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	FLIGHT MANAGEMENT PRINCIPLES		SEQ 100	REV 07

NAVIGATION

Essential navigation functions are described in the volume 1 (1.22.20) but some principles are reemphasized in this chapter due to their operational impact.

POSITION ACCURACY (PROG PAGE)

The HIGH or LOW accuracy is indicated on the PROG page.

This display is the result of the comparison between the estimated position error (EPE) displayed in 6R field and the required navigation accuracy displayed in 6L field.

The required navigation accuracy are defaulted values, defined by airworthiness authorities for various flight areas.

The pilot can modify the required navigation accuracy.

The pilot, when the aircraft is not fitted or not using the GPS primary function, must check the navigation accuracy periodically to confirm the system computation.

When the accuracy changes from low to high (or high to low), both MCDUs and NDs display the message "NAV ACCUR UPGRAD" (or "NAV ACCUR DOWNGRAD").

NAVIGATION ACCURACY CHECK

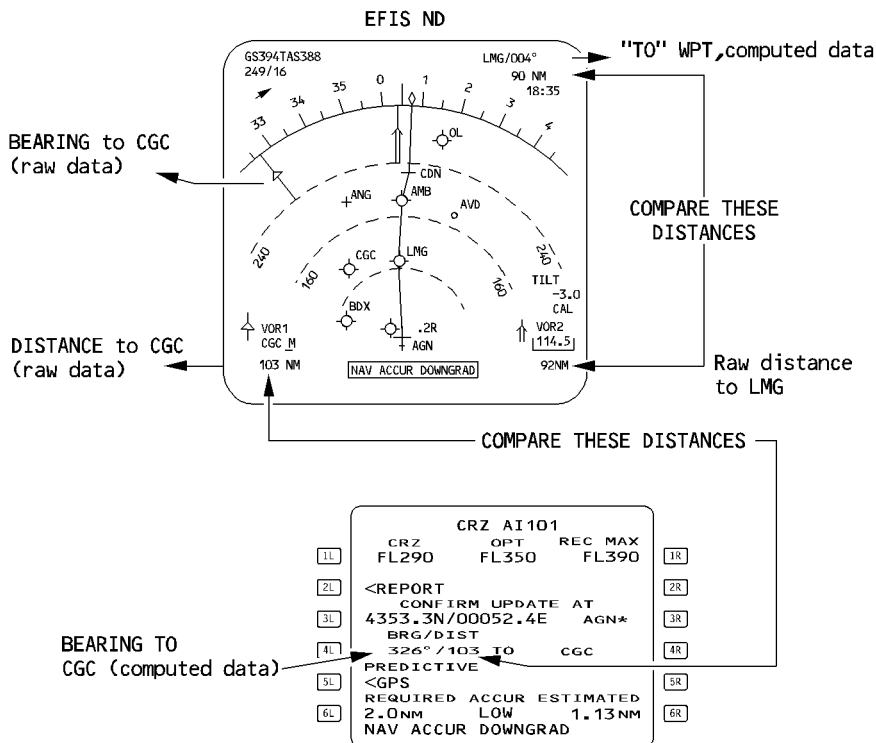
When the GPS primary is available, the navigation accuracy check is not required.

When the GPS primary is not available, the pilot must perform this essential check :

- periodically in cruise
- prior to initiating descent
- when entering a terminal/approach area

The procedure is :

- While en route, check the HIGH/LOW accuracy information.
 - If accuracy is "LOW" (and whenever "NAV ACCUR DOWNGRAD" appears), compare raw data from the tuned navaids with the corresponding FM-computed data on the navigation display or on the MCDU PROG page.
 - If accuracy is "HIGH", perform the comparison periodically (about once per hour).
- In descent and in terminal and approach areas, validate the estimated accuracy, whether it is "HIGH" or "LOW", by comparing the FM data with raw data from the VOR/DME at the destination airfield, if available.



This check verifies and quantifies the FM accuracy. It confirms the reliability of FMGS data itself and of the navigation display presentation. This check also validates the use of the NAV mode.
By comparing the bearing, the pilot may evaluate the validity of the overall check.
In area with high magnetic variation change, this comparison of bearings may not be adequate.

RADIO NAVIGATION TUNING

Each FMGC tunes the navaids it uses for display and computing position.
The FM may tune navaids for display automatically, using an internal logic, or the pilot may tune them manually on the RADIO NAV page.
The FM tunes automatically the DMEs used for position update. It scans them constantly.

NAVAIDS USED FOR DISPLAY

The RADIO NAV page, and the ND show which navaids have been tuned for display.

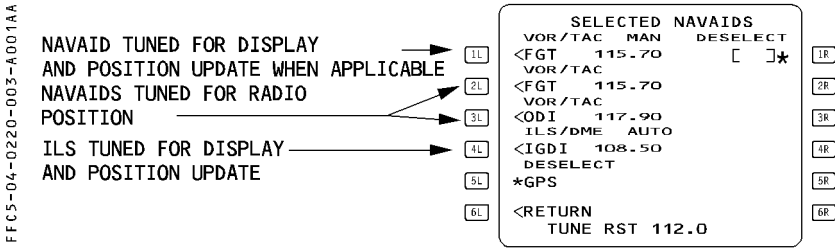
Note : All navaids tuned on RAD NAV page are used for display purpose.

NAVAIDS USED FOR POSITION UPDATE

Navaids used for aircraft's position update are displayed on the SELECTED NAVAIDS page.
If a NAVAID is unreliable, the pilot should deselect it manually.

Note : When the FMGC uses the VOR/DME for radio position, it also uses the related VOR/DME for display.

If the crew has selected manually the VOR/DME for display, and if it is not convenient for the FMGC to use it for position update, the FMGC will require the crew to select another VOR/DME.
The MCDU will display the message "TUNE BBB FFF.F", BBB is the navaid identifier and FFF.F the VOR frequency.



MANUAL TUNING

- WRITE the identifier on the RAD NAV page.
Use the identifier preferably.

RADIO NAV	
VOR 1/FREQ	FREQ/VOR2
CGC / 116.20	114.50/LMG
CRS	CRS
075	[]
ILS/FREQ	
[]/[-]	
CRS	
[]	
ADF 1/FREQ	FREQ/ADF2
TOE/415.00	[-]/[]
← ADF1 BFO	

● If the MCDU displays “NOT IN DATA BASE”

- WRITE the frequency
- DISREGARD the ident that comes up in small font on the MCDU.

When a frequency is entered in the VOR field, the FMGC associates automatically to the frequency tuned the closest navaid identifier with the same frequency, and displays it on the RAD NAV page. This identifier may not be corresponding to the tuned navaid.

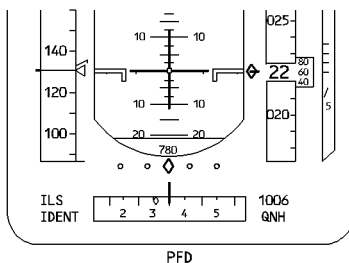
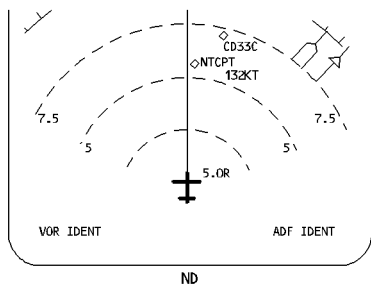
If the closest navaid found in the database is of a different type (e.g. VOR instead of VOR/DME), the crew will obtain a partial tuning (e.g. VOR indication instead of VOR/DME indication).

NAVAID IDENTIFICATION

- CHECK the decoding of the ILS identifier on PFD and the VOR or ADF identifier on ND.

When the navaid identifier is decoded in agreement with that published, no audio check is necessary.

When the decoding is different from the published one, check the audio. Due to Morse coding inaccuracy, wrong decoding may sometimes occur.



FLIGHT PLANNING

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

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

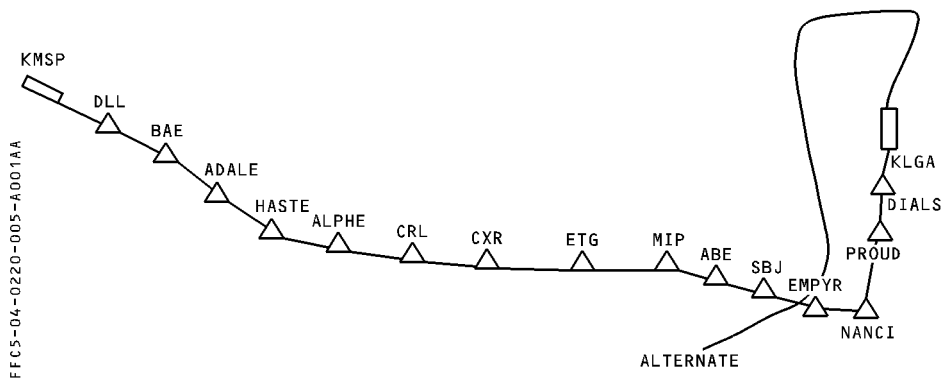
Note : The flight planning function is available for both the primary and secondary flight plans.

LATERAL FLIGHT PLANNING

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

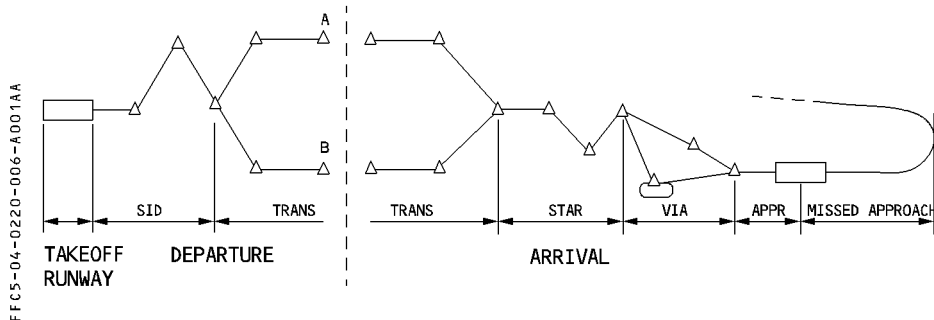
- Takeoff runway
- Standard instrument departure (SID) and transition to en route mode
- En route waypoints and airways
- Transition from en route mode to standard terminal arrival route (STAR)
- Landing runway with selected approach and approach via
- Missed approach
- Alternate flight plan

EXAMPLE



The FMGS is able to string together different types of legs corresponding to specific patterns (such as DME arc legs, or procedure turns) that are heading or track referenced. These are defined in the database : the pilot cannot create these legs.

Departure and arrival procedures that are defined in the database may be divided into several parts, as shown in the following schematic.



FLIGHT PLAN CONSTRUCTION

There are three ways to define the route :

(1) It is a company route, it is in the database, and it is known by the crew.

The pilot enters the name of the CO RTE into the 1L field of the INIT A page, and this action enters all the elements of the flight plan. The database usually includes an alternate route associated with the destination.

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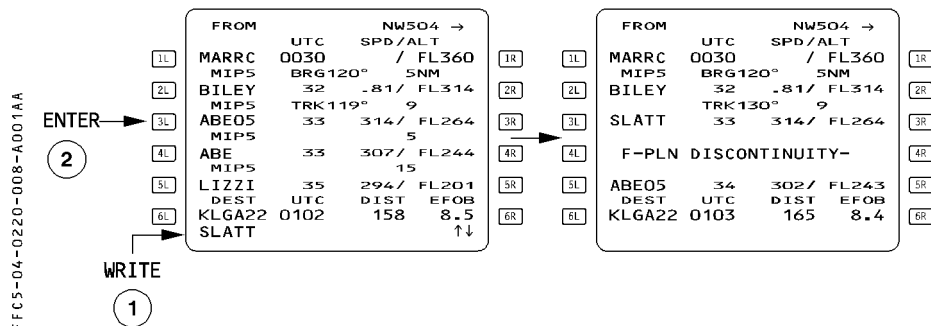
INIT		FROM/TO →
1L	CO RTE 20441	LSGG/LGAT
2L	ALTN/CO RTE LGTS/LGATLS01	INIT REQUEST*
3L	FLT NBR IT5612	ALIGN IRS→
4L	LAT↑↓ 4512.0N	LONG 00727.2E
5L	COST INDEX 540	WIND>
6L	CRZ FL/TEMP FL290 /-42	TROPO 36090

1R 2R 3R 4R 5R 6R

LATERAL REVISION

The crew can revise the lateral flight plan in three ways :

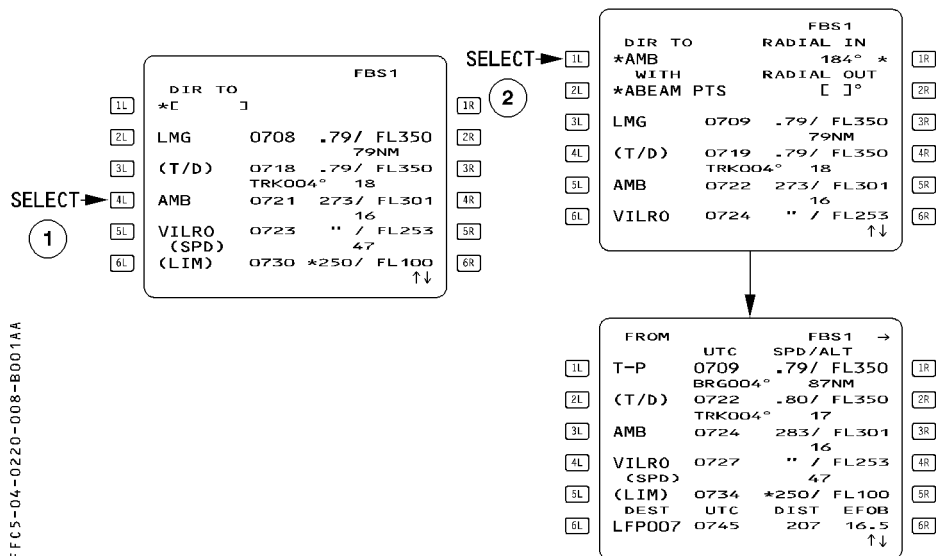
(1) Insert a new waypoint directly on the F-PLN page, or delete a waypoint from it.



When the pilot enters a new waypoint, the following waypoint moves down the flight plan, with a discontinuity shown between it and the new one.

(2) Add a DIR TO.

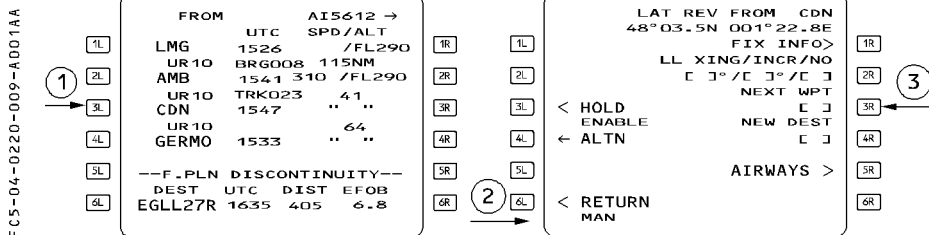
The crew can change the “TO” waypoint of the active leg. The DIR TO function gives access to DIR TO, DIR TO ABEAM or DIR TO/INTERCEPT. The active leg then goes from present position (T/P) to the waypoint selected or inserted as the new “TO” waypoint.



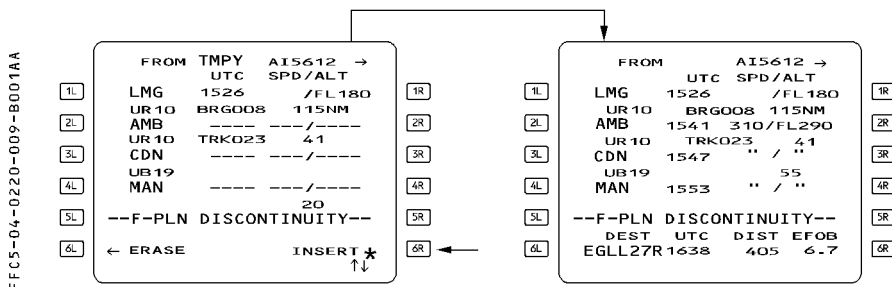
(3) Create a temporary flight plan and then insert it as a revision to the active flight plan.

The crew does this when selecting, deleting, or modifying several waypoints of an airway or procedure at once.

The purpose of the temporary flight plan is to allow the pilot to review the revision on the MCDU and ND before inserting it into the active flight plan.



A temporary revision is displayed for a check and/or new modification. Inserting it will modify the active flight plan.



For detailed explanation please refer 4.04.10.

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VERTICAL FLIGHT PLANNING

Data entry

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

There are three categories of data :

● **Strategic data, which applies to the overall flight profile**

Cost Index (CI)

Cruise Flight Level (CRZ FL), and STEP ALT if any

Zero-Fuel Weight (ZFW)

Zero-Fuel Center of Gravity (ZFCG)

Block Fuel

● **Tactical data for the flight phases**

– Phase switching conditions

Setting of the thrust levers to takeoff-go-around (TOGA) or FLEX positions

Reaching acceleration altitude (ACCEL ALT)

Entering cruise (top of climb, T/C)

Initiation of descent (top of descent, T/D)

Passing a deceleration pseudo waypoint (DECEL PSEUDO WPT)

Touchdown

– Speed profile

V2

Economy climb speed or Mach (ECON CLB SPD/MACH)

Preselected speed or Mach (SPD/MACH PRESELECTION)

Economy cruise Mach (ECON CRZ MACH)

Economy descent Mach or speed (ECON DES MACH/SPD)

Approach speed (VAPP)

– Vertical limitations

Speed limits (SPD LIMIT)

Speed and altitude constraints (SPD AND ALT CSTR), time constraint if any.

● **Weather data**

Winds (for climb, cruise, descent, approach)

Sea level atmospheric pressure (QNH) at destination

Surface temperature (TEMP) at destination

Temperature at cruise flight level.

FLIGHT PHASES

The vertical flight plan is divided into flight phases. For each phase, the FMGS computes the optimum speed or Mach profile.

The flight phases are :

Preflight - Takeoff - Climb - Cruise - Descent - Approach - Go-Around - Done.

FLIGHT PHASES	OPTIMUM SPEED PROFILE	SWITCHING CONDITIONS TO NEXT PHASE
PREFLIGHT	/	SRS takeoff mode engaged and N1 > 85 % (EPR ≥ 1.25) or Ground Speed > 90 kt
TAKEOFF	V2 (V2 + 10)	At acceleration altitude or by engagement of another vertical mode.
CLIMB	ECON CLB SPD / MACH	Reaching cruise FL
CRUISE	ECON CRZ MACH	No step descent, and distance to destination < 200 NM, or all engine operative and selected altitude below Max [FL 200, highest DES ALT CSTR]
DESCENT	ECON DES MACH / SPD	—Overflying (DECEL) pseudowaypoint with NAV (or LOC*/LOC) mode engaged and altitude < 7200 ft AGL —Manual activation of the approach phase.
APPROACH	Vapp (GSMin)	1.to Go Around : when thrust levers at TO.GA detent or 2.to Done : 30 seconds after landing or 3.to Climb : when inserting a new CRZ FL
GO AROUND	Vapp or current SPD whichever is greater. Green Dot at ACC ALT	1.to Approach : Manual activation of the approach phase or 2.to Climb : Above acceleration altitude by —selecting ALTN or —inserting NEW DEST and CRZ FL
DONE	/	To preflight when INIT or PERF key depressed.

Note : During the preflight phase, the pilot inserts the flight plan, which includes all data needed for the flight.

During the done phase, the FMGC erases the data entered for the flight.

If the descent or the approach phase is activated inadvertently (manual approach phase activation, for example), the pilot may reselect a CRZ FL on the PROG page to reactivate the CRZ phase.

VERTICAL REVISION

The pilot uses vertical revisions to enter or modify :

- The speed limit in climb and descent phases
- Constraints on altitude or speed
- A step climb or a step descent
- New wind data
- A time constraint

The vertical revision page is accessed by pressing a right hand select key of the flight plan page.

1L

2L

3L

4L

5L

6L

VERT REV AT MIP
EFOB=12.4 EXTRA=0.8

CLB SPD LIM
250/10000

SPD CSTR ALT CSTR
[] []

MACH/START WPT
*[]/MIP

<WIND STEP ALTS>

<RETURN

1R

2R

3R

4R

5R

6R

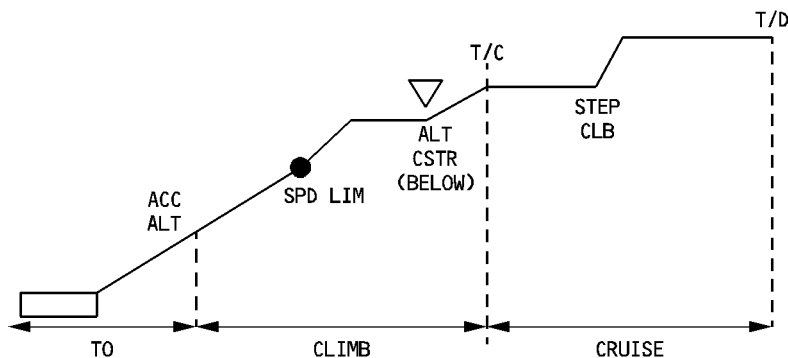
VERT REV AT CRUISE WPT

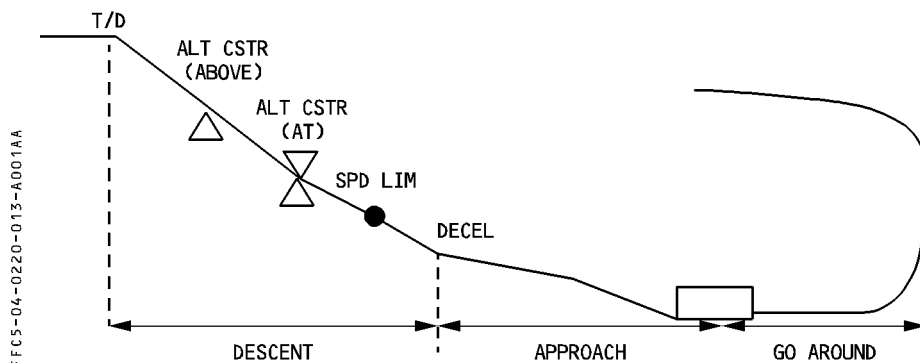
VERTICAL CONSTRAINTS (SPEED, ALTITUDE, TIME)

The pilot enters speed and altitude constraints to either comply with ATC requests and specified procedures, or in response to operational judgment.

Speed limit

A speed limit is associated with altitude, as a maximum speed below a specified altitude (only one in climb and one in descent).





Altitude constraint

Altitude constraints may be attached to specific waypoints in the climb, descent, or approach phases. To meet the altitude constraint, the aircraft must fly over the waypoint at an altitude equal, above or below the altitude constraint as specified by the pilot or the database.

An altitude constraint is considered as missed if the system predicts more than 250 feet of difference between the constraint value and the predicted aircraft altitude.

Altitude constraints are observed in CLB or DES or APP NAV-FINAL modes.

Note : *The database may contain an altitude constraint window (two altitudes between which the aircraft must fly passing over a given waypoint), but the pilot cannot enter such a constraint manually.*

Speed constraint

Speed constraints may be attached to specific waypoints in the climb, descent or approach phases. To meet the speed constraint, the aircraft must fly over the waypoint with a speed equal or less than the speed constraint.

A speed constraint is considered as missed if the system predicts an aircraft speed 10 knots greater than the speed constraint.

Speed constraints are observed when NAV mode is engaged and speed target is managed. Otherwise speed constraints are disregarded.

Time constraint

Time constraint may be attached to any waypoint except the “from” waypoint. It may be entered in cruise or descent phase.

Note : *No constraint can be associated with go around waypoints.*

PERFORMANCE FUNCTION

The performance function :

- Optimizes a flight plan
- Computes predictions

FLIGHT OPTIMIZATION

The optimization function computes :

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

BEST TARGET SPEED

Computed by the FMGS (except for V2), the best target speed (ECON SPD/MACH) is the basis for the managed speed profile.

ECON SPD/MACH is a function of :

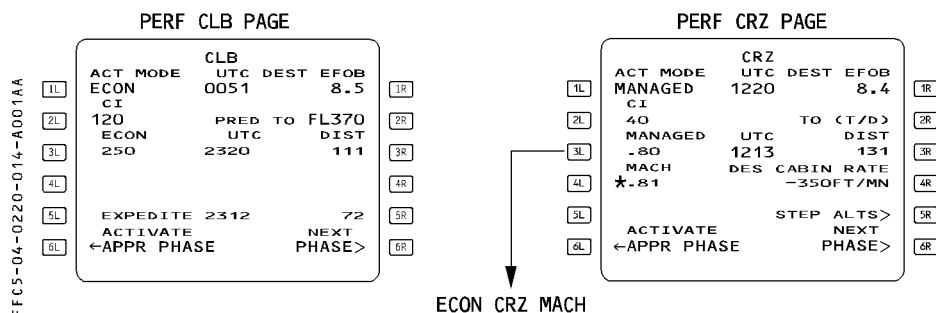
- Cost index (CI)
- Cruise flight level (CRZ FL)
- Gross weight and CG location
- Wind and temperature models

The computer processes the ECON SPDs for the climb and descent phases before the initiation of the flight phase, and freezes the values once the flight phase becomes active.

The computer updates ECON CRUISE MACH (SPD) continually, taking into account current weather conditions and modifications to the flight plan.

If the cruise FL is below FL 250, ECON CRUISE SPEED is computed.

If the cruise FL is above FL 250, ECON CRUISE MACH is computed.



WIND PROFILE

To obtain the best predictions, the pilot must enter the wind for various flight phases and specifically for waypoints in cruise.

ON GROUND : During flight planning initialization, enter the winds for climb and cruise phases using HISTORY WIND and WIND pages. You will enter, manually or with ACARS, different wind values in climb and cruise phases. The system will compute a wind for all waypoints of the F-PLN using linear interpolation between manual/ACARS entries.

This wind profile will be displayed on F-PLN B page and is called forecast wind profile. Pilot or ACARS entries are displayed in large font, system computed winds in small font.

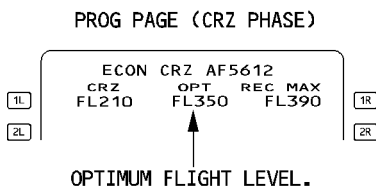
The forecast wind profile will be used to compute fuel and time predictions as well as econ speed/Mach targets.

IN FLIGHT : the system updates the predictions and the current econ speed, using the measured wind at present position. It mixes actual wind and forecast winds to compute the wind ahead of the aircraft but this is totally transparent to the crew.

During cruise, the pilot will enter descent winds and approach wind. The system will update the final predictions, compute the best descent profile and best speed in descent and approach.

OPTIMUM FLIGHT LEVEL

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The optimum flight level indicates the most economic flight level for a given cost index, weight, weather data. It is continuously updated in flight.

It ensures a 15 minute minimum cruise time. It is continuously updated in flight until 15 NM from the top of descent. It is dashed after this point.

You may observe a discrepancy between FMGS and FCOM/QRH value : this is due to the fact that the FMGS computes the optimum flight level with a given cost index where as the FCOM value is computed at a given Mach number.

The optimum flight level is a compromise between fuel and time saving : its computation may show steps due to slight GW, ISA or wind changes. As a consequence, the pilot may observe jumps in optimum flight level.

The computation of the OPT FL considers the wind entries made at the different altitudes (normally at the different CRZ FL).

When flying the subsequent CRZ FL, the OPT FL proposed by the PROG page may be affected by the

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wind entries made at the previous CRZ FL ; these winds are propagated automatically and may be significantly different from the actual winds.

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BEST DESCENT PATH

The vertical flight path is computed to minimize fuel consumption while satisfying the various altitude constraints and the descent speed profile in order to reach VAPP at 1000 feet.

The computer calculates the descent profile before the descent phase is initiated, taking into account :

- All the lateral and vertical flight plan data
- The descent and approach winds, as inserted into the WIND DES page and PERF APPR page, and the required maximum cabin rate of descent.

During descent, the descent profile is updated only if the flight plan is modified or if data for the APPR phase (WIND, VAPP, or LDG CONF) are changed.

COST INDEX (CI)

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

The operations department of the airline usually defines the cost index so as to optimize each company route.

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

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

CI = 999 corresponds to minimum time

CI = Long Range Cruise (Refer to 4.05.50).

COMPUTATION OF PREDICTIONS

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

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

The MCDU and the ND show these predictions, each of which is based on specific assumptions.

Predictions displayed on the Navigation Display (ND)

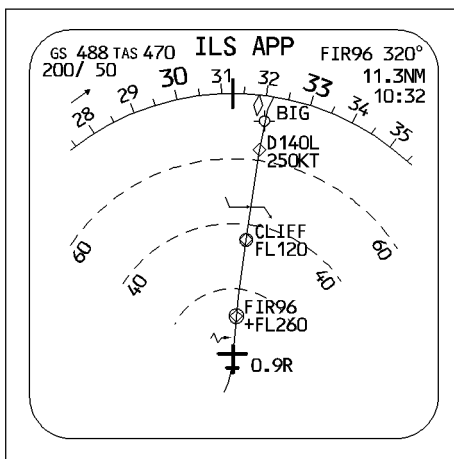
These predictions consist of :

- symbols positioned along the lateral flight plan (NAV mode engaged) or the track line (NAV mode not engaged). These symbols (named as pseudo waypoints) and their meanings are :

Pseudo waypoint	Definition
	Level symbol (top of climb or level-off), at the position where the aircraft will reach : – the FCU selected altitude (blue arrow) or – the constrained altitude, if it is more restrictive than the FCU altitude and if appropriate modes are engaged (magenta arrow).
	Top of descent or continue descent symbol : – top of descent (always white) – continue descent symbol (white if DES is not armed, blue if it is)
	Start of climb symbol : – white if CLB is not armed – blue if CLB is armed
	Intercept point symbol : – the point where the aircraft is predicted to intercept the descent path, if there is any vertical deviation when the aircraft is in DES mode (white if DES is not engaged, blue if it is)
	Speed change symbol : – the point at which the aircraft will initiate an automatic ACCEL or DECEL from current speed to a new computed speed if it encounters a SPD LIM, SPD CSTR, or HOLDING SPD (magenta)

Pseudo waypoint	Definition
	Decelerate point symbol : - Indicates the point at which the aircraft is predicted to decelerate for approach (and thus switch to the approach phase). - Magenta, if in managed speed and NAV or approach mode is engaged. - White, if in selected speed or HDG/TRK mode. - Automatic decelerations only occur when displayed in magenta.
	ALT CSTR symbol set around the constrained waypoint : - magenta when the ALT CSTR is predicted to be satisfied - amber when the ALT CSTR is predicted to be missed - white when the ALT CSTR is not taken into account by the guidance, and the NAV mode is engaged.
	Energy circle symbol (green arc) centered on the a/c position and oriented to the current track line. Represents the Required Distance to Land. Only displayed in descent and approach phase when a selected lateral mode is engaged (HDG or TRK)
Crosstrack error XX.X R or XX.XL (X is a number)	The crosstrack error displays the lateral deviation between the aircraft position and the track of the F-PLN active leg. The value is limited to 99.9 NM left or right.

- predicted time of arrival at the TO WPT (upper right hand corner of the ND), assumes that the aircraft flies direct from present position to the TO WPT at present ground speed.



As a general rule the ND indicates what the aircraft will fly with the current active FG modes.

For example :

- The continuous green line on the ND represents the track the aircraft is currently flying :
 - If HDG/TRK is engaged, the track line is green and the flight plan is dashed.
 - If NAV mode is engaged, the green line is the flight plan.
- If the speed target is manually selected, the speed-change symbol is no longer displayed because it will not be taken into account.
- When the aircraft is not following the vertical flight plan (OPCLB, OPDES, V/S) but the NAV mode is engaged, the system disregards any altitude constraints and puts white circles around the waypoints that have these constraints and positions level symbols accordingly.
- Pseudo waypoints are adjusted each time predictions are updated.

PREDICTIONS DISPLAYED ON THE MCDU

The predictions displayed on the MCDU assume that AP (or FD order) is controlling the aircraft and flying it along the preplanned lateral and vertical flight plan.

Therefore :

- If the aircraft is guided along the flight plan (managed guidance), the MCDU predictions correspond exactly to what the aircraft is doing.
- If the aircraft is not guided along the flight plan (selected guidance), the MCDU predictions assume that it will return immediately to the flight plan, intercepting at a predetermined angle, and will then proceed under managed guidance.
- If the aircraft does not fly the managed speed profile (ECON, SPD CSTR ...), the MCDU predictions assume that it will remain at the present selected speed/Mach until it reaches the next SPD CSTR or SPD LIM or enters the next flight phase.
- The TO waypoint information in the right upper corner are updated as if the aircraft would still fly toward it.

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FROM	AF5612 →
1L LSGG23	TIME SPD/ALT
2L TOP9A	0000 148/ *1365
3L PAS	BRG228 6NM
4L HOLD L	0003 210/ 5500
5L 7000	TRK228 12
6L (SPD)	0006 " / 7000
(LIM)	" 0
TOP9A	0006 210/ 7000
D136E	0007 230/ *FL90
DEST	TIME DIST EFOB
LGAT33R	0220 992 8.4
	↑↓

F-PLN A

FROM	AF5612 ←
1L LSGG23	EFOB WIND
2L TOP9C	15.0 060° /005
3L PAS	BRG228 6NM
4L HOLD L	14.7 " /020
5L 7000	TRK230 12
6L (SPD)	14.6 " /022
(LIM)	" 0
TOP9C	" " 5
D136E	14.5 066° /026
DEST	TIME DIST EFOB
LGAT33R	0220 992 8.4
	↑↓

F-PLN B

TYPE OF PREDICTIONS

	MCDU PAGE :
Pseudo waypoints : T/C, T/D, S/C, S/D, I/P, SPD LIM, DECEL	F-PLN A and B
TIME / SPD / ALT at each WPT and pseudo-WPT	F-PLN A
ETA / DIST TO DEST along F-PLN / EFOB at destination	F-PLN A and B
EFOB / T-WIND at each WPT and pseudo-WPT	F-PLN B
Constrain symbol * at each constrained WPT (TIME / SPD / ALT)	F-PLN A and B
Altitude error in case of missed ALT constraint	VERT REV
EFOB / EXTRA FUEL at each WPT	VERT REV
TIME / EFOB at destination	FUEL PRED / PERF
	CLB / CRZ / DES
TIME / DIST to a selected altitude	PERF CLB or DES
Fuel prediction prior engine start	INIT B
REC MAX FL	PROG
TIME / EFOB at Alternate	FUEL PRED
XTRA FUEL for various Alternates	ALTN
VDEV vertical deviation from vertical flight path	PROG
Required Distance to Land	PROG
Direct Distance to Destination	PROG

EXAMPLES OF MCDU PREDICTIONS

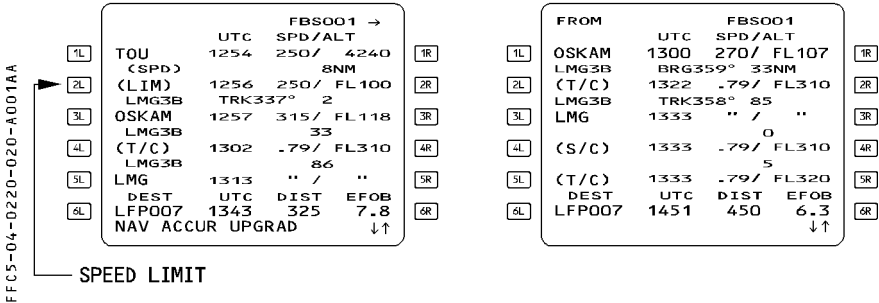
The following MCDU pages display some of the prediction types.

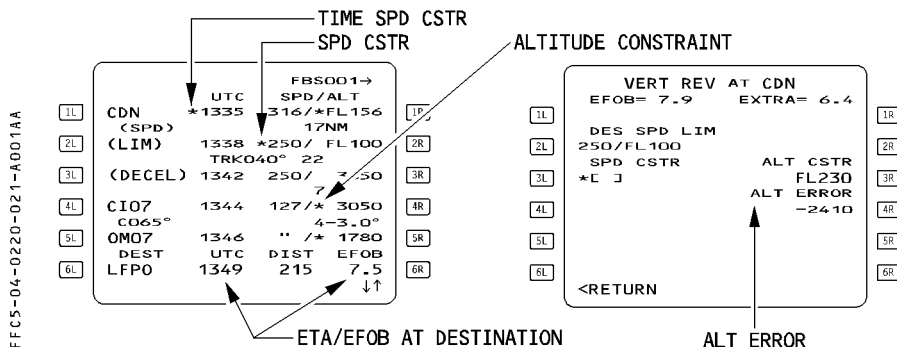
Pseudo-waypoints :

Top of climb (T/C), top-of-descent (T/D), start of climb (S/C) or start of descent (S/D) for step climb/descent, speed limit (SPD LIM), deceleration to approach phase (DECEL)

Time, speed and altitude predictions

TIME/SPD/ALT for all waypoints and pseudo waypoints.

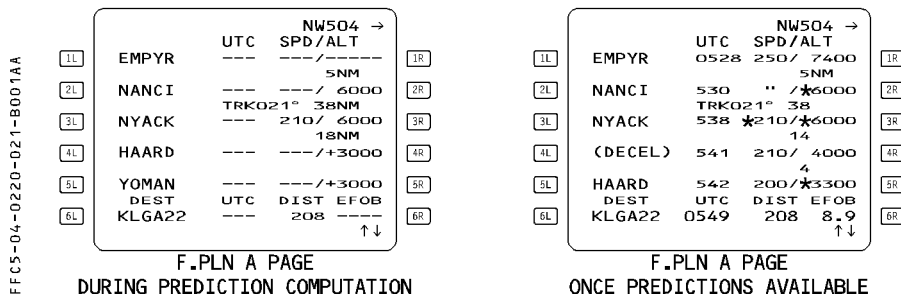




CONSTRAINT SYMBOLS (star)

When a time speed or an altitude constraint is part of the vertical flight plan, it appears on F-PLN A page only at the time of insertion or while predictions are not yet available.

Once available, time, speed and altitude predictions are displayed for all F-PLN waypoints: when a speed or an altitude constraint is in effect at a waypoint, a star symbol appears adjacent to the speed or altitude prediction. If the star is magenta the constraint is predicted to be matched. If the star is amber, the constraint is predicted to be missed.



Note: If an altitude constraint is predicted as missed, the system tells you what will be the error at the specific waypoint.

	FMGS OPERATIONAL PRINCIPLES		4.02.20	P 22
	FLIGHT MANAGEMENT PRINCIPLES		SEQ 001	REV 07

VERTICAL DEVIATION

During the descent, the system tells you, how far you are from the computed descent profile (PFD and MCDU) and predicts where you may rejoin it. VDEV on PFD, predictions on MCDU F-PLN page, symbols on ND display allows you to assess your vertical position versus the computed flight profile. The energy circle displayed on ND, representing the required distance to land from present position and current speed down to destination at VAPP, may also be used to tell you if you need to modify the flight path you intend to fly.

OPERATION RULES CONCERNING PREDICTIONS

- The pilot must keep the flight plan data properly updated during the flight in order to get accurate and meaningful predictions.
- The pilot should rely on the navigation display for short-term predictions. It indicates what the aircraft will do under the currently engaged modes (selected or managed).
- The pilot should rely on the MCDU for long-term predictions when managed guidance is active or about to be reengaged.