22.00 CONTENTS

PREAMBLE

The Auto Flight System is described in the volume 1 and 4 :

- the volume 1 chapter 22 gives a general description of the system and the different functions (architecture, modes, FMA, functions...).
- the volume 4 "FMGS PILOT'S GUIDE" is devoted to the FMGS System operation (MCDU pages, MCDU message, Procedures).

DESCRIPTION

The Flight Management Guidance and envelope System (FMGS) contains the following units :

- Two Flight Management Guidance and envelope Computers (FMGC).
- Three Multipurpose Control and Display Units (MCDU)
- One Flight Control Unit (FCU)
- One Flight Management source selection device.

GENERAL PHILOSOPHY

The Flight Management and Guidance System (FMGS) provides predictions of flight time, mileage, speed, economy profiles and altitude. It reduces cockpit workload, improves efficiency and eliminates many routine operations normally performed by the pilots.
During cockpit preparation the pilot inserts a preplanned route from origin to destination via the Multifunction Control and Display Units (MCDUs). This route includes the departure, enroute waypoints, arrival, approach, missed approach and alternate route as selected from the navigation database. The system generates optimum vertical and lateral flight profiles and predicted progress along the entire flight path. Either FMGC performs all operations if one FMGC fails.
The pilot may modify any flight parameter on a short term basis (SPD, V/S, HDG...) and the FMGS will guide the aircraft to the manually selected target. This pilot controlled guidance is called "selected".
There are two types of GUIDANCE :

- Managed guidance : The aircraft is guided along the preplanned route, vertical, lateral, and speed/Mach profile. This type of preplanned guidance is called "Managed". Predicted targets are computed by the FMGS.
- Selected guidance : The aircraft is guided to the selected target modified by the pilot. Targets are selected on the flight control unit located on the pilots glareshield. The decision to engage a "selected" or a "managed" guidance is always under the control of the pilot.
  Selected guidance has priority over managed guidance.

FLIGHT MANAGEMENT GUIDANCE COMPUTER (FMGC)

Each FMGC is divided into four main parts :

- The Flight Management (FM) part controls the following functions :
  - · Navigation and management of navigation radios.
  - · Management flight planning.
  - · Prediction and optimization of performance.
  - · Management of displays.
- The Flight Guidance (FG) part performs the following functions :
  - · Autopilot (AP) command
  - · Flight Director (FD) command
  - · Autothrust (A/THR) command
- The Flight Envelope (FE) part controls the following functions :
  - · Computation of data for the flight envelope and speed functions
  - · Monitoring of parameters used by FG and FE parts
  - · Windshear and aft Center of Gravity (CG) detection
  - · Computation of GW and CG information
- The Fault Isolation and Detection System (FIDS) part providing :
  - · Acquisition and concentration of maintenance data
  - · Interface with the Central Maintenance Computer (CMC)

Each FMGC has its own database (one Mega words - 16 bits) and each comprises two fields.

- One field, which the pilot cannot modify, contains customer-tailored data and standard navigation data : navaids, waypoints, airways, en route information holding patterns, airports, runways, procedures (SIDs, STARs, etc.), company routes, fuel policy, alternates.

  The customer (airline) is responsible for defining, acquiring, updating, loading and using this data.

  The airline updates this part every 28 days. The data go into each FMGC separately, although it can be copied into one FMGC from the other if the system has the optional crossload function. The updating operation takes 20 minutes to complete or 5 minutes if crossload from the opposite FMGC.
- The second field contains pilot-stored elements that allow the pilot create 20 waypoints, 10 runways, 20 navaids and 5 routes.

Note : When the two FMGCs are not working with the same database, the FMGS operates in independent operation. (See FMGS MODES OF OPERATION).

- Each FMGC also contains an integrated performance database that the FM part uses for computing predictions. The airline does not have access to this database.

MULTIPURPOSE CONTROL AND DISPLAY UNIT (MCDU)

Three MCDUs are installed on the pedestal for flight crew loading and display of data. The use of MCDU allows the flight crew to interface with the FMGC by selection of a flight plan for lateral and vertical trajectories and speed profiles. The crew may also modify selected navigation or performance data and specific functions of Flight Management (revised flight plan, engine-out, secondary flight plan, etc.). Additional data from peripherals (Centralized Maintenance System (CMS), aircraft Communications Addressing and Reporting System (ACARS) can also be displayed. Data that are entered into the MCDU that are illogical or beyond the aircraft capabilities will either be disregarded or will generate an advisory message.
The MCDUs allow back up navigation in case of dual FM failure.

FLIGHT CONTROL UNIT (FCU)

The FCU located on the glareshield, is the short-term interface between the crew and the FMGC. It is used to select any flight parameters or modify those selected in the MCDU. The autopilots and autothrust functions may be engaged or disengaged. Different guidance modes can be selected to change various targets (speed, heading, track, altitude, flight path angle, vertical speed).

FM SOURCE SELECTOR

This selector allow to switch the FMGC data to the offside MCDU and EFIS display in case of one FM failure.

OTHER CREW INTERFACES

THRUST LEVERS

The thrust levers are the main interface between the Flight Management Guidance Computer, the Full Authority Digital Engine Control System (FADEC), and the flight crew. They :
- arm the autothrust at takeoff, when "FLX " or "TOGA" is selected,
- limit the maximum thrust by their position when autothrust is active,
- disconnect the autothrust system when the flight crew sets them to "IDLE",
- command the thrust manually when autothrust is not active,
- engage the common modes (takeoff or go around) when TOGA (or "FLX" for takeoff) is set,
- when positionned between IDLE and CL detent (MCT in engine out), set the autothrust to the active mode.

ELECTRONIC FLIGHT INSTRUMENTS (EFIS)

Two Primary Flight Displays (PFD) and Navigation Displays (ND) provide the crew with full time flight guidance, navigation and system advisory information for all flight phases. An EFIS control panel is located at each end of the glareshield and is used to control both Primary and Navigation Displays. This panel includes controls to select various modes within the PFD. A selector allows the barometric altimeter setting to be displayed on the PFD. Various distance ranges can be selected on the ND, and two toggle switches allow display of either the left or right VOR/ADF bearing pointers to be displayed on the ND.

PRIMARY FLIGHT DISPLAYS

The PFDs combine several conventional flight instrument indications on one color display panel, for centralized reference of flight data.
This centralized color display includes :
- Flight Director attitude guidance targets
- Armed and engaged modes
- Navigation and instrument approach information
- Altimeter setting
- Barometric altitude
- System messages.

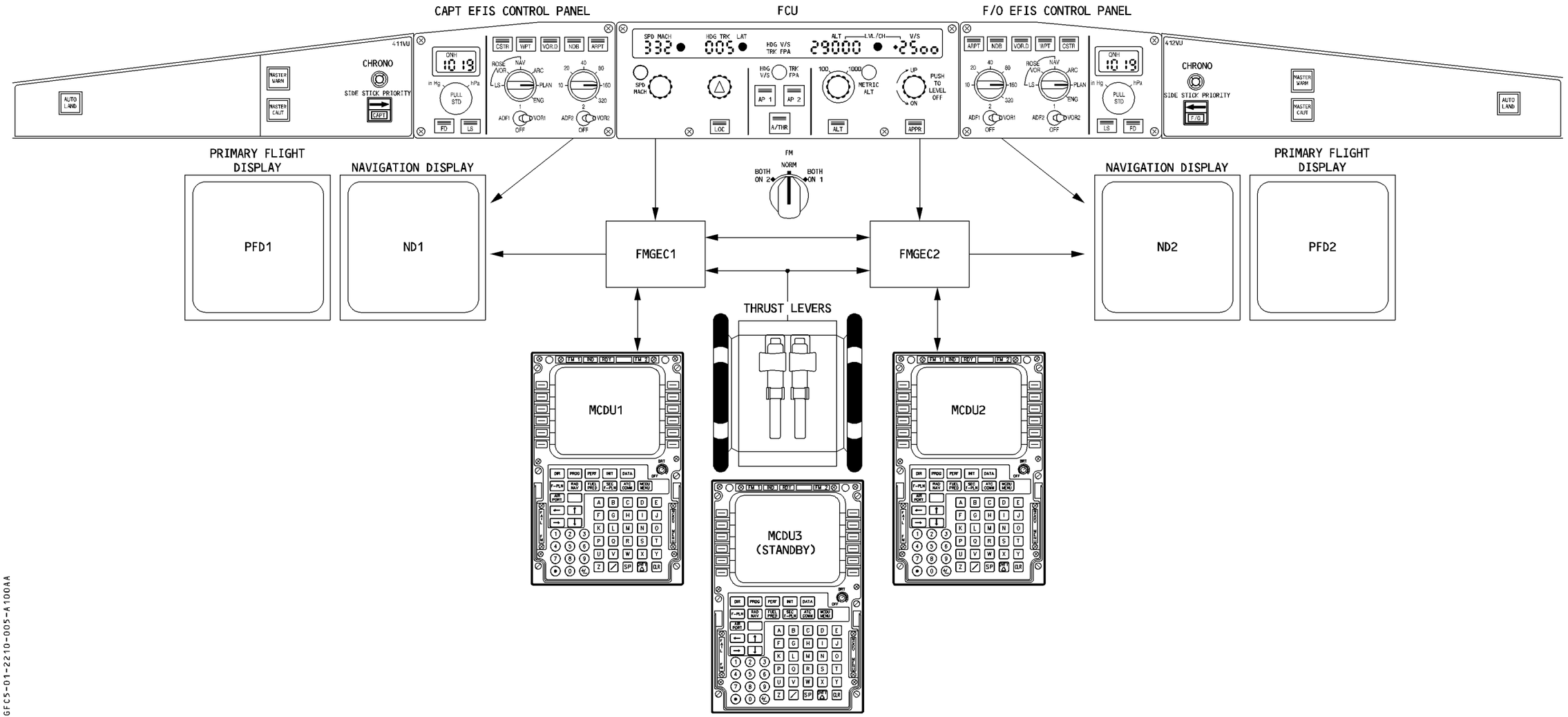
NAVIGATION DISPLAYS

Five different color navigation compass displays can be selected :
- ARC (map mode)
- ROSE NAV (map mode)
- ROSE VOR
R - ROSE LS
- PLAN

Information displayed on these modes uses the aircraft's position as a reference point for the flight plan navigation data (lateral and vertical information).

CREW INTERFACE WITH FMGEC

R



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SYSTEM INTERFACE DIAGRAM

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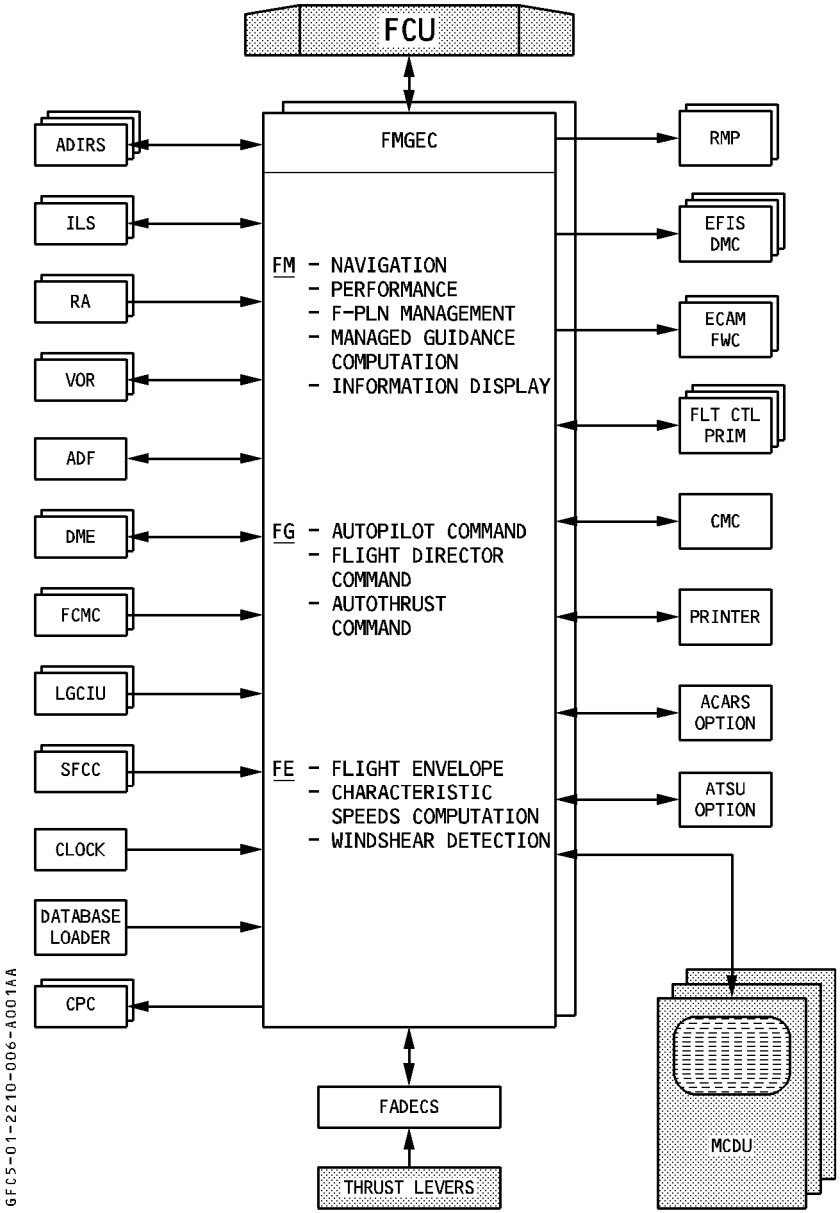
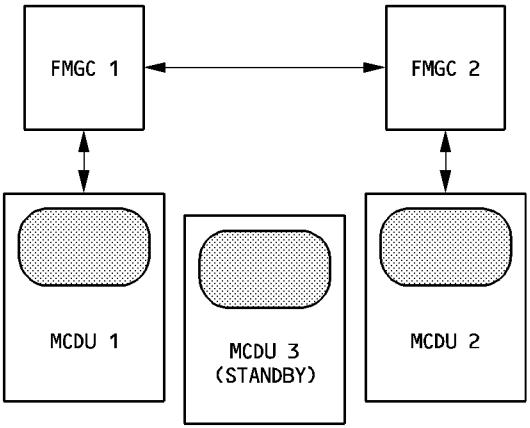


FMGS MODES OF OPERATION

The FMGS has four modes of operation :
- dual mode (the normal mode)
- independent mode. Each FMGC being controlled by its associated MCDU.
- single mode (using one FMGC only)
- back up navigation mode

DUAL MODE

This is the normal mode. The two FMGCs are synchronized : each performs its own computations and exchanges data with the other through a crosstalk bus.
One FMGC is the master, the other the slave, so that some data in the slave FMGC comes from the master. All data inserted into any MCDU is transferred to both FMGCs and to all peripherals.



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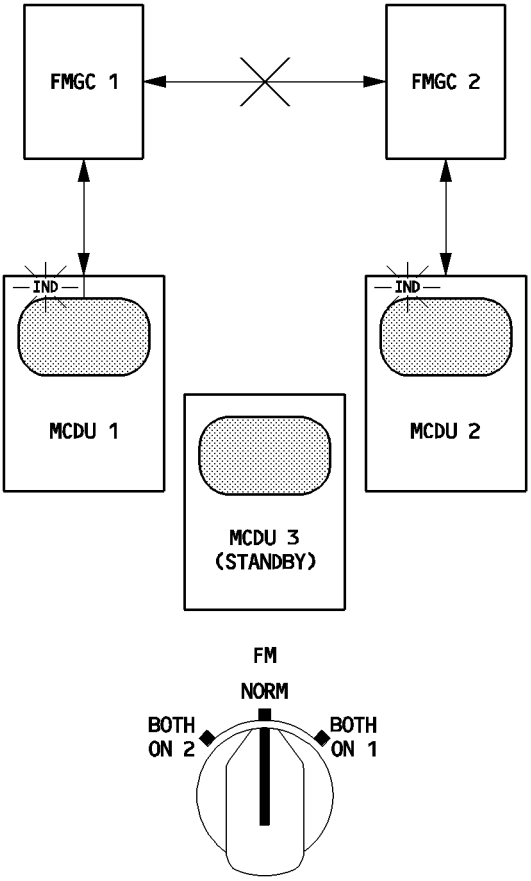
MASTER FMGC LOGIC :

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

R - if no AP/FD is engaged, A/THR is controlled by FMGC1.

INDEPENDENT MODE

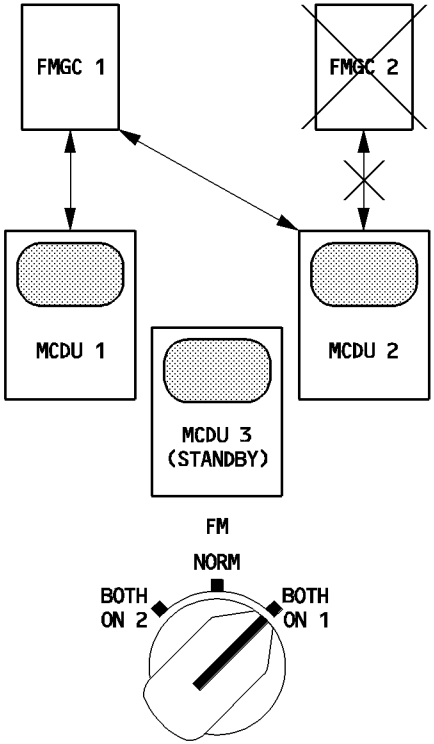
The system selects this degraded mode automatically if it has a major mismatch (database incompatibility, operations program incompatibility . . .). Both FMGCs work independently and are linked only to peripherals on their own sides of the flight deck ("onside" peripherals).
When this occurs, "INDEPENDENT OPERATION" appears on the MCDU scratchpad.
The "IND" annunciator light illuminates amber on the top of the MCDU when the onside FMGC detects an independant operation.
Each MCDU transmits data it receives only to its onside FMGC, and it affects only the onside EFIS (Electronic Flight Instrument System) and RMP (Radio Management Panel).



R For independent mode procedure refer to 4.06.10.

SINGLE MODE

The system selects this degraded mode automatically if one FMGC fails. The pilot selects the FM source selector to transfer the remaining FMGC data to the offside MCDU and EFIS display. The remaining FMGC drives all the peripherals, so, for example, any entry on one
R MCDU goes to both MCDUs.
The ND on the side with the failed FMGC displays "OFF SIDE FM CONTROL" in amber.



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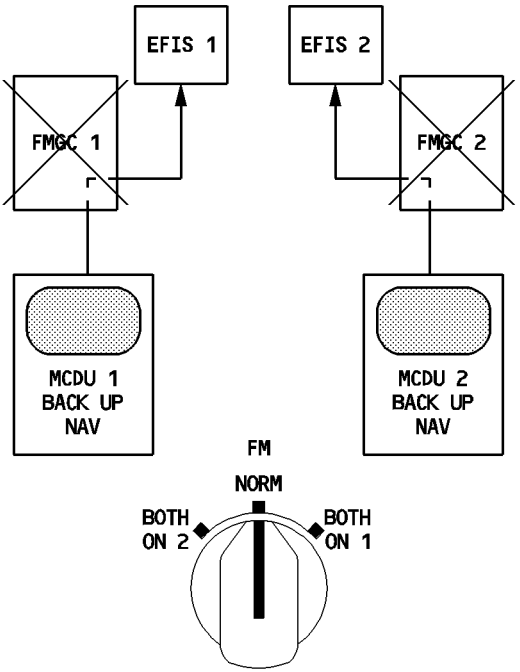
R For single mode procedure refer to 4.06.10.

BACK UP NAVIGATION MODE

The pilot selects on the MCDU menu page this degraded mode when both FMGC fail. He recovers the navigation function through the MCDU and IRS.
The MCDU memorizes the flight plan which has been continuously down loaded in its memory by the FMGC until it failed.
The following features are provided:

- Flight Planning
- Aircraft position using onside IRS or IRS 3
- F-PLN display on ND
- No AP/FD NAV mode
- Limited lateral revision
- F-PLN automatic sequencing



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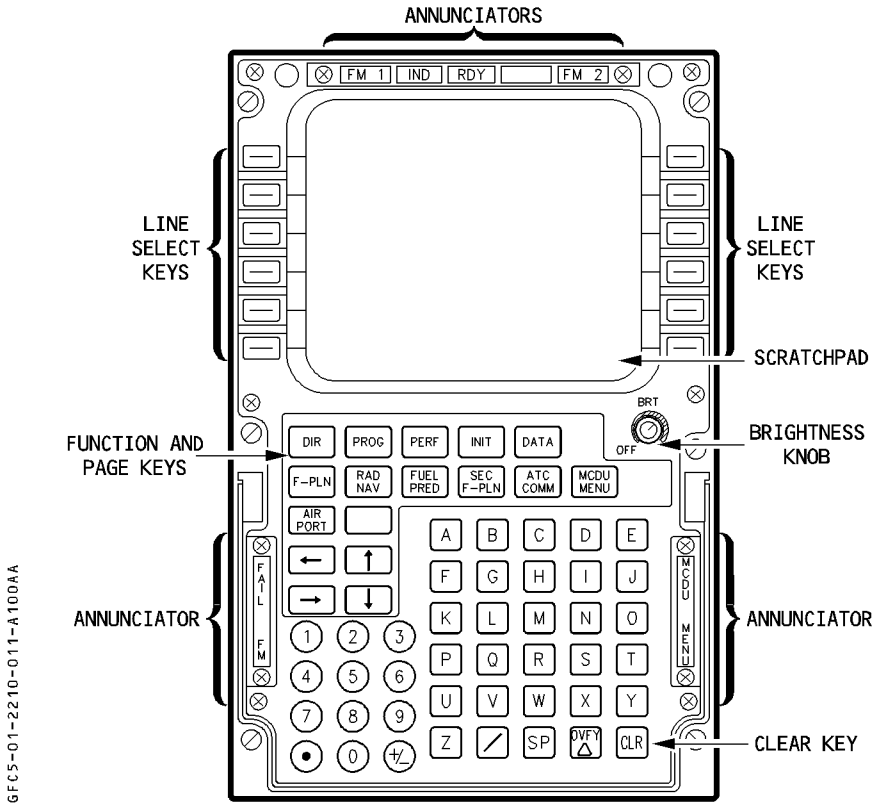
Note : MCDU 3 is not able to operate as back up navigation even when it replaces MCDU 1 or 2.
The back up navigation mode is only accessible on the MCDU MENU page if the FM source selector is set to NORM position.

PILOT INTERFACE

MULTI PURPOSE CONTROL DISPLAY UNIT (MCDU)



GENERAL

The MCDU is a cathode ray tube that generates 14 lines of 24 characters each :

- a title line that gives the name of the current page in large letters,
- six label lines, each of which names the data displayed just below it (on the data field line),
- six data field lines that display computed data or data inserted by the pilot
- The scratchpad line which displays :
  - · specific messages
  - · information the pilot has entered by means of the number and letter keys and which he can then move to one of the data fields.

LINE SELECT KEYS

There is a column of keys on each side of the screen. The pilot uses these to:
- Move a parameter he has entered in the scratchpad to the appropriate line on the main screen.
- Call up a specific function page indicated by a prompt displayed on the adjacent line.
- Call up lateral or vertical revision pages from the flight plan page.

KEYBOARD

The keyboard includes :
- Function and
  - Page keys — Call up functions and pages the pilot uses for flight management functions and computations.
  - ↑ ↓ (or SLEW) keys — Move a page up or down to display portions that are off the screen.
  - ← → key — Moves to the next page of a multi-page element. An arrow in the top right corner indicates that another page is available.
  - AIRPORT key — Calls up the flight plan page that contains the next airport along the current flight plan. Successive pushes on the key show the alternate airport, the origin airport (before takeoff), and the next airport again.
- Number and letter keys allow the pilot to insert data in the scratchpad so that he can use a key to enter it in the main display.
- Three keys have special functions :
  - CLR (clear) key — Erases material (messages or inserted data) from the scratchpad or from certain areas of displayed pages.
  - OVFY (overfly) key — Allows the aircraft to overfly a selected waypoint.
  - SP (space) key — Allows to insert a space in specific messages.

ANNUNCIATORS (on the side of the keyboard)

- FAIL (amber) — Indicates that the Multipurpose Control and Display Unit (MCDU) has failed.
- MCDU MENU (white) — Indicates that the pilot should call up a peripheral linked to the MCDU (such as ACARS or CMS).
- R FM (white) — Comes on while the crew is using the MCDU to display peripherals.

ANNUNCIATORS (on the top of the keyboard)

FM 1 and FM 2 (amber) : the onside FM is failed

Note : – The FM failure annunciator on MCDU 3 comes on only if MCDU 3 operates as a back up of MCDU 1 or 2
– A MCDU has never both FM failure annunciators ON.

IND (amber) : The onside FM detects an independent mode of operation while both FM are healthy.

RDY (green) : MCDU has passed its power up test after its BRT knob was turned to OFF.

R

BRT KNOB

Controls the light intensity of the entire MCDU.

Note : In case of MCDU 1 or 2 failure, its brightness knob has to be switched off to allow the MCDU3 connection to the corresponding FMGC.

DATA ENTRY

The pilot enters data by typing it into the scratchpad on the MCDU. Next, pressing the line select key will load the data from the scratchpad into the desired field. An error message displays if the data are out of range or not formatted correctly. To correct data, the pilot may clear the message with the clear (CLR) key and then retype the message into the scratchpad. Pressing the CLR key when the scratchpad is empty displays "CLR". To clear data from a field, line select CLR from the scratchpad to the data field to be cleared.

MCDU ENTRY FORMAT

The pilot enters information into the MCDU at the bottom line of the scratchpad. When data has lead zeros, they may be omitted if desired. For example a three-digit wind direction of 060 may be typed as 60. The display will still show 060. To enter an altitude below 1000 feet, the lead zero must be added as 0400 for 400 feet. This differentiates the altitude from a flight level.
To enter a double data entry such a speed/altitude, the separating slash must be used. If entering only the first part of a double entry, omit the slash. To enter only the second part of a double entry, a leading slash must be used i.e./0400 feet.

MESSAGES

The scratchpad displays various messages for pilot information. Theses messages are prioritized by importance to the pilot as either amber or white.
Amber messages are :
- Navigation messages
- Data entry message
- EFIS repeat messages

Amber messages are categorized into two types :
- Type 1 message that is a direct result of a pilot action. Type 1 messages are displayed immediately in the scratchpad ahead of other messages.
- Type 2 messages inform the pilot of a given situation or request a specific action. Stored in "last in", "first out" message queue that holds maximum of 5 messages.
  Type 2 messages are displayed in the scratchpad only if there are no Type 1 messages or other data and will remain until all the messages have been viewed and cleared with the CLR key.

White messages are advisory only.

CHARACTERS

Small and large fonts are displayed according to the following rules:
- The title line and the scratchpad are displayed in large font.
- Datafields are usually displayed in large font.
- Label lines are displayed in small font.
- Pilot entries and modifiable data are displayed in large font.
- Defaulted / computed and non modifiable data are displayed in small font.

COLORS

DATA	MCDU COLOR
TITLES, COMMENTS <, >, ↑ ↓ ← → DASHES, MINOR MESSAGES	WHITE
MODIFIABLE DATA SELECTABLE DATA BRACKETS	BLUE
NON MODIFIABLE DATA ACTIVE DATA	GREEN
– MANDATORY DATA (BOXES) – PILOT ACTION REQUIRED – IMPORTANT MESSAGES – MISSED CONSTRAINT	AMBER
CONSTRAINTS MAX ALTITUDE	MAGENTA
PRIMARY F-PLN	GREEN WAYPOINTS, WHITE LEGS
TEMPORARY F-PLN	YELLOW WAYPOINTS, WHITE LEGS
SECONDARY F-PLN	WHITE WAYPOINTS AND LEGS
MISSED APPROACH (not active)	BLUE WAYPOINTS, WHITE LEGS
ALTERNATE F-PLN (not active)	BLUE WAYPOINTS, WHITE LEGS
OFFSET	GREEN WAYPOINTS, WHITE LEGS OFST IN THE TITLE OF F-PLN PAGE
TUNED NAVAID TO WAYPOINT AND DESTINATION	BLUE WHITE

SCREEN PROMPTS

→ : UPPER RIGHT CORNER OF THE SCREEN INDICATES THAT NEXT PAGE IS AVAILABLE BY DEPRESSING THE → KEY.

□□□ : DATA ENTRY IS MANDATORY TO ALLOW THE FMGC TO PERFORM ALL ITS FUNCTIONS.

↑↓ : WHEN THESE ARROWS ARE BESIDE A LABEL LINE, IT IS POSSIBLE TO INCREASE OR DECREASE THE VALUE DISPLAYED BELOW BY PRESSING ⍐ OR ⍗ KEYS ON THE KEYBOARD.

LABEL LINE

DATALINE OR DATA FIELD

--- : THIS DATA WILL BE COMPUTED BY THE FMGC IF IT HAS ENOUGH INFORMATION, PROVIDED OUT OF THE DATA BASE, OR INSERTED BY THE CREW.

← → A TURN (LEFT ← OR RIGHT →) IS SPECIFIED ON THE LEG WHICH STARTS AT THE WAYPOINT ADJACENT TO THE ARROW.

✱ : INDICATES THAT A CONSTRAINT HAS BEEN INSERTED. DISPLAYED ONLY IF PREDICTIONS AVAILABLE.

D : DISPLAYED BESIDE A FIXED WAYPOINT ON THE F-PLN PAGE TO INDICATE THAT THE A/C MUST OVERFLY THE FIXED WAYPOINT

✱ : INDICATES THAT PRESSING THE ADJACENT LS KEY WILL CHANGE PARAMETERS AFFECTING THE ACTIVE SITUATION.

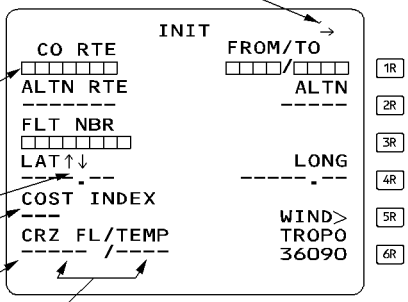
← → : INDICATES THAT PRESSING THE ADJACENT LS KEY WILL CHANGE THE PARAMETERS RELATED TO THE ACTIVE SITUATION.

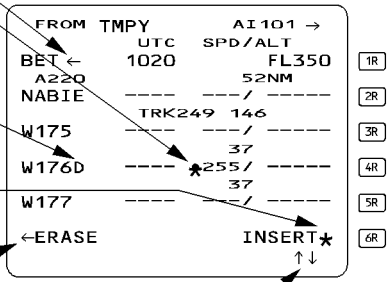
↑↓ : SCROLLING IS AVAILABLE BY PRESSING ⍐ OR ⍗ KEY ON THE KEYBOARD. THE PAGE IS NOT LARGE ENOUGH TO DISPLAY THE WHOLE INFORMATION.

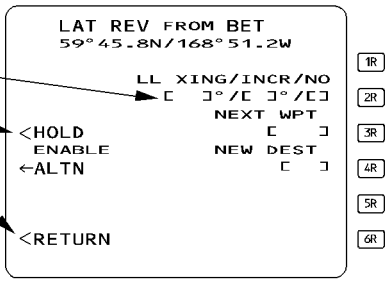
[ ] : A DATA INSERTION IS POSSIBLE.

<OR> : MEANS THAT ANOTHER PAGE MAY BE ACCESSED BY PRESSING THE ADJACENT LS KEY.

+,-:WHEN AN ALTITUDE CONSTRAINT HAS BEEN ENTERED AT A WAYPOINT, THE CONSTRAINT VALUE IS DISPLAYED ON THE VERT REV PAGE.
A PLUS (+) IS DISPLAYED FOR AN OR ABOVE ALTITUDE CONSTRAINT AND A MINUS (-) FOR AN AT OR BELOW ALTITUDE CONSTRAINT.







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MCDU FUNCTION KEYS

The function keys on the Multipurpose Control and Display Units allow the pilot to call up MCDU pages quickly.
The following is a summary of the purpose of each key. (Volume 4, FMGS Pilot's Guide provides a full description of the pages).

DIR — Calls up the DIR TO page, and allows the pilot to proceed directly from present position to any waypoint entered manually or selected in the active flight plan.

PROG — Calls up the progress page corresponding to the phase of the active flight plan that is in progress.
This page displays navigation information and active data such as the optimum and maximum recommended cruise flight levels. It allows the pilot to update the FMGS position and to get a bearing and distance to any location.

PERF — Calls up the performance pages, which display the optimum speed or Mach number for each phase. The pilot can amend these pages. The first page to be displayed is the one corresponding to the current flight phase (except for preflight and done phases).
The pilot can then use the appropriate 6L or 6R key to call up pages corresponding to future flight phases.

INIT — Calls up the flight plan initialization A page, which also gives the pilot access to the B page. The pilot uses the INIT pages to initialize Flight Management for the flight.
The pilot uses the INIT A page primarily to insert his flight plan and to align the inertial reference system.
The pilot uses the INIT B page to insert aircraft weight, fuel on board, CG and various fuel requirements. The FMGS uses this data to compute predictions and fuel planning parameters.
The pilot has access to the INIT A page only in the preflight phase.
INIT B page (not accessible after engine start) is called up by pressing the "NEXT PAGE" key.

DATA Calls up the data index page. This gives the pilot access to various reference pages that show aircraft position, aircraft status, runways, waypoints, navaids, routes and data stored by the pilot.

F-PLN Calls up the flight plan A and B pages, which contain a leg-by-leg description of the active primary flight plan.
The pilot can use the slewing keys to review the entire active flight plan. He can make all lateral and vertical revisions to the flight plan through these pages, using the left keys for lateral revision and the right keys for vertical revision.

RAD NAV Calls up the RADIO NAV page. This page displays the radio navaids tuned automatically or manually through the FMGC.

FUEL PRED Calls up the fuel prediction page. Once the engines are started, this page displays the fuel predicted to be remaining at the destination and the alternate, as well as fuel management data.

SEC F-PLN Calls up the index page for the secondary flight plan.The pilot can use this page to call up the secondary flight plan and all the functions related to it (copying, deleting, reviewing, activating, and the INIT and PERF pages).

ATC COMM Calls up the ATC applications (not activated)

MCDU MENU Calls up the MCDU MENU page, which displays the subsystems currently addressed via the MCDU. The key next to the name of a subsystem enables the crew to select that subsystem.
When the MCDU MENU annunciator lights up, the pilot should press the MCDU MENU key. The menu will have [REQ] displayed next to the name of the subsystem that requires attention.

AIRPORT Calls up the flight plan page which includes the next airport along the current flight plan. The first push on AIRPORT key displays the destination. Successive pushes show the alternate, the origine, and the destination again.

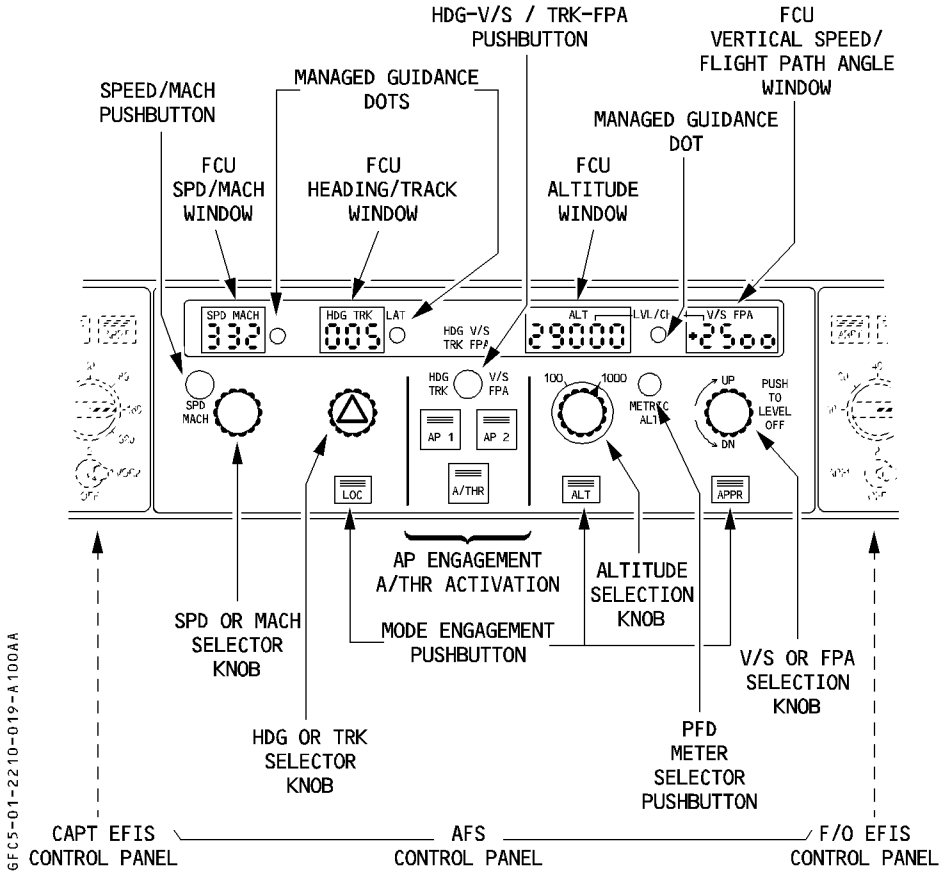
MCDU PAGES

(Refer to FCOM 4.30.20).

FLIGHT CONTROL UNIT (FCU)

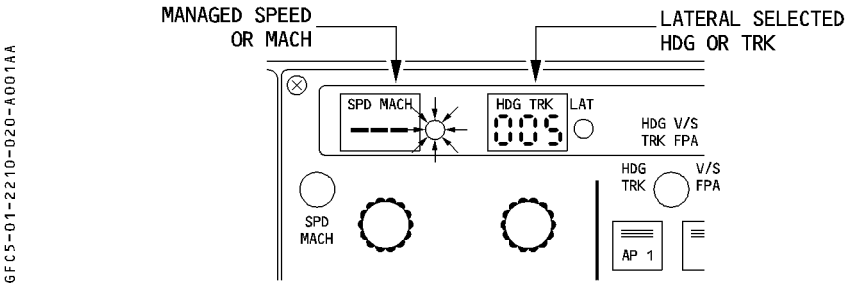
The FCU, which is on the glareshield, actually consists of three control panels : One for the automatic flight controls, and two for the Electronic Flight Instrument System (EFIS).
For a description of the EFIS control panel, see Chapter 1.31.
The FCU has two channels, each of which can independently command the central panel. If one channel fails, the other channel can control all the functions.

R



FCU PHILOSOPHY

The pilot can use two types of guidance to control the aircraft in auto flight. One type is managed by the Flight Management Guidance System (FMGS) ; the other uses target quantities which are manually entered by the pilot.
When the aircraft uses target quantities from the FMGS (managed guidance), the FCU windows display dashes and the white dots next to those windows light up.
When the aircraft is uses target quantities entered by the pilot (selected guidance), the windows display the selected numbers and the white dots do not light up.



Note : The altitude window always displays an altitude selected by the pilot (never dashes).

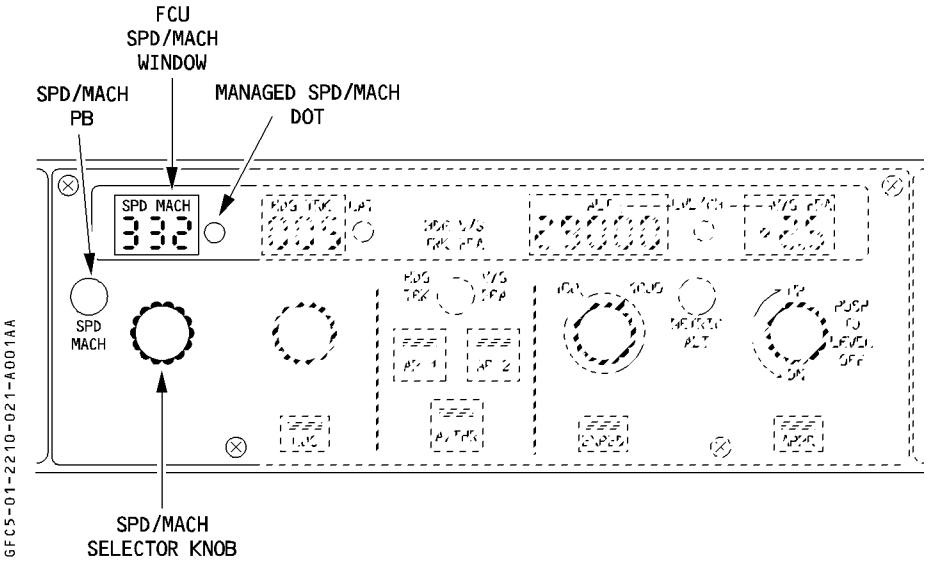
The FCU has four selector knobs :
– SPD-MACH
– HDG-TRK
– ALT
– V/S-FPA

The selector knobs and can be rotated, pushed in, and pulled out.

- In order to arm or engage managed guidance for a given mode, the pilot pushes in the associated selector knob. If, for example, he pushes in the HDG selector knob, he engages
R or arms the NAV mode.
- In order to engage a selected guidance mode, the pilot turns the selector knob to set the desired value, then pulls the knob out to engage the mode with its target value equal to the selected value.

R *Note : In managed guidance (lateral, vertical guidance or managed speed), the*
R *corresponding windown is dashed. Turning a selector knob without pulling it*
R *displays a value that is the sum of the current target and the turn action value. The*
R *display remain 45 seconds before the dashes reappear. This rule does not apply to*
R *the ALT selector knob/window.*

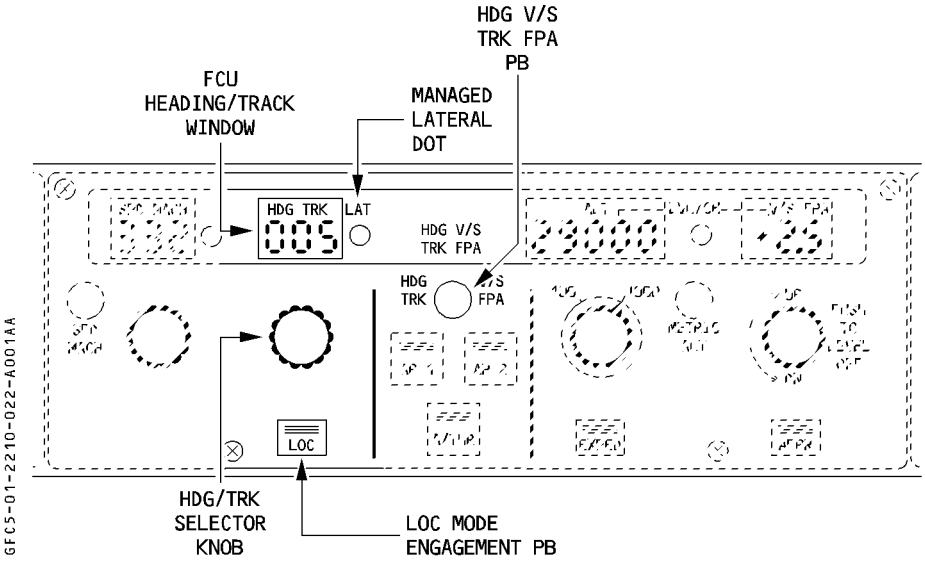
SPEED/MACH CONTROL AREA



- **SPD/MACH selector knob**
  Display range : between 100 and 399 knots for speed, between 0.10 and 0.99 for Mach number.
  One rotation of the knob corresponds to approximately 30 knots or 0.3 Mach.

- **SPD/MACH pushbutton**
  Pushing this pushbutton changes the SPD target to the corresponding MACH target and vice versa.

LATERAL CONTROL AREA



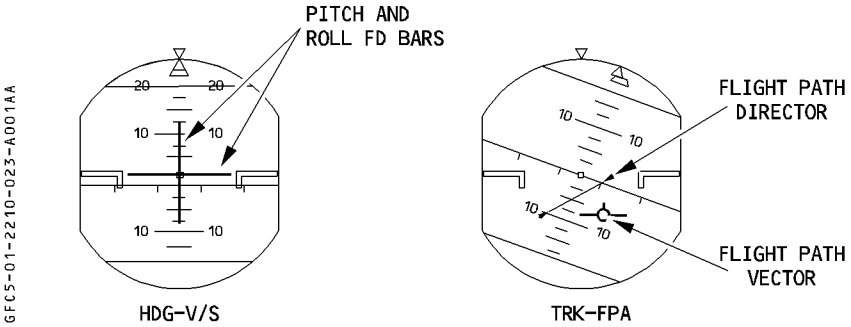
- **HDG/TRK selector knob**
  Display range : between 0° and 359°.
  One rotation of the knob corresponds to 30° (1° per click).

- **LOC pushbutton**
  Pushing this pushbutton arms, engages, or disengages the LOC mode.

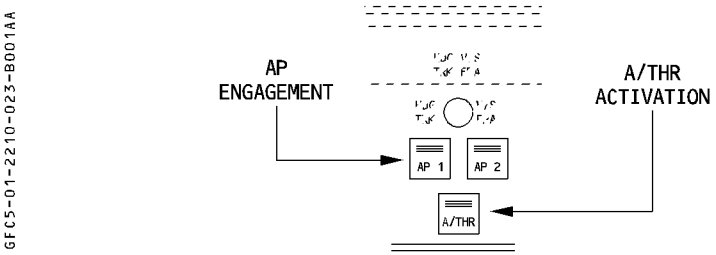
· **HDG V / S - TRK FPA pushbutton**

The pilot uses this pushbutton to select HDG (associated with V/S) or TRK (associated with FPA). Pushing it :

– Displays the Flight Path Vector (FPV) on the Primary Flight Display (PFD) or deletes it.
– Changes heading reference into track reference in the HDG/TRK window and vice versa.
– Changes vertical speed reference target into flight path angle reference target in the V/S-FPA window and vice versa.



AP-A/THR CONTROL AREA



· **AP1 AP2 pushbuttons**

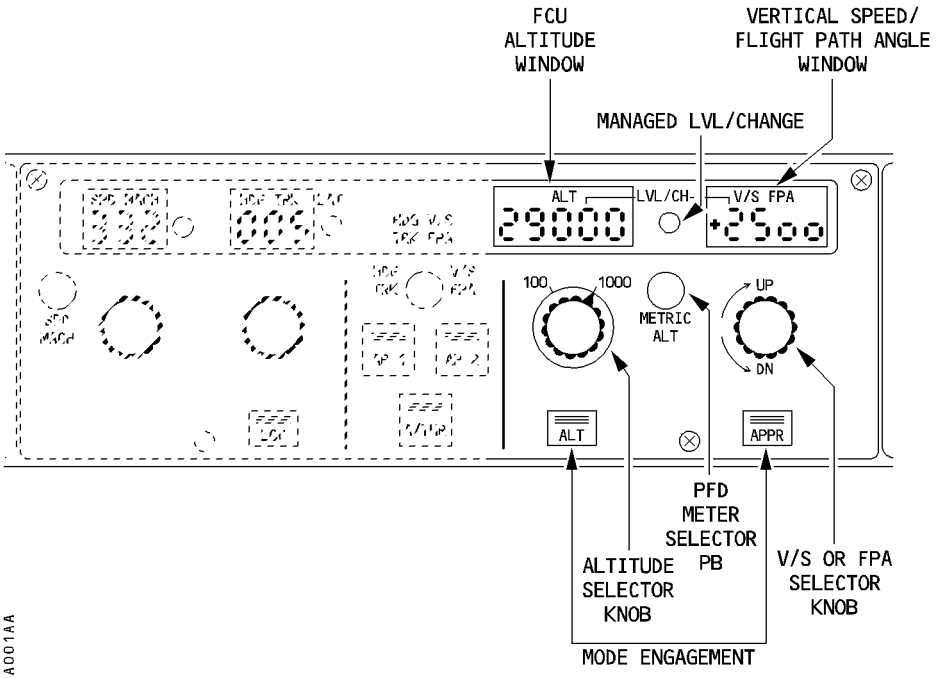
The pilot uses these pushbuttons to engage or disengage the autopilots. The buttons illuminate green when the autopilot is engaged.

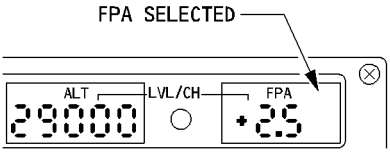
· **A/THR pushbutton**

The pilot uses this pushbutton to arm, activate, or disconnect the autothrust (A/THR). This button illuminates green if the A/THR is armed or active.

VERTICAL CONTROL AREA

R





GFC5-01-2210-024-A001AA

VERTICAL CONTROL AREA (Cont'd)

The FCU altitude window always displays a target value selected by the pilot. It never displays dashes.

· **Altitude selector knob (inner and outer)**
Display range : 100 to 49000 feet
– The outer knob has two positions : 100 and 1000.
– The inner knob sets the altitude in the FCU windows in increments of 100 or 1000 feet, depending upon the position of the outer knob.

· **ALT puhsbutton**
The pilot uses this pushbutton to command an immediate level-off.

· **METRIC ALT pushbutton**
R The pilot uses this pushbutton to display the target altitude (either the FCU-selected
R altitude or the FM altitude constraint), and the current altitude in meters on the PFD.

· **V/S or FPA selector knob**
Range (V/S) : – 6000 to + 6000 feet/minute
2 clicks = 100 feet/minute
If the pilot turns the knob slowly, each click equals 100 feet/minute
Range (FPA) : – 9.9° to + 9.9°
1 click = 0.1°
The pilot turns this knob to set the value of vertical speed (V/S) or flight path angle (FPA) to be displayed in the V/S or FPA window. (He chooses which, V/S or FPA, is to be displayed by pushing the HDG V/S/TRK FPA pushbutton).
One rotation of the knob corresponds to 32 clicks. One complete rotation sets :
FPA = 3.2°
V/S = 1600 feet/minute
When the pilot pushes in the V/S or FPA knob, the system commands an immediate level-off by engaging the V/S, or FPA, mode with a target of zero. The Flight Mode Annunciator (FMA) then displays "V/S = 0" in green, when the V/S or FPA is nulled. If the pilot now turns the knob to enter new V/S or FPA setting, the aircraft changes flight path accordingly.

· **APPR pushbutton**
This pushbutton arms, disarms, engages, or disengages the approach modes :
LOC and G/S modes, if an ILS approach is selected in the active F-PLN.
APP NAV-FINAL modes, if a non precision approach is selected in the active F-PLN.

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GENERAL

The Flight Management part of the FMGC performs four main functions :
- Navigation
- Flight Planning (lateral and vertical)
- Prediction and optimization of performance
- Management of the displays (MCDU, ND, PFD).

NAVIGATION

Essential navigation functions are :
- Computation of position
- Evaluation of position accuracy (also see FCOM Vol 4 for a detailed description of pilot's procedure).
- Radio navigation tuning.
- Alignment of Inertial Reference System.
- Polar navigation.

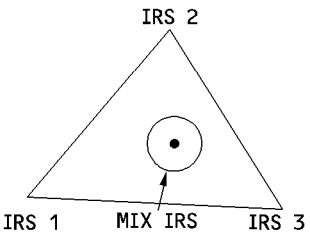
POSITION COMPUTATION

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

MIX IRS POSITION

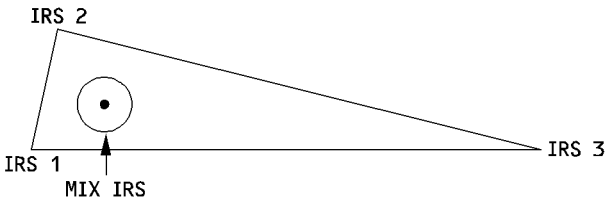
Each FMGC receives a position from each of the three IRSs, and computes a mean-weighted average called the "MIX IRS" position.

GFC5-01-2220-002-A110AA



R — If one of the IRSs drifts abnormally, the MIX IRS position uses an algorithm that
R decreases the influence of the drifting IRS within the MIX IRS position.
R

GFC5-01-2220-002-B110AA



— If one of the IRSs fails, each FMGC uses only one IRS (onside IRS or IRS3). Each IRS position and inertial speed are continuously tested. If the test fails, the corresponding IRS is rejected.

GPS POSITION

Each IRS computes an hybrid position that is a mix IRS/GPS position called GPIRS. Among these 3 GPIRS hybrid positions received by each FMGC, one is selected according to a figure of merit and a priority. The selection is performed using the following hierarchy :

- onside GPIRS position
- GPIRS 3
- opposite GPIRS position

If the GPIRS data do not comply with an integrity criteria, the GPS mode is rejected and radio position updating is used, "GPS PRIMARY LOST" message is displayed on ND and MCDU scratchpad.

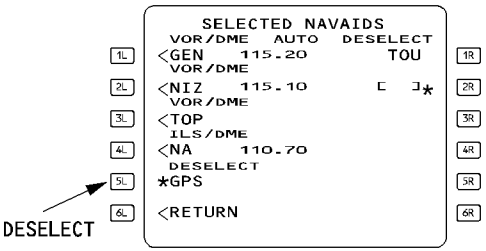
During non ILS approach, the loss of the GPS primary function triggers a triple click aural warning.

When the GPS primary function is recovered, the "GPS PRIMARY" message comes up on ND and MCDU scratchpad. It means that GPIRS data comply again with the required integrity criteria.

As long as GPS primary is in use, all usual required navigation performance are met.

The crew can deselect/select the GPS on the SELECTED NAVAIDS page if necessary.

GFC5-01-2220-003-A110AA



Information concerning the GPS position is displayed on GPS MONITOR page.

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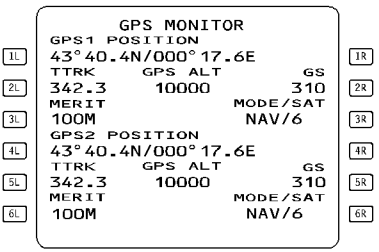
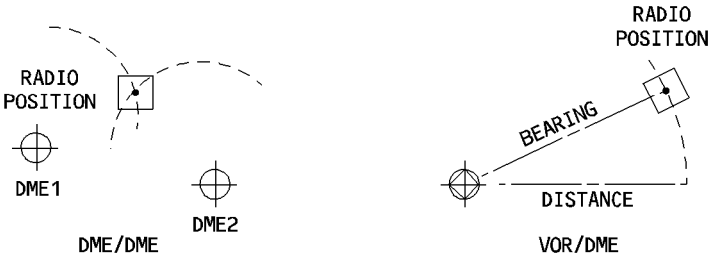


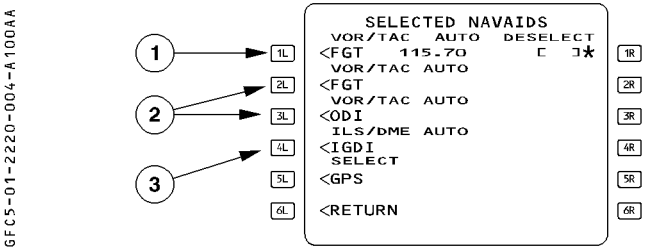
RADIO POSITION

Each FMGC uses onside navaids to compute its own radio position. These navaids are displayed on the SELECTED NAVAIDS page. The navaids it can use are :

- DME/DME
- VOR/DME
- LOC
- DME/DME-LOC
- VOR/DME-LOC

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





(1) VOR/DME selection (auto or manual) for display (onside VOR)

(2) DMEs automatic selection for DME/DME onside radio position.

(3) ILS selection auto or manual for LOC update computation.

FM POSITION

At flight initialization, each FMGC displays an FM position that is the mixed IRS/GPS position (GPIRS).

- At takeoff, the FM position is updated to the runway threshold position, as stored in the database, possibly corrected by the takeoff shift when entered on PERF TO page.
- In flight, the FM position approaches the GPS position, or the radio position if the GPS is not valid, at a rate that depends upon the aircraft altitude.

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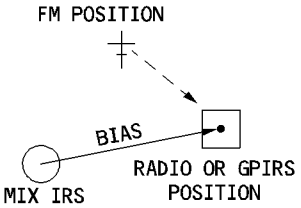


For each IRS, the FMGCs compare the FM position with the IRS position. When this difference exceeds a threshold (depending on the elapsed time since IRS alignment), the
R " CHECK IRS (1, 2 or 3)/FM POSITION" message is displayed on the MCDUs (Refer to FCOM
R 4.03.30).
R When the FWC detects an abnormal IRS drift, the ECAM triggers the FM/IR POSITION
R DISAGREE message. (Refer to 3.02.34).

Bias

Each FMGC computes a vector from its MIX IRS position to the radio or GPIRS position. This vector is called the "bias". Each FMGC continuously updates its bias, if a radio position, or a GPIRS position is available.

If an FMGC loses its radio/GPIRS position, it memorizes the bias and uses it to compute the FM position, which equals the mix IRS position plus the bias.

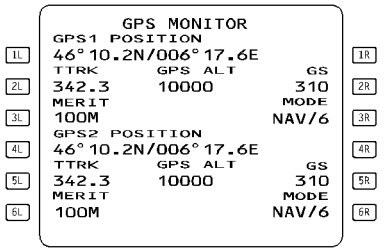
Until the radio or the GPIRS position is restored, the bias does not change.

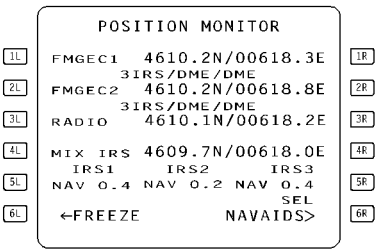
The crew can manually update the FM position. This also updates the bias.

POSITION MONITOR

The crew may check the position computation using the "GPS MONITOR" or "POSITION MONITOR" page.

R





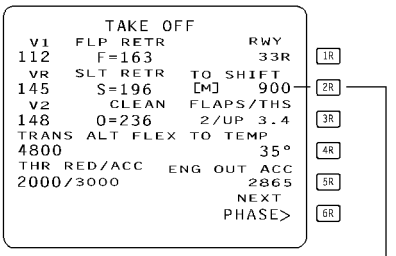
GFCS-01-2220-006-A110AA

1L	FM POSITION (ONSIDE FMGC)
2L	FM POSITION (OFFSIDE FMGC)
3L	GPIRS OR RADIO POSITION (ONSIDE FMGC) WHICHEVER IS USED FOR POSITION UPDATING
4L	MIX IRS POSITION (ONSIDE FMGC)

TAKEOFF UPDATE

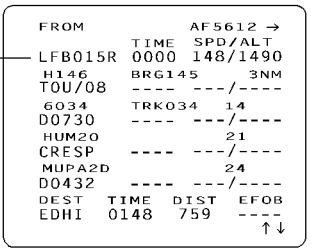
A takeoff update requires that the takeoff runway be part of the flight plan. This provides the most accurate position update.
If the takeoff run starts at an intersection, enter a takeoff shift on the PERF TO page to refine the takeoff update.
An accurate takeoff update ensures a precise aircraft position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

PERF TO PAGE



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

F-PLN A PAGE
(WITHOUT PREDICTIONS)



TAKEOFF RUNWAY IN THE FLIGHT PLAN.

GFCS-01-2220-006-B110AA

NAVIGATION MODES

The FMGS updates the FM position by using radio navaids, or GPS, if available. It can use four main, different, FM navigation modes to make this update. The decreasing order of priority is :

- IRS-GPS
- IRS-DME/DME
- IRS-VOR/DME
- IRS only

During ILS approaches, the system performs a temporary lateral update, using one of the following modes :

- IRS-GOS-LOC
- IRS-DME/DME-LOC
- IRS-VOR/DME-LOC
- IRS-LOC

EVALUATION OF POSITION ACCURACY

The FMGS continually computes an Estimated Position Error (EPE).
It is an estimate of how much the FM position has drifted, and is a function of the navigation mode the system is using.

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

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

The system displays the EPE to the flight crew, and compares it with the Required Navigation Performance (RNP).

– If the EPE does not exceed the appropriate criteria, accuracy is HIGH.

– If the EPE exceeds the appropriate criteria, accuracy is LOW.

The RNP is displayed on the PROG page. These figures are default value and can be modified by the flight crew.

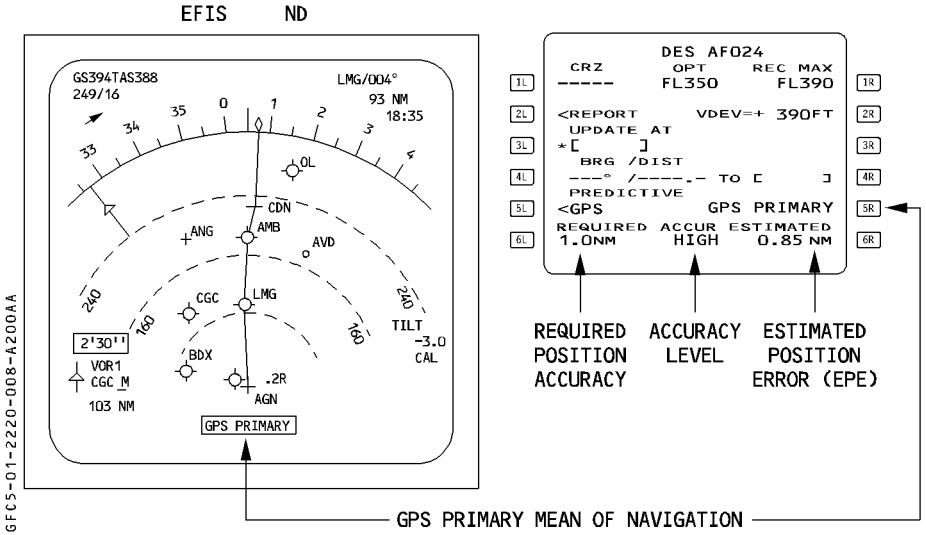
When the message "SYSTEM RNP IS XX.X" is displayed, the flight crew should check the manually-entered RNP value in the REQUIRED field of the PROG page, and clear or modify it, if necessary.

The RNP value shall be in accordance with the specified RNP values of the navigation/approach charts (if a RNP is specified).

This message is also displayed upon a flight area change, if the new required criteria (default value) is smaller than the displayed manually-entered value.

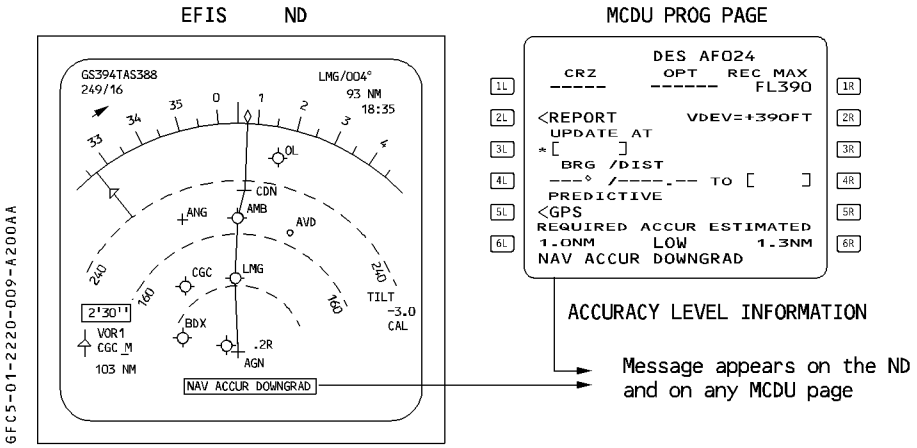
POSITION ACCURACY CRITERIA defined by airworthiness authorities	
FLIGHT AREA	REQUIRED NAVIGATION PERFORMANCE (RNP)
EN ROUTE	3.41 NM
TERMINAL	2.07 NM
APPROACH	VOR/DME 0.61 NM OTHER CASES 0.36 NM

When the position computation uses IRS/GPS mode, the EPE is always smaller than any airworthiness required value. As a result, accuracy is HIGH and GPS is the primary mean of navigation. "GPS PRIMARY" is displayed on PROG page and temporarily on ND.



When the GPS function is lost, a "GPS PRIMARY LOST" message is displayed on the ND and MCDU scratchpads. The MCDU message can be cleared ; the ND message cannot.
During a non ILS approach, a triple click aural warning is also triggered.
When the GPS is lost, NAV accuracy does not immediately downgrade ; but only when the EPE exceeds the required criteria.

R



CAUTION

"HIGH" or "LOW" indicates FM position accuracy, based upon estimated drift.
This is why the flight crew must periodically check position accuracy, when the GPS function is lost.

When the GPS is manually deselected, the "GPS IS DESELECTED" message is displayed on the MCDU, 80 NM before T/D or at approach phase transition.

FM/GPS POSITION DISAGREEMENT

The lower ECAM displays the "NAV FM/GPS POS DISAGREE" amber caution when the GPS PRIMARY function is operative, and either of the FM positions deviate from GPS position 1 or 2 by more than :
– 0.5 minutes of latitude ;
– 0.5 minutes of longitude, when the aircraft latitude is included between 0° and 45° ;
– 0.7 minutes of longitude, when the aircraft latitude is included between 45° and 60° ;
– 1 minute of longitude, when the aircraft latitude is included between 60° and 70°.
The master caution light comes on, and the single chime sounds. This amber caution is inhibited during the takeoff phase.
Above 70° of latitude, a longitude difference does not trigger the alarm.

PREDICTIVE GPS

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

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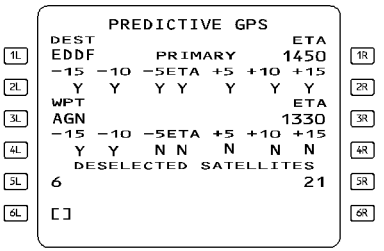


Predictions are displayed on the predictive GPS page at time intervals of 5 minutes (+15 and –15 minutes of ETA).
To access this page, press the 5L key of the PROG page.
This page also enables the deselection of up to 4 satellites at a time.

RADIO NAVIGATION TUNING

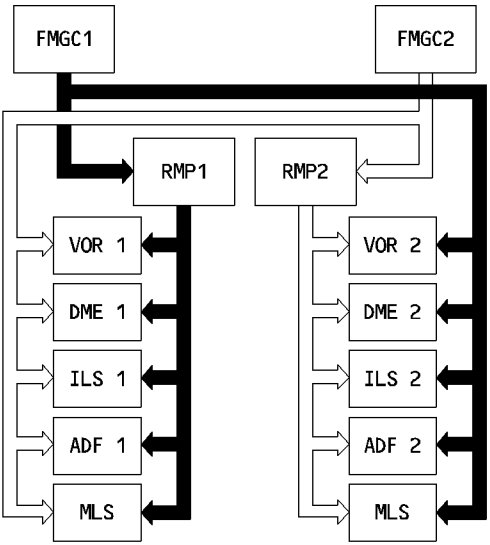
Radio navaids are tuned for two different purposes : display and computation.
Tuning for display may be performed in three different ways :

- automatic tuning (FMGC software)
- manual tuning through the MCDU RAD NAV page
- manual tuning through the Radio Management Panel (RMP) if both FMGCs or both MCDUs fail.

The FMGS automatically tunes the radio navaids for the computation of radio position.

Note : The manual selection of a VOR or VOR/DME may prevent the FMGS from tuning a VOR/DME automatically to compute position. If so, the relevant MCDU will display "TUNE BBB FFF.FF" (BBB = ident, FFF.FF = frequency).

ARCHITECTURE



GFC5-01-2220-011-A001AA

- In dual mode and independent mode each FMGC tunes the navaids on its side of the console (one VOR, 5 DMEs, one ILS/MLS, and one ADF) simultaneously. In these modes, the pilot can also tune the VOR (and associated DME), ILS, and ADF manually.
- In single mode, the valid FMGC will tune both side navaids. The pilot can also use the RAD NAV page to tune both VORs, both ADFs and the ILS manually.

Manual tuning has priority over autotuning.

Note : If one radio receiver fails, both FMGCs use the operative radio receiver to compute the aircraft position.

VOR

Each FMGC may tune one VOR only (manual or automatic).
Autotuning obeys the following priorities for tuning the VOR :
1. The navaid specified for the approach
2. The navaid to be used for computing present radio position
3. For displays purposes
   - A navaid specified for the active leg
   - The "to" waypoint (TO WPT) if it is a navaid
   - The "from" waypoint (FROM WPT) if it is a navaid
   - A waypoint farther along the flight path if it is a navaid
   - The navaid closest to the aircraft's present position

The scratchpad displays "SPECIFIC VOR-D UNAVAIL" if the VOR or VOR/DME required for tuning has been deselected.

Note : If the manual selection of a VOR does not match the VOR requested for autotuning, the relevant MCDU will display : "TUNE BBB CRS XXX"
(BBB = ident of the requested VOR) ; (XXX = course of the requested VOR)

DME

Each FMGC automatically uses its five DMEs as follows :
- One DME for display. It may be manually tuned or autotuned.
- Two DMEs in DME/DME mode for calculating the aircraft's radio position. The FMGC autotunes these as a function of their best accuracy. The flight crew receives no indication that this process is going on.
- One DME autotuned for radio position. This occurs in the VOR/DME mode whenever DME/DME is not available and the conditions for a VOR/DME update are met. In this case, the VOR/DME used for display is identical to the VOR/DME navaid used for the computation of radio position.
- One DME linked to ILS/DME.

ADF

The FMGC autotunes one ADF in any area if the TO or FROM waypoint is an NDB, or in approach when the flight plan specifies an NDB approach and a fix in the approach is the "TO" waypoint. The scratchpad displays "SPECIFIC NDB UNAVAIL" if the NDB required for autotuning has been deselected.

ILS/MLS (ILS)

Each FMGC autotunes one ILS frequency :
- In PREFLIGHT or TAKEOFF phase, when the takeoff runway has an associated ILS/MLS.
- In CLIMB-CRUISE-DESCENT, APPROACH, or GO AROUND phase, when the type of approach in the flight plan is ILS/MLS.
- When the direct distance to destination is less than 300 NM.

The scratchpad displays "RWY/ILS MISMATCH", when the pilot has manually tuned the ILS, and the entered frequency does not match the ILS or LOC IDENT/FREQ requested for autotuning.

R The crew is not allowed simultaneously to tune an ILS and a MLS.

SELECTION OF NAVAIDS ON MCDU PAGES

The MCDU displays navaids tuned by the FMGC on the following two pages :

– RADIO NAV page.

– SELECTED NAVAIDS page.

· RADIO NAV page :

Shows which navaids have been automatically or manually tuned for display purposes.

R

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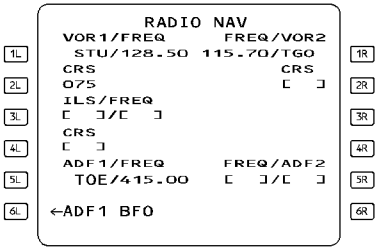

R · SELECTED NAVAIDS page :

Lists the navaids being tuned by the onside FMGC. No navaids can be modified on this page. The pilot may deselect as many as six unreliable navaids for the whole flight (using 1R key).

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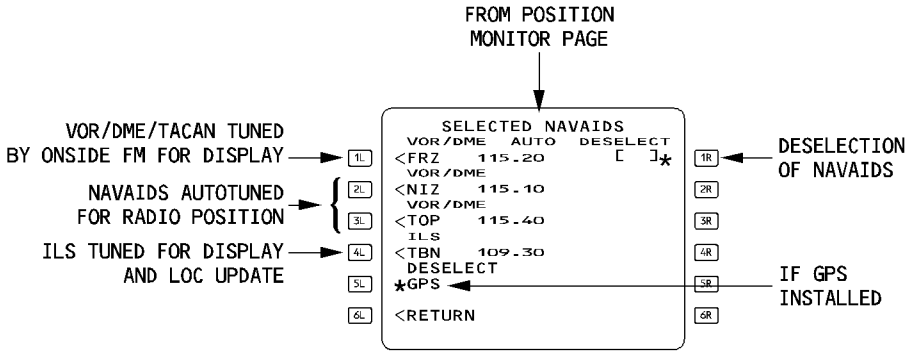
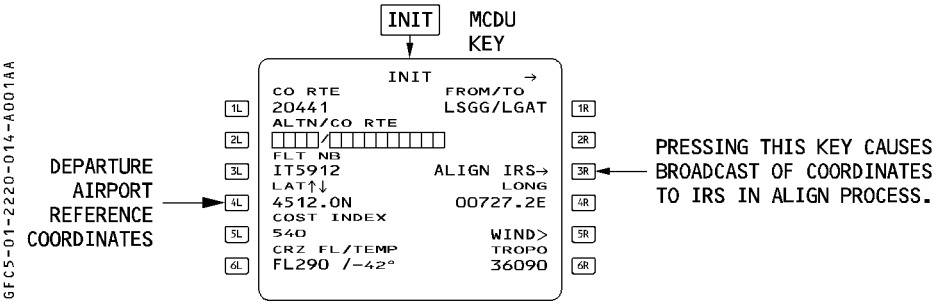


ALIGNMENT OF INERTIAL REFERENCE SYSTEM

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

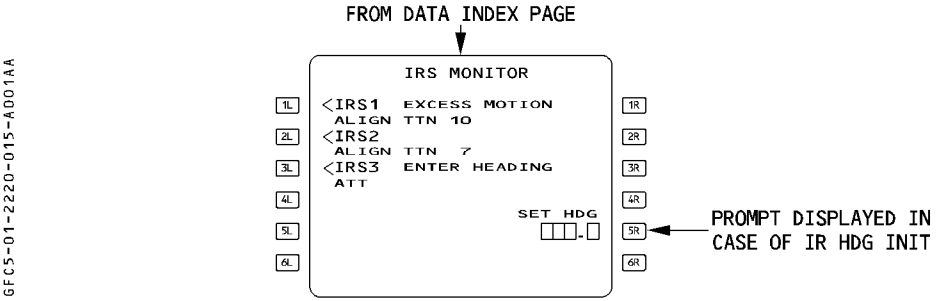


Note : If IRS IN ALIGN memo flashes, during the alignment process, it indicates one of the following :

- *It has detected excessive motion. (It automatically restarts the alignment).*
- *It has detected a mismatch between the position the MCDU has sent to the IRS and the last memorized IRS position. The pilot must enter new coordinates in the MCDU, and realign the IRS.*
- *It has detected a mismatch between the latitude the MCDU has sent to the IRS and the latitude the IRS has computed during the alignment.*

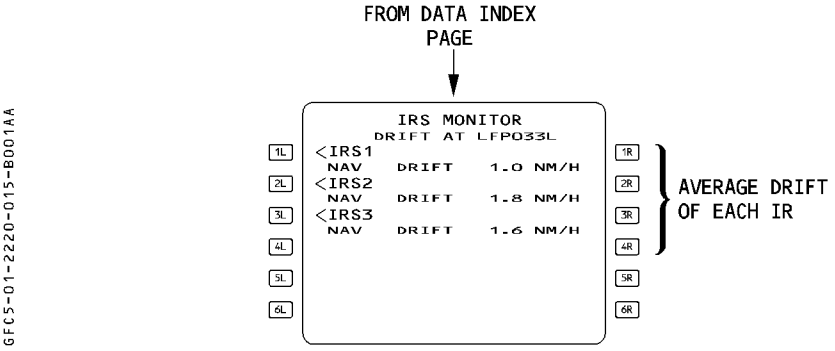
IR IN ATT MODE : HDG SET

When one IRS at least is in ATT mode, the pilot must set and periodically update the heading to have an attitude information. The entry is performed on the MCDU IRS MONITOR page.



AVERAGE DRIFT COMPUTATION

The FMGC computes an average drift on the ground at the end of the flight for each IR. This drift is then displayed on the IRS page.
The drift is the difference between the IR position at landing and the geographic landing position (destination runway threshold plus a shift of 400 m).



The FMGC then computes the time since last alignement.

POLAR NAVIGATION

R IRS are able to provide MAG HEADING between latitudes 82°30N and 60°30S, except in the vicinity of the north magnetic pole.
The FMGC computes the aircraft position within the polar area, even at the North Pole, using the MIX IRS position.

R *Note : The IRS may be aligned up to latitude 73N, without any particular procedures.*
R *Beyond 82° North, between 73N and 82 N (North or South), the required alignment*
R *time is greater and a specific procedure has to be performed. Beyond 82° North or*
R *South, no ADIRS alignment is possible.*

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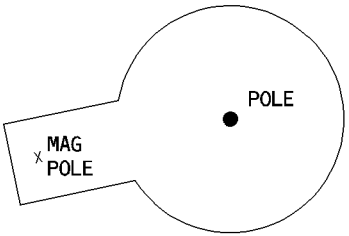


As a general rule, the MCDU displays all parameters referenced to north, according to the NORTH REF pushbutton position.
In order to provide most SAFE and FLEXIBLE operation, a MAG/TRUE NORTH REF pushbutton is available, with various messages provided on the EFIS ND/MCDU and ECAM, indicating what reference should be applicable in the flight area within which the aircraft is flying.

FLIGHT PLANNING

For flight planning, the pilot inserts the following into the FMGS via the MCDU :
- the intended lateral trajectory (lateral flight plan)
- the intended vertical trajectory, which is a speed and altitude profile (vertical flight plan)

The system must have this information in order to compute performance and guidance commands.

GENERAL

The FMGS can contain two different flight plans :
- the ACTIVE flight plan, which is the basis for :
  - · lateral and vertical guidance
  - · MCDU and ND display
  - · radio navigation autotuning
  - · performance predictions
  - · fuel planning
- the SECONDARY flight plan which the pilot may use :
  - · to prepare and store a second departure procedure before takeoff
  - · to plan a diversion
  - · to prepare the next flight leg
  - · to compare predictions or evaluations

Each flight plan is composed of the same elements :
- the primary flight plan, from origin to destination and missed approach
- the alternate flight plan, from destination to alternate destination

The pilot enters the flight plan in either of two ways :
- automatically by selecting a company route. Such a selection will call all the elements of the route out of the database.
- manually by selecting an ORIGIN/DEST pair, and then selecting all successive waypoints, procedures, and vertical constraints on the MCDU.

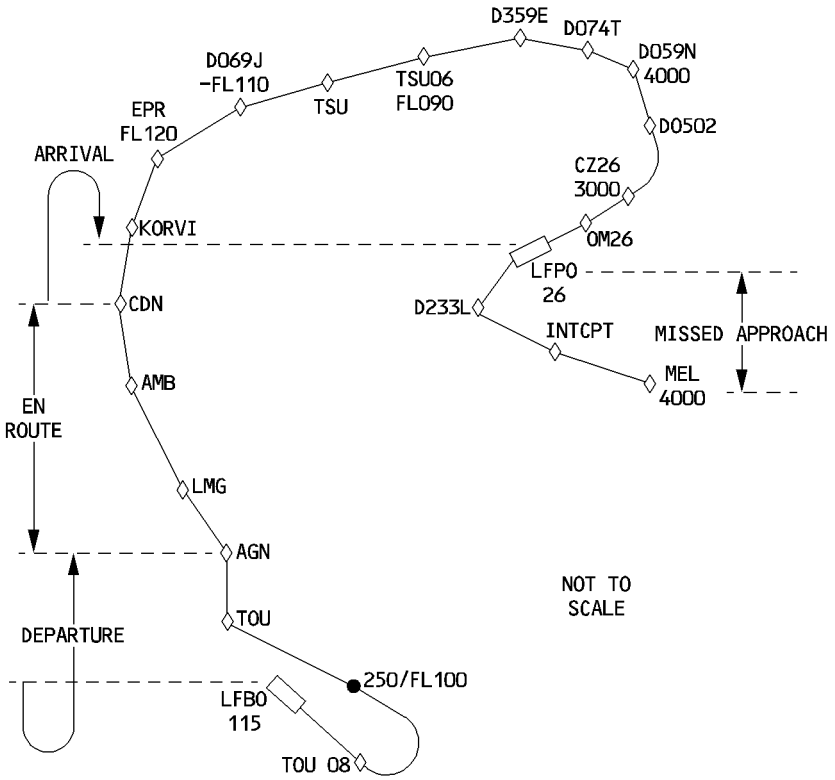
The pilot may then modify the flight plan on the ground or in flight, by making lateral and vertical revisions.

LATERAL FLIGHT PLAN

The lateral flight plan includes the following elements :

- Departure
  - Takeoff runway
  - SID
  - En route transition
- En route
  - En route waypoints and airways
- Arrival
  - En route transition
  - STARs/VIAs
  - Landing runway with selected approach
  - Missed approach
- Alternate flight plan

These elements are defined by waypoints and legs between the waypoints.



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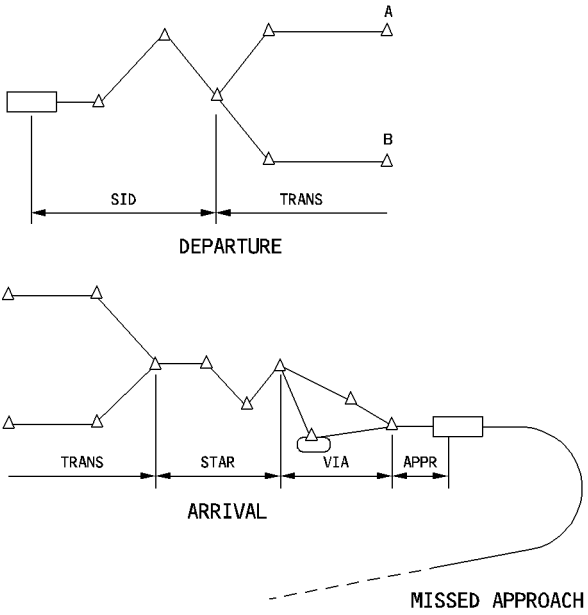
The FMGC strings the legs in sequence automatically.
The flight plan has a discontinuity if any two waypoints do not have a leg defined between them.
The computer assumes that the aircraft will fly a direct leg between the two waypoints that define the discontinuity.

Note : *When the aircraft enters a flight plan discontinuity, the NAV mode automatically switches to the HDG (TRK) mode.*

The FMGS automatically strings additional types of legs when departure or arrival procedures (SID-STAR-TRANS) are defined. Some of these legs are specific legs, such as:
- DME arc leg
- holding pattern to a fix or reverse turn
- course-to-fix leg
- heading leg
- MANUAL leg

The pilot cannot create these types of legs : they are part of the stored departure/arrival procedures he has selected.
The pilot can create only direct legs between manually defined geographic points (navaids, airports, waypoints).

Note : *The departure and arrival procedures are defined in the database to minimize the amount of memory required. They are divided as follows :*
DEPARTURE = SID + EN ROUTE TRANSITION
ARRIVAL = APPR VIA + STAR + EN ROUTE TRANSITION
The SID is the central common part of the departure procedure, as the STAR is of the arrival procedure. En route transitions (TRANS) are the various possible trajectories defined between the last point of the SID and the first en route waypoints and between the last en route waypoint and the first fix of the STAR. "APPR VIAs" are the possible trajectories defined between the last point of the STAR and the first point of the approach.



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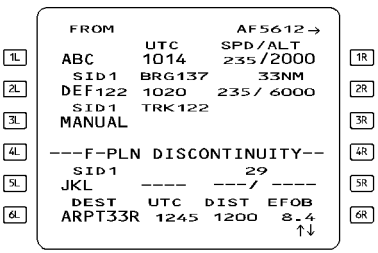
R MANUAL LEGS

R A MANUAL leg stays on a constant course, TRK or HDG and has no termination point. You
R cannot insert it into a flight plan manually (except using the DIRTO RADIAL OUT function,
R refer to 4.03.20) : it is part of a given procedure such as a SID or a STAR. When the aircraft
R is flying a MANUAL leg, the NAV mode remains engaged and predictions assume that the
R aircraft will fly a direct leg from its present position to the next waypoint (DIR TO). When
R the aircraft is cleared to fly to the next waypoint of the flight plan, the pilot performs a DIR
R TO.

R *Note : — In NAV mode a MANUAL leg is sequenced only by performing a DIR TO.*
R *— The use of the descent mode (DES) on a MANUAL leg is not recommended.*
R



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LATERAL REVISIONS

There are two types of lateral revisions :

— lateral revisions that have an immediate effect on the active flight plan
  · The pilot inserts, deletes, or changes an individual waypoint on the flight plan page.
  · The pilot creates a direct leg (DIR TO) from his present position to a selected waypoint.
— lateral revisions that lead to a temporary flight plan (TMPY) before they take effect. For these, you can select, delete, or modify waypoints that belong to an airway or to a procedure (SID, STAR, HOLD, TAKEOFF or LANDING RWY). This modification is made on specific "LAT REV" pages from the flight plan page.

Possible revisions are :

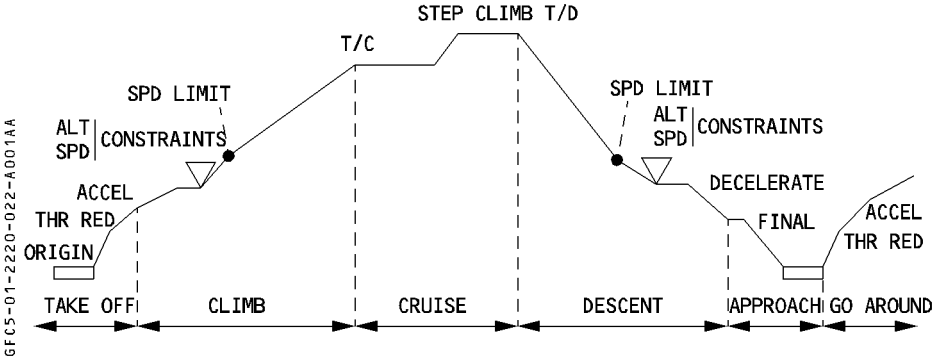
· Insert or modify departure procedure.
· Insert or modify arrival procedure.
· Insert a waypoint.
· Change the destination.
· Insert an airway.
· Insert an offset.
· Insert a holding pattern.
· Select or enable an alternate flight plan.
· FIX information.

R TEMPORARY FLIGHT PLAN

The purpose of the temporary flight plan is to allow the pilot to check a revision on the MCDU and EFIS ND before he inserts the changes into the active flight plan. It is a copy of the active flight plan that has been changed according to the pilot revision. While it is displayed the aircraft will continue to follow the original active flight plan. As long as there is a temporary flight plan, the pilot cannot make revisions on the secondary flight plan. No predictions are computed or displayed on the pages of the temporary flight plan.
For details, refer to 4.04.10 (TEMPORARY F-PLN).

VERTICAL FLIGHT PLAN

The vertical flight plan is divided into the following flight phases.
Preflight - Takeoff - Climb - Cruise - Descent – Approach - Go Around - Done.
All but preflight and done are associated with speed and altitude profiles.



Each phase has an assigned profile of target speeds. For each phase the FMGS computes an optimum (ECON) speed as a function of the strategic parameters (CI, CRZ FL, ZFW, ZFWCG, block FUEL, wind and temperatures) and performance criteria.
ECON speed is the basis of the managed speed profile.
The ECON speed can be modified by presetting a speed or Mach number on the MCDU (PERF page) for the next phase, or by selecting on the FCU a speed or a Mach number for the active phase, or by inserting speed constraints or speed limits on the MCDU vertical revision (VERT REV) page.
The vertical flight plan includes vertical constraints (altitude, speed, time) that may be stored in the data base or entered manually by the crew through vertical revision pages.
The crew may also define step climbs or step descents for cruise purposes. If the crew plans to climb to a higher flight level or descend to a lower level, it can use a vertical revision at any waypoint to insert the new level.
When all the vertical data have been defined, the FMGC computes the vertical profile and the managed speed/Mach profile from takeoff to landing.
For details, refer to 4.03.20 (vertical revision pages).

PERFORMANCE

The performance function includes optimization and predictions.

OPTIMIZATION

The FMGC minimizes cost by optimizing speed. The optimization function computes the following items :

- takeoff, approach, and go-around speeds (F, S, Green Dot, VAPP)
- an optimum target speed for CLB and DES phases (ECON CLB/DES SPD)
- an optimum target Mach number for CRZ phase (CRZ MACH)
- an optimum FL, for information purposes
- an optimum descent profile from CRZ FL down to the destination airport.

These items depend on the data the pilot inserts during lateral and vertical flight planning and revision procedures.
Most are displayed on the PERF pages associated with the appropriate flight phases.

Takeoff, approach and go-around speeds

The FMGC computes takeoff speeds (F, S, Green Dot) during the preflight and takeoff phases, using the performance model in the database and the takeoff weight.
The pilot has to insert V1, VR, and V2 in the PERF TO page manually.
The FMGC uses the performance model and either the predicted landing weight or the current gross weight at transition to the approach phase to compute approach speeds (VLS, VAPP, F, S, Green Dot). On the PERF APPR page, the selected LDG CONF determines the applicable VLS and VAPP, the latter being updated by the WIND correction that the pilot enters on the same page.
The FMGC uses the performance model and gross weight to compute go-around speeds (F, S, Green Dot).

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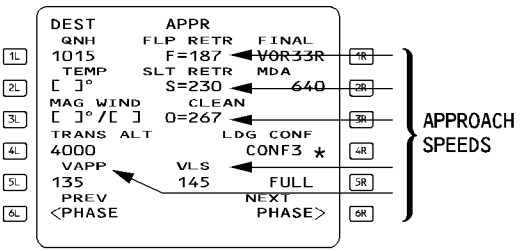


PERF APPROACH PAGE

Optimum target speed for CLB or DES phase

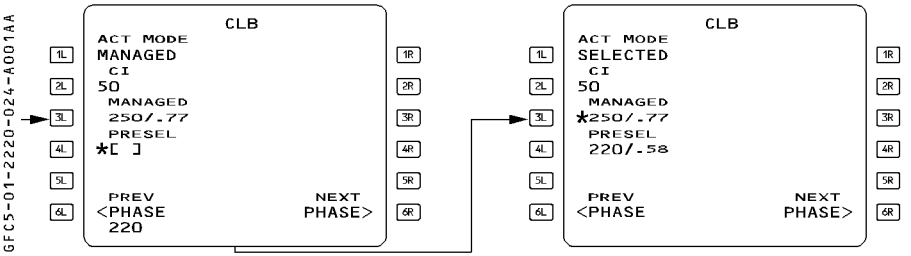
The FMGC computes optimum speeds as functions of :

- the gross weight (GW)
- the cost index (CI)
- the cruise flight level (CRZ FL)
- the wind and temperature models
- the performance factor

When there is no time or speed constraint/limit, ECON SPEED is the optimum speed for the selected cost index. It refers to fuel and time cost and not directly to fuel saving.

R FM calculates ECON CLB speed before the climb phase begins, and this speed cannot be
R changed during the climb phase itself.
R ECON DES speed is used to compute the optimum descent profile and the associated top
R of descent (T/D).

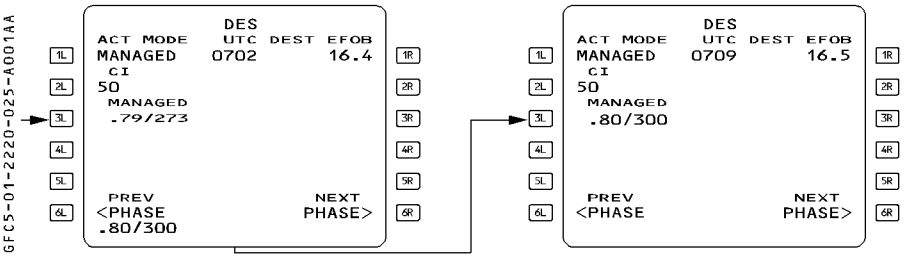
R **Preset target speed for CLB phase**
R The pilot can preselect the climb speed as long as the CLB phase is not active, by inserting
R a speed in the PRESEL field :



R The active mode field changes from MANAGED to SELECTED, and the FM will use the
R entered speed for climb predictions computation. The pilot can revert to managed mode by
R pressing the 3L key.

R **Preset target speed/Mach for DES phase**
R The pilot can change the speed and/or Mach as long as the DES phase is not active by
R inserting a speed and/or Mach in the MANAGED field.
R Although the entered speed is choosen by the pilot, the FMGS uses it to compute the
R descent profile and top of descent. It is therefore part of the managed descent profile.

R



R The pilot can revert to the optimum speed/Mach by clearing the field 3L.

Optimum target Mach number in cruise

FM computes ECON CRZ MACH as the optimum speed and updates it continually, taking into account :

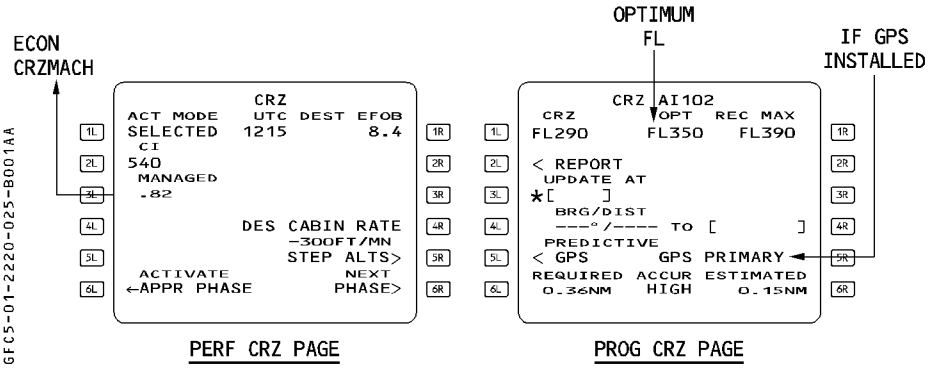
- current weather conditions
- modifications to the flight plan.

Note : Below FL 250 the FMGS calculates ECON CRZ SPD instead of ECON CRZ MACH.

Optimum flight level in cruise

The optimum flight level is the flight level at which the aircraft incurs the lowest cost for a given flight plan, cost index, and gross weight (assuming a 15 minute minimum cruise flight level at that altitude). FM updates it continuously during the cruise phase, and displays it on the PROG page. The PROG page displays dashes for this quantity :

- at least 15 NM before the top of descent
- when the system detects an engine-out condition
- when DES phase is activated.



PERF CRZ PAGE PROG CRZ PAGE

COST INDEX

CI is the ratio flight time cost (CT) to fuel cost (CF).
CI = CT/CF KG/MIN or 100 LB/H
The cost index is used to compute the best economic speed and Mach to be flown considering the ratio between the cost of the flight time and the cost of the fuel.
CI = 0 corresponds to minimum fuel consumption (max range)
CI = 999 corresponds to minimum time
For CI = LRC refer to table volume 4 section 4.05.50
It is recommended to modify the CI in flight :
- In case a fuel problem is encountered, CI = 0 may be selected ; the ECON SPD profile is then computed to ensure minimum fuel consumption.
- In case the aircraft is behind its schedule, CI = 999 may be selected. The ECON SPD profile is then computed to ensure minimum time.

Optimum step point

Only one optimum step point may be computed from the current cruise FL to a higher cruise FL. After insertion, the optimum step point is fixed and no longer updated.
The step altitude, time and fuel savings are provided before the insertion of an optimum step climb point on the STEP ALTS page.

Optimum descent profile

Refer to 4.02.30

PREDICTIONS

The FMGC computes predictions for the primary flight plan and the secondary flight plan and displays them on the Multipurpose Control and Display Units (MCDUs) and on the Navigation Display (ND) of the Electronic Flight Instrument System (EFIS). The computations use the current state of the aircraft (GW, CG, position, altitude, speed, engaged mode of the autopilot or flight director, time, wind, temperature) for the active flight plan.

PREDICTIONS FOR THE PRIMARY FLIGHT PLAN

The predictions displayed on the MCDU assume that the FMGS will guide the aircraft along the preplanned lateral and vertical flight plans. The predictions displayed on the ND assume that the aircraft will continue to operate in the modes (selected or managed) that are currently active.

As long as the aircraft is flying the flight plan under managed guidance, the predictions on the MCDU will match those on the ND.

R If the pilot does not fly the flight plan, the MCDU predictions assume that :
R – The pilot will fly back toward the flight-planned route.
R – The pilot will immediately resume flying the FMGC-managed modes.
R If the pilot does not fly the managed speed profile, the MCDU predictions assume that he
R will maintain the selected speed until he reaches :
R – In the climb or descent phase, the next speed limit or speed constraint if any, or next
R phase,
R – In cruise, the top of descent.
R Then, the predictions assume that the pilot will revert to managed speed.

UPDATE OF PREDICTIONS

The FMGCs recompute the predictions, whenever there is a modification to the :
- Lateral flight plan
- Vertical flight plan
- Forecast atmospheric conditions entered by the crew
- Cost index
- Speed control (managed/selected)

Note : During recomputation, prediction fields on the MCDU pages display dashes.

WINDS USED FOR PREDICTIONS

See VERTICAL FUNCTIONS in the FMGS Pilot's Guide (04.04.20).

EFIS ND PREDICTIONS

Refer to FLIGHT MANAGEMENT PRINCIPLES, 4.02.20.

MCDU PREDICTIONS

Refer to FLIGHT MANAGEMENT PRINCIPLES, 4.02.20.

OTHER COMPUTATIONS

Engine-out case

The FMGS computes an engine-out target speed for each flight phase.
It computes an engine-out maximum altitude (EO MAX ALT) at long-range cruise speed, and displays it on the PROG page.
The new speed target becomes green dot in climb phase or EO CRZ SPD in level flight.
The system computes the flight plan predictions down to the primary destination assuming that the cruise phase is at the lower of CRZ FL or EO MAX ALT.
For the engine out obstacle strategy the system computes a drift down altitude for level of with green dot speed.

Fuel Planning

After the F-PLN, CRZ FL, CI, ZFW, ZFWCG insertion, the FMGC may compute on crew request the minimum fuel to meet the requirements of the flight taking into account a predetermined fuel policy (Navigation Database).
Fuel predictions are automatically performed after the F-PLN, CRZ FL, ZFW insertion. The FMGC has to know the FOB either inserted by the crew (BLOCK FUEL) or computed by the system.

Equi-time point (ETP)

The ETP is a pseudo waypoint along the lateral flight plan at which the time to reach 2 reference waypoints is the same, taking distance and winds into account.

Time Marker

This pseudo waypoint may be created for display on MCDU/ND.

Recommended maximum altitude (REC MAX)

The recommended maximum altitude is the lowest of :
- maximum altitude the aircraft can reach with a 0.3 g buffet margin
- maximum altitude the aircraft can fly in level flight at MAX CRZ rating
- maximum altitude the aircraft can maintain a V/S of 300 feet/minute at MAX CLB thrust
- maximum altitude the aircraft can fly at a speed higher than Green Dot speed and lower than VMO/MMO
- maximum altitude the aircraft is certified (FL 410)

The REC MAX altitude is displayed on the PROG page.
A maximum altitude using a 0.2 g buffet margin is also computed. It is not displayed, but the system uses it to limit CRZ ALT entry.

Predictions for alternates

Predictions for alternates are displayed on the ALTERNATES page.

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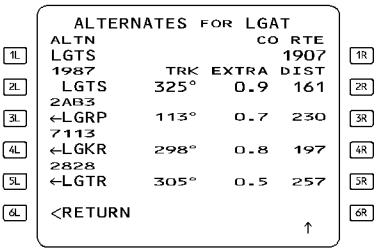


They are based on :

- A default cruise FL equal to 220 if the airway distance is less than 200 NM. otherwise FL 310.
- Simplified wind/temperature models based on crew entries :
  - ALTN CRZ wind as entered in the primary DESCENT WIND page.
  - Wind/temperature at primary destination (APPR page).

  A zero wind and/or zero ISA deviation is assumed by default if there is no crew entry.
- Initial aircraft weight equal to landing weight at primary destination.
- A track equal to mean track between active primary and alternative destination.
- A constant delta ISA and a constant cruise wind.
- Cost index = 0 (minimum fuel)

Note :
- *No step can be inserted in an alternate flight plan.*
- *No predictions are displayed for the selected alternate on flight plan pages, but the pilot can read ALTN trip fuel and time on the INIT B page before engine start, and estimated time and estimated fuel on board at alternate on the FUEL PRED page after engine start.*

Predictions for secondary flight plan

Predictions are provided on the SEC F-PLN, SEC INIT and SEC PERF pages as for the active primary flight plan.

However the predictions are provided for the SEC F-PLN on the condition that the primary and secondary flight plan have their active leg common (same TO WPT).

Predictions for fuel

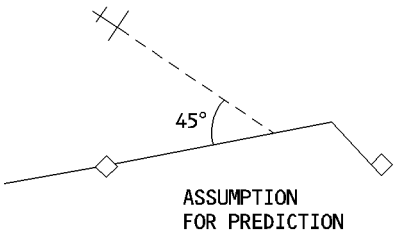
Up to eight fuel policy records may be specified in the navigation database.
If a specific data is not provided in the database fuel policy, the value is the default value given here after :

PARAMETERS		DEFAULT VALUES
RTE RSV	(percentage of route reserve)	5 %
RSV MIN	(minimum value of route reserve)	0 kg
RSV MAX	(maximum value of route reserve)	25.600 kg
RSV FLT	(reserve remains computed in flight)	yes
RSV ALTN	(reserve is computed with alternate trip fuel)	no
FINAL TIME	(time for final holding pattern)	30 min
FINAL FIX	(Fuel burnt in the final holding pattern)	0 kg
FINAL ALT	(altitude of the final holding pattern)	1 500 ft AGL
TAXI	(fuel for taxi)	600 kg
FINAL DEST	(final holding pattern is flown at ALTN)	ALTN

Furthermore RTE RSV, FINAL TIME and TAXI may be modified on the MCDU through the INIT B or FUEL PRED pages.

RETURN-TO-TRAJECTORY ASSUMPTIONS

If the aircraft is not on the lateral flight plan, the FMGC assumes (for prediction) that it will return immediately to the active lateral leg with a 45° convergence angle or that it will fly direct or the "TO" waypoint whenever the required convergence angle is greater than 45°.



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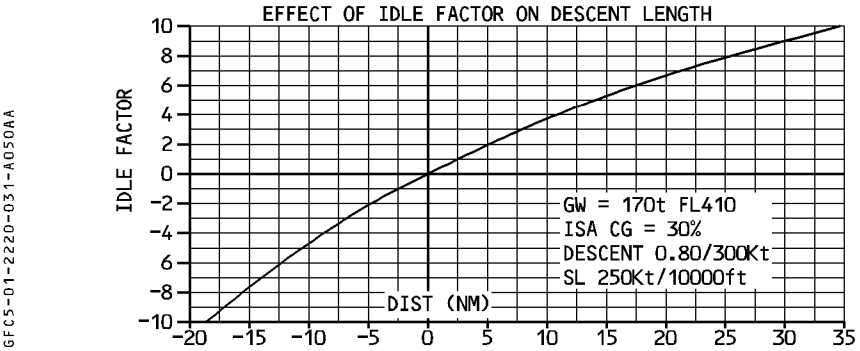
If the pilot flies outside the planned flight plan, predictions are still available, but they assume an immediate return to the flight plan.
For other computations, (Refer to FCOM 4 .02.20).

IDLE/PERF FACTORS

MCDU fuel predictions can be corrected to match the actual aircraft fuel consumption. This is done, on ground only, by modifying the IDLE/PERF factor.

IDLE FACTOR

IDLE and PERF factors use the same principle.
The PERF factor is mainly used for prediction during cruise phase, the IDLE factor is dedicated to the FM descent segment.
The aim of the IDLE factor is to adjust the FM descent predictions, in particular the position of the Top Of Descent (TOD), with the actual engine idle thrust used during descent.
A positive IDLE FACTOR gives an earlier top of descent (shallower path).
A negative IDLE FACTOR delays the top of descent (steeper path).



Example :
IDLE factor + 4 increases the computed descent of 11 NM.

PERF FACTOR

The performance factor is a positive or negative percentage that is used to correct the predicted fuel flow, used for fuel prediction computation within the FMGS. This parameter is necessary when the aircraft's performance differs from the performance model stored in the FMGS database.

This difference can be due to one or both of the following cases :

1. The FMS contains a performance database, used to compute the predictions and the performance data. Due to the numerous possible aircraft configurations, the same performance database is sometimes used for aircraft with slightly different behaviors. In these cases, a PERF factor is entered to correct the computations performed with a
R database not exactly tailored for the given configuration. As a result, the aircraft or
R engine type identification on the MCDU's A/C. STATUS page may not correspond to that
R of the actual aircraft.
2. Since the actual aircraft drag and engine performance deviate from the nominal model due to the aircraft's age, airline Flight Operations will periodically apply a correction factor to adapt fuel predictions to actual fuel consumption.

The PERF factor modifies the predicted fuel flow, according to the following formula :

FFpred = FFmodel (1 + PERF FACT/100)

FFpred is the FF used for prediction.

FFmodel is the FF from the aero-engine model.

This correction is applied throughout the flight, and modifies the performance predictions and the ECON speed or Mach. For example : Entering a PERF factor of + 1.5 means that Flight Operations have evaluated the aircraft fuel deviation as 1.5 %, compared to the basic performance model (0.0).

R **Procedure to modify the PERF factor (on ground only) :**

On the aircraft status page :

– ENTER "ARM" in the CHG CODE line's [5L] brackets.
– WRITE the new IDLE/PERF factors.
– INSERT, using the [6L] key.

A manually-entered IDLE/PERF factor is displayed in large blue fonts. Changing an IDLE/PERF factor is usually the responsibility of maintenance, or Flight Operations.

PERF Factor to be used on FMS1 at delivery, depending on the engine type :

A330–202 CF6–80E1A2 : – 1.0 %
A330–223 PW4168A : – 1.0 %
A330–243 TRENT772B-60 : – 3.0 %
A330–301 CF6–80E1A2 : 0.0 %
A330–321 PW4164 : 0.0 %
A330–322 PW4168 : 0.0 %
A330–323 PW4168A : 0.0 %
A330–341 TRENT768–60 : 0.0 %
A330–342 TRENT772–60 "Old Hardware"* : 0.0 %
A330–342 TRENT772–60 "New Hardware"* : – 2.0 %
A330–343 TRENT772B-60 : – 2.0 %

* "Old Hardware" : Before ESN 41054 ; "New Hardware" : since ESN 41054.

All these numbers assume that : The aircraft is brand-new, anti-ice is off, the air conditioning is on economic, and the conservative Fuel Lower Heating Value (FLHV) is 18400 btu/lb.

When an aircraft ages, fuel consumption degradation will be measured to determine the so-called "monitored fuel factor". This factor corresponds to the deviation of the aircraft's
R actual fuel consumption from the nominal model. Generally, the FLHV that is used during
R fuel factor monitoring is higher than the FMS value. In order not to penalize FMS
R predictions, it is necessary to correct the "monitored fuel factor". For example, add – 1%
R to the "monitored fuel factor", when an FLHV of 18590 btu/lb is used. Once this factor is established by the airline, it should be arithmetically-added to the above-noted performance factor.

MANAGEMENT OF THE DISPLAYS

The flight management system displays navigation, performance and guidance information on :

- the Mutipurpose Control and Display Unit (MCDUs)
- the Navigation Display (ND) of the Electronic Flight Instrument System (EFIS)
- the Primary Flight Display (PFD) of the EFIS.

MCDU DISPLAY

The MCDUs display :

- Position and accuracy information
- Tuned navaids
- Lateral and vertical flight plans (waypoints, pseudo waypoints, constraints)
- Predictions (SPD, TIME, ALT, WIND)
- Fuel predictions and fuel management information (estimated fuel on board, extra fuel)
- Performance data.

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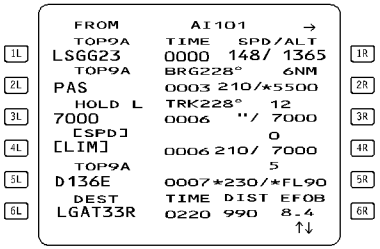
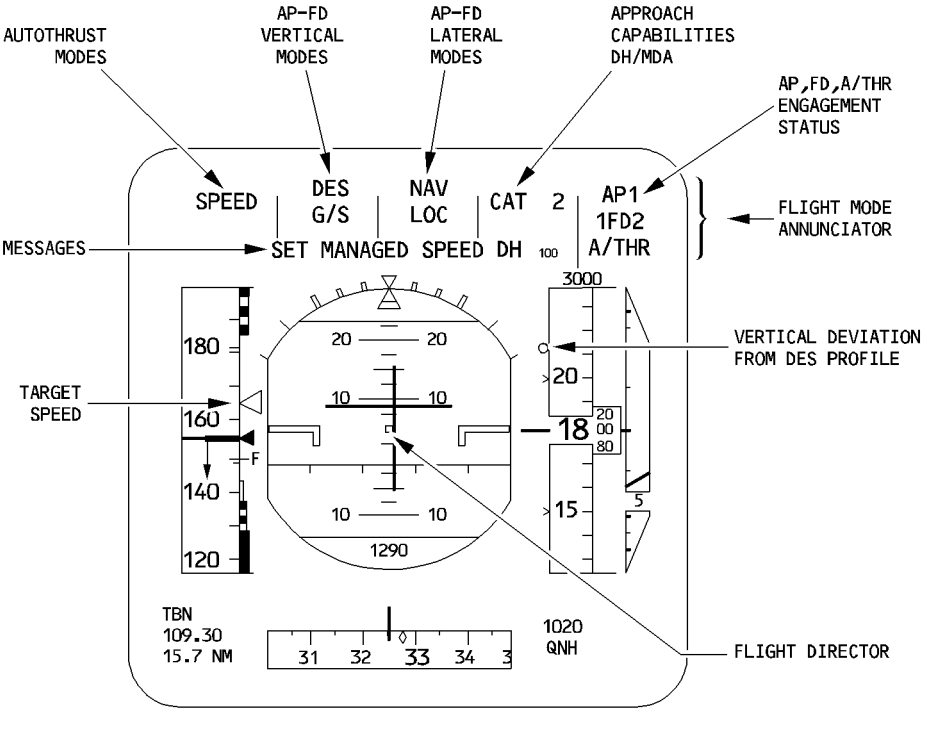


F-PLN page

EFIS PRIMARY FLIGHT DISPLAY (PFD)

Flight Management generates the following information :
- Armed and engaged modes on the Flight Mode Annunciator (FMA)
- FMGS guidance targets (SPD, ALT, HDG)
- Vertical deviation from descent profile
- Messages
- Navigation information

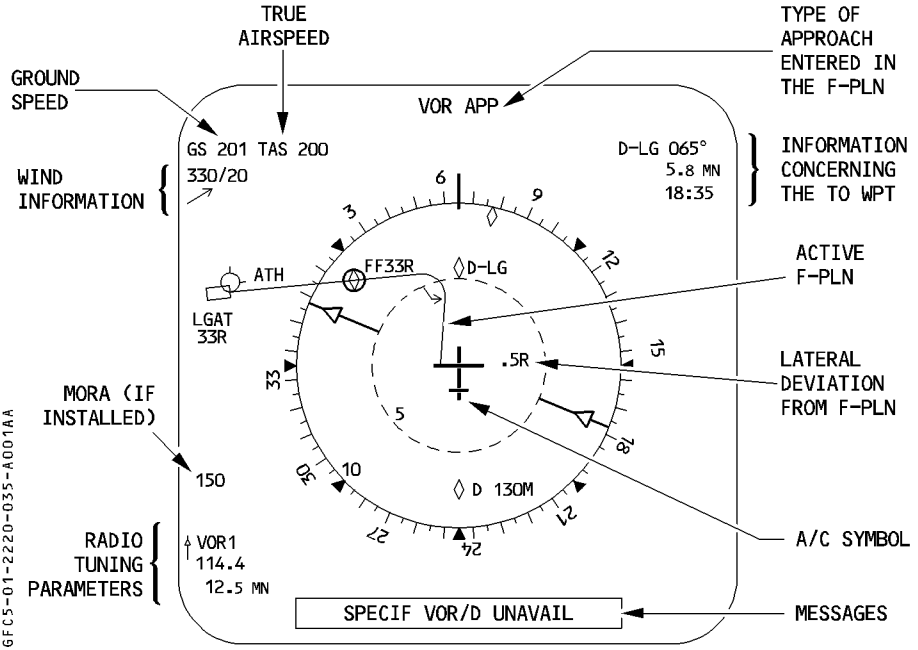


R *Note : For more details concerning EFIS PFD refer to 1-31 chapter.*

EFIS NAVIGATION DISPLAY (ND)

Flight Management (FM) generates the following information :

- aircraft position
- flight plans (active, secondary, temporary, and dashed)
- lateral deviation from primary flight plan
- pseudo waypoints along the flight plan
- raw data from tuned navaids
- wind information
- various options, depending on what the pilot selects on the EFIS control panel : waypoints, navaids, NDBs, airports, constraints
- type of approach selected
- messages



Note : For more details concerning EFIS ND refer to 1.31.45.

COLORS USED FOR DISPLAYING FLIGHT PLANS

F-PLN	Color
Primary flight plan	steady green in managed, dashed green in selected
track line	steady green
alternate flight plan	dashed blue
missed approach	steady blue
offset flight plan	steady green (original flight plan dashed green)
temporary flight plan	dashed yellow
engine-out SID	steady yellow (not inserted)
secondary flight plan	steady dimmed white
abeam / radial	dashed blue

GENERAL

The guidance function is achieved by the Flight Guidance (FG) part of the FMGS which controls :
- the Flight Director (FD)
- the Auto Pilot (AP)
- the Auto Thrust (A/THR).

GUIDANCE MODES

Two types of autopilot and flight director modes are available to guide the aircraft :
- Managed modes, which steer the aircraft along the lateral, vertical, and speed profiles according to the data the pilot inserts into the MCDU. Flight Management (in the Flight Management and Guidance Computer) computes the corresponding guidance targets.
- Selected modes, which steer the aircraft according to target values that the pilot selects and the FCU windows display.

GUIDANCE	MANAGED modes	SELECTED modes
LATERAL	NAV, APP NAV B/C*, B/C, LOC*, LOC RWY RWY TRK GA TRK ROLL OUT	HDG – TRK
VERTICAL	SRS (T.O and G.A) CLB, DES ALT*, ALT ALT CSTR*, ALT CSTR G/S*, G/S FINAL, FLARE	OP CLB, OP DES V/S, FPA ALT*, ALT
SPEED	FMGC REFERENCE (ECON, Auto SPD, SPD LIM)	FCU REFERENCE

MODE SELECTION

MANAGED MODES

- At takeoff, the managed modes engage automatically when the pilot sets the thrust levers at the TO or FLX detent.
- During flight, the pilot can arm or engage the managed modes (if the aircraft meets engagement conditions) by pushing in the appropriate knobs on the Flight Control Unit (FCU).
- The pilot pushes the "DIR TO" key on the MCDU to insert a DIR TO leg. It engages or maintains the NAV mode.
- The pilot pushes the "APPR" pushbutton on the FCU to arm or engage the localizer and glide slope or "APP NAV-FINAL", depending upon the approach type he had inserted in the flight plan.
- The "LOC" pushbutton arms or engages only the localizer mode.

SELECTED MODES

The pilot can engage the selected modes by pulling out the appropriate FCU selection knobs.

INTERACTION BETWEEN AP/FD AND A/THR MODES

The AP/FD pitch modes can control a target SPD/MACH or a vertical trajectory ; the A/THR modes can control a fixed thrust or a target SPD/MACH. AP/FD and A/THR cannot simultaneously control a target SPD/MACH. Consequently the AP/FD pitch modes and A/THR modes are integrated as follows :

- If an AP/FD pitch mode controls a vertical trajectory, the A/THR mode controls the target SPD/MACH.
- If an AP/FD pitch mode controls a target speed or Mach, the A/THR mode controls the thrust.
- If no AP/FD pitch mode is engaged, the A/THR mode reverts to SPD/MACH mode.

In other words, the selection of a pitch mode determines the associated A/THR mode.

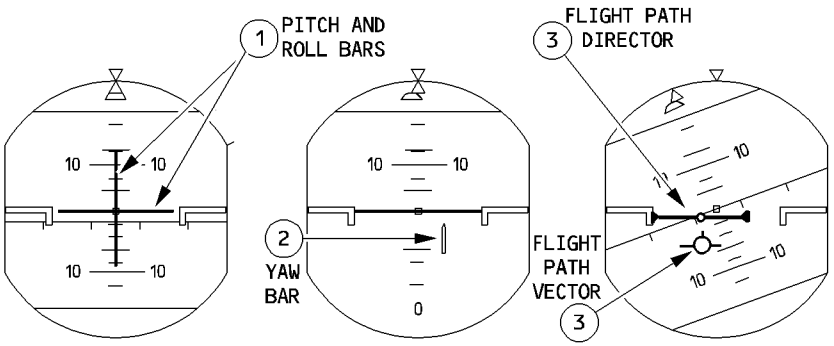
AP/FD pitch modes	**A/THR modes**
V/S – FPA DES (geometric path) ALT*, ALT, ALT CSTR*, ALT CSTR G/S*, G/S FINAL	SPD/MACH MODE
AP/FD OFF	
OPEN CLB/OPEN DES CLB/DES (idle path) SRS	THR (CLB, IDLE) MODE
FLARE	RETARD (IDLE)

FLIGHT DIRECTOR

GENERAL

The Flight Director (FD) displays guidance commands from the Flight Management and Guidance Computer (FMGC) on the Primary Flight Display (PFD).
The pilot may fly the aircraft manually, following FMGC guidance commands, or crosscheck the FMGC orders when the autopilot is engaged.
In normal operations, FD1 displays FMGC1 orders on PFD1 and FD2 displays FMGC2 orders on PFD2.
The FDs use their respective onside FMGCs.
On the PFD :

1. The FD pitch and roll crossbars show pitch and roll demands.
2. Below 30 feet during landing and takeoff, when a localizer is available, the vertical bar is replaced by a yaw bar that gives lateral orders.
3. The Flight Path Director (FPD) symbol relates to the Flight Path Vector (FPV).



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The HDG V/S – TRK FPA pushbutton on the FCU permits the pilot to select either type of reference and display.
The FD pushbutton on the Electronic Flight Instrument System (EFIS) control panel allows the FD bars to be displayed or removed.

FD bars (HDG V/S selected on the FCU)

- The pitch bar is displayed if a vertical mode is engaged. It gives pitch orders for the vertical guidance.
- The roll bar is displayed if a lateral mode is engaged. It gives roll orders for lateral guidance.

Flight Path Director (TRK FPA selected on the FCU)

The display is an alternate way of transmitting flight director commands.

- The Flight Path Vector (FPV) symbol illustrates the actual track and flight path angle being flown.
- The Flight Path Director (FPD) symbol shows the pilot how to intercept and fly the vertical and lateral flight trajectory.
  When the pilot superimposes the FPV and the FPD symbols, the aircraft flies the commanded trajectory.

FLIGHT DIRECTOR (FD) ENGAGEMENT

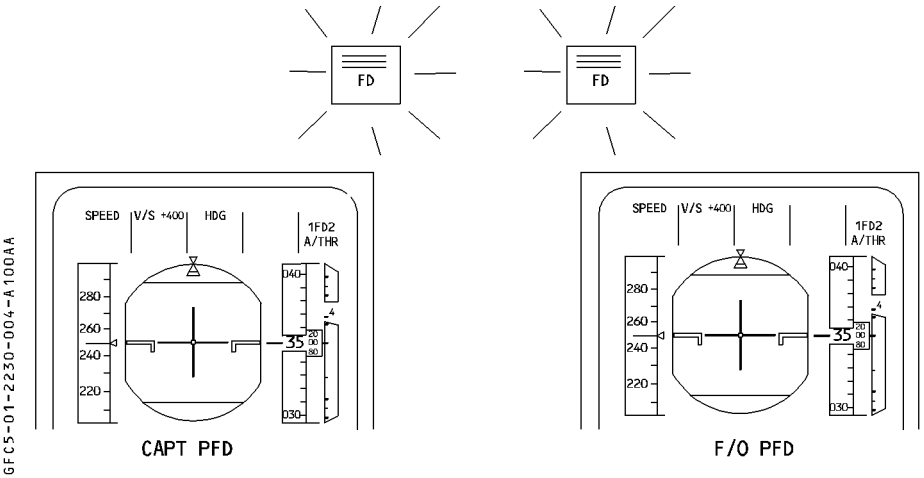
The FDs are automatically engaged whenever the FMGC powers up.

GROUND ENGAGEMENT

- The "1 FD2" symbol appears on both PFDs.
- No FD bars appear on the PFDs. (The PFD displays FD orders when a mode is active on the corresponding axis).
- The FCU windows display dashes.

MANUAL FLIGHT ENGAGEMENT

Provided AP/FD is off (no lateral or vertical mode displayed on FMAs, the two FDs engage in the HDG V/S or TRK FPA mode (basic modes) when FD pushbuttons are pressed.



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AUTOMATIC FLIGHT ENGAGEMENT

- FD bars are automatically restored in SRS/GA TRK modes at go around engagement. If FPV/FPD was previously selected, it reverts to FD bars.

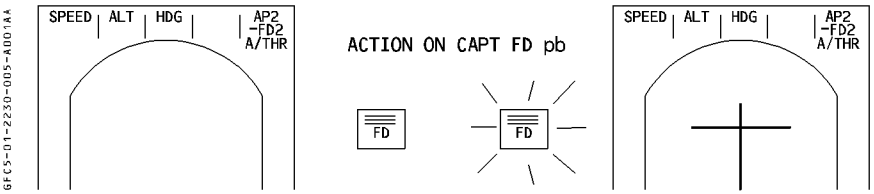
FLIGHT DIRECTOR (FD) DISENGAGEMENT

The flight crew may disengage one or two FDs manually, or FDs may disengage automatically if there is a failure.

MANUAL FLIGHT DIRECTOR DISENGAGEMENT

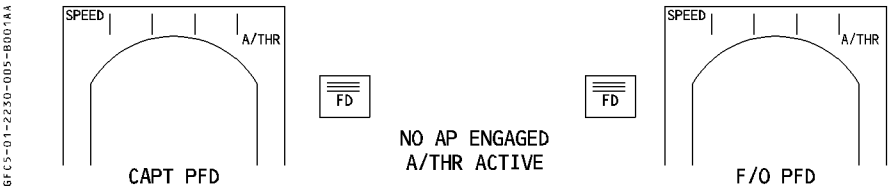
One FD off :

- The FD bars no longer appear on the associated PFD.
- The corresponding FD is disengaged.



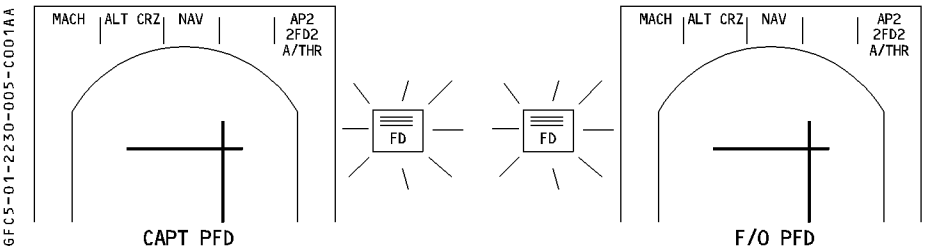
Both FDs off:

- The FD bars disappear from both PFDs.
- If no AP was engaged, lateral and vertical modes disengage. The A/THR, if active, automatically reverts to (or remains in) SPEED/MACH mode.
- If one AP was engaged when FDs are switched OFF, this AP remains engaged in the active modes but the FDs are no longer displayed.



AUTOMATIC FLIGHT DIRECTOR DISENGAGEMENT

If one FD fails or one FMGC is not valid, both PFDs display the remaining FD.



AUTOMATIC DISENGAGEMENT DUE TO SPEED PROTECTION

When APs are not engaged and if you do not fly the FD bars, an automatic disengagement of FDs and corresponding FMA modes will occur if the aircraft speed reaches VMAX in climb with CLB or OP CLB mode engaged or if the aircraft speed decreases to VLS in descent with DES, OP DES mode engaged.
Refer to Automatic speed protection in this chapter.

AUTOMATIC FD REMOVAL

- The FD pitch bar is removed when no vertical mode is engaged or when ROLL OUT is engaged.
- The roll FD bar is removed when no lateral mode is engaged or when the RWY or ROLL OUT mode is engaged.
- Both FDs are removed when the aircraft pitch exceeds 25° up or 13° down, or bank angle exceeds 45°.

Note : If from AP/FDs off, FD2 then FD1, are engaged within 150 milliseconds (one computation cycle), a flip flop of master FMGC may occur.
As a result, no vertical mode engages and dashes are displayed on FMA 1st column, 1st line (A/THR mode).
Engaging V/S mode manually reselects the correct FMGC and restores the display.

FD WARNINGS

FD WARNINGS	CONDITIONS
Pitch FD bar (or FPV) flashes 10 seconds	– if the ALT* mode is lost further to FCU altitude reference change of more than 250 ft. – when in APPR mode (G/S*, G/S, LAND, FINAL) FD reverts to V/S mode (pilot action or loss of vertical approach mode) – one AP or one FD is engaged while both AP/FD were previously off.
Pitch FD bar (or FPV) flashes permanently	Transmission of the GLIDE data is interrupted when in G/S, G/S* or LAND modes above 100 ft RA.
Roll FD bar (or FPV) flashes 10 seconds	– When in APPR mode (LOC*, LOC, LAND, APP NAV) FD reverts to HDG mode (Pilot action or loss of lateral approach mode). – One AP or one FD is engaged while both AP/FD were previously off.
Roll FD bar (or FPV) flashes permanently	Transmission of the LOC data is interrupted when in LOC, LOC* or LAND modes above 15 ft RA.

AUTOPILOT

GENERAL

The AP :
- stabilizes the aircraft around its center of gravity
- acquires and tracks a flight path
- flies the aircraft to an automatic landing or go-around.

The AP commands the :
- position of the flight control surfaces for pitch, roll, and yaw
- nose wheel position.

AP ENGAGEMENT

The flight crew can engage AP1 or AP2 by pressing the corresponding pushbutton on the FCU if the aircraft has been airborne for at least five seconds.
When one AP is engaged, the corresponding FCU pushbutton comes on and AP1 (or 2) is displayed on the FMAs.
In dual BACK UP NAV, AP can be engaged in selected modes if the FG part is available.
AP can be engaged when :
* Aircraft speed is within VLS and VMAX.
* Aircraft pitch angle does not exceed 10° nose down or 22° nose up.
* Bank angle is less than 40°
* On ground, if the engines are not running. It disengages when one engine is started.
* Two APs may be engaged at a time (AP1 active, AP2 in standby), when the localizer/glide-slope or roll out or go around mode is armed or engaged.
  Only one AP can be engaged at a time in all other cases.
* If one AP pushbutton is set to on with both FDs off, the AP engages in HDG V/S or TRK FPA mode, depending upon which the pilot has selected on the FCU.
* If one AP pushbutton is set to on with at least one FD already on, the AP engages in the current active FD modes.
* AP engagement increases the break out force on the sidestick controllers and on the rudder pedals.

AP engagement is indicated by the lighting of the corresponding FCU pushbutton, and by the appearance of "AP1" (or 2) on the PFD's Flight Mode Annunciator.

AP DISENGAGEMENT

AP1 or 2 disengages when :

- The pilot presses the takeover pushbutton on the sidestick.
- The pilot presses the corresponding AP pushbutton on the FCU.
- The pilot pushes on the sidestick harder than a certain threshold. (Disengagement through rudder pedals is only active on ground).
- The other AP is engaged, except when localizer/glideslope modes are armed or engaged, or rollout or go-around mode is engaged.
- Both thrust levers are set above the MCT detent and the aircraft is on ground.
- The aircraft reaches the MDA – 50 feet (MDH – 50 feet), or 400 feet AGL if no MDA/MDH, with APPR mode engaged and a non-ILS approach selected.
- One of the engagement conditions is lost.

  Furthermore, in normal law with all protections available, the AP will disconnect if :
  - High speed protection is active.
  - Angle-of-attack protection is active (α prot + 1° is reached).
  - Pitch attitude exceeds 25° up, or 13° down, or bank angle exceeds 45°.

The standard way for the flight crew to disengage the AP is to press the takeover pushbutton on the sidestick.

When AP is OFF, the associated FCU pushbutton goes off, and the "AP1" (or AP2) is removed from the PFD's FMA.

AP WARNINGS

When the AP is disengaged, the system warns the pilot :

- If the pilot disengages it with the takeover pushbutton on the sidestick, the warnings are temporary.
- If the disengagement results from either a failure, from the pilot pushing the pushbutton on the FCU, or from a force on the sidestick, the visual and audio warnings are continual.

		AP DISENGAGEMENT	
		TAKE OVER PB on SIDESTICK	**BY OTHER MEANS**
CONSEQUENCE	MASTER WARNING	flashing red during 3 sec max	flashing red
	ECAM	red AP OFF message 9 sec maximum	red warning AUTO FLT AP OFF
	AUDIO	cavalry charge 0.5 sec min 1.5 sec maximum	continuous cavalry charge 1.5 sec minimum
	CLR PB on ECAM CONTROL PANEL	extinguished	illuminated
ACTION	MASTER WARNING	extinguishes M.W erases ECAM warning stops audio if pressed within 1.5 sec	extinguishes M.W stops audio after 1.5 sec
	CLR PB on ECAM CONTROL PANEL	No effect	extinguishes CLR pb erases ECAM message calls status
	TAKE OVER PB	extinguishes M.W. erases ECAM warning stops audio if pressed within 1.5 sec.	extinguishes M.W. stops audio after 1.5 sec
ECAM STATUS MESSAGE		NO	YES

AUTOLAND WARNING

The autoland red warning flashes in LAND mode when :

— the radio altitude goes below 200 feet and :

R
- * The aircraft gets too far off the beam (LOC or GLIDE).
- * Or both autopilots fail.
- * Or both localizer transmitters or receivers fail.
- * Or both glide slope transmitters or receivers fail.
- * Or both radio altimeters differ from more than 15 feet.

SPEED/MACH CONTROL

In flight either the AP/FD pitch control or the autothrust may acquire and hold a target speed or Mach number, according to the engaged modes.
The speed control is :
– managed when the target comes from the FMGS
– selected when the target comes from the SPD/MACH FCU window.

MANAGED SPEED/MACH TARGET

When the speed target is managed, the SPD/MACH window of the FCU shows dashes, and the corresponding dot is lighted. The PFD speed scale shows the speed target in magenta.

ENGAGEMENT CONDITIONS

The SPD target is managed whenever AP or FD is engaged and one of the following occurs:
– The pilot pushes in the SPD/MACH selector knob.
– V2 is inserted in the MCDU.
– The speed reference system (SRS) is engaged (takeoff or go-around mode).

Note : At takeoff, SRS will not engage if V2 is not available.

DISENGAGEMENT CONDITIONS

Managed speed disengages any time the pilot selects a speed target on the FCU, or if the speed was preselected.

SPEED PROFILE

The form of the managed SPD profile depends on the lateral NAV mode.
– If NAV mode is engaged, the SPD profile takes into account all the constraints linked to the flight plan.
The SPD profile is :
R V2 - SPD LIM - SPD CSTR (if applicable) - ECON CLB SPD/MACH - ECON CRZ MACH - ECON or selected DES MACH/SPD - SPD LIM - SPD CSTR (if applicable) - HOLD SPD (if applicable) - VAPP

– If NAV mode is not engaged, the SPD/MACH constraints are not considered.
The SPD profile is :

R V2 - SPD LIM - ECON CLB SPD/MACH - ECON CRZ MACH - ECON or selected DES MACH/SPD - SPD LIM - VAPP.

Note : – When both AP/FDs are OFF, A/THR reverts to selected SPEED mode except, when the approach phase is activated on MCDU where both managed and selected SPD are available.
– The managed speed/Mach target may be set below maneuvring speed but as long as the speed target is managed, the FMGS limits the aircraft to the maneuvring speed of the current slats/flaps configuration (VAPP, F, S, Green Dot).
– If the managed speed/Mach target is set above VMAX (VFE, VMO, MMO) the FMGS automatically limits the speed to VMAX.

MINI GROUND SPEED

In approach phase the managed speed target is the Mini Ground Speed target computed by the Flight Guidance (FG) part of the FMGS. Refer to 1.22.30 Autothrust for details.

SELECTED SPEED/MACH TARGET

To use a selected speed/Mach target, the pilot uses the knob on the FCU to set the target speed, which is then displayed in the FCU window. It is also displayed in blue on the PFD speed scale.

Note : The selected speed/Mach target may be set beyond VLS or VMAX, but when autothrust is active, the guidance limits the speed to VLS or VMAX.

Selected speed has priority over managed speed. The only automatic change-over from selected to managed speed target may occur at go-around mode engagement.
In flight, if the situation calls for managed speed, both the PFD and the MCDU display a message proposing a manual change to managed speed (for example, SET MANAGED SPEED, SET HOLD SPEED).

ENGAGEMENT CONDITIONS

The aircraft has a selected speed target under any one of the following conditions :
– The pilot pulls out the SPD/MACH selector knob (5 seconds after lift-off)
– Both AP/FDs are OFF (except in APPR phase)
– The FM speed target is lost except below 700 feet RA in takeoff, LAND or go around mode.
– The MCDU has a preselected speed for the next phase, and the aircraft transitions into that phase.
– The FMGC is powered up in flight.
– 5 seconds after lift off when a takeoff is initiated without managed or selected speed.

DISENGAGEMENT CONDITIONS

The selected speed target disengages when :
- the managed speed target engages
- on ground at AP or FD engagement
- on ground at engine start

Note : It is not possible to activate selected speed mode on the ground with engines running and FD on until after takeoff.

SELECTED DESCENT SPEED

R A manual speed or Mach may be inserted by the crew on the PERF DES page to replace the ECON DES SPD.
In this case, although the value is selected by the crew this speed or Mach is taken into account to compute the top of descent and the descent profile.

SPEED/MACH SWITCHING

- At the crossover altitude, the FMGC automatically changes the selected speed target to the corresponding MACH target.
  The FCU displays the Mach number corresponding to the speed at the switching altitude.

  Note : when the speed is selected, the pilot can do the switching manually by pressing the SPEED/MACH pushbutton on the FCU. The FCU then displays the aircraft Mach number.

- When the target speed is managed, the FMGC commands the switchover automatically as a function of the ECON MACH value.

MANAGED SPEED TARGET MEMORIZATION

A dual FM failure has different consequences when it occurs in different phases of the flight. The system handles target speed and SPD mode as follows :
- During approach with LOC and G/S engaged and radio altitude < 700 feet, the target speed is set to VAPP as previously memorized, and managed SPD target is maintained.
- At go around, the target speed becomes the memorized go around speed, which is the higher of VAPP or the speed when go around was initiated. Managed SPD target is maintained.
- In all other cases managed target speed reverts to selected, the value being the speed at the moment of the failure.

SPEED/MACH FCU WINDOW SYNCHRONIZATION

When the target SPD is managed, the SPD/MACH display of the FCU shows dashes. However, the window displays the target SPD or MACH in the following situations.

- The pilot turns the SPD/MACH selector knob.
  If the pilot does not pull the knob within 45 seconds after turning it, the selection reverts to dashes.
- The pilot manually engages a selected SPD target.
- If the flight crew has manually preselected a speed or Mach number for the next phase on the MCDU PERF page, that preselected SPD/MACH engages when the aircraft enters that phase and the FCU window then displays as the target the preselected speed or Mach.
- If the FMGS is powered up in flight, the synchronized speed/Mach value is the current aircraft speed or Mach number.
- If no V2 is entered at takeoff, the V/S mode engages 5 seconds after lift-off (no speed reference system). The FCU speed target is the speed at V/S mode engagement. (A/THR becomes active when the thrust levers are set in the active range).
- If both FMGCs fail, the speed displayed is the last aircraft speed acquired before the failure.

AP/FD MODES GENERAL

The FMGS has guidance parameters for both AP/FD lateral and vertical modes.

The AP/FD lateral modes are :

RWY, RWY TRK	Runway, Runway track mode
NAV	Nav mode
HDG, TRK	Heading, track mode. Also called basic modes.
APP NAV	Approach Nav mode
LOC*, LOC	Loc capture, Loc track mode
LOC B/C	Loc back course
• LAND	Land mode. Managed submode that includes LOC and G/S modes below 400 feet RA.
• FINAL APP	Final approach mode. Managed submode that includes APP NAV and FINAL modes during non precision approach.
ROLL OUT	Roll out mode. (Autoland)
GA TRK	Go around track mode

The AP/FD vertical modes are :

SRS	SRS mode used for takeoff and go around
CLB	Climb mode
DES	Descent mode
OP CLB	Open Climb mode
OP DES	Open Descent mode
R V/S or FPA R	Vertical speed mode or Flight Path Angle mode. Also called basic modes.
ALT*	Altitude capture,
ALT	Altitude Hold mode
ALT CST*	Altitude constraint capture,
ALT CST	Altitude constraint hold mode
ALT CRZ*	Altitude capture of the cruise flight level
ALT CRZ	Altitude hold of the cruise flight level
G/S*	Glide slope capture,
G/S	Glide slope mode.
FINAL	Final mode (non precision approach)
FLARE	Flare mode (Autoland)

AP/FD LATERAL MODES

HEADING OR TRACK : HDG - TRK

These modes guide the aircraft laterally along a heading or track selected by the flight crew.
The HDG/TRK window of the FCU displays the target heading or track.
The pilot uses the HDG V/S -TRK FPA pushbutton to select heading or track.

ENGAGEMENT CONDITIONS

HDG or TRK is engaged when one of the following conditions is met :
- The pilot pulls out the HDG-TRK selector knob (not sooner than five seconds after lift-off).
- NAV is disengaged, either by the loss of the lateral flight plan or by the pilot entering a flight plan discontinuity.
- FINAL mode (armed or engaged) is lost when the aircraft is in APP NAV mode.
- LOC or LOC* mode is lost.
- The pilot engages the AP/FD with no other mode already engaged (basic mode of AP/FD engagement).
- LOC mode is armed when FINAL APP was previously engaged.
- LOC or LOC* being armed or engaged, the APPR pushbutton is deactivated (above 400 feet).

DISENGAGEMENT CONDITIONS

The engagement of any other lateral mode disengages HDG or TRK.

SYNCHRONIZING THE HDG/TRK WINDOW OF THE FCU

The lateral window of the FCU displays a heading or a track value when :
- The HDG/TRK mode is engaged. The displayed value is the current HDG/TRK or the manually selected value of the target.
- The pilot turns the HDG/TRK selection knob. The value in the window first synchronizes with the current HDG/TRK, then displays the manual selection. It remains displayed for 45 seconds depending upon FCU standard, then vanishes if the pilot does not pull the knob (except in HDG preset).
- A HDG/TRK is preset (see below).
- AP/FD is lost. The value becomes that of the aircraft current heading or track.

Note : If HDG is switched to TRK (or vice versa), the value displayed in the window switches from heading to track (or vice versa).

HDG/TRK PRESET

The system has a HDG/TRK preset function for takeoff and go around.
If the pilot chooses not to fly the flight plan after takeoff or go around, he may preset a HDG or a TRK on the FCU by turning the HDG/TRK selector knob. The value he sets remains displayed in the FCU HDG/TRK window until the knob is pulled.

Operation at takeoff

HDG/TRK preset is available before takeoff and up to 30 feet RA. Turning the HDG/TRK selector knob before 30 feet sets the desired HDG/TRK. As a consequence:

– NAV is disarmed
– At 30 feet, RWY TRK is annunciated until the HDG/TRK knob is pulled.

Operation at go around

Whenever the LOC*, LOC, LAND, FINAL, or GA modes are engaged, the HDG preset is available. If the pilot rotates the HDG/TRK knob to set the value, it will remain displayed in the window. Pull out the HDG/TRK knob to activate the mode and turn the aircraft on to the preset value.

Cancellation

The pilot can cancel a preset HDG/TRK by :

· engaging the NAV mode (DIR TO)
· pushing in the HDG/TRK knob (arming NAV mode)
· disengaging AP/FD

NAVIGATION (NAV)

NAV mode is a managed mode that steers the aircraft laterally along the flight plan defined in the FMGS. It is designed to have a zero cross-track error. The pilot can arm or engage the NAV mode if the MCDU contains a lateral flight plan.

ARMING CONDITIONS

Satisfying one of the following conditions arms NAV :

- The aircraft is on the ground with no HDG/TRK preset and no other lateral mode except runway mode
- The pilot pushes in the HDG/TRK selector knob, unless the LOC mode is engaged.
- The pilot presses the APPR pushbutton, if a non-ILS approach is selected.
- The pilot selects a DIR TO/INTERCEPT when in HDG or TRK mode.

DISARMING CONDITIONS

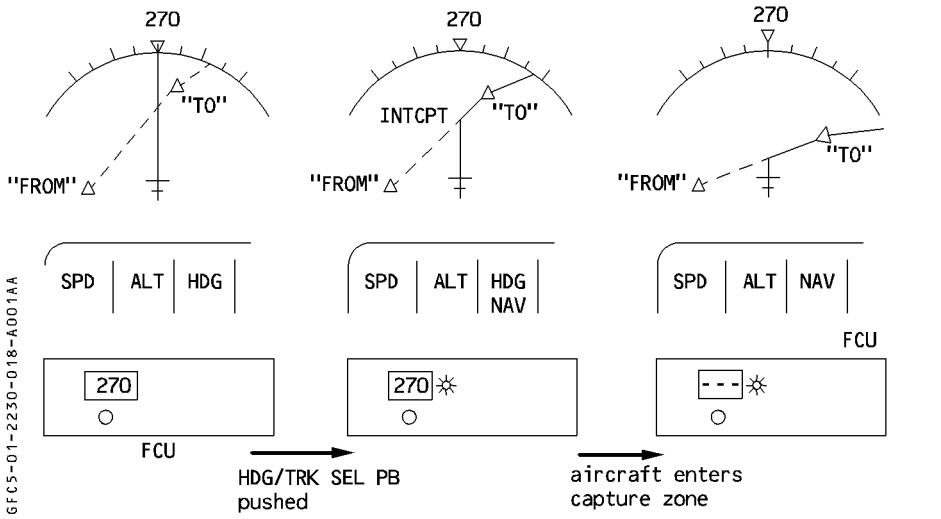
NAV mode disarms if one of the following occurs :

- The pilot pulls out the HDG/TRK selector knob.
- The pilot selects a preset HDG/TRK (TO or GA)
- The pilot arms the LOC mode by pressing the LOC pushbutton.
- The pilot selects GA mode.
- LAND mode has engaged.
- The pilot presses the APPR pushbutton to deselect the non-ILS approach.
- The pilot deselects both AP/FDs.

ENGAGEMENT CONDITIONS

NAV mode engages :

R
- Automatically at 30 feet RA after takeoff (if armed on the ground).
- When the pilot orders "DIR TO" (except below 700 feet RA in LOC mode).
- When the pilot pushes in the HDG/TRK select knob when the aircraft is close to (within $\sim$ 1 NM of) the active flight plan leg.
- Automatically in flight when NAV is armed and the aircraft reaches the capture zone for the active flight plan leg.



CAUTION

When NAV is armed, it will automatically engage if :
the aircraft track line intercepts the flight plan before the TO waypoint and the intercept waypoint (INTCPT) is displayed on the ND and the aircraft reaches the active flight plan leg.

Note : The TO waypoint is displayed in white on NDs and MCDUs.

DISENGAGEMENT CONDITIONS

The NAV mode disengages when :
- Any other lateral mode is engaged.
- The flight plan is lost or the aircraft enters a flight plan discontinuity.
- At MDA-50 feet when APP NAV is engaged.

INTERACTIONS WITH VERTICAL MODES

When NAV mode is engaged, the vertical managed modes CLB or DES or FINAL take into account altitude and speed constraints linked to waypoints on the lateral flight plan. If NAV mode is disengaged the vertical managed modes are not available and all downpath altitude and speed constraints are ignored.

LOCALIZER MODE THROUGH THE LOC PUSHBUTTON

This mode captures and tracks a localizer beam independently of the glide path beam. Pilots use it to fly localizer-only approaches or to initiate an ILS approach when intercepting the glide slope from above.

ARMING CONDITIONS

The pilot arms the LOC mode by pressing the LOC pushbutton, provided that :
- An ILS is tuned (frequency and runway course).
- The aircraft is above 400 feet RA.
- TO or GA mode is not engaged.

DISARMING CONDITIONS

LOC mode is disarmed by :
- Pressing the LOC pushbutton when LOC is armed.
- Arming the NAV mode.
- Engaging the GA mode.

Note : Engaging NAV mode by selecting DIR TO does not disarm the LOC mode.

ENGAGEMENT CONDITIONS

The LOC mode engages automatically when capture conditions are met.

DISENGAGEMENT CONDITIONS

The LOC mode disengages :
- When another lateral mode is engaged.
- When the pilot presses the LOC pushbutton again (engaging the HDG/TRK mode on the current HDG/TRK).

LOC BACK COURSE MODE (LOC B/C)

This mode captures and tracks the back beam of a LOC. This approach is considered as a non precision approach, and must be flown with AP/FD in TRK/FPA modes, A/THR being active.
See FMGS Pilot's Guide 4.05.70 for details. (FCOM Vol 4).

AP/FD VERTICAL MODES

Vertical modes guide the aircraft in the vertical plan.

PRINCIPLES

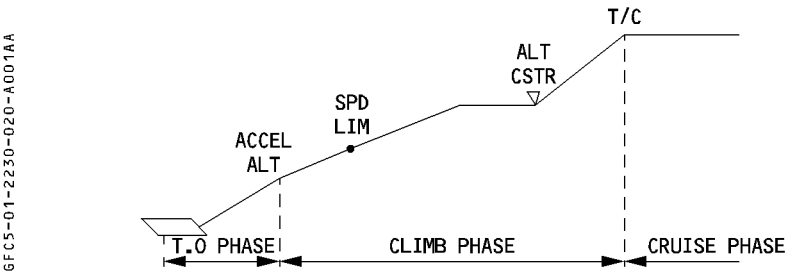
To leave an FCU selected altitude for another target altitude, two things must happen : the pilot must turn the altitude (ALT) selector knob in order to display the new target altitude and either :

- pull out the ALT selector knob to engage the OPEN CLB/DES mode, or
- push in the ALT selector knob to engage the CLB/DES mode, or
- select a target vertical speed (V/S) and pull out the V/S FPA selector knob to engage V/S mode.

This arms ALT mode.

CLIMB MODE (CLB)

CLB mode guides the aircraft in a managed climb, at either a managed or a selected target speed, to an FCU selected altitude, taking into account altitude constraints at waypoints. The system also considers speed constraints if the target speed is managed.
The vertical flight path may include several segments :



The pilot can arm the CLB mode during the takeoff, go around, climb, and cruise phases and engage it during the climb and cruise phases.

ARMING CONDITIONS

The CLB mode is armed :

- on the ground or when SRS mode is engaged (TO or GA) if the following conditions are met :
  - No other vertical mode is engaged.
  - The ACCEL ALT (defined on the MCDU PERF TO or GA pages) is below the FCU selected altitude and the lowest altitude constraint.

– In flight, when the climb or go around phase is active, and the following conditions are met :
  – The lateral NAV mode is engaged, and
  – The FCU-selected altitude is above the aircraft's present altitude and the aircraft captures or flies an altitude constraint.

DISARMING CONDITIONS

The CLB mode is disarmed, if one of the following conditions is met :
– Another vertical mode is engaged.
– The FCU-selected altitude is lower than the present aircraft level.
– The FCU-selected altitude is set at the ALT CSTR, while ALT CSTR* or ALT CSTR mode is engaged.
– The aircraft transitions to DES or APPR phase.
– Arming requirements are no longer met.
R – Vertical flight path validity is lost, or NAV mode is lost with ALT CSTR* or ALT CSTR or
R ALT* or ALT mode engaged.

ENGAGEMENT CONDITIONS

The CLB mode can be engaged, if the following conditions are all met :
– The aircraft has been in flight for more than 5 seconds.
– The selected FCU level is above the present aircraft level.
R – The descent or approach, or go-around phase is not active.
– NAV mode is engaged.
– Glideslope (G/S) mode is not engaged.

CLB mode automatically engages when the aircraft reaches ACC ALT, or sequences a waypoint with an ALT CSTR while CLB mode is armed.
CLB mode manually engages when the pilot pushes in the ALT select knob, with the CLB mode not armed and an altitude constraint not effective.

Note : When CLB mode is engaged :
  – The V/S (FPA) window of the FCU shows dashes.
  – The managed LVL/CH dot on the FCU lights up.
  – The Flight Mode Annunciator displays "CLB" in Column 2.

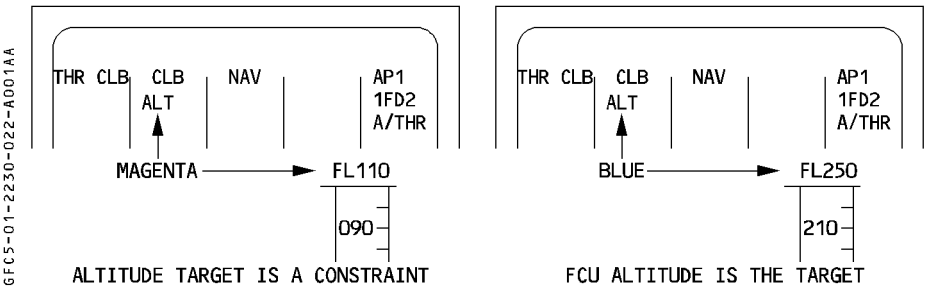
DISENGAGEMENT CONDITIONS

The CLB mode disengages, if one of the following conditions is met :
– NAV mode is lost or disengaged (OP CLB engages). If the aircraft was in CLB toward a constraint, the reversion to OP CLB is accompanied by a triple click aural warning.
– Another vertical mode engages.
– The pilot selects an altitude on the FCU that is lower than the present aircraft altitude. V/S (FPA) engages on current V/S (FPA).

GUIDANCE

Climb mode guides the aircraft up to the FCU selected altitude. It tries to respect speed and altitude constraints.
The AP/FD pitch controls the speed or Mach number target while the A/THR controls the thrust set at maximum climb thrust.
When climb mode is engaged :
The system arms ALT mode and displays the next applicable altitude target on the PFD altitude scale.

– ALT is magenta on the FMA second line and the altitude value is displayed in magenta on the PFD scale if the next altitude target is a constraint.



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– ALT is blue on the FMA second line and the altitude value is displayed in blue on the PFD altitude scale if the next altitude target is the FCU selected altitude.
In climb mode, the system does not modify the target speed to match the altitude constraints. The pilot has to select it manually using the information displayed on the PROG page.
When the aircraft levels off at an altitude constraint, CLB mode arms. It will engage automatically when the waypoint is sequenced. (If the FCU selected altitude is above the constraint).

OPEN CLIMB

The OPEN CLB mode is a selected mode. It uses the AP/FD pitch mode to maintain a speed or a Mach (selected or managed) while the A/THR, if active, maintains maximum climb thrust.

ENGAGEMENT CONDITIONS

The OPEN CLB mode can only be engaged, if all of the following conditions are met :
- The aircraft is in flight for more than 5 seconds.
- The LAND mode is not engaged.
- The FCU-selected altitude is higher than the aircraft's present altitude.

The OPEN CLB mode is engaged, if one of the following conditions occurs :
- The pilot pulls out the ALT selector knob.
- The pilot pulls out the SPD/MACH selector knob, when TO or GA mode is engaged.
- Acceleration altitude is reached, with CLB armed, and NAV mode not engaged.
- NAV mode or vertical F-PLN is lost when CLB mode is engaged. If the aircraft was in CLB toward an altitude constraint, the reversion to OPEN CLB is accompanied by a triple click aural warning.

R

R ALT mode is systematically armed when OPEN CLB engages.

DISENGAGEMENT CONDITIONS

The OPEN CLB mode is disengaged by one of the following conditions :
- Engagement of any other vertical mode.
- Selection of a lower altitude (on FCU) than the current aircraft altitude. V/S (FPA) engages on the current V/S (FPA) (See mode reversions).

GUIDANCE

When OPEN CLB is engaged, the target Speed/Mach is maintained by adjusting the pitch with the elevator, whereas thrust is maintained either by the A/THR or manually by the pilot. Speed may either be selected or managed.
The OPEN CLB mode disregards all altitude constraints up to the FCU-selected altitude.

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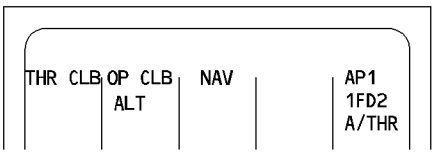


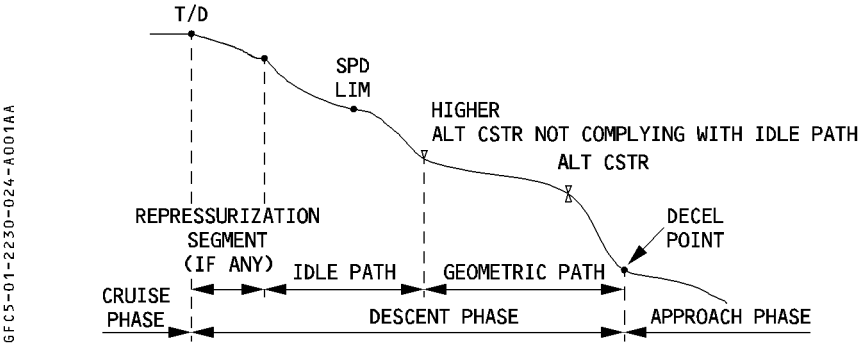
TYPICAL FMA IN OPEN CLB
THE LVL/CH LIGHT IS EXTINGUISHED ON THE FCU

Note : A level change of less than 1200 feet in OPEN CLB mode with A/THR active produces a 1000 ft/min climb.

DESCENT MODE (DES)

DES mode provides managed vertical guidance along a computed descent profile. The profile is computed from "Top of Descent" at the cruise flight level down to the "Decel" point, where guidance begins the deceleration to VAPP, to be reached at 1000 feet above touch down on the final descent path.
The descent profile takes into account wind data and data from the lateral and vertical flight plans, and it is based upon the managed descent speed profile. It does not take holding patterns into consideration.
The descent profile has several segments :

- A repressurization segment. When necessary, this produces a repressurization rate for the cabin during descent. It is a function of the destination airport altitude and the selected cabin rate (defaulted to – 350 feet/min but this can be modified).
- Idle path segment. The AP/FD controls the speed and autothrust stays at idle thrust. Guidance computes this profile from top of descent or the end of the repressurization segment to the first vertical constraint that cannot be flown at idle thrust.
- Geometric path segments. The AP/FD controls the vertical path, and autothrust controls the speed. These segments take the aircraft from the first constraint to the deceleration point.



The descent mode is a managed mode that may be engaged during cruise. It can be armed or engaged in descent and approach phases (unless the FCU selected altitude is higher than the present aircraft altitude).

ARMING CONDITIONS

R The DES mode is armed when an ALT CSTR is captured and the following conditions are
R met :
R – The FCU-selected altitude is lower thant the aircraft current altitude
R – NAV mode or LOC* or LOC mode is engaged.
R – Flight profile is available
R – Takeoff or climb or go-around phase is not active.

DISARMING CONDITIONS

The DES mode is disarmed, if one of the following conditions is met :
- Engagement of another vertical mode.
- FCU-selected altitude is set above the aircraft's current altitude.
- Loss of NAV, LOC*, or LOC mode.
- Switching to the takeoff, climb, or go-around phase.
- Loss of vertical flight path validity.

ENGAGEMENT CONDITIONS

The DES mode can be engaged, when the following conditions are met :
- The FCU-selected altitude is lower than the present altitude.
- NAV, LOC*, or LOC is engaged.
- Takeoff, climb, or go-around phase is not active.
- Vertical flight path is valid.
- TO, CLB, G/S, LAND, FINAL or GA mode is not engaged, and :
  - The aircraft sequences a waypoint, with an ALT CSTR, and DES mode is armed. The DES mode engages automatically, or
  - The pilot presses the ALT selector knob when ALT CSTR* or ALT CSTR mode is not engaged, or
  - The pilot presses the ALT selector knob, ALT* or ALT is engaged and the current aircraft altitude is not an effective altitude constraint of the F-PLN.

Note : When DES mode is engaged :
- *The V/S (FPA) window of FCU shows dashes.*
- *The managed LVL/CH dot on the FCU lights up.*

DISENGAGEMENT CONDITIONS

The DES mode is disengaged, if one of the following conditions is met :

R — NAV mode is disengaged and V/S (FPA) engages. (See reversions). A triple click aural
R warning will sound. (Refer to 1.22.30, mode reversion).
- Another vertical mode engages.
- The pilot selects an altitude on the FCU that is higher than the aircraft's present altitude,

R and the V/S (FPA) engages on the current V/S (FPA). A triple click aural warning will
R sound. (Refer to 1.22.30 mode reversion).
- NAV mode is lost due to a discontinuity in the descent profile. AP/FD reverts to basic

R mode, and a triple click aural warning sounds.

GUIDANCE

Descent initiation

In order to initiate the descent, the pilot :

- Turns the ALT selector knob to set the cleared altitude.
- Pushes in the ALT selector knob.
  - If the aircraft has not reached top of descent (T/D), it will descend immediately at a constant V/S, converging on the descent profile.
  - If the aircraft is at or beyond T/D, it descends immediately at idle thrust.

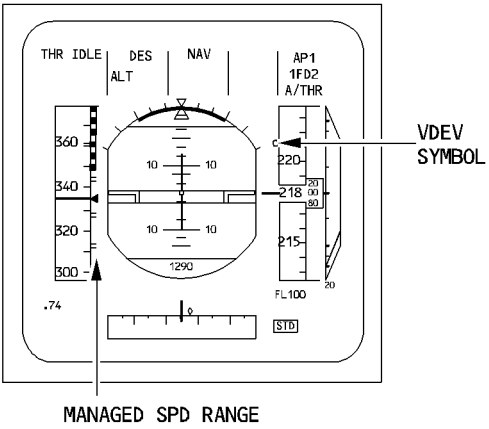
During the descent :

The pilot sees a vertical deviation symbol (VDEV) along the ALT scale on the PFD and on the PROG page, so as to monitor the aircraft vertical position on the calculated descent profile.

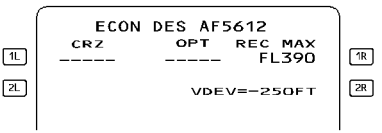
The aircraft may deviate from the DES path while DES mode is engaged if :

- unexpected wind conditions is encountered or,
- anti-icing is turned on or,
- lateral flight plan is modified.

R



PFD display in managed DES mode.



VDEV value on the PROG page

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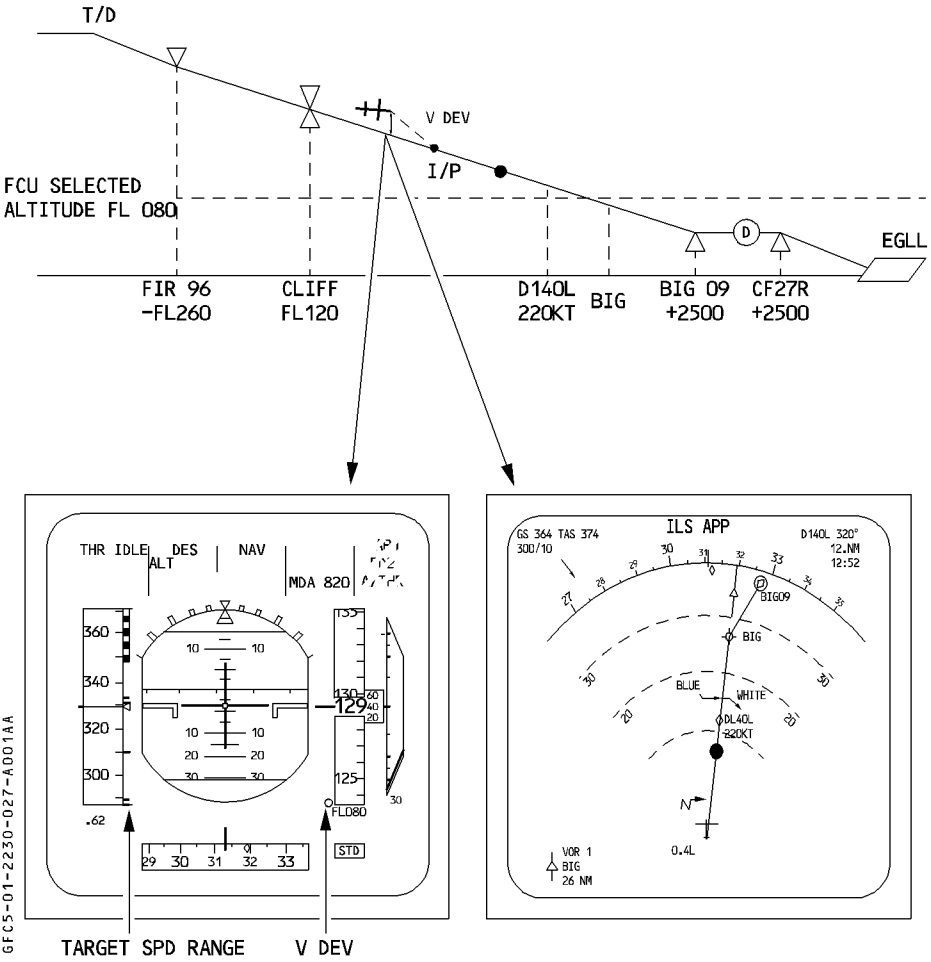
When the speed is managed, a managed SPD range shows, on the PFD, acceptable speed variations around the nominal descent speed target (limited to ± 20 knots).

Associated with the V DEV displayed on PFD, the ND shows an intercept point ∿→ on the flight plan. It indicates the position where the system predicts that the aircraft will intercept the descent profile.

R



– **Aircraft above the descent profile :**

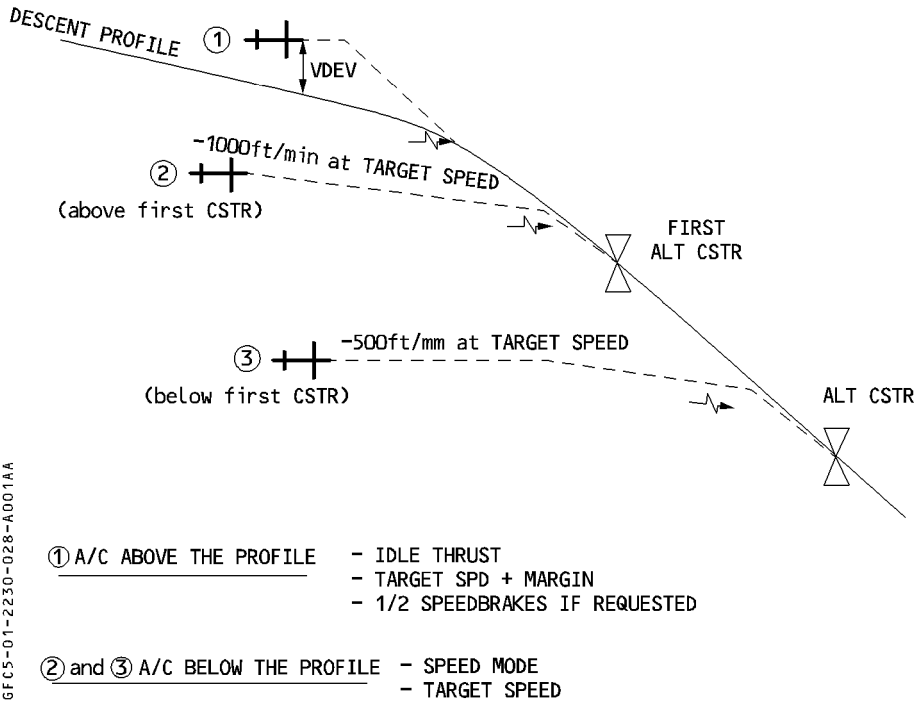
If the aircraft is above the descent profile, the speed will increase toward the upper limit of the managed speed range. If the speed reaches the upper limit, the aircraft will maintain the speed but will deviate from the profile (autothrust at idle).

The navigation display presents a pseudo waypoint ∿↣ (intercept point) along the flight plan, that assumes the aircraft will return to the profile using :

· idle thrust
· 1/2 speedbrake extension
· ECON speed plus a margin (until intercepting the profile).

Whenever the intercept point is predicted to be close to a constrained waypoint, the PFD and MCDU display an "EXTEND SPD BRK" message.

Note : With DES mode engaged, the speedbrakes extension will not necessarily increase the descent rate. It increases only if the aircraft is above path.



– **Aircraft below DES profile**

If the aircraft is below the DES profile, its speed will be maintained at target speed until it reaches the descent profile.

The intercept point on the navigation display is based on the following assumptions :

· if the aircraft is flying an idle segment :
The FMGS maintains V/S = – 1000 ft/min and target speed, until it reaches the constraint altitude or intercepts the profile.

· if the aircraft is flying a geometric segment :
The FMGS maintains a constant – 500 ft/min until it intercepts either the altitude constraint or the profile.

– **Leveling off at a constraint**

· If the aircraft levels off at an ALT CSTR, the DES mode arms and remains armed until the aircraft passes the constraint, then reengages (if the FCU altitude is set below the altitude of the constraint).

· if the FCU selected altitude is that of a constraint, the pilot may continue the descent below that altitude by turning the ALT SEL knob and pushing it in. This arms the DES mode, which reengages when the aircraft passes the constraint waypoint.

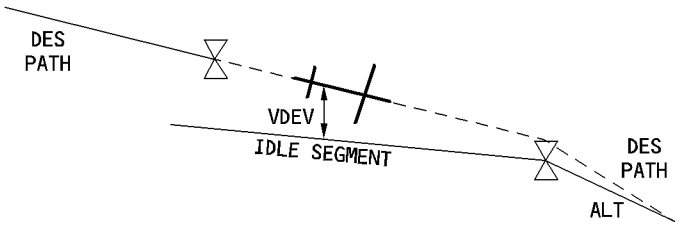
– **Guidance in a hold :**

Just before the aircraft enters a holding pattern, the speed target becomes the holding speed. In the holding pattern, the DES mode commands V/S = – 1000 ft/min while autothrust maintains the holding speed. The aircraft will level off at the next altitude constraint if it is reached during the hold.

The vertical deviation (VDEV) is based on the altitude at which the aircraft is supposed to cross the exit fix in order to be properly positioned on the descent profile.

– **Too steep path :**

A segment between two constraints is called "too steep path" when Flight Management predicts that it is impossible to fly it at the preplanned speed with 1/2 speedbrakes extended. The MCDU displays TOO STEEP PATH and FM does not furnish predictions for the waypoints included in the TOO STEEP PATH segment. When the aircraft reaches the beginning of the too steep path segment, the FM recomputes the VDEV using an idle segment from the end of the too steep path segment.



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– **FMA display**

When DES mode is engaged, the system arms ALT and displays the applicable target altitude on the PFD altitude scale.

· If the next predicted level-off is an altitude constraint, ALT is magenta on the FMA second line and the PFD displays the altitude constraint magenta below the altitude scale.

When ALT CSTR (green) is engaged (aircraft flying at ALT CSTR), the system arms DES blue. When the aircraft meets the constraint, DES engages again automatically.

· If the next predicted level-off is the FCU altitude, ALT is blue on the FMA and the PFD displays the FCU selected altitude in blue.

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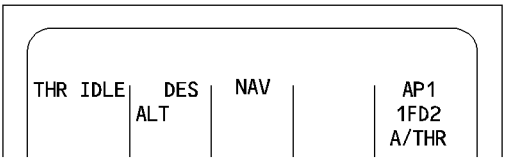


Typical FMA in DES

OPEN DESCENT MODE (OP DES)

The OPEN DESCENT mode is a selected mode. It maintains a SPD/MACH (selected or managed) with the AP/FD pitch mode, while autothrust (if active) maintains IDLE thrust. It is not to be used for final approach.

ENGAGEMENT CONDITIONS

The OPEN DES mode can only be engaged, if the following conditions are met :
- The aircraft has been in flight for more than five seconds,
- LAND mode is not engaged.
- The FCU-selected altitude is lower than the present altitude.

The OPEN DES mode is engaged by :
- Pulling out the ALT selection knob.

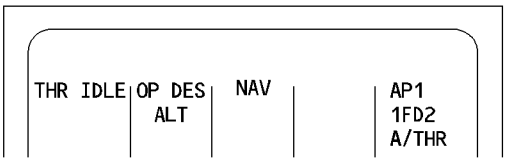
Note : When OP DES is engaged :
- *The FMA displays "OP DES".*
- *The managed LVL/CH dot on the FCU goes out.*
- *The system arms the ALT mode.*

DISENGAGEMENT CONDITIONS

The OPEN DES mode is disengaged by one of the following :
- Manual engagement of another vertical mode.
- Selection of an altitude higher than the present altitude. V/S (FPA) engages on the current V/S (FPA). If within 5 seconds after reversion to V/S, the pilot does not confirm the altitude target change by another expected action, a triple click aural warning sounds, and the V/S (FPA) is boxed white and flashes for 10 seconds.

GUIDANCE

When OPEN DES is engaged, pitch control maintains the target speed/ Mach number, and autothrust maintains idle thrust (or the pilot maintains it manually).
The speed target may be either selected or managed.
The OPEN DES disregards all altitude constraints.



Typical FMA in OPEN DES

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ALTITUDE ACQUIRE MODE (ALT*, ALT CSTR*, ALT CRZ*)

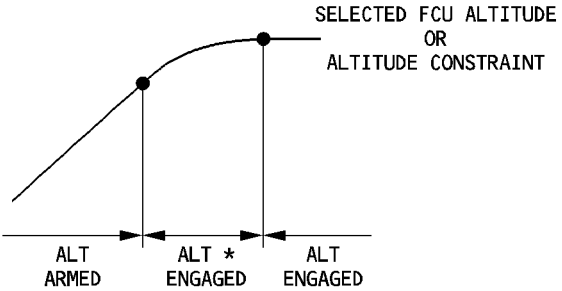
ALT* mode guides the aircraft to acquire the FCU selected altitude.
ALT CSTR* guides the aircraft to acquire an altitude constraint provided by Flight Management.
ALT CRZ* guides the aircraft to acquire the cruise altitude as selected on the FCU and the MCDU PROG page.
Once the aircraft has reached the altitude, the altitude mode ALT or ALT CSTR or ALT CRZ engages.

ARMING CONDITIONS

ALT* or ALT CSTR* or ALT CRZ* can be internally armed but the pilot does not see any display of it.

ENGAGEMENT CONDITIONS

The mode engages when the aircraft reaches the altitude capture zone defined by the aircraft vertical speed (among other parameters).



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Note : ALT and ALT CSTR* cannot be engaged below 400 feet if either the takeoff or the go around mode is engaged.*

DISENGAGEMENT CONDITIONS

- Engagement of V/S mode on current vertical speed by changing the FCU altitude selector knob by more than 250 feet.
  If within 5 seconds after the reversion to V/S (or FPA) the pilot does not confirm the altitude target change by
  - pulling the ALT knob, or
  - setting a new V/S (or FPA) target, or
  - pushing the ALT pushbutton on the FCU,

  a triple click sounds, and the V/S (or FPA) is boxed white for 10 additional seconds.
- Engagement of another vertical mode provided the FCU altitude has been changed by more than 250 feet.

GUIDANCE

The ALT* mode has internal V/S guidance that is a direct function of the difference between present altitude and the altitude target.
The system switches automatically to ALT (altitude hold) when the altitude deviation becomes less than 40 feet.

Note : – *If the baro setting is changed during ALT*, this may lead to an FCU target overshoot due to the change of the current value of the altitude. However ALT* mode will allow the FCU altitude to be regained.*
– *For aircraft equipped with QFE option, a switching from STD to QFE (or vice versa) in ALT CSTR*, will change the target value and a reversion to V/S may occur if the target value is modified of 250 feet or more.*

ALT* and ALT CSTR* modes have internal speed protections that decreases the vertical speed when VLS or Vmax is reached. (VLS or Vmax becomes the priority target).

ALTITUDE HOLD MODE (ALT/ALT CST/ALT CRZ)

The ALT mode maintains a target altitude. This target altitude is either the FCU selected altitude (ALT, ALT CRZ) or an altitude constraint delivered by the Flight Management (ALT CSTR).

ARMING CONDITIONS

The ALT mode arms automatically whenever the aircraft climbs or descends toward the target altitude.
When ALT is armed, the FMA displays the ALT message on its second line :
– blue when the target altitude is the FCU selected altitude
– magenta if the target altitude is an altitude constraint.

ENGAGEMENT CONDITIONS

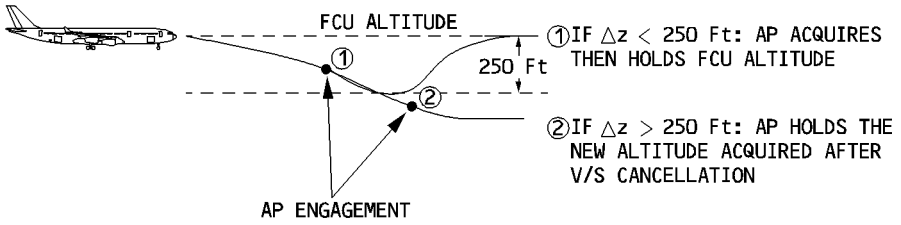
ALT mode engages when :
– the difference between present altitude and target altitude becomes less than 40 feet with ALT* engaged.
– or when the ALT pushbutton of the FCU is pressed.

DISENGAGEMENT CONDITIONS

The ALT mode disengages when any other vertical mode engages.
The ALT pushbutton cannot be used to disengage ALT mode.

GUIDANCE

– The altitude that ALT mode holds is the altitude it memorized when engaged. It is not affected by a change of barometric reference or by a change in the barometric correction.
– When ALT is engaged, the FMA displays "ALT" in green if it is the FCU altitude or ALT CSTR in green if it is an altitude constraint.
– If the AP is engaged while FD is already engaged in ALT mode at the FCU-selected altitude, the autopilot :
· acquires and holds the FCU altitude if present altitude is within 250 feet of it, or
· commands a level-off if present altitude is more than 250 feet from the FCU altitude.



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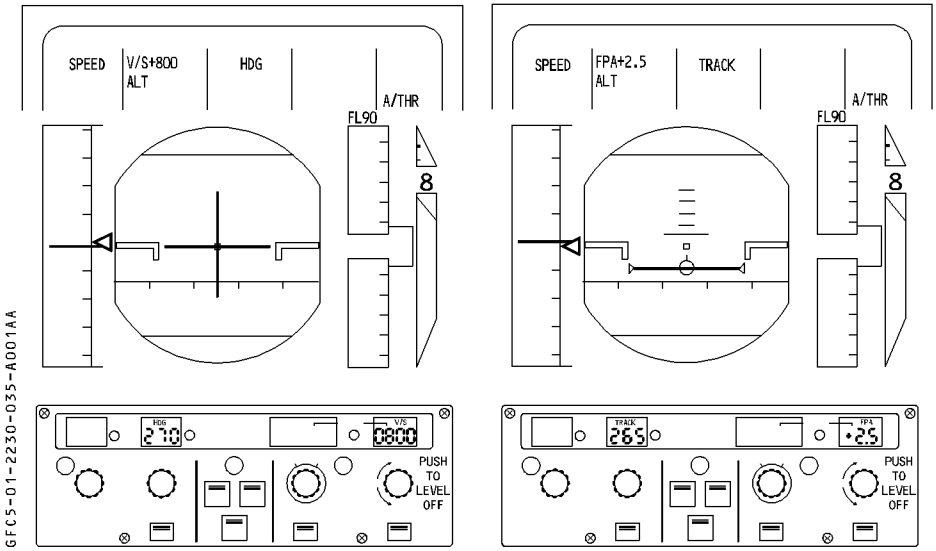
R VERTICAL SPEED MODE — FLIGHT PATH ANGLE MODE (V/S - FPA)

The V/S - FPA is a selected mode. It acquires and holds the vertical speed or the flight path angle displayed in the V/S - FPA window of the FCU.
The HDG V/S TRK FPA pushbutton on the FCU allows the pilot to select either type of reference to be used for guidance and for display on the PFD.

R



ENGAGEMENT CONDITIONS

The pilot can engage the mode manually as follows :
- Pull out the V/S FPA selection knob (at least five seconds after lift-off) or push it in for an immediate level-off (V/S = 0).
- Engage the AP and/or FD if AP and FD were not engaged (basic mode of AP/FD engagement).
- Select a different altitude (more than 250 feet from present altitude) when in ALT*.
- Select a higher altitude than present altitude when in DES, OP DES mode.
- Select a lower altitude than present altitude when in CLB, OP CLB mode.

The mode engages automatically :
- five seconds after lift-off, if no other vertical mode is engaged
- upon loss of G/S* or G/S mode
- upon loss of FINAL mode
- upon loss of LOC* or LOC mode
- upon loss of NAV mode when DES mode is engaged
- upon loss of vertical flight path in DES mode

DISENGAGEMENT CONDITIONS

The pilot can disengage the V/S mode manually by :
– pulling or pushing the altitude selector knob
– initiating a go around.
It disengages automatically :
– when the aircraft reaches the FCU altitude or
– upon G/S* engagement.

GUIDANCE

The FMGC pitch mode guides the aircraft to the target V/S or FPA. The corresponding A/THR mode is SPEED or MACH. The FMA displays "V/S (FPA)".
The V/S (FPA) guidance has priority over the speed guidance. If the selected target V/S or FPA is too high (relative to the current thrust condition and speed), the FMGC will steer the aircraft to the target V/S or FPA, but the aircraft will also accelerate or decelerate. When the speed reaches the authorized limit, the V/S or FPA decreases automatically to maintain the minimum (or maximum) speed limit. (Also refer to reversion modes).

MODE REVERSIONS AND AUTOMATIC SPEED MODE PROTECTION

There are several types of mode reversions. Each one observes a specific logic that can be described as follows :

INTERACTION BETWEEN LATERAL MODES, VERTICAL MODES, AND MANAGED SPEED PROFILE

· **When NAV mode is engaged :**
The FMGS guides the aircraft along the flight plan and considers the constraints attached to the F-PLN waypoints. As a result, managed CLB and DES modes are available.

· **When NAV mode is not engaged :**
The FMGS considers that the flight plan is not followed, and ignores all speed and altitude contraints linked to the flight plan waypoints. As a result, the managed vertical CLB and DES modes are not available. The managed SPD profile disregards the speed constraints.

As a consequence : When NAV mode disengages (manual or automatic)
– CLB mode, when engaged, reverts to OPEN CLB.
– DES mode, when engaged, reverts to V/S mode on current value.
– Speed and altitude constraints are disregarded (but speed limit is retained).
When OPEN CLB or V/S engages following the reversion, the lateral mode is boxed white for 10 seconds. The vertical mode is boxed white.
If disengagement of the NAV mode is not confirmed by one of the following actions within 5 seconds :
· New FCU altitude target
· Level-off
· V/S selection
Then a triple click aural warning sounds. The white box flashes around the vertical mode for 10 additional seconds.

MODE REVERSION DUE TO FCU ALTITUDE CHANGE

1. When an OPEN mode is engaged, the aircraft climbs or descends towards the altitude set on the FCU. If the pilot sets the FCU altitude to a target not compatible with the active open mode, a mode reversion occurs and V/S (or FPA) engages on current V/S (or FPA). This reversion applies to CLB, OP CLB, DES, OP DES.
   e.g. : Reversion from OP CLB to V/S

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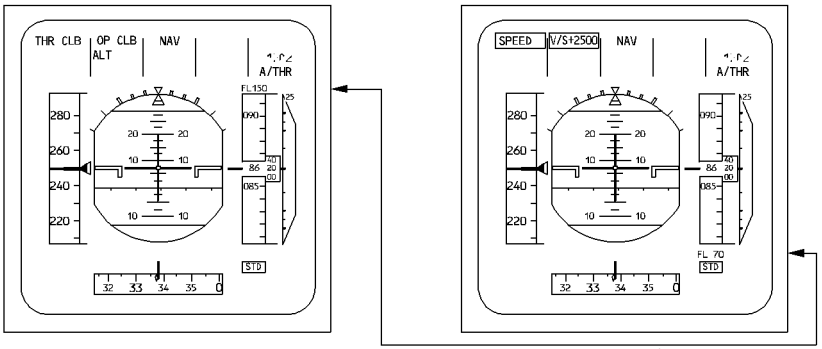

FCU ALTITUDE CHANGE FROM FL150 to FL70

2. If ALT* being engaged, the target altitude is changed of any value greater than 250 feet, V/S (or FPA) engages on current V/S (or FPA).
   Also Refer to mode reversion table.

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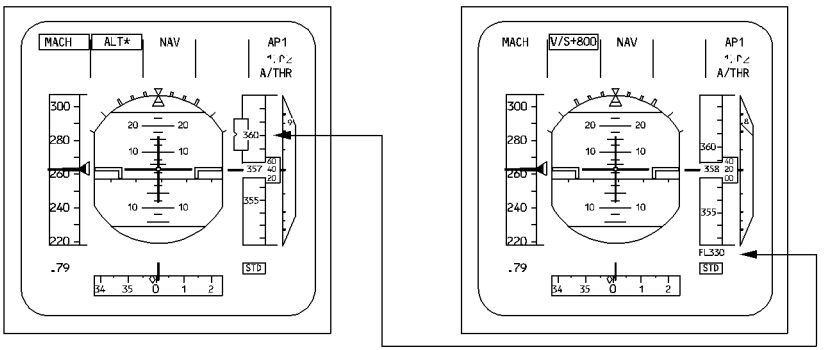


FCU ALTITUDE CHANGE FROM FL360 TO FL330

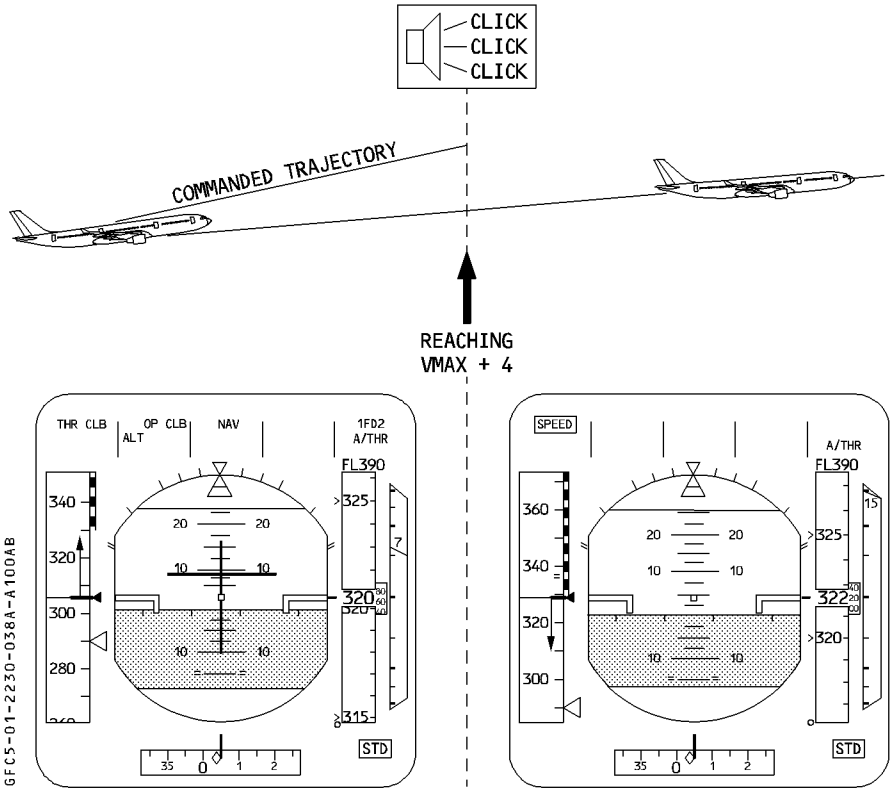
If within 5 seconds after the reversion to V/S (or FPA) the pilot does not confirm the altitude target change by
– pulling the ALT knob, or
– setting a new V/S (or FPA) target, or
– pushing the ALT pushbutton on the FCU,
a triple click sounds, and the V/S (or FPA) is boxed white for 10 additional seconds.

AUTOMATIC SPEED MODE PROTECTION

FDs are engaged in an OPEN mode in climb with AP not engaged

If FDs are engaged in CLIMB, or OPEN CLIMB mode, and the pilot does not follow the FD bars to maintain the commanded climb (pitch too low and autothrust in maximum climb thrust), the aircraft accelerates.

Both FDs disengage when VMAX+4 is reached (VMAX being VMO, VLE or VFE). If the A/THR is active, it reverts to SPEED mode and reduces the thrust to recover the speed
R target. A triple click aural warning sounds.

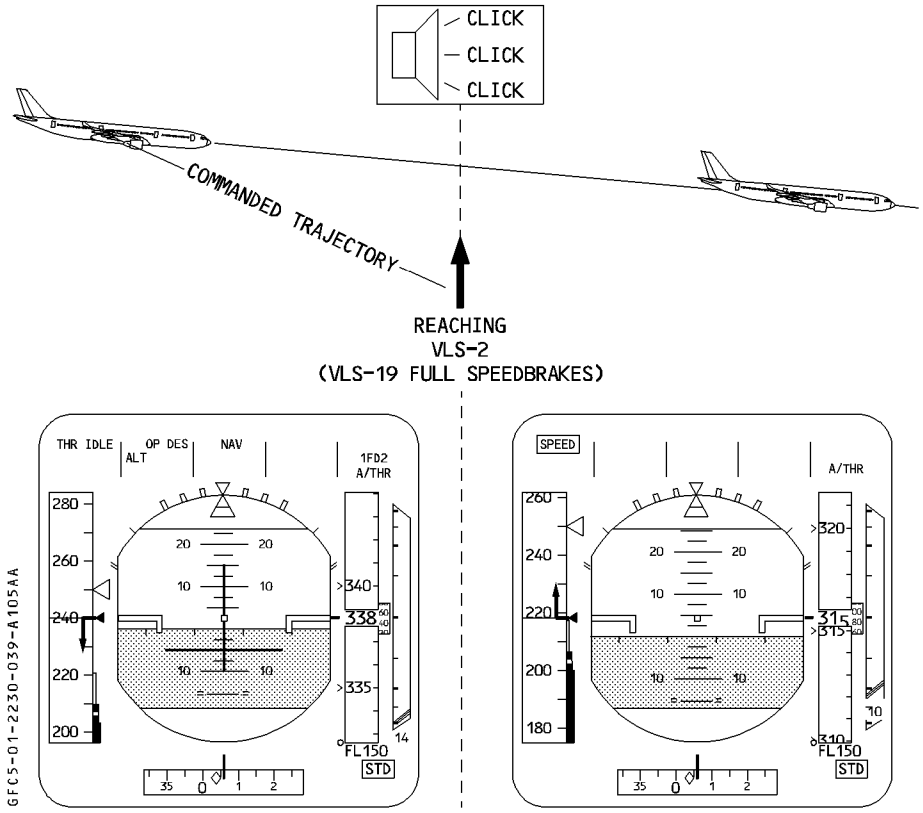


AUTOMATIC SPEED MODE PROTECTION

FDs are engaged in an OPEN mode, in descent with the AP not engaged

If the FDs are engaged in DES or OP DES mode and, if the pilot does not follow the FD bars
R to maintain the commanded pitch, the aircraft decelerates (insufficient descent rate and
R idle thrust).
R If the airspeed reaches VLS-2, both FDs disengage. (If speedbrakes are extended, the FDs
R disengage between VLS-2 and VLS-19, depending on the position of the speedbrakes.)
The A/THR, if active, reverts to SPEED mode upon FD bars disengagement, and increases thrust to recover the speed target. A triple-click aural warning sounds.

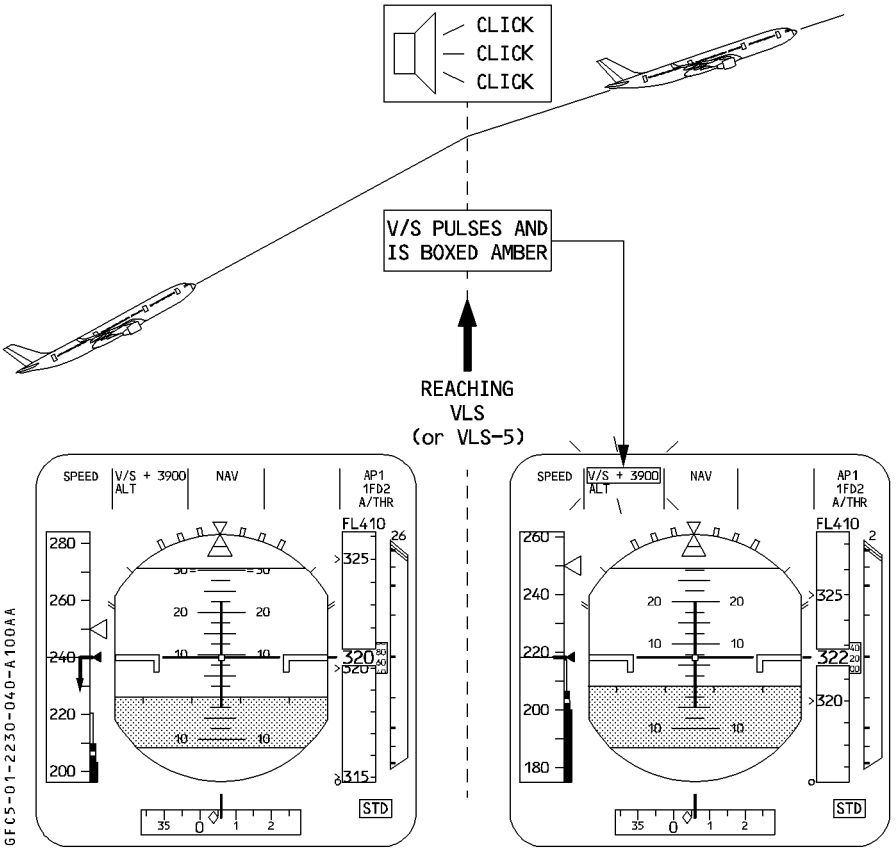
R



AUTOMATIC SPEED PROTECTION IN V/S (or FPA) MODE

R **In climb**

R When climbing with V/S mode engaged : If the selected V/S value is excessive (with
R regards to thrust and speed), the FMGS maintains the V/S target, but the airspeed
R decreases. When reaching VLS (or VLS - 5, if the speed target is VLS), the AP temporarily
R abandons the V/S target, and automatically decreases the vertical speed to maintain VLS.
R The same applies, if FPA mode is used with an excessive FPA target.
R



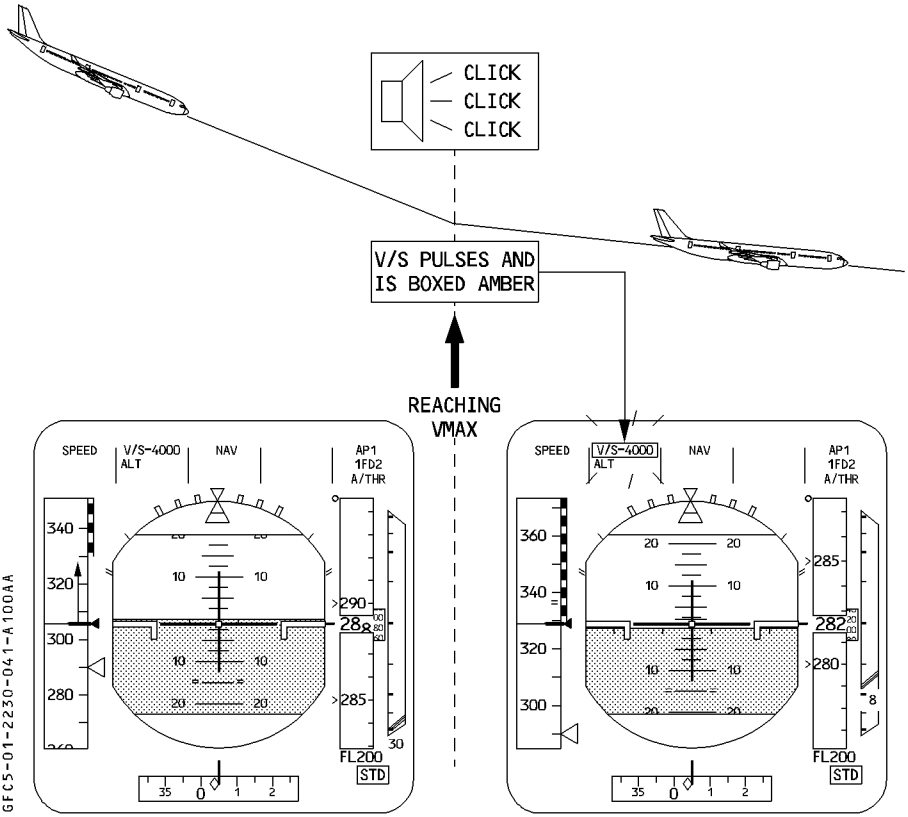
R V/S mode remains engaged.
R On the FMA, the V/S target is boxed with a flashing amber rectangle, and the V/S value
R pulses. Besides, an aural triple click is generated.

R *Note : When flying with FD bars only (AP OFF), the FMGS adjusts the pitch bar so that VLS*
R *is maintained. However, no triple click is generated and the V/S target display on*
R *the FMA remains unchanged.*

AUTOMATIC SPEED PROTECTION IN V/S (or FPA) MODE

R **In descent**

R When descending with V/S mode engaged : If the selected V/S value is excessive (with
R regards to thrust and speed), the FMGS maintains the V/S target, but the airspeed
R increases. When reaching VMAX (VMO or VLE in clean, or VFE + 4 knots), the AP
R temporarily abandons the V/S target, and automatically decreases the vertical speed to
R maintain VMAX.
R The same applies, if FPA mode is used with an excessive FPA target.
R



R V/S mode remains engaged.
R On the FMA, the V/S target is boxed with a flashing amber rectangle, and the V/S value
R pulses. Besides, an aural triple click is generated.

R *Note : When flying with FD bars only (AP OFF), the FMGS adjusts the pitch bar so that*
R *VMAX is maintained. However, no triple click is generated and the V/S target*
R *display on the FMA remains unchanged.*

MODE REVERSIONS

Reversion due to FCU ALTITUDE changes

CONDITIONS	ACTION	CONSEQUENCE
OP CLB engaged CLB engaged	FCU-selected ALT set below a/c altitude	V/S–FPA engages on current V/S–FPA
OP DES engaged DES engaged	FCU-selected ALT set above a/c altitude	
ALT* active	FCU-selected ALT modification (greater than 250 ft)	

Reversion due to the loss of NAV mode

CONDITIONS	EVENT	CONSEQUENCE
CLB engaged	Loss of the lateral managed mode: NAV	OP CLB engages
DES engaged		V/S engages

R **SPEED PROTECTION, when FD orders are not followed by the crew (AP NOT engaged)**

R

CONDITIONS	EVENT	CONSEQUENCE
· FD engaged only (no AP) and · OP DES or DES engaged · A/THR active (IDLE thrust)	IAS = VLS – 2 (if speedbrakes are extended between VLS-2 and VLS-19)	FD bars disappear. If A/THR active, automatic engagement of SPEED mode on the A/THR. Thrust increases, and the speed is regained.
· FD engaged only (no AP) and · OP CLB or CLB engaged · A/THR active (CLIMB thrust)	IAS = VMAX + 4 VMAX = VFE or VLE or VMO/MMO	FD bars disappear. If A/THR active, automatic engagement of SPEED mode on the A/THR. Thrust increases, and the speed is regained.

R **SPEED PROTECTION due to excessive V/S**

R

CONDITIONS	EVENT	CONSEQUENCE
· Excessive V/S or FPA selected in climb	IAS = VLS (or VLS-5, if target = VLS))	The selected V/S (or FPA) target is temporarily abandoned to maintain VLS in climb or VMAX in descent.
· Excessive V/S or FPA selected in descent, and · Clean configuration	IAS = VMAX	
· Excessive V/S or FPA < 0 selected in descent and · Configuration other than clean	IAS = VMAX	

Enhanced mode reversion alertness

The following sequences or mode reversions are highlighted by a triple click :

- V/S selection in ALT*
- SPD selection in SRS
- CLB to OP CLB upon lateral crew action while climbing toward a constraint
- ALT* to V/S when upon ALT target change
- FD disengagement in OPEN modes
- Alerting FMA display when V/S-FPA target is not held
- CLB to OP CLB reversion upon profile loss
- Automatic FD reengagement in basic mode
- DES to V/S upon flight plan loss or upon no lateral crew action
- FINAL DES to V/S upon NAV loss
- Reversion to V/S when selected ALT crosses the current altitude
- Automatic FD reengagement in basic lateral mode
- NAV to HDG upon NAV loss

AP/FD COMMON MODES

GENERAL

These modes are called "common" because they are related to both the lateral and the vertical axes.
The AP/FD common modes are :
– On takeoff : Runway/Runway track associated to SRS vertical modes.
– In approach : ILS approach (LAND) or non-ILS approach (FINAL APP).
– In Go-around : Go-Around Track associated to SRS vertical modes.
These modes are engaged simultaneously on both axes.

<table>
<tr><th colspan="2">COMMON MODES</th><th>VERTICAL</th><th>LATERAL</th></tr>
<tr><td colspan="2">TAKEOFF</td><td>SRS</td><td>RWY
RWY TRK</td></tr>
<tr><td rowspan="3">APPROACH MODES</td><td rowspan="2">ILS APPROACH</td><td>G/S*
G/S</td><td>LOC*
LOC</td></tr>
<tr><td colspan="2">LAND, FLARE,
ROLL OUT</td></tr>
<tr><td>NON ILS APPROACH</td><td>FINAL</td><td>APP NAV</td></tr>
<tr><td colspan="2">GO AROUND
(GA)</td><td>SRS</td><td>GA TRK</td></tr>
</table>

TAKEOFF

Takeoff mode combines the SRS (Speed Reference System) vertical mode with the RWY lateral mode.
Both are simultaneously engaged, but may be disengaged separately.
Takeoff mode is available :
– During the takeoff run and initial climb for FD bars guidance.
– Five seconds after lift-off for AP use.

SRS (SPEED REFERENCE SYSTEM)

The SRS mode controls pitch to steer the aircraft along a path in the vertical plane at a speed defined by the SRS guidance law.

– **Engagement conditions**

The SRS mode automatically engages when the thrust levers are set to the TOGA or FLX/MCT detent, or a derated level (◁), providing :

· V2 has been inserted in the MCDU PERF TO page. If V2 has not been inserted, V/S mode engages 5 seconds after lift off on the current V/S value.
· The slats are extended.
· The aircraft has been on the ground for at least 30 seconds.

– **Disengagement conditions**

The SRS mode disengages :

R · Automatically, at the acceleration altitude (ACC ALT), or if ALT* or ALT CST* mode
R engages (above 400 feet RA).
R · If the crew engages another vertical mode.
R · If the crew selects a speed while in SRS mode : SRS reverts to OP CLB mode, and a
R triple click aural warning is heard.

R *Note : In Engine Out conditions, the SRS mode does not automatically disengage at EO*
R *ACC ALT. Refer to Engine Out procedures.*

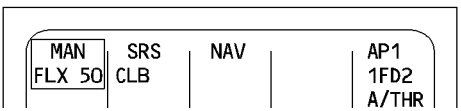
– **Guidance**

In SRS mode, the aircraft maintains a speed target equal to V2 + 10 knots in normal engine configuration. When the FMGS detects an engine failure, the speed target becomes the highest of V2 or current speed, limited by V2 + 15 knots.

The SRS guidance law also includes :

· Attitude protection to reduce aircraft nose-up effect during takeoff (17.5° or 22.5° maximum in case of windshear).
· Flight path angle protection that ensures a minimum climb slope of 0.5°.
· A speed protection limiting the target-speed to V2 + 15 kt.

Note : If during takeoff the pilot inadvertently sets an altitude on the FCU below the current altitude, the aircraft will remain in SRS mode until the pilot takes some other action.



Typical FMA at takeoff with a Flex temperature

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RUNWAY (RWY)

The RUNWAY mode has two submodes :

· RWY mode, which gives lateral guidance orders during takeoff roll and initial climb out (up to 30 feet RA) if a LOC signal is available

· RWY TRK mode, which gives lateral guidance on the track the aircraft was flying at mode engagement (at 30 feet RA)

– **Engagement conditions**

The RWY engagement conditions are :

– The conditions required for SRS mode engagement :
  · V2 is inserted in the MCDU PERF TO page
  · slats are extended.
  · the aircraft has been on ground for at least 30 seconds.
– The aircraft is receiving a LOC signal and LOC deviation is less than 1/2 dot.
– The aircraft heading is within 20° of the ILS related course.
– The ILS course is identical to the runway heading of the origin airport as selected for the active flight plan, if any.

The RWY TRK mode engages automatically at 30 feet (RA) if NAV mode does not engage (NAV not armed prior to takeoff).

– **Disengagement conditions**

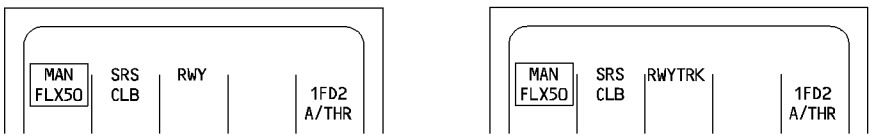
RWY mode disengages if :

– The LOC signal is lost below 30 feet RA or the aircraft heading and the runway heading differ by more than 20°.
– Another lateral mode is engaged.

Note : If the takeoff runway has no ILS or if an ILS back course has been selected RWY mode is not available and the PFD does not display the yaw bar nor RWY on FMA.

– **Guidance**

– The RWY mode uses the LOC signal to guide the aircraft on the runway centerline while the aircraft is on the ground.
  The PFD displays the FD yaw bar.
  The FMA displays RWY.
– The RWY TRK mode guides the aircraft on the track the aircraft was flying at mode engagement.
  The FD displays the conventional guidance bar. The FMA displays "RWY TRK".



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Typical FMA with RWY mode engaged.

APPROACH

The aircraft can fly two different types of approaches :
– ILS (or LOC) approaches
– Non-ILS approaches (VOR/DME, VOR, NDB, RNAV)
The pilot uses an ARRIVAL lateral revison to insert these approaches into the flight plan. The APPR pushbutton on the FCU is used to arm engage the guidance modes related to the approach inserted into the flight plan.
– For an ILS approach, the guidance modes are LOC and G/S.
– For a non-ILS approach, the guidance modes are APP NAV and FINAL (FINAL APP).

ILS APPROACH

The ILS approach mode includes the following modes :

VERTICAL MODE	LATERAL MODE
G/S* (capture) G/S (track)	LOC* (capture) LOC (track)
COMMON MODES LAND - FLARE - ROLL OUT	

The sequencing of these modes is automatic once the pilot has pushed the APPR pushbutton and the conditions for engagement are met.

Selection

The ILS approach is selected when the approach pushbutton of the FCU is pressed and
– an ILS approach or a runway only or no approach is inserted in the Flight Management flight plan (arrival page), and an ILS frequency is set in on the MCDU, or
– both radio management panels are set to NAV and each has the ILS frequency and course set in.

Note : The ILS frequency will be automatically tuned when the direct distance to destination is below 300 NM.

Check approach guidance message

If the pilot inserts a non-ILS approach into the flight plan and then uses the RAD NAV page to manually tune in an ILS, the MCDU displays "CHECK APPR GUIDANCE". This message is a reminder that the available APPR guidance modes are APP NAV and FINAL.

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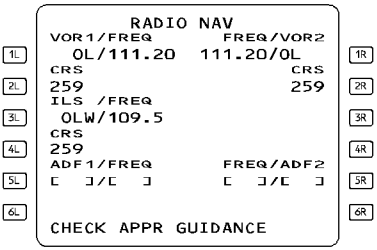


Example : OLW was manually entered on the RAD NAV page although a VOR approach is selected in the flight plan.

Arming conditions of LOC and G/S modes

The pilot arms the (ILS) APPR mode (LOC and G/S in blue on the FMA) by pushing the APPR pushbutton on the FCU, provided that :

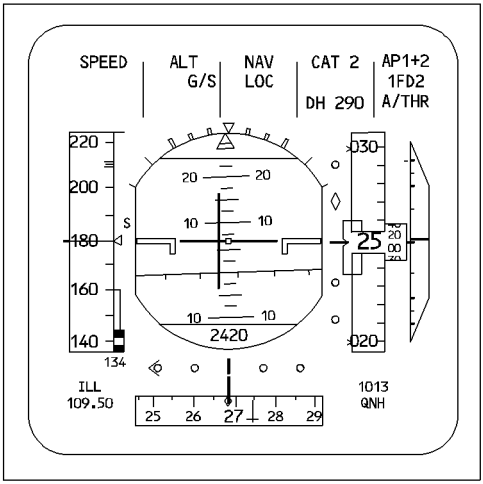
· An ILS approach is selected,
· The aircraft is above 400 feet RA,
· The ILS is available,
· Go-around or takeoff or final mode is not engaged,
· ILS frequency and course are identically set on both receivers.

– LOC and G/S blue are displayed on the FMAs. Both modes will automatically engage when conditions are met.
– Second autopilot may be engaged.
– Current landing capability is displayed on the FMAs.

Disarming conditions of LOC and G/S modes

LS APPR mode is disarmed if the aircraft is above 400 feet and one of the following conditions is met :

– When the pilot presses the APPR pushbutton, both the LOC and the G/S modes disarm.
  · The HDG/TRK mode engages, if the LOC mode was engaged and the V/S or FPA mode engages if the G/S mode was engaged.
– When the pilot presses the LOC pushbutton, only the G/S mode disarms and the V/S or FPA mode engages, if the G/S mode was engaged.
– The pilot pulls the HDG/TRK selector knob.
– The pilot engages the go-around mode.



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LOC AND G/S ARMED

Engagement conditions of LOC and G/S modes

When ILS capture conditions are fulfilled :

– LOC* mode engages, and

– G/S* mode engages. No radio altimeter validity is required with this standard for G/S engagement.

The FMA displays "LOC*", or LOC* and G/S* in green.

Nevertheless, the G/S* mode cannot engage, if :

– LOC* mode is not engaged, or

– The aircraft is above the glide path and its trajectory does not cross the ILS G/S beam.

When the aircraft is established on LOC axis, the LOC mode engages.

When the aircraft is established on the G/S axis, the G/S mode engages.

The FMA displays "LOC" and "G/S" in green. The AP/FD guides the aircraft along the G/S down to 30 feet, and along the LOC during the flare and rollout.

R *Note : G/S* or G/S may engage at altitudes above the operative range of the radio altimeters (8000 feet for TRT, 5000 feet for Collins radio altimeter), but the landing capability displayed on the FMA will reflect the lack of radio altimeter validity (CAT 1 only) until the RAs become active.*

If the radio altimeters fail : LOC, G/S and AP/FDs will disengage and FDs will reengage on basic modes.

Disengagement conditions of LOC and G/S modes

If the aircraft is above 400 feet, the (ILS) APPR mode disengages when the :

- Pilot presses the APPR pushbutton, the system reverts to basic modes (HDG V/S or TRK FPA).
- Pilot presses the LOC pushbutton, the LOC mode remains engaged. The system reverts to V/S FPA, if G/S was engaged.
- Pilot pulls out the HDG/TRK selector knob, the system reverts to basic modes HDG V/S or TRK FPA.
- Go-around engages.
- LOC or G/S signal has been lost for 7 seconds or more above 200 feet RA. AP/FDs disengage and FDs reengage in basic modes (HDG V/S or TRK FPA).

Disengagement conditions of G/S only

- The pilot pulls out the V/S FPA selector knob. LOC mode remains engaged but G/S mode disengages, and V/S or FPA engages.

R - The pilot pushes or pulls the ALT selector knob. LOC mode remains engaged and the mode selected by the crew engages, as a function of the FCU-selected altitude.

LOC capture assistance function

In NAV mode, and when within 20NM of the destination runway, the aircraft is guided with a track angle of 20° from the LOC axis. This helps the aircraft intercept and capture the LOC beam. When the ILS frequency or the ILS ident entered on the RAD NAV page differs from the ILS of the destination runway entered in the Flight Plan :

- The aircraft loses the LOC capture assistance function.
- The "RWY/ILS MISMATCH" message is displayed on the scratchpad.
- The pilot should select HDG mode to perform the LOC capture.

Note : There is no G/S capture assistance. The pilot will ensure that the aircraft's flight path intercepts the G/S beam for G/S engagement.*

LAND MODE

Engagement conditions

LAND mode automatically engages when the LOC and G/S modes are engaged and the aircraft is below 400 feet RA. The FMA displays "LAND", indicating that LOC and G/S are locked. No action on the FCU will disengage LAND mode. FLARE and ROLL OUT modes will successively engage.

Disengagement conditions

LAND mode disengages :

- Upon engagement of the go-around mode,
- If the pilot presses the APPR pushbutton when the aircraft has been on ground for at least 10 seconds with the autopilot disconnected.

Note : When LAND is not displayed on the FMA at/or slightly below 400 feet, the landing capability degrades to CAT 1 and an aural triple click is generated. Autoland is not allowed with CAT 1 displayed on the FMA.

FLARE MODE

R Once the aircraft reaches approximately 55 feet RA (the precise value is a function of V/S),
- FLARE mode engages.
- The FMA displays "FLARE" in green.

R Around 45 feet RA, the AP/FD aligns the yaw axis with the runway centerline, and the
R aircraft starts to flare on the pitch axis. If the autothrust is active, thrust is automatically reduced to IDLE during flare (refer to A/THR RETARD mode).
When both AP/FDs are disengaged, FLARE mode disengages.
After main landing gear touchdown, the autopilot (if engaged) sends a nose down order.

Align sub-mode

R Align is a sub-mode of LAND that lines up the aircraft's axis with the ILS course at
R approximately 45 feet. Align sub-mode is not displayed to the crew.

Note : Align sub-mode is often known as "decrab" function.

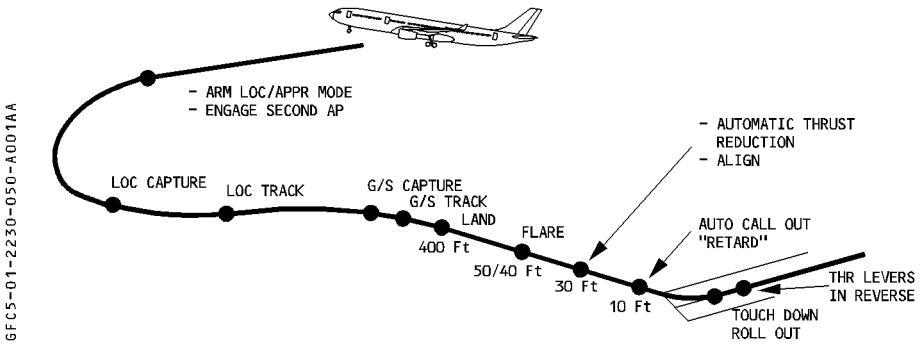
ROLL OUT MODE

At touchdown, ROLL OUT mode engages and guides the aircraft along the runway centerline. The FMA displays "ROLL OUT" in green, and the PFD displays the yaw bar and no FD bars.

SPEED CONTROL

R The autothrust, when active, controls speed. The approach speed target (VAPP) is either
R managed by the FMGS or selected by the crew :
R – When managed, the speed target is computed by the FMGS and may be modified by
R the crew through the MCDU. At 700 feet RA, the current speed target value is
R memorized by the autothrust, to ensure stabilized speed guidance, even if Flight
R Management fails. Below 700 feet, any new VAPP or WIND entry in the MCDU has no
R effect on the speed target.
R – When selected, the autothrust always targets the speed selected on the FCU.

TYPICAL ILS APPROACH



AUTOLAND WARNING LIGHT

The following situations, when occuring below 200 feet RA with the aircraft in LAND mode, trigger the flashing AUTOLAND red warning and a triple click aural warning :
– Both APs OFF below 200 feet RA
– Excessive deviation in LOC (1/4 dot above 15 feet RA) or GLIDE (1 dot above 100 feet RA). In addition, LOC and GLIDE scales flash on the PFD.
– Loss of LOC signal above 15 feet or loss of GLIDE signal above 100 feet. In addition, the FD bars flash on the PFD. The LAND mode remains engaged.
– The difference between both radio altimeter indications is greater than 15 feet.

LANDING CAPABILITIES

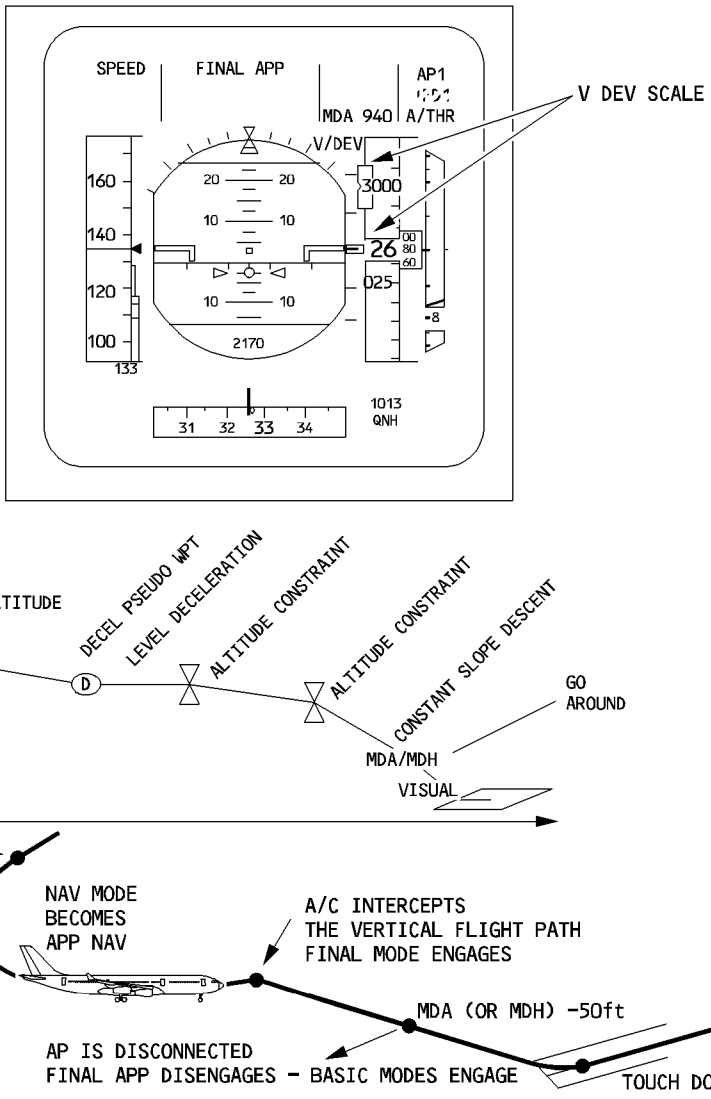
Each FMGC computes its own automatic landing capability according to the availability of computers or sensors or functions. (Refer to 4.05.70).
The FMA displays "CAT1", "CAT2", "CAT3 SINGLE" or "CAT 3 DUAL" messages as soon as the APPR pushbutton is pushed in to arm ILS approach modes.

NON PRECISION APPROACH MODE

This mode guides the aircraft laterally and vertically down to the Minimum Descent Altitude (MDA) or Minimum Descent Height (MDH) along the final descent profile computed by the FMGS.

This mode is used to fly a NON ILS approach (VOR, VOR/DME, NDB, RNAV...) as inserted into the flight plan.

R



A non precision approach includes the following managed modes :
- APP NAV mode for lateral guidance,
- FINAL mode for vertical guidance.

SELECTION

R The non precision approach guidance modes are available, if a non-precision approach
R (VOR, VOR/DME, NDB, RNAV) has been inserted in the active flight plan.

ARMING CONDITIONS

The crew arms APP NAV and FINAL modes by pressing the FCU's APPR pushbutton, provided all of the following conditions are met :
- The aircraft is above 400 feet AGL,
- The active flight plan is valid (lateral and vertical profile),
R - A non precision approach has been selected in the active flight plan,
- GA mode is not engaged.

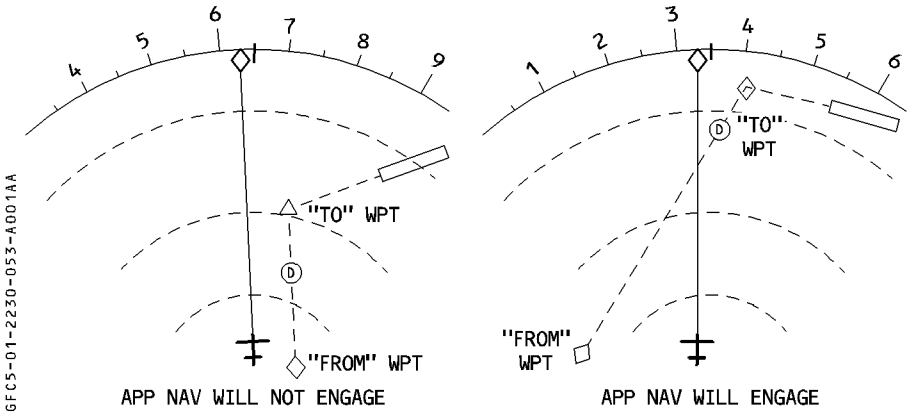
The FMA displays "FINAL" and "APP NAV" in blue.
If NAV mode was already engaged, APP NAV engages immediately.

DISARMING CONDITIONS

FINAL and NAV modes are disarmed, if the pilot :
- Presses the APPR pushbutton, or
- Presses the LOC pushbutton (thus arming LOC mode), or
- Engages GO AROUND mode.

ENGAGEMENT CONDITIONS

APP NAV and NAV modes engage under the same conditions :
If NAV mode was engaged, APP NAV engages immediately. If HDG/TRK is engaged, APP NAV engages when the intercept conditions are met (the aircraft's heading or track intercepts the flight plan's active leg).
FINAL mode engages, if :
- The APPR phase is active and the deceleration point has been sequenced, and
- APP NAV mode is engaged, and
- The crosstrack error is less than 1.5 NM, and
- FINAL mode is armed, and
  - The aircraft intercepts a descending leg of the vertical flight path, or
  - In V/S (FPA) or OP DES mode, the aircraft intercepts a level-off segment of the vertical flight profile, with a selected altitude different from this level-off segment.



DISENGAGEMENT CONDITIONS

The FINAL and APP NAV modes disengage :

- If the pilot pushes the APPR pushbutton (HDG V/S or TRK FPA mode engages)
- If the pilot pushes the LOC pushbutton (LOC mode arms if an ILS is selected otherwise HDG V/S or TRK FPA mode engages)
- R If the pilot pulls out the HDG TRK selector knob, the FMGS reverts to basic modes HDG R V/S or TRK FPA
- R If the pilot engages V/S or FPA mode, FINAL APP NAV disengages and basic modes HDG R V/S or TRK FPA engage.
- Automatically at MDA (or MDH) – 50 feet or 400 feet AGL if no MDA/MDH entered.
- When the GO AROUND mode engages.

GUIDANCE

The FINAL mode guides the aircraft on the vertical profile down to the Minimum Descent Altitude (or the Minimum Descent Height if the aircraft has the QFE pin program installed)
The FINAL mode does the following :

- displays a vertical deviation scale (± 200 feet) on the Primary Flight Display and a VDEV symbol showing deviation from descent path.
- anticipates leaving the altitude selected by the Flight Control Unit when the aircraft reaches the Continue Descent symbol (arrow blue on the navigation display)
- gives precise vertical guidance on the descent and final path with an internal vertical speed limitation to avoid excessive V/S.

If the autopilot is engaged while you are using the APP NAV/FINAL modes, it disengages automatically at MDA (or MDH) – 50 feet.
FD modes revert to basic HDG-V/S or TRK-FPA.

WARNING

A triple-click aural warning sounds, if the GPS PRIMARY function is lost during a non precision approach.

GO AROUND (GA)

Go-around mode combines the Speed Reference System (SRS) vertical mode with the Go-Around Track (GA TRK) lateral mode.

ENGAGEMENT CONDITIONS

Setting at least one thrust lever to the TOGA detent engages both SRS/GA TRK modes, if:
- The flaps lever is at least in position 1, and
- The aircraft is in flight, or
- The aircraft has been on ground for less than 30 seconds (AP disengages and can be re-engaged 5 seconds after liftoff).

FD bars are automatically restored in SRS/GA TRK modes.
If FPV/FPD was previously selected, it reverts to FD bars.
The FMA displays "SRS" and "GA TRK" in green.

DISENGAGEMENT CONDITIONS

- The SRS mode disengages :
  - Automatically, at the go-around acceleration altitude (GA ACC ALT) or if ALT* or ALT CST* mode engages (above 400 feet RA).
  - If the flight crew engages another vertical mode.
  - If the flight crew selects a speed while in SRS mode : SRS reverts to OP CLB mode and a triple-click aural warning is heard.

    Note : In Engine Out conditions, the SRS mode does not automatically disengage at EO ACC ALT. Refer to Engine Out procedures.

- GA TRK disengages when the pilot engages another lateral mode above 100 feet RA. In dual AP configuration, disengagement of the Go-around mode, on either axis, causes AP2 to disconnect.

GUIDANCE

- The SRS law maintains the current speed at Go–around engagement, or VAPP, whichever is higher. Nevertheless, the SRS speed is limited to VLS + 25 kt in normal engine configuration and VLS + 15 kt in engine out. When the SRS mode disengages, the target speed becomes Green Dot speed.
- GA TRK mode guides the aircraft along the current track at Go-around initiation.

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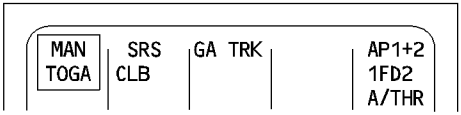


Typical FMA in Go Around

AUTOTHRUST

GENERAL

The autothrust (A/THR) is a function of the FMGS, it includes 2 independent A/THR commands, one per FMGC. Each one is able to control the thrust of both engines
R simultaneously through 2 Engine Interface Units and 2 Electronic Engine Controls (PW or
R RR engines) or 2 Engine Control Units (GE engines). Only one FMGC controls the active A/THR, it is called the master FMGC.

Thrust is controlled :

- automatically when the A/THR is active
- manually by the pilot.

The autothrust is active when the A/THR pushbutton of the FCU is lighted green and A/THR is displayed white in the FMA 5th column.

The position of the thrust levers determines whether A/THR is armed, active, or disconnected.

The autothrust system, when active :

- maintains a specific thrust in THRUST mode
- controls the aircraft speed or MACH in SPEED/MACH mode
- uses ALPHA FLOOR mode to set maximum thrust when the aircraft angle of attack exceeds a specific threshold.

The autothrust system can operate independently or with the AP/FD.

- When performing alone, A/THR always controls the speed.
- If the autothrust system is working with the AP/FD, the A/THR mode and AP/FD pitch modes are linked together. (Refer to 1.22.30 Interaction between AP/FD and A/THR modes).

  When autothrust is active, the FMGS commands the thrust according to the vertical mode logic, but uses a thrust not greater than the thrust commanded by the position of the thrust lever. For example, when the thrust levers are set at the CL (climb) detent, the autothrust system can command thrust between idle and max climb.

  The autothrust system, when armed, automatically activates if the thrust levers are moved into the active range sector. Outside of this range, thrust levers control thrust directly.

MASTER A/THR

The thrust being controlled by one A/THR only, when one AP is engaged, priority is given to the associated autothrust.

When both APs are engaged or no AP/FD engaged, A/THR 1 has the priority.

THRUST LEVERS

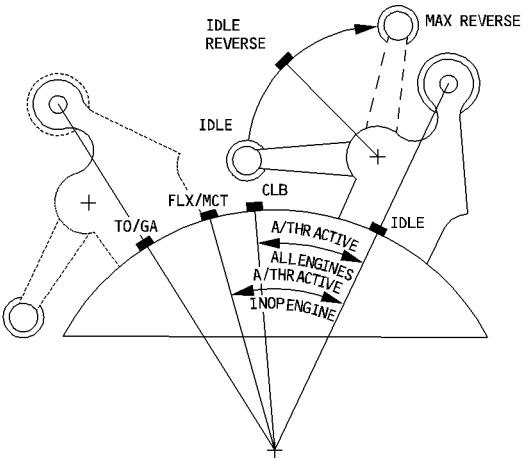
The pilot uses the thrust levers to do the following :
– Manually select engine thrust.
– Arm and activate autothrust (A/THR).
– Engage reverse thrust.
– Engage the takeoff and go around modes.

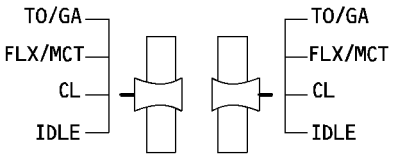
When autothrust is disconnected, the thrust levers control thrust directly : each lever position corresponds to a given thrust.

4 detents divide each of the thrust lever sectors into three segments. The detents are :

TO GA : Maximum takeoff thrust
FLX MCT : Maximum continuous thrust (or FLX at takeoff)
CL : Maximum climb thrust
IDLE : Idle thrust.

When the thrust levers are at the IDLE position, the pilot can pull the reverse levers.





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A/THR ARMING CONDITIONS

R There are a considerable number of A/THR arming conditions. The following is a list of the
R most important ones :

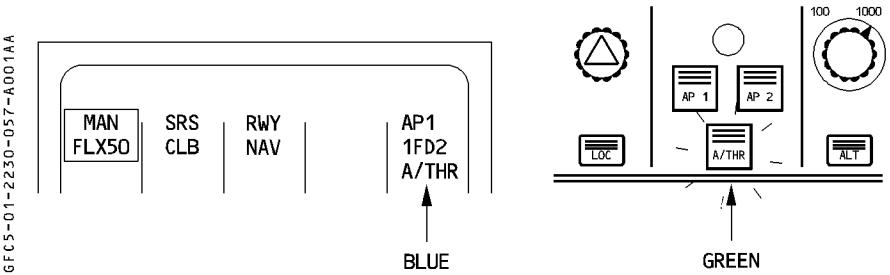
- One FMGC operative
- 2 ADIRS operative
- 2 FADECs operative
- One operative FCU channel
- One LGCIU operative
- A/THR is not manually disabled (instinctive disconnect pushbutton has not been pressed for more than 15 seconds).

The pilot arms the A/THR :

- On ground :
  - By pushing the A/THR pushbutton on the FCU when the engines are not running, or
  - By setting the thrust levers at the FLX or TOGA detent when the engines are running.
- In flight :
  - By pushing the A/THR pushbutton on the FCU while the thrust levers are out of the active range, or
  - R While A/THR is active ("A/THR" white on the FMA), by setting all thrust levers
    R beyond the CL detent or at least one lever above the MCT detent, or
  - By engaging the go around mode.

When the A/THR is armed :

- The FCU's A/THR pushbutton light comes on
- "A/THR" is displayed in blue on the FMA



Note : At takeoff, if the thrust levers are set back to idle, the A/THR disengages and cannot be rearmed until airborne.

A/THR ACTIVATION

The A/THR is active when it controls thrust or speed. The position of the thrust lever determines the maximum thrust that the A/THR system can command (except in α-floor condition).

The A/THR being armed, is activated :

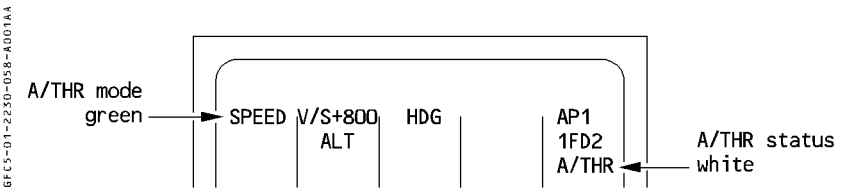
R – when the pilot sets both thrust levers between the CL and IDLE detents (two engines
R operative)
R – when the pilot sets one thrust lever between the MCT and IDLE detents (one engine
R inoperative).
R The A/THR being disconnected, is activated when the pilot pushes the FCU pushbutton
R while the thrust levers are within the active range, including IDLE position

R *Note : When the pilot sets both thrust levers to IDLE position, the A/THR disconnects but,*
R *if the pilot pushes the A/THR pushbutton of the FCU, he will simultaneously arm and*
R *activate the autothrust. Due to the thrust levers position, IDLE thrust will be*
R *maintained.*

– when ALPHA FLOOR is activated, regardless of the initial status of A/THR and the position of the thrust levers.

When A/THR is active :

– The A/THR pushbutton on the FCU lights up.
– The FMA displays A/THR mode in green in the first column and A/THR in white in the fifth column.



EFFECTS OF THRUST LEVER MOVEMENT WHILE A/THR IS ACTIVE

R – When both thrust levers are set above the CL detent (both engines operative) or one thrust lever is set above MCT (one engine operative) the A/THR reverts from active to armed. "A/THR" turns to blue on the FMA and the thrust levers control the thrust directly. The FMA displays "MAN THR" white in its first column.
The thrust levers provide the crew with an immediate increase of thrust when both thrust levers are pushed above the CL detent (2 engines) or the active thrust lever above the MCT detent (one engine operative).

R – When both thrust levers are set below the CL detent (both engines operative) or one thrust lever is set below MCT (one engine operative), a repeating warning (amber caution, single chime, ECAM message "A/THR LIMITED") is activated every 5 seconds until the pilot moves the levers back into the detent. "THR LVR" green is displayed on the FMA.
"LVR CLB" (both engines operative) or "LVR MCT" (one engine operative) flashes white in the first column of the FMA.
This device reminds the crew that the normal operating position of the thrust levers, when A/THR is active, is the CL detent (2 engines) or the MCT detent (one engine operative).

R – When one thrust lever is in the CL detent and the other one out of the detent, the "LVR ASYM" amber message comes up until both levers are set in the CL detent (only with both engines operative).

A/THR DISCONNECT

When the A/THR is disconnected, it is neither armed nor active.
The A/THR can be disconnected in two ways :

* Standard disconnection
  – The pilot pushes the instinctive disconnect pushbutton on the thrust levers (which immediately sets the thrust corresponding to the lever positions) or
  – The pilot sets both thrust levers to IDLE detent.
* Non-standard disconnection
  – The pilot pushes the A/THR pushbutton on the FCU while A/THR is armed/active, or
  – The system loses one of the arming conditions.

R **Below 100 feet radio altitude**

When the radio altitude is below 100 feet and the pilot sets both thrust levers above the CL detent or one above the MCT detent, the autothrust will disconnect. It will rearm automatically when at least one of the thrust levers is set to TOGA.
If the PF set thrust levers above CL detent but below TOGA and come back to CL detent, the A/THR will disconnect and remain disconnected. As a result, the thrust will increase up to CLIMB thrust. The crew has to manually set the appropriate thrust for landing (or go around).

CAUTION

R If the pilot pushes and holds one instinctive disconnect pushbutton for more than 15
R seconds, the A/THR system is disconnected for the remainder of the flight. All A/THR
R functions, including ALPHA FLOOR, are lost and they can only be recovered at the
R next FMGC power-up (on ground).

THRUST LOCK FUNCTION

The THRUST LOCK function is activated when the thrust levers are in the CL detent (or in
R the MCT detent with one engine-out), and the pilot pushes the FCU A/THR pushbutton, or
R the A/THR disconnects due to a failure.
R The thrust is locked at its level prior to disconnection. Moving the thrust levers out of the
R CL or MCT detent suppresses the thrust lock, and reverts to manual control.
R When the thrust lock function is active :
- "THR LK" flashes amber on the FMA.
- ECAM "ENG THRUST LOCKED" flashes every five seconds.
- ECAM displays "THR LEVERS..... MOVE"
- A single chime sounds and the Master Caution Light flashes every five seconds.

All warnings cease, when the pilot moves the thrust levers out of the detent.

A/THR DISCONNECT CAUTION

R The standard disconnection triggers a temporary ECAM message, and a single chime.
R The non-standard disconnection (A/THR pushbutton pressed on the FCU, or A/THR failure)
R triggers continuous visual cautions until the pilot reacts. The single chime sounds.

		A/THR DISCONNECTION	
		BY INSTINCTIVE DISCONNECT OR SETTING TWO LEVERS TO IDLE (if above 50 ft RA)	**BY OTHER MEANS**
CONSEQUENCE	MASTER CAUTION	Is on for 3 sec max	On
	ECAM MESSAGE	Amber A/THR OFF message : 9 sec maximum	Flashing "ENG THRUST LOCKED", amber AUTO FLT A/THR OFF, THR LEVERS..... MOVE (blue)
	AUDIO	Single chime	Single chime
	CLR pushbutton on ECAM CONTROL PANEL	OFF	ON
ACTION	MASTER CAUTION pushbutton	Turns off the MASTER CAUTION light, and erases ECAM message.	Turns off the MASTER CAUTION light.
	CLR puhbutton on ECAM CONTROL PANEL	No effect	Turns off the MC light and CLR pushbutton, and erases the ECAM message. Calls status.
	INSTINCTIVE DISCONNECT pushbutton	Turns off the MASTER CAUTION light, and erases the ECAM message.	Turns off the MASTER CAUTION light.
ECAM STATUS MESSAGE		NO	YES

A/THR MODES

Except in takeoff and go around situations, normal operation of the A/THR system requires the thrust levers to be :

- In the CL detent for the two-engine configuration. If they are not set in the CL detent, "LVR CLB" flashes white on the FMA.
- In MCT detent when in the one-engine-out configuration. If the appropriate lever is not set in the MCT detent, "LVR MCT" flashes white on the FMA.

The A/THR modes are selected automatically in conjunction with the AP/FD modes (except for ALPHA FLOOR).

R

A/THR in THRUST mode	AP/FD pitch mode maintains the speed : OP CLB - OP DES - CLB - SRS - FLARE and DES (IDLE path)
A/THR in SPEED/MACH mode	If neither AP nor FD is engaged
	If AP/FD controls a vertical path V/S-FPA-ALT*- ALT CST*-ALT-ALT CRZ-G/S* -G/S-FINAL and DES (geometric path)
A/THR in RETARD mode	Automatic landing (AP engaged in LAND mode).

THRUST mode

- In THRUST mode, autothrust commands a specific thrust level in conjunction with the AP/FD pitch mode. This thrust level is limited by thrust lever position.

FMA display	Meaning
THR MCT	The most advanced thrust lever is in the MCT detent (engine out)
THR CLB	The most advanced thrust lever is in the CL detent
THR LVR	Either thrust levers are below CL or MCT detent or at least one thrust lever is in CL detent and the other above CL detent.
THR IDLE	All engines at IDLE thrust
THR DCLB 1(2)	The most advanced thrust lever is in the CL detent and the crew has selected a derated climb.

Note : When the A/THR is armed for takeoff or go around, the FMA displays "MAN TOGA" (or "MAN FLX" or MAN DTO ◁) in white to remind the crew that the thrust levers have been positioned properly.

RETARD mode

The RETARD mode is available only during automatic landing (AP engaged in LAND mode). RETARD mode engages at approximately 40 feet RA and remains engaged after touchdown.
The A/THR commands IDLE thrust during the flare and the FMA and engine warning display show "IDLE".
If the autopilot is disengaged during the flare before touchdown, the SPEED mode replaces RETARD mode, and the pilot has to reduce thrust manually.

Note : In automatic landing, the system generates a "RETARD" callout at 10 feet RA, which prompts the pilot to move the thrust levers to IDLE in order to confirm thrust reduction. In manual landing conditions, the system generates this callout as a reminder at 20 feet RA.

SPEED/MACH mode

In SPEED/MACH mode, the A/THR adjusts the thrust in order to acquire and hold a speed or Mach target.
The speed or Mach target may be :
– selected on the FCU by the pilot
– managed by the FMGC.
When in SPEED or MACH mode, the A/THR does not allow speed excursions beyond the following limits regardless of the target speed or Mach number :
– For a selected speed target, the limits are VLS and VMAX (VMO-MMO, VFE-VLE, whichever applies).
– For a managed speed target, the limits are maneuvering speed (Green Dot, S, F, whichever applies) and maximum speed (320/.84-VFE-VLE whichever applies).
The changeover from SPEED to MACH mode is either automatically, performed by the FMGC or manually by the pilot (in selected speed target only) by pushing the SPD/MACH change-over pushbutton.
The FMA displays "SPEED" or "MACH".

MACH MODE IN CRUISE PHASE (A/THR SOFT MODE)

R When the aircraft is in ALT CRZ mode with the autopilot engaged, autothrust engaged in MACH mode, and is within a +/–3 knot range of the target speed, the autothrust soft mode engages. This mode reduces the thrust variation in cruise, specifically in light turbulence. The autothrust soft mode disengages, when the speed deviation from the target becomes too large or the target is modified ; autothrust transition from soft to basic mode may lead to transient thrust variation. This mode is inhibited with the speedbrakes extended, or with an engine-out, or when the Mach target is below 0.65.

SPEED MODE IN APPROACH PHASE

When the aircraft flies an approach in managed speed, the speed target displayed on the PFD in magenta, is variable during the approach.
This managed speed target is computed in the FMGS, using the "ground speed mini" function.

GROUND SPEED MINI FUNCTION PRINCIPLE

The purpose of the ground speed mini function is to take advantage of the aircraft's inertia, when the wind conditions vary during the approach. It does so by providing the crew with an adequate indicated speed target. When the aircraft flies this indicated speed target, the energy of the aircraft is maintained above a minimum level, ensuring standard aerodynamic margins versus stall.
If the A/THR is active in SPEED mode, it will automatically follow the speed target, ensuring efficient thrust management during the approach.
The minimum energy level is the energy level the aircraft will have at touchdown, if it lands at VAPP speed with the Tower-reported wind as inserted in the PERF APPR page.
The minimum energy level is represented by the Ground Speed the aircraft will have at touchdown. This Ground Speed is called "GROUND SPD MINI".
During the approach, the FMGS continuously computes the speed target using the wind experienced by the aircraft in order to keep the ground speed at, or above, the "Ground Speed Mini".
The lowest speed target is lower limited to VAPP, and is upper limited by VFE of next configuration in CONF 1, 2, 3 and VFE – 5 in CONF FULL.
The speed target is displayed on the PFD speed scale in magenta, when approach phase and managed speed are active. It is independent of the AP/FD, and/or ATHR engagements.
Wind is a key factor in the ground speed mini function.

TWR WIND

TWR WIND is the MAG WIND entered in the PERF approach page. It is the average wind, provided by the ATIS or the Tower. Gusts must not be inserted ; they are included in the aircraft target speed computation.

R TWR HEADWIND COMPONENT

R The TWR HEADWIND COMPONENT is the component of the MAG WIND projected on the runway axis (landing runway entered in the flight plan). It is used to compute VAPP and GS mini. . The TWR wind is the wind announced by the ATC and entered in the PERF APPR page (MAG WIND field).

R CURRENT HEADWIND COMPONENT

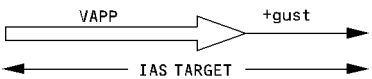
R The actual wind measured by ADIRS is projected on the aircraft axis to define the CURRENT HEADWIND COMPONENT (instantaneous headwind). The CURRENT HEADWIND COMPONENT is used to compute the variable speed target during final (IAS target).

R VAPP COMPUTATION

R VAPP, automatically displayed on the MCDU PERF APPR page, is computed as follows :
R VAPP = VLS + 1/3 of the TWR HEADWIND COMPONENT or VAPP = VLS + 5 knots, which ever is highest.
R "1/3 of the TWR HEADWIND COMPONENT" has 2 limits :
R · 0 knots as the minimum value (no wind or tailwind)
R · +15 knots as the maximum value.
R The crew can manually modify the VAPP and TWR wind values on the PERF APPR page.

R SPEED TARGET COMPUTATION

R The FMGS continuously computes a speed target (IAS target) that is the MCDU VAPP value plus an additional variable gust.



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R The IAS target is displayed on the PFD as a magenta triangle moving with the gust variation.

R Speed target computation above 400 feet :

R The gust is the instantaneous difference between the CURRENT HEADWIND COMPONENT and the TWR HEADWIND COMPONENT. It is always positive (or equal to zero for no wind or tailwind) IAS targets have 2 limits :
R — VAPP as minimum value
R — VFE in CONF FULL or VFE - 5 knots in CONF 1,2 or 3 as the maximum value.

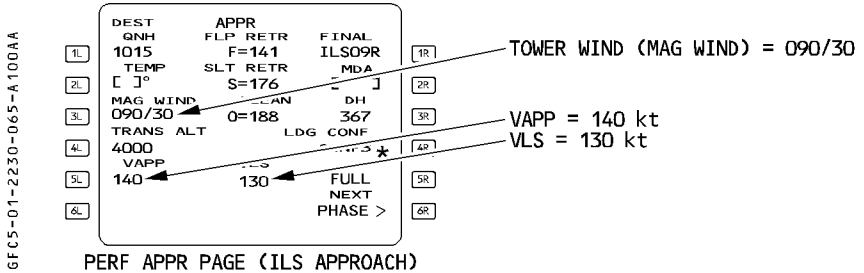
R **Speed target computation below 400 feet :**

R The gust taken into account is only 1/3 of the instantaneous difference between the
R CURRENT HEADWIND and the TWR HEADWIND COMPONENT. This is done to prevent any
R important thrust variation in late final. Min and Max values remain unchanged.

R **GROUND SPEED MINI (GS mini) COMPUTATION**

R Ground speed mini concept has been defined to prevent the aircraft energy from dropping
R below a minimum level during final approach. The GS mini value is not displayed to the
R crew.

R **EXAMPLE**
R



PERF APPR PAGE (ILS APPROACH)

R **IAS TARGET VALUES**

R If we turn the previously explained speed target definition, into formulae, we obtain the
R following result :

R **Above 400 feet**

R If IAS TARGET = Max [VAPP, (VAPP + CURRENT HEADWIND - TWR HEADWIND)] (1)

Current wind in approach	IAS target
(a) 090/50	MAX [VAPP, (140 + 50 - 30) = 160 kt
(b) 090/10	MAX [VAPP, (140 + 10 - 30) = 140 kt
(c) 270/10	MAX [VAPP, (140 + 0 - 30) = 140 kt
(d) 090/30	MAX [VAPP, (140 + 30 - 30) = 140 kt

R (1) For this computation, the TWR HEADWIND is voluntarily limited to 10 kt as a minimum.

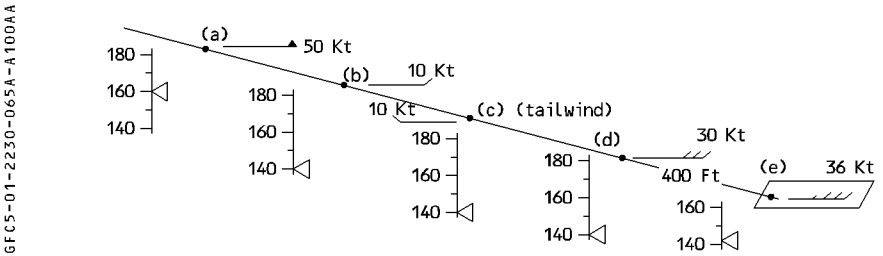
R **Below 400 feet**

IAS TARGET = Max [VAPP, VAPP + 1/3 (CURRENT HEADWIND - TWR HEADWIND)]
That is equivalent to :
IAS TARGET = Max (VAPP, VLS + 1/3 of CURRENT HEADWIND COMPONENT)

R

Current wind in approach	IAS target
(e) 090/36	MAX [VAPP, (130 + 12) = 142kt

R



A/THR MODE REVERSION

CONDITIONS	EVENT	CONSEQUENCES
• A/THR active in THR mode • AP OFF • FD engaged • DES or "OP" DES engaged (CLB or OP CLB)	aircraft speed = VLS (Vmax)	• A/THR reverts to SPD mode • FD bars are removed

For detail refer to "Speed mode protection".

Alpha floor

The ALPHA FLOOR protection is triggered when the FMGCs receive a signal elaborated by the PRIMs. This signal is sent when the aircraft angle of attack is above a predetermined threshold function of the aircraft configuration. The A/THR is automatically activated and commands TOGA thrust regardless of thrust lever positions. This protection is available from lift off to 100 feet RA in approach.

Following indications are then provided :

– A-FLOOR on the FMA and on the EWD as long as α floor conditions are met

– TOGA LK on the FMA when the aircraft leaves the α floor conditions.
TOGA thrust is then frozen

A FLOOR and TOGA LK are displayed in green and surrounded by an amber flashing box.

In order to cancel the ALPHA FLOOR or TOGA LK thrust, disconnect the A/THR.

Note : Alpha Floor is inhibited :

- *– in case of engine failure with flaps extended*
- *– in case of engine failure with derated TO selected*
- *– below 100 feet at landing*
- *– above M.53*

Alpha Floor protection is lost in case of A/THR failure.

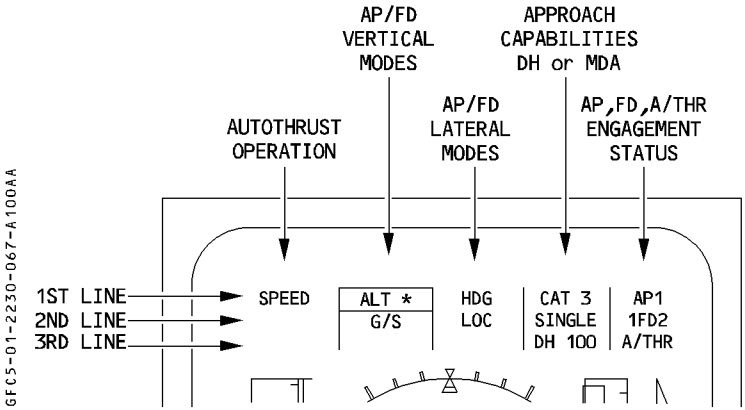
CAUTION

R The system may consider an engine to be failed, when this engine's Thrust Lever
R Angle (TLA) is bellow 5°, and the TLA of other engine is above 5°. Therefore, Alpha
R Floor may be inhibited.
R In manual thrust control, when simultaneously moving both thrust levers back to
R about the IDLE position, and in order to avoid undue Alpha Floor inhibition, check that
R both levers are well-aligned and that no TLA is below 5°.

FLIGHT MODE ANNUNCIATOR (FMA)

The Flight Mode Annunciator (FMA), located on the top of the PFDs, reflects the status of the A/THR, the AP/FD vertical and lateral modes, the approach capabilities, and the AP/FD-A/THR engagement status.

A white box is displayed for 10 seconds around each new annunciation. The white box
R display time may be increased to 15 seconds in some mode reversion cases associated
R with a triple click aural warning.



In the three left columns :

The engaged modes are displayed in green on the first line.
The armed modes are displayed in blue, or in magenta, on the second line.
Modes, armed due to a constraint, are displayed in magenta.
Special messages, are displayed on the third line :

- First priority is given to messages related to flight controls :
  - MAN PITCH TRIM ONLY flashes red for 9 seconds, then remains steady
  - USE MAN PITCH TRIM pulses amber for 9 seconds, then remains steady.
- Lower priority messages related to FMGS.

In the fourth column, approach capabilities are displayed in white

DH or MDA/MDH is displayed in blue.

In the right column, AP, FD, A/THR engagement status are displayed in white

FD is boxed for 10 seconds, in case of automatic FMGC switching.
When armed, A/THR is displayed blue.

Note : The FMGS synchronizes A/THR mode, AP/FD modes, and landing capability to provide identical information on both PFDs.

AUTO THRUST ANNUNCIATIONS (FMA COLUMN 1)

First line

R

DISPLAY	COLOR	MEANING
MAN TOGA	White White box	A/THR is armed, at least one thrust lever is in TOGA detent.
MAN FLX 50	White White box	A/THR is armed, at least one thrust lever is in MCT/FLX detent, with FLX TO temp set at 50°. The other thrust lever is at, or below, the MCT/FLX detent. 50° is displayed in blue.
MAN MCT	White White box	A/THR is armed, at least one thrust lever is in MCT detent, the other is at, or below, this detent.
MAN DTO ◁	White White box	A/THR is armed, at least one thrust lever is in the MCT/FLX detent, with an entered derated level. The other thrust lever is at, or below, the MCT/FLX detent.
MAN THR	White Amber box	A/THR is armed. This indication is not displayed during T.O or GA phases. The most advanced thrust lever is above the CL detent, while the other is in CL detent, or both thrust levers are above CL detent.
THR MCT	Green	A/THR is active in thrust mode and the most advanced thrust lever is in the MCT detent (engine-out).
THR CLB	Green	A/THR is active in thrust mode, and the most advanced thrust lever is in the CL detent.
THR DCLB 1 (2) ◁	Green	A/THR is active in thrust mode ; the most advanced thrust lever is in the CL detent, and the crew has selected a derated climb.
THR IDLE	Green	A/THR is active in thrust mode, and commands idle thrust.
THR LVR	Green	A/THR is active in thrust mode with either both thrust levers out of CL, or MCT detent, or at least one thrust lever in CL detent and the other beyond CL detent.
THR DES	Green	A/THR is active in thrust mode and commands minimum thrust in DES mode.
SPEED or MACH	Green	A/THR is active in SPEED or MACH mode.
A. FLOOR	Green Amber box	A/THR is active and commands TOGA thrust, while α FLOOR conditions are met.
TOGA LK	Green Amber box	A/THR is active and TOGA thrust is frozen (α FLOOR conditions are no longer met).

Second/third lines

The second and third lines display various caution messages.

Second line

DISPLAY	COLOR	MEANING
LVR CLB (flashing)	White	Request to set the thrust levers in CL detent
LVR MCT (flashing)	White	Request to set the thrust levers in MCT detent.

Third line

R

DISPLAY	COLOR	MEANING
LVR ASYM	Amber	(2 engines only). One thrust lever is set out of the CL (or MCT) detent with A/THR active.
THR LK (flashing)	Amber	After A/THR disconnection (FCU pilot's action or failure) resulting in thrust being frozen.

R *Note : The amber caution flashes and a single chime sounds every 5 seconds, as long as the pilots does not take action in the following cases :*

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

AP/FD VERTICAL MODES (FMA COLUMN 2)

First line

R

DISPLAY	COLOR	MEANING
SRS	Green	Takeoff or go-around mode is engaged.
CLB	Green	Climb mode is engaged. The FMGS target altitude is higher than the actual altitude. ALT CSTR are taken into account.
OP CLB	Green	Open Climb mode is engaged. The FCU-selected altitude is higher than the actual altitude.
ALT*	Green	ALT CAPTURE at the FCU-selected altitude is engaged.
ALT CST*	Green	ALT CAPTURE at the ALT CSTR altitude (vertical profile) is engaged.
ALT CRZ*	Green	ALT CAPTURE at the CRZ FL is engaged.
ALT CST	Green	An ALT CSTR is held (vertical profile).
ALT	Green	ALT mode is engaged. The FCU-selected altitude is held
ALT CRZ	Green	SOFT ALT mode and NAV mode are engaged.
DES	Green	Descent mode is engaged. The FMGS target altitude is lower than the actual altitude. ALT CSTR are taken into account.
OP DES	Green	Open Descent mode is engaged. The FCU-selected altitude is lower than the actual altitude.
G/S*	Green	Glide Slope capture mode is engaged.
G/S	Green	Glide Slope mode is engaged.
V/S ± XXXX	Green	Vertical speed mode is engaged to acquire and hold the V/S selected on the FCU. Target is displayed in blue. If the aircraft reaches VLS or Vmax and cannot maintain the target, the indication is boxed amber and flashes, and the target pulses.
FPA ± X.X°	Green	Flight Path Angle mode is engaged to acquire and hold the FPA selected on the FCU. Target is displayed in blue. If the aircraft reaches VLS or Vmax and cannot maintain the target, the indication is boxed amber and flashes, and the target pulses.

Second line

DISPLAY	COLOR	MEANING
CLB	Blue	Climb mode is armed before the climb phase.
OP CLB	Blue	Open Climb mode is armed.
ALT	Blue or Magenta	Altitude mode is armed. – Blue, when the target altitude is the FCU-selected altitude. – Magenta, when the target altitude is an ALT CSTR.
ALT CRZ	Blue	Altitude mode is armed. Target altitude is the CRZ FL.
DES	Blue	Descent mode is armed before the descent phase.
G/S	Blue	Glide Slope mode is armed.
FINAL	Blue	Final descent mode is armed.

Note : Two modes may be armed at the same time : ALT G/S, ALT FINAL, DES G/S, DES FINAL.

Third line

DISPLAY	COLOR	MEANING
SPEED SEL XXX	Blue	Indicates a preset speed associated with the cruise, climb or descent phase.
MACH SEL. XX	Blue	Indicates a preset Mach associated with the cruise, climb or descent phase.

Note : These two messages are displayed in the first and second columns (third line).

AP/FD LATERAL MODES (FMA COLUMN 3)

First line

R

DISPLAY	COLOR	MEANING
RWY	Green	RWY mode is engaged.
RWY TRK	Green	RWY mode is engaged once airborne at, or above, 30 feet.
TRACK	Green	TRACK mode is engaged.
HDG	Green	HEADING mode is engaged.
NAV	Green	NAV mode is engaged to guide the aircraft along the FM lateral F-PLN.
LOC*	Green	LOC capture mode is engaged.
LOC	Green	LOC track mode is engaged.
LOC B/C*	Green	Back beam capture mode is engaged.
LOC B/C	Green	Back beam mode is engaged.
APP NAV	Green	NAV mode is engaged during a NON ILS approach.
GA TRK	Green	GO AROUND track mode is engaged.

Second line

DISPLAY	COLOR	MEANING
LOC B/C	Blue	Back beam mode is armed.
LOC	Blue	LOC mode is armed.
APP NAV	Blue	NAV mode is armed for a NON ILS approach.
NAV	Blue	NAV mode is armed.

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

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

APPROACH CAPABILITIES (FMA COLUMN 4)

First line

DISPLAY	COLOR	MEANING
CAT 1	White	CAT 1 capability available
CAT 2	White	CAT 2 capability available
CAT 3	White	CAT 3 capability available

Second line

DISPLAY	COLOR	MEANING
SINGLE	White	CAT 3 capability available, with FAIL PASSIVE condition.
DUAL	White	CAT 3 capability available, with FAIL OPERATIONAL condition.

Third line

DISPLAY	COLOR	MEANING
MDA/MDH XXX	White Blue	Minimum descent altitude or minimum descent height as inserted by the pilot on PERF APPR page.
DH XXX/NO DH	White Blue	Decision height as inserted by the pilot on PERF APPR page. NO DH: when NO inserted on PERF APPR page.

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

First line

DISPLAY	COLOR	MEANING
AP 1 + 2	White	Autopilot 1 and 2 are engaged.
AP 1	White	Autopilot 1 is engaged.
AP 2	White	Autopilot 2 is engaged.

Second line

DISPLAY	COLOR	MEANING
X FD Y	White	X and Y give the FD engagement status on PFD 1 and PFD 2. X and Y can be 1, 2, –. – : no FD is engaged on the corresponding PFD 1 : FD 1 is engaged. 2 : FD 2 is engaged. e.g. : the normal status (FD 1 and 2 are engaged) is 1FD2.

Third line

DISPLAY	COLOR	MEANING
A/THR	White	A/THR is active.
A/THR	Blue	A/THR is armed and not active.

SPECIAL MESSAGES (FMA COLUMNS 2 AND 3)

Three types of messages are displayed on the third line :
– first priority is given to F/CTL messages
– then vertical FM messages
– then EFIS reconfiguration messages

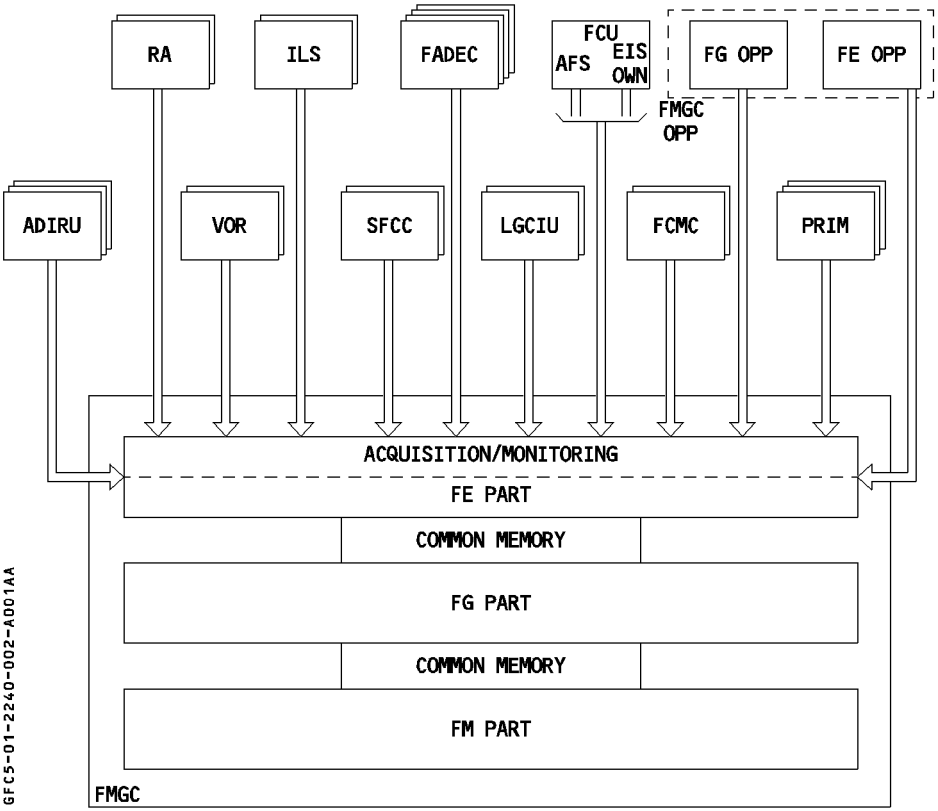
DISPLAY	COLOR	CONDITIONS
MAN PITCH TRIM ONLY	Red	Displayed in case of loss of L + R elevators.
USE MAN PITCH TRIM	Amber	F/CTL are in direct law or in flare law with dual RA failure.
CHECK APP SELECTION	White	The aircraft is in cruise at less than 100 NM from the top of descent or in descent or in approach and: – a non ILS approach has been selected. – an ILS frequency is tuned on the RAD NAV page
SET MANAGED SPEED	White	The SPEED target is selected and a preselected SPEED does not exist for the next flight phase
SET GREEN DOT SPEED	White	The aircraft is in Engine Out mode and the SPEED target is selected. This message is displayed if: the FCU selected speed is : ≤ Green Dot – 10 kt or ≥ Green Dot + 10 kt except in ALT*, ALT mode
SET HOLD SPEED	White	The aircraft is in selected SPEED control, an HM leg is inserted in the F-PLN and the aircraft is 30 seconds before the deceleration zone to the precomputed HOLD SPEED.
DECELERATE	White	This message is displayed if the thrust is not reduced when passing the top of descent, and the aircraft is above the flight profile.
EXTEND SPD BRK	White	DES mode is engaged, idle is selected, and: – either the aircraft is above the vertical profile and the predicted intercept point of the theoretical profile is at less than 2 NM from the next ALT CSTR and the predicted aircraft altitude at next ALT CSTR is greater than ALT CSTR – 500 feet. – or in auto speed control if the aircraft enters in an speedbrake decelerating segment (next speed limit or speed constraint)
RETRACT SPD BRK	White	Speedbrakes are extended, DES mode is engaged and : – ALT* or ALT mode engages or – aircraft is below the path. – CONF 3 or FULL is reached.
EFIS SINGLE SOURCE 1 or EFIS SINGLE SOURCE 2	White	CAPT and F/O Display Units are fed by the same source : either captain side source (1) or first officer side source (2). Range and mode selections can be done only by the appropriate side.
EFIS SWTG NOT ALLOWED	Amber	EFIS configuration selected by the pilot is not allowed: DMC 1 for F/O Display Units or DMC 2 for CAPT Display Units, and conditions for "EFIS SINGLE SOURCE" not fulfilled.

GENERAL

The Flight Envelope (FE) part of the FMGS performs the following functions:
- acquisition and monitoring of parameters used by FE and FG parts
- characteristic speeds computation
- back-up weight and CG computation
- aft CG monitoring
- windshear detection

ACQUISITION / MONITORING

Acquisition and monitoring of buses common to FM, FG or FE are performed by the FE.
Only ARINC buses specific to the FM part are acquired by the FM itself.
Dialogue between FM, FG and FE is achieved through common memories.



The FE function generates the following information:
– flight / ground conditions (LGCIU / SFCC)
– flap / slat configuration (SFCC)
– engine configuration (FADEC)
– ADR / IR parameters after filtering and consolidation (used by the control laws).

CHARACTERISTIC SPEEDS COMPUTATION

FE part computes the characteristic speeds and sends them to:
– the FG which uses them as limits for guidance modes
– the EFIS for display on the PFD speed scale
The following speeds are computed:

R **Minimum speeds**

R – **VLS**
R (Refer to 3.04.10)

R – **Maneuvering speeds F, S, O (green dot)**
R (Refer to 3.04.10)

WEIGHT AND CENTER OF GRAVITY COMPUTATION

The FMGC uses the weight and center of gravity from the FCMC (Fuel Computer) when available.
The GW and CG computed by the FE part are used:
– as back-up in case of dual FCMC failure.
– to trigger the aft CG caution and warning signals (independently of the FCMC).

FE Weight computation (back up)

– When the aircraft is below 14625 feet and 255 knots :
R GW = f(α, CAS, N1/EPR actual, CG from FE part, altitude)
– When the aircraft is above 14625 feet or 255 knots :
GW = TOGW – WFU
TOGW: takeoff gross weight
WFU: weight fuel used acquired from FADECs.

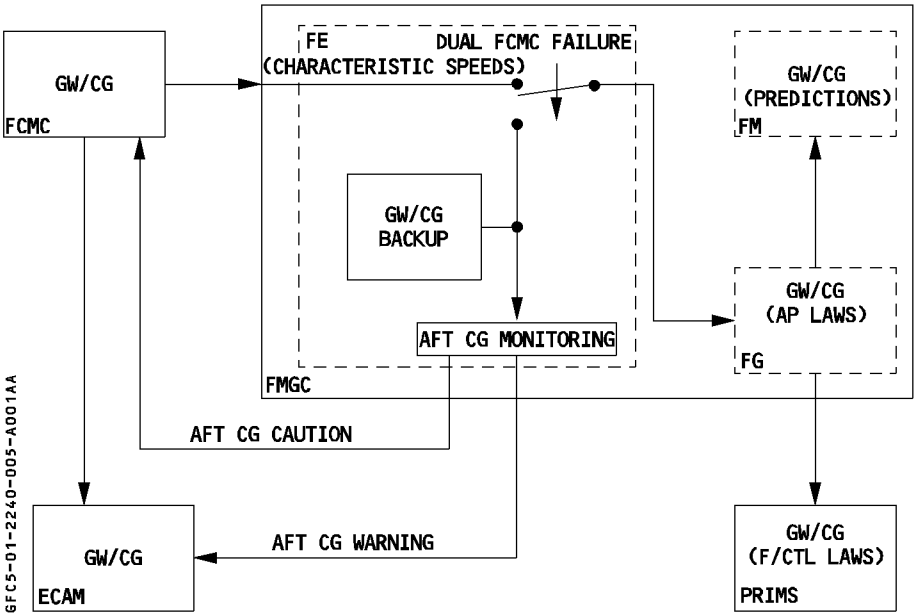
FE Center of gravity computation (back up/aft cg computation)

The CG is computed from the position of the horizontal stabilizer and is function of the N1/EPR, Vc, ALT, MACH and GW from FE part.

AFT CG MONITORING

The flight envelope uses only its own computed gross weight (GW) and center of gravity (CG) to trigger the aft CG signals.
The current CG is compared to the aft CG limit computed from the GW.
If the CG > CG limit –1 %, an aft CG caution signal is sent to the FCMCs. The target CG is then shifted forward by 1.5 % (only one time). If the CG becomes higher than the CG limit the aft CG warning signal is sent to the FWCs which trigger a red warning.

R



R *Note : AFT CG monitoring is available above 20 000 feet if the aircraft is in clean*
R *configuration with speed brakes retracted.*

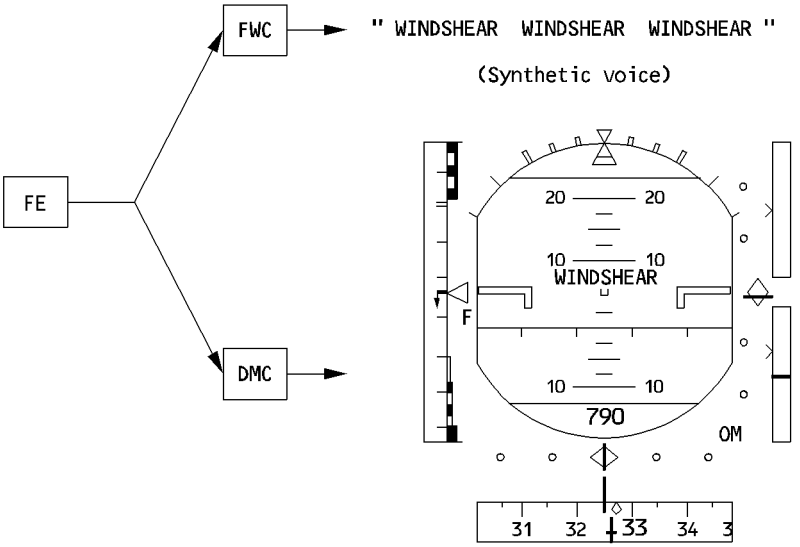
WINDSHEAR DETECTION

A windshear detection signal is generated whenever the aircraft encounters a windshear and the predicted energy level falls below a predetermined safe minimum energy threshold (reactive windshear detection).

Note : The energy threshold is expressed as an angle of attack threshold αo.
The aircraft predicted energy level is $\alpha + \Delta\alpha$ where :
· α is the current angle of attack
· $\Delta\alpha$ is the equivalent AOA computed from measured vertical drafts and longitudinal shears.
If $\alpha + \Delta\alpha > \alpha o$ the windshear conditions are detected.

The windshear detection function is provided in takeoff and approach phase under the following conditions :
– At takeoff, from lift off up to 1300 feet
– At landing from 1300 feet to 50 feet.
– With at least CONF 1 selected.
The warning consists of :
– a visual "WINDSHEAR" red message displayed on both PFDs for a minimum of 15 seconds.
– an aural synthetic voice announcing "WINDSHEAR" three times.

R



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GENERAL

The FMS ACARS function gives an interface between a ground station and one onboard FMGC, allowing data transmission between these two computers via the ACARS Management Unit.
Two different sets of message can be exchanged :
UPLINK messages from the ground station. They consist in reception of data requested or directly sent to the crew.
DOWNLINK messages from the FMGC (master). They consist in reports or requests sent to the ground station.
The FMGS/ACARS interface enables the following ACARS capabilities.
– F-PLN initialization (flight plan and performance data)
– Takeoff data
– Wind data
– Flight reports
– Broadcast data
Crews can send message using ACARS function pages or relevant MCDU pages.
Only one FMGC talks to the ground station. This FMGC is called FMGC "master".

GENERAL SCRATCHPAD MESSAGES

NOT XMITTED TO ACARS : A crew request or report was sent to the ground but the communication was not established or not acknowledged.

NO ANSWER TO REQUEST : A crew request was previously sent to the ground and no answer (uplink message) was received within 4 minutes.

FLIGHT PLAN INITIALIZATION FUNCTION

This function enables lateral and vertical flight plan data as well as performance data to be exchanged between the aircraft and a ground station. The aircraft may send flight plan requests for active and secondary flight plan. (downlink messages). The ground station may send flight plan and performance data (uplink messages) either under aircraft request or automatically without any request.

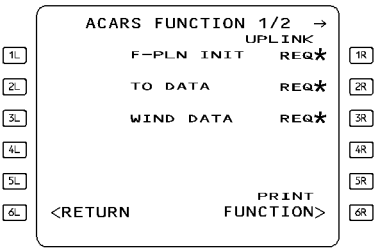
Each uplink message concerns either the active or secondary flight plan but never both flight plans at the same time. The data sent to the aircraft are checked for flight plan consistency.

A MCDU message comes up when an uplink message is received. "ACT (or SEC) RTE UPLINK".

If an error prevents the decoding process of the message, "INVALID RTE UPLINK" is displayed on MCDUs.

Au uplink message can be routed to the active flight plan if no engine is started and no active flight plan exists. Otherwise, it is routed to the secondary. The crew will insert it into the secondary flight plan or will reject it using the CLR key.

Note : The flight plan may also be initialized using the ACARS function page selected from DATA INDEX page.



ACARS FUNCTION PAGE 1
(FROM DATA INDEX)

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PERFORMANCE DATA

On ground and before engine start, the ground station may also send performance data to the aircraft.
Performance data are always associated with the uplink flight plan. It is either automatically inserted with the active flight plan data, or stored in the secondary with the corresponding flight plan.
This message contains part or all of the following data :
ZFW, ZFWCG, taxi fuel, block fuel, cruise flight level, tropopause altitude, cruise temperature, transition altitude, cost index, performance factor.

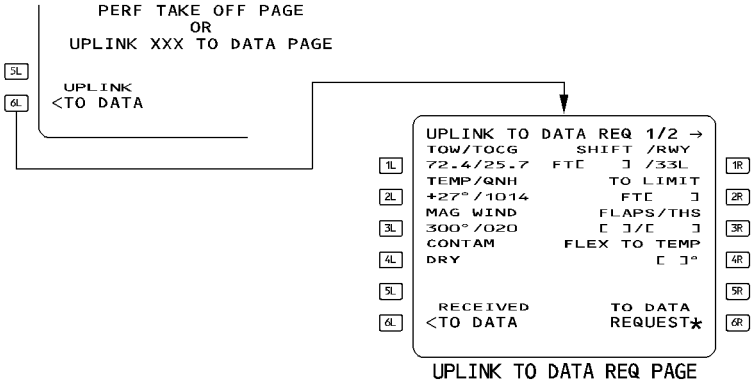
Note : After engine start an uplink performance data message is rejected automatically without any scratchpad message.

SCRATCHPAD MESSAGES RELATED TO FLIGHT PLAN AND PERFORMANCE

INVALID RTE UPLINK	An error is detected, the uplink message is rejected.
ACT or SEC RTE UPLINK	A F-PLN is stored in the active or secondary flight plan.
FLT NUMBER UPLINK	FLT NBR has been initialized within a F-PLN message without previous request.
CHECK FLT NUMBER	The uplinked FLT NBR differs from the one specified in the request.
CHECK CO RTE	The uplinked CO RTE ident differs from the one specified in the request.
INVALID FLT NBR UPLINK	The uplink contains a valid F-PLN but the FLT NBR is invalid.
PERF DATA UPLINK	Performance data is received
INVALID PERF UPLINK	Performance uplink message has been rejected
RTE DATALINK IN PROG	A flight plan modification is performed after a F-PLN INIT request has been sent ; this message is displayed until the uplink is received.
UPLINK INSERT IN PROG	This message is displayed during insertion of a Flight Plan.

TAKEOFF DATA FUNCTION

The takeoff data function is available for the active flight plan only. It is used to request to the ground station, information data for up to 2 runways and to receive this data for up to 4 runways.
The crew sends a request indicating the departure airport, runway idents, CG, GW and weather conditions (such as baro setting wind, temperature...). In response he receives the takeoff speeds for up to 4 runways but only one set of data may be inserted in the active flight plan for the selected active runway.
Takeoff speeds are computed for max and flex takeoff.
The takeoff data function has required the modification of the standard PERF TAKEOFF page and the addition of 2 news pages :
· UPLINK TO DAT REQ page that enables the crew to specify a request to the ground.
· UPLINK XXX TO DATA page (XXX for MAX or FLEX)
These 2 pages are accessed from the PERF TAKEOFF page in PREFLIGHT and DONE phase only.



UPLINK TO DATA REQ PAGE
WITH DEFAULTED VALUE.

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SCRATCHPAD MESSAGES RELATED TO TAKEOFF DATA

TAKEOFF DATA UPLINK : Takeoff data uplink message is received
INVALID TAKEOFF UPLINK : The UPLINK message is rejected

WIND DATA FUNCTION

This function enables the crew to request and to receive forecasted winds associated to the active or secondary flight plan.
The uplink message (ground station to aircraft) may be received upon crew request or automatically without crew request.
The request is initiated from WIND pages or from ACARS FUNCTION page (Refer to 4.03.20).
The uplink wind data when received are directly displayed on the wind pages but not inserted in the flight plan, one set for each flight phase : CLIMB, CRUISE, DESCENT. The alternate wind at alternate cruise flight level is displayed on DESCENT page.

* Winds are associated to altitude for climb an descent phases
* Winds are associated to four altitudes for each waypoint for cruise phase and step level.
  - On ground and without entered winds (except the trip wind), an uplink message is directly inserted in the flight plan.
  - In flight, winds are temporarily stored until the crew inserts them phase per phase. Phase of flight is indicated in the WIND title page.
  - Clearing the INSERT UPLINK* prompt using the CLR key deletes the uplink wind data for the selected phase.

When uplink winds are deleted, the wind page reverts to the previous status.
The flight plan B page is modified of the uplink wind only after it is inserted by the crew. ACARS uplink winds are then considered as crew manual entries (large font).

SCRATCHPAD MESSAGES RELATED TO WIND DATA

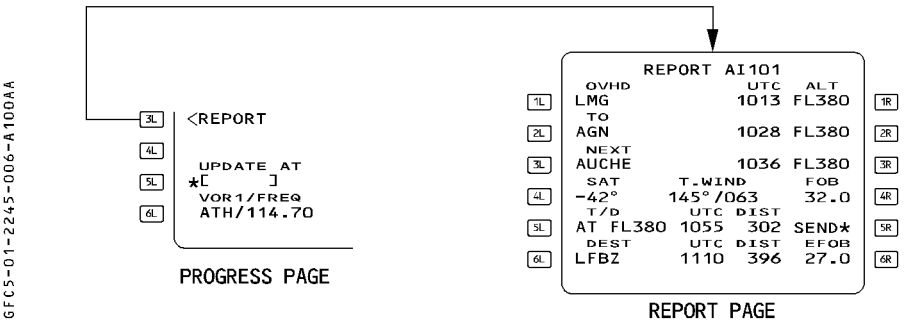
INVALID WIND UPLINK	An error is detected, the uplink is rejected.
WIND DATA UPLINK	Uplinked winds are received.
WIND UPLINK PENDING	A temporary flight plan exists or a DIR TO page is displayed when a wind uplink is received. The message is stored.
WIND UPLINK EXISTS	A F-PLN modification (active or secondary) is attempted when uplink winds are not inserted. This message disappears automatically when the wind uplink is inserted or deleted.
CHECK DEST DATA	The aircraft is at 180 NM from destination, and the destination QNH, TEMP or WIND displayed on the PERF APPR page was received by ACARS uplink or, if following insertion of a descent wind uplink, a conflict concerning the above parameters exists.
CHECK ALTN WIND	The uplinked alternate cruise flight level differs from the default alternate cruise flight level.

FLIGHT REPORTS

Flight reports provide real time information to the ground concerning the aircraft current situation and position.
Several types of flight reports are available :
– The Position report : provides current aircraft position
– the Progress report : provides data relative to the destination
– The Flight-Plan report : provides the active route
– the Performance Data report : provides performance data currently used by FMS.
These reports may be manually initiated via a dedicated prompt or automatically sent in response to a ground request or upon specific conditions.

POSITION REPORT

This report is sent :
– manually via a MCDU prompt or
– following a ground request or
– automatically upon sequencing a designated reporting fix (designated by the ground in a uplink message).
The manual POSITION REPORT downlink prompt is displayed on the REPORT page POS prompt.



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Note : Position report are initiated from active flight plan only.

POSITION report content

The downlinked message contains exactly the REPORT page data.

PROGRESS REPORT

A progress report contains data relative to the aircraft arrival time and EFOB at destination for the active F-PLN.
This downlink message is automatically sent following :

- a ground request or
- a change of destination or
- a change of runway or
- a specific event. The possible events that can be selected in the navigation database policy file are :
  - X minutes to Top of Descent
  - Z minutes to Destination
  - ETA changes more than W minutes from the previous report.

  X, Z and W are minutes of time set in the navigation database policy file.

The progress report cannot be manually sent by the crew via a dedicated MCDU prompt.

PROGRESS report content

- Flight Number
- Arrival Airport Ident
- Destination Runway Ident
- Predicted remaining fuel
- ETA at destination
- Reason for report (specific event, ground request...).

FLIGHT PLAN REPORT

The F-PLN report broadcasts flight plan data to the ground. Only data from the active flight plan can be sent.
This downlink message is sent to the ground :
- automatically following a ground request
- manually by the crew using a prompt displayed on the ACARS FUNCTION page. (Refer to ACARS page description). This prompt may be invalidated through the navigation database policy file.

The Flight Plan report can be downlinked either while on ground or in flight during any flight phase.

FLIGHT PLAN report content

The report contains the active and alternate flight plan.

PERFORMANCE DATA REPORT

The Performance Data report is a downlink message that allows the transmission of performance data (GW, FUEL, CG...) relative to the active F-PLN.
This message is automatically sent following a ground request. Manual sending is not possible.

PERFORMANCE DATA report content

Sends to the ground :
- Current GW
- Cruise Altitude
- Current CG
- Fuel on Board
- Block Fuel
- Reserve Fuel
- Cost Index
- Top of Climb Temperature
- Climb Transition Altitude
- Tropopause Altitude
- Taxi Fuel
- ZFW
- ZFWCG

PRINT FUNCTION

The print function enables several types of data and report to be printed :
* Flight plan initialization data
* Takeoff data
* Wind data
* Preflight report
* In flight report
* Post flight report

The 3 first reports may differ when automatically or manually printed for the following reason :
The automatic process prints the uplink message although the manuall process prints the current active data as displayed on the relevant MCDU pages.
The last 3 reports being processed from the same sources are identical in automatic or manual printing.

Note : ACARS is not necessary linked to printing process. The printing function may be activated within the FMGS and selected independently from the ACARS.

- One or several print functions may be deactivated (refer to PRINT FUNCTION PAGE).
- If an ACARS function is not active, (not selected in the nav database policy file) the printing process is invalidated for this specific ACARS function.

ACARS/PRINTER PROGRAMMING OPTIONS ◁

Option programming for the ACARS/PRINTER functions is obtained through the Navigation Data Base policy file.
The list summarizes the possible options :

ACARS Inhibit	Disables ACARS function
F-PLN Data Request Inhibit	Disables uplink and downlink requests of F-PLN initialization data
Performance Data Request Inhibit	Disables uplink and downlink requests of Performance Initialization data
Takeoff Data Request Inhibit	Disables uplink and downlink request of Takeoff Initialization data
Wind Data Request Inhibit	Disables uplink and downlink request of predicted wind data
Flight Number Enable	Flight Number is included within the F-PLN Request or Progress Report downlinks
Position Report Inhibit	Disables a manual Position Report downlink
Progress Report Triggers	Defines the triggers for the automatic downlink of the Progress Report
F-PLN Report Inhibit	Disables the manual downlink of the F-PLN Report
Auto Print of ACARS uplink	Selects/Deselects the automatic printing of the F-PLN, INIT, TO and wind data uplinks. If Autoprint is selected, the crew can deselect it manually. If auto printing is deselected, the crew cannot manually reselect it.
Auto Print of Flight Reports	Selects/Deselects the automatic printing of the Preflight, Inflight, Postflight reports. If selected, the crew can deselect it manually. If autoprint is deselected, the crew cannot manually preselected it.

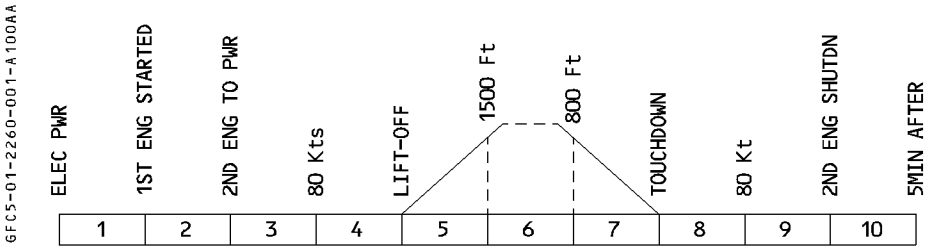
DESCRIPTION

The Fault Isolation and Detection System (FIDS) is installed in FMGC 1. The system achieves the following functions:

– detection and memorization of all internal and external failures
– tests initiation

The FIDS serves as the system BITE (maintenance data concentration).
It is connected to the BITE's of the various AFS computers (FM, FG, FE, FCU, MCDU) and linked to the CMS.
Display and interrogation of FIDS function are done by selecting appropriate key on the MCDU page.

WARNINGS AND CAUTIONS



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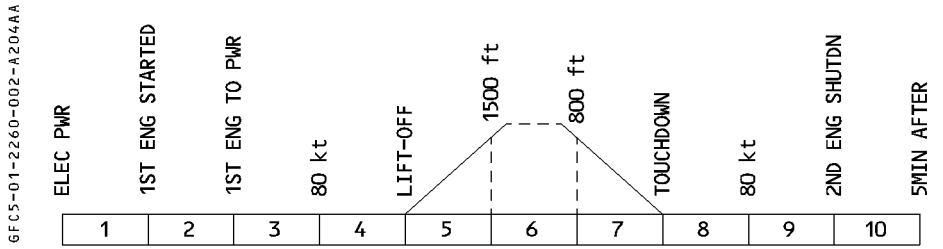
E / WD: FAILURE TITLE condition	AURAL WARNING	MASTER LIGHT	SD PAGE CALLED	LOCAL WARNINGS	FLT PHASE INHIB
AP OFF Involuntary disconnection (Refer to 1.22.30).	CAVALRY CHARGE	MASTER WARN	NIL	NIL	NIL
A / THR OFF Involuntary disconnection (Refer to 1.22.30).	SINGLE CHIME	MASTER CAUT			1,4,8,10
WINDSHEAR (NO ECAM message)	SYNTHETIC VOICE "WINDSHEAR" repeated 3 times	NIL		WINDSHEAR on PFDs	2,3,4 8,9
FM1 or 2 FAULT	NIL			MAP NOT AVAIL on related ND	3,4,5 7,8
FM1 + 2 FAULT				MAP NOT AVAIL on NDs	
A/THR LIMITED A/THR is active, the thrust levers are not in the CLB or MCT detent.	SINGLE CHIME	MASTER CAUT		NIL	all except 6
FCU FAULT Loss of two channels, or complete loss of the FCU.					4,5
REAC W/S DET FAULT Windshear detection function is inoperative.					1,3,4,5 8,10
LOW ENERGY (No ECAM message). Available between 100 and 2 000 feet. Thrust must be increased.	SYNTHETIC VOICE "SPEED" repeated 3 times	NIL			1 to 4 8 to 10
– ILS Capability downgrade. Conditions required for CAT3, CAT2 are no longer fulfilled (Refer to 4.05.70). – Mode reversions (Refer to 1.22.30).	TRIPLE CLICK				2, 3, 4 5, 8, 9 10
AUTOLAND (no ECAM message) Available below 200 feet RA.	NIL	AUTO LAND (red)			
FM/IR POS DISAGREE msg. Discrepancy is detected between any FM position and IRS position.	SINGLE CHIME	MASTER CAUTION			1, 2, 3, 4, 5, 7 8, 9, 10

WARNINGS AND CAUTIONS



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E / WD: FAILURE TITLE conditions	AURAL WARNING	MASTER LIGHT	SD PAGE CALLED	LOCAL WARNING	FLT PHASE INHIB
When GPS primary is lost, the "GPS PRIMARY LOST" message is displayed on the ND and PFD.	TRIPLE* CLICK	NIL	NIL	ND/MCDU message	2, 3, 4, 5, 8, 9, 10
"NAV FM/GPS POS DISAGREE" : When the FMS 1 or 2 position differs from the GPS 1 or 2 position by more than 0.5 minutes of latitude or ; – 0.5 minutes of longitude, if the aircraft latitude is included between 0° and 45° ; – 0.7 minutes of longitude, if the aircraft latitude is included between 45° and 60° ; – 1 minute of longitude, if the aircraft latitude is included between 60° and 70°. Above 70° of latitude, a longitude difference does not trigger the alarm.	SINGLE CHIME	MASTER CAUT		NIL	1, 3 4, 10

* Only during a non precision approach.

MEMO DISPLAY

FM SWTG is displayed in green, when the FM switching selector is on the BOTH ON 1(2) position.

BUS EQUIPMENT LIST

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		NORM			EMER ELEC		
		AC	DC	DC BAT	AC ESS	DC ESS	HOT
FMGC	1					SHED	
	2		DC2				
FCU	A and B					X	
	C		DC2				
MCDU	1				SHED		
	2	AC 2					
	3				GND		
Sidestick locking						SHED	
Rudder artificial feel						SHED	