists of three main functions:

- Select a flight plan which will be the real basis for all computations and displays performed by the FMS,
- align the IRSs by using the position of the airport stored in the FMS data base and called by selection of the flight plan,
- enter the ZFWG/ZFW (**Z**ero **F**uel **W**eight **C**enter of **G**ravity/**Z**ero **F**uel **W**eight) and block fuel which will be used for all the various performance computations.

Indication

According to the pilot selection on the EFIS control panel of the FCU, the flight plan is shown in relation to the aircraft position on the ROSE−NAV or ARC modes. The aircraft model is fixed and the chart moves. The difference between the two modes is that the half range is available when the ND is set to ROSE−NAV mode, as there is only frontal view when it is set to ARC mode. In PLAN mode, the flight plan is shown, with NORTH at the top of the screen, centered on the TO waypoint. Depending on the selected range, the aircraft may or may not be visualized on this display. The plan display can be de−centered by scrolling the flight plan on the MCDU. The PFD shows the FM guidance following engagement of the AP/Flight Director (FD) lateral and longitudinal modes.

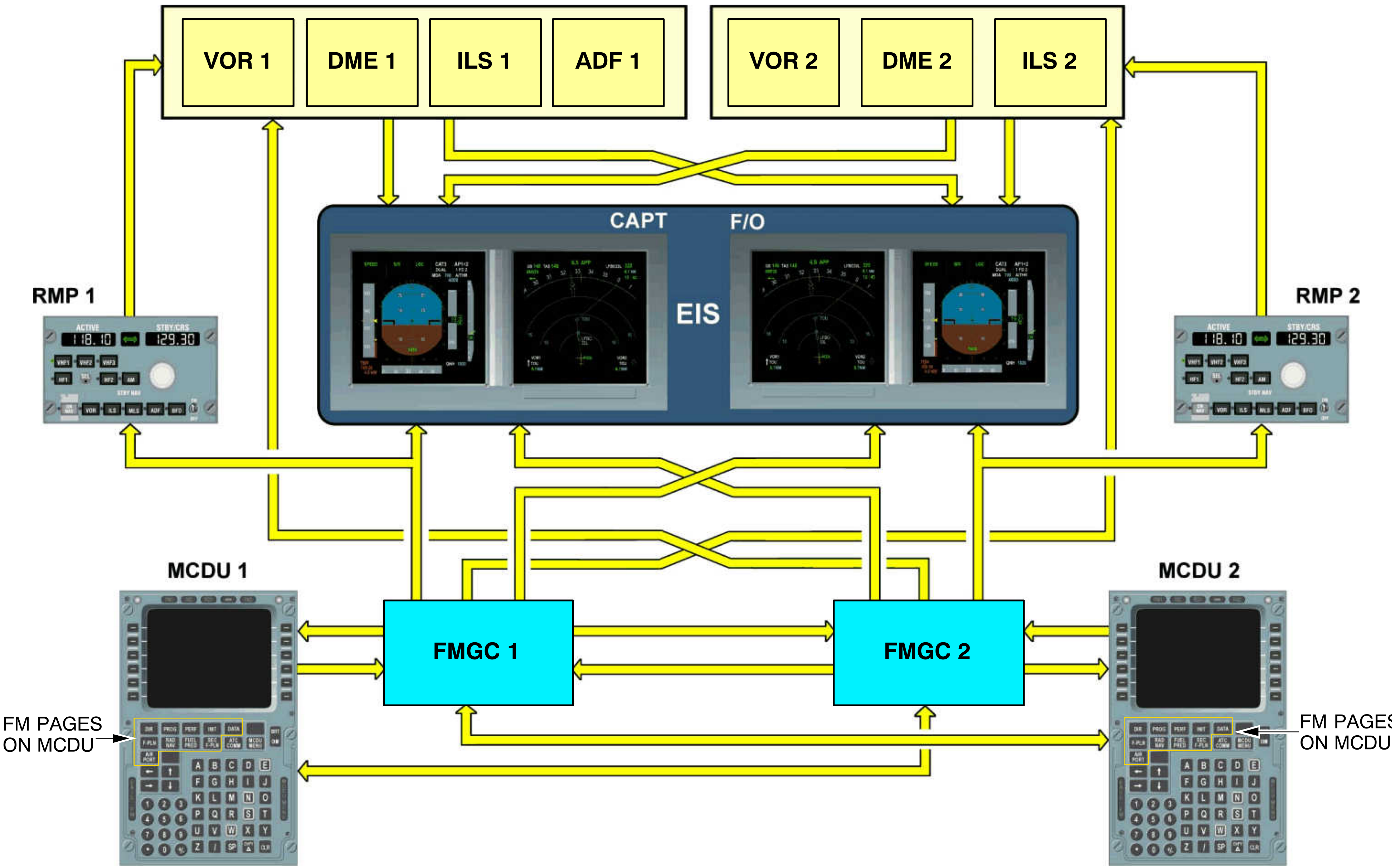


Figure 11 Flight Management Schematic

FMGS MODES OF OPERATION

The FMGS has following modes of operation :

- **Dual** mode (the normal mode).
- **Independent** mode. Each FMGC being controlled by its associated MCDU.
- **Single** mode (using one FMGC only).

DUAL MODE

This is the normal mode. The two FMGCs are synchronized :

Each performs its own computations and exchanges data with the other through a crosstalk bus. One FMGC is the master, the other the slave, so that some data in the slave FMGC comes from the master. All data inserted into any MCDU is transferred to both FMGCs and to all peripherals.

Master FMGC logic:

- If one autopilot (AP) is engaged, the related FMGC is master:
  - it uses the onside FD for guidance
  - it controls the A/THR
  - it controls the FMA 1 and 2
- If two APs are engaged, FMGC1 is master.
- If no AP is engaged and
  - the FD1 pushbutton is on, then FMGC1 is master.
  - the FD1 pushbutton is off, and FD2 pushbutton on then FMGC2 is master.
- If no AP/FD is engaged, A/THR is controlled by FMGC1.

INDEPENDENT MODE

The system selects this degraded mode automatically if it has a major mismatch (database incompatibility, operations program incompatibility . . .). Both FMGCs work independently and are linked only to peripherals on their own sides of the flight deck („onside„ peripherals).

When this occurs, "**INDEPENDENT OPERATION**" appears on the MCDU scratchpad.

Each MCDU transmits data it receives only to its onside FMGC, and it affects only the onside EFIS (Electronic Flight Instrument System) and RMP (Radio Management Panel).

SINGLE MODE

The system selects this degraded mode automatically if one FMGC fails. The remaining FMGC drives all the peripherals, so, for example, any entry on one MCDU goes to both MCDUs.

When one FMGC fails, the corresponding MCDU displays "**OPP FMGC IN PROCESS**" in white. The ND on the side with the failed FMGC has to be set to the same range and mode as the other ND. Otherwise the ND displays "**SELECT OFFSIDE RNG/MODE**" in amber.

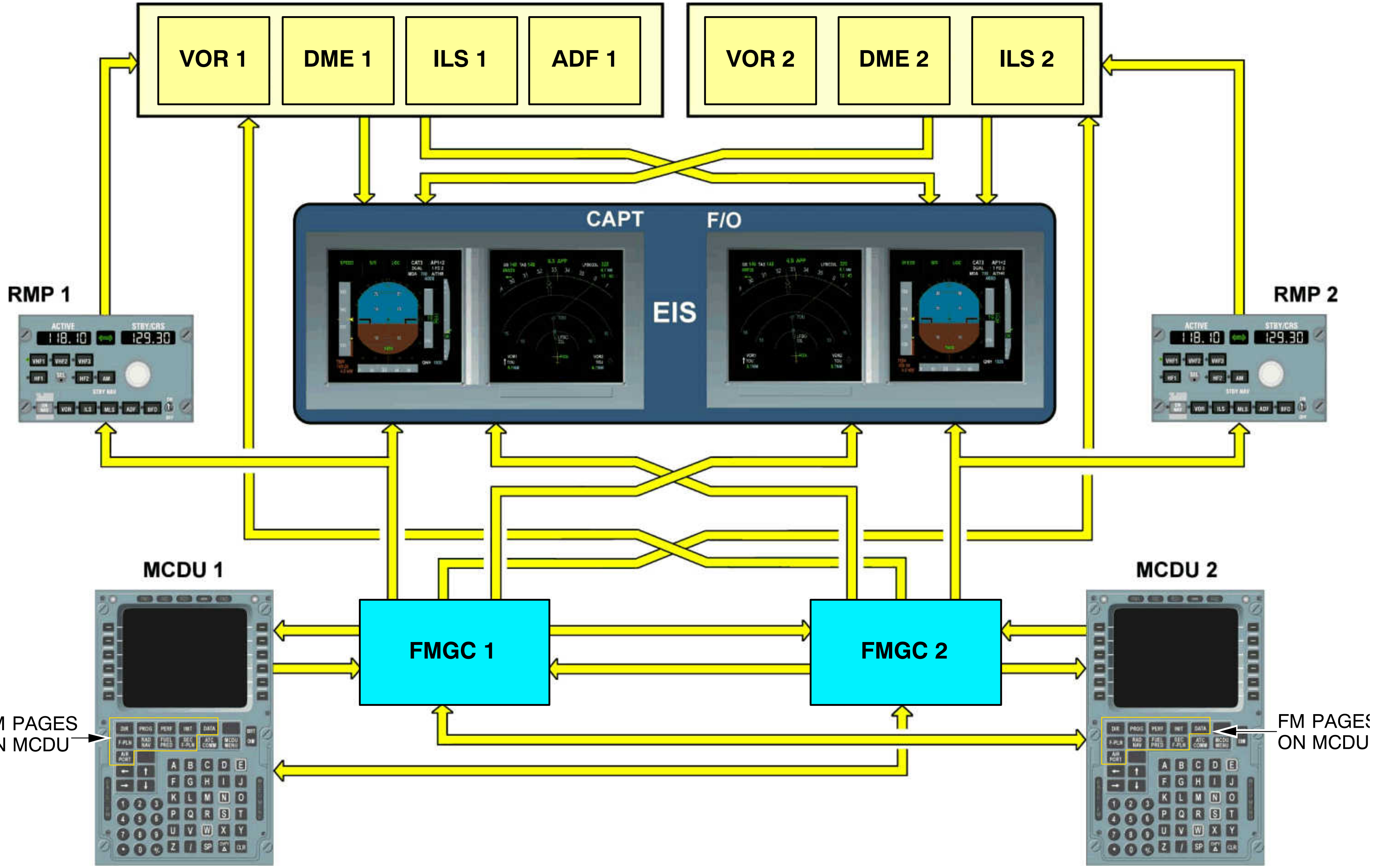


Figure 12 Flight Management Modes

MCDU FM-PAGES DESCRIPTION

DIR TO PAGE

Pressing the "DIR" key under the MCDU screen brings up this page. The [1L] key on this page is the DIR TO key. The pilot presses it to modify the flight plan by creating a direct leg from the aircraft's present position to any selected waypoint. When in NAV mode, the pilot must use this key to modify the active leg or the TO waypoint. Pilot cannot call up this page when the aircraft's present position is not valid.

FLIGHT PLAN PAGE

These pages display all waypoints of the active and alternate flight plans, along with associated predictions. The pilot can make all revisions to the lateral and vertical flight plans through these pages. He presses the left key to revise the lateral flight plan and the right key to revise the vertical flight plan. He presses the F-PLN key on the MCDU console to gain access to the A page of the active flight plan.

AIRPORT PAGE

Calls up the flight plan page that contains the next airport along the current flight plan. Successive pushes on the key show the alternate airport, the origin airport (before takeoff) and the next airport again.

PROG PAGES

The progress page is a multifunction page that allows the pilot to:

- Select a new cruise flight level,
- Crosscheck the Flight Management (FM) system's navigation accuracy and validate it,
- Update the FM position,
- Monitor the descent.

The PROG pages varying according to the flight status:

- Take Off phase,
- Climb phase,
- Cruise phase,
- Descent phase.

RAD NAV PAGE

This page allows the pilot to select or verify the radio navaids tuned for display purposes only. Among these navaids are VOR, VOR/DME, TAC, VORTAC, ILS and ADF. If either RMP is set on NAV, this page is blanked on both MCDUs.

PERF PAGES

The flight plan is divided into the following phases:

- PREFLIGHT, TAKEOFF, CLIMB, CRUISE, DESCENT, APPROACH, GO-AROUND, DONE.

Each phase except the preflight and done phases has a performance (PERF) page. The PERF pages display performance data, speeds related to the various phases and predictions.

Pressing the PERF key on the MCDU console calls up the performance page for the current active phase. Performance pages relating to phases already flown are not available. In the preflight and done phases, pressing the PERF key brings up the takeoff performance page. Pressing the PERF key in the done phase makes the phase transition to the preflight phase.

FUEL PREDICTION PAGE

The pilot presses the FUEL PRED key on the MCDU console to display fuel prediction information at destination and alternate, as well as fuel management data after the engines are started.

INIT A & B PAGES

The pilot uses the INIT A page to initialize the flight plan and align the inertial reference system, but only during the preflight. The pilot uses the INIT B page to initialize gross weight and center of gravity before starting the engines.

SECONDARY PAGES

The SEC F-PLN key on the MCDU console allows the pilot to call up the secondary index page and the secondary flight plan page. The secondary flight plan is generally for a diversion, for predictable runway changes for takeoff, landing or for training.

DATA INDEX PAGES

These pages lists the navigation data entered in the FMGS.

The pilot enters those items labeled "stored" and can modify them. The pilot can call up the others, but cannot modify them.

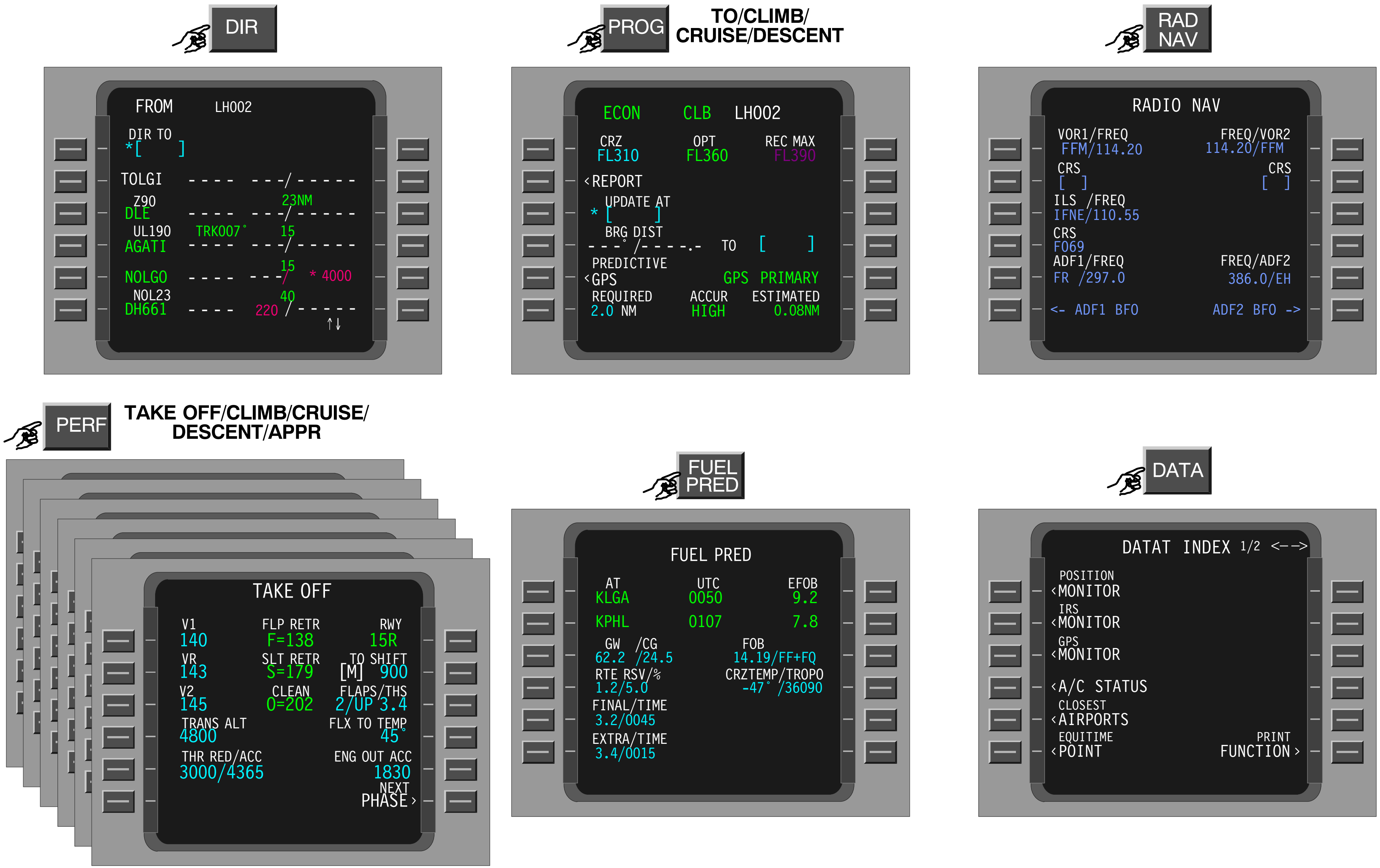


Figure 13 FM-MCDU Pages

06|–70|MCDU IND|L2

FMS AIRCRAFT STATUS PAGE DESCRIPTION

The pilot call this page up by pressing the DATA key on the MCDU console.

(1L) ENGINE TYPE

- The system uses this engine model to calculate predictions.

(2L) ACTIVE DATABASE

- The validity period and part number are displayed in large font.

(3L) SECOND DATABASE

- The validity period and part number are displayed in small font. The pilot can press the 3L key to switch to the second database as the active database.

CAUTION: CYCLING THE DATABASE ERASES THE PRIMARY AND SECONDARY FLIGHT PLANS, AS WELL AS THE STORED DATA. THE FLIGHT CREW **MUST NEVER DO THIS IN FLIGHT.**

(5L) CHG CODE

- This field allows entry of a code which permits modification of the IDLE and/or PERF factor displayed in 6L. It is displayed in the PREFLIGHT and DONE phases. The label is displayed in small white fonts ; the brackets, or the entered value, are displayed in large blue fonts.

STORED

- This field displays pilot−stored data in a large green font. The field is blank, if no data is stored. (The airline can choose to have this data automatically erased at the done phase).

DELETE ALL

- Pressing this key changes the label to “CONFIRM DELETE ALL“ in amber. Pressing this key a second time deletes all pilot−stored data, except data that is part of the active and secondary flight plans.

STATUS/XLOAD

- This prompt gives access to the P/N STATUS and P/N XLOAD pages.

(6L) IDLE/PERF

- These factors can only be modified while the aircraft is on ground. If no value has been entered, the default value, taken from the airline policy file, is displayed in small font.

IDLE FACTOR

IDLE and PERF factors follow the same principle. The PERF factor is mainly used for prediction during the cruise phase.

The IDLE factor is dedicated to the FM descent segment.

The aim of the IDLE factor is to adjust FM descent predictions. In particular, the Top of Descent (TOD) position, with the actual engine idle thrust used during descent.

A positive IDLE FACTOR gives an earlier Top of Descent (shallower path). A negative IDLE FACTOR delays the Top of Descent (steeper path).

PERF FACTOR

The PERF factor is a positive or negative percentage that is used to correct the predicted fuel flow used for computing fuel prediction within the FMGS. It is necessary when the aircraft performance differs from the performance model stored in the FMGS database.

Two reasons for this difference are :

- **a)** The FMS contains a performance database used to compute the predictions and the performance data. Due to the numerous possible aircraft configurations, the same performance database is sometimes used for aircraft with slightly different behaviors. In these cases, a PERF factor is entered to correct the computations performed with a database not exactly tailored for the given configuration.
- **b)** Since the actual aircraft drag and engine performance deviate from the nominal model, due to the aircraft’s age, airline flight operations will periodically apply a correction factor to adapt fuel predictions to actual fuel consumption.
- The PERF factor can only be entered/modified on ground. It is entered in the AIRCRAFT STATUS page, like any other data. A PERF factor change is carried out only by maintenance together with a regular NAV data base update.

IDLE/PERF FACTOR
Some aircraft require the IDLE/PERF factor to be adjusted.
The crew may use the following procedure:
- Enter **ARM** into brackets in the CHG CODE line [5L].
- Write the new IDLE/PERF factor in the scratchpad. Enter this new factor in line [6L].
- The entered factor is displayed in large green font.
- The airline may change the ARM code.

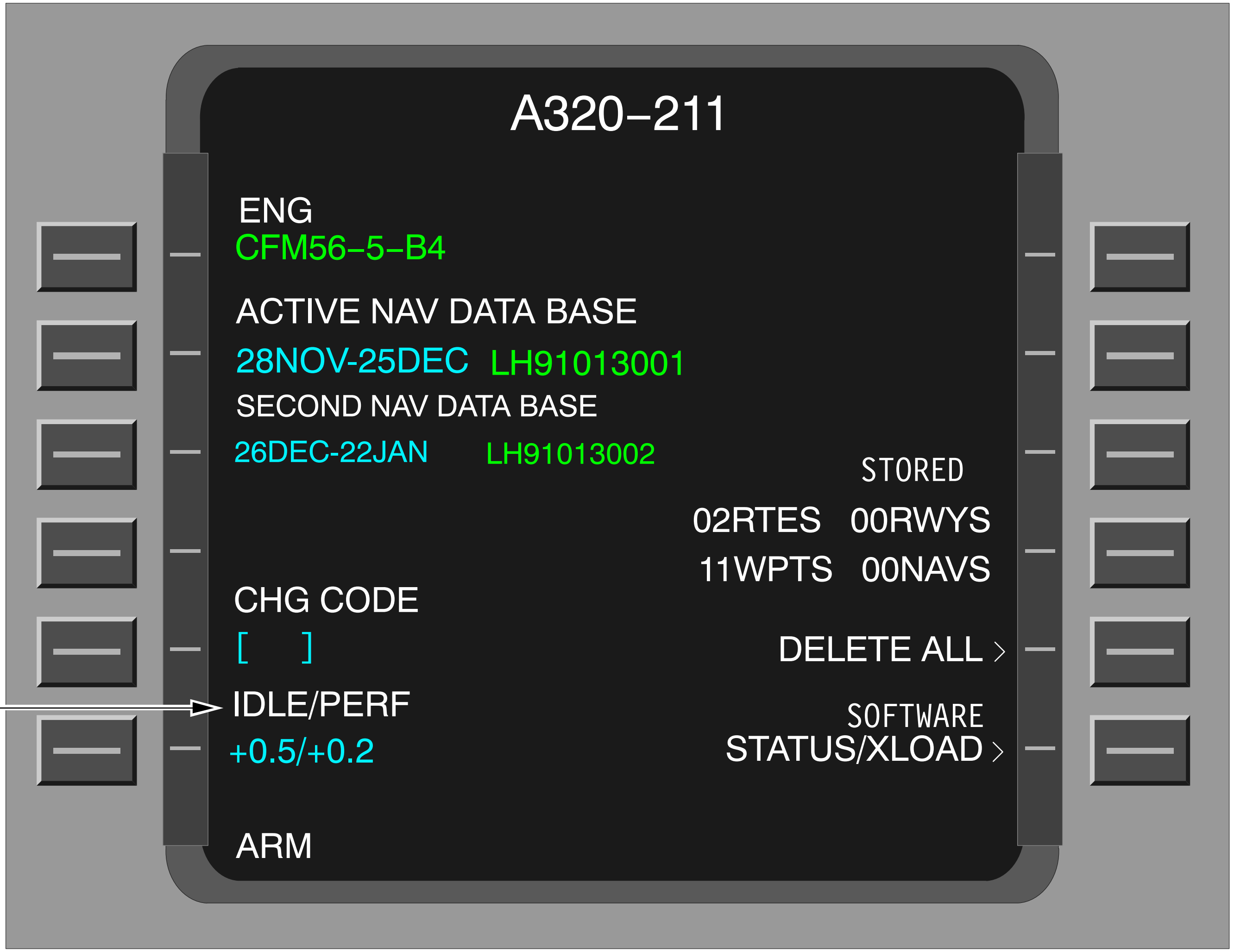


Figure 14 FMS AIRCRAFT STATUS PAGE

FLIGHT PLANNING DESCRIPTION

FLIGHT PLAN

The flight plan is defined by various elements, which indicate the routes the aircraft must follow with the limitations along these routes. The elements are mainly taken from the database or directly entered by the pilot. The limitations are mainly speed, altitude or time constraints originated by the ATC. The function that integrates these elements and limitations to construct a flight plan is called flight planning.

In addition to this, the FM part (**F**light **M**anagement) gives the aircraft position and the follow−up of the flight plan. This is called navigation. Everything can be prepared prior to the take−off but can also be modified quickly and easily during the flight operation. In case of a FM problem, the remaining valid FMGC is used as sole source to command both MCDUs (**M**ultipurpose **C**ontrol and **D**isplay **U**nit) and NDs after automatic switching.

NAVIGATION DATABASE

The navigation database gives all necessary information for flight plan construction and follow−up. The pilot will either select an already assembled flight plan called COmpany ROUTE, or will build his own flight plan, using the existing database contents. This database has a tailored coverage, updated every 28 days. Some room is kept to allow manual entry of 20 NAVigation AIDS, 20 waypoints, 10 runways and 5 company routes.

The database cannot be erased. However and as an option, the manually entered data can be erased when the flight phase is over (i.e. aircraft on ground for 30 seconds). Two cycle database can be loaded and the selection is made automatically by using data from the aircraft clock or manually. The database loading into either FMGC is done with the help of a Portable Data Loader (PDL) or via the Multipurpose Disk Drive Unit (MDDU) if installed. Then the cross loading function allows database loading into the other FMGC through crosstalk busses.

NAVIGATION

The navigation process gives the system with current aircraft state information consisting of present position, altitude, winds, true airspeed and ground speed. This is achieved using inputs from the Inertial Reference Systems (IRS), air data sensors, GPS, navigation radios, Air Traffic Service Unit (ATSU) and Flight Augmentation Computer (FAC) flight envelope computation.

Position can be updated manually or automatically during the flight. On the runway threshold at take−off for example.

DATALINK FUNCTION

The FMS uses the datalink function (ACARS or ATIMS) to exchange data between the ground station and the master FMGC via the ATSU. This interface enables the exchange of flight plan initialization, take−off, wind and broadcast data and flight reports with the ground. Via the ACARS, the crew may send a request for wind data to the ground. In response to this request, or automatically, the ground sends climb, cruise, descent and alternate wind data to the aircraft.

LATERAL FLIGHT PLAN

The lateral flight plan gives the sequential track changes at each waypoint.

VERTICAL FLIGHT PLAN

The vertical flight plan gives an accurate flight path prediction, which requires a precise knowledge of current and forecast wind, temperature and the lateral flight path to be flown.

PERFORMANCE

The performance database contains optimal speed schedules for the expected range of operating conditions. Several performance modes are available to the operator with the primary one being the ECONomic mode. The ECON mode can be tailored to meet specific airline requirements using a selectable Cost Index (CI). A CI is defined as the ratio of cost of time to the cost of fuel. The Fuel Quantity and Indication Computers (FQICs) give the fuel quantity. The speed and the thrust values associated with a given CI are used to determine the climb and descent profiles. Fuel and time are the main actors in this particular part of the FM function and direct the airline choice.

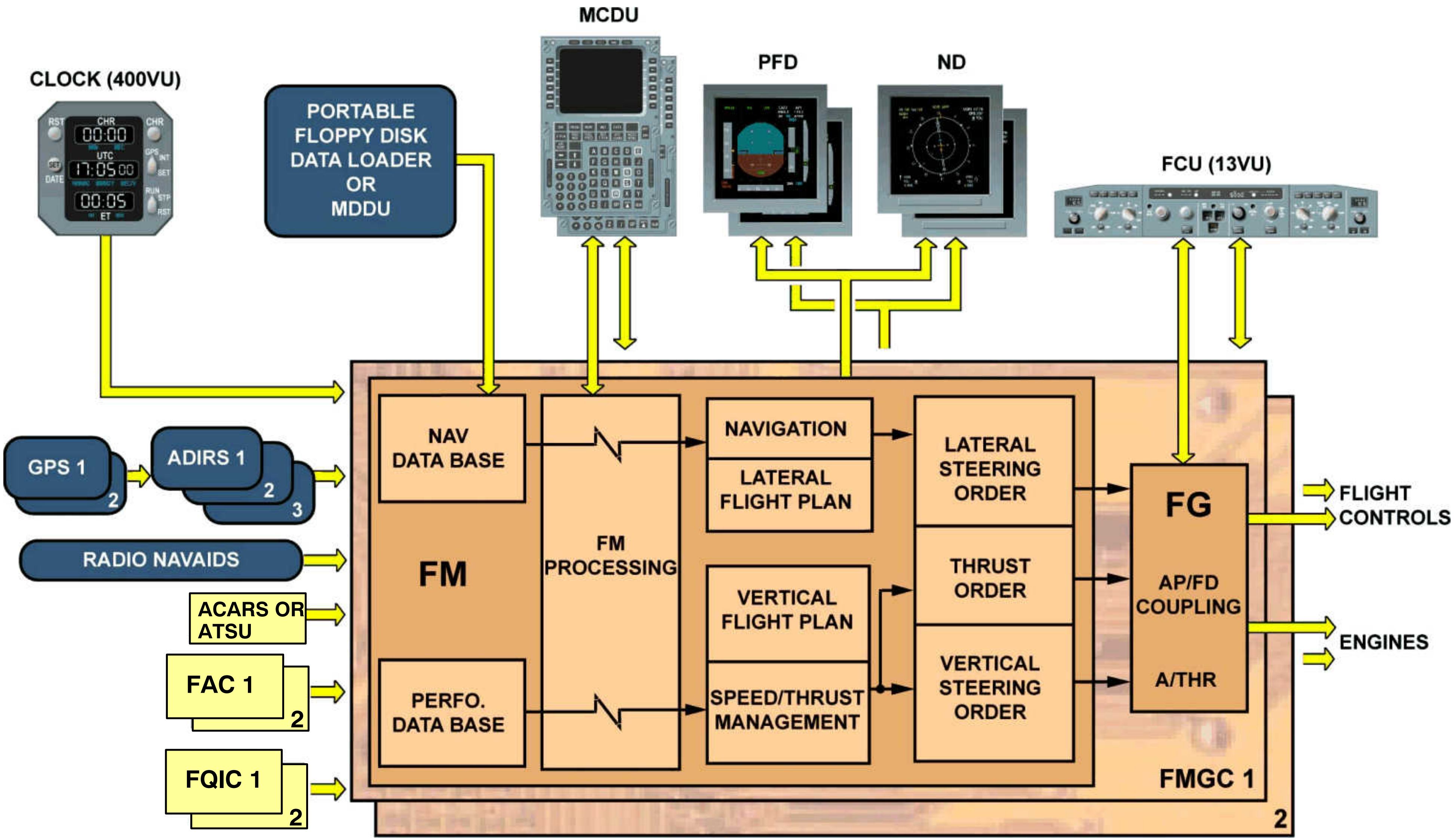


Figure 15 Flight Planning Schematic

FLIGHT PLAN DESCRIPTION

LATERAL FLIGHT PLAN

The lateral flight plan includes the following elements:

- **Departure**:
  - Takeoff runway,
  - SID (**S**tandard **I**nstrument **D**eparture),
  - En route transition
- **En route**:
  - En route waypoints and airways,
- **Arrival**:
  - En route transition,
  - STARs (**S**tandard **T**erminal **A**rrival **R**oute),
  - Landing runway with selected approach,
  - Missed approach,
  - Alternate flight plan.

The departure, en route and arrival elements are defined by waypoints and legs between the waypoints.

The lateral steering order can be followed by the pilot or the AP with the NAV mode selected.

VERTICAL FLIGHT PLAN

The vertical flight plan gives an accurate flight path prediction, which requires a precise knowledge of current and forecast wind, temperature and the lateral flight path to be flown. The vertical flight plan is divided into several flight phases:

- **PREFLIGHT:**
  - fuel, weight and V2 insertions,
- **TAKE−OFF:**
  - speed management, thrust reduction altitude, acceleration altitude,
- **CLIMB:**
  - speed limit, speed management,
- **CRUISE:**
  - top of climb, cruise altitude, top of descent,
- **DESCENT:**
  - speed limit, speed management, deceleration,
- **APPROACH/MISSED APPROACH/GO AROUND:**
  - thrust reduction altitude, acceleration altitude.

The vertical steering order can be followed by the pilot or the AP. Any level change in the vertical profile is initiated after a pull or push action on the altitude selector knob on the Flight Control Unit (FCU), except for departure when the vertical profile is armed on ground and will automatically be active after take−off phase.

Each phase has an assigned profile of target speeds. For each phase the FMGS computes an optimum (ECON) speed as a function of the strategic parameters (CI, CRZ FL, ZFW, ZFWCG, block FUEL) and performance criteria.

ECON speed is the basis of the managed speed profile. The ECON speed can be modified by presetting a speed or Mach number on the MCDU (PERF page) for the next phase, or by selecting on the FCU a speed or a Mach number for the active phase, or by inserting speed constraints or speed limits on the MCDU vertical revision (VERT REV) page.

The vertical flight plan includes vertical constraints (altitude, speed, time) that may be stored in the data base or entered manually by the crew through vertical revision pages. The crew may also define step climbs or step descents for cruise purposes. If the crew plans to climb to a higher flight level or descend to a lower level, it can use a vertical revision at any waypoint to insert the new level.

When all the vertical data has been defined, the FMGC computes the vertical profile and the managed speed/Mach profile from takeoff to landing.

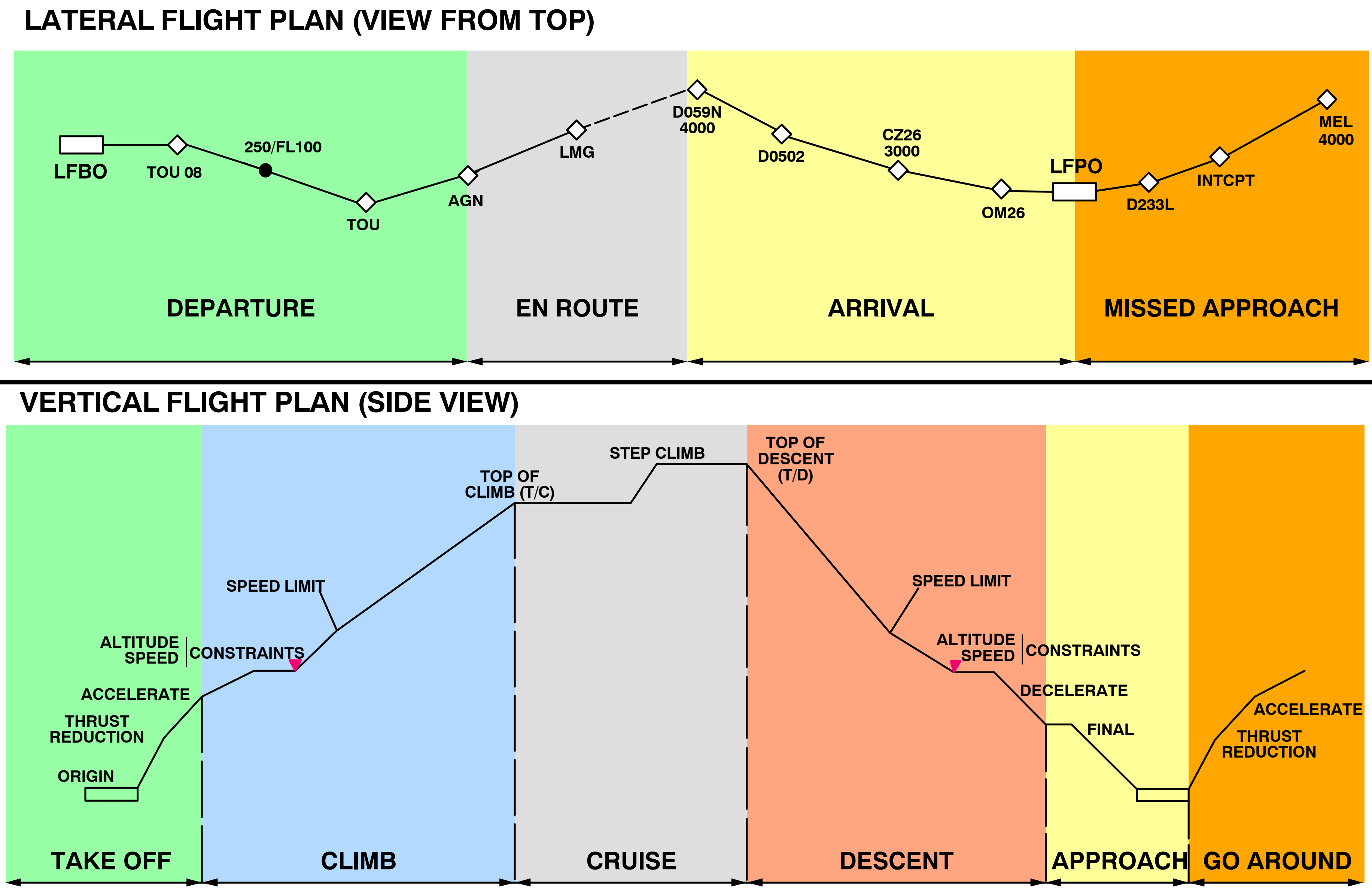


Figure 16 Lateral & Vertical Flight Plan

FLIGHT PLANNING PRESENTATION

GENERAL

The pilot uses the MCDU to insert flight plans into the FMGS:

- a lateral flight plan that defines the intended horizontal flight path,
- a vertical flight plan that defines the intended speed and altitude profile for the aircraft to follow while flying the lateral flight plan.

The flight planning function is available for both the primary and secondary flight plans.

Lateral Flight Planning

To insert the lateral flight plan, the pilot can use either a company route number or an ICAO four−letter city pair. The lateral flight plan includes the following elements:

- Takeoff runway,
- **S**tandard **I**nstrument **D**eparture (SID) and transition to en route mode,
- En route waypoints and airways,
- Transition from en route mode and **S**tandard **T**erminal **A**rrival **R**oute (STAR),
- Landing runway with selected approach and approach via,
- Missed approach,
- Alternate flight plan.

The FMGS is able to string together different types of legs corresponding to specific patterns (such as DME arc legs, or procedure turns) that are heading or track referenced. These are defined in the database. The pilot cannot create these legs. Departure and arrival procedures, defined in the database, may be divided into several parts.

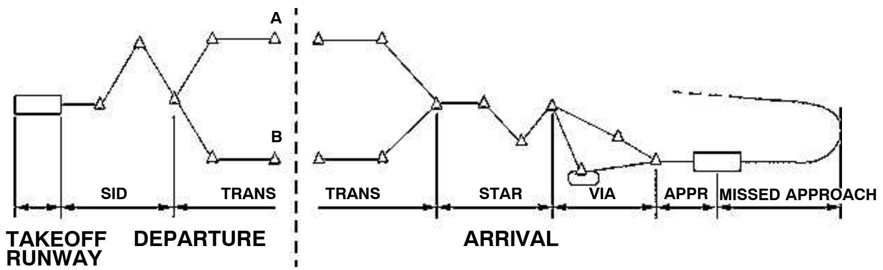


Figure 17 Lateral Flight Planning

Vertical Flight Planning

The vertical flight plan is divided into the following flight phases. Preflight − Takeoff − Climb − Cruise − Descent - Approach − Go Around − Done.

All but preflight and done are associated with speed and altitude profiles.

The vertical flight plan gives the FMGS all the data required to calculate performance and predictions. This data either comes from the data base automatically or is entered manually by the pilot.

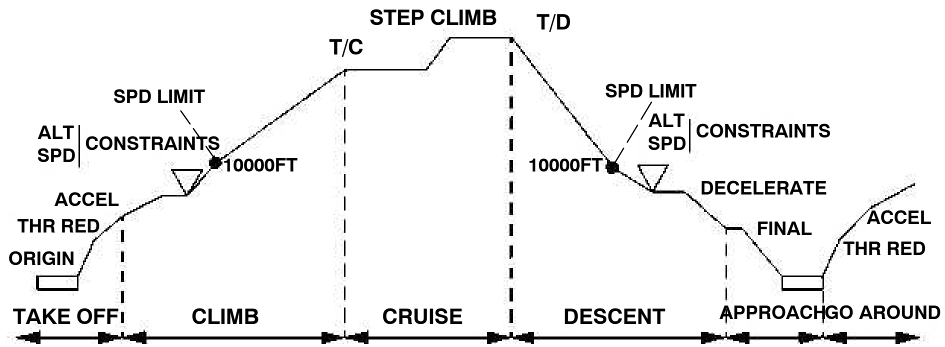


Figure 18 Vertical Flight Planning

FLIGHT PLAN CONSTRUCTION

There are three ways to define the route:

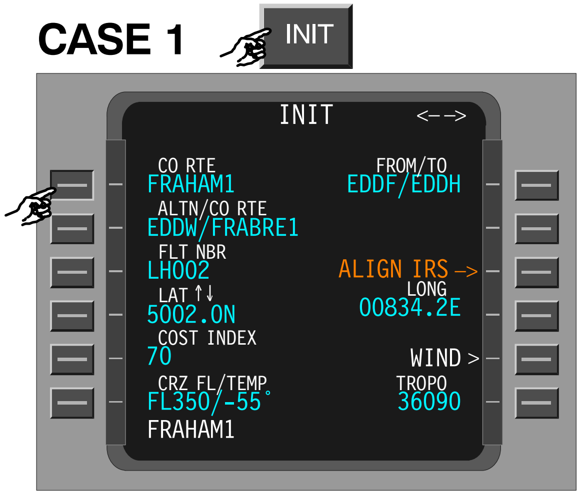
- It is a company route, it is in the database, and it is known by the crew.

  The pilot enters the name of the CO RTE into the 1L field of the INIT A page. This action enters all elements of the flight plan. The database usually includes an alternate route associated with the destination.
- It is a company route and it is in the database, but the crew does not know it is there.

  The pilot enters a city pair in the 1R field. The ROUTE SELECTION page automatically appears and permits the crew to review all stored routes between the two cities before selecting one of them.
- There is no company route between the two cities.

  The pilot enters the city pair in the 1R field. The ROUTE SELECTION page appears and displays “NONE“. The pilot has to manually construct the entire flight plan.

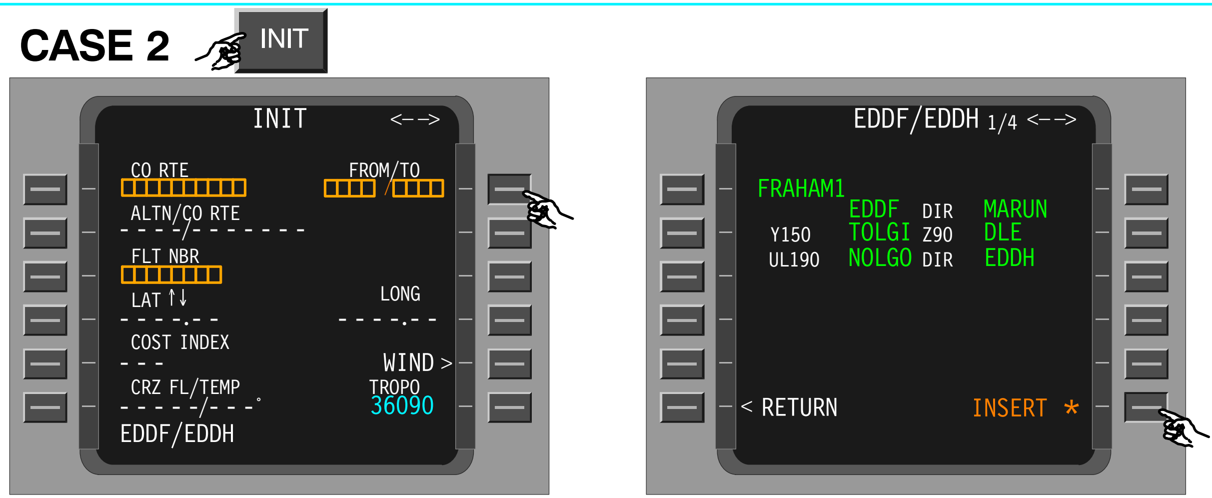
CASE 1



COMPANY ROUTE IS IN THE DATABASE AND IS KNOWN BY THE CREW

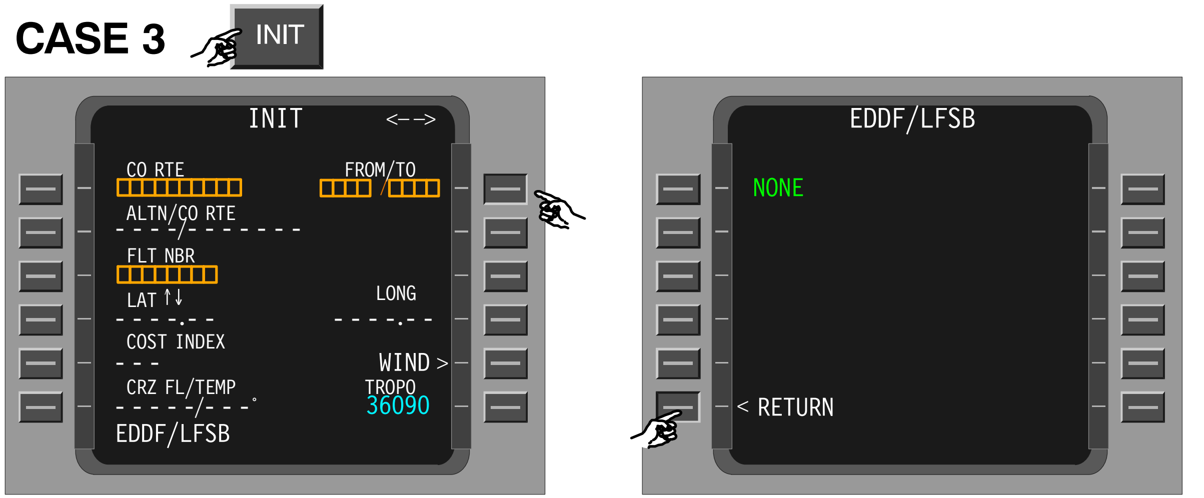
THE FLIGHT NUMBER & WIND DATA HAS TO BE ENTERED AS WELL. THE COST INDEX IS STORED IN THE COMPANY ROUTE.

CASE 2



COMPANY ROUTE IS IN THE DATABASE BUT THE CREW DOES NOT KNOW IT

CASE 3



THERE IS NO COMPANY ROUTE IN THE DATABASE

Figure 19 Flight Plan Entry

08|–70|FP insert|L3

INIT A PAGE SYSTEM OPERATION

The pilot uses the **INIT A page** to initialize the flight plan and align the inertial reference system.

The pilot accesses this page by pressing the INIT key on the MCDU console, but only during the preflight phase.

The pilot may also call up this page by:

- Pressing the "NEXT PAGE" key on the MCDU console, while on the INIT B page, or
- Pressing the key next to "RETURN" or "INSERT" on the route selection page.
- Pressing the key next to "INSERT" on the wind page.

When in the done phase, the pilot may press the INIT key to begin the next preflight phase.

- **[1L] CO RTE**

  If the flight crew enters a company route number, the screen displays all data associated with that route (8 or 10 characters, depending on the pin program). Inserting the CO RTE into the RTE selection page also enters the CO RTE number in this field.

- **[2L] ALTN/CO RTE**

  This field is dashed until a primary destination is entered in the 1R field. If a preferred alternate is associated with the primary destination, it is displayed in this field with the company route identification. The crew may enter an alternate and a company route manually. If preferred alternate is not associated with the primary destination, NONE is displayed in this field. When the alternate route and the primary destination do not match, the MCDU scratchpad displays "DEST/ALTN MISMATCH". If the primary destination is changed, this field is modified accordingly.

- **[3L] FLIGHT NUMBER**

  The flight number appears in this field automatically if it is stored with the company route. The flight crew may modify it or enter a new number here.

- **[4L] LAT**

  The latitude of the departure airport reference point appears here. The flight crew may modify it by slewing or overwriting.

- **[5L] COST INDEX**

  This is usually stored in the data base along with the company route. The flight crew may modify it or enter a new value here. It defaults to the last entered value if a value is not stored in the data base. A Cost Index is defined as the ratio of cost of time ($ / h) to the cost of fuel (cts / pds).

- **[6L] CRZ FL/TEMP**

  The cruise flight level is usually stored in the data base along with the company route. If not, it has to be entered manually. If no cruise flight level is entered, the system will not furnish predictions while the aircraft is on the ground. The flight crew has to enter the temperature at cruise flight level in order to refine the predictions. Otherwise these are computed for ISA conditions. (If no sign is entered, the system uses plus).

- **[1R] FROM/TO**

  This field enables the pilot to enter a city pair (ICAO codes for city of origin and destination). This entry automatically deletes any previously entered company route, and calls up the route selection page. If one airfield of the pair is not in the database, the display changes to the NEW RWY page.

- **[2R] INIT REQUEST**

  This prompt is displayed, if the pilot did not enter an active flight plan, or entered a flight number or a company route that is not in the aircraft database. Selecting this prompt sends the ground a request for active flight plan initialization (downlink message). When the star is not displayed, a downlink message cannot be sent.

  The uplink flight plan is automatically inserted in the active flight plan, prior to engine start, provided an active flight plan does not exist. After engine start, the uplink flight plan is sent to the secondary flight plan and manually inserted or rejected.

- **[3R] ALIGN IRS**

  This field only displays this legend if the LAT and LONG fields are filled in, and at least one of the inertial reference systems is in ALIGN status (IRS in NAV position and alignment process not over). If the pilot presses this key when its field is displaying this legend, the present coordinates are sent to the IRSs, and this completes the alignment process.

- **[4R] LONG**

  This field displays the longitude of the departure airport reference point. The pilot may modify by slewing or overwriting.

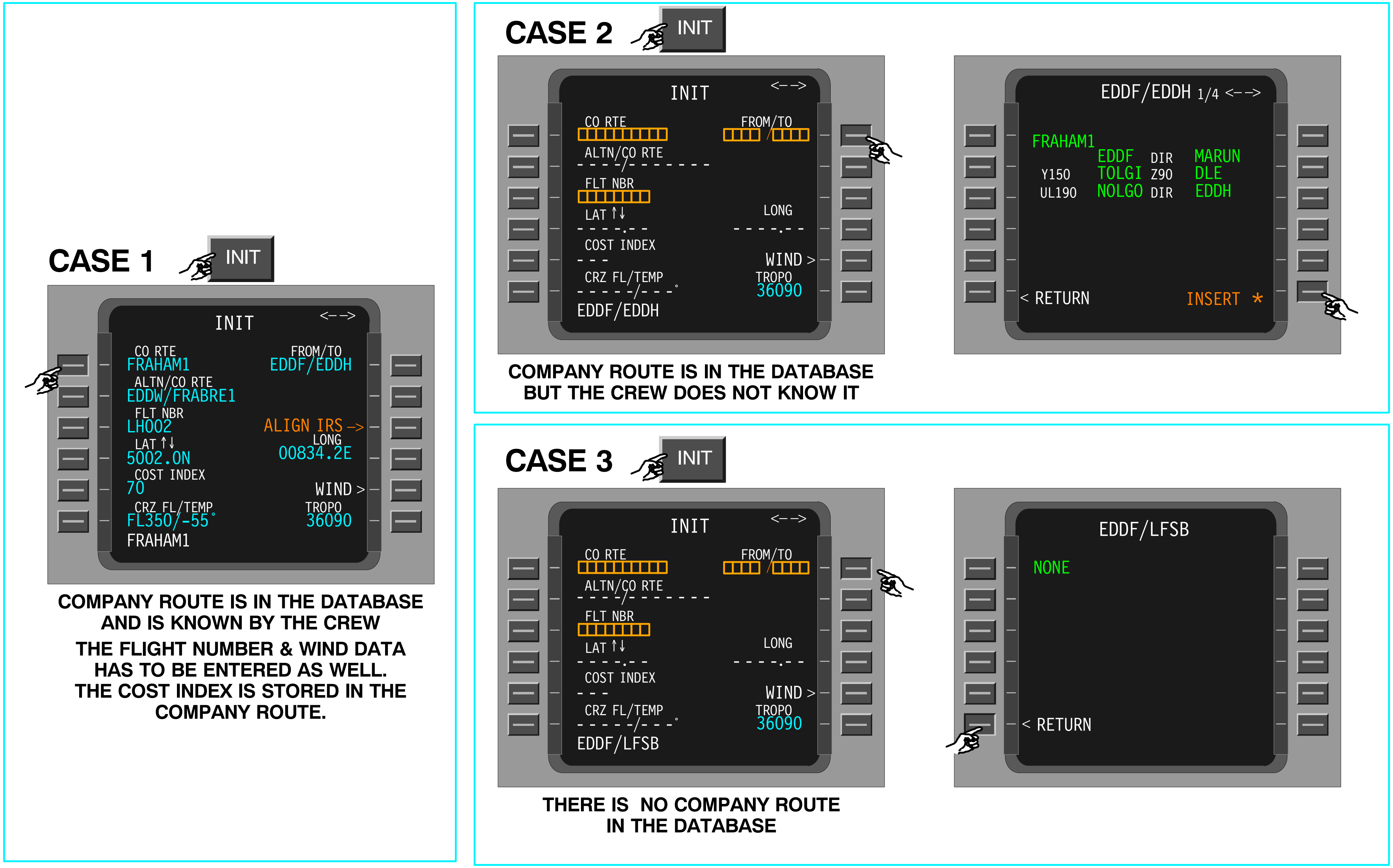


Figure 20 Flight Plan Entry

08|-70|FP insert|L3

INIT PAGE SYSTEM OPERATION CONTINUED

- **[5R] WIND >**

  The pilot presses this key to access the climb wind page, unless a temporary flight plan exists. In this case, the scratchpad displays “TEMPORARY F−PLN EXISTS“.

- **[6R] TROPO**

  The default tropopause altitude is 36090 feet. The pilot can use this field to modify it.

INIT B PAGE

The pilot uses this page to initialize gross weight and center of gravity before starting the engines. The pilot can call it up from the INIT A page by pressing the NEXT PAGE key (or the [->] key depending on the MCDU keyboard) on the MCDU console, as long as both engines have not been started. This page automatically reverts to the FUEL PRED page after the first engine is started.

The FMGC computes its predictions based on the FOB indicated by the FQI (or FAC as backup) from that moment on.

- **[1L] TAXI**

  This is the taxi fuel, which defaults to a preset value, (usually 200 kilos or 400 pounds). The pilot can change the value through this field.

- **[2L] TRIP/TIME**

  This field displays trip fuel and time when predictions become available. The pilot cannot modify this data.

- **[3L] RTE RSV/%**

  This field displays the reserve fuel for the route and the corresponding percentage of trip fuel. It may be blank, if such is the policy of the operator. The pilot can enter either a route reserve or a percentage, and the system then computes the nominal value automatically.

- **[4L] ALTN/TIME**

  This field displays alternate trip fuel and time, assuming that Cost Index = 0 and that the aircraft flies at the default cruise flight level. This field displays its information in a small font, and the flight crew cannot modify it.

- **[5L] FINAL/TIME**

  This field displays hold fuel and time associated with continued flight to the alternate airport (or destination airport if no alternate is defined). The pilot may enter a final fuel or time (at alternate or destination) and the system will compute associated holding fuel/time available. Assumptions include a racetrack pattern 1500 feet above the alternate airport, with the aircraft in the clean configuration at green−dot speed (or in accordance with airline fuel policy established in the database).

- **[6L] EXTRA/TIME**

  This field displays the amount of extra fuel and the available time it represents for holding over the alternate or primary destination if the pilot did not define an alternate.

  EXTRA FUEL = BLOCK (TAXI + TRIP + RSV + ALTN + FINAL)

- **[1R] ZFWCG/ZFW**

  This field displays the location of the zero fuel weight CG. It is an optional entry that defaults to 25%. The pilot can modify this data. The zero fuel weight is a mandatory entry that allows the system to compute speed management and predictions.

- **[2R] BLOCK**

  The block fuel in this field is a mandatory entry that allows the system to predict the estimated fuel on board (EFOB). When the pilot enters a block fuel, the page title changes to INIT FUEL PREDICTION. The FMGC may also compute the block, if the pilot selects the FUEL PLANNING function.

NOTE: If the pilot enters a number in field 1R or 2R that exceeds the limits, the field displays “ENTRY OUT OF RANGE“ and does not accept the value.

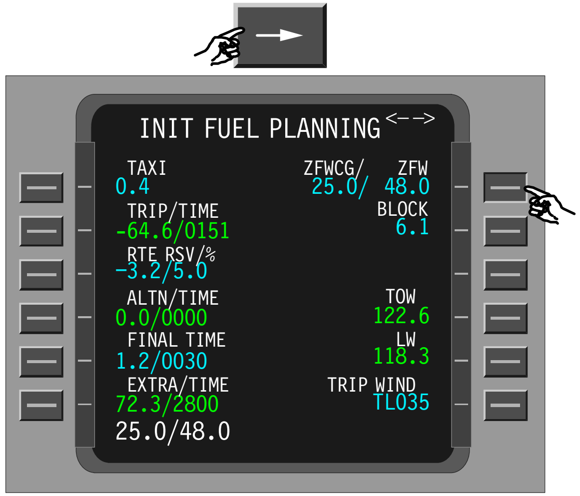
- **[3R] FUEL PLANNING (option)**

  Pressing this key initiates an FMGC block fuel computation. When the pilot selects this function, FUEL PLANNING becomes green, and the BLOCK field is dashed during FMGC computation. The title of the page changes to INIT FUEL PLANNING, and BLOCK CONFIRM* replaces the FUEL PLANNING prompt, when the block fuel is computed by the FMGC. If the pilot modifies the parameters used for the prediction computation before confirmation, the computation automatically restarts and FUEL PLANNING is displayed in green.

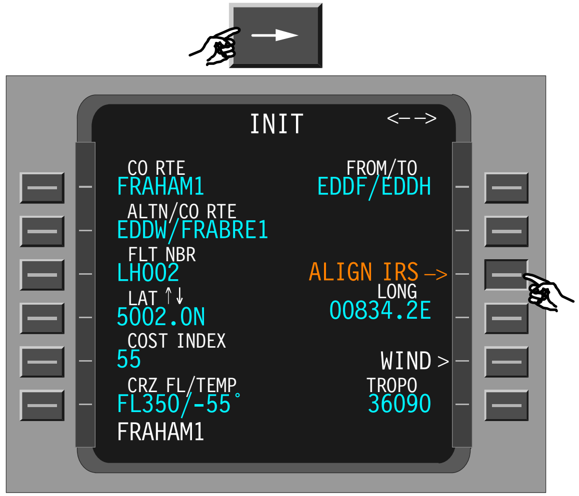
- **[4R] TOW**

  This field displays the computed takeoff weight. The pilot cannot modify it (small font).

NOW FINISH THE FPLN ENTRY

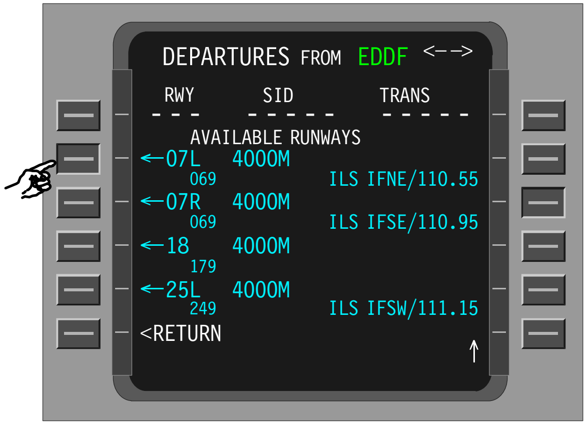


ENTER LOADSHEET DATA
& BLOCK FUEL
(ALL CYAN VALUES MAY BE MODIFIED MANUALLY)

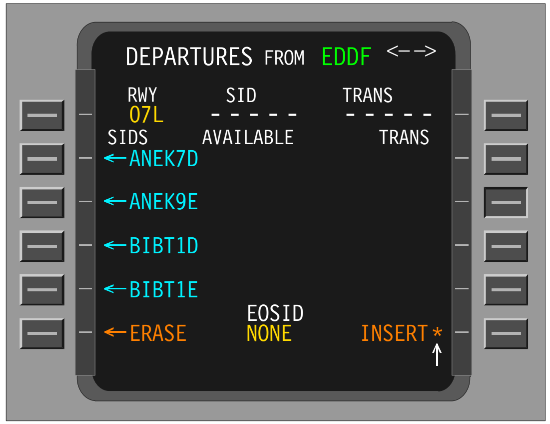


ALIGN THE IRS

ON THE FLIGHT PLAN PAGE SELECT
THE DEPARTURE AIRPORT



SELECT THE DEPARTURE RUNWAY



SELECT THE STANDARD INSTRUMENT
DEPARTURE ROUTE

THE SAME HAS TO BE DONE WITH THE ARRIVAL AIRPORT & STANDARD INSTRUMENT ARRIVAL ROUTE.
FINALLY THE TAKEOFF SPEEDS, FLAP & THS SETTINGS MUST BE ENTERED ON THE “TAKE OFF“ PERFORMANCE PAGE

Figure 21 Finalization of the Flight Plan Entry

- **[5R] LW**
  This field displays the computed landing weight at the primary destination. The pilot cannot modify it (small font).
- **[6R] TRIP WIND**
  This field allows the entry of a mean wind component for the trip from the primary origin to the primary destination. Upon entry of a CO RTE or FROM/TO pair, this field defaults to HD 000 in small blue font. An entry preceeded by -, H, HD is considered as headwind, +, T, TL as tailwind. The entered velocity is displayed in large blue font. As soon as the crew inserts a wind on the CLIMB, CRUISE or DESCENT WIND page, the system no longer considers the trip wind.

PERFORMANCE FUNCTION

The performance function:

- Optimizes a flight plan
- Computes predictions

Flight Optimization

The optimization function computes:

- The best target speed for climb, cruise, and descent (ECON SPD/MACH).
- The best descent path from the cruise flight level to the destination airfield.
- An optimum flight level (for pilot's information).

Cost Index (CI)

This is a fundamental input for the ECON SPEED or ECON MACH computation. ECON SPEED and ECON MACH reduce the total flight cost in terms of flight time and fuel consumption (and not only in terms of fuel saving).

The airline's operations department usually defines the cost index, to optimize each company route.

The pilot does not ordinarily modify the cost index during a flight.

CI = 0 corresponds to minimum fuel consumption (Max Range).

CI = 999 corresponds to minimum time.

Computation of Predictions

The system calculates various predictions for the active flight plan and updates them continually during flight as functions of:

- Revisions to the lateral and vertical flight plans,
- Current winds and temperature,
- Present position versus lateral and vertical flight plans,
- Current guidance modes.

IRS ALIGNMENT

Alignment of the IRS starts when the OFF/NAV/ATT selector switch of the ADIRS control panel is in the NAV position. IRS ALIGNMENT calculations can only be done on ground before take−off, after the pilot entered the current A/C coordinates or after auto alignment by the IRS itself (auto−aligning IRS generation).

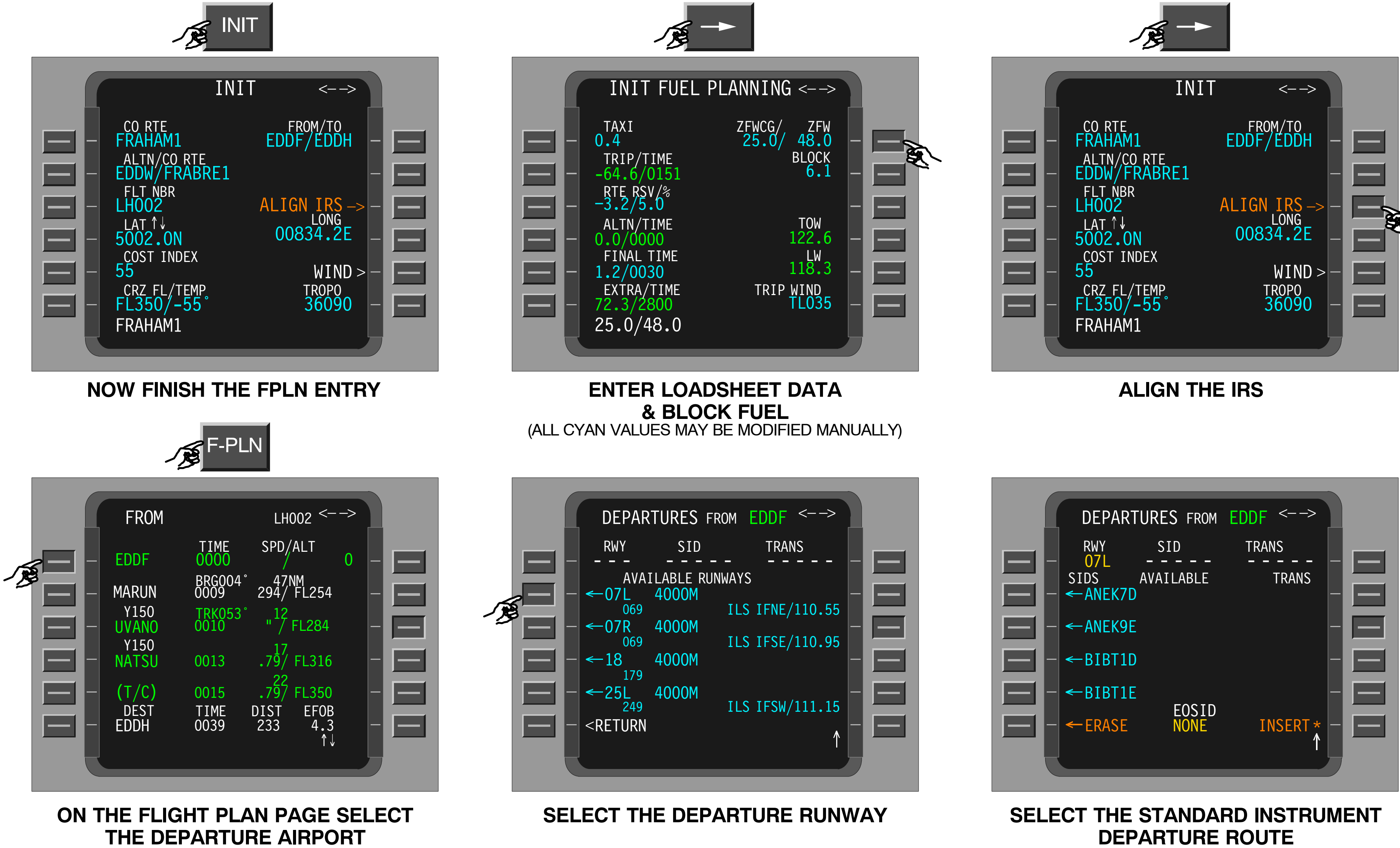
The entry results from a pilot action either (as basic procedure) on the MCDU IRS INIT page accessible from the INIT A page, or (as optional procedure) on the Inertial System Display Unit (ISDU). If the option of the automatic alignment on GPS position is activated (depending of IRS standards), no pilot action is required. The alignment is automatically done in relation with the GPS position.

The alignment is only available on the active Flight Plan and optionally automatically performed on GPS position. In case of bad IRS alignment (at least one of the three IRS has been aligned more than 5 Nm away from the departure airport position), a CHECK IRS/AIRPORT POS message is displayed in the MCDU scratchpad to warn the crew of a discrepancy between origin departure and IRS alignment position before take−off.

The FMGS uses the reference point coordinates of the departure airport to align the IRS. It calls these up from the database automatically after the flight crew has entered a company route or an origin−destination city pair and pressed the ALIGN IRS key. The flight crew can adjust these coordinates manually to the gate position. A normal alignment takes ten minutes, a fast alignment 30 seconds. Fast alignment is used to refine a position when time is limited.

If the "ALIGN" light flashes on the ADIRS control panel during the alignment process, it indicates one of the following:

- It has detected excessive motion. (It automatically restarts the alignment).
- It has detected a mismatch between the position the FMGC has sent to the IRS and the last memorized IRS position. The pilot must enter new coordinates in the MCDU, and realign the IRS.
- It has detected a mismatch between the latitude the FMGC has sent to the IRS and the latitude the IRS has computed during the alignment.
- The IRS has not received a position from the FMGC or the ADIRS overhead CDU.



THE SAME HAS TO BE DONE WITH THE ARRIVAL AIRPORT & STANDARD INSTRUMENT ARRIVAL ROUTE.
FINALLY THE TAKEOFF SPEEDS, FLAP & THS SETTINGS MUST BE ENTERED ON THE "TAKE OFF" PERFORMANCE PAGE

Figure 22 Finalization of the Flight Plan Entry

FLIGHT PLAN INDICATION

INDICATION ON THE NAVIGATION DISPLAY

Flight plan indications are shown in the NAV, ARC and PLAN mode.

The FMGS generates the following information, displayed on the NDs:

- Flight plan (active secondary, temporary, dashed),
- Aircraft position and lateral deviation from the flight plan,
- Pseudo–waypoints along the flight plan,
- Raw data from tuned Navaids and type of selected approach,
- Various display options (waypoints, Navaids, NDBs, airports, constraints).

ROSE NAV MODE/ARC MODE

ROSE NAV and ARC modes give the pilot the same information, but ARC mode limits it to the forward 90° sector.

The values displayed on the ND are in ROSE NAV mode:

- 1/4 of the selected range for the inner circle,
- 1/2 of the selected range for the heading scale circle.

The values displayed on the ND are in ARC mode:

- 1/4 of the selected range for the first inner arc.
- 1/2 of the selected range for the second inner arc,
- 3/4 of the selected range for the third inner arc.

Flight Plan

The active flight plan (the flight plan the aircraft is actually following when the NAV mode is engaged) is represented by a continuous green line. The ND shows only the part of the flight plan that is ahead of the aircraft, as well as the waypoints that are still to be overflown and the waypoint from which the aircraft is coming. The ND does not show a SID (Standard Instrument Departure) or a STAR (Standard Terminal Arrival Route), except for the last waypoint of the SID and the first waypoint of the STAR, when the selected range is 160 or 320 NM. If the primary flight plan is not active, it is represented by a dotted green line. A continuous blue line portrays the missed approach procedure and a dashed blue line portrays the flight plan to the alternate.

The secondary flight plan is represented by a continuous white line. The ND continues to display the active flight plan.

The temporary flight plan is represented by a dotted yellow line.

When the aircraft is off the primary flight plan and is flying toward it in HDG mode with the NAV mode armed, the ND shows the new active flight plan as a continuous green line if the FMGC has computed the intercept path. The part of the flight plan before the interception point shows as a dotted green line.

Waypoint

The ND can show various kinds of waypoints:

- **Flight plan waypoints**
  - The ND shows these as green diamonds (white for the TO waypoint). When the pilot selects the WPT option on his EFIS control panel, the screen shows all waypoints other than flight plan waypoints in magenta.
- **Pseudo waypoint**
  - This is a point of the flight path where the aircraft is predicted to reach a selected altitude or speed.

TO Waypoint

This is the next waypoint to be overflown. This area of the screen also shows:

Waypoint identification (white),

- Track to go (green),
- Distance to go (green),
- Estimated time of arrival (green), assuming the aircraft will fly directly from its present position to the TO waypoint at the current ground speed.

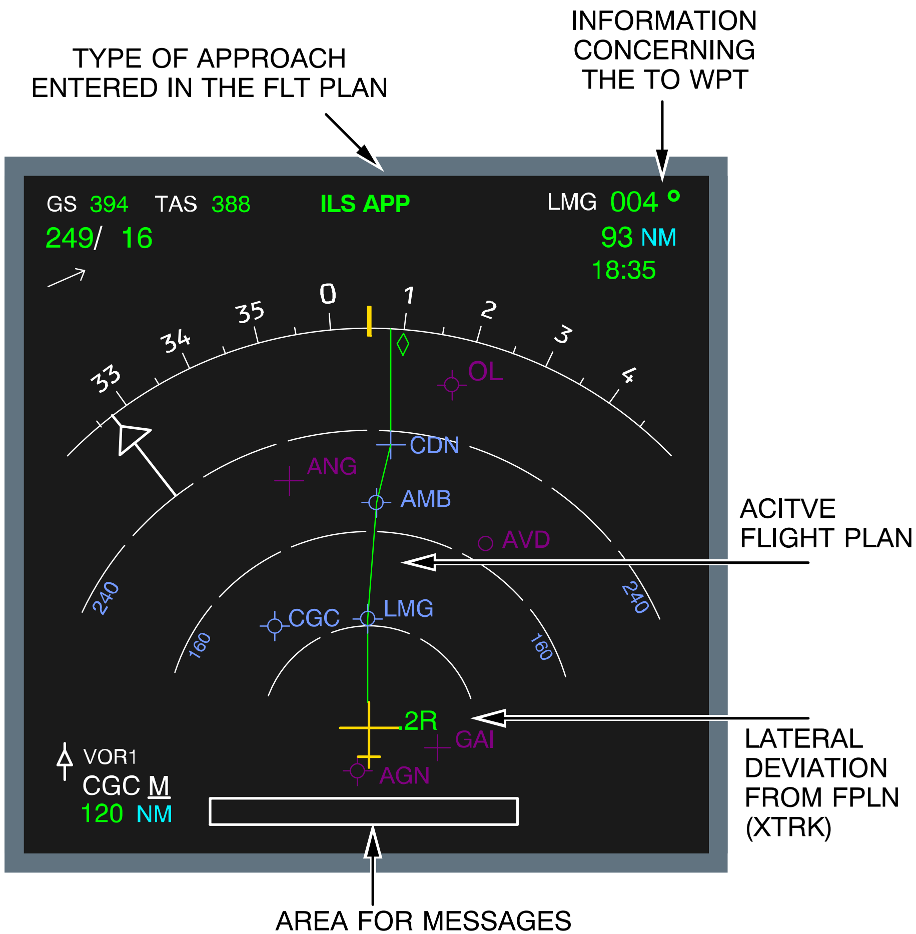
Airport

If the runway is not specified, the airport is represented by a star and the identification is displayed in white. Example: * LSGG. If the runway is specified, it is represented by an oriented runway symbol in white.

The airports that are not displayed as part of the flight plan may be called for display (ARPT pushbutton on the EFIS control panel). They are represented by a star and the identification in magenta.

Procedure Turns and Holding Patterns

These appear only when they are part of the flight plan. For the 160 and 320 NM range scales, each one is represented by a white arrow that originates at the associated fix and indicates the direction of the turn. For shorter range scales and if the procedure turn or the holding pattern is in the next or the active leg, the display shows the full circuit or pattern.



FLIGHT PLAN SYMBOLS ON THE ND:

Figure 23 Flight Plan Indications on the ND (ARC MODE)

PLAN MODE DESCRIPTION

This mode displays statically the flight plan legs on a map oriented to true north. The map is centered on a map reference point that the pilot chooses by slewing to it on his MCDU. The map reference point is the waypoint displayed on the second line of the MCDU F−PLN page. It can be either the active waypoint (next waypoint to be overflown) or any other waypoint of the flight plan.

The pilot can slew the overall flight plan and display it in PLAN mode. The pilot chooses the scale of the map with the range selector (the diameter of the outer circle corresponds to the selected range).

Data on navaids and their characteristics and associated bearing pointers are not available in this mode. Also Weather radar, TCAS and EGPWS information is not available in this mode.

Additional data including constraints, waypoints, NAVAIDS and airports may be selected.

Aircraft Position and True Track

The orientation of the yellow aircraft symbol always indicates the true track of the aircraft. Its position represents the aircraft position given by the FMGS.

Map Reference Point (optionally)

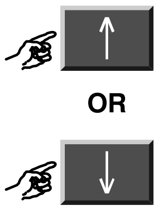
When the pilot pushes the LS pushbutton switch on the EFIS control panel, and if an ILS station has been selected, the display shows an ILS course symbol.

ND IN PLAN MODE

ND IN PLAN MODE

USE MCDU 1 FOR FLIGHT PLAN CHECK ON ND 1 AND MCDU 2 FOR ND2.

USE



OR

TO SCROLL THROUGH FLIGHT PLAN

Figure 24 Flight Plan Indications on the ND (PLAN MODE)

POSITION COMPUTATING SYSTEM OPERATION

GENERAL

Each FMGC computes its own aircraft position (called the "FM position") from a MIX IRS position and a computed radio position or GPS position. The FMGS selects the most accurate position, considering the estimated accuracy and integrity of each positioning equipment. GPS/INERTIAL is the basic navigation mode provided GPS data is valid and successfully tested. Otherwise, navaids plus inertial or inertial only are used.

1 Mix IRS Position

Each FMGC receives a position from each of the three IRSs, and computes a mean-weighted average called the "MIX IRS" position. If one of the IRSs drifts abnormally, the MIX IRS position uses an algorithm that decreases the influence of the drifting IRS within the MIX IRS position.

If one of the IRSs fails, each FMGC uses only one IRS (onside IRS or IRS3). Each IRS position and inertial speed are continuously tested. If the test fails, the corresponding IRS is rejected. The "CHECK A/C POSITION" message comes up on the MCDU, when the radio position and the IRS position disagree by more than 12 NM.

2 GPS Position

Each IRS computes an hybrid position that is a mix IRS/GPS position called GPIRS. For this, each IRS can independently select their GPS source in order to maximize GPS data availability. Among these 3 GPIRS positions received by each FMGC, one is selected according to a figure of merit and a priority. The selection is performed using the following hierarchy:

- onside GPIRS position,
- GPIRS 3,
- opposite GPIRS position.

If the GPIRS data do not comply with an integrity criteria, the GPS mode is rejected and radio position updating is used, "GPS PRIMARY LOST" message is displayed on ND and MCDU scratchpad. During non ILS approach, the loss of the GPS primary function triggers a triple click aural warning.

When the GPS primary function is recovered, the "GPS PRIMARY" message comes up on ND and MCDU scratchpad.

It means that GPIRS data comply again with the required integrity criteria.

As long as GPS primary is in use, all usual required navigation performance are met. The crew can deselect/select the GPS on the SELECTED NAVAIDS page if necessary.

3 Radio Position

Each FMGC uses onside navaids to compute its own radio position. These navaids are displayed on SELECTED NAVAIDS page.

The navaids which the FM can use are:

- DME/DME,
- VOR/DME,
- LOC,
- DME/DME-LOC,
- VOR/DME-LOC.

It uses LOC to update the lateral position using LOC beam during ILS approach. LOC is also used for quick update when in GPS/IRS mode (if GPS installed). If one or more navaids fail, each FMGC can use offside navaids to compute VOR/DME or DME/DME radio position. The radio Navaid selection is displayed on DATA "SELECTED NAVAIDS" page.

4 FM Position and Bias

At flight initialization, each FMGC displays an FM position that is a mix IRS/GPS position (GPIRS). It is subsequently updated:

- At takeoff, when the FM position is updated to the runway threshold position as stored in the data base, possibly corrected by the takeoff shift entered on PERF TO page.
- In flight, the FM position approaches the radio position or the GPS position at a rate depending upon the aircraft altitude.

Each FMGC computes a vector from its MIX IRS position to the radio or GPIRS position. This vector is called the "bias". Each FMGC updates its bias continuously if a radio position or a GPIRS position is available. If an FMGC looses its radio/GPIRS position, it memorizes the bias and uses it to compute the FM position, which equals the mix IRS position plus the bias. Until the radio or the GPIRS position is restored, the bias does not change. The crew can update the FM position manually. This also updates the bias.

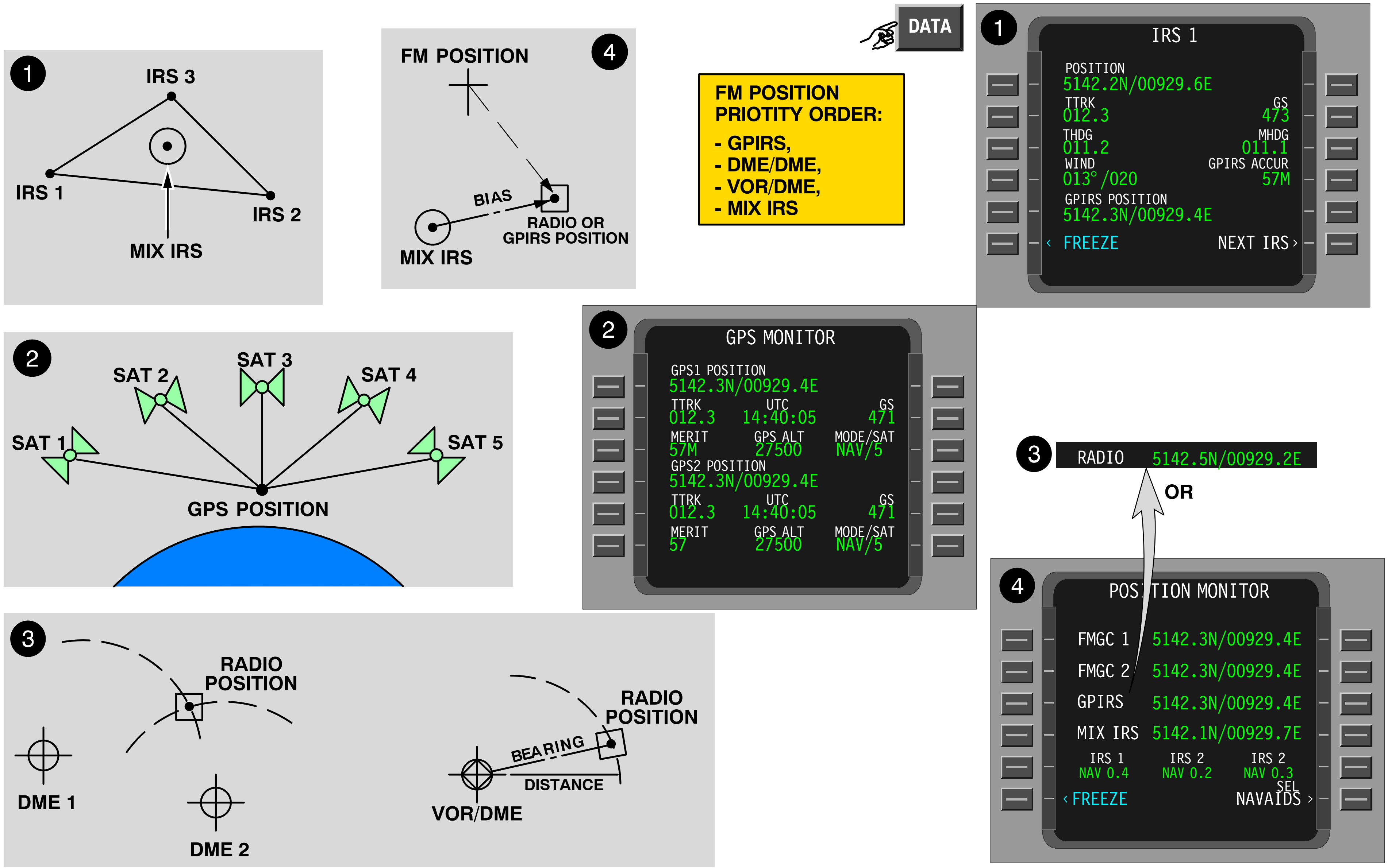


Figure 25 Computation of FM-Position

POSITION COMPUTATING SYSTEM OPERATION

1 TAKEOFF POSITION UPDATE

A takeoff update requires that the takeoff runway be part of the flight plan. This provides the most accurate position update. If the takeoff run starts at an intersection, enter a takeoff shift on the PERF TO page to refine the takeoff update. An accurate takeoff update ensures a precise aircraft position during departure.

2 EVALUATION OF POSITION ACCURACY

The FMGS computes an **E**stimated **P**osition **E**rror (EPE) continually.

It is an estimate of how much the FM position has drifted, and is a function of the navigation mode the system is using.

CURRENT NAV MODE	EPE (THRESHOLD)	REMARK
GPRIS	√(FOM^2 + 100^2) in meters	FOM = Figure of Merit of GPS. If above 0.28 NM the GPS position is rejected.
DME/DME	Tends towards 0.28 NM	EPE decreases from initial value to 0.28 Nm.
VOR/DME	0.1 NM + 0.05 X DME DIST minimum: 0.28 NM	EPE increases or decreases as the distance between the a/c and the VOR/DME
IRS ONLY	± 8 NM/h for the first 21 min. ± 2 NM/h after	EPE increases continuously

NOTE: After an IRS alignment or at takeoff, the EPE is set at 0.2 NM.

Required Navigation Performance (RNP)

The system displays the EPE to the crew and compares it with the **R**equired **N**avigation **P**erformance (RNP). The RNP value shall be in accordance with the specified RNP values of the navigation/approach charts (if a RNP is specified).

- If the EPE does not exceed the appropriate criteria, accuracy is HIGH.
- If the EPE exceeds the appropriate criteria, accuracy is LOW.

When the accuracy changes from LOW to HIGH (or HIGH to LOW), both MCDUs and NDs display the message “NAV ACCUR UPGRAD“ (or “DOWNGRAD“). On A/C equipped with GPS the message “GPS PRIMARY LOST“ is shown in amber on the ND and MCDU. During a non ILS approach, a triple click aural warning is also triggered. The flight crew must periodically check position accuracy, when the GPS function is lost.

FLIGHT AREA	REQUIRED RNP (DEFINED BY AUTHORITIES)	DEFAULT RNP VALUES
EN ROUTE	3,41 NM	2,0 NM
TERMINAL	2,07 NM	1,0 NM
APPROACH	VOR/DME 0,61 NM OTHER CASES 0,36 NM	GPS 0,3 NM OTHER CASES 0,5 NM

GPS/FMS Position Disagreement

When GPS primary is active, and either of the FMGC positions deviate from the GPS positions 1 or 2 by more than 0.5 minutes of latitude or longitude, then the lower ECAM display unit displays the NAV FMS/GPS POS DISAGREE amber message and A/C POS... CHECK in blue.

The master caution light comes on, and the single chime sounds.

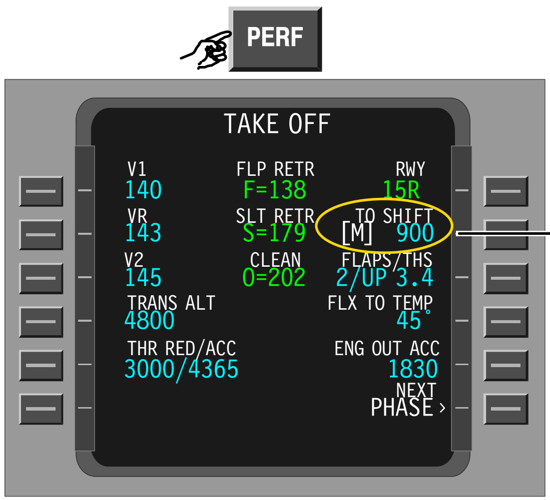
Predictive GPS

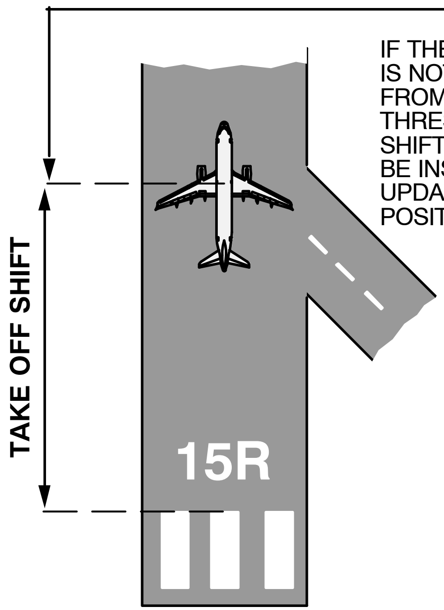
The predictive GPS page is only operative with the Honeywell ADIRS equipment. The predictive GPS function predicts the availability of the GPS within ± 15 minutes of ETA at destination, or at any waypoint entered by the crew.

Predictions are displayed on the predictive GPS page at time intervals of 5 minutes (+15 and -15 minutes of ETA).

To access this page, press the 5L key of the PROG page. This page also enables the deselection of up to 4 satellites at a time.

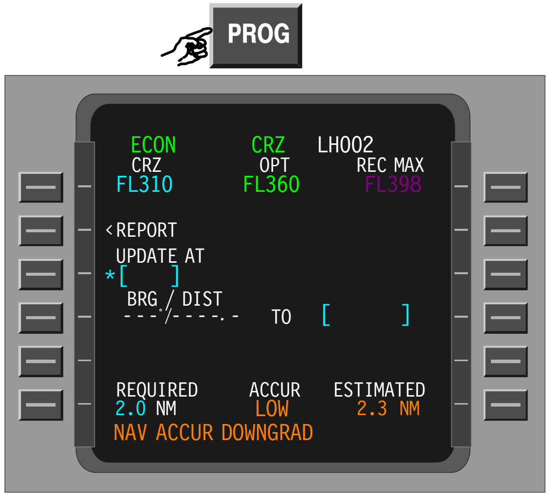
1 TAKEOFF POSITION UPDATE





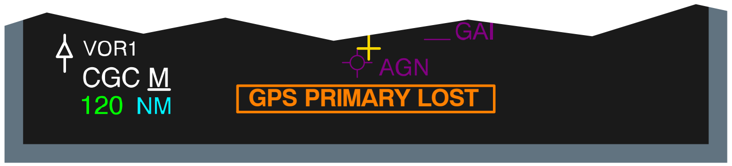
IF THE TAKEOFF IS NOT INITIATED FROM RUNWAY THRESHOLD, T/O SHIFT SHOULD BE INSERTED TO UPDATE THE POSITION

2 POSITION ACCURACY (A/C NOT EQUIPPED WITH GPS)



“HIGH“ OR “LOW“ INDICATES THE FM POSITION ACCURACY BASED UPON ESTIMATED ERROR. THIS IS WHY THE FLIGHT CREW MUST CHECK THE POSITION ACCURACY PERIODICALLY.

POSITION ACCURACY (A/C EQUIPPED WITH GPS)



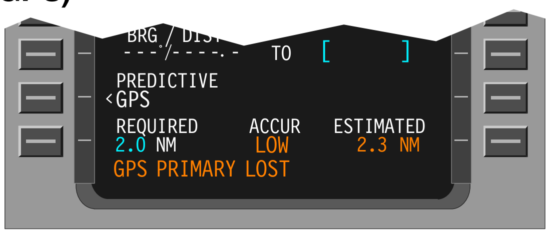


Figure 26 FM Position Update & Accuracy

NAVIGATION BACK-UP DESCRITPION/OPERATION

GENERAL

The MCDU BACK-UP NAV (B/UP NAV) must be used as a back-up system when both Flight Management (FM) parts have failed.The MCDU BACK-UP NAV (B/UP NAV) gives to the crew limited information, which can be used to complete the current flight. The MCDU B/UP NAV is activated through the "SELECT NAV B/UP" prompt on the MCDU MENU page. The B/UP NAV functions work independently and may be activated separately.

FLIGHT PLANNING

Before activation of the BACK-UP NAV function, a condensed form of the flight plan is transferred from the FM part to the MCDU.

This downloading is updated in case of:

- FM primary Flight Plan (F-PLN) changes,
- FM lateral leg sequencing,
- FM long power off,
- FM source selector change,
- FM resynchronization.

Downloading includes waypoint position, waypoint identifier, leg type, discontinuity, overfly and turn direction information in a maximum of 150 legs. At BACK-UP NAV activation, a last updating is done and then any other updating is ignored. A reduced capability is given to the MCDU B/UP NAV function compared to the FM function.

NAVIGATION

The BACK-UP NAV function is based on Inertial Reference (IR) inputs from the ownside IR or IR3, which gives the position, ground speed, track, heading, altitude and wind. The selected IR depends on pilot selection, through the IR source selector, to be consistent with the current displayed IR data on the related PFD and ND. The MCDU B/UP NAV gives, the crosstrack error and the bearing/distance/time to go to the active waypoint, depending on the aircraft latitude/longitude and on the active leg of the flight plan. It supplies the automatic leg change when the TO waypoint is reached.

It is very important to note that all this data is only for display, there is no steering order issued by the MCDU, and the NAV mode cannot be engaged.

ND DISPLAY

The MCDU transmits the BACK-UP F-PLN to the NDs. It has active F-PLN vectors and waypoints related to the fixed aircraft position in ROSE or ARC modes, or to the moving aircraft reference in PLAN mode. In all cases, the flight plan line is dashed in green (as NAV mode cannot be engaged). Options selectable on the EFIS control panel are not allowed (AiRPorT, Non-Directional Beacon, VOR.D, WayPoinT, ConSTRaint).

MCDU PAGE AVAILABILITY

All flight-planning operations are directly applied through the B/UP F-PLN page. It displays each leg of the active route, giving position information for each waypoint, as well as computed course, time and distance for the connecting legs. The revisions, available on the B/UP F-PLN page, are waypoint insertion, waypoint deletion, discontinuity deletion and overfly deletion/insertion.

Pressing the DIR key enables the selection of a waypoint to join it directly. The B/UP F-PLN/DIR TO page is similar to the F-PLN page but line 1 is reserved for waypoint entry. Pressing the PROGress key gives navigation information. The B/UP PROG page displays the aircraft position with identification of the selected IR. It also gives ground speed, and active leg track with aircraft track.

The top line displays the waypoint identifier and altitude at the last sequenced waypoint, also called overhead (OVHD). The bottom line enables access to the B/UP IRS pages. The B/UP IRS pages correspond to IR1 or 2, function of MCDU1 or 2, and IR3. IR provides, for display information about position, the true track, the true and magnetic headings, the ground speed and the wind.

DEACTIVATION

Backup Navigation is deactivated upon one of the following events:

- The Deselect NAV B/UP prompt is pushed on the MCDU MENU page
- The following condition becomes true: onside FM is Healtly and offside FM is failed
- The FM subsystem is selected via its menu text prompt on the MENU page.

When Backup navigation is not available, no Select NAV B/UP nor Deselect NAV B/UP prompt is displayed. The field is blank. Upon Backup Nav deactivation, the Backup Nav functions are disabled and the FM is given back control of the Nav Display.

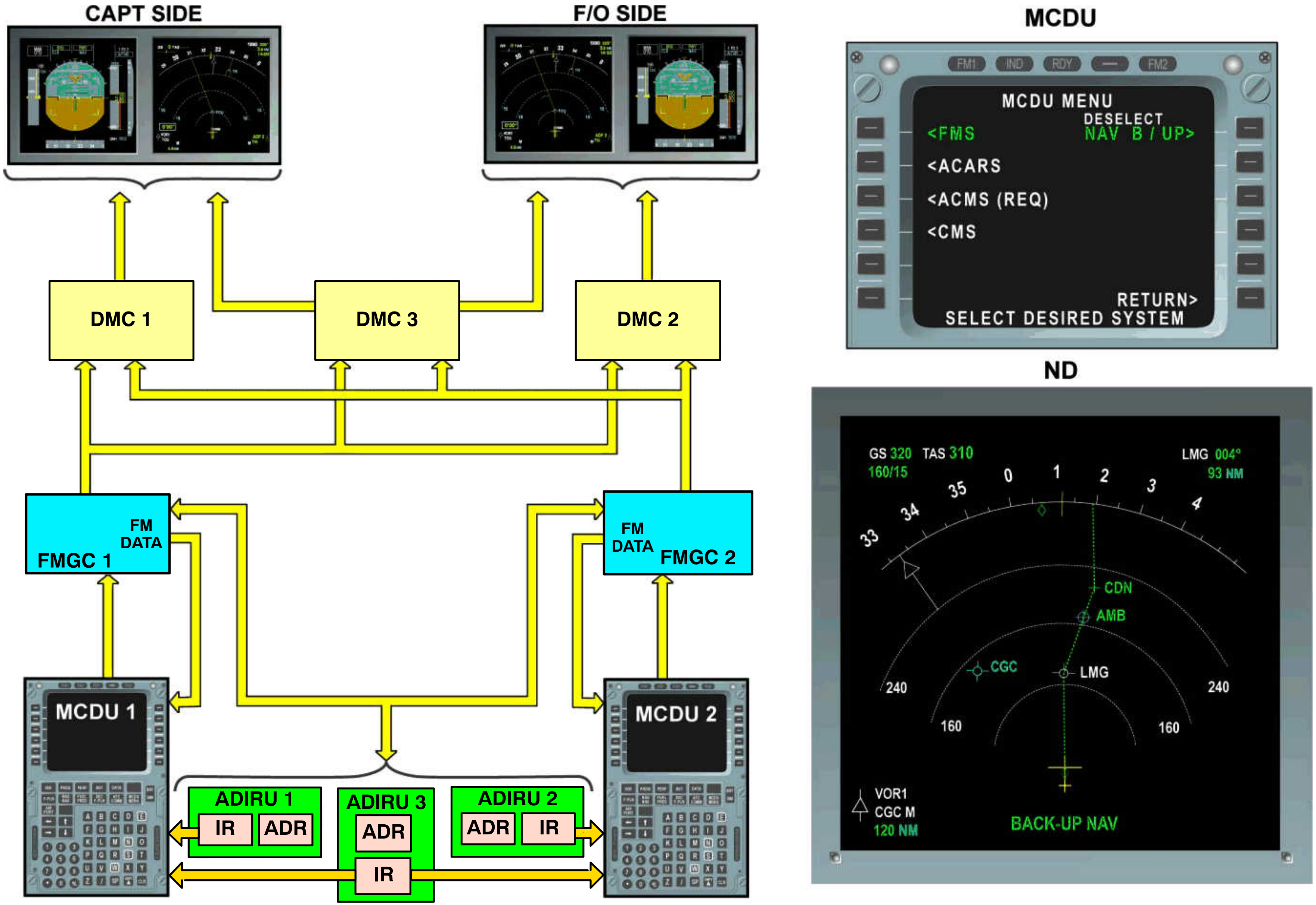


Figure 27 Back-Up Nav Mode

NAVIGATION DATABASE UPLOADING DESCRIPTION

NAVIGATION DATABASE

Overall navigation performance is mainly based on two elements. First, the accuracy of the aircraft position calculation and second, the validity of the flight path definition, as extracted from the navigation database.

The level of validation depends on the type of operations. For example, JAA TGL 10 requires that, for Precision RNAV in terminal area, providers and operators implement a quality assurance program for the navigation database, which may include a navigation database validation process. The highest level of validation is required for RNAV approach, with lateral and vertical navigation.

The navigation databases are revised every 28 days (ARINC cycle). Flights should be conducted with a navigation database that is within its cycle. This should be checked on the MCDU AIRCRAFT STATUS PAGE.

Dispatch with an Outdated Navigation Database

The FAA MMEL for Airbus aircraft have a provision for the dispatch of an aircraft with an outdated navigation database. The EASA MMEL does not have such a provision. This does not mean, however, that it is prohibited to dispatch with an outdated database. The EASA position is that this question is not MMEL relevant and should be addressed at the operational level by the operators with their national authorities.

Airbus recommends flying with an updated navigation database. However, in exceptional circumstances and for a limited period of time, an aircraft can continue to operate beyond the end data of the database cycle, provided it is approved by the national authorities.

The following precautions need to be considered:

- Prior to flight, identify recent changes on the intended route, with the navigation charts and manuals. Some ”strategic” new waypoints, not in the navigation database, may be worth entering as DEFINED WAYPOINT on MCDU.

  Flying with an outdated database, in an airspace that was recently restructured with numerous new waypoints, should be avoided.
- Check SID, STAR and approach procedures of departure, destination and required alternates for recent changes.

  Do not attempt to modify, or manually construct, terminal instrument procedures or approaches.
- Fly terminal instrument procedures and approaches with managed guidance, that are in the navigation database and that have been checked for accuracy. Otherwise, fly the procedure, or the approach, in selected guidance with conventional radio navaid raw data.

The standard FAA MMEL wording is provided below for reference:

SYSTEM & SEQUENCE NUMBERS	ITEM	1.	2. NUMBER INSTALLED	3. NUMBER REQUIRED FOR DISPATCH	4. REMARKS OR EXCEPTIONS
X) Navigation Databases		C	2	2	May be out of currency provided: a) Current Aeronautical Charts are used to verifiy Navigation Fixes prior to dispatch, b) Procedures are established and used to verify status and suitability of Navigation Facilities used to define route of flight, c) Approach Navigation Radios are manually tuned and identified, and d) RAW data is displayed and used as primary or data base is verified accurate for route flight.

Figure 28 FAA MMEL Excerpt

Performance Factors

IDLE and PERF factors follow the same principle. The PERF factor is mainly used for prediction during the cruise phase. The IDLE factor is dedicated to the FM descent segment. The PERF factor is a positive or negative percentage that is used to correct the predicted fuel flow used for computing fuel prediction within the FMGS. It is necessary when the aircraft's performance differs from the performance model stored in the FMGS database. The predicted fuel flow is modified according to the following formula:

FFpred = FFmodel (1 + PERF FACT/100). FFpred is the FF used for prediction and the FFmodel is the FF from the aero engine model.

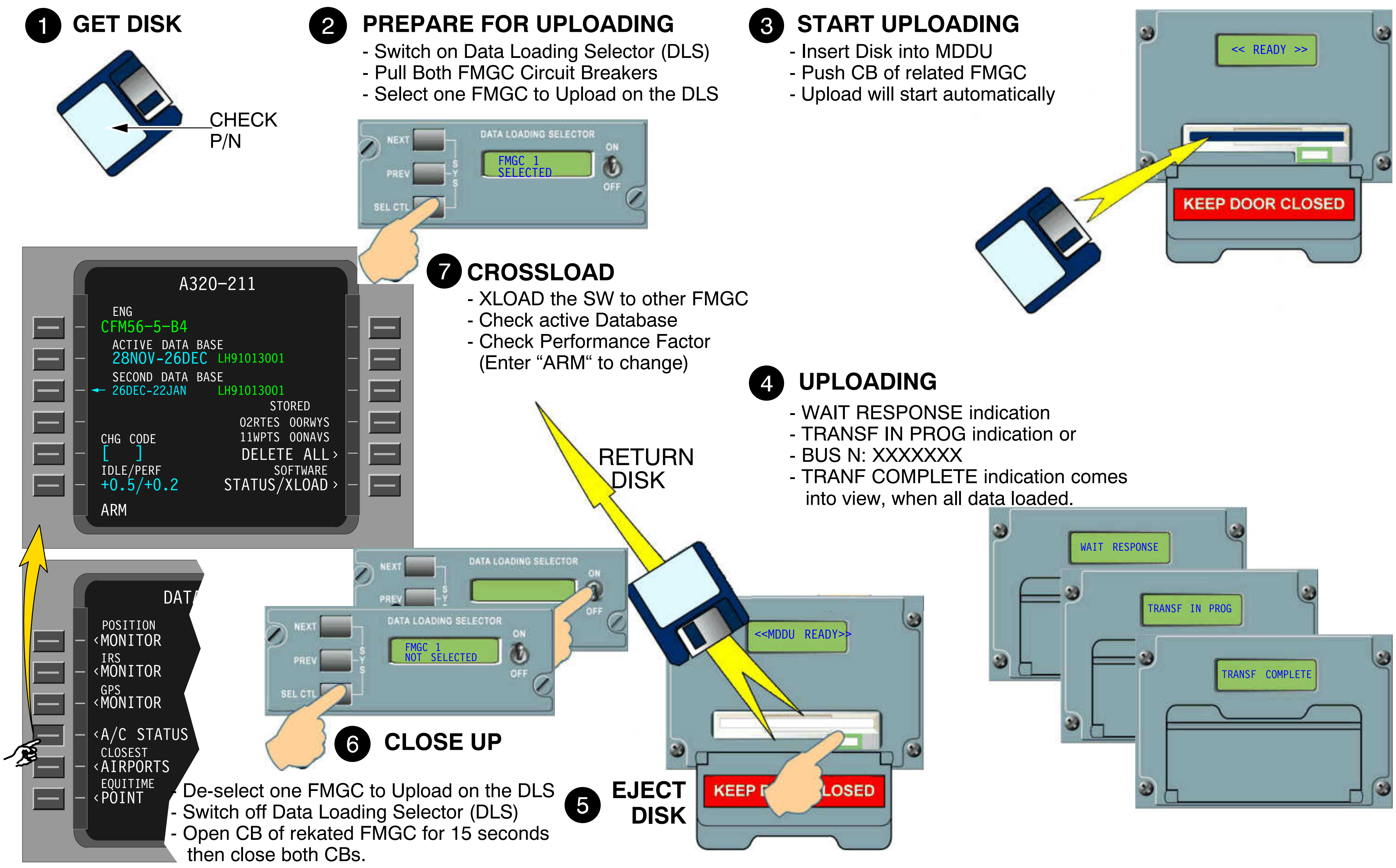


Figure 29 NAV DB Loading Procedure

22–81 FLIGHT CONTROL UNIT (FCU)

FCU DESCRIPTION

GENERAL

The Flight Control Unit (FCU) comprises the auto flight control section and the EFIS control sections. It is located on the glareshield. The FCU consists of two identical computers totally independent.

In general, the FCU provides the short term interface between the crew and the Flight Management and Guidance System (FMGS). The FCU is the main interface to engage functions and guidance modes and to select parameters.

The computers (SIDE 1 and SIDE 2) have separate power supplies. Each side is associated with the controls on the front panel of the unit. The display is common to both sides, whereas the signals are routed via separate paths.

There is one FCU panel which controls two identical processing channels:

FCU 1 and FCU 2. Only one channel is active at a time, the other is in standby. If both channels fail, all FCU controls are inoperative: A/THR, AP/Flight Director (FD) 1 and AP/FD 2 are not available.

FCU Description

The FCU comprises three panels:

- **One center panel (auto flight control section)** which features the controls and the displays associated with the AFS,
- **Two symmetrical panels (EFIS control sections)** located on the left side and on the right side of the center panel.

These panels include the controls and the displays associated respectively with the Captain and the First Officer EFIS display units.

Each part (or computer) of the FCU can manage the controls and the displays located on the front panel of the unit.

Architecture is configured to provide physical separation between the two channels and segregate electrical routing.

NOTE: After the two FCU circuit breakers are opened (during the FCU removal procedure), you may will to see the FCU displays for some time. This is because of the residual polarization of the liquid crystals.

NOTE: An FCU Reset procedure takes 7 minutes.

FCU Display

Here are listed some examples of function engagement, selection of required guidance modes and flight parameters.

The FCU allows:

- engagement of APs, FDs and A/THR,
- selection of guidance modes; e.g. HeaDinG, Vertical Speed (V/S) or TRacK, Flight Path Angle (FPA),
- selection and display of the various guidance targets whenever a manual selection is required (SPeeD – HDG – TRK – V/S – FPA – ALT).

S1/S31	BARO REFERENCE SELECTOR KNOB
S2/S32	in.Hg/hPa SELECTOR KNOB
S3/S33	MODE SELECTOR SWITCH
S4/S34	SCALE SELECTOR SWITCH (NM)
S5/S35	ADF1/VOR1 SELECTOR SWITCH
S6/S36	ADF2/VOR2 SELECTOR SWITCH
S7/S37	FD PUSHBUTTON SWITCH
S8/S38	(I)LS PUSHBUTTON SWITCH
S9/S39	CONSTRAINT PUSHBUTTON SWITCH
S10/S40	WAYPOINT PUSHBUTTON SWITCH
S11/S41	VOR/DME PUSHBUTTON SWITCH
S12/S42	NDB PUSHBUTTON SWITCH
S13/S43	AIRPORT PUSHBUTTON SWITCH
DS1	CAPTAIN BARO DISPLAY
DS2	FCU DISPLAY
DS3	FIRST OFFICER BARO DISPLAY

S15	SPEED/MACH SELECTOR KNOB
S16	HEADING/TRACK SELECTOR KNOB
S17	ALTITUDE SELECTOR SWITCH
S18	100FT/1000FT ALTITUDE SELECTOR SWITCH
S19	VERTICAL SPEED/FLIGHT PATH ANGLE SELECTOR KNOB & PUSH TO LEVEL OFF
S20	LOCALIZER APPROACH P/BSW
S21	HDG-VS/TRK FPA PUSHBUTTON SWITCH
S22	AUTOPILOT 1 PUSHBUTTON SWITCH
S23	AUTOPILOT 2 PUSHBUTTON SWITCH
S24	AUTOTHRUST PUSHBUTTON SWITCH
S25	EXPEDITE PUSHBUTTON SWITCH (OPTION)
S26	METRIC ALTITUDE PUSHBUTTON SWITCH
S27	APPROACH PUSHBUTTON SWITCH
S28	SPEED/MACH PUSHBUTTON SWITCH

Figure 30 Flight Control Unit

FCU SYSTEM DESCRIPTION

SPEED/MACH REFERENCE CONTROL KNOB

The SPD/MACH reference control knob can be pushed or pulled.

It is spring−loaded to neutral. It can also be turned.

Pulled - Selected

When pulled, the Flight Management and Guidance Computer (FMGC) uses a selected reference speed which is displayed on the FCU. The associated managed SPD/MACH dot light is off.

- if the speed window was previously dashed, the value which appears is generally the last managed reference speed,
- if not, there is no change in the window.

Turned

When turned, it changes the displayed speed.

- if a speed was previously displayed, the selected reference speed is modified,
- if the speed window was previously dashed, the first click changes the dashes into the managed reference speed.

  When turned more, this value changes. If the knob is not pulled within 45 seconds the display reverts to dashes.

Pushed - Managed

When pushed, dashes are displayed and the associated managed SPD/MACH dot light comes on. The FMGC uses a managed reference speed.

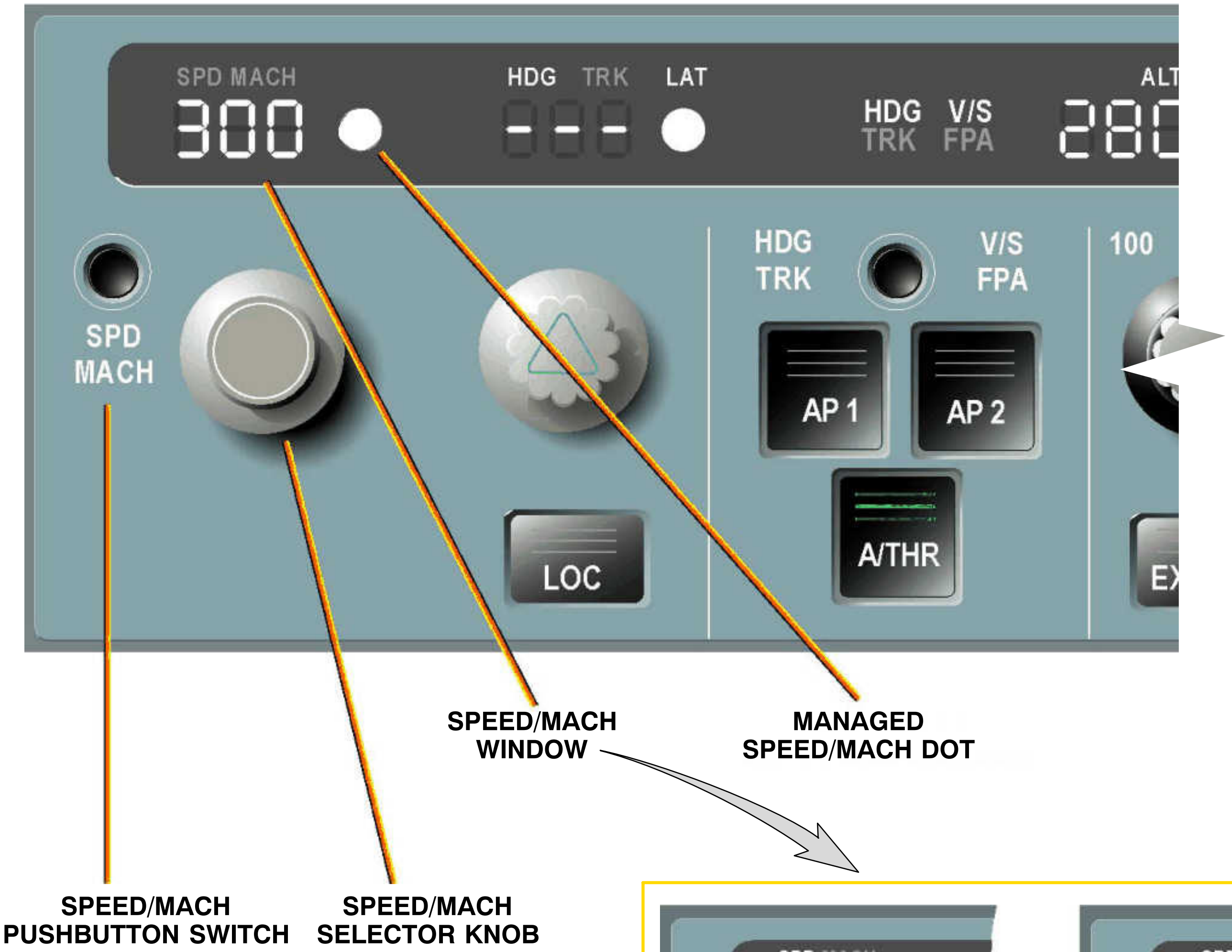
- if dashes are displayed, there is no change,
- if a speed was previously displayed, dashes appear and the light comes on. The reference becomes a managed speed.

NOTE: For Takeoff/Go Around (TOGA) and EXPEDite, the FMGS automatically uses memorized speeds such as V2, VAPProach and green dot. Dashes are displayed and the light is on.

SPEED/MACH SWITCHING

The SPD/MACH P/BSW is only active when a value is displayed in the speed window. In all cases, the SPD/MACH switching is automatic.

The pilot can only perform the switching using the SPD/MACH P/BSW when the reference is selected. The appropriate indication, SPD or MACH is then displayed.



SPEED/MACH Control Area

SPEED/MACH Window

- shows selected SPD or MACH in "selected guidance"
- shows after PWR UP: SPD 100
- "- - -" in "managed guidance"
- Display range: between 100 and 399 KT for speed, between 0.10 and 0.99 for MACH number

SPD/MACH Selector Knob

- Knob pushed: engaged SPD/MACH for "managed guidance"
- Knob pulled: engaged SPD/MACH for "selected guidance"

SPD/MACH Pushbutton Switch

- Depressing this pb changes SPD target to corresponding MACH target and vice versa
(automatic on FL 305)

Figure 31 FCU - Speed/Mach Control Area

HEADING/TRACK LATERAL CONTROL KNOB FUNCTION

The LATeral control knob can be pushed or pulled. It is spring−loaded to neutral. It can also be turned. The LAT window displays a value when HDG or TRK mode is active or when a HDG or TRK preset has been performed. It is dashed in all other cases. The light is on when a managed lateral mode is armed (e. g. NAV, RWY, LAND...)

Pulled - Selected

When pulled, HDG or TRK mode engages with a reference displayed on the FCU. The associated light is off.

- if the LAT window was previously dashed, the value which appears is the present HDG or TRK,
- if not, there is no change in the window.

Turned

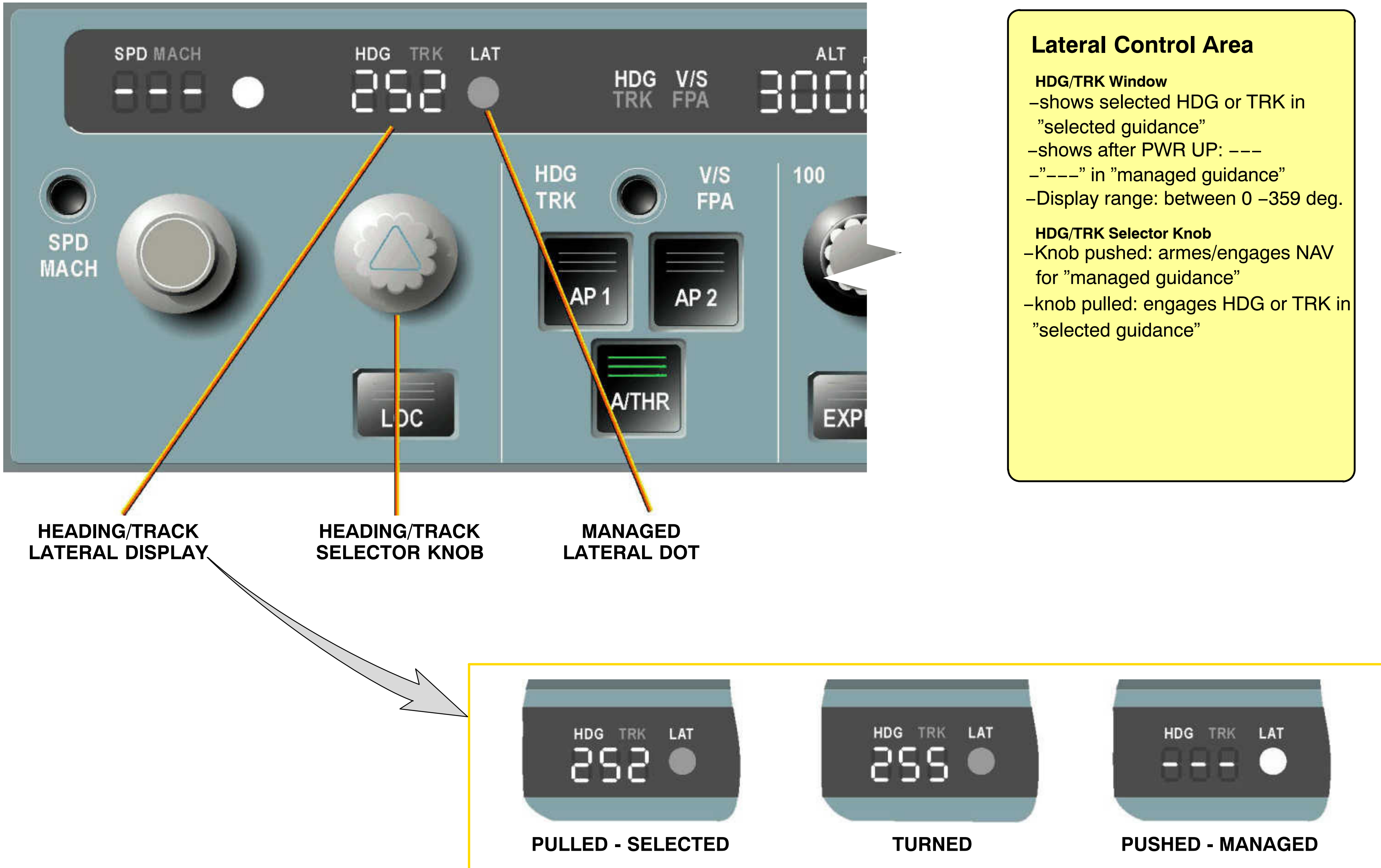
When turned, it changes the displayed HDG or TRK,

- if a HDG or TRK was previously displayed, the selected reference is modified,
- if the LAT window was previously dashed, the first click changes the dashes into the present A/C HDG or TRK. When turned more, the value changes. If the knob is not pulled within 45 seconds the display reverts to dashes.

Pushed - Managed

When pushed, the navigation (NAV) mode is armed. During the arming phase, the HDG or TRK is displayed until interception of the flight plan.

Then, dashes will replace the HDG or TRK. During the arming and active phases, the light is on.



Lateral Control Area

HDG/TRK Window

–shows selected HDG or TRK in ”selected guidance”
–shows after PWR UP: ---
–”---” in ”managed guidance”
–Display range: between 0 –359 deg.

HDG/TRK Selector Knob

–Knob pushed: armes/engages NAV for ”managed guidance”
–knob pulled: engages HDG or TRK in ”selected guidance”

Figure 32 FCU - Lateral Control Area

ALTITUDE SELECTOR KNOB FUNCTION

The outer knob has 2 selectable positions, 100 feet and 1000 feet.

The inner knob sets the altitude in the FCU altitude window with increments depending on the outer knob position. The inner knob can be pushed or pulled and is spring–loaded to neutral. It can also be turned.

Pulled - Selected

When pulled, OPen CLimB or OPen DEScent mode engages if the displayed altitude is different from the present aircraft altitude.

The LeVeL/CHange light is off. Aircraft immediately climbs or descends towards the selected altitude.

Turned

When turned, the displayed altitude changes by thousands or hundreds feet, depending on the outer knob selection.

Pushed - Managed

When pushed, CLB or DES mode engages if the displayed altitude on the FCU is different from the present aircraft altitude. The level change is managed and the LVL/CH light is on.

NOTE: The ALT window always displays a target value selected by the crew. The window is never dashed.

METRIC ALTITUDE PUSHBUTTON SWITCH

This METRIC ALT P/BSW is used to display the FCU altitude target in meters in the lower part of the lower ECAM display unit and optionally to display the target and current altitude in meters on PFD.

NOTE: The target altitude on the FCU is always in feet.

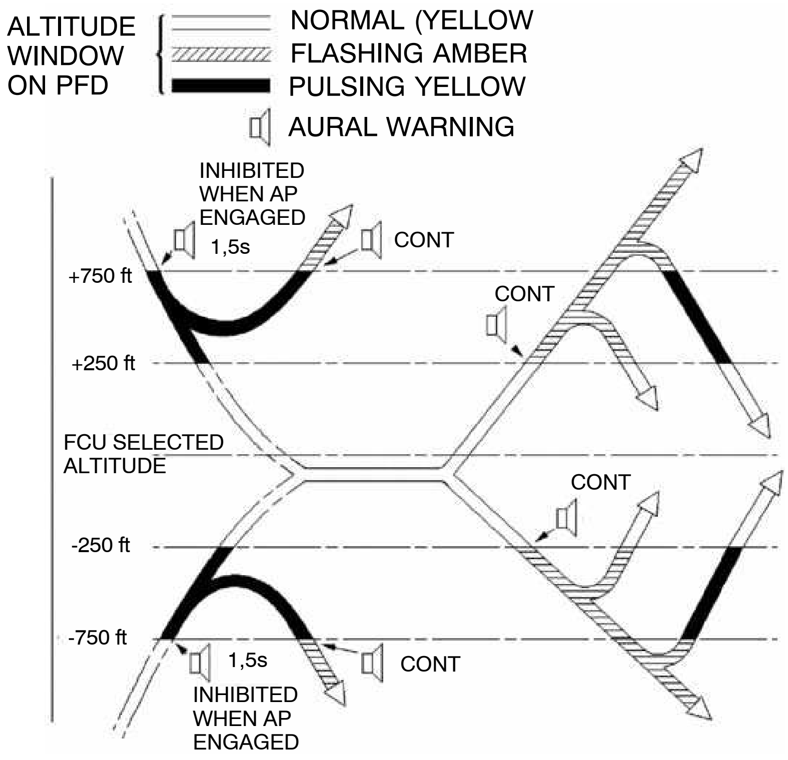
ALTITUDE ALERT FUNCTION

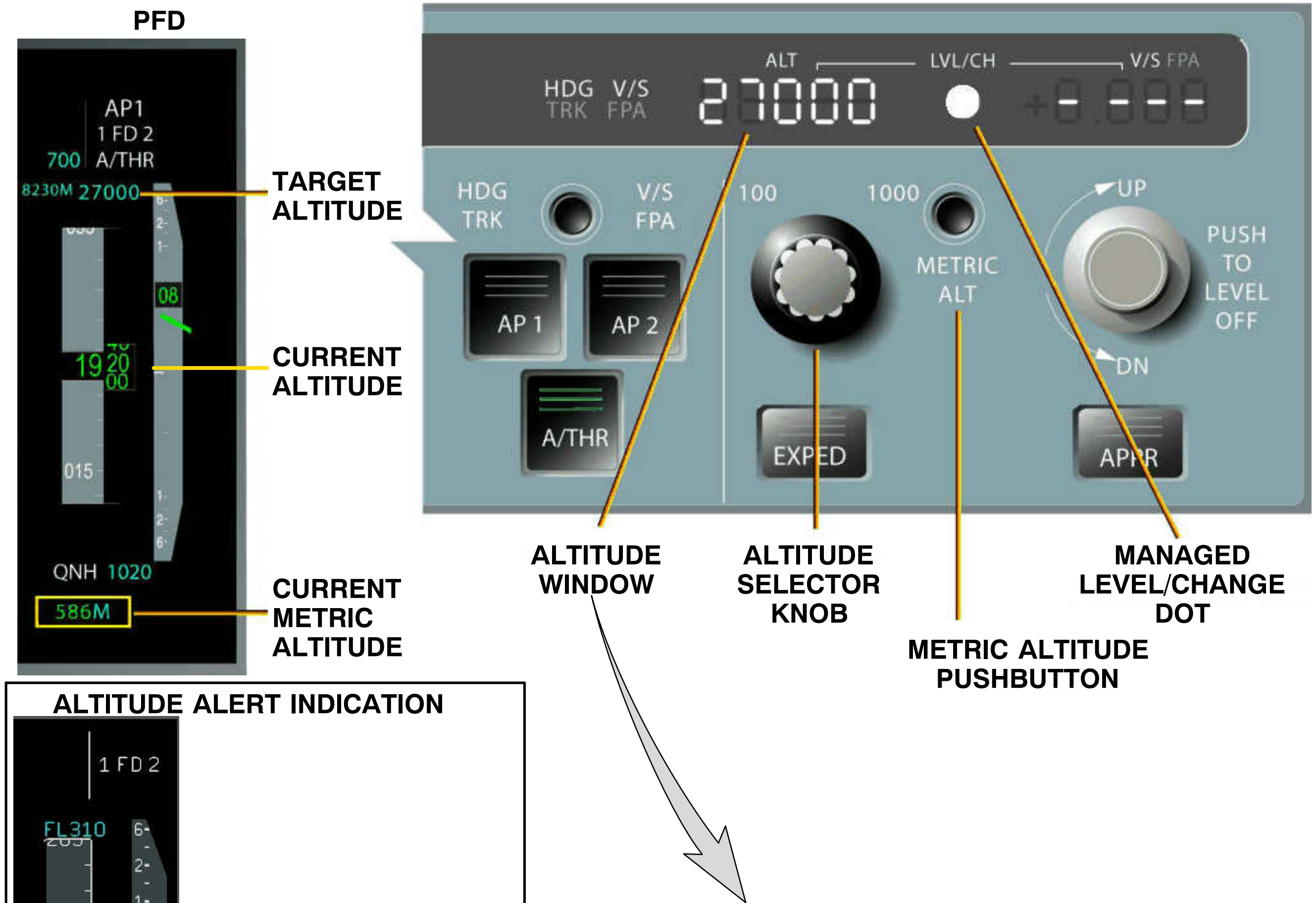
The FWC generates an altitude warning (C chord sound and altitude window of PFD pulsing yellow or flashing amber) when the aircraft approaches a preselected altitude or flight level or when it deviates from its selected altitude or flight level.This warning results from a comparison between the altitude (ADIRS) and the preselected altitude displayed on FCU.

- The selection of a new altitude cancels the continuous C chord, as does the crew‘s pushing the EMER CANC pushbutton of the ECAM control panel or the pressing either MASTER WARN pushbutton.
- The selection of a new altitude stops the flashing of the altitude window.

The altitude alert is inhibited :

- when the slats are out with landing gear is selected down, or
- in approach after the aircraft captures the glide slope, or
- when the landing gear is locked down.





Vertical Control Area (1)

Altitude Window

–always displays a target value selected by the crew. The window is never dashed

Altitude Selector Knop (outer & Inner)

–outer knob has 2 selectable positions: 100ft or 1000ft

–inner knob sets the altitude in the FCU window

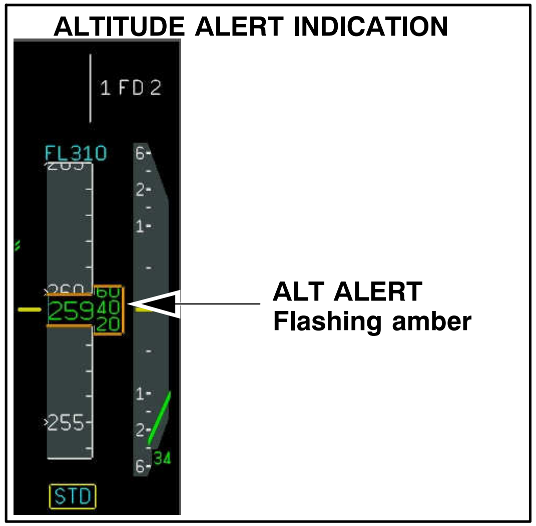
–knob pushed: CLB / DES

–knob pulled: OPEN CLB / OPEN DES

Metric Altitude Pushbutton Switch

–is used to display the FCU altitude target in meters on the ECAM

–on aircraft equipped with the enhanced EIS2 target and current altitude will be indicated on the PFD.



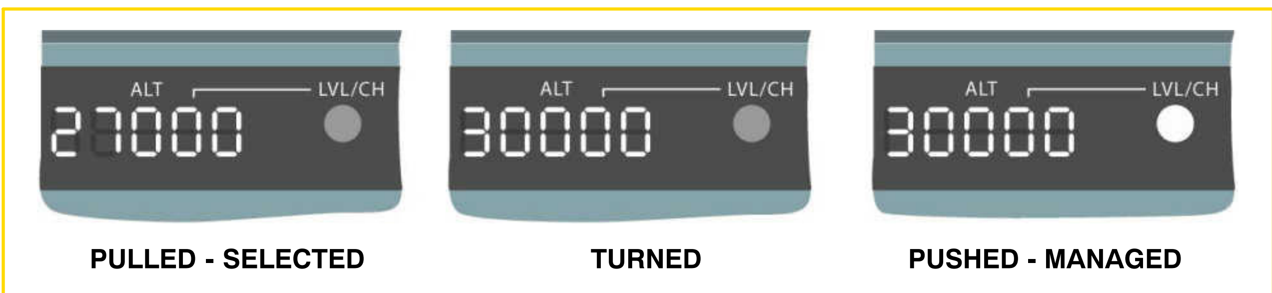


Figure 33 FCU - Vertical Control Area (1)

VERTICAL SPEED/FLIGHT PATH ANGLE CONTROL KNOB FUNCTION

The V/S FPA control knob can be pushed or pulled. It is spring−loaded to neutral. It can also be turned.

Pulled

When pulled, V/S or FPA mode engages with a reference displayed on the FCU. The level change light is off.

If the associated window was previously dashed, the value which appears is the present V/S or FPA.

The ranges are:

- between −9.9 DEG and +9.9 DEG for FPA,
- between −6000 and +6000 feet per minute for V/S.

Turned

When turned, it changes the displayed V/S or FPA. If the associated window was previously dashed, the first click changes the dashes into the present A/C V/S or FPA. When turned more, the value changes.

If the knob is not pulled within 45 seconds, the display reverts to dashes.

Pushed - Level Off

Pushing the V/S FPA rotary knob will command an immediate level off by engaging the V/S FPA mode with a zero target as displayed in the FCU window.

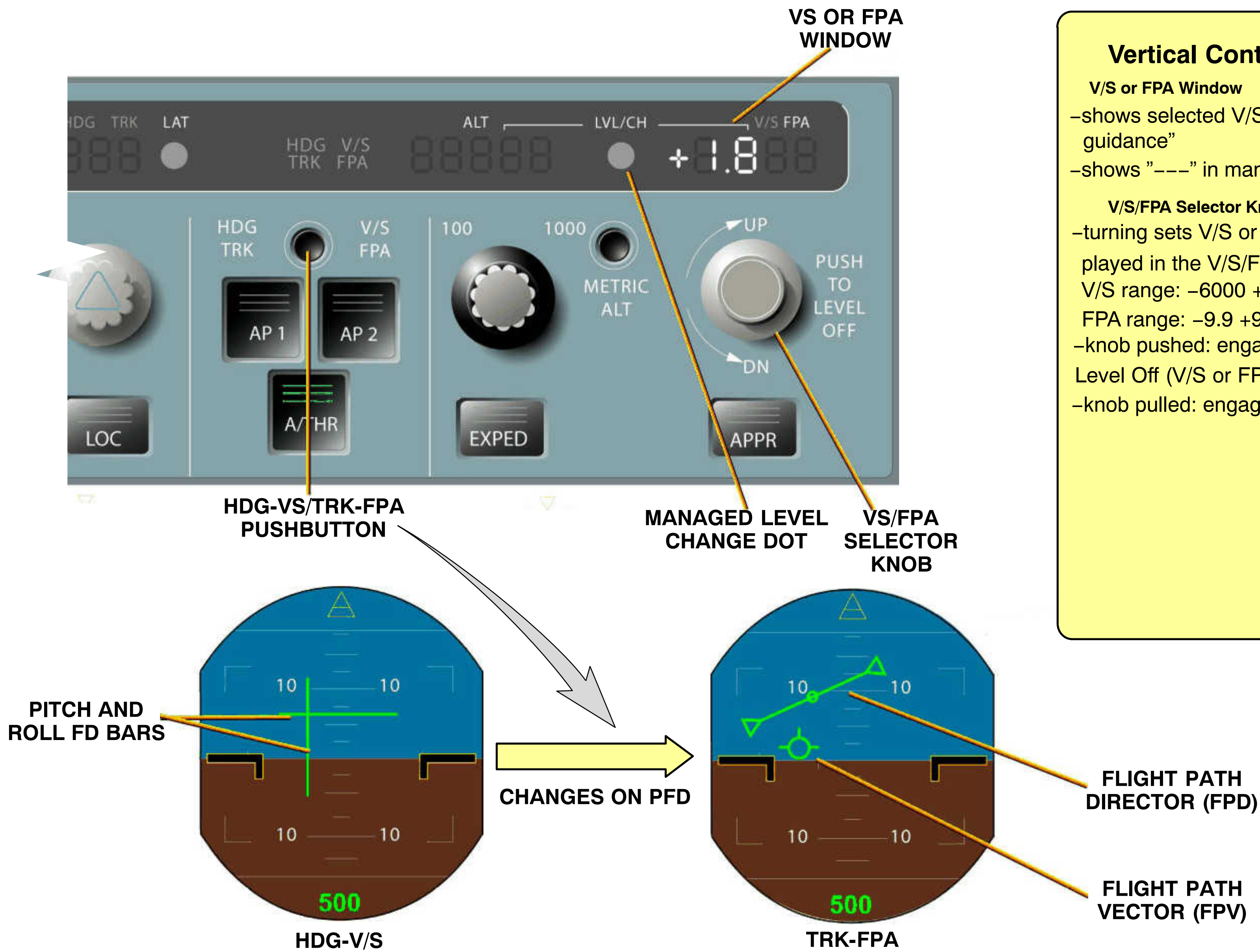
Flight Mode Annunciator (FMA) annunciation will turn to ALT green when levelled off. Any new setting of a V/S or FPA (selector turned) will lead to A/C movement accordingly.

HEADING−V/S TRACK−FPA SWITCHING P/BSW

This P/BSW allows selection of HDG and V/S or TRK and FPA modes.

If any of the modes (HDG, V/S, TRK, and FPA) are active, pressing the P/BSW changes the mode(s) into the corresponding one(s). Pressing the P/BSW changes the HDG−V/S into TRK−FPA on the center of the FCU and vice versa.

NOTE: The FD symbols on the PFD changes and the Flight Path Vector (FPV) and the Flight Path Director (FPD) appears.



Vertical Control Area (2)

V/S or FPA Window

–shows selected V/S or FPA in ”selected guidance”
–shows ”– – –” in manged guidance

V/S/FPA Selector Knob

–turning sets V/S or FPA value to be dis– played in the V/S/FPA window.
V/S range: –6000 +6000 ft/min
FPA range: –9.9 +9.9 deg.
–knob pushed: engages an immediate Level Off (V/S or FPA=0)
–knob pulled: engages V/S or FPA mode

Figure 34 FCU - Vertical Control Area (2)

FCU ENGAGEMENT P/B SWITCHES FUNCTION

AP1 & 2 ENGAGEMENT P/BSW

The AP1 or 2 can be engaged five seconds after lift off, by pressing the related P/BSW. During flight only one AP can be engaged. When the approach mode is armed both autopilots may be engaged for a fail operative automatic landing.

Pressed on:

- AP engagement is confirmed by the three green bars coming on.

Pressed off:

- The related autopilot disengages.

A/THR ENGAGEMENT P/BSW

When pressed on, the A/THR P/BSW manually engages the autothrust function, provided the aircraft is not on the ground with the engines running.

Pressed on:

- A/THR engagement is confirmed by the three green bars coming on.

Pressed off:

- The A/THR function disengages.

NOTE: On ground, A/THR is automatically engaged when take−off is initiated with the thrust levers.

EXPEDITE ENGAGEMENT P/BSW (OPTIONAL)

The EXPED mode can be engaged either to climb or descend, by pressing the EXPED P/BSW.

Pressed on:

- The EXPED engagement is confirmed by the three green bars coming on. This function allows maximum climb or descent profile within the performance envelope of the aircraft.

Disengagement is only possible by engagement of another longitudinal mode.

NOTE: The EXPED function can be optionally deleted. In this case, the associated EXPED pushbutton is also removed.

APPROACH ENGAGEMENT P/BSW

When pressed on, the APPRoach P/BSW arms the LANDing mode.

Pressed on:

- Glide/Slope and LOCalizer modes are armed for capture and tracking if ILS is available, or APPR NAV/FINAL if ILS is not available,

Pressed off:

- Above 400 ft, LAND or APPR NAV mode is disarmed or disengaged.

NOTE: Below 400 ft, LAND mode can only be disengaged by activating GO−AROUND.

LOCALIZER ENGAGEMENT P/BSW

When pressed on, the LOC P/BSW arms the LOC mode.

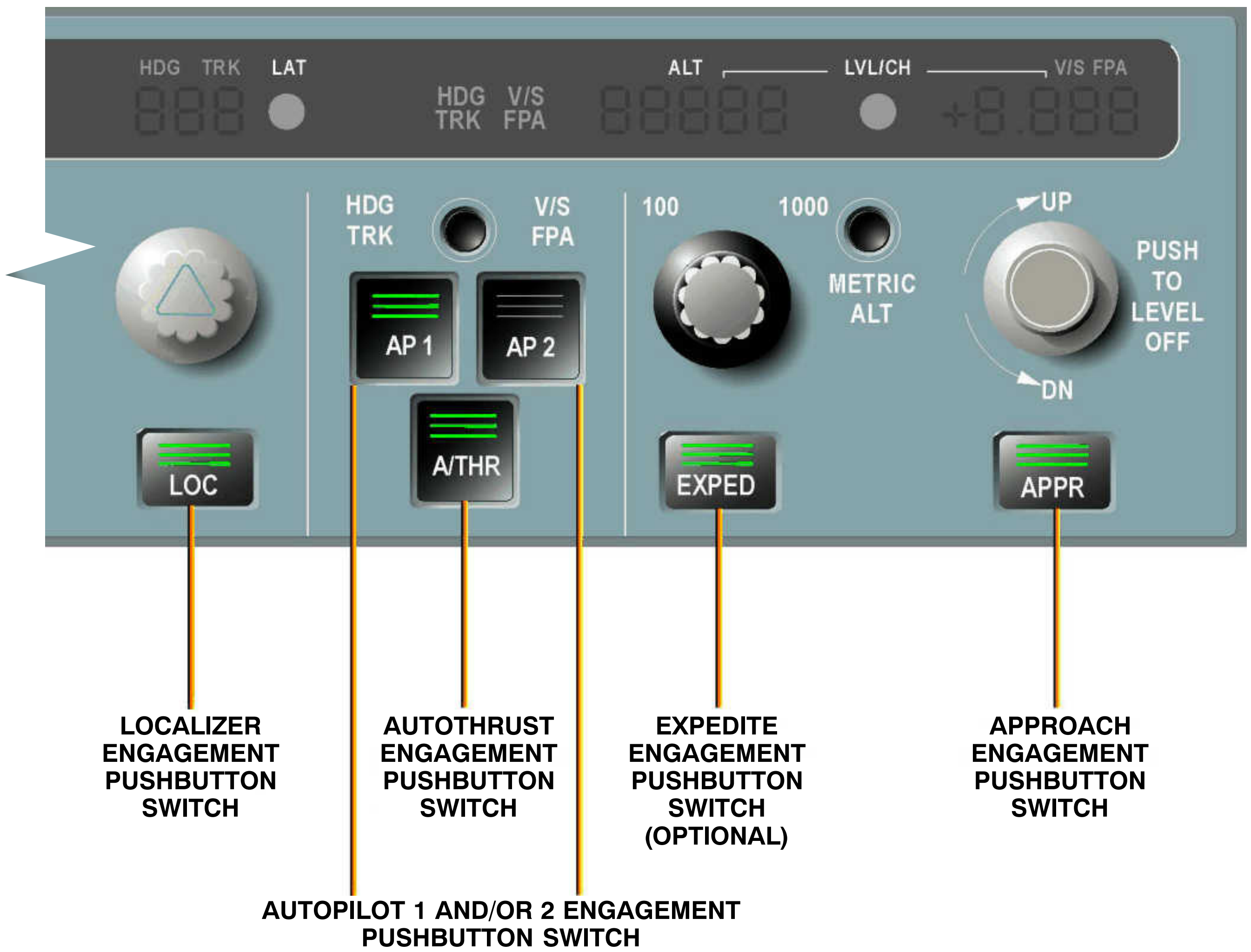
Pressed on:

- LOC mode is generally used when the G/S is not available,

Pressed off:

- before capture, localizer mode is disarmed,
- after capture, localizer mode is disengaged.

In this case the HDG/TRK mode is engaged on the present aircraft heading/track.



Engagement Pushbuttons

Localizer Engagement Switch

-arms, engages or disengages the LOC approach mode

AP1 or AP2 Pushbutton Switch

–engages or disengages autopilot function

–illuminated green when the AP is engaged

Autothrust Pushbutton Switch

–arms, activates or disconnects the autothrust

–illuminated green if the A/THR is armed or active

Expedite Engagement Switch (Optional)

-engages the EXPEDITE CLIMB or DESCENT mode.

Approach Mode Pushbutton Switch

-arms, disarms engages or isengages approach modes.

Figure 35 FCU - Engagement Pushbutton Switches

22−10 AUTOPILOT/FLIGHT DIRECTOR (AP/FD)

SYSTEM DESCRIPTION

The Auto Flight System (AFS) installed on the aircraft is made up of two types of computers:

- the Flight Management and Guidance Computer **(FMGC)**,
- the Flight Augmentation Computer **(FAC)**,

and two types of control units:

- the Flight Control Unit **(FCU)**,
- the Multipurpose Control and Display Unit **(MCDU)**.

CONTROLS

Flight Control Unit (FCU):

- This unit transmits the modes and the references selected by the pilots to the FMGCs. It also enables the selection of the displays on the EFIS display units and the display of the standard baro value for the ADIRUs.

Multipurpose Control and Display Units (MCDU):

- These units permit to enter and display a flight plan and the control parameters required by the FMGCs for flight control.

Takeover and priority pushbutton switches:

- These pushbutton switches identified 8CE1 and 8CE2 are used for AP disconnection and taking of priority in manual control. They are located on the side stick controllers.

Pitch and roll lock solenoids:

- These two solenoids identified 12CA1 and 12CA2 are associated with four side stick lock relays 21CA, 22CA, 23CA and 24CA. They are active when the AP is engaged. They increase the load threshold on the pitch and roll axes.

Thrust control levers:

- These control levers are used by the AP/FD system to engage the TAKEOFF and GO AROUND modes.

Rudder artificial feel solenoid 16CA:

- This solenoid serves to increase the threshold of the rudder artificial feel in the vertical stabilizer. This solenoid is associated with two relays 15CA1 and 15CA2 in the avionics compartment.

AP/FD Functions

The autopilot (AP) and the flight director (FD) functions are:

- stabilization of the aircraft around its center of gravity when the AP/FD system holds vertical speed or flight path angle and heading or track,
- acquisition and hold of a flight path,
- guidance of the aircraft at takeoff by holding runway axis and speed (available in the FD as long as the aircraft is on ground),
- automatic landing and go around.

The autopilot gives orders to control:

- the position of the control surfaces on the three axes: pitch, roll and yaw,
- the position of the nose wheel.

These orders are taken into account by the FACs, ELACs, SECs and BSCU.

The flight director generates guidance orders used in manual control. These orders are displayed on the Primary Flight Displays (PFD) through the Display Management Computers (DMC).

AP/FD Engagement

The AP can be engaged only after takeoff. In cruise, one AP only can be engaged. In ILS approach (landing and roll out included) and in go around, the two APs can be engaged. The AP is engaged by means of the AP1 and AP2 pushbutton switches located on the FCU. In dual−AP operation, the AP1 is active, the AP2 is in standby. With one AP engaged, the controls (side stick controllers and rudder pedals) have an increased load threshold.

The flight director is engaged automatically when the aircraft electrical network is energized. The FD1 orders generated by the FMGC1 control the FD symbols of the CAPT PFD through the DMCs. The FD2 orders generated by the FMGC2 control the FD symbols of the F/O PFD. In case of FMGC failure, the remaining FMGC controls the two PFDs.

The FD orders on the PFDs can be cancelled by means of the FD pushbutton switches located on the FCU. An FD remains engaged as long as its orders are displayed at least on one PFD. The FD orders can be displayed in two ways as a function of the HDG−V/S/TRK-FPA selection made on the FCU.

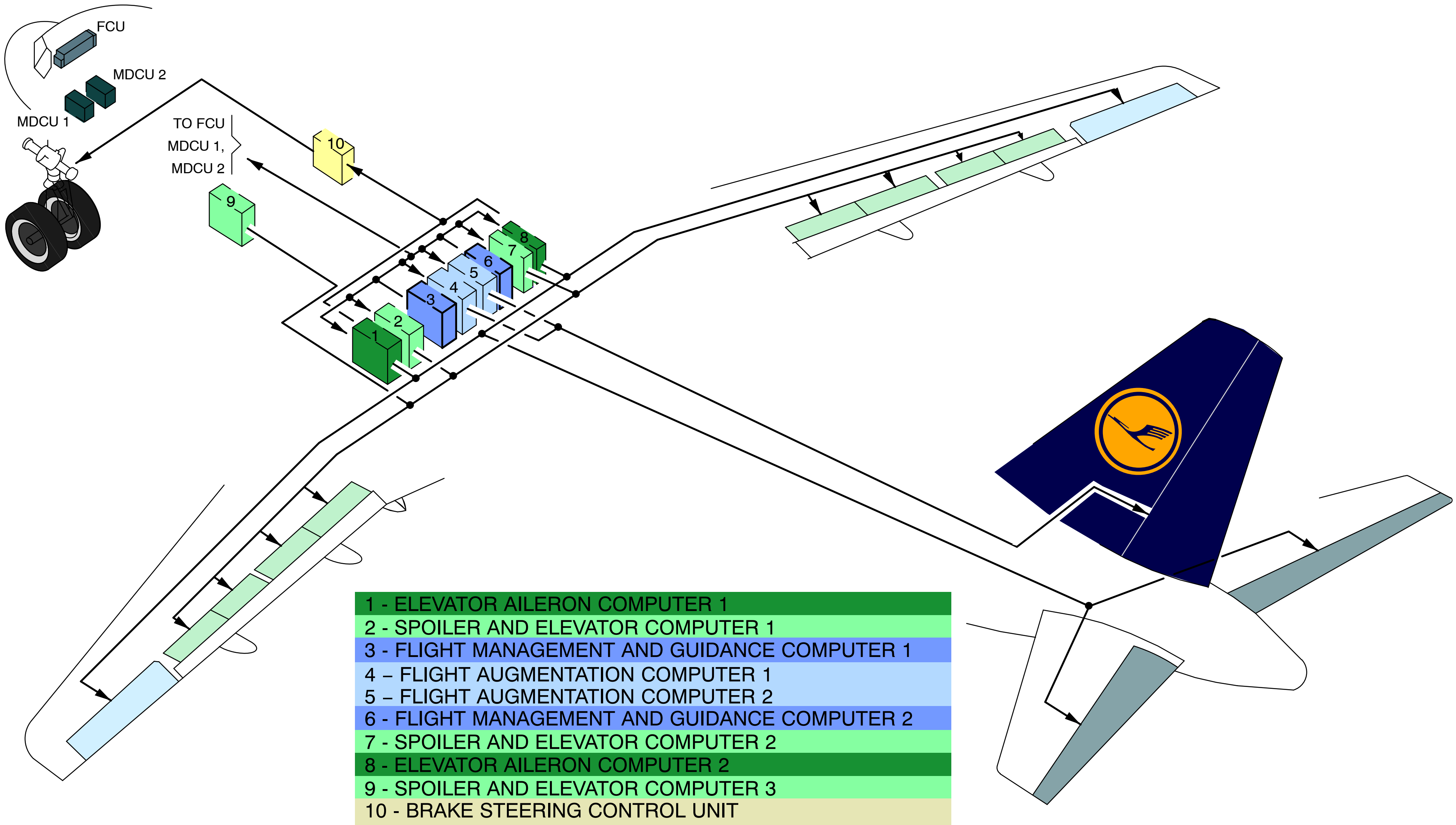


Figure 36 AP/FD Layout & FLT CTRL Components

FMGS ARCHITECTURE

MODES

There are lateral modes and vertical modes.

Basically, one of each is chosen by the pilot or by the system.

The AP being engaged, a lateral mode and a vertical mode are simultaneously active.

According to the flight phases, the **lateral mode** controls the aileron via Elevator Aileron Computers (ELACs), the spoilers via ELACs and Spoiler Elevator Computers (SECs), the rudder via Flight Augmentation Computers (FACs) and the nose wheel via ELACs and the Braking/Steering Control Unit (BSCU).

The **vertical mode** controls the elevators via ELACs.

Autopilot Operation on Ground

For maintenance purposes, the autopilot can be engaged on the ground only with both engines shut down.

Hydraulic power is not required.

When an engine is started, the autopilot disengages.

Autopilot Operation at Take−Off

The autopilot can be engaged in flight, provided the aircraft has been airborne for at least 5 seconds.

Before autopilot engagement, take−off modes can be active for the flight director.

Autopilot Operation at Cruise

In cruise, only one autopilot can be engaged at a time. Ailerons and Spoilers execute the orders of lateral modes, Elevators execute the orders of vertical modes.

Engaging a second AP in cruise disengages the other one.

NOTE: The rudder is not controlled directly by the AP, but by Flight Augmentation Computer (FAC) functions.

Autopilot Operation during Landing

If the airfield is equipped with ILS installations, the autopilot can perform an automatic landing (called CAT III approach with no Decision Height), roll out included.

CAT II or CAT III operation is allowed only, if:

- authorized for the runway to be used, and
- both pilots fulfil the qualification requirements as stated in OM−A 5.1.4.4., and
- in compliance with relevant system limitations (OM−B, chapter 1.20), and with the list of "Airborne Equipment Required for CAT II/III Approach", and
- the airplane capability (CAT II or CAT III) is not cancelled by maintenance.

In addition, the autopilot controls the rudder via the Flight Augmentation Computer.

- **ILS approach:**
  - AP is able to perform a complete landing with descent, flare and roll out. A second AP can be engaged (AP 1 active, AP 2 backup).

After landing, the autopilot gives steering orders for the nose wheel.

- **Roll out:**
  - Steering order to rudder and nose gear depend on aircraft speed. Ailerons and spoilers AP orders are zero.

    NOTE: Spoilers are directly controlled by SECs as airbrakes.

    The pilot normally disengages the AP function(s) by pressing a take over pushbutton located on the side stick at the end of the Roll out, when leaving the runway at the latest (OMB 2−2−85).

If the airfield has no glide slope installation, the pilots can select a LOC or a NAV approach, but the autopilot is disengaged at a given altitude.

- **LOC** (without glide) or NAVigation approach:
  - same principles as for cruise. Pilots have to disengage AP at a given altitude in order to land manually.

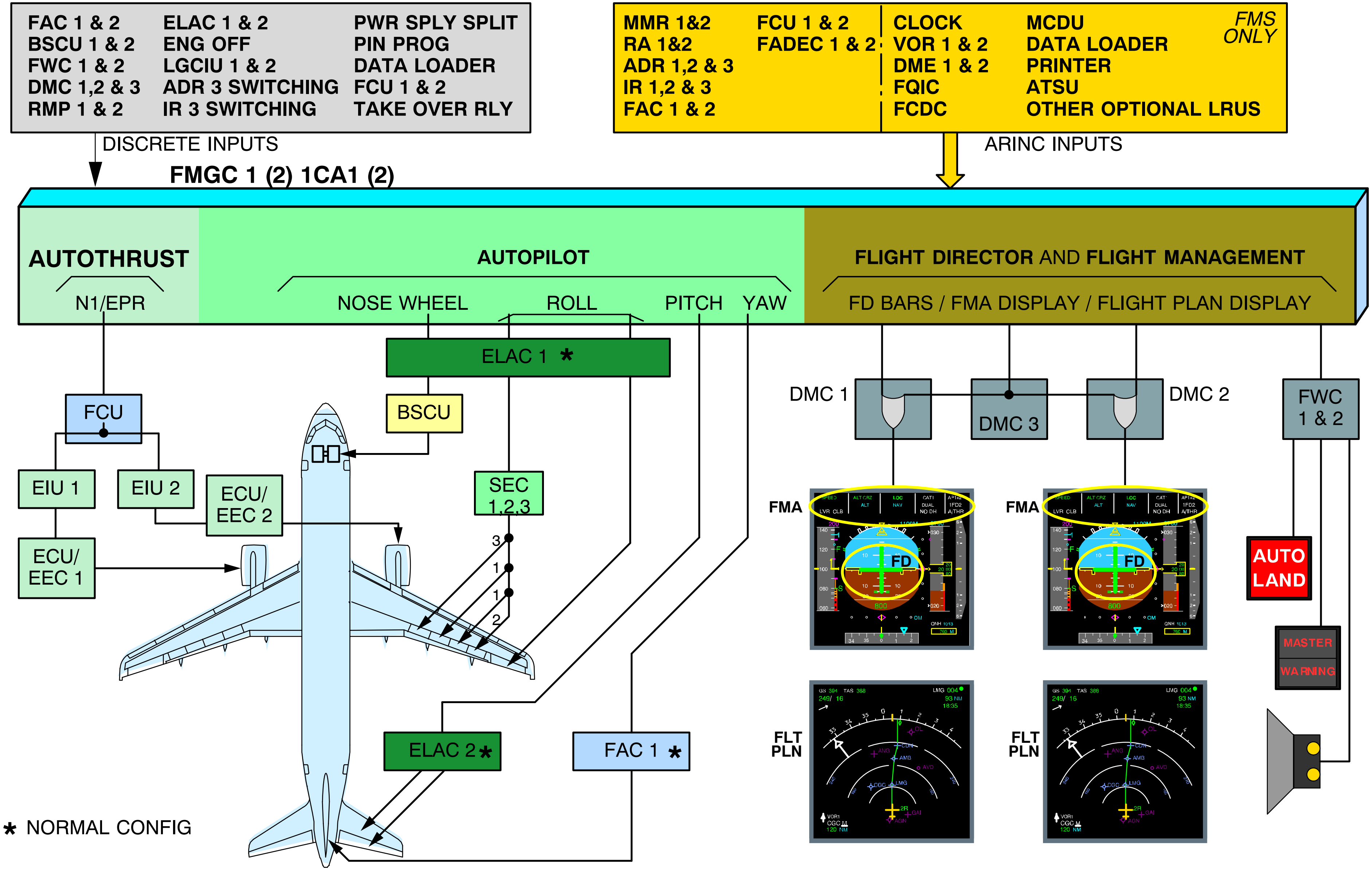


Figure 37 FMGS Architecture

FCU CHANGEOVER SYSTEM OPERATION

FCU CHANGEOVER

In order to ensure segregation of barometric selections and displays, the CAPT and F/O BARO parameters are controlled, in normal operation, independently by the two different FCU processors.

If both FCUs are healthy, the FCU 1 is active and controls:

- Capt BARO selection,
- AFS display,
- AFS and EFIS pushbutton switches,
- as well as ARINC 1 bus.

The FCU 2 controls only :

- F/O BARO selection,
- and ARINC 2 bus.

When FCU 1 is failed, there is a changeover on FCU 2 which becomes full active. It then controls the whole FCU.

When FCU 2 is failed, FCU 1 remains active and also controls F/O BARO selection and ARINC 2 bus.

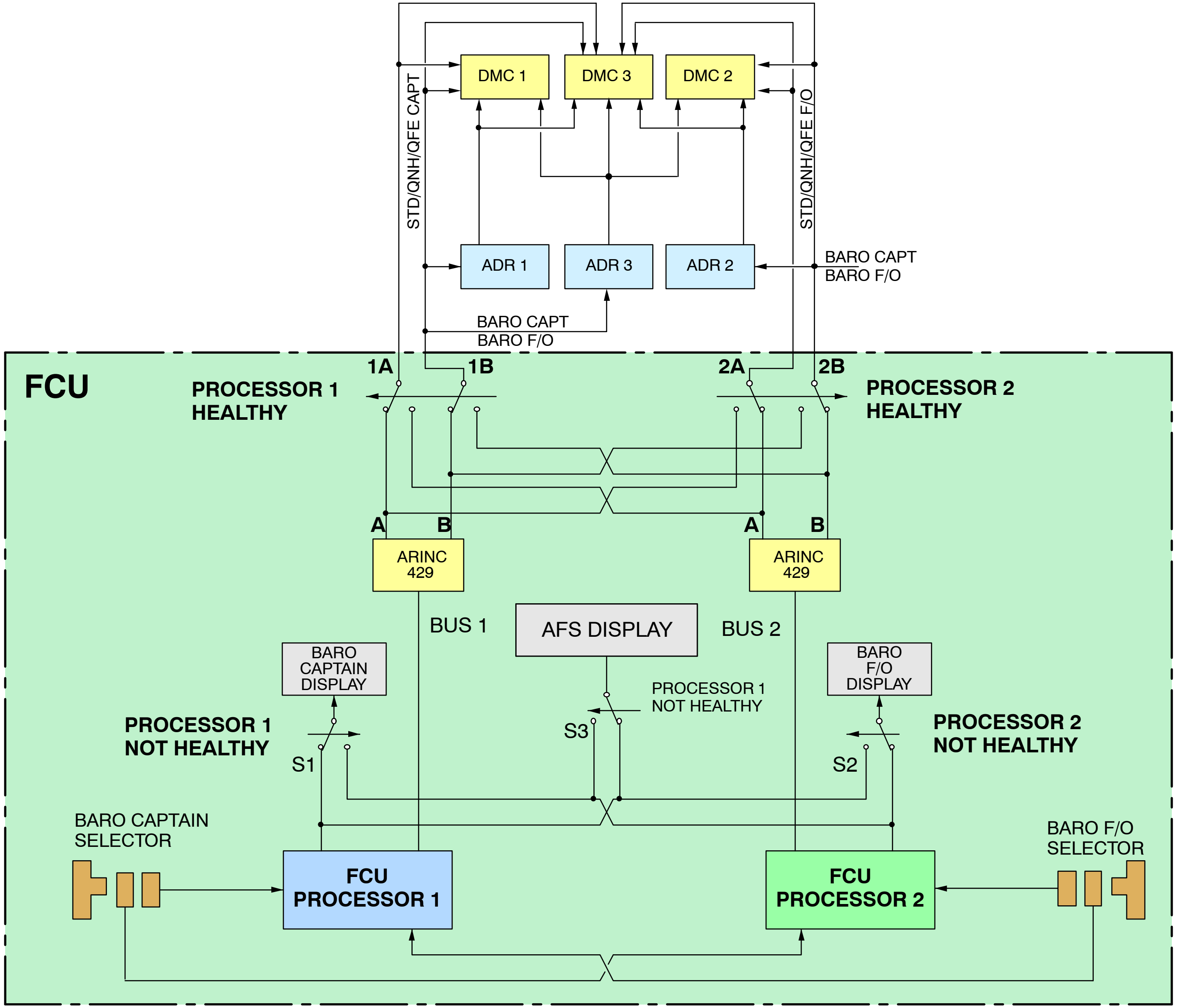


Figure 38 FCU Changeover Block Diagram

FLIGHT DIRECTOR INDICATION

ENGAGEMENT

The Flight Director (FD) functions are engaged automatically as soon as the system is electrically supplied and logic conditions are fulfilled.

FD engagement is indicated on the Flight Control Unit (FCU) by the FD P/BSW green bars and on the top right of each PFD. 1FD2 indication is displayed on each PFD to show that FD1 is engaged on the CAPT side and FD2 is engaged on the F/O side.

PRINCIPLE

The FD displays the Flight Management and Guidance Computer (FMGC) guidance commands on both PFDs. In manual flight, the FD displays guidance orders to help the pilots to apply commands on the controls in order to follow the optimum flight path, which would be ordered by the AP if it was engaged. When the AP is engaged, the FD helps the FMGC demands to be checked.

The FD modes are the same as the AP modes and are selected the same way. The FMGCs calculate AP/FD orders which are transformed into symbols by the Display Management Computers (DMCs). There are two types of symbols: the FD bars, the Flight Path Director (FPD) and Flight Path Vector (FPV) symbols. The central HeaDinG−Vertical Speed (HDG−V/S)/TRacK−Flight Path Angle (TRK−FPA) P/BSW on the FCU makes the pilots switch between these two types of symbols.

FD PUSHBUTTONS

Upon FCU power up, in go around, or when losing the AP during the roll out phase of the landing, the three green bars of the FD P/BSWs come on automatically. A lit FD P/BSW means that the FD symbols can be displayed on the corresponding PFD:

PFD 1 for the CAPT FD P/BSW and PFD 2 for the F/O FD P/BSW. If a lit FD P/BSW is pressed, the green bars go off. Pressing the P/BSW again puts the green bars on again.

A non lit FD P/BSW means that no FD symbols can be displayed on the corresponding PFD.

−FD2 is displayed on each PFD to show that no FD symbols can be displayed on PFD 1 and FD 2 is engaged on the F/O side.

FD BARS

The FD bars can be displayed provided HDG−V/S is selected on the FCU. HDG−V/S is automatically selected at system power up.

NOTE: At certain system configuration changes, the FMGCs send a command to the DMCs to make the FD bars flash for 10 seconds.

AP/FD modes are correctly followed when the FD bars are centered on the fixed aircraft model of the PFDs.

There are three FD bars:

- the pitch bar,
- the roll bar,
- and the yaw bar.

The horizontal pitch bar can be displayed if a vertical mode is active except during the roll out phase of the landing. The vertical roll bar can be displayed if a lateral mode is active. Below 30 feet RA at take−off when a LOCalizer (LOC) signal is available and during landing, the roll bar is replaced by a yaw bar index. This bar is then centered when it is just below the central yellow square.

FPD/FPV SYMBOLS

The FPD and the FPV symbols can be displayed provided TRK−FPA is selected on the FCU.

NOTE: At certain system configuration changes, the FMGCs send a command to the DMCs to make the FPD and FPV symbols flash for 10 seconds.

AP/FD modes are correctly followed when the FPD and FPV symbols are superimposed. The FPD symbol supplies command signals to intercept and fly the lateral and vertical flight path as defined by the FMGCs. The FPD symbol is removed if no guidance mode is provided by the FMGCs.

The FPV symbol represents lateral and vertical flight path information in terms of current track and FPA actually being flown. The FPV symbol position is computed by the Air Data Inertial Reference System (ADIRS).

NOTE: The yaw bar is identical to the FD bar case and appears with the same conditions.

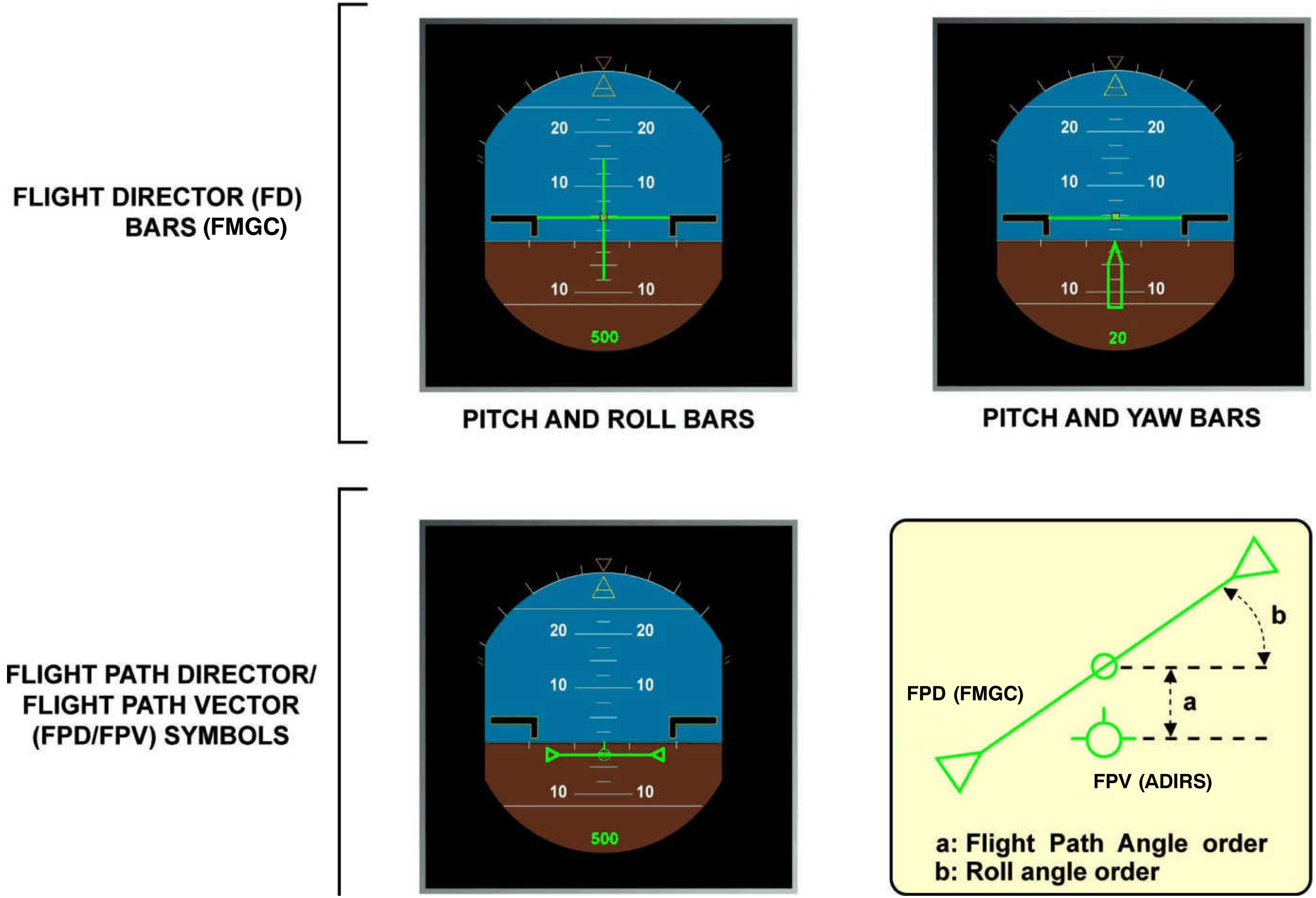


Figure 39 FD BARS & FPD/FPV Symbols

AP/FD ENGAGEMENT DESCRIPTION

FD ENGAGEMENT

The FDs are engaged automatically upon energization of the computers in flight or on the ground.

After the safety tests, at power rise:

- The two FDs engage if no failure is detected by internal monitoring.
- The FMA indications appear on the PFDs but the FD bars are removed.
- The FD orders will be displayed on the PFD for a given axis when a mode is active on this axis.
- If an FD does not engage (FMGC failure detected by internal monitoring), the two PFDs are switched to the valid FD (same FD indication on both PFDs).

FD − Engage Hardware Logic

A part of the FD engage logic is accomplished through the hardware. This logic takes into account the FD ENGD signals (generated in the software) and the FG HLTY signals from the command and monitoring channels:

- Loss of the FD ENGD signal is spread over a period of 200 ms.

The safeguard of the engage signals is ensured by back−up current Vs over a brief period. The CMD and MON FD ENGD wired signals which are obtained are used by:

- The DMCs (FMGC bus selection logic).
- The FCU (FMGC bus selection logic).
- The opposite FMGC (FD COND logic).

AP ENGAGEMENT

The AP is engaged through two pushbutton switches (AP1 and AP2) located on the center section of the FCU. In cruise only one AP can be engaged at a time (priority to the last AP engaged).

Both APs can be engaged when the following modes are active or armed:

- LAND mode,
- GO AROUND mode.

In these cases, the AP1 has priority and is active. The AP2 is in standby and becomes active if the AP1 is lost.

When these modes are released, the AP2 is disengaged automatically. The AP can be engaged on the ground in any mode with engines stopped. The AP disengages when one engine is started.

An AP can be engaged again 5 s after lift−off in active FD modes (if at least one FD is engaged) and, in HDG and V/S modes (if no FD is engaged).

At AP engagement, the load thresholds on the side stick controllers and on the rudder pedals are increased.

AP engagement is indicated by the illumination of the corresponding pushbutton switch (three green bars) and by the AP1 or AP2 indication in the status column on the PFDs.

The pilot can disengage the AP in different ways:

- By action on the engagement pushbutton switch, with the green bars on.
- By action on one takeover and priority pushbutton switch on the side stick controller.

Disengagement of the AP is always indicated by an aural and visual warning.

FLIGHT GUIDANCE HEALTHY LOGIC (FG HLTY)

FG HLTY logic on command side

This signal which is consolidated by a FG HLTY signal from the monitoring channel is generated by the following monitoring functions:

- Internal monitoring of the guidance,
- Internal monitoring of the inner loop CPU,
- Monitoring of the exceptions of the guidance CPU,
- Monitoring of the exceptions of the inner loop CPU,
- Guidance processor watchdog output.

FG HLTY logic on monitoring side

This signal which is also consolidated by the FG HLTY signal from the command channel is generated by the following monitoring functions:

- Software monitoring of the monitor CPU,
- Monitoring of the exceptions of the monitor CPU,
- Watchdog activation.

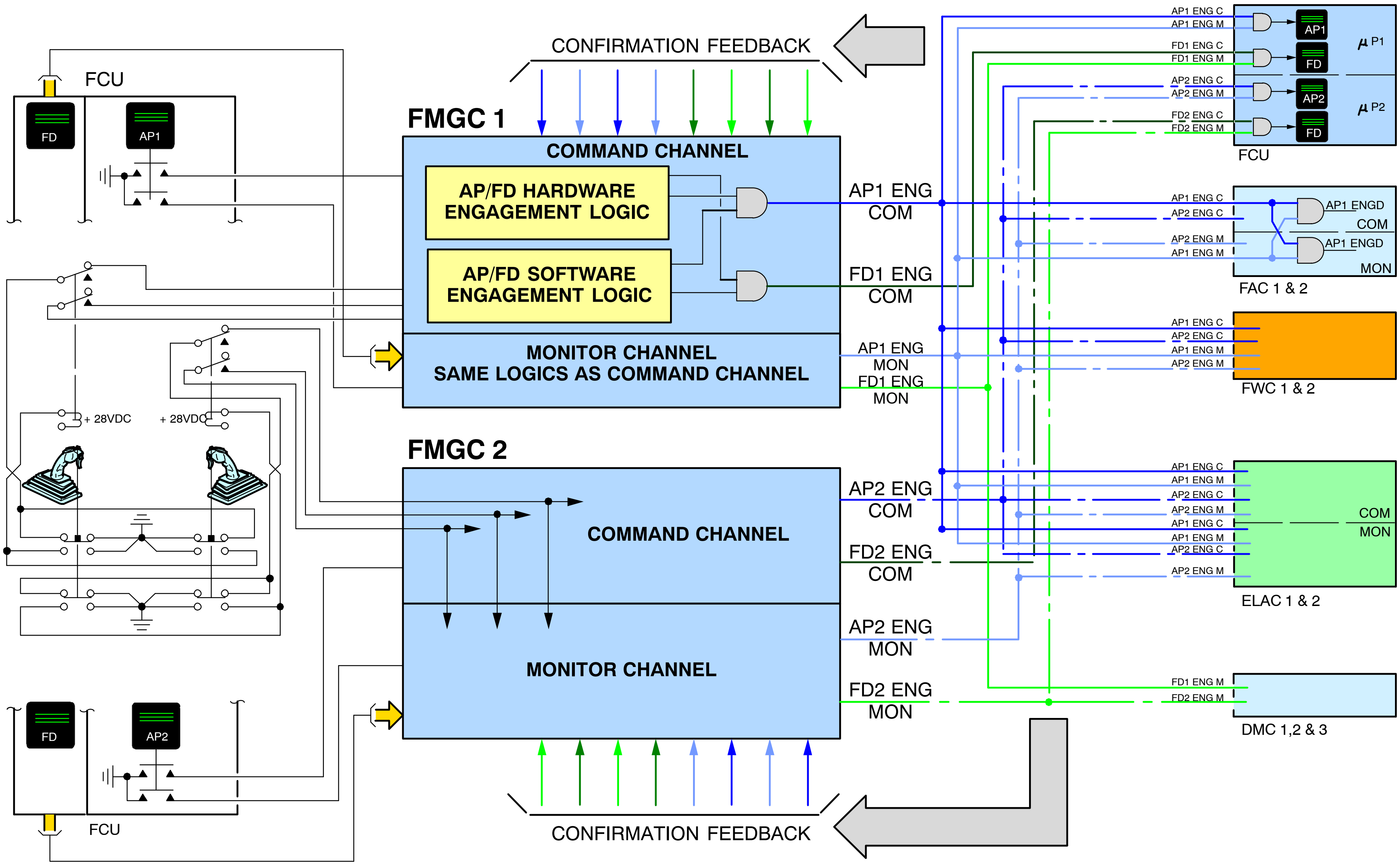


Figure 40 AP/FD Engagement Interface

AP/FD ENGAGE LOGIC DESCRIPTION

AP ENGD Hardware Logic

A part of the AP engage logic is accomplished through the hardware.

It takes into account the following signals:

- AP ENGD boolean generated in the software,
- FG HEALTHY logic signal,
- AP SW wired discrete from the FCU.

The AP ENGD hardware logic utilizes the command and the monitoring channels. Each output discrete takes into account the conditions generated by each generated by each channel. During the safety tests (at power rise) the AP SW signal is inhibited prohibiting engagement through the pushbutton switch.

The disengagement takes place in the hardware logic:

- Upon loss of one of the AP ENGD and FG HEALTHY signals after confirmation of 200 ms,
- Through action on one takeover and priority pushbutton switch located on the side stick controllers,
- Upon detection of long power failure (LPF) by the power unit.

In the event of short interruption, the engage signal maintains its pre−cutoff state. The final circuits are therefore supplied with back−up current (VS). They are isolated from the other signals during the cutoff (SW RESET signal active).

The AP ENGD wired discretes obtained are used by:

- The FACs (selection of AUTO mode and acquisition of yaw axis guidance signals).
- The ELACs (selection of AUTO mode and acquisition of guidance signals, pitch and roll axes and nose−wheel steering).
- The FCU (illumination of the corresponding AP pushbutton switch, 3 green bars, and selection of the FMGCs (generation of the AP warning).
- The opposite FMGC (disengagement of associated AP if in cruise modes, selection of the FMGC having priority).
- The OWN FMGC (engagement wrap around).

AP ENGD SOFTWARE LOGIC

Engagement Conditions

This signal is at 1 (flip−flop set) if all the engagement conditions are activated:

- Action on the engagement pushbutton switch,
- On ground engagement possible in any mode only if the engines are shut down,
- In flight engagement possible 5 s after lift−off,
- Conditions specific to the AP: AP COND,
- Conditions common to the AP/FD: AP/FD COND,
- Conditions common to the AP/FD and A/THR: AP/FD/A THR COND

Disengagement Conditions

This signal is set to O (flip−flop reset) when a disengagement condition is present:

- Action on the engagement pushbutton switch, the associated AP being already engaged,
- Engagement of the opposite AP if the AP is not in LAND or GO AROUND mode,
- Action on one takeover and priority pushbutton switch,
- One engine start on the ground,
- Loss of one condition:
  - either AP COND, or AP/FD COND or AP/FD/ A−THR COND,
- In the event of landing in dual−AP operation, disengagement of AP2 only when the LAND or GO AROUND mode is released.

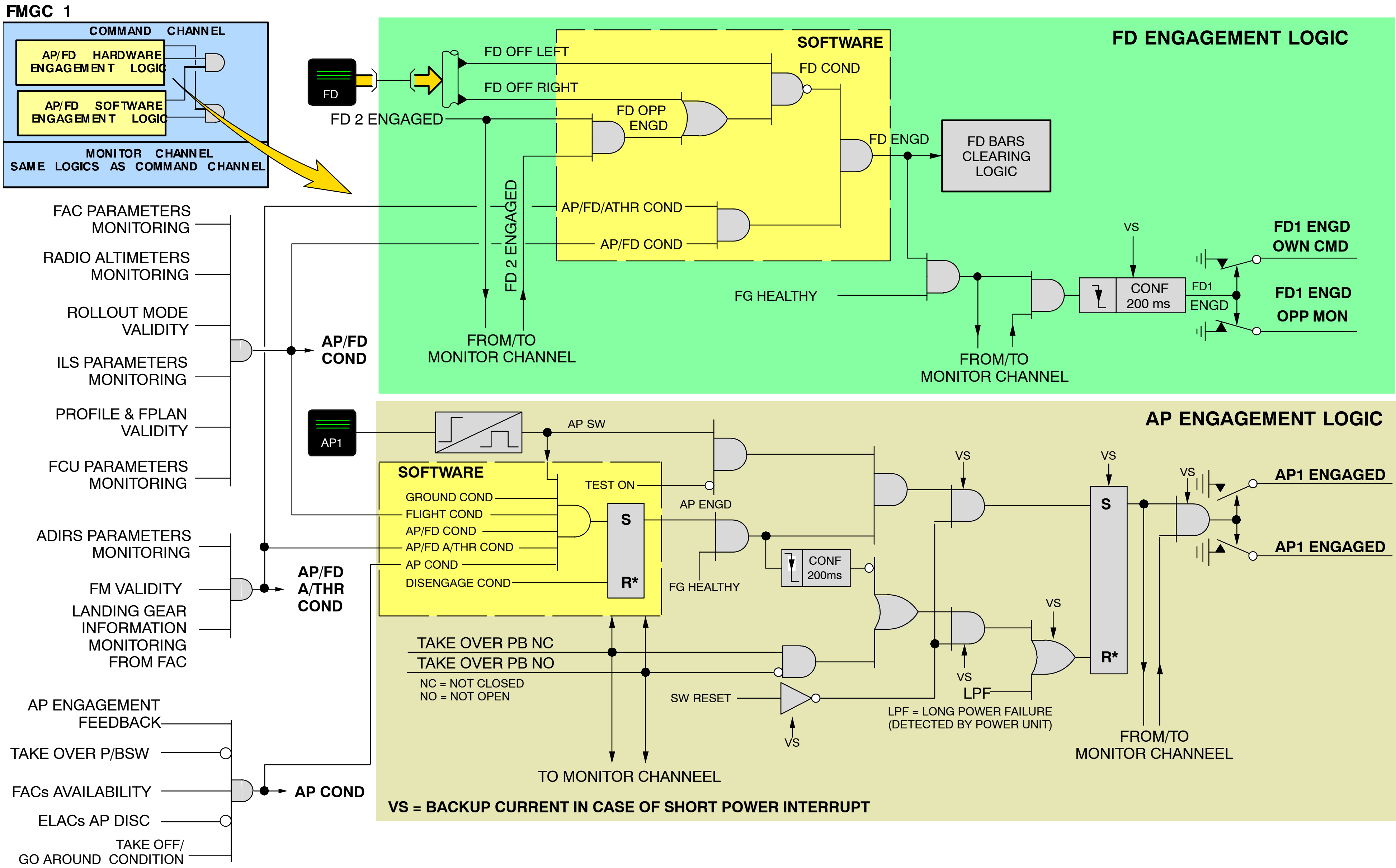


Figure 41 AP/FD Engagement Logic

AP SPECIFIC CONDITIONS SYSTEM OPERATION

A logic covers all the conditions required to engage the AP. These are the following conditions:

Feedback Of Wired Engage Discretes:

- Engagement is confirmed by the feedback of four AP ENGD discretes delivered by each FMGC. Therefore for the FMGC1:
  - The AP ENGAGEMENT FEEDBACK condition (command) is set to 0 upon loss of discrete AP1 ENGD1 or 2 delivered by the command channel,
  - The AP ENGAGEMENT FEEDBACK condition (monitor) is set to 0 upon loss of discrete AP1 ENGD 3 or 4 delivered by the monitoring channel.

No disengagement through AP takeover and priority pushbutton switches.

Availability and validity of peripherals:

- These are peripherals which utilize the AP commands.

  1 FAC:
  - Availability of at least one FAC (CMD and MON FAC HEALTHY wired discretes),
  - Confirmation of FAC operation in AUTO mode further to AP engagement by the FAC,
  - Engagement of the yaw damper function,
  - Engagement of the rudder trim function.
- **2 ELAC**

  Each ELAC generates ELAC AP DISC discretes.

  The AP disengages only upon a command from the two ELACs. The disconnection command from only one ELAC results in a reduction of landing capability.

Loss of one of the above five logic conditions is not taken into account in LAND TRACK, between 100 ft. and the ground.

Conditions specific to GO AROUND and TAKEOFF modes:

On the ground, the engagement of the GO AROUND mode or positioning of the both thrust control levers in or above the MCT/FLX gate result in AP disengagement.

INCREASE OF LOAD THRESHOLD ON SIDE STICK & RUDDER PEDAL

When the AP is engaged, the command and the monitoring channels supply the relays which control the pitch and roll lock solenoids (the command channel provides the +28V, the monitoring channel provides the ground). Each control has its own solenoid.

Each AP has its own relays and can therefore lock the controls.

Side Stick Controllers

The loads are increased on both axes.

The pitch load threshold changes from 0.5 daN to 5 daN. The roll load threshold changes from 0.5 daN to 3.5 daN.

Any load on the side stick controller which exceeds these values, results in AP disconnection (wired discrete from the ELACs).

Rudder Pedals

The load is applied on the rudder artificial feel (addition of a spring in the artificial feel and trim unit).

The load threshold changes from 10 to 30 daN when the AP is engaged.

NOTE: Exceeded load results in AP disconnection.

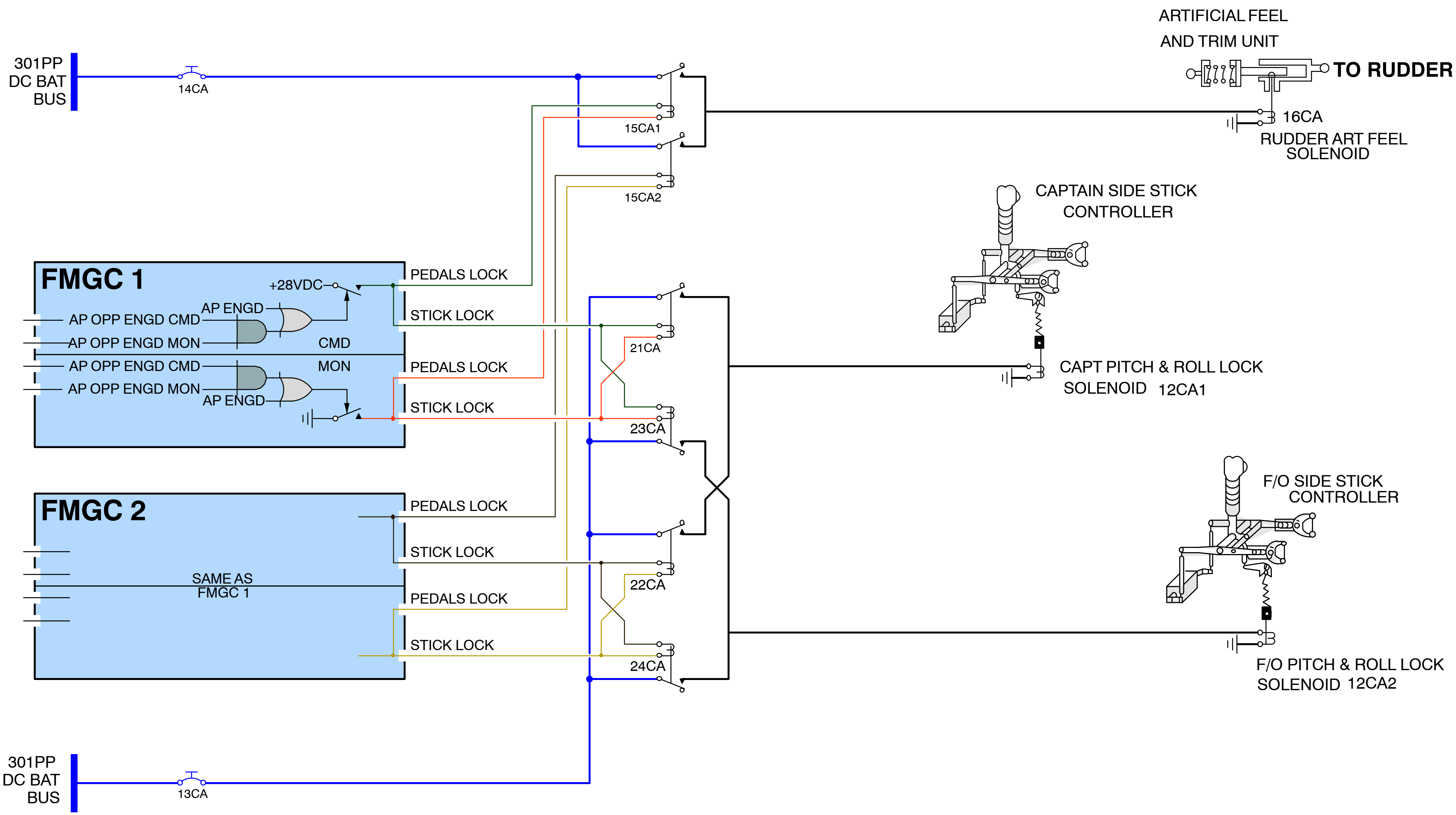


Figure 42 Side Stick Controllers & Rudder Pedals Locking Logic

AP ROLL CONTROL FUNCTIONAL OPERATION

AILERON CONTROL

Each ELAC receives two deflection commands from each FMGC:

- Elevator deflection command DELTA Q (described and shown next paragraph),
- Aileron deflection command DELTA P AIL (ARINC429 label 310).

The ELAC limits these commands. DELTA P command:

- Roll attitude limit equal to plus or minus 60 deg and rolling speed limit equal to plus or minus 10 deg (in landing configuration, this limit is equal to plus or minus 20 deg/s). These limits are a function of Vc (Calibrated Airspeed).

The FMGC command acknowledge logic is with respect to AP engagement wired discretes (2 discretes per AP: command and monitoring), status matrix monitoring of these labels, and concordance between AP engagement wired discretes and boolean information.

In answer, each ELAC generates two ELAC AP DISC discretes (control and monitoring) to command AP disconnection when one of the following conditions is present:

- loss of computation channel validity (comparators),
- loss of power loop validity:
  - theta, phi, Vc, Mach and alpha values out of limits,
  - incidence protection active,
  - speed protection active,
- controls used (side stick controller or pitch trim control wheel).

The AP can be engaged whatever the type of the EFCS control laws: normal, alternate, direct.

In approach phase, upon loss of both radio altimeters, the ELACs inhibit AP engagement with the direct law and in landing gear extended configuration.

The AP disconnects when it receives at least one disconnection command (control and monitoring) from the 2 ELACs.

A disconnection command from one ELAC only leads to a landing capability reduction.

An ELAC priority logic exists for control surface control.

This logic is unchanged with AP engaged:

- ELAC 2 has priority for elevator and THS control
- ELAC 1 has priority for aileron control.

SPOILER CONTROL

Each ELAC receives a spoiler deflection command from the two FMGCs DELTA P SPL (ARINC429 label 311).

The command from the FMGC, selected according to the logic defined in the preceding paragraph, is limited in the ELACs so that roll attitude values are not greater than 60 deg and rolling speeds are not greater than plus or minus 10 deg/s (plus or minus 20 deg/s in approach).

This limited command is sent to the three SECs.

ELAC 1 has priority for spoiler control.

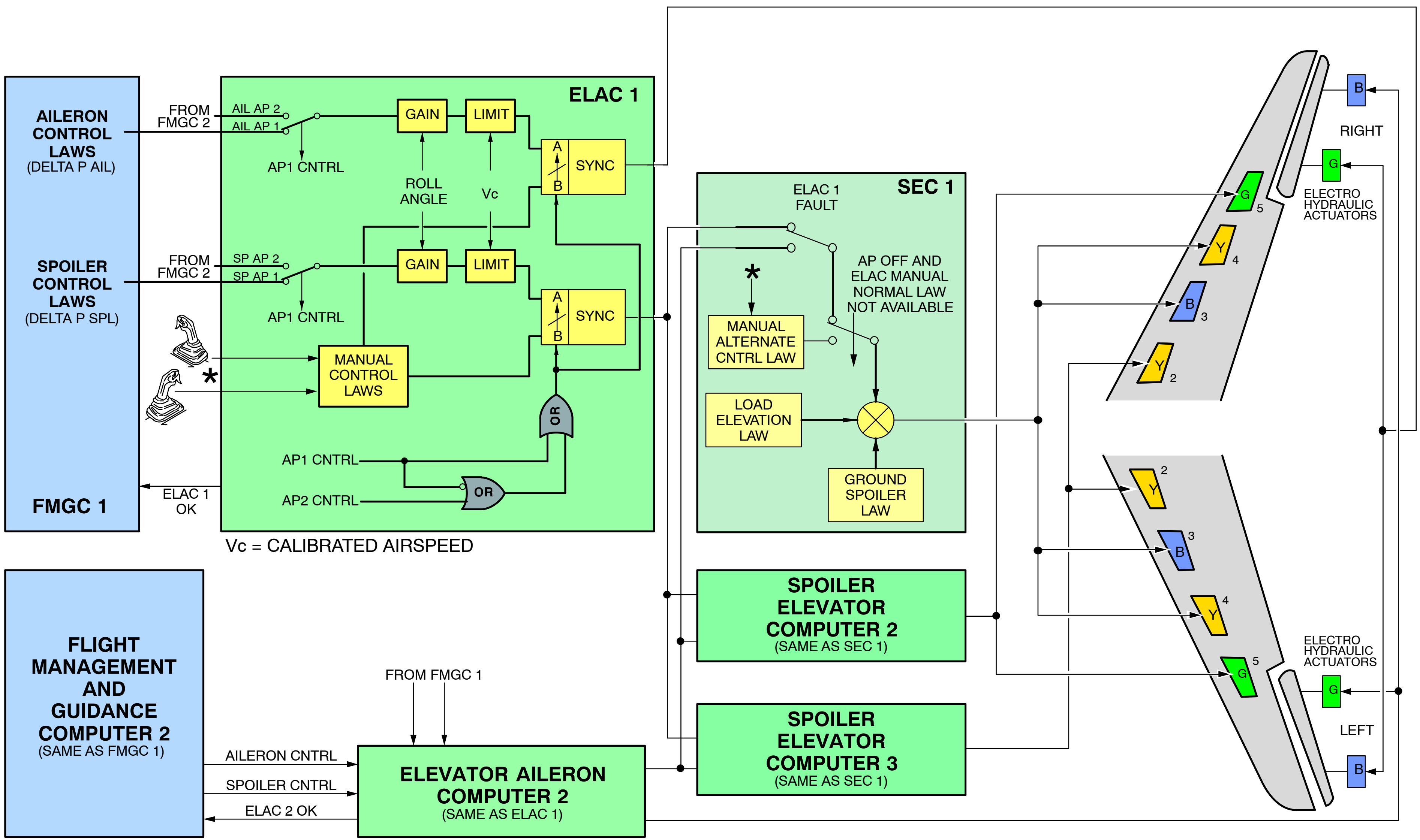


Figure 43 AP Roll Control Schematic

AP PITCH CONTROL FUNCTIONAL OPERATION

ELEVATOR CONTROL

Each ELAC receives two deflection commands from each FMGC:

- Elevator deflection command DELTA Q (ARINC label 314)
- Aileron deflection command DELTA P AIL (described and shown last paragraph).

The ELAC limits these commands. DELTA Q command:

- load factor limit between 0.4 g and 1.5 g. This limit is a function of VC (Calibrated Airspeed), Mach, THS position and load factor.

The FMGC command acknowledge logic is with respect to AP engagement wired discretes (2 discretes per AP: command and monitoring), status matrix monitoring of these labels, and concordance between AP engagement wired discretes and boolean information.

In answer, each ELAC generates two ELAC AP DISC discretes (control and monitoring) to command AP disconnection when one of the following conditions is present:

- loss of computation channel validity (comparators),
- loss of power loop validity:
  - theta, phi, Vc, Mach and alpha values out of limits,
  - incidence protection active,
  - speed protection active,
- controls used (side stick controller or pitch trim control wheel).

The AP can be engaged whatever the type of the EFCS control laws:

- normal,
- alternate,
- direct.

In approach phase, upon loss of both radio altimeters, the ELACs inhibit AP engagement with the direct law and in landing gear extended configuration.

The AP disconnects when it receives at least one disconnection command (control and monitoring) from the 2 ELACs.

A disconnection command from one ELAC only leads to a landing capability reduction.

An ELAC priority logic exists for control surface control.

This logic is unchanged with AP engaged:

- ELAC 2 has priority for elevator and THS control
- ELAC 1 has priority for aileron control.

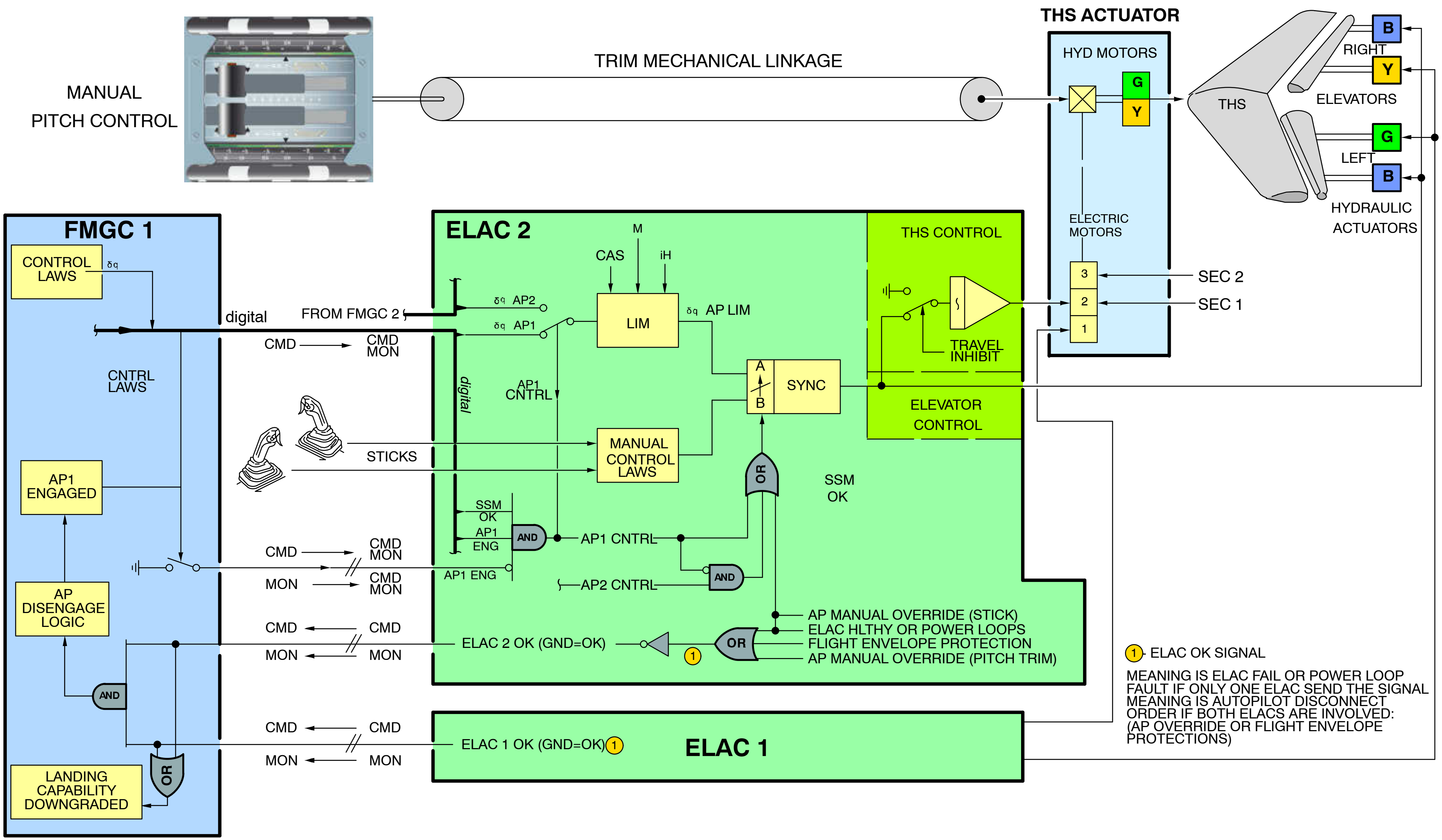


Figure 44 AP Pitch Control Schematic

AP NOSE WHEEL CONTROL FUNCTIONAL OPERATION

NOSE WHEEL CONTROL

Each ELAC receives a nose wheel steering command from the two FMGCs:

- DELTA NOSE WHEEL (label 313).

The ELACs select one status of the two commands (from the FMGC1 and FMGC2) according to:

- AP engagement (discretes and boolean information on the bus),
- label 313 monitoring.

The selected command is sent to the BSCU.

The BSCU uses this command associated with commands from the control wheel and rudder pedals to compute nose wheel control angle.

The command from the FMGC and the command from the rudder pedals are limited with respect to speed.

The command from the FMGC is used after landing during taxiing when the speed is less than 80 kts.

The BSCU generates four discretes (BSCU HEALTHY) whose validity is taken into account:

- for capability computations,
- in the ROLL OUT logic.

It also supplies 2 discretes (wheel speed) for the ROLL OUT logic.

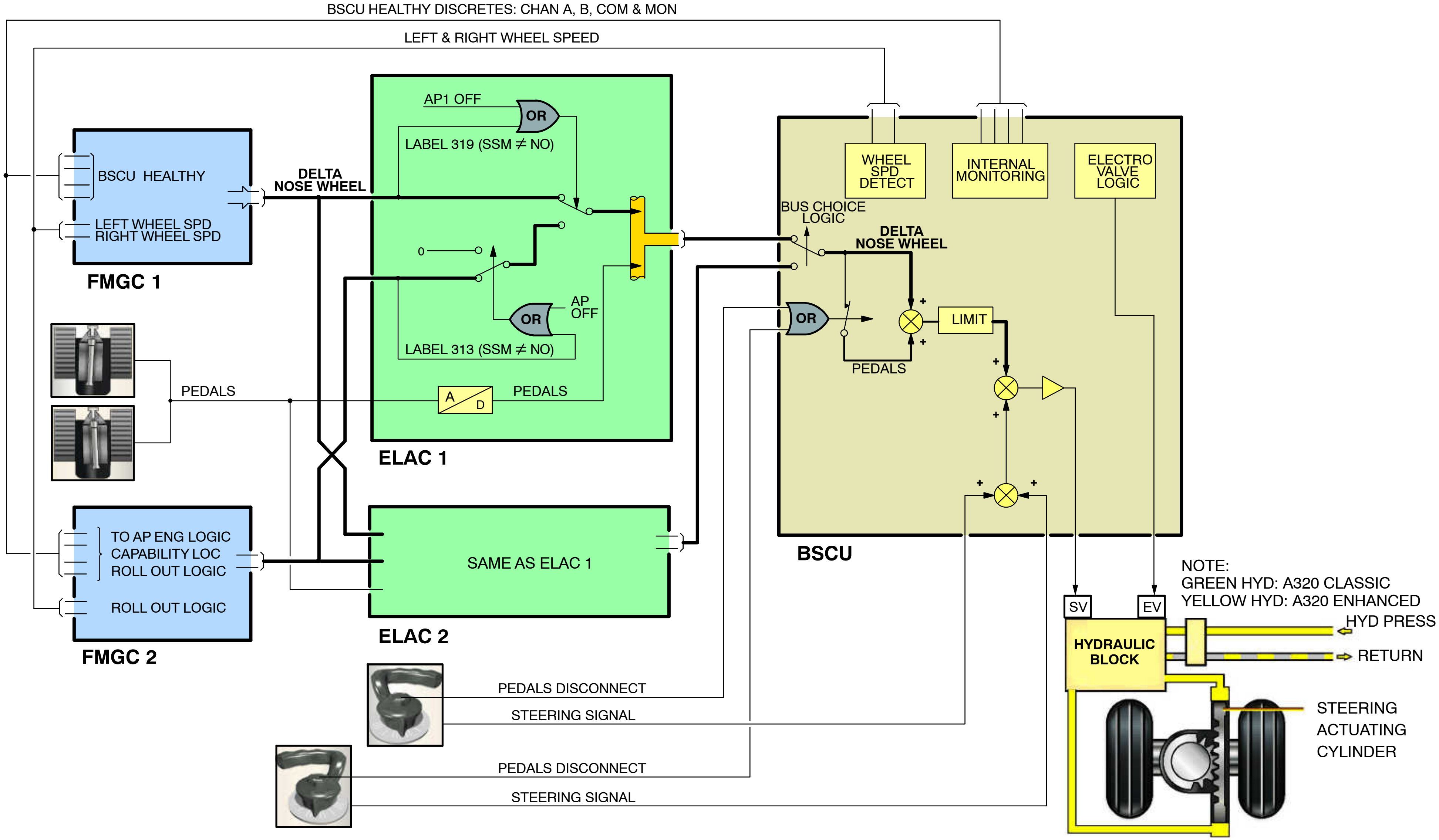


Figure 45 AP Nose Wheel Control Schematic

FLIGHT GUIDANCE PRIORITY LOGIC SYSTEM OPERATION

FG ENGAGEMENT STATUS

The engagement status of the guidance function works on the **master/slave principle.**
The master Flight Management and Guidance Computer (FMGC) imposes all the changes of AP/Flight Director (FD) modes and/or A/THR engagement to the slave FMGC.

Here is an example of a master FMGC. Look at the flow chart to understand the priority logic.

With no AP, no FD1 but FD2 engaged, FMGC2 is the master because, by following the flow chart, the first three answers are NO, but the fourth one is YES.

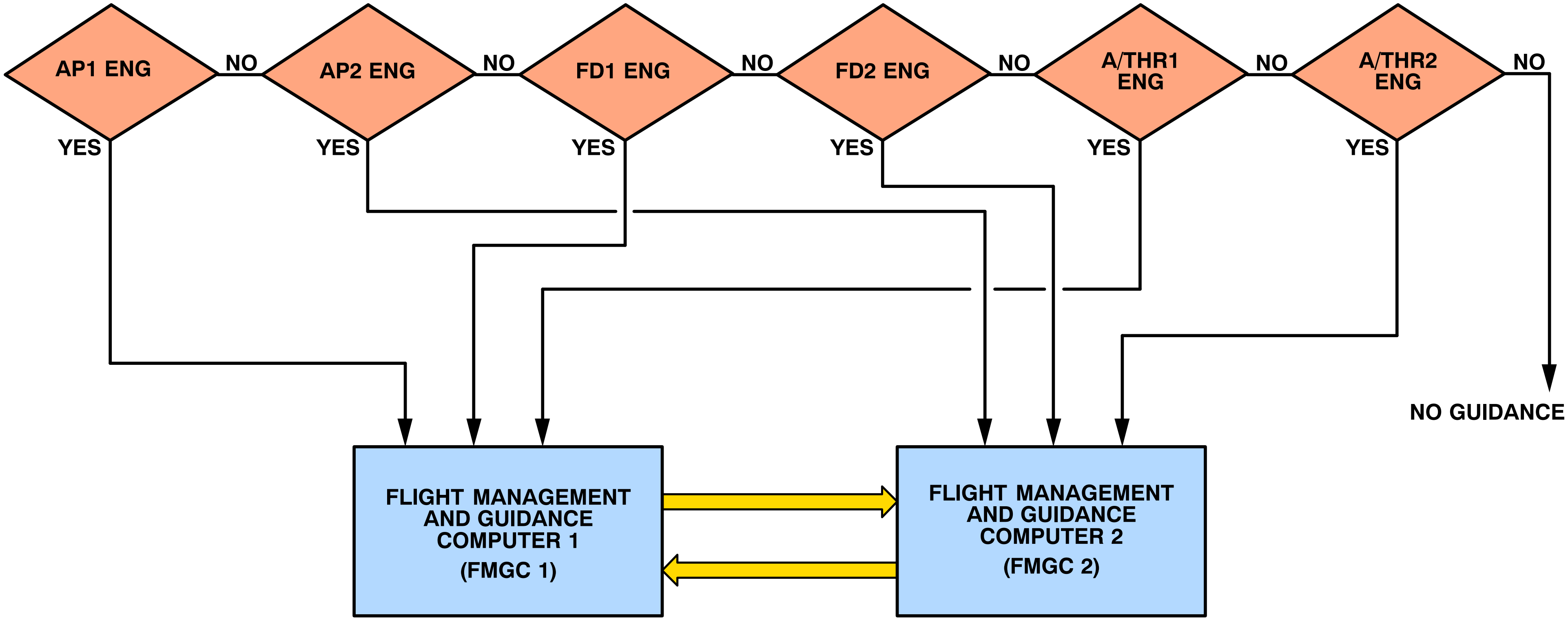


Figure 46 Flight Guidance Priority Logic

FLIGHT DIRECTOR SYSTEM OPERATION

At power up, both FDs are normally engaged in split configuration.

FMGC1 normally drives the FD symbols (crossbars or flight path director symbols) on the CAPT PFD.

FMGC2 normally drives the FD symbols on the F/O PFD. The 1FD2 indication is displayed on each Flight Mode Annunciator (FMA) to show that FD1 is engaged on CAPT side and FD2 is engaged on F/O side.

If one FMGC fails, the remaining FMGC drives the FD symbols on both PFDs. If FMGC1 fails, the 2FD2 indication is displayed on each FMA to show that FD2 is displayed on both PFDs. If both FDs fail, a red flag is displayed on each PFD, provided that the corresponding FD switch is on.

NOTE: In case of loss of both FMGC, the ADIRS parameters can be optionally retrieved using the back−up nav on the MCDU.

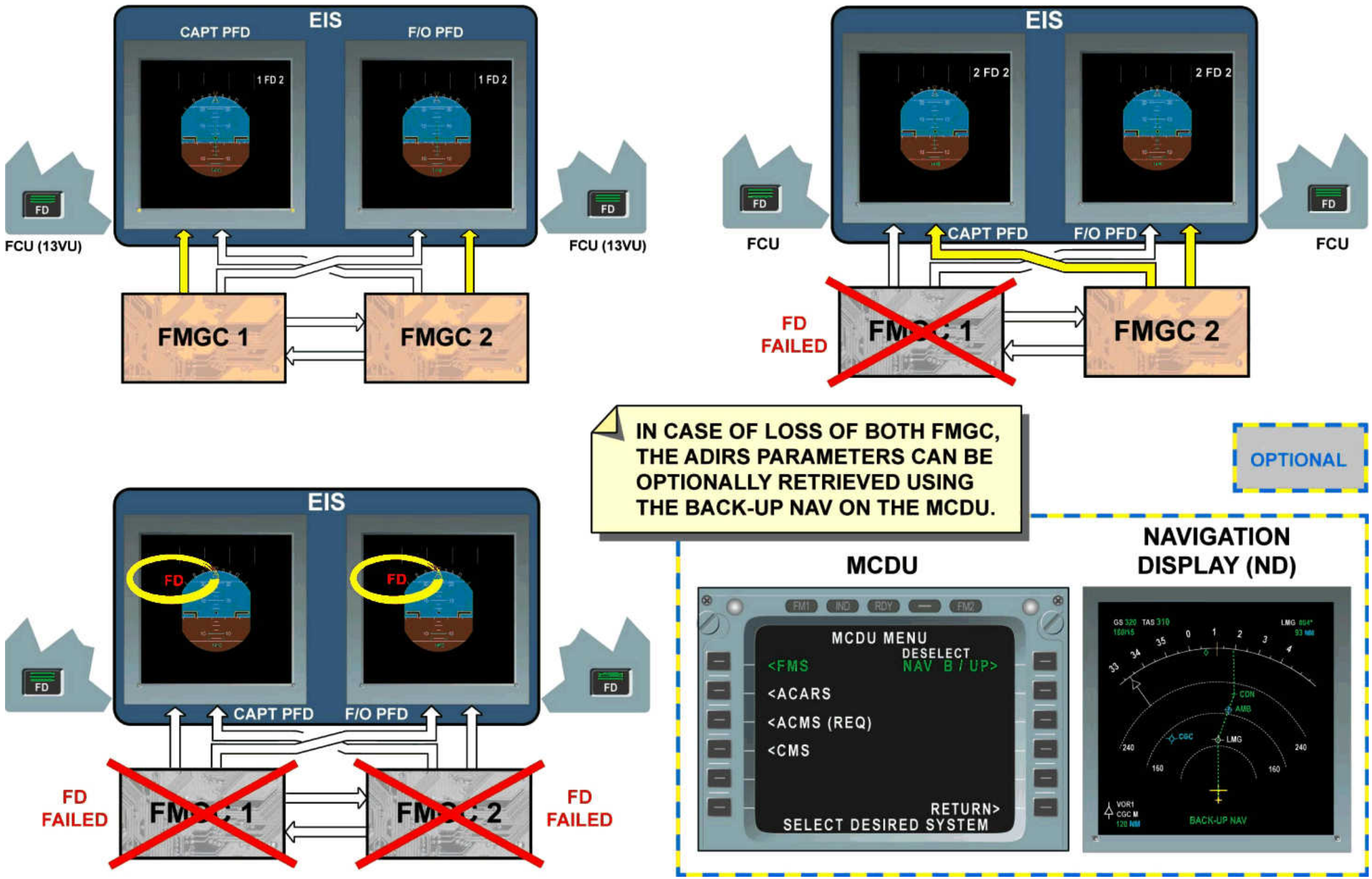


Figure 47 FD Indication Source

FLIGHT MODE ANNUNCIATIONS DESCRIPTION

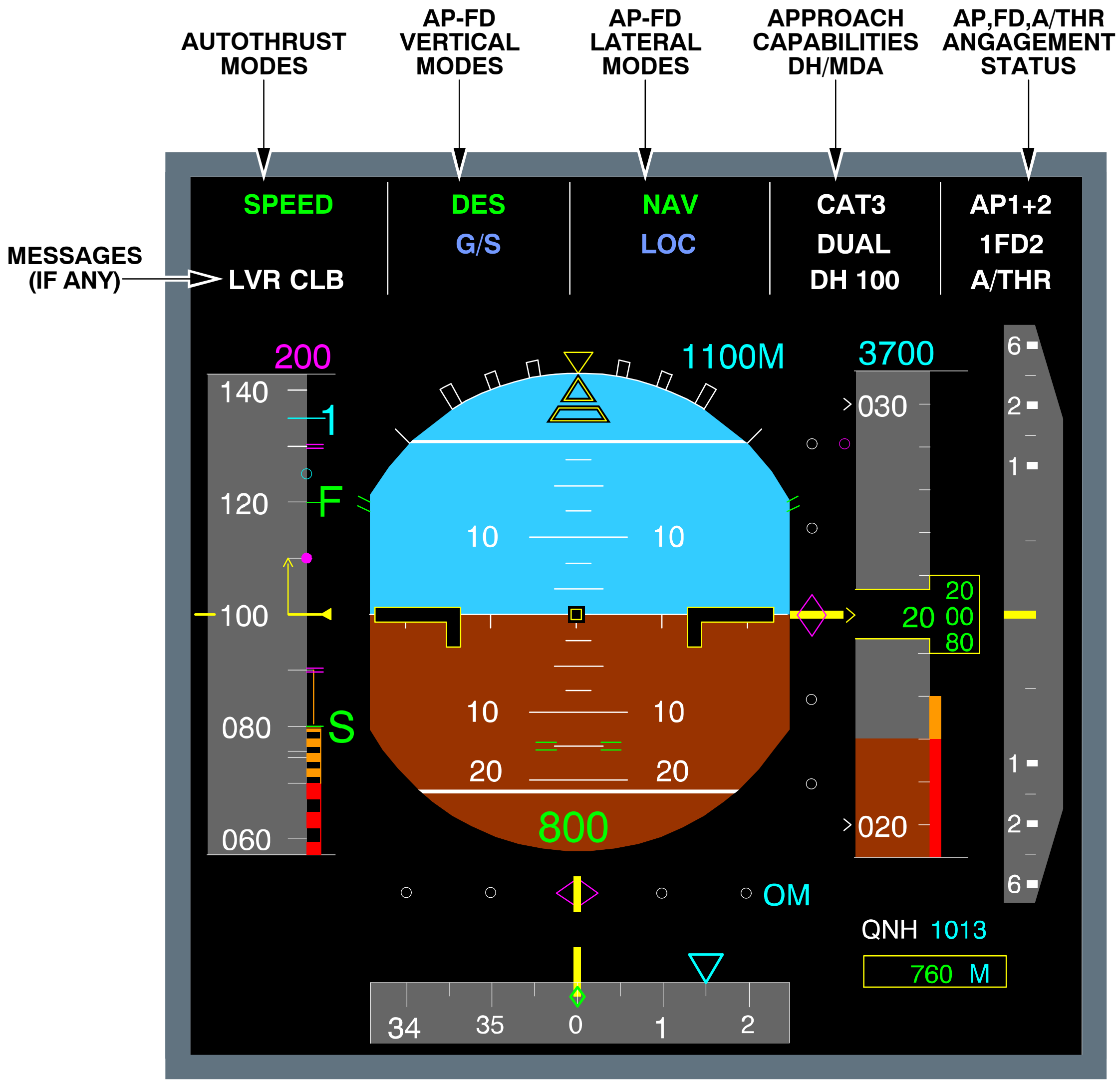
The three types of information on the FMA are:

- A/THR mode/status,
- AP/FD mode and status,
- Flight Management (FM) messages.

The master FMGC, which supplies both FMAs, displays the A/THR information.

The AP/FD information is displayed according to the following logic:

- with at least one AP, the master FMGC supplies both FMAs,
- without AP, with the FDs engaged, FMGC1 supplies FMA1, FMGC2 supplies FMA2,
- without AP, with one FD failed or manually disengaged, the opposite FMGC supplies both FMAs.



FMA INDICATION SOURCE

AP1	AP2	FD1	FD2	FMA1	FMA2
ON	*	*	*	1	1
-	ON	*	*	2	2
-	-	ON	ON	1	2
-	-	ON	-	1	1
-	-	-	ON	2	2

LEGEND:

- * = ON, OFF OR FAULT
- - = OFF OR FAULT
- 1 = SOURCE IS FMGC1
- 2 = SOURCE IS FMGC2

Figure 48 FMA Indication Source

AUTOPILOT/FLIGHT DIRECTOR - MODES PRESENTATION

Mode Selection Principle

A mode can be selected through one of the following possibilities :

- Automaticly, e.g. the altitude acquisition mode is always armed, exept in some cases (approach).
- Action on pushbutton switch located on the FCU.
- Push or pull action on one of the reference selection knobs (speed / mach, heading / track, altitude, vertical speed/flight path angle) on the FCU.
- Cancellation of an engaged mode.
- Position of the thrust control levers (selection of TO or GA modes).

AP – A/THR Mode Compability

The AFS is such that the AP/FD system or the A/THR function always control the speed. The AP/FD has the priority. To do this, the modes of the A/THR system are function of the AP/FD–longitudinal modes.

The table below presents the Cruise Modes.

CRUISE FLIGHT	MODE	AVAILABILITY	PHASES	NOTE
LONGITUDINAL	– Vertical speed (**V/S**) (Acquisition and Hold)	AP / FD	HOLD	Automatic or V/S – FPA – select knob
	– Flight path angle (**FPA**) (Acquisition and Hold)	AP / FD	HOLD	
	– Altitude acquisition (**ALT ACQ**)	AP / FD	ARM – CAPTURE	Armed automatically
	– Altitude hold (**ALT**)	AP / FD	HOLD	Automatic on selected Altitude
	– **DES** (Descent) – **OP DES** (Open Desct)	AP / FD AP / FD	ARM – HOLD HOLD	Altitude select–knob
	– **CLB** (Climb) – **OP CLB** (Open Climb) **-TCAS (OPTIONAL)**	AP / FD AP / FD AP/FD	ARM – HOLD HOLD	
LATERAL	– Heading (**HDG**) – **TRACK** (Acquisition and Hold)	AP / FD AP / FD	HOLD HOLD	Automatic or HDG / TRK select–knob (pulled)
	– Navigation (**NAV**)	AP / FD	ARM – HOLD	HDG / TRK select–knob (pushed)

COMMON MODES (TAKEOFF, LANDING, GO AROUND) PRESENTATION

COMMON MODES	LONGITUDINAL MODES	LATERAL MODES	AVAILABILITY	PHASES
TAKEOFF (TO)	All engines operational : Speed Reference System **(SRS)** : Holding of V2 + 10 kts One engine fail : **SRS :** Holding of Va if Va > V2 V2 if Va < V2 (Va : Actual Speed)	Runway **(RWY)**: – Holding of LOC center-line up to 30 ft RA, – Track above 30 ft RA	FD AP*/ FD (*AP only 5 sec after lift off)	HOLD
GO AROUND (GA)	**SRS :** Holding of Va if Va > Vapp or Vapp if Va < Vapp	**TRACK**	AP / FD	HOLD
LOCALIZER (LOC)		**LOC** capture and track	AP / FD	ARM – CAPT – TRACK
APPROACH (APP)	Glide capture, track **(GS)**, Flare, Rollout or Final desct (FINAL) according to the profile determined by the FMGC (Appr. Page)	**LOC** capture and track Align and Rollout or R – **NAV** approach or **VOR** approach	AP / FD	ARM – CAPT – TRACK

OPTION: AP/FD TCAS MODE PRESENTATION

GENERAL

The new proposed Airbus Auto Pilot/Flight Director (AP/FD) TCAS mode aims at significantly enhancing safety by supporting pilots to fly avoidance manoeuvres requested by TCAS.

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.

- With the Auto Pilot (AP) engaged, it allows the pilot to fly the TCAS RA manoeuvre automatically,
- With the AP disengaged, the pilot can manually fly the TCAS RA manoeuvre by following the Flight Director (FD) pitch bar guidance.

In case of a TCAS RA, the AP/FD TCAS mode will automatically trigger:

- If both AP and FD are engaged, the AP/FD vertical mode reverts to TCAS mode, which provides the necessary guidance for the AP to automatically fly the TCAS manoeuvre,
- If the AP is disengaged and FD are engaged, the TCAS mode automatically engages as the new FD guidance. The FD pitch bar provides an unambiguous order to the pilot, who simply has to centre the pitch bar, to bring the V/S of the aircraft on the V/S target (green zone),
- If both AP and FD are OFF, the FD bars will automatically reappear with TCAS mode guiding as above.

Depending on the kind of alert triggered by the TCAS, the AP/FD TCAS mode will have the following behaviour:

- In case of Traffic Advisory (TA), the AP/FD TCAS mode is automatically armed, in order to bring crew awareness on the TCAS mode engagement if the TA would turn into an RA.
- In case of corrective RA (CLIMB, DESCEND, ADJUST, etc. aural alerts), the aircraft vertical speed is initially within the red VSI zone. The requirement is then to fly out of this red zone to reach the boundary of the red/green V/S zone.

Consequently:

- The TCAS vertical mode engages. It ensures a vertical guidance to a vertical speed target equal to the red/green boundary value on VSI (to minimize altitude deviation) +/-200 ft/min within the green vertical speed zone, with a pitch authority increased up to 0.3g load factor,
- All previously armed vertical modes are automatically disarmed, except the altitude capture mode (ALT*) when the altitude capture is compliant with the RA (i.e. when 0 ft/mn is not within the red VSI zone, as for ADJUST, V/S, RA). In those cases, if the altitude capture conditions are met while in TCAS mode, it will allow safely capturing the targeted flight level.
- The **Auto Thrust engages in speed** control mode (SPEED/MACH) to ensure a safe speed during the manoeuvre,
- The current lateral trajectory is maintained.
- In case of preventive RA (e.g. MONITOR V/S aural alert), the aircraft vertical speed is initially out of the red VSI zone. The requirement is then to maintain the current vertical speed.

Consequently:

- The TCAS vertical mode engages to maintain the safe current aircraft vertical speed target,
- All previously armed vertical modes are automatically disarmed, except the altitude capture mode (ALT*). Indeed, levelling–off during a preventive RA will always maintain the vertical speed outside of the red VSI area.
  So, if the altitude capture conditions are met while the TCAS mode is engaged, it will allow to safely capture the targeted level, thus preventing an undue altitude excursion,
- The Auto Thrust engages in speed control mode (SPEED/MACH) to ensure a safe speed during the manoeuvre,
- The current lateral trajectory is maintained.

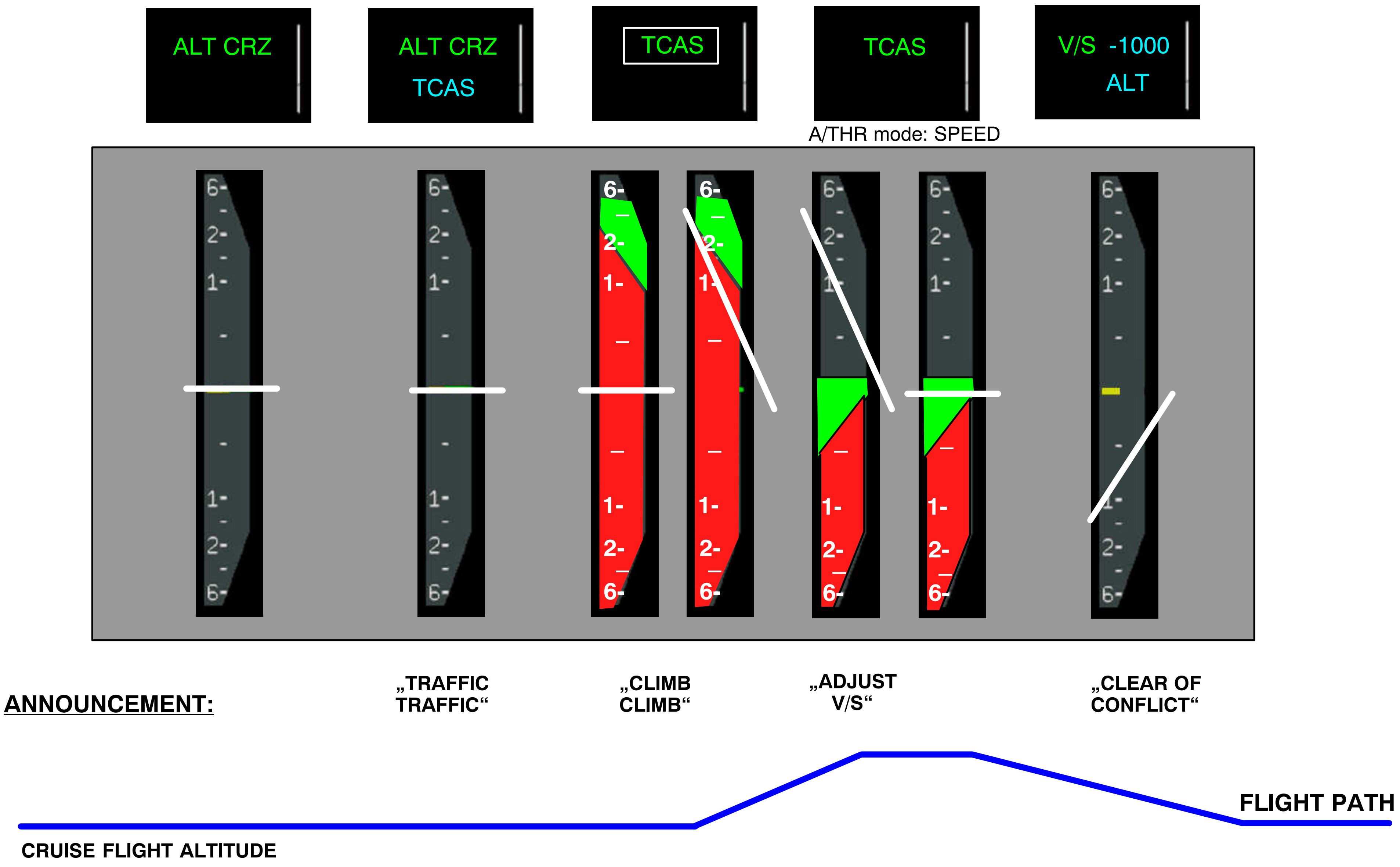
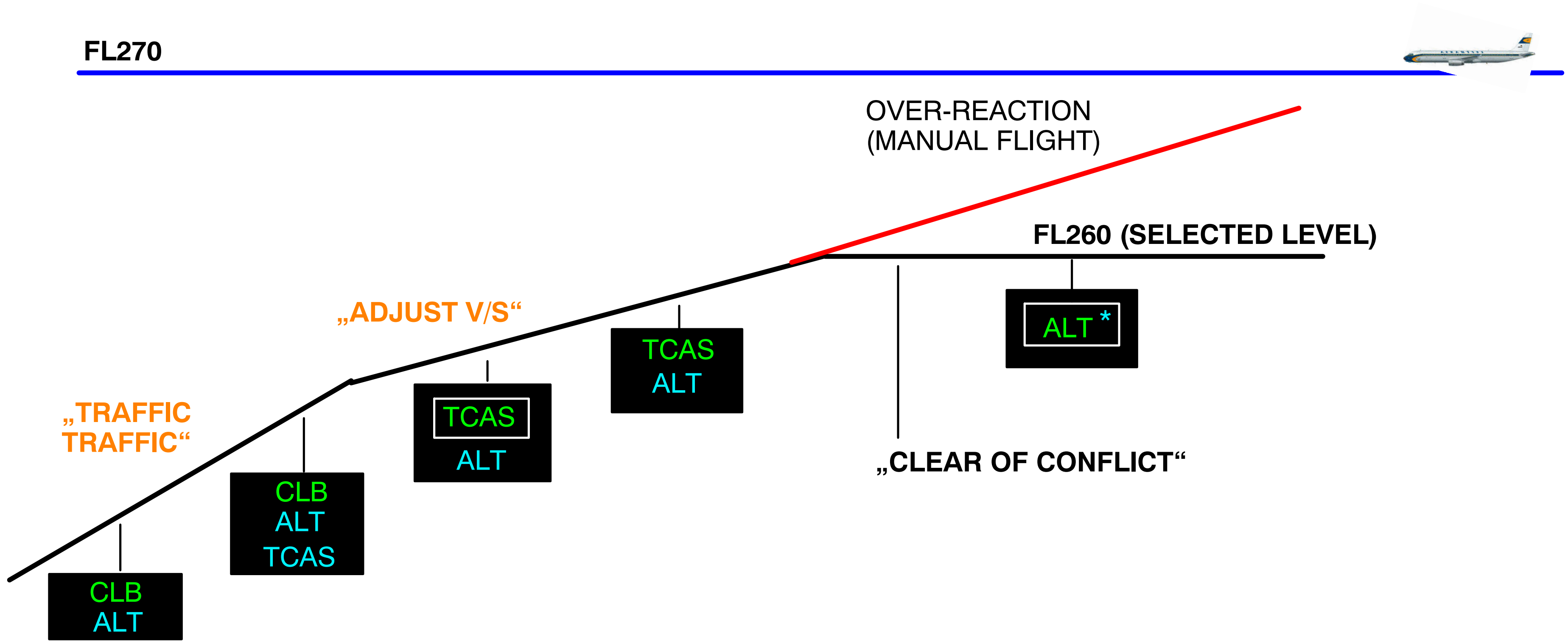


Figure 49 AP/FD - TCAS mode during cruise flight

OPTION: AP/FD TCAS MODE PRESENTATION CONT.

Once clear of conflict, vertical navigation is resumed as follows:

- The AP/FD vertical mode reverts to the vertical speed (V/S) mode, with a smooth vertical speed target towards the Flight Control Unit (FCU) target altitude. The ALT (altitude) mode is armed to reach the FCU target altitude (Air Traffic Control cleared altitude),
- If an altitude capture occurred in the course of a TCAS RA event, once “clear of conflict“, the AP/FD vertical mode reverts to the altitude capture mode (ALT*) or to the altitude hold mode (ALT), the current lateral trajectory is maintained.
- In case of preventive RA (e.g. MONITOR V/S aural alert), the aircraft vertical speed is initially out of the red VSI zone. The requirement is then to maintain the current vertical speed.



**TCAS MODE INITIALLY REDUCES THE V/S
AND THEN CAPTURES THE ALT LEVEL SELECTED**

Figure 50 AP/FD - TCAS mode during climb

FLIGHT MODE ANNUNCIATOR (FMA) COMPONENT DESCRIPTION

GENERAL

The **F**light **M**ode **A**nnunciator (FMA), which is just above the primary flight displays, shows the status of:

- The autothrust,
- the vertical and lateral modes of the autopilot and flight director,
- the approach capabilities,
- and the engagement status of the AP/FD and the autothrust.

After each mode change, the FMA displays a **white box** around the new annunciation for ten seconds.

The white box display time may be increased to 15 seconds in some mode reversion cases associated with an aural triple click.

In the three left columns:

The first line shows the engaged modes in green.

The second line shows the armed modes in blue or magenta.

Magenta indicates that the modes are armed or engaged because of a constraint.

The third line displays special messages:

Messages related to flight controls have first priority :

- MAN PITCH TRIM ONLY in red, flashing for 9 seconds, then steady
- USE MAN PITCH TRIM in amber, pulsing for 9 seconds, then steady

Messages related to the FMGS have second priority.

The fourth column:

Displays approach capabilities in white.

Displays DH or MDA / MDH in blue.

The fifth column:

Displays the engagement status of AP, FD, and A/THR in white.

Displays a box around FD for 10 seconds in case of automatic FMGC switching.

Displays A/THR in blue when autothrust is armed but not active.

NOTE: When one AP is engaged, the master FMGC drives both FMAs. If no AP is engaged, each FMA is driven by its onside FMGC. (The onside FD pushbutton must be ON to display AP/FD modes and approach capabilities).

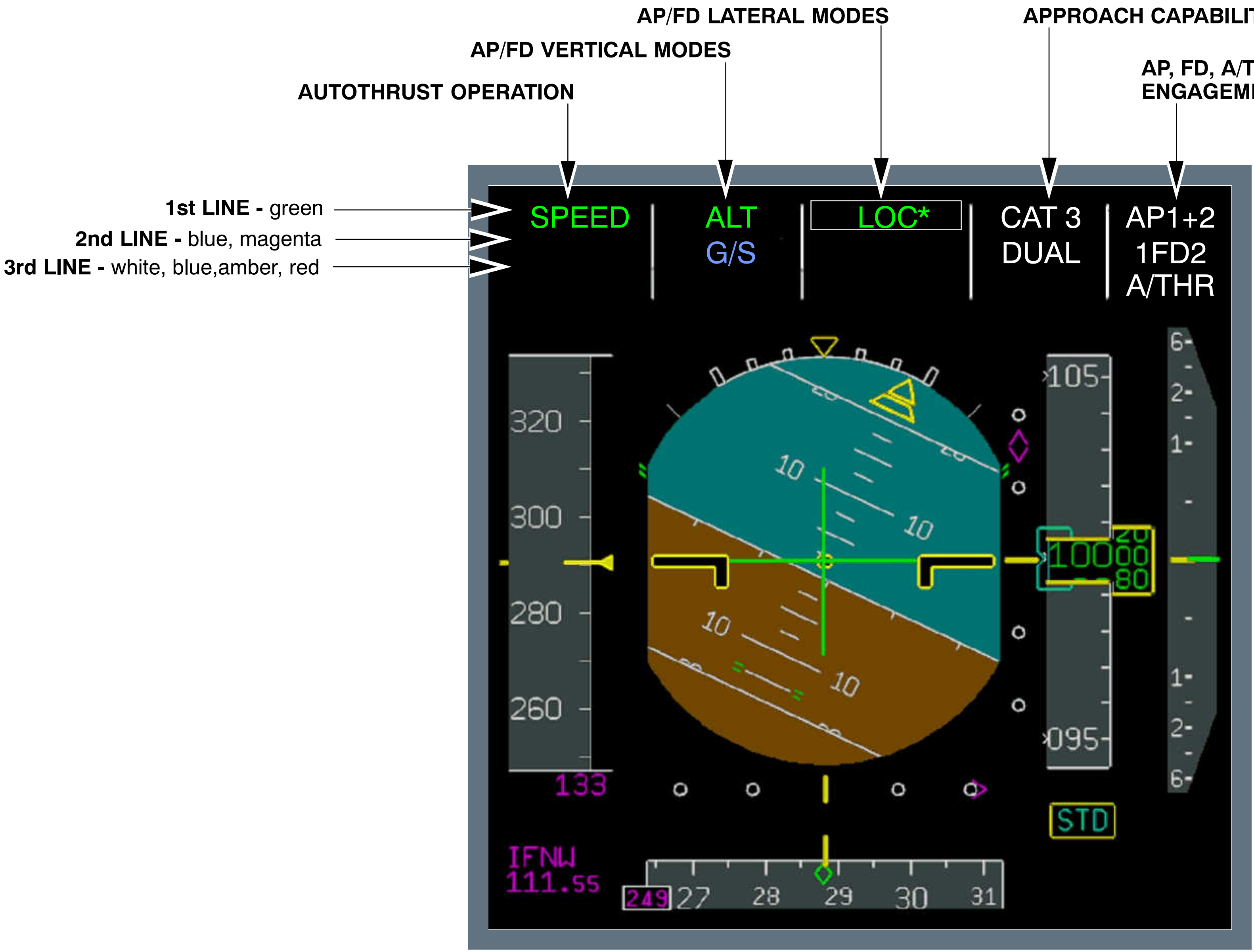


Figure 51 Flight Mode Annunciator

FMA INDICATION DETAILED DESCRIPTION

AUTOTHRUST ANNUNCIATIONS (COLUMN 1) OPERATION

DISPLAY 1st LINE	COLOR	MEANING
MAN TOGA	WHITE WHITE BOX	A/THR is armed, one thrust lever at least is in the TOGA detent.
MAN FLX XX	WHITE WHITE BOX BLUE NUMBERS	A/THR is armed, one thrust lever at least is in the MCT/FLX detent with FLX TO temp set at XX. The other thrust lever is at or below the MCT/FLX detent.
MAN MCT	WHITE WHITE BOX	A/THR is armed, one thrust lever at least is in the MCT/FLX detent, the other being at or below this detent.
MAN THR	WHITE AMBER BOX	A/THR is armed and the most advanced thrust lever is above CL detent (2 engines operative or one above MCT/FLX (ENG out) and not in a detent).
THR MCT	GREEN	A/THR is active and the most advanced thrust lever is in the MCT/FLX detent (engine out).
THR CLB	GREEN	A/THR is active in thrust mode and the most advanced thrust lever is in the CL detent.
THR IDLE	GREEN	A/THR is active and commands idle thrust.

DISPLAY 1st LINE	COLOR	MEANING
THR LVR	GREEN	A/THR is active with both thrust levers below CL detent or the live thrust lever (1 engine) below MCT.
SPEED or MACH	GREEN	SPD/MACH mode is engaged.
A. FLOOR	GREEN AMBER BOX	A/THR is active and commands TOGA thrust while alpha FLOOR conditions are met.
TOGA LK	GREEN AMBER BOX	A/THR is active and commands TOGA thrust is locked (alpha FLOOR conditions are no longer met).

AUTOTHRUST ANNUNCIATIONS (COLUMN 1) CONT.

DISPLAY 3rd LINE	COLOR	MEANING
LVR CLB (FLASHING)	WHITE	Request to set the thrust levers in CL detent.
LVR MCT (FLASHING)	WHITE	Request to set the live thrust lever in MCT/FLX detent.
LVR ASYM	AMBER	(2 engines only). One thrust lever is in CL or MCT/FLX detent and the other one is not in this detent.
LVR THR LK (FLASHING)	AMBER	After A/THR disconnection (pilot's action on FCU or failure) resulting in thrust being frozen. Both thrust levers being in CL detent or one in MCT/FLX (engine out) detent.

NOTE: The amber caution light flashes and a single chime sounds every five seconds as long as the pilot takes no appropriate action in the following cases:

–THR LK
–LVR CLB (if the thrust levers are below the CLB detent).
–LVR MCT (if the thrust levers are below the FLX/MCT detent).

AP/FD VERTICAL MODES (FMA COLUMN 2)

DISPLAY 1st LINE	COLOR	MEANING
SRS	GREEN	Takeoff or go around mode is engaged
CLB	GREEN	Climb mode is engaged. The FMGS target altitude is higher than the actual altitude. ALT CSTR are taken into account.
OP CLB	GREEN	Open Climb mode is engaged. The FCU selected altitude is higher than the actual altitude. ALT CSTR are disregarded.
EXP CLB	GREEN	Expedite Climb is engaged. The selected altitude is higher than the actual altitude. Green Dot is maintained, ALT CSTR are disregarded.
ALT*, or ALT CST*	GREEN	ALT CAPTURE is engaged – ALT* green in case of FCU selected altitude capture. – ALT CST* green in case of ALT CSTR capture (vertical profile)

AP/FD VERTICAL MODES (FMA COLUMN 2) CONT.

DISPLAY 1st LINE	COLOR	MEANING
ALT, or ALT CST	GREEN	ALTITUDE HOLD mode is engaged. – ALT is green when the FCU selected altitude is held. – ALT CST is green when an ALT CSTR is held (vertical profile)
ALT CRZ	GREEN	ALT mode is engaged and CRZ FL is held.
DES	GREEN	Descent mode is engaged. The FMGS target altitude is lower than the actual altitude. ALT CSTR are taken into account.
OP DES	GREEN	Open Descent mode is engaged. The FCU selected altitude is lower thant he actual altitude. ALT CSTR are disregarded.
EXP DES	GREEN	Expedite Descent is engaged. The selected altitude is lower than the actual altitude. Mach 0.80 or 340 knots is maintained, ALT CSTR are disregarded.
G/S*	GREEN	Glide Slope capture mode is engaged.
G/S	GREEN	Glide Slope mode is engaged.

DISPLAY 1st LINE	COLOR	MEANING
V/S +/- XXXX	GREEN + BLUE NUMBERS	Vertical speed mode is engaged to acquire and hold the V/S selected on the FCU. ALT CSTR are disregarded. (AIBA to AIBE, AISH to AIZJ) If the aircraft reaches VLS or VMAX and cannot maintain the target, the indication is boxed amber and flashes, and the target pulses.
FPA +/- XX	GREEN + BLUE NUMBERS	Flight Path Angle mode is engaged to acquire and hold the FPA selected on the FCU. ALT CSTR are disregarded. (AIBA to AIBE, AISH to AIZJ) If the aircraft reaches VLS or VMAX and cannot maintain the target, the indication is boxed amber and flashes, and the target pulses.
TCAS (OPTIONAL)	GREEN	For AP/FD TCAS mode, AP/FD follows TCAS command

AP/FD VERTICAL MODE (FMA COLUMN 2, LINE 2&3)

DISPLAY 2nd LINE	COLOR	MEANING
CLB	BLUE	Climb mode is armed.
DES	BLUE	Descent mode is armed before the descent phase.
G/S	BLUE	Glide Slope mode is armed.
ALT	BLUE OR MAGENTA	Altitude mode is armed. – blue when the target altitude is the FCU selected altitude – magenta when the target altitude is an ALT CSTR.
FINAL	BLUE	Final descent mode is armed.
ALT G/S	BLUE/BLUE	ALT and G/S modes are armed.
ALT G/S	MAGENTA/BLUE	ALT CSTR and G/S modes are armed.
ALT FINAL	BLUE/BLUE	ALT and FINAL modes are armed.
ALT FINAL	MAGENTA/BLUE	ALT CSTR and FINAL modes are armed.
DES G/S	BLUE/BLUE	DES and G/S modes are armed.
DES FINAL	BLUE/BLUE	DES and FINAL modes are armed.
TCAS (optional)	BLUE	AP/FD TCAS mode armed

DISPLAY 3rd LINE	COLOR	MEANING
SPEED SEL: XXX	BLUE	Indicates a preset speed associated with the cruise or climb phase
MACH SEL: .XX	BLUE	Indicates a preset Mach associated with the cruise or climb phase

NOTE: These two messages use both the first and second columns (third line).

A/P/FD LATERAL MODES (FMA COLUMN 3)

DISPLAY 1st LINE	COLOR	MEANING
RWY	GREEN	RWY mode is engaged.
RWY TRK	GREEN	RWY mode is engaged once airborne at or above 30 feet RA.
HDG	GREEN	HEADING mode is engaged.
TRACK	GREEN	TRACK mode is engaged.
NAV	GREEN	NAV mode is engaged to guide the aircraft along the FM lateral F-PLN.
LOC*	GREEN	LOC capture mode is engaged.
LOC	GREEN	LOC track mode is engaged.
APP NAV	GREEN	NAV mode is engaged during a NON ILS approach.
GA TRK	GREEN	GO AROUND track mode is engaged.

DISPLAY 2nd LINE	COLOR	MEANING
NAV	BLUE	NAV mode is armed.
LOC	BLUE	LOC mode is armed.
APP NAV	BLUE	NAV mode is armed for a NON ILS approach.

AP/FD COMMON MODES (FMA COLUMN 2 AND 3)

DISPLAY	COLOR	MEANING
LAND	GREEN	Land mode is engaged below 400 feet RA.
FLARE	GREEN	Flare mode is engaged.
ROLL OUT	GREEN	Roll out mode is engaged.
FINAL APP	GREEN	APP NAV and Final modes are engaged during a NON ILS approach.

APPROACH CAPABILITIES (FMA COLUMN 4)

DISPLAY 1st LINE	COLOR	MEANING
CAT 1	WHITE	CAT 1 capability available
CAT 2	WHITE	CAT 2 capability available
CAT 3	WHITE	CAT 3 capability available

DISPLAY 2nd LINE	COLOR	MEANING
SINGLE	WHITE	CAT 3 capability available, with FAIL PASSIVE condition.
DUAL	WHITE	CAT 3 capability available, with FAIL OPERATIONAL condition.

DISPLAY 3rd LINE	COLOR	MEANING
MDA/MDH **XXXX**	WHITE BLUE	Minimum descent altitude or minimum descent height as inserted by the pilot on PERF APPR page.
DH XXX **NO DH**	WHITE/BLUE WHITE	Decision height as inserted by the pilot on PERF APPR page. NO DH: when NO inserted on PERF APPR page.
DEPENDING ON EFFECTIVITY:		
BARO **XXXX**	WHITE BLUE	Minimum descent altitude or minimum descent height or decision altitude as inserted by the pilot on PERF APPR page.
RADIO XXX **NO DH**	WHITE/BLUE WHITE	Decision height as inserted by the pilot on PERF APPR page. NO DH: when NO inserted on PERF APPR page.

AP/FD – A/THR ENGAGEMENT STATUS (FMA COLUMN 5)

DISPLAY 1st LINE	COLOR	MEANING
AP 1+2	WHITE	Autopilot 1 and 2 are engaged.
AP 1	WHITE	Autopilot 1is engaged.
AP 2	WHITE	Autopilot 2 is engaged.

DISPLAY 2nd LINE	COLOR	MEANING
X FD Y	WHITE	X and Y give the FD engagement status on PFD1 and PFD2. X and Y can be 1, 2, –.–: no FD is engaged on the corresponding PFD 1: FD1 is engaged on the corresponding PFD 2: FD2 is engaged on the corresponding PFD e.g.: the normal status (FD 1 and 2 engaged) is 1FD2.

DISPLAY 3rd LINE	COLOR	MEANING
A/THR	WHITE	A/THR is active.
A/THR	BLUE	A/THR is armed.

SPECIAL MESSAGES (FMA COLUMNS 2 AND 3)

The third line displays three types of messages:

- It gives first priority to flight control messages
- It gives second priority to vertical Flight Management messages
- It gives last priority to EFIS reconfiguration messages

DISPLAY	COLOR	MEANING
MAN PITCH TRIM ONLY	RED	Displayed in case of loss of L + R elevators.
USE MAN PITCH TRIM	AMBER	F/CTL are in direct law.
CHECK APP SEL	WHITE	The aircraft is in cruise at less than 100 NM from the Top of Descent or in descent or in approach and: – a non ILS approach has been selected – an ILS frequency is tuned on the RAD NAV page
SET MANAGED SPD	WHITE	The SPEED target is selected but a preselected SPEED does not exist for the next flight phase.
SET GREEN DOT SPD	WHITE	The aircraft is in Engine Out mode and the SPEED target is selected. This message is displayed if the FCU selected speed is: = Green Dot –10 kt or = Green Dot + 10 kt except in ALT*, ALT mode

DISPLAY	COLOR	MEANING
SET HOLD SPD	WHITE	The aircraft is in selected SPEED control, an Holding pattern is inserted in the F–PLN and the aircraft is 30 seconds before the deceleration point to the precomputed HOLD SPEED.
DECELERATE	WHITE	This message is displayed if the thrust is not reduced when passing the top of descent, and the aircraft is above the descent profile.
MORE DRAG	WHITE	DES mode is engaged, idle is selected, and: – either the aircraft is above the vertical profile and the predicted intercept point of the theoretical profile is at less than 2 NM from the next ALT CSTR. – or in auto speed control and the aircraft enters a speedbrake decelerating segment
VERT DISCON AHEAD (FMS LEGACY)	AMBER	DES mode is engaged and: – a TOO STEEP path exists on the next leg. – the aircraft is less than 30 seconds from the TOO STEEP path

LANDING CAPABILITIES DESCRIPTION

After selection of the AP/FD mode for the conduction of an automatic approach, possibly including an automatic landing, the pilot must be informed about the present capability of the systems.

This is effected by means of the capability indication in the field of vision of every pilot.

A logic (see figure) determines the engage status from the number of active systems:

- **autopilots**,
- **flight directors,**
- **autothrust systems**.

In addition to that the serviceability of all other necessary systems is determined, including the number of disconnected hydraulic and electrical supplies in order to be able to define the level of the prevailing redundancy and consequently the failure behavior:

- **Fail safe**
- **Fail passive or**
- **Fail operational**

The linkage of engage status and failure behavior shows the capability after the respective weather category has been assigned to this result. The capability is displayed for every pilot.

If a change in capability due to a fault on ground or in the airplane systems occurs above the alert height, the approach has to be aborted and a go-around must be initiated.

Below the alert height the existing capability is kept at the respective level.

This means, that an individual fault below the alert height changes the system failure behavior from fail operational to fail passive, but the indication is not changed because the system continues to accomplish its tasks.

In case the landing should be endangered all the same, and a go-around has to be effected, the pilots are requested by means of the red AUTOLAND-Warning to start the go-around maneuver.

One fail passive autopilot or F/D is activated with severely limited redundancy.

This system is allowed to be used in category 1 weather conditions.

Whatever the flight phase, each Flight Management Guidance Computer (FMGC) computes its own automatic landing capability according to the availability of the various sensors and functions.

According to this capability, each FMGC computes the landing capacity which takes into account information from **both** FMGCs.

When the AP and FD are disengaged for one FMGC, the landing capability corresponds to the category of the only FMGC likely to provide automatic landing. When the AP or FD is engaged for the two FMGCs, the landing capability corresponds to the **lowest** category coming from the two FMGCs.

The master FMGC then sends the category of landing to be displayed on both Primary Flight Displays (PFD, on FMA) via the Display Management Computers (DMC).

The LAND 3 FAIL OPERATIONAL capability is obtained, when both FMGCs have the LAND 3 FAIL OPERATIONAL category.

In this configuration, the objective is to continue automatic landing in spite of the simple failures which might affect the various systems used during this phase.

LANDING CAPABILITY INDICATION:

- **CAT 1**
  - One fail passive autopilot or F/D is activated with severely limited redundancy. This system is allowed to be used in category 1 weather conditions.
- **CAT 2**
  - One fail passive autopilot is activated with sufficient redundancy.This system is allowed to be used in category 2 weather conditions.
- **CAT 3 SINGLE**
  - One fail passive autopilot and one autothrust system are activated. This system is allowed to be used in category 3A weather condition.
- **CAT 3 DUAL**
  - Two fail passive autopilots and one autothrust system are activated (a fail operational system exists). This system must be used in category 3B weather conditions.

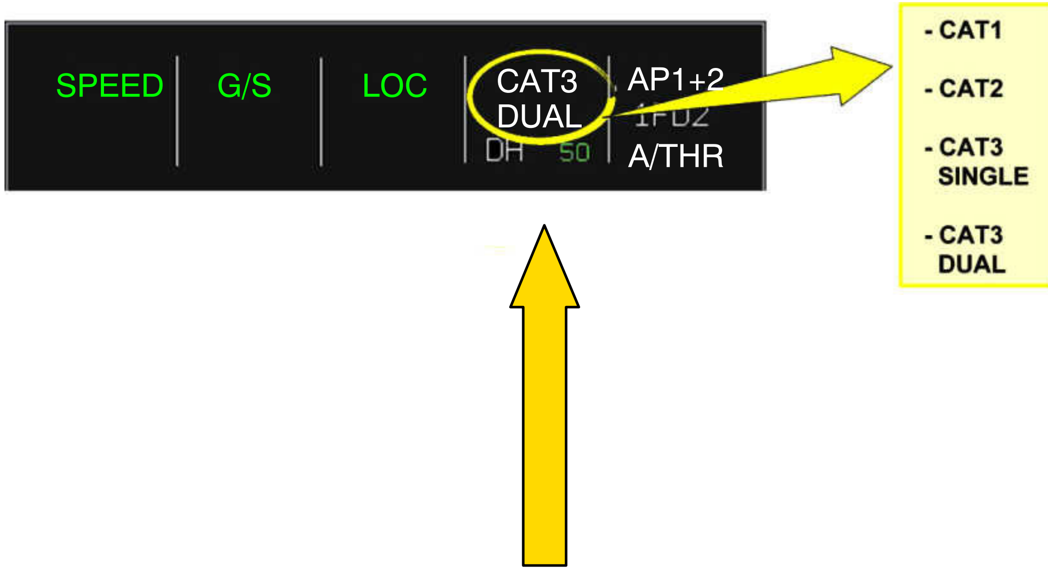
NOTE: Further details have to be taken from the system specific logics (AMM ATA 22) and the Operations Manual - B (OM - B).

Land 3 fail operational capability:
- 2 APs engaged with Land mode armed or Land mode active
- at least 1 A/THR function engaged
- 2 FWCs valid
- AFS supplied by 2 seperate ENG generator systems (PS SPLIT)
- 2 PFDs valid
- 2 ELACs valid
- 2 ILS receivers valid
- 2 Radio-altimeters valid
- 3 IRSs valid
- 3 ADRs valid
- 2 FACs valid
- 2 Yaw dampers engaged
- 2 Ruder trims engaged
- BSCU A or B valid.

Land 3 fail passive capability:
- Land 2 conditions
- at least **1 A/THR** function engaged
- 2 Radio-altimeters valid.

Land 2 capability
- at least 1 AP engaged with Land mode armed or active (RA > 400 ft)
- at least 1 FWC valid
- 2 PFDs valid
- 2 ILS receivers valid.

Land 1 capability
- **1 AP or F/D** engaged
- 1 ILS receiver valid
- 1 Radio- altimeter valid.



CAPABILITY	CATEGORY
LAND 3 FAIL OPERATIONAL	CAT 3 DUAL
LAND 3 FAIL PASSIVE	CAT 3 SINGLE
LAND 2	CAT 2
LAND 1	CAT 1

NOTE:Further details have to be taken from the system specific logics (AMM ATA 22) and the Operations Manual – B (OM – B).

Figure 52 Landing Capability Logic (Simplified Example)

AUTOLAND OPERATION

LOC Mode

Localizer capture shall be achieved with only one overshoot followed by a constant convergent heading (if needed) under the following conditions:

- A track angle error of between 20° and 60°.
- Capture initiated at a distance of at least 10 nautical miles from the runway threshold.
- Aircraft ground speed of 200 kts.
- LOC beam sensitivity of 75 μA per degree.

Still in air the LOC beam shall be tracked to within 7.5 μA.

GLIDE SLOPE Mode

The overshoot on glideslope beam capture shall not exeed 75 μA. If the capture is initiated when the aircraft is on, or above the beam center line, the overshoot shall not exeed 150 μA providing that the capture altitude is above 1500 ft.

Still in air the glideslope beam shall be tracked to within 20 μA.

APPROACH Mode

The automatic flight control system installed enables two types of approach to be considered:

- **ILS approach (LAND mode) :** guidance is performed on the ILS beam (LOC and GLIDE)
- **FMS approach :** guidance is performed from a theoretical path computed by the FMS.

The type of approach is selected by means of the MCDU. The selection of an ILS frequency on the RMP forces the selection of the ILS approach whatever the selection made on the MCDU.

The APPROACH mode (ILS or FMS) is engaged when you push the APPR pushbutton switch on the FCU.

BEHAVIOR OF REDUNDANCY SYSTEMS IN CASE OF AN ERROR; FAILURE BEHAVIOR:

If faults occur in a redundancy system the following terms are related to the possible failure behavior:

- Fail–Safe,
- Fail–Passive and,
- Fail–Operational.

These terms define the behavior of any system after a fault has occurred:

- **Fail–Safe:**

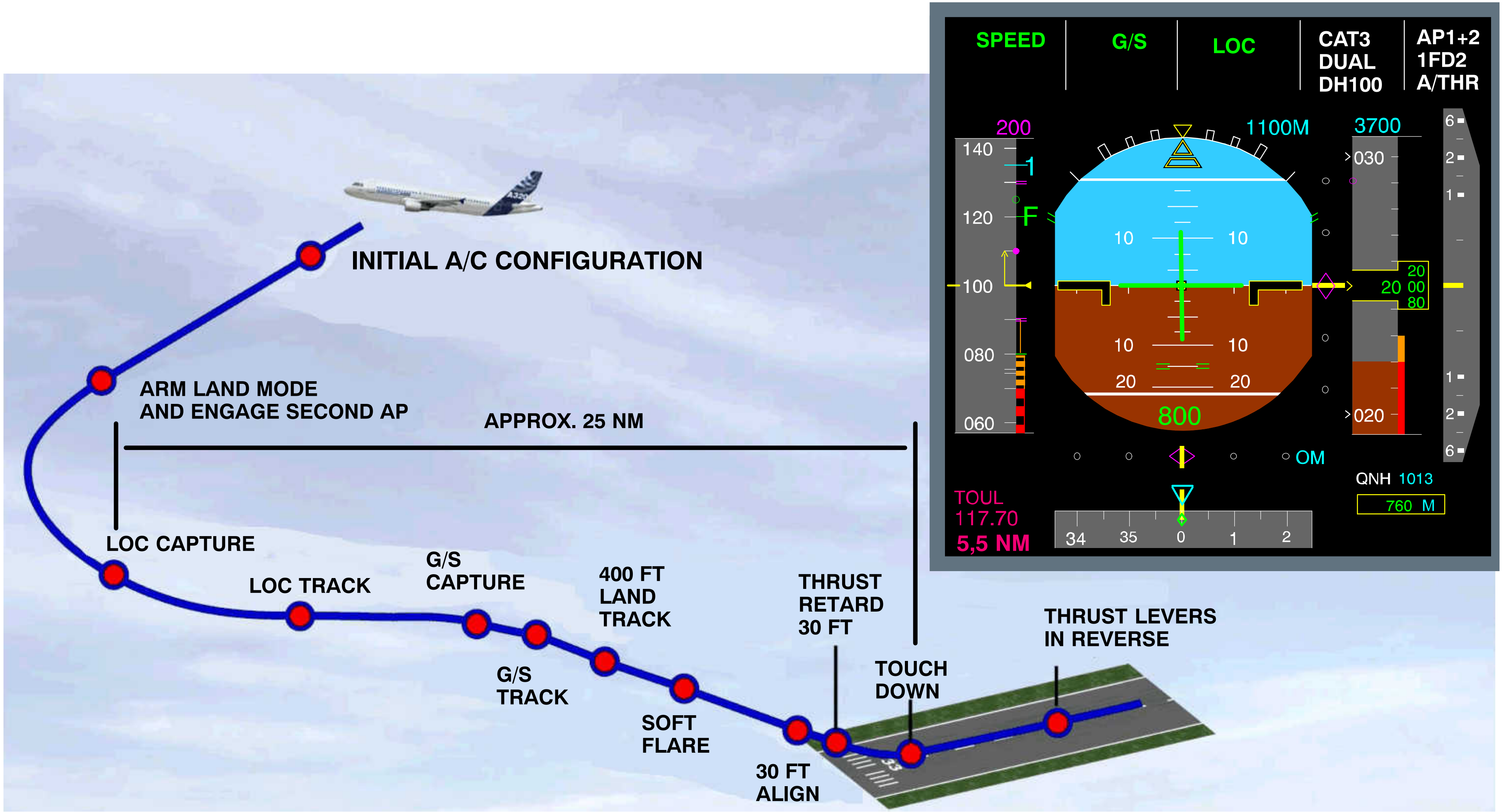
  In case of a fault or a combination of faults the system does not accomplish its function. The output signal is in a controllable fault configuration.
- **Fail–Passive:**

  In case of a fault or a combination of faults the system does not accomplish its function. The output signal is not in a fault configuration; the system is passive. In order to achieve this, an automatic error detection and error suppresion are necessary.
- **Fail–Operational:**

  In case of a fault or a combination of faults the complete system continues to work within the limits of acceptable deviation. The output signal is not in fault configuration and the system remains operative. The system is fault–tolerant.

NOTE: Below 100 ft RA, LAND 3 FAIL PASSIVE and LAND 3 FAIL OPERATIONAL categories are memorized, until the LAND TRACK mode is disengaged or the 2 APs are disengaged. A failure occurring below 100 ft does not cause any capability downgrading.

The CAT 1, CAT 2, CAT 3 SINGLE and CAT 3 DUAL messages are displayed on the FMA according to the landing capabilities send by the FMGCs.



AT 700 FT THE ILS FREQ. AND COURSE ARE FROZEN WITHIN THE ILS RCVR/MMR.

AT 400 FT (LAND TRACK) AUTO-PILOT LATERAL & VERTICAL MODES ARE FROZEN EXCEPT IF GO-AROUND IS SELECTED

Figure 53 Autoland Operation

AP/FD MODES DETAILED DESCRIPTION

ATTENTION: This pageblock provides a deeper understanding about the behavior of the AP/FD functions. Its' content does not represent a mandatory knowledge.

TAKE OFF MODE

This mode provides lateral guidance function, at takeoff on the runway centerline by means of the LOC beam and by following an optimum longitudinal flight path after rotation.

This mode is available:

- for the FD during takeoff run and in flight
- for the AP 5 seconds after lift−off.

The mode is engaged when the pilot selects the takeoff thrust by positioning the thrust control levers beyond the MCT/FLX TO gate.

Engagement of the mode is shown by the green SRS (Speed Reference System) and RWY indications in the Flight Mode Annunciator (FMA) columns corresponding to the longitudinal modes.

Pitch Axis

The pitch guidance law enables holding of V2 + 10 kts in normal engine configuration.

Prior to mode engagement, the pilot must select speed V2 on the TAKE OFF page of the MCDU.

With V2 selected, the managed speed control is activated and **the TO longitudinal mode (SRS)** can be engaged. Without V2 selection on the MCDU, the mode is not engaged on this axis.

The guidance law on the lateral axis provides guidance of the aircraft on the runway centerline by means of the LOC beam. For this, the FM or the pilot selects the ILS frequency associated with the takeoff runway.

This selection can be made:

- Implicitly by selecting the takeoff runway or departure procedure on the MCDU.
- Expressly by selecting the frequency on the RMP or the MCDU.

The lateral TO (RWY) mode can be engaged when the aircraft is at the end of the runway and receives the LOC deviation signals. If the ILS is not available or if the ILS frequency is not selected, theTO mode is not engaged on this axis.

In engine fail detection, the law enables to hold:

- The aircraft speed (Va) if it is greater than V2 when the engine failure occurs, or
- V2 if the aircraft speed (Va) is lower than V2 when the engine failure occurs.

In addition, the guidance law includes:

- An attitude protection to reduce the A/C nose−up attitude during this phase.
- A flight path angle protection to ensure a minimum climbing rate.

Lateral Axis

The guidance law on the lateral axis provides guidance of the aircraft on the runway centerline by means of the LOC beam. The pilot makes this possible by selecting the ILS frequency associated with the takeoff runway.
This selection can be made:

- implicitly by selecting the takeoff runway or departure procedure on the MCDU
- expressly, by selecting the frequency on the RMP or the MCDU.

The lateral TO (RUNWAY) mode can be engaged when the aircraft is at the end of the runway and receives the LOC deviation signals.

If the ILS is not available or if the ILS frequency is not selected, the TO mode is not engaged on this axis.

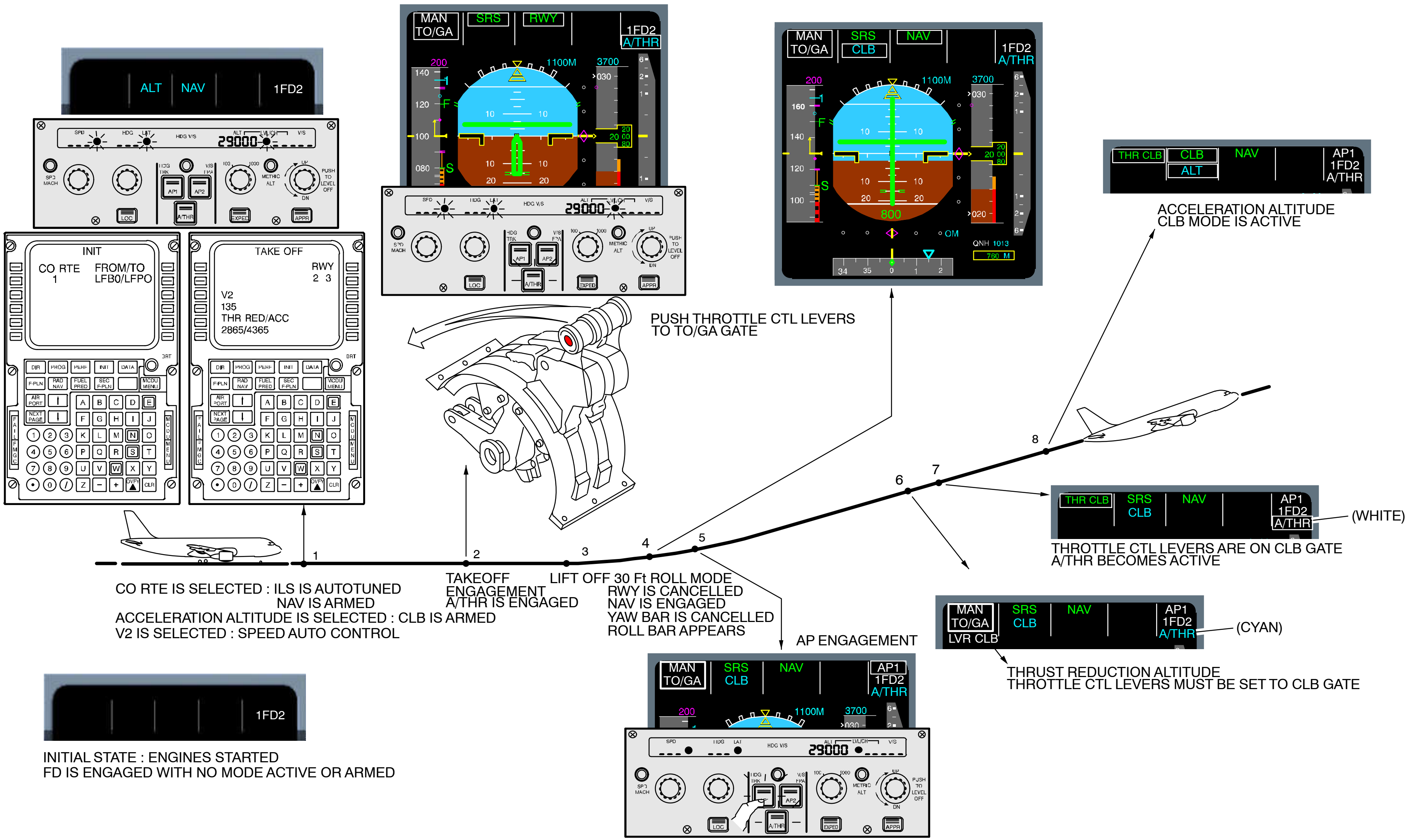


Figure 54 Take Off sequence - NAV Armed

LONGITUDINAL MODES BDESCRIPTION

To ensure aircraft guidance on the longitudinal axis in AP/FD, the pilot can use:

- the modes which ensure capture and holding of a level,
- the modes which ensure control of level changes.

The level change control is ”**selected**” when the pilot imposes the guidance parameters via the FCU. The indication on the FMA is “**OPEN CLB**“.

The level change control is ”**managed**” when the guidance parameters are determined by the FM part. The indication on the FMA is “**CLB**“.

The list of longitudinal modes and sub−modes active in cruise and the control laws and associated references are given in the figure.

ALTITUDE ACQUISITION MODE (ALT ACQ)

This mode permits to acquire the altitude selected in the ALT counter of the FCU or the altitude provided by the FM part when the passage of an altitude constraint in the longitudinal flight plan requires levelling of the aircraft.

The ALT ACQ mode includes an arming phase in which a support mode for level change control ensures convergence toward the desired level.

The ALT ACQ mode becomes active when the capture condition is satisfied i.e. when the aircraft altitude deviation with respect to the target level is lower than a value dependent on the vertical speed. When the target level is actually reached, the altitude hold mode is automatically engaged and replaces the ALT ACQ mode. The ALT ACQ mode is always armed except in the cases below:

- in altitude hold or ALT ACQ mode
- after glide capture
- in V/S−FPA mode when the aircraft deviates from the selected altitude.

FCU Level Acquisition

With the ALT ACQ mode armed, the operating sequence is as follows:

- selection of a flight level on the FCU (during selection, the ALT ACQ mode is inhibited)
- engagement of a support mode which permits to reach the selected level (ALT in cyan on the FMA)
- capture of the selected level (ALT * in green on the FMA)
- switching to the altitude hold mode when the altitude deviation becomes lower than 20 ft.

This operating sequence can be modified if the pilot changes the reference altitude.

During the arming phase:

- If, when the pilot stops his selection the capture condition is met, the ALT ACQ mode is immediately engaged.

During the capture phase:

- If, in spite of the reference change the capture condition is still met, the ALT ACQ mode remains active but a performance degradation may occur.
- If the capture condition is no longer met, the V/S or FPA mode is engaged with the current aircraft Vz or FPA taken as a target at mode engagement.

Acquisition of an Altitude Constraint

With the ALT ACQ mode armed, the altitude constraint delivered by the FM part will be captured:

- if it is located between the level selected on the FCU and the aircraft level
- and if the support mode is a mode for automatic control of level changes.

During the arming phase, the ALT message is displayed in magenta on the second line of the FMA. The condition for activation of the ALT ACQ mode is the same as for the FCU level capture.

The FMA messages associated to the modes of capture and holding of an altitude constraint are displayed in magenta.

If the conditions required to follow the flight plan disappear (loss of NAV mode or loss of longitudinal flight plan) during the capture, the AP/FD switches to the V/S FPA mode and holds the A/C vertical speed.

The FCU level capture is armed again.

ALTITUDE HOLD MODE (ALT HOLD)

This mode permits to hold the altitude selected on the FCU or the altitude constraint delivered by the FM part. The engagement of the ALT mode is automatic when, with the ALT ACQ mode active, the difference between the aircraft altitude and the target altitude becomes lower than 20 ft.

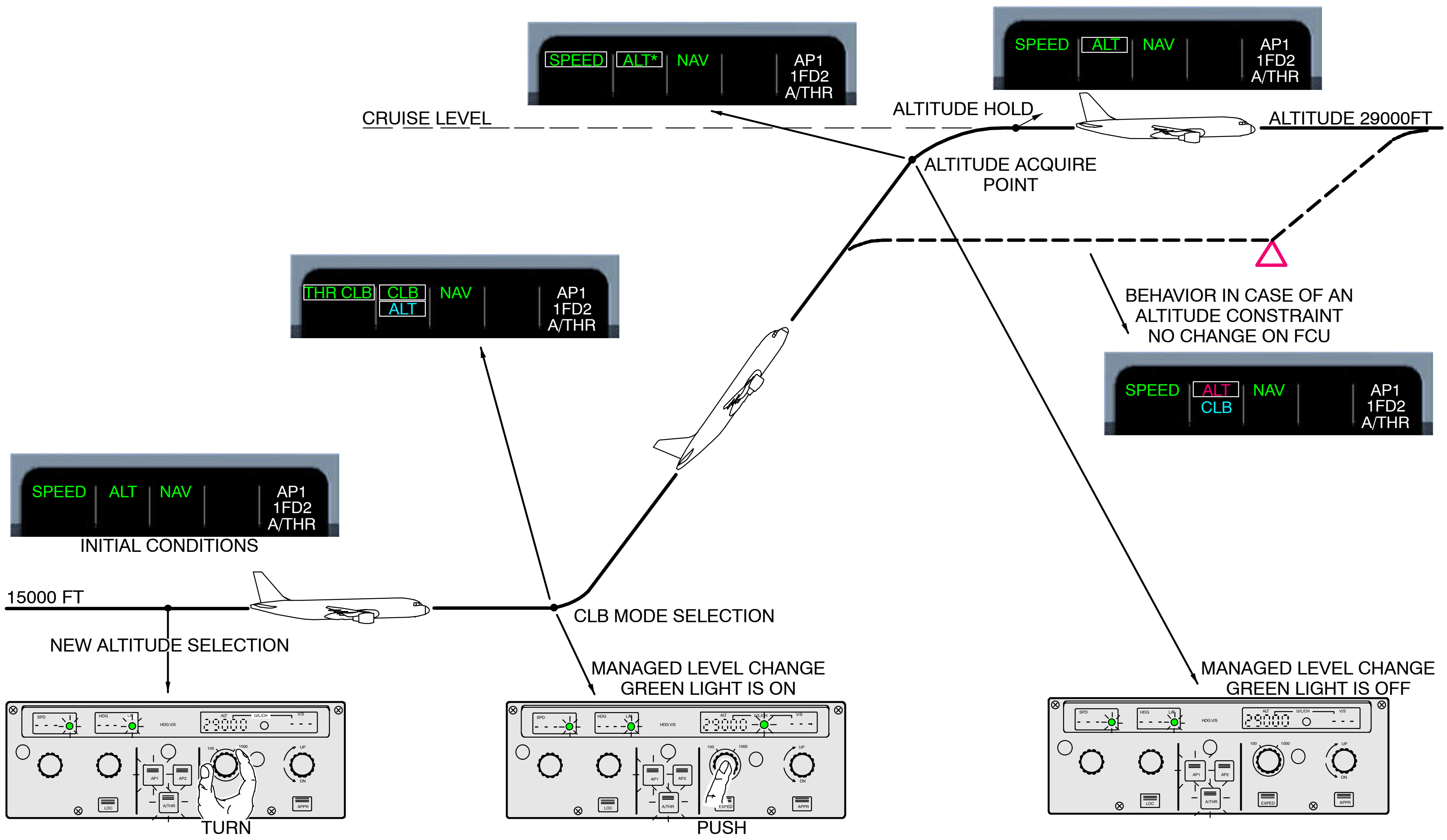


Figure 55 Managed Level Change

LATERAL MODES - HEADING OR TRACK HOLD MODES (HDG/TRK)

The choice between heading and track modes is made according to the selection made on the FCU.

After an in-flight energization, the FCU selection is HDG-V/S and the heading hold mode is engaged at the FD.

An action on the FCU related pushbutton switch causes the selection of TRK-FPA, engagement of the TRK mode and the synchronization of the HDG TRK window on the aircraft track.

A second action on the FCU related pushbutton switch causes the selection of HDG-V/S, engagement of the HDG mode and the synchronization of the HDG TRK window on the aircraft heading.

These logic is valid if the aircraft, with HDG or TRK mode active, is not turning (current target < 5 deg).

If not, an action on FCU related pushbutton switch leads to take the previous target for the new one. So the turn is not interrupted.

The HDG/TRK mode can be engaged in flight through pull action on the heading/track selector knob of the FCU.

At mode engagement, the HDG TRK window of the FCU is synchronized on the aircraft heading (track).

The HDG/TRK mode enables to acquire and hold the heading (track) displayed on the FCU.

The selection on the FCU can be performed before or after the mode engagement.

In fact, with the mode not engaged, the HDG TRK window displays three dashes and if you turn the heading/track selector knob on the FCU, the window is synchronized on the aircraft heading (track).

The pilot can then select a heading (track) which will be taken into account if he engages the HDG/TRK mode.

If the mode is not engaged within 45 s following the selection, the dashes are displayed again in the window and the selection is lost.

The acquisition of the heading (track) displayed during the initial engagement is made in the shortest way. On the contrary, with the HDG/TRK mode engaged, if a change of selected heading (track) is made on the FCU, the acquisition of the new heading (track) will be made following the direction of rotation of the heading/track selector knob of the FCU for the display.

The HDG/TRACK modes are activated if one of the conditions below is met:

- pull action on the HDG TRK selector knob on the ground with engines shut down and in flight 5 s after lift-off
- loss of lateral flight plan, with the NAV mode active and on condition that the FINAL DES mode is not armed or active
- engagement of AP or FD in flight, with no AP/FD engaged
- loss of LOC capture or LOC track due to the loss of the LAND mode, independent of the selection of a lateral mode and of action on the LOC pushbutton switch
- loss of the NAV mode due to the loss of FINAL DES mode active or armed and independent of the selection of a lateral mode (action on the APPR pushbutton switch or selection of the V/S FPA mode)
- loss of the LOC capture or LOC Track mode not in the LAND mode through action on the LOC pushbutton switch
- arming of LOC mode, the NAV mode associated to the FINAL DES mode being active.

LATERAL MODES - NAVIGATION MODE (NAV)

This mode enables the aircraft to be controlled in the horizontal plane using the commands calculated by the Flight Management (FM) section. The mode includes an arming phase, the support mode can be the HDG/TRK or RUNWAY mode and an active phase.

The NAV mode can only be active or armed if a lateral flight plan, calculated by the FM from data introduced on the MCDU, is available.

On the ground, the NAV mode is automatically armed as soon as a flight plan is available. At takeoff, the switching to active NAV occurs at 30 ft.

In the same conditions and if the radio altimeters are failed, the NAV mode becomes active 5 s after lift-off.

In flight, the NAV mode is armed through push action on the HDG TRK selector knob except if the LOC mode is active.

The capture condition is calculated by the FM part. The NAV mode can become active without passing through the arming phase when the pilot modifies his flight plan through the DIRECT TO procedure on the MCDU.

The arming of the NAV mode is indicated to the pilot through the illumination of the LAT indicator light on the FCU.

When the NAV mode becomes active, the light remains on and dashes are displayed in the HDG TRK window of the FCU display.

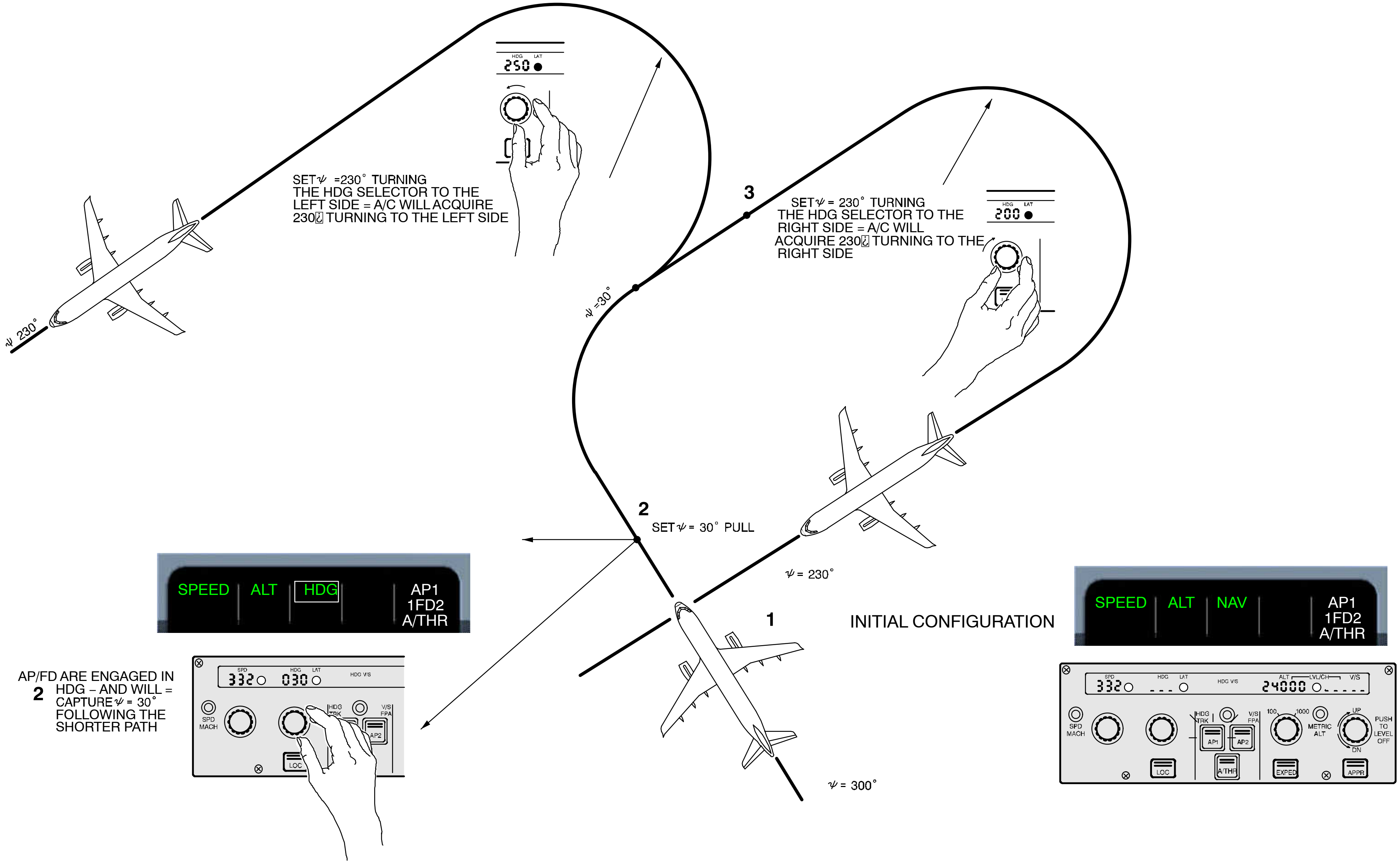


Figure 56 Heading Mode

APPROACH MODE DESCRIPTION

The automatic flight control system installed enables two types of approach to be considered :

- **ILS approach (LAND mode) :** Guidance is performed on the ILS beam (LOC and GLIDE)
- **FMS approach:** Guidance is performed from a theoretical path computed by the FMS.

The type of approach is selected by means of the MCDU. The selection of an ILS frequency on the RMP forces the selection of the ILS approach whatever the selection made on the MCDU.
The APPROACH mode (ILS or FMS) is engaged when you push the APPR pushbutton switch on the FCU.

(1) ILS APPROACH

(a) Characteristics

This mode provides the capture and track of the ILS beam (LOC and GLIDE) and ensures the following functions :

- alignment,
- flare
- and roll out.

This mode is available for the AP and FD. It enables landings to be performed in Cat. III operation. Therefore, the selection of the LAND mode authorizes the engagement of a second AP.

(b) Operational use

The ILS approach can be selected:

- implicitly, through the flight plan definition. In this case, the frequency of the ILS/MMR receivers is adjusted automatically on the value read in FM memory.
- expressly, by selecting a frequency and a runway heading by means of the MCDU or the RMP.

In these conditions, the LAND mode can be armed by action on the APPR pushbutton switch on the FCU. The arming of this mode enables the LOC and GLIDE modes to be armed on the lateral and longitudinal axes. The support modes, active on these axes, remain engaged until the LOC and GLIDE beams are captured.

Switching to the G/S CPT and LOC CPT modes occurs when the capture conditions are met.

When the aircraft is stabilized on the LOC and GLIDE beams:

- the LOC TRACK and GLIDE TRACK modes are activated
- the AP/FD guides the aircraft along the ILS beam to 30 ft.

At this altitude, the LAND mode provides the alignment on the runway centerline on the yaw axis and flare on the pitch axis. When the A/THR is engaged, the thrust reduction (RETARD) is activated.

The ROLL OUT sub−mode is engaged at touchdown and provides guidance on the runway centerline. As the LAND mode is latched below 400 ft. (switching to LAND TRACK), it can be de−activated only by engaging the GO AROUND mode. Actions on the FCU are no longer taken into account.

NOTE: The GLIDE mode can only be captured after LOC mode capture. However the GLIDE capture can be independent from the LOC capture (option activated by pin programming).

(2) FMS APPROACH (AREA NAV OR R.NAV)

(a) Characteristics

This mode provides lateral and longitudinal guidance of the aircraft along a theoretical profile defined by the flight plan (Ref. 22−73−00).
Guidance is ensured down to the MDA (Minimum Descent Altitude), altitude at which the pilot regains control of the aircraft. This mode is available on the AP and FD.

(b) Operational use

The AREA NAV approach is selected through the flight plan. In these conditions, the FINAL DES and NAV modes can be armed on the lateral and longitudinal axes by action on the APPR pushbutton switch on the FCU. If the NAV mode was already active, the mode will remain engaged.

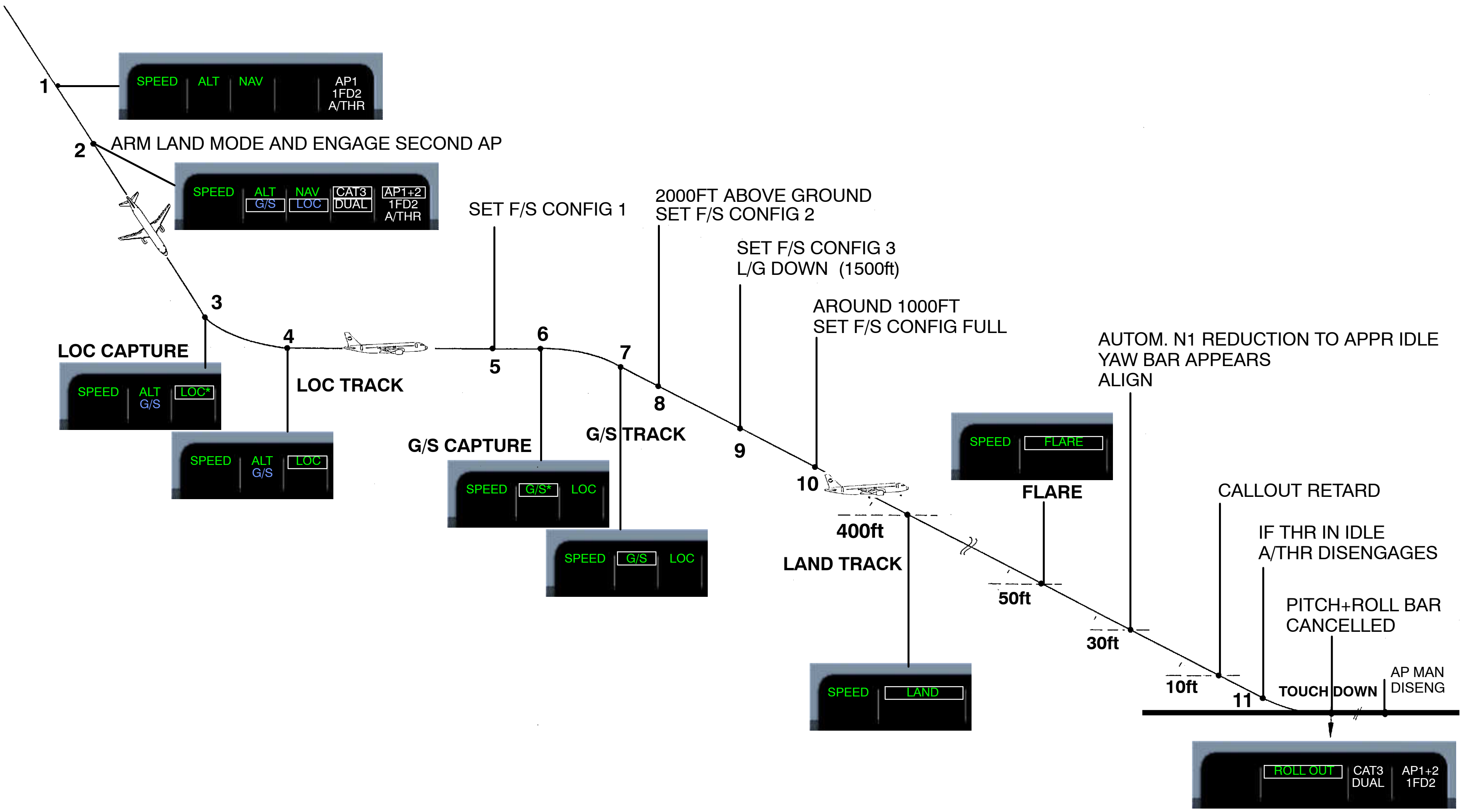


Figure 57 Approach and Landing Sequence - ILS Approach

GO-AROUND MODE DESCRIPTION

On the lateral axis, the engaged mode enables to hold the track followed by the aircraft.

On the longitudinal axis, it ensures managed speed control. The speed reference of the guidance law is the aircraft speed when the mode was engaged (the lower limit of speed is the approach speed).

This mode is available on the AP and the FD. It is engaged when the pilot selects the maximum thrust by positioning the thrust control levers in the TO/GA gate.

Engagement is indicated by the green ”SRS” and ”GA TRK” indications displayed in the FMA sections corresponding to the longitudinal and lateral modes.

Engage Logic

Engagement of the GO AROUND mode results in:

- engagement of the PITCH GO AROUND mode on the pitch axis
- engagement of the ROLL GO AROUND mode on the roll axis.

The PITCH GO AROUND mode can only be disengaged by engaging another longitudinal mode.

The ROLL GO AROUND mode can only be disengaged by engaging another lateral mode.

When in PITCH GO AROUND mode, engagement of a cruise mode is possible only above 100 ft RA.

In dual–AP configuration, disengagement of the GO AROUND mode on one axis causes disconnection of the AP2.

Command Generation - Pitch Axis

Engagement of the PITCH GO AROUND mode calls the SRS guidance law. The speed reference is the aircraft speed memorized when the GA mode was engaged. However this reference speed cannot be lower than the approach speed memorized at 700 ft. during approach.

Command Generation - Roll Axis

Engagement of the ROLL GO AROUND mode calls the TRACK guidance law. The path reference of the guidance law is the path followed by the aircraft when the ROLL GO AROUND mode is engaged.

Heading/Track Preset

The heading/track preset function is available in LOC CPT, LOC TRACK, LAND TRACK and ROLL GO AROUND modes if the pilot selects a heading/track value on the FCU.

In ROLL GO AROUND mode, the NAV mode can be armed only by push action on the heading/track selector knob on the FCU. The preset function can be cancelled.

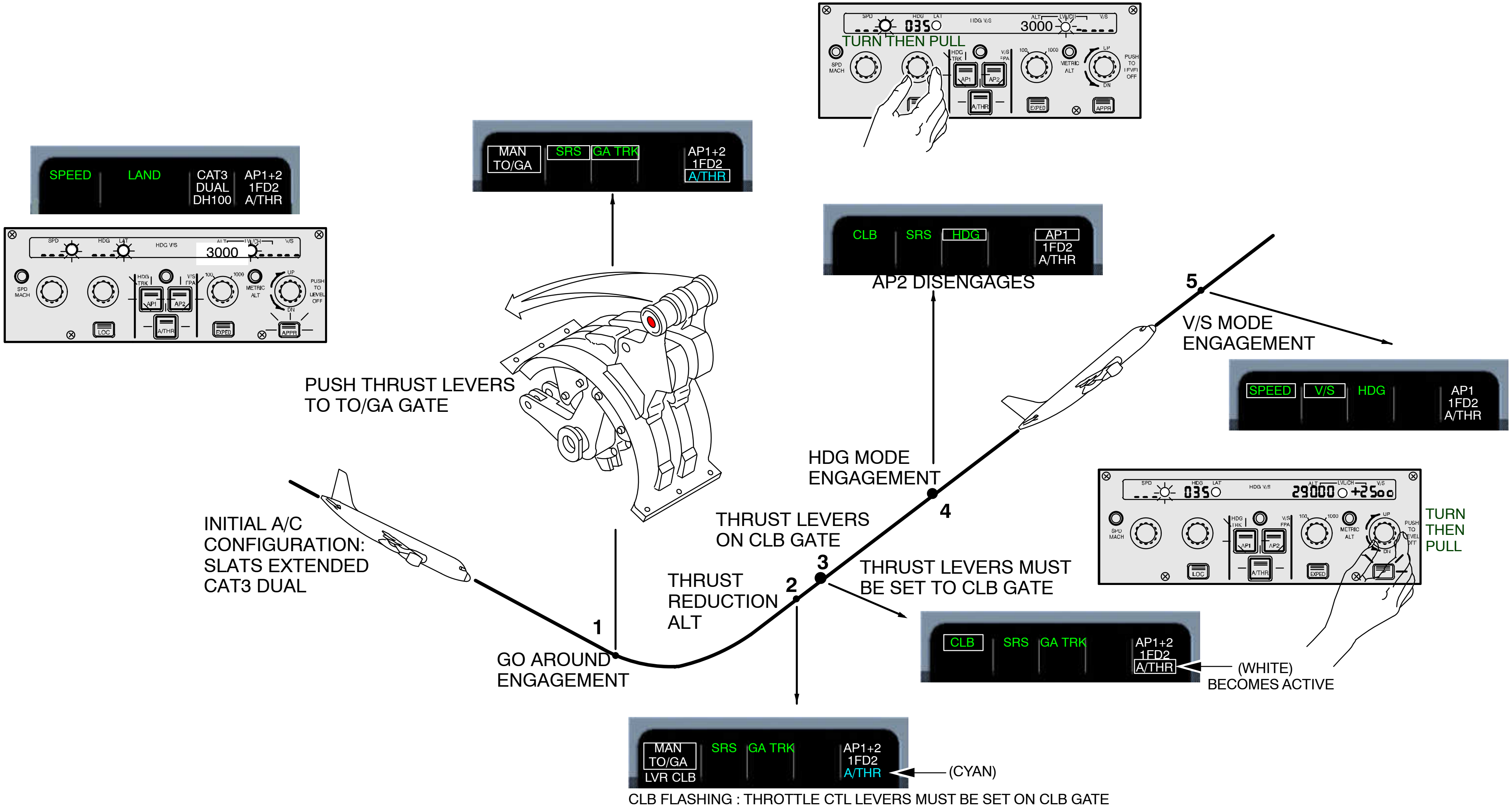


Figure 58 GO - AROUND Sequence

22-30 AUTOTHRUST

AUTOTHRUST INTRODUCTION

GENERAL

The autothrust (A/THR) system is part of the auto flight system and fulfills the following functions through the control of the thrust:

- speed or mach hold (either FMGCs computed or from thrust levers position),
- thrust hold (either FMGS computed or from thrust lever position),
- thrust reduction during descent and during flare in final approach,
- protection against insufficient speed linked to excessive angle of attack.

To fulfill the A/THR functions, the FMGCs communicate with the Full Authority Digital Engine Control (FADEC) via the FCU and the Engine Interface Units (EIUs).

The A/THR is integrated in the Flight Management and Guidance System. The Engine Interface Units (EIUs) and the Electronic Control Units (ECUs)/Electronic Engine Control (EECs), ensure the link between this system and the engines.

The use of digital engine control units permitts to simplify the autothrust system through :

- the deletion of the autothrottle actuator (use of a digital link between the FMGC and the ECUs/EECs)
- the deletion of the limit thrust computation (already performed by the ECUs/EECs)
- the deletion of the limit thrust panel (the ECUs/EECs make this selection automatically depending on the position of the thrust levers).
- the deletion of the TO/GA levers (the engagement of these modes is made through push action on the thrust control levers).

THRUST LEVERS

The engines are manually controlled by thrust levers, which are located on the center pedestal, or automatically controlled by the A/THR system. Two red INSTINCTIVE DISCONNECT pushbuttons, located on the thrust levers, allow the A/THR function to be disengaged (push either one).

Note that the thrust levers never move automatically.

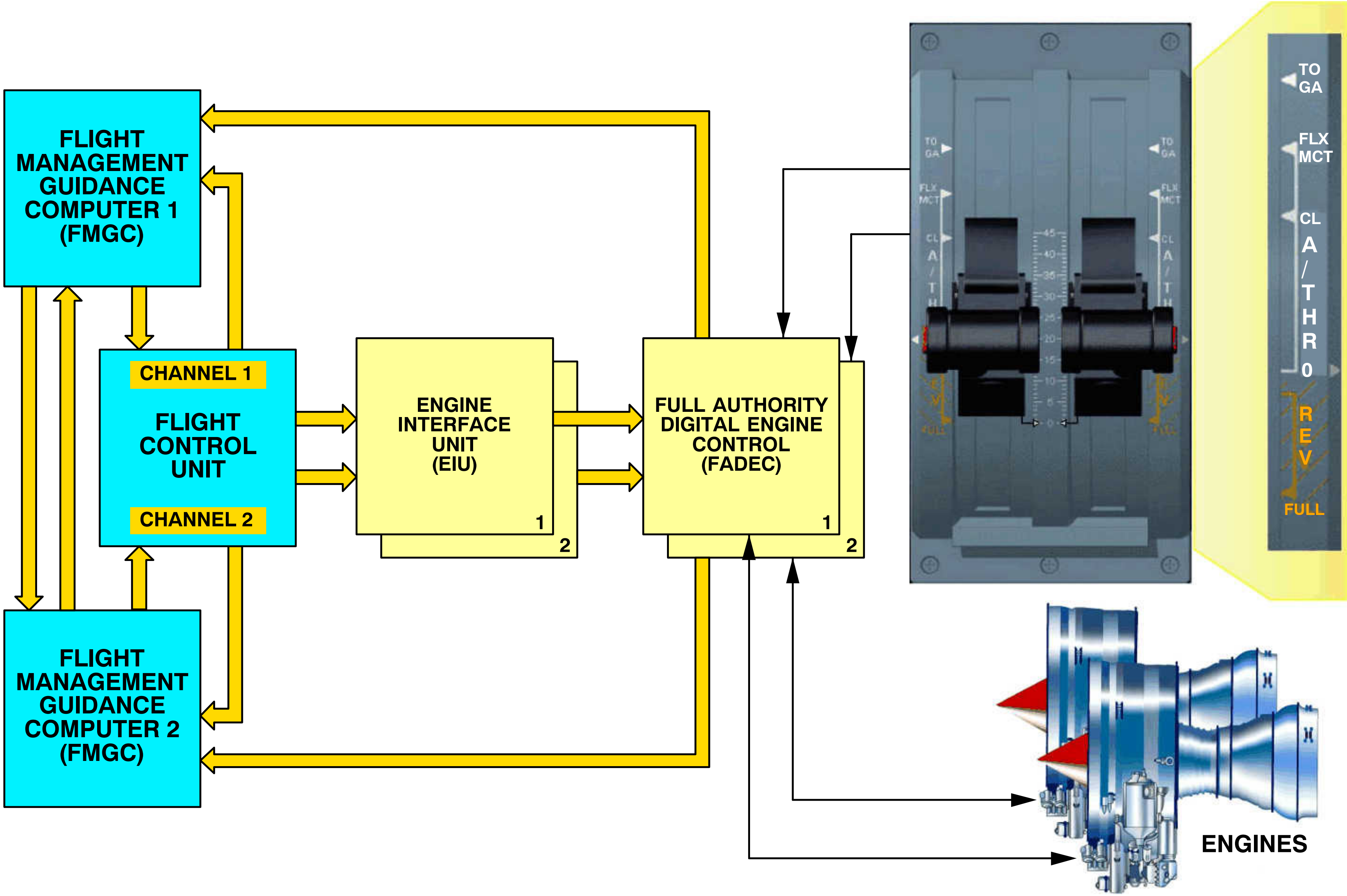


Figure 59 Autothrust - General

AUTOTHRUST DESCRIPTION AND OPERATION

ENGAGEMENT

The engagement of the Autothrust function can be MANUAL or AUTOMATIC:
The Autothrust (A/THR) is engaged MANUALLY by pressing the A/THR pushbutton on the Flight Control Unit (FCU).
This is inhibited below 100 feet RA, with engines running.

The A/THR is engaged AUTOMATICALLY:

- when the Autopilot/Flight Director (AP/FD) is engaged in TAKE–OFF or
- GO AROUND modes, or
- in flight, when the Alphafloor is detected; this is inhibited below 100 feet RA except during the 15 seconds following the lift–off.

NOTE: To effectively have A/THR on engines, the engagement of the A/THR is confirmed by a logic of activation in the Engine Control Unit (ECU).

A/THR Loop Principle

To perform the A/THR function, the Flight Management and Guidance Computer (FMGC) communicates, on the one hand, with the FCU and, on the other hand, with the ECU via the FCU and the Engine Interface Units (EIUs).

A/THR ENGAGEMENT LOGIC

ENGAGEMENT OF AP		ENGAGEMENT OF FD		A/THR ACTIVE
1	2	1	2	
ON	*	*	*	A/THR 1
OFF	ON	*	*	A/THR 2
OFF	OFF	ON	*	A/THR 1
OFF	OFF	OFF	ON	A/THR 2
OFF	OFF	OFF	OFF	A/THR 1 (or A/THR 2 if A/THR 1 fail)

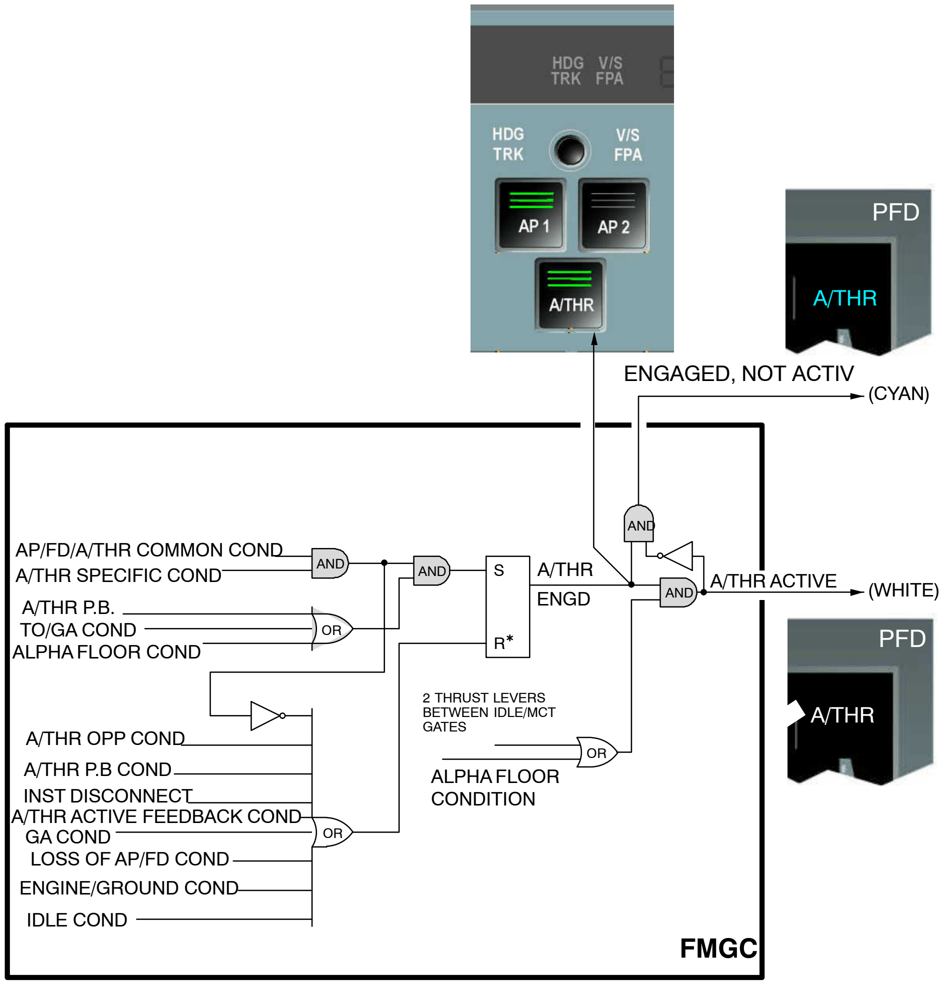


Figure 60 A/THR Engage Logic

FMGC: FLIGHT MANAGEMENT & GUIDANCE COMPUTER
FCU: FLIGHT CONTROL UNIT
EIU: EINGINE INTERFACE UNIT
FADEC: FULL AUTHORITY DIGITAL ENGINE CONTROL
FMA: FLIGHT MODE ANNUNCIATOR

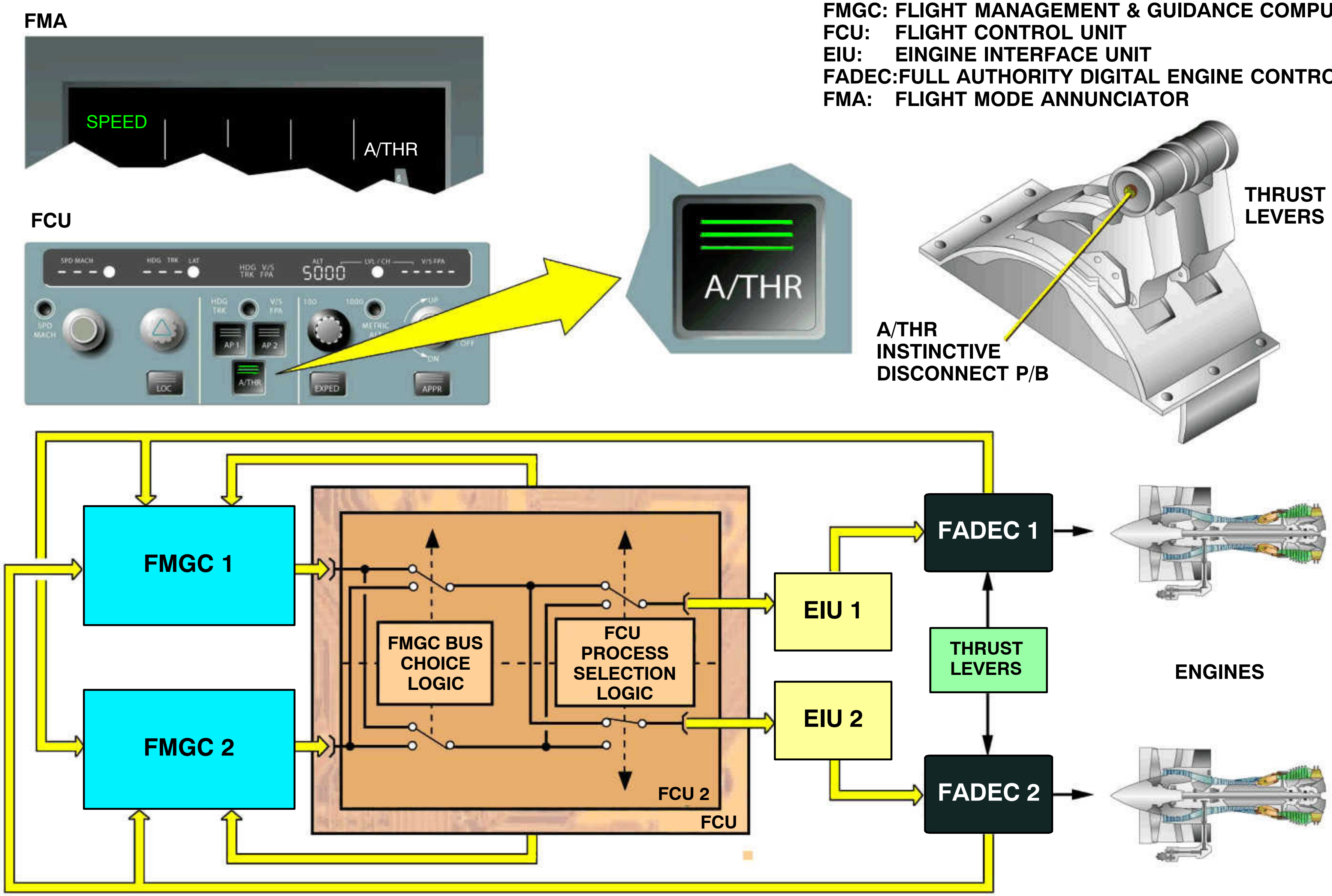


Figure 61 A/THR Engagement

AUTOTHRUST DESCRIPTION AND OPERATION

THRUST LEVERS

The thrust levers are manually operated and electrically connected to the Engine Control Units. Each lever has 4 positions, defined by DETENTS or STOPS, and 3 operating segments.

Note that the thrust levers never move automatically.

The Engine Control Units compute the thrust limit which depends on the position of the thrust levers.
The thrust levers can be moved on a sector which includes specific positions:

- **"0"**: corresponds to an IDLE thrust,
- **"CL"**: corresponds to a CLIMB thrust,
- **"FLX/MCT"**: corresponds to a FLEXIBLE TAKE-OFF thrust or a MAXIMUM CONTINUOUS thrust,
- **"TO/GA"**: corresponds to a MAXIMUM TAKE-OFF/GO AROUND thrust.

The thrust reverser levers only allow REVERSE thrust to be performed. If a thrust lever is in a detent, the thrust limit corresponds to this detent. If a thrust lever is not in a detent, the thrust limit corresponds to the next higher detent.
The FMGCs select the higher of the ECU 1, and ECU 2 thrust limits.

A/THR Function Logic

The A/THR function can be **ENGAGED** or **DISENGAGED**.
When it is engaged, it can be **ACTIVE** or **NOT ACTIVE**.

DISENGAGEMENT case:

- the thrust levers control the engines,
- on the FCU, the A/THR pushbutton light is OFF,
- the Flight Mode Annunciator (FMA) displays neither the A/THR engagement status nor the A/THR modes.

When the A/THR engage logic conditions are present, the A/THR can be engaged.
It is **active or not active** depending on the thrust **lever position**.

A/THR IS ACTIVE IF:

- Setting thrust levers between CL and > IDLE detent position (with **two engines** running),
- or between MCT and > IDLE position detent if **one engine inoperative,**
- selecting the FCU A/THR pb on while the thrust levers are in the A/THR active range,
- activation of ALPHA FLOOR regardless of A/THR initial status and thrust levers position.

WHILE A/THR IS ACTIVE:

- If at least one thrust lever is set out of the CL detent anywhere within the A/THR active range, A/THR remains active.
  A ASYM amber message is displayed on FMA.

WHEN THE A/THR FUNCTION IS ENGAGED AND ACTIVE:

- the A/THR system controls the engines,
- on the FCU, the A/THR pushbutton light is ON,
- the FMA displays the A/THR engagement status (in white) and the A/THR mode.

A/THR IS NOT ACTIVE:

- as soon as one thrust lever is placed outside the active range, the two engines are controlled by the position of the thrust levers. This last as long as the ALPHA FLOOR protection is not activated.

WHEN THE A/THR FUNCTION IS ENGAGED AND NOT ACTIVE:

- the thrust levers control the engines,
- the A/THR pushbutton light is ON,
- the FMA displays the A/THR engagement status (in cyan) and the A/THR mode.

Note that in case of one engine failure, the A/THR activation zone becomes between "MCT" and " > IDLE" stop.

A/THR INSTINCTIVE DISCONNECT P/B

Action of one of the two INST DISC P/B for more than 15 sec. inhibits any engagement of the A/THR function, what ever the reason (FCU A/THR P/B switch, Alpha floor protection etc.).

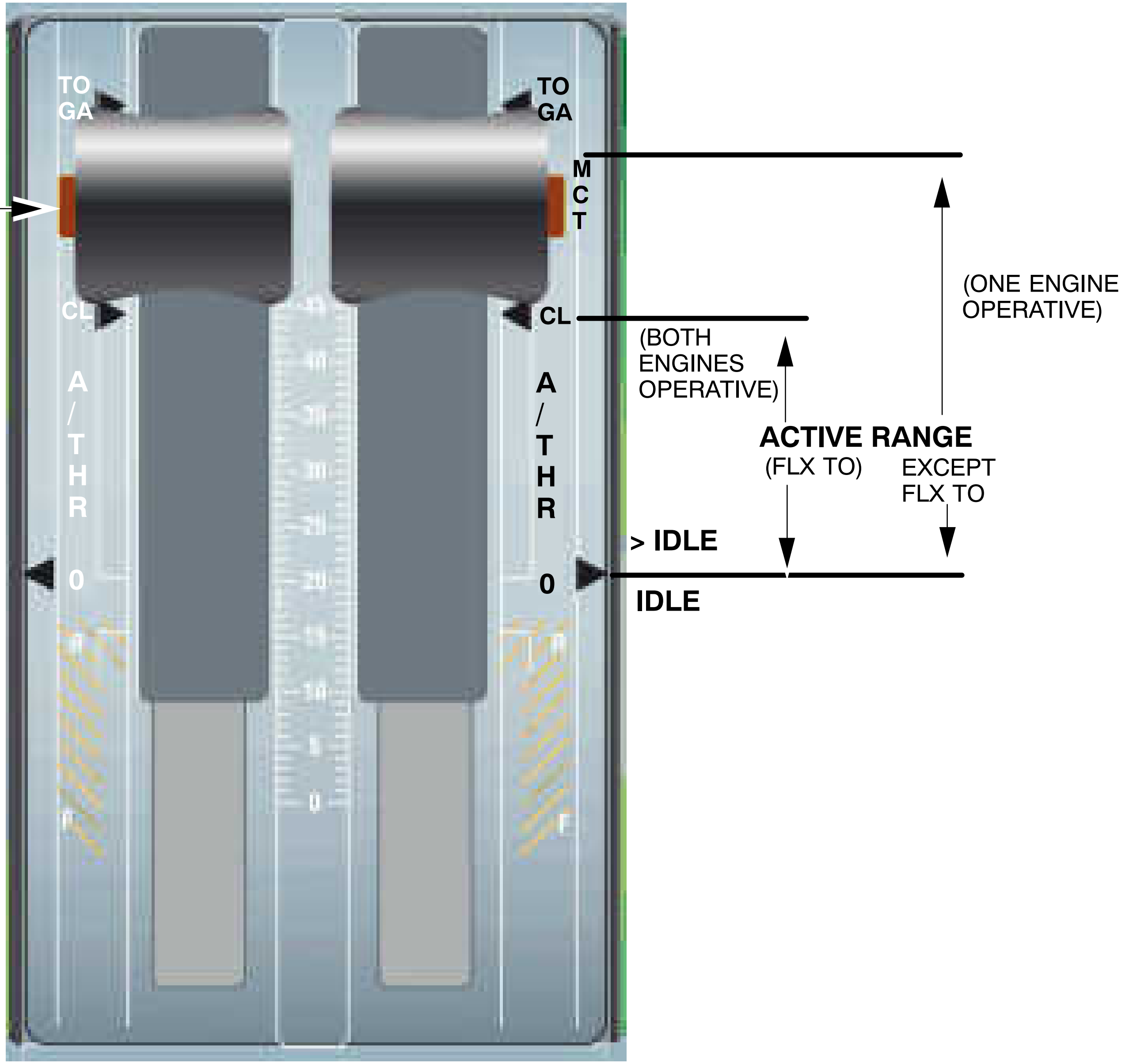


Figure 62 Thrust Levers

AUTOTHRUST MODES

The A/THR function works according to modes and their related reference parameters.

The reference parameter can be:

- a SPEED or a MACH NUMBER; in this case, the source is either the FCU (value chosen by the pilots) or the FMGC itself,
- a THRUST; in that case, the sources are either the ECUs (which compute the thrust limit) when the thrust limit is needed, or the FMGC itself.

The possible Autothrust modes are:

- SPEED,
- MACH,
- THRUST,
- RETARD,
- and ALPHAFLOOR PROTECTION.

The choice of the mode is made by the FMGCs:

- **SPEED** or **MACH** mode, the reference which are selected on FCU or managed by the FMGC,
- **THRUST** mode, where the reference corresponds to a thrust limit computed by the ECUs (according to the thrust lever position), idle thrust in descent or optimum thrust computed by the FMGC,
- **RETARD** mode: A thrust reduced to and maintained at idle during flare,
- **ALPHAFLOOR − PROTECTION**: A TO/GA thrust setting to protect the aircraft against excessive angle−of−attack and windshear.

The A/THR modes depend on the active **vertical mode** of the Autopilot or Flight Director.

When no vertical mode is engaged, the A/THR operates in SPEED/MACH modes except:

- when THRUST mode engages automatically in case of Alphafloor,
- when, A/THR being in RETARD, APs and FDs disengage, the A/THR function remains in RETARD mode.

ALPHAFLOOR

The A/THR function protects against an excessive angle of attack. The Alphafloor signal is detected by the **FACs or ELACs**.

In case of **excessive angle−of−attack**, the FACs send an order to the FMGCs which activate the Alphafloor protection.

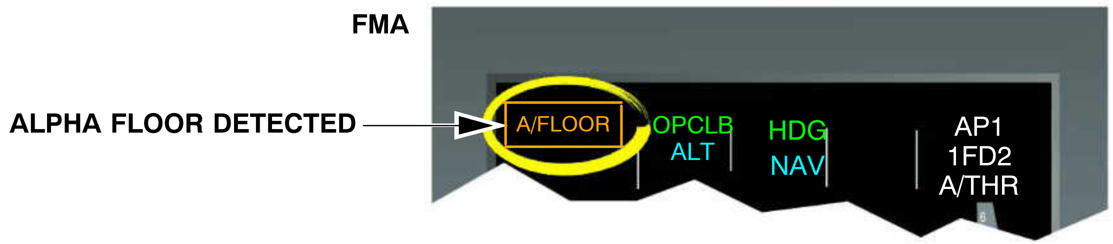
The Alphafloor detection automatically engages and activates the A/THR function, whatever the thrust lever position and the A/THR engagement status the engine thrust becomes equal to Take−Off / Go Around thrust.

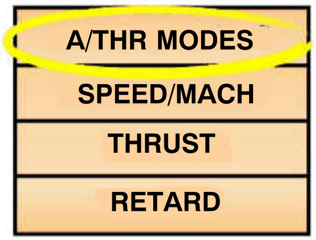
When the A/THR is active with the Alphafloor protection active, the amber message ” A. FLOOR ” is displayed on the Flight Mode Annunciator.

TOGA LK mode

When the A/THR is active with the Alphafloor protection active but, with the Alphafloor detection no longer present in the FACs, the amber message ”**TOGA LK**” (LK for LOCK) is displayed on the FMA.

The Alphafloor protection can only be cancelled through the disengagement of the A/THR function, via the A/THR pushbutton or the A/THR instinctive disconnect pushbutton.





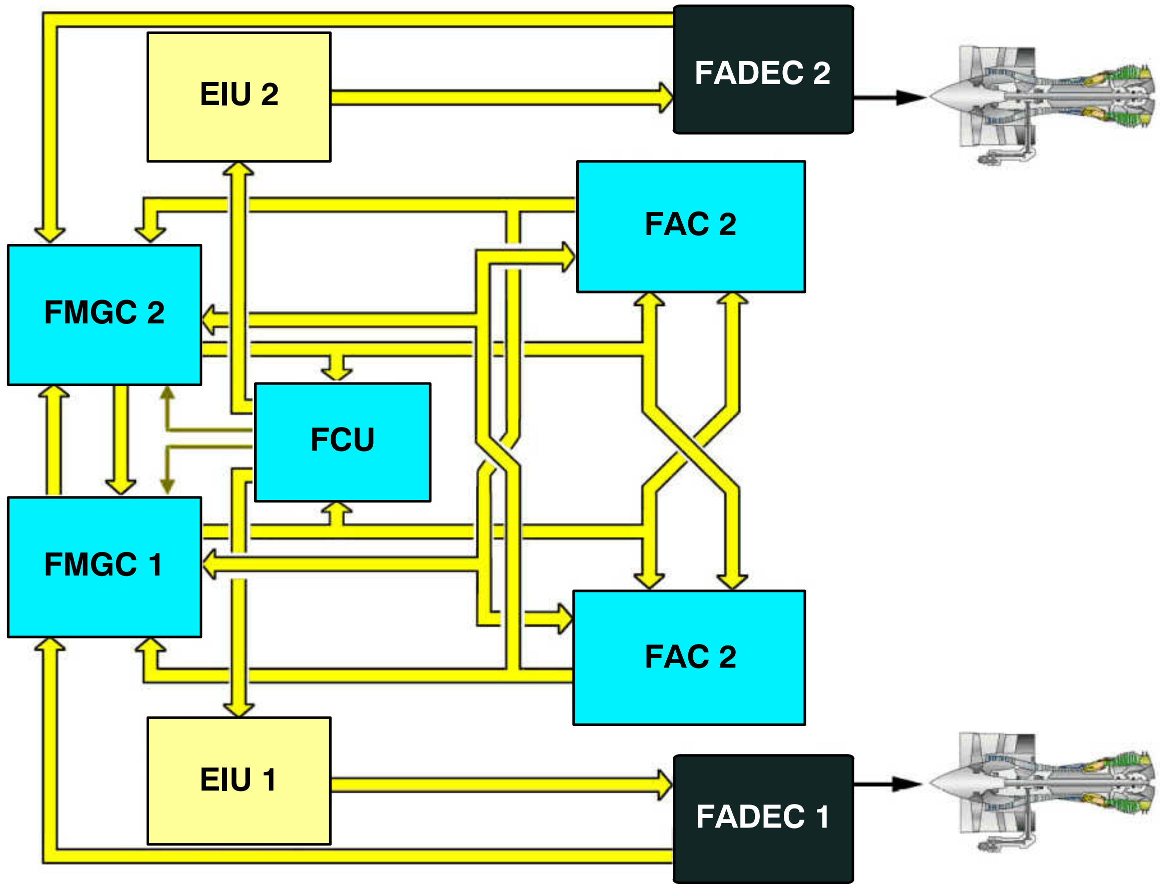


Figure 63 Autothrust Modes

A/THR OPERATION IN FLIGHT

The Aircraft is on GROUND and ready for take−off.
Neither AP nor A/THR are engaged.
The engines are controlled by the thrust levers.

TAKE OFF

For TAKE−OFF, the pilot sets the thrust levers to the TO/GA stop or to the FLEX/MCT detent if a flexible temperature is selected on the MCDU. This engages the A/THR function **(but it is not active)**.

After TAKE OFF

At THRUST REDUCTION ALTITUDE, a message on the Flight Mode Annunciators indicates to the pilots that they have to set the thrust levers in the CL detent.

As soon as the thrust levers are in ”CL” detent, the A/THR is **active**. Then, the thrust levers remain in this position until the approach phase.

If only one thrust lever is set into ” CL − MCT ” area, a message on the FMAs warns the pilot to set the thrust lever to ”CL” detent (LVR ASYM).
The A/THR remains active.

LANDING

During AUTOMATIC LANDING, before touch down, an auto call out, ”RETARD”, indicates to the pilot that he has to set the thrust levers to the ”IDLE” stop.
When he does it, the A/THR disengages. This allows the automatic activation of the ground spoilers if they are in armed condition.

Then, on GROUND, the pilot sets the thrust reverser levers to the REVERSE position.

Disconnection

Besides the normal A/THR operation, the A/THR function is disengaged either by pilot action or in case of a system failure.

The A/THR function can be disengaged either by pressing at least one of the two red instinctive disconnect switches on the side of thrust levers 1 and 2 or by pressing the A/THR pushbutton on the FCU.

A/THR disengagement can also be due to an external system failure. When the A/THR function is active, the actual engine thrust does not necessarily correspond to the thrust lever position.

Consequently, it is important to know what happens after Autothrust disconnection.

As long as a thrust lever remains in its detent, the thrust on the corresponding engine **is frozen** at its last value just before the disconnection.

As soon as a thrust lever is moved from the detent, **or if it was not in a detent**, the thrust on the corresponding engine is **smoothly adapted** to the thrust lever position.

A/THR MODES
SPEED/MACH
THRUST
RETARD

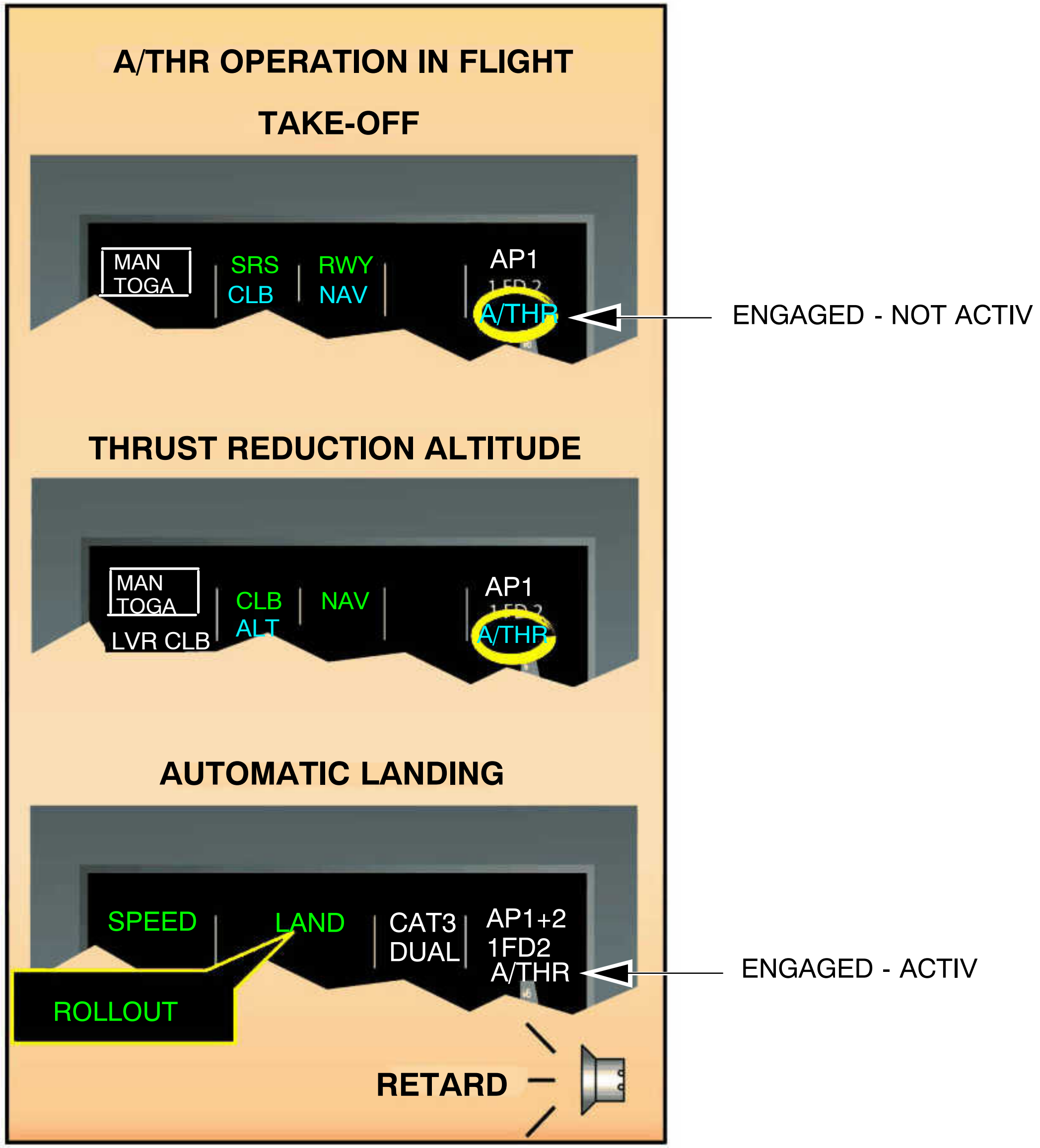


Figure 64 Autothrust Operation

ISOLATION OF THE ENGINES FROM THE A/THR SYSTEM OPERATION

A separation of the ECUs from the FMGCs after a disengagement, is done through the wired discrete that the ECUs receives directly.

This disconnection can be done in two different ways:

- **Standard disconnection;**
  - depress the INST DISC P/B on thrust levers, or
  - set all thrust levers to IDLE detent.
- **Non standard disconnection;**
  - depress the FCU A/THR P/B while A/THR is active (no effect in LAND TRACK), or
  - loss of the arming conditions (e.g. failure condition).

Action on one of the two INST DISC P/B forces the relays of FMGC and ECU to the separate the systems.

Action of one of the two INST DISC P/B for **more than 15 sec. inhibits any engagement of the A/THR function**, what ever the reason (FCU A/THR P/B switch, Alpha floor protection etc.)

Recovering is only possible at next computer power up.

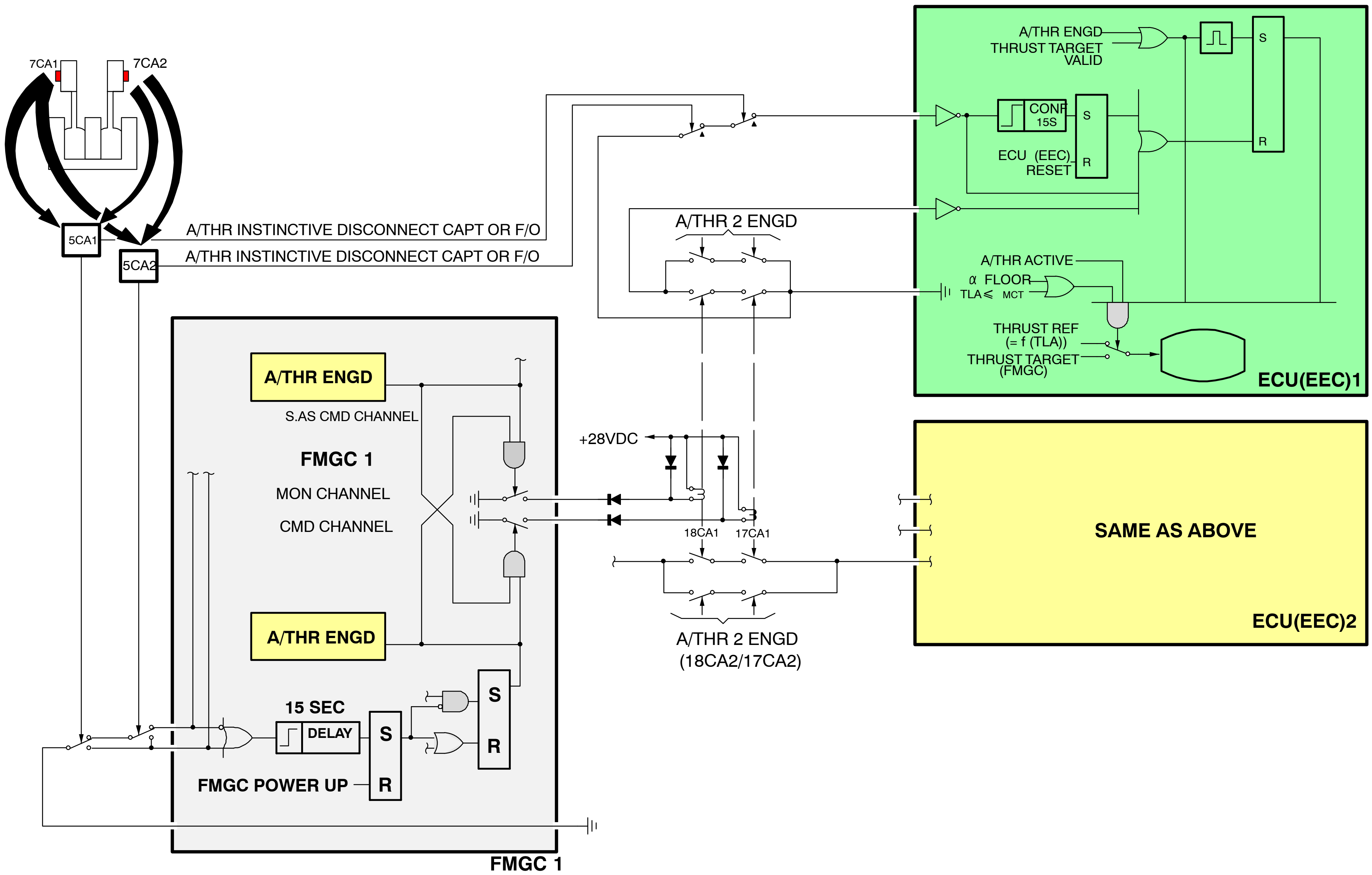


Figure 65 Isolation of the Engines

22–60 FLIGHT AUGMENTATION

FLIGHT AUGMENTATION INTRODUCTION

The flight augmentation part fulfills the following functions:

- rudder trim,
- yaw damper,
- rudder travel limitation,
- flight envelope protection,
- FIDS (Fault Isolation Detection System).

For flight envelope protection, the FAC computes:

- the various speeds for aircraft operation (e.g. flaps limit speed),
- the excessive angle of attack and windshear detection,
- the low energy warning, indicating to the crew that the aircraft is quickly decelerating and that thrust will have to be increased to recover a positive flight path angle through pitch control.

The FIDS function is only active in FAC 1. FAC 1 is connected to the BITE of all the AFS computers and communicates to the Centralized Fault Display System (CFDS).

Operating principles

The FAC is a dual–dual type system for yaw damper, rudder trim and rudder travel functions (fail operational).
FAC 1 and 2 can be engaged at the same time through FAC 1 and FAC 2 push button switches on the overhead panel. Only one system is active at a time: FAC 1 has priority, FAC 2 being in standby and synchronized on FAC 1 orders. An automatic changeover occurs on FAC 2 in case of disengagement or failure of FAC 1.
Partial changeover per function (Yaw damper, Rudder trim, RTL) is possible.
The following functions are achieved upon energization **independently** of FAC pushbutton switches:

- monitoring of the flight envelope,
- computation of maneuvering speed.

The FMGCs and the PFDs receive these information signals as follow:

- FMGC 1 and Capt PFD normally use data from FAC 1,
- FMGC 2 and F/O PFD normally use data from FAC 2.

In the event of failure, the FMGCs and the PFDs use the data from the active FAC.

Yaw Damper

The yaw damper provides manual yaw stabilization:

- The ELACs compute the corresponding data and transmit them to the rudder surface via the servo loop of the yaw damper (FAC).
- alternate law for Dutch roll damping when the ELAC no longer computes
- normal yaw stabilization.
- Dutch roll damping (including turn coordination) when the autopilot is engaged in cruise only.
- engine failure recovery when the autopilot is engaged (the ELACs provide this function in manual flight), (not in clean configuration)

Rudder Trim

The rudder trim provides manual control via a rudder trim control switch located on the center pedestal. In addition the ELACs compute a command signal for rudder deflection (normal yaw damping law including recovery of engine failure) performed by the trim sub–system in manual flight.
Reset of the rudder trim position is possible using a pushbutton switch located on the center pedestal.

- automatic control when the autopilot is engaged which provides the accomplishment of yaw autopilot command and the recovery of engine failure.
- Position of the trim is indicated on the center pedestal.

Rudder Travel Limitation

This function provides the limitation of the rudder travel by displacement of a stop as a function of the speed.

Monitoring of flight envelope and computation of maneuvering speed

This function provides the primary flight display (PFD) with different data displayed on the speed scale.

The FAC also computes the conditions of activation of the alpha floor mode of the A/THR functions (angle of attack protection in case of windshear).

FLIGHT AUGMENTATION COMPUTER (FAC)

FLIGHT CONTROL FUNCTIONS

- RUDDER TRIM
- YAW DAMPER
- RUDDER TRAVEL LIMITING

FLIGHT ENVELOPE PROTECTION

- MANEUVERING SPEED COMPUTATION
- ALPHA FLOOR PROTECTION
- REACTIVE WINDSHEAR DETECTION
- LOW ENERGY AWARENESS

FAULT ISOLATION DETECTION SYSTEM (FIDS)
ONLY ACTIVE IN FAC 1

FIDS: BITE function of the system

The FAC 1 performs BITE function of the whole AFS/FMS.
Each computer includes its own BITE function and is linked to the **FAC 1**.
The MCDU displays the content of the maintenance data via the CFDIU.

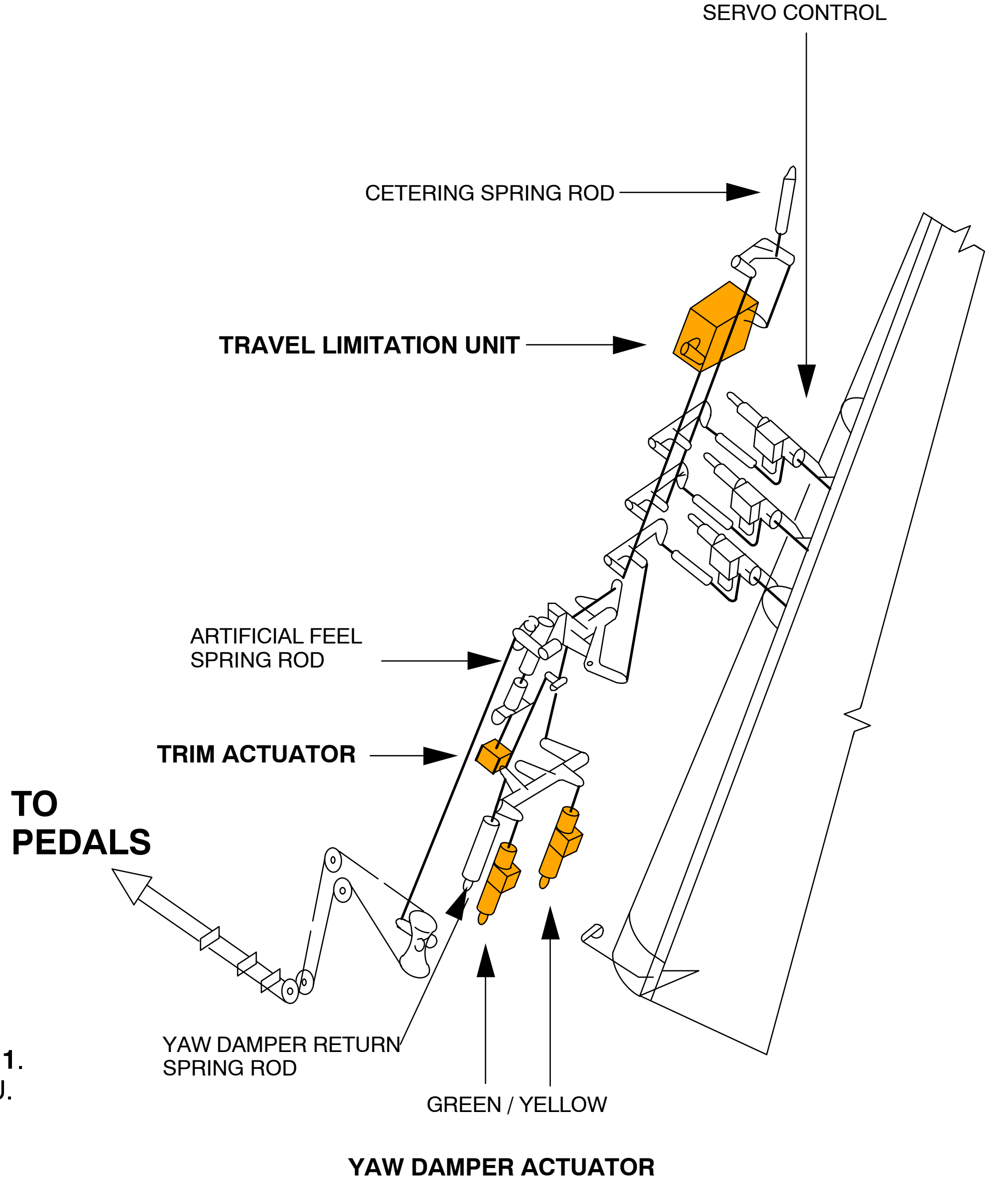


Figure 66 Flight Augmentation Computer Features

FAC ENGAGEMENT DESCRIPTION

NORMAL CONFIGURATION

In normal configuration, when the Flight Augmentation Computer (FAC) P/BSW is pressed in, the FAULT and OFF lights are off, provided the internal monitoring channels are in good condition and the engagement request is present. When the FAC P/BSW is released out, the FAC is disengaged and the white OFF light comes on.

NOTE: The FAC cannot be engaged on ground after power up during the 30 second test. The amber FAULT light flashes.

FAC NOT ENERGIZED OR NOT INSTALLED

If the FAC is not energized and the P/BSW is pressed in, the FAULT light is on with an amber message on the ECAM.

SUBFUNCTION FAULT

If one or more of the following functions fail:

- yaw damper,
- rudder trim,
- rudder travel limitation.

If one or several yaw axis control functions fail, only the amber message appears on the ECAM. The FAULT light remains OFF.

The FAC remains engaged.

COMPUTER FAULT

When the computer itself fails, the FAC is disengaged and the FAULT light comes on with a message on the ECAM. In this case, a FAC reset must be attempted following the ECAM procedure.

NOTE: On ground with engines shut down, the reset is automatic when the fault disappears.

Connection with FLT CTL/FAC Pushbutton Switches

Each FAC is associated with an engagement pushbutton switch located on the FLT CTL panel, on the overhead panel.

This pushbutton switch serves for:

- The engagement or the disengagement of all the **flight control** functions, engagement status : No indication on the pushbutton switch, disengagement status: The OFF legend is on.
- The indication of FAC failures with the FAULT legend. This authorizes a pilot action (FAULT/OFF) to reset the digital section of the FAC. If the action is successful, the FAULT legend goes off and the system can be re-engaged. Therefore in normal operation the legends are off.

In **abnormal operation** these indications are given:

- Computer not energized or not installed: FAULT legend on, ECAM warning,
- FAC failures specific to one function: FAULT legend off ; ECAM warning,
- Common FAC failures which can be reset : FAULT legend on with possible reset by the pilot ; ECAM warning,
- Power-supply transient failures: FAULT legend on with possible reset by the pilot,
- FAC failures on the ground with engines shut down : FAULT legend with automatic reset at failure suppression,
- Power-supply transient failures: FAULT legend on with possible reset by the pilot.

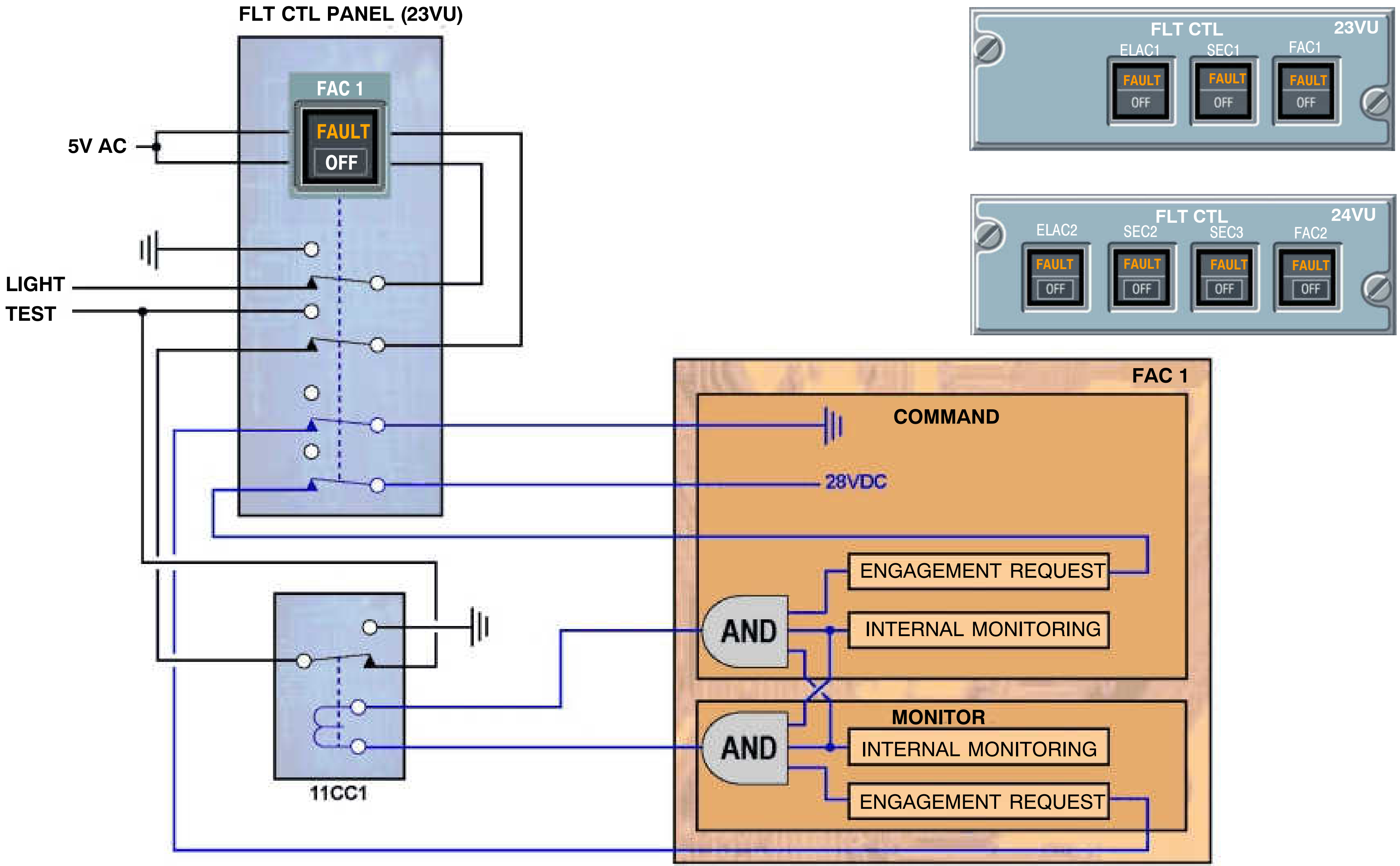


Figure 67 FAC Engagement

FAC FUNCTIONAL DESCRIPTION

GENERAL

The Flight Augmentation Computer (FAC) fulfills the functions given below:

- **YAW DAMPER**

  The yaw damper function ensures:

  - In **manual control**, the accomplishment of the yaw orders from the elevator aileron computer (ELAC) for stabilization and manual turn coordination. It also provides a yaw−damping degraded law in the event of ELAC failure (alternate law).
  - In **automatic control**, the accomplishment of the autopilot orders from the Flight Management and Guidance Computer (FMGC) for:
    - Turn coordination (ILS approach mode and roll out),
    - Guidance (align and roll out).

    It also ensures in automatic flight:

    - Engine failure recovery, (not in clean configuration)
    - Yaw stability,
    - Turn coordination (cruise).

- **RUDDER TRIM**

  The rudder trim function ensures:

  - In **manual control**:
    - The accomplishment of the pilot trim orders from the manual trim control (control and reset).
  - In **automatic control**:
    - The accomplishment of the autopilot orders (autotrim on the yaw axis),
    - The generation and the accomplishment of the engine failure recovery function.

- **RUDDER TRAVEL LIMITING**

  The rudder travel limiting function ensures:

  - The limitation of the rudder travel as a function of a predetermined law,
  - The return to low speed limitation in case of loss of function as soon as the slats are extended.

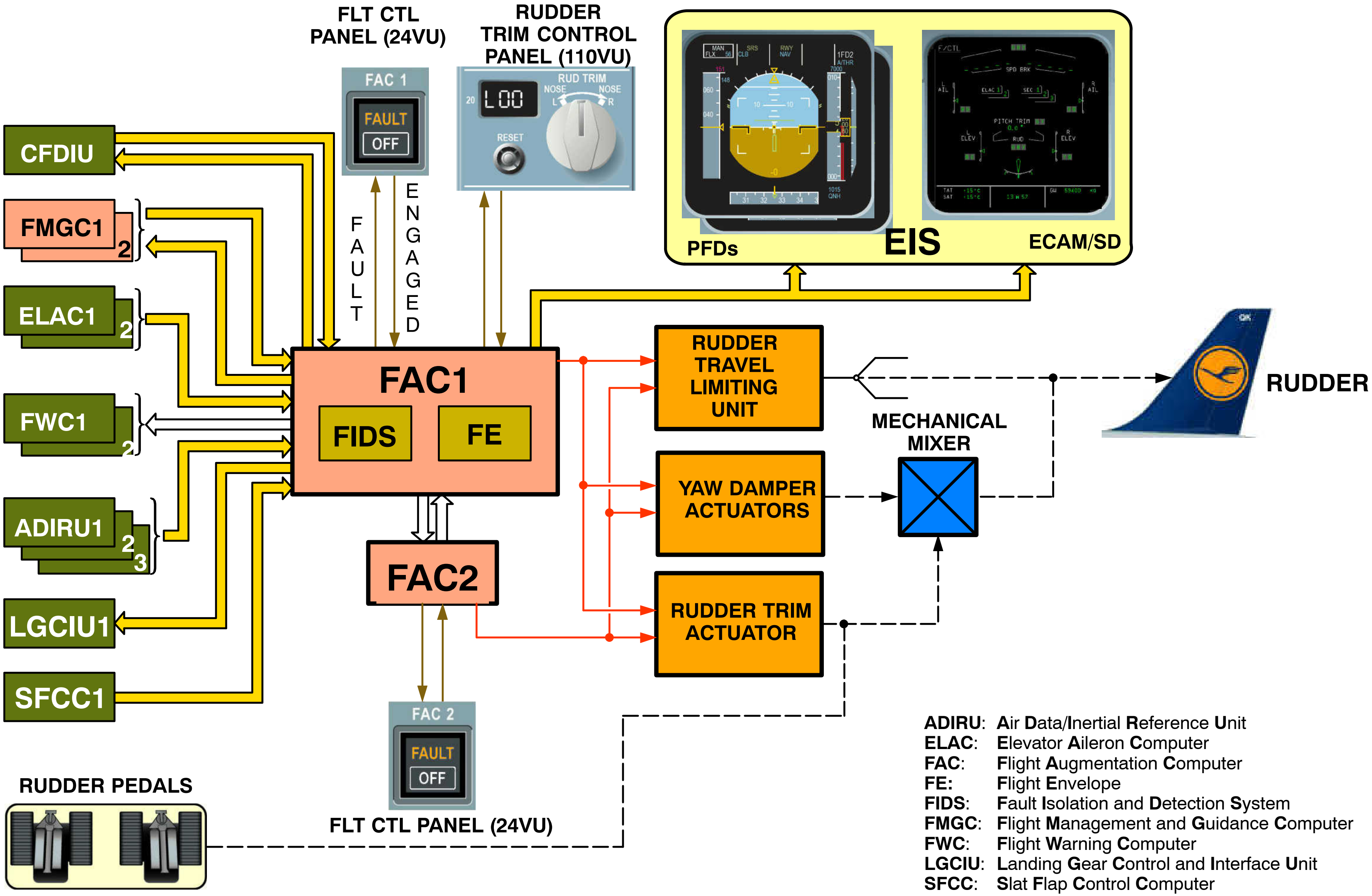
- **Calculation of Characteristic Speeds and Protection of Flight Envelope:**

  The FAC generates, independently of the engage status of the pushbutton switches, different functions necessary to:

  - The control of the speed scale on the PFDs,
  - the adaptation of gains for the FMGC and ELAC,
  - the distribution of signals necessary to the FMGC control laws,
  - the flight envelope protection in automatic flight (speed limits for the FMGC, alpha floor for the autothrust),
  - the display of the rudder trim order and the rudder travel limiter position if available,
  - the windshear detection (option activated by pin program),
  - the low energy detection (option activated by pin program).

The FAC therefore computes:

- the weight and the center of gravity,
- the characteristic speed data,
- the aerodynamic flight−path angle (Gamma actual) and the potential,
- flight−path angle (Gamma command),
- the alpha−floor protection,
- the position of the rudder trim for the ECAM system,
- the windshear detection,
- the low energy warning.



ADIRU: Air Data/Inertial Reference Unit
ELAC: Elevator Aileron Computer
FAC: Flight Augmentation Computer
FE: Flight Envelope
FIDS: Fault Isolation and Detection System
FMGC: Flight Management and Guidance Computer
FWC: Flight Warning Computer
LGCIU: Landing Gear Control and Interface Unit
SFCC: Slat Flap Control Computer

Figure 68 FAC Functions Overview

YAW CONTROL DESCRIPTION

GENERAL

The yaw control is done by the rudder, with a maximum deflection of 25° for the A320 and A321, and 30° for the A318 and A319. The rudder is operated by three moving body servocontrols with a common mechanical input.

RUDDER PEDALS

The two pairs of rudder pedals are connected together. They are linked by a cable loop to the mechanical summing point which in turn is connected to the hydraulic rudder actuators via a differential unit. Mechanical rudder control is always available from the rudder pedals. The pedal position signals are sent to the ELevator Aileron Computers (ELACs) by the transducer (XDCR) unit.

If installed, the Force Transducer Unit (FTU) is used to measure pilots forces applied on the pedals. This information is not used in flight control system but transmitted to the Flight Control Data Concentrator (FCDC) to be recorded by the Digital Flight Data Recorder (DFDR).

ELAC

In manual flight, the ELACs transmit the yaw damping and turn coordination to the Flight Augmentation Computers (FACs) for rudder deflection. There is no feedback to the pedals for yaw damping and turn coordination.

FAC

The two FACs control the yaw damper servo controls. FAC 1 has priority. FAC 2 is in hot stand−by.

RUDDER

The rudder is powered by three hydraulic actuators operating in parallel. The position of the rudder is transmitted to the System Data Acquisition Concentrator (SDAC) through a position XDCR unit. This position is shown on the lower display unit of the ECAM.

FMGC

When the autopilot is engaged, the Flight Management and Guidance Computers (FMGCs) send commands to the FACs for rudder trimming, yaw control and yaw damping function. The FMGCs energize the artificial feel stiffening solenoid to increase the threshold of the rudder artificial feel and to avoid unintentional autopilot disconnection.

YAW DAMPING

The yaw dampers servo activation controls are connected to the rudder hydraulic actuators through a mechanical differential unit: each servo actuator is controlled by its related FAC. No feedback to the rudder pedals is given thanks to the differential unit.

RUDDER TRIM

The rudder trim is achieved by one or two electric motors at a time, each controlled by its associated FAC. In manual flight, the pilot can apply rudder trim at 1degree/sec from the RUDder TRIM rotary switch. Also, an asymmetry compensation function is available in case of lateral asymmetry, and a yaw automatic trim is active for lateral asymmetry and engine failure compensation at 5°/sec. Trimming causes rudder pedal movement.

RUDDER LIMITATION

Rudder deflection limitation is achieved by a variable stop unit driven by one or two electric motors at a time. Each motor is controlled by its associated FAC. The rudder deflection becomes limited as speed is increased. Under 160 kts the stops are in low−speed configuration. Full input/output lever movement to the rudder servo control is available. Between 160 and 380 kts the rudder deflection is limited as a function of speed. The corresponding law is computed by the Flight Augmentation Computers (FACs).

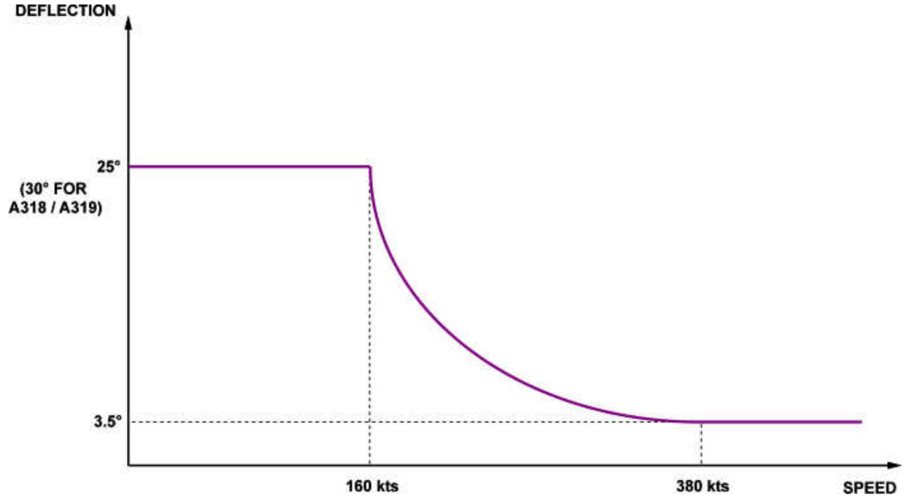


Figure 69 Rudder Travel Limit Values

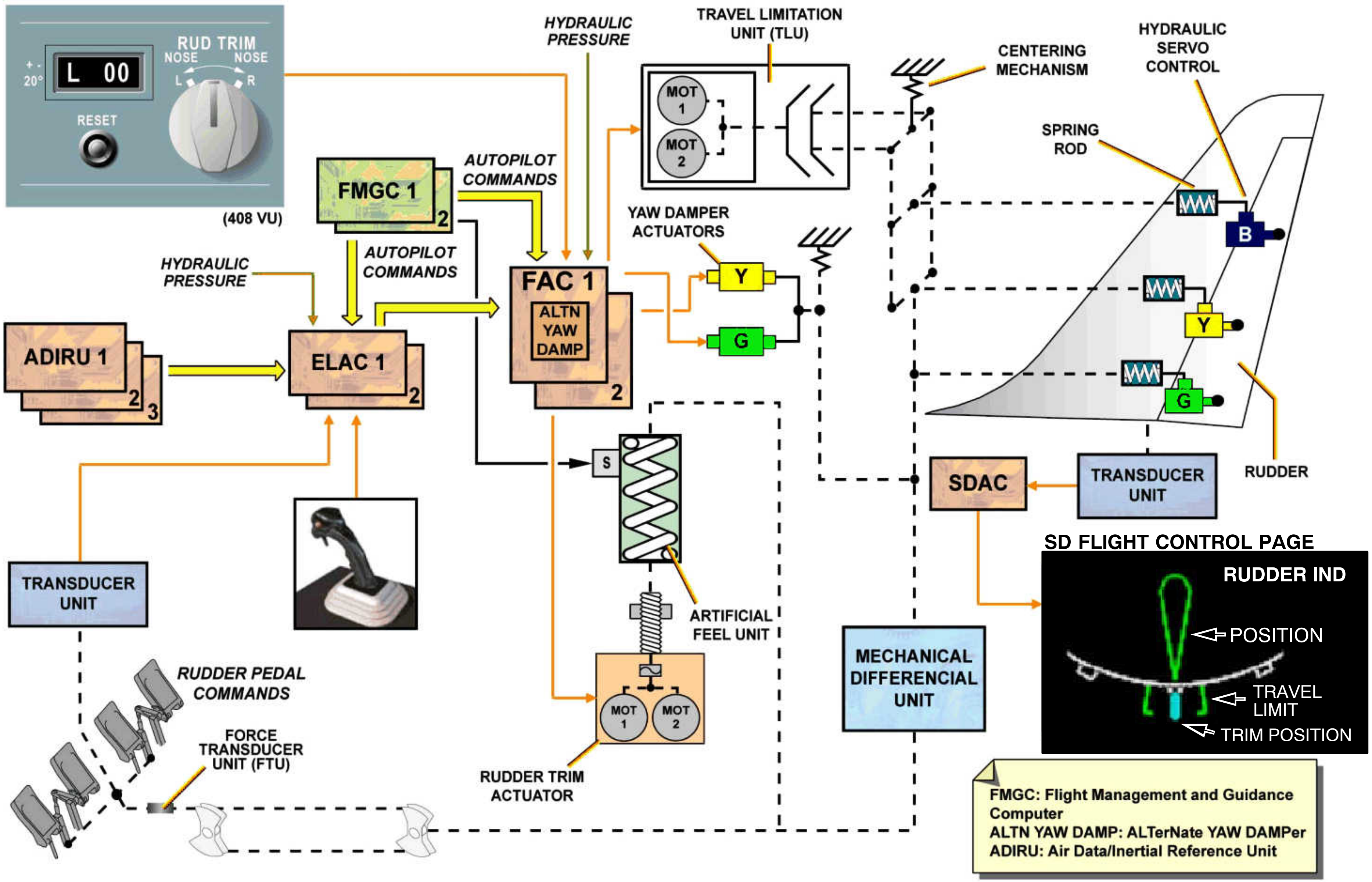


Figure 70 Yaw Control Overview

RUDDER TRIM – DESCRIPTION

Components

There are two rudder trims. All components are duplicated exept the RUDDER TRIM selector and RESET button.

The rudder trim function is achieved by:

- An electromechanical actuator which comprises 2 asynchronous motors connected to a reduction gear by rigid linkage and 4 Rotary Variable Differential Transduceres (RVDT).
- a RUD TRIM selector for manual trim control.
- a RESET pushbutton.
- a rudder trim indicator located to the left of the RUD TRIM selector.
- two Flight Augmentation Computers (FAC 1 and FAC 2).

General

The rudder trim function has two modes: Manual Mode, when the autopilot is not engaged and Automatic Mode when the autopilot is engaged.

The autotrim order is computed by the laws, whereas the manual trim order transits through them. The order is then sent to the actuator. This order is reproduced at the rudder pedals.

Priority is given to the rudder trim of FAC 1; a changeover logic enables to the switch to FAC 2 in case of failure. If both rudder trims fail, the last deflection is maintained

The rudder position is displayed on the RUD TRIM indicator and on the ECAM display unit.

Manual Mode

When the autopilot is not engaged, the rudder trim order is given by the RUDDER TRIM selector.

NOTE: The RESET push button. enables to return the rudder to the neutral position.

Automatic Mode

With the autopilot engaged, the Flight Augmentation Computer calculates the trim order using Flight Management and Guidance Computer and Air Data Reference System data.

NOTE: At touch-down, the AUTO RESET function moves the rudder to the neutral position.

Power Loop

During the autotest triggered by the FAC power up the internal actuator monitoring checks the actuator servo-loop and monitor circuit validity, and the enabling signal reception.

Then the changeover logic enables the trim motor to be supplied and the rudder trim laws control it.

The laws compute the trim order and sent it to the actuator's motor via the Electronic Control Circuit. The feedback in the power loop is provided by two Rotary Variable Differential Transducers (RVDT) for each side.

Monitoring

The computation and the power loop are monitored by comparators. The input parameters are also monitored.

The computation is monitored by the comparators between the FAC Command and Monitor parts.

The FMGC and ADIRS peripheral inputs are always monitored.

The power loop is monitored by the the comparators between the rudder trim order and the position feedback signal.

RUDDER TRAVEL LIMITATION

The rudder travel limitation is computed by the FAC and sent to the rudder travel limiting unit. The FAC rudder travel limiting law computes this limit using the calibrated airspeed (Vc) given by the ADIRS.

YAW CONTROL INDICATION

Rudder position indication

- Symbol and scale become amber in case of blue + green + yellow hyd. low pressure.

Rudder Travel limiter

- Indication of high speed position.

Rudder Trim position

- Becomes amber if rudder trim reset is failed.

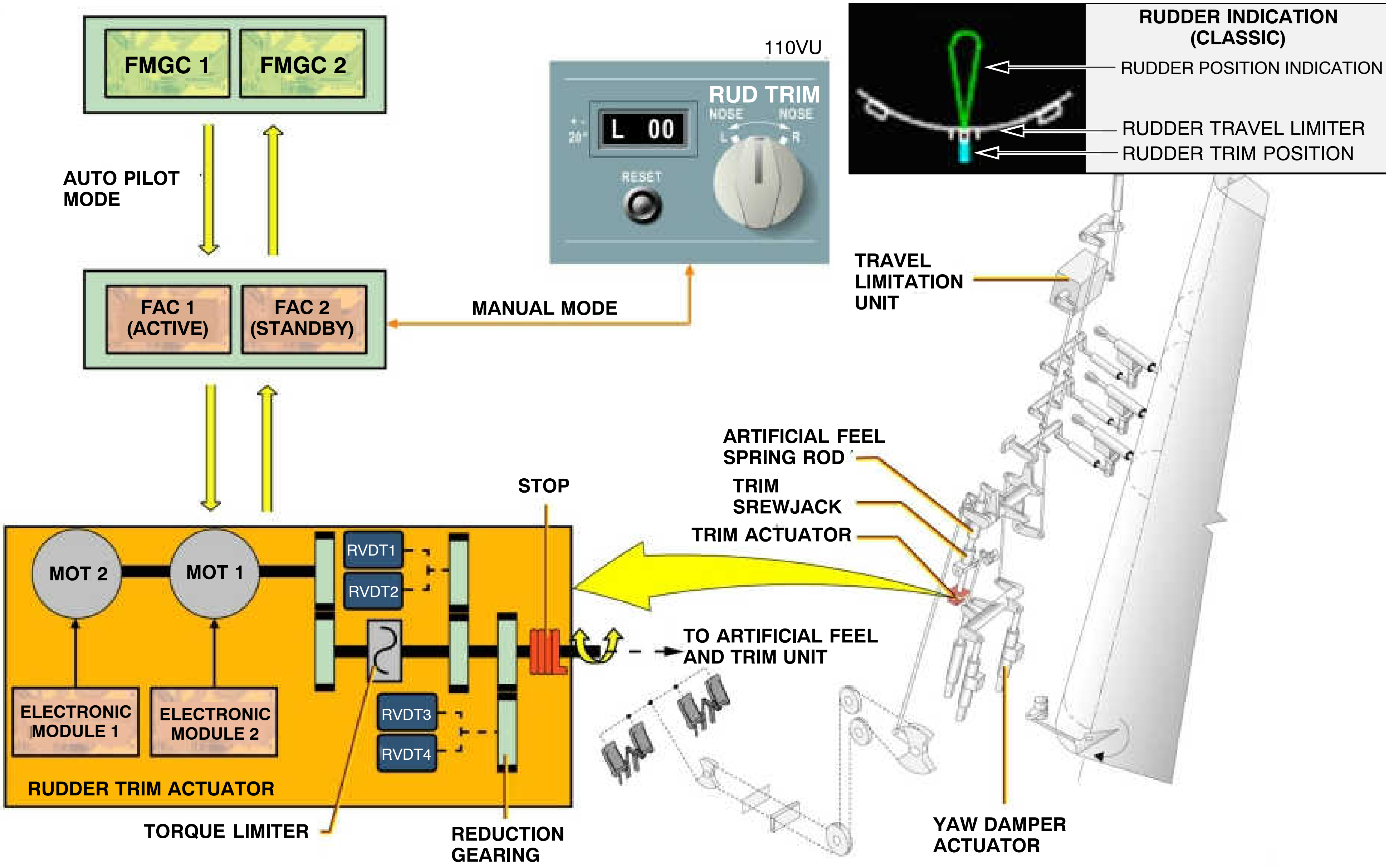


Figure 71 Rudder Trim System

STRUCTURE OF RUDDER TRIM CONTROL LAW

Principle

The rudder trim function ensures a trimmed value of the rudder. This value is reproduced at the rudder pedals. This trim is obtained either manually or automatically.

The value appears:

- On the rudder trim indicator,
- On the display unit of the ECAM system.

The resulting deflection is maintained even in case of total loss of the function. This permits to have a stabilized value, for example in the event of AP loss when an engine failure occurs.

When the changeover principle is retained:

- The side 1 has priority through the side 1 signal,
- Interruption of the actuator enable signals on the standby channel,
- Automatic engagement of the standby channel upon loss or disengagement of the channel 1.

Structure of Rudder Trim Control-Law

The control law generates a deflection order to control the rudder trim actuator through an integrator which memorizes the required position.

This order is generated:

- From the position of the position feedback in synchronization
- From the control order of the pilot trim (the reset is obtained through the unloading of the trim integrator)
- From the ELAC deflection order (Provision only)
- From the **long-term turn-coordination** order for autotrim on the yaw axis
- From the generation of an engine failure detection and its accomplishment .

The engine failure is detected from the lateral acceleration and from the yaw rate through a given threshold. This detection is confirmed by the engine thrust information.

Detection is performed by the command and monitoring sides. The first side which is triggered sends a signal to the opposite side in order to lower its threshold and thus ensure synchronized detection.

The correction signal (fixed deflection values) is then applied, depending on engine failed.

As soon as the engine failure compensation reaches a predetermined threshold, the control law is modified:

- The engine failure compensation is performed directly by the FG command order and the delta p compensation is boostered.
- The monitoring side is equalized on the command side to reduce the dispersion of the integrators.

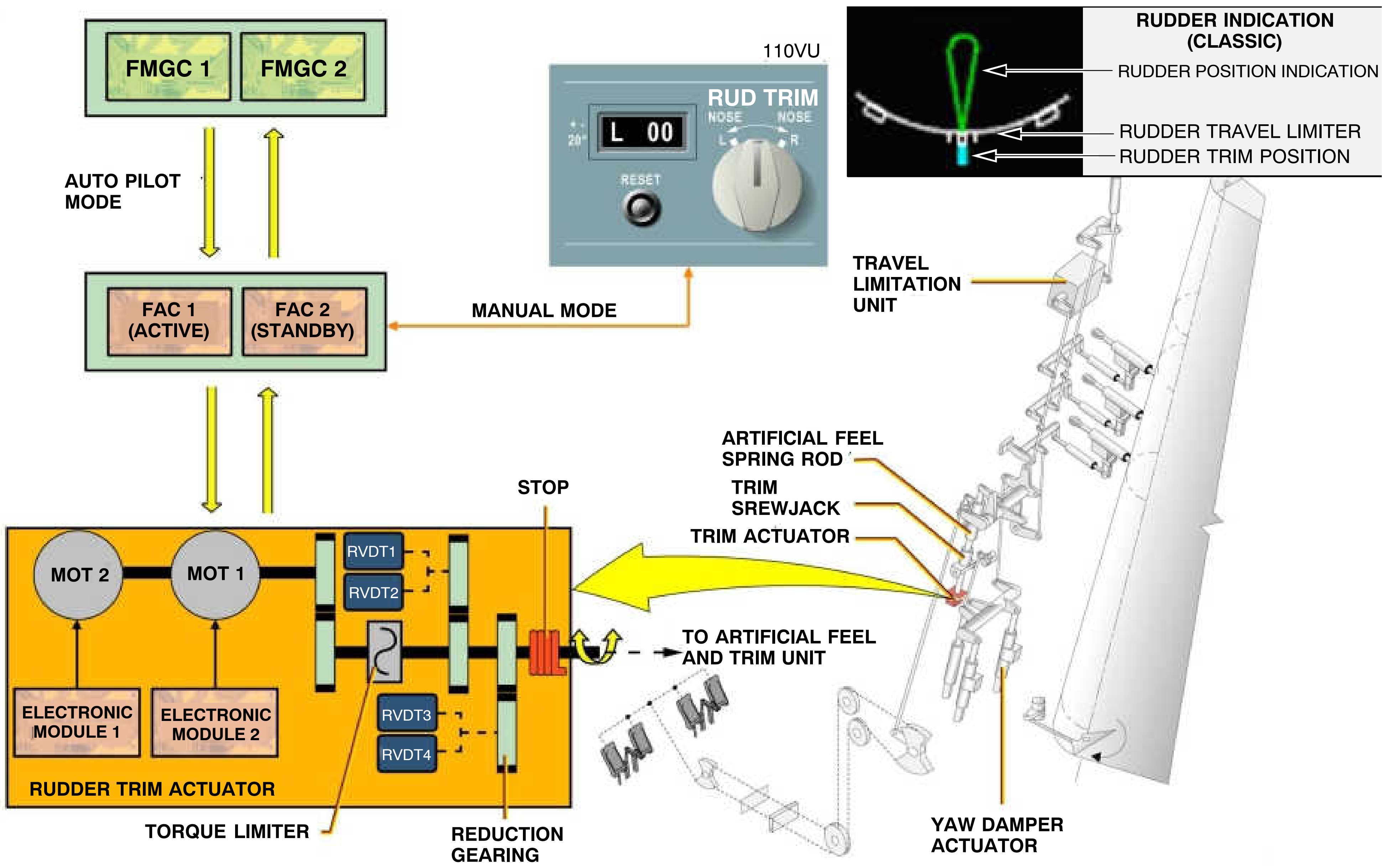


Figure 72 Rudder Trim System

YAW DAMPER - DESCRIPTION

COMPONENTS

There are two yaw dampers. In normal operation both are engaged, but only one is active. Yaw damper 1 has priority.
The yaw damper function is achieved by:

- 2 electrohydraulic actuators with an external centering element. Each actuator comprises 1 jack, 1 Linear Variable Differential Transducer (LVDT), 2 Electro Valves (EV), 2 Bypass Valves, 1 Pressure Switch (PS), 1 Servo Valve (SV),
- 2 Flight Augmentation Computers (FAC 1 and FAC 2),
- 2 Rotary Variable Differential Transducer (RVDT).

General

Yaw Damper one and two operate with the changeover logics. The yaw damper actuators does not move the rudder pedals.

The Yaw Damper function operates as follows:

- Order is computed by the laws and sent to the rudder via the related yaw damper actuator,
- YD actuator 1 is powered by the green hydraulic system,
- YD actuator 2 is powered by the yellow hydraulic system.

Manual Mode

In manual mode, the autopilot is not engaged and the Elevator Aileron Computer sends the turn coordination, and the dutch roll damping yaw orders to the FAC.

Manual Alternate

After a dual Elevator Aileron Computer failure, turn coordination is lost and a simplified alternate law of dutch roll damping is computed by the FAC.

Auto Mode

In auto mode, the FAC computes the dutch roll damping in clean configuration, the engine failure recovery in take-off, go-around and runway modes. The turn coordination law is computed by using roll orders from the FMGC.

When the AP is engaged, the FAC calculates the yaw damper order except in LANDing mode where it is computed by the Flight Management and Guidance Computer (FMGC).

When the AP is engaged:

- dutch roll damping law is given by the FAC using ADIRS data.
- engine failure compensation fast law is given by the FAC using the ADIRS data in Take-Off/Go-Around (TOGA) or RunWaY modes only.
- turn coordination law computes the yaw order to the FMGC roll order.

In LAND mode, the FMGC yaw order controls the yaw damper actuators via the FAC.

Land Mode

When the land mode is engaged, the yaw order is computed directly by the FMGC.

Power Loop

The yaw damper laws control the servovalve and the changeover logic enable to pressurize the jack.

The feedback in the power loop is provided by a Linear Variable Differential Transducer (LVDT) for the Command side and a Rotary Variable Differential Transducer (RVDT) for the Monitor side.

In case of dual monitor loss, a centring spring rod moves the rudder to the neutral position.

Monitoring

At power up, the yaw damper function safety tests are initiated.

The continuity between the standby yaw damper and its servo valve is tested.

The computation is monitored by the comparators between Command and Monitor part. The ELAC, FMGC and ADIRS peripheral inputs are always monitored.

The power loop is monitored by a comparator between the yaw order and the rudder position feedback.

In flight, the hydraulic pressures are monitored by the FAC. The LVDTs and the RVDTs are always monitored.

Pressure Switch Function

The table shows the reaction of the Pressure Switch depending of the engagement-state of the electro valve #1 and #2. You see also the actuator modes.

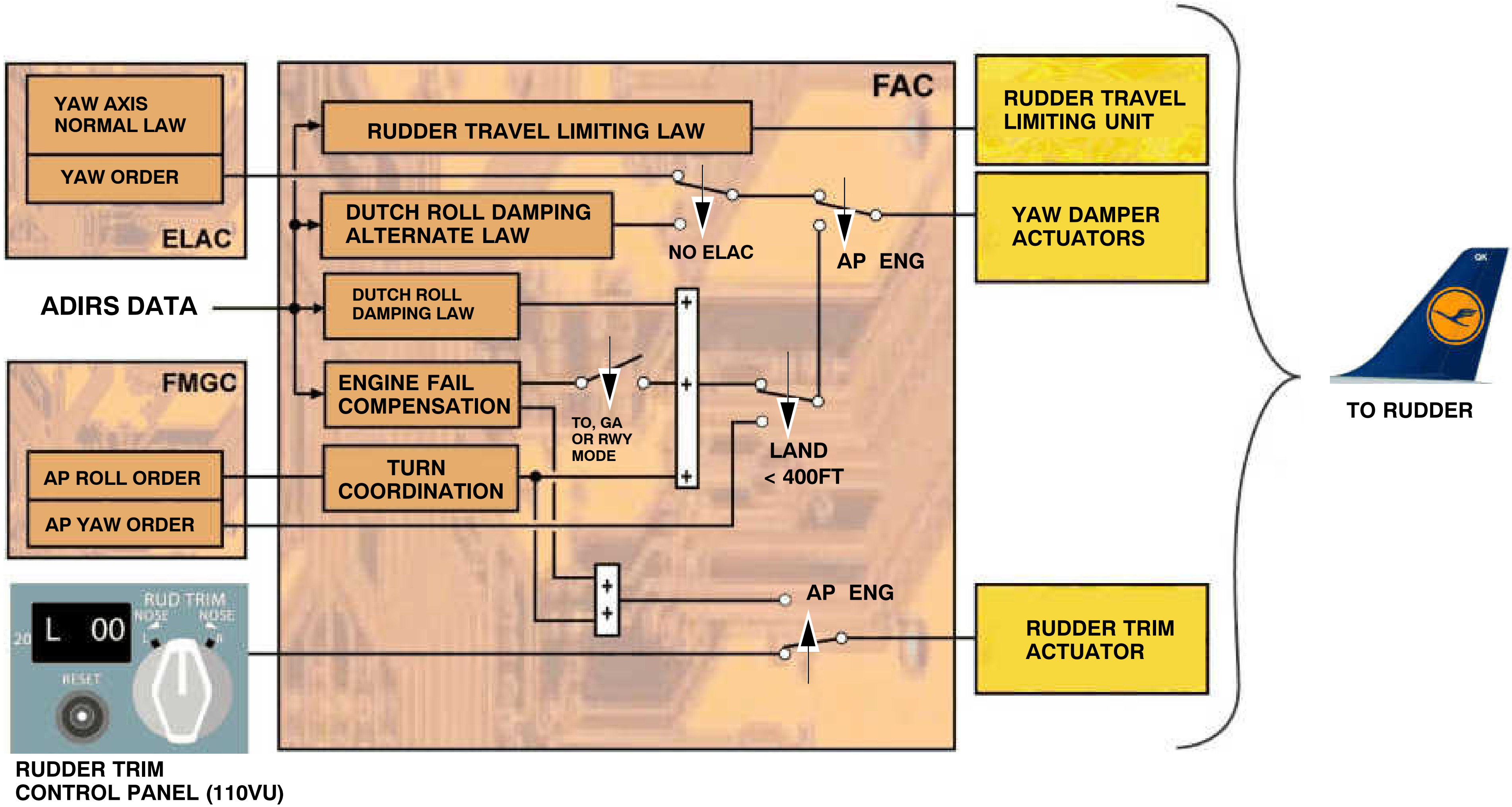


Figure 73 Yaw Damper System

YAW DAMPER SYSTEM OPERATION

COMPONENTS

There are two yaw dampers. In normal operation, both are engaged but only one is active. Yaw damper 1 has priority.

The yaw damper function is achieved by:

- 2 electro−hydraulic actuators with an external centering element. Each actuator comprises 1 jack, 1 Linear Variable Differential Transducer (LVDT), 2 solenoid valves, 2 selector valves, 1 pressure switch and 1 Servo Valve (SV).
- 2 Flight Augmentation Computers (FACs).
- 2 Rotary Variable Differential Transducers (RVDTs)

GENERAL

Yaw damper 1 and 2 operate with the changeover logic. The yaw damper actuator does not move the rudder pedals. The yaw damper function operates as follows:

- order is computed by the laws and sent to the rudder via the related yaw damper actuator.
- yaw damper actuator 1 is powered by the green hydraulic system.
- yaw damper actuator 2 is powered by the yellow hydraulic system.

MANUAL MODE

In manual mode, the AP is not engaged and the ELevator Aileron Computer (ELAC) sends to the FAC:

- the turn coordination,
- the dutch roll damping,
- the engine failure compensation yaw orders.

MANUAL ALTERNATE

After a dual ELAC failure, turn coordination and engine failure compensation are lost. Only a simplified alternate law of dutch roll damping is computed by the FAC.

AUTO MODE

In AUTOmatic mode, the FAC computes the dutch roll damping in clean configuration, the engine failure compensation in Takeoff/Go−Around (TOGA) and RunWaY modes. The turn coordination law is computed by using roll orders from the Flight Management and Guidance Computer (FMGC).

LAND MODE

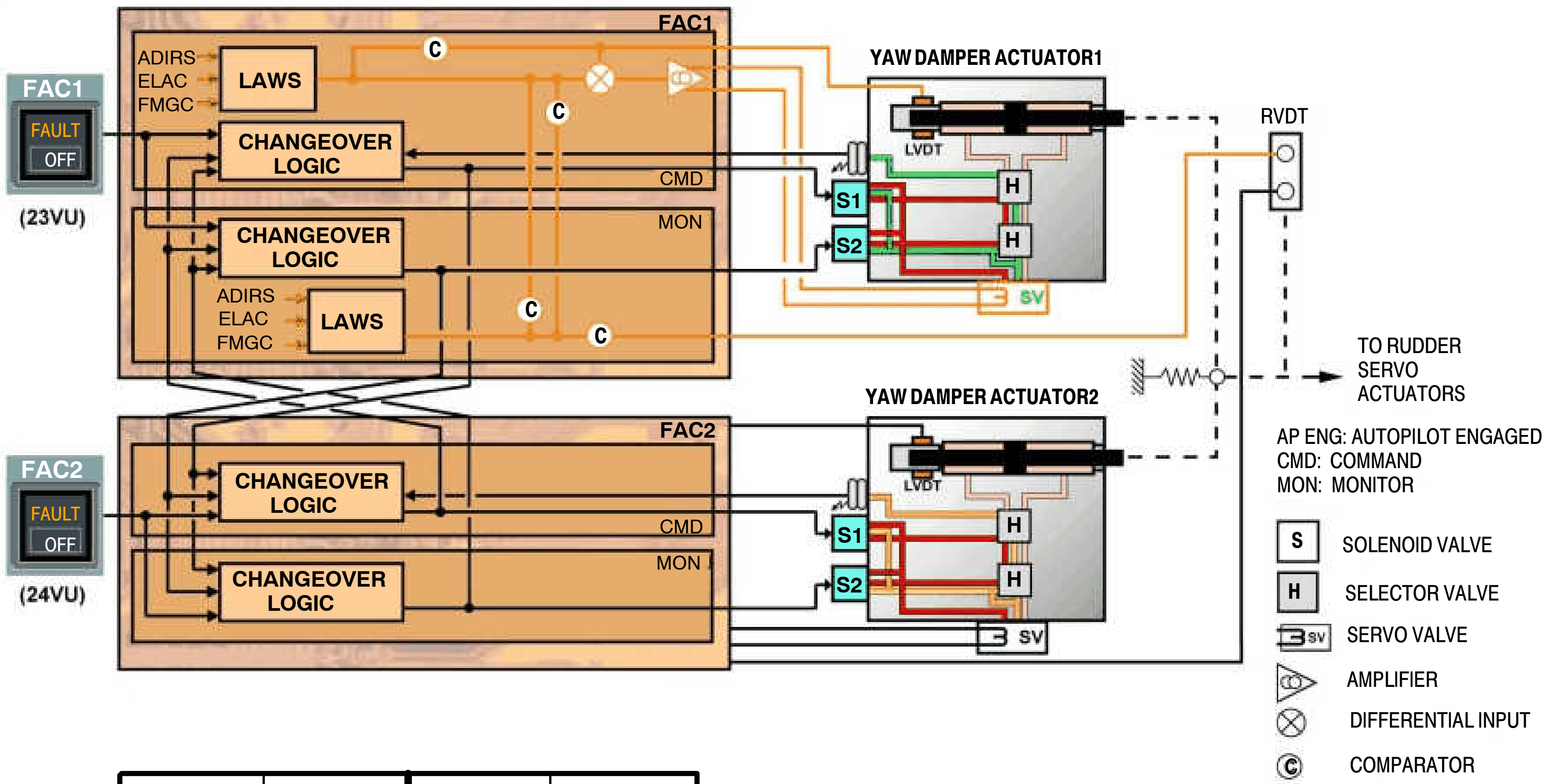
When the LANDing mode is engaged, the yaw order is computed directly by the FMGC.

POWER LOOP

The yaw damper laws control the SV, and the changeover logic controls the two solenoids S1 and S2, which in turn control the selector valves (H). S1 and S2 when powered, move the internal hydraulic parts to a position, which makes it possible for the SV to operate the output jack. If one of the selector valves fails or the signal from the FAC 1 fails, the hydraulic Press switch sends a fail signal to the changeover logic, which then transfer the operation to YD 2. The feedback in the power loop is given by an LVDT for the command side and a RVDT for the monitor side. In case of dual yaw damper loss, a centering spring rod moves the rudder to the neutral position.

MONITORING

At power up, the yaw damper function safety tests are initiated. The continuity between the standby yaw damper and its SV is tested. The computation is monitored by the comparators between command and monitor part. The ELAC, FMGC and Air Data/Inertial Reference System (ADIRS) peripheral inputs are always monitored. The power loop is monitored by a comparator between the yaw order and the rudder position feedback. In flight, the hydraulic pressures are monitored by the FAC.
The LVDTs and the RVDTs are always monitored.



EV 1 (S1)	EV 2 (S2)	ACT	PR.SW
0	0	BY-PASS (INACTIVE)	0
0	1		1
1	0		1
1	1	ACTIVE	0

} Y/D FAIL

Figure 74 Yaw Damper Function

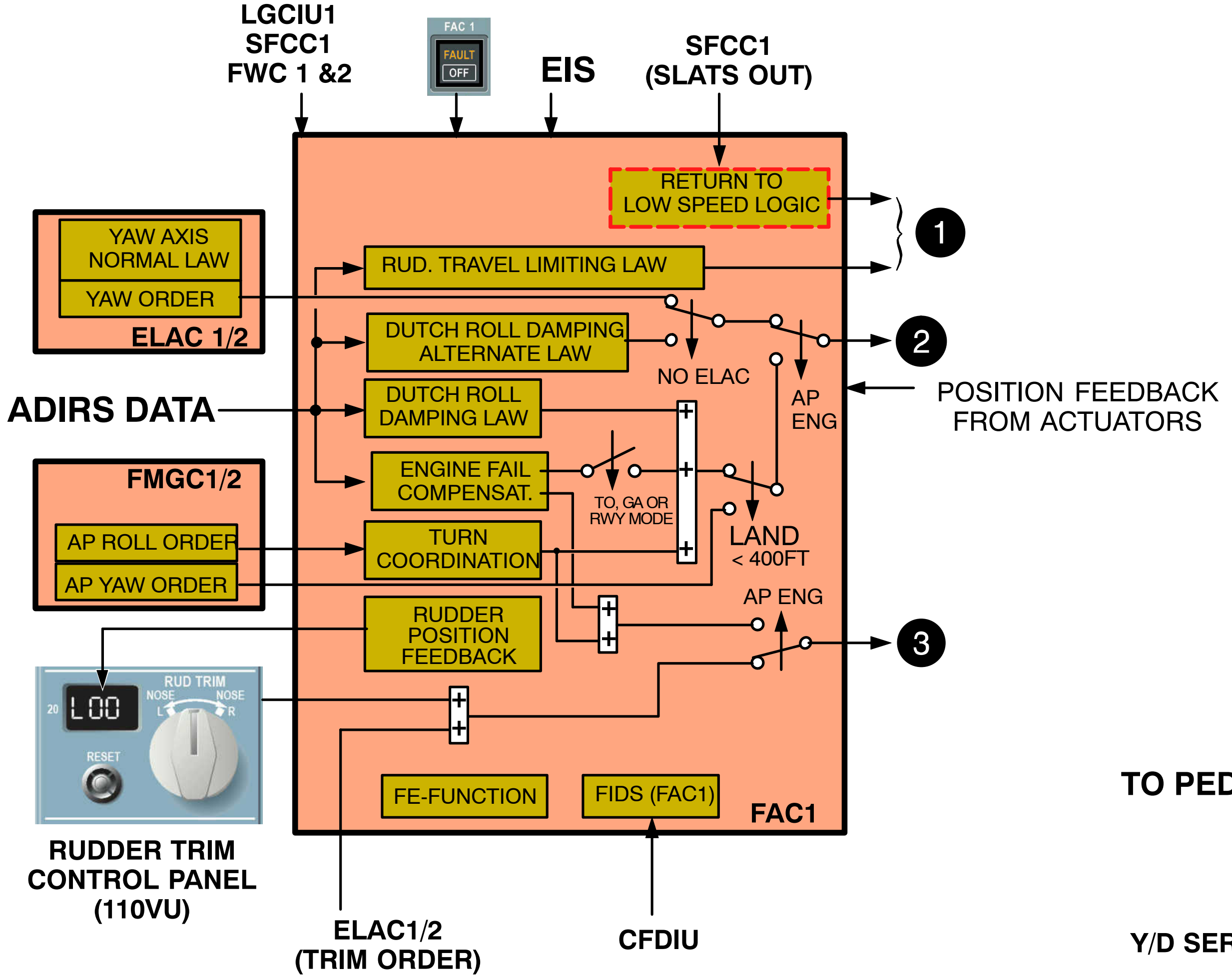
RUDDER TRAVEL LIMITING SYSTEM DESCRIPTIOPN & OPERATION

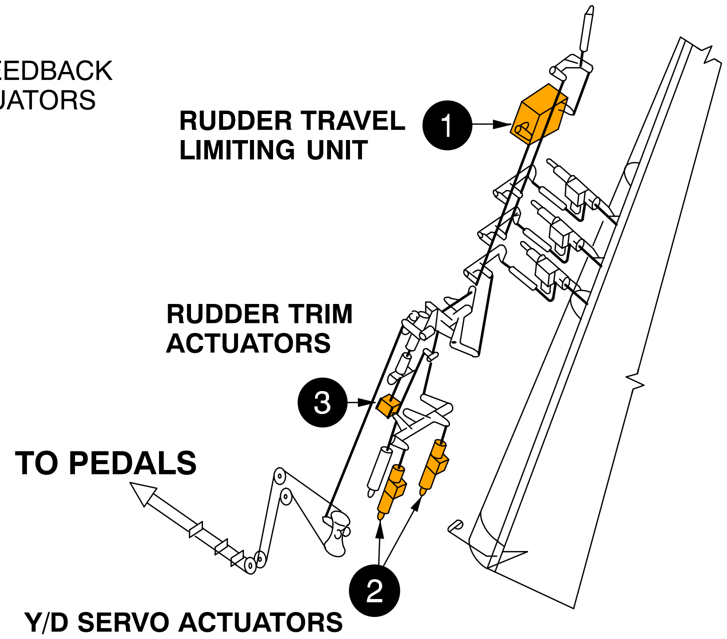
Normal Operation

The active system controls the limitation unit through its motor. It limits the rudder travel according to a parameter specific to the flight envelope i.e. the corrected airspeed (VC).

This parameter which is delivered by the ADIRS (Air Data/Inertial Reference System) is monitored by the FAC.

Each motor has its own power electronic set. A FAC logic interrupts the power of the electronic set on the side which is not active and thus de−activates the associated motor. Two position transducers enable slaving and monitoring of the channel.





ATTENTION: FAC system 1 is shown.
System 2 is similar.

Figure 75 Rudder Travel Limiting

RUDDER TRAVEL LIMITING UNIT DESCRIPTION

The mechanical design of the Travel Limitation Unit (TLU) is such that a single mechanical failure (rupture or disconnection) cannot cause the loss of the travel limitation function.

The TLU has two brushless electric motors separately controlled by an electronic assembly. Each motor drives two screws via a reduction gear and permits the symmetrical linear displacement of two nuts used as adjustable stops.

A non−locking rotary stop limits the stroke of one of the screw/nut assemblies which are irreversible. There are two levers on each connection shaft; one is connected to the input rod and the other is used as a punctual stop.

The movement of each screw is transmitted to a Rotary Variable Differential Transducer via the reduction gear which permits to indicate the position of the variable stop.

NOTE: To prevent icing, there is a heating system which includes two coils and their regulating thermostats.

Return to Low Speed Conditions

A simplified emergency control system (open loop) brings back automatically the stops to the ”low−speed” position when:

- The two FACs are failed
- and slats are extended.

This mode, which is also called emergency mode, serves in case of failure of both FACs or of the power electronic set (when the failure prevents the normal operation of the rudder travel−limitation unit).

This mode which is independent from the normal control, is only initiated at low speed (in slats extended configuration).

A FAC internal logic controls a relay which switches the limitation unit to a control order called emergency control order (independent 26V/400 Hz power supply).

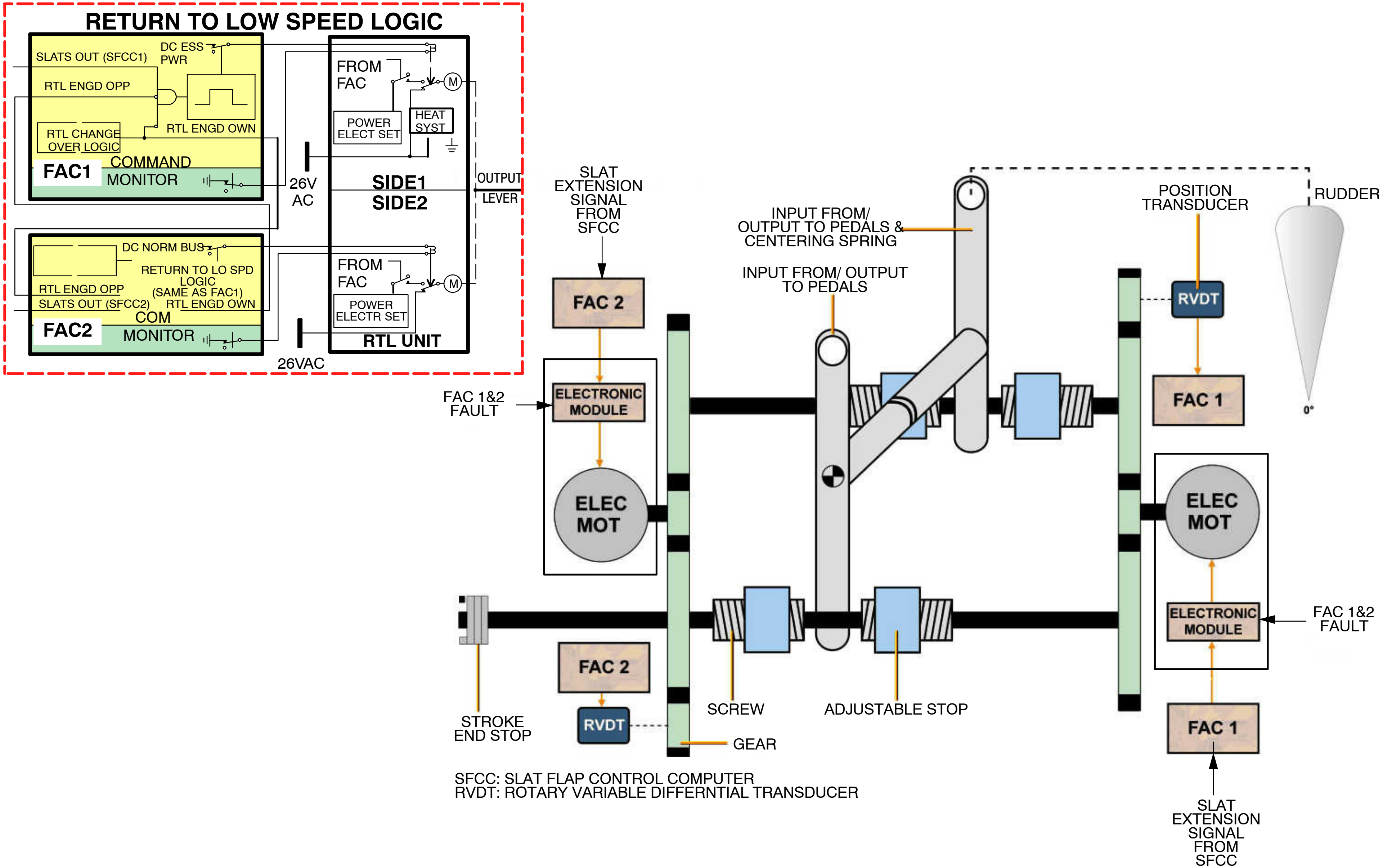


Figure 76 Return to Low Speed Function

YAW AXIS CONTROL OPERATION

ELAC FAILED ALT LAW

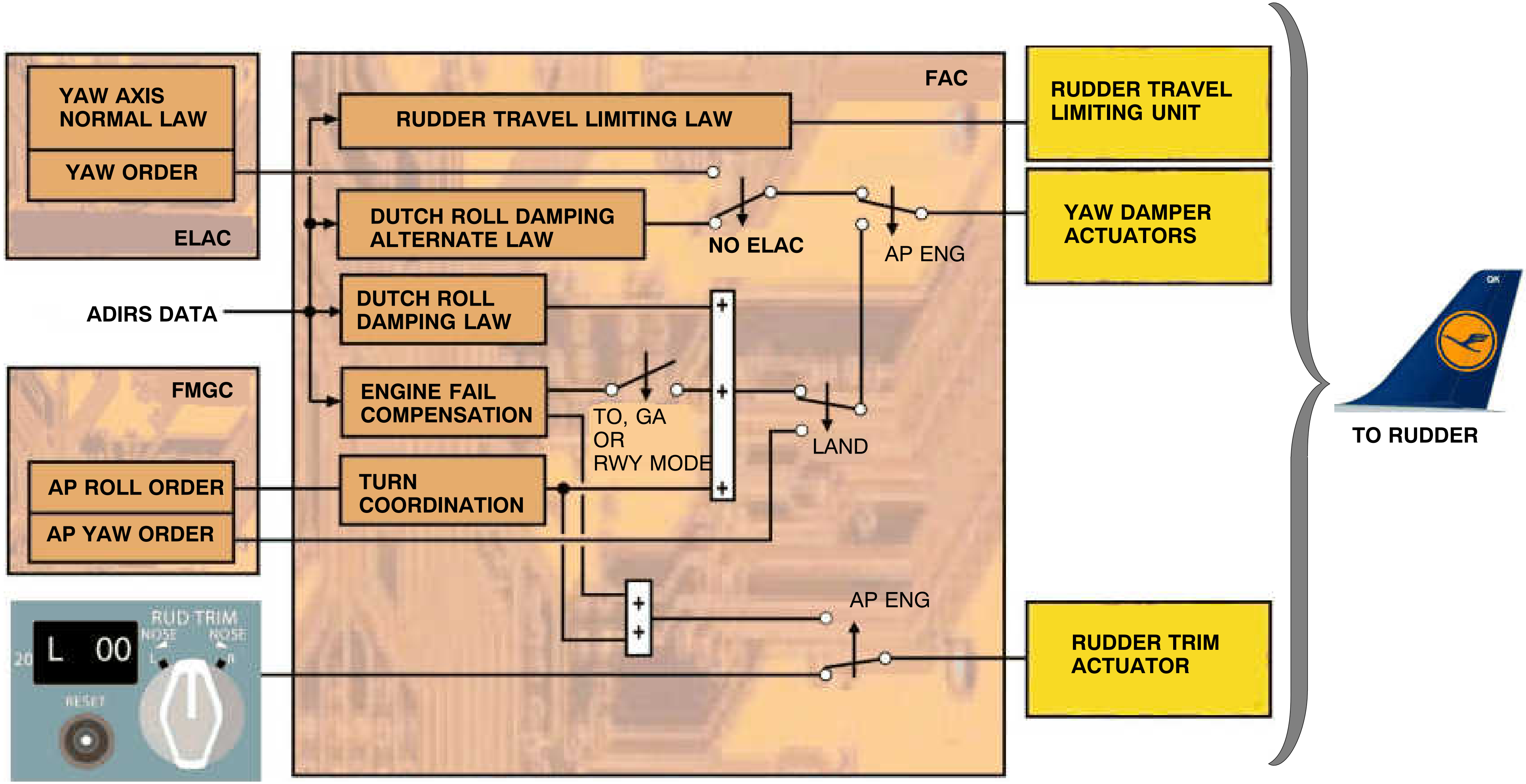
This schematic represents the ELAC failed ALT law.

If necessary, the ELAC must operate in degraded law on the roll axis. In degraded mode indicated by the ELAC, the FAC computes the yaw damper function and generates a simplified law of Dutch roll damping (alternate law).

When the AP is not engaged, the ELevator Aileron Computer (ELAC) calculates the yaw damper order with the normal law.

The yaw damper order calculated by the ELAC provides turn coordination; dutch roll damping and engine failure compensation.

If **both ELACs fail**, only the dutch roll damping (alternate law) is computed by the Flight Augmentation Computer (FAC) using the Air Data Inertial Reference System (ADIRS) data.

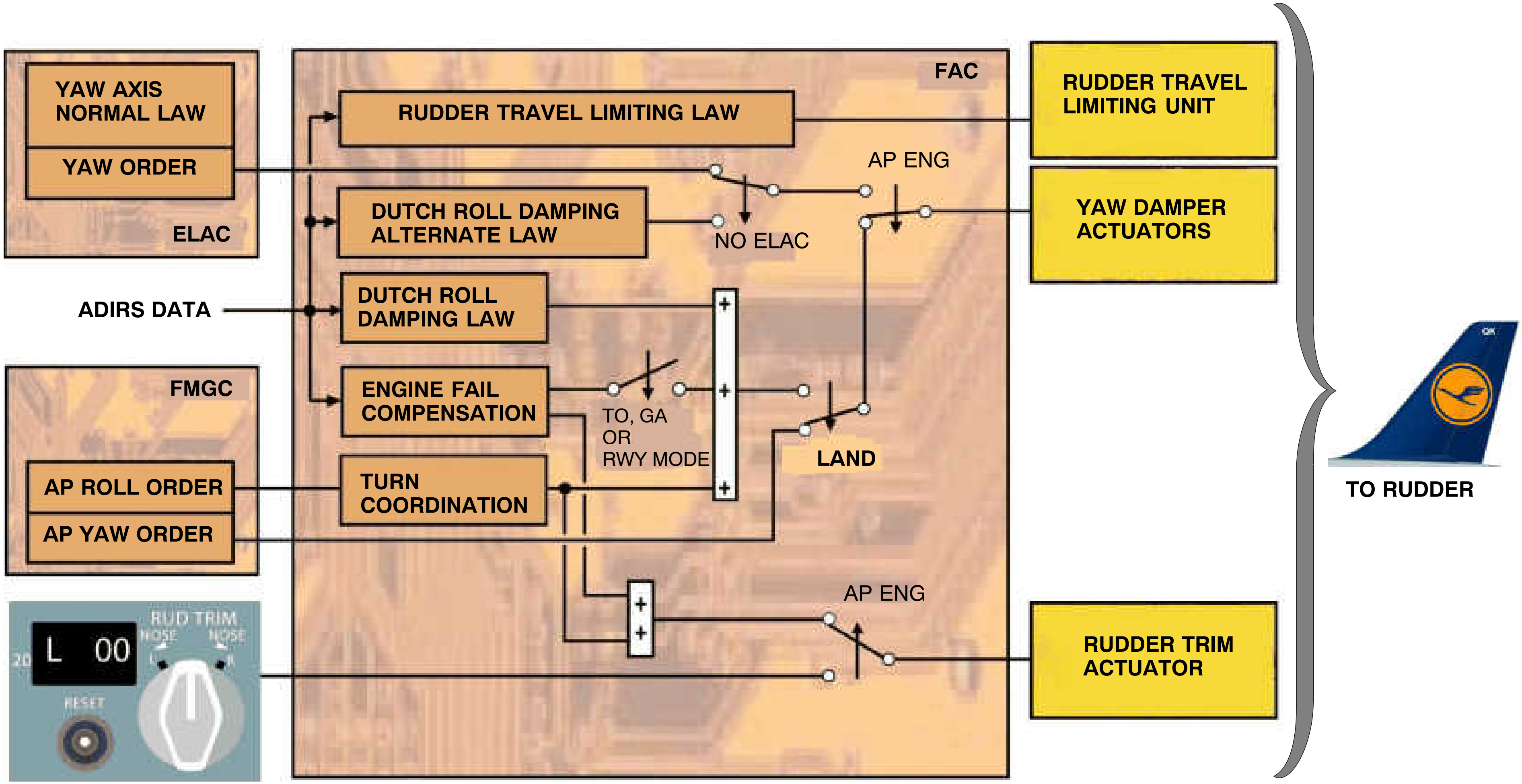


RUDDER TRIM CONTROL PANEL (110VU)

Figure 77 Both ELAC Failed

AUTOPILOT ENGAGED LAND MODE OPERATION

This schematic represents the AP engaged LAND mode. With the autopilot engaged and the Land Mode activated, **Dutch roll damping and Turn coordination are inhibited** and yaw damping is accomplished directly from the FMGC yaw guidance order.



RUDDER TRIM CONTROL PANEL (110VU)

Figure 78 AP LAND Mode Engaed

AUTOPILOT ENGAGED, ENGINE FAILURE COMPENSATION, TOGA/RWY MODE DESCRIPTION

This schematic represents the AP engaged engine comp TOGA/RWY mode.
As soon as the AP is engaged, the yaw damper operates in the mode given below:

- Dutch roll damping,
- Turn coordination to reduce the sideslip in turn as a product of the roll order from the FMGC.

In TO/GA/RWY mode the yaw damper will now include engine failure compensation in the event of an engine failure. This mode provides lateral guidance function, at takeoff, on the runway centerline by means of the LOC beam and by following an optimum longitudinal flight path after rotation.

This mode is available:

- for the FD during takeoff run and in flight,
- for the AP 5 seconds after lift−off.

The mode is engaged when the pilot selects the takeoff thrust by positioning the thrust control levers beyond the MCT/FLX TO gate.

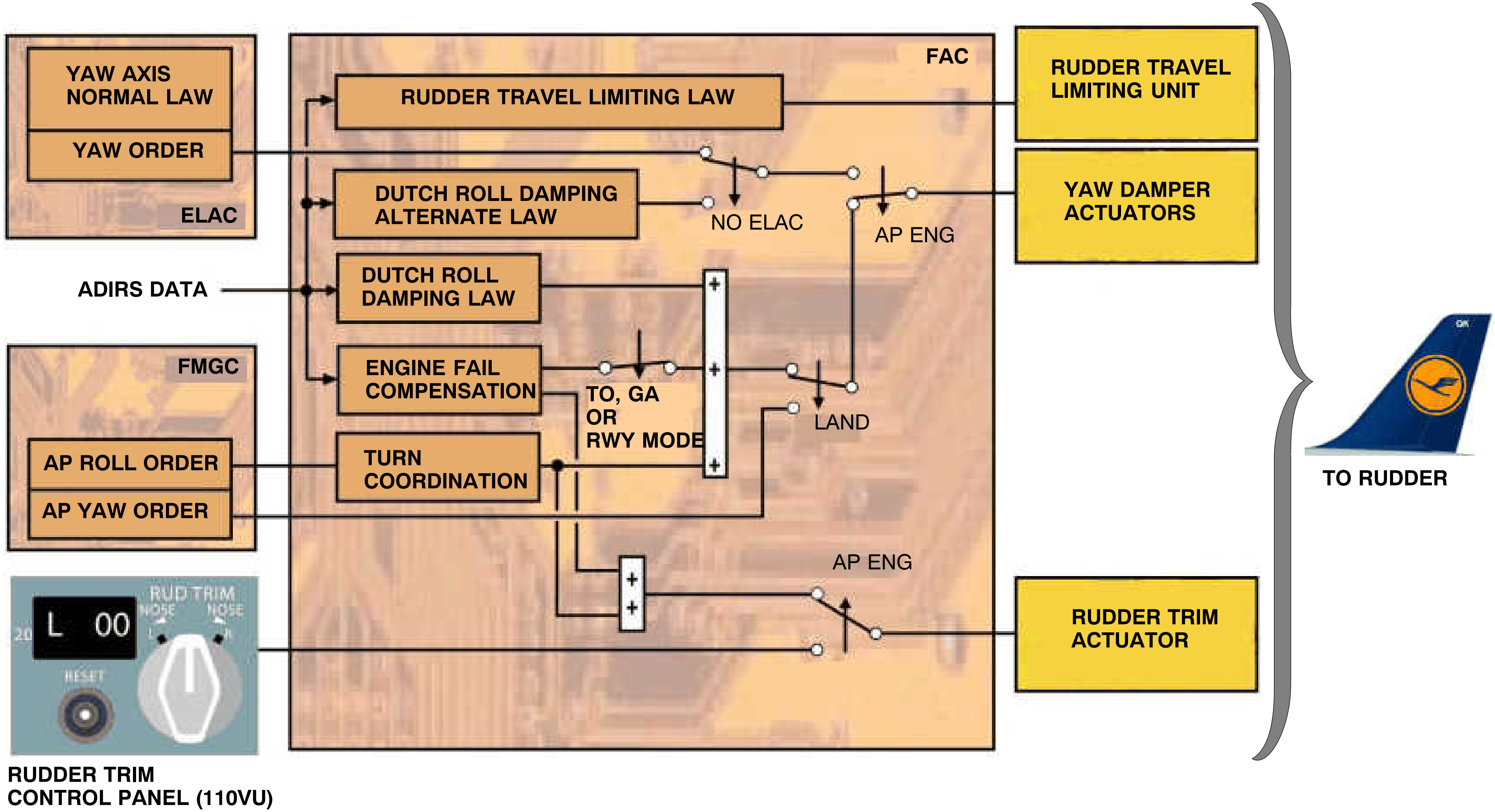


Figure 79 TO/GA RWY Mode

AUTOPILOT ENGAGED, CRUISE MODE OPERATION

This schematic represents the AP engaged cruise. As soon as the AP is engaged, the yaw damper operates in the mode given below:

- Dutch roll damping
- Turn coordination to reduce the sideslip in turn as a product of the roll order from the FMGC.

Additionally, for the rudder trim operation in automatic mode the autopilot has priority thus, the manual pilot trim is not possible in AP engaged configuration. The order for rudder trim deflection is a product of the turn coordination and (in the event of an engine failure) engine fail compensation.

The AP also provides signals which validate the detection of engine failure as a function of the engine rating. In all cases the rudder trim deflection is always indicated on the rudder trim control panel.

YAW DAMPER OPERATION

When the AP is not engaged, the ELevator Aileron Computer (ELAC) calculates the yaw damper order with the normal law.

The yaw damper order calculated by the ELAC provides turn coordination, dutch roll damping and engine failure compensation.

If both ELACs fail, only the dutch roll damping (alternate law) is computed by the Flight Augmentation Computer (FAC) using the Air Data Inertial Reference System (ADIRS) data.

When the AP is engaged, the FAC calculates the yaw damper order except in LANDing mode where it is computed by the Flight Management and Guidance Computer (FMGC).

When the AP is engaged:

- dutch roll damping law is given by the FAC using ADIRS data.
- engine failure compensation fast law is given by the FAC using the ADIRS data in Take-Off/Go-Around (TOGA) or RunWaY modes only.

RUDDER TRIM COMPUTATION

The rudder trim function ensures a trimmed value of the rudder. This value is reproduced at the rudder pedals. This trim is obtained either manually or automatically.

The value appears:

- On the rudder trim indicator,
- On the display unit of the ECAM system.

The resulting deflection is maintained even in case of total loss of the function. This permits to have a stabilized value, for example in the event of AP loss when an engine failure occurs.

The value appears:

- On the rudder trim indicator
- On the display unit of the ECAM system.

The resulting deflection is maintained even in case of total loss of the function. This permits to have a stabilized value, for example in the event of AP loss when an engine failure occurs.

Structure of Rudder Trim Control-Law

The control law generates a deflection order to control the rudder trim actuator through an integrator which memorizes the required position.

This order is generated:

- From the position of the position feedback in synchronization
- From the control order of the pilot trim (the reset is obtained through the unloading of the trim integrator)
- From the ELAC deflection order (Provision only)
- From the long-term turn-coordination order for autotrim on the yaw axis
- From the generation of an engine failure detection and its accomplishment.

The engine failure is detected from the lateral acceleration and from the yaw rate through a given threshold. This detection is confirmed by the engine thrust information.

Detection is performed by the command and monitoring sides. The first side which is triggered sends a signal to the opposite side in order to lower its threshold and thus ensure synchronized detection.

The correction signal (fixed deflection values) is then applied, depending on engine failed.

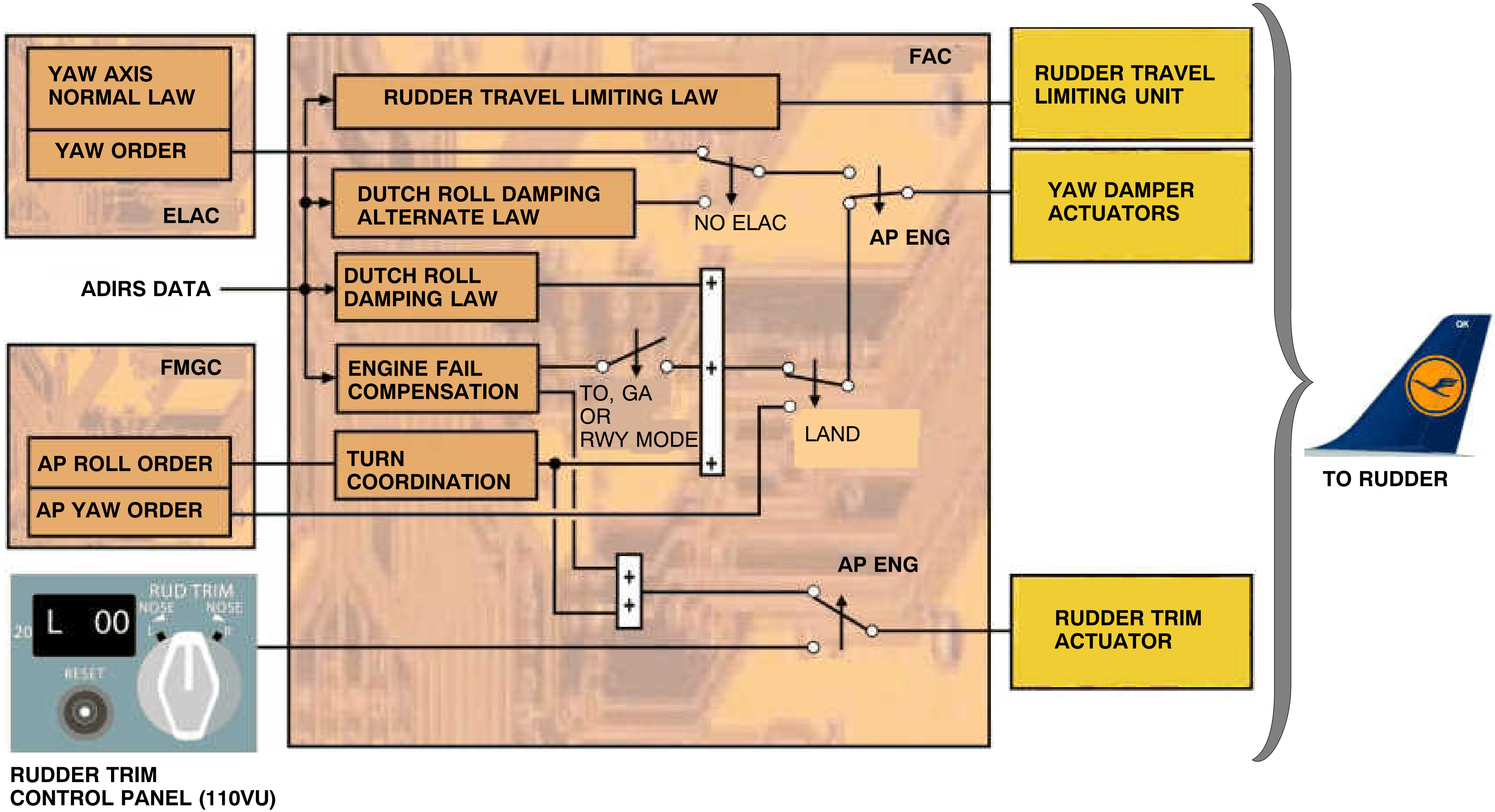


Figure 80 AP Engaged - Cruise Flight

FLIGHT ENVELOPE PROTECTION DESCRIPTION

GENERAL

The function of the Flight Augmentation Computer (FAC) is independent of the FAC engagement P/BSW.

This function gives:

- **Characteristic speeds** on the PFDs through the Display Management Computers (DMCs),
- the **speed limits** to the Flight Management and Guidance Computers (FMGCs) for autoflight,
- the **alpha-floor detection** to the FMGCs for A/THR engagement, if it is not engaged,
- **low energy awareness**.

In addition, the FAC computes the weight and the center of gravity.

SPEED COMPUTATION DISPLAY

The speeds computed by the FAC are sent to the PFD and the speed limits to the FMGCs. In normal operation, FAC 1 data are displayed on the CAPT PFD and the FAC 2 data on the F/O PFD.

If a parameter or the computer fails, the associated PFD is automatically switched to the opposite FAC by the DMC.

If the air data source used by the FAC is different from the data source used by the DMC for speed display, the message **ADR DISAGREE** appears on the ECAM.

SPEED COMPUTATION

Aerodynamic laws and the aircraft configuration parameters are used for the characteristic speed computation.

The computation principle is based on the fact that most of the speed data are a function of the aircraft weight.

In flight, the FAC computes the weight with the Air Data/Inertial Reference System (ADIRS), FMGC and Slat Flap Control Computer (SFCC) parameters and then, from the weight, it computes the characteristic speeds and the Center of Gravity (CG).

On the ground, the FAC uses the weight given by the FMGC.

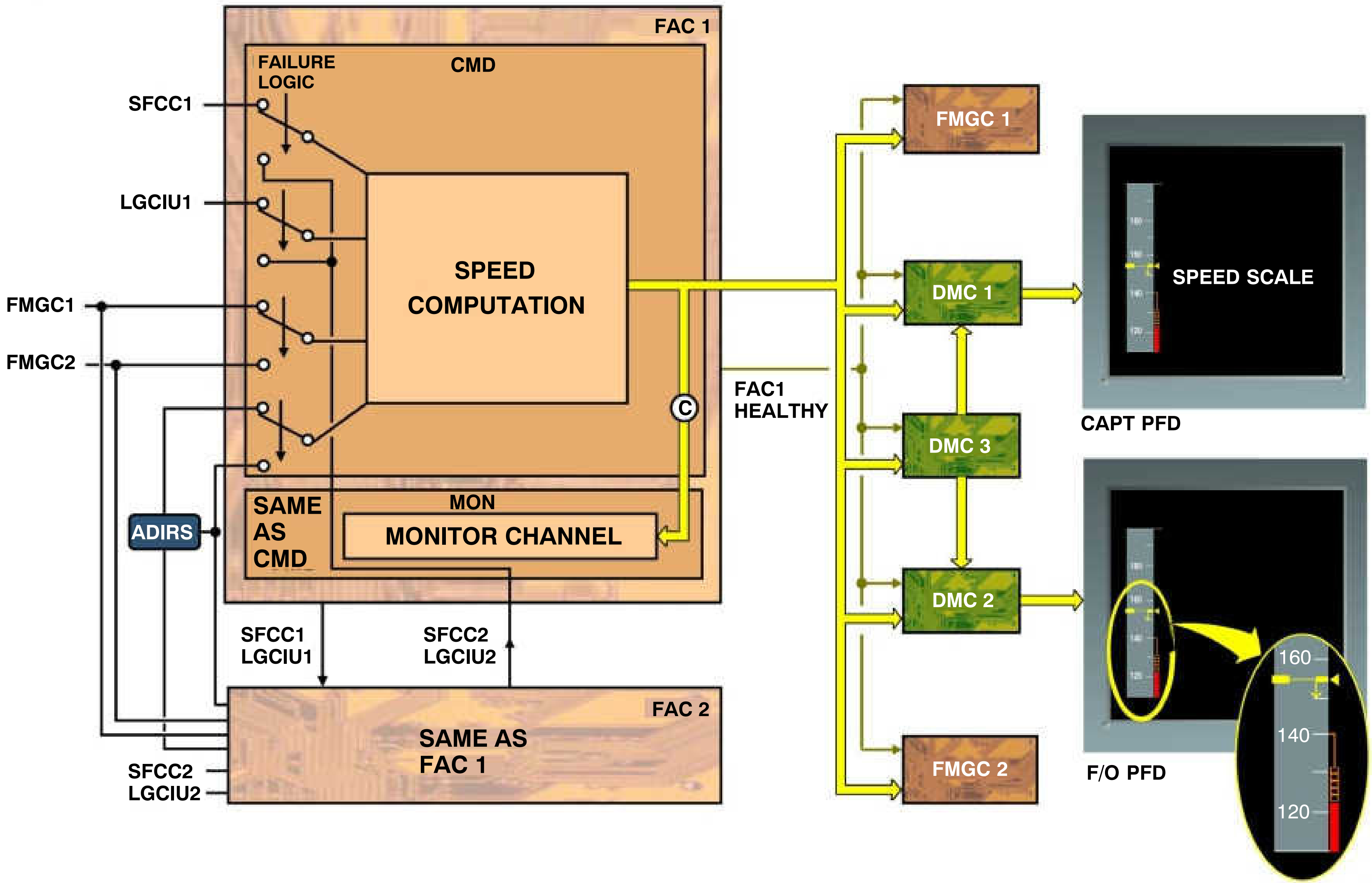


Figure 81 Speed Computation

INDICATION: SPEED LIMITS

MINIMUM SELECTABLE SPEED (VLS)

It is defined by the top of an amber strip along the speed scale and computed by the FACs. The VLS corresponds to 1.13 Vs during take−off or following touch and go. It becomes 1.23 Vs as soon as any flap or slat selection is made. It remains at this value until landing. Above 20000 ft, VLS is corrected for Mach effect to maintain 0.2 g buffet margin. VLS information is inhibited from touch down up to 10 seconds after lift−off.

ALPHA PROTECTION SPEED

The top of a black and amber strip along the speed scale defines the alpha protection speed. It represents the speed corresponding to the Angle−Of−Attack (AOA) at which alpha protection becomes active. The FACs compute this speed in pitch normal law.

ALPHA MAX SPEED

The top of a red strip along the speed scale defines the alpha max speed. It represents the speed corresponding to the maximum AOA that may be reached in pitch normal law. The FACs computes this speed in pitch normal law.

VMAX

It is defined by the lower end of a red and black strip along the speed scale and determined by the FACs. Vmax represents the lowest of the following values:

- VMO (maximum operating speed) or the speed corresponding to MMO (Maximum Operating Mach),
- VLE (maximum landing gear extended speed),
- VFE (maximum flap extended speed).

VSW

The top of a red and black strip along the speed scale defines the Stall Warning Speed (VSW). It represents the speed corresponding to the stall warning. VSW information is inhibited from touch down up to five seconds after lift−off. The FACs computes the VSW in pitch alternate or pitch direct law.

DECISION SPEED (V1)

The decision speed V1 is shown by a cyan symbol. The crew through the Multipurpose Control and Display Unit (MCDU) manually inserts the decision speed. When out of indication range, it is digitally shown on the upper part of the scale. It is removed after lift−off.

MINIMUM FLAP RETRACTION SPEED

This speed is represented by a green −F symbol. It is available when the flap selector is in position 3 or 2. It is computed by the FACs.

MINIMUM SLAT RETRACTION SPEED

This speed is represented by a green −S symbol. It is available when the flap selector is in position 1. It is computed by the FACs.

VFE NEXT Two amber dashes show the predicted VFE at the next flap/slat position. It is given by the FACs and only displayed when the aircraft altitude is below 15000 ft.

GREEN DOT

This is the engine out operating speed in clean configuration. It is displayed in flight only by a green dot. It represents the speed corresponding to the best lift to drag ratio.

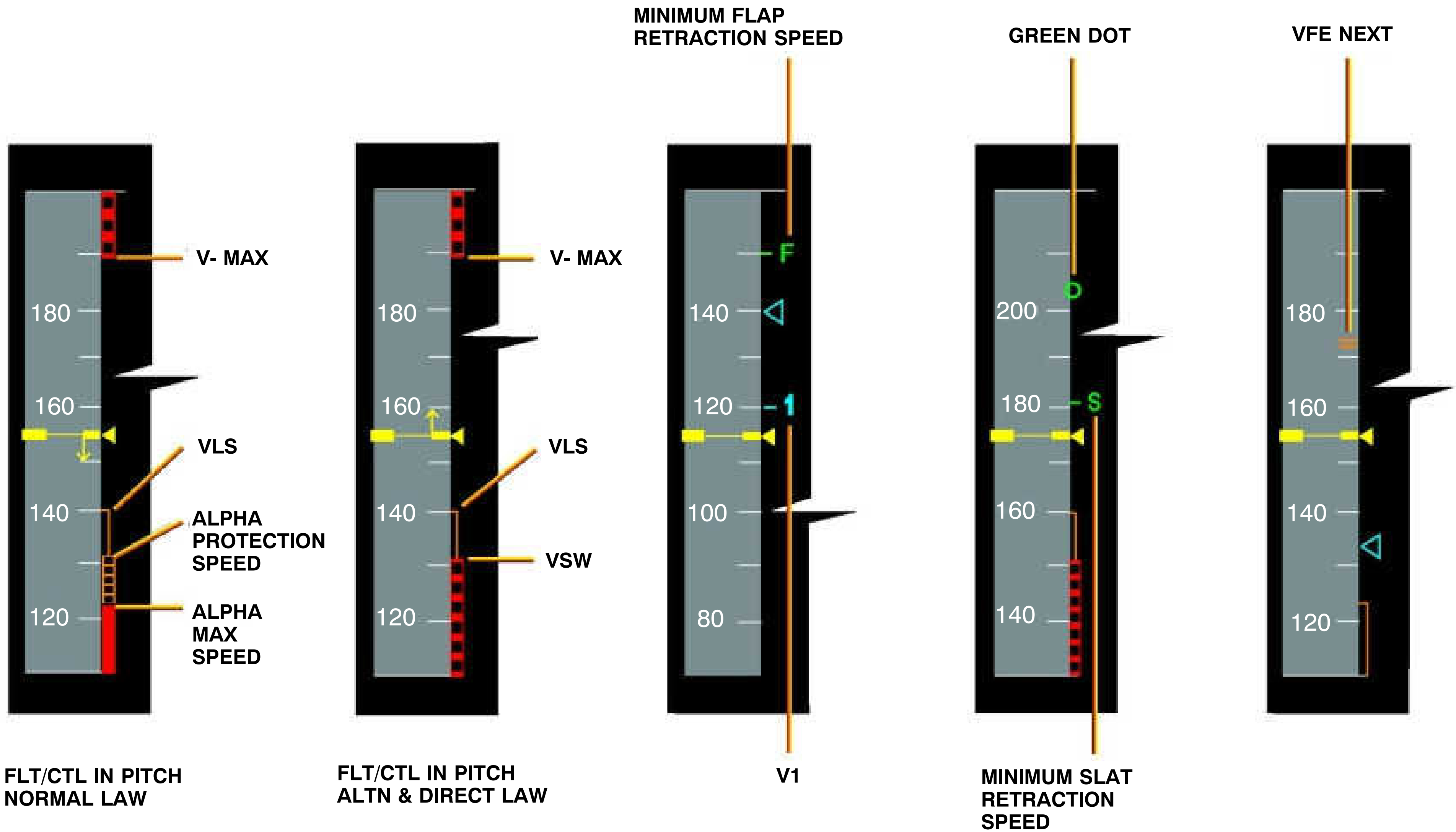


Figure 82 Speed Limits

INDICATION: FLIGHT ENVELOPE DATA ON PFD

SPEED PROTECTION

The green overspeed protection symbol indicates the speed at which overspeed protection becomes active.

SPEED PROTECTION = (VMO + 6 kts / MMO + 0.01).

SPEED TREND

The yellow pointer starts from the speed symbol. The end of this arrow gives the speed value, which will be attained in 10 seconds if the acceleration or deceleration remains constant. This arrow appears only when greater than 2 kts and is removed when less than 1 kt. It is also removed in case of failure of the Flight Augmentation Computers (FACs).

TARGET AIRSPEED

This symbol is either magenta or cyan and gives the target airspeed value or the airspeed corresponding to the Mach number. The target airspeed value is the value computed by the Flight Management and Guidance Computer (FMGC) in managed speed mode (magenta) or manually entered on Flight Control Unit (FCU) for selected speed mode (cyan). The target speed is a magenta double bar when associated with the ECONomy speed range. Otherwise it is a magenta or cyan triangle. When out of speed scale, the target speed value is displayed in numeric form below or above the speed scale.

ECON SPEED RANGE

In descent mode, with the ECON mode, the selected speed is indicated by two magenta thick lines: upper and lower limits calculated by the FMGC. They indicate the range of descent speed: +20 kts and −20 kts or Vmin or VLS whichever is higher.

SPEED LIMIT FLAG

This flag appears when both FACs are inoperative, or in case of SFCC dual FLAP/SLAT channel failure.

In this case the following PFD information is lost:

- VLS,
- S,
- F,
- Green Dot,
- Vtrend,
- Vmax,
- VFE next
- VSW

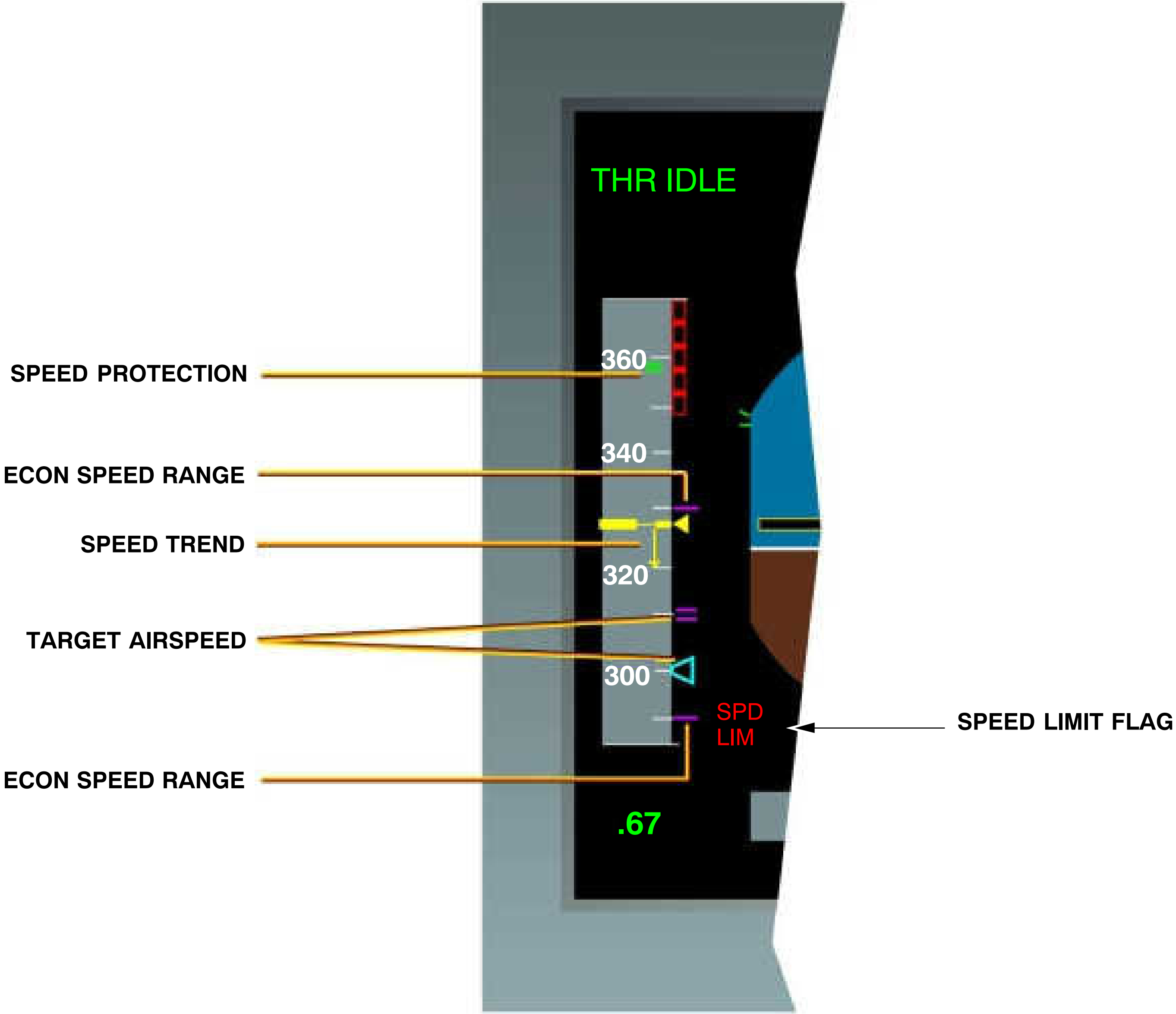


Figure 83 Speed Protection

LOW ENERGY AWARENESS DESCRIPTION

GENERAL

Energy awareness is a software device, which gives the crew an aural warning. This warning indicates that it is necessary to increase thrust to recover a positive flight path angle through pitch control.

The audio warning, "**SPEED SPEED SPEED**", is triggered before alpha-floor and depends on the AOA, configuration deceleration rate, and flight path angle. It is inhibited when

- RA is greater than 2000 ft or
- when alpha-floor is active or
- when the aircraft is in clean configuration.

When this low energy warning appears, thrust must be increased until warning disappears, or alpha floor may be triggered.

This warning is available only with flaps and slats in configuration 3 or Full and with radio altitude between 100 ft and 2000 ft.

The alpha floor function inhibits the low energy warning.

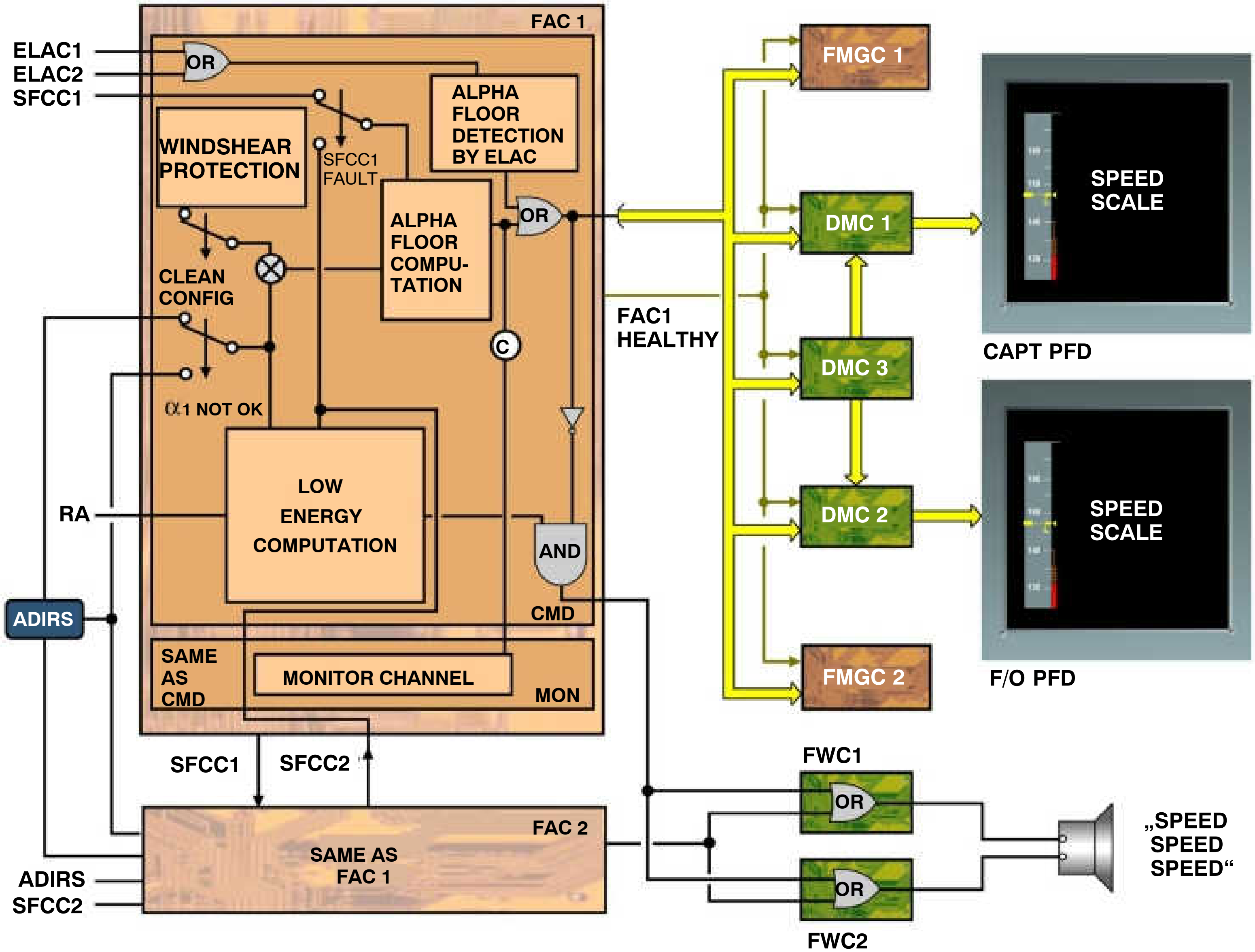


Figure 84 Low Energy Awareness

ALPHA FLOOR AND WINDSHEAR PROTECTION DESCRIPTION

Alpha-floor detection and windshear protection are computed by the FAC or the ELevator Aileron Computer (ELAC) and sent to the FMGC.

This function protects the aircraft against **excessive Angle-Of-Attack** (AOA). The FAC compares the aircraft AOA (alpha) with the predetermined threshold (function of the slat/flap configuration).

This threshold is decreased in case of windshear.

The windshear detection function is provided by the Flight Augmentation Computer (FAC) in takeoff and approach phase in the following conditions:

- At takeoff, 3 seconds after liftoff, up to 1300 feet RA
- At landing, from 1300 feet RA to 50 feet RA
- With at least Config1 selected.

NOTE: If a windshear condition is detected, the red WINDSHEAR message is displayed on the PFD and the aural warning "**WINDSHEAR, WINDSHEAR, WINDSHEAR**" is triggered.

Beyond this threshold, the FAC sends a signal to the FMGC to engage the A/THR function and apply full thrust. If the aircraft is in clean configuration, the windshear compensation function is not available.

The ELAC will trigger alpha-floor in two cases:

- alpha protection condition and side stick deflection > 14 degrees,
- pitch angle > 25 degrees and side stick deflection > 14 degrees.

A dual ADIRS failure results in the total loss of alpha-floor detection.

In case of warning inhibition in both FACs, the **WINDSHEAR DET FAULT** message appears on the upper ECAM display unit during TO or landing as soon as the slats are extended.

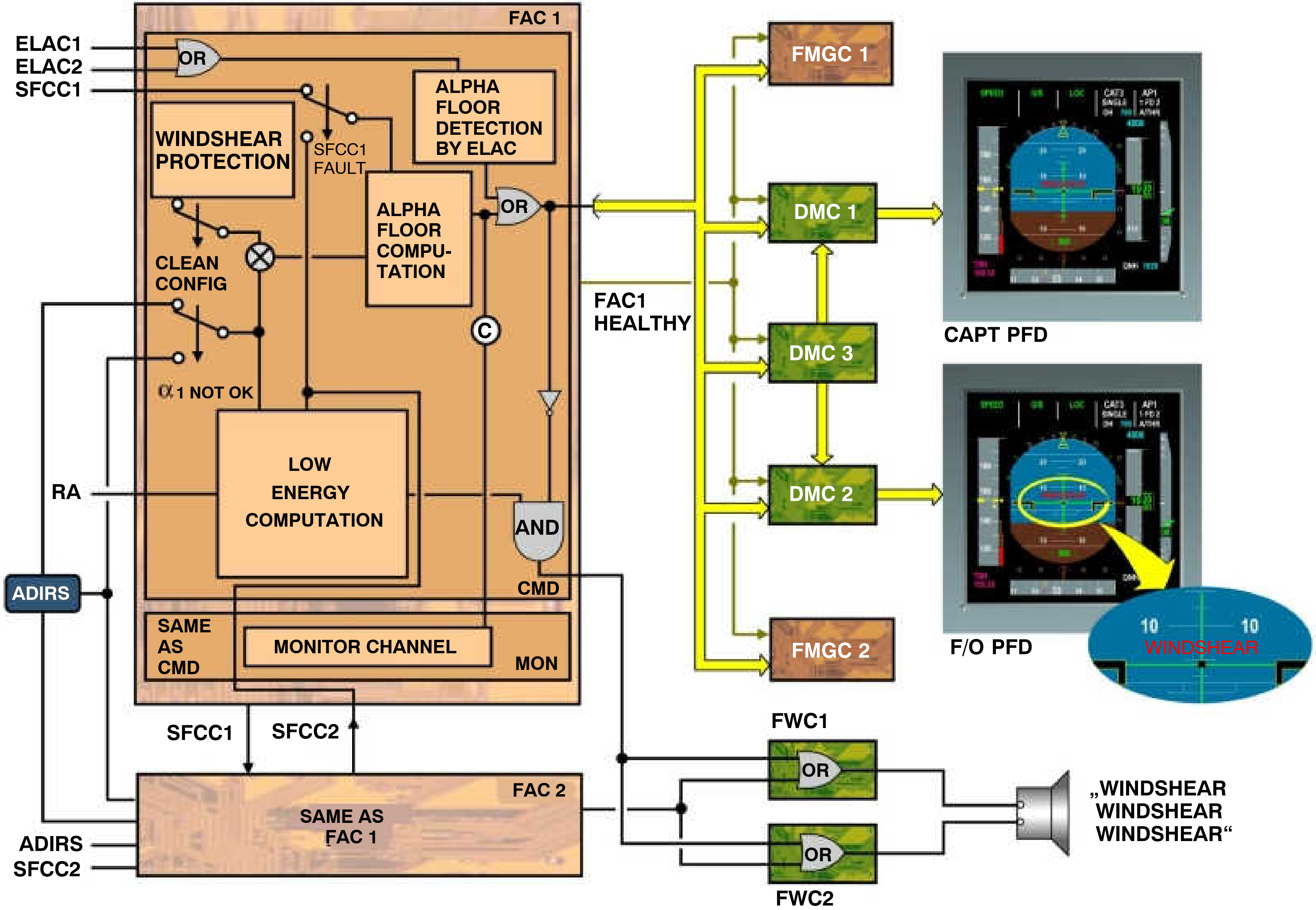


Figure 85 Alpha Floor/Windshear Protection

DETECTION OF ALPHA FLOOR

Computation of Alpha Floor Protection

The alpha floor protection is calculated in the FAC.

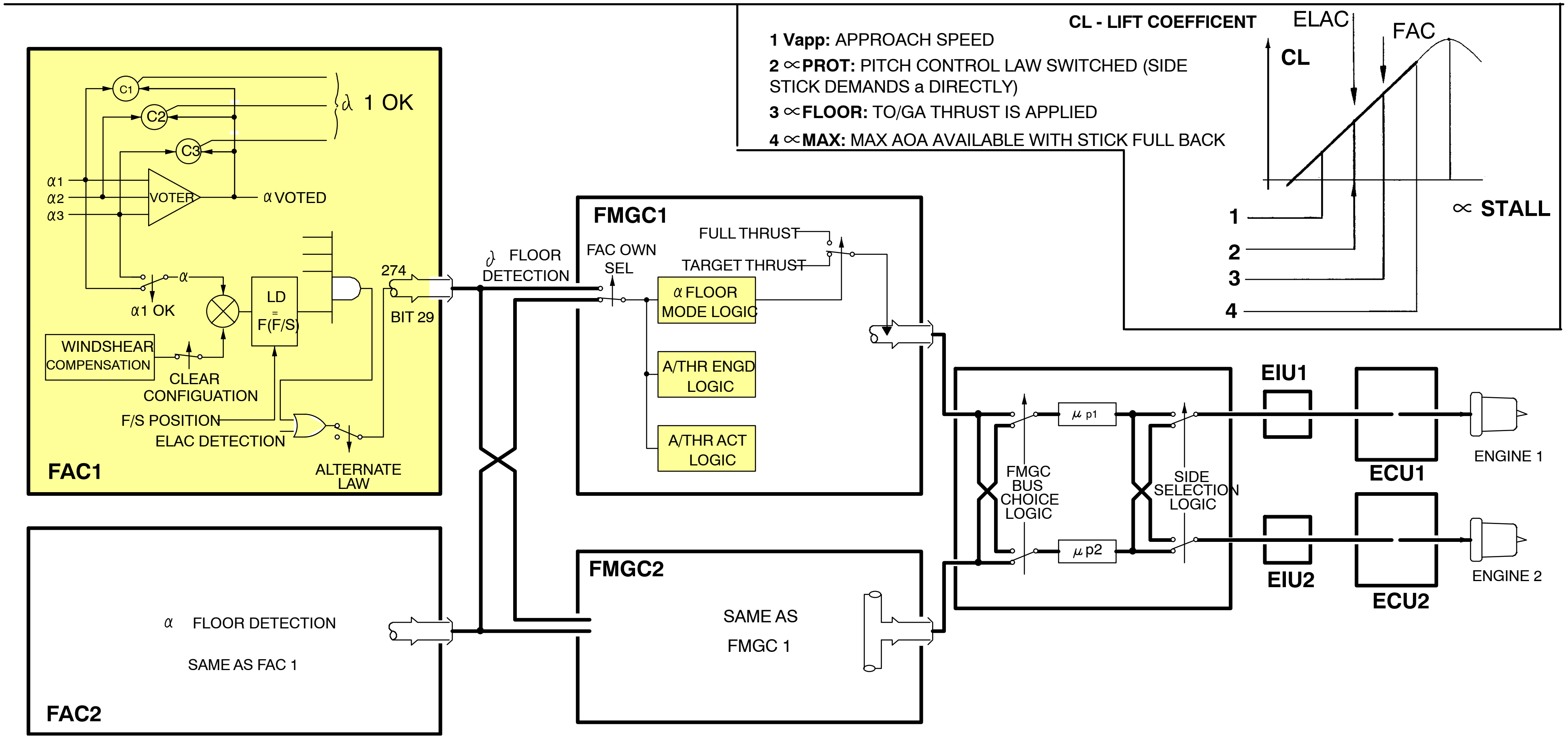
This function enables:

- To protect the aircraft against excessive angle-of-attack.

To do this, a comparison is made between the aircraft angle-of-attack and predetermined thresholds function of configuration. Beyond the thresholds the FAC transmits a command signal to the autothrust which will apply full thrust.

- To protect the aircraft against windshear in approach by determining a wind acceleration (deduced from the difference between ground acceleration and air acceleration).

The ELAC direct computation of the alpha floor protection is taken into account directly as soon as the first detection is made either by the FAC or by the ELAC.



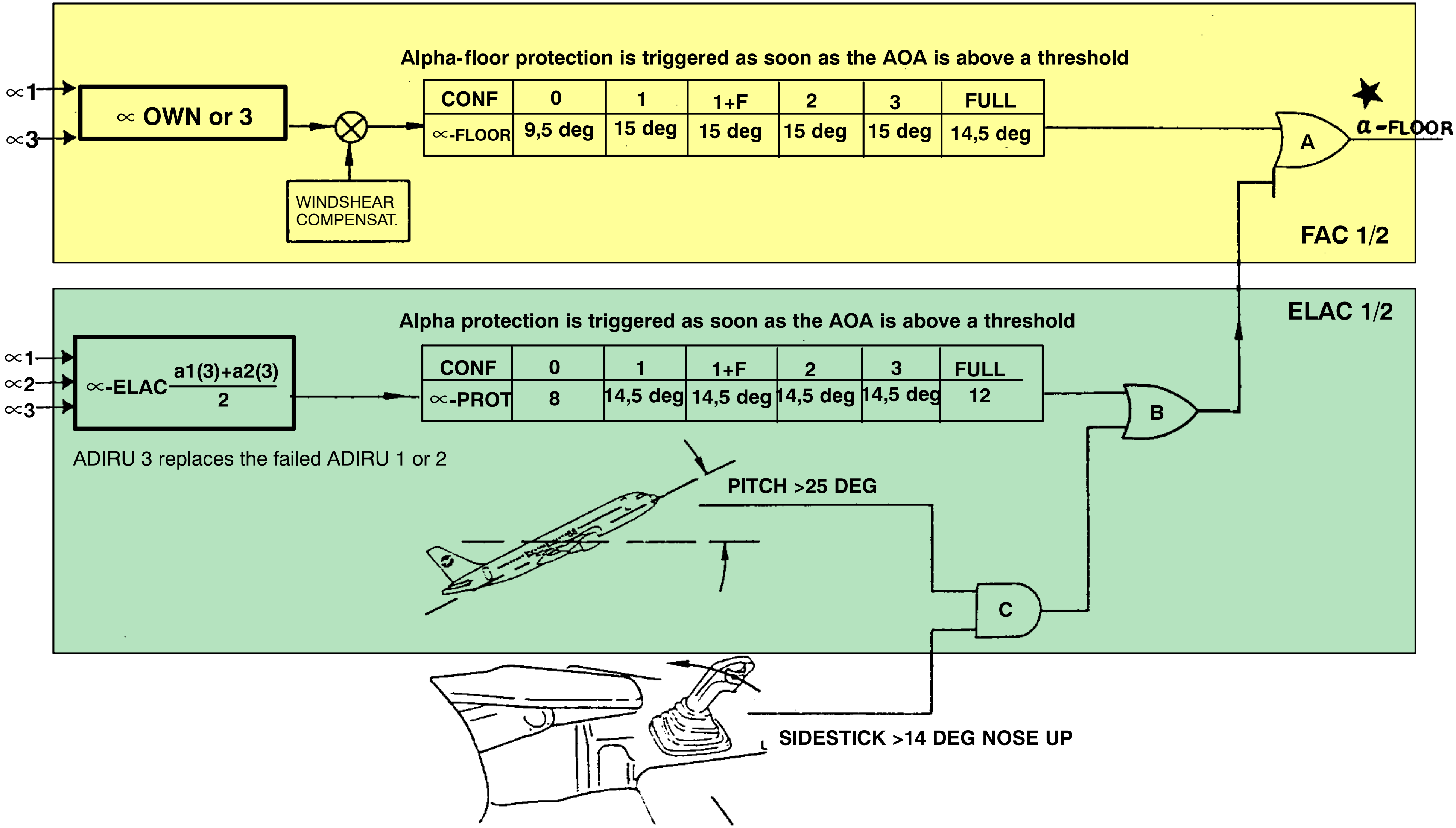


Figure 86 Detection of Alpha Floor

TAILSTRIKE PROTECTION INDICATION (OPTION)

GENERAL

In order to reduce the risk of tailstrike at landing, a audio call−out announcing ”**PITCH−PITCH**” is introduced on **A320 and A321** aircraft. This protection function is activated by PIN−Programming on Flight Augmentation Computers (FAC's).

Tailstrike Pitch Limit Indication

The pitch limit indicates the maximum pitch attitude to avoid the tailstrike risk at landing.

The indication is a fixed value corresponding to the main landing gear compressed. The indication appears at 400 feet radio height. The indication disappears, when there is no longer a risk of tailstrike.

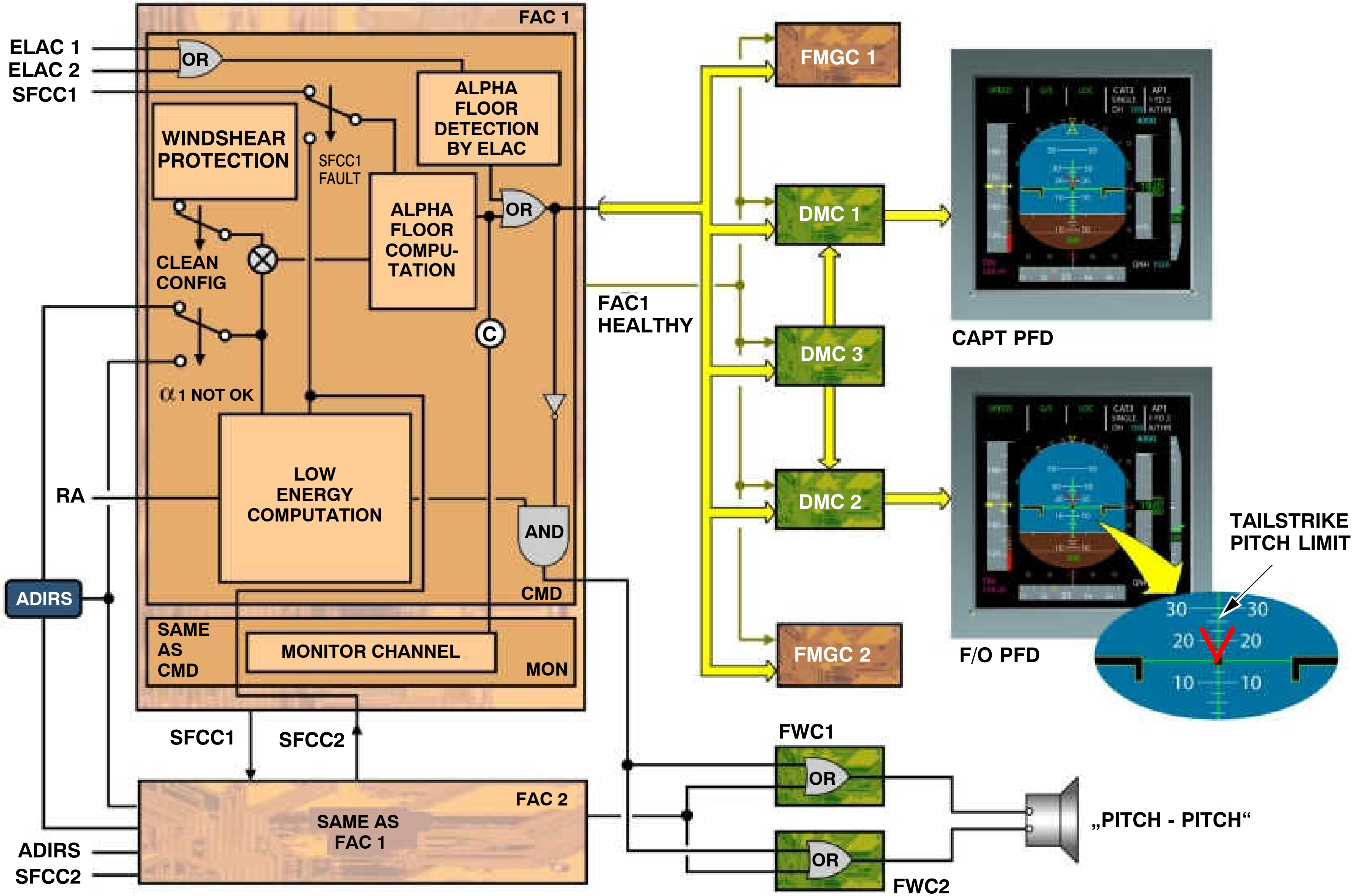


Figure 87 Tail Strike Protection (A320, A321)

22−82 MULTIPURPOSE CONTROL AND DISPLAY UNIT (MCDU)

MULTIPURPOSE CONTROL AND DISPLAY UNIT (MCDU) − DESCRIPTION AND OPERATION

GENERAL

The Multipurpose Control and Display Units (MCDU) provide access to the following:

- FMGC (Flight Management function)
- DATA LINK (ACARS)−optional
- CFDS (Centralized Fault and Display System)
- AIDS−optional
- SAT (SATCOM)−optional
- ATSU−optional.

They are composed of a keyboard and a screen for data entry/display by the pilot or the line maintenance personnel.

THE SCREEN

The MCDU display contains 14 lines, each having 24 characters. Of these 14 lines, the top line (line 1) is normally used as a title line or to display data to which the pilot does not have access. The bottom line (line 14) is the scratchpad line and is used by the pilot to alter the data in the data fields. Lines 2 through 13 are data lines arranged into six pairs (lines 2−3, 4 −5, 6−7, 8−9, 10−11, 12−13). Each pair of lines has a label line (the top of the two lines) and a data line. The data lines are adjacent to the line select keys, and the label line is just above the data line. The line select keys allow entry of data into a field and access to a data or a function identified by that field.

THE KEYBOARD

Alphanumeric Keys

Pressing an alphanumeric key (O through 9, A through Z, . (full point), + (plus), − (minus) and / (slash)) enters that character into the scratchpad of the MCDU.

Mode keys

Pressing a mode key causes a new MCDU page to be displayed and allows access to certain functions. The available mode keys are:

- AIRPORT/F− PLN/DIR/PROG/PERF/INIT/DATA/
- RAD NAV (Radio Navigation)
- FUEL PRED (Fuel Prediction)
- SEC F−PLN (Secondary flight plan)
  (FMGS mode keys)
- MCDU MENU
  (multi−purpose key)
- ATC COMM
  (optional Air Traffic Control mode key for datalink communication).

Function Keys

The function keys are described below:

- Right arrow)= causes horizontal forward page slewing to occur when allowed (also called ”Next Page”).
- (Left arrow)= causes horizontal backward page slewing to occur when allowed (also called ”Previous Page”).
- (Slew up) = causes upward vertical slewing to occur.
- (Slew down) = causes downward vertical slewing to occur.
- CLR = allows clearing of scratchpad and data fields.
- Delta (OVFY) = enters a Delta into the scratchpad.
- one spare key.

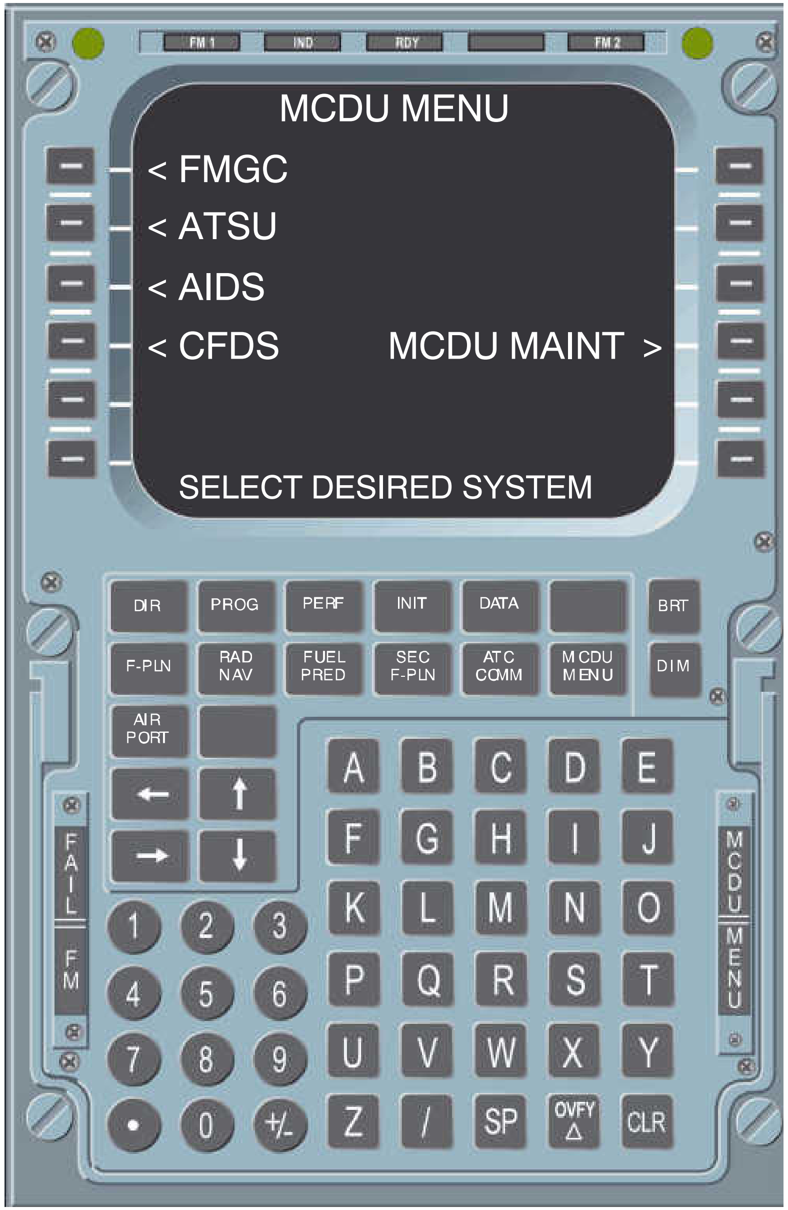
Front Panel Annunciators

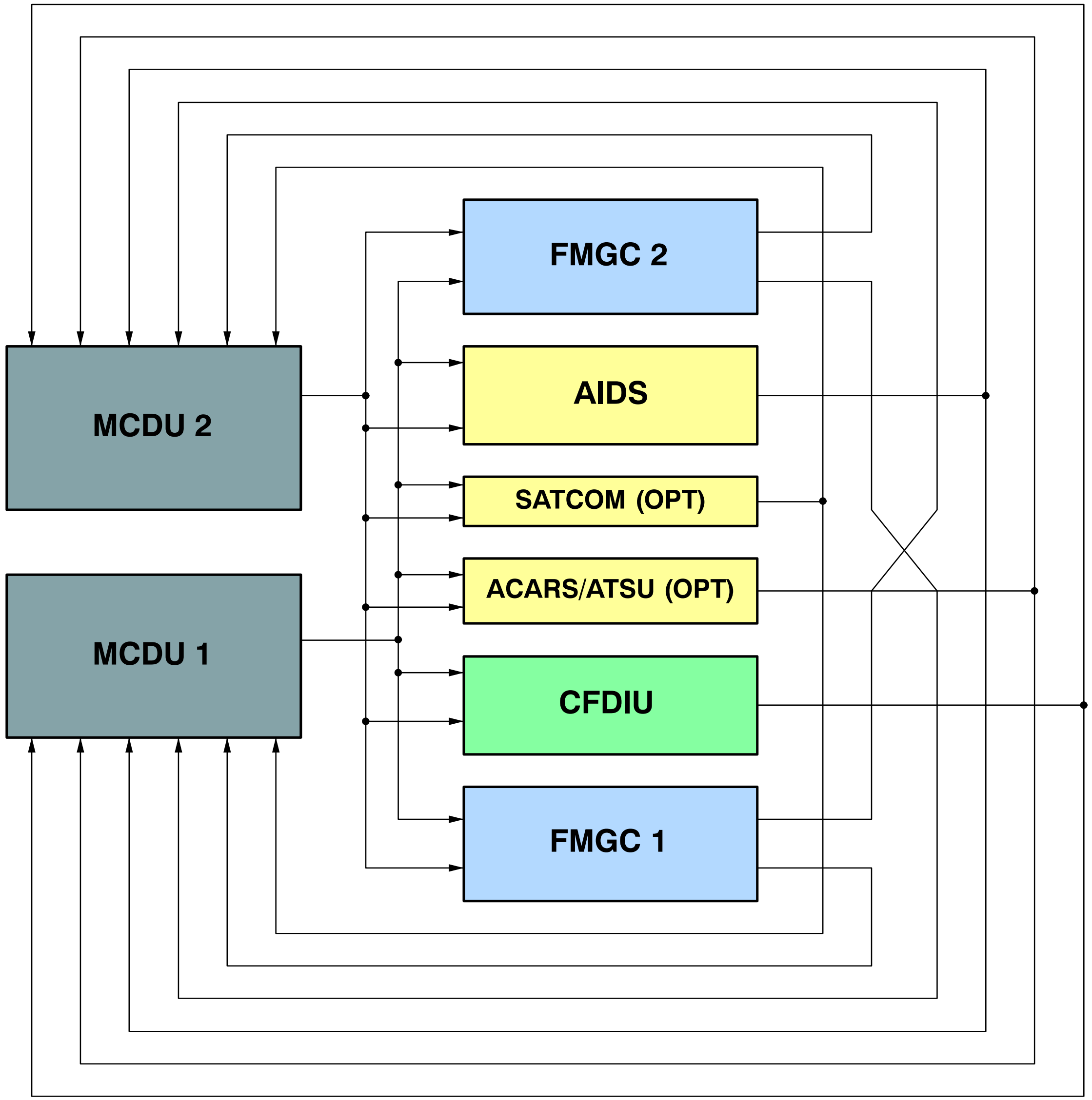
There are three illuminable annunciators on the MCDU front panel:

- FAIL: This annunciator comes on (amber) when the MCDU has failed
- MCDU MENU: This annunciator comes on (white) when a system linked to the MCDU (other than the FM) requests the display
- FM: This annunciator comes on (white) when FM is not the active system and has sent an important message.

BRT/DIM Keys

The BRT/DIM keys allows brightness adjustment of the screen. The fully decreasing of the brightness switches off the MCDU.





NOTE: All lines representing ARINC 429 data buses.

Figure 88 MCDU Interface Schematic

Top Panel Annunciators

There are five illuminable annunciators across the top of the MCDU front panel of which one is spare and not utilized. The spare annunciator is unlabeled but it contains an amber light.

- **FM1 and FM2**

  The FM failure annunciators at the top of the MCDU indicate when a FM failure occurs.

  The FM1 failure light on MCDU1 and/or MCDU2 comes on (amber) if FM1 is the selected FM, the MCDU BRT knob is at ON and the FM1 subsystem identifier word (label 172) is not received for three seconds by the MCDU.

  Likewise, the FM2 failure light on MCDU1 and /or MCDU2 comes on (amber) if FM2 is the selected FM, the MCDU BRT knob is at ON and the FM2 subsystem identifier word is not received for three seconds by the MCDU.

  The corresponding FM failure annunciator on MCDU3 comes on only if MCDU3 operates as a backup to MCDU1 or MCDU2. It comes on only in the context of the failed MCDU selected FM.

  Additionally, a MCDU never has both its FM failure annunciators on. The FM failure annunciators are off when an identifier word is received from the appropriate FM.

- **RDY**

  This annunciator comes on (green) when the MCDU passes its long-term power up or power off reset test after its BRT knob is turned to OFF.

- **IND**

  This annunciator comes on (amber) when the selected FM detects an independent operation (loss of dual mode) while both FMs are healthy. If either FM is failed, the annunciator is not on, regardless of the state of the intersystem bus.

MULTIFUNCTION USAGE - FUNCTIONING

The MCDU is linked to both FMGCs, CFDS, and optional systems. At power-up or after a long term power interrupt, the MCDU communicates with the FMGC and the A/C STATUS page is displayed. To initiate communications with another system other than the FMGC, the pilot presses the MCDU MENU mode key. Then a menu page is displayed (item a) indicating which system is currently active (green) and any system requesting service (white with (REQ) displayed with a space immediately after each menu system identifier).

If the operator does not press any line key after 60 seconds, the MCDU does one of the following actions:

- if an active system exists, the MCDU allows the active system to control the display,
- if no active system exists, the MCDU will continue to display the MCDU MENU page.

If the operator presses the line key adjacent to the desired system, communication is broken with the active system and established with the selected one.

If the line select key corresponds to the currently active system, the communication continues with the system. During the time between selecting the system and receipt of the first text from the selected system, the message “WAIT FOR SYSTEM RESPONSE“ appears.

If communication with the selected system is not established, the MCDU displays the message “(TIMEOUT)“ appears behind the system name.

When a system other than the currently active desires to communicate with the MCDU, it illuminates the MCDU MENU annunciator on both MCDUs to warn the operator. The operator has to press the MCDU MENU mode key to have the MCDU MENU page to know what system is requesting the MCDU.

At the same time both MCDUs may communicate each with a different system. (MCDU 1 - DATA LINK / MCDU 2 - FMGC)

When the FMGC is not the active system, if it has to send an important message, it illuminates the FMGC annunciator.

MCDU LCD VERSION

MCDU CRT VERSION

Figure 89 MCDU LCD & CRT Version

MULTIFUNCTION USAGE - DATA FIELDS

1L – FMGC: allows to activate communication with the FMGCs (A/C status page displayed).

2L – DATA LINK: allows to activate communication with the DATA LINK.

3L – AIDS: allows to activate communication with the AIDS.

4L – CFDS: allows to activate communication with the CFDS.

5L – ATSU: allows to activate communication with the ATSU.

1R – SELECT NAV B/UP: allows to indicates Standby Nav availability. The availability is determined by the MCDU and indicated in the label and prompt lines adjacent to 1R. Standby Navigation is available on MCDU1 and MCDU2 only if the SWITCHING/FM selector switch is at NORM. It is unavailable at all other times.

4R: MCDU MAINT: allows the access to MCDU internal test page.

6R – RETURN: allows to return to the currently active system.

”(REQ)” may be displayed on any line (1L – 5L) with a space immediately after the requesting system ident to indicate that the system is requesting the MCDU.

“(TIME OUT)” may be displayed if the communication is not established with the system.

Messages are displayed in the scratchpad to guide the pilot:

- When MCDU MENU mode key has been pressed, SELECT DESIRED SYSTEM is displayed.
- When a system has been called, WAIT FOR SYSTEM RESPONSE is displayed.
- If the called system does not answer, PRESS MCDU MENU KEY is displayed.

The currently active system is displayed in green, remaining systems are displayed in white. When one system is selected (line select key has been pressed) only this line is displayed in cyan with WAIT FOR SYSTEM RESPONSE in the scratchpad.

SWITCHING LOGIC (FM ONLY)

Each MCDU receives the state of its own FMGC on the discrete FMGC healthy.

When there is no failure (discrete in ground state), each MCDU talks to its own FMGC both ways.

When one FMGC is failed discrete open, both MCDUs talk with the remaining FMGC and the OPP FMGC IN PROCESS indication is displayed in the scratchpad (on the MCDU which switched).

The functioning of both MCDUs remains totally independent as if both FMGCs were valid. In particular each MCDU can talk with any system the operator has selected on the MCDU MENU page.

As soon as the failed FMGC is no more failed, the MCDU reverts to talk with it.

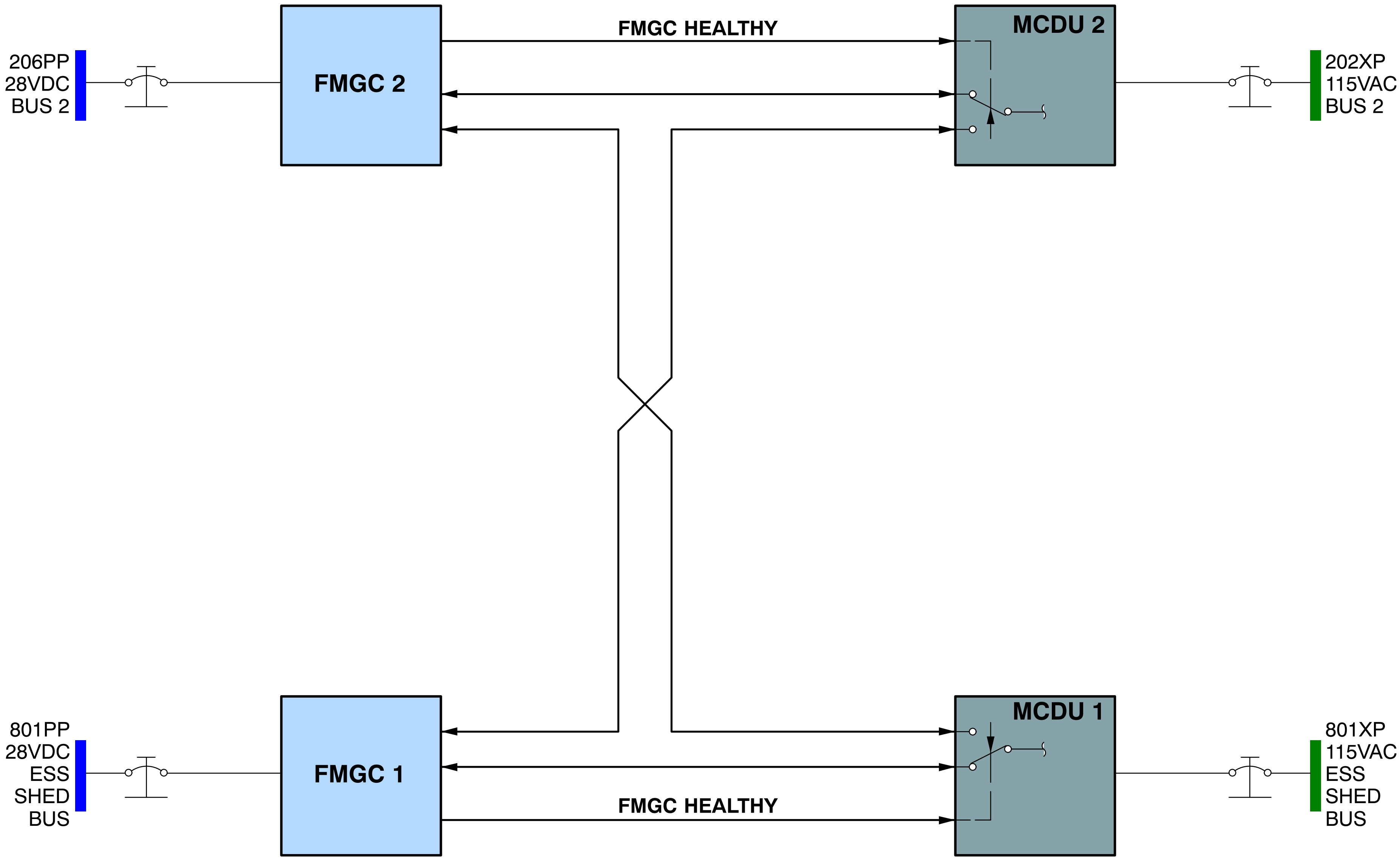


Figure 90 FMGC Switching Logic

22–91 FAULT ISOLATION FUNCTION - PRINCIPLE

BITE AND FIDS DESCRIPTION AND OPERATION

GENERAL

The Auto Flight System is a type 1 system, able to maintain a two–way communication with the Centralized Fault Display System.

It comprises a system BITE **located in FAC 1** called **Fault Isolation Detection System (FIDS)**.

Basically, the faults detected by the computer BITEs are concentrated in the system BITE called Fault Isolation Detection System (FIDS), and can be accessed through the MCDU and the CFDS.

Like for other systems, the CFDIU works in NORMAL MODE and MENU MODE (see ATA 31 – CFDS).

A FIDS card is fitted in each FAC. Both FACs are interchangeable, but only the FAC 1 FIDS is active due to side 1 signal.

Using the MCDU, you can have access to the CFDS fault messages of the AFS.

The BITE of each AFS computer including FCU and MCDUs, can be interrogated via the FAC 1. AFS TEST and LAND TEST can be launched from the MCDUs.

NOTE: When the FIDS has failed, BITEs continue to work, the results can be read in the shop after FAC 1 change.

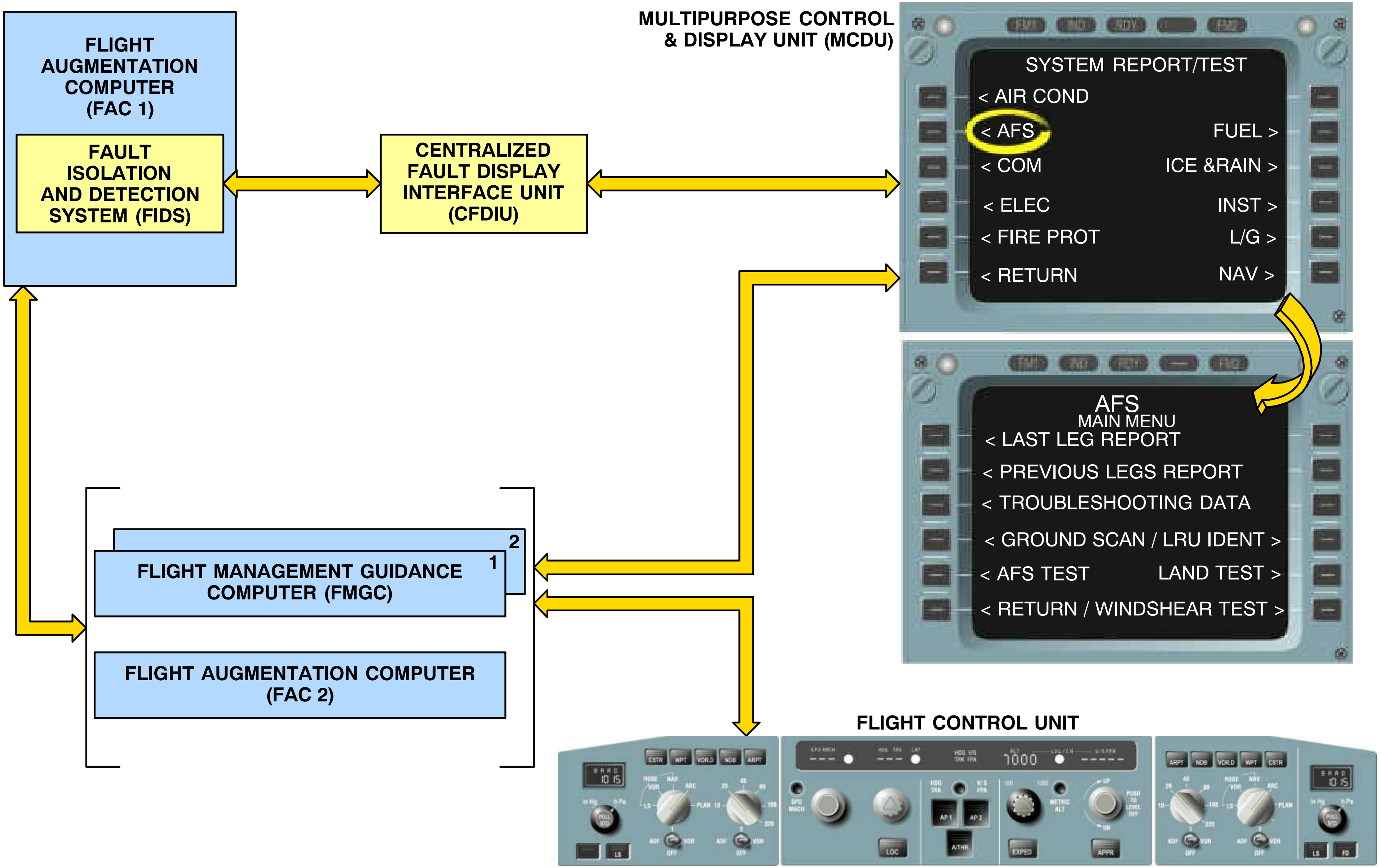


Figure 91 AFS BITE

AFS MAINTENANCE SYSTEM DESCRIPTION

GENERAL

The Auto Flight System (AFS) is a type 1 system, ables to maintain a two–way communication with the Centralized Fault Display Interface Unit (CFDIU). The line maintenance of the AFS is based on the use of the **Fault Isolation and Detection System (FIDS)** active in the Flight Augmentation Computer (FAC) 1 and of the BITEs located in the various AFS computers. Access to the fault data is made through the Multipurpose Control and Display Units (MCDUs) via the CFDIU. Like for other systems, the CFDIU works in NORMAL mode and MENU mode (See ATA 31–CFDS).

FIDS

The FIDS is a card physically located in each FAC. Both FACs are interchangeable, but only the FAC 1 FIDS is active due to the side 1 signal. The FIDS is used as a system BITE to concentrate maintenance information. The FIDS is linked in acquisition and reception to the CFDIU and is connected to the BITEs of the various AFS computers.

It receives commands from the CFDIU, interprets these commands and transfers them, if applicable, to the various BITEs concerned. It receives malfunction reports from the BITEs, manages these reports, and, if applicable, consolidates the BITE diagnosis (occurrence, correlation...) and generates a fault message, which is sent to the CFDIU.

NOTE: If the FIDS fails, the BITEs continue to work and the results can be read in the shop or after FAC 1 change. The NORMAL mode function is the same as in other systems. In addition to the usual system report functions, the MENU mode gives access to GROUND SCAN, AFS TEST and LAND TEST.

BITE

According to its internal architecture, each AFS Line Replaceable Unit (LRU) has one or several BITEs. The basic purpose of a BITE is to detect, isolate, memorize failures, the Flight Control Unit (FCU) and MCDU BITEs only perform the detection task. The failure detection is triggered by specific events listed in the maintenance manual. Example of Flight Guidance (FG) CoMmanD (CMD) triggering event: ILS own failure. The failure localization corresponds to an analysis processed to identify the source of the failure.

FAC/FM/FG BITE

As the FAC and FG have a BITE in the CMD and the MONitor (MON) sides, the fault analysis is generally made on each side and a synthesis is made on the CMD side. Each BITE memorizes the result of the analysis, the failure context, the flight leg number, the time and date of each given failure. Then the BITE sends the result of the analysis, with a maximum of two suspected LRUs in the order of probability, to the FIDS.

FCU BITE

Each FCU BITE computes the maintenance status of its related part and permanently sends this maintenance data to the FG CMD part.

MCDU BITE

The MCDU does the tests on its processor, memory and display unit. If a failure is found by the MCDU BITE:

- the FAIL annunciator comes on and the display is blank,
- the MCDU FAIL output discrete is set and sent to the FM part and then to FG 1 and FG 2 CMD parts through the crosstalk bus,
- no snapshot is taken.

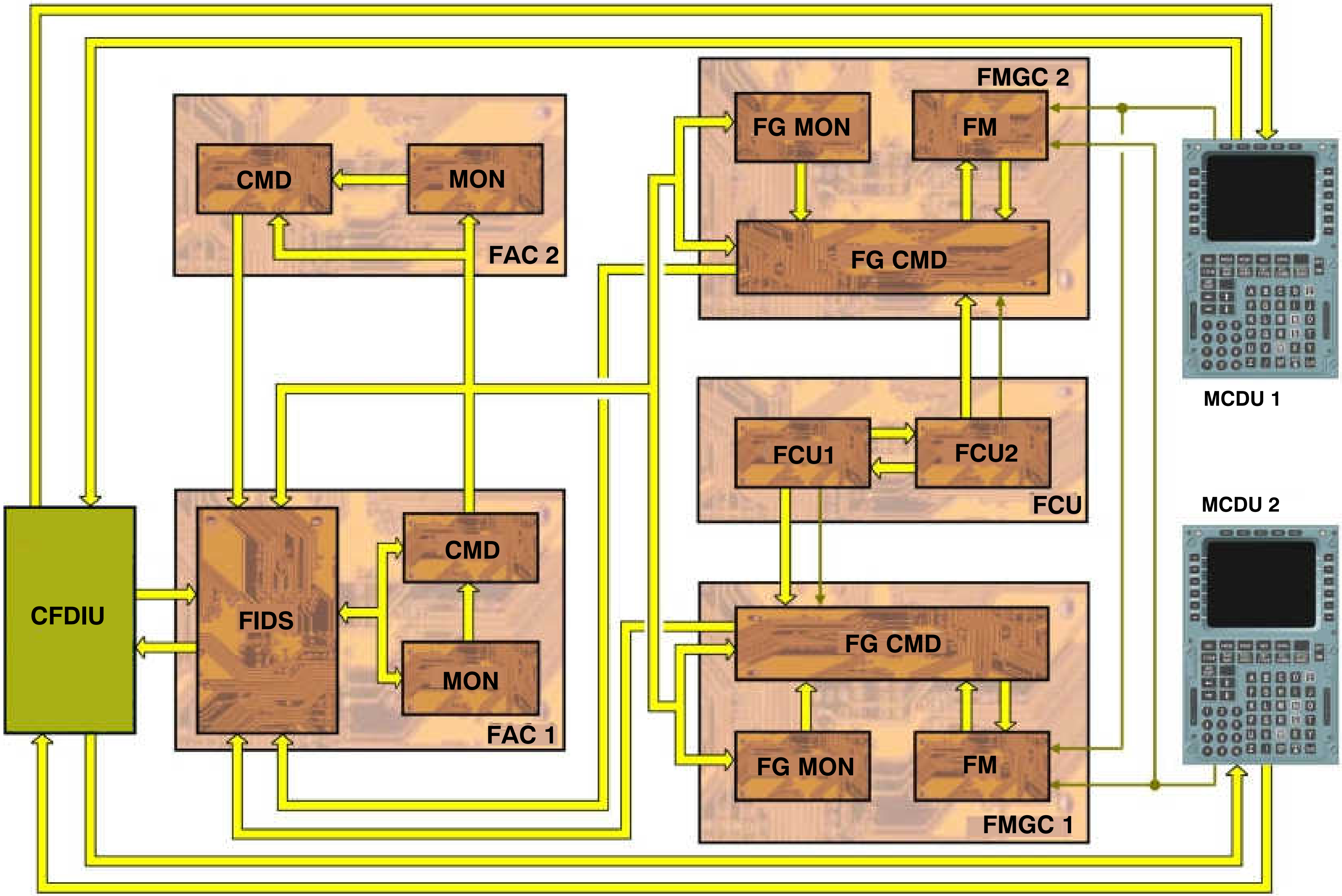


Figure 92 AFS BITE Schematic

AFS TEST PROCEDURE

SAFETY TESTS

After long term power interruption, computers and control units of the AFS do the safety tests also called power−up tests. These tests are only done on ground, except for the FCU, which can make safety tests on ground or in flight. During these tests, no action should be done on the system. If a unit does not pass the safety test, it is declared failed and unusable and an ECAM message is displayed on the STATUS page.

The recommended conditions to do the safety test are:

- aircraft on ground,
- engines stopped,
- hydraulic power (green/yellow) for FAC only,
- pull the C/B of the involved computer (both C/Bs for FCU),
- wait 15 seconds (7 minutes for FCU), and then push the C/B,
- of the involved computer,
- wait 1 minute for safety test execution.

PROCEDURE

This AFS maintenance procedure has to be followed in the event of a pilot report concerning the AFS.

LIST OF LRUS COVERED BY THE FIDS

List of Internal AFS LRUs

- FAC1, FAC2,
- FMGC1, FMGC2,
- FCU,
- MCDU1, MCDU2,
- YAW ACTUATOR 1, YAW ACTUATOR 2,
- RUDDER TRIM ACTUATOR, RTL ACTUATOR,
- YAW DAMPER POS XDCR UNIT,
- TAKE OVER CPT, TAKE OVER FO,
- A/THR INSTINCTIVE DISCONNECT CPT,
- A/THR INSTINCTIVE DISCONNECT FO,
- RUDDER TRIM RESET SWITCH, RUDDER TRIM CONTROL SWITCH,
- RUDDER TRIM INDICATOR,
- FAC1 PUSH BUTTON SWITCH, FAC2 PUSH BUTTON SWITCH.

List of External AFS LRUs

- CLOCK,
- ILS 1, ILS 2, DME 1 DME 2, VOR 1, VOR 2,
- ADIRU 1, ADIRU 2, ADIRU 3,
- ECU 1/EEC 1, ECU 2/EEC 2,
- R/A 1, R/A 2, ACARS (FP),
- LGCIU 1, LGCIU 2, FQIC,
- ELAC 1, ELAC 2, SFCC1, SFCC2, (WEIGHT & BALANCE),
- PRINTER (FP),
- CFDIU, DMC1 (PFD OWN VALID), DMC2 (PFD OPP VALID),
- FWC1 (FWC OWN VALID), FWC2 (FWC OPP VALID),
- BSCUA (BSCU-A HLTY), BSCUB (BSCU-B HLTY),
- 28V DC PWR SUPPLY SPLIT,
- HYD PRESS SWITCH (YELLOW), HYD PRESS SWITCH (GREEN),
- AIR DATA SWITCH, ATTITUDE SWITCH.

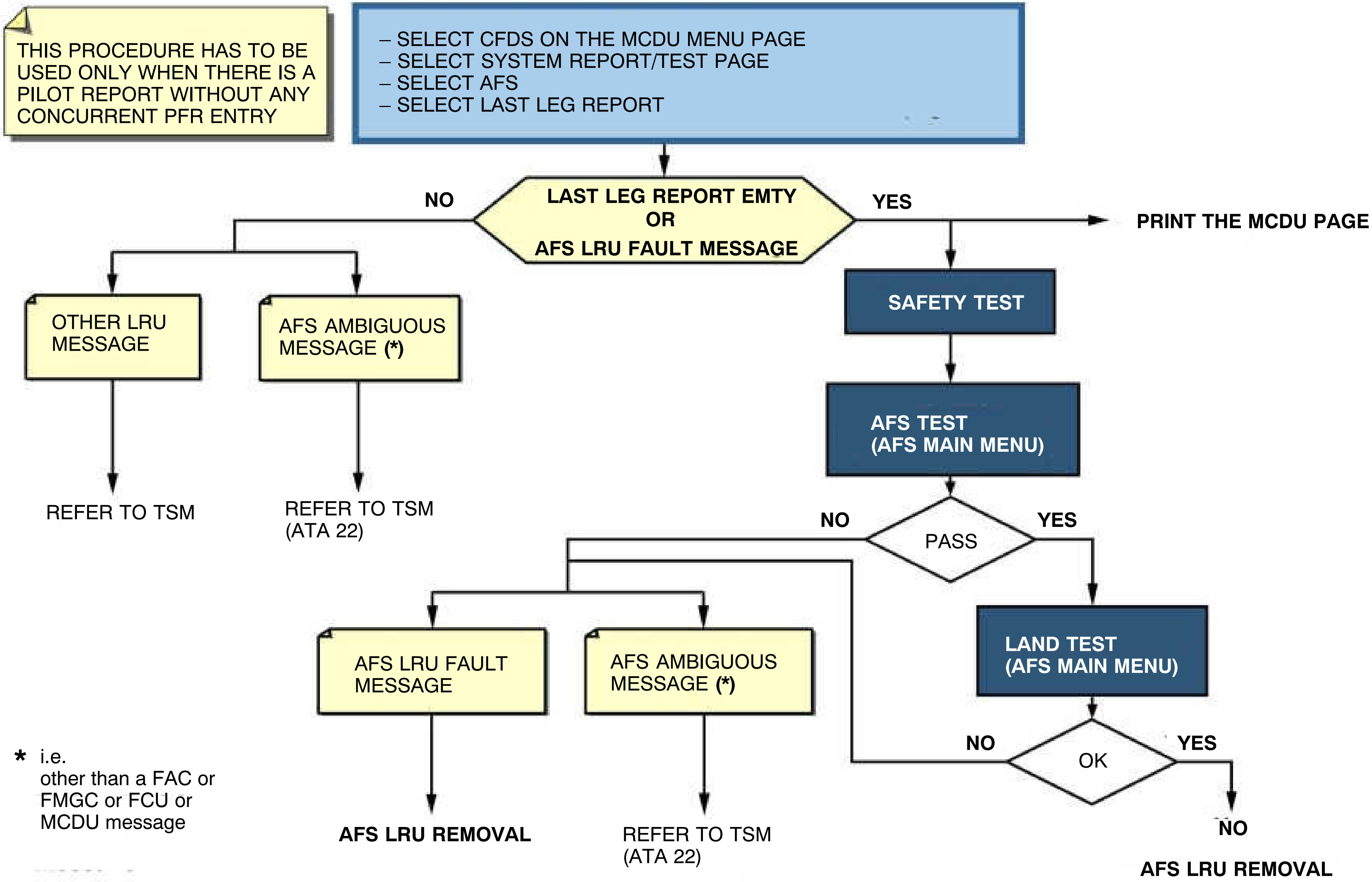


Figure 93 AFS Test Procedure

AFS MCDU MENU DESCRIPTION

GROUND SCAN

The GROUND REPORT function displays failures recorded in the ground area of the FIDS memory. The PRESENT FAILURE SCAN function is used to isolate failures present when the function is selected. The manufacturer for development purposes uses the PROGRAM page.

AFS TEST

The purpose of the AFS TEST is to check the integrity of the AFS after replacement of an LRU (line replaceable unit).

The AFS TEST completes the AFS computer monitoring and safety tests. This test, which is performed in the FACs and the FMGCs (FM and FG sections) consists in:

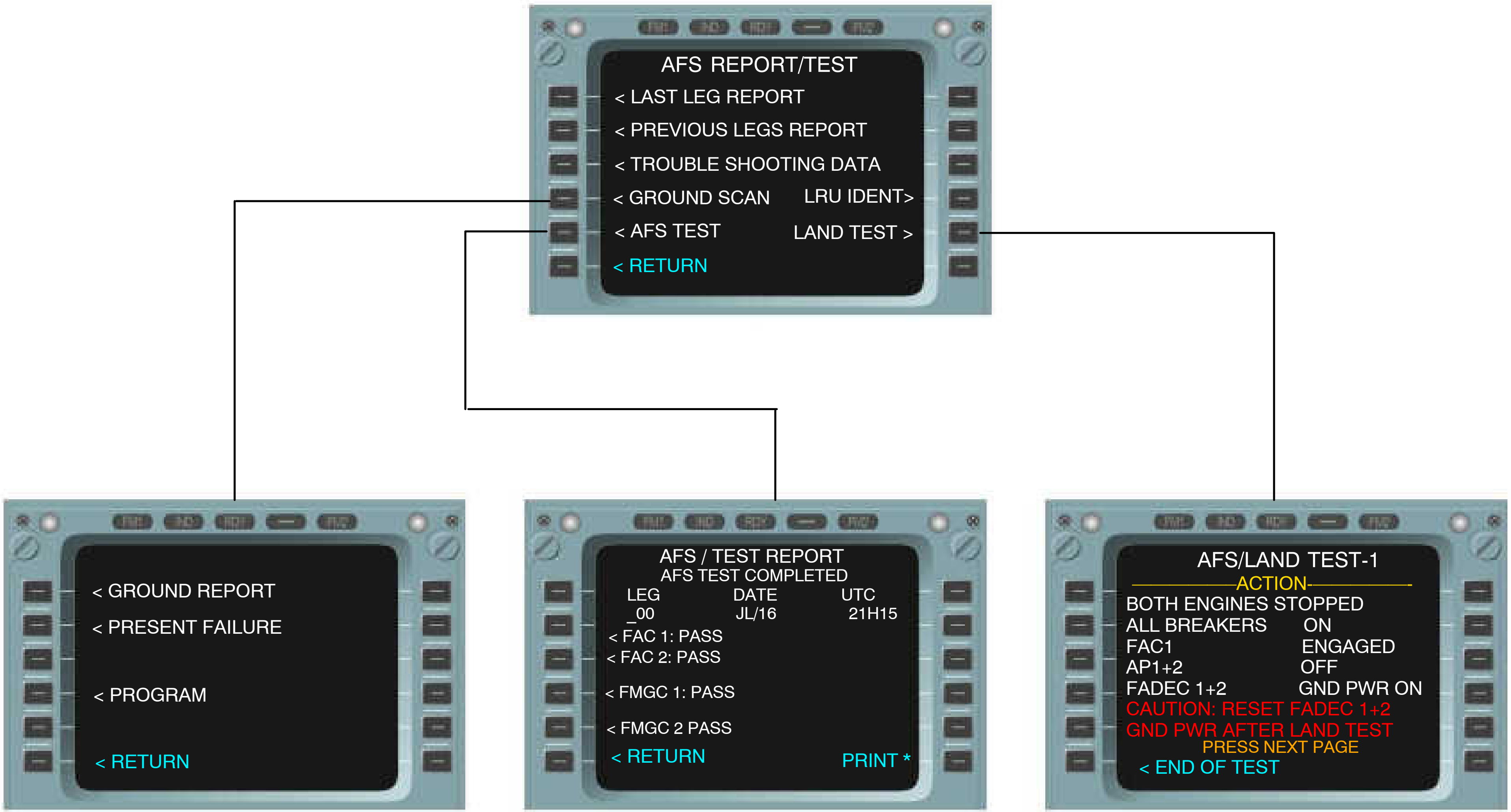
- using the computer safety test results (FAC, FG, FM, FCU and MCDUs),
- the test of symmetrical discrete inputs: FAC COM and FAC MON, FG COM and MON,
- the test of the symmetrical ARINC inputs,
- the plausibility test of the information delivered by:
  - the RUD TRIM/RESET pushbutton switch,
  - the rudder trim control switch,
  - Capt A/THR instinctive disconnect pushbutton switch,
  - F/O A/THR instinctive disconnect pushbutton switch,
  - Capt takeover and priority pushbutton switch,
  - F/O takeover and priority pushbutton switch,
  - FAC engagement pushbutton switch.

An AFS TEST is done:

- to check an AFS LRU before removal,
- to check an AFS LRU after installation,
- to get trouble shooting data (even if the test is OK).

LAND TEST

The LAND TEST gives the test availability of the LANDing mode and equipment required to obtain **CATegory 3**. There are several successive pages in which actions, checks and answers are requested from maintenance.



GROUND SCAN

AFS TEST

LAND TEST

Figure 94 MCDU Menu

AFS TEST OPERATION

LAND CAT 3 CAPABILITY TEST

The purpose of the test is to verify the capability of the involved systems **to perform a CAT 3 fail − operational automatic landing.**

It also verifies the takeover and priority pushbutton switches, the A/THR instinctive disconnect pushbutton switches and the warnings associated to the automatic landing.

The LAND TEST function is mainly performed in the FIDS and utilizes FG failure detection (snapshot, analysis and reporting).

Consequently, the LAND TEST efficiency is identical to the FG BITE efficiency.

Test Principle

This test consists in checking the correct operation of the systems inside and outside the AFS and involved in CAT 3 automatic landing (correct operation of BITEs, system reception, self − test results, interconnections validity).

Chaining of the various pages of the Land Test are described in the next figure.

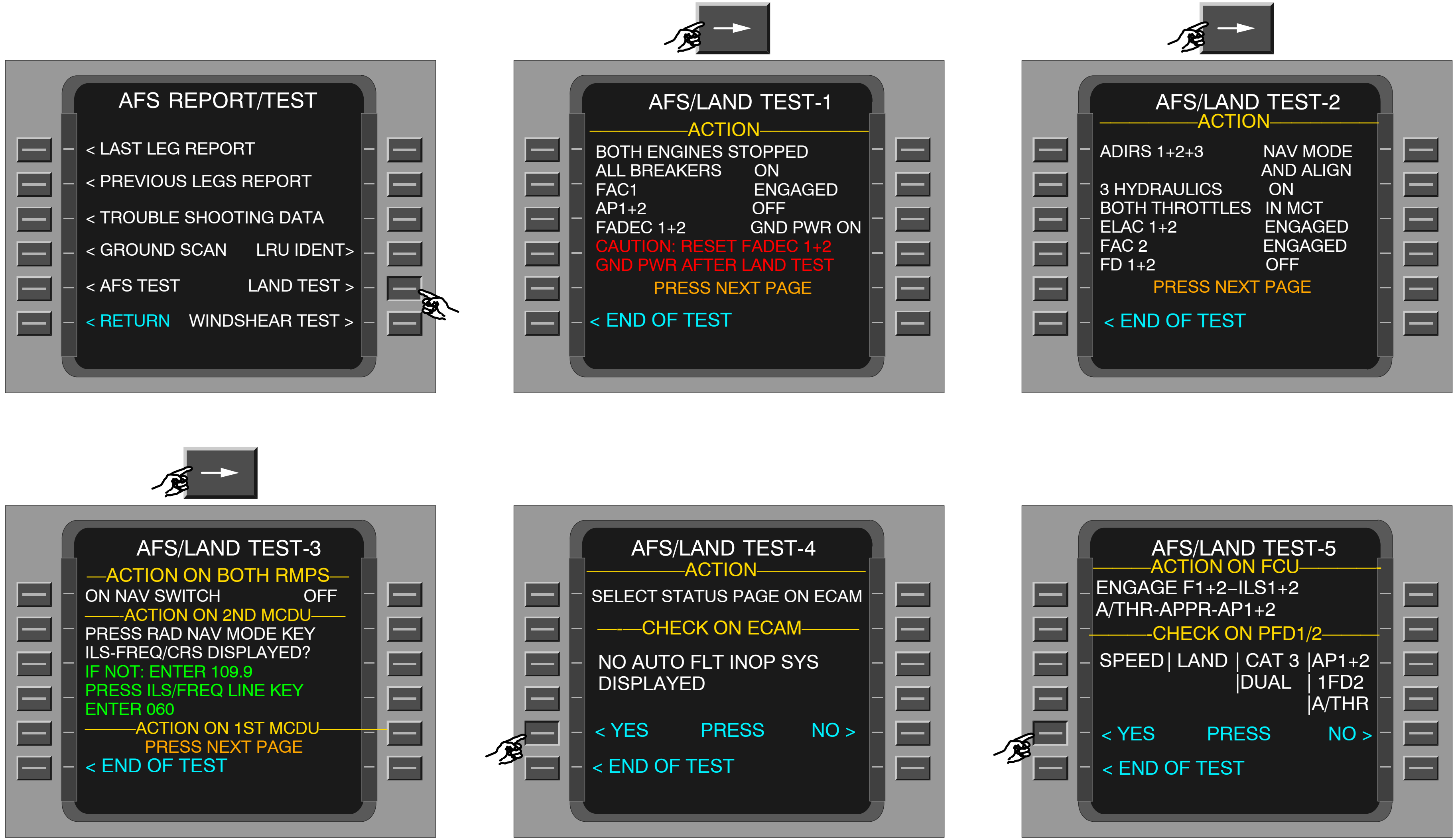


Figure 95 AFS Land Test (1)

AFS TEST RUNNING - OPERATION

Test Running

If a failure occurs prior to the acceptation phase, the test is refused. If a failure occurs after the acceptation phase, the FMGCs remain in LAND TEST condition.

From AFS / LAND TEST−4 page, the operator must answer questions by YES or NO via the MCDU.

- Please answer by YES if agree with sentence,
- NO if disagree. If the answer is YES, the test continues until the last page is displayed (AFS / LAND TEST−9) with TEST OK final message.
- If the answer is NO, an analysis is made at the level of the AFS BITEs in order to detect and isolate the failure. A failure message is displayed on the AFS / LAND TEST REPORT page requesting to check the system concerned by the analysis.
- Each AFS / LAND TEST page displays an END OF TEST indication. Pressing the line key adjacent to this indication results in the transmission of an END OF TEST FIDS command to the four FG BITEs. Reception of this command causes loss of the LAND TEST ACCEPTATION condition for each BITE.

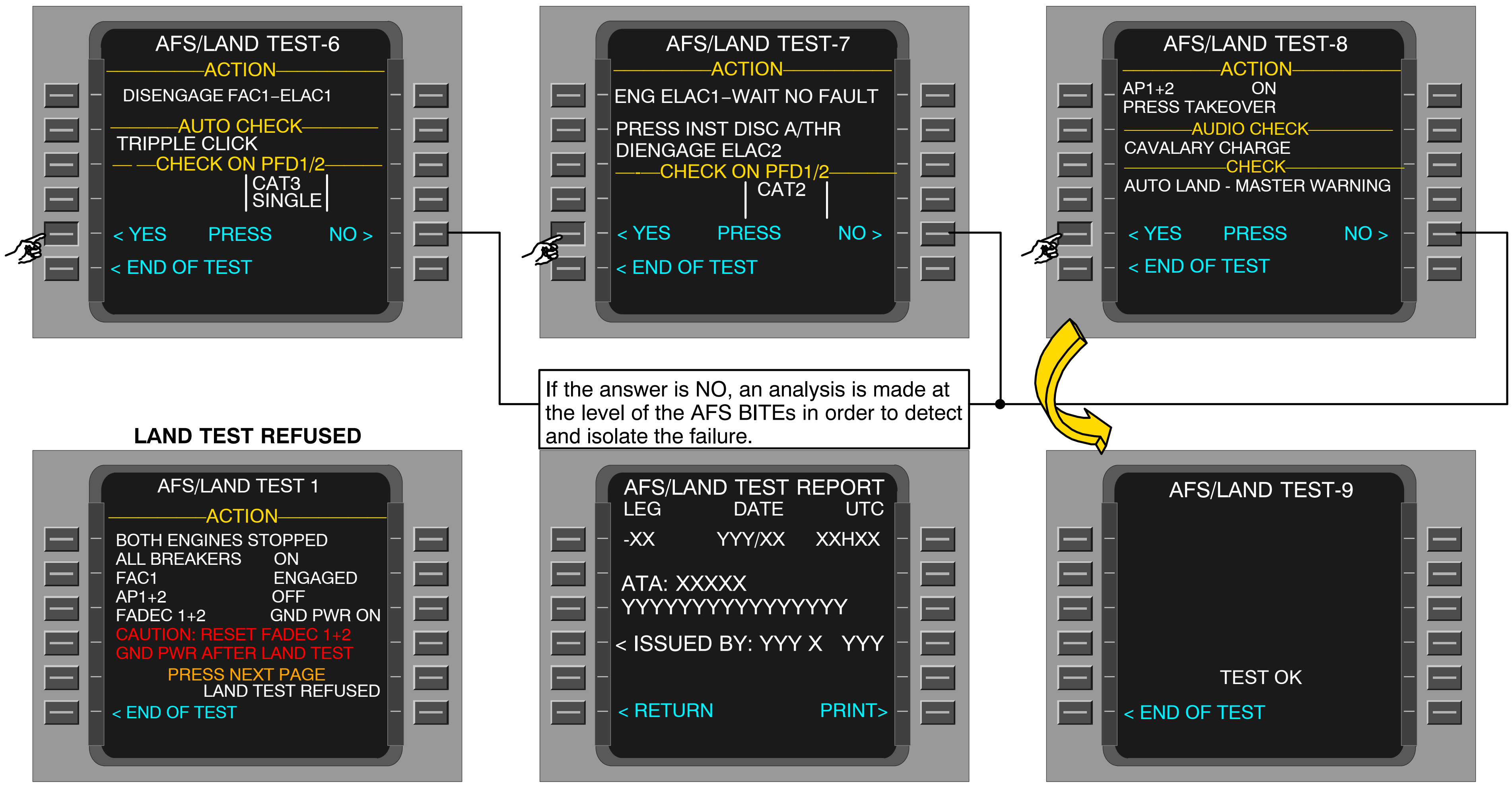


Figure 96 AFS Land Test (2)

FIDS OPERATION

The system has two fault detection and isolation modes:

- **Normal mode** (flight):
  - The system stores the failure data relevant to the AFS in non–volatile memories and transmits these data to the CFDIU.
- **Menu mode** (ground):
  - The system transmits a menu to the MCDU via the CFDIU.

NORMAL MODE

In normal mode, the AFS maintenance system ensures the following functions:

- **FAULT DETECTION**
  - The fault is detected at the level of each computer BITE by constant monitoring of specific variables of the operational software.
- **FAULT ISOLATION**

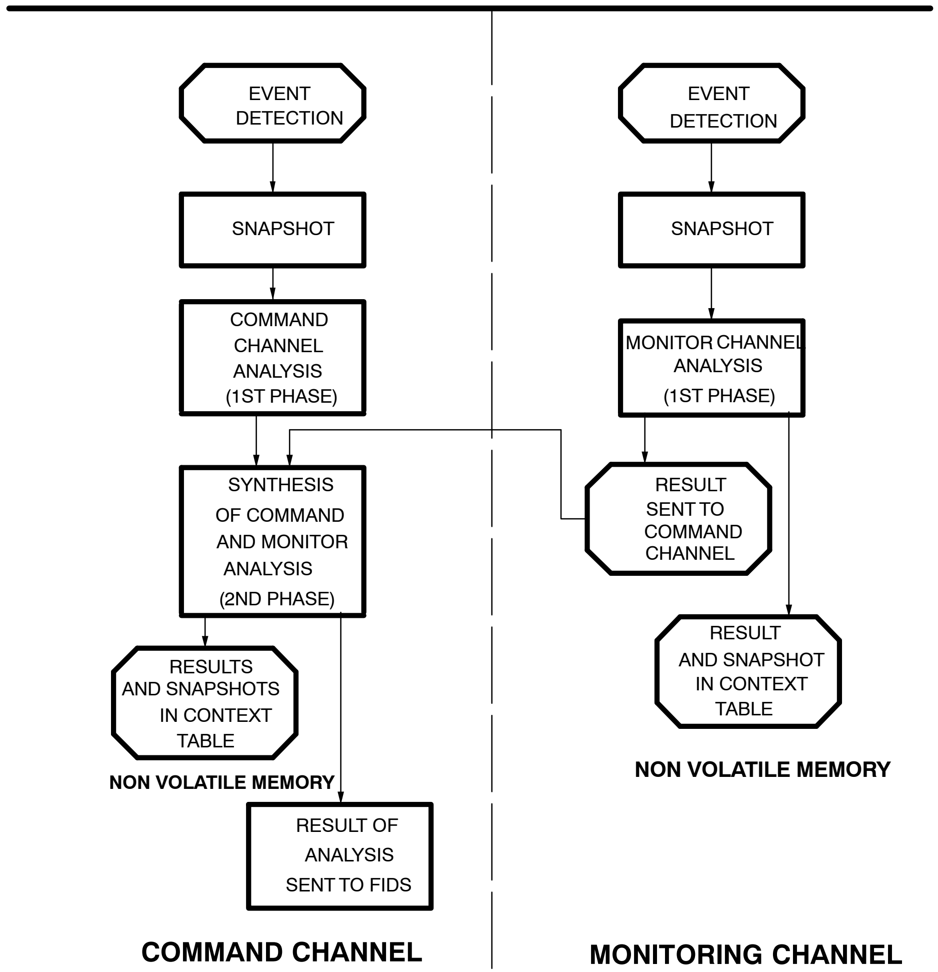
The detection of a fault triggers an analytic process. This process identifies the LRU from which the fault originates. This analysis is performed in two steps:

- **1st step:**
  - A **first analysis** is made at the level of the computer which detected the fault. This first step can itself be split into two phases at FAC and FG level (1st and 2nd phase analysis).
- **2nd step:**
  - A **second analysis** is made at FIDS level. This analysis is called the 3rd phase analysis.
- **Storage** of faults in the non–volatile memories.

To perform the functions described above, the system consecutively performs the following operations:

- Interpretation and execution of the CFDIU commands by the FIDS.
- Interpretation and execution of the FIDS commands by the FAC, FG and FM BITEs.
- Fault detection at the level of each AFS BITE.
- Transmission of maintenance data by the FCU BITE to the FG and by the MCDU BITE to the FM.
- Fault isolation, creation of fault contexts and memorization of these contexts by the FAC, FG and FM BITEs.
- Transmission of the malfunction reports of the BITEs to the FIDS.
- Management and consolidation of the malfunction reports by the FIDS.
- Generation of a fault message from this consolidated diagnosis, which is sent to the CFDIU.
- Memorization of faults by the FIDS.

1st AND 2nd PHASE ANALYSIS



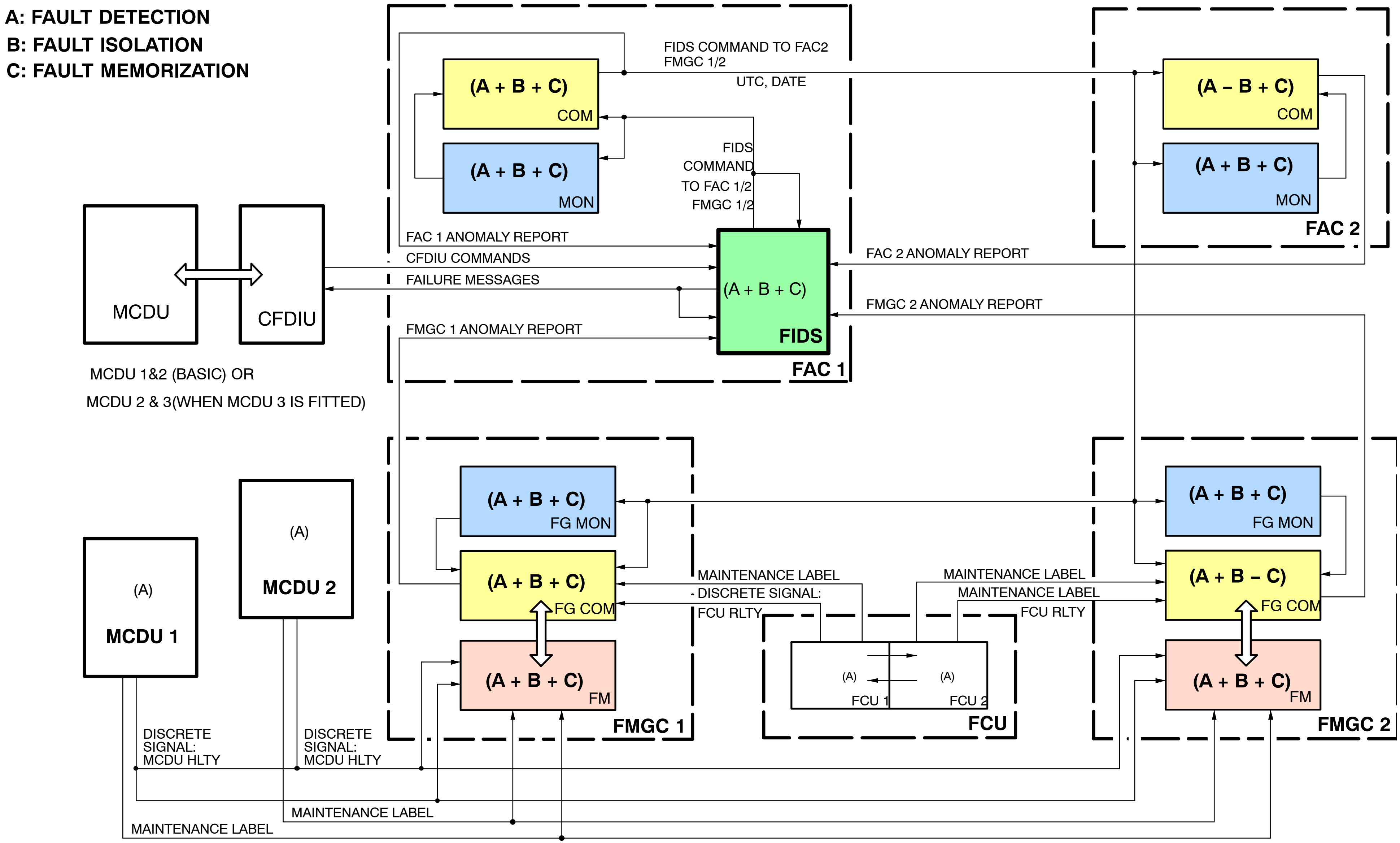


Figure 97 Functional Block Diagram

AFS MCDU MENU OPERATION

GROUND SCAN

Access to the GROUND SCAN function is accessible from the MCDU when the system is in menu mode (when the aircraft is on the ground).

The following three functions can be accessed when the AFS /GROUND SCAN page is displayed:

- GROUND REPORT
- PRESENT FAILURES SCAN
- PROGRAM (if active).

The line key adjacent to the RETURN indication enables selection of the previous menu page.

GROUND REPORT function

This function enables the failures recorded in the ground area of the FIDS memory to be displayed. As this memory is capable of storing three contexts, the three most recent failures can be displayed, the oldest contexts being eliminated. The content of the ground area is erased during computer power up and engine start (NULL to DC2). The failures memorized and visible in the GROUND REPORT are the ones which occurred after the last ground area initialization.

Two types of content can be displayed:

- Only the internal failures that occured on ground are normally displayed by the GROUND REPORT function.
- After selection of the PRESENT FAILURES SCAN function (Ref. para. PRESENT FAILURES SCAN function) all internal and external failures (considering a limit of three contexts) found during this operation are seen in this report. As selection of the PRESENT FAILURES SCAN function erases the content of the ground area, it is highly recommended, prior to this selection, to display this content using the GROUND REPORT function.

Failures are presented with the following data:

- the flight counter (–00) which indicates that the failure occurred on the ground,
- the ATA reference and associated message,
- the computer which identified the failure.

Additional information can be obtained by selecting the **TROUBLE SHOOTING DATA** item (push action on the line key adjacent to the **TROUBLE SHOOTING DATA** indication). The procedure and the displayed content are similar to the LAST LEG REPORT and PREVIOUS LEGS REPORT.

PRESENT FAILURES SCAN function

(GROUND SCANNING)

This function is used to isolate failures present when the function is selected. Therefore an inhibited failure will not be announced. Once the function is activated (push action on the line key adjacent to the PRESENT FAILURES SCAN indication), a wait message is displayed for 40s while the system isolates the present failures.

After this time, the messages are displayed on the GROUND REPORT page. A maximum of three failures, internal or external, present at that time, can be displayed.

As soon as the **PRESENT FAILURES SCAN function** is selected, the ground contexts previously recorded are erased and thus definitively lost.

Each processor (e.g.: FMGC1 COM or FAC2 MON) can announce one failure only (the failure with the highest priority). If two failures are present at the same time, N .1 has to be solved first so that the concerned processor can announce N .2 in a second **PRESENT FAILURES SCAN report**.

PROGRAM

The FIDS include a PROGRAM menu. When this menu is activated it allows to obtain more engineering messages (not useful at maintenance level).

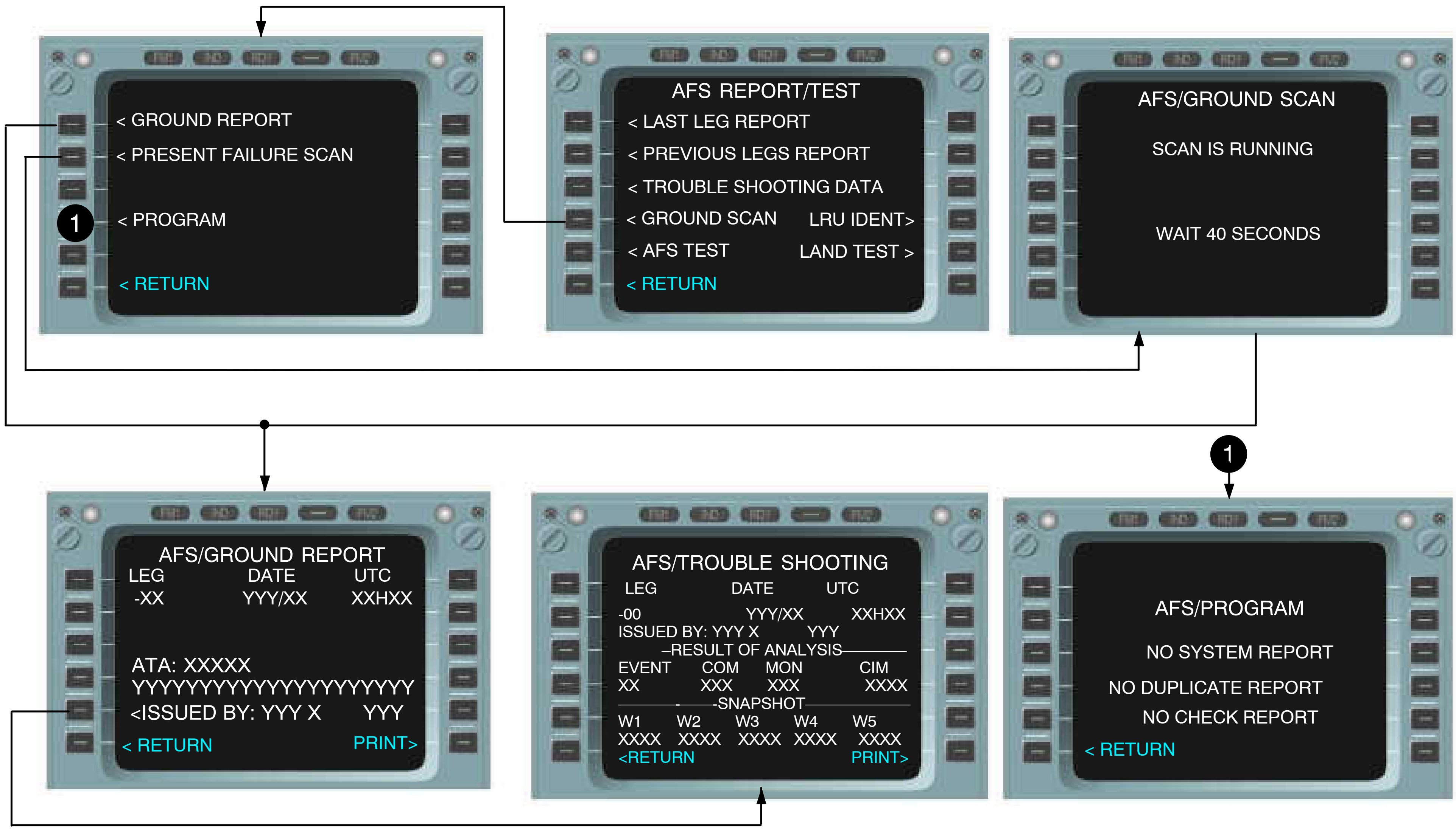


Figure 98 MCDU MENU

MENU MODE OPERATION

MENU MODE

The menu mode is relevant to a specific operation enabled only on the ground. It is based on an interactive dialogue between the FIDS and the MCDU. The functions of the system in menu mode are described in the next figure:

LRU IDENTIFICATION

This function presents, on the ground only, the **PART NUMBER** of the FACs and the FMGCs. The page also gives the **AIRCRAFT IDENTIFICATION**.

The **LRU IDENT** can be obtained after the power−up test only.

This data is available after energization of the FAC and the FMGC as follows:

- for the FAC, after more than 90 seconds,
- for the FMGC, after more than 120 seconds.

TROUBLE SHOOTING DATA

This function presents, on the ground only, additional information relevant to the faults. This page is established from the fault context recorded in the BITE non−volatile memories:

- DATE, UTC, Flight Leg,
- COM (RESANAC), MON (RESANAM) and C/M (RESANA),
- Snapshot data (W1, W2, W3, W4 and W5).

You can print the Trouble Shooting Data (TSD) as follows:

- get access to the SYSTEM REPORT/TEST menu page,
- on this page, push the line key adjacent to the AFS indication,
- on the AFS MAIN MENU page, push the line key adjacent to the TROUBLE SHOOTING DATA indication to get the AFS/TROUBLE SHOOTING page,
- on this page, push the line key adjacent to the BITE SELECTION (FAC1 and FAC2, COM and MON indications to get the AFS/TROUBLE SHOOTING page(s),
- print the AFS/TROUBLE SHOOTING page(s).

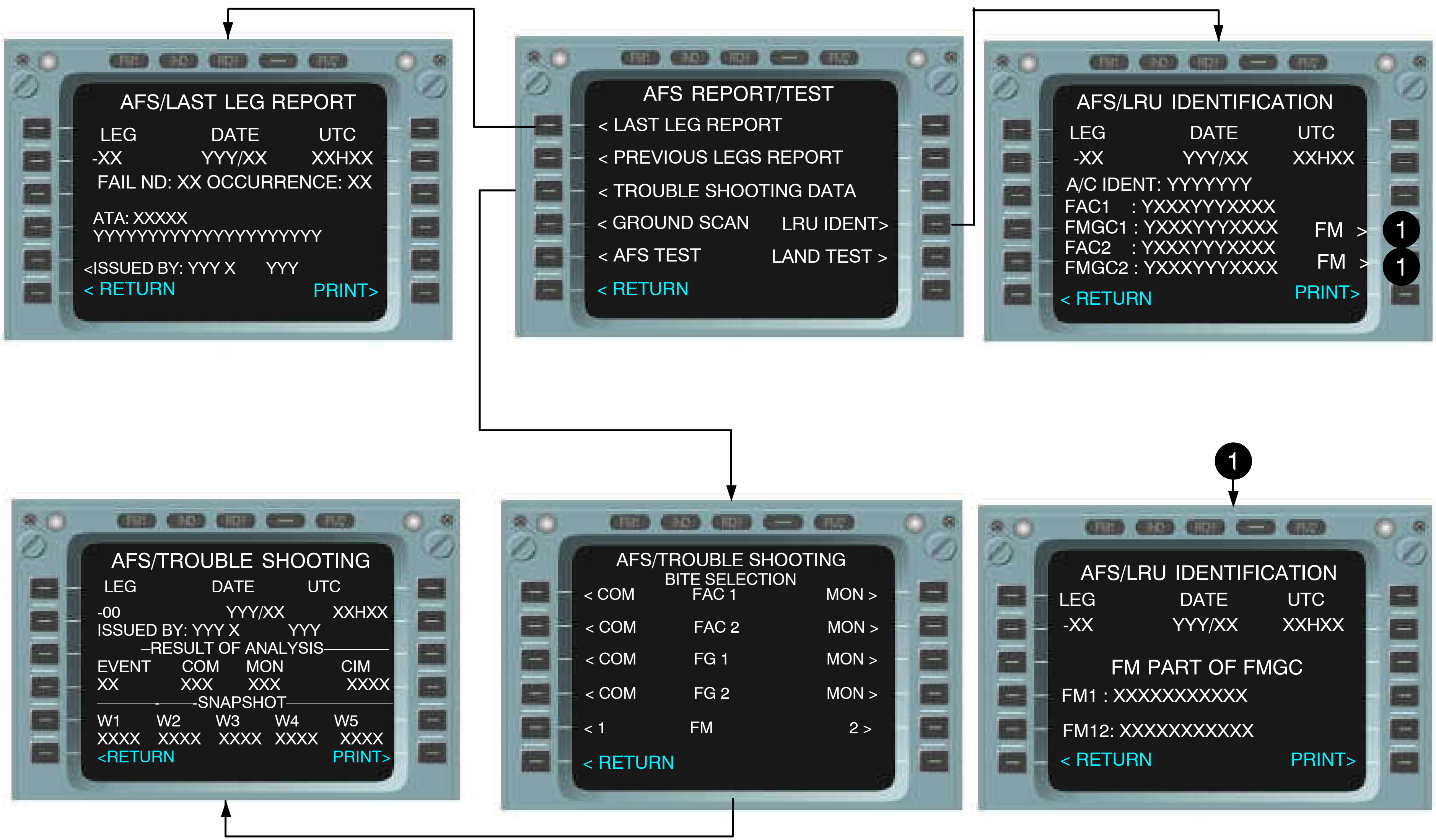
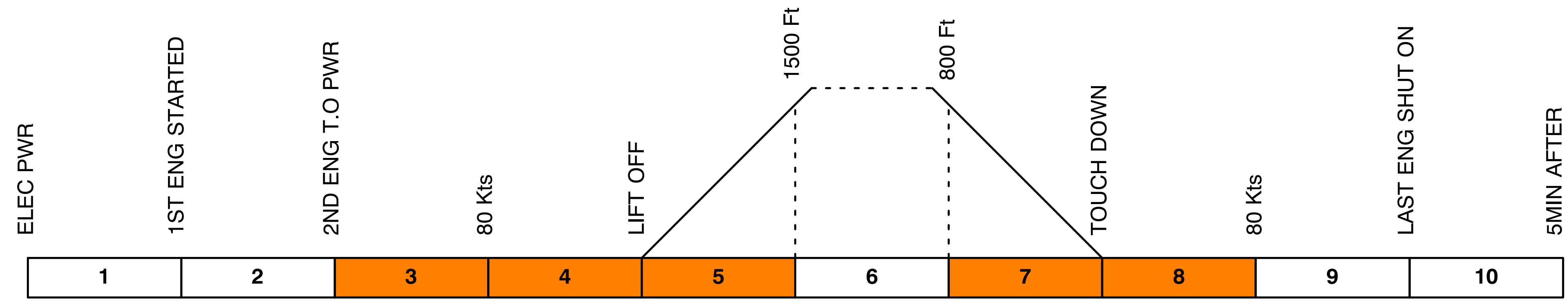


Figure 99 AFS TEST MENU

AUTOFLIGHT SYSTEM WARNINGS



E/WD FAILURE MESSAGE	AURAL WARNING	MASTER LIGHT	SD PAGE CALLED	LOCAL WARNINGS	FLIGHT PHASE INHIBIT
YAW DAMPER 1 (2) FAULT	NIL	NIL	NIL	NIL	3,4,5,7,8,10
YAW DAMPER 1 + 2 FAULT	SINGLE CHIME	MASTER CAUTION	NIL	NIL	3,4,5,7,8,10
RUDDER TRIM 1 (2) FAULT	NIL	NIL	NIL	NIL	3,4,5,7,8
RUDDER TRIM 1 + 2 FAULT	SINGLE CHIME	MASTER CAUTION	FLT CTL	NIL	4,5,7,8
FAC 1 (2) FAULT	SINGLE CHIME	MASTER CAUTION	NIL	FAC 1 (2) FAULT LT	3,4,5,7,8
FAC 1 + 2 FAULT	SINGLE CHIME	MASTER CAUTION	NIL	FAC 1 + 2 FAULT LT	4,5,7,8
FCU 1 (2) FAULT	NIL	NIL	NIL	NIL	3,4,5,7,8
FCU 1 + 2 FAULT	SINGLE CHIME	MASTER CAUTION	NIL	NIL	3,4,5,7,8
WINDSHEAR WARNING	WINDSHEAR	NIL	NIL	WINDSHEAR / PFD	1,2,3,4,8,9,10
REAC W/S DET FAULT	SINGLE CHIME	MASTER CAUTION	NIL	NIL	3,4,5,8,9

Figure 100 AFS ECAM Messages & Inhibition (1)

E/WD FAILURE MESSAGE	AURAL WARNING	MASTER LIGHT	SD PAGE CALLED	LOCAL WARNINGS	FLIGHT PHASE INHIBIT
A/THR OFF	SINGLE CHIME	MASTER CAUTION	NIL	NIL	4,8,10
A/THR LIMITED A/THR IS ACTIVE BUT THRUST LEVERS ARE SET BELOW CL DETENT (2 ENGINES) OR MCT DETENT (1 ENGINE).	SINGLE CHIME	MASTER CAUTION	NIL	NIL	3,4,5,7,8,10
AP OFF	CAVALERY CHARGE	MASTER WARNING	NIL	NIL	NIL
AUTOLAND (NO ECAM MESSAGE). ONLY AVAILABLE BELOW 200FT	NIL	AUTOLAND	NIL	NIL	2,3,4,5,6,8,9,10
LAND CAPABILITY DOWNGRADE CONDITION(S) REQUIRED FOR CAT3-CAT2 ARE NO LONGER FULFILLED	TRIPLE CLICK	NIL	NIL	NIL	2,3,4,5,8,9,10
LOW ENERGY WARNING AVAILABLE BETWEEN 100 FT AND 2000 FT IN CONF >/= 2. NO ECAM MESSAGE	SPEED 3 TIMES EVERY 5 SECONDS	NIL	NIL	NIL	1,2,3,4,8,9,10
WHEN "GPS PRIMARY LOST" MESSAGE IS DISPLAYED ON THE ND	TRIPLE CLICK	NIL	NIL	ND/MCDU MESSAGE	2,3,4,5,8,9,10
NAV FMS/GPS POS DISAGREE WHEN THE FMS 1 OR 2 POSITION DIFFERS BY MORE THAN 0.5 MIN OF LATITUDE OR LONGITUDE FROM THE GPS 1 OR 2 POSITION, THIS MESSAGE COMES UP ON ECAM	SINGLE CHIME	MASTER CAUTION	NIL	NIL	3,4,5,7,8

Figure 101 AFS ECAM Messages & Inhibition (2)

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