

# AIRBUS DESCENT MONITORING

## THE MAGICAL AND MYSTERIOUS WORLD OF THE AIRBUS FMGS

You've probably heard the (really) old joke about Airbus Pilots:

*How can you tell an Airbus Pilot?*

*(S)He's the one who says "What's it doing now?"*

*How can you tell an experienced Airbus Pilot?*

*(S)He's the one who says "It's doing that again!"*

I would like a dollar for every time that I've thought the first thought (when new on the Airbus) and for every time that I've thought the second thought (after being on the Airbus for over a decade). Yes, after over ten years on the Airbus it still throws up stuff that I have either never seen before or have been unable to work out why it does what it does. However, I have managed to sort out the wheat from the chaff and have a reasonable idea of what the FMGS is actually doing now.

For most Airbus drivers the FMGS appears to be a blend of logic(?) and black magic and runs on smoke and mirrors. Just do a quick Google search on the Internet with "Airbus Automation" and you will find several accident reports in amongst all the other stuff. Pilots (just like you) have managed to crash Airbuses because they didn't know, were not aware of, or misunderstood what the FMGS Autoflight system was doing (or trying to do).

In reality the FMGS is just some computer software and does what its programmers, programmed it for. Most of the mysteries of the FMGS are because YOU (yes you!) don't know or are confused with the "rules" that it uses to calculate predictions, display items and symbols (and their colours) on the PFD, ND and MCDU and how it interacts with the AP, FD and A/THR. Make no mistake all these separate bits of kit are related and interact together. That's why the "S" part of the FMGS is in there – it's all part of a SYSTEM.

Whether you like it or not, the Airbus is a glass filled, highly automated aircraft. If you can't hack this fact (or are unwilling to!) then get yourself a Classic conversion fast!!

While the FMGS is busy working away during all Phases of flight, the Descent Phase (and to a lesser extent the Approach Phase) is where most people have trouble.

What follows is one person's attempt to unravel most of the common misconceptions, errors and Gotchas related to monitoring the descent on the Airbus. Everything on the Airbus is inter-related so we'll be looking at the A/THR, AP, FD, displays (PFD, ND and MCDU – symbology and colours) and the FMGS.

Some people try and make monitoring of the Airbus descent into some Black Art that will take years to master. Not so. Have a read of this, which is mainly extracts pulled from the FCOM 1 (Auto Flight), FCOM 4 (FMGS), FCTM and my own personal observations after having made all the mistakes (but I bet there are still some out there waiting for me!).

Couple this new understanding with bog standard, basic mental descent monitoring (I strongly urge you to read, understand and practically apply the Descent Profile Management contained in the FCTM – it's easy and will save your butt when the FMGS does something you weren't expecting) and you will gain year's worth of my muddling, mistake riddled Airbus experience.

*Mistakes are inevitable in aviation, especially when one is still learning new things. The trick is to not make the mistake that will kill you. (Stephen Coonts)*

Really start to look at the displays (PFD, FMA, ND and MCDU) and use the information that they provide in a common sense and practical way. There is no point in looking at the PFD, ND or MCDU unless you know what it is telling you. You will either be ignorant of what is actually occurring or you will make poor decisions based on the incorrectly interpreted information you decipher from the displays. With correct knowledge you can anticipate what the system will do next and if it is not what you want, intervene and make it do exactly what you desire.

After all, that is what piloting is all about and you will enjoy flying so much more!

So sit back, relax(?) and let the games begin!

I don't care how you obtained a copy of these notes, however be aware that these notes are not Cathay Pacific Airways approved documents. While I have done my best to ensure that there are no errors, I can't guarantee this. Official Company publications and FCOMs take precedence over these notes. Therefore, *caveat emptor*, use at your own risk.

If you do find an error, please let me know and I'll correct future versions. Send a Groupwise to Jack Frost – *crwfga*.

# AIRBUS DESCENT MONITORING

## AUTOTHRUST (A/THR)

Let's start off with a look at the A/THR. Why the A/THR? Well it's relatively simple to describe and you need to understand how the FMGS Vertical modes interact with the A/THR to understand why it is doing what it is doing.

### A/THR Engagement Status

The A/THR *engagement status* is displayed on the PFD FMA fifth column (the right hand column, on the third line).

There are three possible engagement statuses. The A/THR modes may be either:

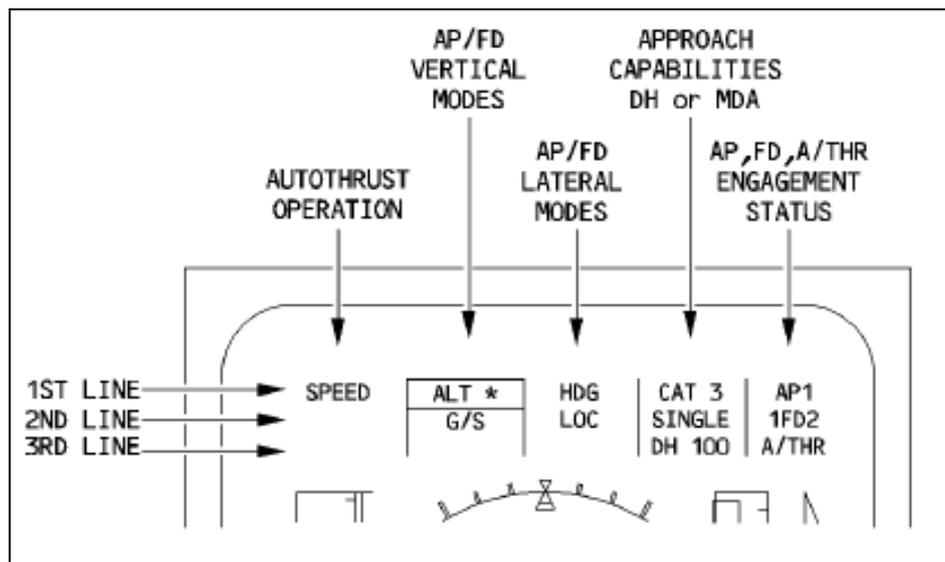
- *Armed* (**A/THR** displayed in blue in the FMA fifth column),
- *Active* (**A/THR** displayed in white in the FMA fifth column), or
- *Disconnected* (FMA fifth column, third line blank and no operation mode displayed in the FMA first column).

### A/THR Operation Modes

The A/THR *operation modes* are displayed on the PFD FMA first column (the left hand column).

There are three general A/THR operation modes:

- *SPEED/MACH*,
- *THR(ust)*, and
- *RETARD* (IDLE thrust and used when in the AP/FD FLARE mode – not considered in this discussion).



### SPEED/MACH Mode

When in SPEED/MACH mode the A/THR will command either a SPEED or MACH that is either the Selected Speed or the Managed Speed. Either **SPEED** or **MACH** will be annunciated in green in the FMA first column.

The system determines automatically when it should change from SPEED to MACH in the climb and vice versa in the descent. The point at which this occurs is called the *crossover altitude* (normally around FL 310 when using Managed Speed, but this does vary depending on whether you are climbing or descending or, using Managed or Selected Speed).

The crossover altitude may be different when using Managed Speed or Selected Speed as the system can use different Speeds/Mach when climbing or descending. Use the PERF CLB or PERF DES page to view the Managed Speed/Mach (and if Selected Speed is used the Speed/Mach used for Selected Speed). For example, in the climb the Managed Speed may be 305/0.82, but if a Selected Speed of 320 Kts is used it may be 320/0.84.

## AIRBUS DESCENT MONITORING

When the speed is Selected, the pilot can do the switching manually by pressing the SPEED/MACH pushbutton on the FCU. When the target speed is Managed, the FMGC commands the switchover automatically as a function of the ECON MACH value.

### THR(ust) Mode

When in THR(ust) mode the A/THR will command an amount of thrust. The FMA first column will display **THR** along with the associated type of THRUST mode (e.g. THR CLB, THR DCLB1(2), THR IDLE or THR DES).

This amount of thrust is usually fixed (in the case of THR CLB, THR DCLB1(2) or THR IDLE), but can sometimes be variable (in the case of THR DES).

### Interaction Between AP/FD And A/THR Modes

The AP/FD vertical pitch modes can control a target SPEED/MACH or a vertical trajectory (or path); the A/THR modes can control a fixed THR or a target SPEED/MACH. AP/FD and A/THR **cannot** simultaneously control a target SPEED/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 SPEED/MACH.
- If an AP/FD pitch mode controls a target Speed or Mach, the A/THR mode controls the THR.
- If no AP/FD pitch mode is engaged, the A/THR mode reverts to SPEED/MACH mode.

*In other words, the selection of an AP/FD pitch mode determines the associated A/THR mode.*

### FMA INDICATIONS

Lateral and Vertical Modes of the FMGS can be either:

- *Armed,*
- *Engaged, or*
- *Disengaged.*

The AP/FD Vertical Modes are displayed on the second column of the FMA.

The AP/FD Lateral Modes are displayed on the third column of the FMA.

For both the Vertical and Lateral Modes:

- The first line displays the *Engaged Mode* in green.
- The second line displays the *Armed Mode(s)* in blue or magenta (if a constraint is involved). In some cases for Vertical Modes two modes may be armed at the same time (e.g. ALT and FINAL).
- The third line displays *Special Messages* or *AP/FD Common Modes* (e.g. ROLLOUT or FLARE).

*What is chiefly needed is skill rather than machinery. (Wilbur Wright, 1902)*

### FMGS FLIGHT PHASES

The vertical flight plan is divided into Flight Phases. For each Phase, the FMGS computes the optimum Speed or Mach profile. You need to understand what each Flight Phase means, what Speed profile it uses and the Switching Conditions that the FMGS uses to change the Flight Phases.

The Flight Phases are:

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

The FMGS Flight Phases are NOT related to the FWC Phases (which are used to inhibit/display ECAM Warnings and Cautions and Take Off and Landing Memos).

## AIRBUS DESCENT MONITORING

Each FMGS Phase except the Preflight and Done Phases has a Performance (PERF) page. The PERF pages display performance data, speeds related to the various phases, and predictions.

Pressing the PERF key on the MCDU calls up the performance page for the current active Phase. Performance pages relating to Phases already flown are not available. To determine which Flight Phase the FMGS is currently in, select the MCDU PERF page. The current Flight Phase title will be GREEN large font (e.g. **DES**). Non current Flight Phases titles will be WHITE large font (e.g. **CLB**).

The two most important Flight Phases for the purposes of this discussion are the Descent and the Approach Phases, but all are included for completeness.

FLIGHT PHASE	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, all engines)	At ACCLN ALT 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	<ul style="list-style-type: none"> <li>▪ Overflying the Decel pseudo waypoint with NAV (or LOC*/LOC) mode engaged and altitude &lt; 7,200' AGL, or</li> <li>▪ Manual activation of the approach phase.</li> </ul>
APPROACH	VAPP (GS Min)	<ul style="list-style-type: none"> <li>▪ To Go Around: When thrust levers at TOGA detent, or</li> <li>▪ To Done: 30 seconds after landing, or</li> <li>▪ To Climb: When inserting a new CRZ FL</li> </ul>
GO AROUND	VAPP or current SPD, whichever is greater.  Green Dot at ACC ALT	<ul style="list-style-type: none"> <li>▪ To Approach: Manual activation of the APPR Phase, or</li> <li>▪ To Climb: Above acceleration altitude by: <ul style="list-style-type: none"> <li>▪ Selecting ALTN, or</li> <li>▪ Inserting NEW DEST and CRZ FL</li> </ul> </li> </ul>
DONE	–	To Preflight when INIT or PERF key depressed.

### ND SYMBOLOGY

Familiarity with the symbology on the ND can help you monitor your descent (after all that's why they are displayed). Know what you're looking at and what the symbols and their colours mean. They can be a great help to plan ahead so that you can anticipate what will occur next and produce an expeditious and efficient approach and arrival.

#### T/D

The top of descent displayed on the FPLN page (T/D) and on the ND  is a position that the FMGS calculates, assuming that the aircraft will begin its descent in *DES mode with Managed speed*, and that the system will guide the aircraft along the FPLN track and the descent profile computed is with all the vertical FPLN data (ALT CSTR, MANAGED MACH/SPEED, SPD CSTR, SPD LIMIT and inserted winds) to reach VAPP at 1,000 feet AGL.

Note: The ND does not display the top of descent arrow when HDG (or TRACK) mode is engaged.

## AIRBUS DESCENT MONITORING

### Level Off (Climb/Descent)

The level off arrow  (climb),  (descent) gives the point on the flight plan where the aircraft will reach the FCU selected altitude.

### Continue (Climb/Descent)

The start of climb  or continue descent  shows the point on the flight plan where the aircraft is predicted to leave the current flight level.

### Intercept Point

The intercept symbol  shows the point on the flight plan where the aircraft will intercept the FMGC computed vertical descent profile. It is displayed in white if DES mode is not armed and in blue when DES mode is armed.

It can appear if the aircraft is either above or below the FMGC computed descent profile.

#### If Above The FMGC Profile

If the aircraft is above the descent profile and in Managed Speed, the speed will increase toward the upper limit of the Managed Speed target range. If the speed reaches the upper limit, the aircraft will maintain the speed but will deviate above the profile (A/THR at IDLE).

The ND Intercept Point assumes the aircraft will return to the profile using:

- Idle thrust,
- Half speedbrake extension, and
- ECON speed plus a margin (until intercepting the profile).

When this symbol reaches the next ALT CSTR waypoint “EXTEND SPD BRK” appears on the PFD and MCDU indicating that speedbrakes must be extended in order to match the next altitude constraint. This is an advisory message.

Note: When DES mode is engaged, the speedbrake extension will not necessarily increase the descent rate. It does so only if the aircraft is *above* the profile. If the aircraft is on or below the profile the AP will maintain the aircraft on profile (or intercept the profile from below) and the A/THR will add thrust to keep the aircraft within the speed target range.

#### If Below The FMGC Profile

The system maintains the target speed (Managed or Selected speed) with the A/THR in SPEED/MACH mode, and at:

- 1,000 ft/min rate of descent (if the aircraft is flying an IDLE segment), or
- 500 ft/min rate of descent (if the aircraft is flying a GEOMETRIC segment),

until it reaches the constraint altitude or intercepts the profile.

### Arrow Symbol Colours (T/C, T/D, Level Off, Continue, Intercept Point)

The various arrow symbols are coloured blue  if using a Managed mode or it is armed (CLB or DES), magenta  if a constraint or white  if using a Selected mode (OP CLB, OP DES, V/S or FPA). The T/D arrow is always white as there is no automatic descent (see initiating descent).

### Speed Change

The speed change waypoint  represents the point(s) of the flight plan where the speed has to change (e.g. SPD LIM).

## AIRBUS DESCENT MONITORING

### Decel

The decelerate waypoint  represents the point of the flight plan where the aircraft is predicted to decelerate for approach. It is displayed in magenta when in Managed speed and NAV or APPR mode is engaged. Displayed in white when in Selected speed mode or HDG/TRK mode. Automatic decelerations occur only when displayed in magenta.

### Energy Circle

The energy circle  is indicated by an arc drawn 20°. The radius corresponds to the required distance to land from present position. The energy circle computed by the FMGC is available in ROSE NAV and ARC modes only.

### Waypoint Altitude Constraints

The constraint waypoint (a circle around the waypoint) is displayed at flight plan waypoints where an altitude constraint (speed constraints are not displayed on the ND with circles) is defined:

- 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 (e.g. OP DES).
- Not displayed when in any other lateral mode except NAV (e.g. HDG).

## DESCENT MODE (DES)

This mode would have to provide the most confusion for pilots when they are trying to monitor the Airbus during descent. If you can understand what the FMGS is trying to achieve and how this translates into AP/FD and A/THR commands when in the DES mode then you can rightfully call yourself an Airbus pilot...if you can't, then you're a passenger.

*There are two kinds of airplanes — those you fly and those that fly you. You must have a distinct understanding at the very start as to who is the boss. (Ernest K. Gann)*

DES mode provides Managed vertical guidance along an FM computed vertical descent profile. The system computes this flight path backwards from the Decel point up to the top of descent (T/D) at the cruise flight level with respect to the speed and altitude constraints. The Decel point is where the guidance begins the deceleration to VAPP, to be reached at 1,000 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 (speed and altitude constraints and SPD LIM), and it is based upon the Managed descent speed profile. It does not take holding patterns into consideration.

### Initiating descent (DES Mode)

The aircraft will not start its descent automatically when reaching the top of descent (T/D). In order to initiate the descent, you set the ATC lower clearance altitude on the FCU, then push the ALT selector knob. The aircraft will then descend immediately.

- If the descent is initiated before the FM computed T/D, the aircraft descends at a constant V/S converging on the descent path from below. The A/THR operational mode will be SPEED/MACH.
- If the descent is initiated after the FM computed T/D, the aircraft descends at idle thrust and attempts to converge on the descent path from above. The A/THR operational mode will be THR IDLE.
- If the descent is initiated at the FM computed T/D, the aircraft is descending on the FM calculated vertical descent profile. The A/THR operational mode will be THR DES.

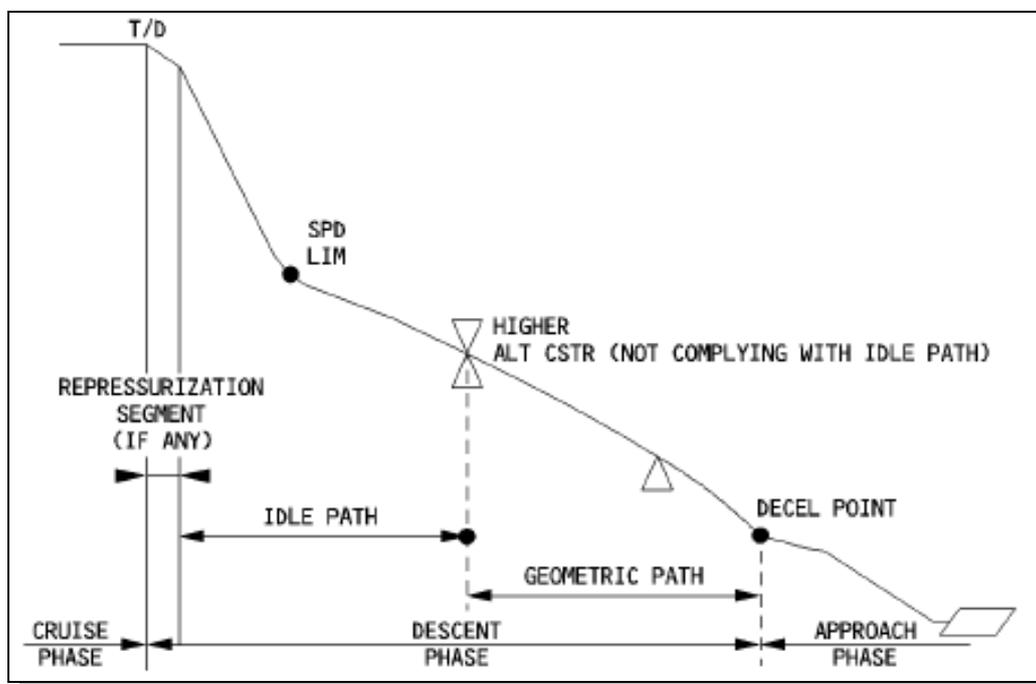
## AIRBUS DESCENT MONITORING

### Descent Profile Segments

Internally, the computer divides the descent path into various segments, depending on the relative positions of the constraints. It starts at top of descent (T/D) by setting up an "Idle" segment that takes the aircraft down to the first constraint, and follows this with "Geometric" segments between constraints.

The descent profile has several segments:

- **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). Don't worry about this segment. Practically it has little bearing on the vertical descent.
- **Idle path** segment. The AP/FD controls the speed and A/THR stays at idle thrust. Guidance computes this profile from T/D or the end of the repressurization segment to the first vertical constraint that cannot be flown at idle thrust.
- **Geometric path** segment(s). The AP/FD controls the vertical path, and A/THR controls the speed. These segments take the aircraft from the first constraint that cannot be flown at idle thrust (and any subsequent constraints) to the Decel Point. Note that there may be more than one Geometric segment and the various Geometric segments may be at different descent angles to satisfy the various altitude or speed constraints at the waypoints contained in the Geometric segments.



When DES mode is engaged, NAV mode is engaged (or another way to look at it is, you won't be able to engage DES mode unless you are in NAV mode), and the system takes into account all altitude and speed constraints.

### Profile Monitoring

The key parameter for monitoring the descent is the vertical deviation (VDEV) displayed on the PFD and on the MCDU PROG page, which indicates whether the aircraft is on, above, or below the FM calculated vertical descent profile.

Well that's what the books say. Ensure that you mentally compute your own vertical descent profile and compare it with the FM calculated vertical descent profile. Blindly trust VDEV at your own peril!

It's not a matter of **IF** you'll get caught out, but **WHEN** you'll get caught out (and by how much)!

## **AIRBUS DESCENT MONITORING**

### **If the aircraft is on the descent profile**

The aircraft is considered to be on the vertical profile when it is within 50 feet of it. VDEV is close to zero, and the system predicts that it will match constraints until the aircraft levels off at the next FCU altitude.

The A/THR adjusts the thrust for the particular segment. The first FMA column may display THR IDLE or SPEED/MACH (depending on whether the Managed Speed reaches the upper or lower limit of the Managed Speed target range) but will normally display THR DES.

### **If the aircraft is above the descent profile**

VDEV is down on the PFD and positive on the PROG page.

The A/THR sets THR IDLE and if in Managed Speed the AP increases speed up to the maximum of the Managed Speed target range by calling for down elevator. If the aircraft reaches the upper limit of the Managed Speed target range, the aircraft diverges from the FM calculated vertical descent profile and maintains the upper limit speed.

### **If the aircraft is below the descent profile:**

VDEV is up on the PFD and negative on the PROG page. The system maintains the target speed (Managed or Selected Speed).

The A/THR is in SPEED (MACH) mode with a 1,000 ft/min rate of descent (if the aircraft is flying an Idle segment), or 500 ft/min (if the aircraft is flying a Geometric segment) until the profile is regained.

### **Managed Speed**

When the speed is Managed, a target speed range displayed on the PFD defines acceptable speed variations around the nominal Managed descent speed target (normally  $\pm 20$  Kts).

- If the aircraft is on the descent profile the AP will maintain the Managed target speed. The AP will vary the speed within this managed target speed to account for minor variations in Winds, Temps, Eng A/I being selected on etc. to keep on the previously FM calculated vertical descent profile. The A/THR will be in THR DES mode (you have to be on profile to get this mode), but will most likely be commanding Idle (check on the EW/D as the FMA will display THR DES).
- If the aircraft is above the descent profile the AP commands down pitch and the speed increases toward the upper limit of the Managed target speed range as the aircraft attempts to converge on the descent profile from above. If this does not increase the descent angle enough, the aircraft deviates (goes high) from the descent profile with the A/THR at THR IDLE.
- If the aircraft is below the descent profile, the AP maintains the Managed target speed until it reaches the vertical profile at reduced V/S (either 1,000 ft/min for an Idle segment or 500 ft/min for a Geometric segment). The lower margin becomes effective when the aircraft is on the descent profile but has to lose speed in order to stay on it. The A/THR may go into SPEED/MACH mode.

The ND shows an intercept symbol that indicates the position where the system predicts that the aircraft will be back on the descent profile. (See MCDU message "EXTEND SPD BRK" and ND Intercept Point Symbology).

### **Too Steep Path**

A segment between two constraints is called TOO STEEP PATH when the FMGS predicts that it is impossible to fly it at the pre-planned speed with half speedbrakes extended.

TOO STEEP PATH AHEAD appears on the MCDU scratchpad when the system predicts this situation. TOO STEEP PATH is also displayed on the FPLN page. The 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. The VDEV makes a jump because it is related to a new profile.

## AIRBUS DESCENT MONITORING

### VDEV

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

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

- Unexpected wind conditions are encountered, or
- Anti-icing is turned on, or
- Lateral FPLN is modified.

VDEV on PFD and PROG page, predictions on MCDU FPLN page and symbols on ND allow you to assess your vertical position versus the *computed* FM descent profile.

### OP DES, V/S OR FPA MODE ENGAGED

In either case, the aircraft is no longer guided on the descent profile and altitude constraints are disregarded. If NAV mode is engaged the ND displays a white circle on waypoints with an altitude constraint. If NAV mode is disengaged, the circles are removed.

The PFD still shows VDEV for reference purposes (but depending how much the actual lateral and vertical descent profile differs from the FM calculated vertical descent profile, the VDEV may give inaccurate or incorrect information).

The target altitude is always the FCU selected altitude (shown in blue). On the ND, the level-off symbol is blue (no constraint).

If NAV mode is engaged and the speed target Managed, speed constraints are taken into account.

### CONSTRAINTS

#### General

Altitude or Speed constraints are only taken into consideration by the FMGS in the *Climb, Descent, or Approach* Phases, but never in the Cruise Phase. Both types of constraints are ignored if entered while in the Cruise Phase.

No constraint can be associated with Go Around waypoints.

#### CLB Mode

When CLB mode is engaged (always associated with lateral NAV mode), the system takes into account all constraints defined by the database or manually entered by the crew.

Nevertheless this mode has the following particularity:

- When in CLB mode if the system predicts that it will miss an altitude constraint, it will **not** modify the target speed. In this case, the pilot may select an appropriate speed in order to meet the ALT CSTR.

#### 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.

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.

# AIRBUS DESCENT MONITORING

## 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 Kts greater than the speed constraint.

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

## MCDU Constraint Symbols

When a time, speed or an altitude constraint is part of the vertical flight plan, it appears on FPLN A page (the actual numbers in magenta) only at the time of insertion or while predictions are not yet available.

Once available, the actual time, speed and altitude predictions are displayed for all FPLN 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. If the aircraft is predicted to miss the constraint by more than 10 knot, the MCDU scratchpad displays SPD ERROR AT WPT ---- .

Note: If an altitude constraint is predicted as missed, the system tells you what will be the error at the specific waypoint by accessing a VERT Revision at that waypoint.

## MCDU Constraint Predictions

The database may define an altitude constraint and speed constraint for each waypoint of the Climb, Descent, and Approach Phases, or the pilot may insert such constraints manually (except at origin, destination, FROM and pseudo waypoints).

The constraints (the actual numbers, e.g. 250/130) are displayed in magenta as long as predictions are not completed.

Once predictions are available, constraints are replaced by computed speed and altitude predictions (in green for all waypoints except the TO and DEST waypoints which are displayed in white) preceded by stars (see above).

*Learning the secret of flight from a bird was a good deal like learning the secret of magic from a magician. After you know what to look for you see things that you did not notice when you did not know exactly what to look for. (Orville Wright)*

## PSEUDO WAYPOINTS

Pseudo waypoints are computed geographical positions corresponding to an event in the vertical flight plan; T/C (top of climb), T/D (top of descent), SPD LIM (speed limit), DECEL (deceleration for approach) etc. The MCDU FPLN shows them as waypoints in parentheses.

## MCDU MESSAGES

Messages displayed on the MCDU are of two types and displayed in two colours:

- Type I: a direct result of a pilot action, or
- Type II: information about a situation or a call for pilot action.
- Amber (A): important
- White (W): less important.

Type II messages are stored in a first-in/first-out message queue (5 messages max.) They are suppressed if correct data is entered or when they no longer apply.

## AIRBUS DESCENT MONITORING

The flight crew can clear all messages by pressing the CLEAR key on the MCDU console.

Some of the more common MCDU Messages displayed during descent and their meanings are:

MESSAGE	TYPE/ COLOUR	CONDITIONS
CSTR DEL ABOVE CRZ FL	II/W	This appears when a flight plan altitude constraint has been deleted because the flight crew has inserted a cruise flight level or step-down altitude that is at or below the flight plan constraint.
DECELERATE (Also displayed on PFD)	II/A	The aircraft is still in cruise phase and managed speed after it reaches the top of descent and it has not begun the descent.
ENTER DEST DATA	II/A	The flight crew has not entered wind, QNH, or temperature for the destination, and the aircraft is 180 NM out.
EXTEND SPD BRK	II/W	DES mode is engaged, idle is selected and the aircraft must decelerate in order to recover the path, or to respect an altitude constraint, a speed limit or a speed constraint.
NAV ACCUR DOWNGRAD (also displayed on ND)	II/A	NAV accuracy has been downgraded from HIGH to LOW.
NAV ACCUR UPGRAD (*EFIS ND)	II/A	NAV accuracy has been upgraded from LOW to HIGH.
RETRACT SPD BRK (also displayed on PFD)	II/W	Speedbrakes are extended, DES mode is engaged and: <ul style="list-style-type: none"> <li>▪ ALT or ALT* engages, or</li> <li>▪ the aircraft is below the path, or</li> <li>▪ CONF 3 or full is reached.</li> </ul>
SET MANAGED SPEED (SET MANAGED SPD is displayed on PFD)	II/A (W)	The target speed is Selected for the current phase, but there is no preselected speed for the next flight phase. When this is so, this message is displayed at transitions from climb to cruise, and from climb or cruise to descent. The message is always displayed at the transition to descent from climb or cruise if Selected Speed is active. It is not displayed if Managed Speed is active.
SPD ERROR AT WPTXX	II/W	In lateral Managed flight, the system predicts that the aircraft will miss a speed constraint by more than 10 kt. When the prediction changes to bring the miss within 5 kt, the message is cleared.
SPD LIM EXCEEDED	II/A	The aircraft is more than 150 feet below the speed limit altitude and more than 10 kt over the speed limit.
TOO STEEP PATH AHEAD	II/A	The system displays this message in Cruise Phase if the aircraft is within 150 NM of its destination or in Descent or Approach Phase and in NAV mode and the descent profile contains a segment that is too steep.

### THINGS TO WATCH OUT FOR

#### SPEED/MACH Crossover

When in Managed Speed the FMGC determines automatically when it should change from SPEED to MACH in the climb and vice versa in the descent. The point at which this occurs is called the *crossover altitude*. The same thing also occurs if you use Selected Speed. This automatic change from SPEED to MACH in the climb and vice versa

## AIRBUS DESCENT MONITORING

in the descent is to prevent overspeeds (in the climb if you remain in SPEED you will eventually reach  $M_{mo}$  and in the descent if you remain in MACH you will eventually reach  $V_{mo}$ ).

So far, so good.

The problem occurs if you manually select either SPEED or MACH by using the SPD/MACH Pb on the FCU. There will now be no automatic change at the crossover altitude.

If you manually select SPEED mode in the climb, the aircraft will climb at that Selected Speed. As you gain altitude the  $M_{mo}$  will start decreasing ( $V_{max}$  will start decreasing on the PFD) and as you continue climbing the Selected Speed will eventually reach  $M_{mo}$  (since at a constant IAS as you climb the Mach No. increases). The reverse happens during descent if you manually select MACH. As you descend the constant Mach No. results in increasing IAS and you eventually reach  $V_{mo}$ .

If you decide to use the SPD/MACH Pb to manually select a SPEED or MACH the FCU SPEED/MACH window will display what SPEED/MACH you have selected.

As a general rule if you are going to manually select a SPEED or MACH by using the FCU SPD/MACH Pb, use MACH in climbs and SPEED in descents to avoid this problem. The reducing gap between your currently Selected SPEED or MACH and  $V_{max}$  on the PFD speed tape should also be a huge hint. If you've got the wrong mode selected, simply push the SPD/MACH Pb to change into the mode you want and (re)set the Selected SPEED or MACH in the FCU window or simply use Managed Speed.

### Decel Point

If you are given extensive radar vectors (and so are using HDG and probably in Selected Speed due to ATC speed control), you will never sequence the Decel Point and so you will remain in the Descent Phase. You can get to the situation in the later stages of the arrival that you push for Managed Speed and the speed target jumps up to 250 Kts (probably because that was the last SPD LIM in the FPLN), the A/THR pours on thrust and you start rapidly accelerating. Just what you don't need when just about to intercept the LOC.

The solution: manually Activate the Approach Phase at a suitable time, early in the arrival. Keep an eye out for the Decel Point on the ND (in white if in HDG). If you pass abeam its position it can remind you to activate the Approach Phase.

### Descent Phase – > 200 NM From DEST

If the FCU selected altitude is lower than the previous CRZ FL *and* if the FPLN DTG to DEST is more than 200 NM, the CRZ FL on the PROG page changes and you remain in the Cruise Phase. In effect the FM thinks you want to do a Step Descent and recalculates the FM predictions and Managed speed target for that situation.

In that case MACH (or SPEED) target is Managed as follows:

- At the start of the descent, the MACH target is the Managed Mach number at the initial cruise flight level.
- When the aircraft reaches the new flight level, the Mach target switches either to the MACH number for the lower CRZ FL, or to the SPEED for the lower CRZ FL if the aircraft reaches the crossover altitude. This logic prevents the aircraft from exceeding  $V_{mo}$  during descent.

The indications you get in this situation are:

- White MCDU Scratchpad message – CSTR DEL ABOVE CRZ FL (if a constraint has been entered at a waypoint prior to the FM calculated T/D point)
- CLR the Scratchpad – A new white MCDU Scratchpad message: NEW CRUISE ALT – FLXXX
- FMA Indications: DES (a cruise descent or in other words a Step Descent)
- PFD Indications – magenta Managed Speed (Cruise Speed) with NO target speed range
- No magenta VDEV on PFD
- MCDU PERF Page – Title “CRZ” in green (Cruise Phase is active)
- MCDU PROG Page – Title “CRZ” in green (Cruise Phase is active) and CRZ ALT – FLXXX and no VDEV.

## **AIRBUS DESCENT MONITORING**

If the FCU selected altitude is lower than the previous CRZ FL and the aircraft is within 200 NM of its destination, the system activates the Descent Phase.

The pilot may reactivate the Cruise Phase by entering a new cruise flight level in the MCDU PROG page.

This is a common problem when arriving from China through SIERA. You quite often get numerous ATC descents in Chinese airspace and all that happens is that a new cruise altitude is selected. The Managed Speed will remain as the Cruise Managed Speed (quite often less than your ECON or Managed Descent speed due to the low cruise altitude). Since you remain in the Cruise Phase (effectively doing a Step Descent) the Altitude and/or Speed constraints that you have (should have?) inserted at SIERA are ignored, with the result that you get high on the required vertical profile and if nothing is done will diverge further above profile. If you're not ready for it you can get really high.

There are two ways to address this problem:

- Consider using Selected Speed and OP DES and S/B and manually calculate the vertical descent profile, or
- To force the FM to enter the Descent Phase when greater than 200 nm from DEST and above FL 200, momentarily set the FCU altitude to below FL 200, push or pull the ALT select knob (Managed or Selected descent) and then reset the desired altitude on the FCU.

### **S/B While in DES Mode**

You can only use S/B in DES mode if above the FM computed descent profile. If you use it on or below the profile the A/THR will add thrust to maintain the speed target (Managed or Selected). If you need to expedite your descent use OP DES, which will command THR IDLE.

### **S/B At Low Speeds**

Below about 220 Kts and certainly less than 200 Kts, the S/B is relatively ineffective. On the Airbus it is really hard to "Slow Down *and* Go Down". You need to think ahead and mentally monitor your descent profile. If you need S/B close to the LOC it is probably because you stuffed up your descent profile.

Using S/B will cause VLS ( $\alpha$  Prot and  $\alpha$  Max as well) to increase. When at low speeds, particularly if clean, using S/B can cause VLS to increase above Green Dot or even your current IAS. If VLS increases to above your current speed and the A/THR is active it will increase thrust to maintain the new higher VLS. This situation may require you to restrict the amount of S/B that you use (which results in a lower VLS and a reduced V/S). If you are really high consider selecting some flap to lower VLS so that more S/B can now be used.

### **V/S (and S/B)**

V/S is a Basic Mode. If you select a V/S then the aircraft will achieve that V/S. The FMGC pitch mode guides the aircraft to the target V/S (or FPA but it is very rare to use FPA during descents). The corresponding A/THR mode is SPEED/MACH.

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. When the speed reaches the authorized limit, the V/S or FPA decreases automatically to maintain the maximum speed limit (an automatic mode Reversion occurs).

If you use S/B when using V/S ensure that the thrust is at IDLE on the EW/D (the A/THR mode will probably be SPEED/MACH – even at IDLE thrust). If it is not the A/THR will add thrust to maintain the Speed with the selected V/S.

### **VDEV**

The VDEV displayed on the altitude scale of the PFD and on the MCDU PROG page is the vertical deviation from the FM *calculated* descent profile. This descent profile is calculated prior to T/D and *remains fixed* until the FM is forced to make a recalculation (e.g. by doing a DIR TO, (re)inserting altitude or speed constraints or reinserting the Cruise Alt on the PROG page).

## **AIRBUS DESCENT MONITORING**

If you alter any of the conditions or constraints that the FM used in calculating the vertical descent profile or the lateral FPLN, then that calculated descent profile will NOT reflect what the aircraft is actually achieving. This results in the FM calculated VDEV (and the information displayed on the PFD and PROG page) being incorrect, or in other words, what the aircraft is actually doing bears little or no relationship to the pre T/D FM calculated descent profile.

So the bottom line is, the VDEV information is only of any value if the aircraft is flying or is very close to both the lateral and vertical profile that the FM used to calculate the vertical profile. So don't get sucked in and blindly follow the VDEV. You still need to mentally compute your own vertical profile to assess whether you are high, low or on the vertical profile.

### **Speed (IAS)**

Your speed (IAS) is an integral part of the vertical descent profile.

You have to slow up at some stage in the approach and this is usually accomplished by either flying level (and this is what the FM uses to make its calculations and predictions) or by reducing your V/S (which is what we strive to do as pilots to maintain a continuous descent profile).

In both cases the vertical profile is affected. So don't forget to include speed in your descent profile planning and monitoring.

### **Entering A Managed Speed**

As long as the Descent Phase is not active, the PERF DES page may be used to insert either a Speed or a Mach number or both to replace the FM computed ECON Managed descent speed.

The FMGS then uses your manually inserted Speed/Mach Managed Speed instead of its automatic ECON Managed speed for computing the descent profile and determining the descent Managed speed profile. Note that even though you have manually modified the FM computed ECON descent speed, it is still considered by the FM to be Managed Speed – it's just different from what the FM automatically computed.

When the system switches to the Descent Phase, it sets the Managed target speed to the entered speed. From there, you can only modify the speed by using the FCU selector knob only (i.e. Selected Speed). Once in the Descent Phase, the pilot cannot change the Descent Managed Speed again.

### **GIGO (Garbage In/Garbage Out)**

The part of the FMGS that computes predictions and descent profiles is essentially a computer program. Like all computer programs if you input incorrect or inaccurate information (Garbage In) you will get incorrect or inaccurate information as an output (Garbage Out).

The FMGS will only be as good as the information that you insert into it. The more accurate information that you can provide it, the better will be its predictions and accuracy.

Take the time to accurately and correctly insert such things as the STAR (and Transition), Altitude and Speed constraints, SPD LIM, Managed Descent Speed, Winds and Temps. Throughout the descent and arrival continually update the lateral (and to a lesser extent the vertical) FPLN to reflect what ATC is currently giving you and what you anticipate they will give you in future (think ahead) by using DIR TO or by clearing the FROM waypoint to get a sensible TO waypoint.

This will give you more accurate predictions, DTG and VDEV.

### **Blindly Accepting The FM Computed Data/Predictions**

Do NOT fall into this trap! You must mentally calculate your own independent vertical profile based on the ACTUAL aircraft performance (not the data used prior to T/D).

The FM computed data and predictions are only as good as the information input to the FM. The vertically calculated FM descent profile is computed prior to T/D and once in the Descent Phase is "fixed" in space.

## AIRBUS DESCENT MONITORING

As soon as you go into HDG, Select a Speed, get track shortening or anything, the FM calculated vertical descent profile will be in error to what you are now actually doing. VDEV will also be in error.

This also applies to not only the arrival but to constraints during the descent. For example ATC requires you to cross MELON at 280 Kts and FL 130 – use your actual V/S, altitude and speed to lose (i.e. time required to achieve the altitude/speed constraint) and your current G/S and DTG (i.e. ETA at the waypoint) and then decide if you require S/B (high) or need V/S (low).

This is one of the most common mistakes you will make during descent monitoring.

Ensure you use the FCTM Descent Monitoring formula to cross check the FM vertical profile. You have been warned!!

### Pitch Down (And Possible Overspeed)

If ATC requires you to reduce speed (so you use Selected Speed) to below the speed that the FM used to calculate the vertical descent profile and you are in DES Mode, the A/THR will set IDLE and you will diverge above the FM calculated vertical profile. VDEV will also be increasing.

If the ATC imposed speed control is now no longer required you can reset Managed Speed. As you are above the FM calculated vertical descent profile and at a speed lower than Managed Speed the following will occur simultaneously:

- The AP will pitch the aircraft down to rejoin the FM calculated descent profile from above, and
- The A/THR will increase thrust to accelerate to Managed Speed.

The IAS will rapidly increase. You have now set yourself up for a self-induced overspeed. The Airbus is notorious for doing this as the AP and A/THR may not react fast enough to prevent this.

Any time the pitch attitude is less than 2.5° nose down, watch the IAS very carefully. If it gets to 5° nose down you will very likely have to manually intervene to prevent an overspeed.

The following are the manual intervention actions to prevent an overspeed in this situation:

- Selected Speed (decrease the Selected Speed if required to pitch the aircraft up). Also removes the Managed Speed target range of  $\pm 20$  Kts,
- Select OP DES (A/THR sets IDLE). Also removes the Managed Speed target range of  $\pm 20$  Kts), or
- Disconnect the AP and manually pitch up (this should be your last resort, but if the IAS increases rapidly may be your only option).

Use common sense here. It's better to accept a slight overspeed by using a calibrated and moderate pitch up than to contain the speed by using an aggressive pitch up with increased G loads – don't forget about the people possibly walking around in the cabin. People have been injured by pilots hooking on too much G to prevent an overspeed.

*If you can't afford to do something right, then be darn sure you can afford to do it wrong.  
(Charlie Nelson)*

# AIRBUS DESCENT MONITORING

## AIRBUS DESCENT MONITORING (A VISUAL GUIDE)

The FM will calculate a T/D point assuming that the aircraft will begin its descent in DES mode with Managed speed, and that the system will guide the aircraft along the lateral FPLN track and the descent vertical profile computed is with all the vertical FPLN data (ALT CSTR, MANAGED MACH/SPEED, SPD CSTR, SPD LIMIT and inserted winds) to reach VAPP at 1,000 feet AGL.

Once the FM sequences into the Descent Phase the FM vertical descent profile is *fixed* (or frozen in space) using all the pre T/D constraints (speeds and altitudes), SPD LIM, Managed Speed (Mach) and Winds. The only way to change this "*fixed in space*" vertical profile is to force the FM to re-calculate a new descent profile. This can be done by performing a DIR TO, or changing the pre-existing or entering new altitude and/or speed constraints.

You *cannot* however change the Managed Speed used to calculate the descent profile. Selecting a different speed or changing the vertical descent mode (e.g. selecting V/S or OP DES) will also *not* change the FM vertical descent profile.

Did you get all that? Let's break up the descent into two separate sections:

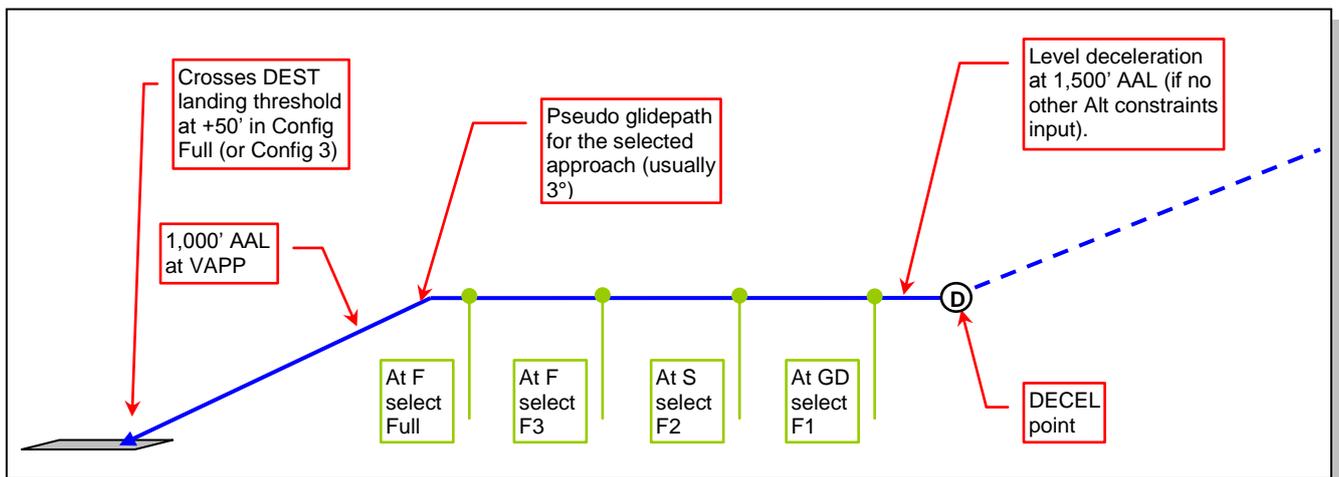
- From the Decel Point to the DEST runway (Approach Phase), and
- From T/D to the Decel Point (Descent Phase).

### Decel Point To Threshold

Let's take a look at how the FM calculates the vertical descent profile from the Decel Point to the DEST runway landing threshold.

The FM actually works backwards from the DEST runway landing threshold and makes several assumptions (that's the way it has been programmed):

- The aircraft will pass over the DEST runway landing threshold at + 50', in Config FULL (or Config 3 if that has been selected on the PERF APP page) provided no abnormally high altitude constraint or TOO STEEP PATH is input at an earlier waypoint,
- The aircraft will descend along the FPLN stored pseudo glidepath (which is part of the FMGC database) for the approach selected for the DEST runway (this is usually a 3° glideslope for most ILS's and Non Precision Approaches, but not always),
- The aircraft will decelerate to reach VAPP at 1,000' AAL, configuring with flap as the aircraft decelerates in level flight (1,500 AAL if no higher Altitude Constraints are entered into the FPLN) with Managed Speed to the various Characteristic Speeds (GD, S, F and VAPP). The aircraft decelerates automatically at the DECEL pseudo waypoint when Managed Speed is active and NAV mode is engaged (DECEL point displayed in magenta). In the Approach Phase the A/THR maintains the manoeuvring speed of the current configuration (GD, S, F or VAPP).
- The FMGS will use level segments for deceleration (rather than a continuous decelerating descent), but any SPD LIM will be a decelerating descent.



## AIRBUS DESCENT MONITORING

This profile assumes the use of Managed Speed in DES mode. After the FM has computed this part of the vertical descent profile it can display the Decel Point on the ND. The Decel Point is where the Approach Phase will activate automatically and a deceleration will occur if you are in NAV and Managed Speed.

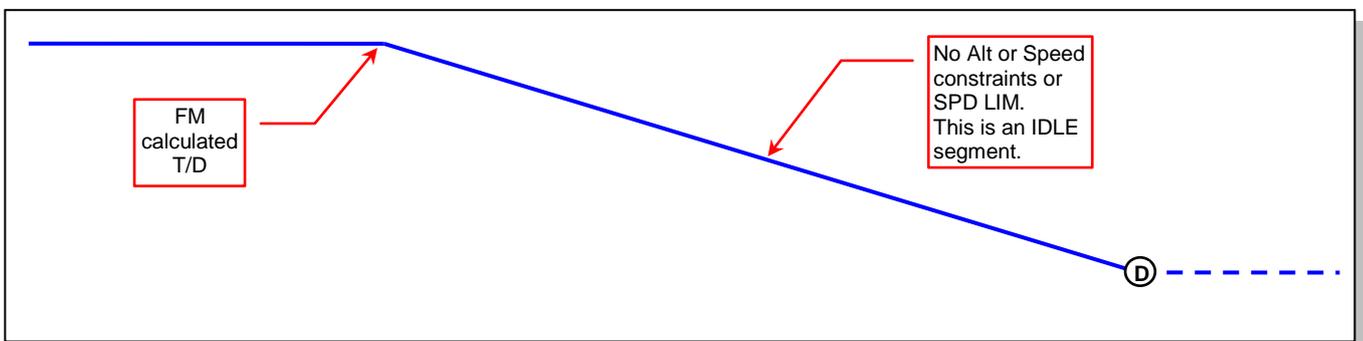
Practically, this area is where most of the action occurs during an arrival and approach and this is where for the vast majority of our arrivals we are under ATC speed and altitude control and radar vectors so it is quite rare to be able to fully utilise all this FM calculated descent information. Most of the time we will have an electronic glideslope (ILS) to refine our manual descent calculations and raw data (G/S, LOC, DME, VOR).

We will focus more on the previous part of the descent; from T/D to the Decel Point, as this is where the majority of confusion exists when trying to work out what the Airbus is doing while in the Descent Phase.

To get the full descent and approach picture just join the Approach Phase (diagram above) and Descent Phase (diagrams below) together at their common point – the Decel Point.

### T/D To Decel Point (No Constraints At All)

Let's assume for the sake of simplicity that this particular arrival has absolutely no altitude or speed constraints and no SPD LIM points i.e. a single Managed Speed is used from T/D to the Decel Point. Since there are no altitude or speed constraints to affect the descent profile this is an IDLE descent segment.



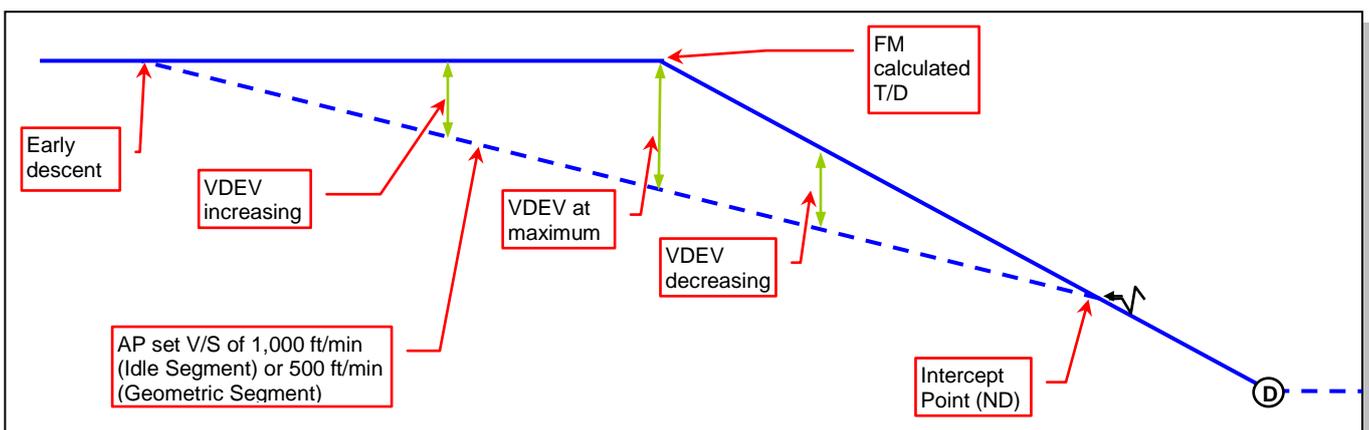
If you were to descend at the FM calculated T/D point in Managed Speed and in DES mode the aircraft would theoretically follow the FM vertical descent profile.

You would observe the following indications on the PFD, ND and MCDU:

- The FMA would display THR DES – DES – NAV,
- The A/THR will maintain the Managed Speed at IDLE thrust. However the only place IDLE will be displayed is on the EW/D as the A/THR operational mode will display THR DES as you are on the FM calculated vertical descent profile, and
- VDEV (on the PFD and PROG page) would be zero.

### Early Descent

What if you started your descent prior to the FM calculated descent point?



## AIRBUS DESCENT MONITORING

If you were to descend in Managed Speed and in DES mode the aircraft would be below the FM vertical descent profile and would attempt to intercept it from below.

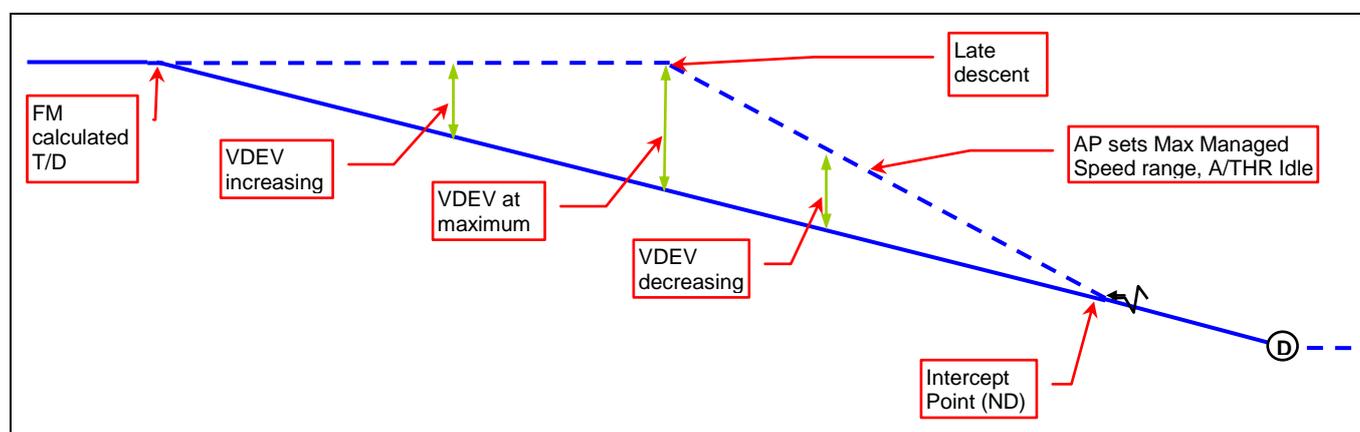
You would observe the following indications on the PFD, ND and MCDU:

- The FMA would display **SPEED (MACH) – DES – NAV**,
- The A/THR will maintain the Managed Speed,
- The AP would set a V/S of 1,000 ft/min in an attempt to re-intercept the FM calculated vertical descent profile from below (for this particular Idle segment – V/S 500 ft/min if a Geometric segment),
- VDEV is up on the PFD and negative on the PROG page, and
- The Intercept Point is displayed on the ND.

You could of course select V/S 500 ft/min (**SPEED – V/S – NAV**) which would have the effect of flattening out the descent angle and thus intercepting the FM calculated descent profile earlier (and bringing the ND Intercept Point closer) – but why make more work for yourself?

### Late Descent

What if you started your descent after the FM calculated descent point?



If you were to descend in Managed Speed and in DES mode the aircraft would be above the FM vertical descent profile and would attempt to intercept it from above.

You would observe the following indications on the PFD, ND and MCDU:

- The FMA would display **THR IDLE – DES – NAV**,
- The speed will increase toward the upper limit of the Managed Speed target range. If the speed reaches the upper limit, the aircraft will maintain the speed but will deviate from the profile (A/THR at IDLE).
- VDEV is down on the PFD and positive on the PROG page, and
- The Intercept Point is displayed on the ND.

The ND Intercept Point assumes the aircraft will return to the profile using:

- Idle thrust,
- Half speedbrake extension, and
- ECON speed plus a margin (until intercepting the profile).

Note: When DES mode is engaged, the speedbrake extension will not necessarily increase the descent rate. It does so only if the aircraft is *above* the profile. If the aircraft is *on or below* the profile the system will add thrust to keep the aircraft on profile and within the speed target range.

In this late descent situation you could Select a higher speed or use up to full S/B. Both methods steepen the descent angle, and thus would intercept the FM calculated profile from above earlier (and bringing the ND Intercept Point closer).

## **AIRBUS DESCENT MONITORING**

### **High Speed Descent**

What if ATC required you to descend at a speed higher (so you use Selected Speed) than that used by the FM to calculate the vertical descent profile when in the Descent Phase (remember the FM vertical profile is now fixed in space)?

A speed higher than used in the FM calculation would result in a steeper descent angle and so you would tend to go below the FM calculated profile (if you used OP DES).

In DES mode the AP will pitch up slightly to maintain the FM vertical profile (it's fixed in space and it wants to follow the profile when in DES mode) and the A/THR will add a little thrust to maintain the new higher Selected Speed.

You would observe the following indications on the PFD, ND and MCDU:

- The FMA will now display SPEED (MACH) – DES – NAV,
- The A/THR will maintain the new higher Selected Speed,
- VDEV (on the PFD and PROG page) would be zero.

### **Low Speed Descent**

What if ATC required you to descend at a speed lower (so you use Selected Speed) than that used by the FM to calculate the vertical descent profile when in the Descent Phase?

A speed lower than used in the FM calculation would result in a shallower descent angle and so you would tend to go above the FM calculated profile (if you used OP DES).

In DES mode the aircraft will initially pitch up to decelerate to the new lower Selected Speed (and so diverge above the FM descent profile) and the A/THR will reduce thrust to maintain the Selected Speed, most likely to IDLE. When the speed has reduced to the lower Selected Speed the aircraft may pitch down slightly in an attempt to maintain or intercept the FM profile from above (it all depends on how far the speed has been reduced). As the FM calculated vertical descent profile assumes IDLE thrust and as you are now at a lower speed you will go above the FM profile in most cases. You will diverge from the FM calculated vertical descent profile further, the longer the lower speed is used (the aircraft is now flying a shallower descent angle).

You would observe the following indications on the PFD, ND and MCDU:

- The FMA will now display THR IDLE – DES – NAV,
- The A/THR will maintain the Selected Speed,
- VDEV (on the PFD and PROG page) most likely will start to increase above profile.

Your only option if you are required to maintain the lower speed is to use S/B to re-intercept the FM profile from above.

### **High On Profile**

The indications when high on profile are very similar to a late descent. When in Managed Speed in DES mode the speed will increase above the Managed Speed up to the upper limit of the Managed Speed target range (usually to a maximum of + 20 Kts) in an attempt to rejoin the FM calculated vertical profile from above.

You would observe the following indications on the PFD, ND and MCDU:

- The FMA will now display THR IDLE – DES – NAV,
- The A/THR will set IDLE thrust, and
- The AP increases speed by calling for down elevator. If the aircraft reaches the upper limit of the Managed speed target range, the aircraft diverges and maintains the upper limit speed, and
- VDEV is down on the PFD and positive on the PROG page.

## AIRBUS DESCENT MONITORING

### Low On Profile

The indications when low on profile are very similar to an early descent. When in Managed Speed in DES mode the speed will be at Managed Speed in an attempt to rejoin the FM calculated vertical profile from below.

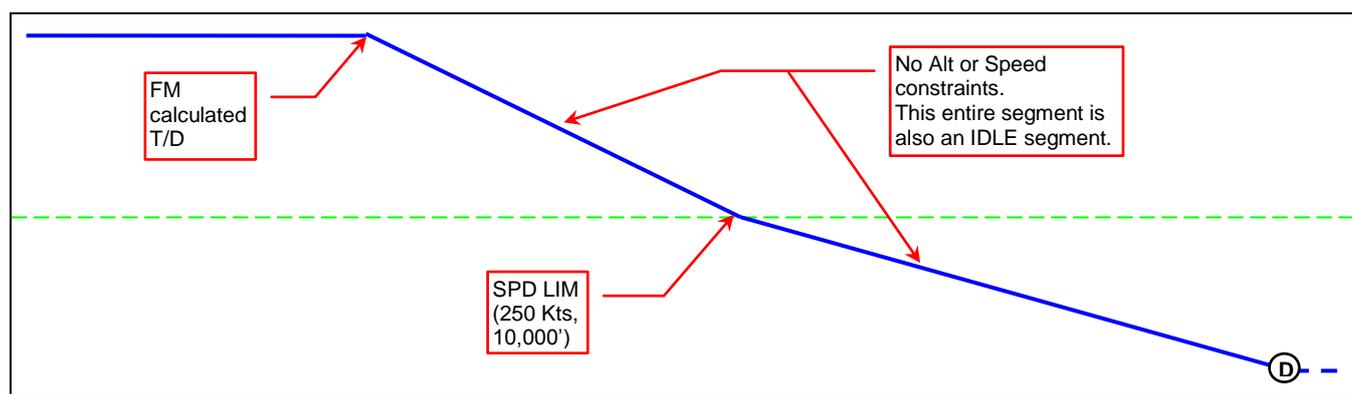
You would observe the following indications on the PFD, ND and MCDU:

- The FMA would display **SPEED (MACH) – DES – NAV**,
- The A/THR will maintain the Managed Speed,
- The AP would select a V/S of 1,000 ft/min in an attempt to re-intercept the FM calculated vertical descent profile from below (for an Idle segment – V/S 500 ft/min if a Geometric segment) until the profile is regained, and
- VDEV is up on the PFD and negative on the PROG page.

### T/D To Decel Point SPD LIM Only

Let's use the same arrival, again with no altitude or speed constraints, but this time with a SPD LIM of 250 Kts at 10,000' i.e. Managed Speed is used from T/D to the SPD LIM point and then the SPD LIM Managed Speed specified (in this case 250 Kts) until the Decel Point.

Once again as there are no altitude or speed constraints to affect the descent profile this is an IDLE descent segment. The SPD LIM point is NOT a speed constraint. The entire descent uses Managed Speed – it's just that it automatically changes to decelerate and reach 250 Kts at 10,000' at the SPD LIM point.



If you were to descend at the FM calculated T/D point in Managed Speed and in DES mode the aircraft would theoretically follow the FM vertical descent profile as before.

You would observe the following indications on the PFD, ND and MCDU:

- The FMA would display **THR DES – DES – NAV**,
- The A/THR will maintain the Managed Speed at IDLE thrust. However the only place IDLE will be displayed is on the EW/D as the A/THR operational mode will display THR DES, and
- VDEV (on the PFD and PROG page) would be zero.

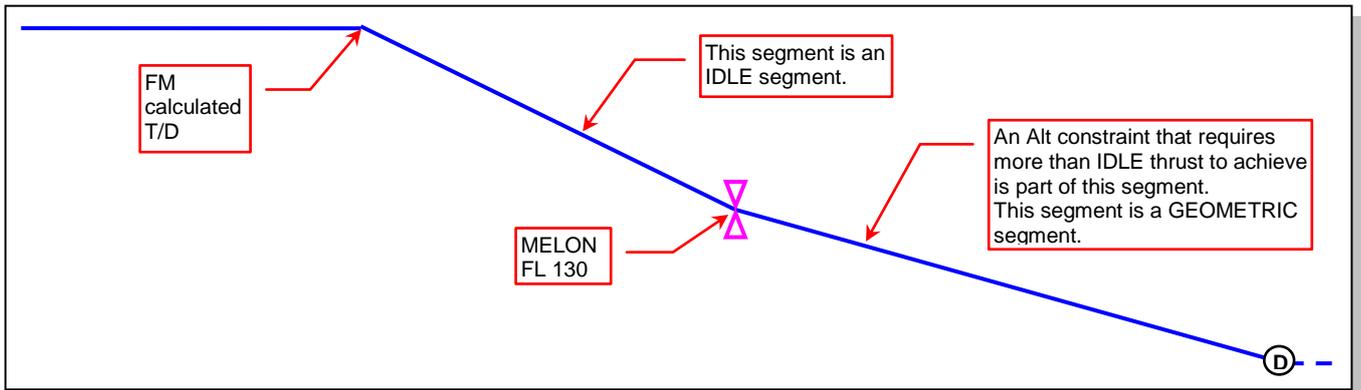
In addition because of the SPD LIM there would be:

- A magenta ball Speed Change pseudo waypoint displayed on the ND,
- SPD LIM would be displayed on the MCDU FPLN page, and
- Sequencing the SPD LIM waypoint would result in the Managed Speed reducing automatically to 250 Kts on the PFD Speed tape (the FMA modes would remain the same, but the aircraft would pitch up slightly while still descending to decelerate at IDLE thrust to achieve 250 Kts at 10,000').

## AIRBUS DESCENT MONITORING

### T/D To Decel Point With An Altitude Constraint

Now let's look at an arrival with an altitude constraint that requires more than IDLE thrust to achieve that constraint. There is no SPD LIM to simplify the explanation.



While the aircraft is in the IDLE segment it behaves almost exactly the same as we have discussed above for all the various high/low/on profile and high/low speed cases. The only real difference is that ALT CSTR may be displayed on the FMA and the ND symbology may be a little different due to the extra altitude constraint.

- The FMA would display THR DES – DES – NAV,

So what happens at the Altitude constraint if we are on profile?

The AP will pitch the aircraft up slightly to maintain the geometric shallower profile and the A/THR will add thrust to maintain the Managed Speed.

- The FMA would display SPEED (MACH) – DES – NAV

That's it – mystery solved.

### T/D To Decel Point With All The Other Variables

The same thing will occur if:

- Only a Speed constraint(s), or
- A combination of an altitude and a speed constraint is used at the same waypoint(s), or
- A combination of an altitude and a speed constraint is used at the same waypoint(s) and a SPD LIM is included.

All that happens is that the FM will calculate the vertical descent profile to take all these various vertical constraints and SPD LIM points into consideration by altering the angle of the Geometric segment (or segments if more than one altitude/speed constraint is used), then adding on the Idle segment to finally work out a T/D point.

All you've got to do then is visualise what happens for the high/low/on profile and high/low speed cases. Try and visualise what the vertical profile will look like from a side view (as in the diagrams) and where you are in relation to that profile. That will determine what AP/FD lateral and vertical modes will be engaged or armed and what operational mode (either SPEED/MACH or THR) that the A/THR will use.

The ND symbology can be a great help here, but only if you know what you're looking at and only if you keep the lateral and vertical FPLN updated.

Mentally confirm ALL FM generated predictions and ensure you are mentally computing your own vertical descent profile to compare with the FM generated data. Because it's not a matter of IF you get caught out, but of WHEN you get caught out (and by how much)!!

*Great pilots are made not born. A man may possess good eyesight, sensitive hands, and perfect coordination, but the end result is only fashioned by steady coaching, much practice, and experience. (Air Vice-Marshall J. E. 'Johnnie' Johnson, RAF)*

## AIRBUS DESCENT MONITORING

### FMA MODES (AND WHAT THEY PRACTICALLY MEAN TO YOU)

The FMA included in the upper part of the PFD is your primary indication of what the FMGS (which also includes the A/THR, AP and FD) is doing. If you understand what the various messages mean then you are far less likely to be caught out or sit there wondering what it is doing.

**Tip of the Day:** Any time you ever wonder “*What is it doing?*” or “*Why is it doing that?*” is a strong indication that you had better:

- Monitor the aircraft’s performance using raw data (i.e. IAS, V/S, HDG, ALT, Attitude) to ensure it is doing what you want it to do, or
- Start thinking about reverting to Basic Modes (HDG, V/S or TRACK, FPA), or
- In extreme cases, disengage the AP (and possibly turn off the FDs) and manually fly the aircraft.

By not knowing or understanding what the system is doing or trying to accomplish, and having to start reverting to monitoring raw data, Basic Modes or manually flying the aircraft means that your workload starts to exponentially increase and you also start to strip away the various “Protections” and automatic safeguards that are built into the FMGS.

Do you recall reading the following extract from the front of most of our Operations Manuals?

#### AUTOMATION

It is Cathay Pacific Airways policy to regard Automation as a tool to be used, but not blindly relied upon.

***At all times, flight crew must be aware of what automation is doing, and if not understood, or not requested, reversion to basic modes of operation must be made immediately without analysis or delay.***

Trainers must ensure that all CPA flight crew are taught with emphasis how to quickly revert to basic modes when necessary.

***In the man-machine interface, man is still in charge.***

Remember that you are a pilot and not a passenger. So it is imperative that you have a good basic understanding of what the FMGS can do.

For this discussion we will once again limit ourselves to the Descent Phase.

### AP/FD VERTICAL MODES

There are 15 AP/FD Vertical Modes that can be engaged and displayed (on the second column, first line) and 7 that can be armed (on the second column, second line) of the FMA.

Don’t panic just yet! We will ignore all the various ALT and ALT\*, SRS and G/S Modes as they are pretty self-explanatory and most pilots can understand them.

During the descent for the vast majority of the time you will use only:

- DES (Managed Mode),
- OP DES (Selected Mode,
- V/S (Basic Selected Mode), or
- FPA (Basic Selected Mode – normally only used after the FAF during a Non Precision Approach or a Visual Approach).

## AIRBUS DESCENT MONITORING

Recall that there is an interaction between the AP/FD and the A/THR. The selection of an AP/FD vertical mode determines the associated A/THR mode.

- The AP/FD can control either a target SPEED/MACH or a vertical trajectory (path).
- The A/THR can control either a target SPEED/MACH or a THR(ust).
- The AP/FD and A/THR **cannot** simultaneously control a target SPEED/MACH.

Let's look at each vertical mode separately.

### OP DES

OP DES is a Selected vertical mode.

This is probably the easiest vertical mode to understand as it behaves like the first basic aircraft that you learnt to fly. You set idle power on the engine and control the speed with the elevators by changing the pitch attitude (remember *Power + Attitude = Performance?*)

By setting OP DES you command the AP/FD to fly the target SPEED/MACH (either Selected Speed or Managed Speed). The Speed is now controlled by using the elevator to change the pitch attitude by the AP/FD. As the AP/FD is controlling the SPEED/MACH the A/THR cannot – so it must control the THR(ust), which it does and sets THR IDLE.

You will always see **THR IDLE** – **OP DES** together.

- No Altitude constraints will be observed and the aircraft will descend at THR IDLE to the FCU selected altitude (indicated on the ND by the blue level off arrow). If there are Altitude constraints included in the FPLN these will be ignored and a White circle will surround the associated waypoints on the ND if in NAV.
- Speed constraints will be observed only in Managed Speed *and* NAV.
- SPD LIM will be observed only in Managed Speed.

### DES

DES is a Managed vertical mode. It can only be set when in NAV lateral mode. DES mode is the only time that you will get the Managed Speed *target range* (normally  $\pm 20$  Kts, limited by  $V_{mo} - 3$  Kts or  $M_{mo} - 0.006$  or if a descent SPD LIM or a Speed constraint is encountered, the speed is limited to the Constraint Speed + 5 Kts) displayed on the PFD Speed tape.

This mode causes the most confusion, as most pilots do not understand how all the various systems (AP/FD, A/THR and FMGS) work together and interact to achieve what has been input into the FMGS via the FCU and MCDU or how the FM “draws” the vertical descent path.

Remember GIGO (Garbage In/Garbage Out). The FMGS will only be able to achieve what you input into it. If you put crap in, you can expect a less than optimal performance. Always endeavour to input the most correct and up to date information into the MCDU and FPLN to get accurate predictions and vertical profile computations.

There are three basic cases that can occur when in the DES mode:

#### On Profile

The aircraft is descending on the FM calculated vertical profile and so VDEV will be about zero.

By setting DES when on profile you command the AP/FD to fly the target SPEED/MACH (Managed Speed *target range*). The Speed is now controlled by using the elevator to change the pitch attitude by the AP/FD. As the AP/FD is controlling the SPEED/MACH the A/THR cannot – so it must control the THR(ust), which it does and sets THR DES.

When **on profile** you will always see **THR DES** – **DES** – **NAV**.

- All Altitude and Speed constraints and SPD LIM will be observed.
- If there are Altitude constraints included in the FPLN these will be displayed on the ND with a magenta circle surrounding the waypoint and a magenta star on the MCDU.

## AIRBUS DESCENT MONITORING

- Speed constraints will have a magenta star next to then on the MCDU predictions.
- SPD LIM will occur automatically if in Managed Speed.

### Above Profile

The aircraft is descending but is above the FM calculated vertical profile and so VDEV will be positive.

By setting DES when above profile you command the AP/FD to fly the target SPEED/MACH (Managed Speed *target range* and it will increase up to the upper limit of the range). The Speed is now controlled by using the elevator to change the pitch attitude by the AP/FD. As the AP/FD is controlling the SPEED/MACH the A/THR cannot – so it must control the THR(ust), which it does and sets THR IDLE in an attempt to intercept the profile from above.

When **above profile** you will always see **THR IDLE** – **DES** – **NAV**.

- All Altitude and Speed constraints and SPD LIM will be observed if possible.
- If there are Altitude constraints included in the FPLN these will be displayed on the ND with a magenta circle if achieved (or amber if not achieved) surrounding the waypoint and a magenta star on the MCDU (or amber star if not achieved).
- Speed constraints will have a magenta star if achieved (or amber if not achieved) next to then on the MCDU predictions.
- SPD LIM will occur automatically if in Managed Speed.
- A blue Intercept Point will be displayed on the ND.

### Below Profile

The aircraft is descending but is below the FM calculated vertical profile and so VDEV will be negative.

By setting DES when below profile you command the AP/FD to fly the trajectory to intercept the profile from below. The Managed Speed *target range* will be displayed but it will use the set Managed Speed only, not the lower limit of the range. The trajectory (or path) is now controlled by using the elevator to change the pitch attitude to set a V/S of either 1,000 ft/min (Idle segment) or 500 ft/min (Geometric segment). As the AP/FD is controlling the trajectory the A/THR must be in SPEED/MACH mode in an attempt to intercept the profile from below.

When **below profile** you will always see **SPEED/MACH** – **DES** – **NAV**.

- All Altitude and Speed constraints and SPD LIM will be observed if possible.
- If there are Altitude constraints included in the FPLN these will be displayed on the ND with a magenta circle if achieved surrounding the waypoint (or amber if not achieved) and a magenta star on the MCDU (or amber star if not achieved).
- Speed constraints will have a magenta star if achieved (or amber if not achieved) next to then on the MCDU predictions.
- SPD LIM will occur automatically if in Managed Speed.
- A blue Intercept Point will be displayed on the ND.

### V/S

V/S is a Basic Selected vertical mode.

By setting V/S you command the AP/FD to fly the selected V/S. The trajectory (or path) is now controlled by using the elevator to change the pitch attitude to set the selected V/S. As the AP/FD is controlling the trajectory the A/THR must be in SPEED/MACH mode.

You will always see **SPEED/MACH** – **V/S** together.

- No Altitude constraints will be observed and the aircraft will descend at the selected V/S to the FCU selected altitude (indicated on the ND by the blue level off arrow).
- If there are Altitude constraints included in the FPLN these will be ignored and a White circle will surround the associated waypoints on the ND only if in NAV.

## AIRBUS DESCENT MONITORING

- Speed constraints will be observed only in Managed Speed and NAV and if the selected V/S allows the required deceleration. Set the V/S too high and even at IDLE thrust (as V/S is a Basic Mode) the aircraft may increase speed above the speed target to achieve the selected V/S.
- SPD LIM will be observed only in Managed Speed and if the selected V/S allows the required deceleration.

### FPA

FPA is also a Basic Selected vertical mode. FPA is normally only used after the FAF during a Non Precision Approach or a Visual Approach (see NPs).

By setting FPA you command the AP/FD to fly the selected FPA. The trajectory (or path) is now controlled by using the elevator to change the pitch attitude to set the selected FPA. As the AP/FD is controlling the trajectory the A/THR must be in SPEED/MACH mode.

You will always see **SPEED/MACH** – **FPA** together.

- No Altitude constraints will be observed and the aircraft will descend at the selected FPA to the FCU selected altitude (indicated on the ND by the blue level off arrow).
- If there are Altitude constraints included in the FPLN these will be ignored and a White circle will surround the associated waypoints on the ND only if in NAV.
- Speed constraints will be observed only in Managed Speed and NAV and if the selected FPA allows the required deceleration. Set the FPA too high and even at IDLE thrust (as FPA is a Basic Mode) the aircraft may increase speed above the speed target to achieve the selected FPA.
- SPD LIM will be observed only in Managed Speed and if the selected FPA allows the required deceleration.

### AP/FD LATERAL MODES

Know how to find the TO Waypoint (the waypoint that the FMGS is trying to get to) is important so you can keep the FM Lateral FPLN as closely aligned as possible to your actual or anticipated track to obtain meaningful predictions from the FMGS. It is displayed in the following places:

- ND – Upper Right Hand corner in green (the *direct* distance to the TO waypoint and the ETA at the *current* Ground Speed are also displayed here),
- ND – The TO waypoint is displayed on the FPLN track line as a waypoint in *white* (all the others are in green), and
- MCDU FPLN – The TO waypoint immediately follows the FROM waypoint. The TO waypoint and its predictions are in *white* (all the others except the DEST waypoint are in green).

There are 11 AP/FD Lateral Modes that can be engaged (on the third column, first line), and 5 that can be armed (on the third column, second line) of the FMA.

Don't panic just yet (again – I'm trying to keep your stress levels down!) Fortunately there are just a few Lateral modes that we normally use during the Descent Phase.

During the descent for the vast majority of the time you will use only:

- NAV (Managed Mode),
- HDG (Basic Selected Mode), or
- TRACK (Basic Selected Mode – normally only used after the FAF during a Non Precision Approach or a Visual Approach).

### NAV

This Lateral Mode is pretty easy.

## AIRBUS DESCENT MONITORING

The AP/FD will follow the green FPLN track line on your ND. The FMGS bases all its lateral predictions (distance and ETA) on following this FPLN track line. The FMGS calculated vertical descent profile (that was computed prior to T/D and is fixed in space once you get into the Descent Phase) is all based on following this FPLN track line as well. So if you diverge laterally from the FPLN track line the vertical predictions will be inaccurate or in error.

The FMGS calculated vertical descent profile assumes Managed Speed. If you are in NAV and you require a different speed than that used by the FMGS then the following will occur:

- Less. At a speed less than the Managed Speed the FMGS used to calculate the profile, you will remain in NAV but probably (depending on the speed difference) diverge vertically above the FMGS calculated profile when you set the lesser Selected Speed. As you will now be above profile the A/THR will change to THR IDLE.
- More. At a speed more than the Managed Speed the FMGS used to calculate the profile then you will remain in NAV and remain on the vertical profile when you set the greater Selected Speed. As you remain on profile the A/THR will change to SPEED/MACH to maintain the higher speed.

### HDG

This Lateral Mode complicates things a little.

When you go into HDG Lateral mode the following happens:

- If in NAV, the Vertical mode reverts to the **current** V/S,
- The ND waypoint altitude constraint circles are removed,
- The FMGS FPLN track on the ND is displayed as a green dashed line and the current aircraft track on the Selected HDG is displayed as a solid green straight line,
- The MCDU FPLN predictions assume that the aircraft will return immediately to the flight plan, intercepting at a predetermined angle (45° intercept to FPLN track if possible, if greater than 45° is required to intercept then direct) and will then proceed under Managed guidance, and
- FPLN waypoints will only sequence if you pass abeam that waypoint within 7 nm.

Ensure that the TO waypoint displayed on the ND and MCDU FPLN is correct. If it is not, all the MCDU predictions and DTG and VDEV information is useless. Update the TO waypoint either by performing a DIR TO (with inbound/outbound radial if required) or by clearing the FROM waypoint until the TO waypoint is the one you desire.

This simple little TO waypoint causes so many pilots to screw up descents because they are now using **and** relying on incorrect information. ALWAYS keep your TO waypoint updated to what your current ATC clearance is or what you anticipate it will be. This will also result in a more accurate DTG on the MCDU FPLN page, which is used when mentally computing your descent profile (I recommend using the FCTM Descent Monitoring formula).

OK, so you're keeping your TO waypoint updated while in HDG. How can you make an assessment as to whether the VDEV info the FMGS is providing is valid?

If you are close to the FMGS FPLN track (green dashed line on the ND and X Track error of less than about 5 nm), then the predictions and VDEV is probably OK to use. Probably – what do you mean Probably? The further out you are (more track miles to fly) the less any error will affect you. The closer in you are (getting close to the LOC now) the more any error will affect you. For example, a VDEV of + 1,500' (above profile), passing FL 350 on descent with 125 nm DTG is OK, but the same VDEV passing 5,000' just prior to LOC intercept with 12 nm DTG is probably not OK.

If you are on the FMGS calculated vertical descent profile and the new HDG will add extra track miles, then you will be below the new actual vertical profile compared to the old FMGS calculated profile. You may need a reduced V/S (make the descent angle shallower). Vice versa if the new heading requires less track miles. Now you may need to increase speed or use S/B (make the descent angle steeper).

Try to visualise a superimposed vertical profile onto the ND displayed FPLN lateral track. This takes a little mental gymnastics as the ND display is a two dimensional plan view from above and now you have to imagine it as a three dimensional offset side view. Now visualise whether you are on, above or below the FMGS calculated vertical

## AIRBUS DESCENT MONITORING

profile (remember this has been frozen in space) with what the aircraft is actually doing (e.g. you might be using HDG and V/S).

- If you're on profile, do nothing (and manually follow the VDEV if it agrees with your mental calculation). This maintains the same descent angle.
- If you're above profile, increase speed or use S/B. This steepens the descent angle.
- If you're below profile, use a reduced V/S or decelerate earlier. This shallows the descent angle.

### TRACK

This does almost exactly the same as HDG. The only difference is that you're now Selecting a TRACK instead of a HDG. All the considerations for HDG apply to TRACK as well.

### THE REAL WORLD

Crikey! This is a piece of cake(?). Why does everyone have difficulty with the Airbus automation?

It is a very rare day that ATC clears you to complete a Procedural STAR and Approach. If you ever get one of these arrivals you can use the FMGS as it was designed to be used – i.e. THR DES – DES – NAV with Managed Speed and sit back and monitor the FMGS do its automatic thing (and it does a bloody good job if you've set it up correctly).

What now if ATC gives you radar vectors, descent and speed control (remember that speed is part of the vertical profile picture) that bears no resemblance to any of the altitude or speed constraints or waypoints that you input into the FMGS?

Welcome to the real world! This is the situation that occurs during most of our arrivals and approaches.

Both the Lateral and Vertical (Speed and Altitude) assumptions and waypoints that you input into the FMGS are now incorrect (remember GIGO?). The predictions on the MCDU and Altitude and Speed constraints are next to useless, as is VDEV. In fact, if you rely on them you can screw your approach up big time (have you been mentally calculating your own vertical descent profile all the way down?).

This is where you start to earn your money. Anyone can do this job when it's easy, but not everyone can do it when it gets hard.

In the real world you've got to visualise what you are actually doing laterally and vertically (I use raw data in ever *increasing* amounts the closer I get to the runway) and compare it with what the FMGS has calculated as its vertical descent profile (I use FMGS derived data in ever *decreasing* amounts the closer I get to the runway).

*Don't ever let an airplane take you someplace where your brain hasn't arrived at least a couple of minutes earlier.*

I think then in terms of on, above or below profile and take action depending on where in the 3D picture I am (on – don't change anything, above – S/B (or may be increase speed), below – V/S).

The closer to the runway I get the more I am using raw data (DME, VOR, NDB, LOC, G/S (but watch out for false LOC and G/S captures if too far from the LOC), 3 times tables (Distance x 300 = Altitude for a 3° glideslope), 5 times tables (Groundspeed x 5 = V/S required for a 3° glideslope) and direct distance to the runway threshold input into the PROG page) and the less I am even looking at any of the FMGS or VDEV predictions.

For what it's worth, during the descent I mentally calculate the following and compare it with the VDEV and FMGS calculated vertical descent profile:

- The required DTG/Altitude using the FCTM Descent Monitoring formula every 5,000' during descent above 10,000',
- The required DTG/Altitude using the FCTM Descent Monitoring formula every 1,000' between 10,000' and 5,000', and
- The required DTG/Altitude using raw data every 1,000' below 5,000'.

## **AIRBUS DESCENT MONITORING**

In the real world you can get any of the following (and most times it will be various combinations of some or all of them):

- High, on, or low on the calculated FMGS vertical profile,
- Speed can be faster, the same, or slower than that used by the FMGS to calculate the vertical descent profile,
- Left, on, or right of the FMGS FPLN track (which results in track lengthening, the same DTG, or track shortening).

How you react these changing situations and how well you understand the FMGS will determine what modes you employ to get the aircraft in the right place, at the right time, at the right speed and the right configuration to execute a safe, expeditious and efficient approach and landing. Easy isn't it!

Good luck and may the Force be with you.

## AIRBUS DESCENT MONITORING

Try and visualise what the FMGS calculated vertical descent profile looks like in three dimensions by superimposing the vertical components upon the two dimensional plan view that you will have displayed on your ND and by looking at the predictions that are provided on the MCDU FPLN page.

The green line represents what you would normally see on the ND with Arc selected on the EFIS Control Panel (i.e. the FMGS FPLN track line). The light blue triangles represent the altitude and/or speed constraints, the blue vertical lines are the altitude extensions overlaid on the plan view to construct the red lines (the 3D track of the aircraft).

This red line remains fixed in space when the FMGS enters the Descent Phase. Now you have to try and visualise where the aircraft is in relation to this red line.

- You can be high, on, or low on the calculated FMGS vertical profile,
- Your speed can be faster, the same, or slower than that used by the FMGS to calculate the vertical descent profile,
- You can be left, on, or right of the FMGS FPLN track (which results in more, the same, or less track miles to touchdown), or
- You can get track shortening or track lengthening (e.g. DIR from MANGO to LIMES).

