

A330-200
TECHNICAL TRAINING MANUAL
MECHANICS / ELECTRICS & AVIONICS COURSE
22 AUTOFLIGHT
GE Metric

**This document must be used
for training purposes only.**

**Under no circumstances
should this document be used as a reference.**

All rights reserved.

No part of this manual may be reproduced in any form,
by photostat, microfilm, retrieval system, or any other means,
without the prior written permission of AIRBUS S.A.S.

■ FQW4200

TABLE OF CONTENTS

AFS GENERAL

● ** System Design Philosophy (1)	1
● ** System Presentation (1)	7
● ** AFS Peripherals and Associated Systems (1)	15
● ** System Control and Indicating (1)	21
● ** Flt Envelope Protection Presentation (1).	39
● Flight Guidance Presentation (1)	45
● Flight Management Presentation (1)	57
● ** FIDS Presentation (1)	63
● Basic Operational Principles (1)	67

FLIGHT ENVELOPE (FE)

● ** Windshear, Alpha Floor & AFT CG Detect (3)	73
● Operational Speed Computation & Display (3)	83
● Flight Envelope Consolidation (3)	89

■ FQW4200

TABLE OF CONTENTS

FLIGHT GUIDANCE (FG)

• Autothrust Operation (3)	107
• ** Flight Guidance Priority Logic (3)	119
• FCU Description/Operation (3).	133
• FMA Description (3)	147

FLIGHT MANAGEMENT (FM)

• Flight Planning (3)	157
• ** MCDU Description (3).	163
• ** Flight Management Priority Logic (3)	173
• EFIS Display (3)	179
• ** Navigation Back-Up (3)	189
• ** Data Base Loading (3)	197

WARNINGS

• ** Warnings (3)	209
-----------------------------	-----

FQW4200 GE Metric

■ FQW4200

TABLE OF CONTENTS

AFS TESTS

- Pwr Interruptions & Power Up Tests (3) 217

AFS COMPONENTS AND ELEC CIRCUITS

- ** Components (3) 235
- FCU Interfaces (3) 243
- MCDU Interfaces (3) 249
- FMGEC Discrete Interfaces (3). 255
- FMGEC ARINC Interfaces (3) 267

THIS PAGE INTENTIONALLY LEFT BLANK

SYSTEM DESIGN PHILOSOPHY

Introduction
General Concept
Navigation
Flight Plan
Operation
AFS/Fly By Wire
System Design

This module highlights the new concept of the AutoFlight System (AFS) and presents the relationship with the Electrical Flight Control Systems (EFCS) 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 AutoFlight System.

This module is not an introduction of all the functions of the system.

GENERAL CONCEPT

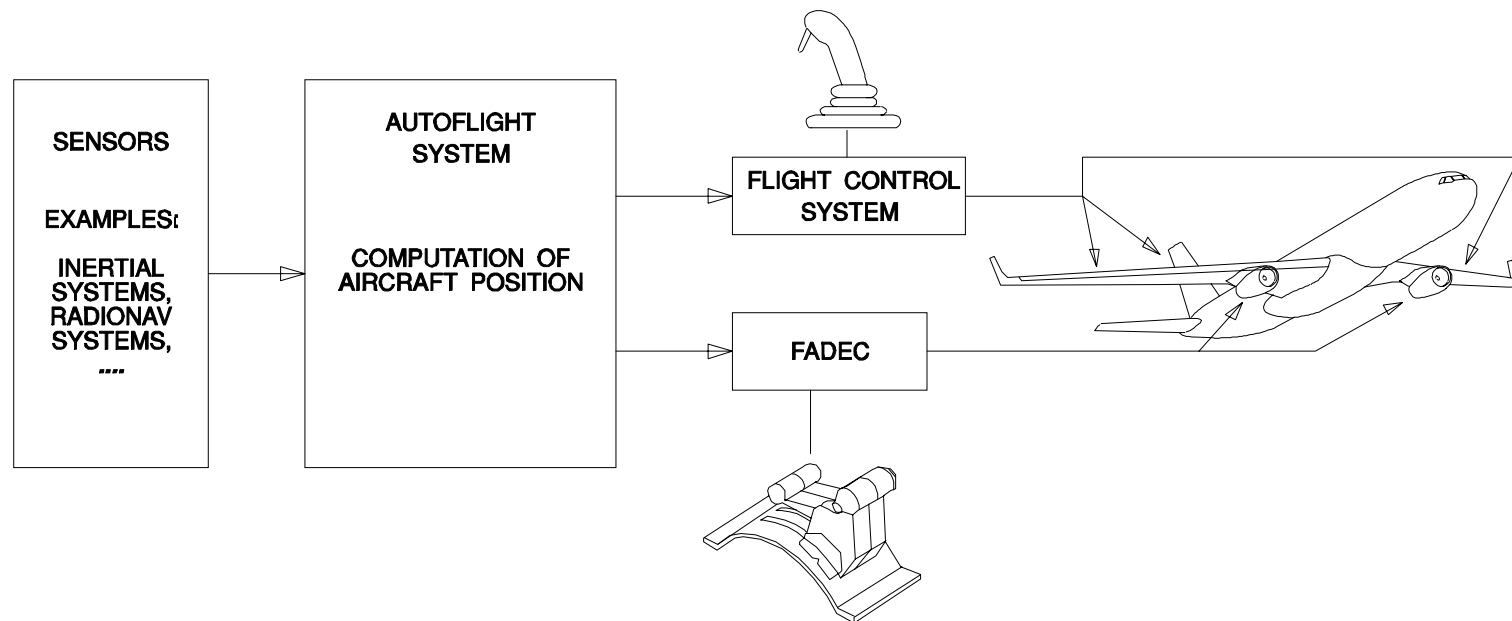
The AutoFlight System calculates orders to automatically control the flight controls and the engines.

The system only computes orders. These orders are not executed by actuators belonging to AFS but by systems which usually control the surfaces and the engines when the AFS is not active i.e. : side sticks and thrust levers.

NAVIGATION

A fundamental function of AutoFlight 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. It can be displayed on the instruments (CRTs).

OPERATION

There are several ways to use the AutoFlight 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.

AFS/FLY BY WIRE

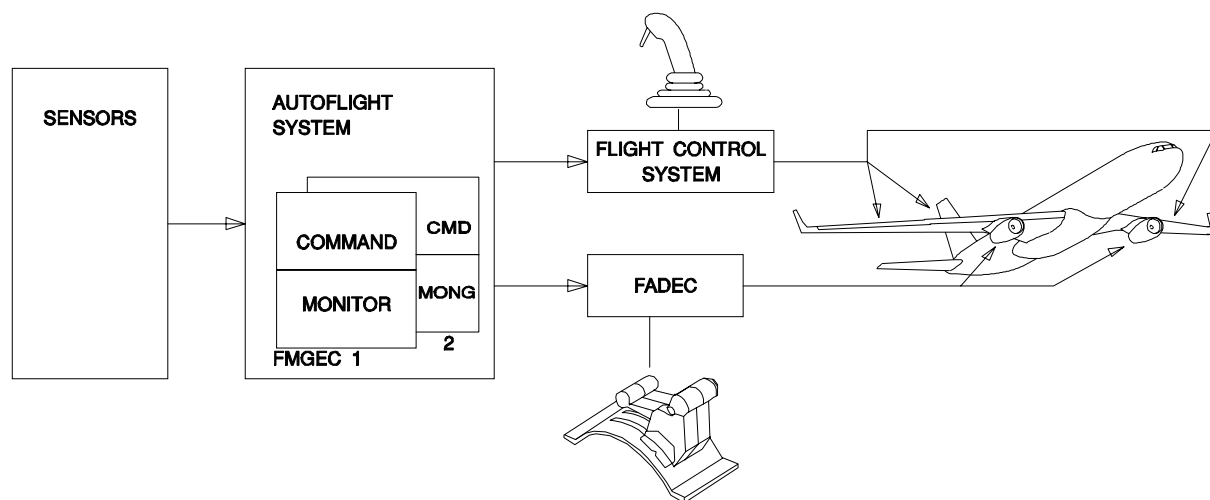
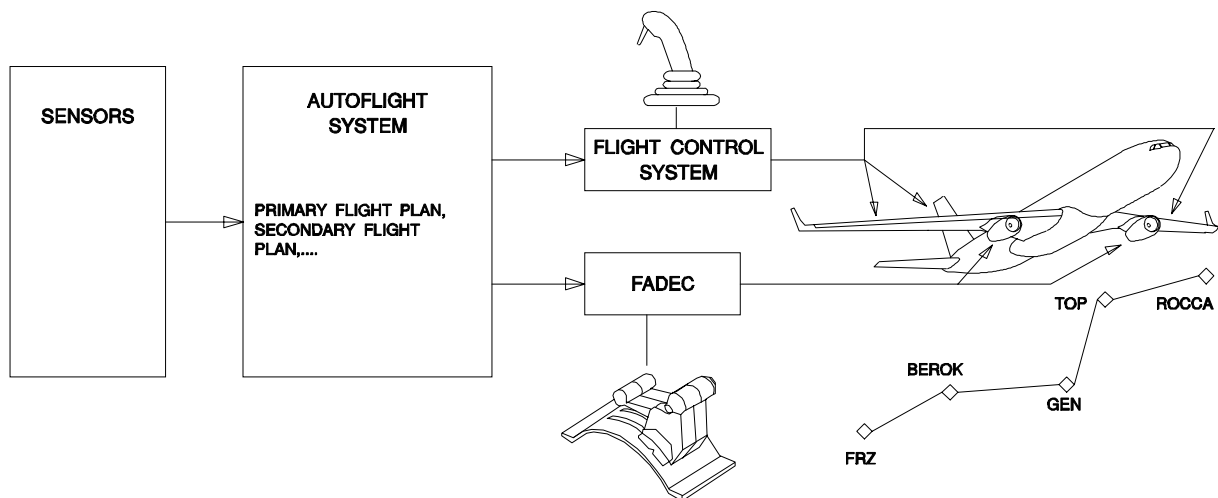
The control wheel steering mode which existed in previous Autoflight System is now ensured by the manual fly by wire mode of the Electrical Flight Control System.

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 stick, it disengages.

SYSTEM DESIGN

To meet the necessary reliability, the AutoFlight System is built around two computers.

Each Flight Management Guidance and Envelope Computer, (FMGEC1 and FMGEC2), has a command part and a monitor part : it is a "FAIL OP" (fail operative) system.



FQW4200 GE Metric

STUDENT NOTES

AUTOFLIGHT SYSTEM PRESENTATION

- Purpose
- General
- Flight Management
- Flight Guidance
- Flight Envelope
- FIDS
- MCDU
- FCU
- Functional Interconnections

PURPOSE

The purpose of this module is to present the general architecture and the functions of the Autoflight System.

Via the Flight Management Guidance and Envelope Computers (FMGECs), the Autoflight System provides three major functions (Flight Management (FM), Flight Guidance (FG), Flight Envelope (FE)) and allows an interface with the Centralized Maintenance System (CMS) by means of the Fault Isolation and Detection System (FIDS).

GENERAL

The Autoflight System consists of :

- two Flight Management Guidance and Envelope Computers,
- one Flight Control Unit (FCU),
- three Multipurpose Control Display Units (MCDU).

The pilots interface with the Autoflight System via the Flight Control Unit for short-term actions and via the Multipurpose Control Display Unit for long-term actions.

The FMGECs provide output commands to the control surfaces, via the Flight Control Primary Computers (FCPCs), and to the engines, through the Flight Control Unit, the Engine Interface and Vibration Monitoring Units (EIVMUs) and the Electronic Engine Controls (EECs).

The Autoflight System data are displayed on the Navigation Displays (NDs) and the Primary Flight Displays (PFDs) via the Display Management Computers (DMCs).

FLIGHT MANAGEMENT

The two Flight Management Guidance and Envelope Computers perform several Flight Management functions.

The FM functions are :

- A/C lateral position computation,
- lateral and vertical navigation,
- flight planning with DMC interface,
- performance and prediction computation,
- data display on MCDUs.

FLIGHT GUIDANCE

The Flight Guidance functions are : Autopilot, Flight Director and Autothrust.

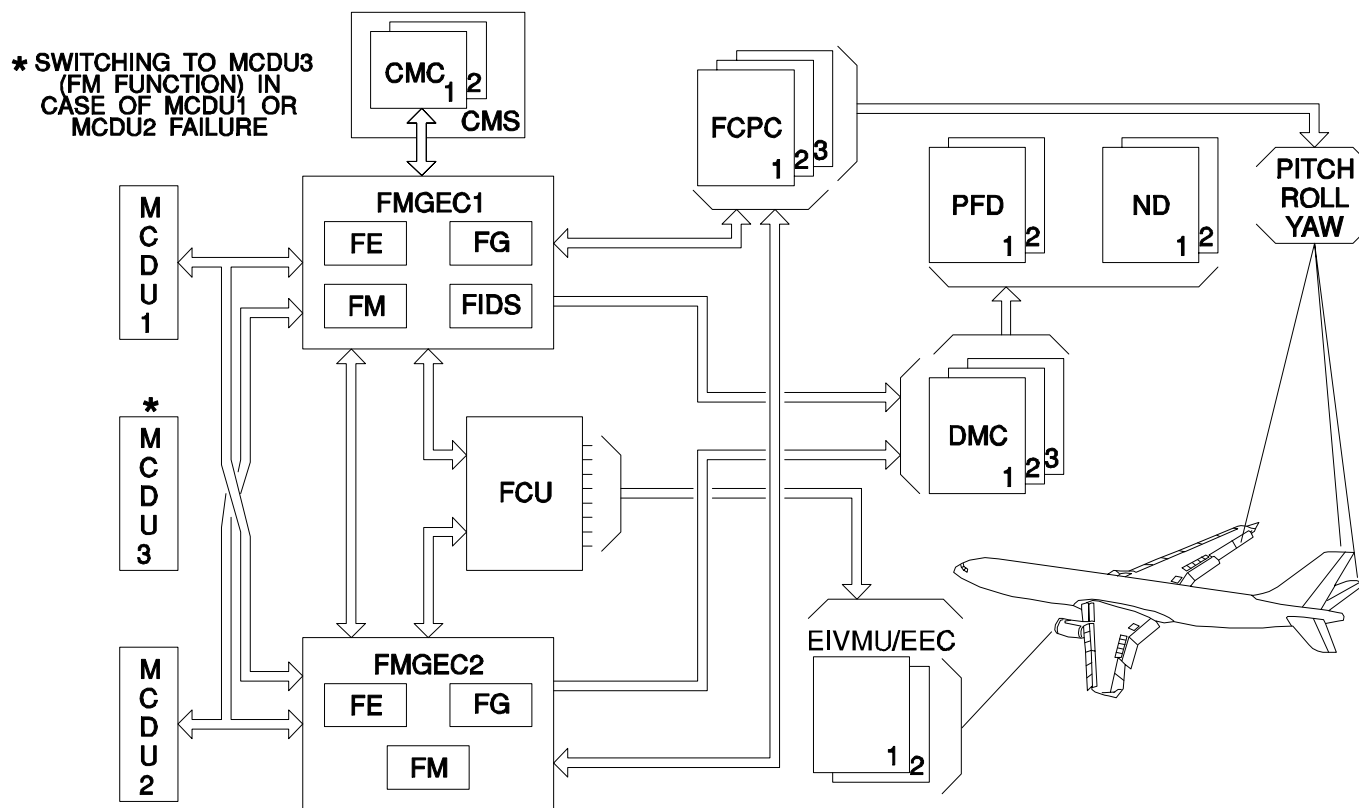
The Autopilot (AP) computes orders for surface deflections.

The Autothrust (A/THR) computes the thrust command for engine control.

The Flight Director (FD) displays to the pilot the orders which would be followed by the AP if it was engaged.

The reference parameters such as speed, heading, altitude and vertical speed, can be selected manually by the crew or can be provided by the system.

The nature of the reference parameters depends on the engaged modes. Note that the A/THR modes depend directly on the longitudinal AP/FD modes.



FLIGHT ENVELOPE

There are several Flight Envelope functions within the Flight Management Guidance and Envelope Computers.

The FE function acquires and monitors parameters used by the Flight Envelope protection, the Flight Management and the Flight Guidance. For example : ADIRS data, navigation data, fuel data, flight control data, FCU data, ...

Speed envelope, consolidation of flight phases and aircraft configuration are Flight Envelope protection functions.

The FE part computes for AFS and flight instruments some characteristic speeds (VFEN, VLS, S, F, Green dot, Vctrend, VMAX, VMAX OP). The FE part monitors and consolidates the flight phases, the gear position, the flaps and slats setting, the flaps and slats jamming, the engine status.

Back-up weight, back-up center of gravity and alphafloor monitoring are Flight Envelope functions.

Weight and center of gravity are always computed by the FE part which only uses them in case of both Fuel Control Monitoring Computers loss. The FE part acquires the alphafloor signal from the FCPCs (α is the angle-of-attack, α_{floor} is a threshold angle, when $\alpha > \alpha_{\text{floor}}$, the alpha floor protection is activated that means the engine thrust is maximal).

Windshear and aft center of gravity detections are Flight Envelope protection functions.

The FE part computes a signal for visual windshear warning on PFD and audio warning by cockpit loudspeakers. The FE part monitors the aft CG limits and triggers a warning in case of overshoot.

FIDS

The Fault Isolation and Detection System centralizes the Autoflight System failure information from Flight Management Guidance and Envelope Computers, Multipurpose Control Display Units and Flight Control Unit.

The FIDS sends the results to the Centralized Maintenance Computers (CMC). This part is fully independent from other parts of the FMGEC except for the power supply. It is only active in FMGEC1.

MCDU

Each Multipurpose Control Display Unit incorporates the following facilities for Flight Management Guidance and Envelope Computer interface :

- colour display,
- full alphanumeric keyboard,
- mode and line select keys.

The MCDUs are used for long-term control of the aircraft (Flight Management) and provide the interface between the crew and the FM part. Each MCDU is coupled to its own FMGEC. MCDU3 is used as a back-up in flight and normally used on ground for maintenance purposes.

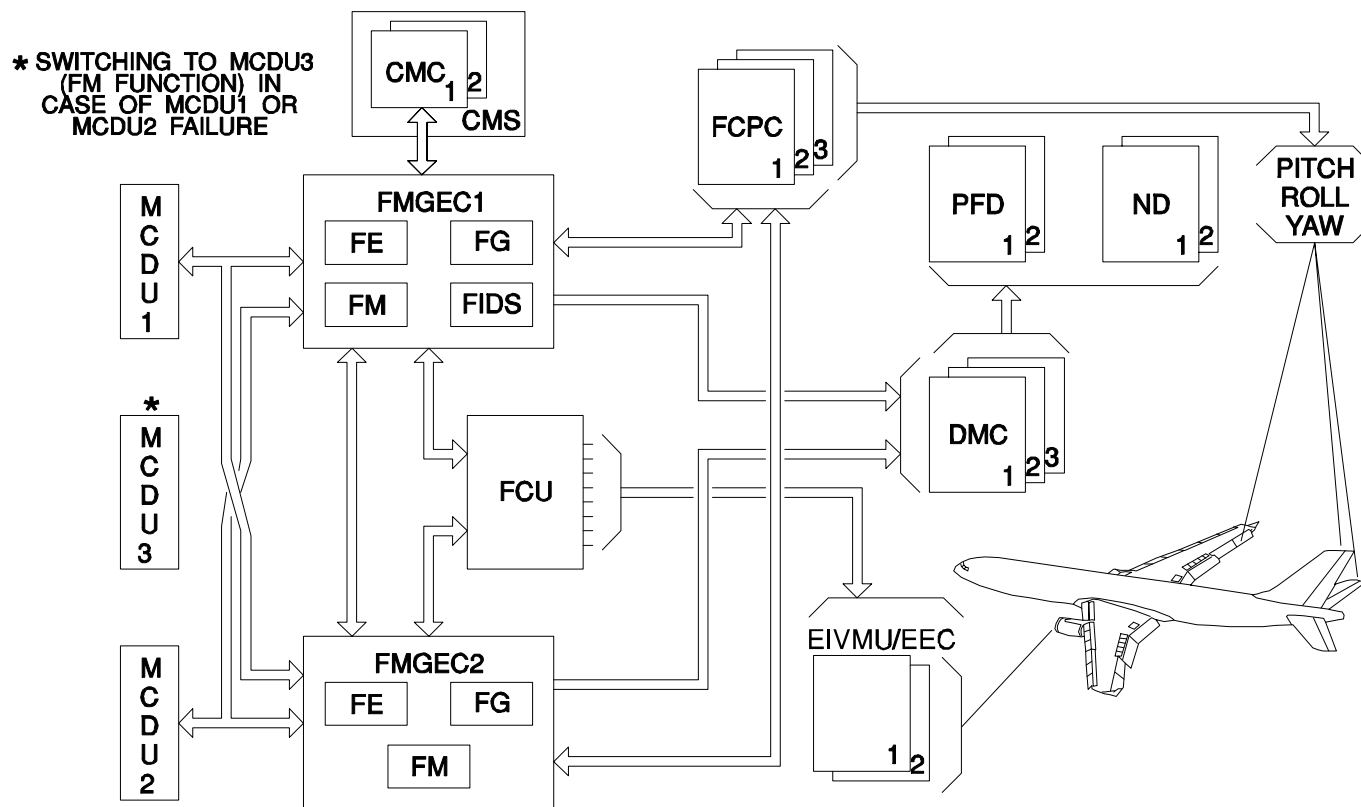
FCU

The Flight Control Unit, installed in the glareshield, is composed of three control panels : one for Autoflight System, two for Electronic Instrument System.

The FCU includes three independent processors (A, B and C).

The Flight Control Unit is used to select the Electronic Instrument System display modes.

The FCU is also used for short-term control of the aircraft : for example, AP, A/THR, FD engagement/disengagement. The FCU is the interface required for transmission of engine data from the FMGECs to the EIVMUs.



FUNCTIONAL INTERCONNECTIONS

The Autothrust function comprises thrust demand, autothrust signal, alpha floor signal, instinctive autothrust disconnect.

The FG part of the FMGEC communicates with the EECs via the FCU and the EIVMUs to perform the A/THR function.

For pitch, roll and yaw controls, taking advantage of the Electrical Flight Control System, the autopilot demands are sent to the surfaces via the Flight Control Primary Computers.

For automatic roll out, the FMGEC computes a nose wheel steering command.

Both Navigation Displays (NDs) and Primary Flight Displays (PFDs) are used by the system to display AutoFlight System information.

The Display Management Computers (DMCs) are the interface between the display units and the FMGECs. Navigation Display is more specific to the Flight Management part and Primary Flight Display is more specific to the Flight Guidance and Flight Envelope parts.

STUDENT NOTES:

STUDENT NOTES

AFS PERIPHERALS AND ASSOCIATED SYSTEMS

- General
- Air Data And Inertial Reference Information
- Radio Navigation Units
- Fuel System
- Loading Of Flight Plan
- A/C Configuration
- Interconnection With Engine Controls
- Interconnection With Flight Controls
- Interconnection With EIS
- Warnings
- Maintenance
- Other Peripherals

GENERAL

The Autoflight System needs peripheral equipment for its operation and delivers signals used by other systems.

The interconnection between the Flight Management Guidance and Envelope System (FMGES) and the peripherals is made in such a way that a single failure of a peripheral has no effect on the AutoFlight System (AFS) function. It is a FAIL OP system.

AIR DATA AND INERTIAL REFERENCE INFORMATION

Three Air Data and Inertial Reference Units are linked to the Flight Management Guidance and Envelope Computers.

Most of the Air Data Inertial Reference Unit (ADIRU) information is used by the Flight Guidance (FG) part (speed, heading,...). The ADIRU provides the A/C position which is used by the Flight Management (FM) part for the navigation (or by the back-up NAV function available in MCDU1/2 in case of failure of both FMs).

RADIO NAVIGATION UNITS

The Flight Management Guidance and Envelope Computers tune the radio navigation receivers through the Radio Management Panel. Then, the receivers send data to the FMGECs.

- . VOR/DME are autotuned and used to update the inertial position.
- . ADF are autotuned when the stations are used as FROM or TO waypoints on flight plan.
- . ILS are autotuned to disengage the FM when capturing LOC and GLIDE. Note that the Radio Management Panel provides a back-up tuning of nav aids.
- . The Global Positioning System (if fitted) position, computed by the ADIRUs, can be used as a principal means of navigation (optional) or as a complementary means of navigation.

FUEL SYSTEM

The fuel system gives information to the Flight Management Guidance and Envelope Computers.

Two Fuel Control and Monitoring Computers (FCMC) provide the A/C weight and Center of Gravity (CG) to the FMGEC for performance computations (prediction/optimization).

LOADING OF FLIGHT PLAN

The Navigation Data Base can be loaded in the Flight Management Guidance and Envelope Computers via the Multipurpose Disk Drive Unit (MDDU) (if fitted).

A/C CONFIGURATION

Two Slat/Flap Control Computers and two Landing Gear Control Interface Units provide the aircraft configuration to the Flight Management Guidance and Envelope Computers.

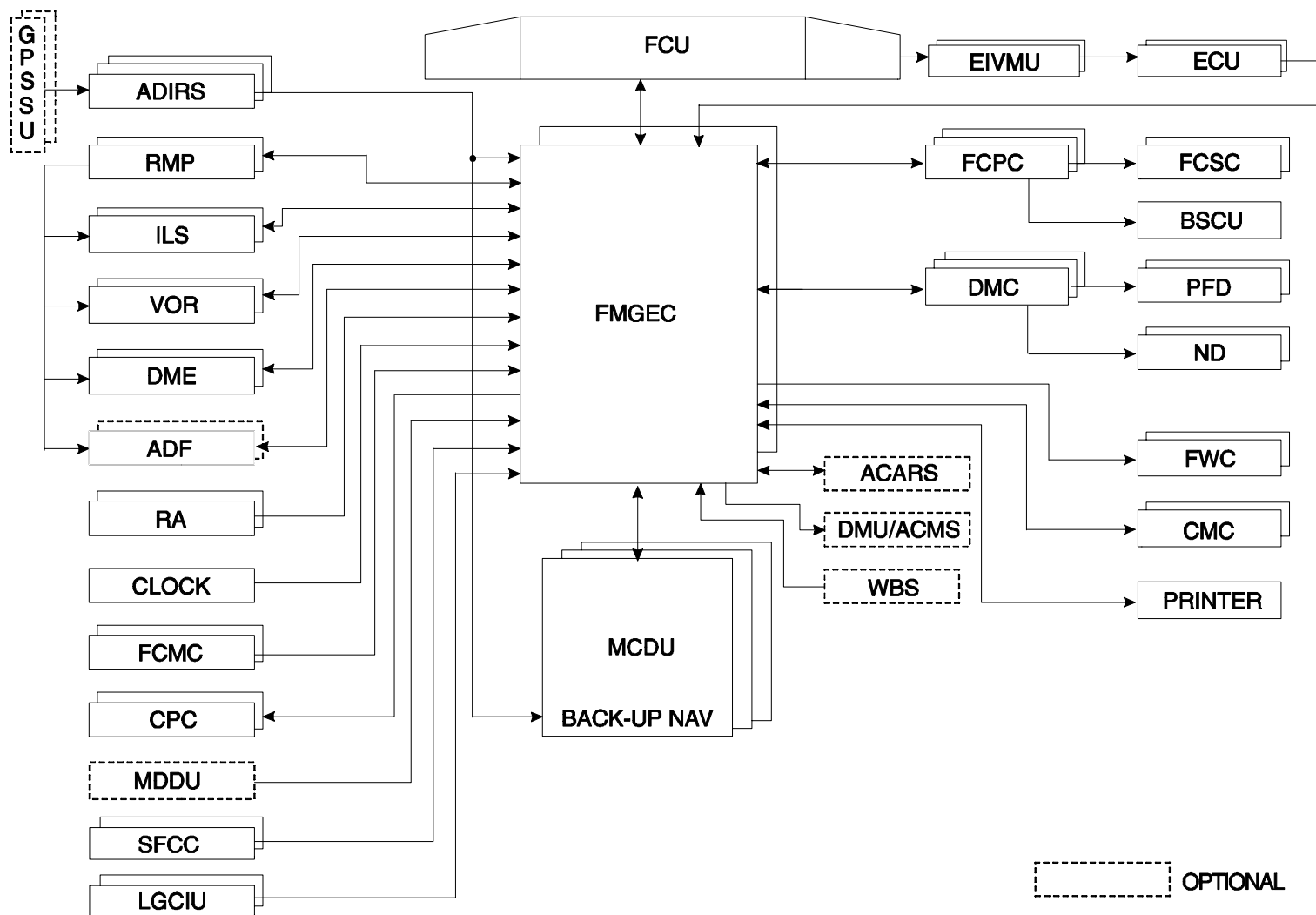
INTERCONNECTION WITH ENGINE CONTROLS

The Flight Management Guidance and Envelope Computers provide output commands to engines via the Flight Control Unit, the Engine Interface Vibration Monitoring Units and the Electronic Control Units.

The FCU selects FG1 or FG2 data, depending on the engaged side, and transmits it to the EIVMUs which re-transmit it to the ECUs.

The FMGEC sends a thrust order, called "thrust target" to the ECUs.

Data from ECU is used for : back-up weight computation, vertical flight plan management, A/THR function (thrust target feedback).



FQW4200 GE Metric

INTERCONNECTION WITH FLIGHT CONTROLS

The Flight Management Guidance and Envelope Computers provide deflection orders to the control surfaces via the Electrical Flight Control System.

The FMGECs send Autopilot orders (pitch, roll, yaw) through output buses to the Flight Control Primary Computers (FCPCs). In turn, the FCPC orders are sent to the surfaces, either directly, or via the Flight Control Secondary Computers (FCSCs) or via the Brake and Steering Control Unit (BSCU). The FCPCs return the surface positions.

The validity of the Flight Control Primary Computers and of the Flight Control Secondary Computers has effect on the Autopilot function.

One valid FCPC and one valid FCSC are enough to maintain the Autopilot function. In case of loss of the three FCPCs, the AP is lost.

Note : this triple failure has no effect on FD or A/THR functions.

INTERCONNECTION WITH EIS

The Display Management Computers are the necessary interface between the AutoFlight System, the Navigation Displays and the Primary Flight Displays. The display units provide an essential visualization of Flight Guidance, navigation and system related information.

On the Primary Flight Display (PFD) there are :

- Flight Director symbols
- Flight Mode Annunciator (FMA)
- FCU/MCDU selected parameters
- characteristic speeds.

Provided that Navigation Displays have been switched on ROSE-NAV/ARC/PLAN mode, information is displayed.

On the Navigation Display (ND) there are :

- A/C position
- Flight Plan presentation.

WARNINGS

The Flight Warning Computer monitors the Flight Management Guidance and Envelope Computer functions.

The Flight Warning Computer (FWC) will generate the corresponding alarm in case of loss of one function.

MAINTENANCE

The Centralized Maintenance Computers are linked to Flight Management Guidance and Envelope Computer 1 and receive the maintenance data concerning all Autoflight System computers.

The Centralized Maintenance Computers (CMCs) allow the system to be tested and the BITE to be read through the MCDU (usually MCDU3).

The FMGECs provide data to the Aircraft Condition Monitoring System (ACMS) (if fitted). Parameters of each FMGEC function can be provided to the ACMS via the Data Management Unit (DMU) (if fitted).

Flight reports, ACMS and BITE information can be printed using the MCDU prompt.

The flight report print-outs indicate company route, flight number and city pair provided by the FMGEC.

OTHER PERIPHERALS

The Flight Management Guidance and Envelope Computers receive data from Radio Altimeters, clock, Weight and Balance System (if fitted) and ACARS (if fitted).

Two Radio Altimeters (RAs) are often used for engagement logics and mode logics.

One clock enables the FM part to be initialized.

One ACARS can be connected as an option to exchange data with the ground.

The optional Weight and Balance System (WBS) can be connected to provide the FM part with the weight and center of gravity initialization.

The FMGECs provide data to the Cabin Pressure Controllers (CPCs).

The required inputs such as landing elevation, flight level, time information and QFE/QNH/STD selection from Flight Management part improve the performance of the Cabin Pressure Controllers.

STUDENT NOTES:

STUDENT NOTES

SYSTEM CONTROLS AND INDICATING

- Flight Control Unit
- Multipurpose Control And Display Unit
- Navigation Display
- Primary Flight Display
- Thrust Levers
- Side Sticks
- Rudder Pedals
- North Reference Switch
- FM Source Selector
- Resets
- Radio Management Panel
- Engine Warning Display/System Display
- Attention Getters

FLIGHT CONTROL UNIT

The Flight Control Unit is installed on the glareshield. The FCU front face includes an AutoFlight System control panel between two Electronic Flight Instrument System control panels.

The AFS control panel allows and displays the engagement of autopilots and autothrust, and the selection of guidance modes and flight parameters.

The two EFIS control panels control and display, for each EFIS side (F/O and Capt), the Primary Flight Display and Navigation Display functions (respectively Baro and FD conditions, and AFS ND modes).

MULTIPURPOSE CONTROL AND DISPLAY UNIT

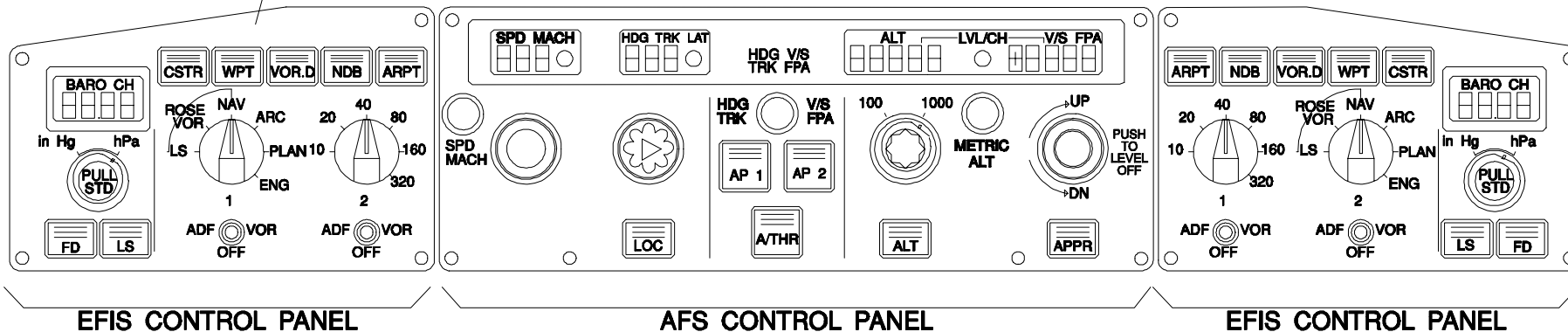
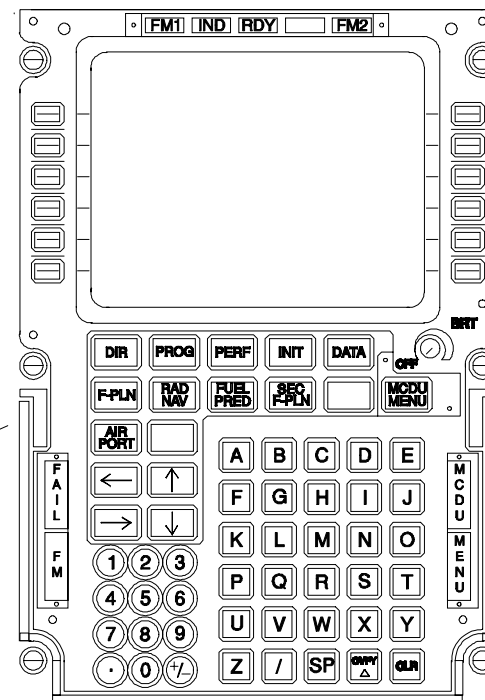
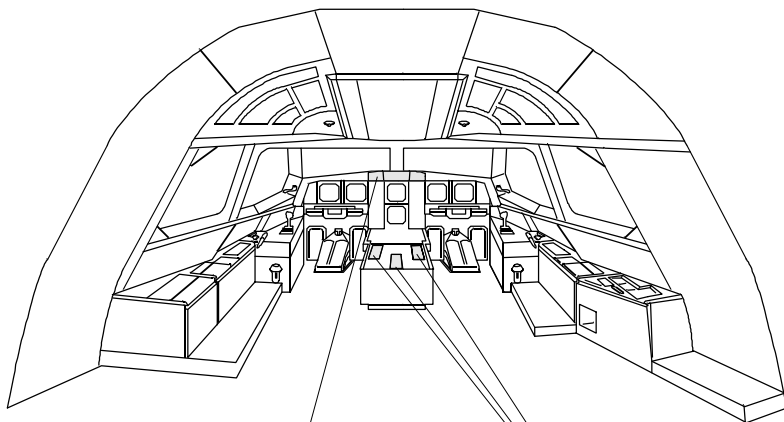
Three Multipurpose Control and Display Units are located on the center pedestal.

The MCDU is the primary entry/display interface between the pilot and the FM part of the FMGEC.

It allows system control parameters and flight plans to be inserted and is used for subsequent modifications and revisions.

It displays information regarding flight progress and A/C performances for monitoring and review by the flight crew.

Note: MCDU3 is used as a back-up in flight.



FQW4200 GE Metric

NAVIGATION DISPLAY

The two Navigation Displays are located on the main instrument panel.

The Navigation Display (ND) is built from :

- the flight plan data,
- data selected via the FCU,
- A/C present position,
- wind speed/direction,
- ground speed/track.

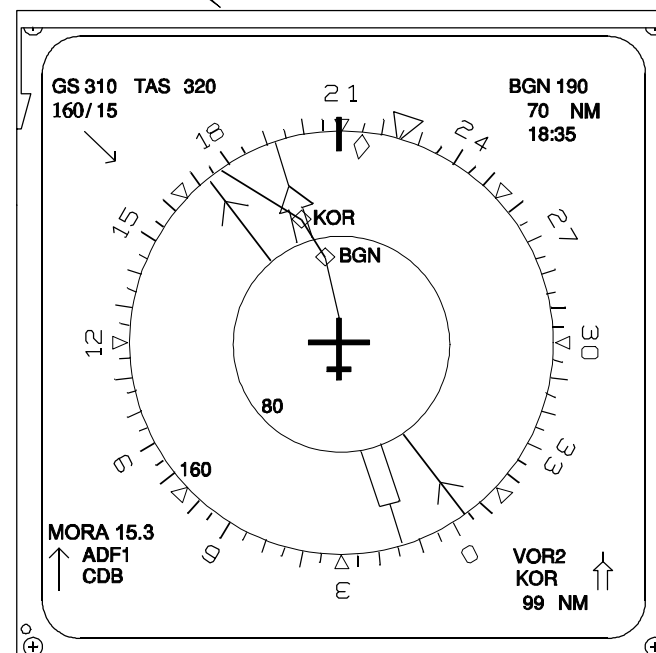
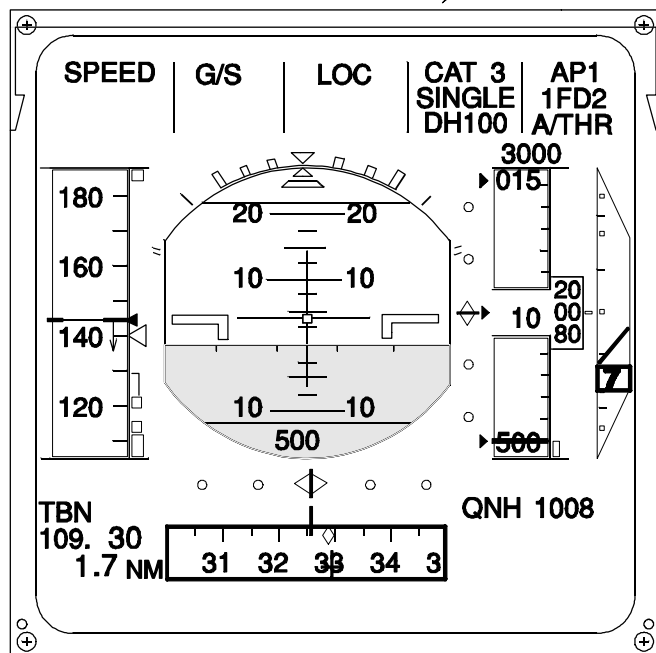
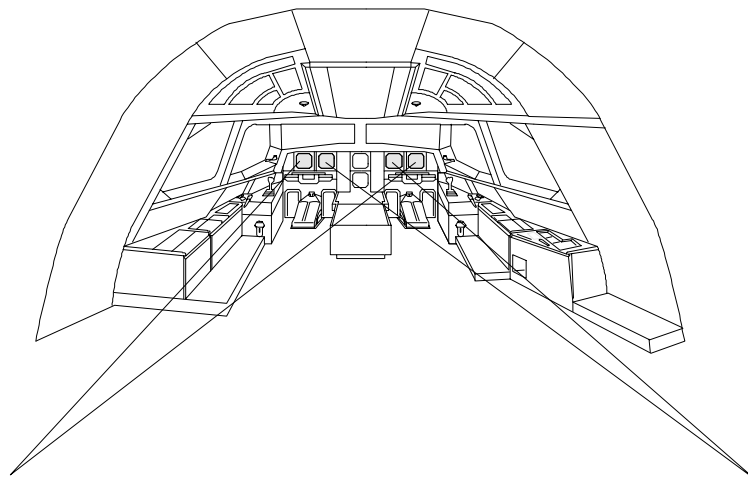
PRIMARY FLIGHT DISPLAY

The two Primary Flight Displays are located on the main instrument panel.

The Flight Mode Annunciator (FMA) is the top part of the Primary Flight Display unit (PFD).

Each PFD displays :

- AP/FD/A/THR engagement status on FMA,
- AP/FD and A/THR armed/engaged modes on FMA,
- FD orders,
- FE characteristic speeds on the speed scale.



FQW4200 GE Metric

THRUST LEVERS

The thrust levers are located on the center pedestal.

The thrust levers allow the Take-Off/Go Around (TO/GA) modes and the Autothrust (A/THR) to be engaged.

Two A/THR instinctive disconnect pushbuttons located on the thrust levers allow the A/THR function to be disengaged.

SIDE STICKS

The Captain and First Officer side sticks are respectively located on the Captain lateral panel and First Officer lateral panel.

The AP is disengaged when the take over priority pushbutton on side stick is pressed or when a force above a certain threshold is applied on the side stick.

RUDDER PEDALS

The rudder pedals are fitted in the Captain and First Officer positions.

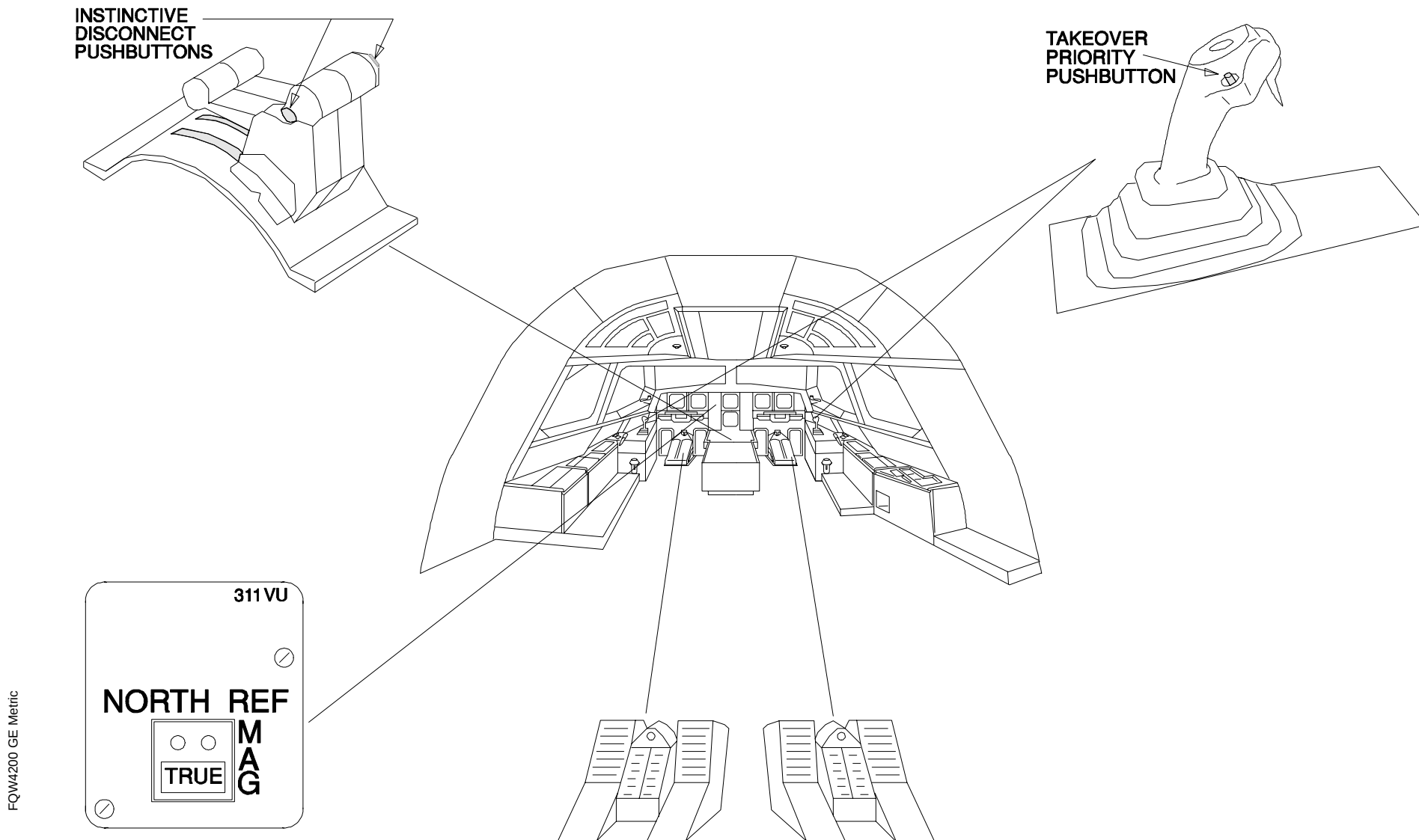
Rudder pedals override disconnects the AP only on ground.

NORTH REFERENCE SWITCH

The North reference switch is located on the main instrument panel, near the Captain Navigation Display.

This manual switch is used for the MAGNETIC/TRUE heading reference selection.

When reaching N81° (or S60°), MCDU and EFIS messages advise the crew to select the TRUE reference. If the pilot forgets to switch the reference, the AP disconnects.



FQW4200 GE Metric

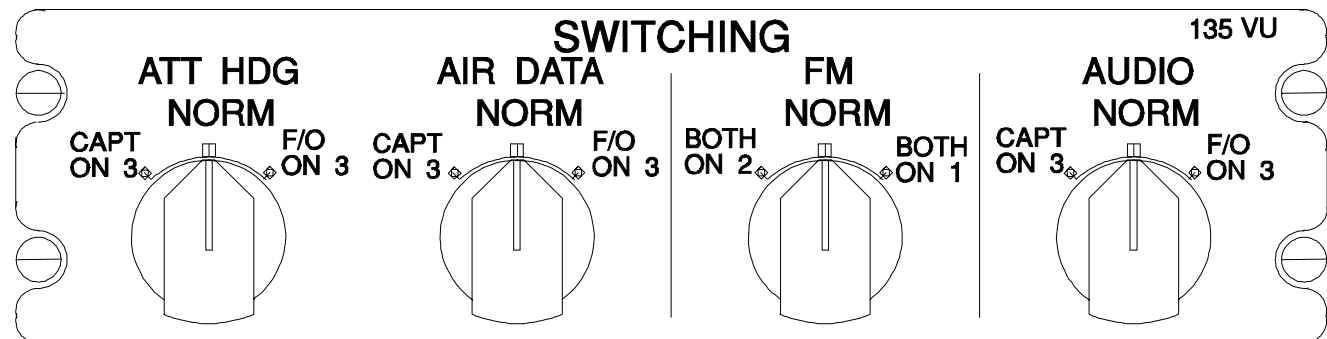
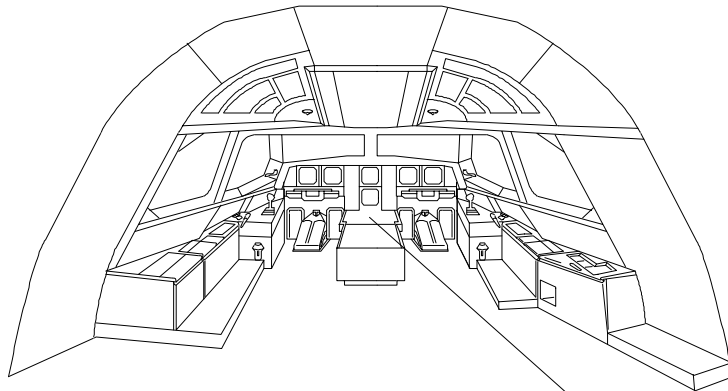
FM SOURCE SELECTOR

The FM source selector is located on the pedestal switching panel.

The manually operated selector called "FM source" has 3 positions : NORM, BOTH ON 1, BOTH ON 2.

NORM position : MCDU1 works with FM1, MCDU2 works with FM2.

BOTH ON 1 (2) position : MCDU1 and MCDU2 work with the same FM1 (2) source.



FM SOURCE SELECTOR SWITCH

FQW4200 GE Metric

RESETS

Note: The circuit breakers are located in the electronics bay.

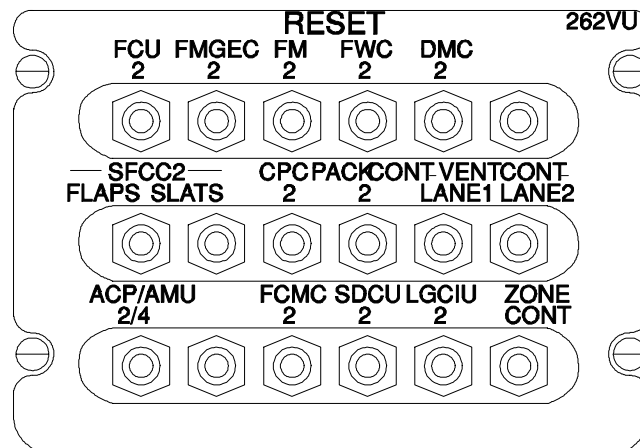
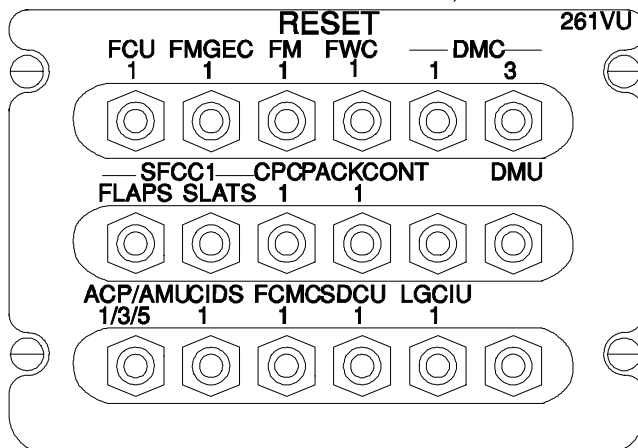
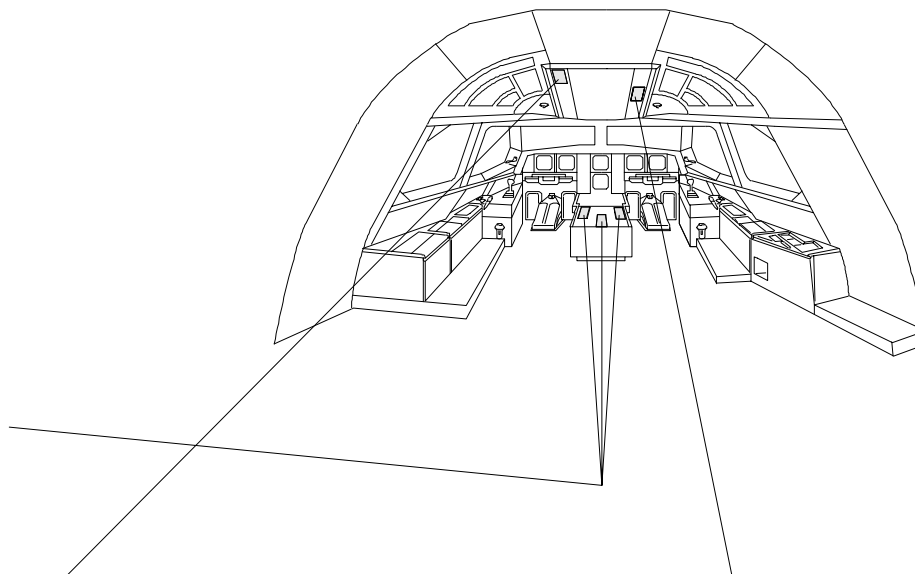
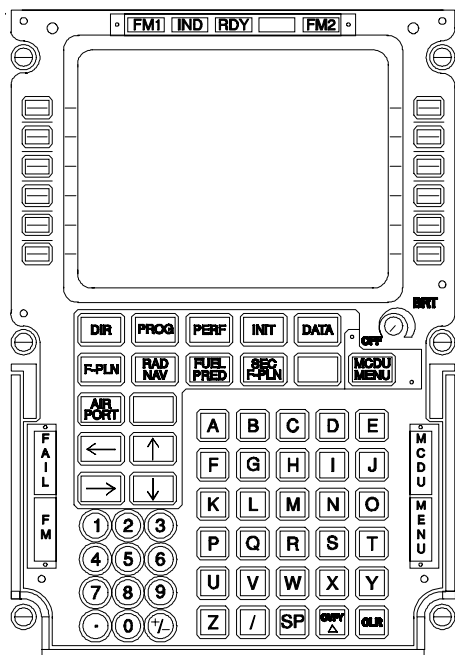
The Flight Management Guidance and Envelope Computers, and Flight Control Unit resets are possible from the cockpit.

The Flight Control Unit reset commands are located on the overhead panel.

The Flight Management Guidance and Envelope Computer reset commands enable global reset of the whole Flight Management, Flight Guidance and Flight Envelope functions, and a power up test.

The Flight Management reset commands are only related to the Flight Management function.

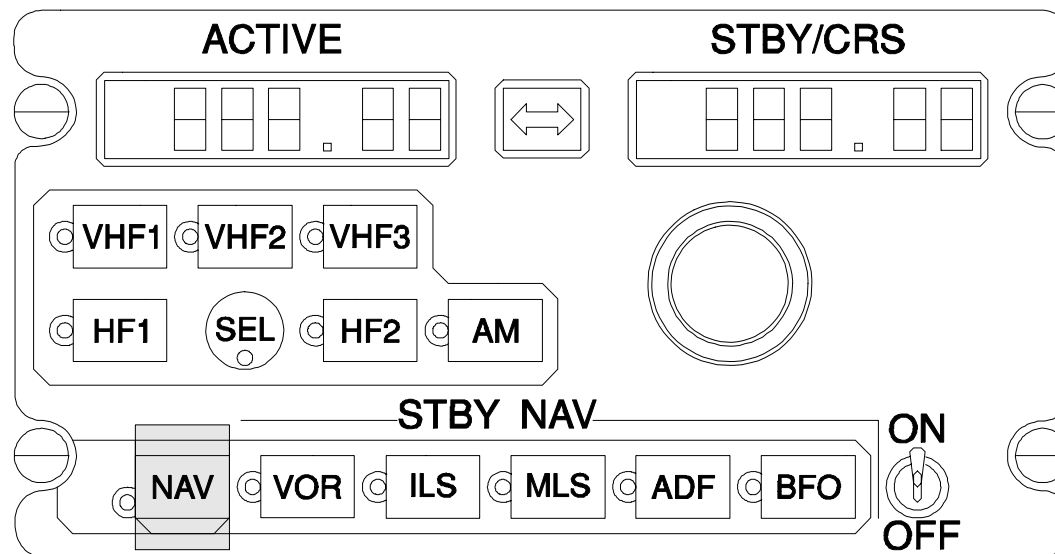
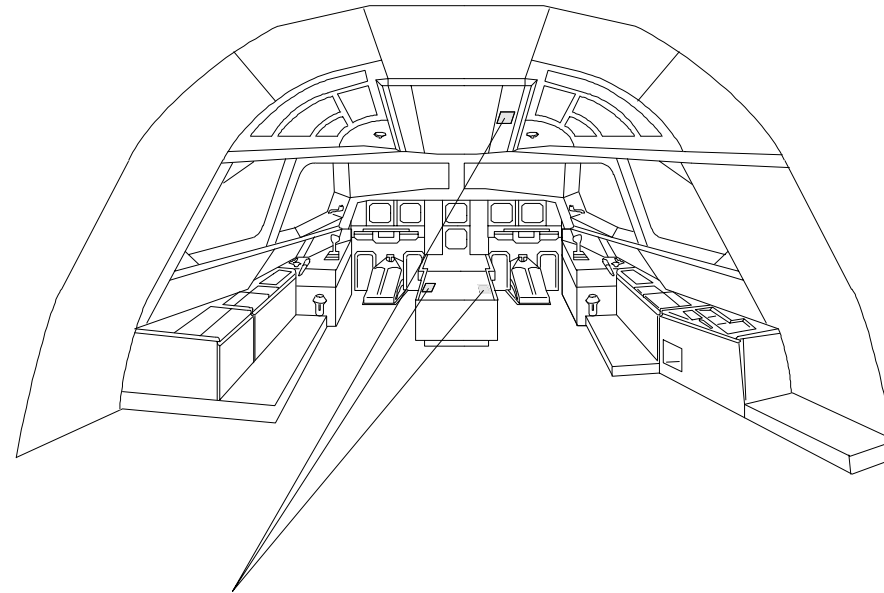
The Multipurpose Control and Display Units resets are manually controlled by switching the bright knob OFF on the MCDU keyboard.



RADIO MANAGEMENT PANEL

The Radio Management Panels are located on the center pedestal near Multipurpose Control and Display Units 1 and 2.

The Radio Management Panels (RMP) are used for navaid selection (except RMP3).

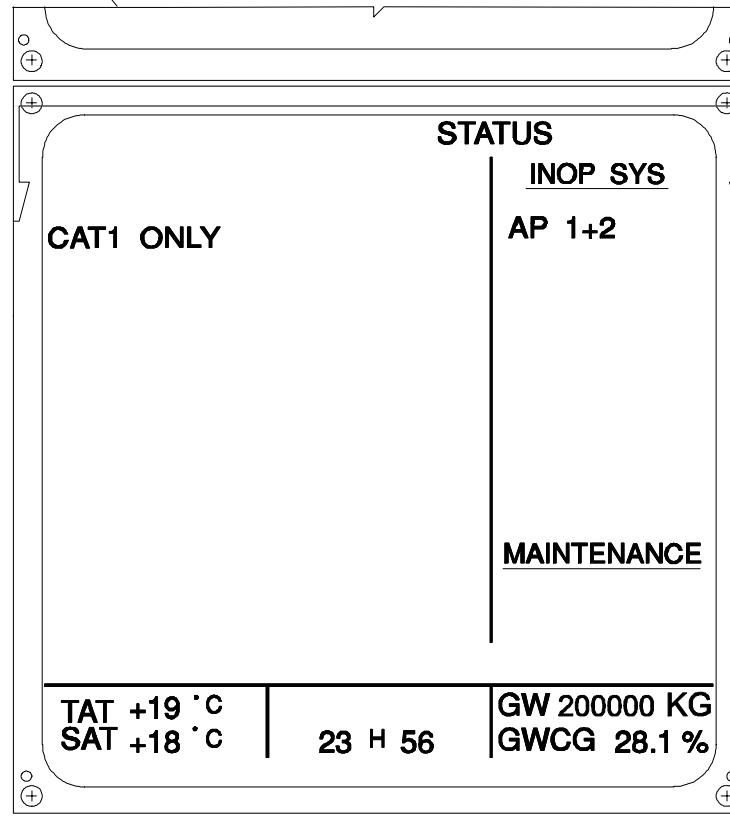
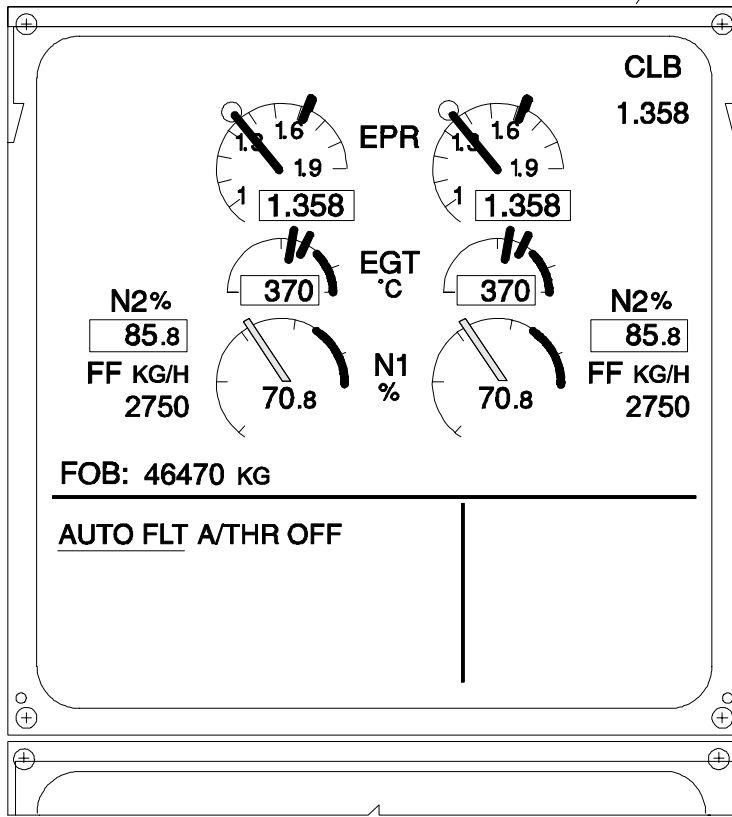
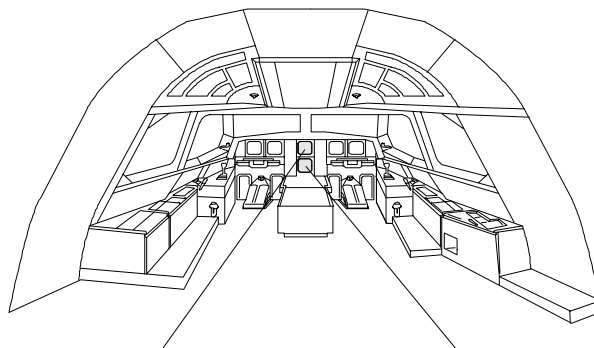


FQW4200 GE Metric

ENGINE WARNING DISPLAY/SYSTEM DISPLAY

The Engine Warning Display and the System Display are located on the main instrument panel. The EWD displays AFS warning messages. The SD displays AFS information such as inoperative systems on the STATUS page.

Note: This is an example of the representation for General Electric CF6-80 engines.

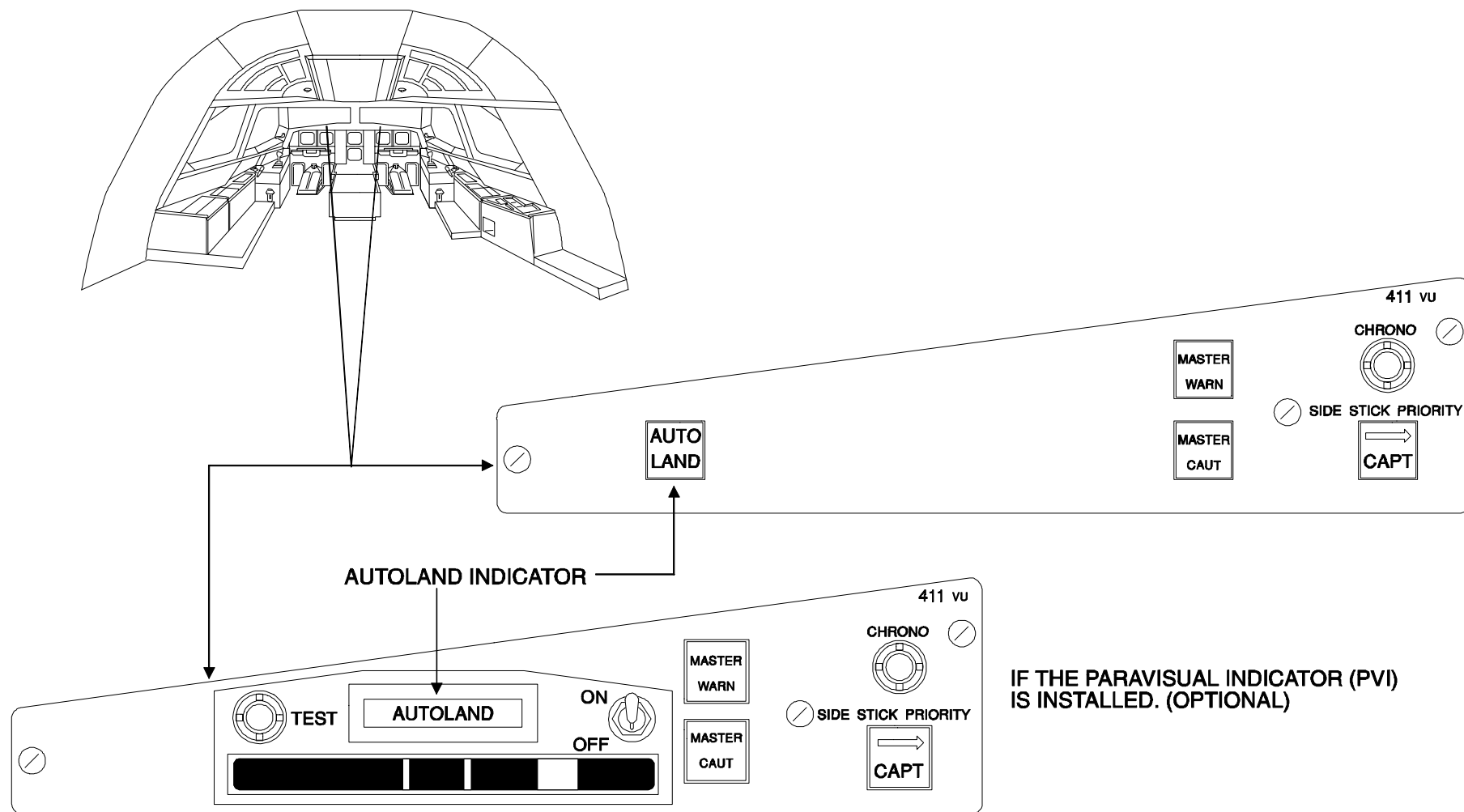


FQW4200 GE Metric

ATTENTION GETTERS

The attention getters are located on the glareshield panel on First Officer and Captain sides.

The MASTER CAUTION and/or the MASTER WARNING are activated when an AFS disconnection occurs. The AUTOLAND warning is activated when a problem occurs during final approach.



FQW4200 GE Metric

STUDENT NOTES

FLIGHT ENVELOPE PROTECTION PRESENTATION

- Purpose
- Acquisition, Monitoring And Reconfiguration
- Parameter Consolidation
- A/C Configuration
- Back-up Weight And CG Computation
- Characteristic Speed Computation
- Alphafloor Acquisition
- Windshear Detection
- Aft CG Detection
- Lateral Asymmetry

The module presents the data acquisition and the processing of various parameters necessary for the Flight Envelope protection.

PURPOSE

The Flight Envelope function ensures acquisition and monitoring of parameters used by Flight Envelope, Flight Guidance and Flight Management functions.

The Flight Envelope (FE) function includes :

- A/C configuration necessary to FG/FE (ground/flight, engines ON/OFF,...)
- characteristic speed computation for FG, FM and EIS
- weight and center of gravity, used by the FG/FE parts and the Electrical Flight Control System, as back-up.
- the detection of configurations outside the normal flight envelope : windshear and aft center of gravity,
- the lateral asymmetry detection.

ACQUISITION, MONITORING AND RECONFIGURATION

The Flight Envelope part performs data acquisition and monitoring of the input ARINC buses by checking the label validity for all parameters.

For critical parameters (such as angle-of-attack (AOA), Computed Air Speed (CAS),...) a comparison is made to check the drift between data supplied by different sources (sensors, computers). Dialog between the three functional parts FE, FG and FM is made via two common memories : between FE and FG, and between FG and FM.

PARAMETER CONSOLIDATION

The Flight Envelope part consolidates certain parameters used in control laws.

FE consolidation is made by cross-comparison of data sent by other systems such as the sideslip sent by the 3 Flight Control Primary Computers, values of which are then, either filtered or, limited in amplitude and variation.

A/C CONFIGURATION

The Flight Envelope part determines the aircraft configuration useful for Flight Guidance and Flight Envelope functions.

The FE part acquires the GROUND/FLIGHT CONDITIONS from the Landing Gear Control and Interface Unit (LGCIU), the SLAT/FLAP CONFIGURATION from the Slat Flap Control Computer (SFCC) and the ENGINE DATA from the Engine Control Unit (ECU).

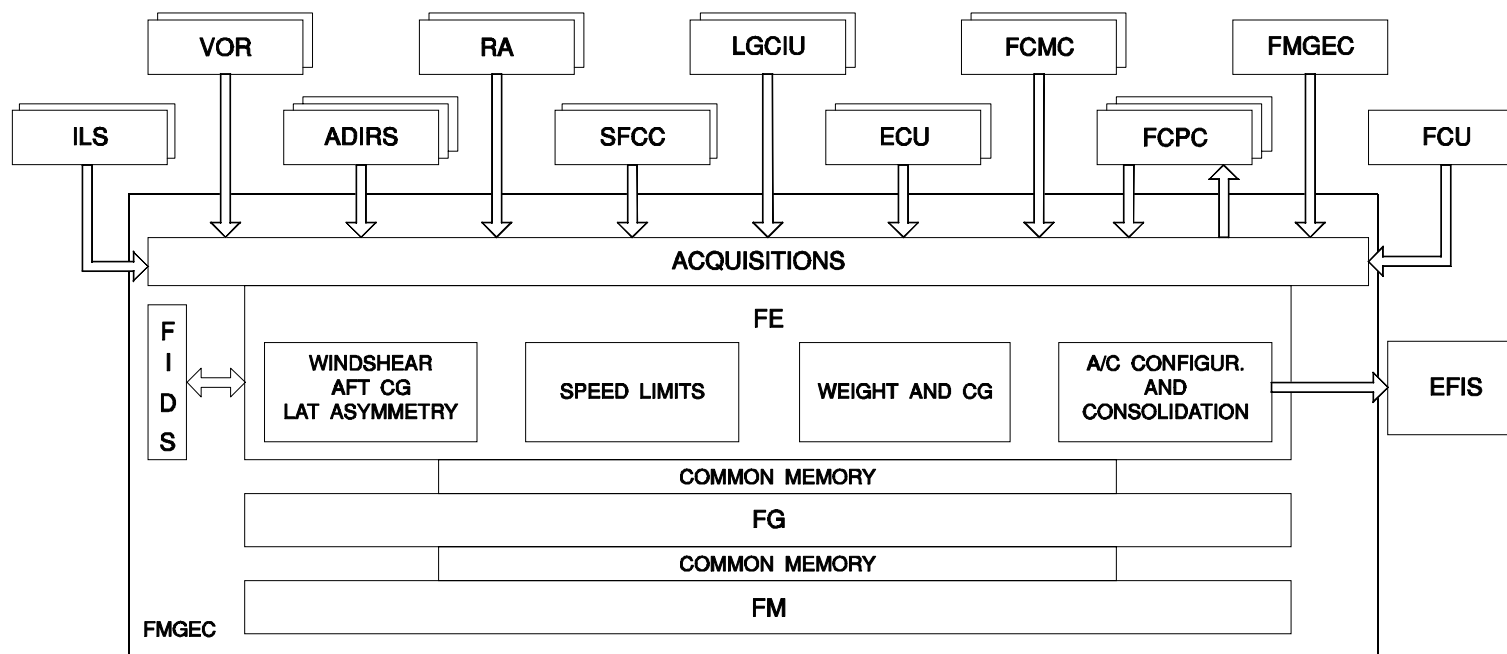
BACK-UP WEIGHT AND CG COMPUTATION

The Flight Envelope function ensures selection of weight and Center of Gravity used by the Flight Guidance, the Flight Envelope and the Flight Controls.

If at least one Fuel Control and Monitoring Computer (FCMC) is valid : the FE part uses the weight and the center of gravity from the FCMC. If both FCMCs are lost : the FE part selects its own weight and center of gravity computations.

The Flight Envelope part computes the aircraft weight and center of gravity. They are used as back-up.

Depending on the flight phase, the FE weight is computed from the stalling speed (VS) and angle-of-attack (AOA) or from the fuel consumption. The FE Center of Gravity is computed from the position of the Trimmable Horizontal Stabilizer. This computation is made in function of engine thrust, CAS and FE weight.



CHARACTERISTIC SPEED COMPUTATION

The Flight Envelope function computes characteristic speeds.

The following speeds are obtained from VS (stall speed) delivered by the FCPCs :

- VLS, lowest selectable speed
- V3 (F), minimum flap retraction speed
- V4 (S), minimum slat retraction speed
- VMAN (Green dot), optimum speed in the event of one engine failure
- VMAX OP, maximum operational speed
- VMAX, maximum speed
- VFE NEXT, maximum extension speed for the next slat/flap configuration
- VC TREND, airspeed tendency.

The speeds are displayed on the Primary Flight Display speed scale.

ALPHAFLLOOR ACQUISITION

The Flight Envelope part only acquires the Alphafloor signal and sends it to the Flight Guidance part.

The FE part acquires the Alphafloor detection signal from the FCPCs. This signal is valid if the Angle-of-Attack exceeds a slat/flap position threshold.

This protection commands maximum thrust to all engines via the ECUs.

WINDSHEAR DETECTION

The Flight Envelope computes a signal to provide a visual windshear warning on the Primary Flight Display and an audio warning through loudspeakers.

This function has NO authority on the autothrust and is only active if Slat/Flap are extended.

AFT CG DETECTION

The two Fuel Control and Monitoring Computers control the Aft Center of Gravity by transferring fuel to and from the trim tank to reduce drag.

The FE function monitors Aft CG limit overshoot by a computation fully independent of the FCMC. In case of overshoot, a warning is generated. This computation is active in clean configuration over 20,000 ft. .

LATERAL ASYMMETRY

For the lateral asymmetry detection, the Flight Envelope part compares the right and left engine thrusts.

This condition is used for the FE computations and the FG function. Engine asymmetry is sent to the FCPCs.

STUDENT NOTES:

STUDENT NOTES

FQW4200 GE Metric

FLIGHT GUIDANCE PRESENTATION

- General
- AP Function
- FD Function
- A/THR Function
- AP Engagement
- FD Engagement
- A/THR Engagement
- Speed Control
- AP/FD/A/THR Mode Principles
- AP/FD/A/THR Mode Examples
- AP/FD Orders
- Landing Capability Computation
- FG Display

GENERAL

The Flight Guidance function performs three functions :

- Autopilot,
- Flight Director,
- Autothrust.

The Flight Guidance (FG) part contains the engagement logics, the mode logics and the control laws associated to the AutoPilot (AP), Flight Director (FD) and AutoTHRust (A/THR) functions. Depending on the engaged modes, the control laws give control surface deflection orders, Flight Director orders and a thrust command to stabilize and to guide the aircraft.

AP FUNCTION

The Autopilot function sends orders to the flight controls.

The AP functions are :

- stabilization of the A/C around the CG, when the AP system holds a flight path,
- acquisition and holding of a flight level,
- acquisition and holding of a speed,
- landing,
- go around.

FD FUNCTION

The Flight Director function displays orders to the pilot to apply on the controls to follow the optimum flight path which would be ordered by the Autopilot if it was engaged.

If AP is engaged the FD function displays the AP orders. The FD modes are the same as the AP modes. The Flight Director is engaged upon energization. However a mode must be active to obtain the Flight Director display.

A/THR FUNCTION

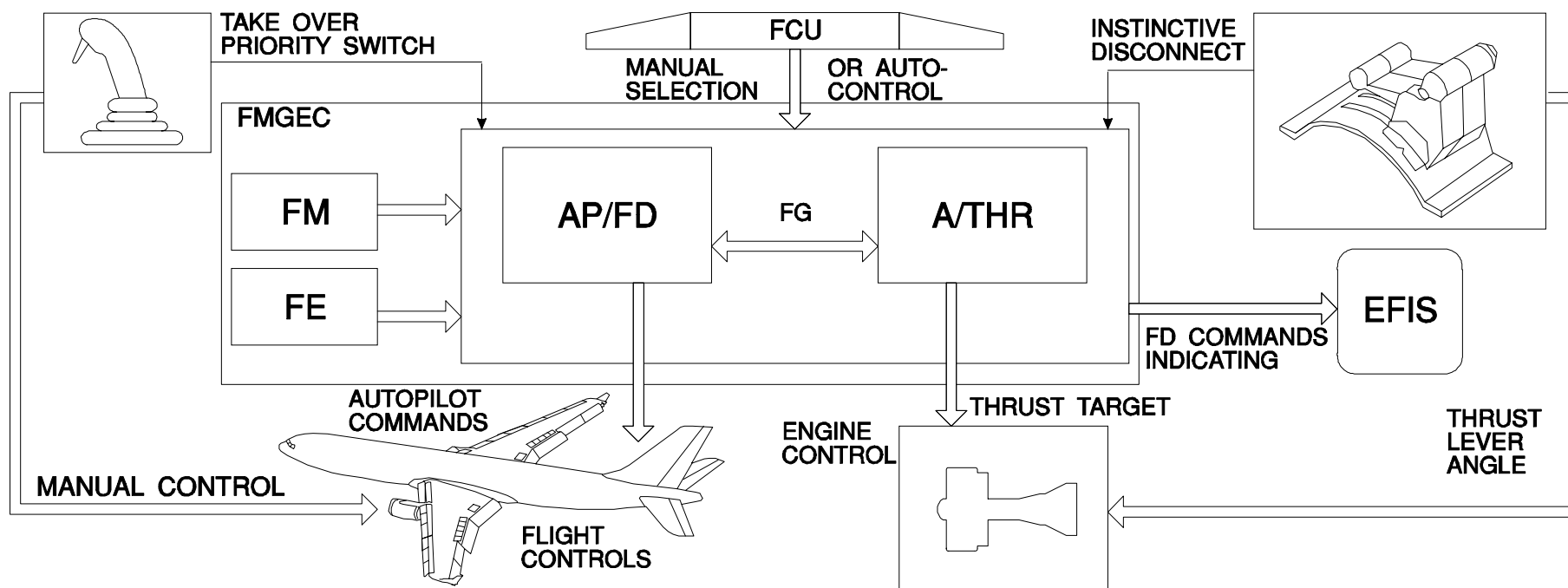
The Autothrust order is computed in the Flight Management Guidance and Envelope Computer and is sent to the Full Authority Digital Engine Control.

The Autothrust function operates in three modes :

- SPEED/MACH : acquisition and holding of a speed or MACH number
- THRUST (THR) : acquisition and holding of a thrust
- RETARD (IDLE) : reduction of a thrust to idle, during descent and during flare in final approach.

The Flight Envelope part acquires the Alphafloor signal detection from the Flight Control Primary Computers. It transmits it to the Flight Guidance part which sends the maximum thrust order to the Engine Control Units.

In Alphafloor protection, the A/THR function protects the A/C against excessive angle-of-attack by setting the thrust to the Go Around thrust limit. The thrust limit computation is performed by the Engine Control Units according to the thrust lever position except if the Alphafloor protection is activated.



FQW4200 GE Metric

AP ENGAGEMENT

Autopilot engagement is performed through a dedicated FCU pushbutton. Only one AP can be engaged at a time. Dual AP engagement is possible in APPR and GO AROUND modes (to be fail operative during AUTOLAND).

When AP is engaged :

- FCU AP pushbutton is ON,
- the side sticks are locked,
- rudder pedal artificial feel stiffness is locked.

Different actions or configurations disconnect the Autopilot.

AP disengagement is obtained by one of these conditions :

- action on one of the take-over priority switch located on the side stick;
- second action on the FCU pushbutton;
- AP unlocking by pilot action on the side stick;
- override of AP yaw order by pilot action on the rudder pedals (only on ground);
- failure detection.

FD ENGAGEMENT

The Flight Director is automatically engaged at power-up and the FCU pushbuttons are ON.

FD symbols can be displayed or not displayed on each PFD by using the associated pushbutton on EFIS control panel.

A/THR ENGAGEMENT

When Autothrust is engaged, the FCU A/THR pushbutton is ON.

A/THR function is performed :

- automatically when TO/GA or FLEX TO mode is engaged or when Alpha floor function is activated
- manually through a dedicated FCU pushbutton.

Different actions or configurations disengage the Autothrust function.

A/THR disengagement is obtained by one of the following actions :

- action on one of the "instinctive disconnect" switches,
- action on the FCU pushbutton,
- setting all thrust levers to idle position,
- setting all thrust levers to reverse area,
- failure detection.

The Autothrust function can be either not engaged, or engaged and not active, or engaged and active.

A/THR system is NOT ENGAGED : the thrust is directly commanded by thrust lever position.

A/THR system is ENGAGED BUT NOT ACTIVE : the thrust is commanded by thrust lever position but system is automatically activated if all thrust levers are set to CLB gate.

A/THR system is ENGAGED AND ACTIVE : the thrust is commanded by FMGEC autothrust order, the thrust levers are in CLB gate.

SPEED CONTROL

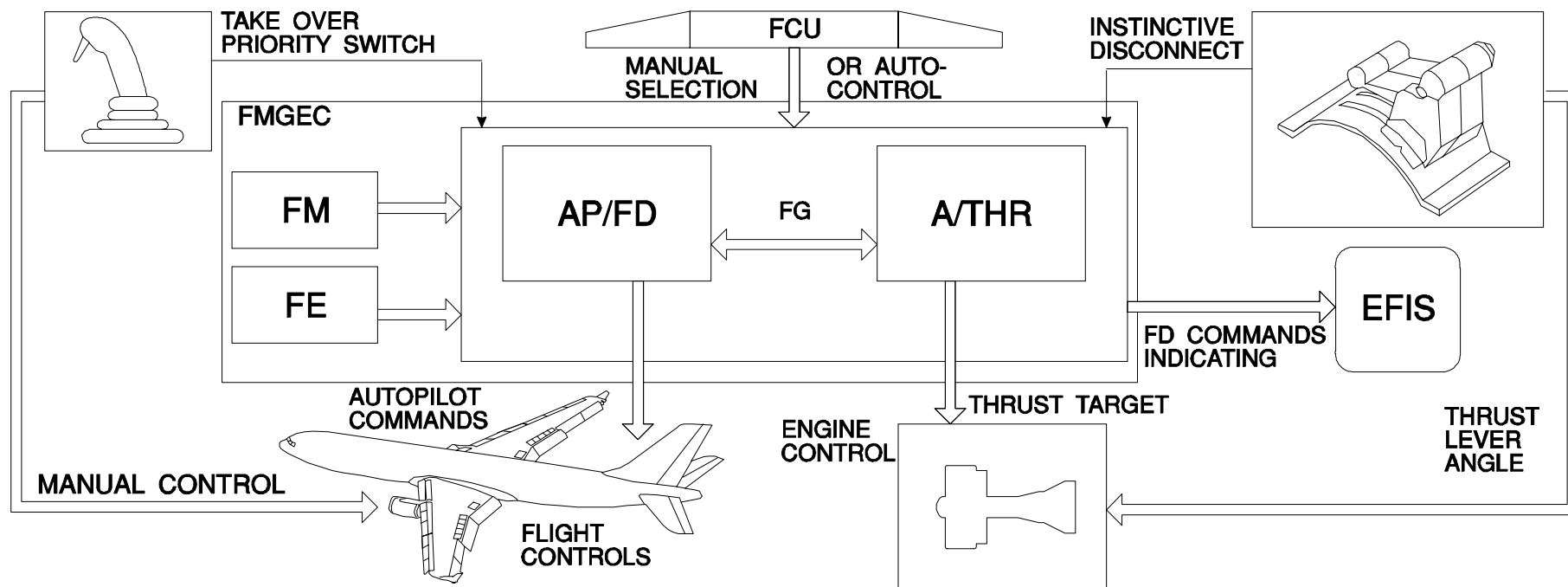
In flight, the Flight Guidance function continuously controls the SPEED/MACH parameter either by the A/THR or by the AP/FD longitudinal guidance.

The FG part computes the switching logic "speed control/MACH control" according to FM data (relative to the flight plan or to the pilot actions on the FCU pushbutton).

The reference speed is always limited by VMAX and VLS.

If the speed reference comes from the FCU, it is called "selected speed"

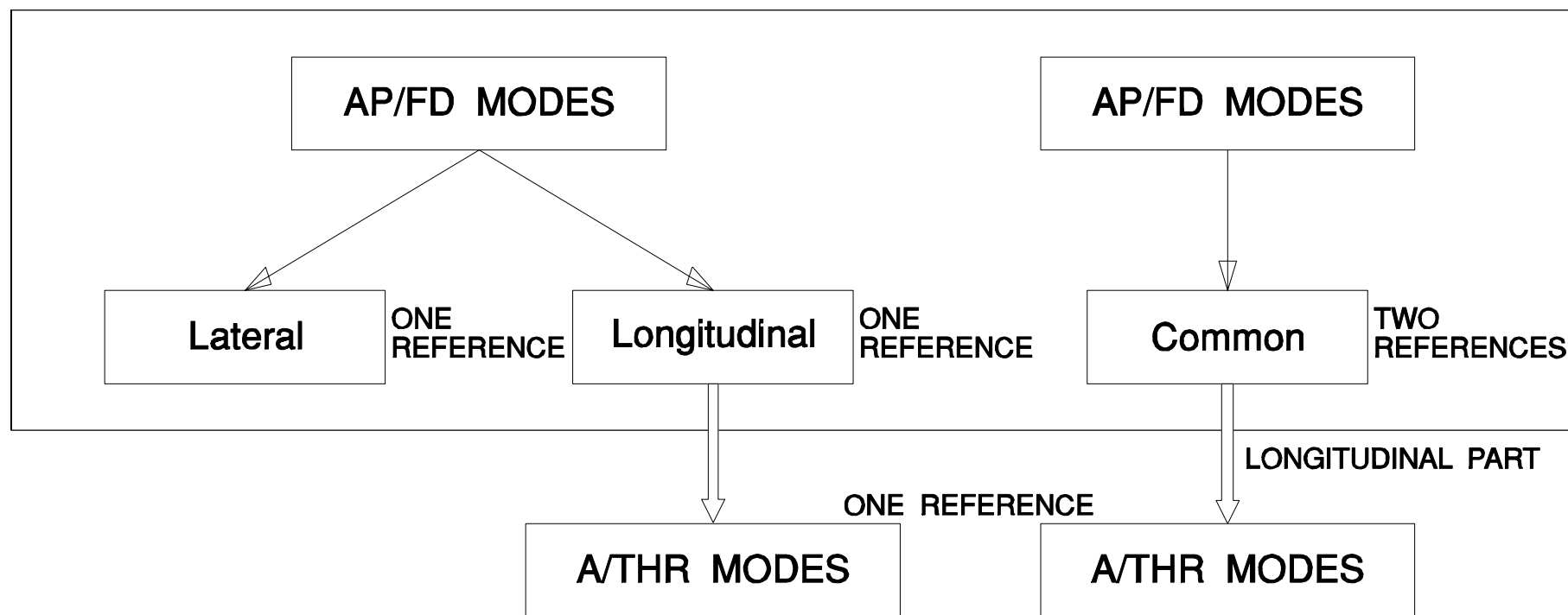
If the speed reference is computed by the FMGEC, it is called "managed speed".



AP/FD/A/THR MODE PRINCIPLES

The pilots choose one lateral and one longitudinal AP/FD mode or a common mode which is a particular association of lateral and longitudinal modes.

The A/THR mode is chosen by the FMGEC and depends on the active longitudinal mode. The AP/FD and A/THR modes are available only when AP/FD or A/THR is engaged. A mode is always associated to a reference (for example : speed, localizer, thrust) and the purpose of the mode consists in holding or following the reference.



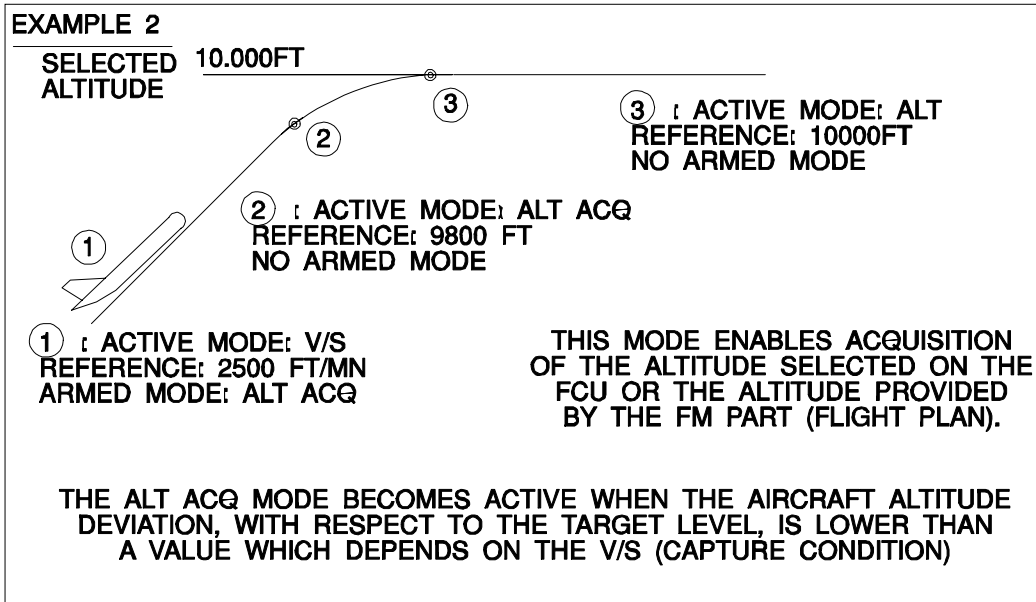
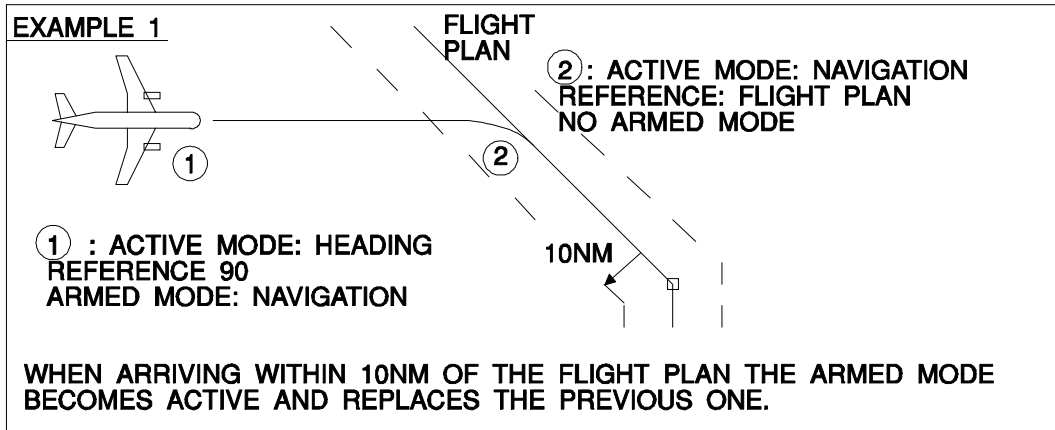
AP/FD/A/THR MODE EXAMPLES

AP/FD and A/THR modes can be armed in acquisition or waiting phases, or can be active in capture or holding phases.

An armed mode becomes active when the A/C captures the reference of this mode (example 1).

Here is an example of longitudinal AP/FD mode (example 2).

When the target level is actually reached, the altitude hold mode is automatically engaged and replaces the ALT ACQ mode.



AP/FD ORDERS

The Autopilot function sends orders to the Flight Control Primary Computers and to the Brake and Steering Control Unit.

The AP generates the following orders :

- deflection orders to the surfaces through the FCPCs.
 - * pitch (elevator and THS).
 - * roll (aileron and spoiler).
 - * yaw (rudder).
- steering orders to the nose wheel through FCPCs and BSCU.

The FD orders are displayed on the Primary Flight Displays through the Display Management Computers.

The FD displays guidance orders :

- generally pitch and roll orders,
- a yaw order, in two cases (Take Off and Landing).

Two types of symbols are used :

- display of (roll, pitch, yaw) bars,
- display of Flight Path Vector, Flight Path Director and yaw bar.

LANDING CAPABILITY COMPUTATION

Each FMGEC computes the landing capability (CAT1/CAT2/CAT3) during the whole flight. This computation depends on AutoFlight System and peripheral system availability.

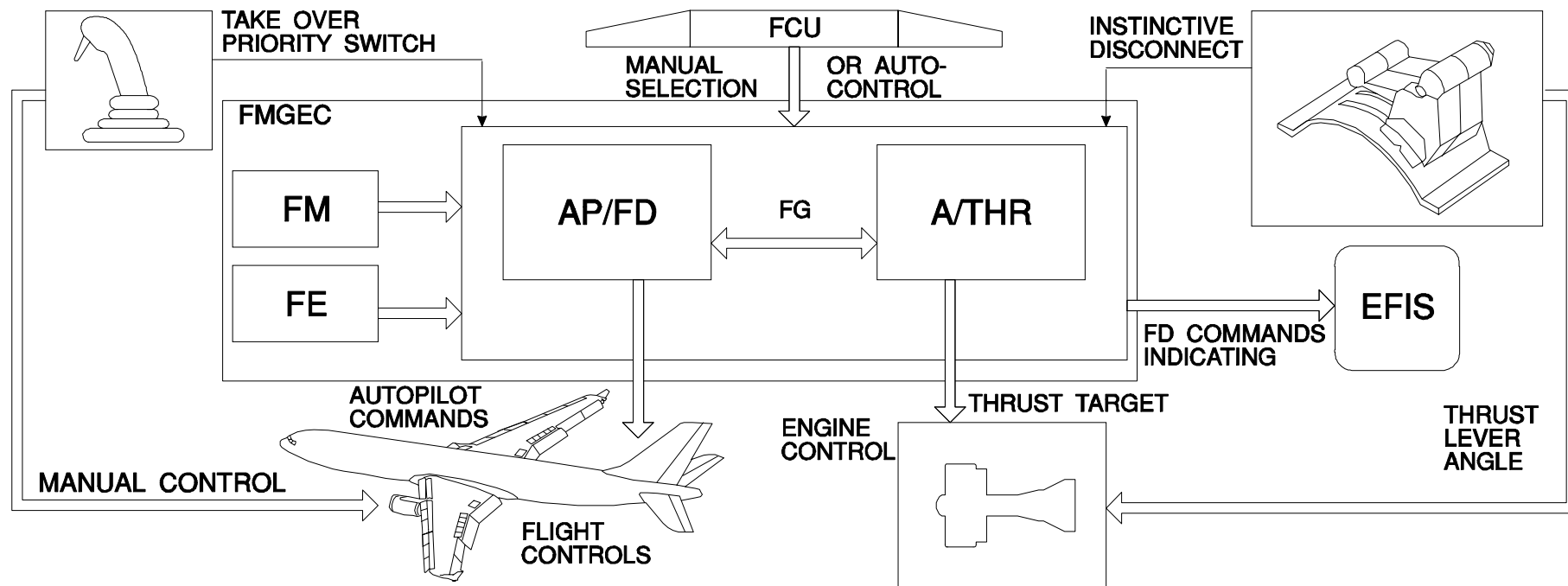
The landing capability availability is displayed on the ECAM status page. The landing capability is displayed on the PFDs (on the Flight Mode Annunciator) when LAND mode is selected. Capability change leads to audio warning "triple click" and new capability display.

FG DISPLAY

The Flight Guidance function displays information on the Primary Flight Display, the Flight Mode Annunciator, the Flight Control Unit and the ECAM page.

AP/FD and A/THR mode indication and engagement status are displayed on the Flight Mode Annunciator. The FD deflection orders are sent to the DMC to be displayed on the PFDs. Additional information is displayed on the PFD such as reference speed.

Landing capabilities are displayed on ECAM STATUS page and FMA. The FG part controls the SPD/M and LAT window displays of the FCU. The FG part controls the lighting of the AFS pushbuttons and indicator light depending on the AP-FD-A/THR engaged functions.



STUDENT NOTES:

FLIGHT MANAGEMENT PRESENTATION

- Purpose
- Flight Plan
- Lateral Functions
- Vertical Functions
- Performances
- Management Displays
- Data Storage
- System Configurations

PURPOSE

The Flight Management part has several functions linked to the flight plan such as lateral and vertical guidance, or displays.

The FLIGHT MANAGEMENT function of each FMGEC, in association with the FCU and two MCDUs, performs :

- aircraft position computation,
- radio nav tuning,
- flight planning,
- lateral navigation and flight phase management,
- speed management,
- performance data,
- displays of flight management data (on MCDU, ND and PFD),
- exchange of information with the ground via the ACARS (if fitted).

FLIGHT PLAN

A typical profile begins with the PREFLIGHT phase at an origin airport through TAKE OFF, CLIMB, CRUISE, DESCENT, APPROACH, and possibly GO AROUND, phases, finishing with the DONE or ROLL OUT phase at a destination airport.

The flight plan is divided into 2 parts : lateral and vertical.

A LATERAL part gives the direction to follow and a VERTICAL part gives the different altitude steps with associated speed and time constraints. To follow the vertical guidance, the lateral guidance must already be active.

The Flight Management performs the flight plan sequencing computation for each type of flight plan.

The FM part provides parameters for several flight plans (F-PLN) such as :

- the PRIMARY F-PLN, which uses parameters such as CO ROUTE, AIRWAYS, TERMINAL PROCEDURES,... for F-PLN assembly,
- the SECONDARY F-PLN, which is prepared for following a new route to a destination mainly depending on fuel consumption,
- the TEMPORARY F-PLN, which is activated when the crew modifies the active flight plan,
- the ALTERNATE F-PLN, which is automatically associated to a primary or a secondary F-PLN, indicating the alternate destination.

LATERAL FUNCTIONS

Flight Management, in association with the Flight Control Unit and two Multipurpose Control and Display Units, performs the lateral navigation.

The lateral functions are :

- initialization of IRSs or GPIRs (if the GPS is installed) and use of their data for A/C position computation,
- navaid selection and tuning (for VOR, DME, ADF, ILS),
- data computation, to be displayed on ND, indicating the A/C position and its lateral deviation from the flight plan,
- lateral steering order computation.

The lateral steering order is followed by the FG part through a specific mode called NAV.

VERTICAL FUNCTIONS

The Flight Management part enables vertical guidance computation in accordance with the lateral flight plan and other data.

The aim of the vertical function is to compute and indicate the optimum cruise flight level limited by top of climb (T/C) and top of descent (T/D). For this, it uses the information sent by the Perfo Data Base and/or entered by the pilot (e.g. cost index, Center of Gravity, weight) :

- vertical flight path construction according to altitudes, speed and time constraints,
- vertical steering order computation.

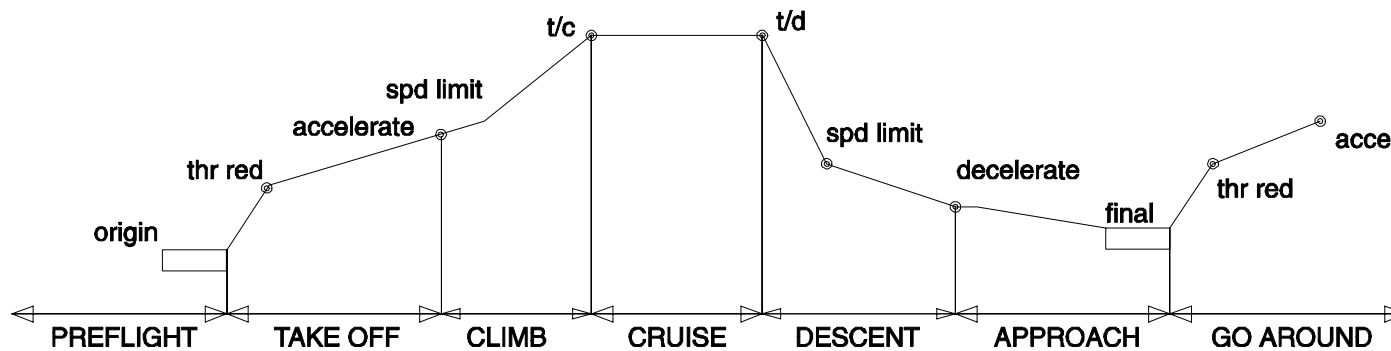
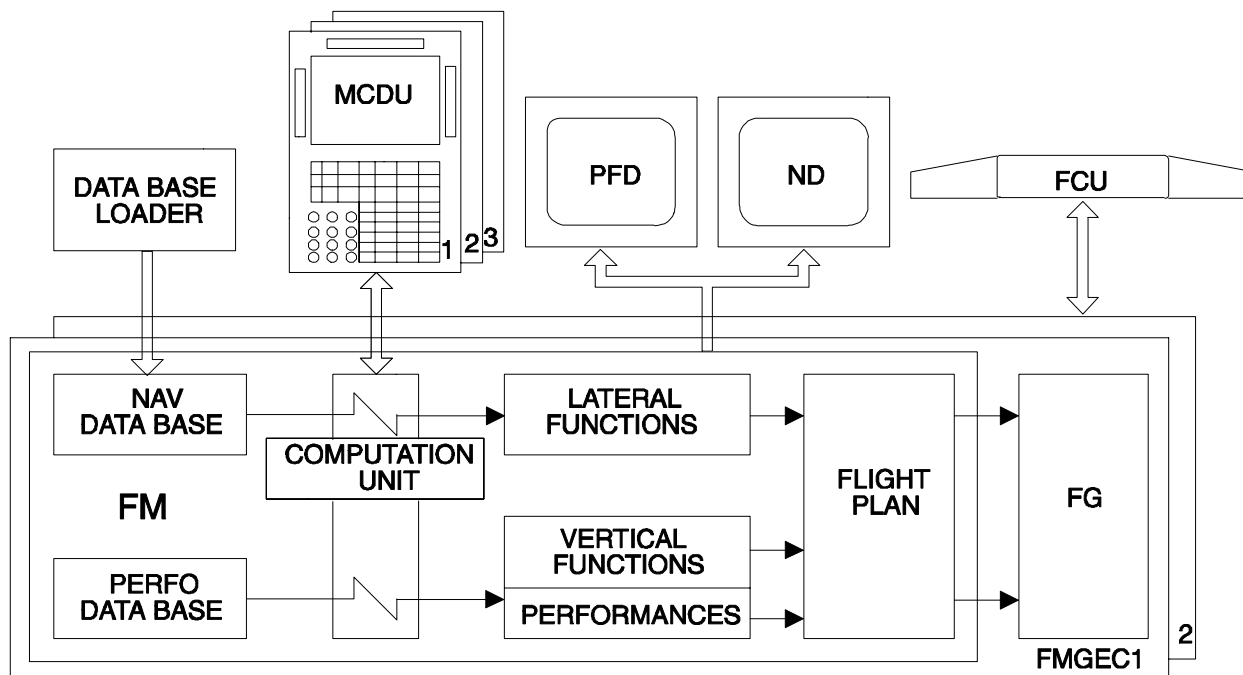
PERFORMANCES

The Flight Management part optimizes the flight plan in terms of speed, thrust, optimum and maximum altitudes. Predictions are provided along the flight path.

The performance function enables the flight cost to be minimized by the optimization of speed, fuel planning and time.

This part also computes predictions along the flight plan such as performance at waypoints (optimum and maximum altitudes, fuel consumption, time to arrival...).

The FM function takes the constraints into account to compute speed, time, altitude and fuel when overflying each waypoint.



FQW4200 GE Metric

MANAGEMENT DISPLAYS

The Flight Management system displays navigation, performance and guidance information through the Multipurpose Control and Display Units, the Navigation Display and the Primary Flight Display for the initialization and the follow-up of the flight plan.

The FM system provides information for MCDU display such as flight plan, constraints, weight and CG, nav aids, performance data...

The FM system displays information on EFIS :

- ND display for F-PLN navigation related data if ROSE-NAV, ARC or PLAN mode is selected,
- PFD display for guidance related data.

Note: If the track-up mode is installed, in ROSE-NAV and ARC modes, the heading dial takes its references from the track and not the heading.

DATA STORAGE

The database is a mass memory, divided into 2 parts : the navigation data base with waypoints, nav aids, runways, for lateral flight plan construction and the performance data base with aircraft aerodynamic and engine models for flight plan optimization.

The navigation data base provides a worldwide coverage. Its content is changed every 28 days by the airline, using a data base external loader (or Multipurpose Disk Drive Unit if fitted). Nevertheless, a small space in the memory is reserved for the pilot entries for new waypoint or nav aid creation. Note that the navigation data base is crossloaded from one FM part to the other.

The performance data base contains fixed data which can only be changed by the manufacturer.

SYSTEM CONFIGURATIONS

The Flight Management part normally operates in dual mode.

Any selection or entry on one side is reported to the opposite side through crosstalk buses. Each computer then makes its own computation and exchanges the various processed data for comparison and validation purposes. Reconfigurations are available to the crew in case of MCDU failures.

One function of MCDU3 is to operate as a BACK-UP for MCDU1 or MCDU2. Priority is given to MCDU1 failure over MCDU2 failure.

Reconfigurations are available to the crew in case of FM failures.

In case of discrepancy detection in dual mode, it is possible, through the FM source selector, located on the switching panel, to reconfigure the two MCDUs to the same FM source.

A Back-up Nav function is available only on MCDU1 or MCDU2.

In case of total loss of FM, it is possible to activate the Back-up Nav function on MCDU1 or 2. In this case, the MCDU itself performs simplified navigation.

STUDENT NOTES:

STUDENT NOTES

FIDS PRESENTATION

Purpose
General
Normal Mode
Menu Mode

PURPOSE

The Fault Isolation and Detection System is the interface between the AutoFlight System and the Centralized Maintenance System.

The Fault Isolation and Detection System (FIDS) performs the following functions :

- detection, isolation and memorization of failures at system level (Normal mode),
- initialization and command of the system test (MENU mode).

Display and interrogation are made by selecting the appropriate control on the MCDU.

GENERAL

The Fault Isolation and Detection System is an electronic device (SOFT + HARD) located in Flight Management, Guidance and Envelope Computer 1. Flight Management, Guidance and Envelope Computer 2 (FMGEC2) is identical to FMGEC1 but the Fault Isolation and Detection System (FIDS) processor is not active.

The FIDS processing is based on failure information provided by the BITE of each AFS computer.

The Built-in Test Equipment (BITE) of Command (CMD) and Monitoring (MONG) channels performs :

- detection, isolation, recording of fault at LRU level (Normal mode).

The fault report is transmitted to the FIDS by the CMD channel. After a FIDS request, in MENU mode, each BITE can be read and the channel tested.

If BITE analysis is not sufficient, the FIDS performs its own analysis by gathering all BITE fault reports.

NORMAL MODE

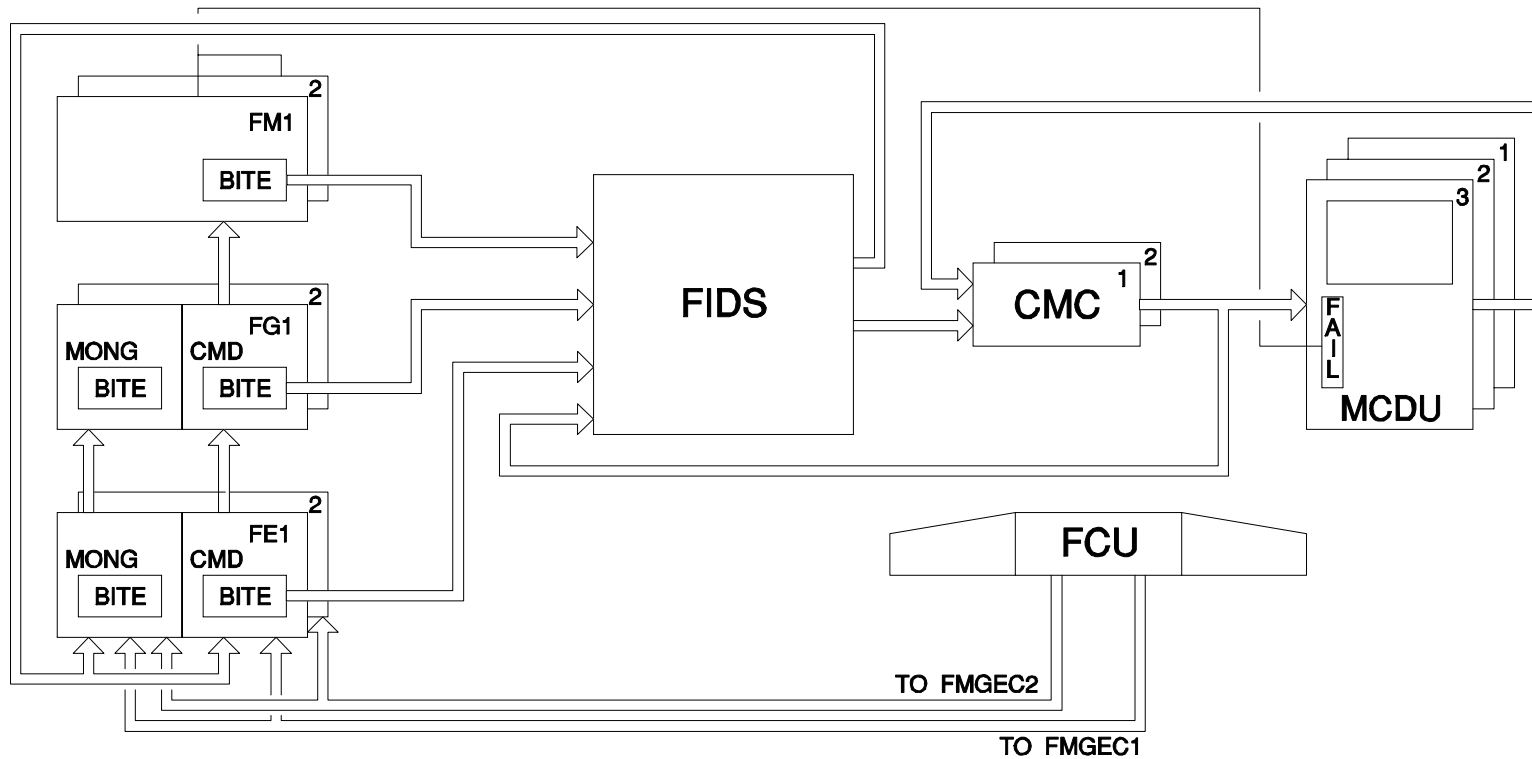
In normal mode, the function of the FIDS is to store all the various BITE analysis results and to transmit this information to the Centralized Maintenance Computer which stores it too.

Centralized Maintenance Computer (CMC) reading is obtained by selecting current leg report in flight or by selecting last leg report or current status on ground.

MENU MODE

By selecting AFS on MENU mode, a request is sent to the FIDS to provide the AFS menu page.

From the AFS MENU page, it is possible to activate the various AFS tests and/or to read the reports stored in the FIDS/BITE.



STUDENT NOTES:

FQW4200 GE Metric

BASIC OPERATIONAL PRINCIPLES

- General
- Data Base Loading
- Power-up Test Engagement
- MCDU Initialization
- A/THR Engagement
- AP Engagement

GENERAL

This sequence describes the operational use of the Flight Management, Guidance and Envelope Computers in a normal operation with a total availability of the concerned functions.

The short-term pilot orders are entered through the FCU. The long-term pilot orders are entered through the MCDU.

Four key-words for the control principle and both types of guidance are to be kept in mind in order to avoid handling errors.

Aircraft control is AUTOMATIC (Autopilot or Autothrust), or MANUAL (pilot action on side stick or on thrust levers). Aircraft guidance is MANAGED (targets are provided by the FMGEC), or SELECTED (guidance targets are selected by the pilot).

DATA BASE LOADING

The data base must be loaded and updated to keep the system operational. Reminder : Only the NAV DATA BASE is periodically updated.

POWER-UP TEST ENGAGEMENT

As soon as electrical power is available, the Flight Director is automatically engaged provided that the power-up is done..

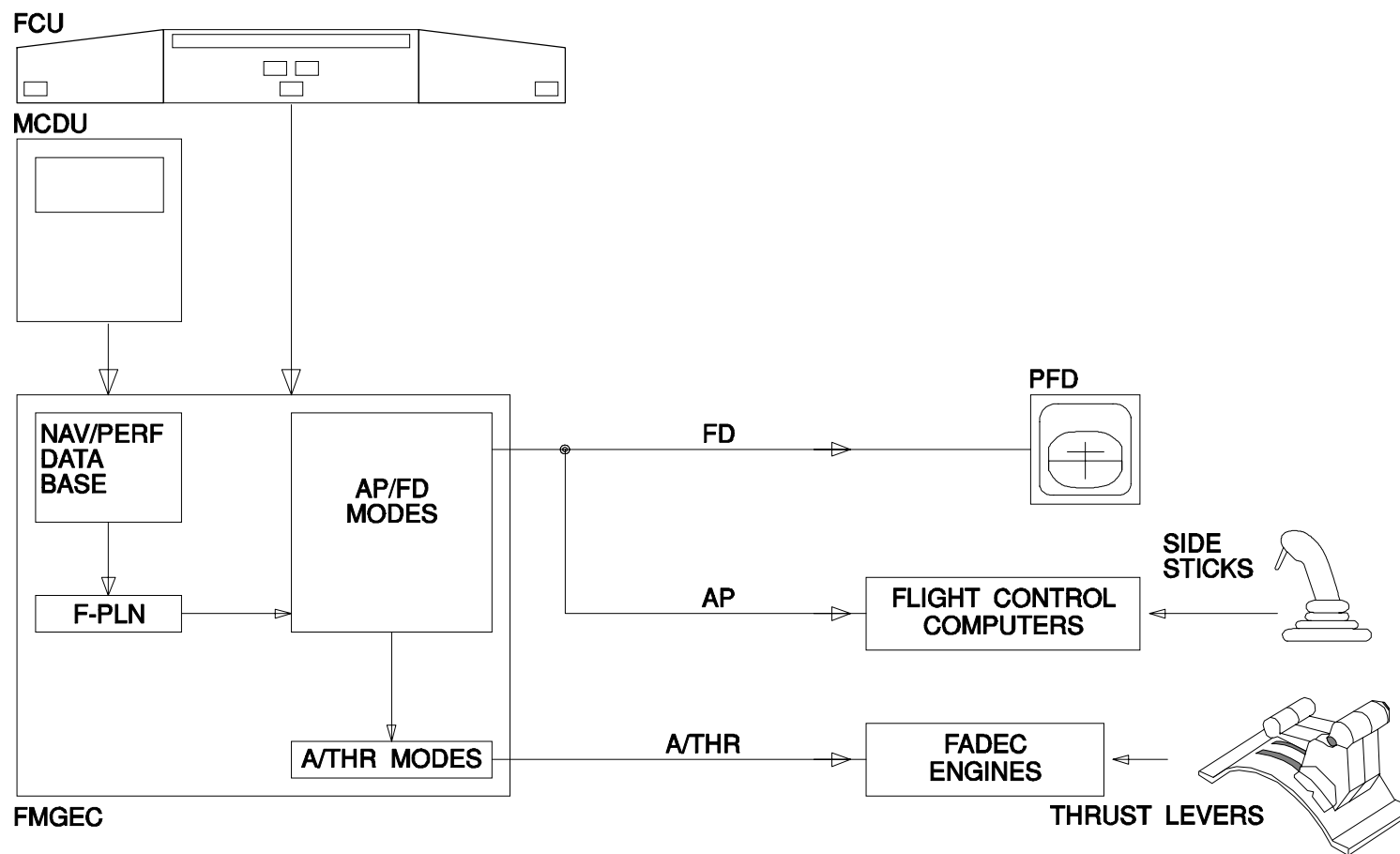
No guidance symbols are displayed until a selected mode active phase is present.

MCDU INITIALIZATION

First, MCDU STATUS page is displayed. Then, the pilot uses the MCDU for flight preparation, which includes :

- choice of the data base,
- flight plan initialization,
- radio nav entries and checks,
- performance data entry (V1, VR, V2 and FLEX TEMP).

V2, at least, must be inserted in the MCDU before take-off. Entry of the flight plan (lateral and vertical) and V2 into the MCDU is taken into account by the FM part and confirmed by the lighting of the associated lights on FCU.



FQW4200 GE Metric

A/THR ENGAGEMENT

Autothrust engagement depends on the movement of the thrust levers for take-off.

When the pilot moves the thrust levers to the TAKE-OFF gate :

- * the FMGEC automatically engages :
 - . the take-off modes for yaw and longitudinal guidance (Speed Reference System(SRS) and RunWay(RWY))
 - . the autothrust function (but it is not active).
- * the FD symbols appear on the PFD.

For take-off, the thrust levers are set to the TO/GA gate or the FLEX-MCT gate if a flexible temperature has been entered on the MCDU.

At the thrust reduction altitude, the FM part warns the pilot to set the thrust levers to CLB gate.

Note : the thrust levers normally will not leave this position until an audio message "RETARD" requests to the pilot to set the thrust levers to IDLE gate before touchdown.

AP ENGAGEMENT

Either Autopilot can only be engaged 5 seconds after lift off. Only one Autopilot can be engaged at a time, the last in, being the last engaged.

After the normal climb, cruise, descent phases, selection of LAND mode (Autoland) allows the second AP to be engaged. After touchdown, during ROLL OUT mode, APs remain engaged to control the aircraft on the runway centerline. Then the pilot disengages the AP at low speed and stops the A/C.

STUDENT NOTES:

FQW4200 GE Metric

STUDENT NOTES

WINDSHEAR, ALPHAFLOOR AND AFT CENTER OF GRAVITY DETECTIONS

- General
- Detection Availability
- Windshear Detection
- AFT Center of Gravity Detection
- Alphafloor Detection

GENERAL

The Flight Envelope (FE) part detects aircraft configurations outside the normal flight envelope such as windshear conditions and aft Center of Gravity (CG) out of tolerated limit.

The Flight Envelope (FE) part also acquires and transmits the alphafloor signal from the Flight Control Primary Computers (FCPC) to the Flight Guidance (FG) part.

FE processings are independent of each other.

A single detection by one of the two Flight Management, Guidance and Envelope Computers (FMGEC) is enough to activate one of these three functions.

DETECTION AVAILABILITY

Windshear detection, AFT CG detection or alphafloor detection depend on flight conditions.

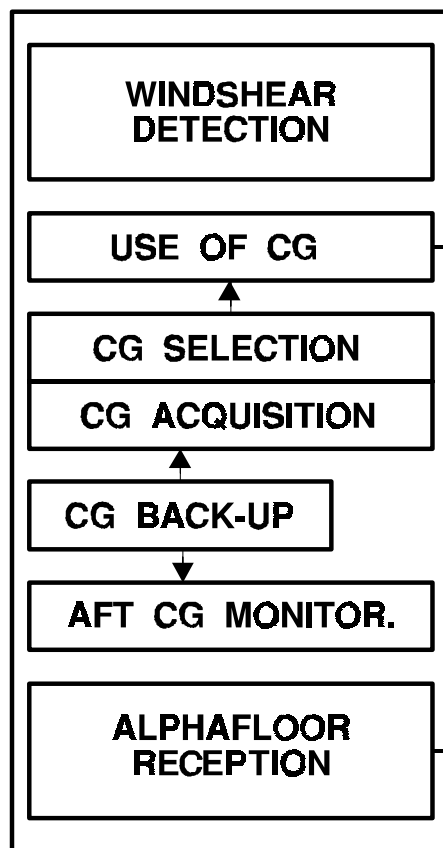
Windshear detection is available during 30 seconds after Take-Off under 250 feet Radio Altimeter (RA) and from 1300 feet RA to 50 feet RA in approach. It is inhibited in clean configuration.

AFT CG detection is available in clean configuration and above 20,000 feet.

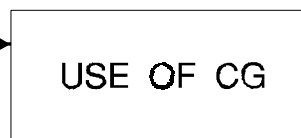
Alphafloor detection is available from take-off to a radio altitude of 100 feet before landing.

FMGEC1

FE



FM



FG



FMGEC2

SAME AS FMGEC1

WINDSHEAR DETECTION

If windshear is detected, the Flight Envelope (FE) function computes a windshear warning.

A visual indication is given on the Electronic Flight Instrument Systems (EFIS) and an aural warning can be heard from the cockpit loudspeakers.

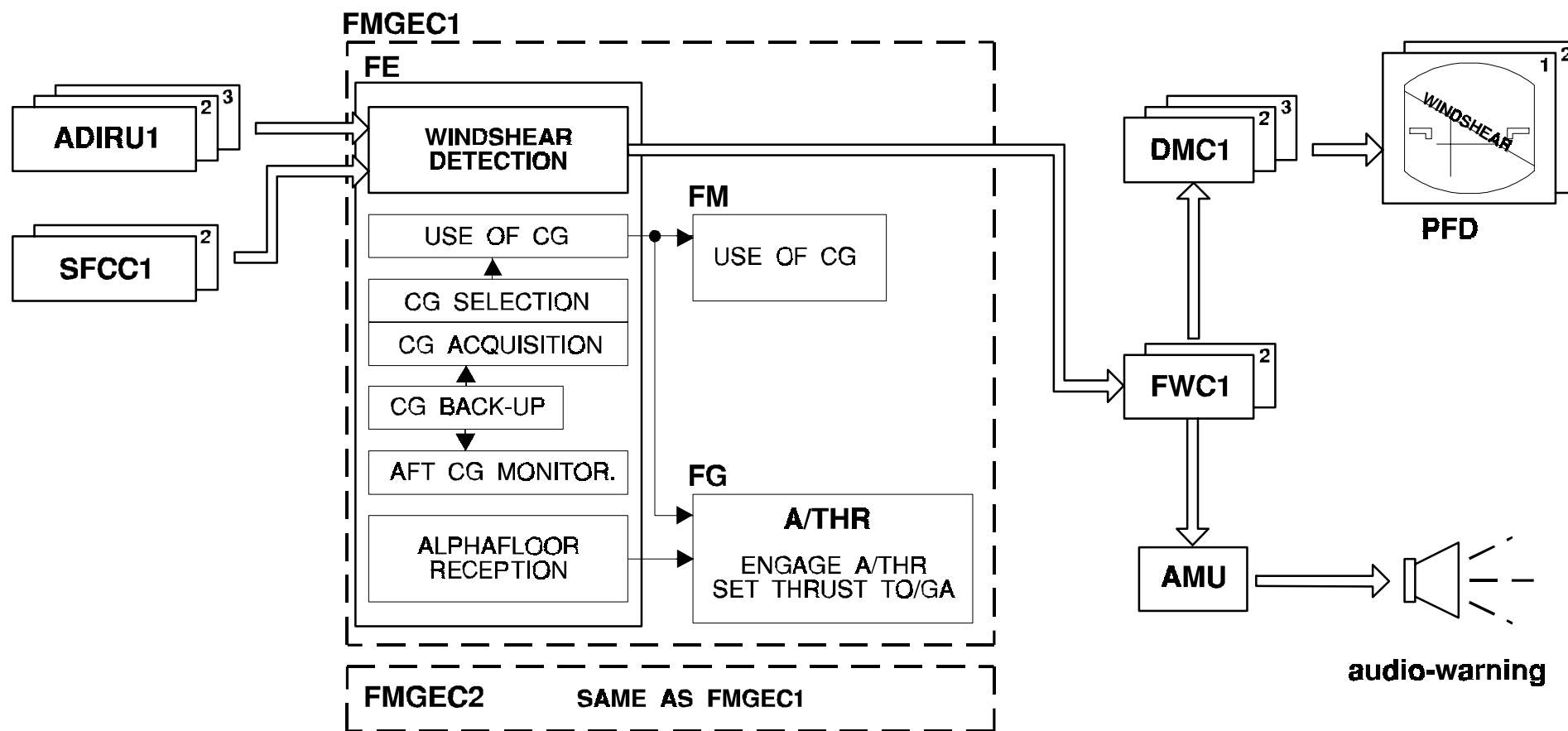
This signal computation is based on an algorithm taking into account longitudinal shears, vertical acceleration, wind components and slat/flap position.

The warning is triggered depending on the shear intensity and a minimal safe aircraft energy (according to speed and flight path).

NOTE :

If both Radio Altimeters (RAs) have failed, the windshear warning is not available.

This warning loss is displayed on the ECAM status page.



AFT CENTER OF GRAVITY DETECTION

In order to improve aircraft performance, the Fuel Control and Monitoring Computer (FCMC) controls the AFT Center of Gravity (CG) position by transferring fuel forward.

The Flight Envelope (FE) function monitors the non-overshoot of the aft CG limits by a computation fully independent of the Fuel Control and Monitoring Computer.

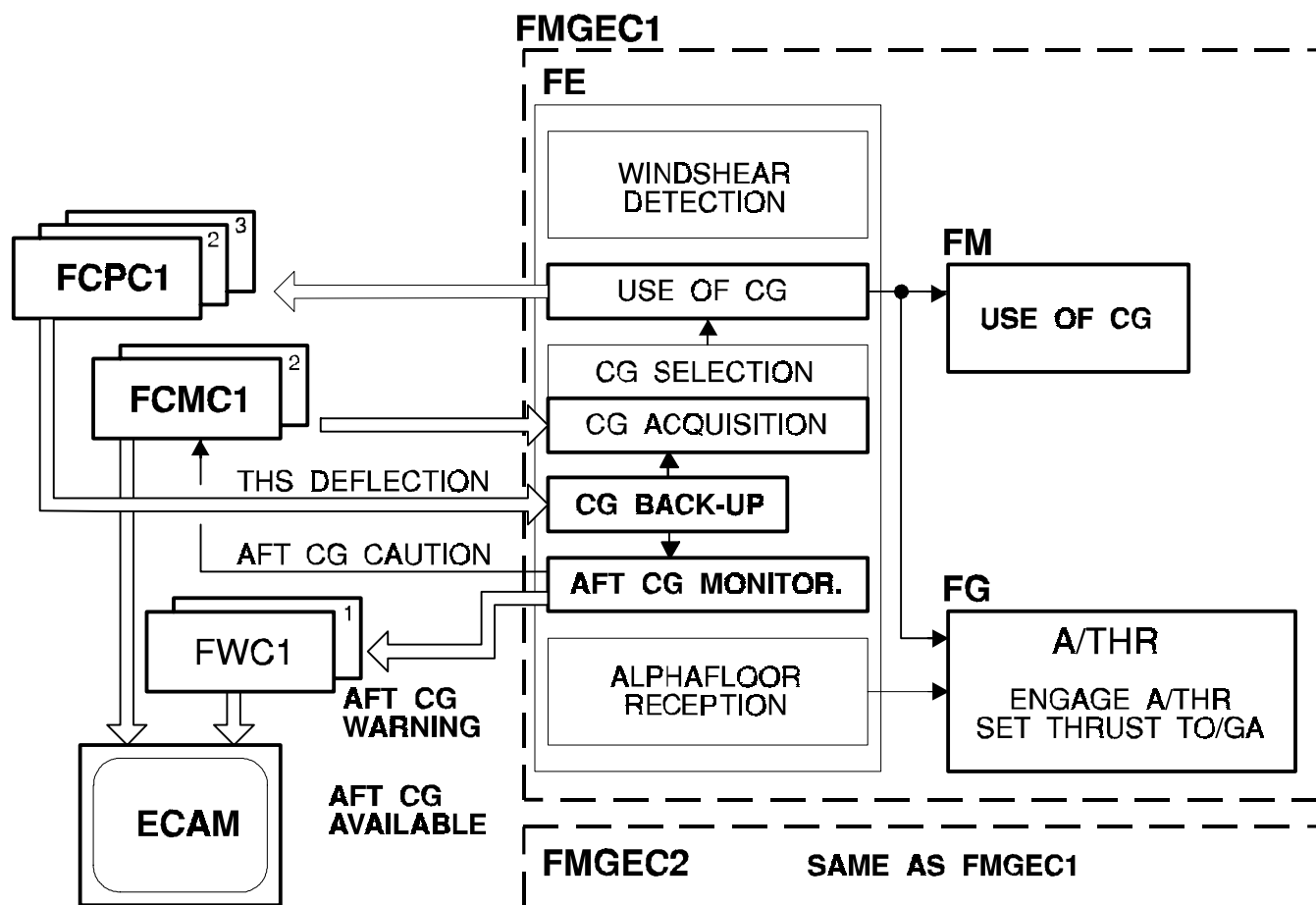
In case of overshooting, the Flight Envelope function provides the Fuel Control and Monitoring Computers with an aft CG caution signal.

If the CG is greater than the limit CG-1%, the information is transmitted to the FCMCs which transfer all trim tank fuel forward.

The Flight Envelope function provides the Flight Warning computers with a CG monitoring availability signal.

If the CG is greater than the limit CG, the Flight Envelope function sends, to the Flight Warning Computers (FWC), an AFT CG warning signal followed by an ECAM message.

AFT CG warning and caution are computed with CG and weight estimations made by the FE part, independent of the FCMC, mainly by using Trimmable Horizontal Stabilizer (THS) deflection.



FQW4200 GE Metric

ALPHA FLOOR DETECTION

The Flight Envelope (FE) part only acquires the Alpha floor detection/activation signal coming from the Flight Control Primary Computer (FCPC).

This creates the Alpha floor condition.

The FE part is involved as a letter box between the FCPCs and the Flight Guidance (FG) part.

The alpha floor condition is used by the FG part and the opposite FMGEC.

It activates the alpha floor protection of the Autothrust (A/THR) function when the detection is made by at least one of the three FCPCs.

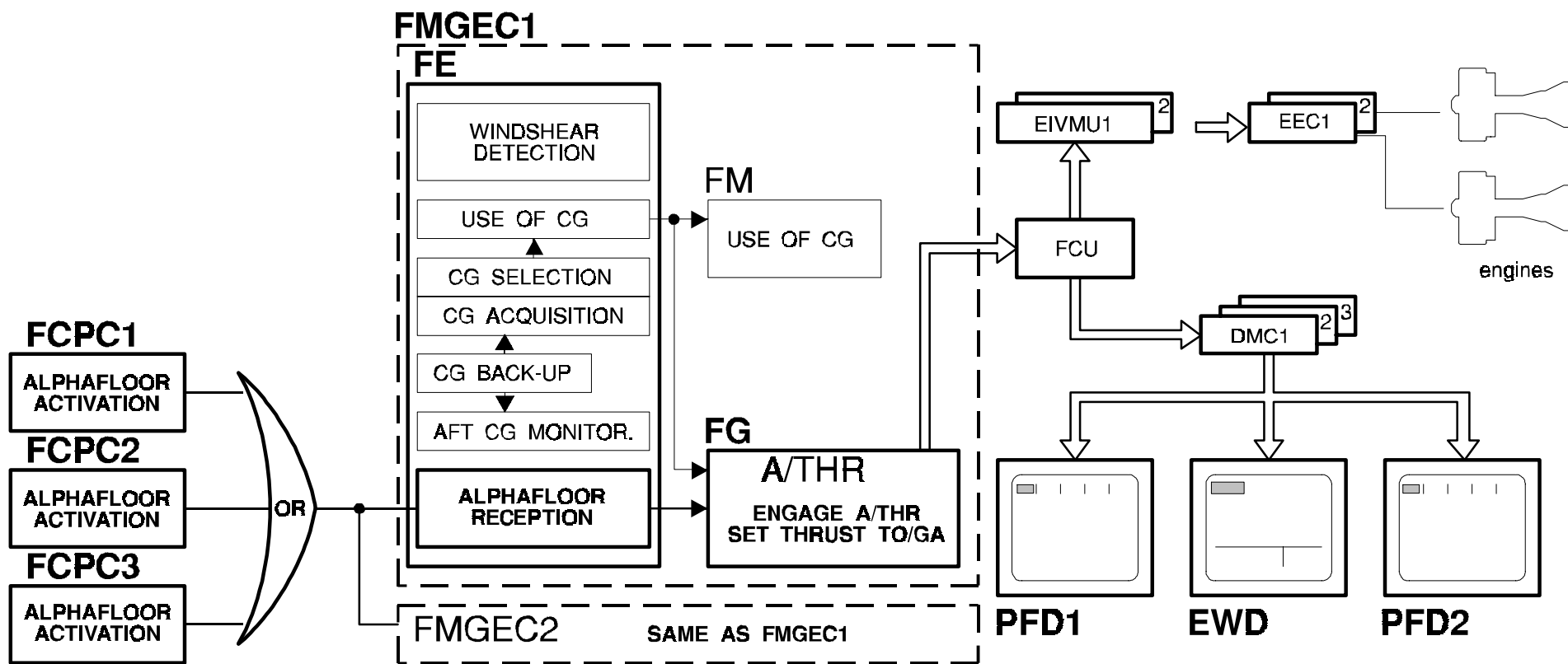
The alpha floor detection function has a full authority on the Autothrust via the Flight Guidance part.

It forces the A/THR to Take-Off/Go Around (TO/GA) thrust even if the A/THR was not previously engaged.

The full thrust signal is sent to the engines via the Flight Control Unit (FCU), the Engine Interface and Vibration Monitoring Unit (EIVMUs) and the Electronic Engine Controls (EECs).

Warning messages are displayed on the Primary Flight Display (PFD) and on the Engine Warning Display (EWD).

The FE function provides the Display Management Computers (DMCs) via the FCU with a Flight Mode Annunciator (FMA) amber message "A.FLOOR" in the A/THR zone and an Engine Warning Display amber message "A FLOOR" at the top left of the screen.



FQW4200 GE Metric

STUDENT NOTES:

FQW4200 GE Metric

OPERATIONAL SPEED COMPUTATION AND DISPLAY

F Speed
S Speed
VLS
VMAN Green Dot
VMAXOP
VMAX
VFEN
VCTREND

The Flight Envelope function computes the limit and maneuvering speeds which are displayed on the speed scale of the Primary Flight Display.

F SPEED

F speed is a maneuvering speed which means minimum flap retraction speed and corresponds to the speed at which flaps can be retracted.

Presentation on the PFD :

F speed is available one second after shock absorber extension and when the slat/flap lever is in position 3 and 2 (that means 26° and 22°).

F speed is represented by a green "F" on the speed scale.

S SPEED

S speed is a maneuvering speed which means minimum slat retraction speed and corresponds to the speed at which slats can be retracted.

Presentation on the PFD :

S speed is available one second after shock absorber extension and when the slat/flap lever is in position 1 (20°).

S speed is represented by a green "S" on the speed scale.

VLS

VLS means lower selectable speed. It is the minimum selectable speed for the actual slat and flap configuration taking into account the control lever position, the real surface position and the speedbrake configuration.

The lowest selectable speed (VLS) provides a safety margin in order to avoid stalling at low speed and buffeting during cruise (throughout the flight envelope).

It is used by the AFS in order to prevent speed undershoot.

Presentation on the PFD :

VLS is displayed one second after shock absorber extension and for all slat/flap configurations.

It is represented by the top of an amber strip in the lower part of the speed scale.

VMAN GREEN DOT

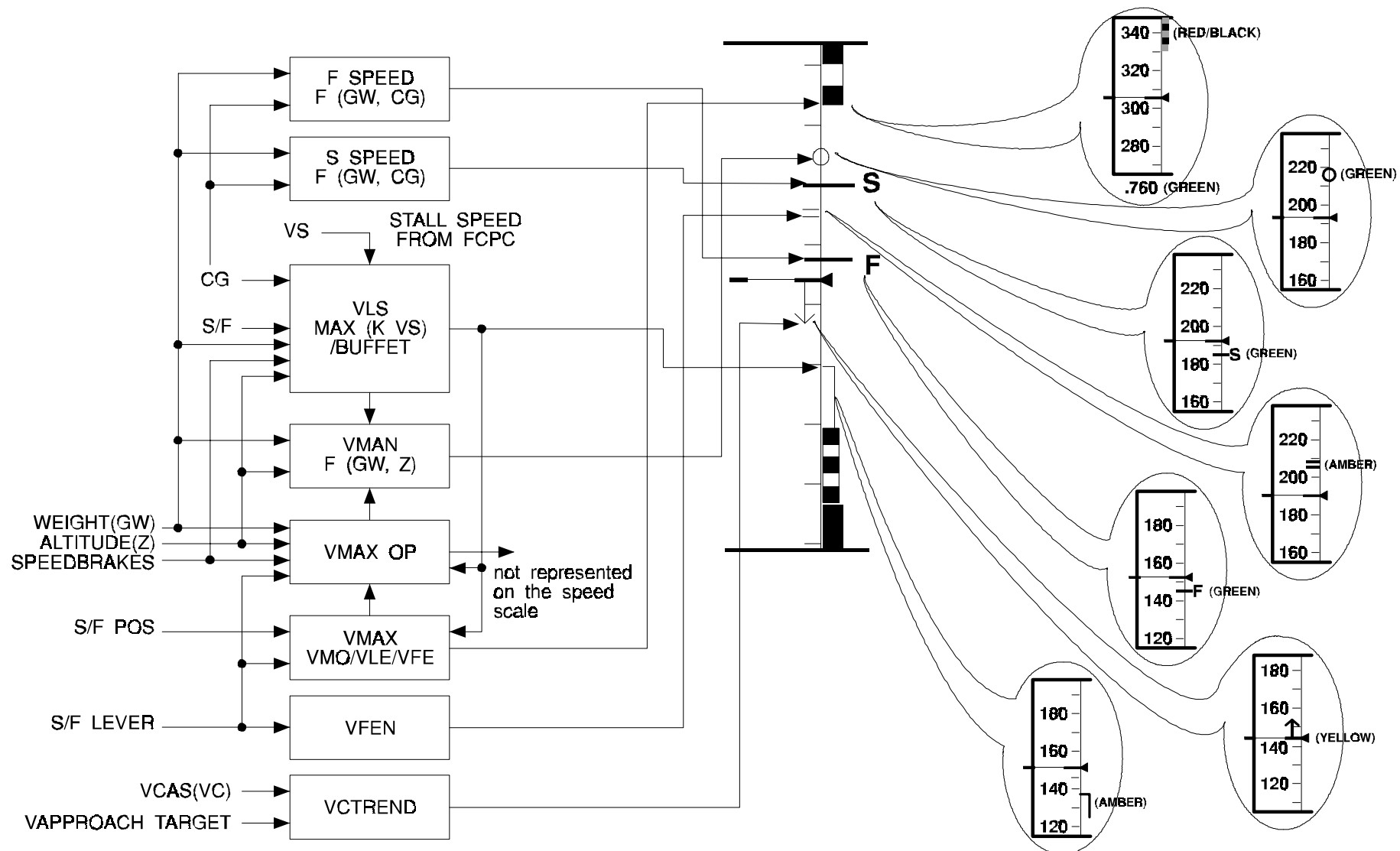
VMAN is a maneuvering speed and is a function of the weight, the altitude and the number of engines running. It is the optimum speed in the event of one engine failure.

VMAN (maneuvering speed or GREEN DOT) is limited by the maximal operational speed (VMAXOP) and the lowest selectable speed (VLS).

VMAN is available when the aircraft is in flight and in clean configuration.

Presentation on the PFD :

It is represented by a green dot on the speed scale.



FQW4200 GE Metric

VMAXOP

VMAXOP is the maximal operational speed used as a limit in the Flight Guidance part. Note that it is not presented on the Primary Flight Display.

In clean configuration, the maximal operational speed (VMAXOP) corresponds to the buffeting limit at 0.2g with respect to weight and altitude.

It is limited by :

- the maximal speed (VMAX) - 5kts and the lowest selectable speed (VLS) in clean configuration,
- the maximum flap extended speed (VFE) and VLS with flaps and slats extended.

VMAX

VMAX speed is the maximal speed. It is used by the Auto Flight System in order to prevent excessive speed.

The maximal speed (VMAX) corresponds to :

- the Maximum Operating Speed/Mach (VMO/MMO) in clean configuration, landing gear retracted,
- the Maximum Landing Gear Extended Speed (VLE) in clean configuration and landing gear extended,
- the Maximum Flap Extended Speed (VFE) with slats and flaps extended, VFE being a function of S/F lever position VMAX is presented only in flight conditions.

Presentation on the PFD :

It is defined by the lower end of a red and black strip in the upper part of the speed scale.

VFEN

VFEN corresponds to the maximum flap and slat extension speed of the next slat/flap configuration.

The predictive Maximum Flap Extended Speed at next S/F position (VFEN) is only function of the slat/flap control lever position.

Presentation on the PFD :

VFEN is displayed below 14625 ft except when flaps are fully extended.

It is indicated by two amber dashes.

VCTREND

VCTREND represents the airspeed tendency, that means the aircraft acceleration or deceleration.

The airspeed tendency (VCTREND) is computed to represent the speed that the aircraft would have 10 seconds later if the acceleration remains constant.

Presentation on the PFD :

VCTREND is displayed if Vc is higher than 30 kts.

It is defined by a yellow pointer initiating in A/C actual speed symbol.

STUDENT NOTES:

FQW4200 GE Metric

STUDENT NOTES

FLIGHT ENVELOPE CONSOLIDATION

- General Acquisition Principle
- Acquisition Consolidation
- Parameter Acquisition Monitoring
- IR Monitoring
- ADR Monitoring
- FCPC Monitoring
- LGCIU Monitoring
- SFCC Monitoring
- EEC Monitoring
- FCMC Monitoring
- VOR Monitoring
- RA/ILS Monitoring
- FCU Monitoring

GENERAL ACQUISITION PRINCIPLE

To provide a good level of confidence in Flight Envelope computations, the Flight Envelope part includes two independent computation channels.

These computation channels include :

- duplicated Input/Output circuits,
- central processor units,
- power supplies,
- different unsynchronized clocks for each channel.

Command and monitor channels are physically segregated and programs of the computation are dissimilar.

Crosstalks between both lanes are achieved through ARINC 429 lines and through some hardware discretes.

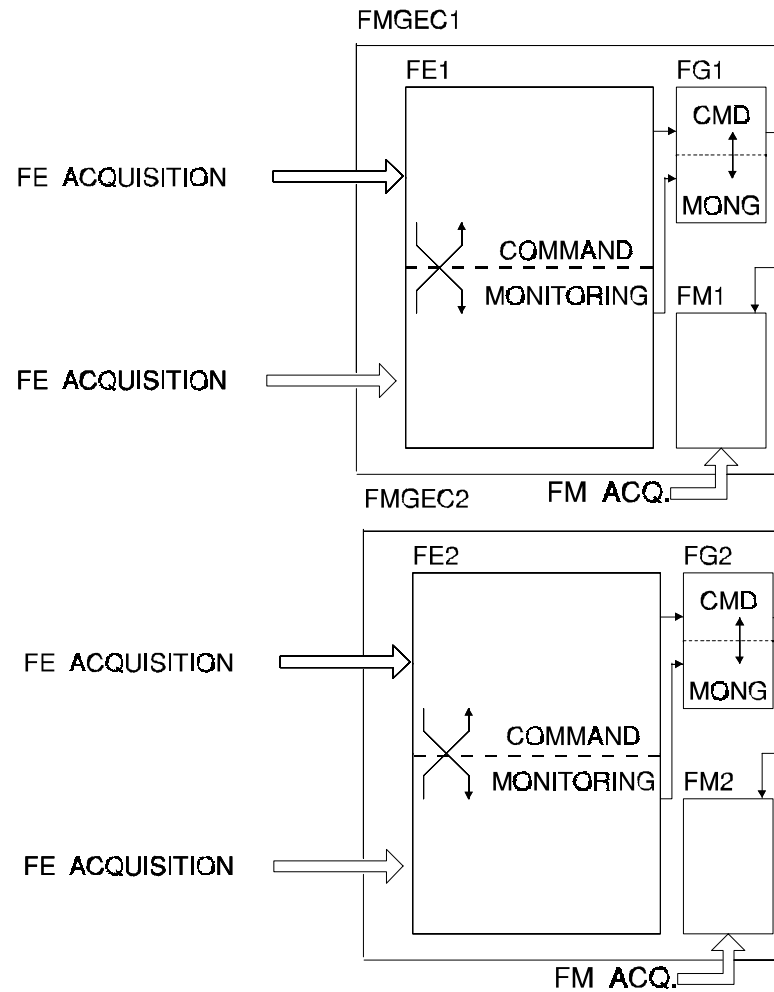
This data exchange is used for monitoring purposes and for transferring parameters that are acquired or computed by only one lane.

NOTE : The Flight Management (FM) part directly acquires some information.

ACQUISITION CONSOLIDATION

The FE function filters and consolidates the parameters used by the control laws.

These parameters are limited in speed and amplitude to passivate erratic values.



FQW4200 GE Metric

PARAMETER ACQUISITION MONITORING

The Flight Envelope part ensures the monitoring of acquisitions by decoding the Sign Status Matrix (SSM) of the received labels and the monitoring of the received data by two-by-two parameter comparison.

The comparison of parameters is separated from the computations made by the voter and the passivator.

The COMPARATOR verifies if there is a drift by comparing parameters two-by-two.

The fast parameters (such as accelerations, rotation speed) are PASSIVATED while the slow parameters (altitudes) are VOTED.

VOTER PRINCIPLE

The VOTER is a three-input-circuit (1, 2, 3). The voter output is the input signal of which the amplitude is comprised between the 2 other input amplitudes. Three inputs are necessary to vote one of them

If one input is missing, it is replaced by a zero value. If two inputs are missing, the vote is no longer possible, so the alternate selection is performed to bypass the voter and input 1 (OWN or 3) is directly taken.

Each FE part uses the voter principle for monitoring some Inertial Reference parameters. Its application will be shown in the IR MONITORING topic.

PASSIVATOR PRINCIPLE

The PASSIVATOR is a three-input-circuit (1, 2, 3). The operation of the passivator is similar to the voter but gives priority to INPUT1.

Input 1 (I/P1) is the valid signal when its value is within the range of (I/P2 +/- TOL1) and (I/P3 +/- TOL2). (TOL : tolerance) These two values determine a MAXIMUM and a MINIMUM. The passivation occurs when I/P1 is out of tolerance, it is then limited by the MAXIMUM or the MINIMUM value according to the closest value.

NOTE : I/P1 is either IR OWN or IR 3 according to the pilot selection on the IR switching panel. This is possible only if IR OWN and 03 are valid.

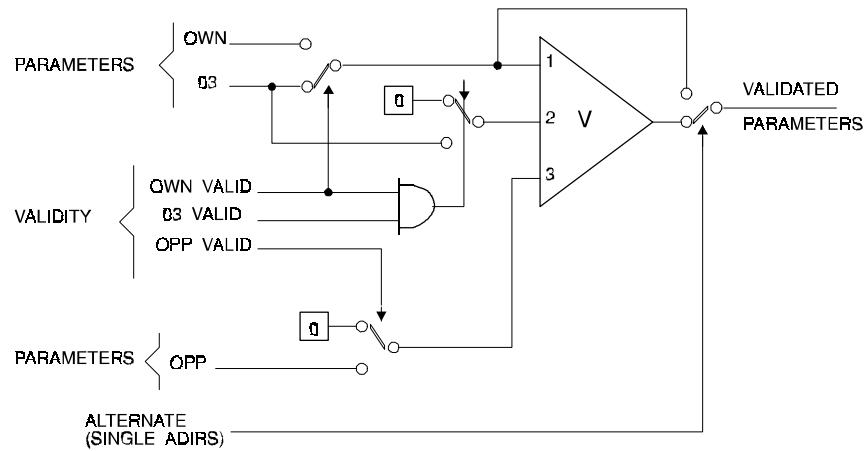
Three inputs are necessary to passivate. If I/P1 is missing, the passivator is useless : it is lost.

This is a reason why two possible data (e.g. : IR OWN/IR 3) are connected to this input : if one data is lost, the other one is automatically used independently of the pilot selection.

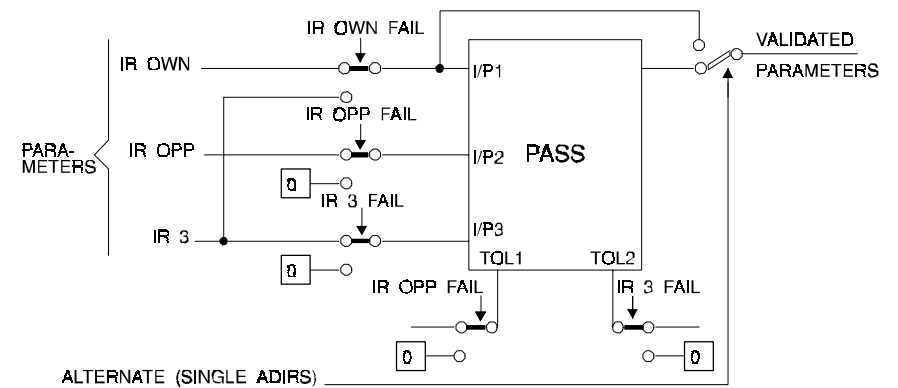
If one of the 2 others fails, I/P2 or I/P3, it is replaced by a null value. If I/P2 and 3 are missing, the passivation is no longer possible, so an alternate selection is performed to bypass the passivator : I/P1 is directly taken.

The FE part uses the passivator principle to monitor some IR parameters. Its application will be seen in the "IR MONITORING" topic.

VOTER PRINCIPLE



PASSIVATOR PRINCIPLE



IR MONITORING

The monitoring functions, performed on the Inertial Reference labels, permit the elimination of wrong signals from the affected source.

The Flight Envelope (FE) command channel acquires the 3 Inertial Reference data from the 3 ADIRUs. The FE monitoring channel acquires IR OWN and IR 03.

TWO-BY-TWO COMPARISON OF CRITICAL PARAMETERS
PITCH ANGLE ROLL ANGLE PITCH RATE ROLL RATE YAW RATE VERTICAL ACCELERATION VERTICAL SPEED (BARO INERTIAL) GROUND SPEED MAGNETIC HEADING

In normal operation, with the 3 IR valid, the configuration is the following :

- on the command side, the FE computations, used by the FG/FM parts, use the critical parameters (voted or passivated) from the 3 IRs and, all the other parameters according to the pilot selection on the IR switching panel : IR OWN or IR 03;
- on the monitoring side, all the parameters are selected between those of IR OWN or IR 03, according to the pilot selection.

In case of a single failure, there is no immediate consequence, but a downgrading of the landing category.

On the command side, the parameters from the lost IR are replaced by fixed values (in general "0") at the voter/passivator inputs.

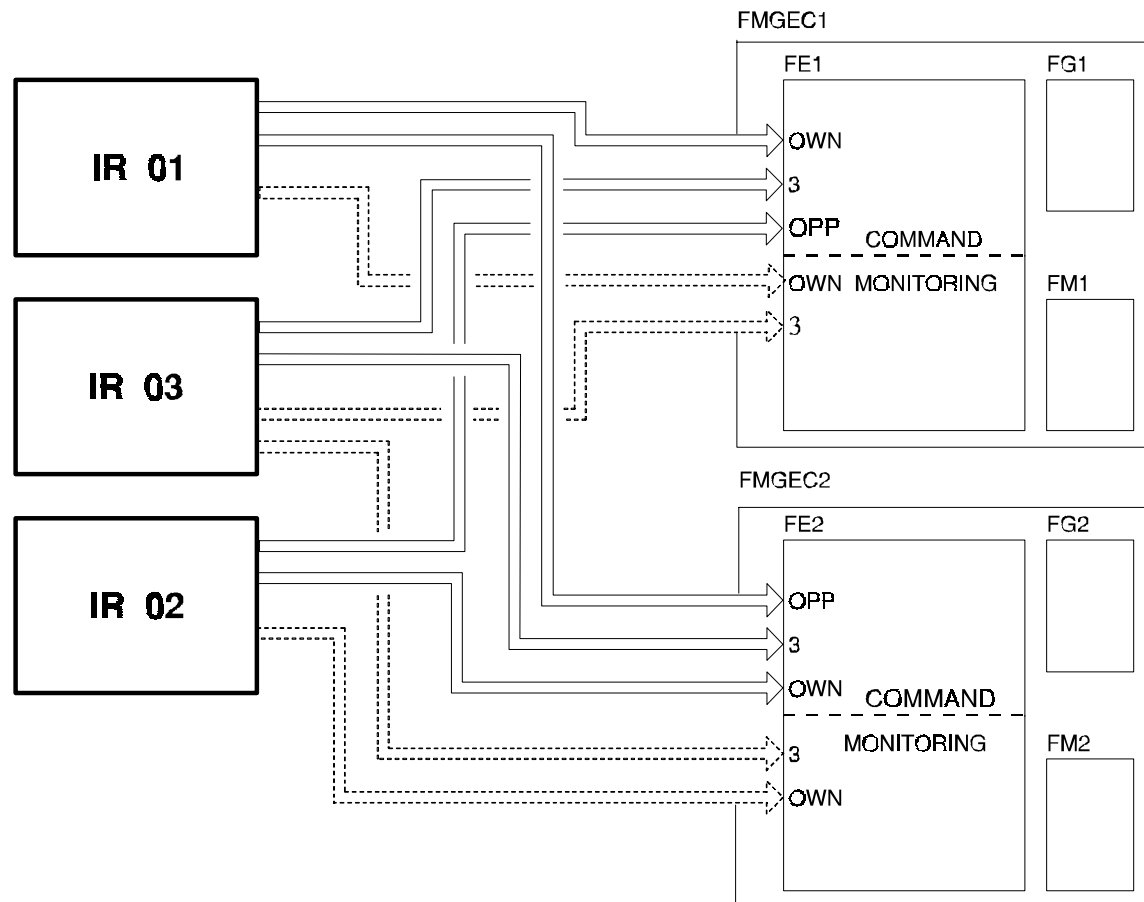
If the IR OPP is lost, the selection between IR OWN and IR 03 is identical, and still consistent with the pilot selection.

If IR OWN or IR 03 is lost, the selection is forced whatever the pilot demand.

In case of dual failure, the Flight Guidance functions are lost while the FE functions remain on one side or both sides (FE1 and FE2) if the remaining IR is IR 03.

On the command side, the critical parameters are monitored by Flight Control Primary Computers using the following parameters : specific accelerometers and rate gyro units.

IR MONITORING



FQW4200 GE Metric

ADR MONITORING

The monitoring function performed on the Air Data Reference labels is similar to the IR label monitoring, but there is only a comparison two-by-two of the source critical data which is performed here in the monitoring channel.

The FE command side receives ADR OWN and ADR 03 buses. The FE monitoring side receives ADR OWN, ADR OPP and ADR 03 buses for comparison purposes.

TWO-BY-TWO COMPARISONS OF CRITICAL PARAMETERS
COMPUTED AIRSPEED (CAS) MACH STANDARD ALTITUDE

All the ADR parameters used by the Flight Envelope and Flight Guidance functions are acquired by the FE COMMAND side.

The FE monitoring side only acquires the parameters compared and/or used by the duplicated functions (such as the speed computation).

The FE monitoring computation takes into account the result generated by the FE command side which monitors all the ADR parameters.

In normal operation, with the 3 ADRs valid, the configuration is the following :

- on the command side, the parameters are selected between those of ADR OWN and ADR 03, according to the pilot selection on the ADR switching panel.
- on the monitoring side, the critical parameters are monitored by comparison and the used parameters are selected between ADR OWN and ADR3, still according to the pilot selection.

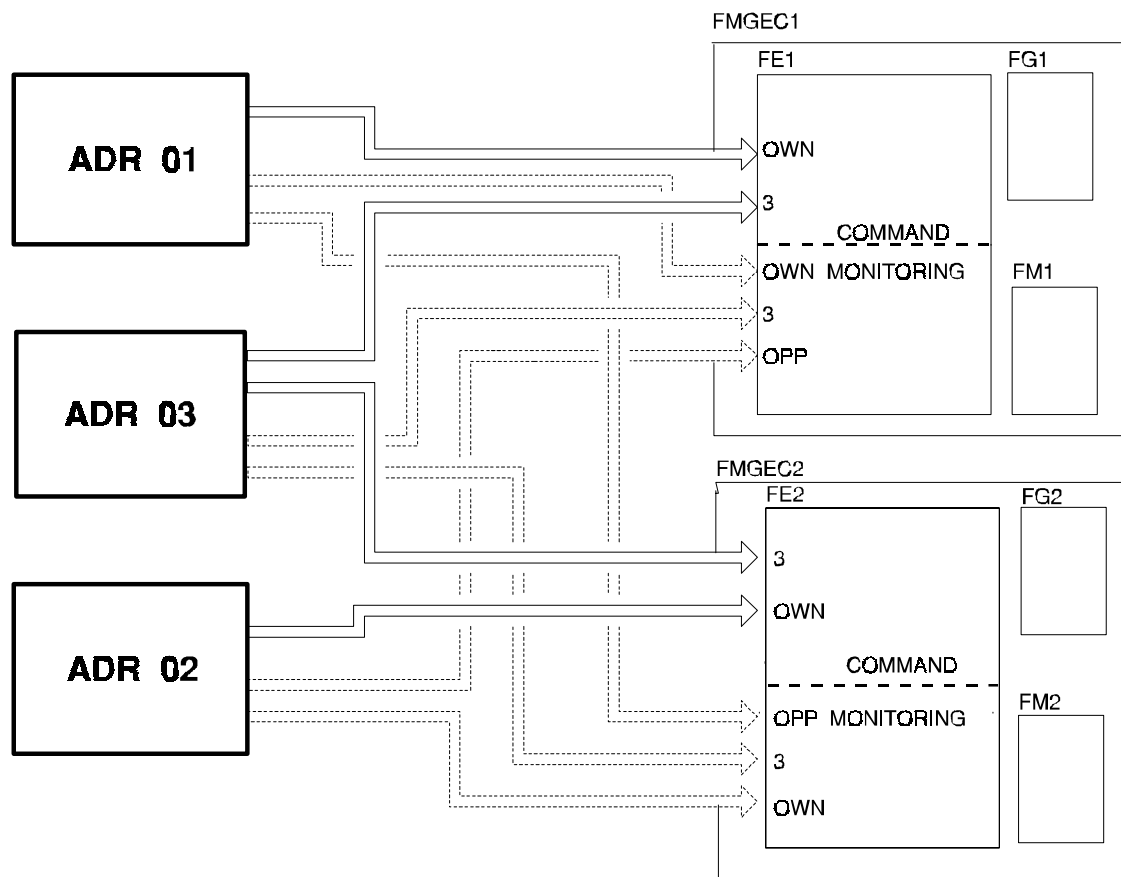
In case of loss of one ADR, that means a single failure, the comparisons with the parameters from the faulty ADR are not taken into account.

With the ADR OWN or ADR 03 lost, the parameter selection is forced to the valid ADR, independently of the pilot selection on the ADR switching panel. If ADR2 fails, this input is ignored, and the selection between ADR OWN and 3 is still consistent with the pilot selection.

A single ADR failure has no immediate consequence, but this leads to a downgrading of the landing category.

In case of loss of two ADRs, the FG functions are lost.
The FE functions are kept on one or both sides.

ADR MONITORING



FQW4200 GE Metric

FCPC MONITORING

The acquisition of the buses from the three FCPCs is identical on the command and monitoring sides.

ACQUIRED PARAMETERS
.AVAILABILITY AND REDUNDANCIES OF CONTROL SURFACES .SIDESLIP .STALLING SPEED .VERTICAL LOAD FACTOR .ALPHAFLOOR DETECTION

Note that in case of a dual IR failure, FCPC parameters are acquired to monitor the critical parameters from the last valid IR.

In the normal case, the FE command and monitoring sides receive the FCPC OWN parameters.

In case of loss of FCPC OWN, the FE COMMAND and MONITORING sides receive the FCPC 03 parameters.

In case of loss of FCPC OWN and FCPC 03, FCPC OPP is selected.

In case of loss of the three FCPCs, the FG and FE functions are lost.

NOTE : The FCPC availability takes into account the FCSC validity.
One of the two FCSCs must be valid with any FCPC.

LGCIU MONITORING

The Flight Envelope part acquires the buses of the OWN and OPP Landing Gear Control and Interface Units.

This data is then compared to the status of the hardwired discrete coming from the Landing Gear Control and Interface Unit

MONITORING PARAMETERS
NOSE GEAR LEFT GEAR RIGHT GEAR

(LGCIU) : nose gear pressed.

This data is used to generate the flight/ground conditions.

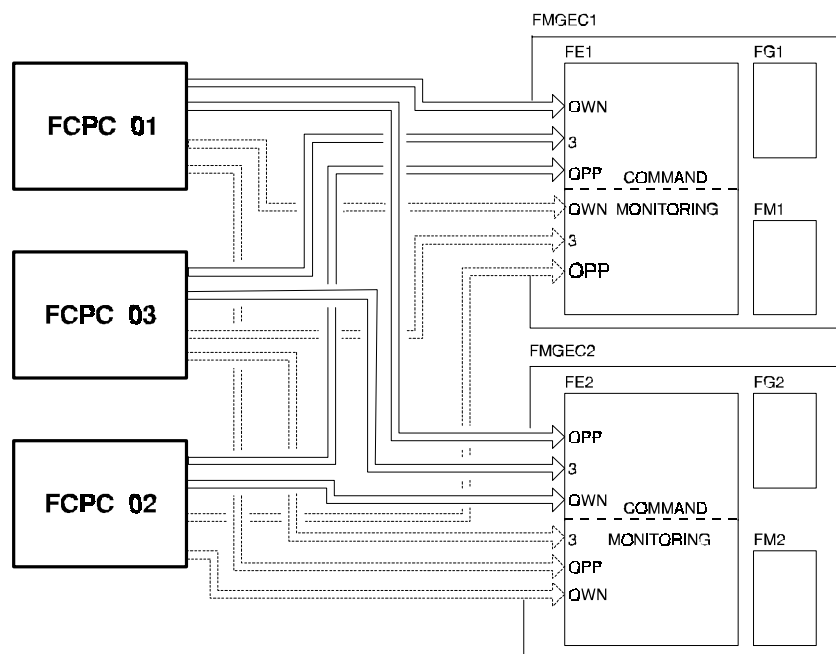
Upon loss of LGCIU OWN validity, the opposite side is selected.

In case of a dual LGCIU failure, the configuration used in the computation is obtained from the Slat/Flap Control Computer.

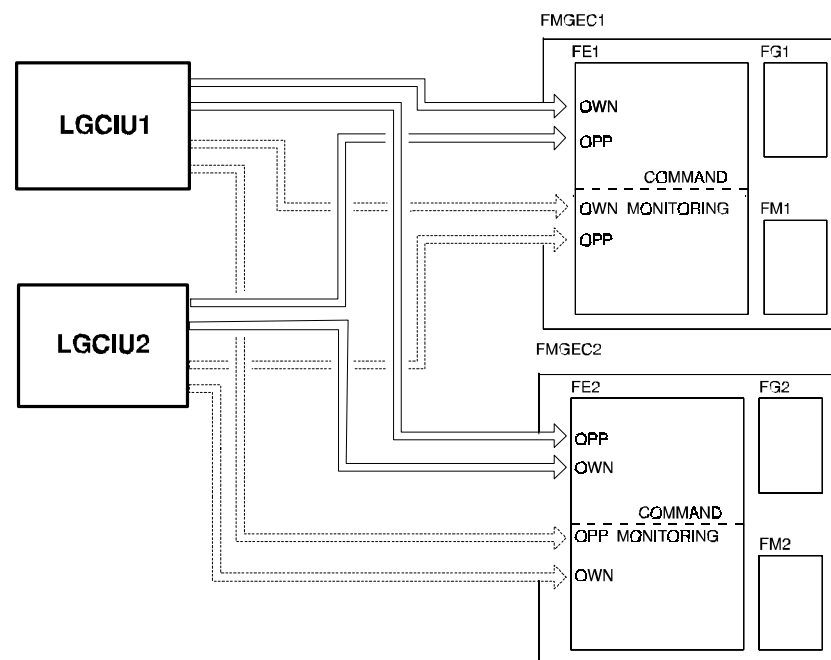
A clean configuration will indicate a retracted landing gear condition.

The slats and flaps extended will indicate an extended landing gear condition.

FCPC MONITORING



LGCIU MONITORING



SFCC MONITORING

The Flight Envelope part acquires the buses of the OWN and OPP Slat/Flap Control Computers.

The FE part monitors the data consistency of the flap and slat control lever position, transmitted on two different labels by the Slat Flap Control Computer (SFCC).

This data is then compared with the status of the hardwired "SLATS EXTENDED" discretes, also coming from the SFCC. It is used to generate the flight/ground conditions.

Upon loss of one label of the Slat/Flap Control Computer OWN, the opposite side is selected.

In case of a dual SFCC failure the configuration used in the computation is obtained from Landing Gear Control and Interface Unit.

The extended landing gear will indicate "FLAPS AND SLATS FULLY EXTENDED". The retracted landing gear will indicate a CLEAN CONFIGURATION.

EEC MONITORING

The Flight Envelope command and monitoring sides receive all engine data, according to a physical distribution, FE1 on the left side and FE2 on the right side.

Each FE side receives data from Electronic Engine Controls (EECs) via channels A & B, and performs the selection of the channel in control given by the related EEC.

PARAMETER ACQUISITION/MONITORING
THRUST LEVER ANGLE (TLA) SELECTION EPR TLA WEIGHT FUEL USED (WFU) EPR LIMIT EPR TARGET FEEDBACK EPR ACTUAL

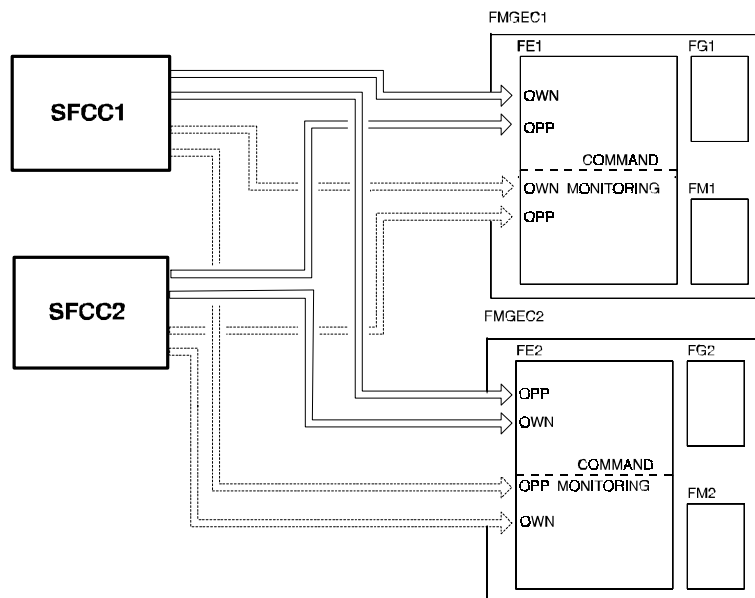
An EEC is declared valid if one and only one channel is active and if all acquisitions are correct on the selected channel.

The FE part computes the engine running and engine shut down conditions on the CMD and MONG channels.

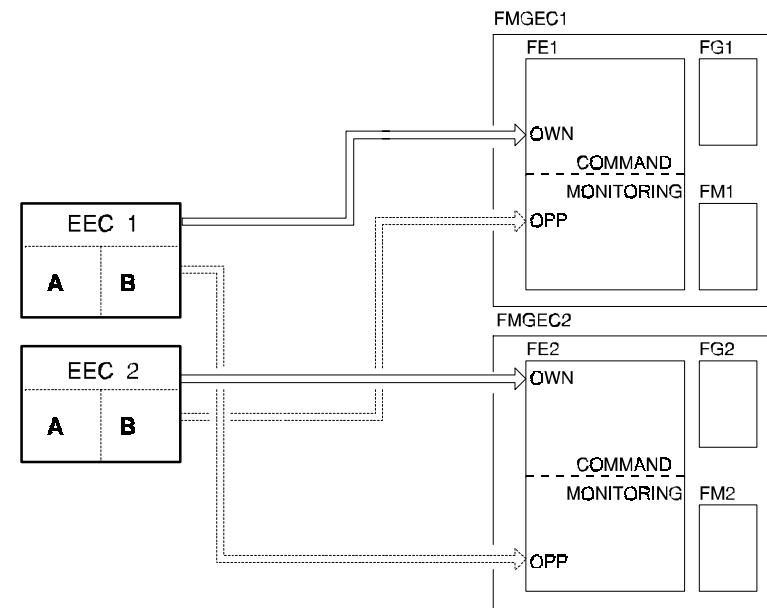
Engine running and engine shut down conditions are used by the FE part for different configurations :

- both engines shut down,
- first engine start on ground (engagement and mode reset),
- actual engine failure or failure simulated by a thrust control lever placed in IDLE position,
- both control levers (TLA) placed in IDLE or REVERSE position (A/THR disengagement).

SFCC MONITORING



ECC MONITORING



FQW4200 GE Metric

FCMC MONITORING

The Fuel Control and Monitoring Computer OWN and OPP data is only acquired on the FE command channel.

LABEL MONITORING
WEIGHT (WGT) CENTER OF GRAVITY (CG)

This data is processed in the FE and the FG parts.

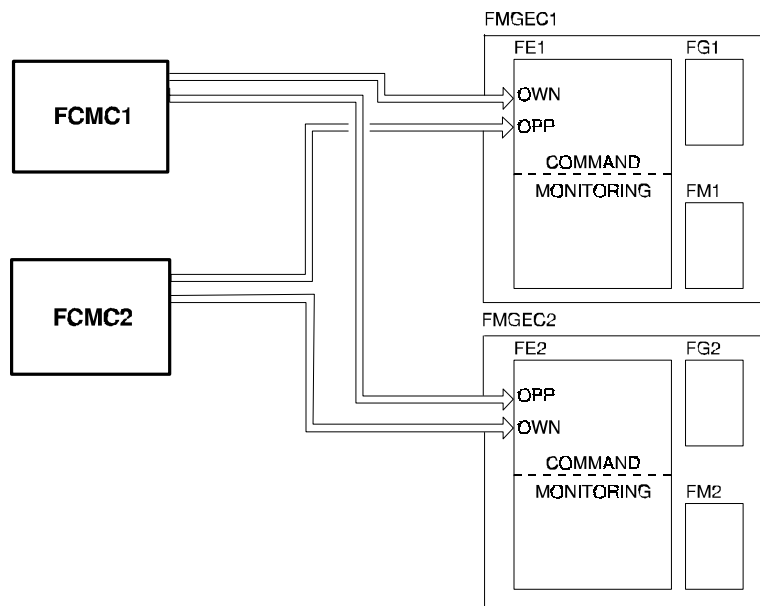
Upon incorrect acquisition of at least one label, the FCMC OPP is selected whatever its validity.

VOR MONITORING

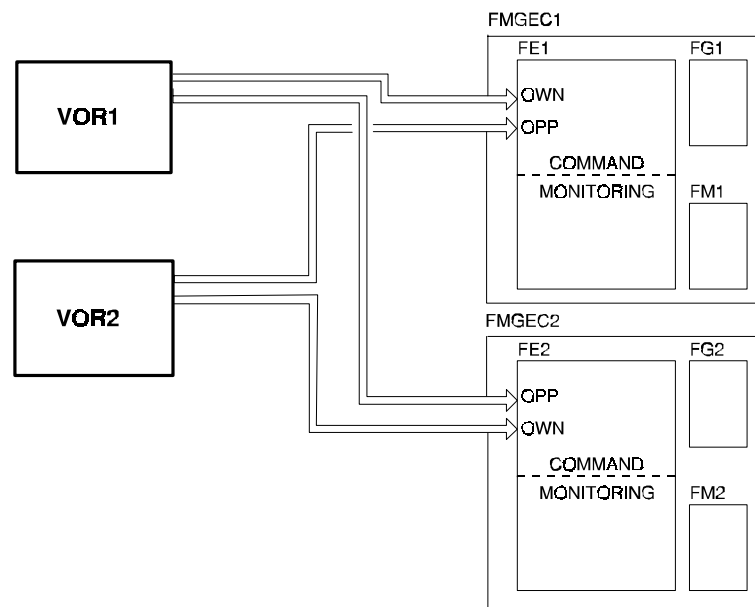
The VOR OWN and OPP data is acquired by the Flight Envelope part.

The VOR OWN and OPP data is only acquired for the Flight Management function. It is transmitted through FE-FG and FG-FM common memories.

FCMC MONITORING



VOR MONITORING



RA/ILS MONITORING

The Flight Envelope part acquires RA/ILS OWN and OPP.

ILS DATA MONITORING
LOC DEVIATION LABEL GLIDE DEVIATION LABEL RUNWAY LABEL FREQUENCY LABEL

RA DATA MONITORING
HEIGHT RADIO ALTITUDE (HRA)

Limitations are entered on the LOC and Glide deviations and on the HRA in order to passivate erratic values

Upon loss of RA OWN/ILS OWN the opposite side is selected.

In case of loss of one RA, the landing category is downgraded (CAT 3 loss).

In case of loss of both RAs, the AP is lost in LAND mode.

FCU MONITORING

For the Autoflight System part, the Flight Envelope function acquires labels

LABEL MONITORING ON COMMAND SIDE
SELECTED SPEED SELECTED MACH SELECTED HEADING SELECTED TRACK SELECTED ALTITUDE SELECTED VERTICAL SPEED SELECTED FLIGHT PATH ANGLE

DISCRETE WORD MONITORING ON COMMAND AND MONITORING SIDES
MODE ENGAGEMENT MODE SELECTION (MATCH OR SPEED) DISPLAY SELECTION (FD BAR OR FPD)

used by the FMGEC and transmitted on the FCU AFS-M bus.

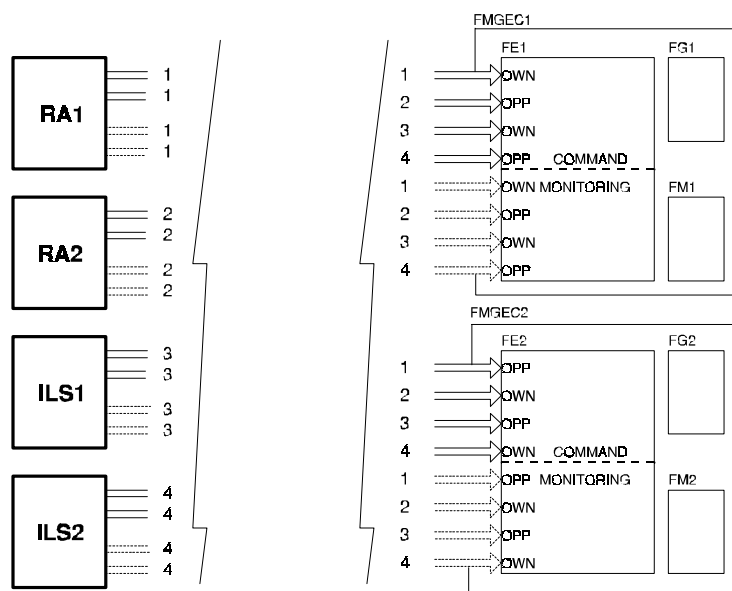
For the EIS part, the acquisition of the boolean baro/STD altitude data is monitored.

In case of FCU-AFS-M bus loss, there is no effect on the Flight Envelope part.

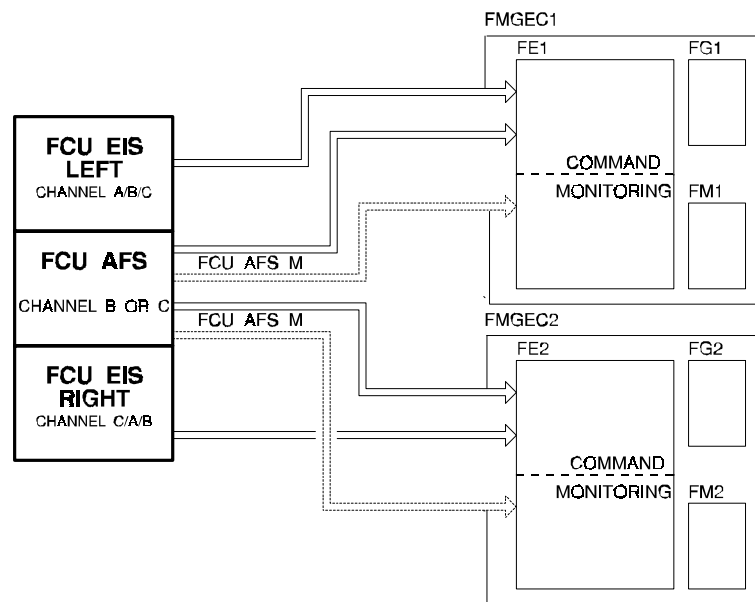
In case of loss of the FCU-AFS-M bus, there is an effect on the Flight Guidance part :

- the AP/FD disconnects except in LAND TRACK mode or in GO AROUND mode,
- the A/THR disconnects.

RA/ILS MONITORING



FCU MONITORING



STUDENT NOTES:

AUTOTHRUST OPERATION

- Engagement
- A/THR Loop Principle
- Thrust Levers
- A/THR Function Logic
- Modes
- Alphafloor
- A/THR Operation In Flight
- Disconnection

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 :

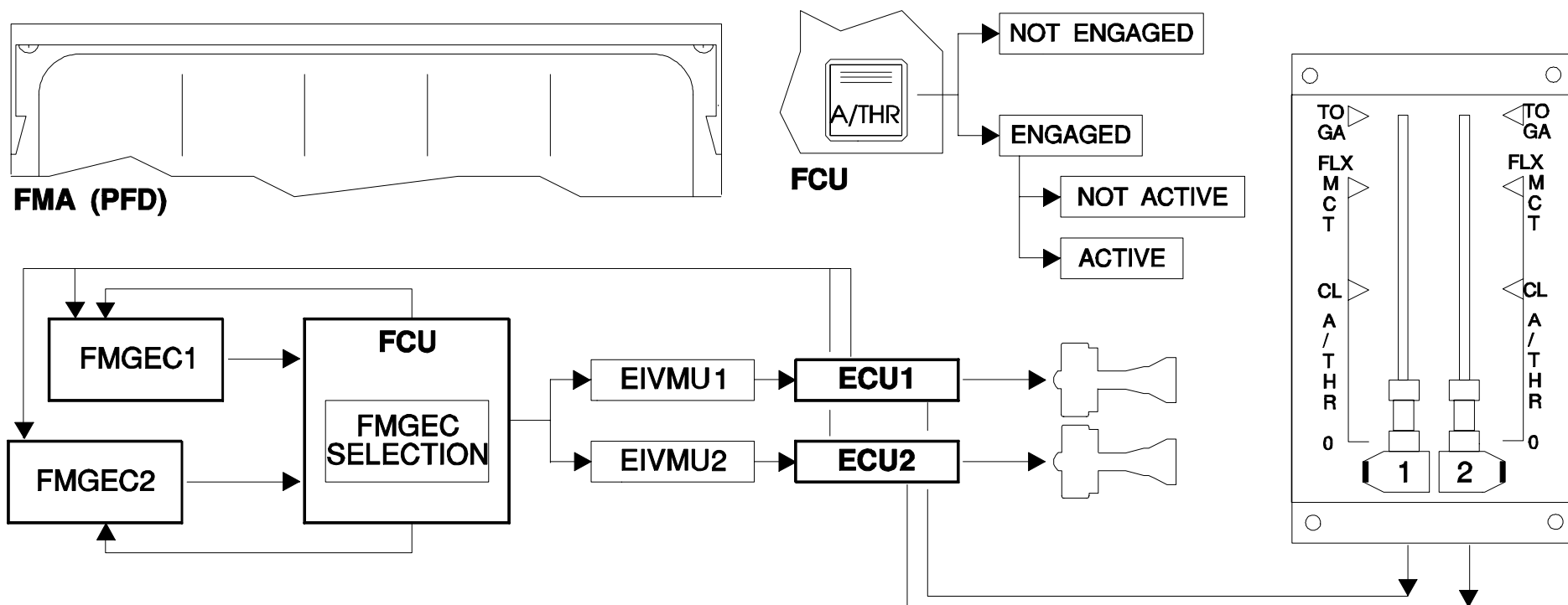
- when the Autopilot/Flight Director (AP/FD) modes are engaged at TAKE-OFF or GO AROUND,
- or in flight, when the Alphafloor is detected ; this is inhibited below 100 feet RA except during the 15 seconds following the lift-off.

Note :

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

A/THR LOOP PRINCIPLE

To perform the A/THR function, the MASTER Flight Management Guidance and Envelope Computer (FMGEC) communicates with the FADEC via the FCU and the Engine Interface Vibration Monitoring Units (EIVMUs).



FQW4200 GE Metric

THRUST LEVERS

The thrust levers are manually operated and electrically connected to the Electronic 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 Electronic 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 FMGECs select the higher of the ECU1 and ECU2 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.

When the A/THR function is DISENGAGED :

- 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 :

- at least, one thrust lever is between "CL" detent (included) and "0" stop (included) and, at the most, one thrust lever is between "MCT" detent and "CL" detent, and if there is no engine in FLEX TO mode,
- or if the Alphafloor protection is active.

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.

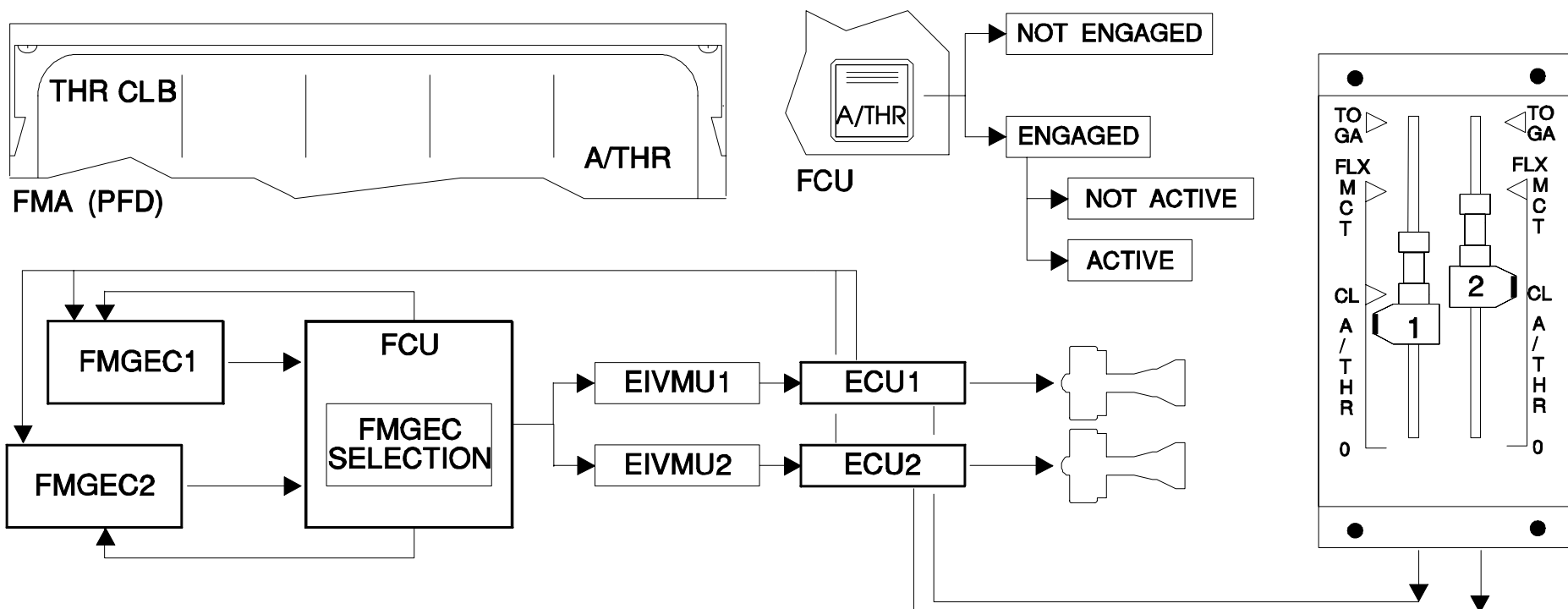
A/THR is NOT ACTIVE if :

- at least, one thrust lever is above the "MCT" detent or, all the thrust levers are above "CL" detent or, at least one engine is in FLEX TO mode,
- and if the Alphafloor protection is not active.

When the A/THR function is ENGAGED and NOT ACTIVE :

- the thrust levers control the engines (as long as a thrust lever is outside the A/THR active area),
- 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 "0" stop.



FQW4200 GE Metric

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 FMGEC 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 FMGEC itself.

The possible Autothrust modes are SPEED, MACH, THRUST, RETARD and Alphafloor protection.

The choice of the mode is made by the FMGECs :

- SPEED or MACH mode, the reference of which are selected on FCU or managed by the FMGEC,
- 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 FMGEC,
- 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 protection activation,
- 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 detection is ensured by each Flight Control Primary Computer (FCPC).

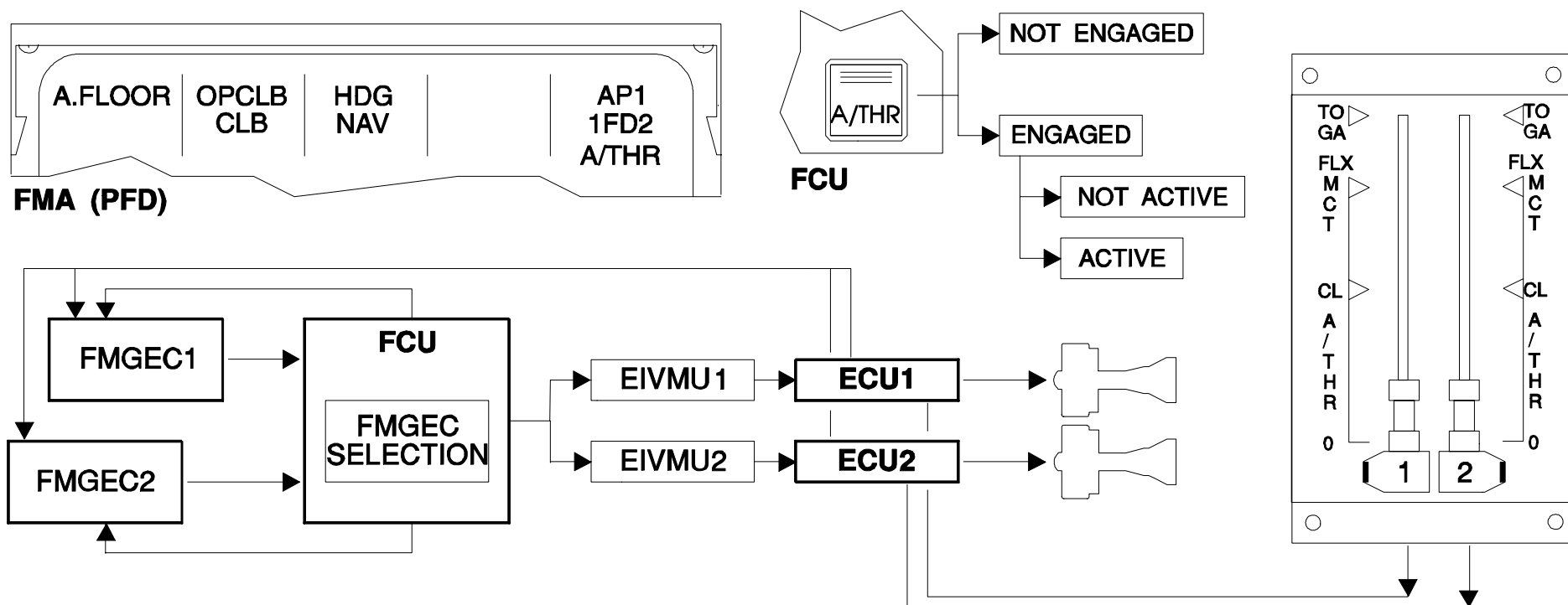
In case of excessive angle-of-attack, the FCPCs send a detection signal to the FMGECs which activates the Alphafloor protection.

The Alphafloor protection automatically engages and activates the A/THR function, whatever the position of the thrust levers 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, a green message "A.FLOOR" surrounded by a flashing amber box is displayed on the Flight Mode Annunciator.

When the A/THR is active with the Alphafloor protection active but with the Alphafloor detection no longer present in the FCPCs, a green message "TOGALK" (LK for LOCK) surrounded by a flashing amber box 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 switches.



FQW4200 GE Metric

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.

To 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).

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.
If a 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 CLB). The A/THR remains active.
Then, the thrust levers remain in this position until the approach phase.

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 "0" 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

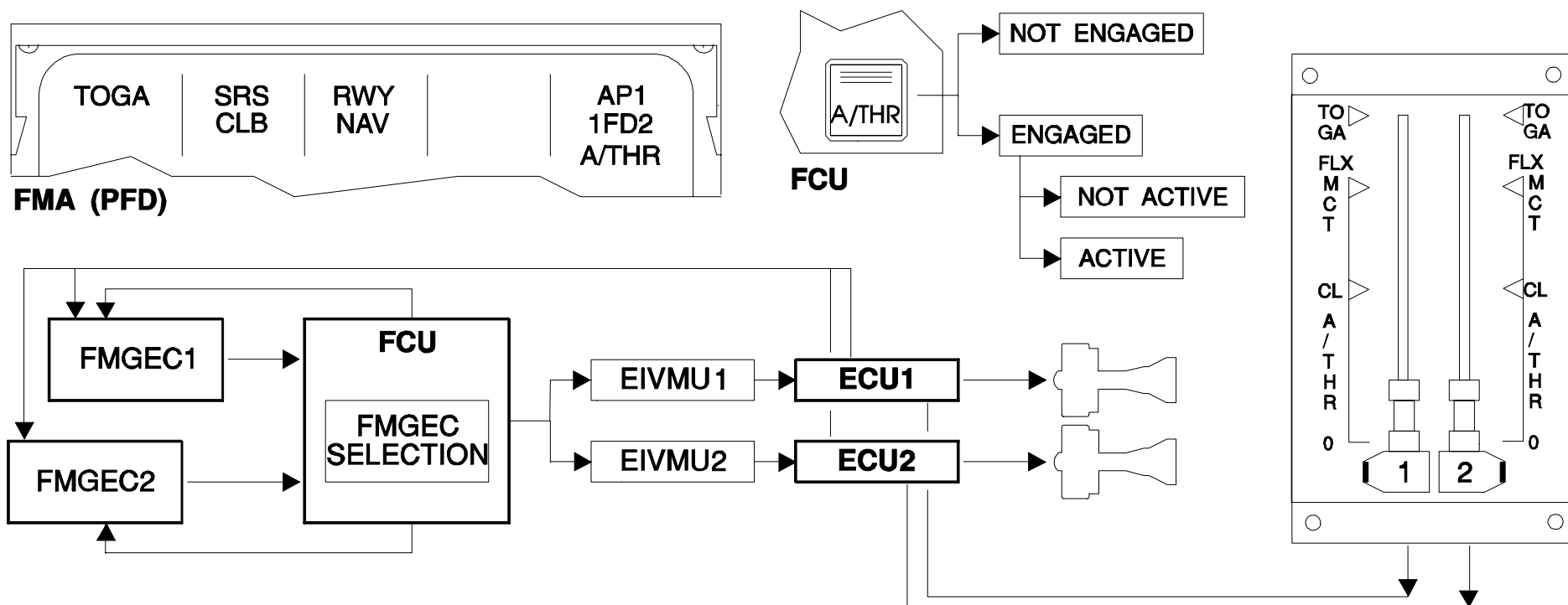
Besides the normal A/THR operation, the A/THR function is disengaged either by pilot action or in case of a system failure.

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 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 :

- When the A/THR function is disengaged through the instinctive disconnect switches, the thrust on the engines is automatically adapted to the corresponding thrust lever position.
- When the A/THR function is disengaged through the FCU A/THR pushbutton or by a system failure:
 - 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.



FQW4200 GE Metric

STUDENT NOTE

-

What happens when the A/THR function is engaged and not active ?

- A - The A/THR system controls the engines and the A/THR pushbutton light is ON.
- B - The thrust levers control the engines and the A/THR pushbutton light is OFF.
- C - The thrust levers control the engines and the A/THR pushbutton light is ON.

When you read the green message "TOGALK" surrounded by a flashing amber box on the FMA of the PFD, what does it mean ?

- A - The A/THR is active with the Alphafloor protection active and the Alphafloor is detected in the FCPCs.
- B - The A/THR is active with the Alphafloor protection active but with the Alphafloor detection no longer present in the FCPCs.
- C - The A/THR is engaged but not active during the take-off phase.

STUDENT NOTES

FLIGHT GUIDANCE PRIORITY LOGIC

Flight Guidance (FG)
Flight Director (FD)
Autopilot (AP)
Autothrust (A/THR)
Flight Mode Annunciator (FMA)
Flight Control Unit (FCU)

FLIGHT GUIDANCE (FG)

The engagement status of the guidance function works on the MASTER/SLAVE principle.

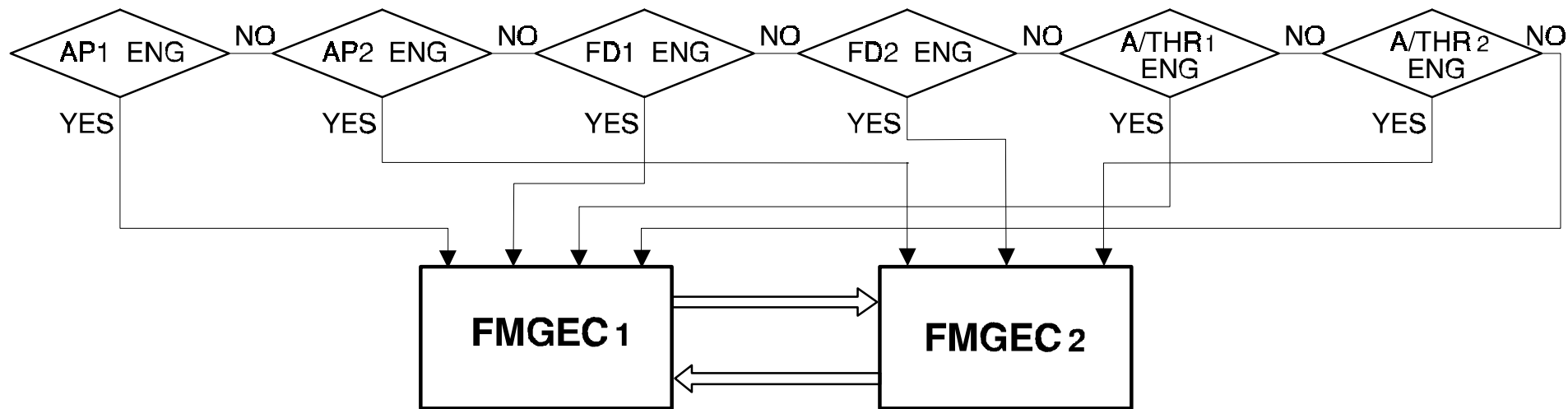
The master Flight Management Guidance and Envelope Computer (FMGEC) imposes all the changes of AP/FD modes and/or Autothrust (A/THR) engagement to the slave FMGEC.

Here is an example of a master Flight Management Guidance and Envelope Computer.

Look at the flow chart to understand the priority logic.

With no Autopilot (AP), no Flight Director 1 (FD1) but Flight Director 2 (FD2) engaged, FMGEC2 is the master because, following the flow chart, the first three answers are "NO", but the fourth one is "YES".

GUIDANCE FUNCTION : ENGAGEMENT STATUS



FLIGHT DIRECTOR (FD)

Upon energization, both Flight Directors (FD) are normally engaged in split configuration.

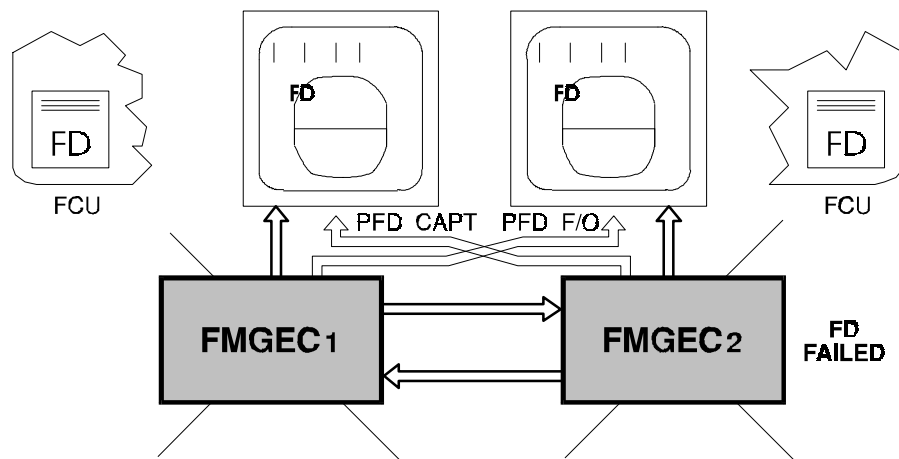
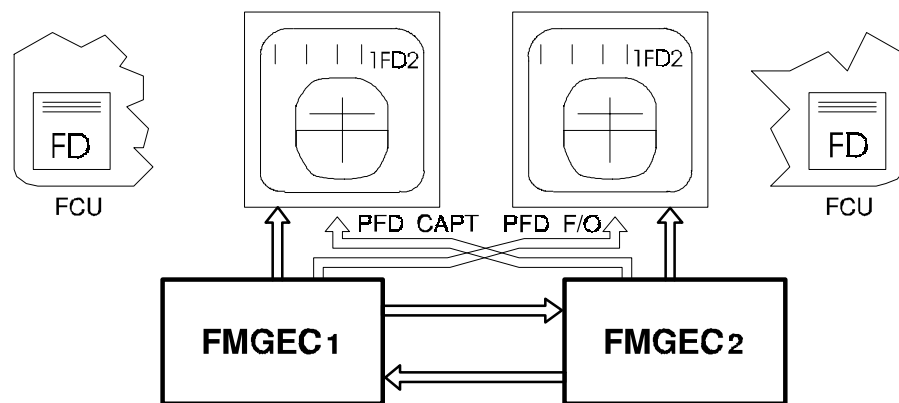
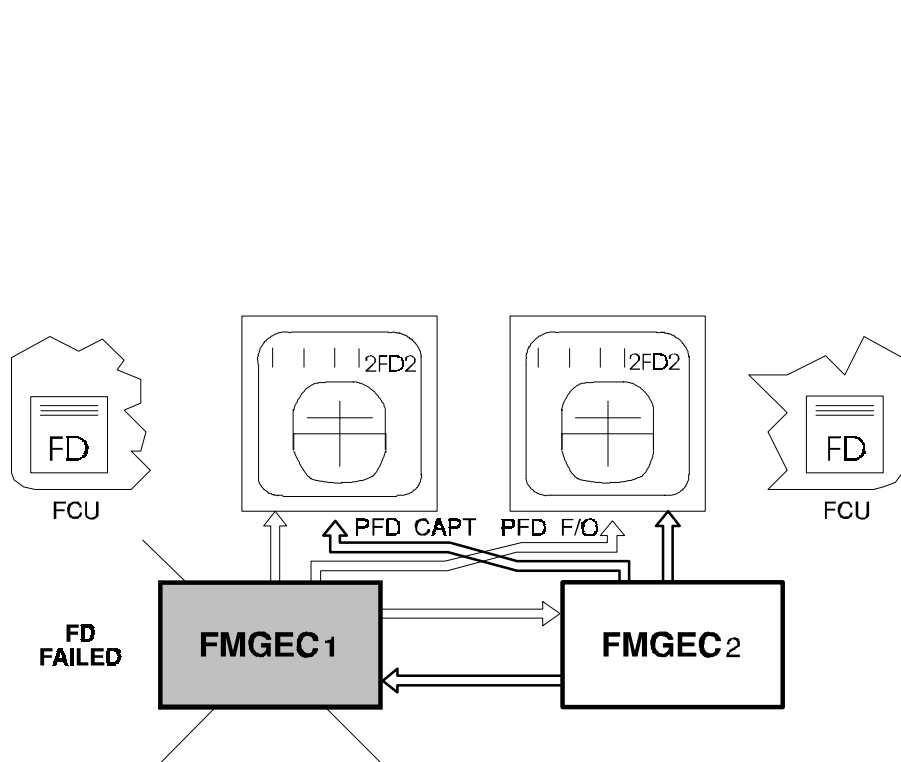
FMGEC1 normally drives the FD symbols (crossed bars or flight path director symbols) on the Capt Primary Flight Display (PFD).

FMGEC2 normally drives the FD symbols on the First Officer (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 FMGEC fails, the remaining FMGEC drives the FD symbols on both Primary Flight Displays.

If FMGEC1 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 both PFDs, provided that the FD switch is still "ON".



AUTOPILOT (AP)

If one AP is engaged, the corresponding FMGEC controls the flight controls through the Flight Control Primary Computers (FCPC).

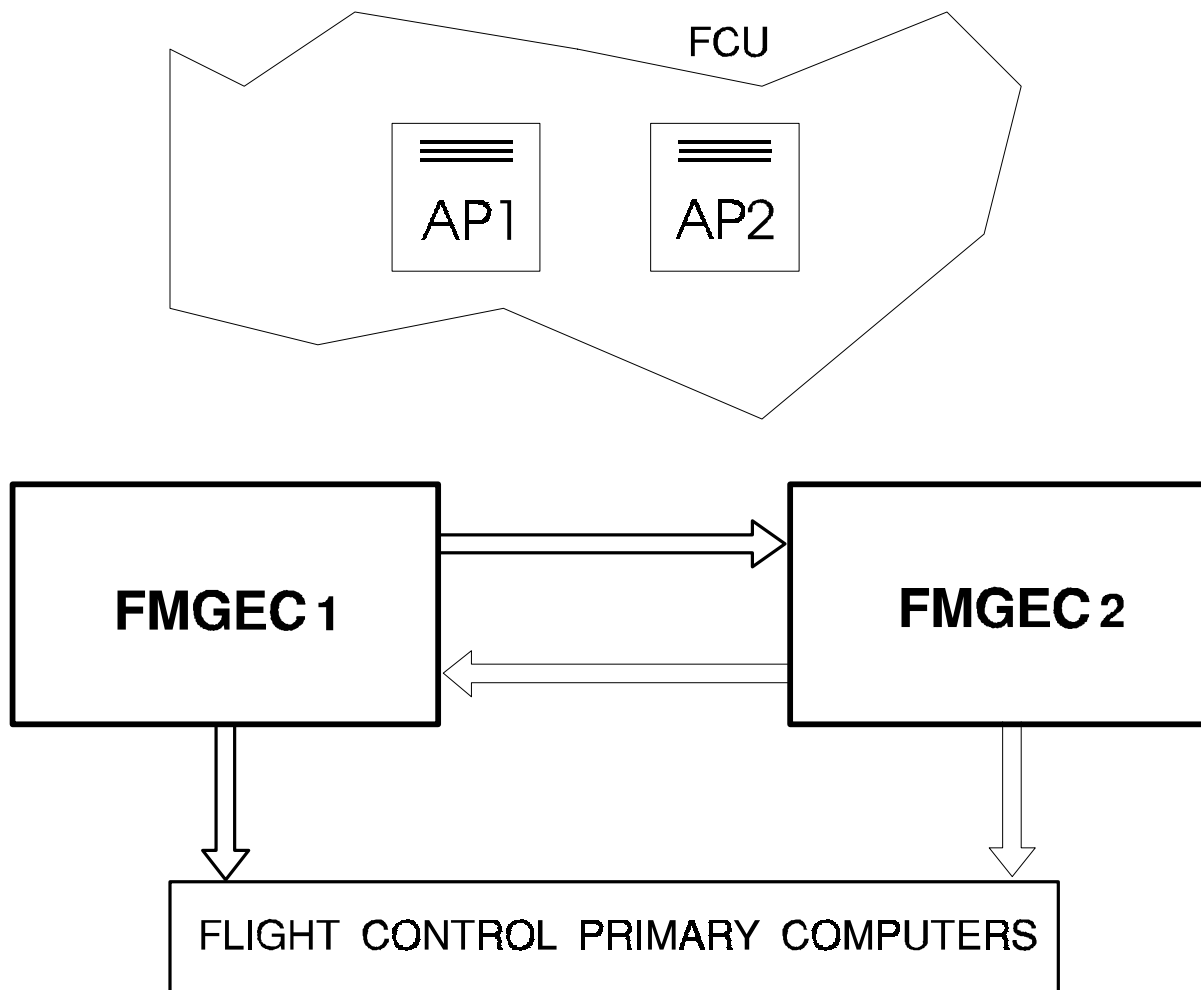
There is no priority logic in single operation. Last engaged Autopilot is the active one.

Both Autopilots can be engaged as soon as the APPROACH mode is selected on the Flight Control Unit (FCU).

AP1 has priority, AP2 is in standby.

The Flight Control Primary Computers (FCPCs) use the AP1 commands first.

The Flight Control Primary Computers (FCPCs) switch to the AP2 commands in case of AP1 disengagement.



FQW4200 GE Metric

AUTOTHRUST (A/THR)

A single Autothrust pushbutton switch located on the FCU enables the engagement or disengagement of the Autothrust function.

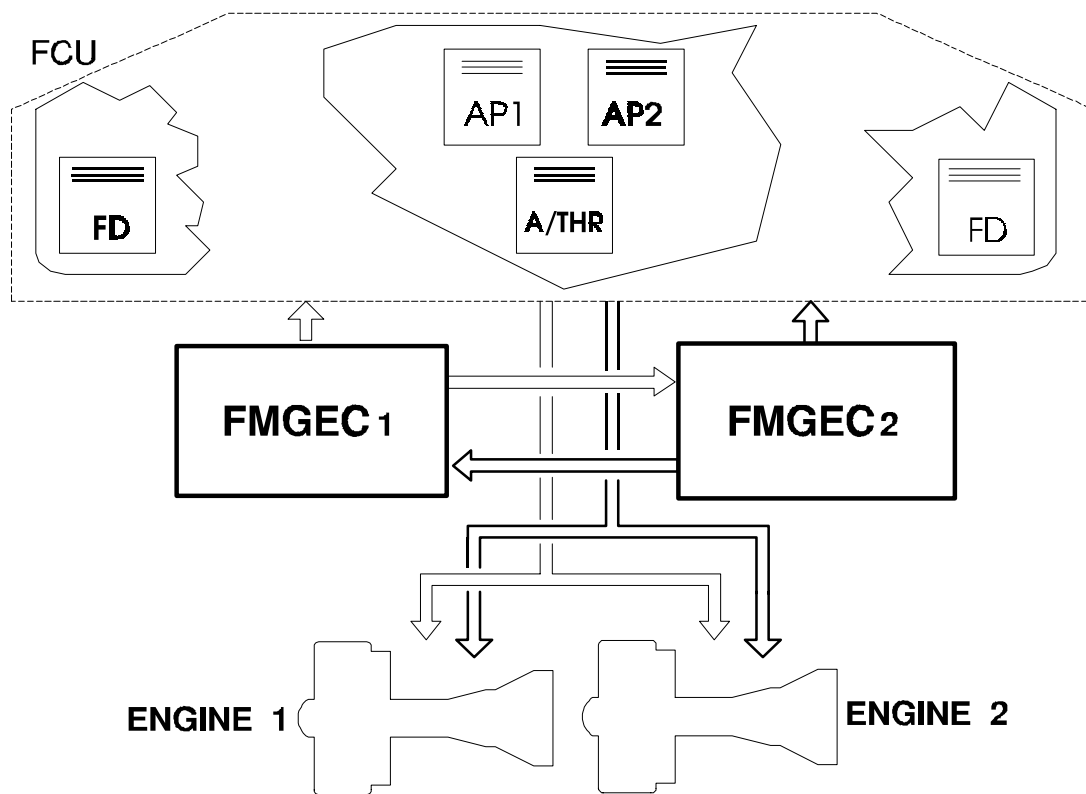
The Autothrust function is, in fact, composed of two systems (A/THR1 and A/THR2) which are ready to be engaged at the same time, but only one system is selected.

However the selection of A/THR1 or 2 depends on the engagement of the AP and FD, i.e. of the master/slave principle which is known by the FCU and summarized in the table.

When the selected Autothrust function is active (according to the thrust lever position), the master FMGEC controls the engines, via the FCU.

Consequently, in automatic control, it is the same FMGEC which controls the engines and the flight controls.

To recover the A/THR function, when one AP (AP1 or 2) is engaged and its own A/THR has failed, the opposite AP should be engaged to switch from the master FMGEC to the other (which now becomes the master) and to switch to the opposite A/THR.



ENGAGT OF AP		ENGAGT 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 ATHR2 IF ATHR1 FAIL

* ON or OFF

FLIGHT MODE ANNUNCIATOR (FMA)

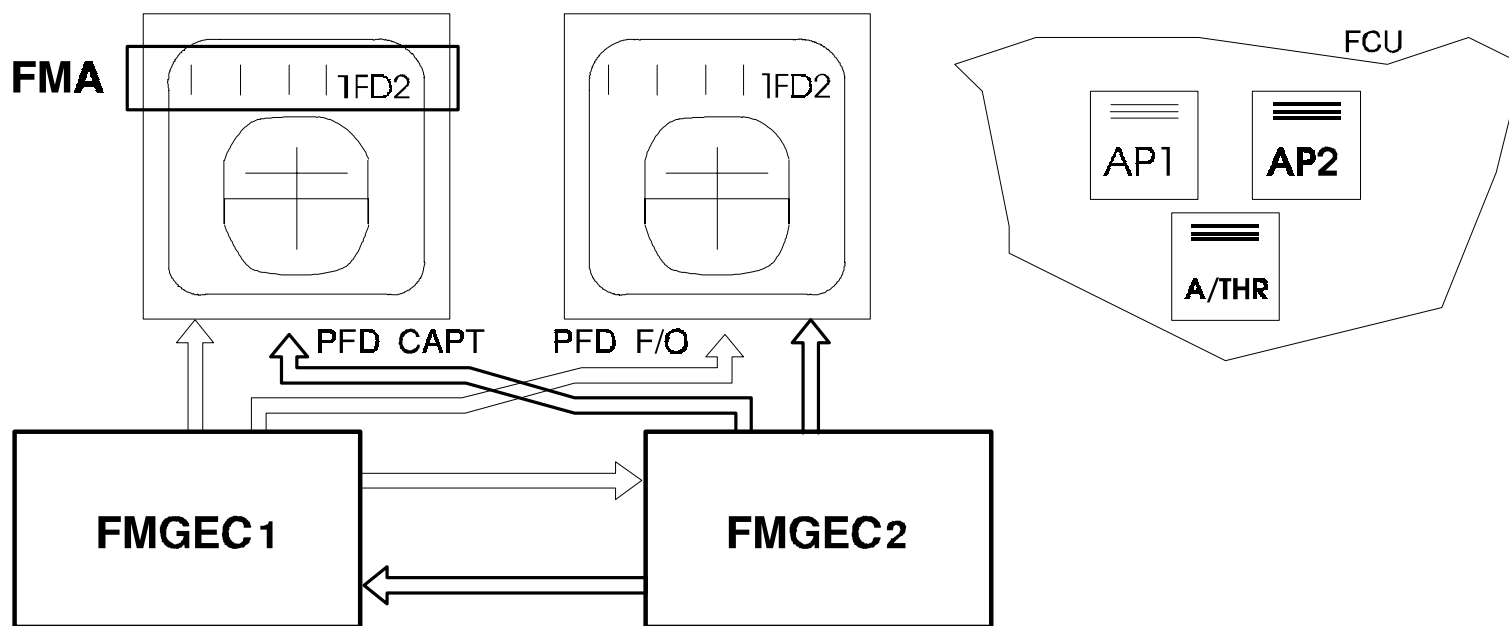
The three types of information on the Flight Mode Annunciator (FMA) are:

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

The Autothrust information is displayed by the master FMGEC which supplies both FMAs.

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

- with at least one AP, the master FMGEC supplies both FMAs,
- without AP, with the FDs engaged, FMGEC1 supplies FMA1, FMGEC2 supplies FMA2,
- without AP, with one FD failed or manually disengaged, the opposite FMGEC supplies both FMAs.



FQW4200 GE Metric

FLIGHT CONTROL UNIT (FCU)

The FCU ensures the interface between the crew and the following three systems :

- Autoflight system, Electronic Flight Instrument Systems (left and right) (including the baro-setting).

The FCU central processing unit consists of three identical computation channels A, B and C.

In normal operating conditions, each computation channel performs a specific function as follow :

- channel A : EFIS LEFT
- channel B : AFS
- channel C : EFIS RIGHT

In the event of one (or several) failed channel(s), a reconfiguration takes place and the remaining channels carry out the functions (see table).

The reconfiguration logic enables a maximum availability of FCU functions. These functions are kept fully independent (in particular for Captain and First Officer baro corrections) in the case of single channel failure.

Note :

- Channels B and C fulfill all Autoflight functions, while channel A partially performs AFS functions.
- Channel A is only used for the selection/display of Speed, Heading, Altitude and Vertical Speed parameters. It cannot be used to engage the AP, FD and A/THR systems.

FAILED CHANNEL	FUNCTIONS		
	EFIS LEFT	AFS	EFIS RIGHT
NONE	A	B	C
A	B	B	C
B	A	C	C
C	A	B	B
A+B	C	C	C
A+C	B	B	B
B+C	A	A*	A

A* : FOR PARTIAL
AFS FUNCTION.

FQW4200 GE Metric

STUDENT NOTES:

FLIGHT CONTROL UNIT DESCRIPTION AND OPERATION

- General
- Display Windows
- Speed /Mach Switching Pushbutton
- Speed/Mach Reference Selector Knob
- Heading/Track Reference Selector Knob
- HDG-V/S TRK-FPA Switching Pushbutton
- Altitude Reference Selector Knob
- Altitude Feet/Meter Switching Pushbutton
- Vertical Speed/Flight Path Angle Ref. Sel. Knob
- Localizer Engagement Pushbutton
- Autopilot Engagement Pushbutton
- Autothrust Engagement Pushbutton
- Altitude Engagement Pushbutton
- Approach Engagement Pushbutton

GENERAL

The Flight Control Unit comprises three control panels :

- one center panel (or AFS control panel) which provides the controls and displays associated with the AFS,
- two Electronic Flight Instrument System control panels belonging to the Flight Control Unit (FCU) but which are not presented in this module.

The Flight Control Unit is used for the following main functions :

- engagement of Autopilot/Flight Director (AP/FD) and Autothrust (A/THR) systems,
- selection of flight parameters (Altitude, Speed/Mach, Vertical Speed/Flight Path Angle, Heading/Track),
- selection of AP/FD modes (e.g. : Heading, Vertical Speed, Track, Flight Path Angle).

The four reference selector knobs include PUSH and PULL position.

A spring returns the selector knob to the intermediate position.
Each knob is fitted with a mechanical notching corresponding to 32 clicks per turn.

The six pushbuttons enable the modes or function engagement with a mechanical return to the rest position.

The three switching pushbuttons permit the flight parameters and the altitude unit to be selected by pressing them.

DISPLAY WINDOWS

The FCU windows display the reference parameters associated to the modes.

The Speed or the MACH number,
the Heading or the Track,
the Altitude,
the Vertical Speed or the Flight Path Angle,
are the reference parameters.

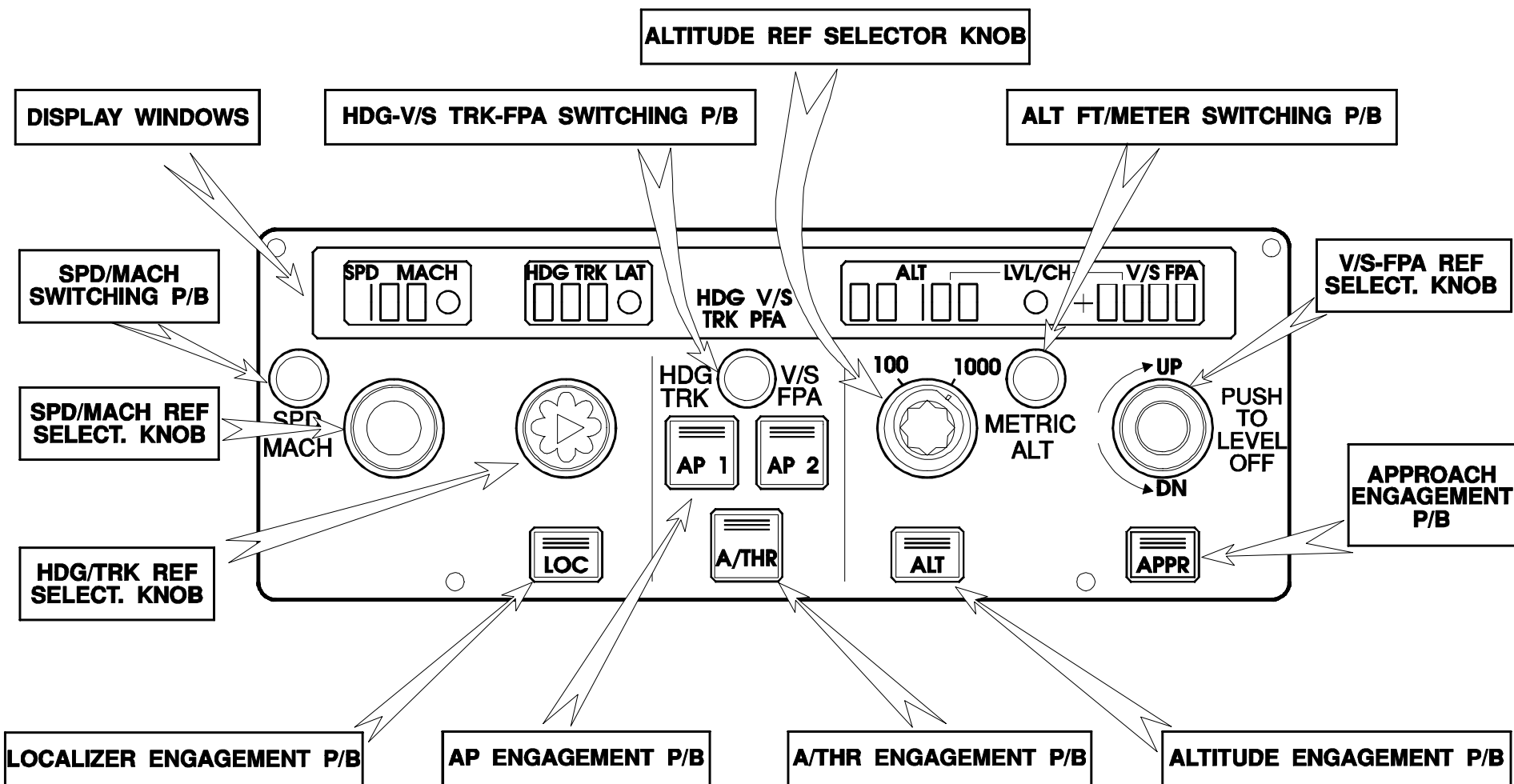
A window is dashed when the corresponding reference is computed or managed by the Flight Management Guidance and Envelope Computer (FMGEC) itself.

The Speed/Mach light is ON when the Speed/Mach reference is managed by the Flight Management Guidance and Envelope Computer.

The "LAT" (lateral) or the "LVL/CH" (level change) lights are ON when a managed mode is armed or active on the corresponding axis.

Example: NAVigation in lateral ; DEScent in vertical.

Note : The ALT window always displays the altitude selected by the pilot on the FCU, it is never dashed.



FQW4200 GE Metric

SPEED/MACH SWITCHING PUSHBUTTON

The Speed/Mach switching pushbutton, close to the speed window, permits "SPEED" or "MACH" modes to be manually selected.

Switching from Speed to Mach (and vice versa) is either automatic at an altitude given by the FM or manual using the Speed/Mach pushbutton.

This manual switching is possible only if the Speed/Mach reference was selected by the crew.

The appropriate indication (SPD or MACH) is always displayed at the top of the window.

SPEED/MACH REFERENCE SELECTOR KNOB

Thanks to the Speed/Mach reference selector knob, the crew chooses and adjusts a Speed or Mach reference or can let the FMGEC choose itself.

If this selector knob is PULLED, the FMGEC uses a selected speed reference which is displayed on the FCU.

The associated light is OFF.

When it is PULLED :

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

If the selector knob is TURNED, the displayed speed is changed :

- 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 it is turned more, this value changes.

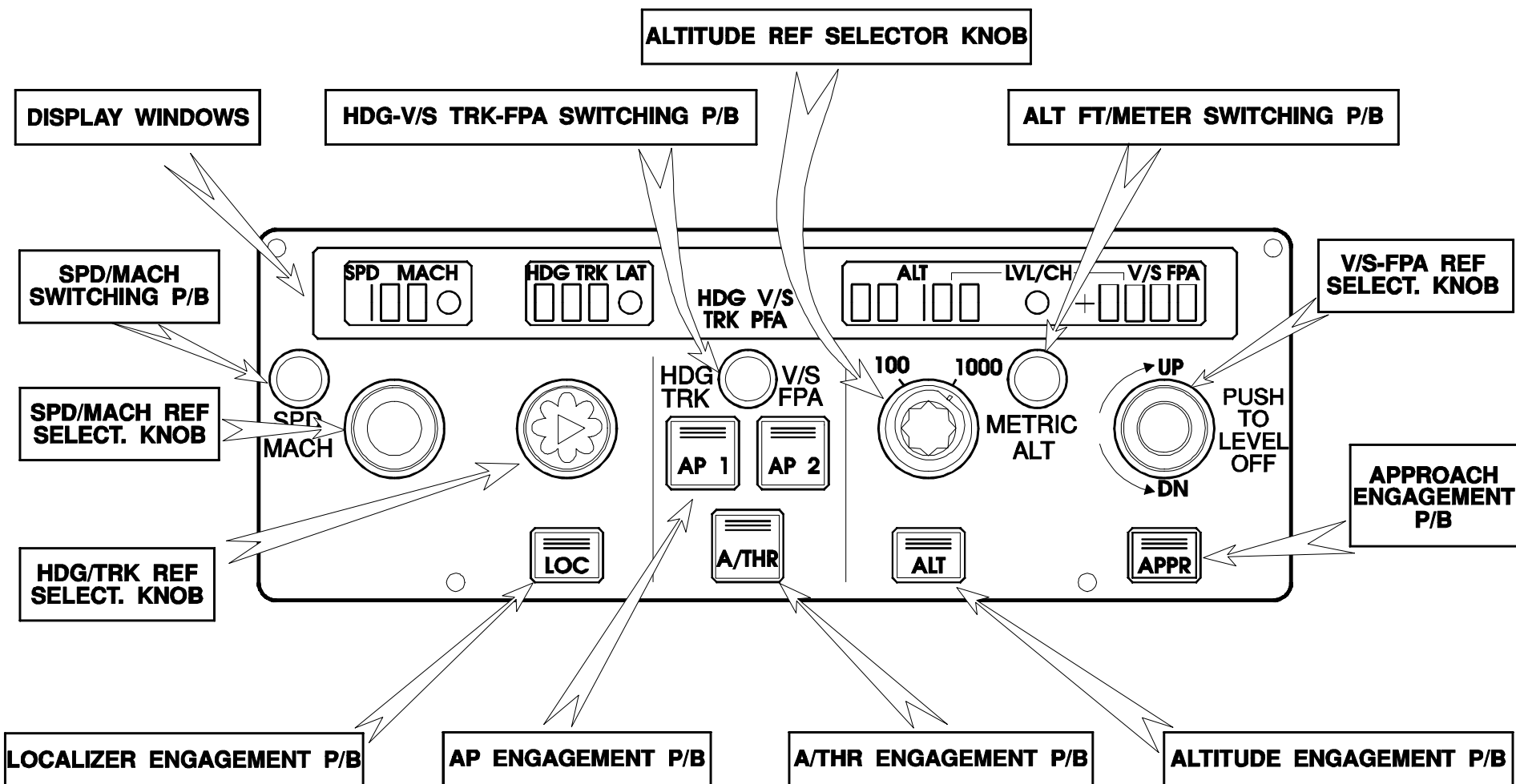
If the knob is not pulled within 10 seconds, the display reverts to dashes.

If the selector knob is PUSHED, dashes are displayed and the associated light is ON.

The FMGEC uses a managed reference Speed or Mach :

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

Note : For Take-Off and Go Around, the FMGEC automatically uses the memorized speeds such as V2 and VAPP.
Dashes are displayed and the light is ON.



FQW4200 GE Metric

HEADING/TRACK REFERENCE SELECTOR KNOB

The Heading/Track reference selector knob serves to choose a selected reference or a managed reference which is used by the FMGEC.

The LAT window displays a value when Heading or Track mode is active or when a Heading or Track preset has been performed.

It is dashed in all other cases.

The light is ON when a managed lateral mode is armed or active (e.g. NAV, RWY, LOC...).

If this selector knob is PULLED, the HEADING (or TRACK) mode engages with a reference displayed on the FCU.

The FMGEC then uses pilot selected values for guidance.

When it is PULLED :

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

If the selector knob is TURNED, the displayed HEADING or TRACK is changed :

- if a Heading or Track 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 Heading or Track ; when it is turned more, the value changes.

If the knob is not pulled within 10 seconds, the display reverts to dashes.

If the selector knob is PUSHED, the lateral NAVIGATION mode is armed for capture and tracking of the flight plan.

The reference is managed.

When it is PUSHED :

- during the arming phase, the Heading or Track is displayed until interception of the flight plan ; then dashes will replace the Heading or Track value ; during the arming and active phases, the light is ON.

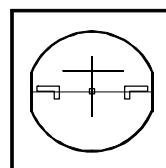
HDG-V/S TRK-FPA SWITCHING PUSHBUTTON

A switching pushbutton is provided in order to select HEADING-VERTICAL SPEED or TRACK-FLIGHT PATH ANGLE in the corresponding reference setting windows.

If any of the modes among HDG, TRK, V/S, FPA (e.g. HDG) is active, PRESSING the pushbutton changes this mode into the corresponding one (i.e. TRK $\longleftrightarrow$ HDG, V/S $\longleftrightarrow$ FPA) with resynchronization on the present A/C value.

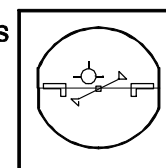
Pressing the pushbutton changes the HDG V/S into TRK FPA on the center of the FCU and vice versa.

Note that the Flight Director symbology on the PFD changes and the Flight Path vector appears.



THIS DISPLAY SHOWS
THE SELECTION OF
HDG V/S.

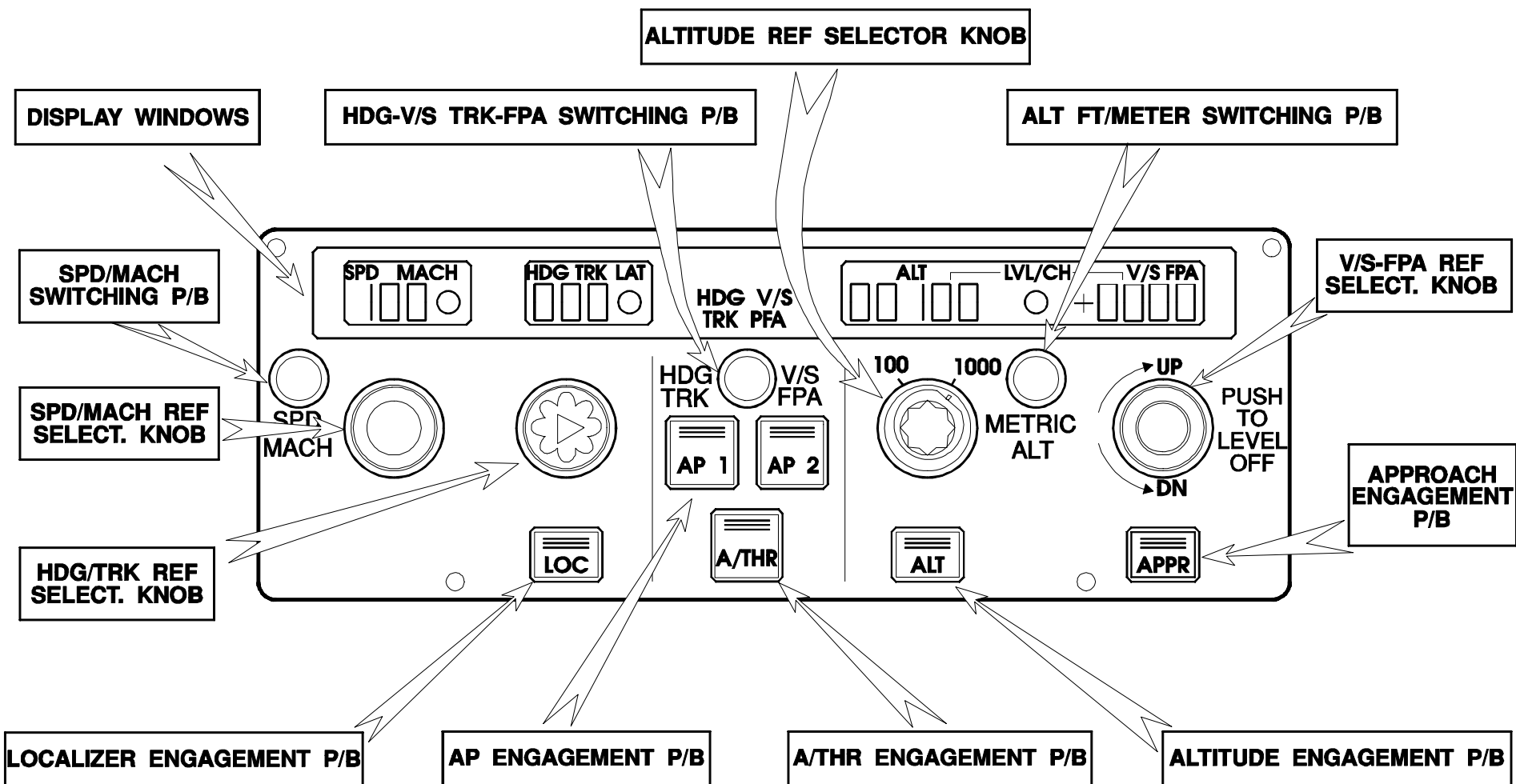
①



THIS DISPLAY SHOWS
THE SELECTION OF
TRK FPA.

②

In GO AROUND mode and if it is PIN programed, the Flight Director, with the cross-bars, is automatically engaged.



FQW4200 GE Metric

ALTITUDE REFERENCE SELECTOR KNOB

The Altitude reference selector knob serves to engage various level change modes, either managed by the Flight Management part or not, and to adjust the altitude to be captured.

When this selector knob is PULLED, OPEN CLimB or OPEN DEScent modes engage if the displayed altitude is different from the present aircraft altitude, and the A/C immediately climbs (or descends) towards the selected altitude. The level change light is OFF.

When it is TURNED, the displayed altitude changes by thousands or hundreds of feet, depending on the outer knob selection.

The Altitude window always displays a value as the pilot must know and be able to control the altitude to be captured.

When the selector knob is PUSHED, CLimB or DEScent modes engage if the displayed altitude is different from the present aircraft altitude.

The A/C follows the vertical Flight Plan.

Note : If, following the vertical Flight Plan, the A/C is in ALT mode with CLB or DES mode armed because of an altitude constraint, a push action on the selector knob has no effect.

ALTITUDE FEET/METER SWITCHING PUSHBUTTON

A switching pushbutton is provided close to the Altitude window in order to set the altitude selection in meters on the ECAM display.

Note that the altitude value selected on the FCU is always in feet.

VERTICAL SPEED/FLIGHT PATH ANGLE REF SEL KNOB

The Vertical Speed or Flight Path Angle reference selector knob serves to engage VERTICAL SPEED or FLIGHT PATH ANGLE modes and to adjust the corresponding reference value.

When the V/S FPA reference selector knob is PULLED, Vertical Speed or Flight Path Angle modes engage, 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 Vertical Speed or Flight Path Angle.

The ranges are :

- between -9.9° and $+9.9^{\circ}$ for FPA,
- between -60 and +60 hundreds of feet per minute for V/S.

When the selector knob is TURNED, it changes the displayed Vertical Speed or Flight Path Angle.

If the associated window was previously dashed, the first click changes the dashes into the present aircraft V/S or FPA.

When it is turned more, the value changes.

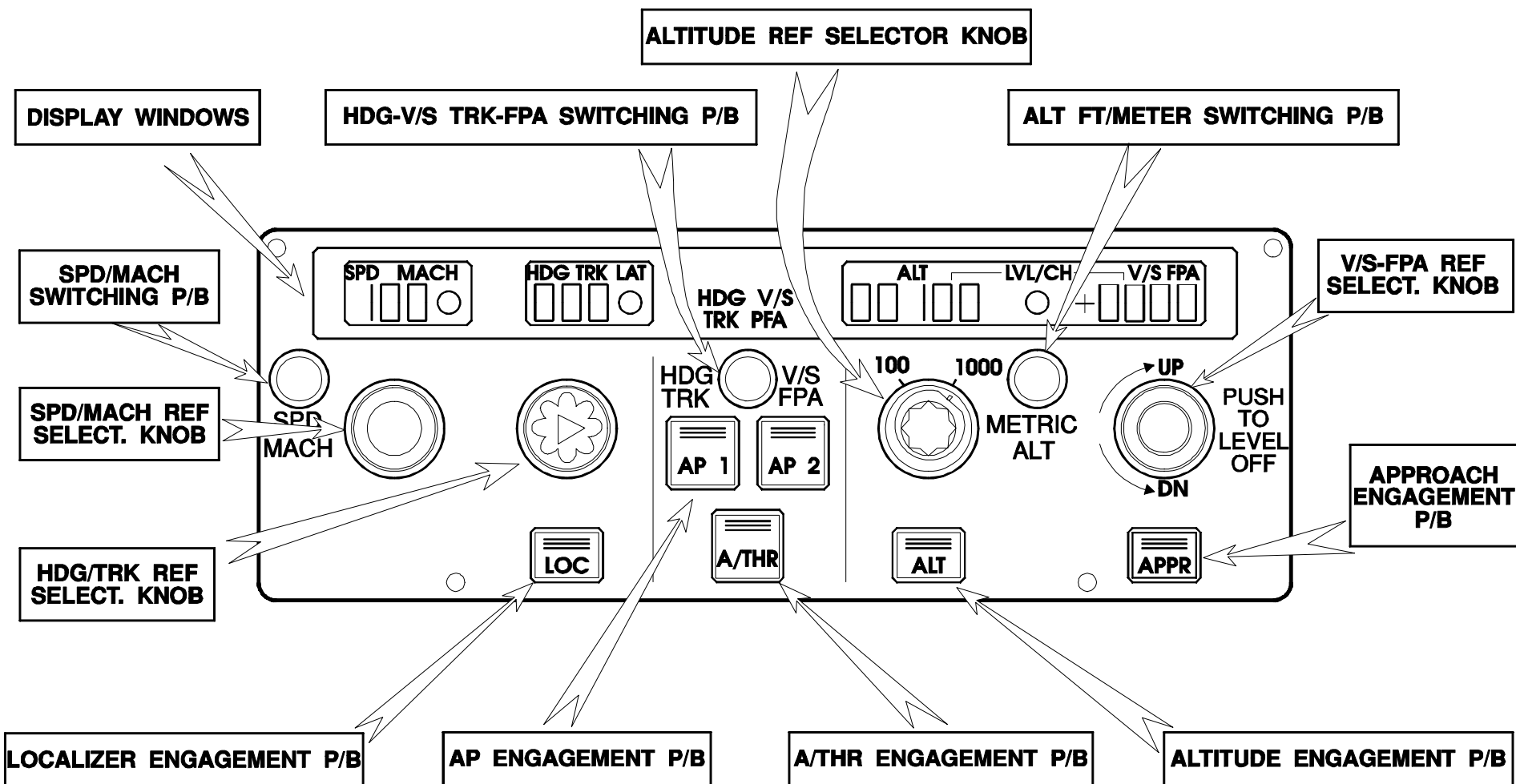
If the selector knob is not pulled within 10 seconds, the display reverts to dashes.

When it is PUSHED, it commands an immediate level off by engaging the V/S FPA mode with a zero target (displayed in the FCU window).

This action is equivalent to the following sequence:

- selection of a zero V/S FPA target,
- pulling action on the V/S FPA rotary knob.

There are dashes in the window and the level change light is ON.



FQW4200 GE Metric

LOCALIZER ENGAGEMENT PUSHBUTTON

The Localizer engagement pushbutton permits the LOCALIZER mode to be used.

When it is PRESSED ON, the LOCalizer mode is armed.
This mode becomes automatically active after capture.

When it is PRESSED OFF, two cases can occur : before and after capture:

- before capture, the LOCalizer mode is disarmed,
- after capture, the localizer mode is disengaged ; in this case, the HDG/TRK mode is engaged on the present aircraft Heading/Track.

AUTOPILOT ENGAGEMENT PUSHBUTTON

Autopilots 1 and 2 can be engaged five seconds after lift off, by pressing the related pushbutton.

When it is PRESSED ON, the Autopilot engagement is shown by the three green bars coming ON.

When it is PRESSED OFF, the related Autopilot disengages.

AUTOTHRUST ENGAGEMENT PUSHBUTTON

Autothrust engagement can be manual or automatic.

It is AUTOMATIC when TO/GA mode is engaged or when the Alphafloor function is activated.

The A/THR function can be MANUALLY engaged by means of the A/THR pushbutton located on the FCU, provided the aircraft is not on the ground, with the engines running.

If the A/THR engagement pushbutton is PRESSED ON, the A/THR engages and this action is shown by the three green bars coming ON.

If the Autothrust engagement pushbutton is PRESSED OFF, the A/THR function disengages.

ALTITUDE ENGAGEMENT PUSHBUTTON

The Altitude engagement pushbutton can be pressed ON at any flight phase to command a level-off, at a resulting altitude, by engaging Altitude mode.

When the ALT pushbutton is PRESSED ON, the ALT mode engagement is shown by the three green bars coming ON.

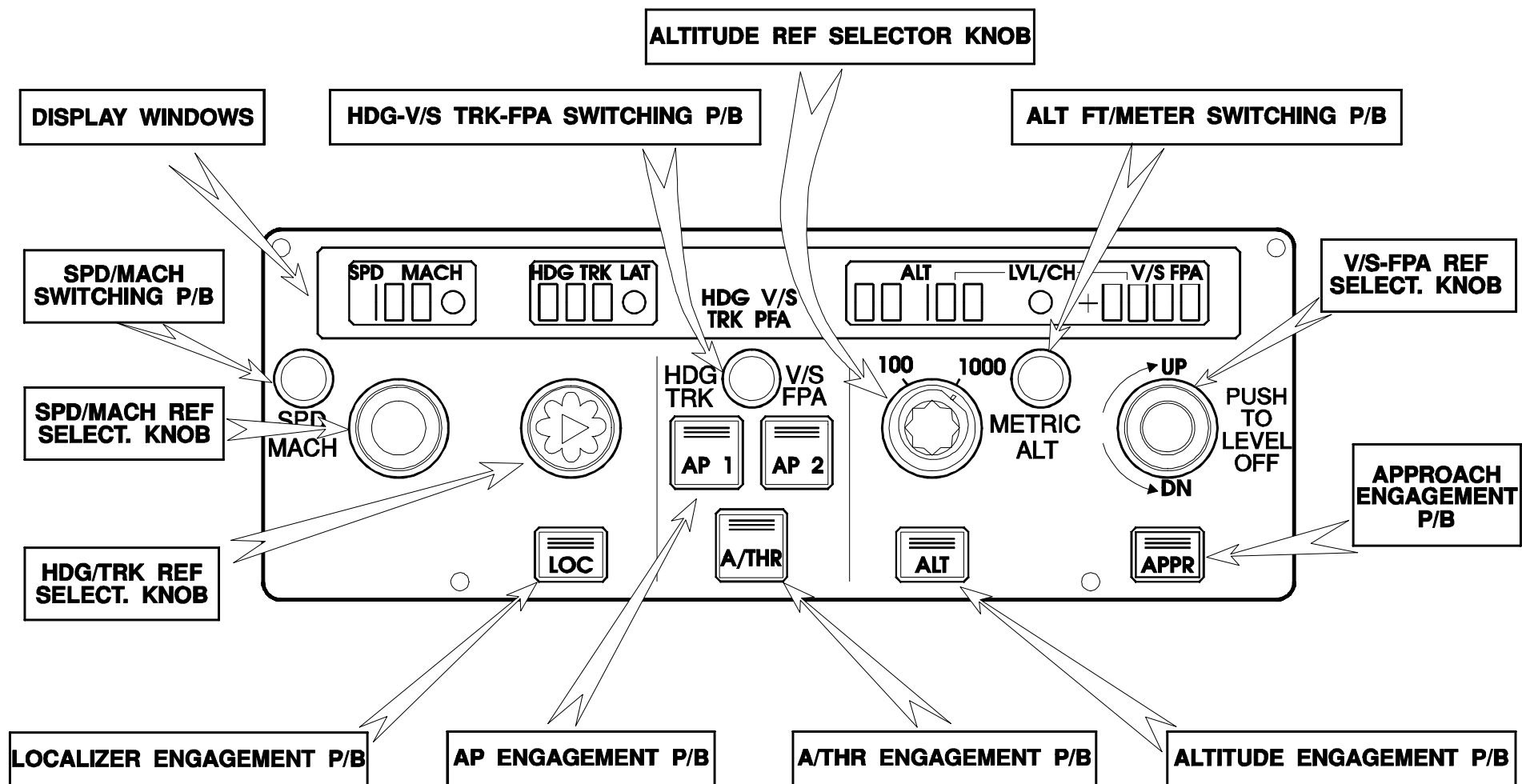
The reference altitude of the mode is the aircraft altitude obtained after reduction of the Vertical Speed to zero.

This value (for example 15,000 feet) is independent from the selected value displayed on the FCU.

When the Altitude pushbutton is PRESSED OFF, there is no result : whatever the case, the Altitude mode is locked.

To disengage the ALT mode, either the pilot must engage another mode such as V/S, OP CLB or OP DES, or, if he wants to recover CLB or DES phases, the pilot must push on the ALTITUDE REFERENCE SELECTOR KNOB.

Note : When an altitude is selected on the FCU and reached, or when a FM altitude constraint is reached, the three green bars come ON on the ALT pushbutton (without any action on this pushbutton).



FQW4200 GE Metric

APPROACH ENGAGEMENT PUSHBUTTON

The APPROACH engagement pushbutton serves to arm LAND mode or FINAL DESCENT and NAV modes according to ILS selection.

In case of an ILS selected through the Flight Plan definition or by the pilot on the MCDU or the Radio Management Panel (RMP) :

- if the APPR pushbutton is PRESSED ON, Glide/Slope and LOCALizer modes (approach modes) are armed for capture and tracking.

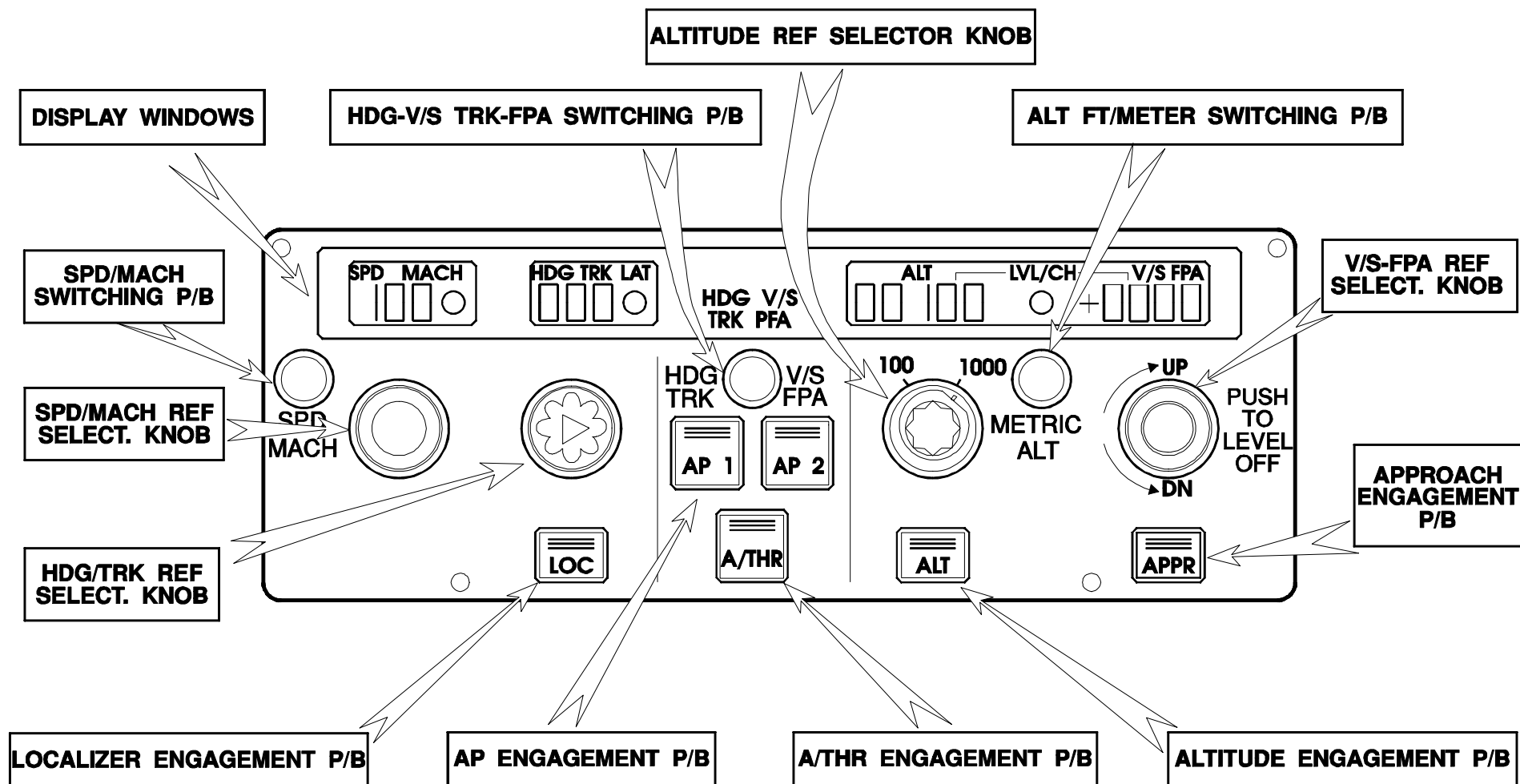
When this pushbutton is PRESSED OFF, and with ILS selected, there are two cases according to the Radio Altitude.

- above 400 feet RA, LAND mode is disarmed or disengaged,
- below 400 feet RA, LAND can only be disengaged by performing a go around.

When it is PRESSED OFF, with no ILS selected, and in case of an AREA NAV approach selected through the Flight Plan, there are two possibilities :

- if the APPR engagement pushbutton is PRESSED ON, FINAL DEScent and NAV modes are armed (if NAV mode was already active, this mode remains engaged) ;
- if the APPR engagement pushbutton is PRESSED OFF, NAV and FINAL DEScent modes are disarmed or disengaged.

Note : FINAL DEScent mode is not designed to be used with the Autopilot until the ground is reached.
When using this mode, pilots have to disengage the Autopilot at Minimum Decision Altitude (MDA).



FQW4200 GE Metric

STUDENT NOTES:

FMA DESCRIPTION

- General
- Colors
- A/THR Zone
- AP/FD Vertical Mode Zone
- AP/FD Lateral Mode Zone
- Landing Category Zone
- Function Engagement Status
- Messages

GENERAL

Information about modes and engagement status of guidance functions, plus some specific messages, are displayed on the Flight Mode Annunciator located at the top of each Primary Flight Display.

The Flight Mode Annunciator (FMA) is divided into five zones :

- ZONE 1 : A/THR information,
- ZONE 2 : vertical AP/FD modes,
- ZONE 3 : lateral AP/FD modes,
- ZONE 4 : landing categories,
- ZONE 5 : engagement status of guidance functions.

Each of the five zones has three lines :

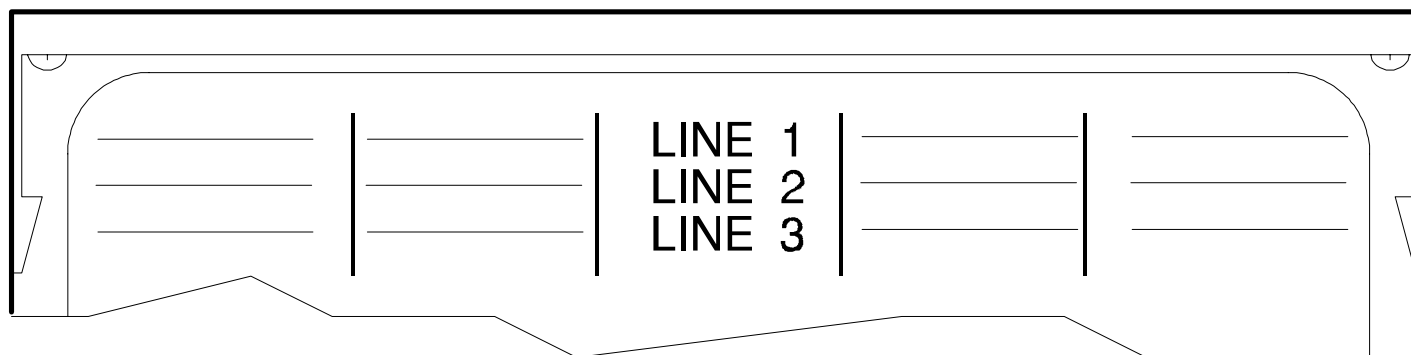
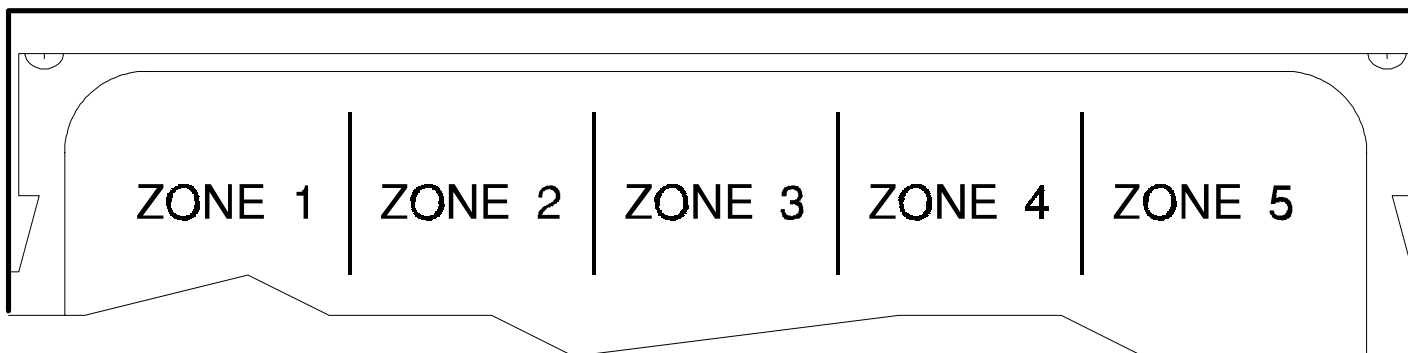
Line 1 gives active modes.

Line 2 gives armed modes.

Specific A/THR messages are written in zone 1.

Advisory messages appear in line 3 of zones 2 and 3.

FREQUENT REFERENCE TO THE FMA INDICATIONS, WHICH ARE DRIVEN BY THE MASTER FMGEC, AS WELL AS A THOROUGH UNDERSTANDING OF ALL STATUS, ARMED AND ENGAGED ANNUNCIATIONS, ARE ESSENTIAL FOR THE SUCCESSFUL OPERATION OF THE AUTOFLIGHT SYSTEM.



FQW4200 GE Metric

COLORS

GREEN :

A/THR and AP/FD active modes.

CYAN :

AP/FD armed modes, A/THR engaged but not active,
V/S, FPA, FLX TEMP, MDA, MDH and DH numeric values.

WHITE :

Flight guidance function engaged and active, landing categories.
Mode change and guidance function engagement make a white box
appear for ten seconds. Messages.
Thrusts (surrounded by boxes) which are held when A/THR is not
active.

MAGENTA :

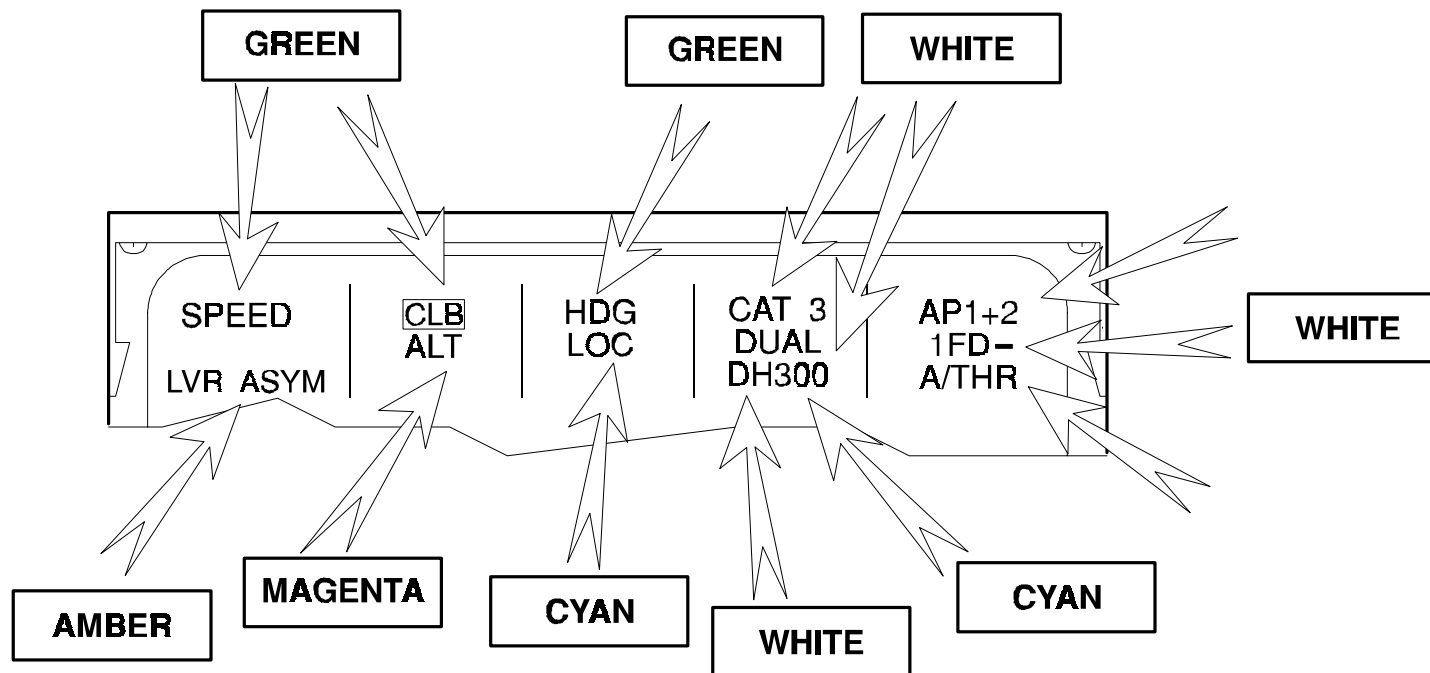
Mode armed because of a constraint which will be followed by the
AFS in longitudinal or lateral autocontrol.

AMBER :

Messages, boxes around certain thrust modes.

RED :

"MAN PITCH TRIM ONLY" message.



A/THR ZONE

Here are all the possible displays in the autothrust zone.

The autothrust function information is displayed :

- on the first line, in GREEN :
THR MCT, THR CLB, THR DES, THR IDLE,
THR LVR, SPEED, MACH
- on the first line, in GREEN with a FLASHING AMBER BOX :

A.FLOOR	TOGALK
---------	--------
- on the first and second lines, in WHITE :

MAN	MAN	MAN	MAN	MAN
TOGA	DTO	FLXxx	MCT	THR
- on the third line, FLASHING AMBER :
THRLK
- on the third line, FLASHING WHITE :
LVR CLB, LVR MCT
- on the third line, in AMBER :
LVR ASYM

Notes :

- If A/THR is not engaged, the zone is blank unless THRLK flashes (that means the thrust is frozen after a disengagement).
- In FLXxx, xx (displayed in cyan) is the value of the selected flexible take-off temperature.

AP/FD VERTICAL MODE ZONE

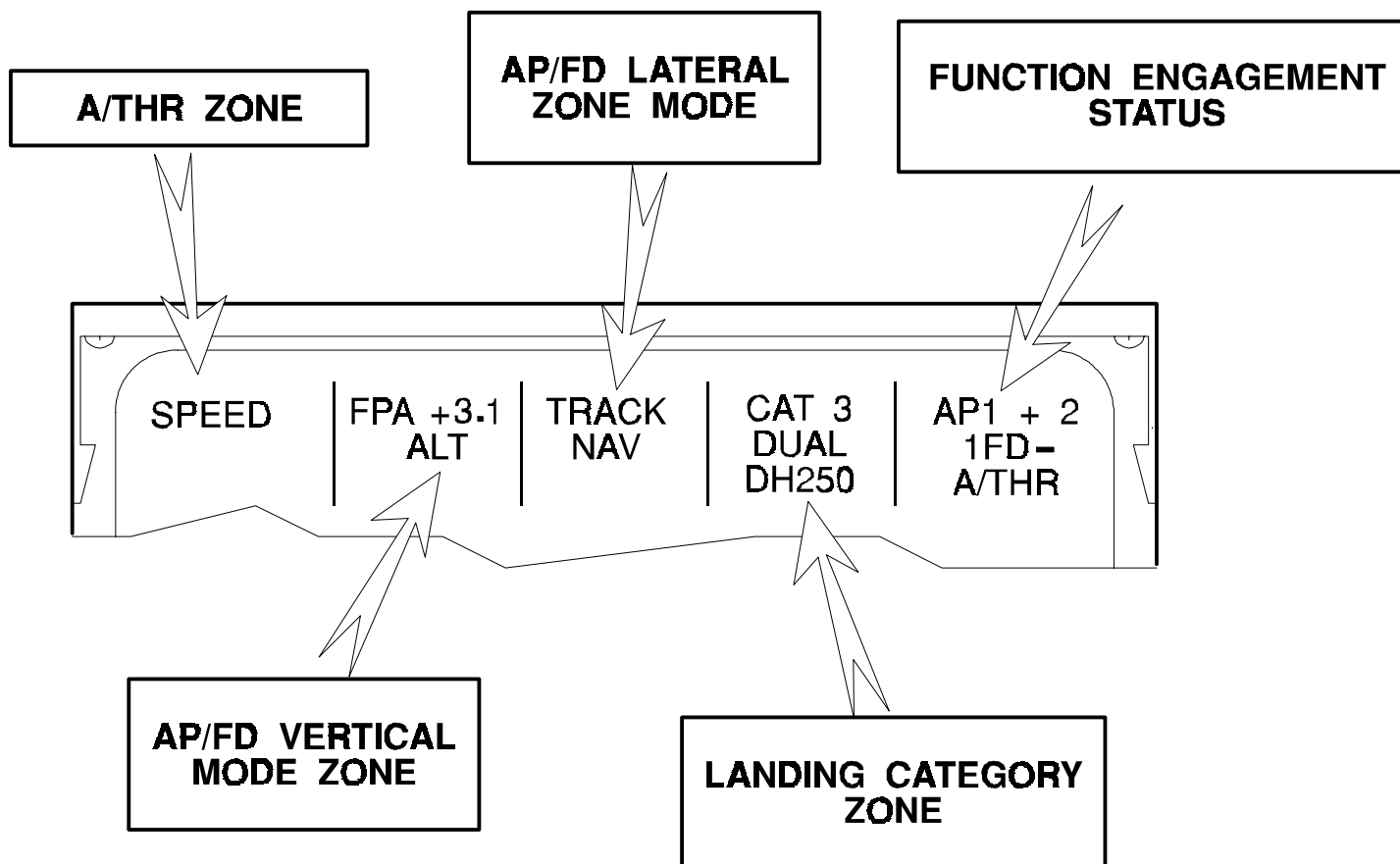
Here is a list of the possible messages in the AP/FD vertical mode zone.

The vertical modes are displayed :

- on the first line, in GREEN :
SRS, ALT*, ALT, ALT CRZ*, ALT CRZ, ALT CST*, ALT
CST, G/S*, G/S, CLB, DES, OPCLB, OPDES,
and LAND, FLARE, ROLL OUT, FINAL APP which are
common to vertical and lateral areas.
- on the first line, in GREEN and CYAN :
V/S+1500, FPA+3.1
- on the second line, in CYAN :
ALT, CLB, DES, OP CLB, OP DES, G/S, FINAL, and SPEED
SEL xxx, MACH SEL .xx which are seen in lateral and vertical
areas
(xxx is a preset speed, .xx is a preset MACH).
- on the second line, in MAGENTA :
ALT.

Note :

There is a possibility to have 2 modes on the second line, e.g.
ALT (M) G/S (C), or ALT (M) FINAL (C) or DES (C) FINAL(C)...



AP/FD LATERAL MODE ZONE

Here is a list of the possible messages in the AP/FD lateral mode zone.

The AP/FD lateral modes are displayed :

- on the first line, in GREEN :
RWY, RWYTRK, HDG, TRACK, LOC*, LOC, NAV,
GATRK, APPNAV, LOC B/C*, LOC B/C and
LAND, FLARE, ROLL OUT, FINAL APP which are common
to vertical and lateral areas.

- on the second line, in CYAN :
NAV, LOC, APPNAV, LOC B/C

LANDING CATEGORY ZONE

Here is a list of the possible messages in the landing category zone.

On the first and the second lines, the possible landing category messages are displayed in WHITE such as :

CAT1 CAT2 CAT3 CAT3
SINGLE DUAL

On the third line, the messages are displayed in WHITE and the numeric values in CYAN and can be :

DHxxx, NODH, MDAxxxx, MDHxxxx.

Note :

Information appears in this zone as soon as LAND mode is armed or active :

DH : Decision Height.
NODH : no Decision Height.
MDA : Minimum Decision Altitude.
MDH : Minimum Decision Height.

FUNCTION ENGAGEMENT STATUS

Here is a list of the possible messages in the engagement status zone.

Engagement status of flight guidance functions are displayed :

- on the first line, in WHITE :
AP1+2, AP1, AP2.
- on the second line, in WHITE :
1FD- (FD1 is engaged on Captain side).
-FD1 (FD1 is engaged on F/O side).
-FD2 (FD2 is engaged on F/O side).
2FD- (FD2 is engaged on Captain side).
1FD2 (both FDs are engaged, one on each side).
1FD1 (FD2 has failed, FD1 is engaged).
2FD2 (FD1 has failed, FD2 is engaged).

- on the third line, in CYAN :
A/THR (engaged and not active).

- on the third line, in WHITE :
A/THR (engaged and active).

MESSAGES

Here are examples of messages appearing on the Flight Mode Annunciator.

Advisory messages appear on the third line in zones 2 and 3.

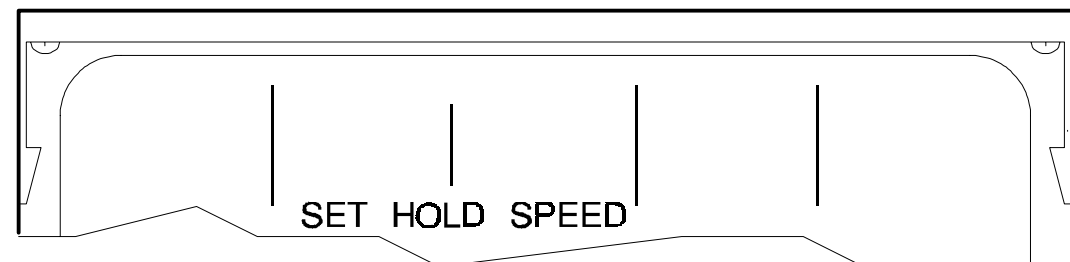
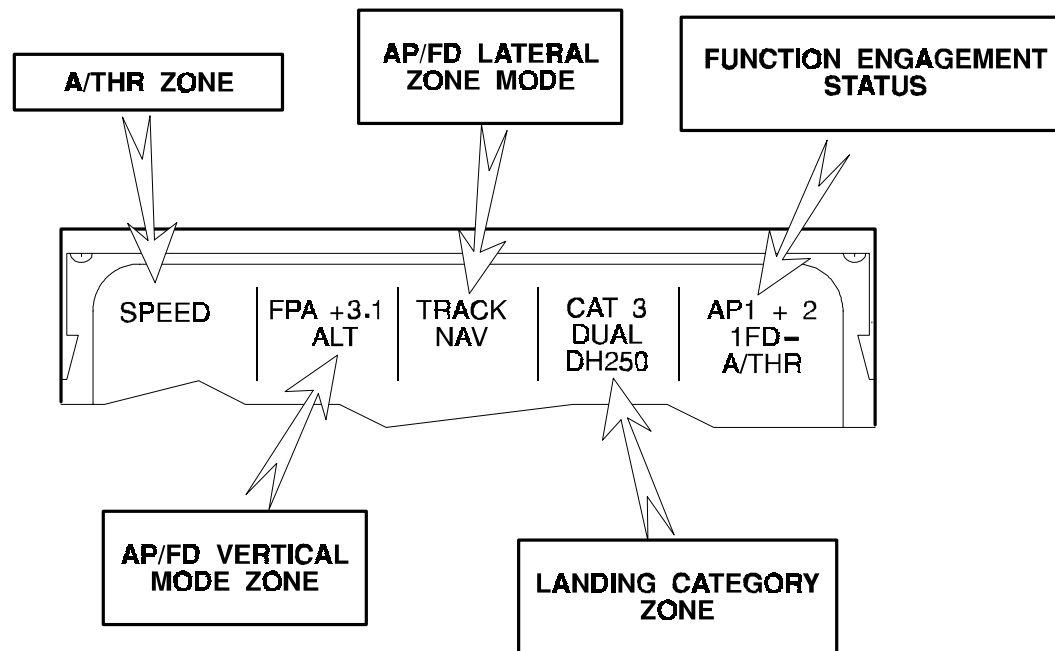
in AMBER :

VERT DISCONT AHEAD, USE MAN PITCH TRIM,
EFIS SWTG NOT ALLOWED.

in WHITE :

EFIS SINGLE SOURCE 1, EFIS SINGLE SOURCE 2,
CHECK APPR SELECTION, DECELERATE,
SET MANAGED SPEED, EXTEND SPD BRK,
SET GREEN DOT SPEED, RETRACT SPD BRK,
SET HOLD SPEED.

There is one red message dedicated to this display area, that is :
MAN PITCH TRIM ONLY.



STUDENT NOTES:

FQW4200 GE Metric

FLIGHT PLANNING

- Flight Plan
- Navigation Data Base
- Navigation
- Lateral Flight Plan
- Vertical Flight Plan
- Performance
- Display

This module explains the flight plan construction and the modifications provided by the Flight Management part.

This is a general description rather than a complete description or utilization of the Flight Management function.

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 data bases or directly entered by the pilot.

The limitations are mainly speed, altitude or time constraints originated by the Air Traffic Control (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 provides 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 an FM problem, the remaining valid FMGEC can be used as sole source to command both MCDUs and NDs after a manual action by the pilot on the FM SOURCE selector switch.

NAVIGATION DATA BASE

The navigation data base provides all necessary information for flight plan construction and follow-up.

The pilot will either select an already assembled flight plan (company route (CO ROUTE)), or will build his own flight plan, using the existing data base contents.

This data base has a worldwide coverage, updated every 28 days.

A crossloading facility is available allowing the data base loading from either Flight Management Guidance and Envelope Computer

(FMGEC) data bases through an intersystem bus. Besides this, some room is kept to allow manual entry of 20 nav aids, 20 waypoints, 5 routes and 10 runways.

The data base cannot be erased, however, the manually entered data can be erased.

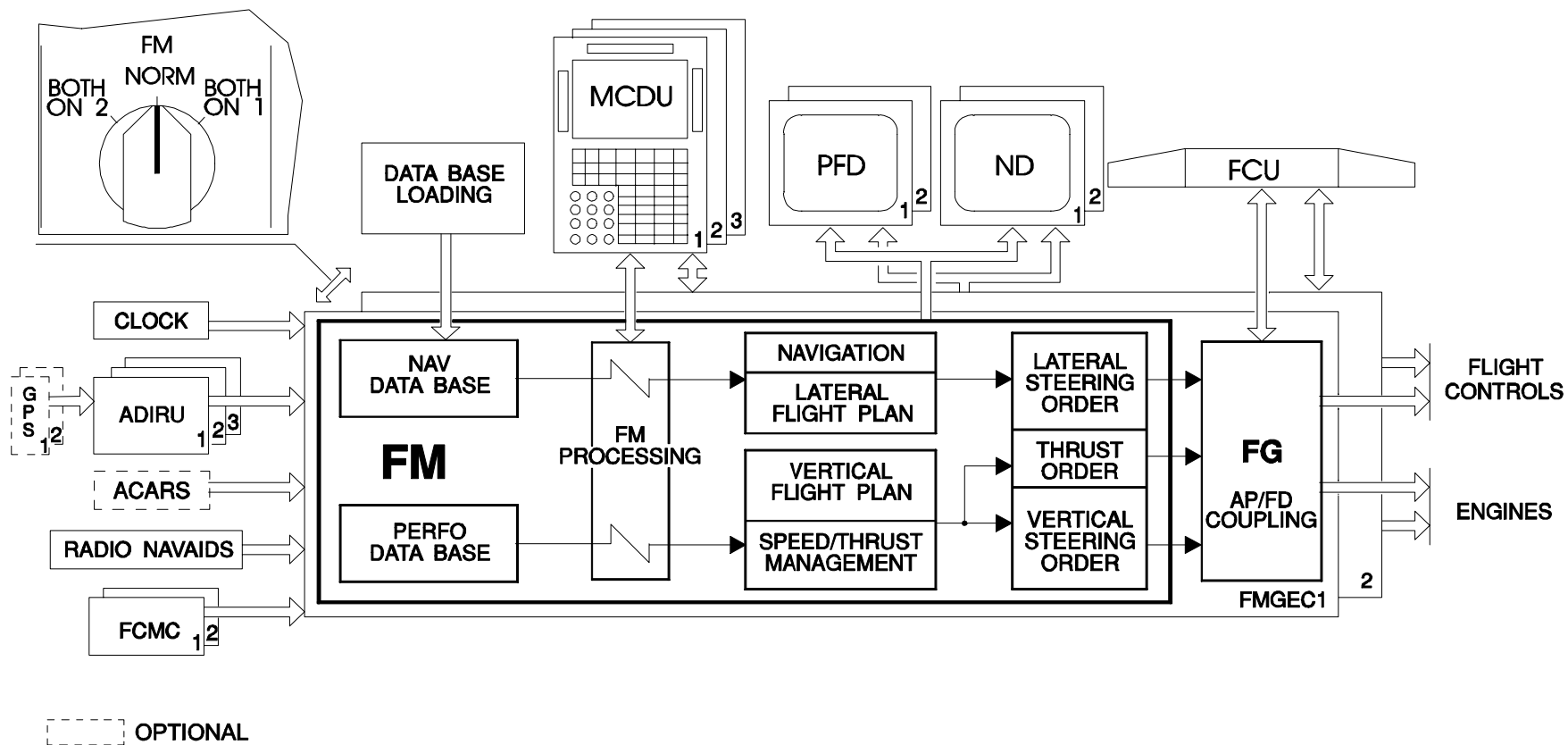
Two cycle data bases can be inserted, the selection is made automatically using data from the aircraft clock.

NAVIGATION

The navigation process provides 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 system, air data sensors, navigation radios and, if installed, Aircraft Communication Addressing and Reporting System (ACARS).

Position can be updated manually during the flight or automatically e.g.: on the runway threshold at take-off.



LATERAL FLIGHT PLAN

The lateral flight plan provides the sequential track changes at each waypoint within 3 main sections.

DEPARTURE :

initial FIX (origin airport), SID...

EN ROUTE :

waypoints, navigation aids...

ARRIVAL :

STAR, approach, missed approach, go around...

The lateral steering order can be followed by the pilot or the autopilot through the NAV mode selected on the Flight Control Unit (FCU).

In case of loss of the FM processor, a simplified Flight Management function is available directly from MCDU1 or MCDU2 only.

This is called BACK-UP NAVIGATION function.

The following features are provided :

- lateral flight planning,
- aircraft position,
- flight plan with crosstrack error (XTRKE).

In this case, there is no Autopilot coupling in NAV mode.

VERTICAL FLIGHT PLAN

The vertical flight plan provides 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/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 management, deceleration.

APPROACH/MISSED APPROACH/GO AROUND :

thrust/acceleration altitudes.

The vertical steering order can be followed by the pilot or the autopilot.

Any level change in the vertical profile is initiated after a push action on a level change selector.

If the ACARS are fitted, the crew may send a request for wind data to the ground via the ACARS. In response to this request, or automatically, the ground sends climb, cruise, descent and alternate wind data to the aircraft.

PERFORMANCE

The performance data base 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 ECONOMY 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 is given by the Fuel Control and Monitoring Computers (FCMCs).

The speed and the thrust values associated with a given Cost Index 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.

DISPLAY

According to the pilot selection on 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 Navigation Display (ND) is set to ROSE 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 decentered by scrolling the flight plan on the MCDU.

The Primary Flight Display (PFD) shows the FM guidance following engagement of the AP/FD lateral and longitudinal modes.

STUDENT NOTES:

FQW4200 GE Metric

MCDU DESCRIPTION

- Display
- Alphanumeric Keys
- Page Keys
- Display Keys
- Line Select Keys
- Front Panel Annunciators
- Data Entry
- Top Panel Annunciators
- Brightness Knob
- Color Code

This module describes the use of the Multipurpose Control and Display Unit (MCDU) flight management function.

Although the MCDU is dedicated to different systems, its primary function enables the pilot to communicate with the Flight Management Guidance and Envelope Computers (FMGECs).

DISPLAY

The MCDU display layout includes the title line and the scratchpad where pilot entries are first made.

FMGEC messages are also displayed on the scratchpad.

The 6 data field lines display either data from FMGEC or data entered by the pilots (in large or small font).

The 6 label lines, displayed in small font, contain the title of the data field just below.

ALPHANUMERIC KEYS

The alphanumeric keys are used for writing data on the bottom line of the screen, called scratchpad.

Pressing an alphanumeric key (0 to 9, A to Z, (., +/-, Δ (OVFY) means OVERFLY, SP means SPACE) enters the corresponding character onto the MCDU scratchpad.

PAGE KEYS

Each management function is shown on a specific display called a page.

Pressing a page key causes a new MCDU page to be displayed and allows certain functions to be chosen.

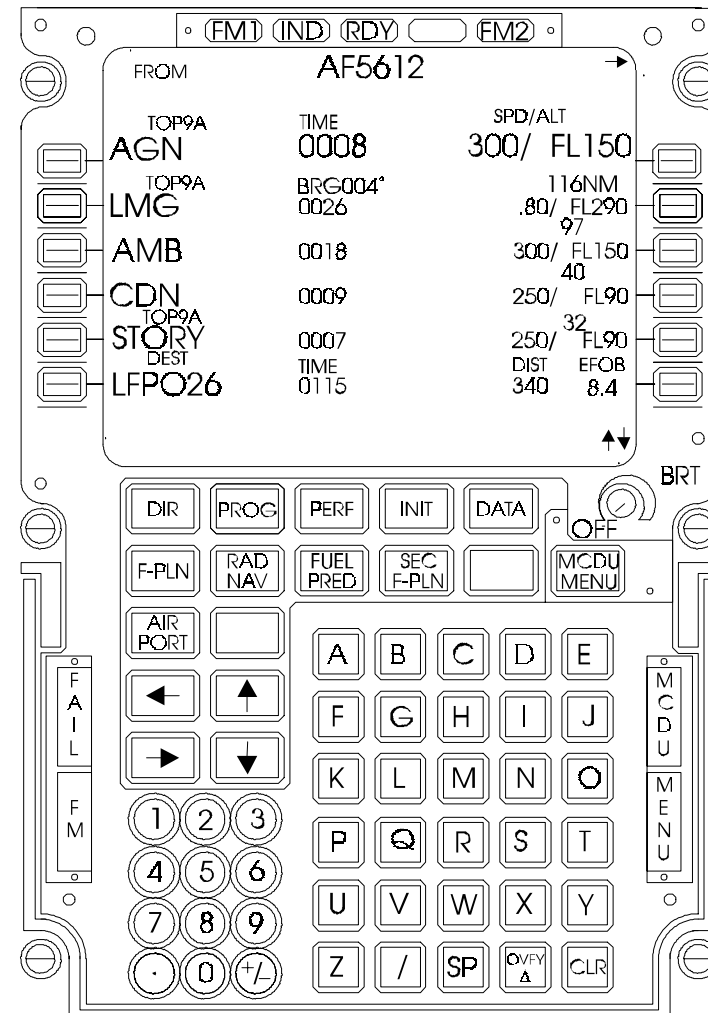
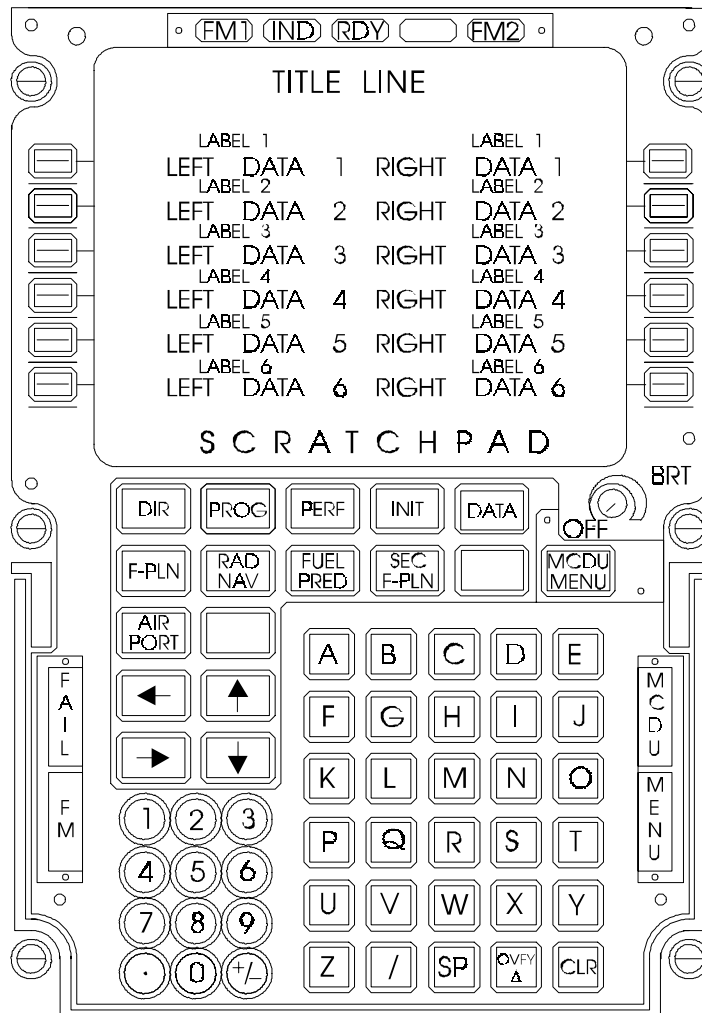
The available page keys are :

- the FM page keys (AIRPORT, F-PLN, DIR, PROG, PERF, INIT, DATA, RAD NAV, FUEL PRED, SEC F-PLN),
- the multipurpose page key, MCDU MENU,
- two spare unlabelled page keys which have no effect when they are pressed.

By pressing a page key, the corresponding page is displayed.

The displayed F-PLN page shows waypoints and legs which form a sequence of the flight plan.

Information about the destination is also displayed.



DISPLAYS KEYS

The five display keys comprise four slew keys and a clear key.
Some pages provide information which is complementary to that of another page.

These pages are identified with a symbol (←, →) at the top right hand corner of the display.

 causes horizontal forward page slewing when it is allowed (also called "NEXT PAGE").

After the last page, the first one is presented again.

When there are more than two pages, the page rank is displayed.

 causes horizontal backward page slewing when it is allowed (also called "PREVIOUS PAGE").

Some pages are too long to be entirely displayed on the screen.

These pages are identified with a symbol (↑, ↓) at the bottom right corner and can be slewed up or down by pressing the related slew keys.

 "slew up" key causes upward vertical slewing when it is allowed.

 "slew down" key causes downward vertical slewing when it is allowed.

Another use of the slew keys is to increment or decrement certain values shown on the screen.

These values are identified by adjacent arrows.

The fifth display key is the CLEAR key, located at the bottom right of the MCDU.

 allows the crew to clear data such as messages displayed on the scratchpad and various parameters displayed on the screen.

Note :

A line is cleared when the CLR message appears on the scratchpad line.

LINE SELECT KEYS

Lateral keys called line select keys are used to insert, activate, modify or delete data in the suitable data field.

Line Select Keys (LSK) can also be used to select a new page or to perform an action displayed in the adjacent data field.

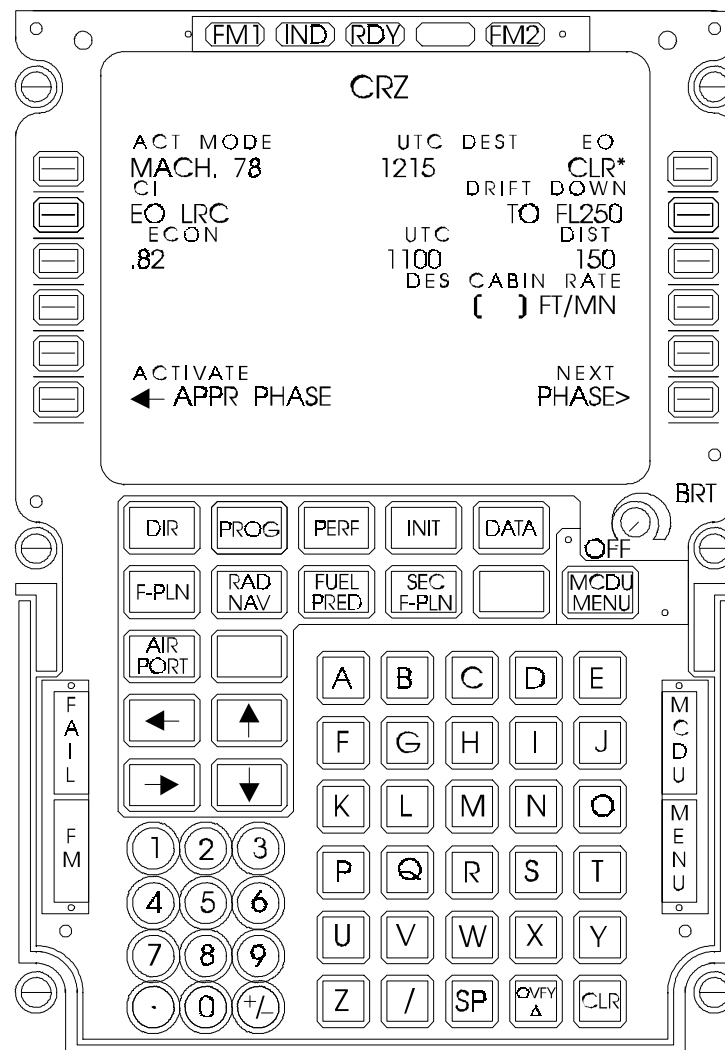
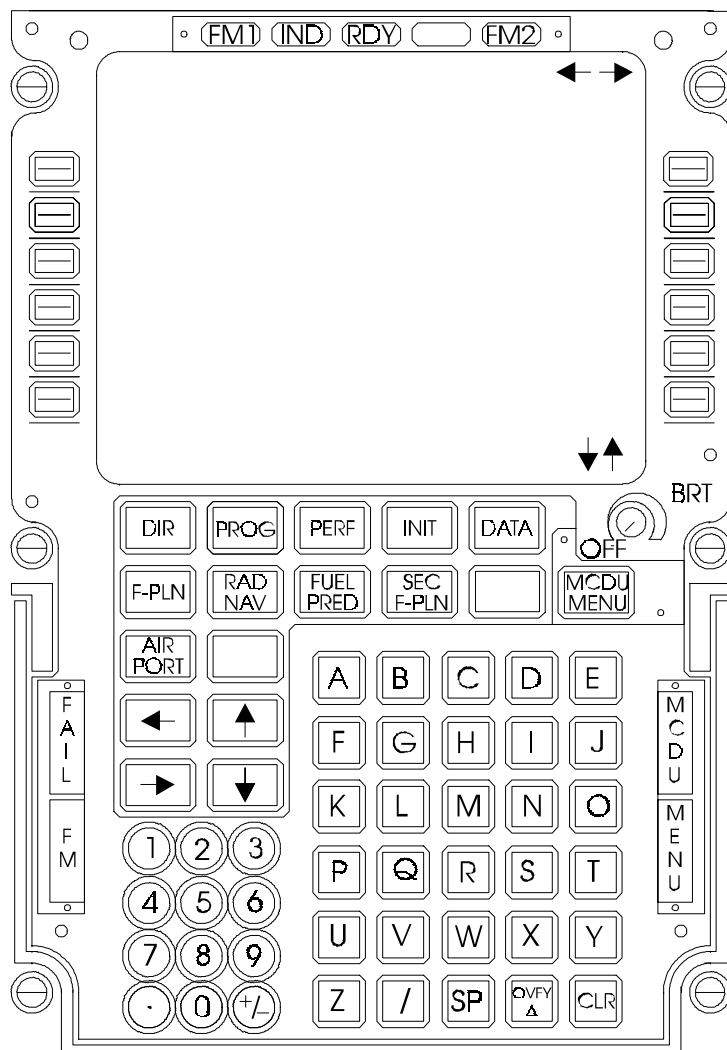
Actions are identified by symbols such as :

"<" means : a new page can be called by pressing the adjacent LSK,

"*" means : a FMGEC function can be activated,

"[]" means : data may be inserted in this line,

" ← " enables data to be selected or to be activated.



FQW4200 GE Metric

FRONT PANEL ANNUNCIATORS

F A I	There are three annunciator lights on the MCDU front panel. The FAIL annunciator comes on amber when the MCDU has failed.
F	The FM annunciator comes on white when the FM is not the active system and it has sent an important message to display. In this case, any page key can be pressed to return to the Flight Management related display. Important messages are those displayed in amber.
M C D	
M E N	The MCDU MENU annunciator comes on white when a system, linked to the MCDU, other than the FM, requests the display.

DATA ENTRY

To enter any data into the FMGEC, the pilot must first type the data on the scratchpad using the alphanumeric keyboard.

The data is then inserted into the suitable data field by pressing the corresponding line select key.

--	--	--	--	--	--	--	--	--	--

Data entry in amber boxes is mandatory.
White dashed lines indicate that data will be calculated and displayed by the FMGEC when it has enough information to do so.

The scratchpad is limited to a maximum of 22 characters.
When the Line Select Key is pressed, the FMGEC checks the data format and data acceptability.

If data is not accepted, a specific message (white) is sent :

FORMAT ERROR
or NOT IN DATA BASE
or NOT ALLOWED
or ENTRY OUT OF RANGE.

TOP PANEL ANNUNCIATORS

There are five annunciator lights across the top of the MCDU front panel. Only four of them are used.

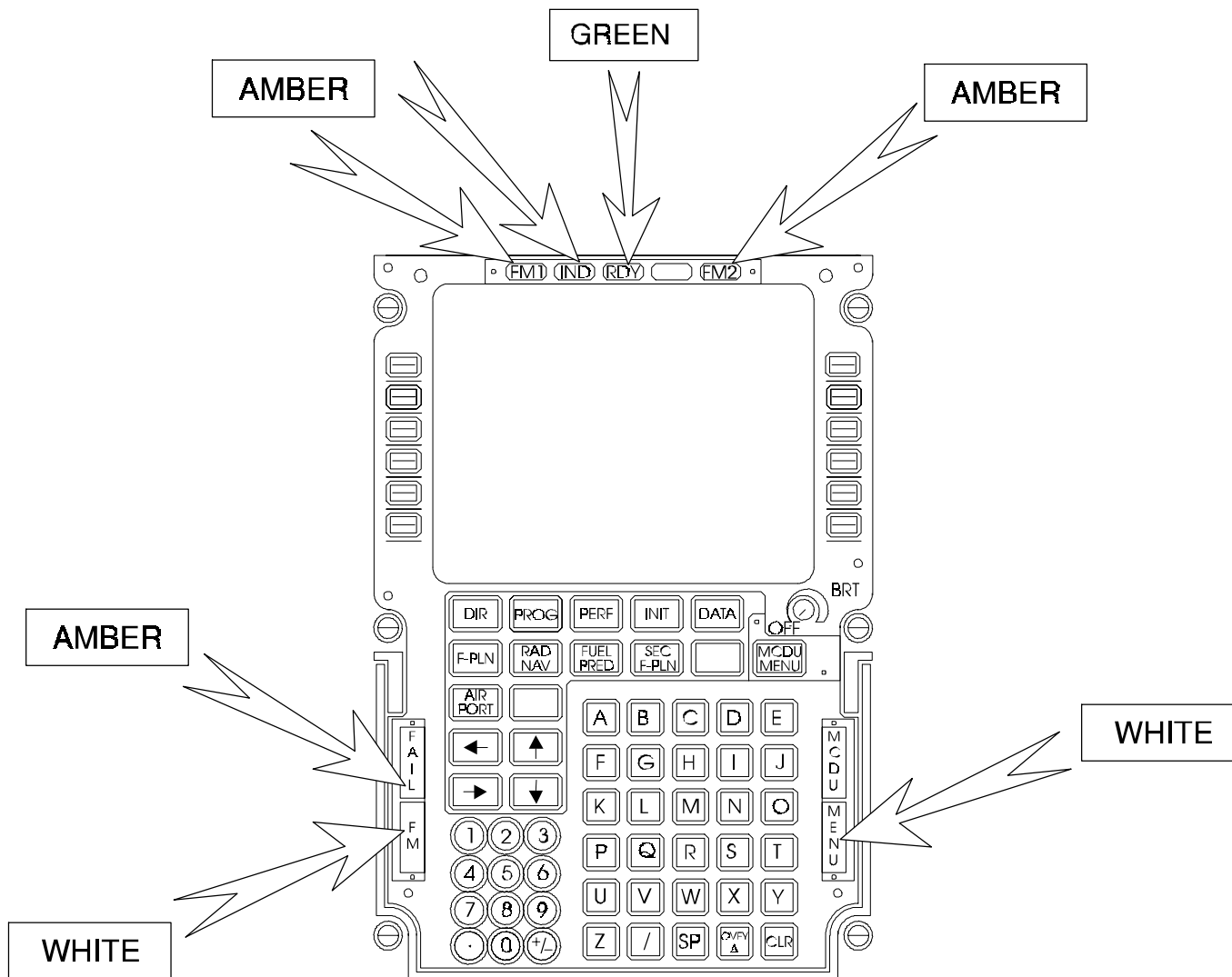
FM1	FM2	The FM failure annunciators indicate when an FM failure occurs.
The FM1 (FM2) failure light comes on amber when FM1 (FM2) is detected failed by the MCDU. This light comes on on the MCDU communicating with the failed FM, depending on FM source selector position. The MCDU3 annunciator only comes on if MCDU3 is used to replace MCDU1 or MCDU2. The light goes off if FM1 (FM2) is successfully reset.		

The READY annunciator indicates that the MCDU is ready to be used after a power-up.

RDY	After a successful reset, the green RDY light remains ON, as long as the brightness knob is in the OFF position, to inform the crew that the MCDU is now available.
-----	---

The INDEPENDENT annunciator indicates the loss of FM dual mode.

IND	This IND annunciator comes on amber when the selected FM has detected an independent operation while both FMs are healthy.
-----	--



FQW4200 GE Metric

BRIGHTNESS KNOB

The brightness knob allows the MCDU to be powered up and reset and the screen brightness to be adjusted.

The brightness knob has "ON" and "OFF" positions.

COLOR CODE

The color code enables the data and information displayed on the MCDU to be differentiated.

Titles, comments, dashes, symbols and minor messages are displayed in WHITE.

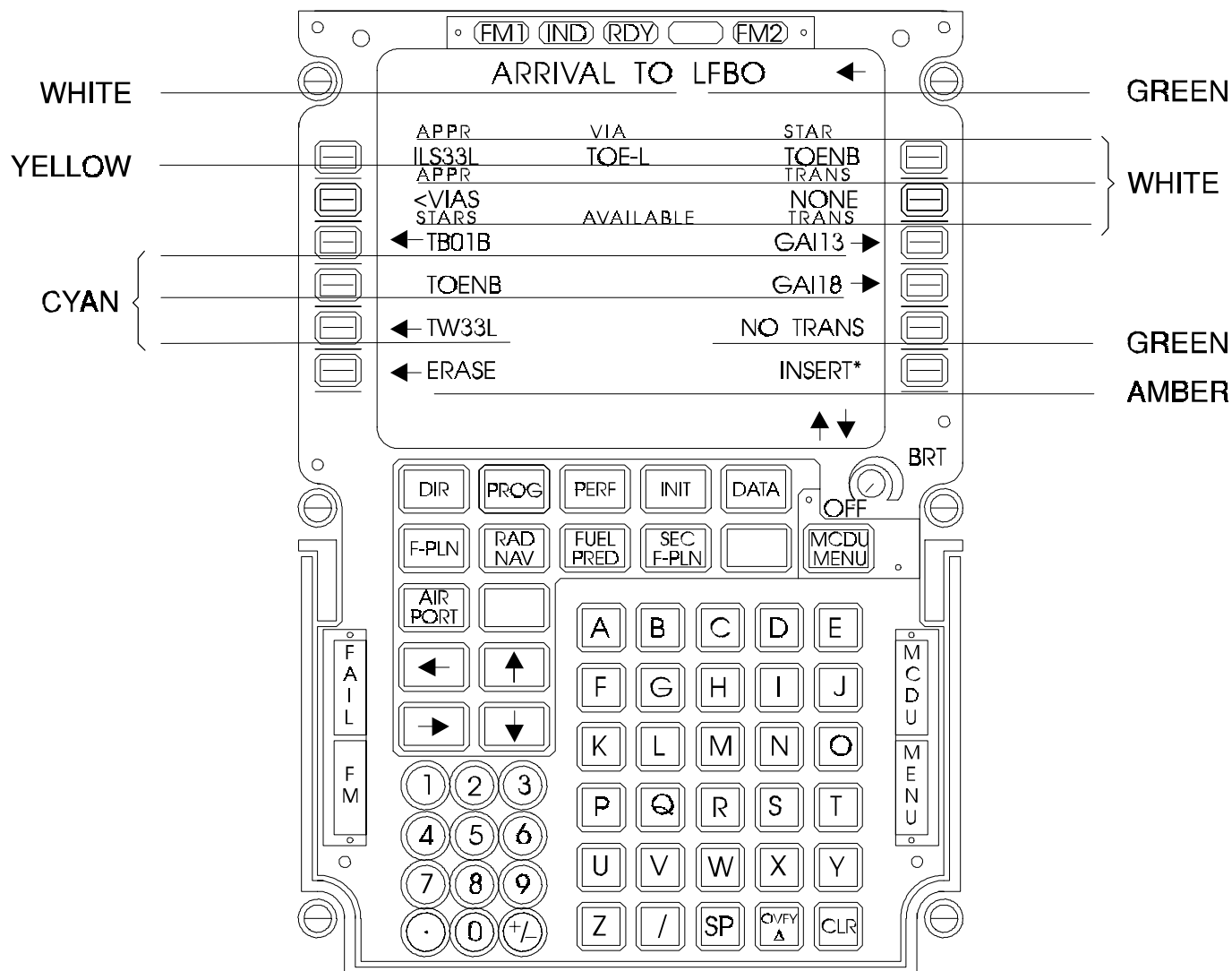
Non modifiable data or active data are displayed in GREEN.

However, in temporary flight plan, the same data is shown in YELLOW until it is validated by an insertion.

The modifiable data and selectable data are displayed in CYAN.

Mandatory data, boxes, required pilot actions and important messages are displayed in AMBER.

Data associated with the flight plan constraints is indicated in MAGENTA as well as the maximum permitted flight level.



FQW4200 GE Metric

SSTUDENT NOTES:

FLIGHT MANAGEMENT PRIORITY LOGIC

FM Operating Modes
Mode Operation
MCDU
Displays
Radio Navigation
FM Switching
MCDU Switching

FM OPERATING MODES

There are three operating modes : NORMAL, INDEPENDENT, SINGLE.
At Flight Management (FM) initialization, that means at power up, both FM parts exchange information.

Initial cross-comparison is made on the following parameters : Nav data base, perf data base and soft program serial numbers, A/C, engine type and program pin.

If the Flight Management (FM) parts agree, NORMAL mode is active.

When keys are pressed, they are immediately processed by both FM's, regardless of the Multipurpose Control Display Unit (MCDU) from which they originate.

If the FM parts disagree, INDEPENDENT mode is active.

Each FM part manages its own Multipurpose Control and Display Unit (MCDU).

If one FM part has failed, SINGLE mode is active.
Both MCDUs are driven by the remaining FM part.

Note :

An FM failure or an independent configuration is indicated by the lighting of the corresponding legend "FM1", "FM2", "IND" on the top of the MCDUs.

MODE OPERATION

In NORMAL mode, the FM part receives the master/slave activation from the Flight Guidance (FG) part.

The MASTER computer imposes the following parameters upon the SLAVE computer :

- . flight phase
- . flight plan sequencing
- . active performance mode and speeds
- . clearance and maximum altitudes
- . ILS frequencies and courses, if any.

After a flight plan change, there is a comparison on the active leg and, every second, on the active performance mode and active guidance mode. If it is different, the slave computer will synchronize itself to the master one by copying the master values.

Also, aircraft position, Gross Weight (GW) and target speeds from master and slave computers are compared every second.

If the difference is greater than 5 Nm, 2 tons or 2 Kts respectively, an appropriate message is displayed on the MCDUs :

- FMS1/FMS2 POS DIFF
- FMS1/FMS2 GW DIFF
- FMS1/FMS2 SPD TGT DIFF

Pilot action is then required.

In INDEPENDENT mode, there is no interaction from one system to the other one. The Flight Management Guidance and Envelope Computers (FMGECs) only send their status information to each other (e.g., in this case, the INDEPENDENT mode).

In SINGLE mode, both MCDUs are driven by the same FM part, but they can still display different pages. Messages linked to the navigation process are displayed on both MCDUs.

MCDU

As already presented in the FM OPERATING MODES topic, the MCDUs work differently.

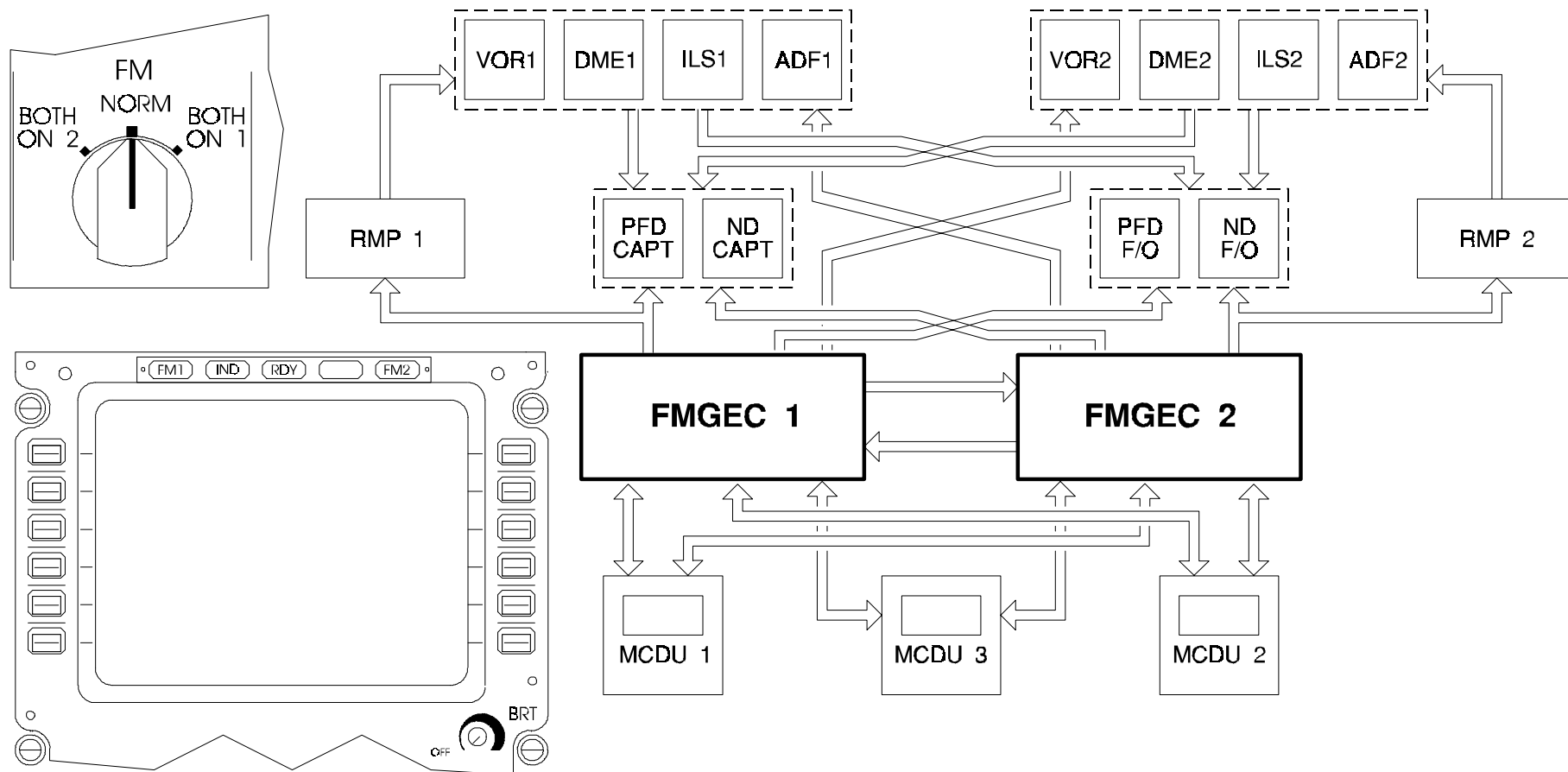
In NORMAL mode, the MCDUs can be used simultaneously on different pages. Any modification or entry on one MCDU is transmitted to the other MCDU via the FMGEC crosstalk.

In INDEPENDENT mode, both MCDUs operate separately.

The "IND" light, at the top of the MCDUs, indicates this operation.

In SINGLE mode, both MCDUs basically work as in normal mode, but with the only valid FMGEC.

The "FM1" and "FM2" lights, at the top of the MCDUs, indicate the FM1 and FM2 failures.



FQW4200 GE Metric

DISPLAYS

Flight Management information is displayed on Navigation Displays (NDs) and on Primary Flight Displays (PFDs).

For FM information, in NORMAL or INDEPENDENT modes, FMGEC1 supplies PFD1 and ND1, FMGEC2 supplies PFD2 and ND2. In SINGLE mode, the remaining FMGEC supplies all the displays.

RADIO NAVIGATION

The schematic shows the architecture of the radio navigation receivers controlled by the FMGECs in NORMAL or INDEPENDENT modes.

For the selection of radio navigation frequencies and courses, in normal or independent modes, each FMGEC controls its own side receivers through a Radio Management Panel (RMP).

Only the actual frequencies and courses from the receivers are displayed on the PFDs and the NDs.

In case of a FMGEC failure, the valid FMGEC controls its own side receivers as usual, through a Radio Management Panel, but also the other side receivers, directly without going through a RMP.

The pilot must first transfer both FMs to the same source (see topic "FM SWITCHING").

If both FMGECs fail, the crew must use the Radio Management Panels to select the frequencies and courses.

FM SWITCHING

Laid out on the pedestal switching panel, there is a manually operated switch called "FM SOURCE".

It has 3 positions : NORM, BOTH ON 1 and BOTH ON 2.

Setting the switch to "NORM" position, assuming no MCDU has failed, will validate the normal configuration :

- MCDU1 works with FM1,
- MCDU2 works with FM2.

Setting the switch to BOTH ON 1, enables MCDU1 and MCDU2 to work with the same FM1 source.

This also makes the two operative Display Management Computers (DMCs), feeding the two Electronic Flight Instrument System (EFIS) displays, work with the same FM1 source.

Setting the switch to BOTH ON 1 will also enable the nav aids to be tuned from the same FM1 source.

Setting the switch to BOTH ON 2, enables MCDU1 and MCDU2 to work with the same FM2 source.

This also makes the two operative Display Management Computers (DMCs) feeding the two EFIS displays work with the same FM2 source. Setting the switch to BOTH ON 2 will also enable the nav aids to be tuned from the same FM2 source.

Note :

All the above also applies to MCDU3 when it replaces MCDU1 or 2 switching operation (in case of failure of MCDU1 or 2).

If FM1 has failed, MCDU1 can be switched manually through the "FM SOURCE" selector switch.

MCDU1 is switched to work in full capability with FM2, and this, without disturbing the link FMGEC2 $\Leftrightarrow$ MCDU2. If FM2 has failed, the same applies but with MCDU2.

As an alternative way and provided the switch is in "NORM" position, the Back-up Nav function of MCDU1 or 2 can be activated through a specific prompt on the MCDU MENU page, to cover failure of FM1 or 2.

MCDU SWITCHING

Turning the brightness knob of one MCDU to "OFF" permits the MCDU switching.

This knob is located on each MCDU front panel.

The way to proceed is the following :

- turning to "OFF" the brightness knob of MCDU1 (MCDU2), controls the transfer from MCDU1 (MCDU2) (which is blank and inoperative) to MCDU3 of the FM function (normally FM1(2)).

If the BRT knob is in OFF position, the RDY annunciator is lit to indicate the good result of the power up test.

- turning to "OFF" the brightness knob of MCDU3, makes MCDU3 inoperative and transfer is no longer possible.

Note :

If both MCDU1 and 2 are turned OFF, the transfer from MCDU1 to MCDU3 will have priority over the one from MCDU2.

If MCDU1 or MCDU2 has failed, MCDU3 must be able to work with FMGEC1 or FMGEC2 in order to replace MCDU1 or MCDU2 for the Flight Management function.

For a dual MCDU1 and 2 failure, MCDU3 has to operate as MCDU1.

This reconfiguration does not include the Back-up Nav function which remains selectable on MCDU1 or 2 only, and not on MCDU3.

STUDENT NOTES:

EFIS DISPLAY

FM Display on PFD
FM Display on ND
Data Base Display P/B
FM Source Switching
Back-Up Nav Switching
MCDU Failure

FM DISPLAY ON PFD

The Primary Flight Display (PFD), as main guidance instrument, displays the data computed or inserted on the Multipurpose Control and Display Unit (MCDU).

This data can be ECON speed targets and target altitudes in managed guidance modes, V1 and V2, Decision Height (DH) or Minimum Decision Altitude (MDA) in approach.

At the top of the Primary Flight Display, the Flight Mode Annunciator (FMA) provides the pilot with the DH or the MDA.

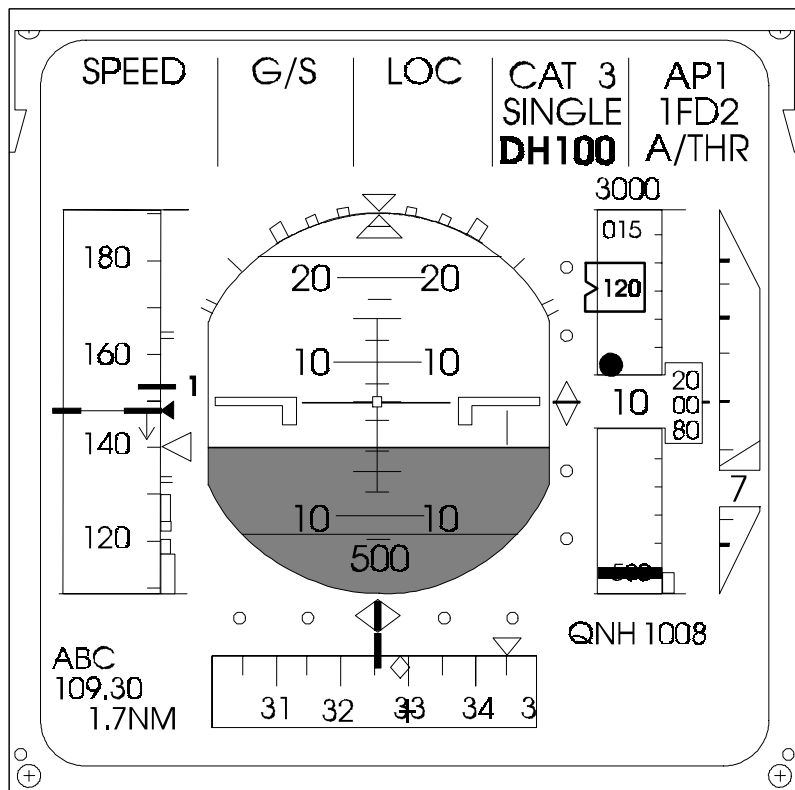
The speed scale displays the Flight Management data such as the speed target and V1.

The altitude scale displays the altitude constraint from the Flight Management (FM) part and the linear vertical deviation with respect to the FM theoretical vertical flight plan (F-PLN).

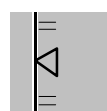
Landing elevation is also indicated by a blue horizontal bar on the altitude scale.

Note :

The FM guidance is associated to the FG modes (NAV, CLB, DES).



DH100 DECISION HEIGHT (WHITE AND CYAN)

 **ECON TARGET SPEED (MAGENTA)**
WITH HIGH AND LOW MARGINS
IN DESCENT MODE

 **V1 SPEED (CYAN)**

 **ALTITUDE
CONSTRAINT
(MAGENTA)**

 **LINEAR VERTICAL
DEVIATION
(MAGENTA)**

 **LANDING FIELD
ELEVATION
(CYAN)**

FM DISPLAY ON ND

The Navigation Display (ND) works in six different modes selected on each Electronic Flight Instrument System (EFIS) control panel of the Flight Control Unit (FCU).

In ROSE-NAV, ARC and PLAN modes, the Navigation Display (ND) displays the flight plan computed in the FM part at a scale defined by the range selected on the FCU.

The ND represents basically : the aircraft position, the flight plan data, the range selected on the FCU, autotuned nav aids.

Note :

The aircraft position is fixed in all display modes except in PLAN mode, where it moves along the flight plan.

There is correspondance between the flight plan displayed on the ND and the MCDU FLIGHT PLAN page if no scrolling has been done on this page.

The TO waypoint characteristics are displayed at the top right hand corner of the Navigation Display (ND) :

- ident (in white) and bearing (in green),
- distance to go (in green),
- Estimated Time of Arrival (ETA), (in green).

The rest of the flight plan line and waypoints is displayed in green.

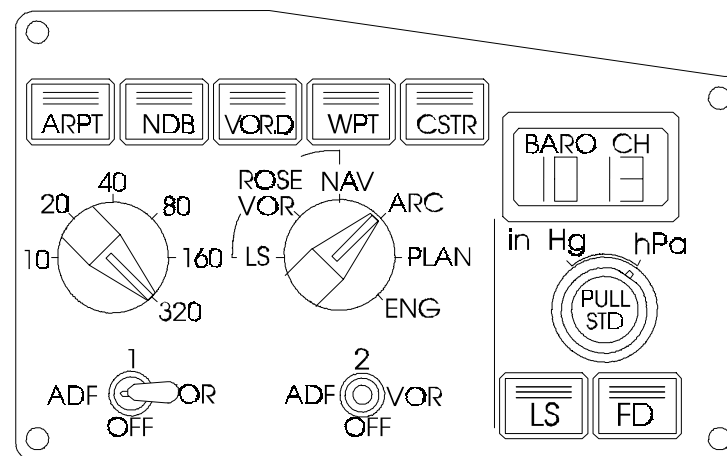
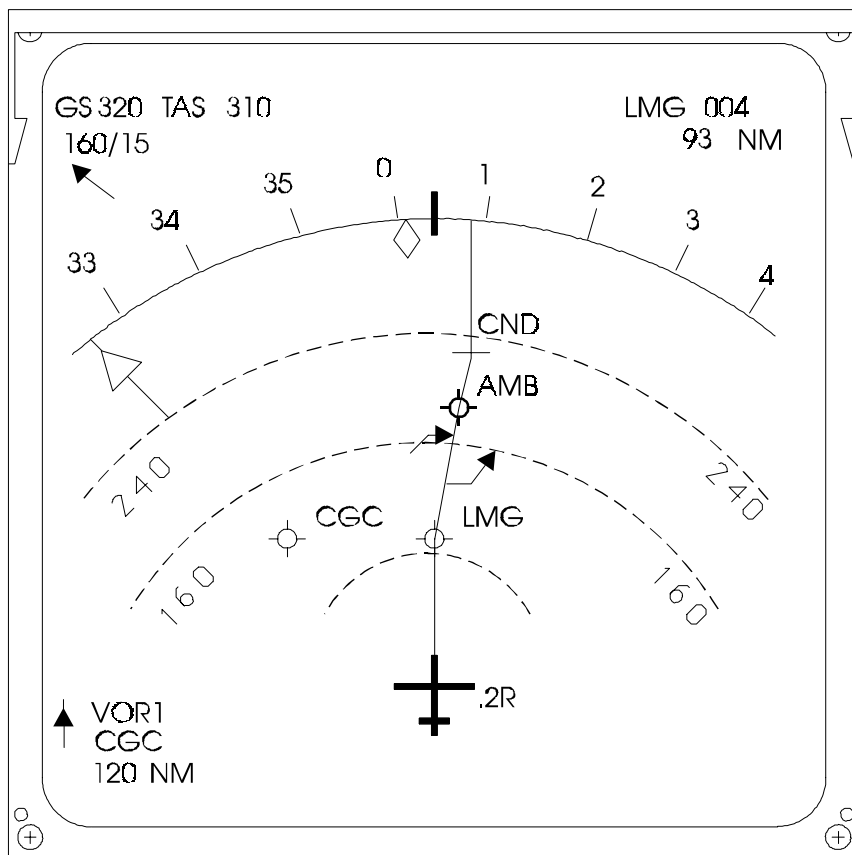
A crosstrack deviation, if any, is also provided, in green, on the left or right hand side in nautical miles.

Note :

Wind speed and direction, ground speed and track are computed by the FM part and transmitted to the Display Management Computers (DMCs) which also receive the same data from the Air Data and Inertial Reference Units (ADIRUs).

Radio nav aids are displayed in cyan when they are autotuned by the FM part.

Specific symbols can appear, along the flight plan, corresponding to some maneuvers such as Start of Climb (S/C) in white, Top of Climb (T/C) in cyan, Top of Descent (T/D) in white, holding pattern and turn procedure.



FM1 IND RDY FM2			
FROM	UTC	AEF101	
LACOU	1039	SPD/ALT	
	BRG007	/ FL191	
LMG	1051	.79/ FL330	
(S/C)	1051	.79/ FL330	
(T/C)	1055	.79/ FL370	
UR10		.68	
AMB	1104	.80/	
DEST	UTC	DIST	EFOB
EGLL27R	1147	392	6.5

DATA BASE DISPLAY P/B

By pressing these five interlocked pushbuttons : WPT, VOR.D, NDB, ARPT and CSTR, different information from the Navigation data base is available and will be displayed in magenta.

Note that these options are exclusive and the priority is given to the last which has been selected.

When the WPT pushbutton is pressed, all waypoint locations in the related range, are transmitted to the ND to be displayed.

When the VOR.D pushbutton is pressed, all VOR and/or DME stations locations in the related range, are displayed on the ND.

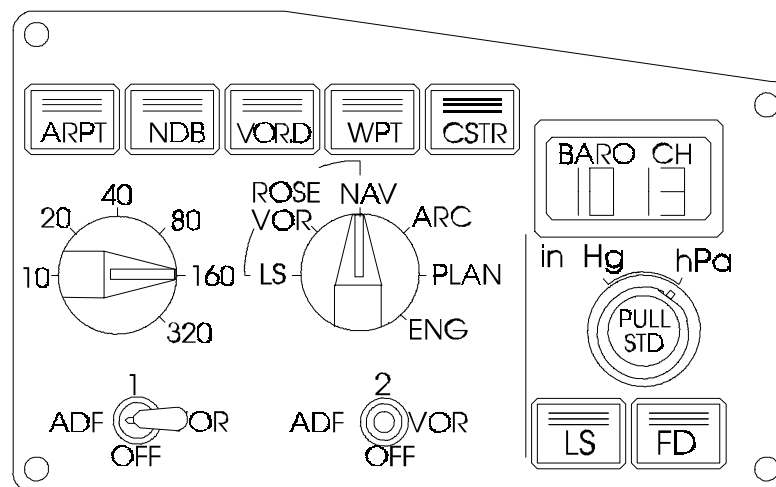
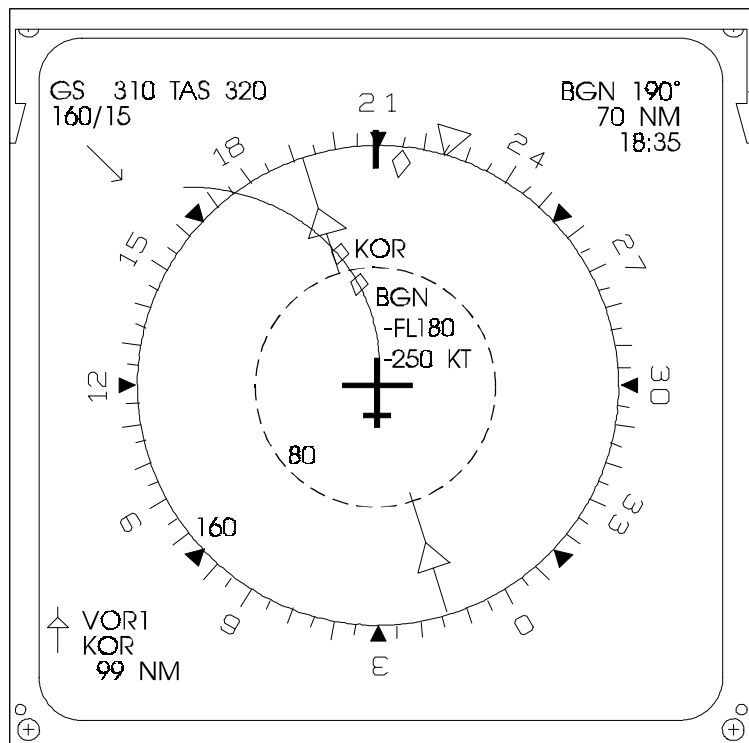
When the NDB pushbutton is pressed, all Non Directional Beacon station locations in the related range, are transmitted to the ND to be displayed.

When the ARPT pushbutton is pressed, all airport locations available to the aircraft, in the related range, are transmitted to the ND to be displayed.

When the CSTR pushbutton is pressed, all speed, altitude and time constraints (if any) on one or several waypoints, are transmitted to the ND to be displayed.

For example, the constraints on the BGN waypoint are :

- an altitude at or below the flight level 180, and
- a speed below 250 kts.



FM SOURCE SWITCHING

The ND always follows the setting of the SWITCHING/FM selector switch.

In normal setting, each ND, via each related Display Management Computer, displays EFIS data from the onside FM part.

If "BOTH ON 1" or "BOTH ON 2" is selected, both NDs, via related Display Management Computers, display EFIS data from FM1 or FM2 only.

If an FM has failed and this FM is selected to drive its onside ND, then the corresponding ND does not receive EFIS data and, thus, displays "MAP NOT AVAILABLE".

BACK-UP NAV SWITCHING

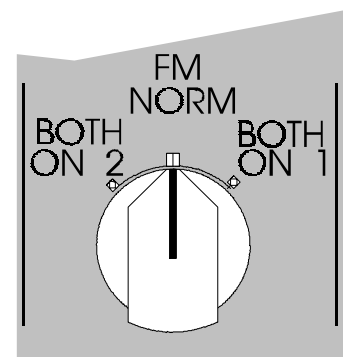
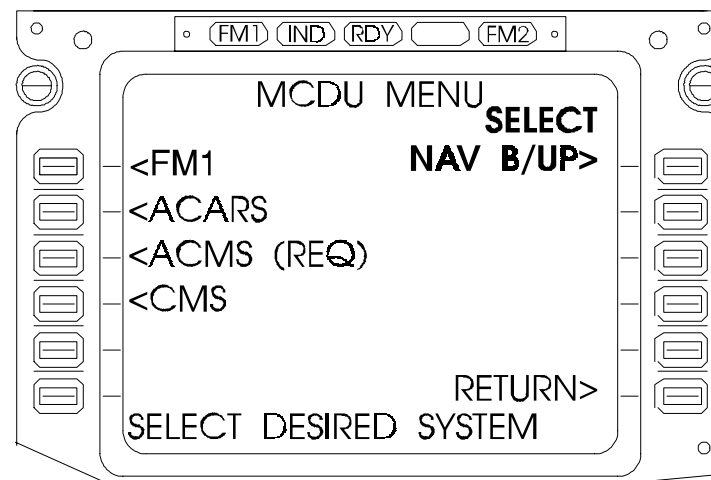
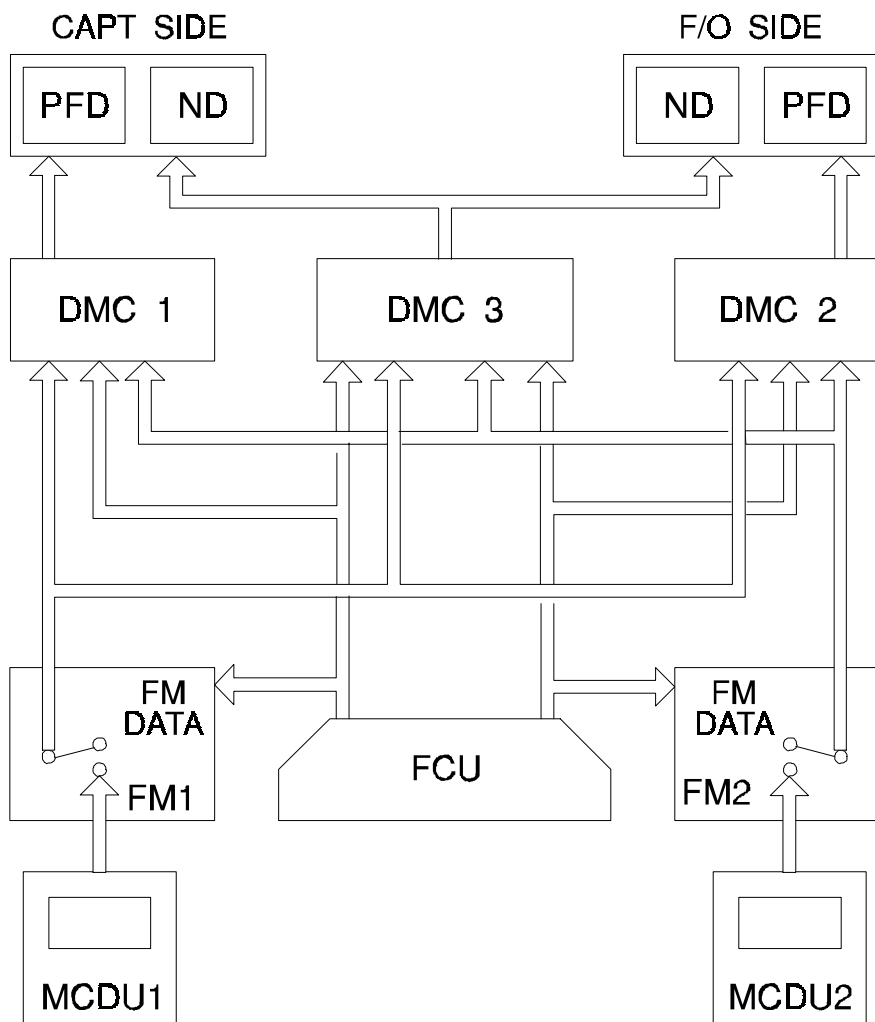
The pilot may activate back-up navigation via the MCDU MENU page when the SWITCHING/FM selector switch is in NORM position.

When back-up navigation is activated, the MCDU is responsible for supplying the EFIS with relative lateral data mainly the aircraft position and the flight plan with the associated crosstrack error if it exists.

An amber "BACK-UP NAV" message is also displayed at the bottom of the ND for pilot information.

MCDU FAILURE

If a MCDU failure occurs on side 1 or 2, or if a MCDU is turned off via its BRT knob, as long as the transmitting FM is healthy, the transmission to the EFIS continues despite the loss of this MCDU.



FQW4200 GE Metric

STUDENT NOTES:

FQW4200 GE Metric

NAVIGATION BACK-UP

- General
- Flight Planning
- Navigation
- ND Display
- MCDU Page Availability
- Deactivation

GENERAL

The MCDU BACK-UP NAV must be used as a back-up system when both Flight Management (FM) parts are failed, supplying the crew with limited information which can be used to complete the current flight.

The Multipurpose Control Display Unit (MCDU) BACK-UP NAV (B/UP NAV) is activated through the "SELECT NAV B/UP" prompt on the MCDU MENU page.

This prompt is available at all time, regardless of the status of FM1 or FM2, provided the FM SOURCE selector is set to the NORM position.

If the FM source selector is moved from the NORM position to one of the two other positions, BACK-UP NAV is deactivated.

Finally, there is no interconnection between MCDU1 and MCDU2, so, the B/UP NAV functions work independently and may be activated separately.

Note :

MCDU3 does not have this option, even when it is used to replace MCDU1 or MCDU2.

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 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 performed and, then, any other 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 provide position, ground speed, track, heading, altitude and wind.

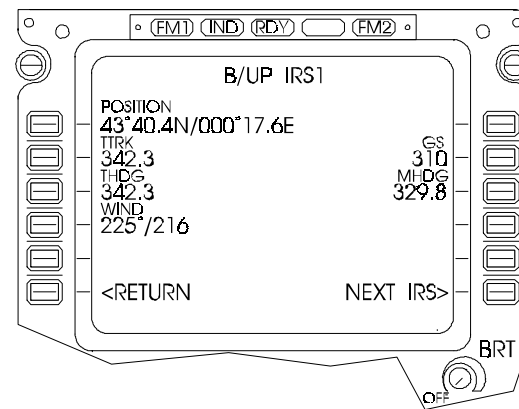
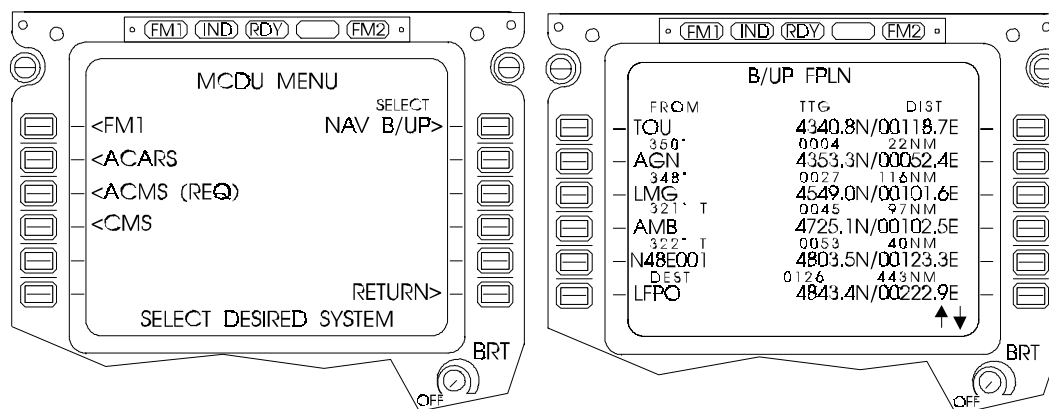
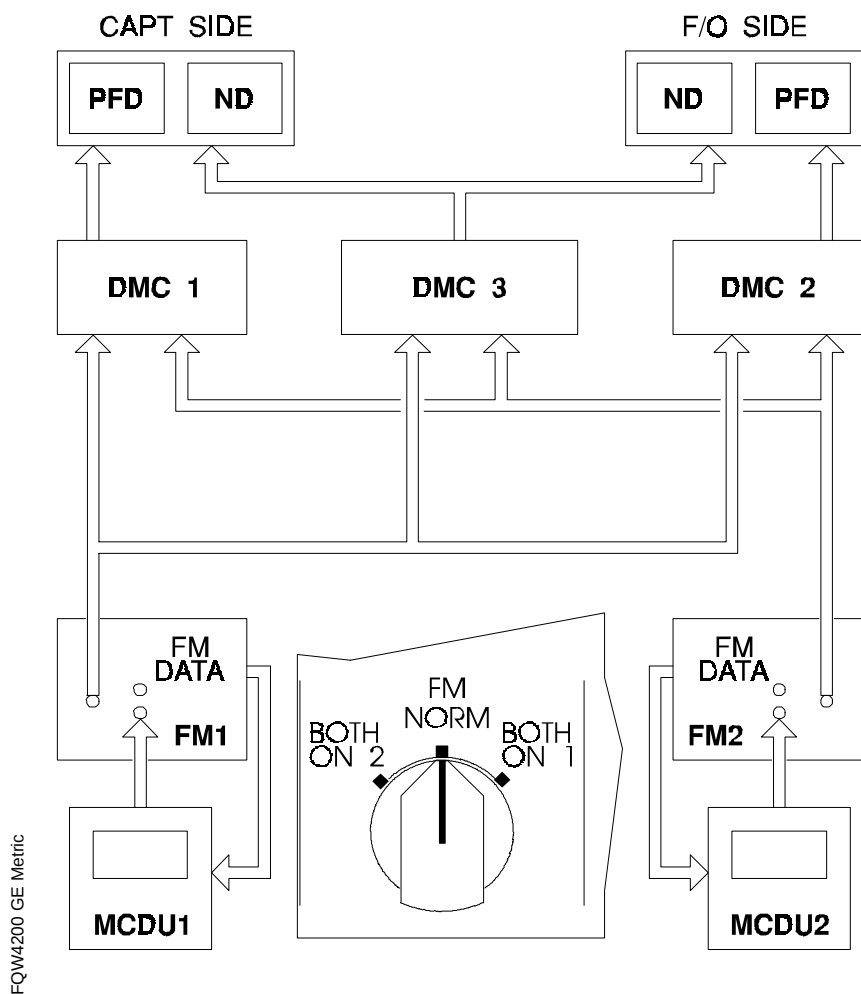
The selected Inertial Reference (IR) depends on the pilot selection, through the IR source selector, to be consistent with the current displayed IR data on the corresponding Primary Flight Display (PFD) and Navigation Display (ND).

The MCDU B/UP NAV provides, in function of the aircraft latitude/longitude and of the active leg of the flight plan, the crosstrack error and the bearing/distance/time to go to the active waypoint.

It supplies the automatic leg change when the TO waypoint is reached.

Important note :

All this data is only for display, there is no steering order issued by the MCDU, and the NAV mode cannot be engaged.



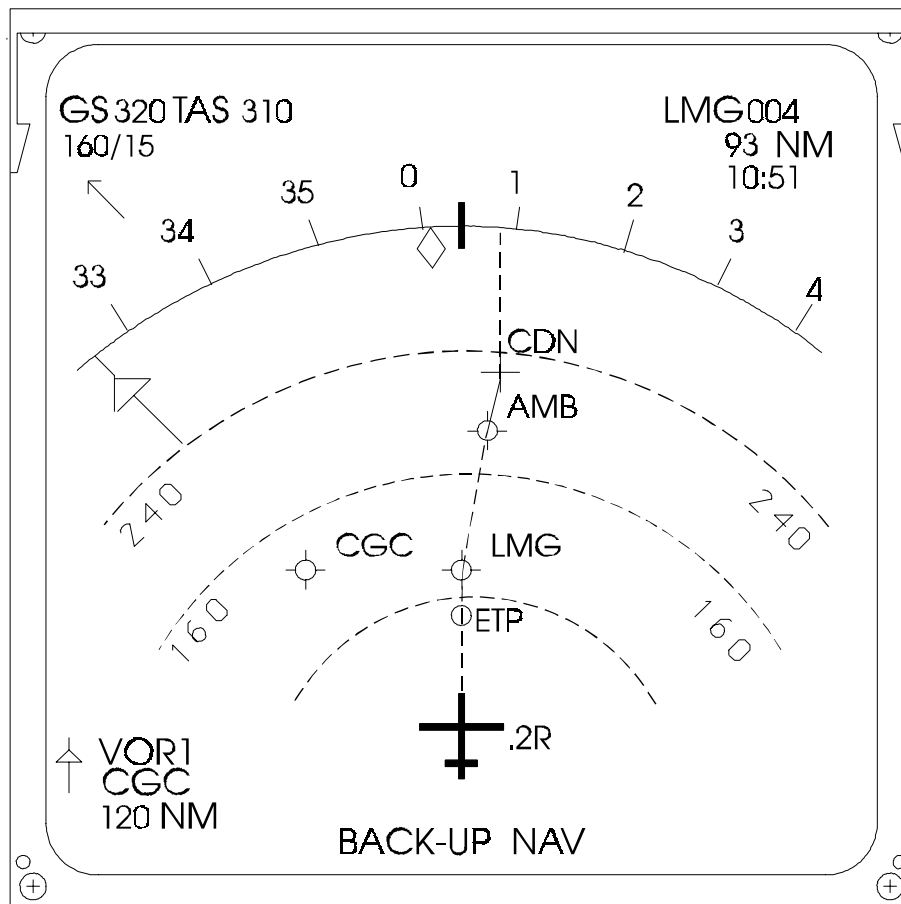
ND DISPLAY

The MCDU transmits the BACK-UP flight plan (F-PLN) to the Navigation Displays.

It consists of 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 Electronic Flight Instrument System (EFIS) control panel are not allowed (WPT, ARPT, VOR.D, NDB, CSTR).



FQW4200 GE Metric

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, providing 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,
- overfly deletion/insertion.

Pressing the DIR key enables the selection of a waypoint to join it directly. The B/UP FPLN/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 provides ground speed, 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

When the BACK-UP NAV function is voluntarily left, the return is performed on the MCDU MENU page.

DESELECT NAVB/UP prompt must be pressed to return to normal operation.

B/UP FPLN			B/UP FPLN			B/UP PROG			B/UP IRS1		
FROM	TTG	DIST	DIR TO			OVHD	ALT		POSITION		
TOU	4340.8N/00118.7E		[350°]			CYN	24300		43°40.4N/000°17.6E		
350°	0004 22NM			0004 22NM		BRG/DIST/TTG		TO	TTRK		GS
AGN	4353.3N/00052.4E		AGN	4353.3N/00052.4E		-----/-----/-----		[]	342.3		310
348°	0027 116NM		348°	0027 116NM					THDG		MHDG
LMG	4549.0N/00101.6E		LMG	4549.0N/00101.6E					342.3		329.8
321° T	0045 97NM		321° T	0045 97NM					WIND		
AMB	4725.1N/00102.5E		AMB Δ			IRS1 BASED POS		GS	225°/216		
322° T	0053 40NM		322° T	0053 40NM		4340.6N/00017.7E		310 KT			
N48E001	4803.5N/00123.3E		N48E001	4803.5N/00123.3E		DTRK					
DEST	0126 443NM		321° T	0147 81NM		346°					
LFPO	4843.4N/00222.9E		N49E002	4916.8N/00204.6E		<IRS1		IRS3>			
									<RETURN		NEXT IRS>

MCDU MENU	
<FM1	DESELECT
<ACARS	NAV B/UP>
<ACMS	
<CMS	
	RETURN>
SELECT DESIRED SYSTEM	

STUDENT NOTES:

DATA BASE LOADING

Loading Description
Loading Operation
Crossloading Description
Crossloading Operation

LOADING DESCRIPTION

This module presents the updating of the Flight Management data base using the Portable Data Loader.

Every 28 days, a new Navigation Data Base must be loaded into each Flight Management Guidance and Envelope Computer.

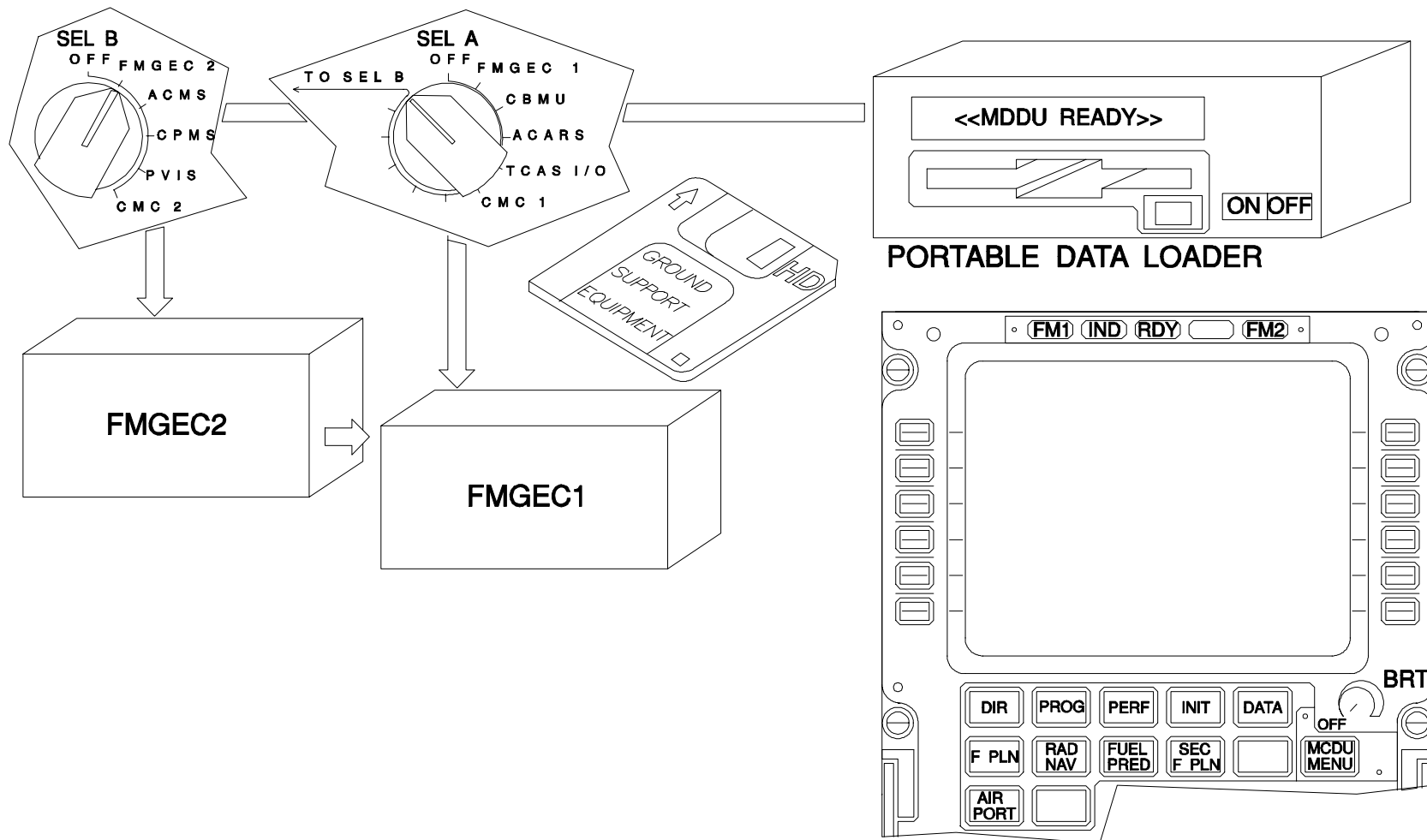
The data is stored for two successive 28-day cycles (current and next cycles).

The appropriate cycle is automatically selected using the aircraft clock data.

The automatic selection may be overridden. The Navigation Data Base is updated using the Portable Data Loader (PDL) and the data loader selector switches.

The loading of one FMGEC (1 or 2) lasts about 20 minutes.

The loading is a complete one : there is no saving of the previous cycle even if the already loaded data is identical.



FQW4200 GE Metric

LOADING OPERATION

Here is the procedure for loading the Navigation Data Base loading using a Portable Data Loader. The procedure shown is for the loading of the FMGEC1 Navigation Data Base.

After having energized the A/C electrical circuits, you verify that the switch of the PDL is in the OFF position. You remove the blanking cap from the data loader connector. Then you connect the PDL cable to the data loader connector.

- Now, you must switch MCDU1 on.

The A/C STATUS page appears on the MCDU.

- On the PDL, you must put the switch in the ON position.

The MDDU READY indication is shown on the Portable Data Loader.

- Now, among the diskettes that are supplied, use the diskettes related to FMGEC1. These diskettes are identified as follows :

"1/2 - Data Base 340/330" (1/2 for first disk)

"AB4-9308-001 - 22/07/93 to 19/08/93".

- Then, you open circuit breaker 5CA1 in the avionics compartment.

On MCDU1, the amber FM1 annunciator comes on.

- Now, put the data loader selector switches in the appropriate configuration to allow the FMGEC1 Navigation Data Base to be loaded.

OK, you set the DATA LOADER/SEL A selector switch to FMGEC1 and the DATA LOADER/SEL B selector switch to OFF to load the FMGEC1 Navigation Data Base.

- Now, put the first disk (1/2) into the PDL disk drive.

On the PDL, the READY indication is shown followed by the WAIT RESPONSE indication a few seconds later.

- After these indications on the PDL, you have to close circuit breaker 5CA1 in the avionics compartment.

After a few seconds, READY is displayed followed by WAIT RESPONSE and, immediately after, TRANSF IN PROG indication. After about 10 minutes, the EJECT DISK indication is shown.

- Now, according to the PDL indications, eject the disk from the PDL disk drive.

On the PDL, the INSERT NEXT DISK indication is shown.

- Now, put the second disk (2/2) into the PDL disk drive.

On the PDL, after a few seconds, the TRANSF IN PROG indication is shown. About 10 minutes later, the TRANSF COMPLETE indication is shown.

- Now, according to the PDL indications, eject the disk from the PDL disk drive.

On the PDL, the MDDU READY indication is shown.

- Now, you must set the two DATA LOADER selector switches to OFF.

On MCDU1, the amber FM1 annunciator goes off.

- On the MCDU, push the mode key which allows the MCDU MENU page to be displayed.

On MCDU1, the MCDU MENU page comes into view.

- On MCDU1, push the line select key adjacent to the FM1 indication.

On MCDU1, an FM page comes into view.

- On MCDU1, push the mode key which allows the DATA INDEX page to be displayed.

On MCDU1, the DATA INDEX page comes into view.

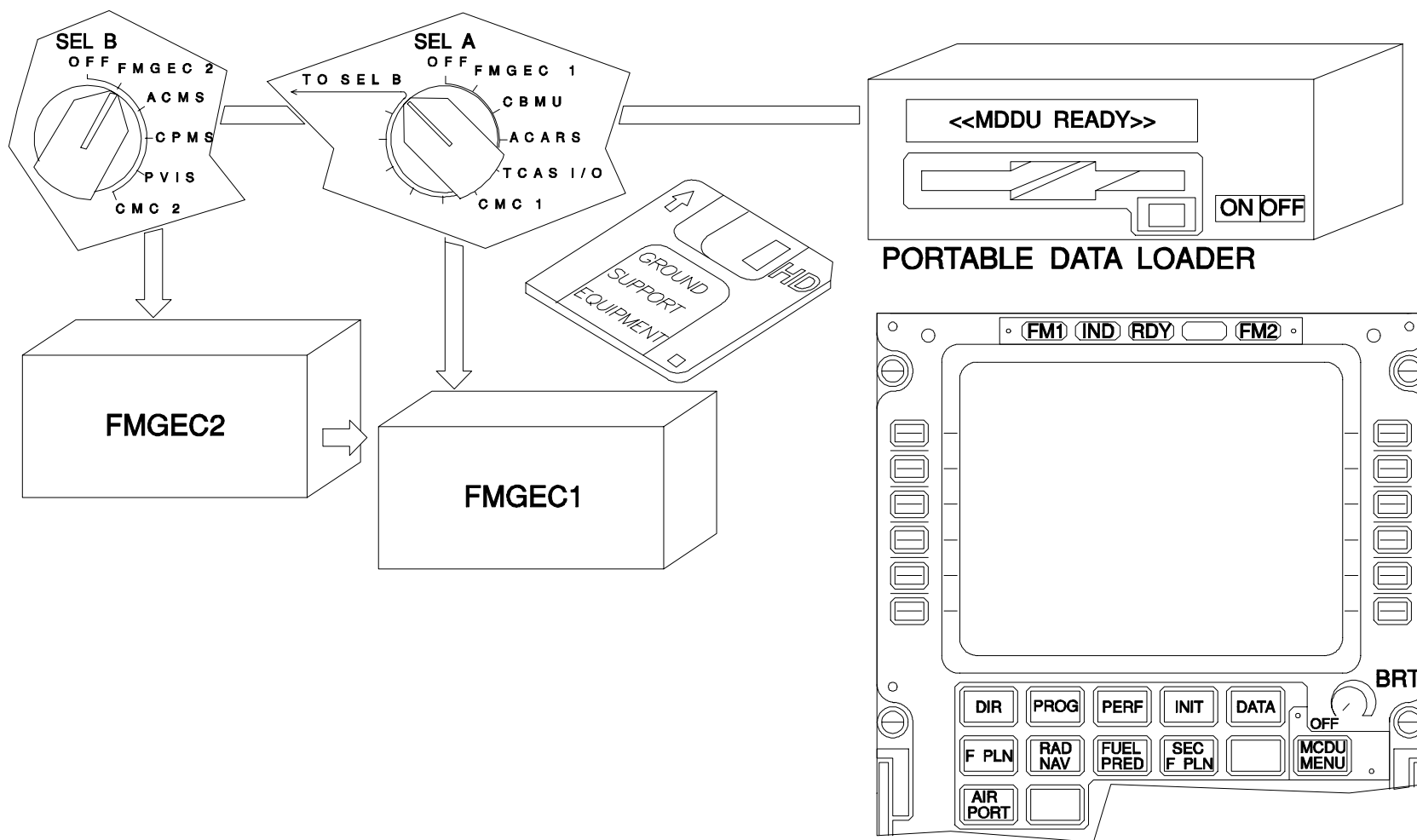
- On MCDU1, push the line select key adjacent to the A/C STATUS indication.

On MCDU1, the A/C STATUS page comes into view.

Once this page is displayed, you must make sure that the ACTIVE DATA BASE is correct for the dates shown and that the reference is the same as the DB/N reference read on the disk.

- When the Nav Data Base loading operation is done, you must put the aircraft back in its initial configuration.

You come back to the MAINTENANCE MENU 1/2 page by pushing the MCDU line key adjacent to the RETURN indication. Then you set the BRT knob to OFF. On the PDL, you set the switch to the OFF position and you disconnect the PDL cable from the DATA LOADER connector.



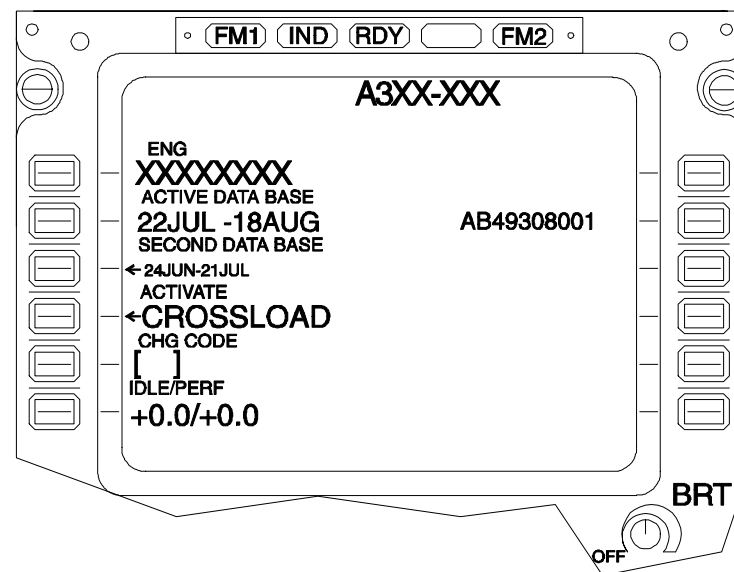
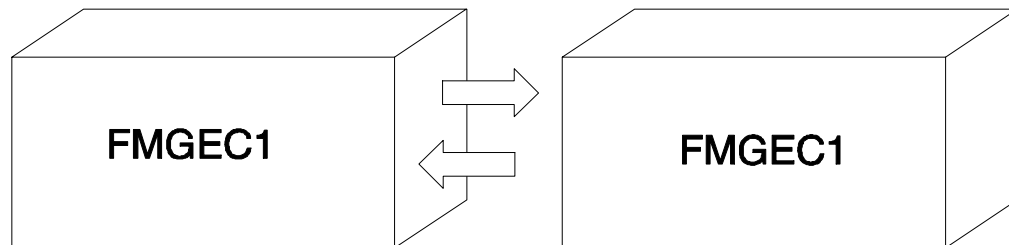
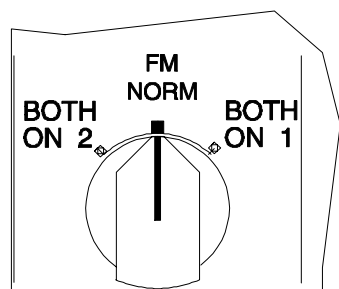
FQW4200 GE Metric

CROSSLOADING DESCRIPTION

The crossloading allows an FM part to transfer its Nav Data Base to the opposite FM.

The crossloading is activated from the Multipurpose Control Display Unit (MCDU), via the A/C STATUS page. This operation lasts less than 20 mn. The A/C STATUS page displays an ACTIVATE CROSSLOAD prompt when the following is true :

- the current active flight phase is PREFLIGHT or DONE,
- the FM source selector is set in the NORMAL position,
- the FM system mode is in INDEPENDENT operation, that means, the Nav Data Base loaded in one FM is different from the other.



CROSSLOADING OPERATION

Pressing the line select key associated to the "ACTIVATE CROSSLOAD" prompt identifies the transmitting FM. In this example, the transmitting FM is FM1.

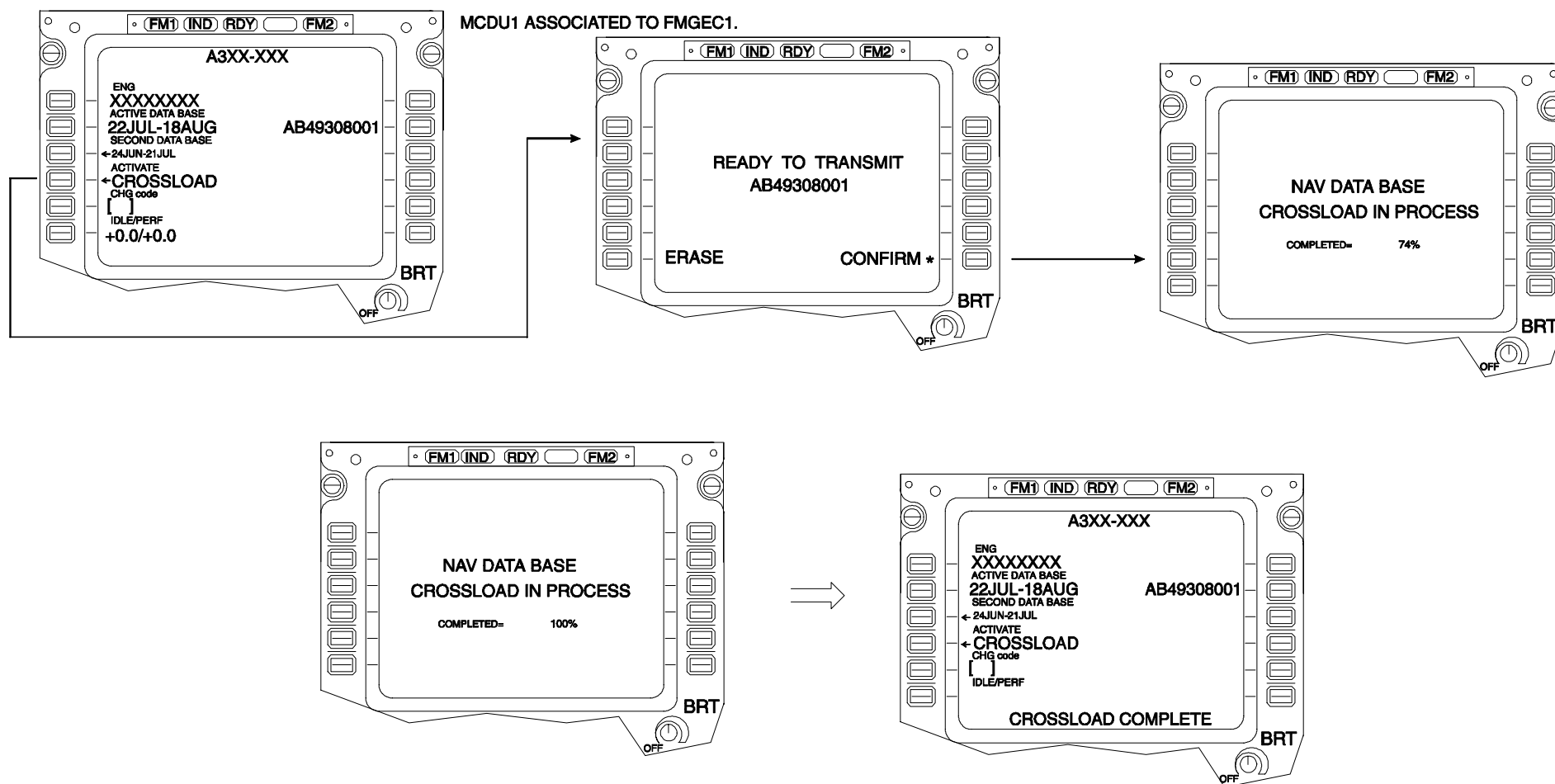
Any subsequent MCDU key presses, relative to the FMGEC subsystem, are ignored until the "READY TO TRANSMIT" page is displayed.

Selecting the CONFIRM prompt causes each FM part to display the "NAV DATA BASE CROSSLOAD IN PROCESS" page.

Any subsequent MCDU key presses, relative to the FM, are ignored while the two FMs establish crossloading communication and attempt to prepare for crossload. The "NAV DATA BASE CROSSLOAD IN PROCESS" page on the transmitting FM displays the percentage completed of the transfer.

Upon successful completion of the crossload, both FMs revert to the A/C STATUS page.

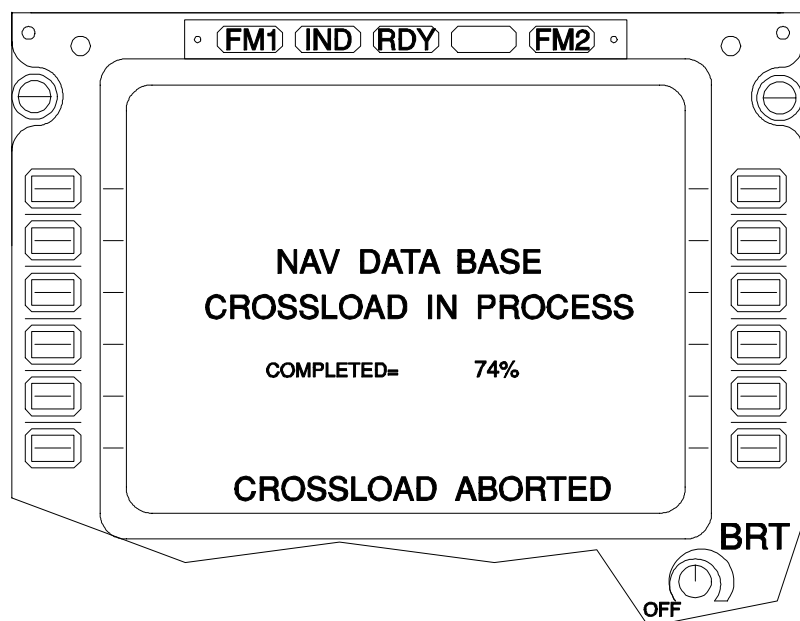
The "CROSSLOAD COMPLETE" message is displayed in the scratchpad of each MCDU associated to each FM part.



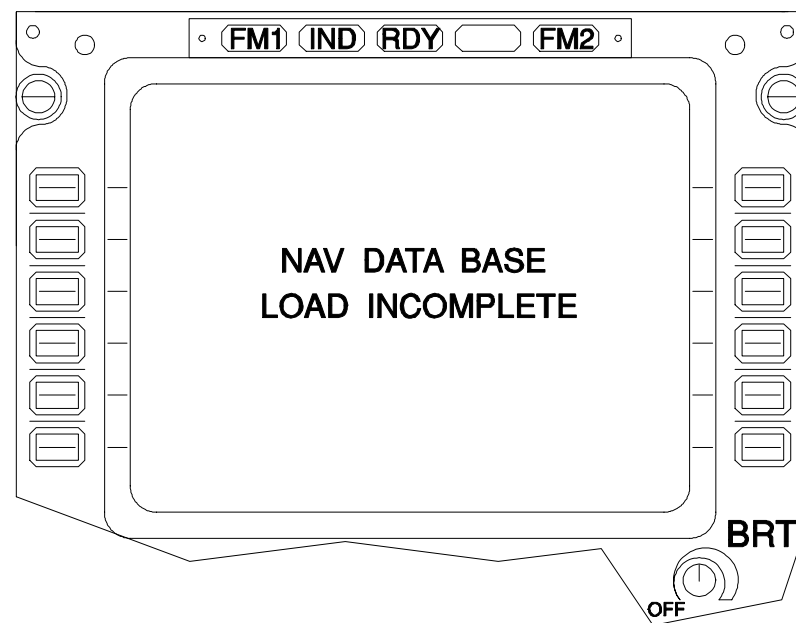
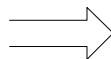
If there is any communication failure during the transfer or after the transfer, the "CROSSLOAD ABORTED" message is displayed in the scratchpad of each MCDU associated to each FM.

The "NAV DATA BASE LOAD INCOMPLETE" message is displayed on the receiving FM :

- if the Nav Data Base does not exist or has been loaded incorrectly or incompletely or,
- if a failure occurs while performing the Nav Data Base CROSSLOAD function.



MCDU1 ASSOCIATED TO FMGEC1.



STUDENT NOTES:

WARNINGS

Altitude Alert
AP Off
Autoland Warning
A/THR Off
A/THR Inop On One Engine
A/THR Limited
Capability Change
Windshear Warning
Windshear Det Fault
Low Energy Warning
FM1(2) Fault
FM1+2 Fault
FD Failure
FCU Fault
MCDU Failure

ALTITUDE ALERT

The ALTITUDE ALERT takes into account the difference between the aircraft altitude and the reference altitude selected on the Flight Control Unit (FCU).

The altitude alert is triggered when the aircraft approaches or leaves a selected altitude on the FCU. On the Primary Flight Display (PFD), the altitude window :

- is flashing amber or,
- is pulsing yellow or,
- is steady yellow.

AP OFF

Loss of the AUTOPILOT (AP) is detected by the Flight Warning Computer (FWC) and the related warning is divided into two cases.

If the AP disconnection is VOLUNTARY, that means due to an action on the take over priority pushbutton :

- the red message "AP OFF" appears in the right memo area and is displayed 9 seconds maximum,
- the "MASTER WARNING" light comes on for 3 seconds,
- the "CAVALRY CHARGE" aural warning sounds for 0.5 seconds min. and 1.5 sec. max.

The second case is when the loss of the autopilot is due to a reason other than an action on the takeover priority pushbutton. If both autopilots are engaged and just one is lost, the warning is not triggered.

If the AP disconnection is UNVOLUNTARY, that means that the AP loss is due to a reason other than an action on the take over priority pushbutton (e.g. : failure) :

- the red message "AUTO FLT AP OFF" appears in the left lower area on the Engine Warning Display (EWD),
- the "MASTER WARNING" light comes on,
- the "CAVALRY CHARGE" aural warning sounds for 1.5 seconds max.

AUTOLAND WARNING

The AUTOLAND warning is generated by the Flight Warning Computer. The AUTOLAND warning can only be triggered in LAND mode, below 200 feet with at least one AP engaged. This red warning flashes in case of :

- disengagement of both APs below 200 ft, or
- excessive LOC deviation above 15 ft, or
- excessive GLIDE deviation above 100 ft, or
- no computed data from ILS receivers, in LOC capture (or track) above 15 ft and in GLIDE slope or LAND track above 100 ft.

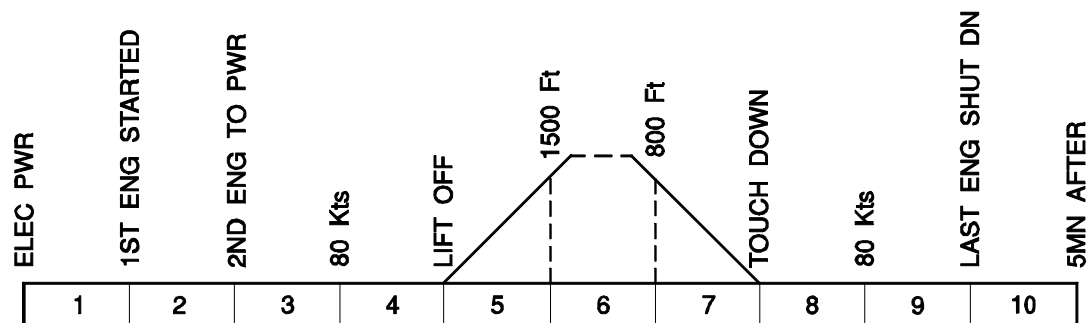
A/THR OFF

The AUTOTHURST (A/THR) LOSS warning is generated by the Flight Warning Computer. The autothrust loss warning is divided into two cases. In case of an A/THR disconnection due to an action on an instinctive disconnect pushbutton or, to the thrust levers setting to IDLE position above 50 ft :

- an amber message, "A/THR OFF", is displayed in the right memo area, for 9 seconds max,
- the MASTER CAUTION light comes on amber for 3 seconds,
- the SINGLE CHIME aural warning sounds.

When the A/THR loss is due to other reasons (unvoluntary disconnection) :

- the amber message, "AUTO FLT A/THR OFF" is displayed in the left lower area of the EWD,
- the cyan message, "-THR LEVERS.....MOVE" is also displayed, as long as the thrust is frozen by the FADEC,
- the SINGLE CHIME aural warning sounds.



E/WD : FAILURE TITLE	AURAL WARNING	MASTER LIGHT	SD PAGE CALLED	LOCAL WARNINGS	FLT PHASE INHIB
ALTITUDE ALERT	C. CHORD	NIL	NIL	PFD ALTITUDE WINDOW	G/S CAPT or L/G HANDLE DOWN and FLAPS IN CONF 4 or F.DES MODE ACTIVE
AP OFF	CAVALRY CHARGE	MASTER WARN	NIL	NIL	NIL
AUTOLAND WARNING	NIL	AUTO LAND	NIL	NIL	ALL EXCEPT LAND MODE
A/THR OFF	SINGLE CHIME	MASTER CAUT	NIL	NIL	3, 4, 8

A/THR INOP ON ONE ENGINE

The AUTOTHRUST INOPERATIVE ON ONE ENGINE warning is detected by the Flight Warning Computer.

When the A/THR is inoperative on one engine :

- the amber message, "AUTO FLT A/THR ENG 1 OFF", (1 for engine 1 failed) is displayed in the left lower area of the EWD,
- the cyan message, "-THR LEVER 1..MAN ADJUST" is also displayed,
- the MASTER CAUTION light comes on amber,
- the SINGLE CHIME aural warning sounds.

A/THR LIMITED

The AUTOTHRUST LIMITED BY THRUST LEVER POSITION is detected by the Flight Control Unit and the Flight Warning Computer.

When the A/THR is limited :

- the amber message, "AUTO FLT A/THR LIMITED", is displayed in the left lower area of the EWD and is repeated every 5 seconds until thrust levers are set in the correct position,
- the cyan message, "THR LEVERS.....CLB", is displayed if all engines are running,
- the cyan message, "THR LEVERS.....MCT", is displayed if one engine is out,
- the MASTER CAUTION light comes on amber,
- the SINGLE CHIME aural warning sounds.

CAPABILITY CHANGE

The CAPABILITY CHANGE warning is detected by the Flight Management Guidance and Envelope Computer (FMGEC).

This warning is triggered by the FMGEC when it detects the loss of a system required for a higher capability (e.g. : one AP failure during the approach).

In case of landing capacity downgrading :

- the CLICK aural warning sounds,
- a new landing category is displayed on the Flight Mode Annunciator (FMA).

This downgrading is frozen below 100 feet except in case of loss of both APs.

WINDSHEAR WARNING

The WINDSHEAR warning is detected by the Flight Warning Computer. If the predictive windshear function is activated, the "W/S AHEAD" message appears on the PFD in case of predictive windshear detection.

This message flashes for 9 seconds and remains steady in amber or in red, according to the intensity of the predictive detection.

When a windshear is detected a warning is triggered :

- the red message, "WINDSHEAR", is displayed on the PFD,
- the WINDSHEAR aural warning is repeated 3 times by a synthetic voice.

WINDSHEAR DET FAULT

The WINDSHEAR DETECTION FAULT is detected by the Flight Warning Computer.

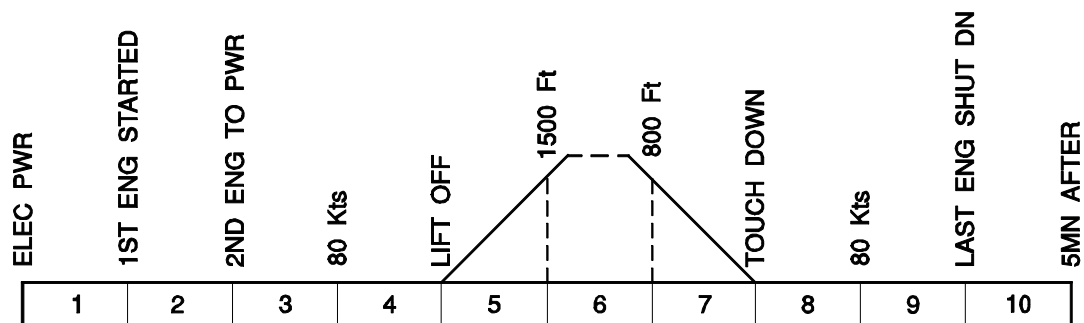
When the windshear detection capability is lost :

- an amber message, "AUTO FLT WINDSHEAR DET FAULT", is displayed on the left lower area of the EWD,
- the MASTER CAUTION light comes on amber,
- the SINGLE CHIME aural warning sounds.

LOW ENERGY WARNING

The LOW ENERGY WARNING is detected by the Flight Warning Computer.

The "SPEED SPEED SPEED" synthetic voice is triggered every 5 seconds each time the aircraft energy becomes lower than a threshold under which the thrust shall be increased to recover a positive flight path angle.



E/WD : FAILURE TITLE	AURAL WARNING	MASTER LIGHT	SD PAGE CALLED	LOCAL WARNINGS	FLT PHASE INHIB
A/THR INOP ON ONE ENGINE	SINGLE CHIME	MASTER CAUT	NIL	NIL	2, 3, 4, 5 8, 9
A/THR LIMITED	SINGLE CHIME	MASTER CAUT	NIL	NIL	3, 4, 5 7, 8
CAPABILITY CHANGE	CLICK	NIL	NIL	NIL	2, 3, 4, 5 8, 9, 10
WINDSHEAR WARNING	WINDSHEAR	NIL	NIL	PFD MESSAGE	2, 3, 4 8, 9, 10
WINDSHEAR DET FAULT	SINGLE CHIME	MASTER CAUT	NIL	NIL	1, 3, 4, 5 8, 10
LOW ENERGY WARNING	SPEED	NIL	NIL	NIL	1, 2, 3, 4 8, 9, 10

FM1(2) FAULT

The FM 1 OR FM 2 FAULT is detected by the Flight Warning Computer.
When FM 1 or 2 is faulty :

- the red message, "MAP NOT AVAILABLE", is displayed on the related Navigation Display (ND),
- the FM1 (or FM2) annunciator comes on amber on the Multipurpose Control Display Unit (MCDU),
- an amber message, "AUTO FLT FM 1 FAULT", and a cyan message, "-FM SOURCE...BOTH ON 2" are displayed on the left lower area of the EWD,
- the MASTER CAUTION light comes on amber,
- the SINGLE CHIME aural warning sounds.

FM1+2 FAULT

The FM 1+2 FAULT is detected by the Flight Warning Computer.

When both FMs are faulty :

- FM1 and FM2 annunciators come on amber on the MCDU,
- an amber message, "AUTO FLT FM 1+2 FAULT", and cyan messages, "-FM SOURCE.....NORM", "-NAVAID TUNING..USE RMP", "-LDG ELEV....MAN ADJUST" are displayed on the left lower area of the EWD,
- the MASTER CAUTION light comes on amber,
- the SINGLE CHIME aural warning sounds.

If the FM SOURCE selector is set to NORM position, the MCDU BACK-UP NAV function is available.

FD FAILURE

In case of non-engagement or disengagement of both Flight Directors (FDs), not due to the FD pushbuttons, a FD red flag appears on both Primary Flight Displays.

The FD failure can be internal or due to peripherals. This warning is generated by a Display Management Computer (DMC) logic. It is displayed when the FD pushbuttons are ON on the FCU, the attitude is valid and not excessive, both FMGECs are seen invalid or both FDs are disengaged. The flag on a given PFD is inhibited when the corresponding FD pushbutton, located on the FCU, is off.

FCU FAULT

The FCU PARTIAL OR TOTAL LOSS is detected by the Flight Warning Computer.

If the FCU is partially or totally lost (2 channels at least) :

- an amber message, "AUTO FLT FCU FAULT", and cyan messages are displayed on the left lower area of the EWD,
- the MASTER CAUTION light comes on amber,
- the SINGLE CHIME aural warning sounds.

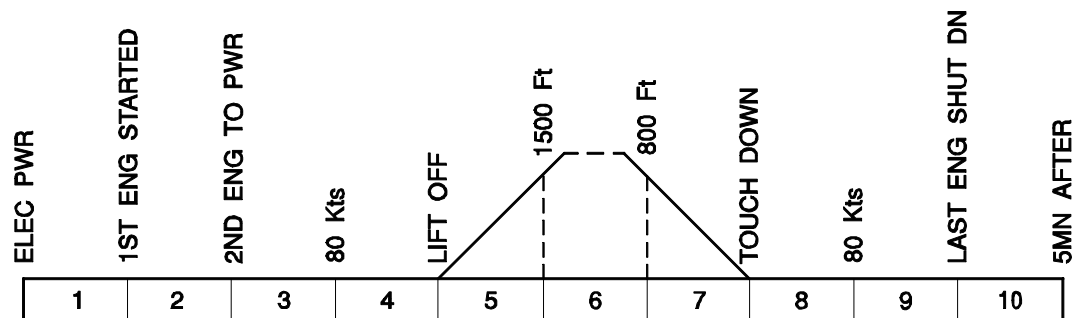
Note : in case of total FCU loss, the cyan message, "-PFD BARO REF : STD ONLY", is also displayed on the EWD. The Flight Path Vector is automatically displayed and the standard barometric value is frozen.

When the FCU is lost, the Display Management Computer (DMC) generates the display on the Navigation Display in ROSE-NAV mode with a 80 Nm range only.

MCDU FAILURE

When an MCDU fails, a dedicated annunciator comes on on the MCDU keyboard.

When the MCDU fails, an amber annunciator, "FAIL", warns the crew about this failure. This warning is generated by the MCDU itself.



E/WD : FAILURE TITLE	AURAL WARNING	MASTER LIGHT	SD PAGE CALLED	LOCAL WARNINGS	FLT PHASE INHIB
FM1 (2) FAULT	SINGLE CHIME	MASTER CAUT	NIL	ND MESSAGE MCDU "FM1/2" ANNUNCIATOR	3, 4, 5 7, 8
FM 1 + 2 FAULT	SINGLE CHIME	MASTER CAUT	NIL	MCDU "FM1/2" ANNUNCIATORS	3, 4, 5 7, 8
FD FAILURE	NIL	NIL	NIL	PFD MESSAGE	FD P/B OFF
FCU FAULT	SINGLE CHIME	MASTER CAUT	NIL	NIL	3, 4, 5
MCDU FAILURE	NIL	NIL	NIL	MCDU "FAIL" ANNUNCIATOR	NIL

STUDENT NOTES

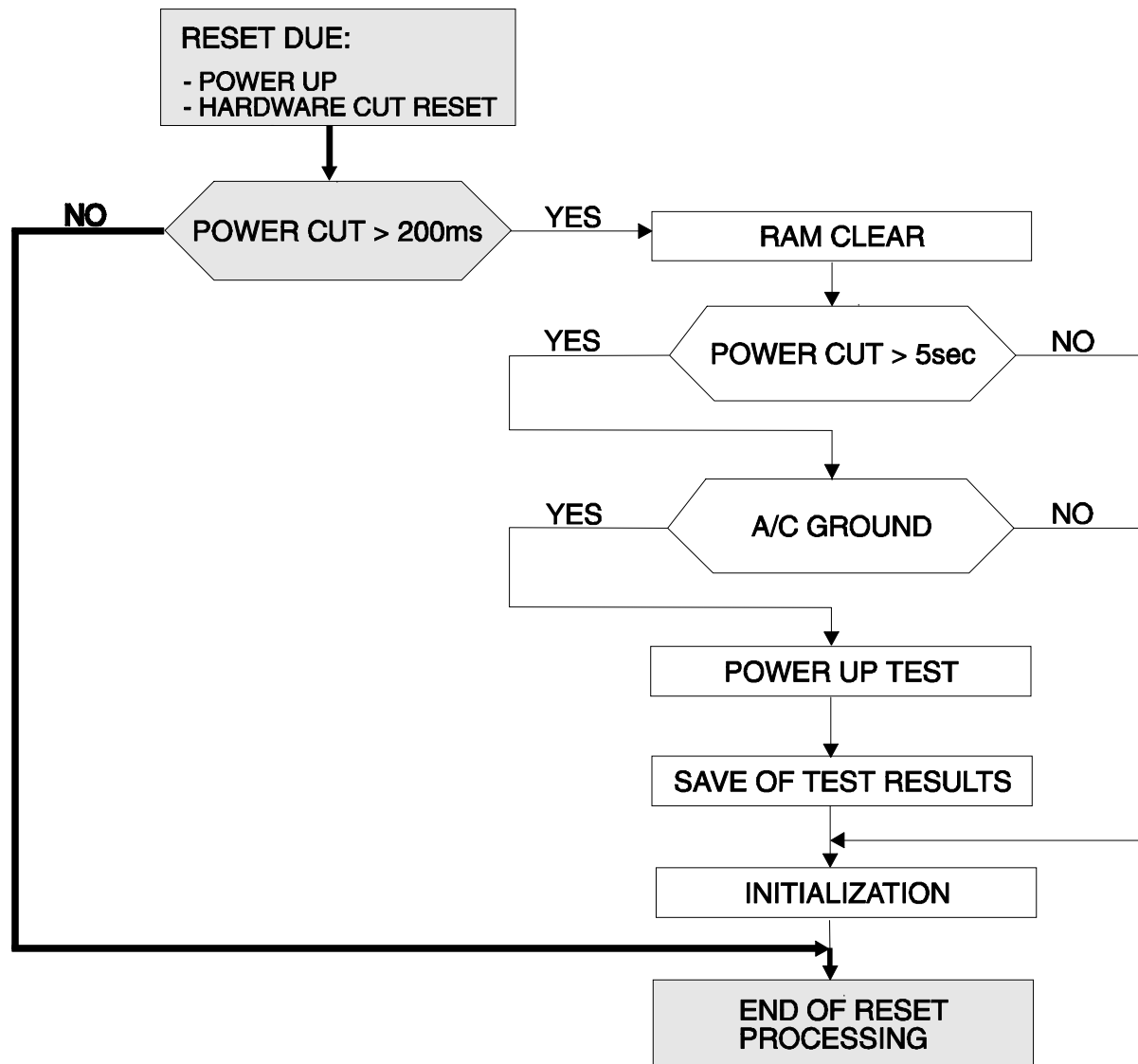
POWER INTERRUPTS AND POWER-UP TESTS

- Interruption < 10 MS
- 10 MS < Interruption < 200 MS
- 200 MS < Interruption < 5 sec
- Interruption > 5 sec
- Power-up test
 - FM power-up test
 - FCU power-up test
 - MCDU power-up test
 - Manual resets

INTERRUPTION < 10 MS

For the FMGEC, FCU or MCDU, the transparency time may be around 10 ms and these interruptions do not affect the system.

The only effect is on the MCDU Cathode Ray Tube (CRT) which will momentarily flash.



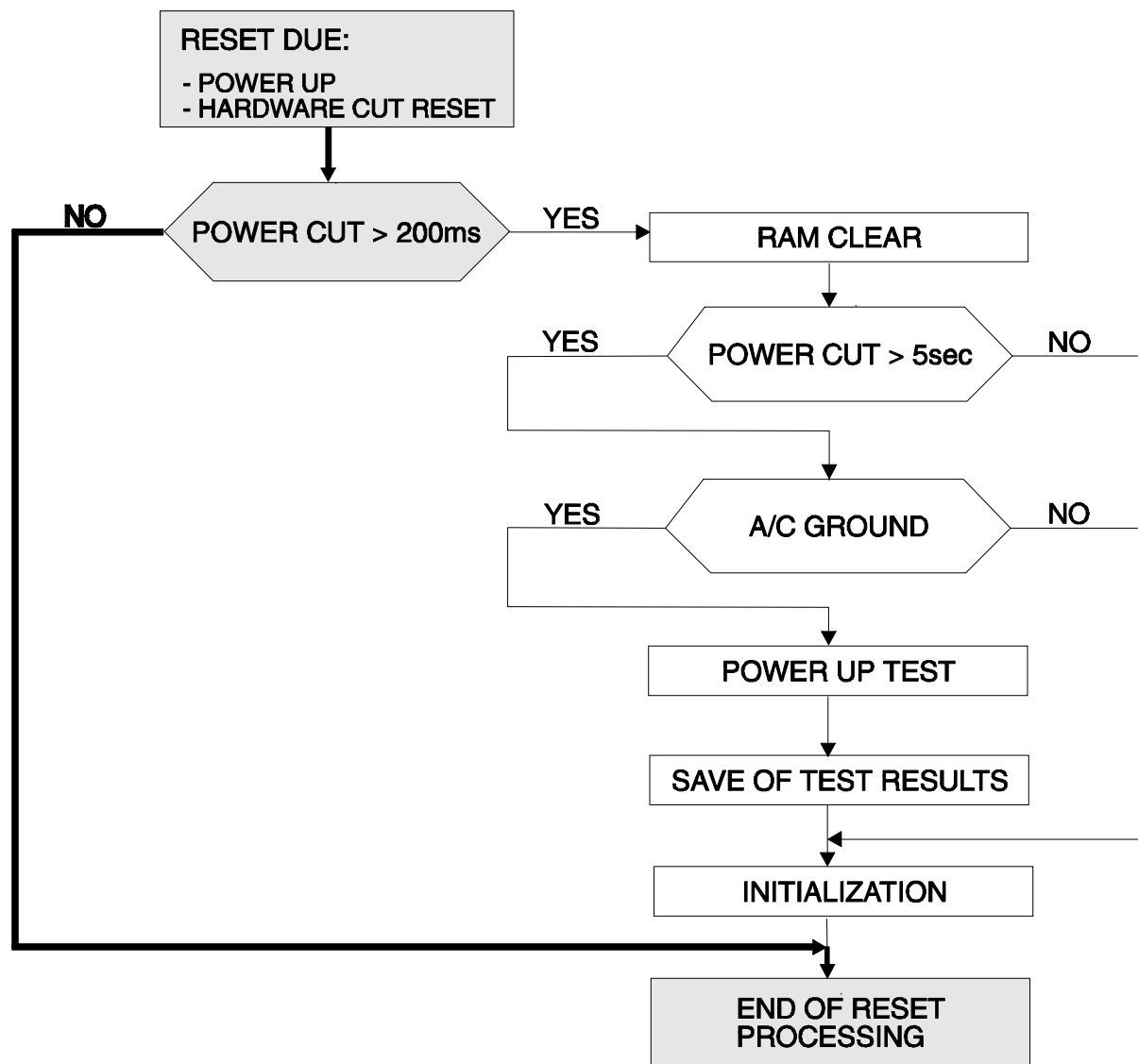
FQW4200 GE Metric

10 MS < INTERRUPTION < 200 MS

This type of cut off is a Short Power Fail.

The FMGEC/FCU/MCDU are recovered after the power interruption.

In particular the data displayed on the MCDU and the FCU and the output bus data for all the equipments are recovered after a short power fail without pilot action.



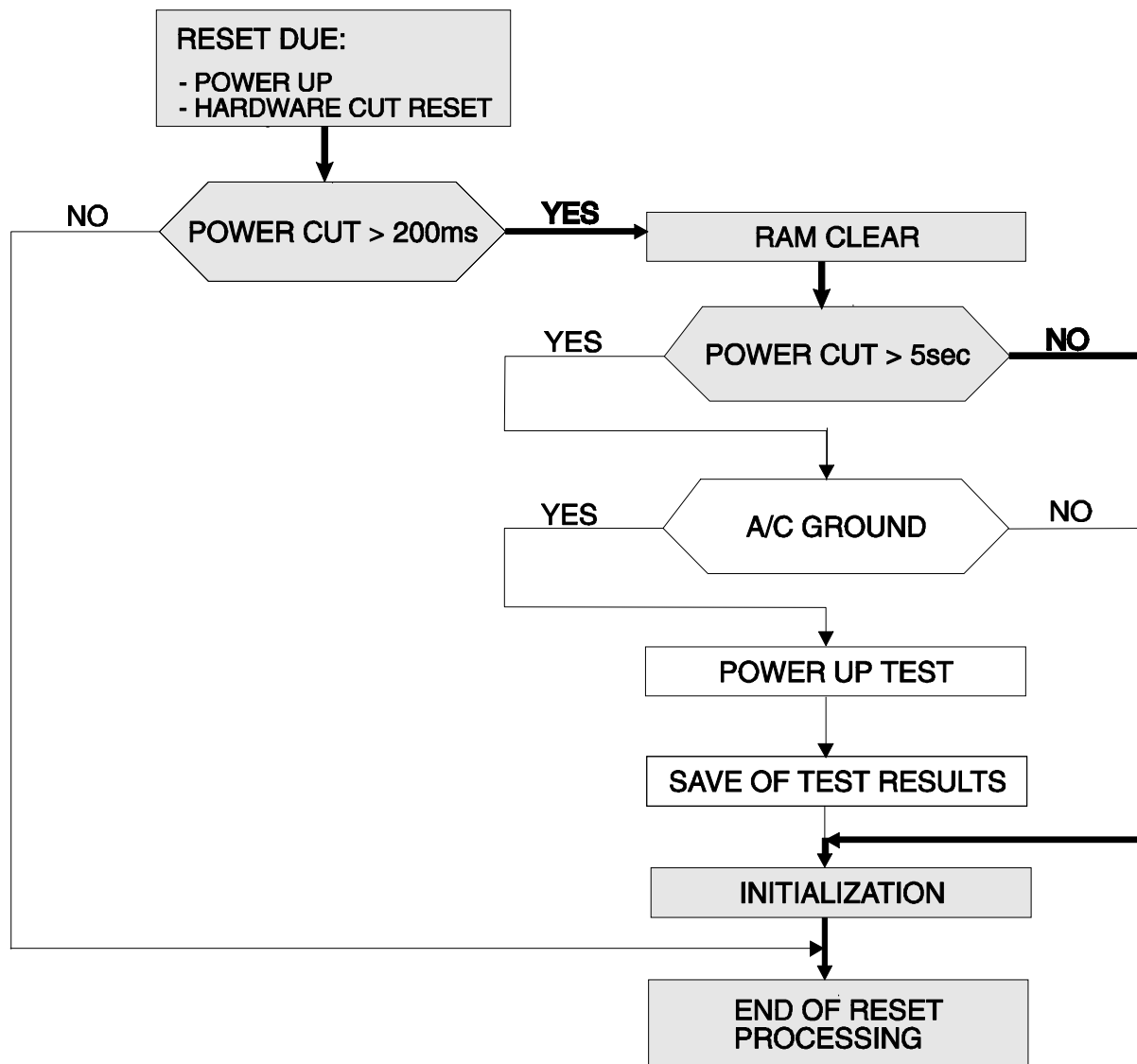
FQW4200 GE Metric

200 MS < INTERRUPTION < 5 Sec

This type of cut off is a Long Power Fail.

A complete initialization of the system is performed, indicating that a long power fail occurred.

The protection of data stored in the RAMs cannot be longer than 500 ms, except for the FM RAM which is supplied by a 5V back-up battery (for the FM part, the system status previous to the interruption is stored).



FQW4200 GE Metric

INTERRUPTION > 5 Sec

This type of cut off is a Very Long Power Fail.

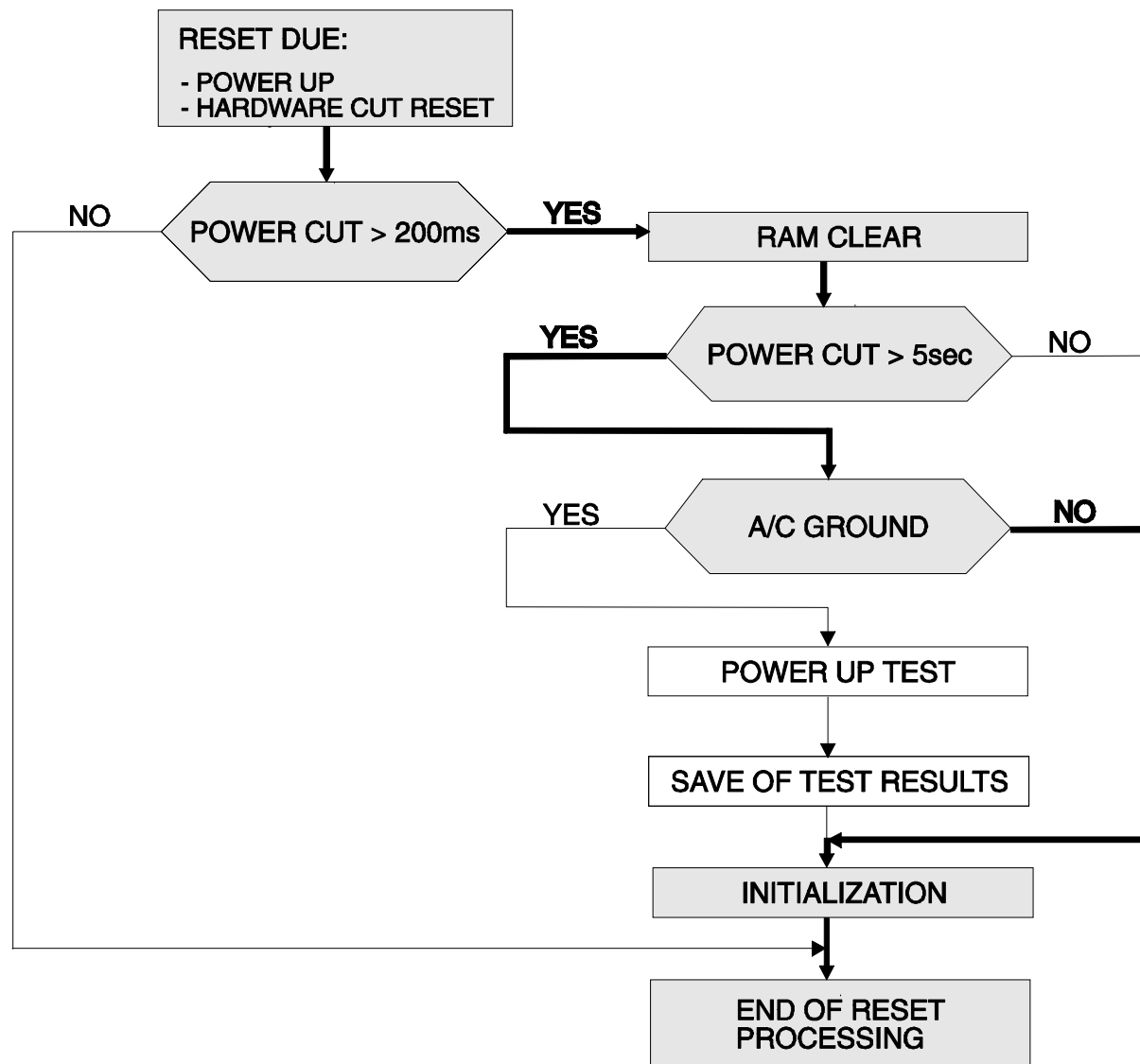
This leads to an automatic reset where, as long as the reset command is held, the computer behaves as not powered or not active.

This also leads to safety tests on ground.

Note:

The FCU retrieves any selected data after an interruption of 5 minutes or less.

Due to the 5V back-up battery, the FM retrieves the flight plan data for display on the MCDU whatever the interruption time.



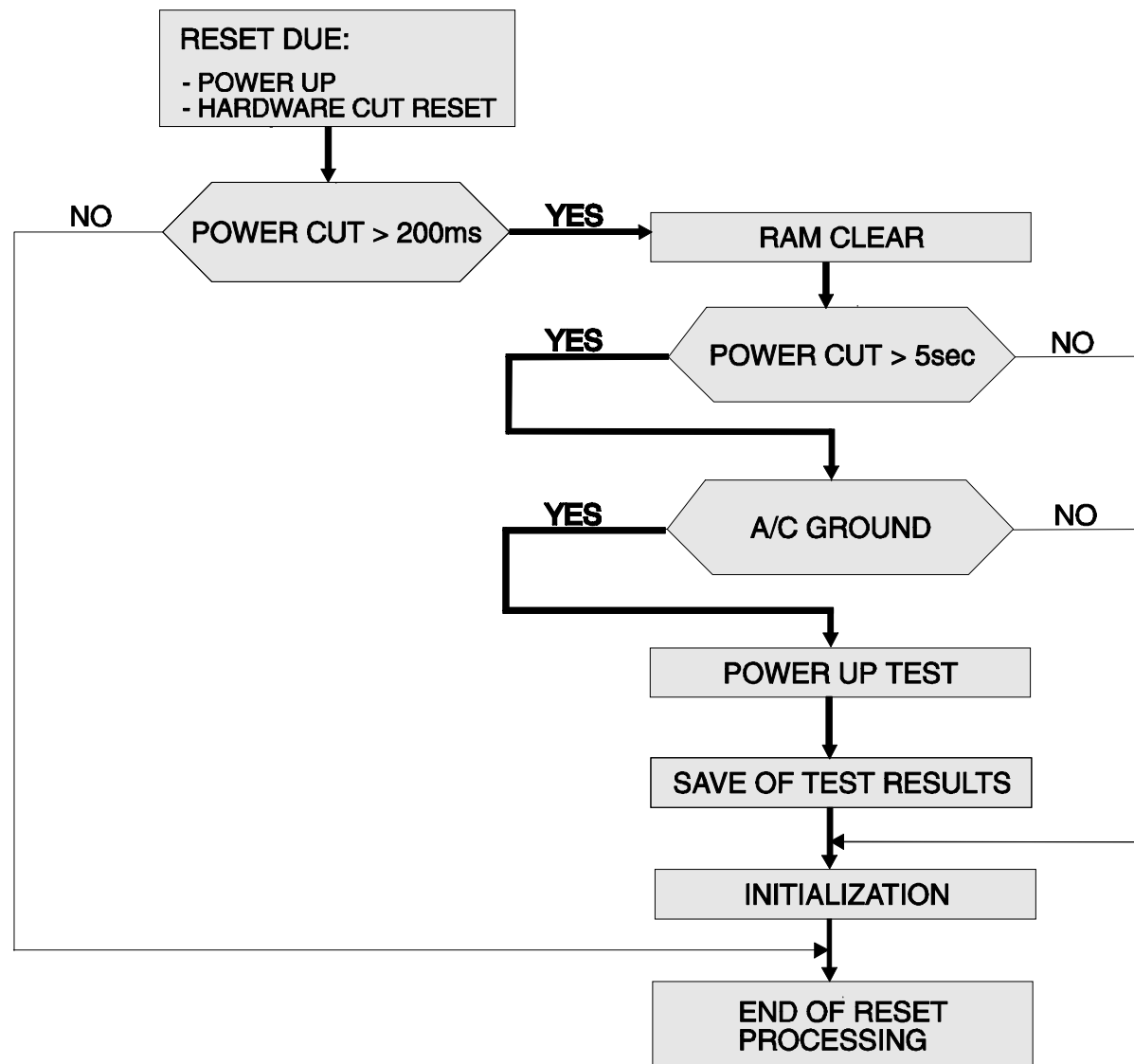
FQW4200 GE Metric

POWER-UP TEST

Power-up tests are performed when the aircraft is on the ground, following a power cut longer than 5 seconds.

The duration of the tests does not exceed 40 seconds in normal cases.

The power-up tests carry out an interface test and an analysis (sent to Centralized Maintenance System).



FQW4200 GE Metric

FM POWER-UP TEST

Following a reset or a transient reset greater than the transparency time of 10 ms, the flight management part executes specific internal tests called power-up test.

It verifies minimum FM hardware integrity and proper initialization.

The total execution time of this test is less than 2 seconds.

FCU POWER-UP TEST

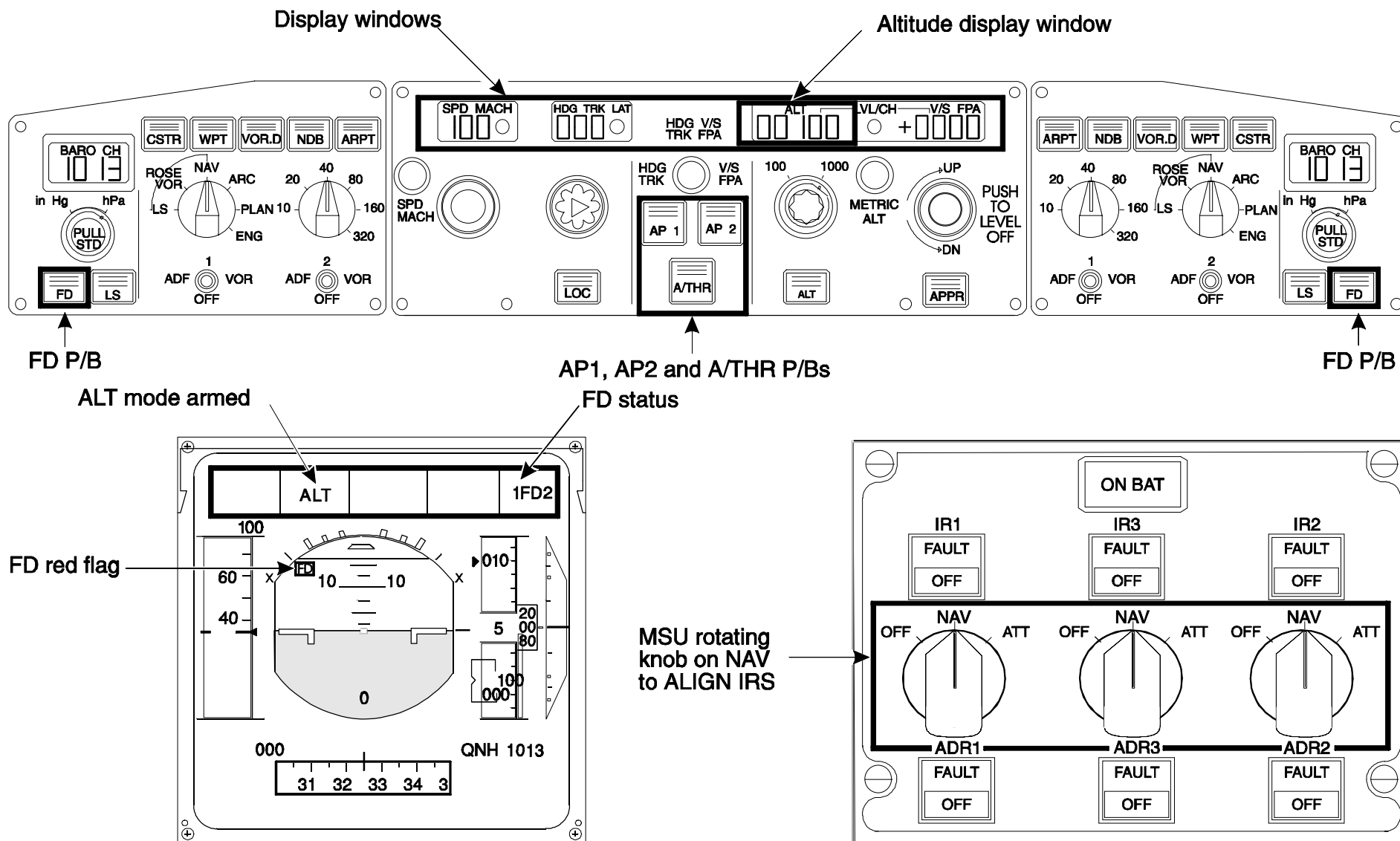
The FCU power-up test has to be performed to confirm system availability. The FCU power-up test is initiated automatically on the channels concerned (A-B/power supply 1, C/power supply 2) when the following conditions are met:

- A/C on ground,
- restoration of electrical power after power cut off longer than 5 seconds.

The duration of this test is 1 minute. Note that at this moment, the Flight Director pushbutton lights come on but the FD function is not yet available. On initialization, the FCU returns to a neutral configuration. The flashing of AP1, AP2 and A/THR pushbuttons proves the success of the internal tests. The Flight Director is finally engaged and the Flight Director red flag removed from Primary Flight Displays when the Inertial Reference System providing the position has been correctly initialized with a delay of 10 minutes and when the present position is entered.

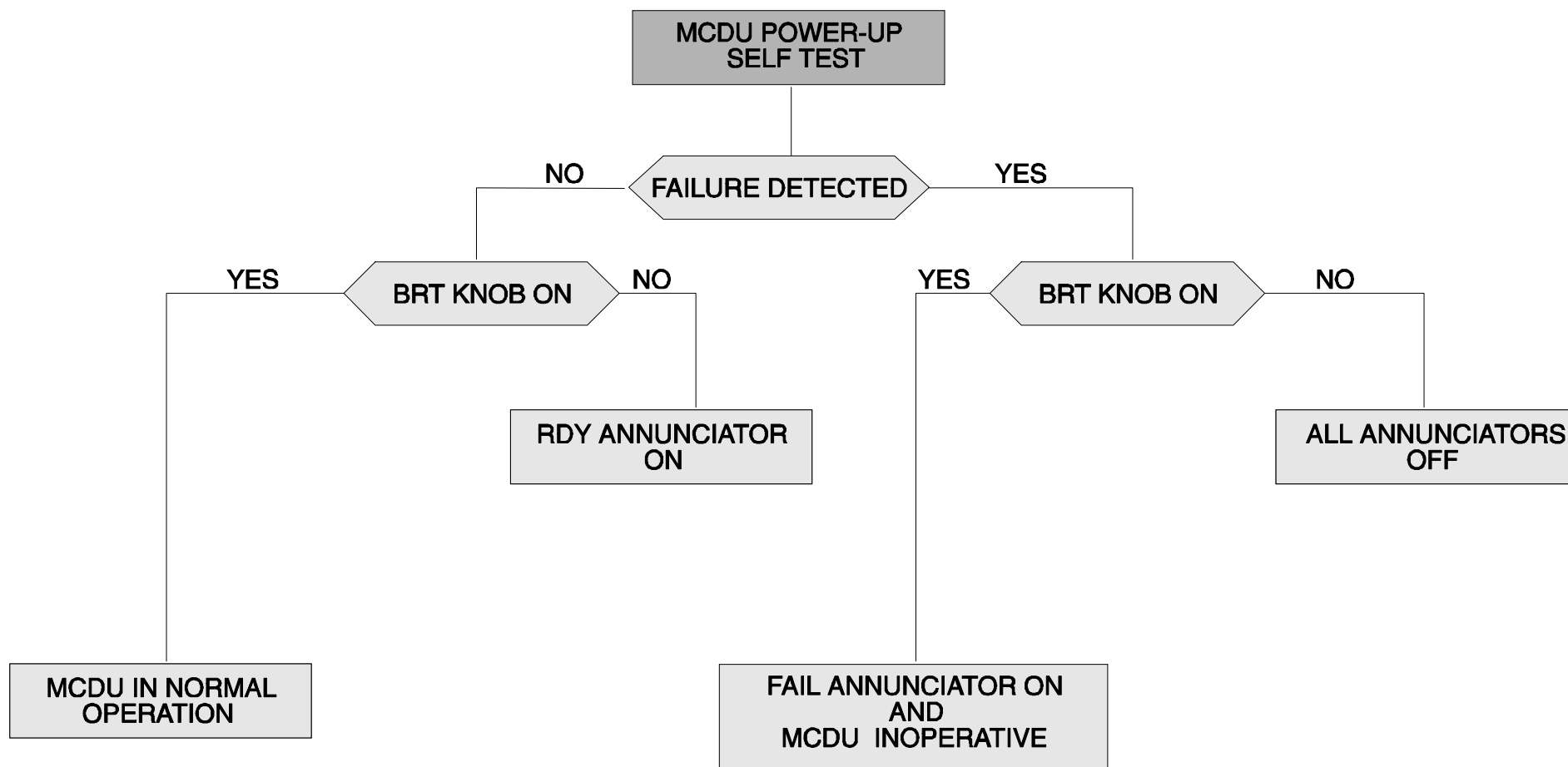
Flight Director status is indicated on the Flight Mode Annunciator. The altitude, by default 100 feet, is displayed on the FCU.

The altitude mode is automatically armed and displayed on the Flight Mode Annunciator.



MCDU POWER-UP TEST

After a long term interruption or the movement of the brightness knob from ON to OFF position, the MCDU extinguishes all annunciators and performs its power-up self test.



FQW4200 GE Metric

MANUAL RESETS

The reset function is available in the cockpit on the overhead panel.

The FM C/B resets only the FM part.

The FMGEC C/B resets all the FG, FE and FM parts.

Safety tests will be run if the A/C is on ground with engines stopped. In flight, the FM or FMGEC C/B reset leads to the disconnection of the ownside autopilot (if it was engaged) with the resynchronization of both FMs.

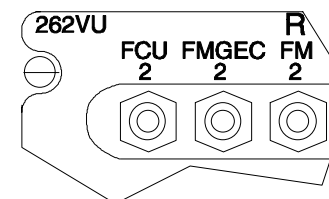
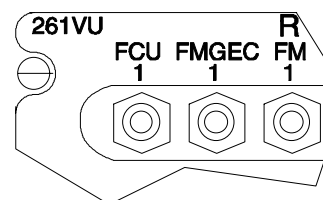
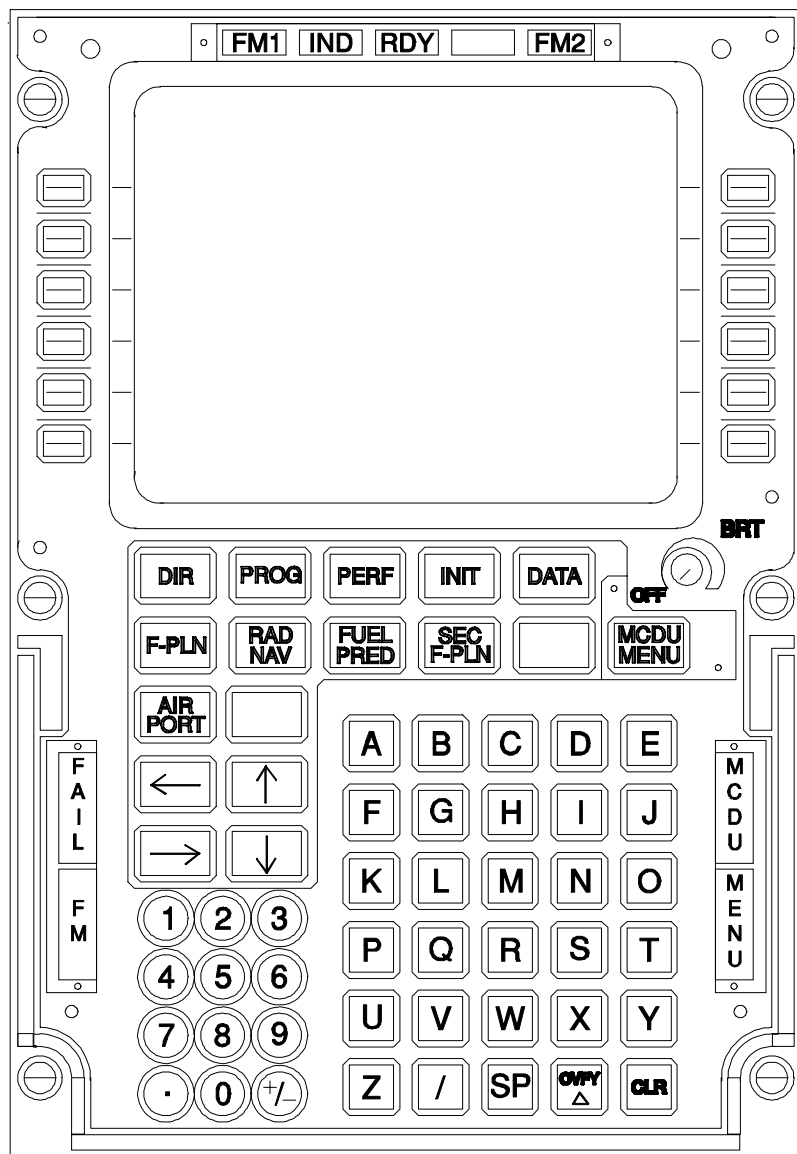
The MCDUs are reset by the brightness knob (ON/OFF).

A complete FCU reset is performed by pulling the FCU C/B longer than 5 mn.

The RESET is activated by sending a ground signal to the computer or the function.

When the reset state is confirmed and as long as the reset command is held, the computer behaves as not powered or not active.

The operational functioning of the computer is active when the control signal is back to the NO RESET state.



FQW4200 GE Metric

STUDENT NOTES:

COMPONENTS

FCU
MCDU
FMGEC

FCU

FIN : 3CA

ZONE : 210

COMPONENT DESCRIPTION

The Flight Control Unit (FCU) comprises the Autoflight control panel and the EFIS control panels (weight = 7.4 Kg).

Internal description :

- three computation channels (A, B and C).
- two identical units which generate filtered 28 VDC, 15 VDC and 5 VDC from the aircraft 28 VDC network to supply channels A and B (PSU1) and channel C (PSU2).
- a consolidated power supply unit.
- circuits for switching data from the active channels to the control panels and to peripherals.
- a reconfiguration logic circuit.

Interconnection between the FCU and the other systems is ensured by four connectors.

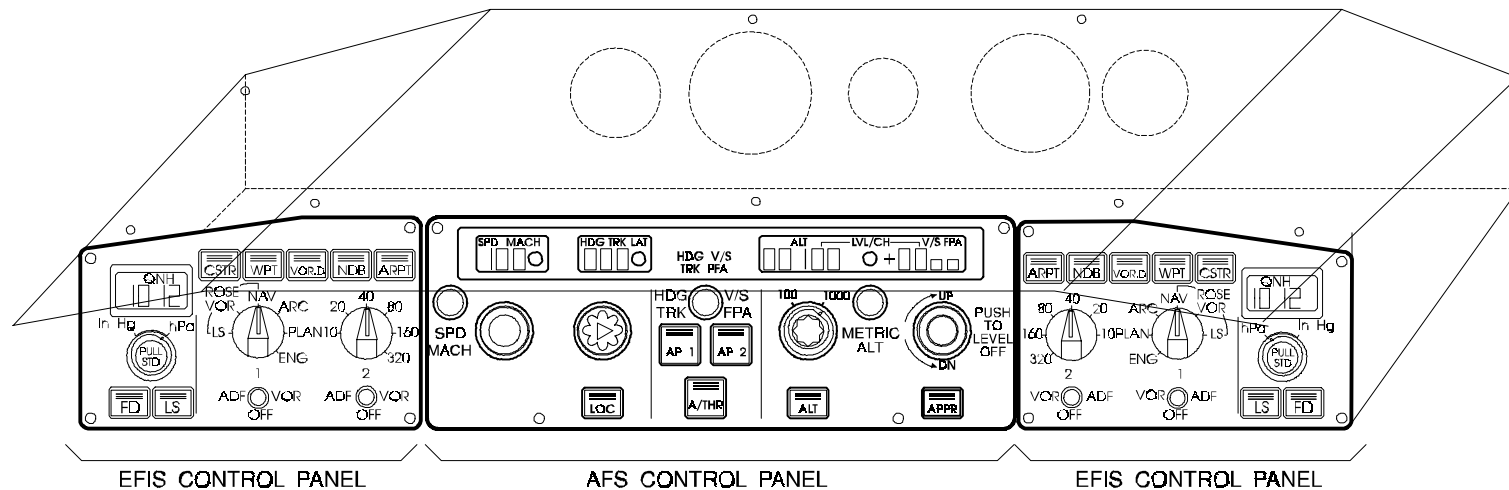
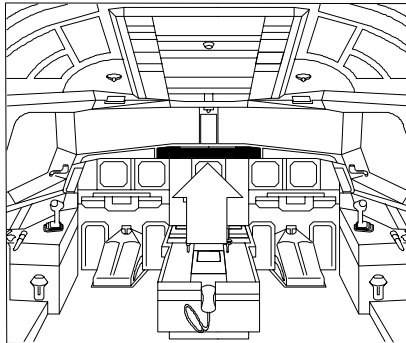
REMOVAL INSTAL

Open safety and tag these circuit breakers :

PANEL	DESIGNATION	FIN	LOCATION
721VU	INTL LT PED + MAIN	3LF	513
722VU	FCU C	8CA2	R42
724VU	FCU A+B	8CA1	E68

- 1-Hold the lower panel and loosen the 3 DZUS fasteners by a quarter turn.
- 2-Open the lower panel.
- 3-Remove the four screws and washers from the FCU.
- 4-Pull the FCU from its housing.
- 5-Disconnect the electrical connectors.
- 6-Put blanking caps on the disconnected electrical connectors.

To install the FCU, perform the opposite actions in reverse order.



FQW4200 GE Metric

MCDU

FIN : 2CA1, 2CA2, 2CA3

ZONE : 210

COMPONENT DESCRIPTION

The MCDUs are composed of a keyboard and a screen for data entry/display by the pilot or the line maintenance.

Weight : 9.5 Kg.

The MCDU includes :

- an ARINC control and memory I/O.
- a keyboard and discrete I/O.
- a memory (EEPROM/RAM/PROM).
- a processor (SDP 185).
- a character generation and video.
- a video/deflection driver.
- a video unit (CRT).
- a low voltage power supply which generates voltages for the circuits.
- a high-voltage power supply which generates voltages for the video.

The MCDU is equipped with two identical input/output connectors.

REMOVAL INSTALL

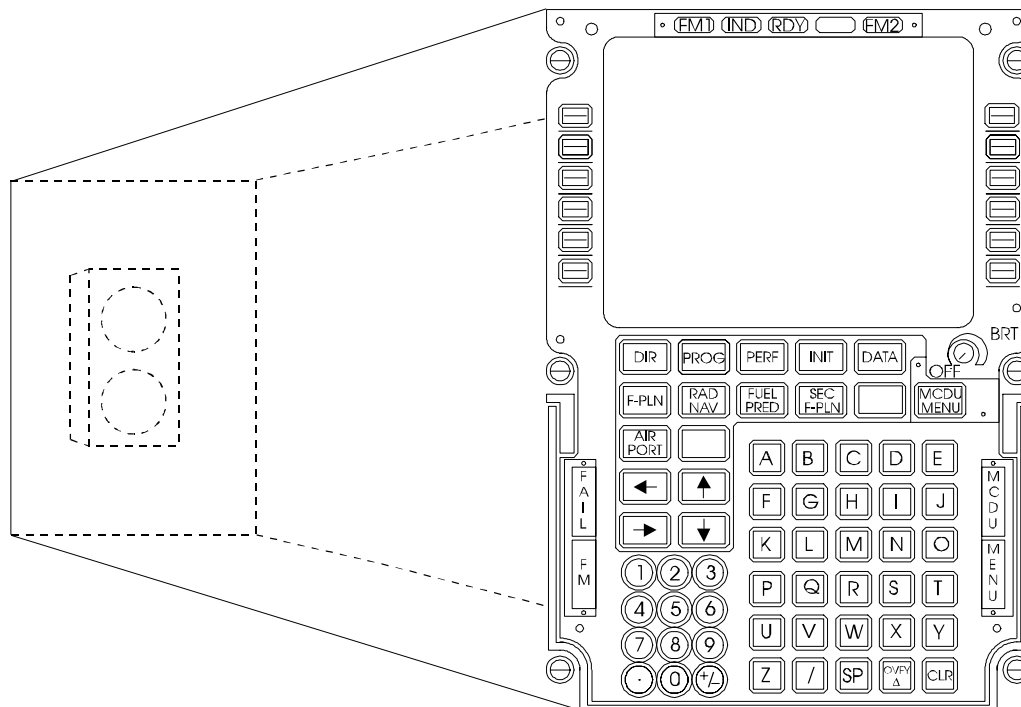
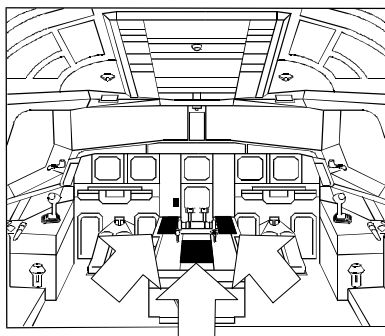
Open safety and tag these circuit breakers :

PANEL	DESIGNATION	FIN	LOCATION
721VU	INTG LT SVAC	5LF	H05
742VU	MCDU1	7CA1	Q61 (2CA1)
722VU	MCDU2	7CA2	C47 (2CA2)
742VU	MCDU3	7CA3	Q65 (2CA3)

Removal of the MCDU :

- 1-Loosen the 6 DZUS fasteners from the MCDU by a quarter turn.
- 2-Pull the MCDU from its housing with the handle.
- 3-Disconnect the electrical connectors.
- 4-Remove the MCDU.
- 5-Put blanking caps on the disconnected electrical connectors.

To install the MCDU, perform the opposite actions in reverse order.



FQW4200 GE Metric

FMGEC

FIN : 1CA1, 1CA2

ZONE : 121, 122

COMPONENT DESCRIPTION

The Flight Management Guidance and Envelope Computer (FMGEC) is a digital computer to 8 MCUs.

7 boards in the computer are equipped with an On Board Replaceable Memory Module (OBRM).

From left to right :

- FE MONG, FG MONG, FIDS.
- FE CMD, FG CMD.
- FM MP (Main Processor).
- FM DBP (Data Base Processor).

Weight = 12.9 Kg.

The computer is equipped with a back connector.

Note that all usual cautions must be taken on this back connector to avoid any pin damage or Electro-Static Discharge (ESD) problem.

REMOVAL INSTAL

Open safety and tag these circuit breakers :

PANEL	DESIGNATION	FIN	LOCATION
721VU	FMGEC1	5CA1	R10 (1CA1)
722vu	FMCEC2	5CA2	R43 (1CA2)

1-Loosen the nuts.

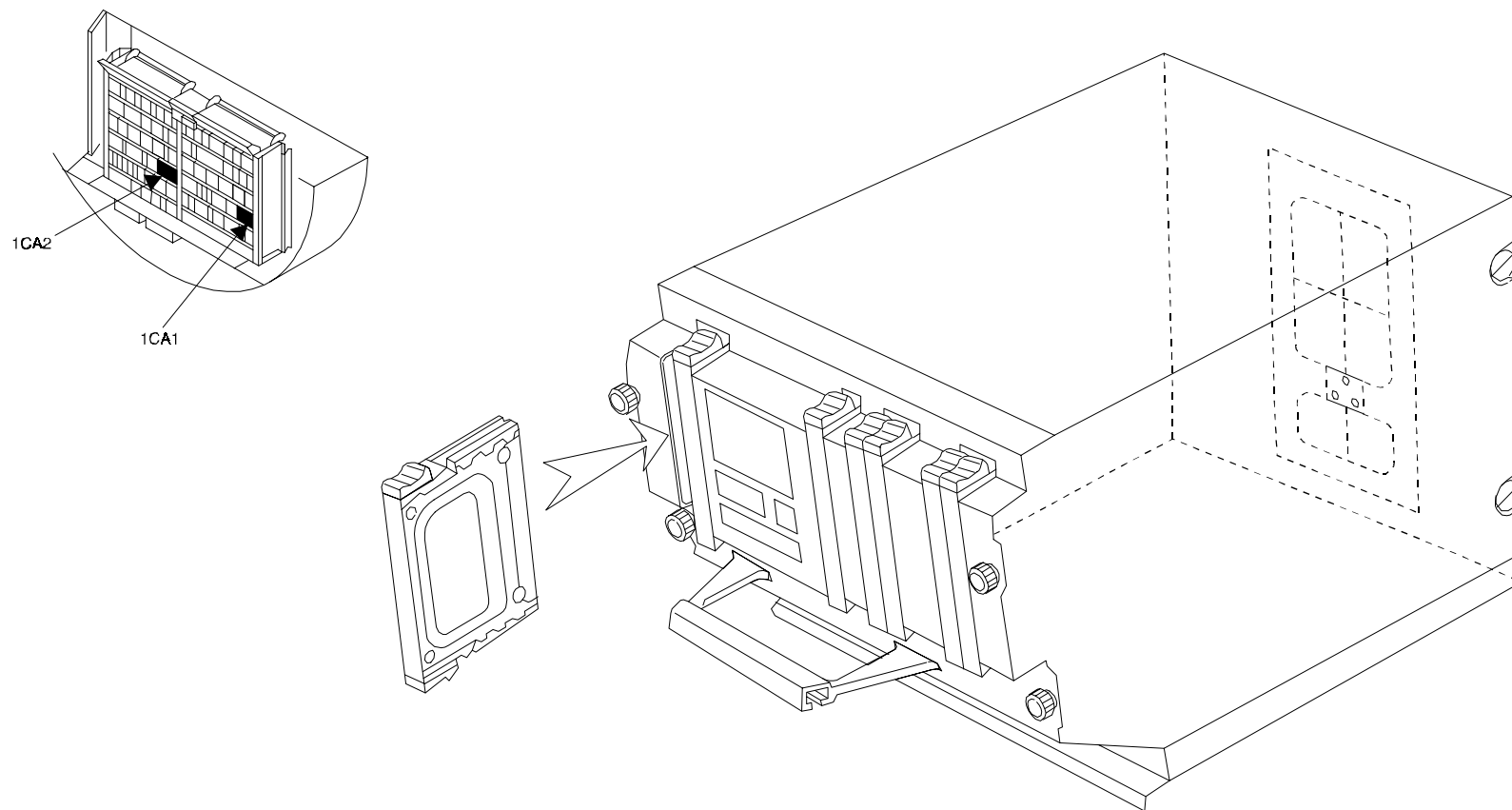
2-Lower the nuts.

3-Pull the FMGEC on its rack to disconnect the electrical connectors.

4-Remove the FMGEC from its rack.

5-Put blanking caps on the disconnected electrical connectors.

To install the FMGEC, perform the opposite actions in reverse order.



FQW4200 GE Metric

STUDENT NOTES

FCU INTERFACES

Discrete Inputs
Discrete Outputs
ARINC Inputs
ARINC Outputs

The Flight Control Unit (FCU) receives 21 discrete inputs and 6 ARINC 429 bus inputs. It has 9 discrete outputs and 6 ARINC 429 buses.

DISCRETE INPUTS

The Landing Gear Control Interface Units (LGCIUs) send the nose gear compressed information to enable the power-up test to be triggered.

The Flight Management Guidance and Envelope Computers (FMGECs) send the Autopilot (AP), Flight Director (FD) and Autothrust (A/THR) engagement discretes to authorize the lighting of the associated pushbuttons on the Flight Control Unit (FCU) front panel.

They also send the "FCU valid" discretes which are the result of the comparison between the FMGEC EPR target sent to the FCU and the FCU EPR target sent to the Electronic Engine Controls (EECs).

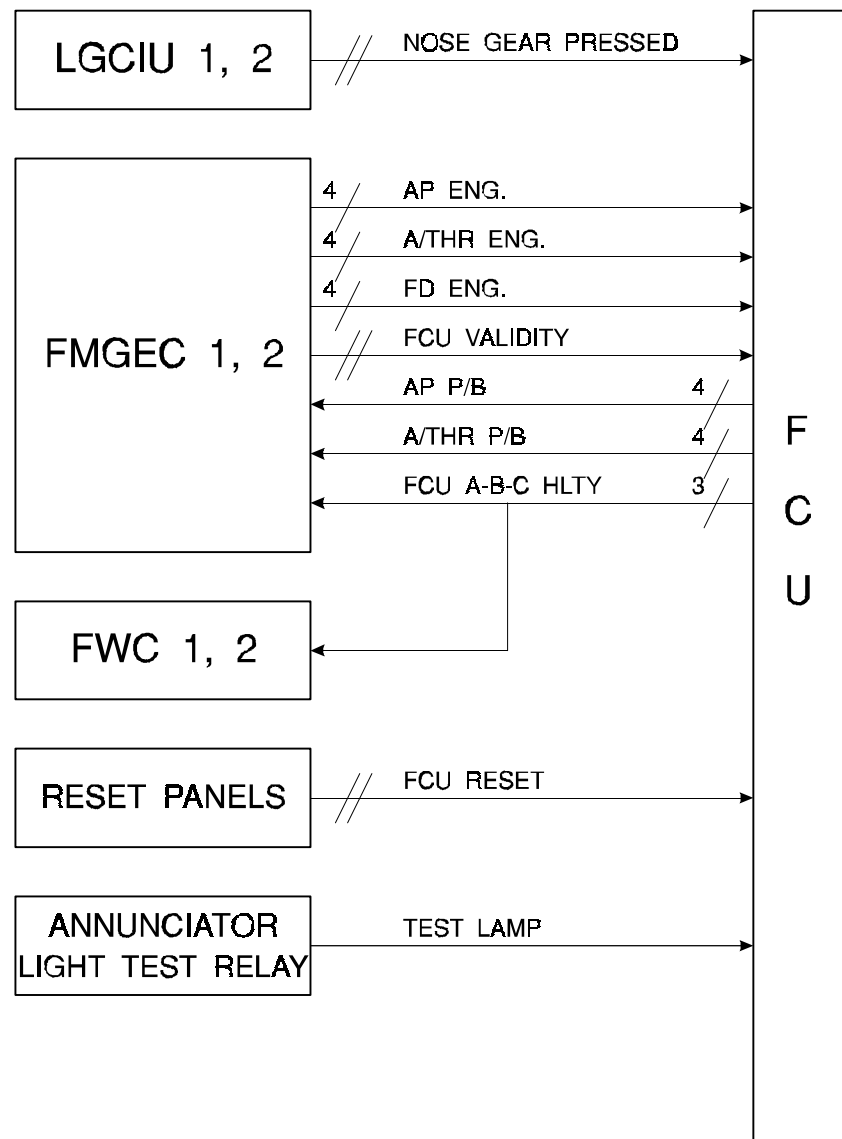
The reset circuit breakers, located on the overhead panel, send a ground signal to reset the FCU processors.

The annunciator light test relay sends a discrete signal to test the FCU lamps.

DISCRETE OUTPUTS

The FCU delivers control data for AP1, AP2 and A/THR engagement to each FMGEC. This data is directly issued from the engagement pushbuttons.

Each FCU processor sends its own FCU HEALTHY signal to the FMGECs and to the Flight Warning Computers (FWCs).



FQW4200 GE Metric

ARINC INPUTS

For synchronization and internal monitoring purposes, output buses are looped back to the three FCU channels.

These buses, EIS CP-L, EIS CP-R, AFS M1 and AFS M2 send data concerning each FCU control panel.

In order to avoid display modifications during reconfigurations, the channels, non-active on a given function, synchronize on the values computed by the active channel.

Each FMGEC uses ARINC buses to compare, for the channel active on the Autoflight System (AFS) function, the data received from the FCU with its transmitted data.

ARINC OUTPUTS

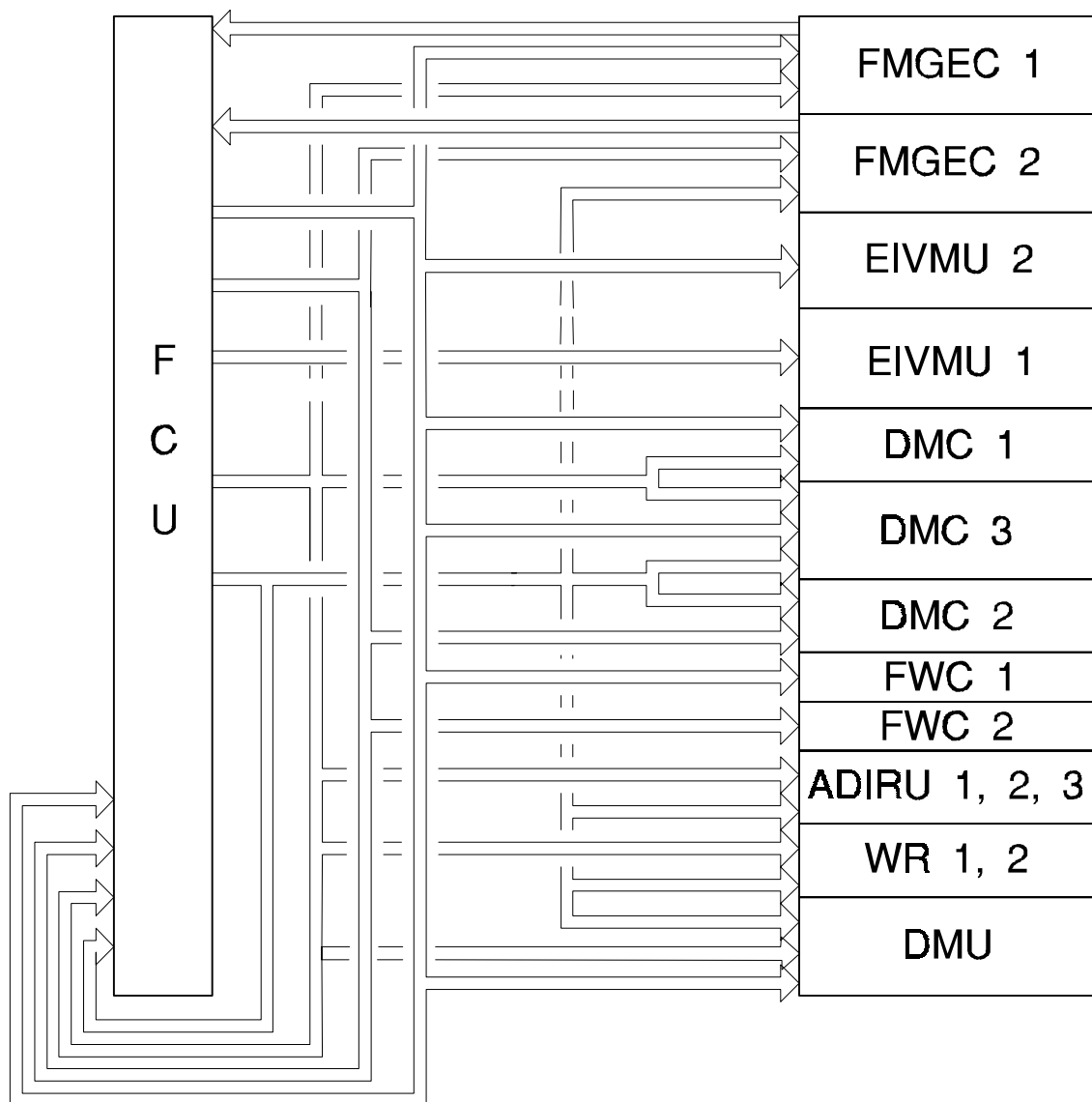
The FCU delivers messages on a total of 6 ARINC buses.

For segregation reasons, the transmission of data to the engines has required the creation of four identical outputs for the AFS function.

These buses also send data for display and warning.

Two buses are associated to the Captain and First Officer control panel functions. They deliver display information, range and mode, reference parameter selection,...

The EIS buses and two AFS buses are used to send data back to the FCU for comparison.



FQW4200 GE Metric

STUDENT NOTES

MCDU INTERFACES

Discrete Inputs
Discrete Outputs
ARINC Inputs
ARINC Outputs

The Multipurpose Control and Display Units (MCDUs) receive data from other systems via 9 discretes and 9 ARINC 429 buses. They send information via 3 discretes and 2 ARINC buses.

DISCRETE INPUTS

The FM source selector switch sends the selection of the FM operating mode (NORMAL, BOTH ON 1 or BOTH ON 2).

This information is useful for the Multipurpose Control Display Units (MCDUs) to know with which Flight Management (FM) side they work. MCDU3 receives the status of MCDU1 and MCDU2.

The position of their brightness selector knob (ON/OFF) indicates to MCDU3 if it replaces MCDU1 or 2 or not.

The North reference pushbutton switch sends the selection of the heading reference (TRUE or MAGNETIC) to MCDU1 and 2.

The parameters referenced to North are displayed on the MCDU according to the pushbutton switch selection, whatever the mode of operation, FM normal or back-up nav.

The lights of each MCDU are tested via a discrete issued from the annunciator light test relay.

The ATT HDG selector switch informs MCDU1 and 2 about the selection of the inertial reference.

It can be NORMAL or CAPTAIN side on Inertial Reference 3 (IR3), or First Officer (F/O) side on IR3.

The position of the MCDU is defined by two program pins that are only read after long-term power cuts.

These pins defined whether the MCDU is installed on the left side (MCDU1), on the right side (MCDU2) or in the center (MCDU3).

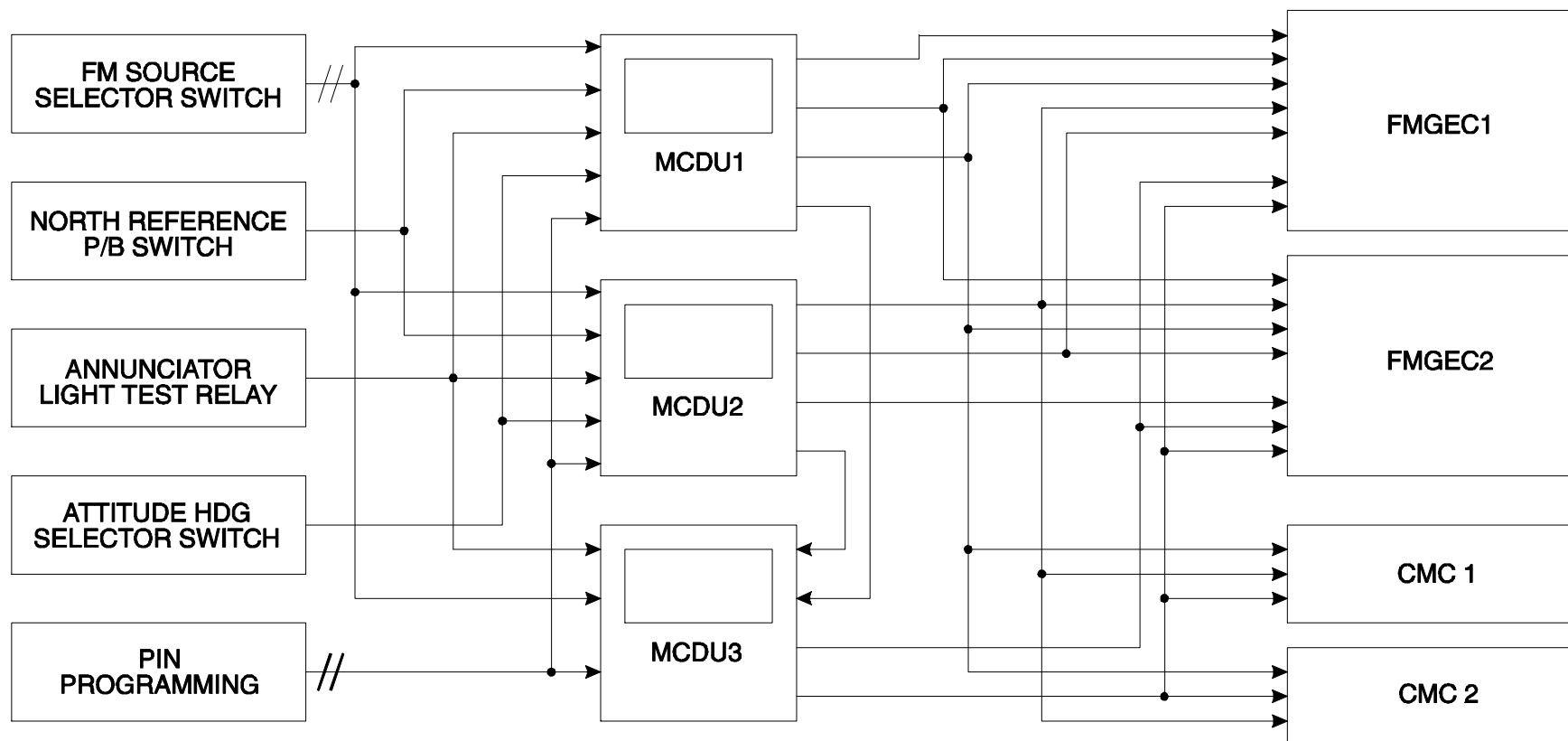
DISCRETE OUTPUTS

Each MCDU sends the brightness knob selection (ON/OFF) to FMGEC1 and 2, and Centralized Maintenance Computers (CMCs) 1 and 2.

MCDU1 and 2 also send this information to MCDU3.

The Flight Management Guidance and Envelope Computers (FMGECs) receive the MCDU HEALTHY signal from each MCDU.

MCDU1 and 2 send the NAV BACK-UP selection information to their associated FMGEC.



FQW4200 GE Metric

ARINC INPUTS

Each MCDU receives data from the Aircraft Communication Addressing Reporting System (ACARS) if fitted.

This data is used to manage the display of the Aircraft Communication Addressing Reporting System specific pages.

ACARS messages are also transmitted and displayed on the MCDU.

Air Data Inertial Reference Units (ADIRUs) 1, 2 and 3 transmit IR data such as the present position, magnetic heading, true track, true heading, ground speed and wind. All this data is displayed on MCDU pages.

Centralized Maintenance Computer (CMC) 1 sends maintenance information to MCDU1, 2 and 3. CMC specific pages are then displayed (e.g. SYSTEM REPORT TEST). This CMC bus allows the system test and the trouble shooting to be done.

The Data Management Unit (DMU) (if fitted) sends data to MCDU2 and 3 to manage and display the Aircraft Condition Monitoring System (ACMS) specific pages. Note that the Aircraft Condition Monitoring System option is not available from MCDU1.

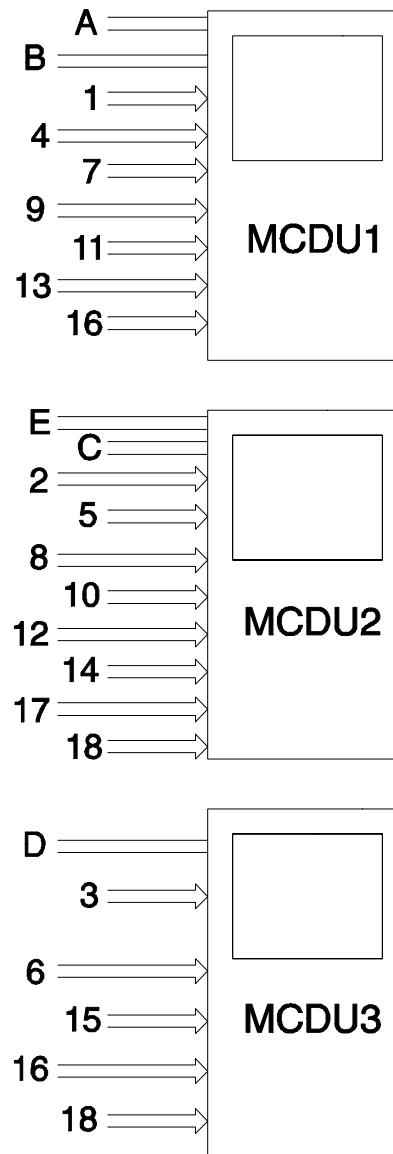
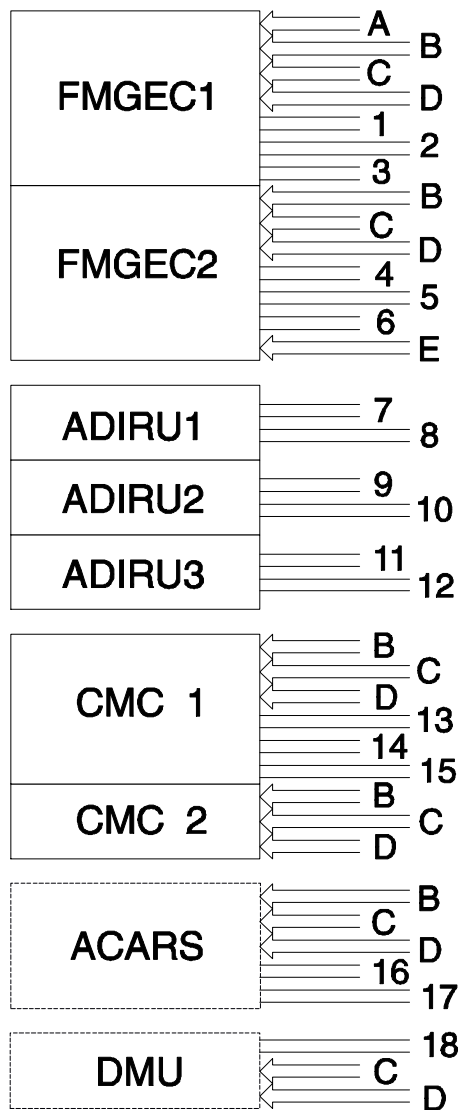
Each FMGEC transmits flight management data to each MCDU. This data is displayed on FM specific pages.

ARINC OUTPUTS

MCDU1 and 2 send background and dynamic Electronic Instrument System (EIS) data to their associated FMGEC.

MCDU1 and 2 also transmit data, entered by the pilot, to the FMGECs, the CMCs, and the ACARS. This data comprises messages and system interrogations.

Via MCDU2 and MCDU3, some ACMS information is transmitted to the Data Management Unit (DMU) (if fitted).



 **OPTIONAL**

STUDENT NOTES

FMGEC DISCRETE INTERFACES

FM Input
FM Input Pin Programming
FGE Input
FGE Input Pin Programming
FIDS Input
FIDS Input Pin Programming
FM Output
FGE Output

Each Flight Management Guidance and Envelope Computer (FMGEC) receives 123 discrete signals, 41 of which being pin programs. Each FMGEC also provides 23 discrete signals to the Autoflight System (AFS) and to external systems.

FM INPUT

The Proximity Switch Control Unit (PSCU) sends the "door closed" information to the Flight Management (FM) part..

The FM source selector switch sends data via two discretes to the Flight Management (FM) part. This data defines the selection of the working FM : NORMAL, BOTH ON 1 or BOTH ON 2.

Each MCDU gives information about the position of its brightness knob and about its validity. MCDU1 and MCDU2 inform their associated FM about the activation or deactivation of the NAV BACK-UP function.

The opposite Flight Management Guidance and Envelope Computer (FMGEC) indicates, to the transmitting FMGEC, if the crossload is activated or not by setting the crossload enable discrete.

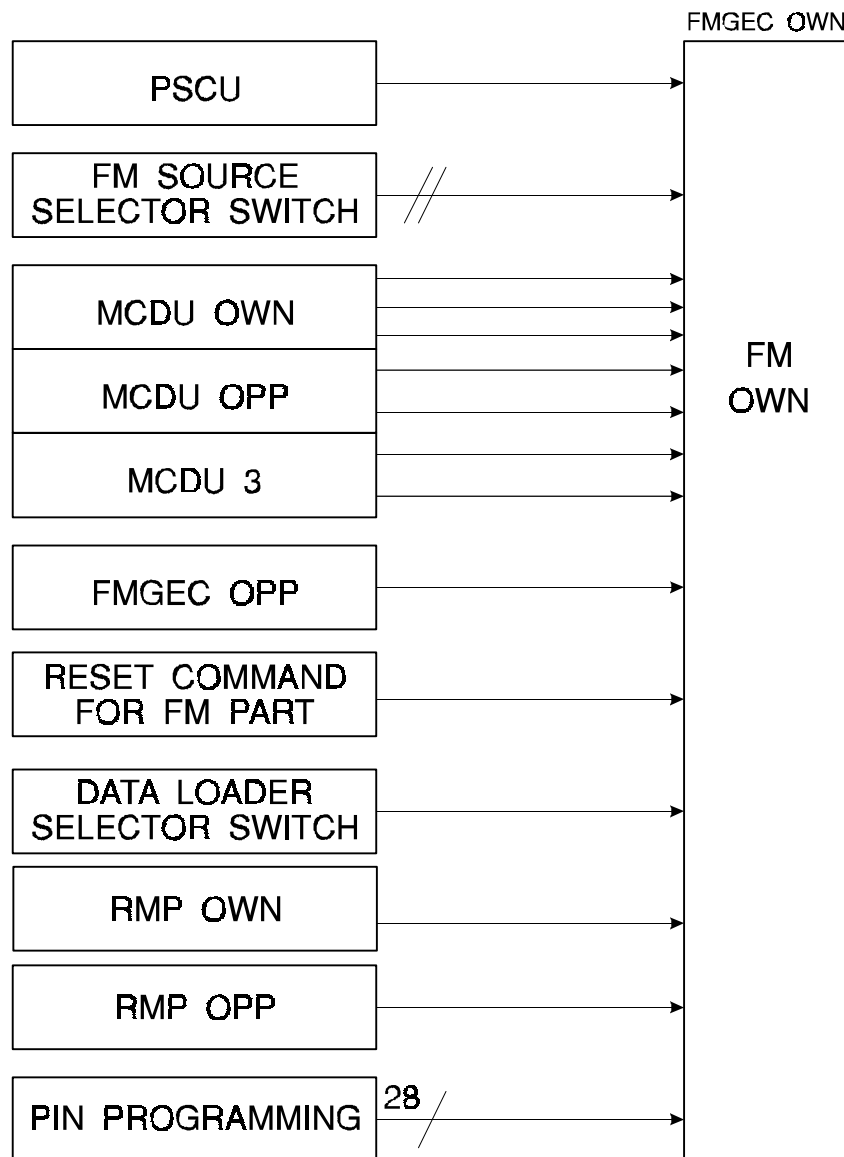
FM1 and FM2 parts receive a reset order from the cockpit reset commands. The data loader selector switch informs the FM part about the ground condition and about its position when set to FM or not. This data is useful to the FM part to activate the Navigation Data Base loading via the Multipurpose Disk Drive Unit (MDDU).

Radio Management Panel 1 and 2 (RMP1 and 2) send information to both FMGECs. With this discrete, the FMGECs know if the RMPs are in STANDBY NAV mode or not. When the RMPs are in NAV mode, neither the FM part nor the pilot can tune the radio frequencies on either side of the PROG and RAD NAV MCDU pages.

FM INPUT PIN PROGRAMMING

The use or the selection of the following parameters are defined by pin programming :

- number of ADF (1 or 2)
- use of Aircraft Communication Addressing and Reporting System (ACARS) or not
- aircraft type
- engine manufacturer
- engine type
- feet selection
- pound selection
- Minimum Decision Height (MDH) selection
- FM parity (pin programming parity for FM part)
- fuel policy
- use of Global Positioning System (GPS) or not
- use of Minimum OFF Route Altitude (MORA) grid or not
- use of JETTISON fuel or not
- track-up display in ARC mode
- VMO/MMO function definition
- use of Weight and Balance System (WBS) or not.



FQW4200 GE Metric

FGE INPUT

The Brake Steering Control Unit (BSCU) sends four discretes which indicate the validity of each channel. The Brake Steering Control Unit also sends the right and left wheel speed (speed 70kts) information to allow the ROLLOUT mode to be triggered as soon as the wheels touch down.

The Landing Gear Control and Interface Unit (LGCIU) sends the "nose gear pressed" information via two discretes. This information is used to consolidate the LGCIU data acquisition by comparison with the ARINC bus data.

Selection of the master FMGEC and disengagement of the AP, associated to the slave FMGEC in all modes except LAND and GO AROUND modes, are defined by 4 discretes from FMGEC OWN and 4 discretes wrapped around FMGEC OPP.

The selection of the A/THR having priority is given by two discretes coming from FMGEC OPPOSITE and 4 discretes wrapped around FMGEC OWN. Each FMGEC receives two FD engaged wired discretes from the command and monitoring channels of the opposite FMGEC. These are taken into account in the FD CONDITION logic.

The FE HEALTHY signals are sent from the own FMGEC and the opposite FMGEC. They are taken into account for the AP-FD-A/THR CONDITION logic.

The opposite FMGEC also informs about the FM availability taken into account in the AP-FD-A/THR CONDITION logic.

The Flight Control Unit (FCU) delivers four discretes associated with AP1, AP2 and A/THR pushbuttons and used in the AP, A/THR logic conditions. It also sends three signals corresponding to the validity of processors A, B and C. This is the result of comparisons between the thrust targets sent by FMGEC to the Flight Control Unit and by the FCU to the Electronic Engine Control (EEC).

Both A/THR instinctive disconnect pushbutton switches send two discretes to each FMGEC. An action on one of these switches for more than 15 sec. inhibits any further engagement of the A/THR function.

The FG and FE parts are reset via a discrete coming from the FMGEC cockpit reset command located on the reset control panel.

All the following discretes are used in the landing capability logics :

- the North Reference pushbutton switch sends the heading reference information.
- the Air Data selector switch and the Attitude Heading selector switch respectively give the Air Data Reference (ADR) and the Inertial Reference (IR) selection.
- the Flight Warning Computers (FWCs) inform the FMGECs about their validity.
- the Display Management Computers (DMCs) inform the FMGECs about the Primary Flight Display (PFD) validity.
- the FMGEC power supply split relay also gives information for the landing capability computation.

Engine Interface Vibration and Monitoring Units (EIVMUs) send the "engine stopped" information in order to trigger the power-up tests.

Each FMGEC command and monitoring channel receives 6 engagement enable discretes from the Flight Control Primary Computers (FCPCs). The AP disconnects when an FMGEC channel receives all FCPC engagement enable discretes in open status.

The Slat/Flap Control Computers (SFCCs) inform each FMGEC of the slat/flap configuration. This data is used in case of failure of both LGCIUs. An action on one of the instinctive disconnect pushbutton switches results in AP disengagement. This data is sent to each FMGEC and is used in the AP CONDITION engagement logic.

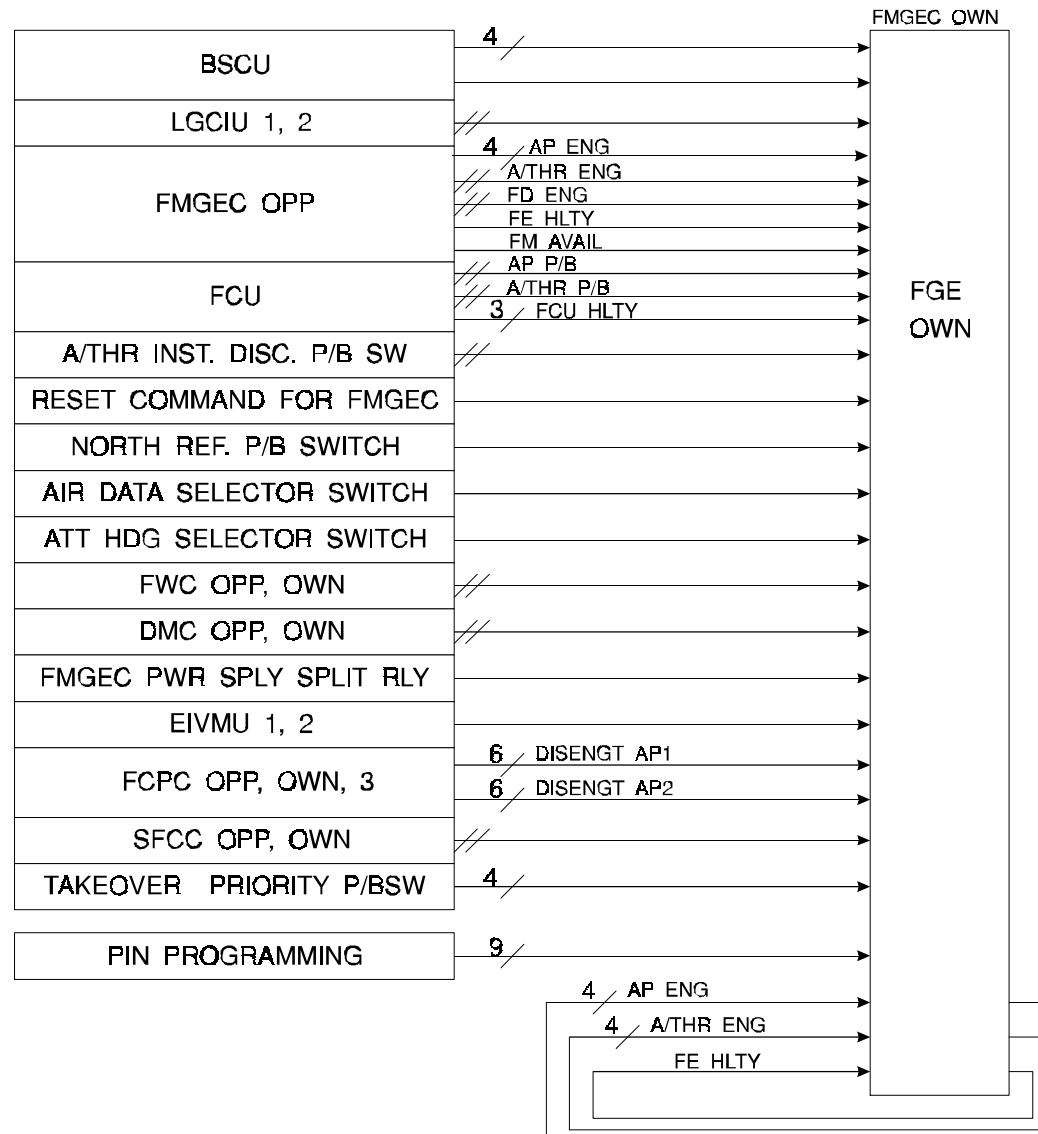
FGE INPUT PIN PROGRAMMING

The aircraft version is defined by pin programming.

The FE parity is also defined by pin programming.

The option of having the glide slope capture before the localizer acquisition is given by pin programming.

The selection of side 1 or 2 for FMGEC1 and 2 is made by pin programming.



FQW4200 GE Metric

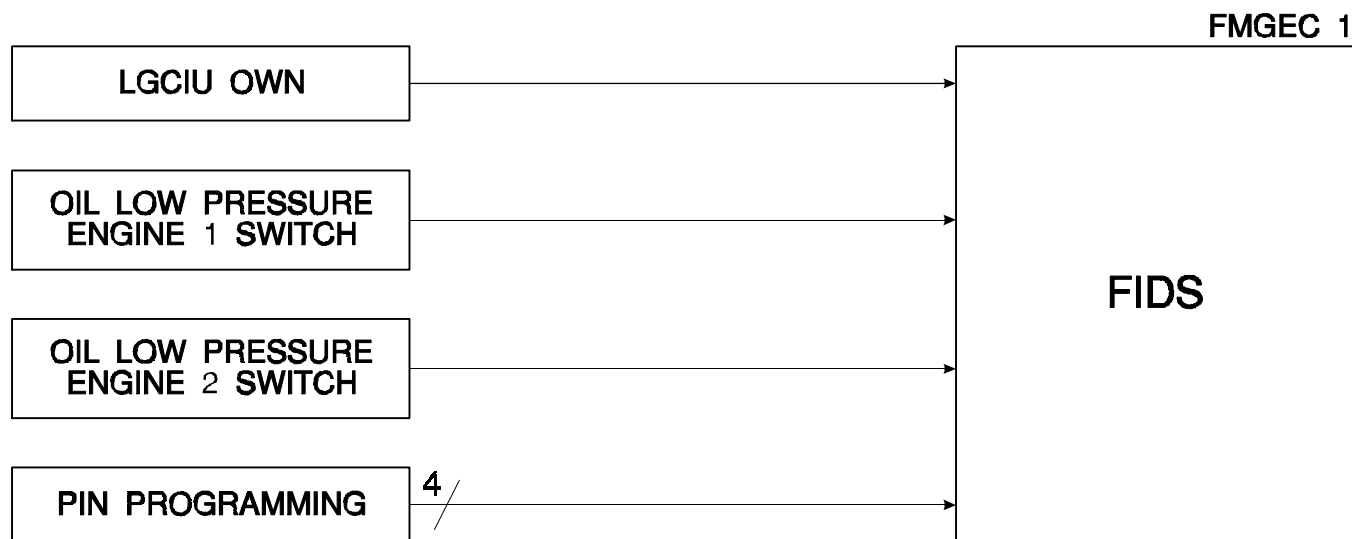
FIDS INPUT

The Landing Gear Control and Interface Unit (LGCIU) sends the "nose gear pressed" information which determines the maintenance phase. This data is safety information in case of a problem of transmission of the Centralized Maintenance Computer (CMC) information.

The oil low pressure engine 1 and 2 switches give the following information : aircraft on ground with engines stopped. This defines the maintenance phase.

FIDS INPUT PIN PROGRAMMING

Four pin programs define the type of the aircraft.



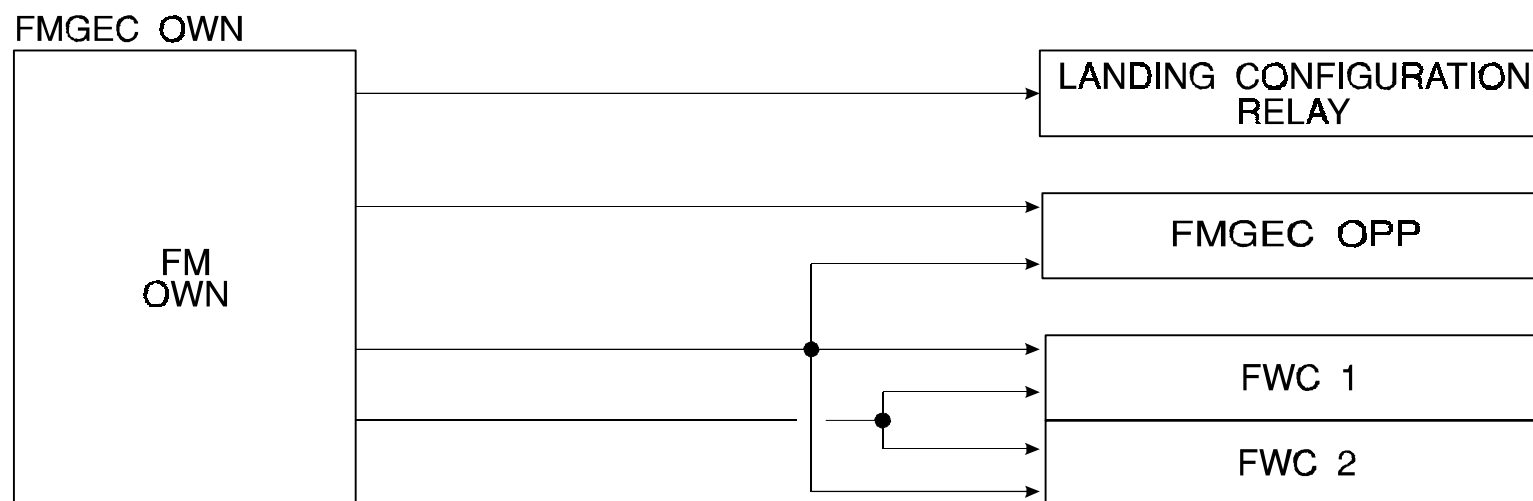
FM OUTPUT

The selection of the landing configuration, CONF3 or not, on the APPROACH page, is sent to the landing configuration relay used by the Ground Proximity Warning System (GPWS) and the ECAM.

The crossload enable discrete is sent to the opposite FMGEC.

The FM availability data is sent to the opposite FMGEC and to the Flight Warning Computers (FWCs).

The NAV BACK-UP discrete is sent to the FWCs.



FQW4200 GE Metric

FGE OUTPUT

The aft Center of Gravity detection is sent to the Fuel Control Monitoring Computers (FCMCs).

Information about the engagement of the autopilot is sent to both FMGECs, to the FCPCs, to the FWCs and to the FCU.

Information about the engagement of the autothrust is sent to both FMGECs, to the FCU and to the relays.

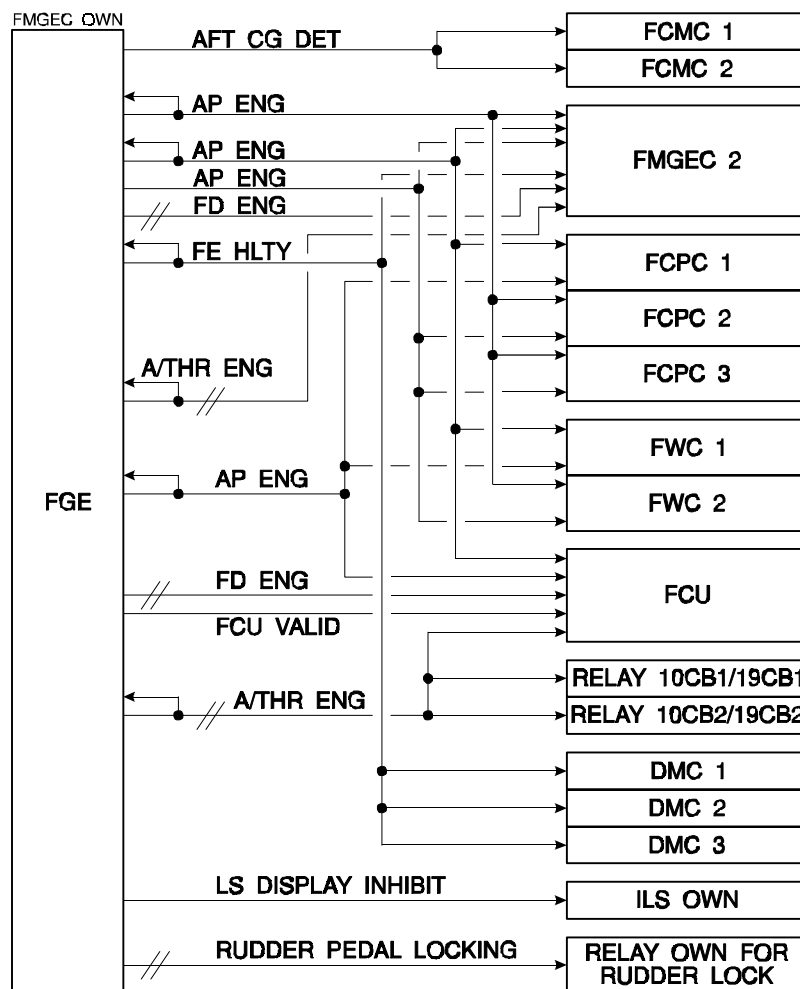
The FCU validity discrete is sent back to the FCU.

Information about the engagement of the flight director is sent to the opposite FMGEC and to the FCU.

The FE HEALTHY discrete informs the FMGECs and the DMCs about the FE status.

The LS display inhibition through the FCU LS pushbutton is sent to the Instrument Landing System (ILS).

The locking of the rudder pedals is sent to the corresponding side through two discretes.



FQW4200 GE Metric

STUDENT NOTES

FMGEC ARINC INTERFACES

FM Input
FGE Input
FIDS Input
FM Output
FGE Output
FIDS Output

FM INPUT

When fitted, the Aircraft Communication Addressing and Reporting System Management Unit (ACARS MU) sends flight plan initialization, wind messages and advisory messages under FMGEC request.

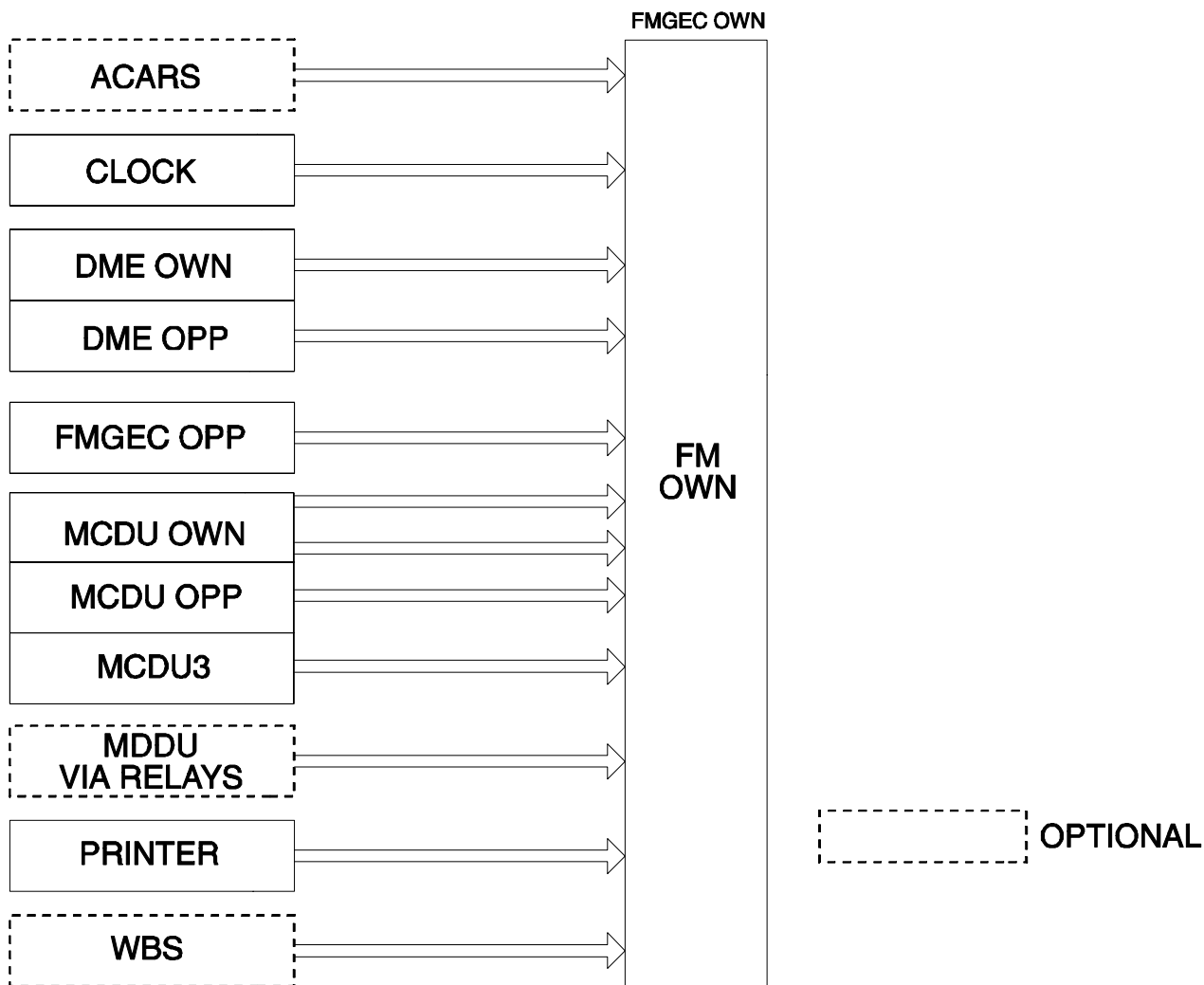
The clock gives time and date to initialize the Flight Management (FM) part. The Distance Measurement Equipment (DME) gives distance information (ro,ro) to the FM part. This information is taken into account in the radio position computation.

Both Flight Management Guidance and Envelope Computers (FMGECs) exchange FM information and compare their computations using ARINC buses : this is crosstalk.

The Multipurpose Control Display Unit (MCDU) associated to the FM OWN provides information for the Electronic Flight Instrument System (EFIS) switching relay used for back-up navigation.

The Multipurpose Disk Drive Unit (MDDU) (if fitted), via relays, allows the navigation data base to be loaded in the FM part.

The printer delivers the protocol and the acknowledge signal to the FM part. The Weight and Balance System (WBS) (if fitted) sends weight and center of gravity information which is used for the take-off initialization.



FQW4200 GE Metric

FGE INPUT

The Air Data and Inertial Reference Units (ADIRUs) send Air Data Reference (ADR) parameters such as Mach number, altitude standard, true air speed and computed air speed. They also deliver Inertial Reference (IR) information such as : accelerations, rotation speeds, attitudes, ground speed, magnetic and true track/heading, wind data,...

All this data is:

- monitored and used by the FE part, for its own computation,
- used by the Autopilot (AP), Flight Director (FD) and Autothrust (A/THR) functions,
- used for FM computations.

Each Electronic Control Unit (ECU) sends back A/THR data such as thrust target feedback, A/THR active, A/THR inoperative and alpha floor feedback information. This is to check the good transmission of the information given by the FMGEC.

Both Fuel Control Monitoring Computers (FCMCs) deliver weight and center of gravity parameters used by the FE part for the aft CG monitoring and by the FM in the weight initialization.

Each Flight Control Primary Computer (FCPC) sends its own sensor inputs and the rudder/Trimmable Horizontal Stabilizer (THS) positions to synchronize the Autopilot order at the engagement.

The stalling speed is taken into account in the FE characteristic speed computation.

The computer and surface availability is one of the AP engagement conditions.

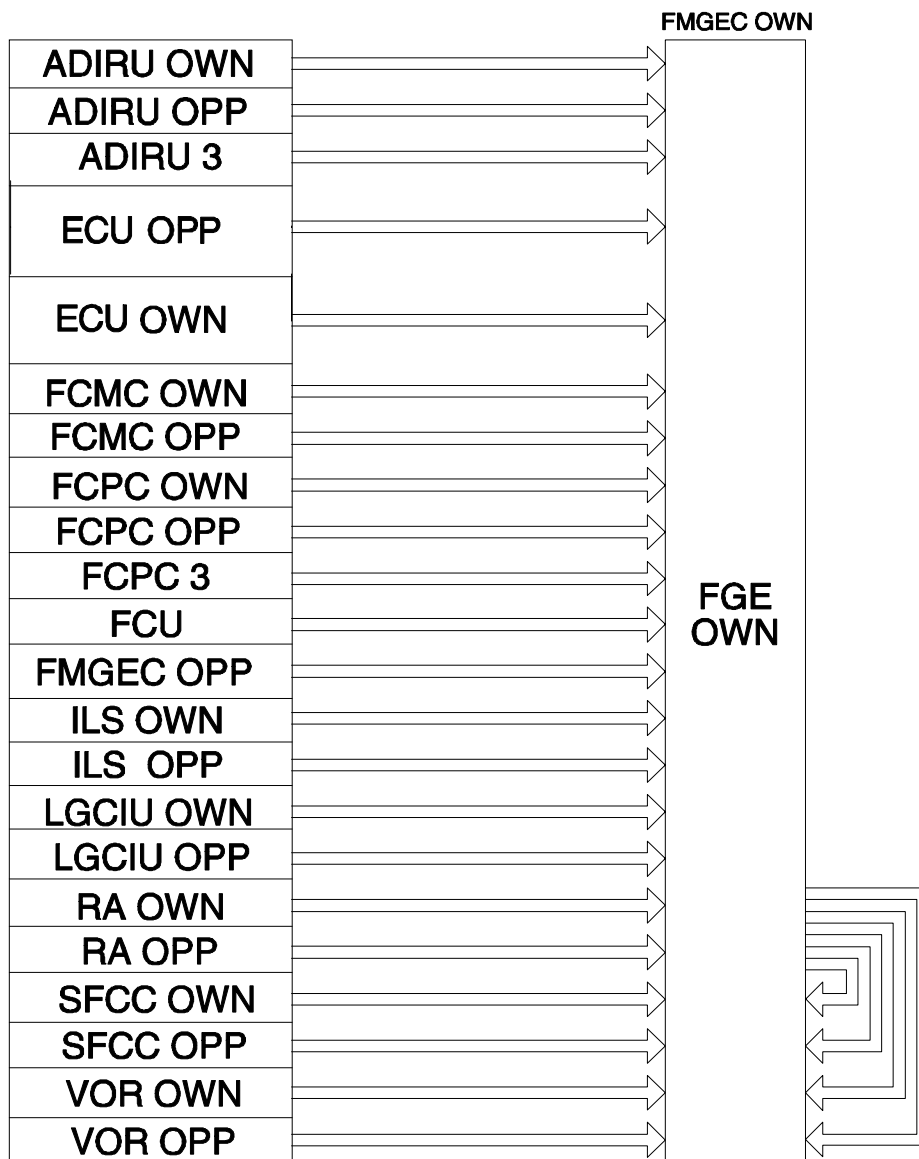
The Flight Control Unit (FCU) sends back data to be compared with the data transmitted by the FMGEC (thrust target, alpha floor signal). Mode selection, range selection, reference parameter selection are sent to the FMGEC.

Crosstalks between FMGEC command and monitoring channels are achieved through ARINC 429 buses. This data exchange is used for monitoring purposes and for transferring parameters that are acquired or computed by only one channel.

FE and FG data is sent by the opposite FMGEC to be compared with the data computed by the own FMGEC.

FMGEC1 sends Fault Isolation and Detection System (FIDS) data to each FMGEC for maintenance purposes.

Both Instrument Landing Systems (ILS), VOR and Radio Altimeters (RAs) deliver position and height information while the Landing Gear Control and Interface Units (LGCIUs) and the Slat/Flap Control Computers (SFCCs) give the aircraft configuration to the FE part.



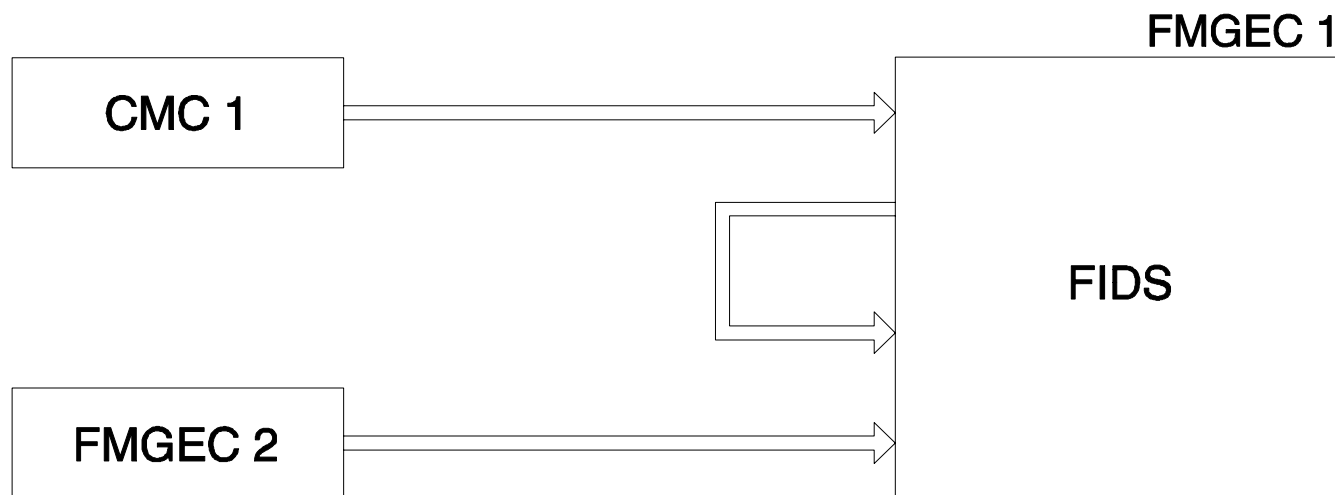
FQW4200 GE Metric

FIDS INPUT

Centralized Maintenance Computer 1 (CMC1) delivers maintenance information to the Fault Isolation and Detection System (FIDS) located in FMGEC1.

The Fault Isolation and Detection System receives commands and requests from CMC1.

FMGEC1 and 2 transmit the name, the part number and the serial number of each Autoflight System component to the FIDS through ARINC buses. All this data and messages coming from both FE COMMAND channels are delivered to the FIDS in order to build a failure context.



FM OUPUT

The FM part sends flight plan initialization, take-off data, wind data and flight reports to the ACARS Management Unit and to the printer (if fitted). The FM part sends the result of its computation to be displayed on each Multipurpose Control and Display Unit (MCDU).

FM Electronic Flight Instrument System (EFIS) background and dynamic data are delivered to the Display Management Computers (DMCs) and to the Ground Proximity Warning Computer (GPWC) as well as the present position of the aircraft.

FMGEC OWN sends radio navigation data (frequency and course) to its associated Radio Management Panel (RMP) and directly to its opposite navigation systems : VOR, DME, ILS, ADF.

The FM part delivers the latitude, longitude and magnetic heading to each ADIRU.

The FM part sends the following data to the Cabin Pressure Controller (CPC) :

- landing field elevation,
- cruise flight level,
- final cruise flight level,
- time of arrival,
- top of climb time,
- top of descent time.

The FM part provides fuel information to both Fuel Control and Monitoring Computers (FCMCs) such as Zero Fuel Weight (ZFW) and ZFW Center of Gravity (ZFWCG).

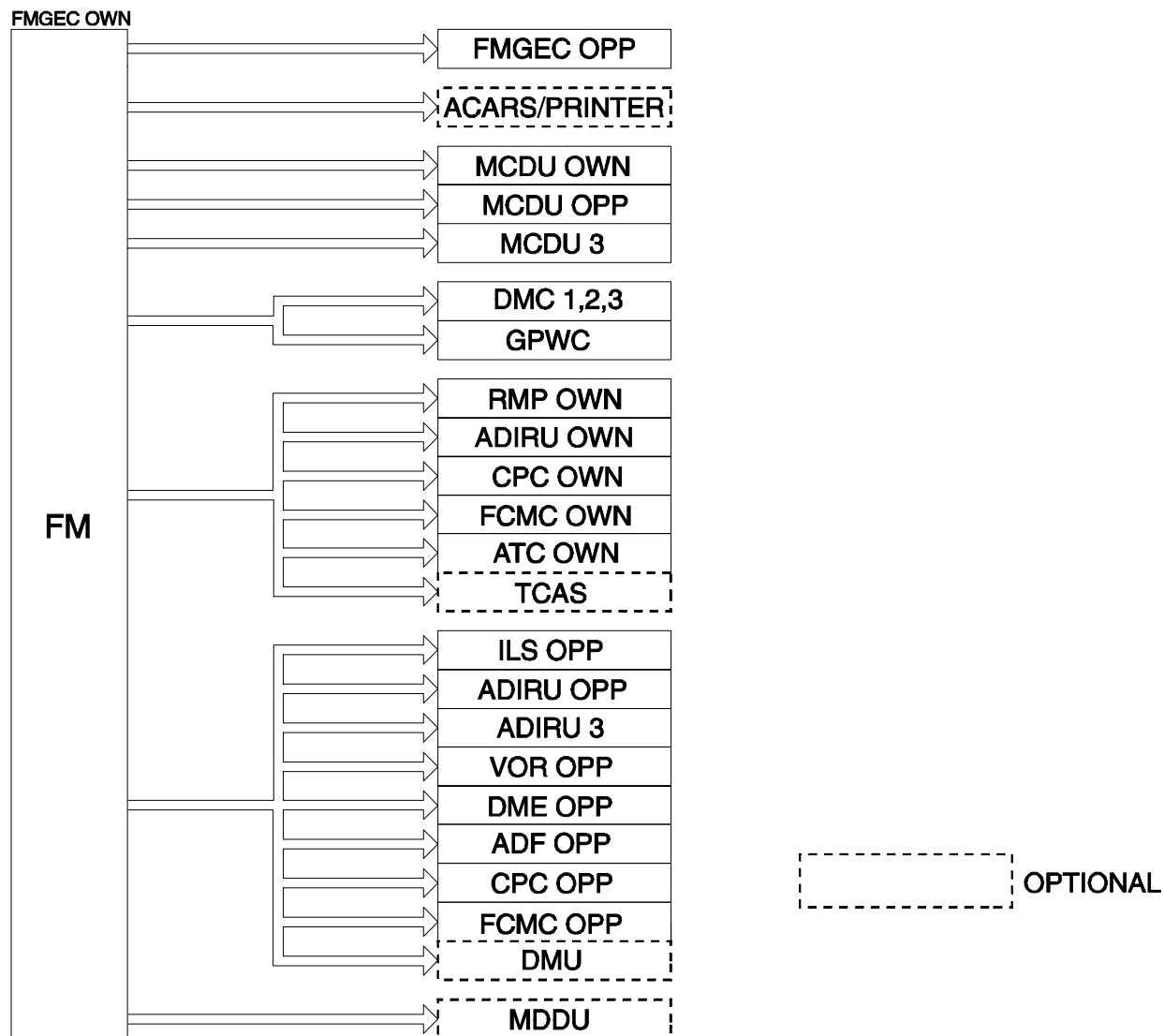
All the FM information readable through the Aircraft Condition Monitoring System (ACMS) is sent to the Data Management Unit (DMU) (if fitted).

The flight identification is delivered to the Air Traffic Control (ATC).

The performance limitations are sent to the Traffic Collision Avoidance System (TCAS) (if fitted).

To ensure crosstalk and the dual mode, FM information is transmitted to the opposite FMGEC.

Data loading information is sent to the Multipurpose Disk Drive Unit (MDDU) (if fitted).

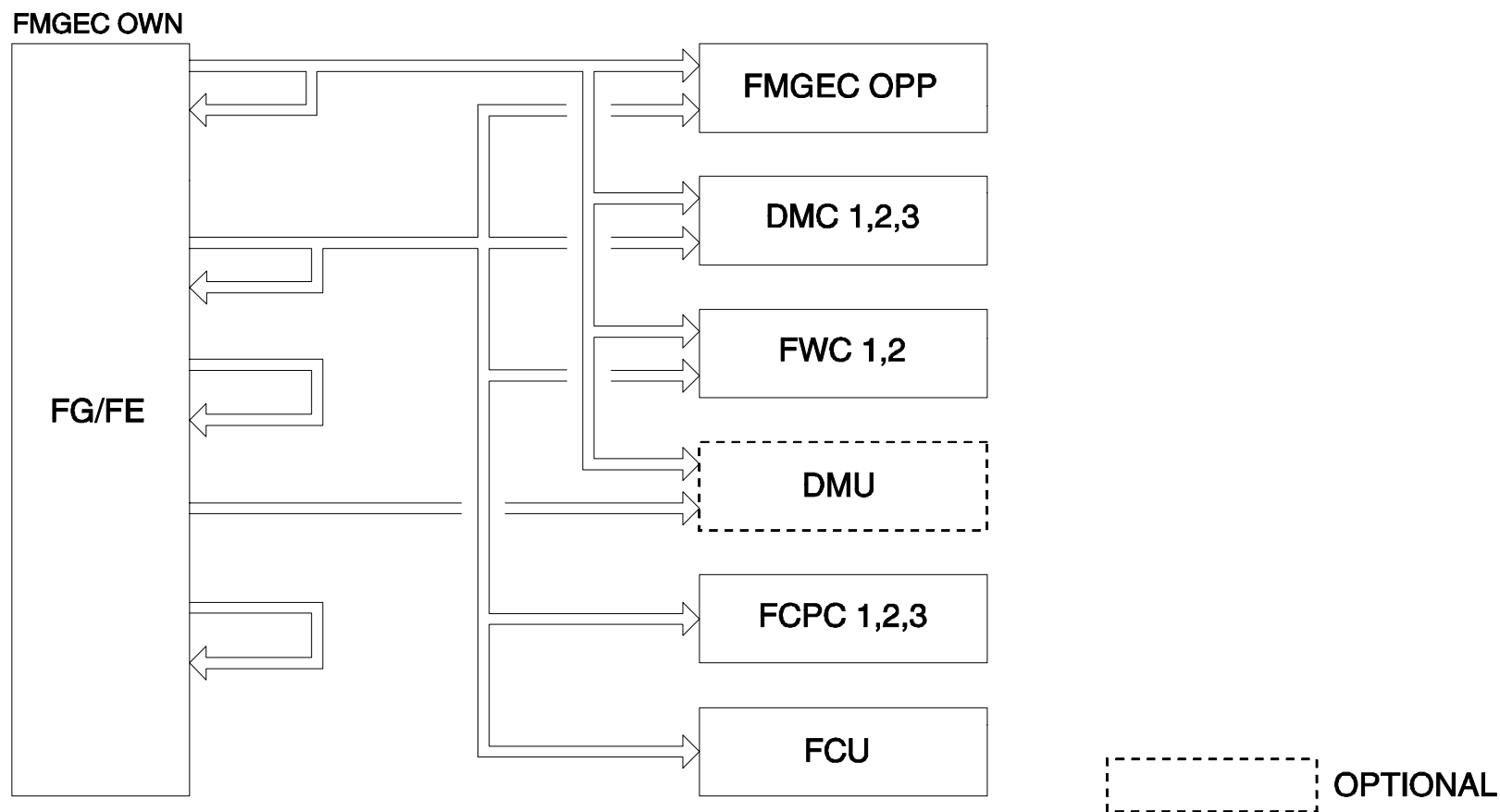


FGE OUTPUT

Flight Envelope data such as characteristic speeds, warning messages, weight and CG parameters is sent to both FMGECs, to the DMCs, to the FWCs and to the DMU if fitted.

Flight Guidance data such as roll, pitch, yaw orders, V2 speed, Vappr speed, target speeds, thrust target, modes.... is delivered to both FMGECs, the Flight Control Unit (FCU), the Flight Control Primary Computers (FCPCs), the Display Management Computers (DMCs) and the Flight Warning Computers (FWCs).

Two ARINC buses containing FE and FG information are wrapped around each FMGEC.



FIDS OUTPUT

Maintenance requests or commands issued from the CMC are sent to both FMGECs.

Maintenance and BITE information issued from each AFS component is sent to CMC1.



STUDENT NOTES