

TRAINING & FLIGHT OPERATIONS SUPPORT DIVISION

# A320 Family

## Instructor Support





## A320 INSTRUCTOR SUPPORT

The purpose of this document is to supply some background and concentrating knowledge and to be an assistance for Instructors in terms of properly delivering their briefing and in order to be ready to answer trainees questions.

This document does not replace the FCOMs, which are the reference.

This document outlines furthermore the WHYs of most of the recommended procedures, suggests some efficient practices, which best suit the intended Cockpit Design Philosophy.

Consequently, while the briefing notes describe the specific issues which have to be covered by instructors on given topics, the Instructor Support document provides the arguments needed by them to efficiently brief the trainees on those given topics.

This document supports the instructors standardisation requirements.

Finally, flight instructors will refer to the Instructor Support document in order to carry out the briefings required during IOE.

**THIS DOCUMENT IS FOR INTERNAL USE ONLY**



# A320 INSTRUCTOR SUPPORT

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## **A. NORMAL OPERATION**

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**1 - AIRCRAFT DOCUMENTATION****❖ The MMEL and MEL**

The MMEL is the **Master Minimum Equipment List** published by the A/C manufacturer and certified. It allows an aircraft to be dispatched with some items of equipment or some functions inoperative - provided some specific limitations or procedures, or maintenance actions are carried out - in order to avoid delays or cancellations.

Some items are left open "as required by regulations" as their requirements may vary (e.g. NAV, COM...).

The MEL is the **Minimum Equipment List** published by the operator and approved by local authorities; it is necessarily at least as restrictive as the MMEL.

It consists of 4 sections:

- Section 1 – List of pieces of equipment which may be inoperative for dispatch according to JAA and local AA approved list.
- Section 2 – Associated operational procedures.
- Section 3 – Associated maintenance procedure.
- Section 4 – List of ECAM warnings associated to the dispatch conditions

During line operation, the aircrews have to use the Airline MEL.

The MEL contains following basic information:

- the list of equipment or functions which may be inoperative for dispatch,
- the associated operational procedures,
- the associated maintenance procedures,
- the list of ECAM caution / warnings associated with the corresponding dispatch conditions,
- the rectification interval for each item of the MEL.

Each item / equipment listed in the MEL is identified using the ATA 100 format (Air Transport Association 100); as for FCOM, the full six figures of this breakdown are used: for example 21-52-01, 21 refers to the Air Conditioning – 52 to the Air cooling system – 01 for the Air Conditioning Pack.

**NOTE:**

The dispatch of the aircraft may be possible with some secondary airframe parts missing. This situation is either reported to you by the Technical Log or is noticed during the exterior inspection. In such a case, refer to the "Configuration Deviation List" (CDL) in the Aircraft Flight Manual (AFM) chapter 6. You will find there, if the dispatch is allowed with such a deviation, the possible additional limitations or performance penalties. If a missing item is not mentioned in the CDL, the dispatch is not possible.

**General Operational Rules for the MEL:**

1. The MEL theoretically applies to Revenue flights (out of base, the A/C should be clean of failures, or hold items must be mentioned in the technical log and approved).
2. If a failure occurs or a component is degraded or a function is inoperative **up to the commencement of the flight** ("point at which an aircraft begins to move under its own power for the purpose of preparing for Take-off" JAR-MMEL/MEL.005(d); which means **taxi**), the crew must refer to MEL.  
 If a failure occurs **during the taxi phase** before the start of the take-off roll, any decision to continue the flight shall be subject to **pilot judgement** and **good airmanship**. The commander may refer to the MEL before any decision to continue the flight is taken (ACJ, MMEL/MEL.001).  
 This is particularly true for those failures which might affect the take-off performance (e.g. loss of spoilers, brake failure, loss of EPR mode with N1 rated mode...).
3. Check at the end of MEL chapter 0 (General) the ATA summary, in order to identify the ATA number associated to the failed system (e.g.: Air Conditioning ATA 21), or use the list of ECAM caution titles in Chapter 4 to identify more precisely the full six figure ATA number related to this failure.
4. Go to MEL chapter 1 and carefully identify the item associated to the failure:
  - If the failed item is NOT mentioned in the MEL, the dispatch is NOT possible with the failed item.
  - If the failed item is mentioned, read carefully the description provided as well as the conditions under which the DISPATCH is or is not possible.
  - If the DISPATCH is POSSIBLE, check whether
    - . The Rectification interval (CAT A, B, C or D) is not yet expired and/or
    - . A placard is required (\*) and/or
    - . A specific OPERATIONAL procedure or limitation applies (O) and/or
    - . A specific MAINTENANCE action applies (M).
5. In case an OPERATIONAL procedure or limitation applies, refer to MEL chapter 2. Enter chapter 2 with the ATA number, and check:
  - the potential Applicable Performance Penalties (e.g. MTOW, FLX ...),
  - the potential Flight Domain Limitations (e.g. SPD, CONF ...),
  - the potential Applicable Special procedures (e.g. MAN ENG START ...) and
  - some systems which must be turned off.
6. If a PLACARD or MAINTENANCE actions are required, call for the maintenance specialist and refer to MEL chapter 3 to determine the necessary actions.

**NOTE:**

When the MEL asks for both a maintenance and operational procedure, the maintenance action has to be performed **before** applying the operational procedure.

Be aware that in case of an ETOPS sector, some items are mandatory for ETOPS dispatch. This is specifically mentioned in the MEL.

During the training, the MMEL will be used for LOFT exercises only; some extracts will be provided when necessary for specific simulator exercises.

## 2 - COCKPIT PREPARATION AND SOME CG CONSIDERATIONS

### ❖ Cockpit preparation

- Do not pressurize the **yellow hydraulic system** without advising the ground maintenance crew.
- If a flight control surface position, displayed on the ECAM FLT/CTL page, does not correspond to the handle position, advise the maintenance crew prior to acting on an hydraulic pump.
- Prior to external inspection, check the ECAM:
  - press the RCL p/b for at least 3 sec to review cautions/warnings from the previous flight. If there are any, advise maintenance and review the technical log and MEL.
  - refer to the HYD / ENG pages to check Hydraulic fluid and oil levels.
  - refer to the DOOR page to check the oxygen pressure.
- The pattern of scan depends on whether the pilot is PF, PNF, CM1, CM2 with differing areas of responsibility (FCOM 3-03-6 SOP Cockpit Preparation).  
A useful mnemonic may be used for cockpit preparation:
  - S** Scan (overhead panel and area of responsibility)
  - P** Program (program the FMGS)
  - I** Instruments (check flight instruments: PFD, ND, FCU, ECAM)
  - T** Take off Briefing (before engine start).
- During a quick turn around, do an IRS FAST ALIGNMENT, if the reported G/S, at previous engine shutdown, was greater than 5 kts.

#### NOTE:

A few words about the **cockpit or flight crew oxygen information**. The minimum flight crew O<sub>2</sub> bottle pressure values are provided in FCOM (3.01.35) as O<sub>2</sub> operating limitations.

On the ECAM S/D DOOR page, the Oxygen pressure is provided.

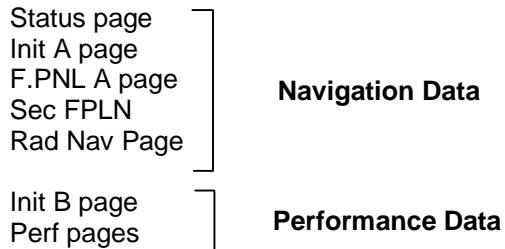
When the O<sub>2</sub> P/B is OFF on the overhead panel, the OXY indication is amber; once this P/B is switched ON, OXY turns white unless the pressure is indicated less than 400 PSI.

An amber half box is displayed around the digital pressure indication (which may be green) to indicate that the bottle pressure is less than 1500 PSI; this is an advisory indication to help the crew and line maintenance team to anticipate when the bottle should be refilled.

The REGUL LO PR amber indication is displayed when a too low pressure in the O<sub>2</sub> low pressure distribution system is detected by the low press switch (< 50 PSI).

❖ **FMGS programming**

The normal sequence of FMS programming consists in filling up Navigation Data and then Performance data:



This sequence of data entry is the most practical; indeed INIT B shall not be filled in immediately after INIT A, because the FMGS would then be able to compute predictions. All subsequent entries would then be longer to achieve due to this prediction process.

On certain pages there are amber boxes, all must compulsorily be filled.

However in order to provide a good prediction, all fields of the various pages shall be properly filled in (INIT A, B, FPLN, PERF) with all the available planned data for the flight.

- On the STATUS page, the DATA BASE validity date is to be checked, as well as the navaids or wpts possibly stored in previous flights, and the applicable PERF FACTOR.
- The FPLN A page is to be completed as thoroughly as possible: T/O runway, SID with ALT/SPD constraints, and even the expected T/O time, the proper transition to the cruise waypoints and the intended step climb/descents.
- The SEC FPLN is to be filled whenever a specific condition is foreseeable, such as T/O runway change, alternative SID or after take off in flight turn back.
- The RAD NAV page is checked, and any required navaid manually entered using the ident. Should a navaid be reported unreliable on NOTAM, it will be deselected on the SELECTED NAVAID page.
- The INITB page will then be used as follows:
  - Insert expected ZFWCG / ZFW (load sheet not yet available)
    - Insert Block fuel
  - When the load sheet is available
    - . update ZFWCG/ZFW
    - . insert the Block Fuel
    - . If PRINT function is available (option), print the PREFLIGHT DATA.
      - This listing provides all the predictions which may be used during the initial part of the flight.
- The PERF CLB/CRUISE pages are to be used to preselect a Speed or Mach if:
  - initial climb speed is required, (e.g. Green dot speed if a sharp turn after T/O is required),
  - a specific cruise Mach Number is required at the beginning of cruise.
- The FPLN must be cross-checked by both crew members using:
  - The MCDU with FPLN page + slew keys.
  - The ND in PLAN mode, range as required, with CSTR selected on EIS CTL panel.
 

This check is to be done for the SID till the first waypoint in cruise
  - The computerized F.PLN (CFP) versus the F.PLN displayed on page providing the ROUTE SELECTION.
  - The overall distance of the route (6<sup>th</sup> line of FPLN page) versus CFP distance is to be checked.

**NOTE:**

- It often happens that the loadsheet is brought very late to the crew – However in many cases the crew knows what the expected ZFW is, how much fuel is required for the sector. Thus the crew know the expected TOW which allows then **to prepare the expected T/O speeds and FLX TEMP**. It is advisable to do it, so that when the actual TOW is available, it will be very rapid to determine the actual T/O speeds.
- When the loadsheet is provided, it is obviously good practice to check that all the data is reasonable and within limits. Furthermore the loadsheet specifies the **number of passengers**, which allows the crew to determine which **PACK FLOW** to select.:

A/C Version	If PAX less than	PACK FLOW
<b>A 319</b>	- 85	- LO *
<b>A 320</b>	- 115	- LO *
<b>A 321</b>	- 140	- ECON

- \*But if the weather is very hot and humid, select Hi.
- Finally, once the loadsheet is checked, the PF determines T/O data; PNF as well – Once the crosscheck is achieved between pilots, the PNF will dictate the values of ZFWCG/ZFW and FOB, and the T/O data to the PF who will insert them in the associated pages of the MCDU (INIT B, PERF T/O).

❖ **Some considerations about the CG**

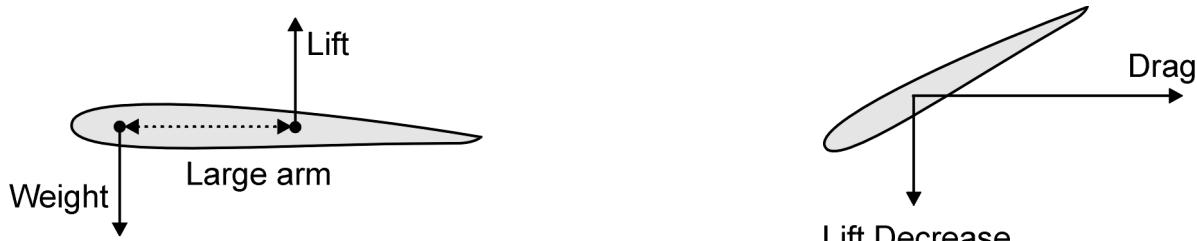
The location of the CG has significant influence on Performance, on Loading flexibility, on structure and on handling characteristics when in Direct Law.

All those factors contribute to define the CG envelope.

- **Performance considerations**

The weight and lift forces do create a pitching moment which is counteracted by the THS setting.

When the CG is located forward, the resulting pitching down moment is counteracted by a large THS nose down setting which induces a lift decrease and a drag increase.



**As a general rule, FWD CG penalizes the Performance**

• **At Take-off and landing, it affects:**

- \* **The Stall speeds:** Typically on A330/A340, the stall speed increases by 1.5 kts when CG varies from 26% to full forward CG. This affects take-off and landing speeds thus associated distances.
- \* **The rotation maneuver:** It is "heavier", thus longer at forward CG. This affects the take-off distance. For example, on an A340 at 250 t, the TOD increases from 3165 m to 3241 m, when CG varies from 26% to full forward CG, which represents a 2.42% TOD increase (T/O, FLAP3, PACK: OFF, ISA, ALT 0).

- \* The climb performance itself: For example, if a climb gradient of 5% is required (e.g. due to obstacles) in the previous take-off conditions, the MTOW is reduced from 257.6 t down to 256.2 t when CG varies from 26% to full forward CG.  
This is why on A320 and A340 take-off performance charts are provided at forward CG (which in most cases is penalizing) and at 26%; these last charts may be used provided the actual aircraft CG is at least 28%.
- **In cruise**, an AFT CG minimizes the THS induced drag, thus improves fuel consumption. For example, the fuel increase on a 1000 nm cruise segment is as follows, considering a heavy aircraft in high altitude and CG 20% or 35%:

A/C TYPE	FUEL BURN INCREASE
A320s	Negligable
A330	220 kg
A340	380 kg

This explains why there is a trim tank system on A330/A340.

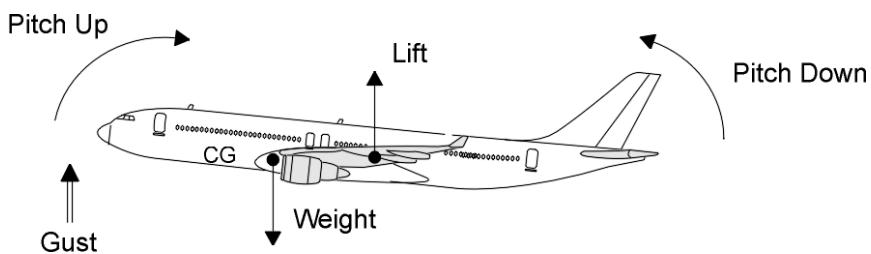
- **Handling Characteristics considerations**

On fly by wire aircraft, in Direct Law, the handling characteristics of the aircraft are affected by the location of the CG as a mechanically controlled aircraft:

- **Stability Issue - Aerodynamic Centre or Neutral Point**

The aircraft is considered as stable, if in case of a perturbation or gust, the aircraft tends to react back towards its previous status.

The aerodynamic centre, also called neutral point, is the location where an increase (or decrease) of lift is applied when the aircraft angle of attack varies.



The hereabove gust causes an angle of attack increase, thus an additional lift; the aircraft is stable if the lift/weight forces do create a pitch down moment resulting in a decrease of the angle of attack.

**Aircraft is stable if CG is forward of Aerodynamic Centre or Neutral Point.**

- **Maneuvering criteria - Maneuver point**

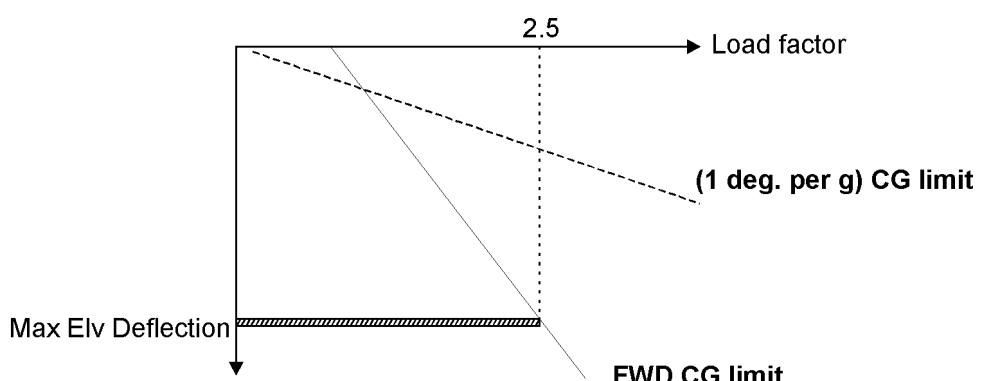
Depending upon the CG location, a given deflection of the elevator causes a more or less sharp aircraft maneuver. In other words, the CG has a direct influence on the maneuverability of the aircraft.

If a very small deflection of the elevator causes "a lot of g", the efficiency of the elevator is very high; the aircraft is considered as very touchy to maneuver.

The maneuver point is the location of the CG for which the efficiency of the elevator is infinite.

The CG must obviously be forward of the maneuver point by a lot. This lot is defined by a maneuverability criteria which states that "**at least 1° of elevator deflection is required to pull 1g load factor**". This condition defines the AFT CG limit maneuverwise.

But the CG must not be too far forward: indeed, the maximum elevator deflection must allow to pull at least the maximum acceptable load factor (e.g. 2.5 g). This condition defines a FWD CG limit maneuverwise.



- **Ground handling characteristics**

Essentially at high GW (thus at take-off), the CG is limited AFT so as to ensure enough Nose Gear adherence to allow an efficient aircraft steering on the ground.

- **Take-off rotation characteristics**

The CG must be limited so as to allow:

- enough maneuverability during rotation → FWD CG limit.
- enough margin versus potential tailstrike → AFT CG limit.

Obviously the THS is preset nose up in case of forward CG or nose down in case of AFT CG, in order to get homogeneous aircraft rotation. But certification maneuvers require to demonstrate "abuse cases" such as taking-off with FWD CG limit while THS is set nose down.

- **THS stall potential**

- in approach with flaps extended, there is a nose down moment counteracted by a THS nose up setting. The more CG is forward, the more THS nose up setting is required. This may lead to a THS stall, more particularly in cases of push over where the pilot pushes hard on the stick when he notices a significant speed decrease.

This limits the FWD CG in approach.

- in Go Around or Alpha Floor, the thrust increases to TOGA, more particularly at low speeds induces a significant pitch up moment which increases when CG is more AFT. The elevator efficiency must allow to counteract this pitch up moment, even at very low speed.

This limits the AFT CG in Go-Around and Alpha Floor.

- **Structural Considerations**

The CG cannot be too much forward due to Nose Gear structural limits; it cannot be too much AFT due to wing and main landing gear strut limit.

- **Loading Considerations**

All the previous criterias allow to determine limits which, for example, would favor AFT CG configurations for obvious performance efficiency.

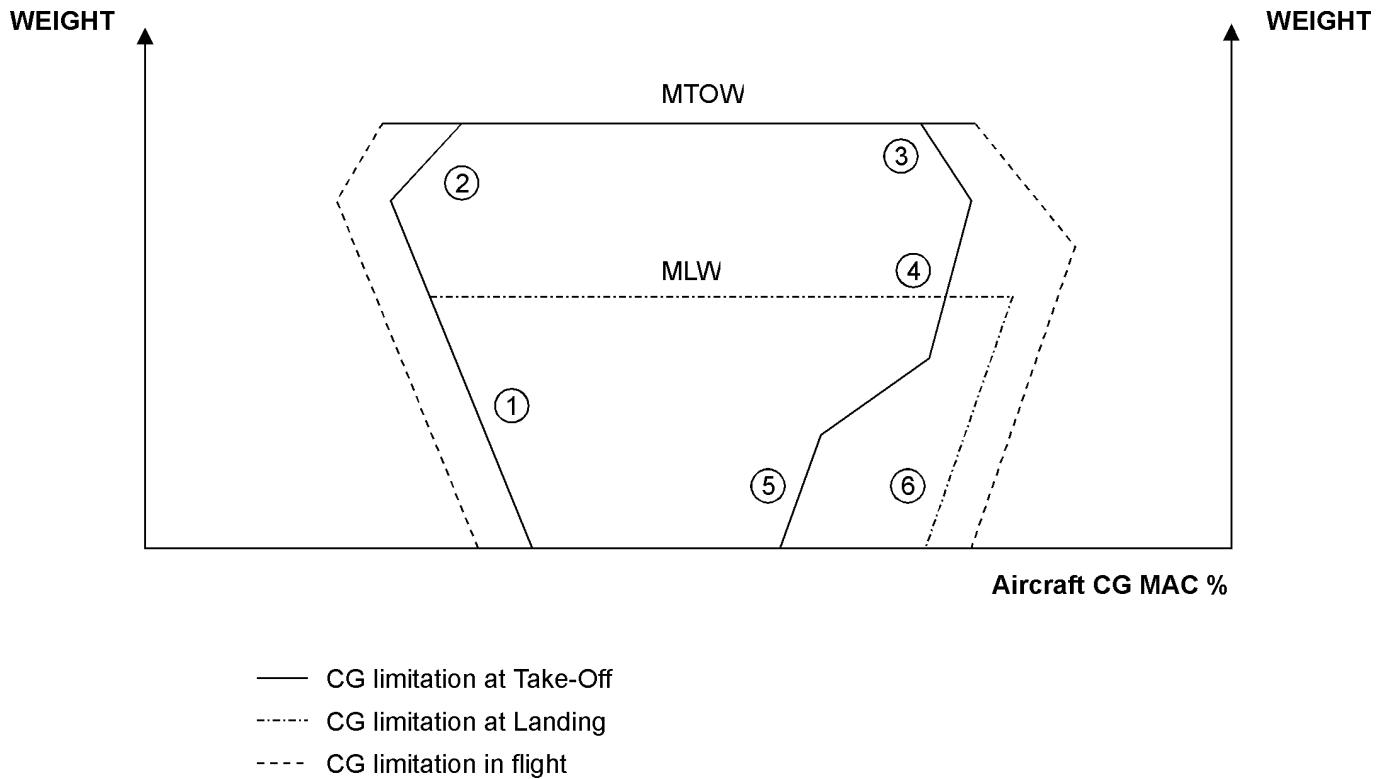
However, the CG envelope must also take into account loading flexibility constraints.

- **Passenger movement**

The CG envelope must also allow passenger to move in the cabin.

This is the reason why once the take-off CG envelope has been determined, as well as the landing one (which is less constraining), then the inflight envelope is defined usually providing at least a 2% margin with the previous envelopes.

- Typical resulting CG envelope:



① Performance / loading compromise at take-off

② Nose gear strength structural limit

③ Main gear strength structural limit

④ Alpha floor limit

⑤ Nose gear adherence limit

⑥ Alpha floor limit (landing)

The inflight limit is deduced from the take-off / Landing envelope by adding a 2% margin, provided all handling characteristics criteria are fulfilled.

**❖ PF/PNF task sharing and cockpit preparation sequence and scan**

The FCOM and QRH detail this essential phase of the flight. A particular geographic scan has been developed in order to maximize the resource involvement in the spirit of ACRM. Accordingly the PF/PNF concept applies from the time the crew arrives at the aircraft till they leave the machine. Each crew member task has specific actions intended to offer optimal cross check and communication while efficiently achieving the desired outcome.

**PF and PNF make up a team.**

Consequently:

- Preliminary cockpit check and exterior inspection by PNF.
- PF briefs the Cabin Crew, starts the cockpit preparation and inserts the F PLN data into the MCDU. He scans the overhead panel primarily to ensure that the IRSs are ON.
- Once the PNF is back into the cockpit, the crew will insert perfo data in the FMS and cross check the resulting data; then they will carry out the entire scan of the overhead panel (there is no urgency to set the Fuel Pumps ON).

**As a sum up of cockpit preparation**, the crew shall keep in mind that this phase of the flight is never a quiet phase. Many people get into the cockpit, the PNF goes for the external inspection while the PF programs FMS. Once PF and PNF are both in their seats they have to inform each other of their mutual actions so as to be fully in the loop:

- PNF advises PF of the result of the external inspection,
- Both review the OVHD panel,
- Both review the essential data inserted in the MCDU,
- Both review the EIS Ctl panel (Range, mode, CSTR) and FCU (initial expected target altitude),
- Both review EIS: PFD – ND (SID in plan),
- Both review ECAM (amongst others Oil, Hyd, Fuel gauges) and
- Both review the Pedestal (PKG brake, RMP ...).

### 3 - TAKE OFF BRIEFING

The main objective of the Take off briefing is for the PF to inform the PNF of his intended course of actions during Take off and initial climb, in normal and abnormal situations. It may be completed by specific Captain's instructions. Any misunderstanding shall be clarified through questions.

The briefing must be PRAGMATIC, that is to say adapted to the take off actual conditions; it must be SHORT and covered in a LOGICAL manner.

When specific data is reviewed (V speeds, FLX, LDG ELEV, SID ...) it shall be cross-checked on the associated peripheral (PFD, ECAM, ND and MCDU).

❖ **The following KEY ITEMS shall be mentioned:**

**1. Normal situation**

- All PERF T/O DATA: V1/VR/V2 – FLEX – CONF – THR/ACCEL ALT – PACKS.
- Specific runway / weather condition. Use of Anti Ice (A/I).
- Key items of ATC clearance - initial cleared altitude and trajectory.
- Transition altitude - MSA - Constraining SID ALT CSTR if any.
- Use of the Radar ...
- Reminder of major NOTAM, MEL or CDL item.

**2. Abnormal situation (EO at take off)**

- Who calls STOP; who actually STOPS the A/C.
- EO ACCEL ALT
- Minimum initial climb altitude (MSA, Circuit pattern altitude ...).
- Expected procedure (left/right down wind, radar vector to runway, ...).
- Potential overweight landing with associated configuration (to be checked in QRH).

Such a briefing shall be done without rush, when the workload is low so that it enables to the pilots to properly concentrate.

Therefore it will be done once FMGS, FCU etc. ... are properly programmed and set, close to the end of the cockpit preparation and before the engine start.

Should the take off conditions change after engine start, then a short briefing concentrating on the main changes will be carried out: e.g. V speeds / FLX / CONF - Trajectory - Altitudes.

## 4 - ENGINE START

The normal engine start procedure is the AUTO START procedure; the MANUAL START procedure is used exceptionally in specific cases. During an AUTO START procedure the FADEC protects the engines against HOT, HUNG START, START STALL ..., it detects these phenomena and takes the appropriate action (reducing the fuel flow, or cutting it off, cranking the engine, attempting a new start etc. ...). This significantly saves engine life time.

The engines are started in sequence, preferably engine 2 first.

### ❖ AUTO START

- Check thrust levers are at Idle.
- Set IGN/START to START. Check amber crosses disappear on ECAM E/W-D and APU bleed pressure stable.
- Set ENG 2 MASTER ON.
- Check in order:  
     STARTVALVE OPENS → N2 → IGN A (B) → FUEL FLOW → EGT → OIL PRESS rising.  
     ONCE START VALVE CLOSES → Note PEAK EGT, and Eng Vibration → Parameters stabilized.
- **Then repeat for ENG 1.**

For IAE engines a 30 sec crank phase is systematically applied by FADEC before IGN and FUEL FLOW in order to avoid rotor bow.

### Remarks:

- If the thrust lever is not at idle at engine start, an ECAM alert will be triggered requesting lever to be set at idle. Failing to comply might be hazardous since the engine will accelerate rapidly to the thrust determined by the lever position.
- When both engines have been started, set the IGN / START switch back to NORM, to allow PACKS to be back ON.
- Once the engines are started, set APU BLEED to OFF to prevent engine exhaust gas re-ingestion.
- In case of any abnormal during ENG START, follow the ECAM and **do not interrupt** the FADEC protective actions by non-requested actions on START panel.

### ❖ MANUAL START

Manual start is to be used **exceptionally** in case of STARTER VALVE problems or low EGT margins or in case of high residual EGT or to CRANK the ENG DRY (e.g. to get EGT down) prior to sending fuel ON; it may be recommended for high altitude operation.

Manual start of the engines is also recommended after aborting a start because of an engine stall, or engine EGT overlimit, or low start air pressure. Consider dry cranking the engine 30 sec after an aborted start.

During MAN START the FADEC ensures a PASSIVE monitoring of Engine parameters, with potential warnings. The starter is **automatically** cut off at about 50% N2.

Furthermore, the **starter engagement is limited in time and in number of successive attempts**:

- CFM: 4 times 2 mn with 20 sec between each start.
- IAE: 2 times 2 mn + 1 time 1 mn with 15 sec between each start.
- This is the reason why the use of the stopwatch is recommended.
- Check that Thrust Levers are at Idle.
- Select IGN / START switch to START. Check amber crosses disappear on ECAM E/WD and APU BLEED pressure stable.
- Press the MAN START P/B on the overhead panel; START STOPWATCH (for monitoring the start cycles, if applicable, at least) and check:
  - START VALVE OPENS → N2 rising.
  - When  $N2 \geq 20\%$  (max motoring speed recommended), MASTER ON and check.
  - IGN A (B) → FUEL FLOW → EGT → OIL PRESS rising.
  - AT  $N2 > 50\%$  START VALVE closes (check time), set MAN START OFF.
  - Note PEAK EGT and Engine Vibrations → Parameters stabilized

**Then repeat for the other engine.**

**Remarks:**

- When both engines have been started, set the IGN START switch back to NORM.
- Finally it is good to keep in mind the **average IDLE parameters** which are:

$N1 \approx 20\%$  -  $N2 \approx 60\%$  - EGT 400° C - FF 300 kg/h

for IAE engines EPR  $\approx 1.01$ .

❖ **Tail pipe fire**

In the event of a second engine start attempt, a tail pipe fire may occur. In such a case:

- Shutdown the affected engine **using the Eng Master switch**; (do not use the FIRE P/B, nor the Engine Fire Extinguishing bottles).
- Crank the engine using APU or opposite engine bleed air.

Refer to p 79 for tail pipe fire details.

## 5 - TAXI AND BRAKING

Before taxiing, check NW STREERG DISC amber MEMO is not displayed on ECAM to confirm NWS is available.

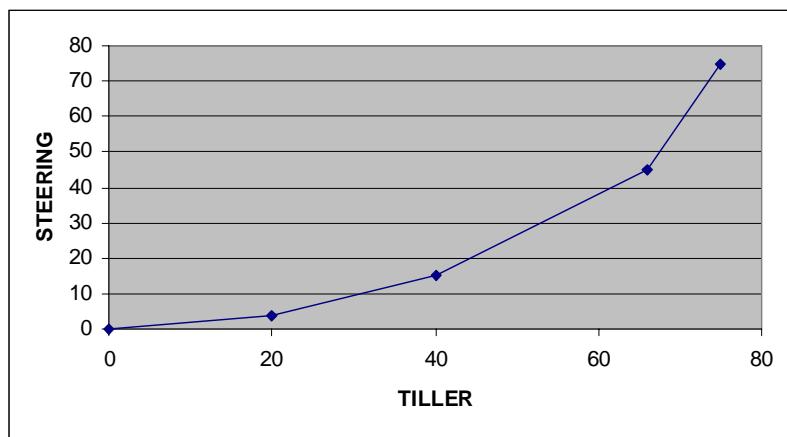
During taxi, there are several issues: taxi roll and steering, braking.

### ❖ Taxi roll and steering

In order to initiate the taxi roll, the use of minimum thrust is recommended to avoid FOD (N1 40 % max).

Taxi with APU BLEED OFF (APU bleed valves closed - engine bleed valves open) to avoid ingestion of exhaust gases by the air conditioning system.

The **Nose Wheel Steering** is « **by wire** »; the relationship between the tiller and the nose wheel angle is not linear, but the force on the tiller is light and independent of the deflection.



The **pedals** do control the nose wheel steering at low speed ( $\pm 6^\circ$  with full pedal deflection).

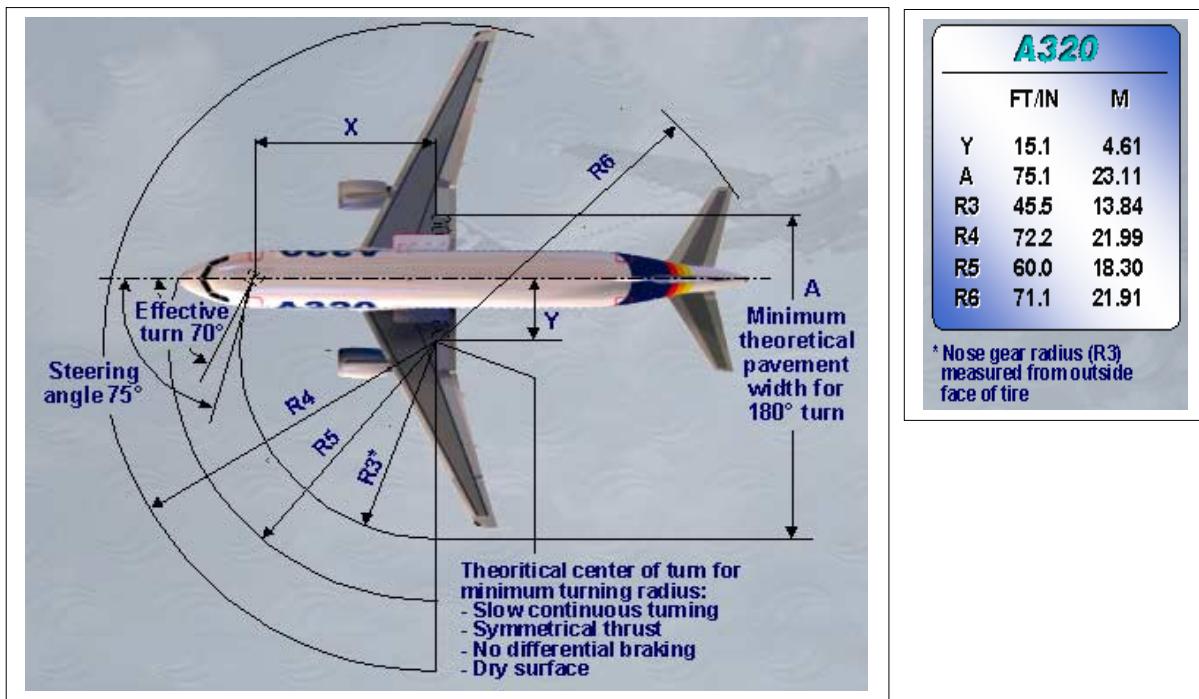
- Consequently when you taxi on straight taxiways and on shallow turns, use the pedals to steer the aircraft keeping a hand on the tiller.
- In sharper turns, use the tiller smoothly and progressively: a rapid movement on the tiller does not induce a very rapid movement of the steering mechanism which is limited to approx. 12 °/sec per inertia.

Conversely, if a big input has been set on the tiller, avoid trying to adjust to a lower setting which often causes uncomfortable oscillations; keep this tighter turn and steer out a little earlier.

When exiting a sharp turn, **anticipate** the steer out.

If both pilots act on the tiller or pedals their inputs are **added**, till the maximum value of steering angle programmed within the BSCU.

On **wet or contaminated runways**, taxi with reduced speeds; avoid large tiller inputs in case of skidding. Take benefit of differential engine thrust for shallow turns, as well as of smooth differential braking which might be more efficient than the nose wheel steering.



Minimum Turn Radius (assuming symmetrical thrust and no differential braking).

The figures are provided for A320-200.

The minimum runway width (pavement) required for 180° turns is 30 m (99 ft). The turn application assumes symmetrical thrust and no differential braking. The specific 180° turn procedure is described in A320 FCOM 3.03.10.

- **Nose radius:**

- A319	- 16.6 m
- A320	- 18.3 m
- A321	- 22.5 m

- **Tail radius:**

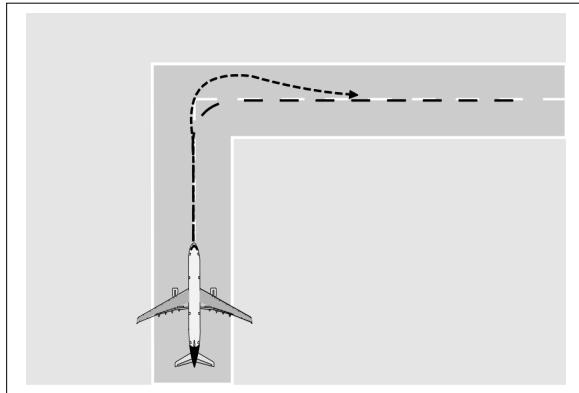
- A319	- 19.8 m
- A320	- 21.9 m
- A321	- 24.2 m

- **Wing Tip radius:**

- A319	- 21.4 m
- A320	- 22.1 m
- A321	- 22.1 m

Effective steering angle: 75°.

## OVERSTEERING TECHNIQUE



For A 321 (longer a/c), it may be necessary to consider oversteering technique, main gear being 20 m behind the pilot.

In case of a 180° turn on the runway a specific procedure is provided in SOP. Keep in mind that:

- You should not let the G/S drop below 8 kts during the maneuver in order to avoid stopping.
- You may use differential thrust setting, by adding thrust on outer engines ( $\geq 50\% N1$ ).
- The use of differential braking is not recommended due to gear stress.

Finally on wet or contaminated surfaces, more specifically when turning on the runway white or yellow painted markings, tight turns lead to jerky rides of the nose wheel which are noisy and uncomfortable.

### ❖ Braking

The brakes are carbon brakes. They have twice the life of steel brakes and they weigh less than steel brakes. Carbon brakes are tolerant to thermal overloads and they maintain maximum torque capability at high temperatures. They do not weld as steel brakes. Their maximum temperature is limited by adjacent component heat capacity (e.g. hydraulic fluid inflammation temperature). Their efficiency improves slightly with wear; they do not melt. But considerable wear and rise in temperature occur during taxi due to successive brake applications; at each brake release there is a small amount of oxidation of the surface which is removed at next brake application.

**The brake wear check is done during External Inspection with Parking Brake set ON.**

However the brake temperature should not generally rise above **150° before T/O for proper RTO**. Thus consider using brake fans during taxi, if temperature gets close to that value. Don't use brake fans during T/O.

As a general rule, don't ride on the brake; let the speed increase to around 30kts in straight lines and then press smoothly the pedals to reduce speed down till GS 10 kts and release.

When you reach a sharp turn, press the pedals smoothly to bring the speed down to 10 kts.

Parking brake particulars:

- Note that, when the parking brake is ON, pressing on the pedals has no effect on the braking. Consequently if for any reason the aircraft moves forward while parking brake is ON, the parking brake must be released in order to get braking efficiency from the pedals (on latest A320s, a modification provides the availability of pedal braking even if parking brake is ON).

If the ACCU PRESS drops to 1500 PSI, be aware that loss of efficiency of the parking brake can be sudden. Before taxiing, the brakes must be checked; this check consists in verifying that the Normal braking has actually taken over when parking brake is off, and thus that both BRAKE yellow pressure indications remain at 0 when pedals are pressed. The most comfortable way to carry out this check is:

- while parking brake is ON, press pedals down and
- release the parking brake and check that both BRAKE yellow pressure indicate 0.

Another method consists in releasing the parking brake, in order to set the aircraft moving; then the pilot presses the pedals smoothly. He checks:

- the aircraft decelerates gently,
- the Yellow brake pressure indicates 0 on both gages of the indicator.

Be aware of Passenger comfort.

If any braking problem is encountered during taxi, set the **A/SKID - NWS switch to OFF with no pedal braking**. Then use pedal braking with care by modulating the pressure.

NWS is then lost as well, thus use differential braking to steer the aircraft.

Other drills:

- After start up or during taxi, **PF** has to **check the Flight Controls**; he will successively move the stick and rudder pedals while watching outside the aircraft during straight line taxiing (or when A/C is stopped); while moving the pedals he will simultaneously press the pedal disconnect P/B on the tiller with the palm. **PNF** will check the proper movement of the surfaces on the ECAM. **PF must keep head up during the check**.
- The **PNF** has **merely to move his stick** to ensure that those inputs are transmitted to the associated surfaces and that the stick is "free", he checks the stickcross movement on PFD. The purpose of this check is thus different from the one of the PF Flight Control check.
- If the ATC modifies the clearance, this must be reflected on MCDU, FCU and possibly RMP; a short briefing shall confirm those modifications.
- If the T/O has to be achieved with PACKS OFF for performance reasons, APU BLEED may be used with PACKS ON if Air conditionning is desired; this allows to maintain the required engine performance level and passenger comfort. In case of APU auto shutdown during T/O, the engine thrust is frozen, till the thrust is manually reduced; the PACKS revert to engine bleed which causes an increase of EGT to keep the N1 (EPR) target.

If the T/O is performed with one PACK unserviceable, the procedure states to set the failed PACK to OFF. The T/O may be performed with the other PACK ON (if performance permits), with TOGA or FLX thrust, the PACK being supplied by the onside Bleeds. In this asymmetric bleed configuration, the N1 take off value is limited to the value corresponding to the Bleed ON configuration.

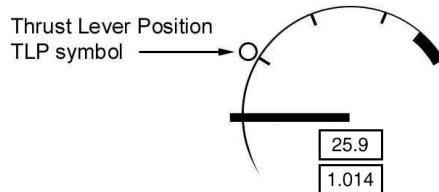
## 6 - TAKE OFF

The take off is actually divided into various sequences:

❖ **Take off initiation and power set:**

- **Set the power in 2 steps in case of headwind and crosswind till 20 kts:**

- bring thrust levers to 50 % N1 (1.05 EPR) position using the thrust lever symbol on the N1 (EPR) gauge.
- wait till all engines are set to 50 % N1 (1.05 EPR) and stabilized.
- then bring thrust levers to FLX or TO notch in one movement.
- keep half stick forward till 80 kts and then release it progressively to neutral by 100 kts.



- **Set the power in 3 steps in case of tailwind or strong crosswind:**

- bring thrust levers to 50 % N1 (1.05 EPR) position on the 2 engines,
- then move thrust levers to 70% N1 (1.15 EPR) rapidly,
- set TO or FLX TO progressively, to reach the thrust by 40 kts G/S,
- keep full stick forward till 80 kts and then release it progressively to neutral by 100 kts,

**This ensures that all engines will accelerate similarly and efficiently.**

Then check:

- the FD pitch bar (and yaw bar if ILS avail),
- the FMA (to be announced by PF and checked by PNF),
- the position update on the ND (A/C symbol on RWY threshold),
- the power setting (Actual N1/EPR = N1/EPR rating limit before 80 kts, announced by PNF),

Note that:

- **Rolling take off** is recommended whenever possible.
- If the thrust levers are not set to the proper T/O detent (e.g. in FLX instead of Max T/O), a message comes up on the ECAM. Push thrust levers full forward.
- If ATC requests you to maintain runway center line, simply turn the HDG selector and, select the most probable HDG target expected. NAV mode will disarm and RWY TRK mode will engage on FD after lift off and will guide the A/C on the runway center line.
- During initial roll, stick shall be pushed halfway forward in most cases, to improve NLG adherence with ground.

❖ **Take off roll:**

- Use the rudder pedals to steer the A/C. The NWS will be effective till 130 kts. **Don't use the tiller beyond 20 kts.**
- Avoid using the stick into wind; indeed this increases the natural tendency of the a /c to turn into wind.
- In case of low visibility take off (RVR down to 125 m) visual cues are the primary means to track the runway center line. If an ILS is available on departure runway, the PFD yaw bar provides an assistance in case of fog patches.

❖ **Rotation:**

- Pull on the stick smoothly to ensure a continuous rotation rate (typically 3 °/s).
- **Avoid** being aggressive on the stick, or **adding sudden stick input when the A/C pitch reaches around 8°**, so as to avoid tailstrike.
- Rotate initially to target pitch 10°; once airborne adjust the pitch to the FD bar pitch (SRS order). The FD does not provide a rotation rate order, but a pitch order to fly the T/O speed profile once airborne.
- Keep the stick laterally centered during the rotation, then keep wings level.
- Once airborne the FD lateral bar will come up automatically.
- AP is available 5 sec after lift off (100 ft).

NOTE:

The AP/FD SRS mode ensures a pitch guidance at Take-Off or Go-Around, so as to provide a safe and efficient pitch control in this touchy phase.

In order to simplify its description, it is said that with all engines operative, the SRS commands a pitch leading to an IAS = V2 +10 and, that with one engine inoperative, it commands a pitch leading to an IAS = V2. This description is schematically true.

Actually, at take-off, the SRS uses as a computation target V2+10, with all engines operative (AEO), the aircraft speed at the time of failure limited to V2 and V2+15 with one engine inoperative (OEI).

The FG then computes the pitch command which full fills following objectives and is the minimum of:

- pitch to get V2 + 10 with AEO, or the OEI speed,
- maximum pitch: 17.5°,
- pitch required to climb with a minimum climb gradient of .5°, limited to 22.5°.

This explains why, in many take-off cases, the IAS which is actually flown is neither V2 + 10 (AEO) nor V2 (OEI).

Once again, **the take-off SRS mode provides a pitch command to fly a given speed schedule during the take-off segments, but is not intended to provide a pitch rate command during rotation.**

❖ **Tail strike considerations:** Refer to FCOM bulletin 22 for briefing about tail strikes:

CONDITION	TAILSTRIKE PITCH ATTITUDE	
LANDING GEAR	COMPRESSED	EXTENDED
A319	13.9 °	15.7 °
A 320	11.7°	13.7°
A 321	9.7°	11.4°

The **recommended flap configuration** to provide best tail clearance at take off is **CONF 2**. It is therefore to be used whenever performance allows, considering furthermore that when CONF 1 + F is chosen, take off close to V2 mini may have to be achieved.

In order to avoid tail strike, rotate **at VR (not before!)** and control a constant/smooth rotation rate without any aggressive or abrupt aft action on the stick more specifically when a positive attitude is already achieved.

In case a tail strike occurs, consider a landing at the nearest airport (origin for example) for inspection purposes. If however in such conditions the A/C has to climb, consider not pressurizing.

❖ **Thrust Reduction / Acceleration:**

Usually THR RED ALT = ACCEL ALT; it is defaulted to 1500 ft AGL in FMS but modifiable by the pilot as required by the procedure (e.g. noise abatement).

Reaching **THR RED ALT**, LVR CLB comes up on FMA; bring the thrust levers back into CLB detent.

- Note that if FLX TEMP is very high, FLX N1 (EPR) is close to CLB N1 (EPR) but never below.
- When THR LVRs are set in CLB detent, ATHR is ON. If SRS mode is still engaged, the FD pitch bar will order a pitch down depending upon the amount of thrust decrease in between TOGA or FLX TO and CLB thrust. When handflying, follow the pitch down order.

Reaching the **ACCEL ALT**, the target speed is set automatically to initial climb speed.

- Note that there is a significant pitch down order on the FD bar.
- Retract Flaps when IAS  $\geq$  F with a **positive speed trend**.
- Retract Slats when IAS  $\geq$  S with a **positive speed trend**.
- On A321, if the Take-off is achieved at **high GW**, S speed is above  $V_{FECONF1+F}$ . In that case:
  - accelerate towards S; at 210 kts the **Flap autoretraction system** retracts the Flaps to 0 and VFE on PFD goes to  $V_{FECONF1}$  230 kts.
In that case, should the IAS drop back below 210 kts, flaps will not extend back to 1 + F.

**NOTE:**

If the FCU ALT is low, ALT\* will engage rapidly after lift off, before the A/C reaches THR RED or ACCEL ALT. In that case, LVR CLB comes up on FMA and target speed goes to initial climb speed.

The same will happen if the pilot manually pulls OPEN CLB or V/S.

In many cases, THR RED ALT = ACCEL ALT. Thus the LVR CLB message comes up simultaneously on the FMA with CLB (OPCLB) mode, and target speed increases. In that case, when hand flying the aircraft, follow the FD pitch down order first, and then set THR LVRs into CLB detent.

❖ **Other drills in take off:**

- On the EFIS Control panel, select CSTR.
- If the A/C is TCAS equipped, select ABV (if available).
- If there is weather, use the radar and set TILT + 4°.
- If there is terrain around the airport or along SID, set TERR ON ND to ON to allow EGPWS display.
- If PACKS are set to OFF at take off, select them back ON **only once** thrust is reduced in order to avoid potential resulting EGT increase.
- Set them back ON **sequentially** to improve PAX comfort ( $\Delta t \leq 10$  sec), as per FCOM procedure.
- In case of crosswind take off, keep the runway center line using the rudder pedals but NOT the tiller. Avoid setting the side stick into wind, which increases the natural tendency of the A/C to turn into wind.
- At rotation, laterally center the side stick.
- During take off roll, try to roll the aircraft with the nose wheel away from the runway centerline lights so as to minimize the resulting jerks and noise.

NOTE:

The FADEC operates with its own temperature sensor. If, in hot weather, the sensor heats up, its detected temperature could be higher than TFLX (e.g. OAT 35°, TFLX 40, sensor temp 45°). Once the engine rotates and the aircraft taxies, the sensor temperature will slowly become equal to OAT.

However, as long as sensor temperature is higher than TFLX, the N1 (EPR) limit value provided by the FADEC and displayed on ECAM E/W Display is TOGA.

NOTE:

Reminder of some characteristic speeds.

SPEED	A319		A320		A321	
	CFM A319-115	IAE A319-132	CFM A320-212	IAE A320-233	CFM A321-211	IAE A321-231
<b>VMCL</b>	110	108.5	108	109	114	114
<b>VMCA</b>	114.5	109.5	110.5	111.5	114	114
<b>VMCg CONF 1+2/ CONF 2</b>	113.5	107.5	110.5	112.5	104.5	109

\* VLS is limited by VMCA at T/O; by VMCL in all other phases.

\* VMCA, VMCL, VMCg, varies also with altitude.

A319 - 115      CFM56 - 5B7  
 A319 - 132      IAE V2524 - A5  
 A320 - 212      CFM56 - 5A3  
 A320 - 233      IAE V2527 - A5  
 A321 - 211      CFM 56 - 5B3  
 A321 - 231      IAE V2533 - A5

## 7 - CLIMB

The transition into CLIMB phase occurs at ACCEL ALT or more precisely when SRS mode disengages; target speed goes to initial climb speed.

### ❖ Climb Speed profile - Speed managed / Speed selected

The best climb speed profile is the managed speed profile which takes into account GW, CI, CRZFL, Altitude and Speed constraints.

However selected speed will be used in climb when required. Among others:

- Pre-select speed on ground prior T/O on PERF CLB when:
  - the FPLN has a sharp turn after T/O ( $\Delta$ HDG > 90°) - pre-select Green Dot speed,
  - a high angle of climb is advisable after T/O because of noise, obstacles - pre-select Green dot speed,
  - the ATC requests a specific speed, in that case pre-select that speed.
- Select a speed on FCU during climb if;
  - so cleared by ATC,
  - turbulence is experienced,
  - higher rate of climb is required. In that case a lower speed while in CLIMB, OP CLIMB, is selected on the FCU down to Green dot minimum as long as FL < 250; the same applies when ATC requests to expedite through a given FL,
  - in higher altitude, 0.76 M is a good Mach Number to climb. You may select it, when normal speed may be resumed, press the SPD P/B on the FCU.

When selected speed is used, the predictions on the FPLN page assume the selected speed is kept, till the next planned speed modification in the FPLN. E.g. suppose O = 200 is pre-selected for initial climb, suppose SPD LIM (250 kt/10000 ft) is part of the vertical FPLN. The predictions on FPLN page assume that 200 kt are maintained from ACCEL ALT, up to 10.000 ft (SPD LIM) where managed speed is supposed to be resumed. If at a higher altitude the pilot selects a turbulence speed (e.g. 275 kt) and there is no SPD CSTR or SPD LIM till top of climb (TOC), 275 kt is supposed to be maintained till next phase, that is till TOC in this example.

In other words in Selected speed the FM predictions are meaningful.

Furthermore on PERF CLB page, the pilot can read the predictions to any inserted altitude with the selected speed; on the ND the  level arrow assumes selected speed when it is used.

#### NOTE:

When speed is selected in lower altitude, there is an automatic change to Mach at a specific FCU cross over altitude (usually FL305).

❖ Altitude considerations

The FMS PROG page provides:

- The MAX REC ALT which corresponds to 0,3 g buffet margin
- The OPT ALT which depends upon GW, CI but also FPLN remaining cruising distance, temp, ...

This information is used among other to rapidly answer to ATC: « can you climb to FL ... » for example.

NOTE:

A CRZ ALT higher than max altitude corresponding to 0,2 g buffet cannot be inserted.

The PERF CLB page provides predictions to a given FL in terms of time and distance assuming CLB mode; all constraints are considered in these predictions. The given FL is either defaulted to the FCU target altitude, or it may be manually inserted.

Note that the  level arrow on the ND assumes the current AP engaged mode (thus if CLB mode, altitude constraints are considered).

This information on ND and PERF CLB is used, among other, when ATC requests to know when a given level will be reached, or to rapidly answer to ATC: «can you make FL ... by XYZ waypoint ?»

Finally on the FPLN page, the Altitude predictions assume that the pilot will immediately select back all managed modes (lateral or vertical), should these modes not be engaged.

Baro setting: switching from QNH (QFE) to STD is done at Transition Altitude. If not, QNH will flash on the PFD.

In most areas of the world, whenever ATC clears you to climb to a FL, you can select STD, even below Transition. In other areas such as US, this is not allowed. Apply local customs.

❖ Climb mode management

The recommended AP/FD modes in climb are CLB if ATC clears the aircraft along the FPLN, or OP CLB if ATC gives radar vectors or clears A/C direct to a given FL, disregarding ALT CSTR.

If ATC requires you to expedite through a given FL:

- select a lower speed on the FCU for best speed/alt trade off,
- or use a higher V/S.

**Typically, with all engines operative, turbulence speed may be considered as best rate of climb speed, and green dot as best climb gradient speed.**

If ATC gives a 1000 feet level change (e.g. from 7000 to 8000) use V/S mode for smoother guidance and less thrust variation.

If you use a high V/S for any reason, it may happen that the A/C is unable to climb with this high V/S and to maintain the target speed with Max Climb thrust for performance reasons.

In that case, the AP will pitch up to achieve the target V/S and ATTHR will increase to MAX CLB thrust to achieve the target speed. Then, if unable, the aircraft will decelerate maintaining V/S. If then the speed reaches VLS, the AP will pitch down to maintain VLS.

NOTE:

Be aware that above FL 300, if the A/C speed has significantly decreased, it takes a long time to reaccelerate.

**❖ Other drills:**

- When crossing 10.000 ft, it is a good practice to watch the ECAM MEMO so as to ensure that some drills have not been left behind: e.g. LDG LT OFF / SEAT BELTS OFF (according to flight conditions). It is also time to clear the manually inserted navaids on MCDU NAVAID page, so as to allow full autotuning, to select ARPT on EFIS Ctl panel and COPY ACTIVE into secondary.
- During CLB properly adjust the RADAR TILT. If used at T/O, the tilt was around + 4°. During climb, tilt the antenna down so as to get ground returns on the top edge of ND.  
If TCAS available, use the ABOVE option.
- If during CLB, there is a major change in ATC clearance routing, use the PRINT FUNCTION (DATA IN FLT PRINT) to get the latest updated predictions on a listing, once all revisions are carried out (optional).
- As a general rule set PF MCDU preferably on PERF CLB, PNF MCDU preferably on FPLN.

## 8 - CRUISE MANAGEMENT

### ❖ Reaching the Initial cruise Flight Level:

- When reaching the Initial cruise Flight Level:
  - Ensure ALT CRZ on FMA.
  - Cross check FMS NAV ACCY.
  - Review ECAM main pages
  - Set TCAS to ALL (if applicable), or to BELOW if cruise altitude within 2000 ft from FL 390.
  - EFIS CTL panel, select ARPT.
  - Properly update lateral and vertical F.PLN.
  - Print F.PLN (optional).
- When reaching the initial cruise Flight Level, ensure that **ALT CRZ** is displayed on FMA. If ALT CRZ is displayed on FMA this means that the FCU target altitude is set to the initial planned CRZ FL as displayed on PROG page.

If ALT CRZ is not displayed on FMA this means that the FCU target altitude is set BELOW the CRZ FL as displayed on PROG page. This is typically the case when ATC clears the A/C at a lower initial cruising flight level than pre-planned.

It is important to have ALT CRZ on FMA at the initiation of cruise for fuel efficiency purposes. Indeed this ensures that the proper initial cruise Mach Number is targeted furthermore with ATHR in MACH mode, the AP altitude control is SOFT which means that if the Mach number slightly deviates from its target, the AP will allow small altitude variations around the cruise altitude (typically +/- 50 ft) in order to keep the Mach constant thus preventing thrust changes. This minimizes the fuel consumption in cruise.

Hence, if when reaching the initial cruise Flight Level ALT CRZ does not appear on FMA, update the CRZ FL on PROG page.

#### NOTE:

Once in ALT CRZ mode, if ATC clears the A/C to a higher level, then the cruise flight level is automatically reassigned when the FCU altitude is set to this higher level, and the AP/FD is in CLB/OP CLB or V/S modes. The same occurs when a Step Climb or Step Descent are part of the vertical flight plan and climb or descent is commanded.

- In many cases during the Cockpit Preparation, **cruise winds and temperatures** have not been inserted at successive waypoints in the FPLN. This is normal because these insertions are time consuming in that phase. This is why, in most cases, only initial cruise flight level and temperature are inserted on INIT A page, average winds for Climb and Cruise on HISTORY WIND, and, if applicable, step in vertical FPLN in order to ensure reasonable fuel and time initial predictions at the beginning of the flight.

If this is so, when reaching the CRZ FL, insert WIND and TEMP at various waypoints in cruise.

In order to do so, take the computerized FPLN and determine the waypoints where a wind/temp entry is necessary, according to the following rule of thumb (and use of common sense...):

- at the first waypoint in cruise, insert wind DIR/VEL, and temperature at the initial CRZ FL.
- at next waypoint where wind differs by 30° or 30 kts and temperature by 5°.
- Review **FUEL** predictions and XTRA.
- Once all cruise data is inserted, **PRINT the latest predictions** (DATA IN FLT PRINT). Always keep the latest PRINT, which will be used for reporting, and also should a major FMS FAULT occur (optional).

#### ❖ Cruise Altitude Profile

The cruise altitude profile is generally provided on the computerized FPLN. It is determinated as a function of A/C GW, of COST INDEX, length of the FPLN, winds and temperature and possible ATC constraints.

Initially, during the cockpit preparation, the crew inserts the cruise altitude profile as follows:

- initial CRZ FL on INIT A page,
- if applicable, step on VERT REV (STEP PRED) page, as step at waypoint.

If the A/C GW, as inserted on INIT B, is higher than expected, it may happen that the initially planned CRZ FL is higher than the MAX REC ALT. The FMGS then outputs a message, to inform the crew of the problem.

- It is important to fly **close to the OPT FL** during the cruise. The OPT FL is provided on PROG page function of (GW, CI, WIND ...). This is the current OPT FL.

One Step Climb (SC) or one Step Descent (SD) can be inserted in order to optimize the profile on high gross weight conditions. A Step Climb or Step Descent will not be accepted if it does not ensure at least one minute of flight time at the new altitude.

The strategy to systematically climb higher is not necessarily more efficient because:

- cruising too high (OPT + 2000) starts to be penalizing performance wise,
- the time to reach a too high FL is long, thus penalizing in certain cases and affecting engine life time,
- the additional fuel required during climb must be compensated by enough cruising time at upper flight level and
- wind consideration must be taken into account.

The FCOM Vol. 3 (In Flight Performance) provides valuable tables which assist the pilot to decide to climb (or descent) to a new CRZ FL taking into consideration the wind component differences between both FLs.

- The REC MAX FL ensures a 0.3 g buffet margin and a minimum rate of climb (300 ft/mn) to reach it. It is not a function of CI. The REC MAX ALT indicates the present climb capability of the aircraft.

Hence the consideration of REC MAX ALT and OPT ALT will guide the pilot to best choose the CRZ FL, when ATC gives restraining clearances such as: "are you able for FL 390, or maintain FL 310".

- In cruise always fly with ALT CRZ mode on the FMA. If the A/C climbs from one CRZ FL to another, the ALT CRZ is automatically updated.

If the A/C descends towards a lower CRZ FL, the ALT CRZ is usually updated except if it does so within 200 NM from destination. Thus when reaching lower FL, check ALT CRZ on the FMA. If it is not displayed, update the CRZ FL on PROG page, if judged necessary.

#### ❖ **Cruise Mach Profile - Cost Index (CI)**

The **cost index** is a number through which the economic strategy of the flight is determined. The cost index takes into consideration the price of the fuel and of the flight time. The cost index determines the speed/Mach profile for all flight phases (climb, cruise, descent), which is also called ECON SPD/MACH.

- If fuel consumption is the essential economical factor on a given sector (price of fuel very high), the CI is a low figure. CI = 0 represents Maximum Range.
- If flight time is the essential economical factor, CI is a high figure. CI = 999 represents minimum time.

The Cost Index is processed by the Airline flight ops department. It may be assigned to each Co Rte in the FMS data base. In that case, when inserting the Co Rte on INIT A page, the CI comes up automatically, else you have to insert it.

**The Cost Index is a strategic parameter, which applies to the whole flight.**

Once the CI is inserted along with the FPLN, GW, CRZ FL etc. ..., the FMS computes the ECON SPD/MACH PROFILE for CLB/CRZ/DES. The MANAGED SPD PROFILE includes the ECON SPD/MACH as well as the ATC restrictions such as SPD LIM (250 kt/10.000 ft) or SPD CSTR.

It is recommended to fly MANAGED SPD/MACH during cruise. The crew must be aware that the target Mach will vary as a function of GW, FL etc. ... but also as a function of headwind component and ISA variations.

E.g. if headwind + 50 kts  $\Rightarrow$  Target goes up 0.01 (approx.).

Flying MANAGED SPD/MACH in cruise ensures the best economical flight.

**If ATC requires a FIXED MACH**, this is a tactical clearance. **This FIXED MACH is to be SELECTED** on the FCU.

All predictions are updated accordingly down to the next S/C or T/D. They are therefore realistic.

The Cost Index is NOT to be modified in cruise except for valid strategic operational reasons such as:

- XTRA FUEL gets close to 0 and
- XTRA FUEL is ok, but time of arrival is late.

In such cases, the crew will envisage to insert a COST INDEX corresponding to LRC (refer to QRH), or to minimum time, to solve those operational problems.

**NOTE:**

- CI has an effect on OPT FL.
- It is absurd to play with CI to get a given Mach Number in cruise. Select the given Mach number on the FCU; the FMS updates all predictions accordingly.
- If in cruise, the Managed Mach appears to be obviously wrong, check the PERF factor on A/C STATUS page.

**❖ Periodic Drills to be achieved in cruise**

- Periodically review the **main ECAM pages**: MEMO and ENG / BLEED / ELEC / HYD / FLT CTL / FUEL, and note any significant parameter deviations.
- Periodically cross check the **FMS NAV ACCY** using any available raw data (DME, VOR, ADF or even RADAR image in MAP).

**NOTE:**

If GPS is primary, this check is not really necessary, unless an amber navigation message comes up.

- In RVSM airspace, the validity of the altitude reading has to be checked periodically (between ADR1, ADR2, ADR3 on PFDs, and also stand by altimeter).
- Periodically check the **FUEL ESTIMATES**. EFOB at Wpt & Destination, XTRA fuel, and FOB + Fuel Used = Initial Fuel (in order to detect a leak).

**NOTE:**

When checking fuel, ensure proper fuel distribution, balance, and temperature. If imbalance, proceed to fuel balance procedure only after (FOB + FU) check.

**Repeat these drills every 45 mn or so.**

- If ATC modifies the routing, revise the FPLN. Once achieved, get the latest IN FLT PRINT (optional).
- If there is weather, use the LATERAL OFFSET facility to determine how many NM left/right of track are required to avoid it. Once cleared by ATC, insert it in the FPLN. All predictions are then meaningful, and sequencing of FPLN occurs.
- Adapt ND ranging to circumstances; modify RADAR TILT as a function of ND range.
- Select CSTR (for MORA) on PF EFIS Ctl panel and ARPT on PNF side.

❖ Fuel considerations

The fuel consumption of the A/C is directly affected by:

- **the way the A/C is operated:**

- fly as close as possible to OPT FL (+1000 ft / -4000 ft),  
As a rule of thumb up to ISA +15:

$$\text{OPT FL} \approx 570 - 3 \times \text{GW (t)}$$

$$\text{MAX FL} = \text{OPT FL} + 15$$

Above ISA +20:

$$\text{OPT FL} = \text{MAX FL} \approx 560 - 3 \times \text{GW (t)}$$

- use Managed Speed; the target will be adjusted according to wind and temperature,
  - ensure that ALT CRZ is active which ensures that CRZ Mach is the target and that soft ALT mode is active on AP (after 2 mn in cruise),
  - ensure that fuel is properly balanced and
  - don't carry excessive XTRA fuel.
- **the outside environmental conditions** such as wind and temperature (higher temperature and headwinds than expected have an adverse effect on fuel consumption).

Some examples on an A 320 (CFM): regarding the **effect of cruise altitude**:

GW [t]	TEMP [°C]	Range per ton = NM/t		
		OPT - 4000	OPT	OPT + 1000
73.5	ISA	159	FL350 164	TBD
	ISA + 10	162	163	TBD
66	ISA	175	FL370 181	TBD
	ISA + 10	175	180	TBD

At 66 t, the OPT FL is FL370; considering the **effect of cruise winds**, it is efficient:

- to descend to FL330, if the headwind is lower by at least 15 kts,
- (See FCOM VOL3 – 3.05.15).

• **Fuel temperature considerations**

- The temperature of the fuel carried in the wings and in the trim tank tends to decrease in cruise; it is directly affected by the TAT.
- The minimum fuel temperature in the inner tank should be higher than the freezing point of the fuel (- 47°C for the Jet A1); typically freezing point +5°.
- When the fuel freezes, this means that there are wax crystals floating in the fuel which can prevent proper fuel feed of the engines, or fuel transfers.

Thus the ECAM outputs a caution when the fuel temperature reaches:

- - 48°C for A 319 & A 320 [L(R) OUTER or INNER TK LO TEMP] and
- - 46.5°C for A 321 [L(R) WING TK LO TEMP].

Apart from the ECAM actions required, the crew must consider:

- either to descend towards hotter areas,
- or to increase the Mach Number

keeping in mind the fuel penalty such maneuvers do cause.

Below tropopause, a 4000 ft descent results in an increase of 8°C on OAT and approximately 7°C on TAT (lower Mach). An increase of 0,01 Mach result in an increase of around 0.7° TAT. Keep in mind that it takes a long time for the fuel to stabilize at a new temperature.

**NOTE:**

At Mach 0.78, TAT - SAT  $\approx$  26°C.

**EFFICIENT CRUISE MANAGEMENT = KEEP AHEAD OF THE A/C  
WITH ALL AVAILABLE TOOLS**

## 9 - CRUISE - DESCENT AND APPROACH PREPARATION - APPROACH BRIEFING

Whenever possible, the PNF will get the ATIS or the destination weather, runway in use, conditions etc...

This will allow the PF to **program the FMS** as follows:

**F F.PLN revisions**

- lateral (Appr, STAR, Transition) and ALTN F.PLN and
- vertical (Speed, Alt CSTR checked or added).

**P PERF DATA**

- PERF DES - Check Managed Descent Speed and modify if required.
- PERF DES - Enter a couple of Descent winds.
- Enter QNH / DEST WIND / LDG CONF / MDA or DH – PERF APPR.

NOTE:

- MDA for baro referenced minima or DH for radio altitude referenced minima.
- PERF GO AROUND - Check Go Around THR RED / ACCEL ALT.

**R RAD NAV**

Manually tune VOR / DME of destination airfield on one side using the Ident and insert navaid ident in the BRG / DIST field of PROG page, for NAV ACCY crosscheck during descent. This applies even if GPS is primary, (this is a precaution in case of potential loss of GPS PRIMARY in descent or approach).

**S SECONDARY F.PLN**

COPY ACTIVE and revise SEC F.PLN according to circumstances:

- Alternative approach
- Circling etc...

Once the entries are cross checked and computed, Top of descent (TOD) checked consistent with raw data, it is time for APPR briefing. The main objective of the APPR briefing is for the PF to inform the PNF of his intended course of actions during descent, initial, intermediate and final approach, as well as missed approach as programmed in the FMS. Any misunderstanding shall be clarified through questions.

**The briefing** must be PRAGMATIC, therefore adapted to the actual conditions of approach. It must be SHORT and conducted in a LOGICAL manner. As for the T/O briefing, F.PLN data is cross-checked on ND PLAN and on chart, whereas specific data is checked on MCDU or other peripherals.

The following KEY ITEMS shall be mentioned:

- Weather and runway conditions at DEST,
- Expected RWY and APPR (ND),
- Any NOTAMS affecting STAR / APPR / LANDING,
- Keypoints of STAR / TRANSITION / APPR + CSTR (ND),
- Holding characteristics, if expected,
- MEA, MSA, Transition Altitude, MDA / DH (PFD, ND) – Obstacles,
- Landing CONF + use of REV + use of A/BRK,
- Mini Fuel at DEST for ALTN (MCDU - FUEL PRED and FOB),
- Missed Appr + GA ALT and ALTN and
- TOD (time, position).

The descent and approach preparation and briefing must be done early enough to get properly prepared and provide the proper information. Typically 80 NM to 60 NM before TOD is a good time.

**NOTE:**

If no data is inserted for the approach 200 NM from DEST, ENTER DEST DATA message comes on the MCDU to advise the crew to get prepared for the arrival.

Once weather conditions are available in the cockpit, temperature and significant weather (rain, snow or ... blue sky) may be transmitted to Cabin Crew for passenger interest.

## 10 - DESCENT

In order to carry out the descent and to reach the Initial Approach Fix (IAF) in good situation, the crew has at its disposal Descent guidance modes and descent monitoring means. The modes and monitoring means are actually linked.

Basically there are:

- the managed DES mode which guides the A/C along the FMS pre-computed descent profile, as long as the A/C flies along the lateral F.PLN, i.e. DES mode is available if NAV is engaged.  
As a general rule when DES mode is used, the descent is monitored using VDEV called yoyo on PFD, or its digital value on the PROG page, as well as the ↘ level arrow on the ND.
- the selected OP DES or V/S modes which are used when HDG is selected or when ALT CSTR may be disregarded or for various tactical purposes. As a general rule when OP DES or V/S modes are used, the descent is monitored using the Energy Circle, (displayed if HDG or TRK modes) and the ↘ level arrow on the ND. When the A/C is not far away from the lateral F.PLN (small XTK), the yoyo on PFD is also a good indicator.

NOTE:

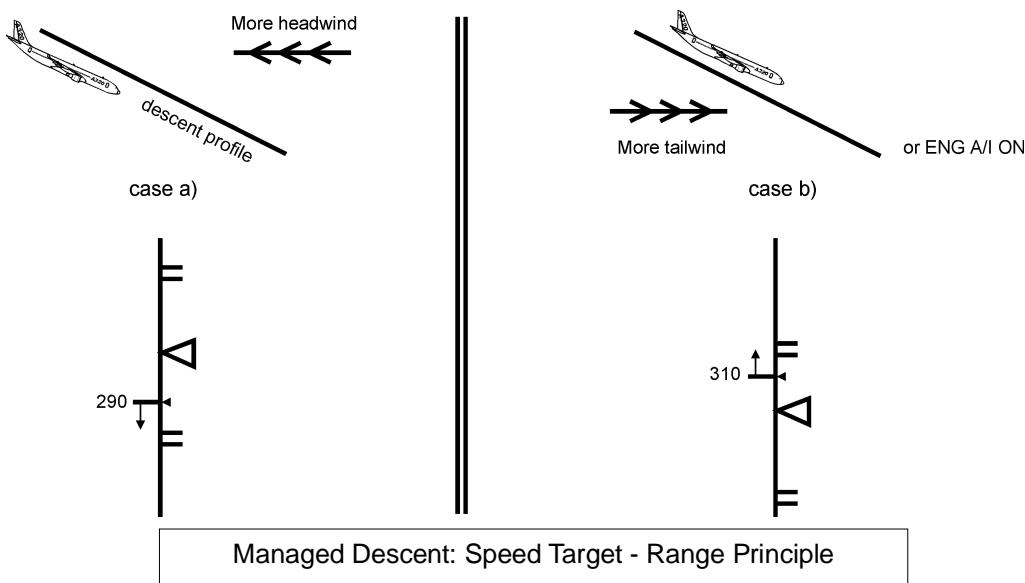
With early FMS versions, when in HDG mode, the descent is monitored using REQ DIST TO LAND versus DIRECT DIST TO LAND on PROG page.

### ❖ Managed Descent

When DES is engaged, the AP/FD guides the aircraft on the **pre-computed descent path or profile**, according to pilot's entries (descent speed, altitude constraints, wind etc. ...).

However the actual external conditions might not be those predicted; the use of ENG Anti Ice (A/I) for example rises up the Idle thrust level.

- Consequently when DES mode is engaged with Managed Speed, the A/C speed is allowed to vary within a given range around the Nominal Target Descent Speed ( $\pm 20$  kts, limited to  $V_{MAX}$ ), in order to give some flexibility to DES mode to keep the A/C on path when external conditions vary.



- **Case a):**

If the A/C tends to get **below path**, the current speed decreases towards the lower limit of the speed target range to keep the A/C on path with IDLE thrust. If the speed reaches the lower limit, then SPEED mode engages on the A/THR, to keep the A/C on path at that lower speed.

- **Case b):**

If the A/C tends to get **high above path**, the current speed increases towards the higher limit of the speed target range to keep the A/C on path with IDLE thrust. If the speed reaches the higher limit, THR IDLE is obviously on the A/THR; but the AP will not allow the speed to increase more than the higher limit to track the descent path. Thus the VDEV will slowly increase.

- If DES mode is engaged and the speed is selected, the descent profile is **unchanged**. Consequently DES mode will do its best to keep the A/C on the descent profile but it will not allow the speed to deviate from its target.

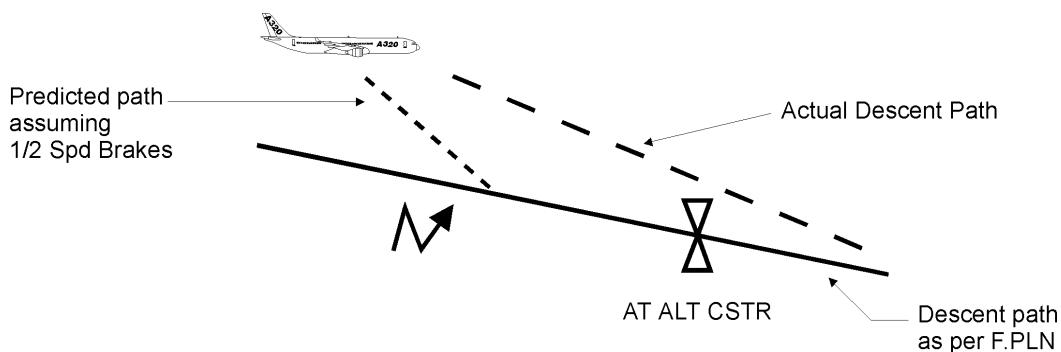
Let us suppose a descent profile computed assuming managed speed 300 kts. If the pilot selects 275 kts, the A/C will most probably deviate above the descent profile and VDEV will increase.

In many cases, ATC interferes with the proper achievement of the descent, and causes the A/C to be high above path or too low. If DES mode is used, it will do its best to recover the descent path and match the constraints:

- Suppose the **A/C is high above path** and the pilot is cleared down. He presses DES mode with Managed Speed. The AP will pitch the A/C down so as to fly the highest speed of the speed target range, with THR IDLE.

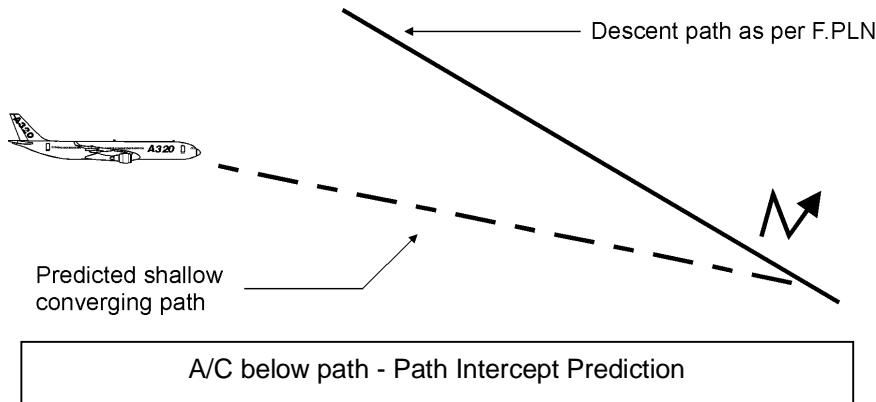
On the ND, an INTCPT point is displayed as a blue  symbol. It materializes where the A/C will intercept the descent profile, assuming  $\frac{1}{2}$  SPD BRAKES extended. Thus if speed brakes are not extended, the  will slowly move forward till it gets close to an altitude constrained waypoint. The EXTEND SPD BRAKE message then comes up. This technique allows an altitude constraint to be matched with minimum use of speed brakes.

Therefore when HIGH ABOVE PATH, monitor VDEV and  to recover the descent path.



A/C above path - Path Intercept Prediction

- Suppose the A/C is below path and the pilot is cleared down. He presses DES mode with managed Speed.



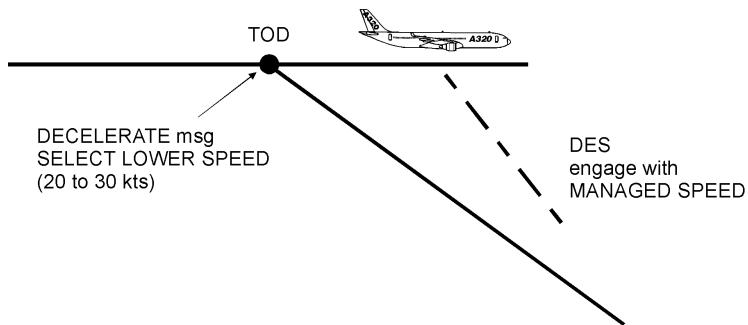
The DES mode will guide the A/C on a shallow descent converging towards the descent profile (1000 ft/mn or less depending on the circumstances) with the ATTHR on SPEED mode.

The  intercept point is then at a fixed position along the flight plan on the ND; it indicates the location where the descent path will be intercepted.

These last 2 cases occur at each descent initiation where ATC requests:

- either an **early** descent before TOD  ; a shallow converging descent is commanded by DES mode (SPEED – DES on FMA),
- or a **late** descent beyond the TOD  ; a steep converging descent is commanded by DES mode, the A/C accelerating towards the top speed of the speed target range (THR IDLE - DES on FMA).

In that last case a message DECELERATE is provided on PFD once TOD is sequenced; this is an indication to the pilot to select a lower speed (subject to ATC permission) in order to minimize the distance spent beyond TOD, and to recover the descent profile more rapidly when DES mode is engaged and A/C accelerates to descent speed with managed speed back ON.



A/C at CRZ altitude - Beyond TOD

Thus Managed DES mode makes the best use of A/C speed within the speed target range and of thrust (Idle or Speed mode on A/THR) to track the descent profile. This is materialized on FMA by THR DES/DES, THR IDLE/DES, SPEED/DES mode indications.

- If, for any reason, the ATC requests a steeper descent while the A/C is in DES mode, on path or below, pull OPEN DES mode, increase speed and use SPD BRK if necessary. But don't select higher speed, or extend speed brakes with managed DES, because in most cases this will result in thrust increase, the aircraft being guided on the descent path by DES mode.
- If HDG is pulled, DES mode reverts to V/S. In other words, selecting a Heading does not induce any change in A/C pitch behaviour. It is then time for the pilot to increase/decrease the V/S target or select OPDES depending on circumstances.

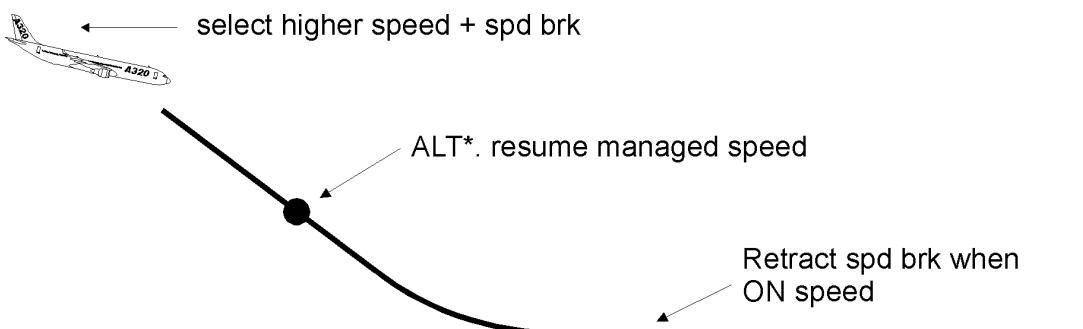
**NOTE:**

The pre-computed descent path is actually divided into successive descent segments. From TOD to the first constrained waypoint it is an "idle segment", then geometric segments. The Idle segment assumes a given managed speed flown with "Idle +  $\Delta$ " thrust, this " $\Delta$ " thrust above idle gives some flexibility for the FG to keep the A/C on the descent path in case ENG A/I is used, or winds vary. This explains THR DES on FMA. The Idle factor set on A/C STATUS page allows the  $\Delta$  to be adjusted: e.g. if - 2 is set, the Idle segment is steeper.

❖ **Selected OP DES or V/S**

These selected modes are used during **Radar Vectors** or for **pilot tactical interventions**.

- When **OPEN DES** is pulled the A/C will descend **unrestrictedly** down to FCU selected altitude, with THRUST IDLE and speed target managed or selected. With managed speed, there is no longer a speed target range as when managed DES is ON, since it no longer has any meaning and is useless in OP DES mode.
  - If you wish to steep the descent down:  
Select a higher target speed (subject to ATC permission); extend speed brakes if necessary, with OP DES mode.  
Resume the normal speed when reaching ALT\* at the earliest or ALT, and retract speed brakes when approaching target speed.



Speed management in descent for best altitude/speed trade off - OP DES mode

**NOTE:**

If you command a deceleration while the A/C is still in OP DES and too high, this brings the A/C still higher above the intended path. Indeed, the A320 will get into a very shallow descent in order to decelerate.

- If you wish to shallow the descent, select a lower target speed or possibly V/S mode.

- When V/S is used, the A/C is guided to that V/S with SPEED mode on ATTHR.
   
In descent V/S is used:
  - for small step descent, in order to get a smooth guidance with reduced thrust variations and
  - when the A/C is significantly below path, a constant shallow V/S may be selected to smoothly recover (come back) to the intended path.

If for any reason, V/S is selected with a high V/S target or typically after a DES → V/S reversion, the A/P will pitch the A/C down to fly the target V/S. Thus the A/C will tend to accelerate, while ATTHR commands idle thrust to try to keep the speed. When IAS reaches a speed close to VMO or VFE, the AP will pitch the A/C up so as to fly a V/S allowing VMO or VFE to be maintained with idle thrust.

**NOTE:**

On the latest FG standard, when the target V/S as selected on FCU is no longer matched by the A/P to keep the A/C within normal speed envelope, V/S is boxed amber on the FMA.

- The monitoring cues used with OP DES and V/S are:
  - level symbols on the ND, related to FCU target altitude,
  - - - Energy circle on the ND, when HDG or TRK modes are ON. This materializes the required distance to descend, decelerate and land from present position
  - and the yoyo on the PFD, which may be used when the A/C is « not far » from the lateral F.PLN (small XTK). It then gives a good assessment of whether the A/C is low or high related to the descent profile.

❖ **Holding patterns**

If ATC requires the A/C to hold, insert the holding pattern in the F.PLN. The FMS computes the holding at **green dot speed** taking into consideration the ICAO holding speed limits function of altitude (subject to holding table):

230 kts up to 14.000 ft,  
 240 kts up to 20.000 ft and  
 265 kts above.

If managed speed is used, the A/C will **automatically** decelerate to the holding speed at a point which is materialized by the speed change symbol along the F.PLN, if **NAV is ON**.

**Clean configuration** is recommended for fuel considerations, and the LAT REV HOLD page indicates the latest possible time to exit the hold in order to carry enough fuel for the remainder of the flight.

The holding pattern is **not included** in the descent path computation since the FMS does not know how many patterns will be flown. Once the A/C enters the holding pattern, the yoyo indicates the instantaneous VDEV between the A/C current altitude, and the altitude the A/C should fly at the exit fix of the holding pattern so as to be there on the descent path; all other predictions assume one pattern.

DES mode guides the A/C down at **V/S – 1000 ft/mn**, while in the holding pattern.

❖ **Various Drills in descent**

- Before TOD, select destination **VOR/DME needle**, press **CSTR** button on EFIS CTL panel, and set **TCAS** to **BELLOW**.
- As a general rule, preferably set **PF MCDU on PROG, PNF MCDU on F PLN**.
- Periodically crosscheck FM NAV ACCY. At TOD, entering TMA (typically 50 NM from destination), entering Approach Zone (15 NM from destination) and whenever a NAV ACCY DNGRADED or an amber navigation message comes up.
- At 10.000 ft, LDG Lights/Seat belts / ILS button if required.
- If RADAR is to be used, adjust the TILT up along with descent progress.
- If EGPWS is available, select TERRAIN ON ND on one side (it is exclusive of RADAR image) and Radar on the other side.
- BARO REF - select QNH whenever cleared down to an ALTITUDE, at transition level at the latest.
- If ENG A/I is to be used and you notice that this brings the A/C high above path, extend  $\frac{1}{2}$  SPD BRAKE to compensate.
- Whenever ATC orders a level off and A/C is high above path, SELECT a lower speed. When ATC clears you to resume descent, OP DES pull and SELECT a higher speed.
- Don't forget simple rules such as:

Remaining DIST (NM) to descent =  $\Delta$  ALT (ft) / FPA ( $^{\circ}$ ).  
 Reach 9.000 ft/250 kt by approximately 30 NM from touch down.

- Speed brake half extension  $\Rightarrow$  Descent gradient increases by 50 %.  
 → Speed brake full extension  $\Rightarrow$  Descent gradient increases by 90 %.

Descent speed	Angle of descent	Half speed brakes	Full speed brakes
325 kt	5 $^{\circ}$	7.5 $^{\circ}$	9 $^{\circ}$
300 kt	4 $^{\circ}$	6 $^{\circ}$	8 $^{\circ}$
250 kt	3.3 $^{\circ}$	5 $^{\circ}$	7 $^{\circ}$
210 kt	3 $^{\circ}$	4.5 $^{\circ}$	6 $^{\circ}$
Emergency descent - MMO/VMO, Full speed brakes			10 $^{\circ}$

EFFICIENT DESCENT MANAGEMENT = BEST SPEED VS ALT TRADE OFF

## 11 - APPROACHES

The approach briefing by instructors needs to be STRUCTURED so that pilots have a **good guideline** or SKELETON applicable to any type of approach. All approaches shall then be flown similarly.

Therefore, the approach briefing notes are structured as follows:

1. General Approach Briefing
2. ILS Approach
  - Standard ILS,
  - High above G/S and
  - ILS with raw data.
3. Non Precision Approach
4. Circling Approach
5. Visual Approach

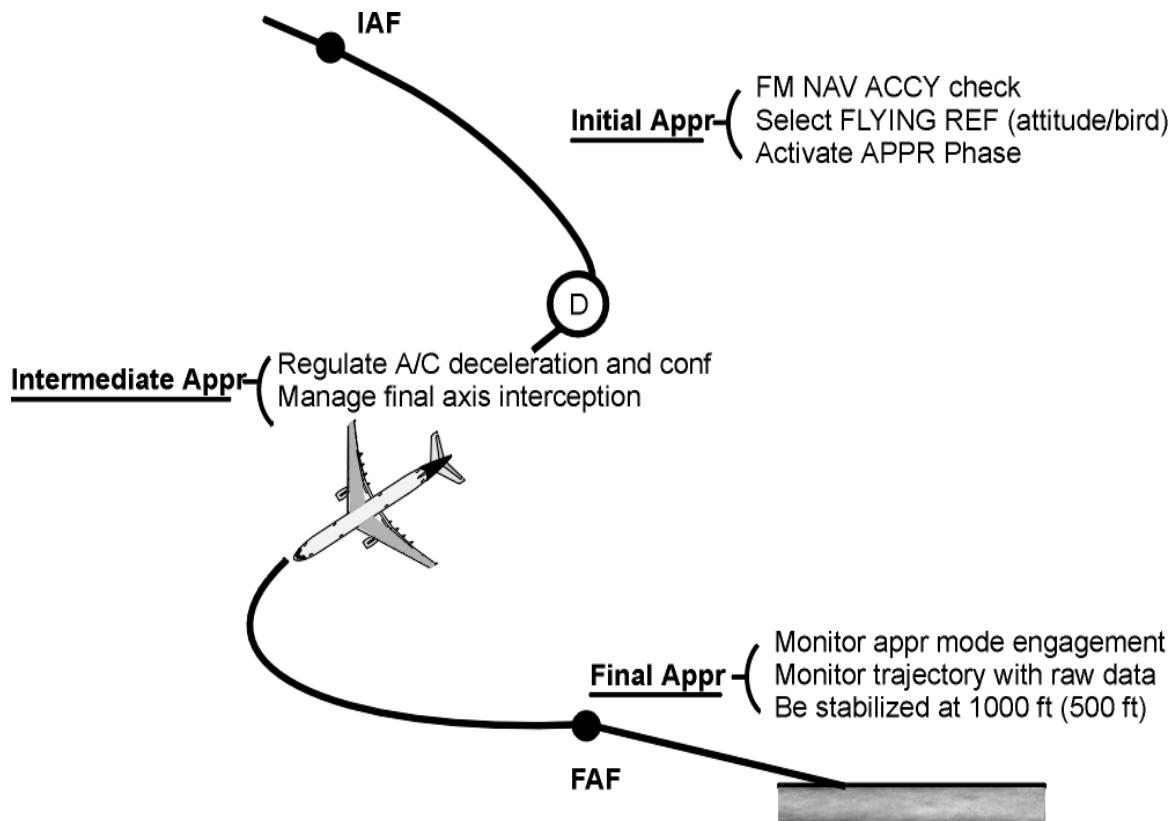
Once the skeleton has been given in the first General approach briefing 11/1, it is then only a matter of cascading the specific particulars for each approach type.

## 11/1 - GENERAL APPROACH BRIEFING

All approaches are divided into 3 parts:

- the Initial Approach, from IAF ( $\approx$  15 NM from destination) to the activation of approach phase materialized by the (DECEL) pseudo waypoint,
- the Intermediate Approach from (DECEL) to FAF and
- the Final Approach from FAF to landing or minimum.

In each of these parts there are various drills which have to be achieved regardless of the approach type.



Drills to be achieved throughout the 3 phases of any approach

### ❖ Initial approach

- a) FM NAV ACCY check using raw data (not necessary if GPS primary).  
The result of the NAV ACCY check determines the strategy on how to conduct the approach. Which display mode will be used on ND and which guidance modes may be used with AP/FD.  
E.g., if check is positive or GPS is Primary:
  - PF and PNF ND on ARC or ROSE NAV,
  - AP/FD Lateral/Vertical managed modes may be used and
  - EGPWS set ON.

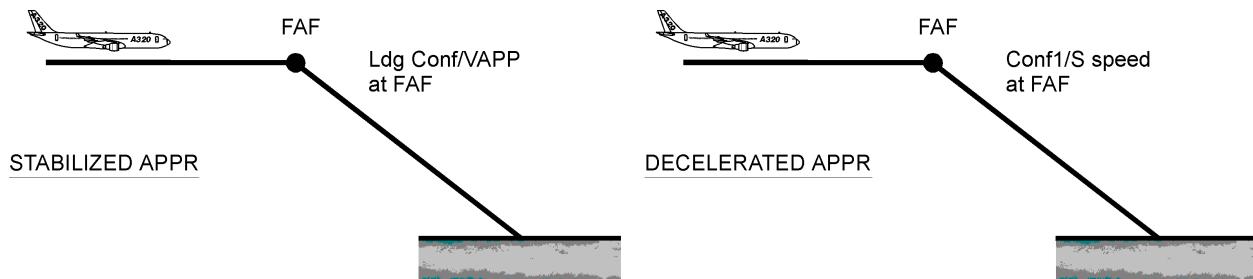
- b) Select the BEST FLYING REFERENCE for the approach.
- The FPV (called BIRD) is best adapted for all types of approaches and is strongly recommended for NPA or VISUAL approaches (BIRD ON).
  - Attitude associated to FD crossbars is still most commonly used to fly ILS approaches (BIRD OFF).

c) ACTIVATE THE APPR PHASE

The purpose of this activation is to initialize the deceleration towards VAPP or towards the speed constraint inserted at FAF, whichever applies.

There are actually 2 approach techniques:

- the stabilized approach technique for which the A/C reaches FAF in Landing CONF and VAPP; the Final Approach is flown down with VAPP and
- the decelerated approach technique for which the A/C reaches FAF in CONF1 and S speed. Then, when flying below 2000 ft AGL, the pilot will continue the deceleration and configuration changes so as to be stabilized with VAPP and Landing Configuration, at 1000 ft (IMC) or at 500 ft (VMC) at the latest.



- **Stabilized** Approach Technique is generally used for NPAs.
- **Decelerated** Approach Technique is normally used for ILS approaches.

The FMS provides a (DECEL) pseudo waypoint materialized by a  along the FPLN on the ND, indicating where to start the deceleration towards approach speed VAPP.

 is computed assuming a decelerated approach technique. Hence, if you wish to fly an NPA or a stabilized approach, insert VAPP as a SPEED CSTR at FAF, in order to get a valuable (DECEL) pseudo waypoint.

When NAV mode is engaged with managed speed, the Approach phase activates automatically when sequencing (DECEL) or .

When HDG mode is selected (e.g. for radar vectoring), you will have to manually activate the Approach phase on appropriate PERF page.

**Other drills:**

- ensure proper sequencing of the FPLN when radar vectored (monitor the TO waypoint on ND),
- check adequate NAVAIDS are selected,
- ensure the ILS P/B is properly set and
- ensure proper setting of BARO REFERENCE.

**❖ Intermediate Approach**

The purpose of the intermediate approach is to bring the aircraft at the proper speed, altitude and configuration at FAF, and to guide the aircraft to the proper final trajectory at FAF.

**a) Aircraft deceleration and configuration changes**

Managed speed is recommended.

Since the APPR Phase is activated, the target magenta Speed on PFD is VAPP; the ATHR which most probably is in SPEED mode, will guide the aircraft towards the target speed, lower limited to maneuvering speed of current configuration:

e.g.: if CONF0, maneuvering speed is O (higher than VAPP) and  
if CONF1, maneuvering speed is S (higher than VAPP).

Hence the deceleration will be achieved by successive changes of configuration:

- for ILS approaches, when O + 10 kt is reached, select CONF1; the A/C will decelerate to S.
- for NPA or stabilized approaches, when successive Maneuvering speeds + 10 kt are reached, select next CONF (this prevents thrust increase by ATHR when reaching maneuvering speeds):
  - O + 10 kt      ⇒      Select CONF1,
  - S + 10 kt      ⇒      Select CONF2, then landing gear down and in sequence,
  - F + 10 kt      ⇒      Select CONF3, then CONF FULL.

Hence if ATC requests to maintain a given speed down to a given position, select the Configuration for which the maneuvering speed is the closest:

e.g. ATC requests: «maintain 180 kt till 8 NM inbound the runway», the Procedures is:

- select CONF1. If S is within 5 kt of the request, keep managed speed. Else, select 180 kt on the FCU.
- reaching 8 NM inbound, press the speed P/B on the FCU to resume managed speed and further deceleration.

**You may fly BELOW the maneuvering speed of the current configuration, provided you fly ABOVE VLS.**

**b) Interception of the Final Approach axis**

Refer to applicable raw data (LOC, needles or XTK).

If ATC clears the interception of the Final approach trajectory along the FPLN route, use NAV mode if FM ACCY CHECK is OK.

**Once cleared for the Approach by ATC, press the APPR P/B to arm the approach modes when applicable.**

**Other drills:**

- When selecting Next Configuration, check IAS is lower than VFE next CONF.
- If TWR gives a new wind for landing, update it on PERF APPR.

❖ Final Approach

- a) Monitor the Final Approach mode engagement:
  - G/S \* or FINAL engagement when required, or select Final descent path FPA reaching FAF,
  - if the capture or engagement is abnormal, take over manually by selecting the proper FPA.
- b) Monitor the Final Approach using raw data:
  - LOC - G/S deviation symbols for ILS,
  - VDEV - XTK and FPLN for managed APPR (GPS primary),
  - VDEV - XTK + needles / DME / ALT for NPA (non GPS primary) and
  - Needles / DME / ALT / Time for NPA when FM NAV ACCY check is negative.
- c) Managed speed is recommended to benefit from the GS MINI SPEED guidance. It assists the pilots in case of longitudinal shears.
  - Aircraft must be stabilized in Landing CONF at VAPP
    - by 1000 ft (IMC)
    - by 500 ft (VMC)

**At the latest**

  - If there is a significant change in tower wind, PF shall ask PNF to modify it on PERF APPR, above 1000 ft AGL.
  - If the A/C has a tendency to be FAST and/or HIGH on final, EXTEND LANDING GEAR earlier, but below 220 kt preferably.

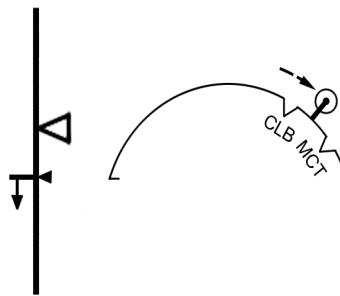
Don't use SPD BRK on final, which have little efficiency at low speed, and auto retract when:

SPEED BRAKE AUTO RETRACT	CONF
A 319 and A 320	FULL
A 321	3 and FULL

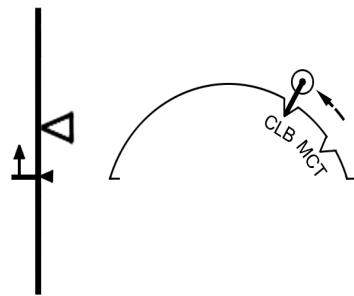
NOTE:

If you select next CONF, with IAS > VFE NEXT CONF, with FPA mode engaged, the AP/FD will deviate from target FPA and will shallow the descent in order to decelerate the A/C towards VFE.

- Keep hands on the thrust levers while ATHR is ON in final, so as to be prepared to react when needed. If for any reason the speed drops below VAPP significantly, push the levers forward above CLB detent (but below MCT) till the speed trend arrow indicates an acceleration. ATHR is then armed with MAN THR white on FMA. Then bring the thrust levers back into CLB detent. This is enough to be quickly back on speed.



Speed drop  
Move levers  
above CLB



Acceleration  
Bring levers  
back to CLB

Speed drop in approach - Recommended Recovery Technique

- A deceleration below VAPP may occur in following cases:
  - GPWS terrain avoidance maneuver,
  - Collision avoidance maneuver,
  - Windshear escape maneuver.In all those cases, the pilot shall slam all thrust levers to TOGA.

**NOTE:**

Be aware that if you move thrust levers up to TOGA, SRS / GA TRK will engage.

- Go around altitude must be set on the FCU. This is done at Final approach descent initiation either when G/S or FINAL modes engage or, if FPA mode is used when the A/C current altitude is below the Go Around altitude (in order to avoid an undue ALT \*).
- In case a major navigation problem occurs such as loss of raw data, FM NAV ACCY check negative or other, interrupt the approach.
- Reaching MDA or DH, at MINIMUM auto call out:
  - if visual, continue and land if the A/C is properly established or
  - if no visual, Go Around.

This explains why MDA is not set as target altitude on the FCU. MDA is a decision altitude. Should the MDA be set as FCU target, this would cause a spurious ALT\* when getting close to MDA, bringing the A/C above final path and destabilizing the approach at a critical moment.

## 11/2 - ILS APPROACH

### A) Standard ILS approach

Decelerated approach is recommended. The following particulars apply for ILS approaches:

#### ❖ Initial Approach

- For CAT I ILS, insert D(A) value into MDA field [or D(H) value into MDH field for QFE equipped a/c] on PERF APPR page, since these are baro referenced.
- For CAT II, III, ILS insert DH into DH field on PERF APPR page, since DH is a radio altitude.
- Check that ILS P/B is illuminated on EFIS CTL panel, and that LOC G/S scales and deviations are displayed on PFD.
- Check ILS IDENT on PFD; if no or wrong ident displayed, check the audio ident.
- Select Attitude flying reference on FCU, in other words **BIRD OFF**.

#### ❖ Intermediate Approach

- If ATC clears for LOC capture only, press LOC P/B on the FCU
- If ATC clears for the approach at a great distance (e.g. 30 NM)
  - press APPR P/B,
  - LOC/ G/S modes will arm/engage,
  - be aware that G/S may be perturbed,
  - **CAT I** will be displayed on FMA, till a valid R/A signal is received.
- If G/S INTCPT altitude is AT or BELOW 2000 ft AGL, select CONF2 when reaching one dot below G/S.

#### ❖ Final Approach

- Monitor with ILS deviations on PFD.
- In case of a DOUBLE RECEIVER failure, interrupt the approach (RED LOC/GS flags - ILS scales removed - AP trips off - FD goes to HDG - V/S).
- In case of the ILS GROUND TRANSMITTER failure, AP/FD will remain ON with LOC/GS modes; this is because such a failure is most commonly transient. In such a case, LOC/GS deviation indexes are lost, ILS scales and FD bars flash. If R/A < 200 ft, Red LAND warning is triggered.
- If the failure lasts more than several seconds, or in case of Red LAND warning, interrupt the approach.
- Be aware that if for any reason you pull on V/S selector, while LOC/G/S track modes are engaged (ab. 400 ft), HDG mode will automatically engage as well (with FM2, pulling V/S with LOC - G/S, does not modify the lateral mode which remains LOC).
- Hence if a heading was preset, the AP/FD will turn the A/C towards the preset heading.
- Autoland may be attempted on CAT I ILS beam; however this requires proper visual references (at least CAT I), proper monitoring and immediate take over if anything seems abnormal.
- Furthermore this may be done only with the airline permission.

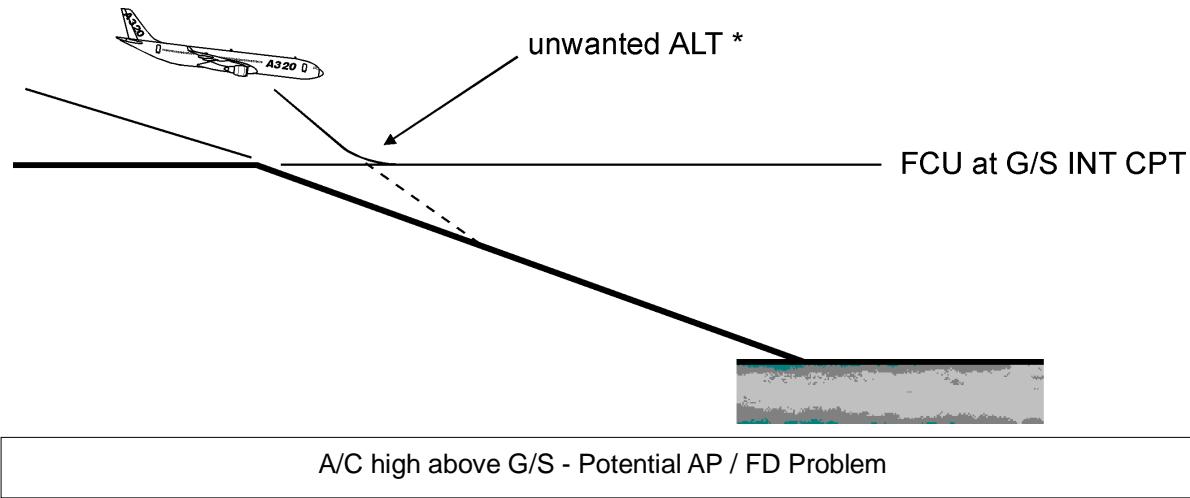
NOTE:

On A320, for ILS approaches with G/S higher than 3.5°, stabilized approach technique is recommended.

## B) Glide Slope Interception from above

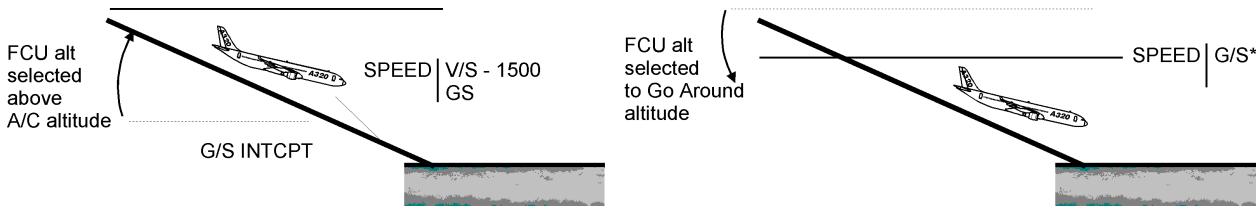
The problem is actually linked to the following factors:

- High speed,
- FCU altitude usually set at G/S INTCPT altitude and
- G/S mode does not intercept from above.



In such a case, the reaction of the crew must be rapid to succeed to stabilize the A/C at 1000 ft AGL, VAPP, LDG CONF on G/S.

- In order to get the best rate of descent, select LDG DN early (IAS < 220 kt) and successive flap configurations reaching VFE next.
- Then, typically, fly **CONF2 - LDG GEAR DN - IAS = VFE<sub>2</sub> - 5**, in descent. This configuration gives you the best flexibility to capture glide slope.
- Select FCU altitude ABOVE A/C altitude in order to prevent undue ALT \*.
- Select **V/S - 1500 ft** (up to - 2000 ft/mn maximum).
- When getting close to G/S, with G/S mode armed, G/S \* will engage - Monitor the capture with raw data (pitch, G/S deviation).
- When G/S \* engages, set FCU altitude to Go Around altitude.
- Resume deceleration and flap configuration extension to reach VAPP, CONF FULL, and be stabilized on G/S by 1000 ft AGL.



In case you feel you are too high or you won't make it,  
do not hesitate to ask for a 360° turn for example.

**NOTE:**

If, with high V/S, IAS increases to VFE, the AP/FD will no longer keep the target V/S. The AP/FD will pitch the A/C up to shallow the descent so as to fly a speed lower than VFE. Do not extend Landing gear at too high speed (> 220 kts) in order not to overstress the doors, and to minimize the noise.

**C) ILS with raw data (CAT 1 only)**

This is very seldom achieved in line; however in certain remote failure cases it may be necessary.

In most cases the **BIRD** is available such as in case of a total FCU failure.

The approach technique is a **STABILIZED** approach. The following particulars apply:

❖ **Initial Approach**

- Set BIRD ON as flying reference.

❖ **Intermediate Approach**

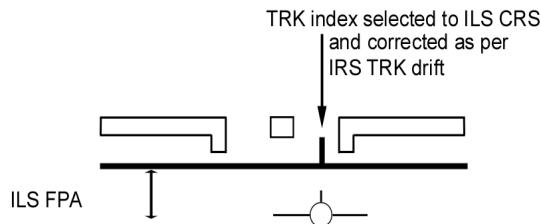
- Decelerate and reach FAF with CONF FULL - VAPP.
- For LOC interception use any available data (LOC deviation index, needles, XTK or FPLN if available).
- Set the ILS CRS as TRK selected target on the FCU once established on the localizer, so as to have it displayed as reference track index on the PFD horizon line, and HDG – TRK scale.
- For LOC tracking fly the BIRD to the TRK index on the horizon when LOC deviation is 0.

❖ **Final Approach**

- When  $\frac{1}{2}$  dot below G/S, initiate a smooth capture of the G/S by flying the BIRD down to the G/S flight path angle.
- Monitor the raw data
  - if LOC index deviates, fly the Bird into the direction of the LOC index relative to the TRK index on the horizon line,
  - once back on LOC, fly the BIRD back to the TRK index,
  - if LOC deviates again, this means that there is a slight drift in the IRS TRK, which affects the BIRD; correct the selected TRK as per the determined IRS track drift and
  - if G/S index deviates, make small corrections ( $1^\circ$ ) in the direction of the deviation.

**NOTE:**

The BIRD is computed out of IRS data. Thus it may be affected by IRS data drift amongst others (TRK). A typical TRK error at the end of a flight is  $1^\circ$  to  $2^\circ$ .



ILS with raw data - Use of FPV

**The BIRD is NOT best adapted to fly GO AROUND.** Indeed, the go around is a pitch dynamic maneuver, during which the bird is lagging behind due to the inertia of the aircraft.

Hence if GO AROUND is initiated while BIRD is ON, it is then recommended to ask the PNF to set BIRD OFF, in order to fly with the attitude reference and FD bars.

**NOTE:**

With the latest FCU (and proper pin program), at go around initiation - FDs are automatically turned ON - flying reference reverts to attitude (HDG - V/S). Bird disappears and crossbars are displayed.

**11/3 - NON PRECISION APPROACHES (NPA)**

The **stabilized** approach technique is recommended. Reach FAF with CONF FULL and VAPP.

The following particulars do apply to NPAs.

The overall strategy of NPA completion is to fly it « **ILS alike** » with the same mental image or representation, and similar procedure. Instead of being referred to an ILS beam, the AP/FD guidance modes and associated monitoring data are referred to the FMS F.PLN consolidated by raw data, with the exception of LOC only approaches, where LOC mode and localizer scale are to be used. This explains why the crew must ensure that the FMS data is correct; FMS accuracy, FPLN data (lateral and vertical), proper leg sequencing.

**❖ Initial Approach**

- NAV ACCY CROSS CHECK is most essential since it determines:
  - which AP/FD guidance mode may be used,
  - which ND DISPLAY mode may be used and
  - which raw data must be used.

If GPS is PRIMARY or NAV CROSS CHECK is POSITIVE. Managed and selected AP/FD modes may be used, as well as ND ROSE NAV / ARC modes.

If NAV ACCY CHECK is NEGATIVE. Selected AP/FD modes may only be used, and monitoring is achieved with raw data only.

If GPS is PRIMARY at the beginning of initial approach, it will most probably remain primary throughout the approach. However if for any reason GPS PRIMARY is LOST then:

- a GPS defined approach cannot be flown as if ILS signal was lost for ILS approach and
  - a VOR (NDB ...) approach may be continued, as if without GPS. The strategy is merely a function of NAV ACCY CHECK.
- 
- Set the BIRD ON as flying reference.
  - Set VAPP as SPD CSTR at FAF, in order to get a meaningful (DECEL) pseudo waypoint.

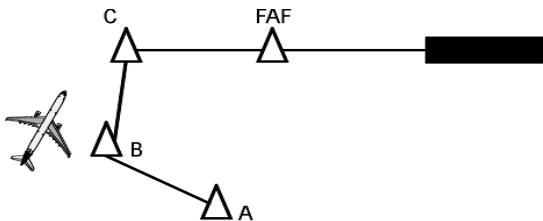
**Other drills:**

- ILS P/B set to OFF in order to get VDEV BRICK on PFD (except for LOC only approaches, where ILS P/B is set ON and the yoyo is used as VDEV),
- NAVAIDS - ensure that approach reference navaid is inserted and display associated needles.

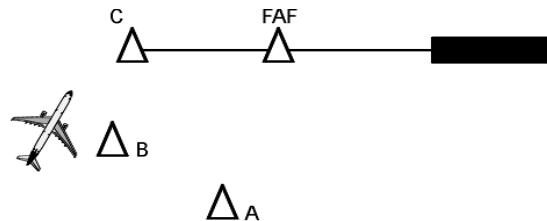
### ❖ Intermediate Approach

It is very important to have a **correct FPLN** in order to ensure a proper Final Approach guidance. Indeed the NAV and APPR NAV modes are always guiding the A/C along the ACTIVE LEG of the FPLN, and the managed VERTICAL mode ensures  $VDEV = 0$ ,  $VDEV$  being computed along the remaining FPLN to destination.

Hence **monitor the proper sequencing** of the FPLN, more specifically if HDG is selected. Check on ND top right hand corner that the TO WPT is the most probable one, or meaningful.



Radar Vectors : pilot has not cleared A, B.  
A is still TO WPT - Hence no proper guidance available nor predictions.



Radar Vectors : pilot has monitored the TO WPT and cleared successively A and B when no longer probable. Hence  $VDEV$  is meaningful and APPR NAV or NAV may be armed.

#### Radar vectors - Properly Monitor FPLN Sequencing

##### - When cleared for the approach:

- if managed approach  $\Rightarrow$  press APPR P/B (this brings  $VDEV$  brick up if not yet there),
- if selected approach  $\Rightarrow$  select adequate TRK on FCU to carry out the interception.

#### Other drills:

- The monitoring of the interception must be achieved using the applicable raw data depending upon the result of the NAV ACCY CHECK or whether GPS is PRIMARY.

### ❖ Final Approach

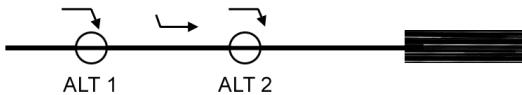
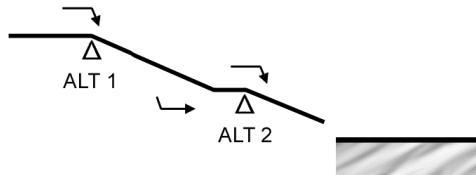
The final Approach will be flown either **MANAGED** or **SELECTED**.

##### - **If MANAGED Approach**

- Monitor the engagement of FINAL APP mode; use  start of descent blue symbol on ND,  $VDEV$  and FMA on PFD.
- Use ATTHR and Managed speed.
- With GPS PRIMARY, monitor  $VDEV$  / XTK / F.PLN on ND.
- For VOR - ADF ... approaches, monitor  $VDEV$  / XTK / F.PLN confirmed by needles on ND, and DME versus altitude if available.
- Set Go Around Altitude.

If for any reason, FINAL APPR does not engage at start of descent  , rapidly select FPA convergent to the Final Descent Path so as to fly with  $VDEV = 0$ . Once  $VDEV = 0$ , you may try to re-engage APPR.

In certain cases, the FINAL APPR flies an « IDLE DESCENT Segment » from one ALT CSTR to another, followed by a level segment. This is materialized by a magenta level off symbol on ND followed by a blue start of descent .



Final approach trajectory - an idle descent segment

If during the final approach the message **NAV ACCY DNGRADED** comes up, immediately refer to raw data:

- If the **check is OK**, you may **continue**.
- If the **check is NEGATIVE**, select **TRK - FPA** and refer to **raw data**.

If during the final approach, the message GPS PRIMARY LOST comes up while the A/C flies a GPS approach, INTERRUPT the approach.

Reaching MDA, at MINIMUM call out:

- if visual and properly established, continue and land with AP OFF and both FDs OFF or
- if no visual, Go Around.

**NOTE:**

Non precision approaches (NPA) must be **properly coded in the Nav Data Base** so as to be satisfactorily flown with the APPR NAV/FINAL managed modes. This coding, more specifically the vertical part of it, is verified by the airlines.

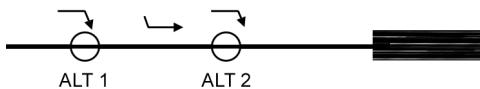
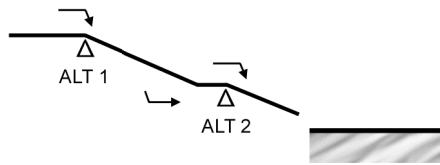
Should there be any **doubt on the vertical F.PLN**, the crew may then elect to fly the approach with **NAV/FPA** modes, provided the NAV ACCY CHECK is OK.

**NOTE:**

If you fly an NPA with managed modes, do not modify the Final Approach F.PLN data (clear waypoints or modify altitude constraints); do not insert DIR TO an intermediate waypoint of the final approach segment.

- **If SELECTED Approach**

- Overfly FAF, properly identified, and
- select TRK = Final APPR CRS,
- select FPA = Final APPR path (actually start the final descent 0.3 NM before FAF).



Final approach using the bird with AP/FD -  
TRK/FPA modes

- Use ATHR and Managed speed.
- If GPS PRIMARY, monitor VDEV/XTK/F.PLN on ND. For VOR, ADF approaches, monitor Raw data.
- Set Go Around altitude ONCE the A/C altitude is below that altitude.

Reaching MDA

- If visual and properly established, continue & land with AP OFF and both FDs OFF.
- If not visual, Go Around.

NOTE:

If at MDA, distance to runway is not properly assessed, you may level off at MDA till MAP, at the latest. Then Go Around.

- **If LOC ONLY approach**

As for all Non Precision Approaches, the recommended flying reference is the Bird; the recommended FG modes for the final approach are **LOC/FPA** with managed speed on ATHR.

In initial approach select the ILS P/B ON, on the EFIS CTL panel.

In intermediate approach, press LOC P/B on the FCU to arm LOC mode and monitor LOC\*.

In final approach, coming to FAF, select FPA = Final approach path and monitor the final approach with LOC deviation index, DME/ALT or time, yoyo ...

- **If LOC BACK COURSE approach**

The recommended flying reference is the BIRD and the FG recommended modes for final approach are **TRACK-FPA** with managed speed on ATHR.

Before or during initial approach: select the ILS with its **front course** on RAD NAV page. **Do not select the ILS or LS P/B on EIS Control Panel** since the localizer deviations on the PFD will be provided in opposite direction.

On the PF side, select ROSE ILS on EIS Control Panel to get the proper localizer deviations (this is why the ILS front course is inserted on RAD NAV).

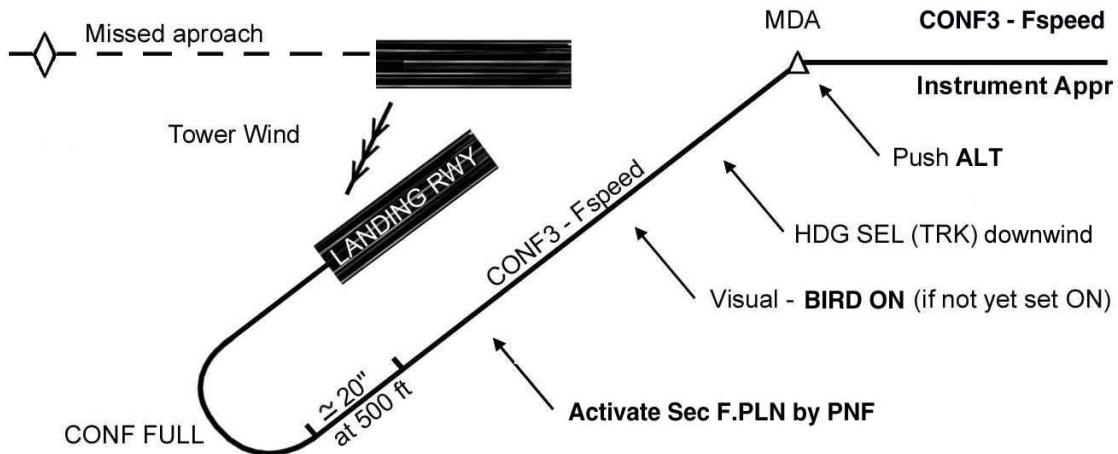
During intermediate approach: use TRK mode to align the aircraft on the localizer. The PNF ND on ARC mode provide valuable information to achieve that goal, provided FMS ACCY is OK or GPS is Primary.

In Final approach: use FPA mode to set the aircraft on the final descent path. The PNF ND should then be set to ROSE ILS.

## 11/4 - CIRCLING APPROACH

The circling approach is flown when the tower wind is such that the landing runway is different from the runway fitted with an instrument approach, which is used to descend and approach in order to get visual of the airfield.

The **instrument approach** prior the circling is a **stabilized** approach flown in **CONF3 - L/G Down - F speed**, with BIRD ON or OFF, depending upon the approach type. BIRD will be selected ON at the beginning of circling if not before, and circling pattern is flown visual with FDs OFF.



Typical Circling Approach - Lateral Profile

### - Descent and Approach Preparation

#### F Flight Plan Revisions

- Lateral F.PLN - the approach is the Instrument Approach to destination.
- Vertical F.PLN - insert F speed constraint at FAF, since instrument approach will be flown CONF3 – L/G DN – F Speed.  
This allows you to have a proper descent profile, proper prediction, VDEV, etc. and a comprehensive ND.

#### P Perf Data

- PERF APPR - insert Tower wind as usual.

#### R Rad Nav

- The insertion of the instrument approach ensures proper autotune; else manually tune the desired Navaid.

#### S Sec F.PLN

- Copy Active F.PLN. Revise the Approach by selecting the Landing Runway (keep the F.PLN discontinuity).  
Thus while in the visual pattern, after having activated the SEC F.PLN, it will be most comfortable to have a proper ND display, materializing the landing axis and runway.

**- Final instrument approach**

Fly it with **CONF3 - L/G GEAR DN - F speed**, with the usual technique.

Reaching MDA - push TO LEVEL OFF.

- If visual, proceed down wind (HDG SEL or TRK SEL).
- If no visual, fly till MAP. If no visual till MAP, Go Around.

**- Circling approach**

- Once visual, proceed downwind, initially with HDG or TRK mode in order to join downwind.
- Set **BIRD ON**, keep ATTHR ON, and set both FDs to OFF.
- **Activate SEC FPLN**. This ensures a comprehensive ND and a proper GS MINI managed speed target when on final approach to landing runway.
- Circling approach must be flown VISUAL. In case of loss of visual contact with ground, proceed **for GO AROUND and MISSED APPROACH as defined for the instrument approach**. The missed approach must be flown with raw data, since it is no longer part of the F.PLN. Thus the crew has to anticipate how to join the published missed approach, turn direction, configuration in the turn, initial climbout altitude. If a sharp turn is expected, keep FLAP3 (or FLAP2) and low speed; in other words, delay flap retraction until properly on trajectory, if required.

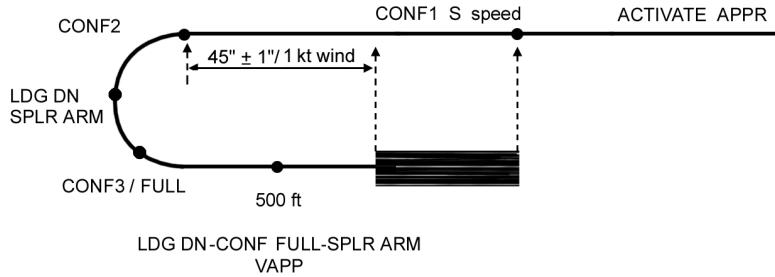
**NOTE:**

If landing is achieved on opposite runway to the instrument approach, when leveling at MDA with visual references acquired, turn (L or R) 45° during 30 sec to join downwind.

The recommended configuration for the instrument approach part of the procedure is CONF3 - LDG DN with all engine operative or one engine inoperative. The reason for landing gear being selected down so early is not to trigger the landing gear not down red warning, and to have to disregard it.

## 11/5 - VISUAL APPROACH

The visual approach is flown with (FPV) **BIRD ON**, AP/FDs off, **ATHR ON** and **managed speed**.



Typical Visual Pattern - Lateral Profile

### ❖ Initial Approach

As a help to have a comprehensive display on ND, ND may be set to ROSE NAV to assist the pilot to visualize the circuit from mid-downwind.

At the beginning of downwind leg, activate the APPR PHASE. The FCU altitude target is selected as downwind leg altitude, and the FCU track target to downwind leg course.

### ❖ Intermediate / Final approach

- **Downwind CONF1 - S speed.**
- Ask PNF to set downwind leg TRK (index on horizon line as an assistance).
- Assess A/C position visually (XTK is an assistance).
- End of downwind - CONF2 start base turn.
- During base usually shallow descent - ask LDG DN / SPLR arm.
- Ask PNF for RWY TRK and GO AROUND ALT on FCU.
- Then FLAP3 / FLAP FULL.
- At 500 ft, the A/C must be stabilized (L/G DN - FLAP FULL - VAPP).

### ❖ Other drills

- In case of turbulence / misalignment ... be SMOOTH on the side stick. The A/C is « naturally » very stable.
- Once established on the descent path, DON'T DUCK UNDER in short final.

AN AIRCRAFT PROPERLY STABILIZED ON SHORT FINAL  
WILL HAVE A SAFE LANDING.

**12 - PRECISION APPROACHES - CAT II - CAT III**
**❖ General Consideration**

- The only Precision Approaches are CAT I, II and III approaches. Since those approaches are flown to very low DHs, with very low RVRs, the guidance of the aircraft on the ILS beam, and the guidance of the aircraft speed must be CONSISTENTLY of HIGH PERFORMANCE and ACCURATE so that the transition to visual conditions (if any) is achieved with the aircraft properly stabilized. Hence:
  - The **Autoland** is the **preferred landing technique** in such conditions.
  - Any failure of the automated systems shall not significantly affect the aircraft attitude and trajectory.
  - The **aircrew task sharing and procedures** allow you to rapidly detect any anomaly and thus lead to the right decision.
- The general strategy for Precision Approaches is similar to the one applied for a standard ILS (or CAT I) approach.

The main differences are outlined hereunder:

ILS Category Strategy	CAT I	CAT II	CAT III	
			DH	NO DH
<b>Flying Technique</b>	Hand flown or AP/FD, ATHR		AP / FD / ATHR down to DH	AP/FD/ATHR and Autoland
<b>Minima &amp; Weather*</b>	DA (DH) Baro ref Ceiling + visibility	DH Radioaltimeter RVR		
<b>Autoland</b>	Possible with precautions Normal DA applies	Available & Recommended		Autoland must be used
<b>Overweight Landing</b>	Handflown in exceptional circumstances	Autoland possible exceptionally - precautions		

\* for CAT II/CAT III approaches, the **weather at ALTN** must be at least equal or better than **CAT I**.

- In order to fly a precision approach:
  - the aircraft equipment and systems required must be available (FCOM 4.05.70),
  - the airport equipment and installation required must be available and serviceable,
  - the airport has to be operating in CAT II/III conditions,
  - the aircrew must be qualified,
  - the specific wind limitations (30 kts head, 10 kts tail, 20 kts cross), and the maximum altitude limit as per AFM must be applied:

<b>319</b>	All	9200 ft
	Basic	2500 ft
<b>320</b>	CFM mod 24617	9200 ft
	IAE mod 23893	6500 ft
<b>321</b>	Basic	2500 ft
	CFM 24385 or IAE 24386	5750 ft

- G/S must be comprised between 2.5° and 3.15°.

**NOTE:**

If **CATII/III training** is being achieved on a given airfield, the **airport must be advised**. CAT II/III training may be done on CAT I installation with precautions.

- The landing capability of the airborne systems is announced on the FMA:
  - CAT3 SINGLE is announced when the airborne systems are fail passive which means that a single failure will lead to the disconnection of the AP without any significant consequent deviation from the flight path and from present attitude, the aircraft remaining in trim. Manual flight is then required. This explains why DH is 50ft.
  - CAT3 DUAL is announced when the airborne systems are fail operational. In case of a single failure, the AP will continue to guide the aircraft on the flight path. Should the failure occur below the alert height the Autoland maneuver will be achieved safely; in that case no capability degradation is indicated. Such a redundancy allows NO DH or a DH 20ft.
  - However the indication CAT3 DUAL (SINGLE), which ensures that the level of redundancy of the essential automated systems and of the required information is achieved, does not mean that the overall A/C status allows for such low minima. Indeed some A/C systems are not monitored within this indication (e.g. wipers, STD BY ATT indicator ...).

**NOTE:**

**Alert Height 200 ft.** The Alert Height is defined for CAT III operations with a fail-operational system. It is linked to the probability of failure of the automatic landing system. If a failure affecting the fail operational criteria occurs below Alert height, no category degradation is indicated to the crew. An operator may choose an Alert Height LOWER than the one mentioned in the AFM but not higher.

❖ **Operational Consequences**

TASK SHARING

- The task of each pilot is essential and complementary.  
The PF supervises the approach (trajectory, attitude, speed) and takes appropriate decisions in case of failure and/or at DH.  
Since the approach is flown with AP/ATHR ON, the PF must be continuously ready to take over
  - \* if any AP hardover is experienced,
  - \* if a major failure occurs and
  - \* if any doubt arises.
- The PNF monitors the following parameters
  - \* the FMA (LAND - FLARE - THR IDLE),
  - \* the Auto Call out,
  - \* the A/C trajectory or attitude exceedances. He will carry out the following call outs as per the table hereunder:
  - \* the possible failures.

Parameter	Exceedance	Call out
IAS	VAPP – 5 / + 10 kt	Speed
V/S	> 1000 ft/mn	Sink Rate
Pitch	> 10° < - 2.5°	Pitch
Bank	> 7°	Bank
LOC	> ¼ dot	Loc
G/S	> 1 dot	Glide

**- Exceedances and PNF associated call out -**

- The PNF state of mind is to be “**Go Around Minded**”.  
Additionally the PNF takes care of ATC communication and applies the specific procedures associated to CAT II / III operations.
- The PF is usually the Captain (CM1) and PNF is the F/O (CM2).

FAILURES

In case a failure occurs during final approach there are three possible strategies:

- continue the approach down to DH,
- continue the approach to HIGHER DH or
- Go Around.

In case of major failure during final approach, the following general rule applies:

- if the failure occurs **ABOVE 1000 ft**, **take appropriate action**; continue the approach down to applicable minima.
- if some failures occur **BELOW 1000 ft and ABOVE 200 ft**, **Go-Around unless visual**. Those failures are: one AP OFF, Capability degradation (triple clic), Amber cautions, Engine failure, Std by Attitude indicator flag.
- if those occur **BELOW 200 ft**, **continue the approach**.
- if AUTOLAND red light comes up **BELOW 200 ft**, Go-Around. (2 APs OFF, LOC - G/S signal loss, LOC - G/S excessive deviation).
- **if NO FLARE at 30 ft R/A, Go-Around unless visual.**

NOTE:

If LAND green does not come up by 350 ft R/A, a Go-Around must be initiated. This is not a failure as such; however it means that the AP is not properly stabilized at that altitude, which might cause guidance instability lower and no proper autoland.

If ALPHA FLOOR is triggered below 1000 ft with no visual references, Go-around.

- Some requirements are specific to CATIII with NO DH, because an Autoland is compulsory. These are not necessarily monitored and thus not indicated.
  - Incorrect ILS CRS ( $\Delta 5^\circ$  with runway CRS) leads to incorrect autopilot DECRAB. Check ILS CRS at 350 ft. If incorrect, continue approach down to CAT II minima (AP must be set OFF at 80 ft latest).
  - Nose Wheel Steering - Anti skid failure. This will affect proper landing roll out function.
- If failure ABOVE 350 ft R/A:**  
 NWS failure  $\Rightarrow$  continue down to 50ft DH,  
 A/SKID failure  $\Rightarrow$  continue down to CAT II minima,  
**If failure BELOW 350 ft and ABOVE 200 ft**  $\Rightarrow$  Go Around.
- - The precision approaches are flown with AP/FD + ATHR ON. It is recommended to systematically set BOTH APs ON even for CAT II or CAT III DH50 approaches.
- In case ATHR goes OFF during the approach above 1000 ft:**
  - try to set it back ON,
  - if only one AP is ON, set the other one ON and then try ATHR ON,
  - if ATHR is not recovered, only CAT II approach may be flown.

**Always keep hands on thrust levers during final approach.**

#### SUMMARY OF FAILURES AND CONSEQUENCES:

Failure	Action ABOVE 1000 ft	LANDING CATEGORY
1 Engine Out	ECAM procedure – Land CONF FULL	CAT III SINGLE
Loss of ATHR	Switch AP – Set ATHR back ON	CAT II if ATHR not recovered
NWS	N/A	CAT III SINGLE (set AP OFF at touchdown)
A/SKID	N/A	CAT II (set AP OFF at touchdown)
SLATS/FLAPS	N/A	CAT I (set AP OFF at 500 ft latest)
2 R/A	Land in CONF 3	CAT I with raw data
1 PFD/1ND	Use switching to recover	CAT I if no recovery

- \* Due to the loss of hydraulic redundancy.

#### REACHING DH

- For precision approaches, DHs are lower than 100 ft and RVRs are very short. Therefore it is not easy for the PF to get a good assessment of the A/C proper positioning versus the touchdown zone; and the time for this is short.
  - Before the approach initiation CAREFULLY adjust your seat position.
- If no visual or if any doubt, Go Around immediately with NO ARGUMENTS
  - Thrust levers TOGA
  - Fly SRS FD Bars or AP
  - Flaps retract on schedule.

In order to be ready mentally for Go Around, the CALL OUTs are essential; but for CATII approaches, the AUTO CALL OUT is NOT mandatory; thus if not available the CALLOUT must be done by PNF.

For CATIII approaches, the AUTO CALL OUT is mandatory and has to be monitored by the PNF.

#### NOTE:

Actually in all cases of Autoland, Auto call out shall be available.

### SOME SYSTEM PARTICULARS

- The FMGS monitors its landing capability. If both APs are engaged, the capability displayed on FMA corresponds to the LOWEST of both APs.  
 There is **no capability degradation below 200 ft (alert height)**, due to the extremely low probability of a second failure within the remaining time.
- A capability degradation is shown on FMA enhanced by the triple click, and/or on ECAM (e.g. CATII ONLY) in case of malfunction on following monitored systems:  
 AP - FD - ATTHR - PFD - DMC - R/A - ILS - ADR/IR - ELAC/FAC - YAW DAMP, RUD TRIM - HYD - BSCU channel - ELEC split - FWC - DH indication.
- The AUTOLAND red light comes up on the glareshield if the aircraft is below 200 ft RA with at least one AP ON, and one of the following event occurs:
  - both APs trip off,
  - excessive beam deviation is sensed (LOC above 15 ft, G/S above 100 ft),
  - localizer or glide slope transmitter or receiver fails,
  - a RA discrepancy higher than 15 ft is sensed.

But there are several other systems not monitored with regard to capability degradation (technical feasibility) among others.

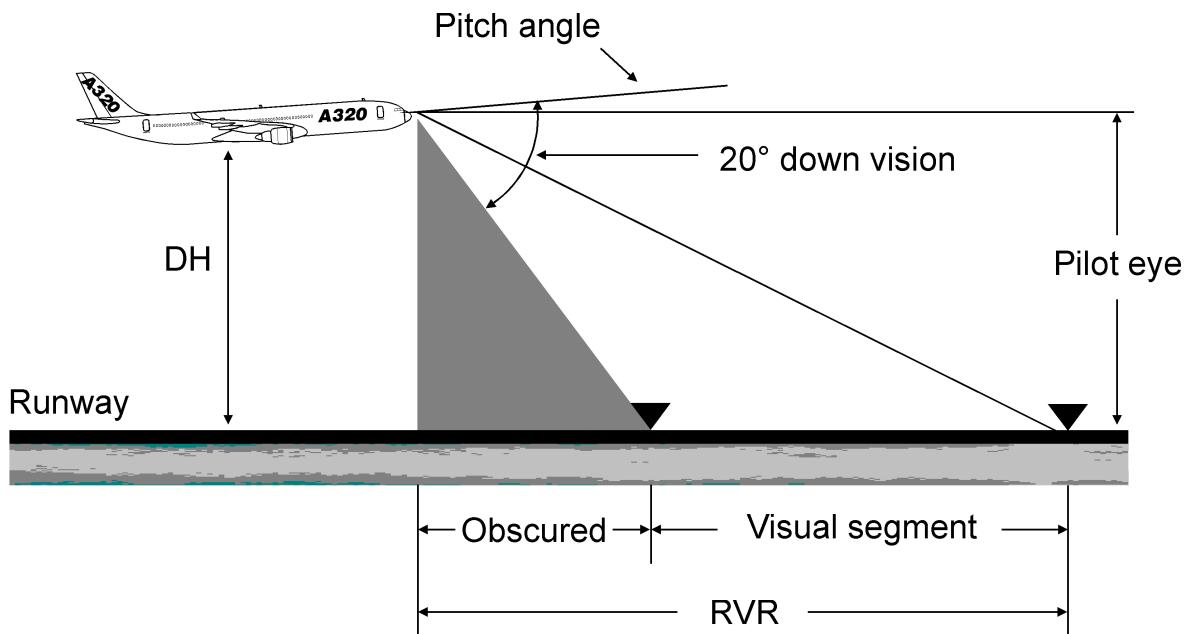
Window heat - Wipers - ND - VHF - A/SKID - NWS - AUTO CALLOUT - RUD TVL LIM - STD BY ATT (which must be available in case of loss of main attitude indication to initiate safely a go around).

When AP is on with LOC - G/S engaged:

- below 700 ft R/A, all data coming from the FMS are frozen (ILS tune inhibit, target speed etc.),
- at 350 ft R/A, LAND must appear on FMA. This ensures that the remainder of the approach guidance will be correct,
- LAND might come below 300 ft R/A, which is too late; usually the triple click comes up before,
- below 400 ft R/A, the FCU is frozen. Any action on FCU is disregarded by the FMGC (pressing AP - ATTHR P/Bs or change of modes etc.).
- But the I/Ds on STICK and LEVERS are effective, regardless of Radio Altitude.
- LAND mode can only be disregarded by Go Around (thrust levers on TOGA),
- once A/C on ground, if thrust levers are set to TOGA, this engages SRS / GA TRK modes and sets APs to OFF. This is useful for Touch and Go's,
- FLARE comes at or below 40 ft. THR IDLE at or below 30 ft R/A,
- the RETARD AUTO CALL OUT is:
  - at 20 ft R/A for manual landing, as an indication and
  - at 10 ft R/A for autoland, as an order.

❖ **Landing / Roll out**

- Although when LAND mode appears on FMA, this ensures that all is set for autoland, it is most recommended that the PNF announces FLARE. The PF should then notice a **pitch up reaction** of the aircraft.
- During FLARE, Decrab and Roll out, the PF shall watch outside to assess that the maneuver is OK considering the available visual references or if DH is very low, to achieve the visual references.
- Note that landing lights might be prejudicial to acquire visual reference.
- AUTO BRAKE is recommended; it ensures a symmetrical brake pressure application. However be aware of possible dissymmetry in case of Xwind and wet runway.
- Select MAX REV when MLG is on ground; this triggers the Partial Lift Dumping (PLD) which ensures that both MLG will be properly on ground.
- Monitor the ROLL OUT with the available visual references.
- Once the A/C is properly controlled (speed and lateral trajectory), PNF advises ATC.
- In case of CAT II, Autoland is recommended. If the PF takes over, he shall do it 80 ft R/A at the latest; this ensures a good transition for the manual landing.



❖ **Reaching DH - Visual Segment and Minimum RVR (A320)**

Height/Dist.	CAT III		CAT II
DH	15 ft	50 ft	100 ft
Pitch	5.4°	4.7°	4.7°
Pilot eye	36 ft	71 ft	121 ft
Visual segment	60 m	60 m	120 m
Obscured	43 m	79 m	134 m
Minimum RVR	103 m	139 m	254 m

❖ **Approach briefing associated to precision approaches before TOD**

Considering all the specifics of Precision Approaches, the approach briefing will outline additionally to the standard approach briefing:

- the airport specific requirements,
- the general task sharing strategy, and exceedance call outs and
- the general strategy in case of failure (above/below 1000 ft).

❖ **Precision Approach Minima Reminder**

<b>Approach Category</b>		<b>ICAO</b>	<b>FAA</b>	<b>JAA</b>
<b>CAT II</b>	<b>DH</b>	100 ft ≤ DH < 200 ft	100 ft ≤ DH < 200 ft	100 ft ≤ DH < 200 ft
	<b>RVR</b>	350 m ≤ RVR 1200 ft ≤ RVR	350 m ≤ RVR < 800 m 1200 ft ≤ RVR < 2400 ft	300 m ≤ RVR 1000 ft ≤ RVR
<b>CAT III A (single)</b>	<b>DH</b>	No DH or DH < 100 ft	No DH or DH < 100 ft	DH < 100 ft typic 50 ft
	<b>RVR</b>	200 m ≤ RVR 700 ft ≤ RVR	200 m ≤ RVR 700 ft ≤ RVR	200 m ≤ RVR 700 ft ≤ RVR
<b>CAT III B (dual)</b>	<b>DH</b>	No DH or DH < 50 ft	No DH or DH < 50 ft	No DH or DH < 50 ft typic 20 ft
	<b>RVR</b>	50 m ≤ RVR < 200m 150 ft ≤ RVR < 700 ft	50 m ≤ RVR < 200 m 150 ft ≤ RVR < 700 ft	75 m ≤ RVR < 200 m 250 ft ≤ RVR < 700 ft
<b>CAT III C</b>		No DH	No DH	
		No RVR limitation	No RVR limitation	

Acceptable operational correspondance meter/feet (ICAO)

15 m = 50 ft	150 m = 500 ft	250 m = 800 ft	500 m = 1600 ft
30 m = 100 ft	175 m = 600 ft	300 m = 1000 ft	550 m = 1800 ft
50 m = 150 ft	200 m = 700 ft	350 m = 1200 ft	600 m = 2000 ft
75 m = 250 ft		400 m = 1400 ft	800 m = 2400 ft
100 m = 300 ft			1000 m = 3000 ft

## 13 - VAPP DETERMINATION

### ❖ VAPP in Normal Configuration

- VAPP is defined by the crew to perform the safest approach; it is a function of GW, CONF, WIND, ATHR ON/OFF, ICING, DOWNBURST.
- VAPP is computed out of VLS (1,23 VS1G) of the landing configuration:

$$VAPP = VLS + \Delta \text{ maximum of}$$

$\left\{ \begin{array}{l} 5 \text{ kts for ATHR} \\ 5 \text{ kts for severe icing} \\ 1/3 \text{ of STEADY headwind (max 15 kts)} \end{array} \right.$

- **In 95% of the cases the FMGC provides the valuable VAPP on PERF APPR page**, once FLAP 3 or FLAPS FULL landing configuration has been inserted, as well as tower wind:

$$VAPP = VLS + \max \left\{ \begin{array}{l} 5 \text{ kts, } 1/3 \text{ tower wind component on landing RWY in the FPLN} \end{array} \right.$$

Be aware that the wind direction provided by the Tower or ATIS is given in the same reference as the runway direction (magnetic or true) whereas the wind provided by VOLMET, METAR or TAF is always true.

On PERF APPR, the FMS considers the wind direction to be in the same reference as the runway direction; therefore if the airport is magnetic referenced, insert the magnetic wind direction.

NOTE:

VAPP is computed at predicted LW while the A/C is in CRZ, DES phases. Once in APPR phase, VAPP is computed using current GW.

- **Can you insert a lower VAPP if no wind ?** Yes, provided the landing is performed manually with ATHR OFF and there is no ice or expected downburst.
- **Can you increase the VAPP manually ?** Yes in case of a strong suspected downburst. In that case:
  - VAPP = VLS + max 15 kts can be inserted.

NOTE:

In case of expected downburst, you might obviously envisage to delay landing or divert.

❖ **VAPP in Case of Abnormal Configuration (slats / flaps, flight controls etc...).**

When a slats / flaps abnormal configuration occurs, the PFD displays a correct VLS related to the actual slats / flaps configuration, except if both SFCCs have failed.

In some of these abnormal configurations, it is advisable to fly at a minimum speed higher than VLS **to improve the handling characteristics of the A/C**. The ECAM then outputs the  $\Delta$ VLS to be added to the VLS value displayed on PFD, when the abnormal configuration is reached.

**Hence VAPP will be  $\geq$  VLS +  $\Delta$ VLS  $\rightarrow$  from ECAM**

In order to prepare the approach and landing, the pilot needs to know VAPP in advance; but the VLS is not necessarily available at that time on the PFD because the A/C flies at a higher speed or because the abnormal CONF is not yet reached.

Hence VAPP will be determined using the QRH (2.25). The principle is to refer to VREF (VLS CONF full), which can be read on PERF APPR or QRH, and to add  $\Delta$ VREF from the QRH table.

$$\text{VAPP} = \text{VREF} + \Delta\text{VREF} + \text{WIND CORR}$$

→ VLS CONF FULL → from the table

**$\Delta$ VREF + WIND CORR is limited to 20 kts**

Thus if  $\Delta$ VREF > 20, there is no wind correction to apply.

❖ **Some consideration regarding GS mini guidance**

- As a general rule, use MANAGED SPEED in approach, in order to benefit from of the Ground Speed mini guidance (GS mini) which assists the pilots in **managing longitudinal shears, or severe gusts**. There are some exceptions to this rule in some abnormal configurations, dictated by the fact that the resulting target speeds might be very high.
- The purpose of the GS mini guidance in approach is to always **keep the A/C energy level above a minimum value**, regardless of the wind variations or gusts - This minimum level is the energy the A/C will have at landing with the expected tower wind; it is materialized by the ground speed of the A/C at that time which is called GS mini:

**GS mini = VAPP – Tower head wind component**

In order to achieve that goal, the A/C GS should never drop below GS mini in the approach while the winds are changing – Thus the A/C IAS must vary while flying down in order to cope with the gusts or wind changes.

In order to make this possible for the pilot or for the ATHR, the FMGS continuously computes an IAS target speed, which ensures that the A/C GS is at least equal to GS mini; the FMGS uses the instantaneous wind component experienced by the A/C:

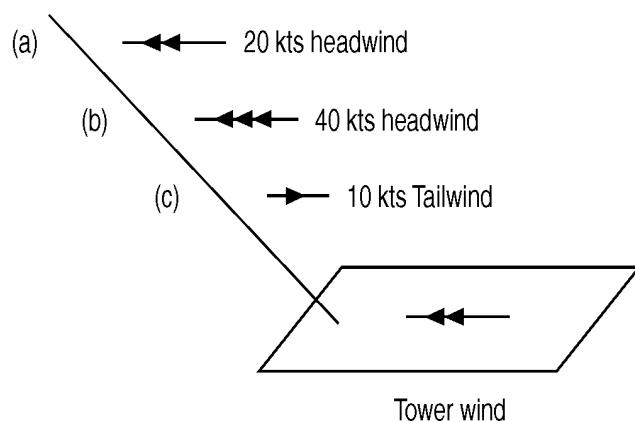
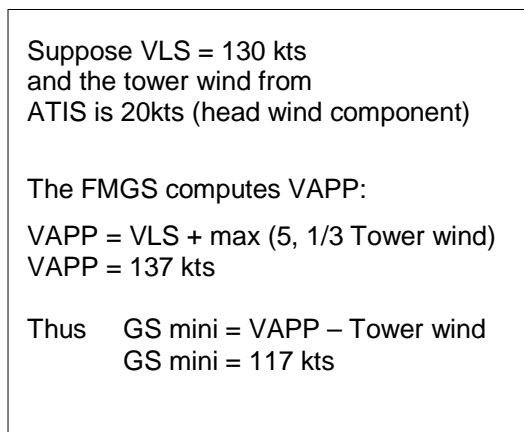
**IAS Target Speed = GS mini + Current headwind component**

This target speed is limited by VFE-5 in case of very strong gusts, by VAPP in case of tailwind or if instantaneous wind is lower than the tower wind; below 400ft, the effect of the current wind variations is smoothly decreased so as to avoid too high speeds in the flare (1/3 of current wind variations taken into account).

The GS mini guidance has 3 major benefits:

1. It allows an **efficient management of the thrust** in gusts or longitudinal shears. Thrust varies in the right sense but in a smaller range ( $\pm 15\%$  N1) in gusty situations which explains why it is recommended in such situations.
2. It provides additional but rational safety margins in shears.
3. It allows pilots "to understand what is going on" in perturbed approaches by monitoring the target speed magenta bugs: when it goes up = head wind gust.

The following schematic explains those advantages:

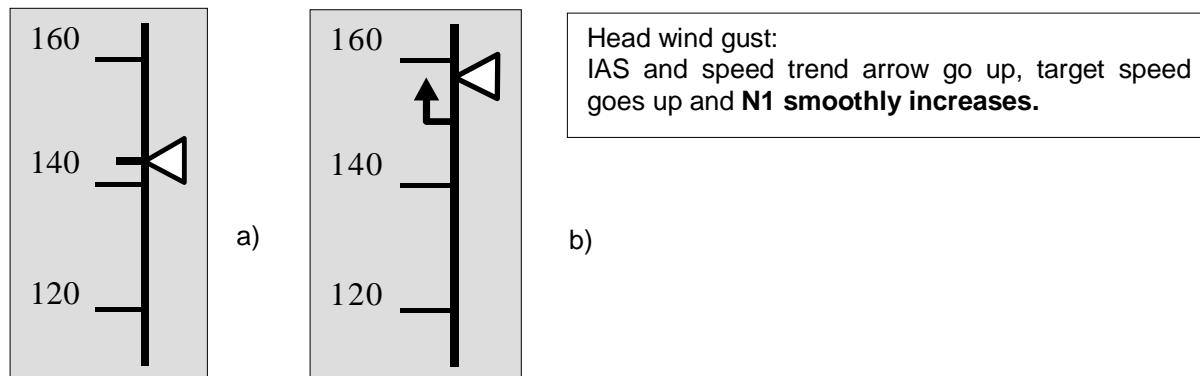


The FMGS will therefore compute the IAS target speed = GS mini + current wind.

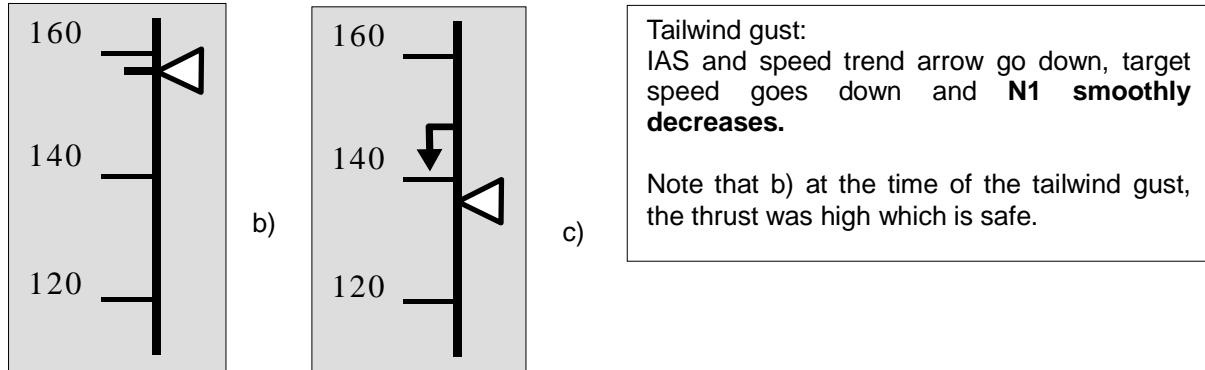
In the 3 cases of the schematic, we will read on PFD speed scale:

- a) Target speed = 137 kts,
- b) Target speed = 157 kts,
- c) Target speed = 137 kts (because VAPP is the minimum value).

We can notice that in between a) and b) we have a front gust. We shall see on the PFD speed scale the target speed going up from 137 kts to 157 kts, while simultaneously the speed trend arrow and the IAS will go up for obvious aerodynamic consequences; the thrust will increase, but not excessively because of the speed trend already experienced.



In case of a tailwind gust, which often follows a head wind gust in a shear, IAS and speed trend arrow go down, as well as the target sped; N1 smoothly decreases – This is what happens in between b) and c).



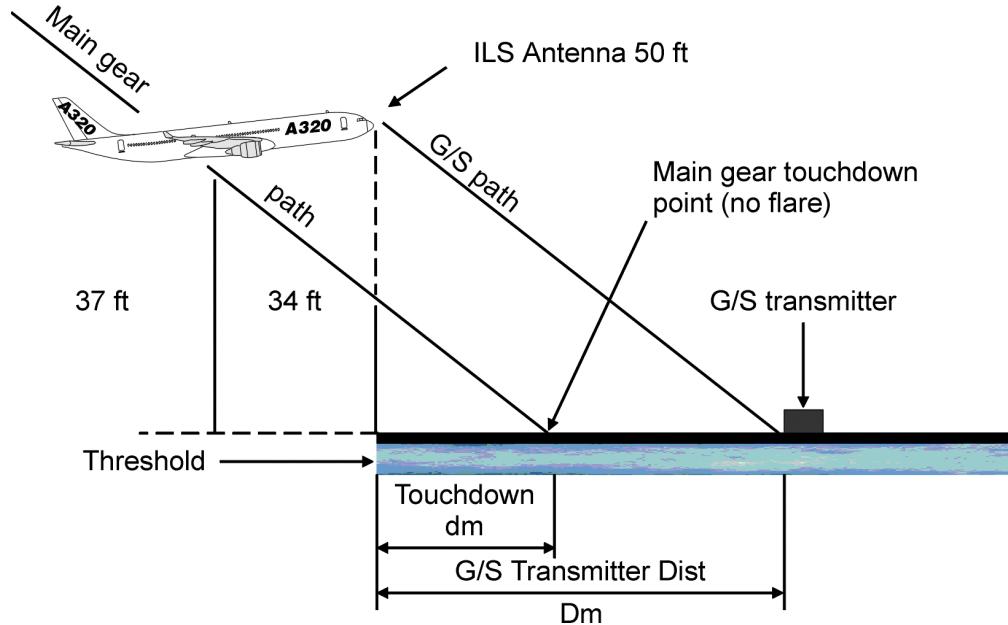
NOTE:

- The ATIS and TOWER wind is a two minute average wind; gusts are considered if in the past 10 mn the peak wind value exceeds by typically 10 kts or more the two minute average wind.
- The METAR is a ten minute average wind, with 10 minute gusts. It is always referenced to True North.
- The wind information used by the FMGS for the Managed Speed target control during the approach (GS mini guidance) is provided by the onside IRS (update rate typically 10 times/sec); thus it is an instantaneous wind information.

## 14 - LANDING, FLARE, ROLLOUT AND BRAKING

There are 3 steps in the landing: Flare / Touchdown / Rollout.

### ❖ Aircraft Approach and Landing Geometry at 50 ft (A 320)



A/C conditions A 319/A 320/A 321	G/S path	Dm	dm
A/C ILS antenna at 50ft	2°5	227 m 236 m/223 m	348 m
CONF FULL – Pitch ≈ 4° No flare	3°	187 m 198 m/182 m	291 m

The pilot eyes are approximately at 56 ft when crossing runway threshold.

### ❖ Flare

- Once AP is set to OFF using the Instinctive Disconnect button on the stick either on short final or in the flare, be smooth on the stick. The A/C is stable.  
If you feel that you are very ACTIVE on the stick, release it; the A/C will stabilize.
- When transitioning from IMC to VMC, watch the BIRD position versus the A/C attitude symbol in the center of PFD; this gives a good assessment of the drift, thus in which direction to look for the runway.  
But then:
  - don't turn towards the runway,
  - don't duck under.
- The final approach with crosswind is conducted flying the aircraft track to the runway centreline, i.e. applying a drift correction. This is a "crabbed approach" with wings level.

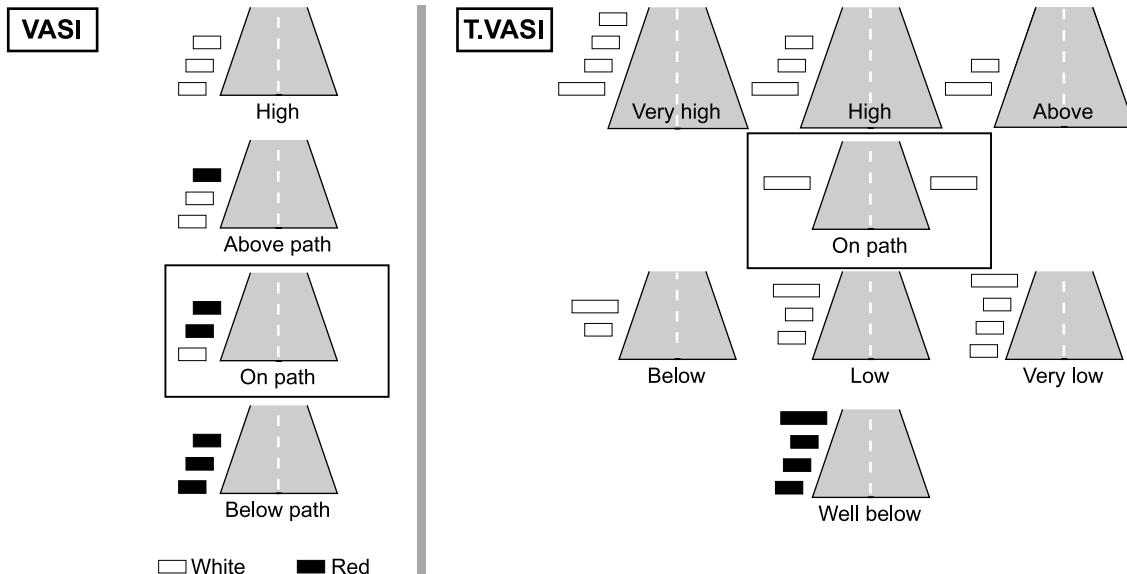
## FLARE ITSELF

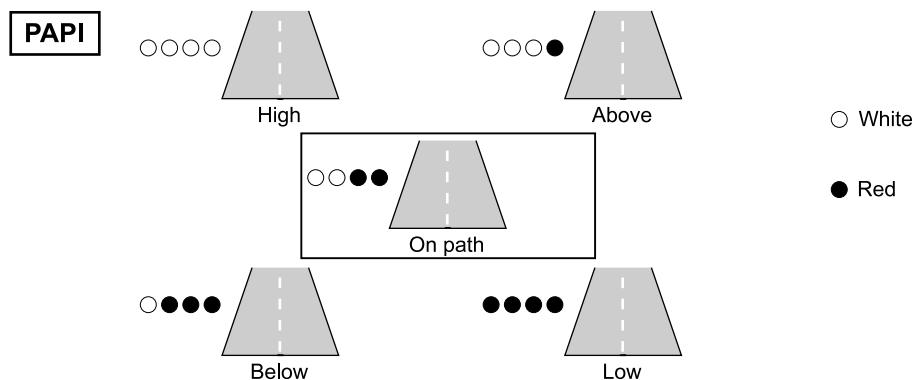
- When reaching 50 ft RA, the pitch law is modified to flare mode: indeed, the normal pitch law which provides trajectory stability is not the best adapted for the flare maneuver. The system memorizes the attitude at 50 ft, and that attitude becomes the initial reference for pitch attitude control. As the aircraft descends through 30 ft, the system begins to reduce the pitch attitude (2° down in 8 sec). Consequently as the speed reduces, the pilot will have to move the stick rearwards to maintain a constant path. The Flare technique is thus very conventional.  
Feedbacks and static stability augmentation are removed on ground.  
The roll is a roll **rate law** till the A/C is on ground.
- Start the Flare at around 20 ft; it is a progressive aft action on the stick. A continuous aft pressure has to be applied as usual.
- At 20 ft a call out « RETARD » reminds the pilot to retard thrust lever. It is a reminder, not an order. Indeed with ATTHR ON, SPEED mode is effective except if autoland (AP ON with LAND/FLARE). Therefore if you are late to retard the thrust levers in a MANUAL landing, the ATTHR will add thrust during the Flare to keep the A/C on target speed.
- In order to assess the Flare and the A/C position versus the ground, look out well ahead of the A/C.
- However if PITCH > 10°, PNF shall announce it.
- The typical pitch increment in Flare is approximately 4° which leads to a - 1° flight path angle associated to a 10 kts speed decay in the maneuver. These are « typical » figures.

## VASI - TVASI - PAPI approach slope / path indicators

VASI and TVASI are providing the crew with an aim point located adjacent to the installation, as well as a mean to stabilize the aircraft on a proper constant visual approach path.

**The boxed displays are to be used in approach.** They ensure a wheel clearance above threshold of about 20 feet, on the A320 family.





PAPI is aligned with a G/S path. As the VASI it provides an aiming point adjacent to the installation, and materializes a constant visual approach path to assist the pilot in the visual part of the approach.

ICAO requirements specify that PAPIs should be positioned such that Minimum Eye Height over Threshold (MEHT) gives adequate wheel clearance for aircraft which are regular users. Thus, for each runway PAPI are adjusted so as to provide adequate wheel clearance to regular user aircraft.

MEHT is not easily accessible to pilots; they are only on national publications.

On the A320 the eye to wheel height is approximately 25 ft and the minimum wheel clearance over threshold is 20 ft. Thus a PAPI may be followed below 200 ft on A320 provided the MEHT > 45 ft.

## ❖ Avoiding Tailstrike (refer to FCOM bulletin N°22)

- Deviation from normal landing technique is the main cause of tailstrike at landing:
    - too high speed drop below VAPP (pitch up to avoid high sink rate),
    - prolonged hold off to do a « kiss » landing,
    - flare too high and
    - no control of the de-rotation once the A/C is on ground.
  - Once the A/C closes up the ground and touches, there are factors which increase the tendency of pitch up such as the ground reaction itself at aft C.G., the ground spoilers deployment. Smoothly control the de-rotation.

### Typical values of ground clearance in pitch:

A/C	Pitch with Ldg Gear compressed	Pitch with Ldg Gear extended
A 319	13.9°	15.7°
A 320	11.7°	13.7°
A 321	9.7°	11.4°

### Typical values in bank for wing tip or engine scrape:

A/C	Bank with Ldg Gear compressed	Bank with Ldg Gear extended
A 319/A 320/A 321	16°	18°

## CROSSWIND LANDING

- During the Flare, the roll normal law is still effective. Thus when the pilot applies a **RIGHT** rudder pedal input for example, the aircraft yaws and rolls to the **RIGHT**; but it stabilizes with a steady bank angle. The more pedal input there is, the more induced yaw and bank there is with stick free. The aircraft will then turn gently to the right.

- If the A/C comes for landing with wind from the LEFT, and if the pilot wishes the A/C to land with the fuselage aligned with runway center line, he has to apply some rudder to the RIGHT. Thus, if he does not act laterally on the stick, the A/C will turn to the right because of the resulting bank angle and because of the effect of the wind.  
In order to keep the A/C on the runway center line, the pilot will have to apply some stick to the left.
- Hence the **recommended technique for crosswind landing is:**
  - **apply rudder** to align the A/C on runway center line and
  - **act on the stick** (on the opposite direction) to maintain the A/C on the center line, with possibly very slight wing down into wind.

NOTE:

In strong crosswind, a full decrab might lead to a significant into wind aileron input causing a significant bank angle. The pilot must be aware that there are aircraft geometry limitations in pitch and in bank not only to prevent incurring a tailstrike but to prevent scrapping the engine pod, the flaps or the wing tip.

In such conditions, a partial decrab is preferable.

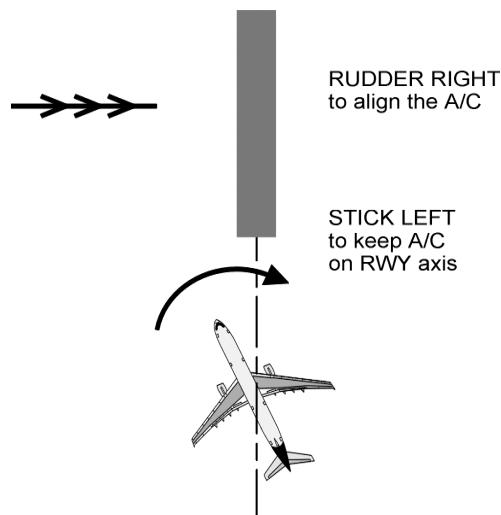
Example: with 30kt crosswind, a full decrab leads to 10° bank angle, whereas a partial decrab (5° crab angle remaining) requires only 5° bank angle.

NOTE:

The Maximum Demonstrated Crosswind (maximum encountered crosswind component during flight test) is published in the AFM. It is not an operating limitation (unless stated); it applies to a steady wind and does not necessarily reflect the maximum capability of the aircraft.

A Maximum Computed Crosswind reflects the aircraft capability in terms of rudder, roll and wheel cornering capability.

DECRAb TECHNIQUE WITH CROSS CONTROLS



DECRAb TECHNIQUE = CROSS CONTROLS

NOTE:

Once on ground avoid putting stick into wind, for better steering efficiency.

❖ **Derotation, roll out and braking**

• **Derotation**

- When the A/C is on ground, pitch and roll laws are basically direct.
- As a consequence, when the A/C touches down, the pilot has to fly the nose down gently by maintaining a slight aft pressure on the stick to slow down the de-rotation movement.
- When the A/C touches down with at least one Main Landing Gear and when at least 1 thrust lever is in the reverse sector, the ground spoilers partially automatically deploy to around 10° to ensure that the A/C will properly sit down on ground. Then the ground spoilers automatically fully extend. This is the Partial Lift Dumping function (PLD).
- It is not recommended to keep nose high in order to supposedly increase the aircraft drag during the initial part of the roll out; this technic has a poor efficiency. Furthermore it leads the pilot to delay full thrust reverser application as well as brake application. Finally, it increases the potential of tailstrike.

• **Roll out**

- During the **Roll out**, use the **rudder pedals** to steer the aircraft on the runway centreline; initially the rudder will ensure the steering function at high speeds, and below around 100 kts the Nose Wheel Steering function commanded by the pedals will take over.
- In case of crosswind various precautions need to be considered:
  - \* Avoid deflecting the stick into wind. It has practically no efficiency, but adverse side effects on braking. Indeed, it creates a differential down force on the wheels into the wind side due to the aileron deflection, and it creates a differential drag effect due to spoiler retraction on the out of wind side. These differential effects favors the "natural into the wind" turn tendency of the aircraft.
  - \* The reversers have a destabilizing effect on the airflow around the rudder and thus decrease the efficiency of the rudder. Furthermore, it creates a side force, in case of a remaining crab angle, which increases the lateral skidding tendency of the aircraft. This adverse effect is quite noticeable on contaminated runways with crosswind. In case a lateral control problem occurs in high crosswind landing, consider to set reversers back to Idle.
  - \* In lower speeds, the directional control of the A/C is more problematic, more specifically on wet and contaminated runways. Differential braking is to be used if necessary. On wet and contaminated runways, the same braking effect may be reached with full or half deflection of the pedals; additionally the anti skid system releases the brake pressure on both sides very early when the pilot presses on the pedals. Thus if differential braking is to be used, totally release the pedal on the opposite side to the expected turn direction.

- **Braking**

A proper braking technic will minimize the landing distance.

- \* However there are many factors during final approach which affect the landing distance and reduce some of the regulatory margins built in the minimum required distance for landing:
  - factors increasing the TAS at landing:  
airport elevation 1000 ft, and/or QNH 980 hPa adds 10% to actual landing distance
  - a 10% excess in approach speed, adds some 20% to actual landing distance
  - a 50 ft excess in altitude at runway threshold (i.e. flying 100 ft at runway threshold) adds some 300 m to the actual landing distance.
  - a long flare may add to some 30% to actual landing distance (typically to bleed a 5% excess in approach speed).

**Thus a properly stabilized approach on path and on speed is essential for a proper landing as well as to minimize landing distance.**

- \* What are the systems, once the aircraft is on ground, which participate to the braking?

These are the Ground Spoilers, the Reversers and the brake on wheels:

- the Ground Spoilers have three effects: they contribute to the aircraft deceleration by aerodynamic drag, **they increase considerably the wheel braking efficiency by increasing the load on the wheels** and in case of Autobrake selected, they allow the autobrake to function (A/Brake triggered by Ground Spoiler extension signal).

In terms of aerodynamic drag, the ground spoilers are efficient at high speed and participate to some 30% in the landing distance.

- the thrust reversers have a significant braking efficiency at higher speeds, say down to 70 kts, below which their efficiency drops rapidly; their efficiency is independent from the runway condition.

The Maximum reverser thrust is obtained at N1 between 70% to 85%; it is not necessary to go higher because no additional drag is obtained.

Below typically IAS 60 kts, there is a risk of engine stall; this is why it is recommended to smoothly bring the reverser thrust to Idle at around this speed. However, it is allowed to keep Maximum Reverser thrust down to aircraft stop, in emergency situation.

- From touchdown to Maximum Reverse thrust available, it takes typically between 6 sec to 14 sec (selection of Max Rev at MLG touchdown, or at NLG touchdown). Thus, in case Auto Brake is used, the participation of the reverser in landing distance varies with the A/Brake deceleration rate selected:

- \* if MED is selected (.3 g or 6 kts/sec), the brakes takes the major part in braking contribution and the reverser some 10% to 15%.
- \* if LO is selected (.15 g or 3 kts/sec), the reversers take some 25% in braking contribution.

- Finally the Actual Landing distances demonstrated in flight test and provided in FCOM/QRH do not include the use of reversers (which constitute a safety margin).

- the wheel brakes are obviously the main actors in aircraft deceleration on ground; the brake force from wheels are a function of:

- \* the force on tires due to load on wheels,
- \* the brake coefficient,
- \* the contact area of the tires with the runway,
- \* the friction coefficient between the tires and the runway.

Thus the braking efficiency depends upon the A/C speed, the load on wheels, the wheel speed (free rolling, skidding or locked wheels), the runway condition but also the brake temperature and wear.

The antiskid system maintains the skidding factor close to the point providing maximum friction force; with full pedal braking with anti skid the typical deceleration rate is 10 kts/sec (or .5g).

The brake efficiency depends upon the brake temperature despite the fact that carbon brakes are tolerant to thermal overloads and maintain maximum torque capability at high temperatures. A BRAKE HOT warning comes up so that the temperature in the middle of the brakes is **below the hydraulic fluid ignition point, typically 400° C**. The indicated brake temperature is provided by sensors located close to the brakes but not inside the brakes; this is why the BRAKE HOT message comes up at 300°C.

**BRAKE HOT WARNING PURPOSE IS TO PREVENT FIRE  
AFTER L/G RETRACTION IN CASE OF HYD FLUID LEAKAGE**

Thus the proper use of all braking means at landing and during subsequent taxi, as well as proper use of brake fans will allow minimizing turn around time: indeed the minimum turn around time ensures that the brakes will cool down sufficiently so as to have the capability to absorb the energy built up during an RTO, should it occur during the next T/O; in other words, the cool down will be sufficient so that no BRAKE HOT warning will be triggered during the next taxi for T/O.

Brake fans will therefore be used after the landing roll to cool down the brakes after a significant braking action. The indicated temperature will drop faster than the actual brake temperature, because of the sensor location (typically indicated temp 150°, actual brake temp 300°). The brake fans must not be used during T/O roll or landing roll in order to avoid deterioration. After landing, it is advisable to select them on when brake temperature rises and the aircraft reaches the gate to avoid thermal oxidation of the brakes.

When reaching the gate, if there is a significant difference in brake temperature between the wheels of the same gear, this materializes a potential problem with brakes: e.g. if one wheel reaches the limit temperature of 600° while all other wheels indicate less than 400° to 450°, this indicates that there is a potential problem of brake binding/or permanent brake application on that wheel. If, on the contrary, one wheel is at or below 60° C whereas the others are beyond 200°, this indicates that there is a potential loss of braking on that wheel.

The brake wear is a factor affecting braking efficiency more specifically in case of RTO: indeed the maximum energy which can be absorbed by a brake is proportional to the weight of its heat sink. With Carbon brakes, the wear is directly linked to the **number of pedal applications**; pressing the pedals and modulating the pressure without releasing the pedals is therefore a recommended technic for minimizing the brake wear.

You may use either pedal braking or Auto Brake; Auto Brake may be used in LO or MED for landing, MAX is used for RTO. It controls a given deceleration rate (.15g and .3g). The **DECEL light** indicates that the **selected deceleration rate** is or is not achieved, irrespective of the functioning of the autobrake. For example, DECEL might not come up when A/Brake is selected on a contaminated runway because the deceleration rate is not reached with the A/Brake properly functioning, whereas DECEL light might come up with LO selected on Dry runway while the only reversers achieve the selected deceleration rate without A/Brake being actually activated (in other words DECEL light is not an indicator of the A/Brake operation as such or not, but that the deceleration rate is reached).

The Autobrake minimizes the number of brake applications thus the brake wear; therefore, except for those cases where A/Brake selection is strongly recommended, it is up to the Captain's discretion to select it, whenever he foresees a significant need for wheel brake application.

- **Overall recommendations for the ground phase:**

- Always **Arm the ground spoilers**.
- Use **A/Brake** on Short, or on Wet & Contaminated runways, if poor visibility or with Autoland. MED is recommended.  
 Selection of A/Brake is left at Captain's discretion in other cases; more particularly when significant need of wheel brake application is foreseen (brake wear consideration).
- **Smoothly** fly down the aircraft **derotation**.
- During **Roll out**, track the runway centreline using the **rudder pedals** but not the tiller.  
 In case of crosswind:
  - \* Avoid stick into wind.
  - \* Be aware that Max Reverser thrust might laterally destabilize the aircraft.
  - \* On wet or contaminated runway, differential braking might be necessary; release totally the pedals on the opposite side to the expected turn direction.
- At **MLG touchdown**, select **REVERSER IDLE** and once **NLG is on ground**, select **MAX REVERSER**, unless required earlier. Don't wait the REV green indication on ECAM to pull for MAX REVERSER.  
 Reaching typically 70 kts, set gently reversers back to IDLE REVERSER and keep it IDLE till taxi speed is reached.  
 In emergency situations, MAX REVERSER may be considered till aircraft stop.
- **In case of A/Brake use, select LO or MED for landing.**  
 Monitor the DECEL light on the A/Brake panel; be aware that DECEL light merely indicates that the intended deceleration rate is achieved.  
 On wet and contaminated runway, in case of uneven contamination, the A/Brake might destabilize the aircraft laterally; consider deselecting it.
- In case of **PEDAL BRAKING**, press on the pedals once the NLG is on ground unless earlier required. In order to minimize brake wear, press on the pedals and **modulate the pressure** as required without releasing.
- Select **BRAKE FANS once taxi speed is reached**; at the earliest but not prior to landing (to avoid deterioration of those fans); to avoid thermal oxidation, it may be delayed till at the gate.
- Reaching the gate, check the brake temperature and report any major difference in between two brake temperatures.

- Landing distances in QRH

- The **actual landing distance** published in FCOM and QRH (4.0) is the certified landing distance demonstrated using manual landing technique, ground spoilers and full pedal braking from touch down to complete A/C stop, but with no reverser. Therefore there is quasi no margin in the actual landing distance to stop the aircraft within that distance, to the exception of the marginal effect of the reversers: in order to take into account runway slope, temperature effect, landing speed uncertainties, runway wet conditions... the regulations define an adequate coefficient to determine the "required landing distance" (or minimum required runway length) at destination or alternate out of this actual landing distance.

Therefore the actual landing distance is used for two purposes:

- \* For **aircraft dispatch**, in order to determine the "required landing distance" at destination, which represents the minimum runway length required for landing at destination.
- \* In flight, in case of landing in **abnormal configuration**, in order to determine the additional amount of landing distance caused by this situation. The multiplicative factor determined in the QRH is to be applied to the actual landing distance CONF FULL.
- The **Landing distances in autoland with Auto brake** is to be used in flight in case of diversion or in case the crew wishes to assess the landing distance at destination in case of wet & contaminated runway conditions for example. Those distances are indeed determined in autoland with A/Brake LO and MED; thus the flare phase is close to what an airline pilot will manually fly and the braking technic is more representative of the airline pilot braking technic, than full pedal braking at touchdown as done in certification flights.  
 In case of a diversion, if autoland is expected with a failure affecting the landing distance, the resulting landing coefficient factor is to be applied on the Actual Landing distance determined with manual landing technic, but not on the landing distance determined in autoland.

**GOOD LANDING IS ENSURED AFTER A PROPERLY STABILIZED APPROACH  
ON PITCH, ON PATH, ON SPEED**

**OPTIMUM LANDING DISTANCE IS OBTAINED BY ADEQUATE USE OF BRAKING MEANS:  
GND SPOILERS, REVERSERS, AUTO/MANUAL BRAKING**

NOTE:

As a rule of thumb, if the aircraft flies above runway threshold at MLW:

- at too high speed: + 10 kts, landing distance increased by 200 m
- too high altitude: + 50 ft, landing distance increased by 300 m
- with ground spoilers not armed, landing distance increased by 250 m
- if runway wet, multiply landing distance by 1.3; if compacted snow, by 1.7; if slush, by 2; if icy, by 3.5...  
 These are typical values.

**❖ Shutting down the engines - Potential of Tail Pipe Fire**

- When the aircraft taxies back to the gate, the crew must respect a **minimum time required** on certain engines **between landing (use of reverser) and engine shut down**.
- **A tail pipe fire** may occur at engine shutdown (as well as engine start), due to an **excess of fuel** in the combustion chambre or an **oil leak** in the LP turbine race.  
The excess fuel results either from an overfuel command by the FADEC or from a rotating stall, or from a malfunctioning ignition system (or from a second engine start). This excess fuel ignites in the combustion chambre with the engine rotating too slowly; it leads to an **INTERNAL fire within the engine core** or some fuel burn in the aft LP turbine race; this fire is contained within the engine and has a minimum risk to develop in an engine fire.  
The oil which burns a "**lazy fire**" in the aft LP turbine race, comes at the time where an engine is shutdown with no sufficient time running at idle; there is no significant risk of hazard for the engine, but a considerable dense, black then white smoke develops out of the engine.
- Thus in case of reported Engine Tail Pipe Fire:
  - Shutdown the Engine with **Engine Master Switch** (do not use the Eng Fire P/B, neither Engine fire extinguishing bottles).
  - Crank the engine using either opposite or APU bleed, or external pneumatic power.

NOTE1:

Shutdown then crank actions:

ENG MASTER OFF / AIRBLEED PRESS ESTABLISH / ENG MODE SEL CRANK / MAN START ON.

The start valve automatically reopens when N2 > 20%.

NOTE2:

Extinguishing the Engine with the Eng Fire P/B prevents the possibility of engine cranking. The engine fire extinguishing bottles spray the agent so as to extinguish the fire in the nacelle compartment; the agent does not reach the LP turbine and does not extinguish a fire in the combustion chambre.

NOTE3:

If a tail pipe fire is reported after the last engine shutdown with no GPU readily available, a ground fire extinguisher is to be used as last means (chemical or dry chemical powder causes serious corrosive damage to the engine).

## 15 - GO AROUND

The Go Around is always a touchy maneuver because it is often unexpected.

Thus if during the approach you feel the A/C is not properly stabilized, or will not be well positioned at MDA etc. DON'T DELAY YOUR DECISION. An EARLY Go Around is SAFER than a low and last minute one.

The Go Around is initiated systematically by thrust levers to TOGA.

This ensures (if FLAP1 at least selected):

- SRS and GA TRK modes to engage,
- Missed approach becomes the ACTIVE F.PLN and the previously flown approach is strung back into the F.PLN and
- Go Around phase is activated.

NOTE:

If Go Around is triggered at higher height above landing airport or at low weight, you may consider to reduce thrust to MCT or CLB whenever the a/c is established in pitch since, with TOGA thrust, the resulting rate of climb is very high.

The recommended flying reference for Go Around is ATTITUDE, because it is a dynamic maneuver.

Hence if BIRD was ON (NPA or VISUAL APPR) ask PNF to set it OFF (if applicable).

NOTE:

On certain versions of A320, the switching from BIRD ON to OFF is automatic at Go Around as well as the selection of FDs ON.

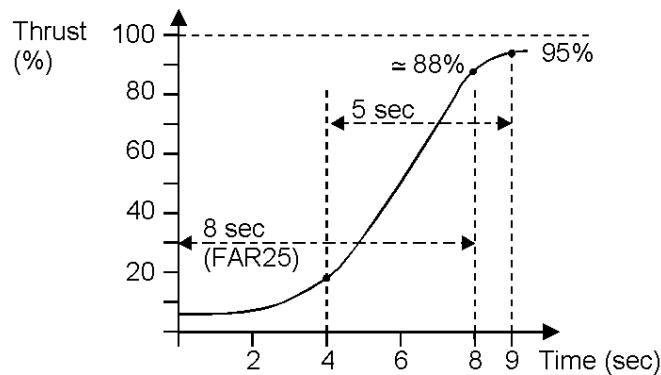
The SRS mode guides the A/C on MAX of [VLS, VAPP or IAS at time of Go Around].

SRS mode remains active till GA ACCEL ALT, or engagement of any other pitch mode (ALT\*, V/S ...).

The GA TRK mode guides the A/C on the memorized track at the time of TOGA selection.

In order to fly the MISSED APPR, ask PNF to engage NAV mode or HDG mode, as suitable.

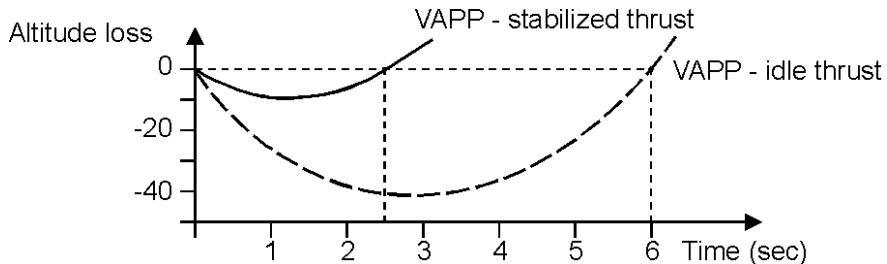
- When the pilot sets TOGA thrust for Go Around, it takes some time for the engines to spool up due to the acceleration capability of the high by pass ratio engines.



The engine certification criteria ensures a Maximum time to accelerate **from 15% to 95% of the Go Around thrust in 5 sec.** (FAR 23). 15% of TOGA is typically the thrust required to fly VAPP in landing configuration on a typical - 3° descent path.

The airframe certification criteria ensures that, **within 8 sec.**, the thrust which can be achieved from approach idle, allows the aircraft to fly the minimum "**Landing climb gradient** **3.2%**", with all engine operative in landing configuration.

- Therefore when the pilot initiates a Go Around while on the final descent path, he must be aware that **the aircraft will initially lose some altitude**. This altitude loss will be greater:
  - If the initial thrust is close to Idle.
  - If the aircraft speed is lower than VAPP (backside of the thrust/speed curve).



During the Go Around phase the target speed is GREEN DOT above GA ACCEL ALT.

#### How to get out of Go Around phase ?

The purpose of getting out of the Go Around phase is to obtain the proper target speed, and proper predictions depending upon the continuation of the flight as decided by the pilot.

During the missed approach the crew will elect a strategy which it will indicate to the FMS (indeed the FMS is unable to choose a strategy!...):

- either come back and land → ACTIVATE APPR PHASE,
- or divert to an ALTN airfield. There are 3 possibilities to indicate this to the FMS:
  - the ALTN FPLN has been prepared  
⇒ Lat Rev at TO WPT + ENABLE ALTN,
  - the SEC FPLN has been prepared to a diversion airfield  
⇒ ACTIVATE SEC FPLN (HDG mode must normally be active).
  - Nothing has been prepared! Then select SPD 250 kt + OP CLB to initiate climb. Insert NEW DEST + CRZ FL; then finalize the diversion FPLN.

The Go Around phase will automatically switch to CLB phase (or to appropriate phase - depending on altitude), and managed speed target is then initial climb speed.

#### Once the aircraft has started the final approach, a Go Around or missed approach must be considered:

- If there is a loss or a doubt about situation awareness.
- If there is a malfunction which jeopardizes the safe completion of the approach.
- If the ATC changes the final approach clearance resulting in rushed reaction from the crew or potentially unstable approach.
- If the approach is unstable in speed, altitude, flight path (vertical or lateral) or configuration, in such a way that most probably it won't be stable by 1000 ft AGL in IMC, or by 500 ft AGL in VMC.
- If adequate visual cues are not obtained at MDA or DH.
- If any GPWS/TCAS or Windshear alert occurs.

## 16 - ETOPS

### ❖ Background

ETOPS stands for **E**xtended range **T**win engine aircraft **O**Peration**S**.

ETOPS describes the operations of Twin Engine A/C over routes that contain waypoints located further than one hour flying time from an adequate airport at one engine inoperative cruise speed.

The ETOPS regulations are applicable to overwater or overland operations and to all revenue flights with passengers or freighters.

The purpose of ETOPS regulations is to provide a **greater flexibility** in twin engine aircraft operation while maintaining a high level of safety.

In the 80's ICAO formed an ETOPS study group to examine the flexibility of extended range operation, while the FAA begun the design of AC 120-42 which defines the US criteria for ETOPS.

During the 80's and 90's the various aspects of ETOPS criteria have been thoroughly reviewed by the industry allowing now to consider over 180 mn ETOPS (up to 207 mn is proposed by the US to day, for obvious reasons...!).

### ❖ Regulatory Aspects of ETOPS

The purpose of the regulations is to ensure that twin engine A/C operating under ETOPS are at least as reliable as the existing 3 or 4 engine A/C.

**The regulations cover 2 aspects:**

**a) The A/C ETOPS type design approval.**

The A/C manufacturer has to demonstrate that the A/C complies with the ETOPS design criteria. Any changes required to the A/C basic design are contained in the "Configuration, Maintenance and Procedure Standards" (CMP) which is an authority approved document.

Design considerations cover the following issues:

- Propulsion System Reliability,
- Electric power redundancy and distribution consideration,
- APU design,
- Single Engine operation with adequate system redundancy,
- Ice protection for engine and air frame,
- all system safety assessment to take into account the max diversion time,
- adequate fire extinguishing system for cargo and
- crew workload consideration under failure conditions.

The ETOPS capability assessment is done by the Airworthiness Authorities who analyze the IFSD rates (In Flight Shut Down) and all in-service events in order to grant the Maximum allowed ETOPS diversion time for the candidate A/C. The A320 family is granted 120 mn with all installed engines. A319CJ is planed to be granted 180 mn in 2001. Up to now, no airline has officially requested for the A320 family an extension of the diversion time up to 180 mn.

**b) The ETOPS operational approval given to the airlines.**

The airline has to demonstrate its competence to the authorities regarding flight operations, flight procedures, A/C configuration, maintenance, dispatch practices and ETOPS training.

Each authority defines its own means of compliance stating the method the airline has to use to demonstrate its competence.

In order to get 120 mn diversion time approval, the regulations require from the candidate airline to accumulate 12 months of consecutive in service experience on the A/C and engine type. But an "**accelerated ETOPS approval scheme**" may be applied by the airline.

**❖ ETOPS Flight Dispatch**

The ETOPS flight preparation process determines the specific documentation and data, which will be handed over to the crews at flight dispatch.

**a) Definitions****- ETOPS operation**

Flight conducted on a twin engine A/C over a route containing a point further than 60 mn flying time from an ADEQUATE airport.

The "Maximum Diversion Distance" with 60 mn diversion time is determined in STILL AIR and ISA conditions according to specific rules.

→ See diversion speed schedule.

**- Adequate Airport**

Airport acknowledged by the AA, which satisfies A/C performance requirements at expected LW. The airport must be available at the expected time of use, capable of ground operational assistance, equipped with at least one approach navaid, fire fighting and rescue facilities.

**- Suitable Airport**

Adequate airport which satisfies ETOPS dispatch weather requirements within a validity period (one hour before earliest ETA, to one hour after the latest ETA). Wind limitations at landing are to be considered.

**- Maximum Diversion Time**

Granted by the AA - From 75 mn to 180 mn from a diversion airport; it is used to determine the ETOPS area of operation for dispatch purposes.

**- Maximum Diversion Distance**

Distance covered in Still Air/ISA or  $\Delta$  ISA conditions within the maximum diversion time at the SELECTED ONE ENGINE OUT SPEED and ASSOCIATED ALTITUDE.

The EEP (ETOPS ENTRY POINT) is located at 60 mn flying time from the last ADEQUATE AIRPORT. The EXP (ETOPS EXIT POINT) 60 mn from the first ADEQUATE AIRPORT.

The ETPs (Equitime Point) and CP (critical point) are determined from SUITABLE AIRPORTS with FORECASTED ATMOSPHERIC CONDITIONS.

**b) ETOPS AREA OF OPERATIONS – DIVERSION STRATEGIES.**

The ETOPS area of operation is the area in which it is permitted to conduct a flight under ETOPS – it is a function of

- Adequate Airports,
- Max Diversion Time granted by AA and
- EO Speed Schedule.

This area of operations is determined once, in Still Air conditions and ISA. It does not need to be reassessed.

The Airline chooses the DIVERSION STRATEGY to be applied in order to determine the ETOPS area of operation. The Diversion strategy defines, amongst others, the **Engine Out Speed** schedule which will condition the **Diversion Distance**; thus the diversion strategy will be determined so as to ensure a minimum overlap of the diversion distance circles, a proper obstacle clearance if any, and a safe fuel policy.

There are 3 possible Diversion Strategies:

- STANDARD - CRZ MACH 0.78 M/300 kt descent down to LRC CRZ FL,
- OBSTACLE - DRIFTDOWN GREEN DOT/MCT descent; when obstacles are cleared, then cruise at LRC CRZ FL and
- ETOPS FIXED SPEED STRATEGY - Several speed samples are defined for each aircraft type. This is the "minimum time strategy", which however must allow the net flight path to clear the obstacles.

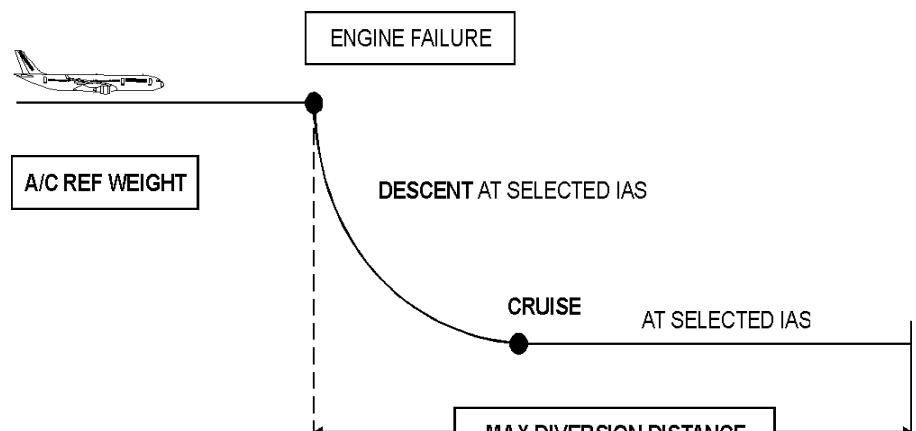
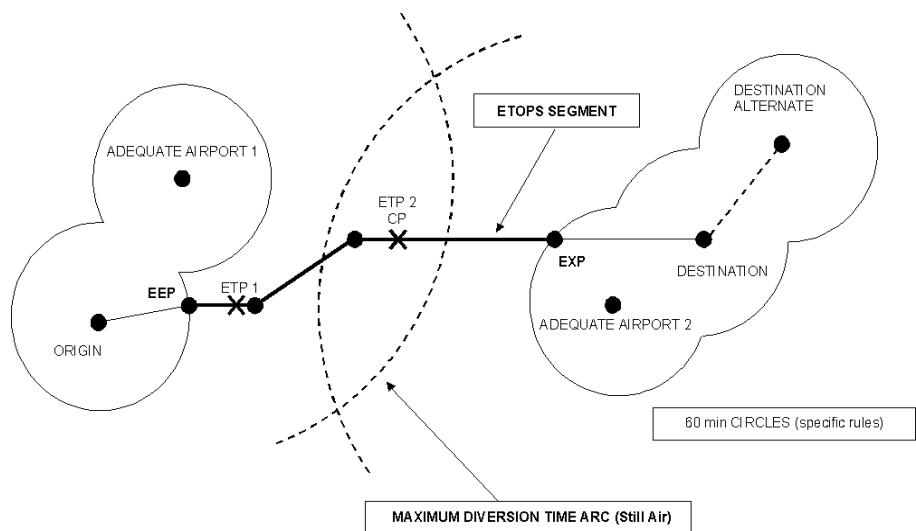
For the A320 the typical speed scenarios are 0.80 M/350 kt at MCT or 0.78 M/320 kt at MCT.

Thus the operator determines a reference GW and selects a diversion strategy. It allows him to draw the maximum diversion distance circles around the adequate airport and thus to determine the ETOPS area of operation.

FCOM 2.04.40 provides the 60 mn maximum diversion distance at FL170 (as per JAR OPS 1-245) used to decide if a route is ETOPS. This distance is used to draw the 60 mn distance circles and to locate the EEPs and EXPs.

e.g	A319-113/114 (CFM56-5A1/A3)	TOW = 75500 kg	D = 386 NM
	A319-132 (IAE V2524-A5)	TOW = 75500 kg	D = 405 NM
	A319CJ-115 (CFM56-5B7)	TOW = 75500 kg	D = 407 NM
	A319CJ-133 (IAE V2527M-A5)	TOW = 75500 kg	D = 407 NM
	A320-214 (CFM56-5B4 SAC)	TOW = 77000 kg	D = 403 NM
	A320-232 (IAE V2527-A5)	TOW = 77000 kg	D = 402 NM
	A321-111/112 (CFM56-5B1/B2 SAC)	TOW = 80000 kg	D = 401 NM
	A321-131 (IAE V2530-A5)	TOW = 80000 kg	D = 395 NM
	A321-211 (CFM56-5B3)	TOW = 89000 kg	D = 385 NM
	A321-231 (IAE V2533-A5)	TOW = 89000 kg	D = 373 NM

FCOM 2.04.40 provides the diversion distances for various speed schedules and GW, used to draw the maximum diversion time circles or arcs and thus to determine the area of operations.



**c) Determination of SUITABLE Airports.**

An adequate airport is SUITABLE when the weather forecasted at this airport is better in terms of ceiling and visibility than the REQUIRED MINIMA FOR DISPATCH during the EN ROUTE ALTN SUITABILITY PERIOD. Landing wind limitations are to be considered as well.

- The required minimum at en route alternate for dispatch for ETOPS are HIGHER than the normal defined minima at the airport. They are determined by the FAA or JAA regulations; they are published in FCOM 2.04.40.

e.g: ONE RUNWAY with one instrument approach ILS or NPA (+ Circling or not):

- > minimum alternate airfield ceiling = [DH or MDH] + 400 ft or Circling minima,
- > minimum alternate airfield visibility = authorized visibility + 1500m (JAA rule).

The surface conditions (forecast crosswind component, including gust) must not exceed the maximum permitted crosswind for landing; fluid contaminated runway is to be considered (2.04.10).

e.g.: for the A320 family (3.01.20):

- max crosswind for LDG demonstrated 33 kts gusting 38kts and
- max tailwind for LDG 10 kts.

Be aware that:

- Runway course is MAGNETIC (except at very high latitudes),
- METAR & TAF give TRUE wind,
- VOLMET gives TRUE wind and
- ATIS & TWR give MAGNETIC wind.

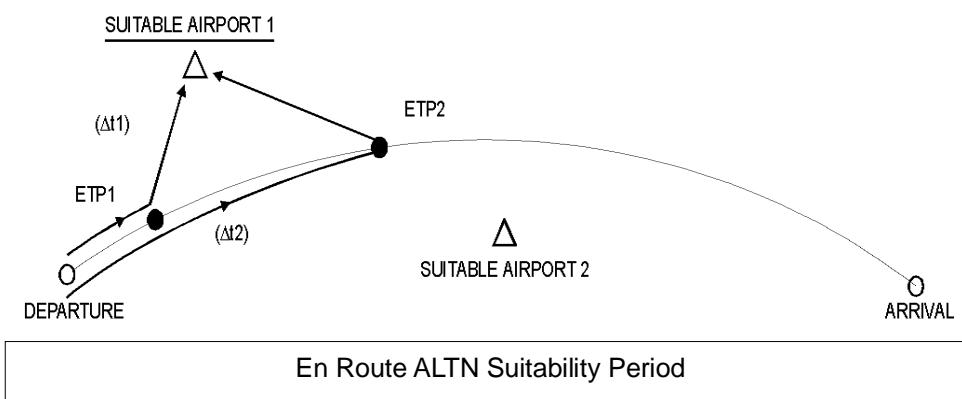
e.g.: SONDERSTROM

- RUNWAY 10 is 100° magnetic. Variation 40° W,
- METAR WIND 125°/ 35 kt is TRUE (= WIND 165°/ 35 kt is MAGNETIC),
- ➔ CROSSWIND = 32 kt.

The EN ROUTE ALTN SUITABILITY period is determined as being between

- ONE HOUR BEFORE THE EARLIEST TIME OF ARRIVAL and
- ONE HOUR AFTER THE LATEST TIME OF ARRIVAL.

This suitability period is provided for the ESTIMATED TIME OF DEPARTURE. It must be **UPDATED** with the ACTUAL DEPARTURE TIME.



Let us consider the example here above:

ETP1 - equitime point between departure and suitable airport 1,

ETP2 - equitime point between suitable airport 1 and 2,

ETPs are determined FOR THE ENG FAIL CASE (EO cruise altitude, wind, time).

**NOTE:**

The ETPs determined in the FMS are computed with two engine operative.

**Δt 1** from departure to suitable 1 is determined at NORMAL CRUISE SPEED / FL, via ETP1.

**Δt 2** idem to suitable 2 via ETP2.

PERIOD = (ETD + Δt1 - 1h); (ETD + Δt2 + 1h).

**[EN ROUTE ALTN SUITABILITY PERIOD = (ETD + Δt1 - 1h); (ETD + Δt2 + 1h)]**

#### d) Fuel Requirements

The dispatcher determines the fuel required for a given route considering

- STANDARD FUEL PLANNING and
- SPECIFIC ETOPS FUEL REQUIREMENTS.

The STANDARD FUEL PLANNING is:

- TAXI + TRIP + RSV + ALTN + 30 mn HOLD at ALTN.

The SPECIFIC ETOPS REQUIREMENTS consist in determining the fuel, which would be required to reach a suitable airport in case of

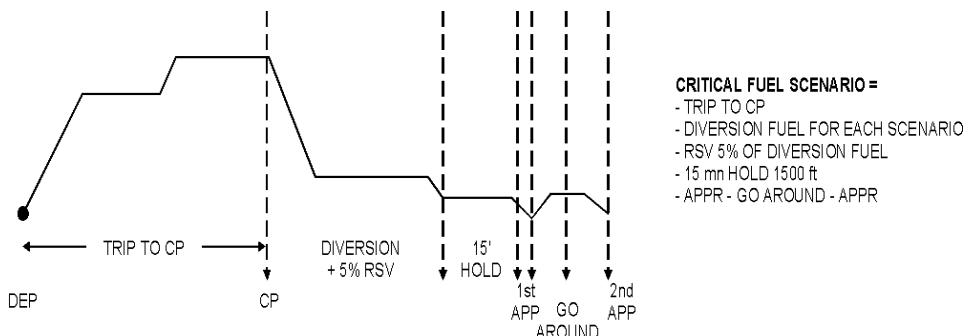
- an Engine out situation,
- a failure of the pressurization system and
- an engine failure linked to a pressurization failure.

This fuel is computed from each ETP to the associated suitable diversion airport, for each failure case.

The ETP on the route which is CRITICAL REGARDING THE ETOPS FUEL REQUIREMENTS is called CRITICAL POINT (CP). It is usually the LAST ETP of the ETOPS SEGMENT.

The dimensioning FAILURE SCENARIOS are:

- FAILURE OF PRESSURIZATION and
- FAILURE OF PRESSURIZATION + EO, for the A320.



#### NOTE:

A contingency around 2% to 3% is recommended on the trip to CP although not required by regulations.

Considerations for ETOPS Fuel:

- Diversion fuel tables from CP to LDG including holding/2 approaches/Go Around for the 2 dimensioning failure scenarios are provided in FCOM 2.04.20.
- Additional fuel is to be considered for ICING conditions:
  - > for EAI / WAI use and
  - > for potential ice accretion on unheated surfaces.

Additional fuel due to the potential drag of ice accretion on unheated surfaces is a %age of the fuel burnt during the considered exposure time. The value of this %age is equal to 5 times the forecast exposure time in hours (1 hour → 5%, 2 hours → 10%).

If moderate icing is forecast, the above fuel provision is divided by 2 (see FCOM 2.04.40 - ETOPS CRITICAL FUEL RESERVE).

Some airlines add a contingency on the trip from departure to CP (as recommended hereabove).

FUEL RQD FOR ETOPS SECTOR = MAX {STD FUEL, SPECIFIC ETOPS FUEL REQUIREMENT}

**e) Crew Duties at Flight Dispatch.**

The following mnemonic can help. It is MNPS (which has nothing to do with the North Atlantic operation or Minimum Navigation Performance!).

**Meteo:** TAF/METAR/SIGMET at departure/arrival/en route alternate.  
 Consider SUITABILITY PERIOD  
 TEMSI-ICING FORECAST  
 WIND/TEMP at CRZ FL and DIV FL

**Notam and Navigation:**

Check departure/arrival/en route alternate Notams.  
 → CONFIRM SUITABLE AIRPORTS.  
 ETOPS Area chart - Check ETOPS Area (EEP-EXP) - Identify ETPs.

**Performance:**

Perf. factor / CI / Icing constraints / MEL - CDL constraints.

Review CFP

- versus ATC F.PLN,
- check Trip Fuel (2.05.40),
- check Critical Fuel Scenario (2.0540); whether additional ETOPS fuel required or not.

Determine FUEL RQD and Expected TOW → T/O data.

Determine WINDs to be inserted for the FMS - en route and overhead suitable Airports for ETPs.

**Status:** Aircraft for ETOPS dispatch,  
 Crew (qualified ...).  
 The Route itself.

**NOTE:**

Be aware that **the time estimates from an ETP to two associated suitable airports are usually different on the CFP**. This is normal because ETPs are determined for the engine failure case, which means at EO cruising altitude with associated winds and at the selected EO IAS.

The predictions on the CFP from ETP assume the **CRITICAL FUEL SCENARIO** which is in most cases the failure of pressurization or the combination of Engine failure and Failure of pressurization.

If the critical case is the pressurization failure, for example, the estimates will assume the aircraft will fly at FL100, with associated winds at that FL and with LRC speeds at FL100.

- The estimated times at suitable airports will be different.
- The time between ETP at a suitable airport may be greater than the "approved diversion time" (120 mn or 180 mn) which are used to determine the "ETOPS area of operation"; but those times are used to determine the so called Maximum Diversion Distance in still air, at the selected one engine out speed.

**❖ ETOPS In Flight Operation.**

The crew must be AWARE OF THE DISPATCH CONSTRAINTS (weather minima, fuel); but must be aware that NORMAL CONDITIONS APPLY ONCE IN FLIGHT in terms of weather minima, fuel estimates at CP. Furthermore in case of emergency (depressurization, EO) the Captain will elect the most suitable speed schedule or strategy, which might be different from the one of the dispatch, if he judges it to be necessary.

**a) Cockpit Preparation (ETOPS Specifics)**

- Crew ensures that MAINTENANCE PREFLIGHT checks are completed
- Specific system checks: STAND BY GEN (ASAP so as not to corrupt refuel, cabin etc.) and FUEL X FEED valve.
- IRS: Perform full alignment.
- FMS handling as for any Long Range Flight.  
 Additionally insert EEP/EXP on STORED WPT page (CFP ETPs may also be stored).

**b) After Engine Start**

Once the engines are started and BEFORE THE A/C IS MOVING UNDER ITS OWN THRUST, ETOPS MEL restrictions have to be applied.

Once the A/C is taxiing, the MEL does not apply any longer, unless the airline policy is different or captain's decision.

**c) In Flight****Before reaching EEP**

- Insert wind/temp into FMS for proper predictions.
- Copy Active into SEC FPLN and prepare first applicable diversion FPLN.
- Check weather at en route ALTN by listening to VOLMET or by contacting Airline Flight watch via ACARS, HF STOCKOLM... or any other means. Weather at suitable airports must be BETTER THAN STANDARD PUBLISHED MINIMA (or than authorized minima if higher).
- A/C Status must be ok for ETOPS.
  - ➔ If WEATHER or A/C STATUS become NOT SATISFACTORY, the crew must contact the ETOPS FLT WATCH OFFICE for a possible REROUTING, which must be available before EEP.

**Once in ETOPS Area**

- There is no longer a requirement for weather to remain BETTER THAN STD MINIMA.
- Always check weather at DEST and ALTN.
- Update the ETPs along with flight progress.

**Fuel Monitoring**

- Normal or STD fuel policy applies.
- Amongst others, the FUEL at CP must be above the minimum required to continue the flight to destination or to en route alternate in normal conditions; the amount of fuel must allow the aircraft to land at least at destination or divert and land, with at least the FINAL reserve (30 mn hold at 1500 ft).  
The CP shall not be considered as a reclearance point.

**Navigation**

- Standard navigation procedures apply. With GPS PRIMARY, no specific precautions.
- In case of loss of GPS PRIMARY:
  - > use any VOR/DME or BEACON to consolidate FMS position,
  - > determine the BEST IRS on DATA POS MON,
  - > in case of loss of one IRS, use AP on side of the BEST IRS and
  - > consult the CLOSEST ARPT and update ETPs as required.

**d) Diversion**

There are specific reasons to divert in case of ETOPS:

- weather at suitable airport getting below minima BEFORE EEP,
- failure requiring LAND ASAP,
- failure leading to excess FUEL CONSUMPTION (depressurization, fuel trapped in CTR TK, ...) and
- Cargo Fire (divert at maximum speed).

## 17 - RVSM

**A few words about Reduced Vertical Separation Minimum airspace where the aircraft flying between FL 290 and FL 410 are separated vertically by 1000 ft instead of 2000 ft.**

The purpose of RVSM is to allow to increase the traffic rates in saturated airspaces, while keeping up the same safety level. Since vertical separation is planned to be reduced, this necessitates some requirements on aircraft equipment, on flight crew training, on ATC personnel training, on aircraft maintenance and MEL, and on altitude performance monitoring.

The RVSM has been first implemented in the NAT MNPS area initially between FL330 to FL370, then in the full altitude intended range. This first operation has allowed to detect the existence of spurious Traffic advisories (this has dictated the TCAS II change 7, amongst others), as well as some wake vortex encounters (this has dictated some specific lateral offset procedures in case some special weather conditions are encountered). Then RVSM has been applied over Pacific, and will be applied over Europe.

As for any special operation of this type (ETOPS, RVSM, MNPS...) following considerations apply:

**1. The A/C must be certified for RVSM:**

- Minimum altimetry performance must be demonstrated (e.g. the mean Altimetry System Error must be within 80 ft).
  - The A/C must carry a minimum set of equipment which in turn dictates the MMEL dispatch conditions which are:
    - 2 ADR or 2 ADCs.
    - 1 ATC transponder.
    - 1 FCU for altitude selection and climb/descent AP mode selection (2 FCU channels minimum).
    - 1 Autopilot.
    - 1 FWC for altitude alert.
    - 2 PFDs and DMCs for altitude display.
  - A comparative check of altitude readings in flight at 3 different flight levels from all altimetry sources must fall within tolerances (in FCOM 3-04-34 see below), and must be recorded.
- 2. The airline must be approved for RVSM operation** by local Authorities, which necessitates that all operation documentation has been amended, that flight crews are trained, that the maintenance program is reviewed and that the airline participates to an "altitude keeping performance" monitoring program.
- 3. Specific procedures** have to be applied,
- by the maintenance team, on the equipment required for RVSM,
  - by the crews in flight.

**The outstanding in flight procedures are:**

**• Cockpit preparation:**

- Maintenance log / form properly documented.
- RVSM MEL dispatch conditions are fulfilled.
- RVSM tolerances properly fulfilled on each PFD (on side ADR versus ADR3;  $\Delta$  ALT < 25 ft).
- Review weather forecast with particular attention to severe turbulence.
- Check letter W in field 10 of ATC Flight Plan.

**• Before reaching RVSM airspace:**

- Any failure of the required equipment leads to rerouting away from RVSM airspace.
- Two main altimeters indications on STD setting must be within 200 ft.
- If one ADR fails, check the remaining ADRs versus the STD BY ALTI and note the  $\delta$ . This will be useful in case of a subsequent failure.

• **Within RVSM**

- Use AP for cruise Flight and level change (OVERSHOOT < 150 ft).
- Periodically check ADR tolerances ( $\Delta$  ALT < 200 ft); use AP and ATC on side ADR in agreement.

**NOTE:**

The TCAS (unless change 7) may output some spurious TAs (and exceptionally RAs) when crossing or overtaking a traffic.

• **Problems within RVSM**

The nature of the problem is linked to the ability to properly maintain a Flight Level:

- Loss of altimeter redundancy (only one PFD indication)
- Loss of two APs
- Failure of a system affecting the aircraft's ability to maintain the flight level
- Severe turbulences ...
  - NOTIFY ATC; "Unable RVSM due to equipment or turbulences..." and apply the contingency procedure as assigned by ATC.
  - Report the failure in the maintenance log.

Altitude Tolerances for RVSM operation				
	IAS [kt]	ADR1 / ADR2 on PFD [ft]	ADR1 (ADR2) ADR3 on PFD [ft]	STD BY ALT1/ ADR1 - ADR2 - ADR3 [ft]
GROUND	-	20	20	-
FL50	250	50	80	130
FL100	250	55	80	185
FL200	300	90	145	295
FL300	.78 M	130	355	390
FL410	.78 M	130	365	445

**NOTE:**

The Airline must report within 72 h to the responsible authority height keeping deviations if those exceed:

- Over 300 ft (total vertical error as measured during altimeter monitoring program)
- An altimeter system error over 245 ft.
- A cleared altitude deviation over 300 ft.

## 18 - PERFORMANCE CONSIDERATIONS

### I - General

The wing of the A320 has been designed to be best efficient at "around" a cruise Mach Number of 0.78 (which defines its sweep angle and thickness).

However the cost of a given sector depends upon the fuel consumption but also of many other factors such as

- Over flight charges,
- Price of fuel at origin, destination leading to possible fuel tankering,
- Price of flight time (crew, maintenance ...),
- Wind gradient, flight plan constraints (such as constant Mach ...) and
- Aircraft GW itself etc.

For each sector, the airline determines a cost factor:

$$\text{the COST INDEX CI} = \frac{\text{COST 1 mn FLIGHT}}{\text{COST 1 mn FUEL}}$$

where the cost of variable items is considered. The greatest variables are FUEL / MAINTENANCE. However despite the fact that the crew costs are fixed, duty time constraints leading to a night stop will modify the costs index of a given sector.

Once a COST INDEX is determined for a given sector, this allows the FMS to generate a CLIMB / CRUISE / DESCENT SPEED profile which will minimize the cost, by balancing the cost of fuel against the cost of time.

For example, if the fuel consumption is the essential economical factor on a given sector, the COST INDEX will be LOW (0 is MAX RANGE), the time is the essential economical factor on a given sector, the COST INDEX will be HIGH (999 is MIN TIME).

It is essential to understand that once the CI is defined for a given sector, the MANAGED SPEED PROFILE will be computed by the FMS, as well as the OPTIMUM FLIGHT LEVEL, OPTIMUM STEP etc. Furthermore with Cruise Wind variations and temperature changes, the Cruise Mach number will vary, as it varies also with GW and cruise altitude.

For example at GW 65 t FL350 on an A320-212 / CFM56-5A3

CI	WIND COMPONENT	ECON CRZ MACH [M]
0	Head Wind 100 kt	0.782
	Still Air	0.781
	Tail Wind 100 kt	0.769
50	Head Wind 100 kt	0.790
	Still air	0.796
	Tail Wind 100 kt	0.802
100	Head Wind 100 kt	0.811
	Still Air	0.804
	Tail Wind 100 kt	0.803

As a consequence, the COST INDEX IS NOT TO BE MODIFIED BY THE CREW IN FLIGHT, unless for FUEL or FLIGHT TIME CONSIDERATIONS.

If for any reason, the crew wishes to fly at a GIVEN FIXED CRUISE MACH NUMBER, SELECT IT ON THE FCU (all predictions will be updated accordingly).

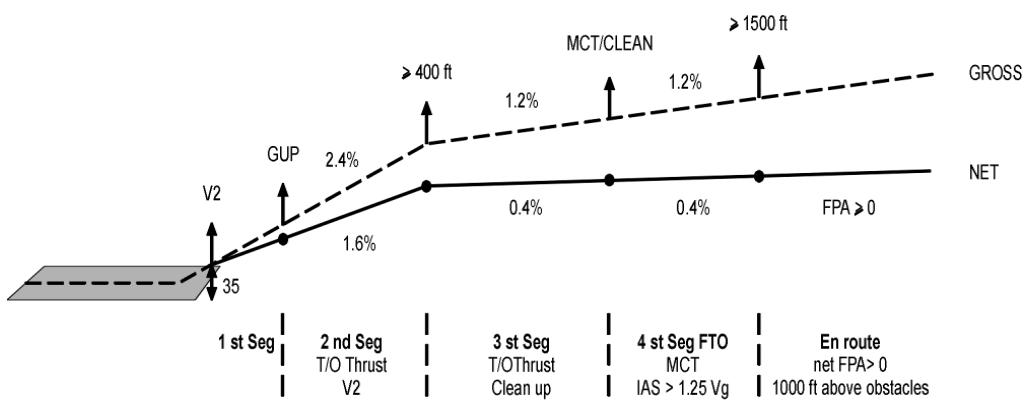
## II - Take off Considerations

### Unreliable Speed Indication

Before ACCEL ALT → TOGA / PITCH 13°  
 Crossing ACCEL ALT → CLB / PITCH 10°  
 + 15 sec FLAP1  
 + 15 sec FLAP0

### Performance Data

#### T/O Segment Reminder



The ENGINE OUT ACCELERATION ALTITUDE must be

- at least HIGHER than the MINIMUM ALTITUDE required for OBSTACLE CLEARANCE, but limited to the ALTITUDE reached at the END of CLEAN UP with 10 mn TOGA THRUST

### Definition of speeds associated to Take-off

**VMCG:** mini control speed on the ground, using PRIMARY CONTROLS only (no NWS). Maximum rudder force 68 kg / Maximum lateral deviation on ground 30 ft.

**VEF:** engine failure speed allowing the crew to recognize the failure and act when reaching V1. There is typically 1 sec between VEF and V1 (which leads to approx 4 kts).

On a twin engine, if the Take-off is CONTINUED following an engine failure BEFORE VEF, this leads to a significant increase in Take off Dist (TOD). E.g if the failure occurs 8 sec below VEF, V2 will be reached at 10 ft instead of 35 ft at the end of TOD.

**VMBE:** maximum braking energy speed, at which the brakes can absorb all the energy required.

VMBE becomes a limiting factor at high OAT on long runways. An RTO achieved in such circumstances may lead to very hot brakes, tires automatically deflated and potential fire.

**V1:** Commital speed for Take off. V1 call out must be made so that "ONE" is called when V1 is reached.

**VMU:** minimum unstuck speed is the speed at which the aircraft can safely lift off the ground and continue take off. VMU is a function of GW, Aircraft configuration and altitude.

**VR:** rotation speed. Allows the aircraft to reach V2 at 35 ft with engine failed. A rotation initiated before VR leads to a potential tailstrike.

The HIGHER THE FLAP SETTING, the GREATER THE TAIL CLEARANCE is.

**V2:** minimum speed reached at 35 ft with one engine failed. It must be between 1.13 Vs1g and 1.28 Vs1g. The HIGHEST V2 is, the BETTER IS THE A/C CLIMB OUT GRADIENT IN T/O SEGMENTS.

**VMCA:** minimum control speed with one engine out using maximum rudder deflection and 5° bank angle towards engine inoperative.

Flying BELOW VMCA leads to a significant INCREASE of the SLIDE SLIP (Beta Target); thus, if in case of an engine failure the PILOT IS UNABLE TO CENTER BETA with FULL RUDDER → ACCELERATE.

**Relations between all those speeds:**

VMCG  $\leq$  VEF  $\leq$  V1  $\leq$  VMBE

VR  $\geq$  1.05 VMCA

VLOF  $\leq$  V MAX TIRE

V2  $\geq$  1.1 VMCA

On SA family, Vmax tire = 195 kt

A/C	VERSION	ENGINE	VMCG	VMCA [kt] (Alt = 0 ft)	VMBE
<b>A319</b>	A319-111	CFM 56-5-B5	105.5	108	170.6
	A319-112	CFM 56-5-B6	108	111	164.2
	A319-113	CFM 56-5-A4	104	108	166.9
	A319-114	CFM 56-5-A5	107.5	111	171.4
	A319-115	CFM 56-5-B7	113.5	114.5	169
	A319-131	IAE V2522	104.5	107	173.1
	A319-132	IAE V2524	107.5	109.5	172.2
	A319-133	IAE V2527M	111.5	133	171.9
<b>A320</b>	A320-111	CFM 56-5-A1 *	107	105	174.2
	A320-211	CFM 56-5-A1 *	107	105	160.2
	A320-212	CFM 56-5-A3	110.5	110.5	156
	A320-214	CFM 56-5-B4	111.5	110	155.1
	A320-231	IAE V2500	101.5	108.5	160.7
	A320-232	IAE V2527	112.5	111.5	158.7
	A320-233	IAE V2527E	112.5	111.5	158.4
<b>A321</b>	A321-111	CFM 56-5-B1	104.5	109	171.9
	A321-112	CFM 56-5-B2	106	110.5	171.4
	A321-211	CFM 56-5-B3	106	114	173.4
	A321-131	IAE V2530	109	112.5	167.9
	A321-231	IAE V2533	109	114	170.1

\* A320 – 111 MTOW 68 T; A320 – 211 MTOW 77 T

**NOTE:**

VMBE provided here is with no wind, no runway slope, ISA and CONF2.

VMCG and VMCA are function of altitude.

The certification of the A320 has matched the Amendment 42 of JAR / FAR which has considerably increased the safety margins in case of an engine failure.

For A 319 & A 321, a so called "post amendment 42" applies which states that a 2 sec delay (at constant V1 speed) is to be applied between the stop decision and the first pilot reaction in order to determine the acceleration/stop distance.

**Influence factors for Take off performance:**

There are obviously many factors influencing the take off performance such as aircraft GW, aircraft configuration, outside conditions (OAT, wind, pressure), the runway available and the obstacles.

Those factors allow the basic T/O DATA to be determined, which have still to be modulated by other influence factors which must be applied on tactical basis:

- **Runway is WET:** this affects the acceleration/stop capability of the aircraft (as well as possibly, its lateral controllability in case of crosswind). Thus once MTOW and associated T/O speeds, or FLX TEMP and associated speeds are determined on a DRY runway (this is the basic T/O data),
  - a weight decrement and associated speed decrease must be applied
  - or a  $\Delta$ TFLEX decrement and associated speed decrease must be applied.
- **AIR COND ON:** the basic T/O data is often provided on the RTOW charts supposing AIR COND OFF. In that case if PACKS are ON engine bleeds
  - a weight decrement and associated speed decrease must be applied for MTOW
  - or a  $\Delta$ TFLEX decrement must be applied; **NO** speed decrease is to be applied, since the  $\Delta$ TFLEX decrement compensates for the thrust drop caused by the AIR COND.
- **QNH different from standard:** in case of low pressure, the engine thrust is lower than in STD conditions. Thus in case QNH << STD
  - a weight decrement and associated speed decrease must be applied for MTOW
  - or a  $\Delta$ TFLEX decrement must be applied to compensate this thrust drop.
- **ANTI ICE:** the same method applies. The decrements are often not provided on the RTOW charts but as defaulted values in a FCOM specific table.

**FLEXIBLE TEMP for T/O reduced thrust - RTOW chart use.**

Whenever maximum T/O thrust is not necessary due to aircraft GW or/and runway conditions, it is most efficient to REDUCE the T/O THRUST in order to SAVE ENGINE LIFE. By limiting the thrust, the centrifugal forces are reduced on engine components (blade tip less contact with compressor case). The deposit of molten metal is reduced further back in the engine (which affects the aerodynamic and thermodynamic efficiency of the engines), the EGT is reduced (thermal stresses are reduced on the blades, lowering the bending effects).

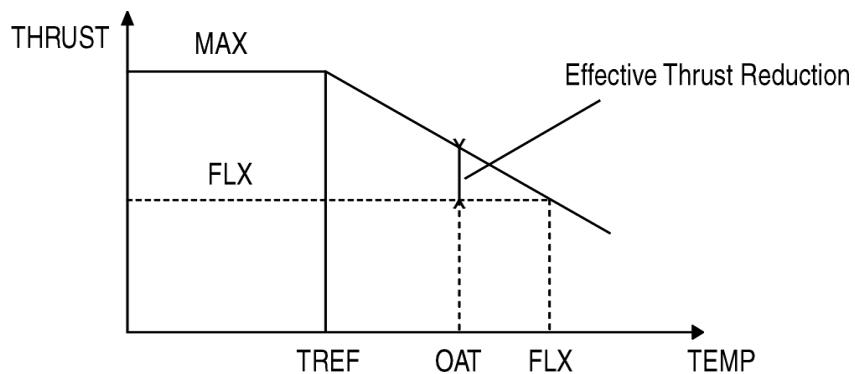
All A320 engines are high by-pass Turbo Fan engines FLAT RATED till a given temperature called TREF; this means that BEYOND TREF the maximum thrust of the engine reduces.

Thus by determining an assumed value of outside air temperature which would allow the engines to provide the thrust required to take off the aircraft in the current conditions, this allows to THE THRUST TO BE REDUCED. This temperature value is called FLEX TEMP.

THE HIGHER THE FLX, THE MORE THE THRUST IS REDUCED,  
 THE LOWER IS THE ENGINE EROSION RATE.

The percentage of the effective Thrust reduction is a function of (FLX TEMP – OAT).

FLX TEMP - OAT [° C]	8°	14°	20°	25°	29°
EFFECTIVE THRUST REDUCTION [%]	5	10	15	20	23
<b>Indicative figures for A 320-212/ CFM56-5A3</b>					



**FLX is limited as follows:**

- Max authorized FLX THRUST reduction 25%,
- FLX T/O N1/EPR  $\geq$  MAX CLB N1/EPR,
- FLX TEMP by definition  $>$  TREF and OAT.

A/C	VERSION	ENGINE	TREF [°C]	TMAX [°C]	TMAX.FLEX [°C]
<b>A319</b>	A319-111	CFM 56-5-B5	ISA + 30	ISA + 40	ISA + 45
	A319-112	CFM 56-5-B6	ISA + 30	ISA + 40	ISA + 53
	A319-113	CFM 56-5-A4	ISA + 30	ISA + 40	ISA + 44
	A319-114	CFM 56-5-A5	ISA + 22	ISA + 40	ISA + 44
	A319-115	CFM 56-5-B7	ISA + 29 up to 2000 ft ISA + 18 between 5000 and 10 000 ft +1 Deg.C per 1000 ft above 10 000 ft up to ISA + 23 at 15 000 ft Linear interpolation between 2000 and 5000 ft	ISA + 40	ISA + 53
<b>A319</b>	A319-131	IAE V2522	ISA + 40 at 8000 ft ISA + 30 at 13 000 ft Linear interpolation between 8000 ft and 13 000 ft	ISA + 40	ISA + 65
	A319-132	IAE V2524	ISA + 40 at 0 ft ISA + 30 at 5000 ft Linear interpolation between 0 and 5000 ft	ISA + 40	ISA + 65
	A319-133	IAE V2527M	TREF = f(Zp) TBC or Read it on Takeoff chart	ISA + 40	ISA + 53
<b>A320</b>	A320-111	CFM 56-5-A1	ISA + 15	ISA + 40	ISA + 41
	A320-211				
	A320-212	CFM 56-5-A3	ISA + 15	ISA + 40	ISA + 45
	A320-214	CFM 56-5-B4	ISA + 29 up to 2000 ft ISA + 18 between 5000 and 10 000 ft +1 Deg.C per 1000 ft above 10 000 ft up to ISA + 23 at 15 000 ft Linear interpolation between 2000 and 5000 ft	ISA + 40	ISA + 53
<b>A320</b>	A320-231	IAE V2500	ISA + 15	ISA + 40	ISA + 46
	A320-232	IAE V2527	Read it on Takeoff chart	ISA + 40	ISA + 55
	A320-233	IAE V2527E	Read it on Takeoff chart	ISA + 40	ISA + 55
<b>A321</b>	A320-231	IAE V2500	ISA + 15	ISA + 40	ISA + 46
	A320-232	IAE V2527	Read it on Takeoff chart	ISA + 40	ISA + 55
	A320-233	IAE V2527E	Read it on Takeoff chart	ISA + 40	ISA + 55
	A321-111	CFM 56-5-B1	ISA + 15	ISA + 40	ISA + 43
	A321-112	CFM 56-5-B2	ISA + 15	ISA + 40	ISA + 43
	A321-211	CFM 56-5-B3	ISA + 15	ISA + 40	ISA + 43
	A321-131	IAE V2530	ISA + 15	ISA + 40	ISA + 45
	A321-231	IAE V2533	Read it on Takeoff chart	ISA + 40	ISA + 42

**NOTE:**

The use of FLX TEMP adds some "safety" margins for T/O.

Indeed if  $V1 = 160 \text{ kt}$  with  $\text{FLX } 65 \rightarrow V1 \text{ TAS} = 172 \text{ kt}$ .

If the OAT =  $35^\circ \text{C}$  that day, the effective  $V1 \text{ TAS} = 164 \text{ kt}$ .

The STOP calculations are computed on  $V1 \text{ TAS } 172 \text{ kt}$  (as well as would be the GO calculation on the  $\text{FLX } V2 \text{ TAS}$ ).

This somehow corresponds to a  $V1$  gain of  $8 \text{ kt}$ , which could equate to  $8 \text{ (FLX TEMP - OAT) meters gain on distances}$ .

**The RTOW charts** are not exactly the same for A320 and for A319/A321 (Octopus).

They also may have different presentations according to airline's choice: entry with GW or with TEMP. For Octopus charts, the influence factor corrections are provided either in 2 lines or 4 lines.

For A320 charts, the corrections are found in FCOM 2-02-24. In all cases the principle to determine the T/O data is the same:

**1. Determine the MTOW and apply the influence factor corrections.**

For Octopus charts, as per the order, those factors are provided on the chart:

- for the 1<sup>st</sup> influence, apply the correction from first 2 lines (unless OAT > TVMC in which case the last 2 lines apply) - NO SPEED CHECK VERSUS  $V1 / VR / V2 \text{ MIN, VMU}$  is necessary,
- for the 2<sup>nd</sup> or 3<sup>rd</sup> influences, apply the corrections as follows:
  - if only 2 lines are provided, achieve a SPEED CHECK,
  - if the SPEED CHECK is NOT SUCCESSFUL, T/O is NOT POSSIBLE UNDER THE PRESENT CONDITIONS,
  - if 4 lines are provided, USE THE 2 BOTTOM LINES (no speed check required).

**2. Determine the FLEX TEMP and apply the influence factor corrections.**

For Octopus charts:

- for the 1<sup>st</sup> influence correction, apply the FLX and Speed corrections as required, and CHECK SPEEDS VERSUS  $V1 / VR / V2$  and VMU,
- for the next one, same method. If 4 line corrections are provided, you may use the BOTTOM 2 LINES with NO SPEED CHECK; this is very conservative.

If the SPEED CHECK is NOT SUCCESSFUL, FLX is NOT POSSIBLE. Use MAX T/O and the SPEED associated to MTOW or the SPEEDS ASSOCIATED to CURRENT GW if all those speeds are lower.

**NOTE:**

For Octopus charts, if GW is lower than any GW provided on the charts, apply all influence corrections first. Then apply the speed decrement corresponding to lower GW, e.g.  $1 \text{ kt/t}$ , and check the resulting speed versus  $V1, VR, V2 \text{ min}$  and VMU.

**T/O CONFIGURATION CHOICE**

CONF 1 + F / CONF 2 / CONF 3 may be elected for T/O.

A high T/O CONF is preferable to minimize tailstrike risks, or on rough runways to decrease the T/O speeds.

A low T/O CONF (1+F) is preferable to optimize the climb gradient more specifically in hot weather.

As a consequence the general criteria to determine the best T/O CONF are:

- HIGHEST FLX TEMP (engine life saving),
- LOWER T/O SPEED and
- PREFERRED CONF FOR COMFORTABLE A/C HANDLING (e.g. tailstrike).

The preferred T/O CONF is thus CONF2 as long as it does not induce a reduction of FLX TEMP higher than  $5^\circ$ .  
 CONF 2 provides the best compromise to fulfil these criteria.

**Various other factors influencing Take-off**

**Brakes**

The Carbon brakes are quite efficient when hot ( $\leq 100^\circ \text{C}$ ) or with some wear.

However the Carbon brake temp increases rapidly with brake application.

The HOT BRAKES caution comes up at  $300^\circ \text{C}$  indicating that if the L/G is retracted, there is a potential risk of fire caused by this temperature being spread to the hydraulic system.

IF HOT BRAKES BEFORE T/O, DO NOT T/O.  
 IF HOT BRAKES DURING T/O, DO NOT RETRACT L/G.  
 DO NOT USE BRAKE FANS DURING T/O, OR IF FIRE.

### Tires

Under inflation is one of the major cause of tire failure; it heats up faster and may cause a breakdown of the rubber material.

The tire develops a BRAKING force when the tire is rolling (not when skidding).

The Brake coefficient is high on a dry runway and LOWER on a WET runway where the brake loss increases with speed.

Tire wear favors Aquaplaning. With normal tire pressure (around 180 PSI) the aquaplaning speed on STANDING WATER is around 120 kt, on SLUSH around 130 kt.

**A tire failure causes longer T/O distances.**

### Line Up allowance

Line up allowances after a 90° turn or 180° turn are included in the take off data determination e.g.

ASDA	A 319	A 320	A 321
ASDA line up allowance (90° turn)	23.1 m	25.5 m	28.0 m
ASDA line up allowance (180° turn)	26.4 m	27.5 m	35.8 m

### Some Rules of Thumb

Flex Temp [°C]	Δ Thrust [%]	Δ N1 [%]	Δ EGT [°C]	Δ EPR
+ 10	- 6	- 2,9	- 30	- 0,048

Air Cond	Δ Flex Temp [°C]	Δ Thrust [%]	Δ EGT [°C]
Off	+ 3	+ 2,4	- 10

Δ Thrust [%]	Δ N1 [%]	Δ EGT [°C]	Δ EPR
25	- 14	- 251	- 0,128

Runway shortening [m]	Δ TOW [t]	Δ OAT [°C]
- 100	- 1.5	- 5

### III - Climb Considerations

#### Unreliable Speed Indication

##### MAX CLB THRUST

PITCH 7°	till FL 100	IAS $\leq$ 250 kt
PITCH 5°	FL > 100	IAS $\leq$ 280 kt
PITCH 3°	FL > 200	M 0.76

#### Performance data

En Route climb gradient (from 1500 ft AGL at origin):

- Gross climb gradient with one EO 1.1 %
- Net climb gradient 0

#### Obstacle clearance criteria:

- Net flight path must be  $> 0$ , 1000 ft above all obstacles, 4.34 NM either side of track,
- Drift down net slope after EO, 2000 ft above all obstacles, 4.34 NM either side of track.

#### Maximum altitude (FCOM 3.05.15)

- 0.2 g buffet margin,
- limited by minimum rate of climb capability and
- limited by flying CRZ MACH NR with MAX CRZ thrust.

#### Optimum altitude

- for a given CRZ Mach Nr  $\rightarrow$  gives the best specific range
- for the MANAGED SPD PROFILE  $\rightarrow$  provides the best cost for the given sector. Thus it is directly affected by CI, PERF FACTOR.

#### Step Climb (FCOM 3.05.15)

A step climb is worth being achieved if:

- there is not a significant additional headwind at higher altitude (approx 25 kts),
- the additional fuel consumed in climb (0.1% of GW) is compensated by enough Cruise time and descent.

#### FMS data

- REC MAX ALT  $\rightarrow$  0.3 g buffet margin.
- OPT ALT is a function of CI, PERF FACTOR, WIND and TEMP forecasted as a consequence of pilot's entries and remaining cruise distance.

#### Maximum gradient / V/S Climb Speeds with one engine inoperative

- The Maximum Climb gradient speed is the speed, which allows the aircraft to reach a given altitude within the SHORTEST DISTANCE. (e.g close obstacles ),

MAX CLB GRADIENT SPEED = G.DOT  
varies from 205 kt at 60 t to 225 kt at 70 t  $\rightarrow$  + 2 kt/1 t

G.DOT is close to the best L/D ratio speed - It increases with Zp.

The Maximum V/S climb speed all engine running is used to expedite through a given FL; in other words when the a/c is asked to cross a given FL in SHORTEST TIME (TMA altitude constraints etc.).

I.e.: Aircraft weight = 70 000 kg

MAX V/S CLIMB SPD with ALL ENG OPERATIVE  $\approx$  CLOSE TO TURB SPD  
 varies from 279 kt at FL100 to 260 kt at FL250  $\rightarrow$  - 1.3 kt/1000 ft

NOTE:

This is also the Minimum Consumption - Distance speed in climb, in other words the speed for which the fuel consumption in climb is the lowest.

From FL100 to FL250

MAX V/S CLIMB SPD with ONE ENG OPERATIVE = G.DOT  
 Varies from 210 kt at 55 t to 225 kt at 70 t  $\rightarrow$  1 kt/ 1 t

NOTE:

OEO G.DOT speed = AEO G.DOT - 10 kt.

Rules of thumb for A 320:

**OAT < ISA + 15:**

- OPT FL = 570 – 3 x GW (t) OPTo
- MAX FL = OPT FL + 15
- Time to MAX = 30 mn / Fuel burned = 2.2 t / D (NM) to TOC = 120 NM + GW (t). Correction per – 1000 ft / - 2 mn /- 15 NM.

**OAT  $\geq$  ISA + 20:**

OPT FL = MAX FL = OPTo – 10

Time to MAX = 36 mn / Fuel burned = 2.6 t / D (NM) to TOC = 140 NM + GW (t)

Various other considerations in Climb

- Slats and Flaps extended are penalizing with regard to Climb gradient. Furthermore the loss of climb gradient in turn WITH SLATS/FLAPS EXTENDED is greater than in CLEAN CONF.
- This is why in single engine operations the FG BANK ANGLE is LIMITED to 15° while S/F are extended and speed is below F or S. In clean CONF when IAS  $\geq$  G.DOT, the FG bank angle is limited to 25°.
- Obstacles must be clearly identified on departure, as well as for low altitude turn backs (even with EGPWS which does not necessarily carry artificial obstacles in its data base). Maneuvering below MSA or below circling minima must be fully studied by the crew and is done under the sole responsibility of the Capt.
- It may not always be possible to achieve MSA within 25 NM before starting to turn away from the Final T/O segment; in such cases a SAFE ALTITUDE must be determined above terrain to allow the aircraft to maneuver back towards the airport.

- The RADIUS OF TURN of the trajectory is a function of TAS and BANK.

TAS [kt]	RADIUS (15° $\Phi$ ) [NM]	RADIUS (25° $\Phi$ ) [NM]
150	1.2	0.7
180	1.8	1.0
210	2.4	1.4
250	3.4	2.0
300	4.9	2.8
480	12.5	7.2

#### IV - Cruise Considerations

##### Unreliable Speed Indication

N1 82 %  
 Pitch 2°      M 0.76      FL  $\geq$  250

##### NOTE:

Even on IAE engines where the thrust is controlled using EPR, it is preferable to use N1 as reference in such circumstances.

##### Performance data – as for climb

The FMS is an essential assistance for the pilot to achieve an efficient monitoring of the cruise, and an efficient cruise.

- Reaching the first CRZ FL, ensure **ALT CRZ** mode on FMA. This means that:
  - the aircraft will fly at the intended **CRZ MACH No**,
  - the AP will operate in altitude soft mode for more efficient thrust regulation.
- Insert WINDS and TEMP at successive waypoints of the cruise. It is not necessary to insert them at all waypoints obviously, but when winds and /or temp vary by more than approx 30° or 30 kt and 5°.
- Having done that, the **OPTIMUM FUNCTIONS** of the FMS are valuable:
  - the OPT FL is meaning full.
- **MANAGED SPEED** is mostly recommended. Indeed it allows the aircraft to fly an **ECON SPEED** profile during cruise as determined by the FMS.
- The **COST INDEX** is a strategic parameter in cruise. It is to be changed **only for STRATEGIC purposes** such as XTRA FUEL getting close to 0.
- In case the ETA at destination is beyond schedule and ETA is an important cruise management factor on the sector, insert **SCHEDULE TIME of ARRIVAL** as time constraint at destination. The FMS will adapt the **ECON SPD** profile so as to best match the ETA time constraint.
- The FMS MAX REC ALT is 0.3 g buffet limit altitude. The crew may elect to fly higher if necessary. He will be advised that he is flying beyond the 0.3 g boundary by a message. The **MAX [MAX ALT]** above which managed modes are no longer available is defined by the 0.2 g limit.
- In case ATC requires the aircraft to fly at a **FIXED CRZ MACH NR**, **SELECT IT** on the FCU. All predictions are updated accordingly in cruise till next STEP or T/D, where the FMS assumes that Managed speed will be resumed.

##### NOTE:

It is **absurd and pointless** to try to adjust a Cost Index to match such a tactical ATC constraint. A Tactical constraint is to be matched using the FCU per design. Furthermore per definition, the **ECON CRZ MACH** profile varies with the flight progress.

FCOM 3.05.15 provides all the data necessary for proper cruise management.

Do not forget the effects of:

- AIR COND LO      - 0.6 %
- ENG A/I      + 3 %
- ENG + WING A/I      + 6 %

ISA deviation      ISA + 10      + [0.05 % x Dist] [kg]

##### Turbulence

- Light      < 1.2 g
- Moderate      1.2 to 1.5g
- Severe      > 1.5 g

Speed 250 (FL200)/275/0.76 for A319 and A320  
 Speed 265 (FL230)/300/0.76 for A321

## V - Descent Considerations

### Unreliable Speed Indication

Thrust Idle

Pitch - 2° 0.76 / 280 kt

- The MAXIMUM SPD in DESCENT allows MAXIMUM V/S IN DESCENT when thrust is idle.
- THE MINIMUM GRADIENT DESCENT is obtained at G. DOT SPEED.
- The wind in descent has a significant influence on the descent FPA and thus on the descent distance:
  - with TAILWIND, FPA decreases and GND DIST increases.
- When the A/C is **HIGH ABOVE PATH**:
  - SELECT HIGHER SPD (as allowed by ATC) + SPD BRK EXTEND with OP DES,
  - KEEP HIGH SPD TILL ALT\*,
  - only then SELECT LOWER SPD (or Activate Appr) and RETRACT SPD BRK when getting close to intended Target Speed.
- The FMS provides an efficient assistance to properly carry out the descent provided the LATERAL FPLN and VERTICAL FPLN are properly filled in, descent winds if significant, are properly inserted, and PERF APPR page completed:
  - the FMS computes a DESCENT PROFILE; it provides, on EFIS PFD and MCDU PROG, the VERTICAL DEVIATION of the A/C vertical position versus the descent profile (VDEV also called YOYO).
  - the VDEV is an excellent cue to monitor the descent when in NAV mode or when in HDG (TRK) modes as long as XTK is within 5 NM.
  - when in **HDG (TRK)** modes, on latest versions of the FMS, it computes the **ENERGY CIRCLE** displayed on the ND which represents the distance required to descend from present altitude down to landing elevation, and to decelerate from descent speed to VAPP (including SPD LIM) and land.
  - On previous versions, this information is available on MCDU PROG page.
  - when SELECTING A SPD on the FCU (e.g for TURBULENCE), the A/C is still guided on the original descent path.
  - The ↘ level off symbol on the ND along the F. PLN or TRK LINE materializes the position where the A/C will reach the FCU in the CURRENT AP/FD ACTIVE mode.
- **EMERGENCY DESCENT** One of the goals of the Emergency Descent is to reach a lower level (FL < 140) without triggering the PAX O2 mask deployment. Thus the emergency descent is achieved with
  - IDLE THRUST,
  - HIGH SPEED (up to VMO-MMO if failure permits),
  - SPD BRAKES extended.
- On A320, the rate of descent is approximately 6000 ft/mn; which means that it takes approximately 5 mn to descend from FL 390 to FL 100, and approximately 40 NM.
- **Holding Speed and Configuration** The MAXIMUM ENDURANCE HOLDING is achieved:
  - with CLEAN CONF,
  - at G. DOT speed (actually the speed is slightly lower than max L/D ratio speed),
  - at level as high as approximately FL 250.

Rules of thumb to monitor descent:

$$D [NM] = \Delta FL \times 3 + 10 + 2 \% \text{ per 10 kt tailwind}$$

Crosscheck with FPA:

$$D [NM] = \Delta FL / FPA [^{\circ}]$$

$$V/S [ft/mn] = GS \times FPA [\%] = GS \times FPA [^{\circ}] / 0.6$$

**NOTE:**

The descent profile is computed as the succession of several descent segments. From TOD to the first constrained waypoint the descent segment is called "**Idle segment**"; it assumes a given speed profile with thrust equal to IDLE +  $\Delta$ . This  $\Delta$  allows a more flexible guidance of the aircraft on the precomputed descent path, when out side conditions vary or Anti Ice is selected. The Idle Factor on the A/C STATUS page is used to adjust the  $\Delta$ ; a negative value increases the descent path angle.

## VI - Approach Considerations

### Unreliable Speed Indication

CONFIG	Speed [kt]	AOA	Pitch attitude [°]	Slope [°]	N1 [%]
Clean	250		3.0	-	63
Clean	G.Dot	5.5	5.5	-	55
1	S	7.5	7.5	-	57
2	F	8.0	8.0	-	55
3	F	7.0	7.0	-	58
3/GD	F	7.0	4.0	- 3.0	50
FULL/GD	VLS + 5	5.5	2.5	- 3.0	53
FULL/GD	VLS	7.0	4.0	- 3.0	51

### Rules of thumb:

- At Green Dot speed, clean aircraft configuration, set N1 to the aircraft weight value in tons.
- On final approach, landing configuration, set N1 to the aircraft weight value minus 2%.

### Performance Data

#### There are runway distance limitations

On Dry Rwy	Landing Dist Available	$\geq$ Actual Landing Distance /0.6
On Wet Rwy	LDA wet	$\geq$ 1.15 x Actual Landing Dist /0.6
	LDA wet	$\geq$ 1.92 x Actual Landing Dist

On Contaminated Rwy LDA contaminated  $\geq$  1.92 x Actual Landing Dist

The Actual Landing Distances are provided in QRH and are used essentially for dispatch considerations to determine the Landing Distance Available (LDA) which is to be compared to the runway length at destination.

The **GO Around limitation** requirements are twofold:

#### Approach Climb criteria

- minimum gradient 2.1 % - OEO/TOGA/L/G UP/FLAPS one detent up, as compared to approach configuration.

#### Landing Climb criteria

- minimum gradient 3.2 % - AEO/Thrust after 8 sec from flight idle /L/G DN, FLAPS in APPR CONF - A320 is NEVER landing climb limited.

### Aircraft Category

A/C Category	IAS [kt] at threshold	IAS [kt] initial App	Circling [kt]	Final App [kt]	Missed App [kt]	Final Missed App [kt]
C	121/140	160/240	180	115/160	160	240
D	141/165	185/250	205	130/185	185	265

A319/A320/A321 are Category C aircraft.

### PCN/ACN

The Aircraft Classification Number must be lower than the Pavement Classification number. PCN varies with the life of the pavement since it is a function of the traffic, traffic distribution etc. On a FLEXIBLE pavement (asphalt - concrete) occasional movements with ACN = PCN + 10 % are allowed.

On a rigid pavement (concrete surface) occasional movements with ACN=PCN + 5% are allowed.

### Actual Landing distance / Landing distance determined with autoland

- Actual landing distance is used for dispatch in order to determine the minimum runway length which should be available for landing (or minimum LDA).
- Actual landing distance CONF FULL is to be used in ABNORMAL CONFIGURATION, where a multiplicative factor is provided in QRH in order to determine the expected landing distance in such configuration whether in manual landing, or in autoland.

- Landing distance determined in Autoland with Auto Brake LOW/MED are very realistic distances which are used in flight, for example in case of diversion (no coefficient to be applied).

### APPROACH SPEED VAPP

- In most cases in normal configuration the FMS computes VAPP considering the STEADY WIND inserted by the pilot in PERF APPR and the landing configuration selected.
  - In case of suspected wind shear or downburst, or in case of strong gusty cross wind, the FMS VAPP may be overwritten by the pilot (up to VLS + 15 max).
  - In all those cases, use MANAGED SPEED in approach.
  - In case of ABNORMAL CONFIGURATION determine VAPP
    - either as PFD displayed VLS +  $\Delta$ VLS from ECAM + WIND CORR,
    - or as VREF (VLS CONF FULL) +  $\Delta$  VREF + WIND CORR from QRH 2.23.
- In such a case use SELECTED SPEED in approach.

### OVERWEIGHT LANDING

- Overweight landing may be achieved exceptionally with care (limit V/S to 360 ft/mn).
- Determine if CONF3 or CONF FULL shall be used depending upon the Approach climb gradient requirement (QRH).
- Be aware that the transition from FPA - 3° in approach to the Go Around climb gradient requires a lot of energy and therefore some altitude loss (< 100 ft).

### MISSED APPROACH CLIMB GRADIENT

- The crews must be aware that the 2.1% approach climb gradient requirement has nothing to do with the actual climb gradients which may be necessary in a missed approach.
- The crews must consider the obstacles, which are in the missed approach flight path.
- The SAFE ALTITUDE to use as a reference for acceleration is either the published missed approach altitude, or the MSA.

In case of **COLD TEMPERATURE** the target altitudes must be corrected.

- When significantly below ISA, the height above the field must be corrected by adding the following corrections:

HEIGHT [ft]	Corrections to be added [ft]		
	ISA - 10 °C	ISA - 20 °C	ISA - 30 °C
500	20	40	60
1000	40	80	120
2000	80	160	240
3000	140	260	380
4000	180	340	500
5000	220	420	620

## 19 - USE OF FLYING REFERENCES - ATTITUDE OR BIRD (FPV)

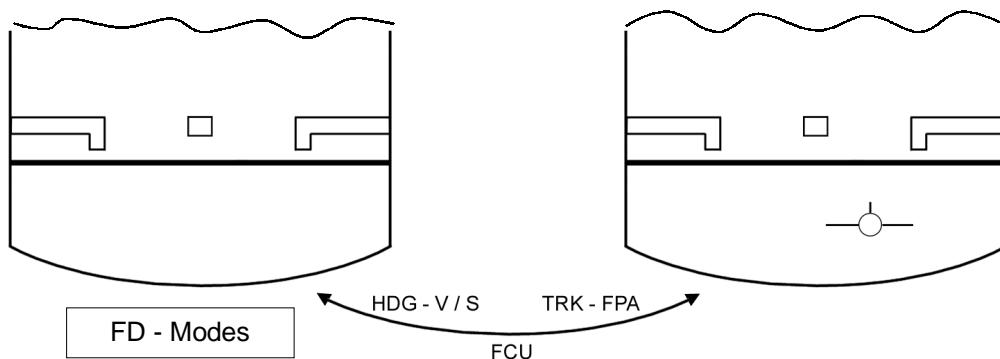
On the PFD 2 flying references may be selected:

- The ATTITUDE
- The FLIGHT PATH VECTOR called BIRD.

The selection is done on the FCU by pressing the P/B identified as HDG – V/S (for ATTITUDE) TRK - FPA (for BIRD).

THE ATTITUDE is a flying reference to be used for DYNAMIC MANEUVERS such as T/O and GO AROUND. Indeed an action on the stick has an immediate effect on the A/C attitude; thus the pilot can immediately and accurately control this parameter in those maneuvers.

The BIRD or FLIGHT PATH VECTOR (FPV) represents the A/C trajectory; in dynamic maneuvers it is directly affected by the A/C inertia. It reacts with a delay. Thus it is difficult to control in dynamic but when the pilot wishes to fly a STABILIZED SEGMENT OF TRAJECTORY, then the BIRD is well adapted.



### FLYING REFERENCE SELECTION ON THE FCU

When to use the BIRD ?

- The BIRD may be used in all flight phases, except T/O and GO AROUND.  
It is more specifically recommended for NPAs, VISUAL CIRCUITS, VISUAL FLYING.

What to check when pressing the HDG - V/S / TRK - FPA knob ?

- If you press this P/B, this means that you wish to select the BIRD ON or OFF.  
Hence, when you press this P/B, CHECK BIRD ON or BIRD OFF on the PFD.

If the APs/FDs are ON, the internal FG guidance parameters are a function of the flying reference you have selected:

- If BIRD ON, the basic guidance parameters of AP/FD will be TRK-FPA.
- If ATTITUDE ON, the basic guidance parameters of AP/FD will be HDG-V/S.  
This explains the name of the P/B located on the FCU.

As a consequence if the APs/FDs are in the basic modes HDG - V/S and you select the BIRD ON, the basic modes will change to TRK - FPA.

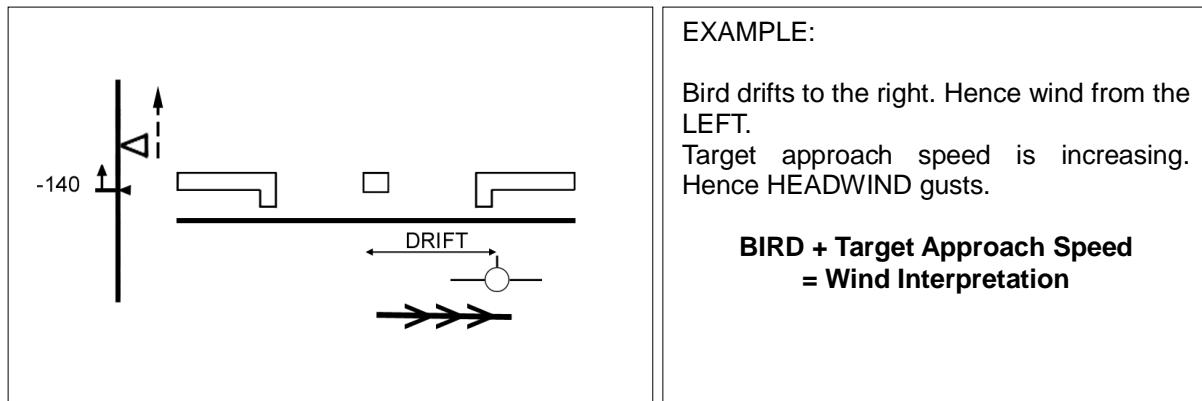
In all other cases the modes do not change (e.g. NAV - LOC - CLB - DES - ALT - G/S ...).

The BIRD is a very efficient flying reference in APPROACH since:

- It gives the TRAJECTORY PARAMETERS flown by the A/C,
- It rapidly warns the pilot of WIND DIRECTION changes and
- It rapidly warns the pilot of DOWNBURST.

**Along with the GS MINI target speed, it is an excellent indicator of shears, or wind variations.**

Furthermore just by looking at the BIRD versus the center of PFD, the pilot gets immediately the FEELING of the wind direction; consequently when the A/C reaches MDA, the pilot knows the direction where to search for the runway.



The BIRD is computed out of IRS data. It is therefore affected by the errors of the ADIRS.

This is most obvious on the TRK, which, at the end of a flight, may be typically wrong by 1,5° to 2°.

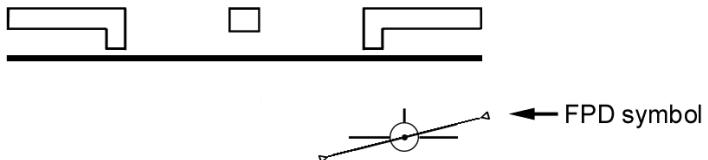
This may be easily determined during the approach.

When FD P/B is set to ON, the Flight Path Director (FPD) symbol is displayed on PFD and referred to the bird. The bird represents the A/C trajectory (TRK and FPA) and is thus affected by the **A/C inertia**.

The FPD is also referred to TRK and FPA thus affected by the A/C inertia; this gives the pilot the impression of some kind of sluggishness of the FPD orders as compared to the orders of the FD crossbars. This is inherent to the BIRD and FPD type of information.

Thus **be smooth** when you follow FPD orders.

BIRD ON with PFD



## 20 - USE OF AP/FD

These are some highlights regarding the use of AP/FD.

- The APs/FDs are an assistance to the pilot to fly the aircraft **WITHIN** the NORMAL FLIGHT envelope in order to achieve the best performance in T/O, GA, CLB or DES phases. In order to follow the ATC clearances (lateral or vertical) and in order to fly down and autoland the A/C repetitively with very high accuracy for CAT II and CAT III conditions.
  - ➔ AP can be set ON when the aircraft is within the Flight Envelope (attitude, bank, speed). It automatically goes OFF, when normal flight envelope is significantly exceeded.
  - ➔ Don't try to engage the AP when it is out of the Flight Envelope; the FBW control laws are there to assist you to BEST come back within the flight envelope according to your chosen strategy.
- The APs/FDs operate in MANAGED & SELECTED modes. The choice of the modes is a strategic decision of the pilot. The pilot chooses Managed modes when he expects the aircraft to fly along the preplanned F.PLN he has inserted in the MCDU. He chooses Selected modes for specific ATC interventions (e.g. radar vectors), or when time does not permit to reprogram the FMS to fulfill an ATC clearance.

As a general rule the MANAGED modes may be used when the FMS works properly, which essentially means that:

- the FMS Navigation Accuracy has been crosschecked and is good, or if GPS available, GPS is primary,
- the ACTIVE F.PLN is meaningful: in other words, the intended lateral & vertical trajectory is inserted, and the sequencing of the F.PLN is properly monitored.
  - ➔ If these 2 conditions are NOT fulfilled, use SELECTED modes and monitor using Raw Data.
- The 2 main interfaces to AP/FD are the FCU and the MCDU.
  - The FCU is the SHORT TERM interface to AP/FD. This means that when you have to achieve a short term intervention (ATC HDG, expedite, speed etc...). SELECT it on the FCU. You will do it head up and by far more rapidly.
  - The MCDU is the LONG TERM interface to AP/FD. This means that, in most cases except DIR TO. You will prepare the long term lateral or vertical revisions or you will PRESET SPEEDs for next flight phases on the MCDU. This is the reason why it is important to use all the facilities available to get prepared for future events (e.g Preset of speeds, SEC.FPLN, etc.).  
 If future events are prepared, this allows you to use the MCDU for SHORTER TERM type of interventions such as LATE CHANGE of RWY, CIRCLING, DIVERSION en ROUTE, or DIVERSION to ALTN.

**ANTICIPATE WITH THE FMS**

- The FCU and MCDU have to be used according to following rules so as to ensure:
  - safe operation (proper entries made),
  - safe inter pilot communication (know each other intentions) and
  - comfortable operation (use “available hands” where there are).
- The FCU:
  - ⇒ When AP is ON, PF selects targets and modes; he announces them.
  - ⇒ When AP is OFF, PF asks PNF for selection; PNF confirms.  
In case PNF is using R/T with ATC, PF may do it himself but must announce it to PNF.
- THE MDCU: the same rule applies. A systematic crosscheck must be carried out.  
Low altitude time consuming entries into MCDU are to be avoided below 10000 ft and restricted to those which are essential, which are short and which bring obvious operational advantages: tower wind on PERF APPR, DIR TO, RADNAV entry, LATE CHANGE of RWY, ACTIVATE SEC FPLN, ENABLE ALTN.
- Any entry on the FCU must be confirmed by a CHECK of the related TARGET and MODE on PFD/FMA. Any major entry on the MCDU must be cross-checked.
- Be aware that when you act on the FCU or MCDU, you give an ORDER to the AP/FD. This means that you expect the aircraft to fly accordingly.
  - Keep always in your mind those 2 questions:
    - ⇒ WHAT DO I EXPECT THE A/C TO FLY NOW ?
    - ⇒ WHAT DO I EXPECT THE A/C TO FLY NEXT ?
  - If the aircraft does NOT obey to your order
    - ⇒ Possibly SELECT the TARGET you wish, if previously MANAGED
    - ⇒ Or set AP OFF, and FLY the A/C manually according to your expectation.
- The FMA indicates which of AP/FD/ATHR is ON and the operating modes. The pilot must watch the FMA, as well as the guidance Targets in order to know whether the AP/FD/ATHR work according to his intent, and what will happen next.

**PF must watch the FMA and announce Mode Changes to PNF**

- To set the AP OFF, use the I/D (Instinct Disconnect p/b) on the stick.  
The instinctive override action on the stick consists in pushing or pulling the stick while AP is ON; this action sets the AP OFF. It is to be used as per design intent, that is in case of an instinctive reaction (to an AP hard over for example).
- When you hand fly the aircraft with FDs ON, the FD bars or FPD symbol give you lateral and vertical orders according to the active modes which YOU HAVE CHOSEN. As a consequence:
  - ⇒ Fly with FD or FPD centered.
  - ⇒ If you do NOT follow FD orders, set it OFF.

It is strongly recommended to set both FDs OFF; this ensures the ATHR SPEED mode, if ATHR ON.

- The AP can be engaged **WITHIN** the normal flight envelope, 5" (100 ft) after lift off.

It may be used:

- down to the A/C landing roll out in case of **AUTOLAND**, within the limitations provided in FCOM,
- down to MDA in other approaches.

- It may also be used in case of:

- Engine failure without any restriction including **AUTOLAND**, within the demonstrated limits,
- **Abnormal configuration, down to 500 ft AGL**; extra vigilance is required in those configurations and the pilot must be ready to take over should the aircraft deviate from its intended and safe flight path. (Abnormal configuration includes slats/flaps abnormal).

## 21 - USE OF ATHR

### ❖ Principle

The ATHR computer (within the FG) interfaces directly with the engine computer: the FADEC.

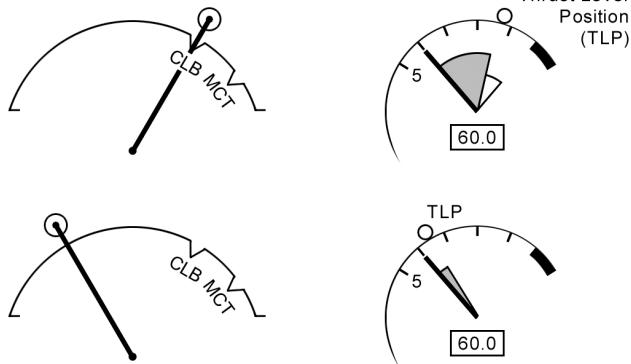
The ATHR sends to the FADEC the thrust targets necessary:

- To acquire and maintain a target speed when in SPEED mode.
- To get a specific thrust setting (CLB, IDLE ...) when in THRUST mode.

When the ATHR is ON, the thrust lever position determines the MAXIMUM THRUST which can be commanded by the ATHR when in SPEED or THRUST mode. Thus the thrust levers with ATHR ON act like a thrust limiter or as a thrust rating panel.

The thrust levers are not BACK DRIVEN by the ATHR computer; they are positioned by the pilot in a specific detent on the thrust lever range.

The monitoring cues of the ATHR system are THE REAL ENERGY CUES of the A/C:



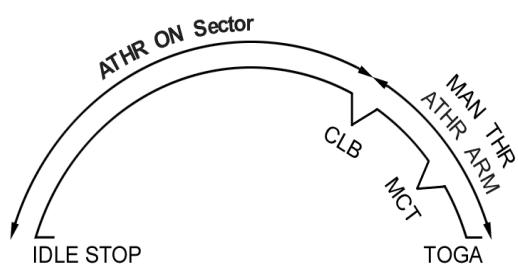
- Speed, acceleration or deceleration materialized by the speed trend vector.
- N1 and N1 command on N1 gauge.

**Thrust lever position (TLP)  
determines maximum Thrust for  
ATHR**

In other words the thrust lever position is NOT a monitoring cue of the proper functioning of the ATHR; with a conventional Autothrottle, thrust lever position should Not be either considered as a cue since in many hazardous cases, the thrust lever position is misleading (Eng fail, thrust lever jammed ...).

### ❖ How to use it?

In **ALL ENGINE OPERATIVE** situation.  
The ATHR may be ON, only when the thrust levers are in between IDLE STOP and CLB detent.  
When thrust levers are **BEYOND** the CLB detent, the thrust is controlled **MANUALLY** to the thrust lever position and the ATHR is armed.



ATHR armed means that the ATHR is ready to be back ON, when the pilot sets the thrust levers back into the CLB detent (or below). ATHR is displayed blue in the FMA.

At T/O the thrust levers are set either full forward to TOGA or in the FLX detent; the thrust is controlled manually to the thrust lever position, and the ATHR is armed; thus it is indicated blue on FMA.

After T/O when reaching the THR RED ALT, the thrust levers are set back by the crew in the CLB detent, which sets the ATHR ON. MAX CLB will therefore be the maximum normal thrust setting, which will be commanded by the ATHR in CLB, CRZ or DES and APPR if required.

If one thrust lever is set BELOW CLB detent, the FMA outputs a message LVR ASYM to remind this fact to the crew (e.g. this configuration might be required by a high vibration level on one engine).

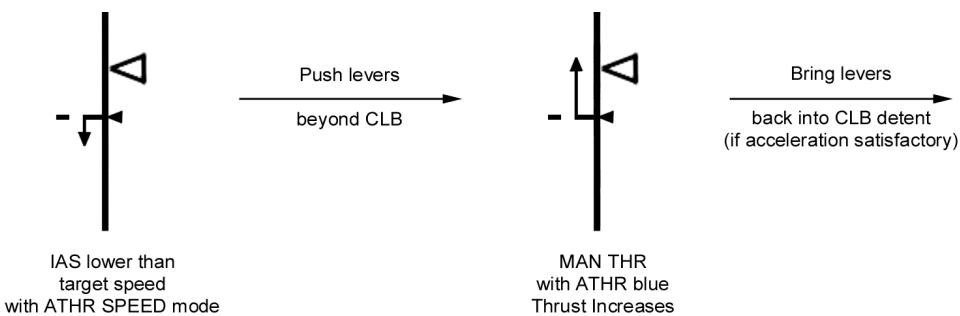
But if ALL thrust levers are set BELOW CLB detent with ATHR ON, then a REPETITIVE ECAM CAUTION is triggered, because there is NO OPERATIONAL REASON to be in that situation, and to limit the ATHR authority on all the engines, permanently:

→ AUTO FLT AUTOTHRUST LIMITED caution comes up on ECAM.

In such a case, → either bring all thrust levers back into CLB detent  
→ or set ATHR OFF.

If you set all thrust levers BEYOND CLB detent while the ATHR is ON, you control the thrust manually to the thrust lever position. FMA displays MAN THR white and ATHR gets armed. LVR CLB flashes on FMA as a reminder. This technique is most efficient when the A/C speed drops significantly below the target.

Once you are satisfied with the A/C speed or acceleration, bring the thrust levers back into CLB detent. ATHR is back ON.



Speed drop in approach - Recommended Recovery Technique

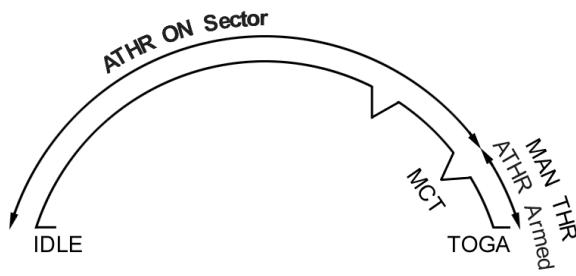
NOTE:

When you use this technique during approach, to regain VAPP for example, move the thrust levers forward of CLB detent but don't go beyond MCT. Indeed, in most cases it is useless and you risk hitting the TOGA stop which will engage the Go Around mode.

In EO Situation:

Exactly the same principles apply, except that ATHR may be ON only when the thrust levers are set between IDLE STOP and MCT.

**WITH ONE ENGINE INOPERATIVE**



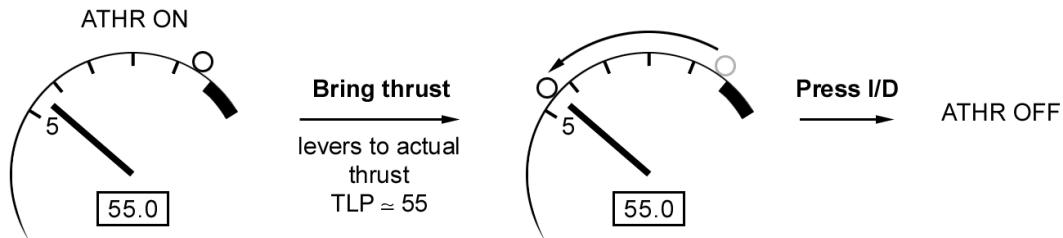
In case of EO, the levers will be in MCT detent, throughout the rest of the flight, because MCT is the maximum thrust, which may be normally commanded by the ATHR for climb or acceleration through all flight phases such as CLB, CRZ, DES, APPR.

### Set ATHR OFF

ATHR may be set OFF either by pressing the I/D on the thrust levers or by pressing the ATHR P/B on the FCU, or by bringing all thrust levers back to Idle.

The normal procedure to set ATHR OFF is to press the I/D:

- If this is done without precautions while the thrust levers are in CLB detent, the thrust will increase to MAX CLB thrust. This may cause an undesired thrust change: e.g. during approach, the ATHR, being in SPEED mode, commands N1 around 55 %. If the pilot presses the I/D, the ATHR is set OFF and the thrust goes to MAX CLB which perturbs the approach.
  - So the recommended technique to set ATHR OFF is:
    - bring back thrust levers roughly to the current thrust setting using the TLP symbol on thrust gauge,
    - press the I/D.
- This technique minimizes the thrust discontinuities, when setting ATHR OFF.



Set ATHR to OFF - Recommended Technique

You may also set ATHR OFF by setting thrust levers back to IDLE stop.

This is commonly used in descent when ATHR is on THR IDLE or at landing. Indeed during the FLARE with ATHR ON, thrust levers are set in the CLB detent. Thus when thrust reduction is required to land, bring thrust levers to the IDLE stop smoothly. This action retards the thrust and sets ATHR OFF.

The "RETARD" call out is a reminder to do so; it comes in the flare at 20 ft, except if autoland where it comes at 10 ft.

Note that once thrust levers are set back to idle and ATHR is OFF. You can set it back to ON by pressing the ATHR P/B on the FCU and bringing back thrust levers into the applicable detent. Don't delay this last action in order to avoid the ECAM "Autothrust limited" message.

It is NOT recommended to set ATHR OFF with the ATHR P/B located on the FCU.

This is considered as an UNVOLUNTARY ATHR OFF command (as if it was due to a failure - creating an ECAM action).

Consequently, the THRUST is frozen and remains LOCKED at the value it had when the pilot has pressed the ATHR P/B, as long as the thrust levers remain in the CLB or MCT detent. If the pilot moves the thrust levers out of the detent, the thrust is manually controlled and thus unlocked.

An ECAM caution and FMA message are triggered during thrust lock:

- THR LK amber on FMA. ECAM caution is:  
**AUTO FLT ATHR OFF**  
**ENG THR LOCKED**  
**THR LEVERS ..... MOVE**

In that case, whenever you move the thrust levers out of the detent, you recover full manual control and THR LK is removed from FMA.

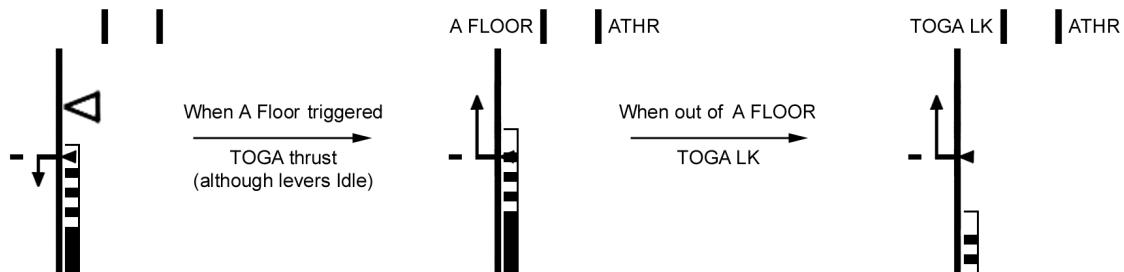
Don't use this feature, unless I/D inoperative.

#### A FLOOR

When the aircraft AOA increases BEYOND a threshold called ALPHA FLOOR, which means that the A/C has decelerated a lot (below ALPHA PROT speed), the ATHR is set ON automatically and sends TOGA thrust, regardless of thrust lever position.

Example:

A/C in descent with the thrust levers manually set at IDLE. Suppose that the A/C decelerates, while hand flying with FD OFF as indicated on FMA:



Speed scale and FMA indications in a typical A.FLOOR case

When the speed decreases so that AOA reaches the ALPHA FLOOR threshold, ATHR engages and sends TOGA thrust despite the fact that the thrust levers are in Idle position.

Suppose that now the A/C re-accelerates.

When the speed increases so that the AOA gets below the ALPHA FLOOR threshold, TOGA thrust is maintained or locked in order to allow the pilot to reduce the thrust when he JUDGES it to be necessary.

- FMA displays TOGA LK, meaning that TOGA thrust is locked.
- The only way to recover the desired thrust is to set ATHR OFF using the I/D.
- A FLOOR is available when FBW is in NORMAL LAW from lift off to 100 ft R/A at landing. It is inhibited if one engine is unserviceable.

❖ **When to use ATHR ?**

- ATHR is recommended throughout the flight. It may be used in most failures cases such as:
  - Engine failure including autoland and
  - Abnormal configurations.
- At take off, set thrust levers to FLX/TOGA as required.  
 The thrust is then manually controlled and ATHR is armed (e.g. MAN TOGA).
- At THR RED ALT, set thrust levers to CLB detent. ATHR is ON and operates in a mode, THR or SPEED, associated to AP/FD vertical mode.  
 You may keep the ATHR ON throughout the flight.
- During APPROACH, hold the thrust levers. Whenever additional thrust is required, push on the levers, not exceeding MCT detent. MAN THR is on FMA and thrust increases.  
 When enough acceleration is obtained, bring the thrust levers back into CLB notch. ATHR is back ON. Keep hands on levers.
- FLARE and LANDING  
 When thrust retardation is required, bring the thrust levers smoothly to IDLE stop. ATHR is then OFF.  
 The "RETARD" call out comes up as a reminder as long as levers are above idle.
- FOR GO AROUND  
 Set all thrust levers to TOGA. The thrust is manually controlled to TOGA; MAN TOGA on FMA, ATHR is armed.  
 Additionally SRS / GA TRK modes engage, Go Around phase activates and Missed Approach + previously flown approach become the active F.PLN.  
 In case of a Go Around at low weight, or at a higher height, once TOGA is set and the A/C is established in pitch, you may consider to set the thrust levers back into MCT or CLB detent if very high climb performance is achieved.
- ENGINE FAILURE  
 Set LIVE engine thrust lever to MCT as per FMA LVR MCT message and ECAM caution.
- MONITOR ATHR with: FMA - SPEED / SPEED TREND on PFD - N1/N1 command (EPR) on ECAM E/W-D.

NOTE:

During approach the ATHR operates in SPEED mode. There is NO automatic RETARD except in AUTOLAND. This explains why the RETARD call out comes at 20 ft in all cases, except AUTOLAND where it comes at 10 ft.

## 22 - FLIGHT DIRECTOR / AUTOPILOT / ATTHR - MODE CHANGES AND REVERSIONS

## ❖ Mode Change / Reversion Objectives

AP/FD and ATTHR operate in given modes. The choice of a mode is a strategic decision of the pilot.

The modes are therefore manually engaged by the pilot; but they may change automatically as per built in logics dictated by:

- the integration of AP/FD/ATHR,
  - the integration of FMS within AP/FD/ATHR,
  - the logical sequence of modes and
  - the so called « mode » reversions.

The integration of AP / FD / ATTHR follows the logic, the pilots apply, to control the aircraft. Indeed, there is:

## A DIRECT RELATION BETWEEN A/C PITCH CONTROL and ENG THRUST CONTROL in order

- to manage the A/C energy,
  - if AP/FD pitch mode controls a vertical trajectory (e.g. ALT, V/S, FPA, G/S etc.),  
→ the **ATHR controls a SPEED**,
  - if AP/FD pitch mode controls a speed (e.g. OP CLB, OP DES etc.),  
→ the **ATHR controls a THRUST** (THR CLB, THR IDLE)
  - if NO AP/FD pitch mode – i.e. AP OFF and FD OFF,  
→ the **ATHR controls a SPEED**.

Thus, when there is an AP/FD pitch mode change, there is an associated ATTHR mode change.

**NOTE:**

This explains why on FMA, the ATTHR mode and the AP/FD vertical mode columns are adjacent.

## The logical sequence of modes:

- It is « normal » for an A/C to climb towards a given altitude; thus it is logical that if a pilot selects a V/S mode towards a target altitude, or if he wishes to climb towards a target altitude in OP CLB, the AP/FD provides the order to climb, capture and then track this altitude.

Thus when you engage those modes you will simultaneously and automatically ARM the NEXT LOGICAL mode. For example:

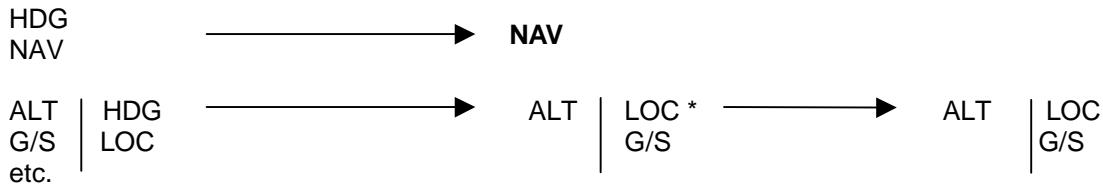


The modes then change sequentially.

- The pilot may also in some cases ARM himself a mode in advance, because he wishes the AP/FD to intercept a given trajectory.

Typically NAV, LOC - G/S, APPNAV - FINAL may be ARMED by the pilot.

When the capture or tracking conditions occur, then the modes will change sequentially: e.g.



As a summary, such LOGICAL MODE CHANGES occur when modes are ARMED and indicated BLUE on PFD.

#### The integration of FMS within AP/FD/ATHR

When a pilot has defined a FPLN, the FMS considers this FPLN as a WHOLE, that is LATERAL + VERTICAL FPLN. Consequently the FG will guide the A/C along the FPLN as a WHOLE, that is:

- along the LAT FPLN (NAV – APP NAV modes) and
- along the VERT FPLN (CLB – DES – FINAL modes).

**Vertical Managed modes can only be used,  
if Lateral Managed NAV mode is used.**

But if the pilot elects to fly away from the lateral FPLN, the FG will no longer guide along the vertical FPLN.

Thus, if for example:

- HDG (TRK) mode is selected, while NAV is engaged along with CLB or DES modes, then CLB/DES mode will disengage and a mode reversion will occur.

#### The mode reversions

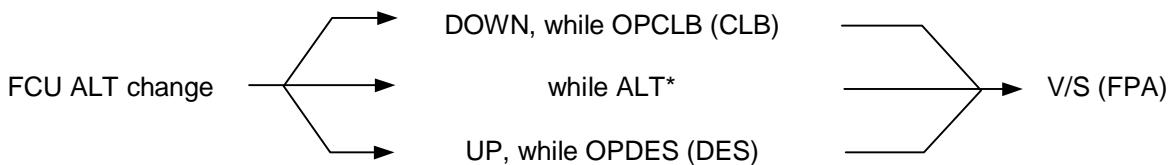
The mode reversions are automatic mode changes which occur somehow unexpectedly, but which ensure a COHERENT AP/FD/ATHR operation following pilot interventions:

- the pilot CHANGES the FCU ALT TARGET in specific conditions,
- the pilot ENGAGES a mode on ONE AXIS which automatically DISENGAGES the associated mode on the OTHER AXIS and
- the pilot HANDFLIES the A/C with FD ON, but does NOT follow the FD ORDERS thus leading the A/C to the border of the Flight Envelope.

In all those cases a MODE CHANGE or REVERSION WILL OCCUR.

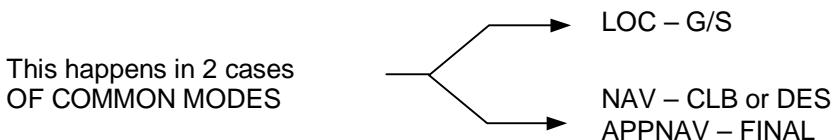
❖ MODE REVERSION MECHANIZATION

- A. The pilot CHANGES the FCU ALT TARGET making the active VERTICAL MODE impossible:



This reversion to V/S (FPA) mode on current V/S target, does not modify the PITCH behavior of the A/C. It leaves it to the pilot to change it as required.

- B. The pilot engages a mode on one axis, which DISENGAGES the ASSOCIATED mode on the OTHER AXIS.



The logic is as follows:

In CLIMB:

If CLB/NAV are engaged and then if HDG or TRK mode is selected

⇒ CLB reverts to OP CLB

In DES:

If  $\left. \begin{array}{l} \text{DES/NAV or,} \\ \text{FINAL APPR or} \\ \text{selected} \\ \text{LOC - G/S} \end{array} \right\}$  are engaged and then if HDG or TRK mode is

⇒ DES or FINAL or G/S revert to V/S.

This reversion does not modify the PITCH behavior of the A/C.

It leaves it to the pilot to decide what to do next, according to circumstances.

Note that HDG may be either manually selected by the pilot, or automatically in case NAV is engaged and the A/C flies into a LAT FPLN DISCONTINUITY (LAT DISCONT AHEAD message).

NOTE:

In case of LOC - G/S or FINAL APPR modes, if V/S (FPA) is selected, the lateral mode reverts to HDG (TRK).

**C. The pilot hand flies the A/C with FD ON, and does NOT follow the FD PITCH ORDERS**

This reversion is an ATHR MODE REVERSION effective when the ATHR is in THRUST MODE (THR IDLE, THR CLB) and the A/C reaches the BORDERS of the SPEED ENVELOPE (VLS, VMAX), because the pilot does not handfly the FD pitch orders:

- If | THR IDLE | OPEN DES (DES) | and the pilot pitches the aircraft Up, the speed decreases.

Reaching VLS            ATHR REVERTS TO SPEED MODE.

- If | THR CLB | OPEN CLB (CLB) | and the pilot pitches the aircraft DOWN, the speed will increase.

Reaching VMAX            ATHR REVERTS TO SPEED MODE.

The ATHR in SPEED mode automatically readjusts the thrust to regain the target speed.

On latest aircraft versions, FD bars are REMOVED, since they are NOT FOLLOWED by the crew.

THE MODE REVERSIONS, which are sometimes unexpected, are an ADDITIONAL REASON TO PROPERLY MONITOR THE FMA.

## 23 - FMS NAVIGATION ACCURACY - CROSSCHECK, POSITION UPDATE, GPS

### ❖ General

The FIRST and ESSENTIAL function of the FMS is NAVIGATION; which is to compute the FMS position as accurately as possible.

The validity of all the other FMS functions depends upon the accuracy of the FMS position.

Furthermore, the ACCURACY of the FMS position dictates the strategy which the pilot will apply in the use of Autopilot / Flight Director modes as well as on the type of display to be used on the ND.

FMS NAV ACCY → { Auto Pilot / Flight Director modes (managed or selected).  
ND modes (Arc - Rose NAV / Rose VOR – ILS, raw data).  
EGPWS (ON/OFF).

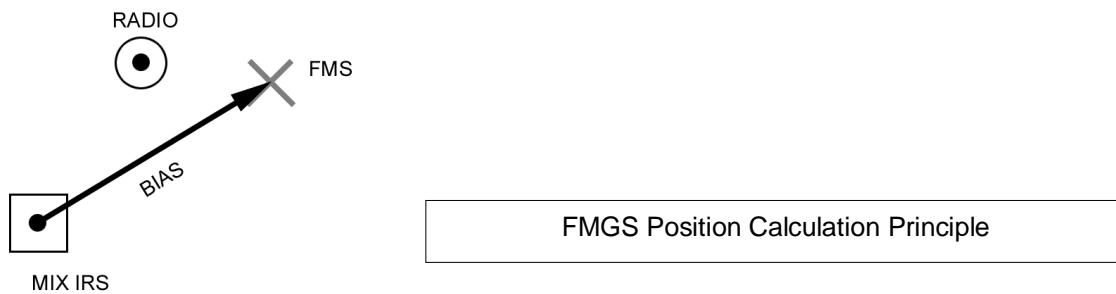
**FMS NAV ACCY check is a Periodic Drill  
to be achieved throughout the flight.**

### ❖ Reminder of key points in aircraft position computation

#### Without GPS Primary

The FMS position is derived from the 3 IRS positions which are blended into a MIX IRS position and from a RADIO position whenever 2 DMEs, or a VOR/DME, or a GPS supplemental are available. The GPS supplemental is considered as an additional kind of navaid; it is accepted if it falls within a circle around the radio or the MIX IRS position.

When a RADIO position is available, the FMS position tends towards the Radio position.



Hence the FMS continuously computes:

- the FMS position out of MIX IRS and RADIO positions,
- the BIAS between MIX IRS and FMS position, so as to benefit from the latest update when the RADIO position becomes unavailable and
- the ESTIMATED POSITION ERROR (EPE) of its own position.

The ESTIMATED POSITION ERROR (EPE) is an ESTIMATE; this means that the FMS considers the instantaneously available navigation means used in the elaboration of the FMS position, applies specified tolerances to each one of them and processes the EPE. Those tolerances assume that the navigation means work properly; but they ignore possible excessive drifts of the IRSs, or erroneous locations of navaids within the Nav Data Base, for example.

Consequently the HIGH / LOW accuracy information provided on PROG page are INDICATORS to the crew of the POTENTIAL ACCY of the FMS position versus a specified accuracy criteria.

The EPE is an ESTIMATE.  
HIGH/LOW and thus NAV ACCY UPGRADED/DNGRADED messages are merely  
INDICATORS to the crew of the estimated accuracy of the FMS position  
versus required criteria.

### With GPS Primary

- The GPS directly interfaces with the IRSs which output a GPIRS position.  
When a GPIRS position is available, it supersedes the RADIO position if available, so that the FMS position tends to the GPIRS position.

The GPS provides 2 essential data, additionally to position (Lat/Long/Alt):

- **The ACCURACY** of the Lat/Long position: it is a direct function of the satellite constellation in view of the aircraft. If the satellites are low on the horizon, or if their respective position is unfavorable, the resulting accuracy will be poor. It is provided as a "Figure of Merit".  
This accuracy can be computed with a high probability of confidence.
- **The INTEGRITY**, which is a direct function of the number of satellites in view of the aircraft, allows a defective or erroneous satellite to be rejected. If 5 or more satellites are in view, several combinations of those satellite signals may be used to process "several positions" and to carry out reasonableness tests on the satellite signals themselves.

Therefore if the GPS position (or GPIRS position) fulfills the INTEGRITY and ACCURACY criteria, this means that this position is the BEST RAW DATA position available.

GPS PRIMARY = ACCURACY + INTEGRITY CRITERIA met > GPIRS = RAW DATA

#### ❖ Some details on the information provided:

#### PROG Page:

- Indicates GPS PRIMARY.
- Indicates the value of the Estimated Navigation Accuracy in green. It is either the one as computed by the GPS when GPS PRIMARY is available, or the EPE when GPS PRIMARY is LOST.
- Indicates the Required Navigation Accuracy in blue. To day it is either the Navigation accuracy criteria as required in cruise, TMA or approach area, or it can be manually inserted.
- If the Estimated Nav Accy is less than the Required Nav Accy, HIGH accuracy is displayed (or LOW if vice versa). These indications will allow the RNP concept (required nav performance) linked to FANS to be addressed.

#### NOTE:

RNP is equivalent to required navigation accuracy.

**SELECTED Navaid page:**

**DESELECT GPS prompt:**

- it is provided in order to allow the crew to prevent the FMS from using the GPS data for position computation, should a major problem occur with GPS. GPS PRIMARY LOST message is then displayed on MCDU and ND. The GPS can be reselected later on the same page.

**GPS PRIMARY prediction page:**

- GPS PRIMARY allows the crew to carry out approaches down to MDA 250 ft AGL. GPS PRIMARY criteria (INTEGRITY + ACCURACY) depends upon the SATELLITE CONSTELLATION status at a given time, in a given location; this is predictable (ephemerides). Therefore, it is most valuable for crews to know if GPS PRIMARY will be available at DESTINATION, or at ALTN. This information is provided on GPS PRED page when the A/C is fitted with IRS Honeywell.

**ND / MCDU messages:**

- GPS PRIMARY- When GPS PRIMARY is again available. This message is clearable.  
 GPS PRIMARY LOST: when GPS PRIMARY is lost. Clearable on MCDU but not on ND.

**❖ Summary**

FLIGHT PHASE		FMS POSITION	
		WITHOUT GPS PRIMARY (no GPS or GPS supplemental)	GPS PRIMARY
On ground before T/O		MIX IRS	GP IRS
T/O		Updated at runway threshold (shift)	
GPS AVAIL	With Navaids	Tends to RADIO	GP IRS
	Without Navaids	MIX IRS + BIAS	GP IRS
GPS PRIM LOST	With Navaids	Tends to RADIO	
	Without Navaids	MIX IRS + BIAS	

**NOTE:**

When GPS is supplemental (hybrid function), it is considered as a navaid, thus it is part of the Radio Position.

**NOTE:**

FMS/GPS POSITION DISAGREE message comes up from time to time when  $[\text{FM} - \text{GPS}] \geq 0.5 \text{ NM}$  in LAT or LONG. This occurs due to different reference co-ordinates being used in New Data Base, in T/O or LOC update cases.

## ❖ Operational Consequences

### General rules:

- Use HIGH / LOW as INDICATORS.
- Periodically CROSSCHECK NAV ACCY. Once in climb, every 45 mn in cruise and before TOD, reaching TMA and IAF, and whenever a navigation doubt occurs.
- Use NAV ACCY DNGRADED message as an indication to crosscheck the navigation accuracy.
  - If GPS is PRIMARY, crosscheck is not necessary.
  - If GPS PRIMARY is LOST, crosscheck is necessary.

### Consequences of the crosscheck:

- The result of the NAV ACCY crosscheck determines the operational consequences. It is not the role of NAV ACCY UP/DN GRADED messages or HIGH/LOW indications which are merely indicators, and must be used to trigger a crosscheck.
- The operational consequences of the nav accy crosscheck are:  
If the crosscheck is POSITIVE or GPS is PRIMARY:
  - AP/FD Lateral / Vertical Managed modes MAY BE USED,
  - ND ARC and ROSE NAV modes ARE USED by both PF & PNF with needles, when required and
  - EGPWS is set to ON.

### If the crosscheck is NEGATIVE:

- AP/FD Lateral / Vertical Managed modes may be used WITH CARE except in Approach where selected modes have to be used.
- ND ARC and ROSE NAV may be used WITH CARE and WITH RAW DATA by PF and PNF except in approach where PF has to refer to raw data systematically.
- Be prepared to switch to selected modes and to ROSE VOR/ILS, if you have a doubt.
- EGPWS must be set to OFF.

### NOTE:

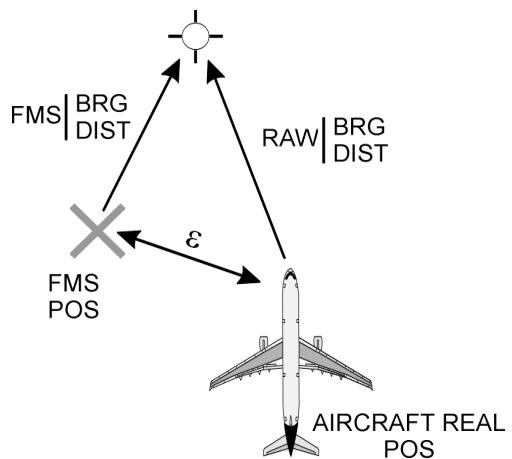
Whenever a doubt arises, revert to selected modes and raw data only, to avoid any confusion. On the other hand one must be aware that, in cruise for example, if no navaid available and no GPS primary, the EPE continuously rises without any damageable consequence. The FMS position slowly drifts along with the drift of the IRSs, while its position is affected by the latest determined bias.

Navigation accuracy crosscheck technique:

The principle consists in comparing the Bearing/Distance:

- as calculated by the FMS position and given navaid stored in the FMS data base,
- as directly provided by the Raw Data received from the navaid which materializes the relative position of the aircraft with the navaid.

The difference allows the error  $[\varepsilon]$  to be quantified.

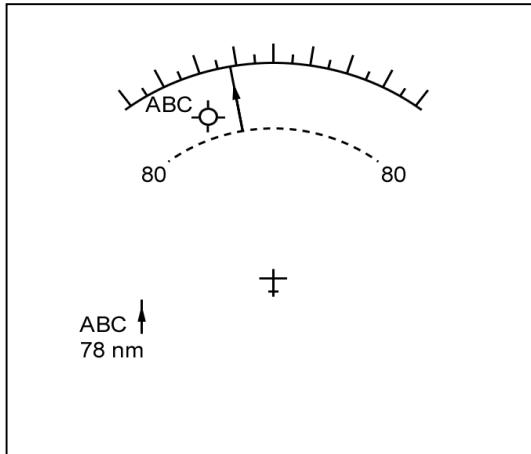


- Technique used in the various flight phases:

**En Route:**

- On ND use the relative position of the pointer with the navaid symbol and the DME distance versus the distance to the navaid symbol materialized by the range markers. This allows a quick visual nav accy crosscheck. Possibly use RADAR MAP image when flying over oceans and reaching islands or a coast line.

**FMS NAV ACCY  
cross check principle**



Note:

It is also possible to use raw data provided on the DDRMI, which is associated to the tuned navaid on RAD NAV page, to compare with FM computed data by entering VOR name on PROG page (BRG/DIST TO).

- In Descent, TMA and approach:

- insert destination or arrival VOR/DME ident on NAVAID and on PROG pages (BRG/DIST field) on PF side and
- compare DME and Needle Bearing on ND, to BRG/DIST on PROG page and determine the difference.

Strategy in Non Precision Approach:

- A Non Precision Approach is flown using AP/FD managed modes and ND ARC or ROSE NAV, display modes only if the FMS NAV ACCY crosscheck is POSITIVE or GPS is PRIMARY.
  - In case of no GPS available, the reference navaid raw data of the NPA must be displayed, at least on PF side. [e.g. VOR/DME approach. The VOR/DME raw data (pointer + DME) must be selected on PF side].
  - In case of GPS PRIMARY, this is not compulsory.
- In case the **NAV ACCY DNGRADED** msg comes up, proceed immediately with a **NAV ACCY CROSS CHECK**:
  - if POSITIVE, continue as before and
  - if NEGATIVE, revert to SELECTED MODES, and SELECT ROSE VOR at least on PF side.
- In case of GPS PRIMARY, two types of approaches are flown:
  - the NPA defined with a VOR, VOR/DME, TAC, ADF... (also called overlay approaches):
    - ➔ although not compulsory, it is recommended to select the associated needles on the ND.
    - ➔ in case GPS PRIMARY LOST msg comes up, proceed immediately with a NAV ACCY CROSS CHECK and adapt your strategy as if no GPS is available.
  - The NPA is a GPS defined approach:
    - ➔ the raw data is the FMS position and
    - ➔ in case GPS PRIMARY LOST msg comes up, the approach must be interrupted.

❖ **Position Update on PROG page**

This function is to be used **EXCEPTIONALLY** in case a MAJOR MAPSHIFT occurs, or in case of an obvious major position error, noticed by specific messages such as CHECK A/C POSITION, FM1/FM2 POS MISMATCH...

After having analyzed the situation, the UPDATE will be decided or not.

The RECOMMENDED TECHNIQUE is to carry out an UPDATE OVER a beacon by pressing the UPDATE prompt once, estimating that the A/C overflies the beacon, using the associated needle.

The potential induced error at FL390 is approximately 4 to 5 NM. When a position update is achieved, the EPE is automatically set to a higher value, and Navigation Accuracy is Low.

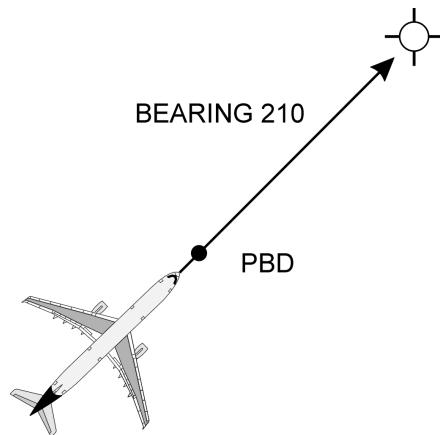
However this update will allow the FMS to resume its normal navigation function.

**NOTE:**

Another technique which may be used WITH CARE is to update on a BRG/DIST from the beacon. Insert P/B/D in the update field and when you reach it, press UPDATE.

The potential induced error is by far lower when DIST is over 60 NM.

Be careful with the bearing value you insert. Be aware that you have to insert a BEARING (do not make a 180° error).



Exceptional position update technique

## 24 - FLIGHT CONTROLS - HIGHLIGHTS ON HANDLING CHARACTERISTICS

The relation between the pilot input on the stick and the aircraft response is called the CONTROL LAW which determines the HANDLING CHARACTERISTICS of the A/C.

The Fly by wire system accommodates for 3 sets of control laws depending upon the integrity and redundancy status of the computers, peripherals and of hydraulic generation. These 3 sets are: NORMAL LAW - ALTERNATE LAW - DIRECT LAW.

### ❖ Normal Law

The Normal Law is most commonly available and accommodates single failures.

The handling characteristics of the normal law within normal flight envelope are:

- the aircraft is STABLE and MANEUVERABLE,
- same response is obtained from the aircraft consistently,
- the efforts on stick are balanced in pitch and roll.

} regardless of A/C IAS,  
Altitude, GW and CG.

The handling characteristics of the normal law at the border of the flight envelope are:

- full authority given to the pilot to achieve Maximum Performance of the A/C,
- allow an instinctive / immediate reaction from the pilot in emergency and
- reduce the potential to overcontrol / overstress the aircraft.

In general, when the pilot acts on the stick, he directly orders an aircraft response (pitch or roll rate, or...). Thus the aircraft directly achieves the pilot orders; there is no longer a need to "bracket" on the stick as on a non fly by wire aircraft where the pilot had to continuously adjust the stick and trim so as to get the desired aircraft behaviour.

### CHARACTERISTICS IN PITCH

When acting on the stick the pilot commands a constant G load maneuver and the aircraft response is G Load / Pitch rate. The pilot order is therefore consistent with the aircraft response "naturally" expected by the pilot, Pitch rate at low speed / Flight Path rate or G at high speed.

Hence STICK FREE, the A/C maintains the flight path even in case of speed changes. Furthermore, STICK FREE in case of Configuration changes, or thrust variations, etc... the pitching moment effects are reduced by the feedbacks in the control law itself and compensated for by precommands. With STICK FREE in turbulence, small deviations do occur on the flight path but with a tendency of the A/C to regain a steady condition.

As a consequence the A/C is a STABLE PLATFORM and AUTOTRIMMED; it needs to be flown with minor corrections from the pilot on the stick, when the A/C deviates from its intended flight path.

**Don't fight with the stick; if you feel you overcontrol, release the stick.**

The pitch law as described here above is NOT best suited for TAKE OFF and FLARE, where stable flight path is NOT what the pilot naturally expects.

Hence the computers adapt AUTOMATICALLY the control laws to the flight phases, transparently to the pilot:

- GROUND LAW** → the control law is DIRECT law and  
**FLARE LAW,** → the control law is PITCH law.

As a consequence, those maneuvers are achieved most naturally. The Flare, for example, requires a permanent AFT pressure on the stick from the pilot to achieve a progressive flare, and the derotation consists in smoothly flying the NLG down with a small aft pressure on the stick.

## LATERAL CHARACTERISTICS

When acting laterally on the stick, the pilot orders and gets, most naturally, a ROLL RATE.  
Hence STICK FREE, he orders 0 roll rate; thus the current bank angle is maintained within  $\pm 33^\circ$ .

As a consequence, the A/C is LATERALLY STABLE and NO AILERON TRIM is required.

But the lateral law is also a mixture of ROLL and YAW demand with:

- Automatic Turn coordination,
- Automatic Yaw damping and
- Yaw damper initial response to a major aircraft assymetry.

During a Normal Turn (bank within  $\pm 33^\circ$ ), in level flight:

- move the stick laterally only since there is pitch compensation in turn,
- the more you move the stick laterally, the greater the resulting roll rate (e.g.  $15^\circ/\text{sec}$  at max deflection) and
- you don't need to use the rudder.

In case of Steep Turns (bank angle greater than  $33^\circ$ ), you have to hold a lateral pressure on the stick to keep the bank and an aft pressure on the stick to keep level flight.

Indeed spiral stability is reintroduced and pitch compensation is suppressed beyond  $33^\circ$ , since there is no operational reason to fly with such high bank angles for a lengthy period of time in normal circumstances.

## REACTION TO ENGINE FAILURE

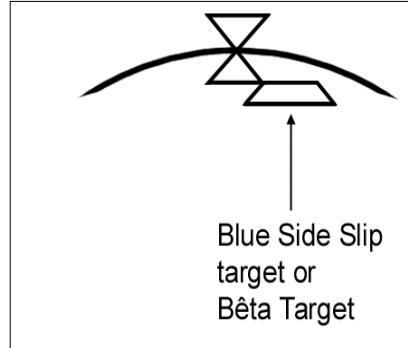
If an engine failure occurs and the pilot maintains stick free, the natural tendency of the A/C to roll and yaw is CONTAINED by the lateral normal law.

STICK FREE, the A/C will reach approximately  $5^\circ$  constant bank, a constant side slip, and a slowly diverging heading rate.

### The lateral behaviour of A/C is quite safe !

But the pilot is then the **BEST** to adapt the lateral trimming technique to the experienced circumstances. Actually the most effective flying technique performancewise with engine failure at T/O is to fly **CONSTANT HDG** with **ROLL SURFACES RETRACTED**. This dictates the amount of Rudder required, and the **RESIDUAL SIDE SLIP** resulting from that technique.

Hence in order to indicate the amount of rudder required to fly properly with an EO at T/O, the measured SIDE SLIP index is SHIFTED on the PFD by the residual side slip computed value, and displayed in blue instead of yellow, and called **BETA TARGET**; by pressing the rudder pedal to center the BETA TARGET index, the pilot will fly with the RESIDUAL SLIP as required by the EO condition. Thus the A/C will fly at constant heading with roll surfaces retracted.



As a summary, in case of engine failure at T/O:

- smoothly pitch the A/C down to keep safe speed (as per SRS),
- no hurry to react on the pedals, since the A/C is laterally safe,
- center the Beta target with rudder pedals and
- zero the residual heading drift with small lateral stick inputs.

### PROTECTIONS

One of the essential tasks of a pilot is to keep the A/C within the normal flight envelope, for safe and high performance flight completion.

This task is not very easy on older generation aircraft when encountering dangerous or hazardous situations, such as windshear.

The purpose of the protection provided is:

- to give **FULL AUTHORITY** to the aircrew to **CONSISTENTLY** achieve the **BEST POSSIBLE A/C performance** in those extreme conditions,
- to **reduce the risks** of overcontrolling or overstressing the A/C and
- to provide the pilot with **AN INSTINCTIVE** and **IMMEDIATE PROCEDURE** to achieve the best possible performance when required.

### The following protections are provided:

BANK ANGLE PROT	(max 67° - corresponding to a 2.5 g turn)
LOAD FACTOR PROT	(max 2.5 g in clean)
MAX PITCH PROT	(30° Nose Up – 15° Nose Dn)
HIGH AOA PROT	(for BEST AERODYNAMIC PERFORMANCE)
HIGH SPEED PROT	(not to overshoot design speed limits)

these 3 are linked

These protections have NOT been designed to allow pilots to exceed the **NORMAL FLT ENVELOPE**, which is considered as **VIOLETION**. These protections have been designed to assist pilots in emergency situations, where under stress conditions only an instinctive and rapid reaction will save the situation. The protections make this reaction possible. See chapter 22.

❖ **Alternate Law**

In some cases of double failure, the integrity and redundancy of the computers and peripherals are not high enough to achieve the Normal law with its protection.

The degradation is progressive depending upon the availability of remaining peripherals or computers.

The ALTERNATE LAW characteristics (triggered usually in case of 2 failures) are:

- Pitch Law = same as normal law with FLARE in DIRECT,
- Lateral Law = Roll Direct,
- most protections lost except:
  - ➔ Load factor protection and
  - ➔ Bank angle protection if roll normal still available.

What happens at the border of the flight envelope ?

It is as on a **NON PROTECTED A/C**:

- in high speed, natural aircraft static stability is restored with OVER SPEED WARNING and
- in low speed, the auto pitch trim stops at  $V_c$  prot (below VLS) and natural longitudinal static stability is restored, with STALL WARNING at 1.03 VS1g.

NOTE:

In certain failure cases such as loss of VS1g computation or loss of 2ADRs, the longitudinal static stability cannot be restored at low speed; in case of loss of 3ADRs it cannot be restored both at low and high speed.

The yaw is either yaw alternate associated to roll direct or mechanical yaw all through pedals and rudder trim.

As a summary with ALTN law:

- within the Normal Flight Envelope, the handling characteristics are the same in pitch as with the normal law and
- outside the Normal Flight Envelope, the pilot must take proper preventive actions to avoid loss of control, or high speed excursions as he would do it on any non protected A/C.

Note that, in ALTN law VMO is reduced to 320 kt and that A.FLOOR is inhibited.

❖ **Direct law**

In case of triple failure (e.g. IR or DOUBLE IR (2<sup>nd</sup> not self detected)), direct law is triggered:

- elevator deflection is proportional to stick deflection; the maximum deflection is a function of CONF and CG,
- aileron and spoiler deflections are proportional to stick deflection but vary with the A/C CONF and
- pitch trim is commanded manually.

As a summary with DIRECT law:

The handling characteristics are those of a **very good natural aircraft quasi independent of CONF and CG**, and thus obviously with no protections, no automatic pitch trim, but with overspeed or stall warnings.

NOTE:

Refer to FCOM 1.27.30 for complete information.

❖ Indications

The degradation of control laws is indicated on ECAM as well as on PFD.

On ECAM:

in ALTN:	ECAM EW/D	<b><u>FLT CTL ALTN LAW (PROT LOST)</u></b>	MAX
SPEED 320			
in DIRECT:	ECAM EW/D	<b><u>FLT CTL DIRECT LAW (PROT LOST)</u></b>	MAX
SPEED 320/.77		MAN PITCH TRIM USE	

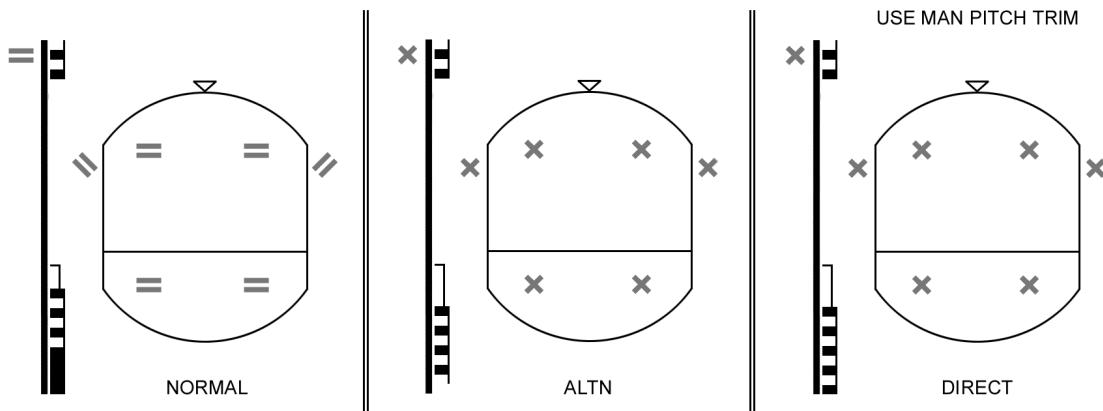
On PFD:

The flight control status awareness of the crew is enhanced on the PFD.

Indeed the availability of PROTECTIONS is outlined by specific symbols = (green), and by the specific formatting of the low speed information on speed scale, in normal law.

When protections are lost, amber crosses X are displayed instead of the green protection symbols =.

When automatic pitch trim is no longer available, this is indicated as USE MAN PITCH TRIM amber message below the FMA.



Fly By Wire status awareness through the PFD

Just by watching his main instrument the PFD,  
the pilot is immediately aware of the control law status and ops consequences

❖ Additional information regarding control laws

**THE MECHANICAL BACK UP**

The purpose of the mechanical back up is to be able to achieve all safety objectives in MMEL dispatch condition, thus to cover a TEMPORARY TOTAL ELEC LOSS, or a TEMPORARY LOSS OF 5 FBW COMPUTERS, or to cover the loss of BOTH ELEVATORS, or a total loss of AILERONS and SPOILERS.

In case of such MOST IMPROBABLE FAILURE, the mechanical B/UP allows the pilot to SAFELY STABILIZE THE AIRCRAFT using the RUDDER and MAN PITCH TRIM while reconfiguring the systems.

Pitch control is through Pitch Trim Wheel. Act smoothly on it since the effect of the THS is very important due to its large surface.

Lateral control is through RUDDER: the rudder induces a significant roll with a slight delay. So apply some rudder to turn, and wait for the reaction; when you wish to stabilize wings level, anticipate.

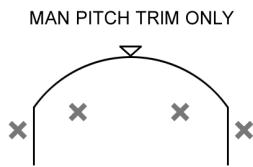
The problem here is NOT TO FLY THE A/C ACCURATELY, but to KEEP THE A/C IN A SAFE STABILIZED ATTITUDE, allowing the lost systems to be restored.

The pilot is immediately aware of the MECHANICAL B/UP by the red message on the PFD: MAN PITCH TRIM ONLY.

**NOTE:**

Mechanical B/UP is effectively most improbable with the FBW architecture.

Let us keep in mind that in case of total ELEC failure, the ELAC 1 and SEC 1 are fed either by CSM-G or BAT and you will fly in ALTN law!



**ABNORMAL ATTITUDES**

Suppose that for any reason the A/C is FAR OUTSIDE the NORMAL FLIGHT envelope and reaches some ABNORMAL ATTITUDES, the normal controls are actually modified so as to allow the crew to best efficiently regain normal attitudes (a typical reason would be a mid air collision ...).

The so called ABNORMAL ATTITUDE law is:

- pitch ALTN with load factor protection (without autotrim) and
- lateral Direct Law with yaw alternate.

These abnormal laws are triggered when Pitch (50° up, 30° down), Bank (125°), AOA (30°, -10°), Speed (440, 60 Mach (0,96; 0,1) are reaching extreme values.

As for aerodynamic upsets, it is MOST IMPROBABLE that they make the aircraft reach such attitudes, because the FBW PROTECTION would have reacted FAR IN ADVANCE thus minimizing the effect of such upsets.

The FBW architecture and control laws explain why upset recovery maneuvers need not to be trained on Airbus protected A/C.

**❖ Side Stick and Priority P/B**

- \* When the pilot acts on the stick, he actually sends an order (an electrical signal) to the FBW computer. Thus if the PNF acts on the stick as well, both signals or orders are added.  
Thus, as on any other aircraft type, PF and PNF shall not act on the stick simultaneously.  
**If the PNF (or training captain) needs to take over, he must press on the priority P/B and announce "I have controls".**

In case of a pilot who collapses on the stick, or in case of a mechanical side stick failure leading to a jammed stick (there is no ECAM caution associated), the "failed" stick order is added to the "non failed" side stick order.

In such a case, the pilot will press the priority P/B during at least 30 sec. in order to deactivate the "failed" side stick.

- \* In case of a **SIDE STICK FAULT ECAM** warning due to an electrical failure, the affected side stick order sent to the computer is forced to zero; in other words the affected side stick is deactivated, which explains why there is no associated procedure to that warning.

**NOTE:**

When a side stick is deactivated by the opposite side stick priority P/B, it can be reactivated by pressing its own priority P/B.

## 25 - FLIGHT CONTROLS - HIGHLIGHTS ON THE PROTECTIONS

One of the essential tasks of the crew is to keep the A/C within the LIMITS of the NORMAL FLT ENVELOPE.

But circumstances bring pilots to violate those limits, because of EXTREME SITUATIONS, or mishandling or mismanagement of the A/C.

Protections have been built so as:

- to give FULL AUTHORITY to the crew to CONSISTENTLY achieve the BEST ACHIEVABLE A/C PERFORMANCE in extreme conditions,
- to REDUCE the RISKS of overcontrolling / overstressing the A/C and
- to provide an INSTINCTIVE, IMMEDIATE procedure to the crew to achieve that BEST POSSIBLE PERFORMANCE.

### ❖ Bank angle protections

± 67° in Normal Flight envelope (2.5 g level flight).

± 45° in High Speed protection.

The Bank protections prevents ANY MAJOR UPSET or pilot mishandling to bring the A/C in high bank situations where the recovery technique is complex due to the difficulty to properly assess the situation thus to readily react. It provides full authority to the crew to achieve MOST EFFICIENTLY any required roll maneuver.

### ❖ High speed protection

Beyond the design speeds VD/MD, which are greater than VMO/MMO, there are potentially aircraft control problems, structural problems due to high air loads. Therefore the margin between VMO/MMO and VD/MD must be such that any possible overshoot of the normal flight envelope does not cause any major problem.

In order to protect the A/C against dangerous phenomena which might be encountered in a dive or a vertical upset, the high speed protection adds a positive NOSE UP G demand to the stick order. Incidentally, this has allowed the margin between VMO/MMO and VD/MD to be reduced.

Thus in a dive:

- STICK FREE, the A/C will slightly overshoot VMO/MMO and fly back towards the envelope and
- STICK FULL FORWARD, the A/C will significantly overshoot VMO/MMO without reaching VD/MD; at around VMO + 16 / MMO + 0.04 the stick nose down authority is smoothly reduced to zero which does not mean that the aircraft stabilizes at that speed.

Thus the pilot has full authority to achieve a high speed / steep dive escape maneuver when required with a REFLEX action on the stick.

#### NOTE:

OVERSPEED warning is provided.

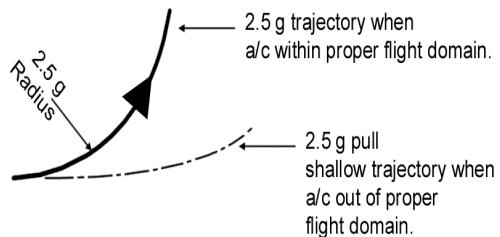
❖ **Load factor protection**

On commercial aircraft high load factors are encountered in evasive maneuvers from potential collision, or CFIT etc.

Pulling "g" is efficient as long as the resulting maneuver is actually flown with this g number; if the A/C is unable to fly this trajectory or maneuver, pulling "g" is detrimental for the performance.

On commercial aircraft the maximum load allowed structurally is:

- 2.5 g in clean CONFIG
- 2.0 g with FLAPS extended



On most commercial A/C, the **flight domain** where an efficient 2.5 g maneuver is possible, is **very remote**. Furthermore no G load continuous information is provided in cockpits, which leads to the fact that airline pilots are not used to control this parameter .

This is, by the way, substantiated by the experience which shows, that in emergency situations, the reaction on a yoke or stick is initially HESITANT; then LATER it is AGGRESSIVE.

With the LOAD FACTOR PROTECTION, the pilot may IMMEDIATELY and INSTINCTIVELY pull full AFT STICK:

- the A/C will initially fly a 2.5 g maneuver without loss of time; then if the pilot still has to keep full aft stick because not clear from danger, the HIGH AOA PROT will take over. **The load factor protection enhances the high AOA protection.**

The G LOAD PROT allows an IMMEDIATE REACTION thus escape, without any risk of overstressing the A/C.

The experience also shows that an immediate 2.5 g reaction provides a LARGER OBSTACLE CLEARANCE than a maneuver achieved HESITANTLY, with a high G load delayed reaction (2 sec delay).

❖ **High Pitch Attitude protection**

Excessive pitch attitudes caused by upsets or undue maneuvers lead to hazardous situations:

- too high Nose Up → very rapid loss of energy and
- too low Nose Dn → very rapid gain of energy.

Furthermore no emergency situation requires to fly at attitudes greater than [+ 30°, - 15°].

Hence the pitch attitude protection will prevent any upset to pitch the A/C beyond those limits.

**Furthermore the pitch attitude protection ENHANCES the high speed, high load factor and high AOA protections.**

❖ **High AOA protection**

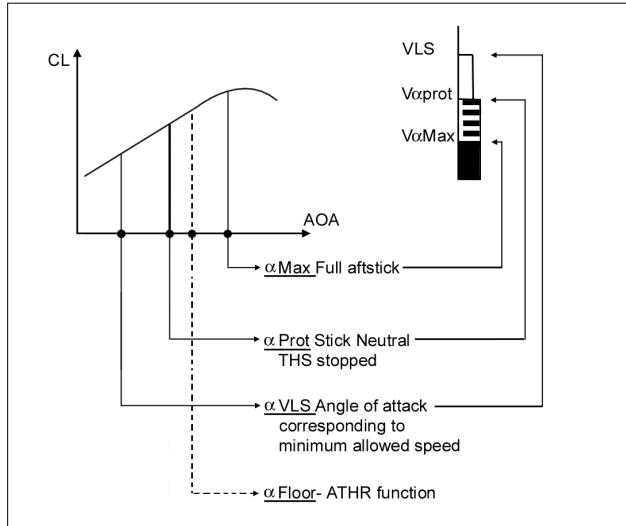
The high AOA protection gives full authority to the pilot to achieve consistently the best lift achievable by the aircraft, by pulling full aft stick in dangerous situations which is instinctive, while minimizing the risks of stalls or loss of control.

The high AOA protection is an AERODYNAMIC protection:

- if the pilot exceeds the normal flight envelope for any reason, the pilot will be aware of that fact because the auto pitch trim stops; the A/C will sink down to maintain its current angle of attack ( $\alpha$  PROT, strong static stability), which is a significant change in the A/C behaviour.
- if he then pulls full aft stick, he commands MAX AOA which nearly corresponds to ALPHA CL Max; furthermore if the speed brakes were extended, they automatically retract.

Additionally to this aerodynamic protection 3 **ENERGY** features enhance it:

- if ATHR is in speed mode, it will not allow the speed to drop below VLS even if the target speed is below VLS,
- a LOW ENERGY aural warning is triggered when the a/c energy level drops below a given threshold. Function of IAS, ACCEL/DECEL, FPA etc.  
e.g. if the a/c decelerates at 1 kt/s and the FPA = - 3°, the warning will come up at approx VLS - 8 kt. If the FPA = - 4°, the warning will come up at approx VLS - 2 kt.



This warning SPEED - SPEED - SPEED drives the pilot towards the SPEED scale so as to re-adjust the thrust. It comes up just before A.FLOOR engages. It is available below 2000 ft RA, if FLAP  $\geq$  2.

- If the AOA still increases or the speed still drops, the angle of attack reaches ALPHA FLOOR threshold, where the ATHR sends TOGA thrust and engages except if one Engine Out.

In case of an emergency situation such as Windshear or CFIT, where the pilot wishes to get the BEST PERFORMANCE of the A/C, he is fully assisted to achieve this goal by:

- the ATHR which adds thrust to maintain the Speed above VLS,
- the Low Energy Speed – Speed warning which enhances pilot awareness,
- the ALPHA FLOOR which provides TOGA thrust,
- the HIGH AOA protection which provides maximum aerodynamic lift and
- the automatic Speed Brake retraction which minimizes the drag.

**Procedures in case of GPWS / SHEAR**

Thrust Levers TOGA

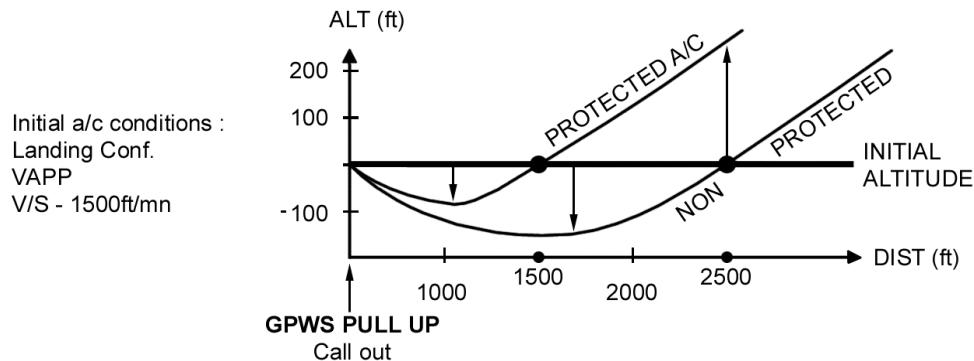
Pull Full Aft stick \*

Maintain wings level initially

(\*) for shear fly SRS, till full aft stick.

This gives you MAX LIFT / MAX THRUST / MINI DRAG, immediately.

Consequently the resulting CFIT escape maneuvers are BY FAR more efficient.



CFIT escape maneuvers on Protected and Non Protected A/C

These are typical trajectories flown either by all PROTECTED A/C (A320, 330 or 340), or by all NON PROTECTED A/C (A310, B737, B747, B777 !), when the pilot applied the escape procedure after hearing the GPWS PULL UP Warning.

This demonstrates the efficiency of the protection which ensures a **50% lower duck under, a 50% shorter bucket distance, a more than doubled safety margin in terms of reaction time and a significant altitude gain ( $\cong 250$ ft)**.

These characteristics are common to **all** protected A/C. This is because the escape procedure is simple to achieve, and allows the pilot to fly the A/C at a constant AOA close to the max AOA, whereas it is most difficult to fly the stick shaker AOA on a non protected aircraft.

## 26 - PREDICTIVE AND REACTIVE WINDSHEAR

### ❖ General

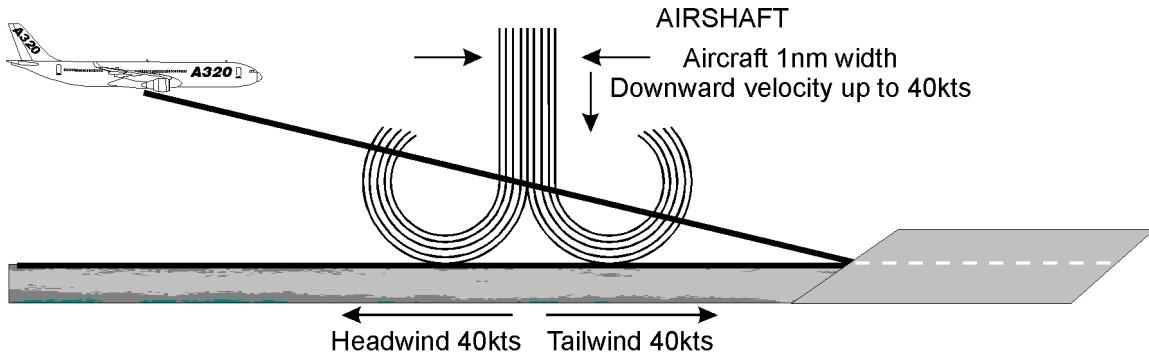
During take off and landings, windshear and microbursts have been the cause of numerous aircraft accidents.

This type of phenomena is mostly due to cool shaft of air, like a cylinder, between  $\frac{1}{2}$  NM to 1,5 NM width that is moving downward. When the air encounters the ground, it mushrooms in a horizontal direction curling inward at its edges.

The downward airmass velocity in such narrow shafts ranges from 20 kts to 40 kts; when it reaches the ground, the outflow resulting winds vary from front to back with velocities ranging from 20 kts to 80 kts.

The microbursts affect the aircraft safety for 2 reasons:

1. The aircraft flies in the airmass. When the airmass moves downward so does the aircraft. The aircraft flight path is thus severely affected.
2. The aircraft lift is related to the relative velocity of the air traveling over the wing. When the wind varies suddenly from front to back, the lift significantly reduces which causes the aircraft to descend, or to reach very high AOA.



The windshear and microbursts are thus a hazardous phenomenon for an aircraft at take off and landing. Thus the strategy adopted to prevent catastrophic consequences is:

1. Increase crew awareness of potential microburst or windshear so as to delay take off or landing.  
⇒ PREDICTIVE WINDSHEAR SYSTEM.
2. Inform the crew of unexpected airmass variations.  
⇒ FPV sudden drop, Approach Target Speed variations (GS mini).
3. Warn the crew of significant loss of energy.  
⇒ Low energy warning (SPEED, SPEED, SPEED), REACTIVE WINDSHEAR SYSTEM.
4. Provide efficient tools to escape out of the shear or get through.  
⇒ ALPHA FLOOR (TOGA from ATHR), SRS pitch order (AP, FD) high AOA protection, GS mini.

❖ Increase crew awareness of POTENTIAL microburst or windshear

The best strategy is to AVOID microbursts, thus delay T/O or APPR. In order to do so, the pilot needs to be advised that such phenomena will be encountered.

**PREDICTIVE WINDSHEAR (PWS)**

When the airshaft of a microburst reaches the ground, it mushrooms outward carrying with it a large number of falling raindrops. The RADAR is able to measure the velocity of the water droplets, thus to assess wind variations.

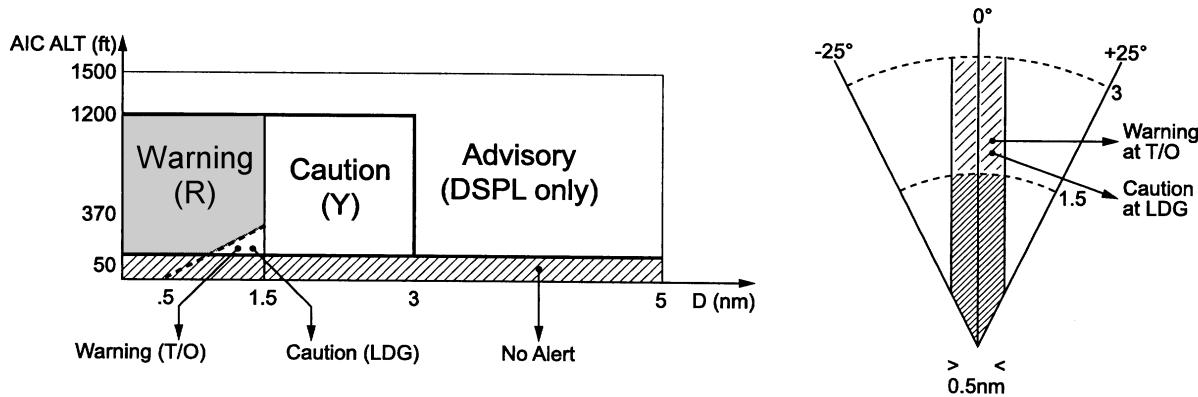
As it scans across the windshear, it will detect raindrops moving toward it at one range, and raindrops moving away from it at a greater range. The principle of the measure is the detection of the doppler frequency shift on the reflected microwave pulses caused by the shear.

The radar can thus determine THE WIDTH of the SHAFT and THE SEVERITY of THE SHEAR by the droplet velocity variations. When the SEVERITY exceeds a given threshold, windshear alerts are triggered.

The PWS operates **AUTOMATICALLY** when the A/C is below 2300 ft AGL, whether the radar is set On or Off.

An alert is issued (ICON and/or AURAL) if a SHEAR is DETECTED within 5 NM, at an altitude **AT or BELOW 1500 ft AGL**.

There are 3 types of alert levels: ADVISORY, CAUTION and WARNING function of the A/C altitude, flight phase (T/O or Landing) and proximity of the microburst.



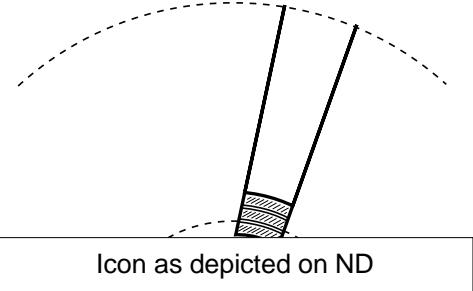
Windshear caution - Warning Areas at Take off and Landing

WINDSHEAR CAUTION and WARNING AREAS at T/O and Landing (warning is inhibited at IAS < 100 kt till 50 ft on Lift off).

ALERT LEVEL		AURAL MESSAGE	VISUAL PFD	VISUAL ND
WARNING	T/O	"WINDSHEAR AHEAD" (twice)	WINDSHEAR AHEAD (red)	Windshear ICON
	LDG	"GO AROUND WINDSHEAR AHEAD"		
CAUTION		"MONITOR RADAR DISPLAY"	WINDSHEAR AHEAD (amber)	ICON
ADVISORY				ICON

The aural messages have priority over TCAS and GPWS, but are overridden by Reactive W/S and stall warning.

- Windshear ICON = Red + Black sectors and 2 Yellow radial lines.
- Here a W/S is detected 2 NM ahead with a right hand bearing.


**NOTE:**

If the ND range is > 10 NM, a message W/S SET RANGE 10 NM (windshear, set range 10 NM) is provided.

**NOTE:**

A PWS OFF/AUTO switch is provided on the radar CTL panel. If set to OFF, PRED W/S OFF appears green or amber on ECAM MEMO, once engines are running.

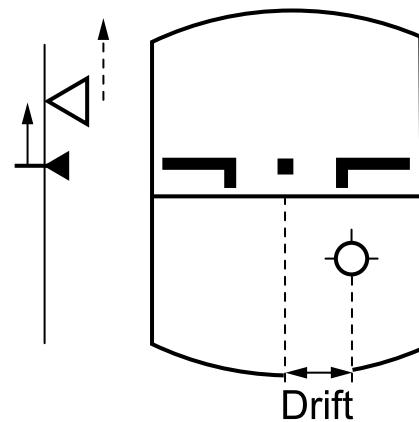
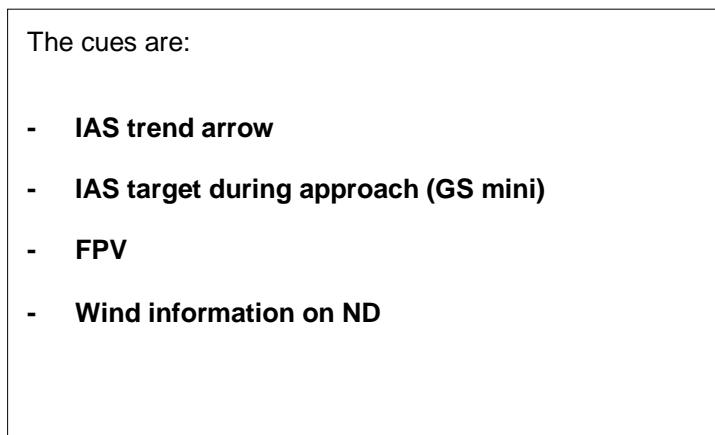
**❖ Procedure linked to PWS**

- Predictive windshear alert = highly probable windshear
- At take off
  - Delay Take Off or Reject during T/O Run
  - If during Take Off roll or initial climb
    - TOGA
    - Monitor closely SPEED/SPEED TREND
    - Ensure that Flight Path clears any shear suspected area
    - If within the shear do NOT modify A/C configuration
- At landing
  - In case of ADVISORY ICON or CAUTION
    - Delay landing or Divert
    - Watch Radar and evaluate severity

- Envisage CONF3
  - Use Managed speed and consider a VAPP increase
  - Use autopilot with ILS to help for an earlier detection of vertical path deviation
  - Be prepared for RECOVERY
- In case of GO AROUND WINDSHEAR AHEAD message
- TOGA
  - Keep Configuration till out of shear
  - Follow SRS till full aft stick if necessary

❖ **Inform the crew of unexpected airmass variations**

There are several cues provided on the EFIS, which assist the pilot in determining significant airmass variations symptomatic of potential presence of microburst. These are available essentially in approach.



During an approach the PF monitors essentially the PFD:

- The target speed during approach (GS mini), along with IAS trend arrow advises him immediately of a strong headwind gust, or of a tailwind gust. If the ATHR is on, the resulting thrust management is therefore significantly improved (here on the fig. - Head wind gust).
- The FPV position relative to the center of the PFD advises him of the wind direction. If the PF flies a constant track and notices that the relative position of the FPV versus the center of the PFD varies rapidly, he is going to deduce that the A/C experiences a wind direction change (here on the fig. - Wind from the left leading to a drift to the right).
- A sudden FPV downward movement is the first cue, which allows the pilot to suspect that the A/C is going through a downdraft.

PROCEDURE

- MONITOR THE ENERGY CUES, SPEED TREND, SPEED TARGET MOVEMENT in approach and FPV in SUSPECTED SHEAR CONDITIONS.
- IN CASE OF SIGNIFICANT ENERGY LOSS (FPV sinks down, Large SPEED TREND down arrow ...), GET PREPARED FOR RECOVERY.

❖ **Warn the crew of significant loss of energy**

Two features are provided to the crew to achieve that goal:

1. the LOW ENERGY warning provided below 2000 ft R/A in CONF  $\geq 2$  and
2. the REACTIVE WINDSHEAR warning provided at take off and landing up to 1300 ft R/A in CONF  $\geq 1$ .

NOTE:

At landing, the reactive windshear is inhibited below 50 ft.

The LOW ENERGY WARNING advises the pilot of a lack of energy (speed, thrust) which limits the maneuverability capability of the A/C; if not taken care of rapidly, ALPHA FLOOR will then take over. Low energy warning is processed by FCPC.

The energy level of the aircraft is translated into a value of Angle of Attack function of the A/C SPEED, ACCELERATION, FLIGHT PATH ANGLE. This Angle of Attack value is compared to a threshold; when it overshoots this threshold "SPEED, SPEED, SPEED" repetitive message is triggered. This warning drives the PF eyes to the Speed Scale asking for rapid reaction.

Here are some typical values of the speed at which the warning could occur in two different circumstances:

DECEL	FPA	Warning at
- 1 kt/s	- 3°	VLS - 7 kt
- 1 kt/s	- 4°	VLS - 1 kt

Warning comes **below VLS** depending upon Low energy level.

In shear conditions this is the first warning to come up PRIOR TO ALPHA FLOOR.

The REACTIVE WINDSHEAR WARNING is provided by the Flight Envelope computer, which computes actual and predicted energy level of the aircraft as an Equivalent Angle of Attack.

This Equivalent Angle of Attack is a function of detected HEAD/TAILWIND CHANGE conditions, MEAN WIND COMPONENT, DETECTED DOWN DRAFT WIND, filtered by R/A value.

This Equivalent Angle of Attack is compared to a threshold function of the A/C configuration.

When the threshold is reached a "WINDSHEAR WINDSHEAR WINDSHEAR" aural warning is triggered, with an associated WINDSHEAR red message on PFD.

The crew reaction to such a warning has to be immediate.

## PROCEDURE

IF "SPEED - SPEED - SPEED" WARNING COMES UP

- WATCH SPEED SCALE and
- ADD THRUST.

IF REACTIVE WIND SHEAR WARNING COMES UP

- |                                |  |
|--------------------------------|--|
| TAKE OFF                       | <ul style="list-style-type: none"> <li>• BEFORE V1 – STOP (if significant SPD/SPD trend variations).</li> <li>• AFTER V1 – TOGA / FOLLOW SRS till full aft stick and KEEP CONF</li> </ul>  |
| IN FLIGHT<br>or in<br>APPROACH | <ul style="list-style-type: none"> <li>• TOGA / FOLLOW SRS till full aft stick and KEEP A/C CONF           <ul style="list-style-type: none"> <li>- monitor FLIGHT PATH and SPEED,</li> <li>- if AP ON, it automatically disengages at AOA PROT + 1°,</li> <li>- if no FD, pitch to 17.5° initially and adjust for MINIMUM HEIGHT LOSS.</li> </ul> </li> </ul> |

### ❖ Efficient tools to escape

To assist the crew to escape, there are:

1. the ALPHA FLOOR which is function of the ATHR,
2. the SRS AP/FD pitch law and
3. the Fly By Wire High Angle of Attack protection.

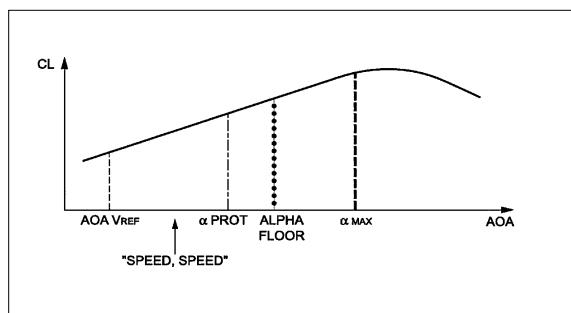
**ALPHA FLOOR** condition is processed by FCPC and triggered by FMGC which engages ATHR and sends TOGA on all engines.

ALPHA FLOOR provides an ADDITIONAL LEVEL of ENERGY when the A/C AOA gets very high.

ALPHA FLOOR is fully automatic and available from LIFT OFF to 100 ft R/A at Landing.

It is **INHIBITED** in case of **ENG FAILURE**.

ALPHA FLOOR is indicated on FMA as A.FLOOR which changes into TOGA LK when the A/C angle of attack has decreased. The only means to get rid of TOGA LK (which means that TOGA thrust is locked) is to set ATHR OFF. (see chapt. 18).



### SRS AP/FD pitch law

The SRS pitch mode is used in T/O and GO AROUND so as to ensure the BEST A/C CLIMB PERFORMANCE, with ALL ENG OPERATIVE and ENG FAILURE.

However it also ensures a MINIMUM CLIMB OUT FLIGHT PATH ANGLE, in order to cope with DOWNDRAFT or WINDSHEAR situations.

This explains why the PROCEDURE asks the PF to FOLLOW THE FD PITCH BAR (or set AP ON) and **POSSIBLY TO PULL FULL AFT STICK** so as to obey the SRS orders and thus **minimize height losses**.

**The HIGH ANGLE of ATTACK protection**

The HIGH ANGLE of ATTACK protection allows the PF to pull FULL AFT STICK if needed, either to follow the SRS FD BARS or to rapidly counteract a down movement of the FPV / a height loss / a deviation below the final path or G/S, or a GPWS warning.

**Pulling full aft stick provides:**

- **MAXIMUM LIFT**
- **MINIMUM DRAG** by automatic retraction of the speed brakes, should those be extended.

For details see chap. 22.

## 27 - EGPWS AND GPWS

### ❖ Technical Background

The Enhanced GPWS incorporates the functions of the basic GPWS with the following added features:

- Terrain Clearance Floor (TCF),
- Terrain Look Ahead Alerting and
- Terrain Awareness Display (TAD).

The purpose of the Enhanced GPWS functions is to provide a better situational awareness to the crew through the TAD, and to give earlier CAUTION and WARNING to the pilot to initiate a safe recovery maneuver.

The computer incorporates a world wide TERRAIN DATA BASE with varying degrees of resolution. It has also an airport data base (coordinates of runway center point of all hard surface runway longer than 3500 ft). The earth is divided into grid sets with the record of the highest terrain altitude in each element of the grid. The resolution of the data base is a function of the geographic location. It is a HIGH RESOLUTION GRID around an airport, and SMALL RESOLUTION GRID away from airport. There are 5 levels of resolution (from 15 arc sec. to 5 mn arc or 5 NM).

Having an FMS (and possibly a GPS) on board, the EGPWS determines present position, track and ground speed, which will be used to advise the crew of any potential conflict with terrain. When the terrain violates specific computed boundaries on the projected flight path of the A/C, the associated threats will be announced to the crew.

#### a.) Terrain Clearance Floor (TCF)

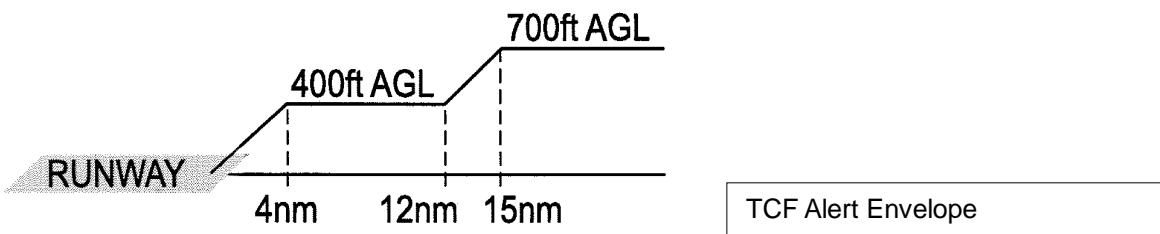
The TCF alert function adds an additional element of protection to the standard GPWS by alerting the pilot of possible premature descent, (for example for NPAs), regardless of aircraft configuration.

It creates an increasing terrain clearance altitude envelope around an airport, directly related to the distance from the runway. When the aircraft enters this envelope, an alert is triggered.

The alert is a function of A/C position, of the nearest airport location and of current Radio Altitude measure (R/A). It protects the A/C against an attempt to land on "no airfield".

The TCF is available in ALL FLIGHT PHASES and is a complement to the basic GPWS mode 4.

- AURAL MSG - **TOO LOW TERRAIN** (2)
- **GPWS** red light illuminates (see note in § b).

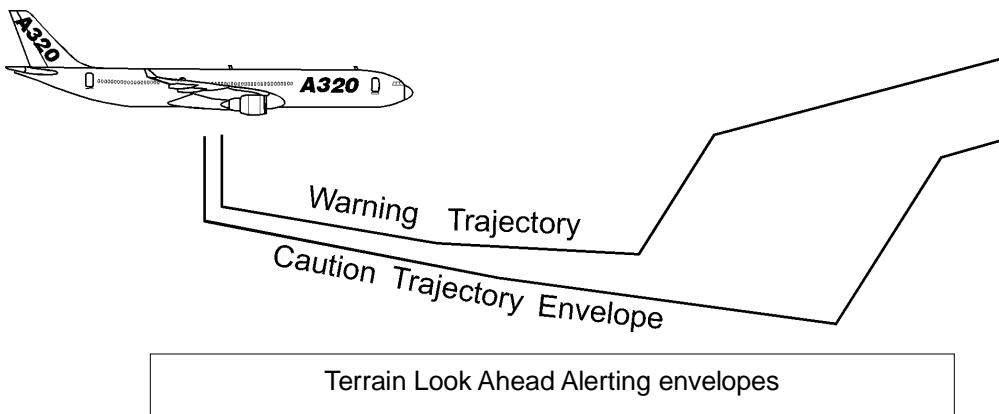


#### NOTE:

As a reminder, the GPWS mode 4 TOO LOW TERRAIN alert is inhibited with the landing gear down.

**b.) Terrain Look Ahead Alerting**

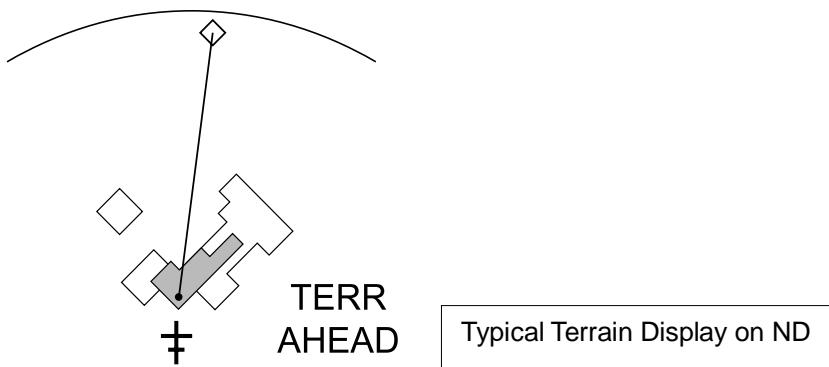
The Terrain Alerting algorithms compute two trajectory envelopes from the A/C position, speed and track, which originate below the A/C as an added margin for safety. When the boundaries of these two envelopes conflict with the terrain data, alerts are triggered.



When the CAUTION ENVELOPE conflicts with the terrain:

- GPWS RED LIGHT (see NOTE below),
- TERRAIN AHEAD (amber) on ND,
- TERRAIN data displayed on ND with SOLID YELLOW areas and
- Aural "TERRAIN AHEAD" repeated every 7 sec.

This **caution** gives typically 60 sec reaction time prior to potential terrain conflict.



When the WARNING ENVELOPE conflicts with the terrain:

- GPWS RED LIGHT (see NOTE below),
- TERRAIN AHEAD (RED) on ND,
- TERRAIN data displayed on ND with SOLID RED areas
- Aural "TERRAIN AHEAD, PULL UP" repeated continuously.

This warning gives typically 30 sec reaction time.

NOTE:

- The EGPWS has priority over the PWS.
- In case an airport is not stored in the EGPWS data base, the EGPWS uses the smallest resolution; this may cause early and unexpected TERRAIN AHEAD / TERRAIN AHEAD / PULL UP alerts with terrain display popping up on the ND. This must be reported to the Airline Operations.

Furthermore, when operating from/to airports known as not being in the data base, set EGPWS TERR P/B OFF on the overhead panel when the A/C is within 15 NM from that airport.

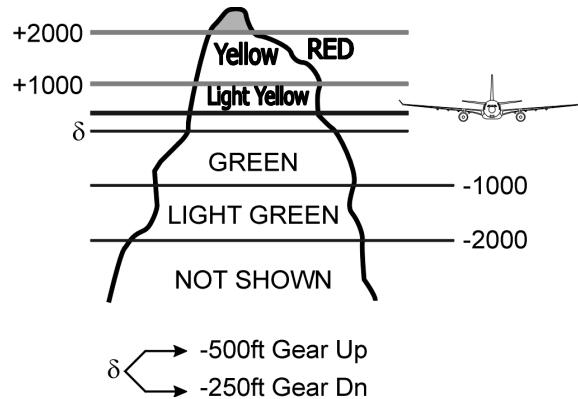
- If TERR ON ND P/B is pressed OFF, and a caution or warning is triggered, terrain data are automatically displayed on the ND, and the TERR ON ND light comes up.
- On latest EGPWS version, the GPWS / G/S lights located on the left and right main instrument panels next to the PFD are replaced by PULL UP / GPWS light. PULL UP red light comes up when TCF or TAD alerts are triggered.

**c.) Terrain Awareness Display (TAD)**

The TAD displays an image of the surrounding terrain in varying density dot patterns of Green, Yellow and Red.

The display is generated by comparing the A/C altitude to terrain data in the EGPWS data base; thus those patterns represent a SPECIFIC TERRAIN SEPARATION with respect to the aircraft.

The terrain is not shown if more than 2000 ft. below the A/C altitude or if its elevation is within 400 feet of the runway elevation nearest the A/C.



**d.) Recall of the basic GPWS mode 1 to 5 functions.**

**Mode 1: Excessive Descent Rate**

WARNS THAT THE A/C DESCENT RATE WITH RESPECT TO ALTITUDE AGL IS EXCESSIVE.  
AVAILABLE in ALL FLIGHT PHASES.

- Alert:**
- 1) - SINK RATE (twice)
  - 2) - then PULL UP (continuously)
  - 3) - GPWS RED LIGHT

**Mode 2: Excessive closure to Terrain**

WARNS THE PILOT OF RAPIDLY RISING TERRAIN WITH RESPECT TO THE A/C.

- Alert:**
- 1) - TERRAIN - TERRAIN
  - 2) - then PULL UP (continuously)
  - 3) - GPWS RED LIGHT

**Mode 2A** active during climb out, cruise, initial approach when Flaps are not in landing conf and A/C not on G/S center line.

**Mode 2B** is desensitized to permit landing maneuvers close to terrain WITHOUT UNDUE alerts. It is automatically triggered when Flaps in Ldg Conf or ILS G/S within 2 dots.

With LDG GEAR dn and flaps ldg conf, PULL UP call is suppressed.

**Mode 3: Altitude Loss After T/O**

WARNS THE PILOT OF A SIGNIFICANT ALTITUDE LOSS AFTER T/O OR LOW ALTITUDE GO AROUND (> 245 ft) with gear or flaps not in landing conf.

- Alert:**
- 1) - DON'T SINK
  - 2) - GPWS RED LIGHT

**Mode 4: Unsafe Terrain Clearance**

WARNS THE PILOT FOR INSUFFICIENT TERRAIN CLEARANCE AS A FUNCTION OF THE PHASE OF FLIGHT, SPEED AND/OR A/C CONFIGURATION.

**Alert:**

TOO LOW TERRAIN	
TOO LOW GEAR	(500 ft R/A)
TOO LOW FLAPS	(245 ft R/A)
GPWS RED LIGHT	

Actually this mode is divided into three submodes:

- **4A** Cruise approach with Gear Up. This provides alerting cruise for flight into Terrain where terrain is not rising significantly or A/C not descending rapidly:  
TOO LOW TERRAIN - TOO LOW GEAR (if R/A < 500, IAS < 190).
- **4B** Cruise approach with Gear Down and Flaps not in landing Conf:  
TOO LOW TERRAIN - TOO LOW FLAPS (if R/A < 245, IAS < 160)
- **4C** After T/O or low altitude Go Around when Gear or Flaps are not in landing conf. It alerts the crew that the terrain is rising MORE STEEPLY than the A/C is climbing. A MINIMUM TERRAIN CLEARANCE (MTC) is defined and increases with R/A up to 500 ft if IAS  $\leq$  190 kts and up to 1000 ft if IAS increases to 250 kts: TOO LOW TERRAIN.

**Mode 5: Excessive G/S deviation**

WARNS THE PILOT WHENEVER THE A/C DESCENDS BELOW THE GLIDE SLOPE.

**Alert:** GLIDE SLOPE / GLIDE SLOPE with G/S amber light

It starts below 1000 ft AGL, and the loudness and rate of the message increases. Below 150 ft AGL it is desensitized to reduce nuisance alerts. Pressing the G/S P/B stops the alert and turns off the amber G/S; in case of a new violation the alert comes back again.

❖ **Commands and Controls Specifics**

**EGPWS functions** (TFC – TAD – Terrain Look Ahead Alerting).

- Commanded ON on the overhead panel by TERR P/B is set next to the other GPWS P/Bs. The last 2 EGPWS functions provide displays on ND which are incompatible with the Radar display. Therefore on the main instrument panel, there is a specific P/B whether to display the terrain or not.
- TERR on ND P/B next to each ND  
When ON, the radar image is suppressed; TILT indication goes OFF and TERR comes up instead on ND. The image of the terrain has a "texture" different from the radar image, and the sweeping starts from the middle of the screen ("curtain sweep").  
When OFF, the terrain data is not displayed on ND unless an alert comes up where the terrain "pops up" (and supersedes PWS message).

**GPWS basic functions – particulars**

For GPWS, the landing configuration is by DEFAULT FLAPS FULL. If landing is to be performed in FLAPS 3 (for go around climb performance reasons or in case of windshear), LDG FLAP 3 p/b should be selected ON on OVHD panel. Flap mode is then inhibited when CONFIG 3 is selected.

In this case ECAM LDG MEMO displays FLAPS ..... 3 rather than FLAP ..... FULL.

Note that on MCDU PERF APP page, LDG CONF selection does compute VLS and associated deceleration prediction but is not connected to GPWS.

**NOTE:**

The GPWS red light on the main instrument panel indicates an alert triggered by any mode of the GPWS or EGPWS (TAD and TCF).

On latest GPWS / EGPWS versions, the GPWS / G/S lights located on the left and right main instrument panels next to the PFD are replaced by PULL UP / GPWS lights. The PULL UP red light comes up when GPWS MODE 1 and 2 alerts are triggered, as well as when EGPWS TAD or TCF alerts are triggered. The GPWS amber light comes up when the other GPWS mode alerts are triggered.

❖ **Procedures**

a.) **Precautions:**

- EGPWS specific functions: TAD, TERRAIN LOOK AHEAD ALERTING and TFC may be used ONLY IF NAV ACCY IS CHECKED GOOD.  
Hence if NAV ACCY CHECK IS NEGATIVE (or GPS NOT PRIMARY AND NAV ACCY CHECK IS NEGATIVE), set EGPWS OFF.
- TAD function is to be used for TERRAIN AWARENESS, BUT NOT FOR NAVIGATION.

**NOTE:**

On early EGPWS versions, EGPWS must be inhibited if A/C is pin programmed with QFE, until the EGPWS is modified.

On certain A/C versions, EGPWS is automatically inhibited when ACCY LOW, with TERR STBY green on ECAM memo.

b.) **Procedures themselves:**

Check that TERR P/B and GPWS P/B are pressed IN on OVHD panel.

In approach:      TERR ON ND pressed IN on PF side (terrain suspected)      } or vice  
                     TERR ON ND OFF on PNF side when RADAR REQUIRED      } versa  
                     If NAV ACCY CHECK IS NEGATIVE (and GPS not primary), set EGPWS OFF.

IN CASE OF ANY WARNING INCLUDING "PULL UP"

"WHOOP, WHOOP PULL UP" "TERRAIN WHOOP WHOOP PULL UP"  
                     "TERRAIN AHEAD PULL UP"

**IMMEDIATELY AND WITH NO ARGUMENTS**

- TOGA
- PULL FULL AFT STICK
- CHECK SPD BRK RETRACT
- INITIALLY WINGS LEVEL

(When situation requires, TURNING IS TO BE ENVISAGED)

IN CASE OF ANY TERRAIN / DESCENT / CONFIGURATION ALERTS

"TERRAIN AHEAD" "SINK RATE" "DON'T SINK"  
                     "TOO LOW TERRAIN - GEAR - FLAPS" "G/S"

**IMMEDIATELY AND WITH NO ARGUMENTS**

- ADJUST FLIGHT PATH or GO AROUND or
- CLIMB and TURN AS NECESSARY or
- ADJUST CONFIGURATION or GO AROUND
- RE-ESTABLISH ON G/S or PRESS G/S P/B IF UNDUE ALERT.

## 28 - TCAS II

### 1. Some technical background

The TCAS monitors the airspace surrounding the aircraft by interrogating the transponder of other aircraft.

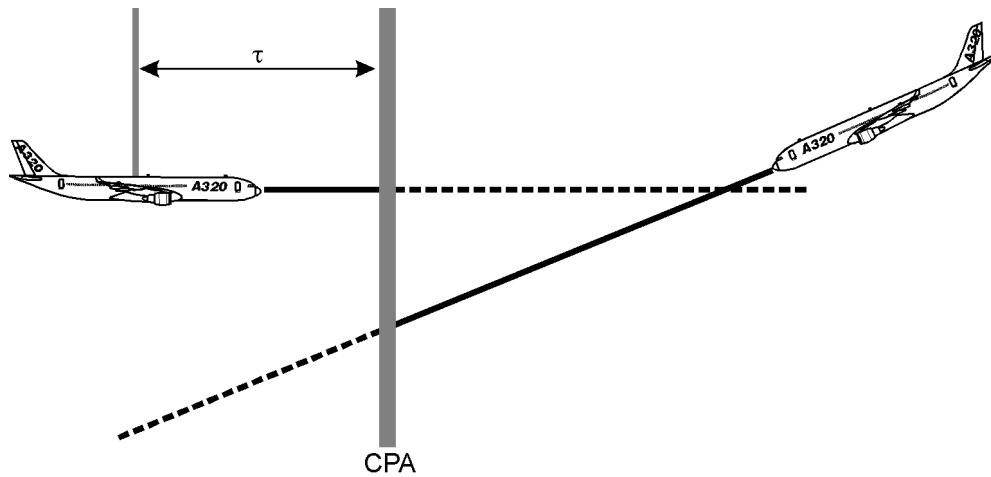
The reply of the transponders allow the following to be calculated:

- the BEARING/RANGE to the intruder
- the closure rate and
- the RELATIVE ALTITUDE DIFFERENCE and the V/S of the intruder (if mode C-S available).

From that data, the TCAS II predicts the TIME TO ( $\tau$ ) and the SEPARATION AT the intruder's closest point of approach (CPA).

If the TCAS II predicts that the SEPARATION is BELOW SAFE BOUNDARIES → TRAFFIC ADVISORY (TA) is triggered and informs the crew that the INTRUDER is in the VICINITY.

If the TCAS II predicts a COLLISION THREAT → RESOLUTION ADVISORY (RA) is triggered to maintain a safe separation between the aircraft. The RA is COORDINATED between the aircraft and the intruder, both using an ATC mode S. The RAs are thus COMPLEMENTARY.



- In case of a RESOLUTION ADVISORY, the crew must FOLLOW IT PROMPTLY and SMOOTHLY.

The crew should NEVER MANEUVER in the OPPOSITE DIRECTION of the RA since maneuvers are coordinated.

- Always attempt to VISUALLY CLEAR the airspace before maneuvering the aircraft in response to a TCAS ADVISORY. The purpose of the TA is to advise the crew to ATTEMPT TO GET VISUAL CONTACT with the intruder. NO EVASIVE ACTION should be SOLELY BASED on the TA.

The maximum range of intruder detection depends upon TCAS and DMC standards.

- TCAS II maximum range is 40 NM.
- TCAS 2000 maximum range is 80 NM.

With DMC pre V40 standard, intruder may be displayed with ND ranges selected at or below 40 NM.

With DMC V40, intruders may be displayed for any selected range; thus with TCAS 2000 up to 80 NM.

**NOTE:**

Some TCAS are programmed with specific aircraft limitations (max. alt. when A/C climbs at 1500 ft/mn ...). Some RAs (climb, increase climb ...) are inhibited if RA maneuver cannot be achieved safely.

On some other TCAS this does not exist and has to be achieved manually by selecting TA on the Ctl panel (e.g. Engine Out, Ldg Gear extended...), thus inhibiting RA.

**NOTE:**

The TCAS may work only if the intruder's A/C is equipped with a transponder; if the intruder has a Non Altitude Reporting transponder (NAR), then only TAs may be issued based on closure rate. In that case, NAR traffic is not displayed above 14500 ft.

**NOTE:**

Some TCAS are automatically set in STD BY on ground. Other TCAS are wired to INHIBIT display of traffic called "ON GROUND TRAFFIC" (below 400 ft AGL).

When ATC is set to AUTO, when the aircraft is on ground, it still emits in mode S.

**NOTE:**

TCAS II can track up to 45 aircraft, display up to 30, co-ordinate up to 3 at once; this is within  $\pm$  9900 ft and 30 NM range.

## 2. Display of advisories, Aural messages, consequential actions

INTRUDER	DISPLAY	TYPE OF COLLISION THREAT	AURAL	ACTION
No THREAT TRAFFIC or OTHERS	◊ ↑ – 17 (w)	Relative altitude > 1200 ft Range > 6 NM <b>NO THREAT</b>		
PROXIMATE	◊ ↑ – 10 (w)	Relative altitude < 1200 ft and Range < 6 NM Considered as <b>NO THREAT</b>		
TRAFFIC ADVISORY (TA)	• ↑ – 09 (Y)	τ between 20 sec (< 550 ft) and 45 sec (> 10000 ft) <b>POTENTIAL THREAT</b>	"TRAFFIC"	ESTABLISH VISUAL CONTACT NO EVASIVE MANEUVER SOLELY ON DISPLAY
RESOLUTION ADVISORY (RA)	█ ↑ – 06 (R) + V/S PFD	τ between 20 sec (>500 ft) and 35 sec (>20000 ft) <b>COLLISION THREAT</b> Requires ATC mode C with the intruder	<u>PREVENTIVE</u> "MONITOR V/S" <u>CORRECTIVE</u> "CLIMB, DESCEND"	FOLLOW RA SMOOTHLY and FIRMLY

TYPE of RA	AURAL	ACTIONS
PREVENTIVE RA	"MONITOR VERTICAL SPEED"	<b>DON'T ALTER YOUR FLIGHT PATH</b> (red sector on PFD V/S)
<b>CORRECTIVE RA</b>		
CLIMB CROSS OVER CLIMB V/S RESTRICTED CLB DESCEND CROSS OVER DES V/S RESTRICTED DES	"CLIMB, CLIMB" "CLIMB, CROSSING CLIMB" "REDUCE CLIMB" "DESCENT, DESCENT" "DESCENT, CROSSING DESCENT" "REDUCE DESCENT"	(green and red sector on PFD V/S) SMOOTHLY and FIRMLY (0.25 g) FOLLOW GREEN SECTOR WITHIN 5 sec.
CHANGE from CLB to DES CHANGE from DES to CLB INCREASE CLB (DES) RATE	"DESCEND, DESCEND, NOW" "CLIMB, CLIMB, NOW" "INCREASE CLIMB (DESCENT)"	(green and red sector on PFD V/S) FIRMLY (0.35 g) FOLLOW GREEN SECTOR WITHIN 2.5 sec

The TAs and RAs are provided when the relative altitude between two aircraft are:

- less than respectively 850 ft / 750 ft below FL300,
- less than respectively 1200 ft / 800 ft above FL300.

When clear of conflict, "**CLEAR OF CONFLICT**" aural message comes up; if initially in level flight, or in climb, or in descent, resume initial conditions unless otherwise advised by ATC.

**NOTE:**

All RAs are converted to TAs below 500 ft AGL. TA aural is inhibited below 400 ft AGL.

### 3. Specifics of the control boxes

#### Mode selector

**TA** TA ONLY on ND. RAs are converted into TAs.

TA triggered when  $\tau < 20$  sec regardless of altitude.

GPWS, Stall warnings, windshear warning have priority.

**TA/RA** All intruders and advisories provided if ATC is ON and ALT RPT is ON.

#### Traffic Selector

**THRT** Non Threat and Proximate intruders displayed only if at least one TA/RA is triggered.

**ALL** Non Threat and Proximate intruders FULL TIME displayed within  $\pm 2700$  ft.

**ABV/BLW** Non Threat Traffic displayed within  $\pm 9900$  ft,  $\pm 2700$  ft (e.g. ABV: if + 9900 ft, - 2700 ft).

### 4. Procedures

- In climb select ABOVE.
- In cruise select ALL or BELOW if cruise altitude within 2000 ft from FL410.
- In descent select BELOW.
- In heavy traffic TMA select THRT.
- In specific cases such as landing on converging runways or take off towards an identified traffic, flying towards an area where undesired RA will be triggered, select TA.
- In case of ENG failure or A/C degraded performance select TA.
- Once the aircraft is on ground, set TCAS to OFF (with transponder to AUTO and aircraft on ground, mode S is still transmitted; thus the TCAS of the aircraft in flight detect the signal from the aircraft on ground).

In case of a **TA**, always attempt to visually clear the airspace before maneuvering the A/C. Else no evasive maneuver based solely on TA displayed on ND.

With a TA, it is a good practice for the PF (or Cpt) to announce to the PNF or (F/O) "I have controls, you watch outside".

In case of **PREVENTIVE RA "Monitor Vertical Speed"**

- maintain Flight Path and keep V/S out of Red Sector.

In case of **CORRECTIVE RA "CLIMB" "DESCENT"**

- Smoothly and promptly react HAND FLYING to follow Green V/S Sector
- Set AP and ATTHR OFF – maneuver 0.25 g maximum.

In case of **CORRECTIVE RA "CLB (DES) NOW" "INCREASE V/S**

- Firmly HAND FLY the V/S Green Sector (AP and ATTHR OFF 0.35 g).
- Set AP and ATTHR OFF – maneuver 0.35 g maximum.

In case of **"CLIMB" "CLIMB NOW" "INCREASE CLIMB" in Final Approach – GO AROUND.**

In all cases try to establish visual contact and advise ATC.

**When "CLEAR of CONFLICT" resume level flight, climb or descend unless otherwise directed by ATC.**

**NOTE:**

A new version of TCAS II is now available and called TCAS II change 7.

It includes the following improvements:

- All TAs aural are inhibited below 500 ft AGL (instead of 400 ft, for consistency with the logic of RA reversion to TA at 500 ft).
- Multi aircraft management is improved especially during climb and descent (up to 30 aircraft).
- Covers the cases where the intruder does not follow an RA.
- Suppresses nuisance RAs at higher altitudes, thus allowing proper RVSM operation (TA - RA triggered if  $\Delta$  ALT less than respectively 850 ft / 700 ft up to FL 420).
- RA aural warnings are more explicit:
  - Preventive RA: "monitor V/S" is changed to "maintain V/S maintain" or "maintain V/S crossing, maintain".
  - Corrective RA: "Reduce Climb" or "reduce Descent" is changed to "adjust V/S adjust".
- The preventive RA on PFD is more explicit by providing a Green band, which justifies the change in the aural RA warnings.
- Finally surveillance is increased to 10.000 ft.
- The TCAS signal emitted by aircraft on ground are automatically eliminated.

## 29 - USE OF RADAR

### ❖ Technical Background

The latest radars transmit at extremely high frequencies in the X band (8 to 12.5 khz); this makes it possible to build highly directional antennas, small enough to fit in the nose cones of the A/C. The characteristics of such X band radars are: GOOD RESOLUTION – GOOD RETURN.

The latest radars have 2 functions: WEATHER DETECTION / AVOIDANCE and MAPPING.

The mapping function is secondary. It uses a PENCIL BEAM which allows a larger range than a FAN BEAM. The pencil beam is such that ground targets which generate LARGE DIFFERENCES IN SIGNAL are easily mapped (mountain, cities, coast lines...), whereas those which generate EVEN DIFFERENCES IN SIGNAL are difficult to resolve (calm sea, even ground).

The Weather Radar (WX) detects PRECIPITATION DROPLETS: RAIN DROPS / WET HAIL / WET SNOW / WET TURBULENCE etc.

The strength of the echo is a function of the drop size, composition and amount. Water particles reflect 5 times as much as ice particles of the same size.

Consequently CLOUDS/FOG/CLEAR AIR TURB/LIGHTNING/WIND... are NOT detected by radar.

THE WEATHER RADAR IS TO BE USED  
TO DETECT/ANALYZE/AVOID SIGNIFICANT WEATHER.  
**It is NOT a PILOT OPERABLE TERRAIN or COLLISION  
AVOIDANCE SYSTEM.**

The pilot has several tools to operate the radar:

- the TILT of the antenna,
- the GAIN of the receiver (automatic or manual) and
- the MODE of operation (WX, WX + T, MAP).

Some radars provide a Ground Clutter Suppression function which is operative in WX mode and suppresses 85% of stationary targets or ground targets – GCS.

Some radars provide RCT function which is used temporarily to help to detect weather or build ups presence BEYOND existing detected weather.

**EFFECTIVE TILT MANAGEMENT IS THE SINGLE, MOST EFFECTIVE KEY TO GET A MORE  
INFORMATIVE WEATHER RADAR DISPLAY.**

The antenna is stabilized. The angle between the weather radar antenna and the local HORIZON is the TILT.

When the pilot selects a TILT ANGLE on the radar CTL PNL, displayed on ND, this angle is the one between THE RADAR ANTENNA AND HORIZON REGARDLESS of THE A/C PITCH/BANK if within the stabilization limits (typically  $\pm 15^\circ$  pitch,  $\pm 35^\circ$  bank).

The stabilization of the antenna is achieved using IRS data.

The WET TURBULENCE is characterized by a wide velocity variance between the rain drops. The return velocity variance of the droplets is measured by the Doppler principle. Indeed the velocity variance of the droplets creates a return signal frequency shift due to the relative motion between the A/C and the droplets.

When the shift is beyond a given threshold, turbulence is detected.

**TURBULENCE CAN BE DETECTED UP TO 50 NM, ONLY IF WET.**

The GAIN CONTROL is mostly used in AUTO or CAL.

However the analysis of weather, or the adjustment of map returns may require a JUDICIOUS use of Gain.

**IN WEATHER MODE, DETECTION OR EVALUATION OF BUILD UP SHALL ALWAYS START IN AUTO/CAL GAIN MODE.**

**IF GAIN IS THEN USED MANUALLY FOR DEEPER ANALYSIS OF WEATHER IT MUST BE RESET TO AUTO/CAL ONCE ANALYSIS COMPLETED.**

The gain reduction allows the detection of the strongest part of a cell displayed in red on ND. Indeed by slowly reducing the gain, the red areas (level 3 return) slowly turn into yellow areas (level 2 returns), while yellow areas turn into green ones (level 1 return).

The red area which is the latest to turn into yellow is the strongest part of the build up. THIS STRONGEST AREA HAS TO BE AVOIDED BY THE GREATEST DISTANCE.

#### ❖ Some Weather Considerations

An FAA advisory circular regarding thunderstorms (AC 00-24B) provides most valuable guidelines on how to fly with regard to thunderstorms.

"Thunderstorms gather every weather hazard known to aviation in one vicious bundle".

- **Squall lines** (narrow band of active thunderstorms usually ahead of a cold front in moist and unstable air – maximum activity late afternoon).
- **Tornadoes** (violent thunderstorms draw air into their cloud bases with great vigor. If the incoming air has an initial rotation motion, this creates an extremely concentrated vortex from surface well into cloud).
- ➔ An aircraft entering a tornado is almost certain to suffer structural damage even in the hidden part of the tornado within the cloud (violent turbulence, dust, debris...).
- **Turbulence** (strongest gusts/turbulences occur with shear between updrafts and downdrafts. Shear turbulence is encountered up to 5000 ft above a thunderstorm and 20 NM laterally. In low altitude, gusts front move far ahead of the rain fall - 15 NM).
- ➔ It is almost impossible to maintain constant altitude in a storm. Allow altitude to "ride the waves".
- **Icing** (updraft carry large amount of large droplets, up above the freezing level to  $-16^{\circ}$  C. Below that temperature most of the supercooled water sublimates into ice crystals. As for the supercooled water itself, it freezes immediately on impact to an aircraft).
- ➔ Clear icing occurs very rapidly in thunderstorms where OAT is between  $0^{\circ}$  and  $-15^{\circ}$  C.

- **Hail** (the supercooled droplets which turn into ice crystals, get bigger and bigger as they encounter other droplets. They get bigger and bigger and can be thrown several miles ahead of a dark storm cloud, in clear air. As they fall, they melt and you get a mixture of rain and hail).
- ➔ Hail is one of the worst hazards in a storm. It can be expected in the cloud, and in clear air ahead of a storm below the anvil.
- **Low ceiling and visibility** (in the cloud and in precipitation). Precision instrument flying is almost impossible below storms because of all packed hazards.
- **Effect on altimeters** (pressure falls rapidly with the approach of a storm and rises sharply with gusts).
- ➔ Errors can reach 100 ft.
- **Lightning** (intensity and frequency have no simple relationship with other storm parameters).
- ➔ Lightning can puncture the skin, damage communication/nav systems, ignit fuel, cause errors on magnetic compass, blind the pilot.
- **Engine water ingestion** (engine may ingest only a small amount of water; beyond that amount, it can cause flame out, stall, structural failures which are favored by thrust changes).
- ➔ Establish constant thrust setting when closing up a storm or heavy turbulence.

To standardize "thunderstorm" language between a weather radar operator and pilots, the use of VIDEO PROCESSOR LEVELS (VIP) is promoted.

The radar echo intensity levels are scaled from 1 to 6 for radar observers:

- |       |  |
|-------|--|
| VIP 1 | Weak,  |
| VIP 2 | Moderate = light to moderate turb + possible lightning,                  |
| VIP 3 | Strong = severe turb possible, with lightning,                           |
| VIP 4 | Very strong = severe turb likely with lightning,                         |
| VIP 5 | Intense = severe turb likely, lightning, hail likely, wind gusts and     |
| VIP 6 | Extreme = severe turb, lightning, large hail, surface wind gusts + turb. |

Thunderstorm build up and dissipate rapidly ➔ DO NOT PLAN A COURSE BETWEEN ECHOES.

Use GROUND RADAR data to determine the areas of echoes to be avoided.

Use AIRBORNE RADAR to analyze and actually avoid build ups; use visual cues whenever available. PLAN THE AVOIDANCE EARLY ENOUGH between 100 NM to 50 NM from an echo.

Be aware THAT THE RADAR MAY BE CLEAR OF ECHOES BEHIND A BIG ECHO which masks existing build ups (use of RCT).

Be aware THAT THE RADAR MAY BE CLEAR BETWEEN ECHOES. DO NOT GO IN BETWEEN IF 2 MAJOR RED and MAGENTA ECHOES ARE SEPARATED BY LESS THAN 40 NM.

Be aware THAT TOP OF BUILD UPS WITH HAIL OR WITH SMALL DROPLETS MIGHT NOT BE DETECTED OR PROVIDE SMALL ECHOES.

Be aware THAT DRY TURBULENCE IS NOT DETECTED AND CAN OCCUR UP TO 5000 ft ABOVE BUILD UPS.

NOTE:

The LIDAR is integrated into RADAR, and it is able to detect some DRY turbulence. It emits a laser pencil beam (length of wave 2 microns) which can be used to measure the relative motion of small dry particles by doppler effect. The LIDAR shall be available in close future.

## PILOT BEHAVIOUR WITH WEATHER

### 1. AVOIDANCE RECOMMENDATIONS

- WHENEVER SUSPECTED WEATHER, SCAN FOR IT BY VARYING RADAR TILT
- DO NOT UNDER ESTIMATE A THUNDERSTORM EVEN IF ECHO IS WEAK (wet parts only are detected).
- AVOID ALL CELLS RED + MAGENTA BY AT LEAST 20 NM.
- DEVIATE UPWIND RATHER THAN DOWNWIND (less chances of turb or hail)
- DON'T ATTEMPT TO FLY BELOW A STORM EVEN VISUAL (turbulence, shear, altimetry).
- USE TURB DETECTION TO ISOLATE TURBULENCE FROM PRECIPITATION.
- SEVERE TURB MAY BE ENCOUNTERED UP TO 5000 ft ABOVE A CELL.
- STORMS WITH TOPS ABOVE 35000 ft MUST BE CONSIDERED HAZARDOUS.
- FREQUENT AND VIVID LIGHTNING INDICATES A HIGH PROBABILITY OF SEVERE TURB.

### 2. IN CASE OF STORM PENETRATION

- SEAT BELTS / SHOULDER HARNESS / CABIN CREW TO YOUR SEATS / LOOSE OBJECTS SECURE.
- ATTHR OFF: SET THRUST LEVER TO TURBULENCE N1 AND PRESS ATTHR I/D.
- AP OFF IF SEVERE TURB - RELAX ALTITUDE, FAVOUR ATTITUDE.
- COCKPIT LIGHTS FULL ON (Storm, Flood max, EIS max) WATCH INSTRUMENTS (against blindness).
- ENG A/I ON - (be aware of potential SPD unreliable situation).
- AVOID MOST CRITICAL ICING CONDITIONS (OAT between 0°C - 15°C).
- **Take best advantage of your radar.**

#### AVOIDANCE RULES

DECISION TO AVOID:	NOT LATER THAN 40 NM
AVOID BY AT LEAST:	20 NM whenever possible - 5000 ft above UPWIND Below FL 230 OAT < 0° - 10 NM mini Below FL 230 or OAT > 0° - 5 NM mini

### ❖ Use of RADAR

Effective TILT MANAGEMENT is the MOST IMPORTANT KEY FOR WEATHER AVOIDANCE:

- TILT is directly linked to PHASE OF FLIGHT and ND RANGE,
  - WEATHER SCANNING is achieved by VARYING THE TILT,
  - the basic value of ANTENNA TILT IS SUCH TO ALLOW IT TO PAINT THE FIRST GROUND RETURNS on TOP OF THE ND.
- GAIN is mostly used in AUTO or CAL.
    - Before EVALUATING WEATHER, start with GAIN in AUTO/CAL.
    - MANUALLY VARY THE GAIN TO DETERMINE THE STRONGEST PART OF A CELL.
    - Set the GAIN BACK TO AUTO.
  - WX + T and TURB are used to locate the WET TURBULENCE AREAS.
    - When using TURB DETECTION, adjust TILT to eliminate GROUND RETURNS up to 90 NM.
    - TURB is detected within approx. 50 NM and not affected by GAIN setting.
  - For MAPPING, TILT and GAIN have to be adjusted harmoniously because the ground returns vary greatly with the angle of the radar beam, which illuminates them.
    - MAP is to be used to detect PROMINENT TERRAIN (mountain, city, coastline).
    - Adjust TILT and GAIN – MAPPING COVERAGE VARIES WITH TILT and A/C ALTITUDE.

TILT ANGLE (MAP)	AREA SCANNED AT FL 330
3° DN	72 NM to 190 NM
5° DN	47 NM to 190 NM
7° DN	36 NM to 70 NM
10° DN	26 NM to 41 NM

PHASE OF FLIGHT	DETECTION AND MONITORING PROCEDURES	REMARKS
TAXI	Clear on parking area, set ND to lowest RNG, TILT DOWN then UP; check appearance/disappearance of GND RETURNS	RADAR CHECK AWAY FROM PEOPLE
TAKE OFF	Weather suspected SLOWLY SCAN up to + 10° then TILT + 4°	Scanning along departure path
CLIMB	To avoid OVER SCANNING, TILT DOWNWARD as the A/C climbs and maintain GND RETURNS ON TOP OF ND	TILTangle function of ALT/ND RANGE
CRUISE	Use WX TILT slightly NEGATIVE: maintain GND RETURNS ON TOP OF ND. Range 320 - TILT $\approx -1^\circ$ Range 160 - TILT $\approx -1.5^\circ$ Range 80 - TILT $\approx -3.5^\circ$ Range 40 - TILT $\approx -6^\circ$ Use TURB to ISOLATE Turbulence – GAIN to AUTO	In higher altitudes when closing Weather: - Decrease ND range - TILT move down. No ground returns beyond line of sight $D_{nm} = 1,23\sqrt{ALT \text{ ft}}$ FL 370 D 240 NM Poor ground return over calm sea / even ground
DESCENT	During DES, TILT UPWARD about + 1° / 10.000 ft in higher altitudes, then + 1°/5000 ft below 15.000 ft	
APPROACH	TILT + 4°	To avoid ground returns

**NOTE:**

Weather and ground returns are difficult to differentiate. A change in TILT rapidly changes the shape and color of ground returns and eventually cause them to disappear which is not the case for weather.

Use of RADAR ON GROUND requires precautions since it can cause damage to human body. Distance for MAX PERMISSIBLE EXPOSURE LEVEL (MPEL 10 mw/cm<sup>2</sup>) = 4 m with X band radar.

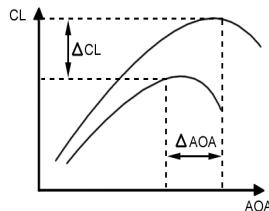
## 30 - ADVERSE WEATHER OPERATIONS

### ❖ General

The adverse weather operation addresses following topics:

- **Cold Weather operation and icing conditions**
- **Turbulence**
- **Windshear**
- **Volcanic ashes**

Refer to FCOM VOL 3 (3.04.30 and 91).



### ❖ Cold weather operation and flight in icing conditions

A wing contaminated with ice has different characteristics from a clean wing. The airflow, which smoothly follows the shape of the wing when clean, separates from the wing covered with ice when AOA increases. Thus the Maximum Lift is reduced, stall may occur at lower AOA and Drag increases as well.

- ➔ Ice accretion on the wing while the A/C is on the ground may significantly affect the safety of the Take Off, and the initial climb performance.
- ➔ Ice accretion on the wing in flight has the same consequences; minimum speeds are affected.

Consequently whenever OAT is below 0° C and there are moisture cues around (fog, rain, snow, ice crystals, slush, ice etc.) a thorough exterior inspection must be carried out and ALL CRITICAL SURFACES have to be inspected and clear of ice/snow: wing leading edge and upper surface, vertical and horizontal tailplane, slats, flaps and control surfaces.

Furthermore specific equipment shall be checked to be free of ice and snow: landing gear, engine inlet, fan, drains, bleeds, probes, radome, Fuel Tank Vent.

- ➔ This inspection will determine the Captain's Decision to proceed for a ground De icing/Anti icing treatment.

#### NOTE :

An aircraft after landing may have its wing temperature below 0° C while OAT is above 0° C. In case of drizzle or rain falling on the wing, ice will accumulate on the upper wing, with light frost under wing.

3 mm of frost under wing is acceptable.

The exterior inspection may be affected by the cold soak procedure, which is applied in very cold weather conditions:

- the Outflow valves are closed, the Cpt seat is full forward, the batteries may have been removed and specific water draining procedures have been applied,
- these systems shall be more specifically verified.

In very cold weather some systems might be affected:

- the EFIS/ECAM when cockpit temp is very low,
- the IRS alignment which takes a longer time (15 mn).

Pitot and window heat may be used on ground; they automatically operate at low level.

### **The ground de icing / anti icing procedure is decided by the Captain.**

When an aircraft is contaminated with frost, ice, snow etc., it must be DE ICED prior to take off; furthermore if there are risks of further icing, the surfaces must be ANTI ICED.

The DE ICING / ANTI ICING process consists in spraying fluid over the aircraft.

There are three types of fluids:

1. **Type 1** (glycol + water - No thickener); it is heated prior to application and the water dilution allows to lower down its freezing point.  
The hold over time is short (time of anti ice fluid efficiency measured from beginning of application).
2. **Type 2** (glycol + water + thickener) has a longer protection time.  
The hold over time is a function of glycol concentration, and weather conditions.  
The protective film efficiency is also affected by wind velocity, jet blast...  
Hold over times are provided on specific tables.
3. **Type 4** similar to type 2 but providing longer hold over times.

Depending upon the severity of the weather, a ONE STEP or TWO STEP de icing / anti icing procedure will be applied.

The ONE STEP procedure consists in a single application of heated and diluted de icing / anti icing fluid; the amount of heated fluid is large and the hold over time starts at the beginning of the spray.

- Hold over time is shorter and this procedure is somehow more costly.
- Thus it must be used when moisture is low.

The TWO STEP procedure consists in spraying heated and diluted de-icing fluid first; then a protective anti icing coating is built by a second not heated fluid spray. These two sprays must be achieved consecutively. The hold over time starts at the beginning of the second spray.

Specific tables give guidelines on when to use those procedures.

## PRECAUTIONS

- Fluids to be used must be in accordance with airline requirements and AMM.
  - Aircraft anti icing may be performed with ENG and APU running or stopped.
- ➔ **Do not start APU or ENG during spraying.**
- Aircraft de ice / anti ice must be achieved SYMETRICALLY on both sides of the A/C; avoid ingestion of de icing fluid by APU or ENG.
  - If repeated anti icing is required, the surfaces must be systematically de iced first, prior to spraying the anti icing fluid.

## PROCEDURES

Specific procedure is provided before and after spray, the purpose of which is to prevent de icing / anti icing fluid from penetrating the aircraft (BLEED OFF, DITCHING P/B) - Keep Engine Bleeds OFF after spray with engine running at higher N1 (EPR). Keep APU running with bleeds OFF after spray for a couple of minutes...

Good communication with ground crew must be established.

After the spray, a check of the surfaces must be carried out.

A De icing / Anti icing report must be filled in.

Slats / Flaps and Flight Controls may now be moved since clear of ice.

At the end of a flight, in extreme cold conditions, a cold soak protection is requested when a longer stop over is expected.

- In flight

- Taxi, Take off and Landing precautions on contaminated runways have been detailed in chap. 29.
  - Consider using ANTI ICE when SAT / TAT < 10° C and visible moisture.
    - ENG A/I                    when SAT between 0° and – 40° C and Icing conditions  
                                  or if SAT below - 40° C and flight in CBs.
    - WING A/I                    when Ice apparent on wipers or Ice detectors.
  - If Anti ice is used at T/O, apply TOW weight or FLX TEMP penalty.
  - If ENG ANTI ICE must be selected ON with ice build up apparent (**late selection**).
    - Eng mode selector to IGN.
    - Retard one engine and select ENG A/I.
    - Adjust thrust back smoothly and wait for stabilization.
    - Proceed the same with other engines.
    - Eng mode selector back to NORM.
  - In approach, whenever temperature is below ISA -10, the target altitudes provided by ATC must be corrected by adding the values provided in the hereunder table:

HEIGHT [ft]	Corrections to be added [ft]		
	ISA - 10 °C	ISA - 20 °C	ISA - 30 °C
500	20	40	60
1000	40	80	120
2000	80	160	240
3000	140	260	380
4000	180	340	500
5000	220	420	620

## Miscellaneous

- With SLATS EXTENDED, avoid prolonged flight in icing conditions or retract them.
  - If ICE ACCUMULATION on wings, the minimum speed VLS is increased by 5 kt (10 kt on A 321 for CONF 3).
  - A prolonged flight in icing conditions shall be reported to maintenance (engine inspection... ).

**NOTE:**

Icing on surfaces occur when TAT is lower than 0° C.

Risks of water in clouds are encountered when SAT between 0° and - 15° C.

- **TAT = SAT +  $\Delta$ :**  
 $\Delta$  is function of Mach: + 25°C (0.7), + 20°C (0.6), + 13°C (0.5), + 5°C (0.3).

**FUEL TEMPERATURE** must be above the minimum specified temp so as to keep its fluidity. When the temp is too low a caution is triggered (- 48°C for A319 & A320, -46.5° C for A321).

The TAT is a good indicator of fuel temp potential problems.

Consider increasing Mach, or descending if necessary: refer to chap. 8.

❖ **Landing on iced or very slippery runway**

Landing on a very slippery or iced runway is **obviously to be avoided**.

However if conditions make such landing necessary keep in mind that:

- The aircraft must be stabilized at minimum VAPP at runway threshold.
- The aircraft must overfly runway threshold at 50 ft, not more.
- A long flare is to be avoided.
- The use of ground spoiler is compulsory.
- The reversers shall be selected immediately at touch down.
- The landing distance factor to be applied to actual landing distance is approximately 3.5, on an iced runway to get an assessment of the expected landing distance.

Limited crosswind can be sustained (approx 5 kts on an iced runway).

In case of crosswind, be aware that:

- The side stick must be centered during roll out to prevent asymmetric wheel loading, thus resulting asymmetric braking effect increasing the intowind turn tendency of the aircraft.
- The Auto Brake MED is recommended on contaminated runway.
- The use of reverser, which is recommended, might induce some directional problems by creating a side force increasing the lateral skidding tendency and by reducing the efficiency of the rudder due to the perturbation of the airflow around the vertical tailplane.
- The use of differential braking when required must be done by totally releasing the pedal on the opposite side to the expected turn direction (indeed on a very slippery runway the same braking effect may be produced with full or half deflection of the pedal).

❖ **Flight in Severe Turbulence**

- Turbulence area awareness:

Extensively use MET reports and charts to determine the location and altitude of possible CBs, storms and CAT.

In flight use the RADAR (weather, weather + turbulence temporarily, as well as the reports from other aircraft).

- If Take off has to be achieved with high turbulence:
  - Wait F + 20 kt, **→ to retract surfaces**
  - Wait S + 20 kt (or VFE - 5 kt). **→ to retract surfaces**
- In case of Moderate Turbulence:
  - Keep AP ON,
  - Keep ATTHR ON and managed speed in cruise and in approach (GS mini most effective).

In case of SEVERE TURBULENCE:

- Keep AP ON; the altitude might temporarily vary. This is normal.  
If you feel like setting the AP OFF because it reacts roughly, preferably use the I/D on the stick and keep ATTITUDE constant.  
Avoid overriding the AP with the stick, since when AP goes OFF, the resulting stick deflection may cause a brutal A/C response.
- SET the ATTHR OFF more specifically in cruise: set thrust levers to turbulence N1 as per QRH and press I/D. The turbulence speed profile must be followed:

<b>A319 &amp; A320</b>	250 kt below FL 200 275 kt/M 0.76 above FL 200
<b>A321</b>	265 kt below FL 230 300 kt/M 0.76 above FL 230

Avoid high thrust changes; however don't let the speed drop too significantly since this decreases the buffet margins.

In approach set the ATTHR ON with managed speed, to gain benefit from GS mini guidance.

- Miscellaneous:

**SEAT BELTS ON / NO SMOKING ON,  
PILOT harness ON,  
ALL WHITE LIGHTS ON** in thunderstorm.

**SET SEAT BELTS ON WHENEVER EXPECTING TURBULENCE  
TO PREVENT INJURIES**

NOTE:

- It is not necessary to set the engine mode selector to Ignition. Indeed, in case of engine flame out, the igniters will be triggered automatically.
- When you set the ATTHR OFF, set the thrust levers to the intended N1 and depress the I/D. This will minimize the thrust changes, which have to be avoided in those conditions.

❖ **WINDSHEAR at T/O and LDG**

- Windshear awareness

Extensively use MET Reports, Tower reports in order to locate possible Windshear in T/O segment or Approach area.

The PREDICTIVE W/S (PWS) system must be set ON; it advises the crew of potential windshear AHEAD of the A/C.

The REACTIVE W/S system detects a windshear and sends an AURAL warning as well as a message on PFD. It is available between ground and 1300 ft AGL.

- Operational Rules

- If W/S suspected at T/O, **DELAY T/O**.
- If W/S reported in approach area, or detected by PWS, **AVOID** the W/S area.
- If necessary, hold as long as necessary and consider fuel requirements or fly to ALTN.
- In case W/S is encountered, immediately and **WITH NO ARGUMENT**:
  - SET TOGA thrust (if DERATED T/O, set TOGA when required; be aware of VMC potential problem).
  - FLY SRS FD pitch orders rapidly, smoothly but not aggressively,
  - consider using full back stick if necessary to follow SRS or minimize height loss,
  - while in the windshear, **DON'T CHANGE THE CONFIGURATION** (it induces additional drag, or rises the minimum speeds).

**NOTE:**

Speed, Speed Trend, Attitude, Flight Path angle, Flight Path vector, V/S are good indicators of the situation.

**NOTE:**

Refer to chapter 24 for more details.

In approach, use ATHR ON with managed speed, to benefit from GS mini guidance.

❖ **Volcanic Ashes**

**Volcanic ashes** or dust are composed of very ABRASIVE particles which may cause engine surge, accumulation of volcanic material on turbine vanes and cause severe damage to aircraft surfaces most exposed to airflow. Refer to FCOM VOL3 (3.04.91).

- ➔ Avoid flying into such areas and
  - Avoid flying into airfields covered with volcanic ashes.

**For ground operation**, following GENERAL PRECAUTIONS must be applied if necessary:

- **Exterior Inspection.**
  - ash to be removed from lubricated surfaces, seals, engines...
  - ash to be removed around ENG INLET.
- **APU:** if possible DO NOT USE.
- **ENG START** with Jet Air Turbine and Ground Power Unit.
- **CRANK** before start.
- **KEEP BLEEDS OFF** during taxi and keep thrust as low as possible.
- **T/O:** Rolling T/O is advisable with smooth thrust application.
- **LANDING:** Reversers do not use unless necessary.
- **WIPERS** do not use.

**IN FLIGHT:** the problem is to detect volcanic dust which might not be visible (dust in cockpit, smell similar to elec. smoke, engine misbehavior such as EGT increase, thrust loss, engine stall).

The **essential actions** to be taken are:

- If feasible, make a 180° turn,
- Engine protection:
  - ATHR OFF / Thrust reduce / Set all bleeds ON – Pack High flow – Eng and wing anti ice ON in order to increase the surge margin,
  - Eng mode selector to IGN,
  - Monitor EGT if EGT rises, consider shutting down the associated engine.
  - Restart when out of volcanic area and within start envelope.
  - APU shall be started as well, because it may be useful for engine relight in flight and
  - Crew Oxygen mask ON - Consider PAX Oxygen.

**NOTE:**

Be aware that after engine relight, some parts of the engine might be eroded, leading to a higher EGT and FF.

**Consider landing on the nearest suitable airport.**

The volcanic ashes may corrupt the IAS / MACH indication by contaminating the pitot sensors. If IAS becomes unreliable refer to "flight with unreliable speed indication" in the QRH.

## 31 - FERRY FLIGHT WITH LANDING GEAR DOWN

### ❖ General

All data linked to ferry flight is provided in FCOM VOL 2 and MEL.

One of the key issues for this flight is obviously the performance degradation at T/O, CLB, CRUISE.

### ❖ Flight with Landing gear down

Before such a flight refer to FCOM VOL 2 (2.04.25) and to MEL.

The flight is possible with the gear doors properly closed.

In case of a normal flight, if the landing gear fails to retract, refer to FCOM VOL 2 for flight continuation.

### PERFORMANCE CONSIDERATIONS

The **TOW determination** must take into account:

- 2<sup>nd</sup> segment gradient requirement,
- Final Take off requirement,
- En Route requirement (eng failure drift down net flight path obstacle clearance).

The 2<sup>nd</sup> segment gradient requirement is fulfilled by applying a CONSTANT WEIGHT REDUCTION to the normal MTOW as determined on RTOW.

Once an MTOW is determined, read the speeds corresponding to this weight in the normal RTOW charts.

### Final T/O, Climb and Drift down Speeds

- In Final T/O segment, IAS = VLS.
- In Climb, IAS / MACH = 230/0.50.
- Drift down out of cruise, IAS = Green Dot.

### Go Around Performance

Determine the Go Around limiting weight as for a normal flight and apply a 15 % reduction to this limiting weight.

### Some System Limitation

- Disregard FMS fuel predictions.
- Disregard FMS Speed Computation: use SELECTED SPEEDS.
- VMO / MMO - 235 / 0.60.  
 ➔ modify VMO/MMO selection in avionics compartment (LDG DOWN configuration).
- Should a failure lead to ALTN Law, DIRECT Law will actually be triggered due to the fact that landing gear is down.

### Procedure

- **T/O: CONF 1 + F - No Tail Wind.**
- **Preset** 230 kt Climb SPD on PERF CLB.
- Holding: CONF1
- Avoid Icing conditions

### NOTE:

In certain cases the ferry flight may be associated to flight without pressurization due to structural issues. In that case:

- either limit FL to 100,
- or climb to a higher level with 02 masks,

In both cases, keep PACK ON with outflow valves fully open.

## 32 - WET AND CONTAMINATED RUNWAYS

### ❖ General

The take off and landing from wet and contaminated runway has 2 operational aspects:

1. Performance and limitations and
2. Specific operational characteristics.

There are major differences in operational constraints between a so-called WET RUNWAY (which can be covered with a small amount of slush, standing water, wet/dry snow) and a CONTAMINATED RUNWAY (which is covered with a bigger amount of wet/dry snow or slush).

The definitions of those runways are quite accurate, and provided in FCOM VOL 2 (2.04.10).

### ❖ Performance Considerations

- The problem consists essentially in determining the take off data.
- The dispatch from WET or CONTAMINATED RUNWAY is possible if:

#### WET and CONTAMINATED

- A/SKID & GND SPOILERS available
- Uniform depth & density of contaminant
- Friction coefficient derived from flight tests

#### CONTAMINATED

- All reversers available
- Take off with TOGA thrust (no FLX)
- or DERATED TOGA thrust

- The take off data for WET and CONTAMINATED runways assume:

15 ft screen height at the end of T/O segment  
15 ft obstacle clearances provided by net trajectory } Instead of 35 ft

- Consequently the principle in determining the Take off data from wet and contaminated runway is as follows:

- Determine MTOW and associated V1/VR/V2 } on DRY runway taking  
Or FLX TEMP and associated V1/VR/V2 } into account QNH/BLEED
- Determine if the runway is WET or CONTAMINATED; if CONTAMINATED determine the level of contamination (e.g. 6.3 mm or 1/4 inch slush...).
- Then apply the corrections or decrements as provided in the related tables.
  - Check that the resulting take off speeds are GREATER than MINIMUM V1 (VMCG considerations), MINIMUM VR/V2 (VMCA or VMU considerations).  
If they are LOWER than the minimum values, apply further decrements.  
However in some cases SPECIFIC RTOW CHARTS must be computed because the decrement method is not accurate enough.
- For WET runways, several tables are provided depending upon the availability of thrust reversers.  
On WET runways, decrements can be applied EITHER on MTOW or on FLX TEMP.
- For CONTAMINATED runways, several tables are provided depending upon the type of contamination (standing water, compacted snow ...).

- CONTAMINATED runways, decrements are applied to MTOW in order to determine a MTOW on contaminated runway.
- If actual TOW is lower than MTOW (contaminated), the take off speeds are directly read from the tables.
- Landing distance assume an even distribution of contaminant, the use of full pedal braking from touchdown onwards and an operative anti skid system.  
 The braking effect due to aerodynamic drag (ground spoilers + impegement drag caused by spray pattern of the fluid contaminant on the landing gear and airframe) and due to thrust reversers is obviously important on a more contaminated runway.

## OPERATIONAL CONSIDERATIONS

### DO NOT TAKE-OFF FROM ICY RUNWAY

As a general rule, it is NOT recommended to take off from HIGHLY CONTAMINATED RUNWAY (2 inch Dry snow or 1 inch of Wet snow).

### Taxiing before take off

Taxi at low speeds and use as low thrust settings as possible. There is however no risk of nose wheel steering splashing contamination into the engines.

In icing conditions with rain/snow falls, on taxiways covered with slush or snow, **taxi with CONF 0** in order to avoid contamination of the flap/slat extension system

- as a consequence the BEFORE T/O C/L shall be interrupted at the FLAP configuration check and
- once holding short of the T/O runway, or during alignment on the T/O runway, extend the FLAP to the T/O CONF and complete the before T/O C/L.

During taxi, use BRAKES with care (no A/SKID at low speed) as well as NWS. Avoid large tiller inputs to correct for skidding.

- use Differential thrust to smooth the turns, and smooth differential braking.
- in sharp turns, keep a low GS (5 kts to 7 kts) in order to minimize the effects of the Nose Wheel slippage (noise, vibration, jerks).

### Take off and RTO

- In the T/O Brief, mention all the particulars linked to runway contamination.
- Set TOGA Thrust on contaminated runway.
- The Maximum recommended XWIND component is specified for each type of runway condition.
  - The Directional control of the A/C is best ensured by the rudder:  
 use pedals; NEVER use the tiller and  
 use Differential Braking if necessary. Release totally the pedal on the opposite side of the intended turn direction.
- Rotate at VR, NOT BEFORE.
- In case of RTO:
  - use MAX REV: however in case of XWIND be aware that reversers increase directional control problems by perturbing the airflow around the rudder.
  - use Pedals and diff braking if necessary. Release totally the pedal on the opposite side of the intended turn.

### NOTE:

Eng start selector may be set to IGN START if eng anti ice is OFF.

## Landing and return to gate parking

- Consider a diversion to an airport with better runway conditions, if the destination runway conditions are poor, more specifically if additionally there is crosswind, or if the reversers or ground spoilers are failed.
- Use of **AUTOBRAKE is recommended** as long as the contamination is even; preferably MED
- Approach is achieved with NORMAL VAPP (standard + 5 kts correction on top of VLS is taking care of ice accretion).
- Shoot for a firm touch down and select MAX REV as soon as MLG is on ground (PLD will then increase weight on wheels).
  - Be aware that in case of XWIND, and directional control problems, the reversers destabilize the rudder efficiency and creates a side force increasing the intowind turn tendency of the aircraft. Consider using Idle Rev.
  - Use of Diff Braking might be necessary (release totally the pedal on the opposite side to the expected turn direction).
- The maximum sustainable crosswind is a function of the reported braking action (see table hereunder)
- Stick into wind shall be avoided since it increases directional control problems.
- Taxi back to the gate with SLATS/FLAPS extended. Don't retract them in order to avoid any potential damage, caused by crushing the ice present in slats slot during retraction.
- Be smooth on the tiller.
- Once engines are stopped, a visual inspection shall be achieved to determine whether the flat / slats system is free of contamination. Then only, these may be retracted using the ELEC HYD PUMP.
- Be aware that the deceleration is much less than normal (DECEL light might not illuminate on Auto Brake panel) and that directional problems increase at low speed.

Reported braking action - Index	Reported Runway friction coef.	Equivalent Runway Condition	Maximum Crosswind for Landing
Good -5	$\geq .4$	Dry / Damp / Wet	35 kts
Good / Medium - 4	.39 to .36	Damp / Wet (< 3 mm)	30 kts
Medium - 3	.35 to .30	Slush or Dry snow	25 kts
Medium / Poor - 2	.29 to .26	Dry snow	20 kts
Poor -1	$\leq .25$	Standing water / Wet snow	15 kts
Unreliable - 9	Unreliable	Ice - Risk of hydroplaning	5 kts

### - Maximum sustainable crosswind function of runway condition -

#### NOTE:

The concept of Equivalent runway condition is to be used only to determine the maximum crosswind, but not for the computation of take off and landing performances since it does not account for the effects of the displacement and impingement drag.

#### NOTE:

- With dry snow the reverser might reduce the visibility, more specifically at low speeds. Set Idle Rev or stow it in case of reduced visibility.
- The maximum XWIND component recommended in approach is the same as for T/O.
- Landing distances with A/BRAKE are provided in QRH; it gives a good assessment of the runway distance required at various levels of contamination.

## **B. ABNORMAL OPERATION**

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## 1 - ECAM PHILOSOPHY

### ❖ General

The ECAM system is a central component of the Airbus 2 crew member cockpit; it is fully linked to the Dark Cockpit and Forward Facing Crew Cockpit concepts.

The purpose of the ECAM is:

- to display the aircraft system information,
- to monitor the aircraft systems,
- to provide the actions required by the crew in most normal/abnormal and emergency situations.

As a consequence, the ECAM being available in most failure conditions, it is a significant step forward towards the paperless cockpit and the removal of memory items.

The ECAM being used for SYSTEMS OPERATION, it provides

- PERMANENTLY the engine control parameters, total FOB, S/F CONF, as well as TAT/SAT, TIME, GW, CG, which is data needed throughout all flight phases,
- WHEN NEEDED, the system synoptics, which is necessary for the pilot to achieve a task, or during a given phase,
- WHEN NEEDED, written messages describing actions required in case of failure, or improving crew awareness of the OPERATIONAL STATUS of the aircraft in degraded situations, or assisting the crew in TEMPORARY SYSTEM operation.

The ECAM is driven by three essential computers:

- the DMCs (which drive the DUs),
  - the SDACs (which acquire most of the data and send the signals necessary to display the synoptics; it sends to the FWCs the data necessary to generate the ECAM msg),
  - the FWCs (which acquire data from SDACs and some A/C sensors in order to generate alert messages, aural alerts, flight phases etc. and also to achieve R/A, DH/MDA call outs and Landing Speed increment computations. RED WARNINGS are processed by FWCs, amber cautions as well but through SDACs).
- Thus, in case of total failures of the FWCs, the system operation is done using QRH and OVHD panel.

### ❖ 3 Design Principles and Particulars

#### 1. INFORMATION PROVIDED WHEN NEEDED

The information is provided only when needed; else it disappears.

This dictates the OPERATING MODES OF THE ECAM:

- **Normal mode:** automatic flight phase related mode (for System Display and Memo),
- **Failure related mode:** automatic display of abnormal/emergency procedures and of associated system synoptic on SD in case of failure,
- **Advisory mode:** automatic display of the SD associated to a drifting parameter and
- **Manual mode:** manual display of any SD by acting on the ECP (ECAM CTL panel).

Additionally some failures are NOT DISPLAYED during a given flight phase in order not to distract the pilot from his essential task during a touchy flight phase: T/O INHIBIT – LDG INHIBIT.

## 2. FAILURE LEVELS AND CRITICALITY

The failures are classified in 3 LEVELS depending on their CRITICALITY, in other words on the OPERATIONAL CONSEQUENCES.

The FWC will thus display the failures in their order of criticality.

Furthermore if a failure of a system affects another system, the FWC will display the PRIMARY FAILURE first, the consequential or SECONDARY failure subsequently.

In order to make it INSTINCTIVE to the crews, a simple COLOR CODING of the information is used to indicate the CRITICALITY of the SITUATION, as well as an adapted AURAL signal.

LEVEL OF FAILURE	CRITICALITY	COLOR/AURAL	PILOT REACTION
LEVEL 3	SAFETY	RED / CONTINUOUS REPETITIVE	IMMEDIATE
LEVEL 2	ABNORMAL	AMBER / SINGLE CHIME	AWARENESS, THEN ACTION
LEVEL 1	DEGRADATION	AMBER / NONE	AWARENESS / MONITORING

**NOTE:**

The color coding is also used for other purposes such as Green for normal ops, Blue for required actions and limitations, White for titles/remarks, Magenta for messages.

## 3. FEED BACK PRINCIPLE

In case of MEMO (messages, or T/O and LANDING memos), in case of ADVISORY, in case of a FAILURE, there is a feedback to the crew materialized

- on the system synoptic regarding the status of given components,
- by the action line disappearing when the related action is completed.

In other words, whenever a failure or an advisory occurs, the associated System Display page is provided on the bottom CRT. Allowing the crew to analyze the situation, materialized by the status of the various affected components of the synoptic. If a procedure is proposed to the crew by various action lines, each action line disappears once the corresponding action is achieved.

The ECAM reacts to failures as well as to pilot actions.

## 4. ECAM PARTICULARS

**Redundancy:**

In case of loss of one DU, the remaining DU is able to display both the E/W-D, and the SD, called by the pilot on the ECP. The ND may also be used to recover the second DU. In case of loss of 2 ECAM DUs, the ND is able to do the same after having switched the selector ECAM/ND XFR to associated side.

**ECP:**

(ECAM Control Panel) allows any SD page to be called on pilot request.

- RCL key allows a warning/caution message just cleared by the CLR key to be visualized. Furthermore pressed more than 3 sec it recalls caution messages inhibited by EMER CANCEL.
- ALL allows the SD pages to be successively displayed for review. Furthermore in case of ECP failure, it allows any SD page to be accessed (release it when the required SD page is displayed).

**EMER CANCEL:**

suppresses ANY AURAL associated to a Red Warning, but does not affect the warning; or it cancels the AURAL and the CAUTION for the rest of the flight. The purpose of EMER CANCEL is to suppress any FLUCTUATING caution. This is materialized on STATUS PAGE by the title "CANCELLED CAUTION".

**MASTER WARNING/CAUTION:**

These are ATTENTION GETTERS in case of a failure.

Pressing the related P/B extinguishes the light (except for STALL/OVERSPEED...) and stops the aural (except for the same cases).

In case of ALTITUDE ALERT AURAL, pressing MASTER WARNING stops the aural.

**T/O CONFIG P/B:**

is part of the system. It simulates T/O power application and allows the pilot to check that S/F, PITCH TRIM, RUD TRIM, SPD BRAKES, BRAKE TEMP, PKG BRAKE, FLX TEMP NOT SET, DOORS are in proper status for T/O.

**NOTE:**

In case of ECP failure the keys CLR, RCL, STS, ALL & EMER CANCEL operate since they are hard wired to the FWC/DMC.

**❖ Operational Use of the ECAM**

The following rules are a direct consequence of the design philosophy of the ECAM. One of the main purposes of the ECAM is SYSTEM MANAGEMENT in a 2 CREW COCKPIT environment. Consequently TASK SHARING is an ESSENTIAL issue in the ECAM operation more specifically in case of ABNORMAL.

**1. In case of NORMAL OPERATION**

- PERIODICALLY review the main systems during flight (Eng, Bleed, Elec, Hyd, Fuel, Flt Ctl) to know if everything is OK and detect a potential problem in advance.
- The ECAM MEMO must be included in the instrument SCAN; in most cases during cruise, it should be blank. It helps the pilot to notice that a system, temporarily selected such as SEAT BELTS/IGNITION/ENG ANTI ICE ..., has been forgotten ON.
- When STS label is displayed at the bottom of E/W-D, this means that there is a STATUS to be reviewed. Consequently, when C/L calls for STATUS review, press STS only if the label is displayed.
- At engine shutdown if there is a STS, it pulses at the bottom of E/W-D. Review the STATUS page as a help to fill in the technical log.
- In order to check whether IRS are aligned, review the MEMO; remaining time of alignment is displayed if the alignment is not completed. It is useless to refer to OVHD panel.

**2. In case of ECAM ADVISORY**

The first pilot who notices an Advisory announces "ADVISORY on XYZ system".

The PF asks the PNF for a review of the drifting parameter.

### 3. In case of ABNORMAL or FAILURE OPERATION

In case of ABNORMAL, the task sharing and crew coordination are essential in order to PROPERLY FLY THE A/C while PROPERLY DEALING with the FAILURE.

There are very FEW MEMORY ITEMS:

- Emergency Descent Initiation,
- First reaction in case of unreliable Speed Indication,
- Loss of Braking,
- Wind shear (reactive & predictive),
- EGPWS & GPWS and
- TCAS.

#### **TASK SHARING RULES in case of ABNORMAL**

Since there are two essential sets of functions to be achieved, (fly and deal with the failure) both pilots must be aware of what is going ON when an abnormal occurs, and during the completion of the associated drills.

Thus the role of each pilot must be quickly assigned and known.

PF is usually PF throughout the flight UNLESS CM1 decides to take control.

→ PF announces "**I have control and/or communication**".

PNF confirms "**You have control and/or communication**".

PF will then control the A/C Flight path, Speed, Configuration and engines (this is why the PF always controls the thrust levers even in case an ECAM action is required on thrust levers); he will deal with navigation and communication; he will initiate the ECAM action to be done by PNF and check that the actions are properly completed.

For some items such as FIRE P/B - ENG MASTER - IDG - IRS, a positive confirmation by PF is required prior to switching them OFF.

PNF has quite a heavy role since he handles the ECAM actions and assists the PF on his request.

→ PNF reads ECAM and C/L, executes the ECAM actions on PF command, asks for PF confirmation to clear, executes the actions required by PF.

The PNF never touches the Thrust Levers even if so asked by the ECAM (normally action of PF unless otherwise advised by customer's procedure).

When a failure or abnormal occurs, the general scheme of actions is as follows:

- the first pilot to recognize the problem announces the
- MASTER WARNING or CAUTION - TITLE OF THE FAILURE,
- the PF properly controls the A/C: FPA/BANK/BETA/IAS – Once properly stabilized (at around 400 ft AGL, at T/O - GA or APPR; this is a good compromise between A/C stabilization and action delay), the PF orders ECAM ACTION.

Then:

PF	PNF
<p>« ECAM ACTION »</p> <p>After crosscheck actions properly done confirms « CLR XYZ* »</p> <p>Calls « STOP ECAM » if specific procedure has to be done (except in case of fire); then « CONTINUE ECAM »</p> <p>After crosscheck confirms « CLR STATUS »</p> <p>* XYZ - call affected system or component</p>	<p>Reviews SD and reads ECAM Achieves the action Checks associated line disappears Once all lines away asks « CLR XYZ* »</p> <p>Continues the action or reads STATUS</p> <p>Once all done asks « CLR STATUS »</p> <p>« ECAM ACTION COMPLETED »</p>

#### Operation of the ECAM with one ECAM DU only available

- In case of one ECAM DU failed, the other one displays the E.W/D. In that case, there is not Automatic System or Status page display when a failure or advisory occurs; the display of a system synoptic is provided on the remaining DU by pressing on the related system P/B on ECP. The synoptic is displayed as long as the P/B is pressed.
- In case of an advisory or a failure, the PNF has therefore to call for the affected system synoptic by pressing the associated key on the ECP. When an advisory occurs, ADV flag pulses white at the bottom of the E.W/D.

#### Some remarks on ECAM

- When a failure occurs it is important to review the SD prior to act, in order to get a proper assessment of the situation. This is the main reason to have the SD associated to the failure being displayed.
- **LAND ASAP RED:** indicates a high level of emergency. Don't delay actions and consider closest airport.
- **LAND ASAP AMBER:** the crew has to assess the seriousness of the situation and possibly review the selection of a suitable airport.
- Some actions have **no feedback** on ECAM; the blue line does not disappear. For example, ATC NOTIFY or VHF 1 (2) (3) USE or MIN RAT SPEED 140 etc. Some procedures **require reference** to QRH; this is the case of ABNORMAL CONF, EVACUATION etc. This is indicated by PROC APPLY on the ECAM. It is good practice to LOCATE the associated C/L in the QRH.
- In case of OEB, **the affected procedure or status is suppressed.** The ECAM states: REFER TO QRH (if applicable - depending on FWC status). The OEB modified procedure is provided at the end of the QRH.

- In some failure cases, the STATUS asks for a specific procedure to be achieved in approach. STS page is automatically displayed when (among others - refer to FCOM) CONF 1 is selected, as a reminder for APPR C/L. Properly review the STS and apply the required procedure.
- All procedures, not provided on the ECAM in case of abnormal situation, are in the QRH.

The ECAM is an EFFICIENT TOOL in case of ABORMALS, provided:

- it is CAREFULLY handled,
- actions are done and checked on SD,
- proper crosscheck is applied and
- care is taken not to be distracted.

## 2 - REJECTED TAKE-OFF (REFER FCOM 3-02-01)

The rejected T/O is a difficult, touchy and potentially hazardous procedure at high speed because

- being seldom achieved, this induces a delay,
- there are many reasons not to obtain proper deceleration: brake wear, tire status, brakes not fully applied if pilot takes over,
- remaining RWY not enough in case of RWY limited (e.g. A/C lines up too long, rolling T/O with slow thrust application etc.)
- uncertainty on A/C GW, thus non adequate speeds and
- in certain cases CM1 decides to call STOP; then PF acts, which causes a delay.

Consequently AI recommends:

- CM1 to set thrust at T/O and keep thrust lever control till V1 call out and
- CM1 to call STOP and to STOP the A/C e.g. CM1 is PF till V1.

Furthermore the earlier a malfunction is detected the safer is the RTO; therefore in case of any ECAM at low speed BELOW 100 kts → STOP.

### At high speed ABOVE 100 kts, STOP ONLY FOR SERIOUS matters:

- either in case of not inhibited ECAM warnings (ENG FAIL - LO OIL PR - ENG/APU FIRE - REV UNLK - L + R ELV FAULT) which affects flight safety on short term basis or
- in case of detected thrust loss or tire failure till V1 - 20 kt inducing noticeable engine damage etc.

***But heavy vibration on NLG at high speed should not cause a stop.***

\* The procedure is therefore as follows:

CM1	CM2
<p>Calls STOP Sets thrust Idle + Rev</p> <p>Sets PKG BRAKE to PARK Cabin crew advises " Cabin Crew at your station " Calls for ECAM ACTION Confirms ATC " Abort T/O + additional info "</p> <p>If required, request " EVAC C/L" Advises CC of which side EVAC Presses EVAC and cancels the horn Advises ATC</p>	<p>Monitors REV GREEN + SPLRS + DECEL Advises ATC of RTO</p> <p>Achieves ECAM actions Locates " On Gnd Emer Evac C/L" in QRH Reads the on ground Emer EVAC C/L</p>

**ENGINE FIRE ON GROUND**

Same procedure but once ECAM actions are completed, refer to ENG FIRE ON GND paper C/L (QRH 1.05.).

**PRECAUTIONS**

- When you stop the A/C and A/BRAKE MAX decelerates the aircraft, avoid pressing the pedals (which might be a reflex action).
- If you don't feel a deceleration, use the brakes and press the pedals FULLY down. Don't forget to STOW REVERSERS at low speed.
- Don't forget to set PKG BRK ON to achieve the ECAM actions.
- If Engine Stall is experienced (high EGT, heavy vibration and noise, flames on the exhaust, poor engine response to thrust lever etc.), STOP although no Caution/Warning.
- If EVACUATION, don't forget that the A/C will be powered by BAT ONLY during C/L completion -> DOME LIGHT ON.
- Once EVAC C/L is done -> SEATS TO BE MOVED MECHANICALLY.
- Don't get confused between ON GND EVAC C/L and ENG FIRE ON GND C/L.

**NOTE:**

If fire/flames are experienced during engine start "ENG TAILPIPE FIRE C/L" is to be done. (Refer to p 79).

In case normal braking does not work, select NWS/A/SKID switch to OFF in order to select ALTN BRK. Be careful with the rudder pedals. Indeed if they are fully down when you set the switch off you will blow all your tires since A/SKID does not work.

### 3 - ENGINE FAILURE/FIRE AFTER V1

In case such type of failure occurs after V1, the essential and **primary** actions are linked with the **A/C handling**; the A/C must be properly STABILIZED in PITCH/SPEED and LATERALLY on the proper TRACK before starting any drill.

Thus the PF controls:

- PITCH at around 12.5° or SRS,
- YAW and BANK without RUSH: when  $\beta$  target comes up, smoothly and continuously press on the pedal to center it and then act on the stick laterally to fly constant heading,  
**no rush**: don't forget that the Yaw Damper will react to a detected side slip and, hands off the stick, the aircraft will bank at about 5° maximum. Thus laterally the A/C is a stable platform. On the other hand, if with full rudder you cannot center the beta target, this means that the A/C speed is too low (most probably below VMCA). In that case, check IAS and PITCH; most probably pitch down is required and
- consider the use of TOGA which will provide you extra thrust in order to achieve the initial climb even more safety.

The A/C control in case of EO at T/O and GA is most comfortable and by far easier than on certain mechanically controlled A/C. This is due to the pitch and roll control laws which make the A/C very stable, and to the efficiency of the Yaw Damper which assists the pilot in counteracting the yaw movement.

**Thus be calm, don't over control it! Act in following order:**

**PITCH for SPD → RUDDER (ZERO BETA TARGET) → STICK (HDG CONSTANT)**

PF may then use the RUDDER TRIM to release the pressure required on the pedal. Finally PF may ask PNF to set AP ON. PF must then closely monitor the reaction of the AP in the same order.

**NOTE:**

*Once CONF1 → 0 is ordered, normal side slip (yellow) is provided on the PFD. When it comes up, it is not properly centered due to the difference of the nature of the information (calculation source and meaning). Adjust rudder pedals accordingly.*

*Don't fight with the rudder trim, use it once stabilized.*

#### PROCEDURE

The principle of this procedure is obviously to ensure a SAFE A/C handling, a proper task sharing, and to define an order in the various drills which facilitates the proper achievement of each one:

**STABILIZE A/C PATH → INITIAL ECAM → ACCEL and CLEAN UP → REMAINING ECAM (to STS) → AFTER T/O C/L → STATUS**

The PF will command the various sequences of those drills.

When the failure occurs, the PNF announces ENG FAILURE/FIRE and cancels the MASTER WARNING thus the aural.

PF	PNF
<p>Stabilizes the A/C: PITCH/SPD – YAW/BETA – AIL/TRK TOGA if necessary Asks for ECAM ACTION</p> <p>EO ACCEL ALT " Stop ECAM " " PUSH TO LEVEL OFF " Orders A/C CONF clean up At G.DOT asks " OP CLB " and sets thrust levers to MCT Asks " Continue ECAM "</p> <p>Orders " Stand by STATUS" Asks " After T/O C/L "</p> <p>Orders " Read STATUS "</p>	<p>Executes ECAM till ENG relit/ 2<sup>nd</sup> agent discharge</p> <p>Acts on FCU as per PF orders and selects successive CONF Resumes ECAM action Asks " CLR XYZ " Announces " STATUS "</p> <p>Reads " After T/O C/L " " After T/O C/L completed "</p> <p>Reads STS - asks " CLR STATUS " " ECAM ACTIONS COMPLETED "</p>

## REMARKS

- The procedure asks to retard Thrust Levers → **done by PF**.
- The procedure asks to set MASTER SWITCH OFF and PRESS FIRE P/B. This must be **confirmed by PF** prior to be achieved by PNF.
- The procedure asks to determine if there is any structural damage. This is not so simple. Some cues might be: high vibration prior engine stopped, stall, OIL very low quantity or low press, hydraulic failure, N1 or N2 around 0, etc.
- If a relight is considered, it may be attempted at a later stage once A/C is cleaned up.
- If an immediate return is considered, the crew might consider to keep CONF1 (be aware it will be 1 + F thus penalizing if more climb required! Flap autoretraction may be used to get slats extended only).
- TOGA is allowed for 10 mn (5 mn FAA) maximum.
- Consider starting the APU and the use of APU BLEED if performance limited.
- Be aware of MSA.
- Use of AP is recommended.
- Bank angle is limited to 15° if IAS < maneuvering speed (F or S or G.DOT).
- If EOSID is in the Data Base, TMPY EOSID is triggered if BEFORE the diversion point between SID/EOSID. Else it is displayed for information on the ND. Thus either INSERT EOSID, or in the second case follow it with HDG mode.

## 4 - FAILURE OF SOME ENGINE COMPONENTS

### ❖ EIVMU

There is one EIVMU per engine which achieves the interface function between various peripherals and the FADEC (e.g. BMC – Norm start – Norm Ign selection...), as well as vibration monitoring.

EIVMU is a **Go Item**. If it fails the following functions are lost:

- Manual start,
- Vibration indication,
- ATHR on the affected engine,
- Reverser,
- Modulated Idle (only approach Idle) and
- FLX T/O.

However Alternate auto start / CONT REL with ENG ANTI ICE ON / ATHR on other engine are available.

### ❖ TLA DISAGREE / FAULT

There are 2 resolvers per thrust lever and per engine.

The thrust levers are directly linked to the FADEC.

Two types of problem may occur:

**TLA DISAGREE** which means that the 2 resolvers are seen to disagree by the FADEC which has therefore a problem to set a given thrust.

Thus the thrust will be set as follows depending upon the moment of the failure:

Prior T/O	→	Idle
During T/O	→	Highest T/O thrust or TOGA maintained
In flight in clean	→	Highest thrust from the 2 resolvers (max MCT)
Whenever CONF 0 → 1	→	Idle (or if LDG DN)

**TLA FAULT** which means that no signal is transmitted from thrust levers to FADEC.

The thrust is set as follows:

Ground	→	Idle
During T/O	→	Thrust is frozen (FLX or TOGA)
In flight, clean	→	MCT
CONF 0 → 1	→	Idle (for approach and Go Around) (or if LDG DN)

ATHR is available with those thrust limits; LVR CLB is flashing even with TLA in CLB.

The REVERSER on affected engine is INOP.

#### NOTE:

*The TLA symbol, moves along the N1 (EPR) gauge erratically in case of disagree; whereas it goes from MCT to IDLE in case of fault.*

❖ **N1 rated / unrated mode (IAE)**

Whenever EPR cannot be computed by the FADEC, N1 mode is triggered. This happens when a failure occurs on Pressure and Temperature sensors within the engines.

In this case the EPR gauge is amber on E/W-D.

Depending upon the sensors which have failed, the engine can operate either in N1 rated or N1 unrated modes:

- **if sensed EPR** (based on P2 – engine inlet total pressure – and P5 – LP turbine exit total pressure) is unreliable => **N1 rated**
- **if computed EPR** (based on T2 – engine inlet TAT – and ambient pressure from engine sensors) is unreliable => **N1 unrated.**

**N1 rated mode**

The FADEC computes EPR function of TLA and translates it into an N1 TLA function of Mach.

In this case ATHR is INOP; thus when the failure occurs, THR LK is displayed on FMA. The procedure asks to select N1 mode on both engines, so as to allow them to be simultaneously and similarly controlled (same TLA on both).

**The A/C can be dispatched with N1 rated mode** (see MEL); but the performances are degraded at T/O, Go Around, Max EO ALT.

No FLX T/O possible.

Tables are provided to adjust N1 for a given M (0.78) at different CRZ FL (see tables FCOM 3.05.02).

The N1 gauge on ECAM E/W-D displays N1 TLA, N1max etc.

**NOTE:**

If for any reason, a failure leads to a reversion to N1 rated mode during taxi for T/O, be aware that the T/O performance penalties are provided in the MEL. This is an example where MEL is used during taxi.

**N1 unrated mode**

The FADEC computes N1 function of TLA, ALT and limits it to N1 red line or N1 max.

In this case ATHR is INOP as well (THRLK).

N1 mode has to be selected on both engines as well.

**The A/C cannot be dispatched with N1 unrated mode.**

The N1 gauge on ECAM E/W-D does not display N1 TLA.

## 5 - EMERGENCY ELECTRICAL CONFIGURATION

The Emergency Electrical Configuration is due to the loss of all AC BUSSES (AC BUS 1+2) causing the engagement of the CSM-G or STANDBY GEN. This malfunction may be caused by:

- either the loss of all AC GEN,
- or the loss of one engine and the failure of the opposite and APU generators,
- or the loss of both engines.

In all those cases, the CSM-G comes in line; the CSM-G is driven by the BLUE HYD system which is not powered with such failures. This is why the RAT extends.

Consequently, when such a combination of malfunctions occurs, the RAT extends and then, the CSM-G comes on line which explains why during 5 sec the electrical network is powered by batteries only.

They are two RAT types: the “**old**” or **smaller/less powerfull** one which equips the early A320s. The “**new**” or **bigger/more powerfull** one which equips the A319/A321 and the latest A320s.

The role of the RAT is to provide 5 kVA electrical power either in emergency electrical configuration where it is used for CSM-G and blue hyd power for flight controls, or in certain cases of double hydraulic failures (B+Y, B+G) where it supplies blue hydraulic pressure only.

The RAT is a kind of a turbine which runs at roughly constant RPM; when aircraft IAS drops, the RAT stalls, which is more symptomatic when the landing gear is down.

Therefore, **in all cases of RAT extended**, it is recommended by ECAM to fly **at or above RAT MINI speed 140 kts**;

- but with the “old” RAT, when landing gear is selected down, the CSM-G automatically disconnects,
- with the “new” RAT, when landing gear is selected down, the CSM-G remains on line.

The CSM-G provides 5 kVA on the network and feeds the AC/DC ESS bars and the AC/DC ESS SHED bars; the loads on those bars are such that the flight is comfortable.

The batteries feed only the AC/DC ESS bars and DC HOT bars; which means that the loads are reduced and that the flight time is limited. Furthermore when the aircraft is on ground, typically at rest (IAS < 50 kts), the AC ESS which feeds the CRTs is lost, in order to minimize the electrical use of the batteries: keep in mind that when the battery voltage drops down to 20 V, there is little time left of battery operation, and the battery life drops down as well.

Note that once the CSM-G powers the electrical network, it has priority on the AC/DC ESS bars feeding over any other generator which might still be available.

- with the “old” RAT, if the CSM-G has disconnected with landing gear selected down, it may be reconnected by selecting landing gear up and pressing the EMER GEN MAN ON P/B; if the landing gear cannot be retracted, CSM-G is recovered by pulling the LGCIU1 C/B and pressing the EMER GEN MAN ON P/B.
- with the “new” RAT if the CSM-G is in line, it cannot be disconnected.

### Operational Consequences in Case of Emer. Elec. Configuration

- Sequence of events

EVENT	“OLD” A320 RAT	“NEW” A320-A319-A321 RAT
AC BUS 1 + 2 LOSS	→ 5 sec Batt only	→ RAT extends + CSM-G on line
LDG DOWN	BATT ONLY (AC/DC SHED lost)	CSM-G
IAS < 125 kts		BATT ONLY RAT stalls
IAS < 50 kts		BATT ONLY and AC ESS lost

- With the OLD RAT:

Once landing gear is extended, the flight time is limited to 22/25 mn. Some convenient loads are lost such as FAC1 (characteristic speeds are lost on PFD) ND1, FMGC1 (RMP1 must be used to tune the navaids), ATC1. Thus landing gear must be extended at about 1000 ft AGL for landing.

If the flying time has to be extended, the landing gear must be retracted or if not possible, the LGCIU1 C/B must be pulled, and EMERG GEN MAN ON P/B must be pressed (see FLT ON BAT ONLY proc in QRH).

- With the NEW RAT:

There is no more flying time limitation since the CSM-G feeds the network till 125 kts at landing. Thus, the overall approach is by far more comfortable with all CSM-G loads available till landing, provided speed is kept above 125 kts.

- In all cases:

- If both generators are lost, the pilots may be tempted to start the APU in order to benefit from APU GEN. Be aware that a successful coupling of the APU GEN to the network is remote and that each APU start reduces the battery time availability by approx. 3.5 mn.
- Characteristic speeds are lost in final approach.
- Navaids must be tuned on RMPs.
- All types of approaches are flown manually with raw data (no AP, FD or ATHR)
- The flight control law is initially ALTN and thus DIRECT once landing gear is down.
- The BSCUs are lost; thus, no NWS, no ANTI SKID available during roll out but alternate braking used up to 1000 psi; furthermore, the reversers are lost.
- RA 1 + 2 are lost with their associated auto callouts; thus call outs by PNF.

**What are the pilots left with to achieve their main task ?**

Obviously FCOM 3.02.24 outlines the available systems. The following table provides the essential systems:

**- WHAT ARE THEY LEFT WITH -**

TASK	ASSOCIATED SYS	OLD RAT		NEW RAT	
		LDG UP	LDG DN	IAS > 125	IAS < 125
OPERATE	ELAC1/SEC1	X	X	X	X
	FAC1	X	LOST	X	LOST
	FCDC1	X	X	X	X
	CONTROL LAW	ALTN	DIRECT	ALTN	DIRECT
	DMC1 (3)	X	X	X	X
	PFD1	X	X	X	X
	FADEC1	X	X	X	X
NAVIGATE	ND1	X	LOST	X	LOST
	VOR1	X	X	X	X
	DME1 – ADF1	X	LOST	X	LOST
	ILS1	X	X	X	X
	ADIRS1 (3)	X	X	X	X
	FMGC1	X	LOST	X	LOST
MA - NA - GE	E.W/D	X	X	X	X
	SDAC1 / FWC1	X	X	X	X
COMMU- NICATE	RMP1	X	X	X	X
	VHF1	X	X	X	X
	HF1	X	LOST	X	LOST
	ACP1 + 2	X	X	X	X
PAX COMFORT	BMC1	X	LOST	X	LOST
	X BLEED	X	AUTO ONLY	X	AUTO ONLY
	CPC1	X	X	X	X
	O2CREW	X	X	X	X
	O2PAX	X	LOST	X	LOST

**NOTE:**

If switching has been done on DMC3 or ADIRS3 prior to electrical failure, those are powered in emer elec conf  
 On IAE engines, N1 UNRATED or DEGRADED mode only is provided by the FADEC.  
 NEW RAT on A320 available from MSN 1045 onwards provided FWC E3 is installed.

## 6 - DOUBLE HYDRAULIC FAILURE

Although this is an **improbable** double failure in operation, it is a **dimensioning** failure case for abnormal operation on Airbus aircraft because of the following consequences:

- loss of APs,
- Flight Controls degraded law (alternate and direct law),
- landing in abnormal configuration,
- thorough use of ECAM, QRH and paper c/l and
- properly envisage different safety factors for approach and go around.

The loss of two hydraulic systems systematically causes the loss of the auto pilot system, thus the role of the PF on stabilizing the a/c flight path will be more demanding.

Although ALTN law (with landing gear retracted) is available and quite comfortable, the handling of the a/c will be affected by the loss of the following flight control parts or systems:

- pitch trim,
- elevators,
- ailerons,
- slats/flaps,
- brake system (normal, autobrake, alternate, antiskid),
- NWS and
- spoilers.

### Major effects on a/c handling and procedures:

- Roll control is always affected by loss of spoilers. With one hydraulic system remaining, there is always one part of the high lift devices lost (whether slats or flaps).
- Landing gear has to be extended by gravity (paper c/l) and NWS is systematically lost. In the event of loss of G + B, the speed has to be increased to 200 kt during gravity extension to provide a good pitch control until stabilized. The flight controls revert to direct law. To leave the runway after landing under these circumstances might become a demanding exercise. Thus high speed turn off may preferably satisfy the demand rather than 90° turns.
- The landing will need most likely a high speed touch down as the abnormal configuration may require a greater speed increment (i.e. VREF + 30 kt - depending on a/c version - refer to QRH chapter 2). Both normal and alternate braking may be lost and the braking relies on yellow brake accumulator without antiskid.
- The approach after landing gear extension may require (ECAM procedure) a voluntary disconnection of the ATHR (G + B) in order to obtain an easier a/c pitch control during approach and go around.
- In the event of loss of G + Y hydraulics, the pitch trim is lost. The procedure thus requires the landing gear extension at VAPP at the earliest, since the integrator provides a trim with the elevator as long as the landing gear is not extended. If this procedure is missed, the flare and the pitch control in case of go around may be difficult. The PFD message MANUAL PITCH TRIM USE after landing gear extension should thus be disregarded.
- In the event of loss of G + Y there is high pitch during approach and go around expected (slats may be extended only), causing a duck under during approach because of PFs eye position in relation to the runway and causing a risk of tail strike upon touch down (A321). To properly brief the PNF to watch the pitch during approach and touch down becomes thus essential.
- Hard pitch inputs on side stick during approach may trigger spurious stall warnings. The PF should thus manage a well stabilized approach with the landing gear down early in order to avoid those distractions that may cause an unnecessary go around.

## Procedure sequence

A dual hydraulic malfunction is considered as an **Emergency** situation (LAND ASAP in red on ECAM memo status) and shall be declared as such to the ATC units.

The general procedure recommended sequence is as follows:

- 1.) PF should be well declared. CM1 may take the opportunity to shift from PNF to PF tasks.
- 2.) ECAM actions including a/c status reading should be done as prescribed in SOPs.
- 3.) QRH tables in chapter 2 (ABNORMAL PROCEDURES) and in chapter 4 (IN FLIGHT PERFORMANCE) become the reference next in order to whether confirm or to calculate, VAPP, FLAPS lever position, actual landing distance etc.
- 4.) FMGS may be prepared next (suitable position prior to land). VAPP should be set as a reminder.
- 5.) The a/c configuration should be established early prior to approach (on down wind or on a suitable place on long final) by asking for and performing SLATS FLAPS JAMMED C/L till landing configuration has been achieved. The PNF should brief the PF on go around procedure (minimum) from the same c/l. The procedure should be performed entirely with selected speed.
- 6.) For landing gear gravity extension, the L/G GRAVITY EXTENSION paper c/l should be asked for and should be performed while doing the actions. It is strongly recommended to have the gear down and be stabilized prior to starting the final descent.
- 7.) The approach briefing should concentrate on safety issues and should be given early, probably after FMGS preparation or in any other suitable moment of the sequence. It should mention all the special items above concerning the situation amongst the normal approach briefing.

### NOTE:

For PF's awareness, the S/F jammed c/l and the L/G gravity extension c/l additional information (NOTES written in small font) may be read after ECAM has been completed and thus may be skipped whilst configuring the a/c or whereas extending the landing gear by gravity.

## Rules for VAPP and landing distance calculation:

- The QRH tables (chapter 2) are providing corrections related to VREF (1.23  $V_{S1G}$  for CONFIG FULL). These corrections probably correspond to a combination of different abnormal configuration cases e.g. SPLR loss and ELEV loss, each case calling for a given CONFIG selection and a given  $\Delta VREF$ . The MINI CONFIG and the MAX  $\Delta VREF$  shall be selected as a basic rule.
- For the **landing distance**, the correction coefficients should be multiplied, if a combination of abnormalities affects both the a/c configuration and the braking capability. Else the highest correction coefficient should be taken if only one type of abnormal (configuration or braking capability) is affected.  
 However refer to QRH (2.27) for complete information concerning VAPP and landing distance increment calculation.

## 7 - ABNORMAL SLATS/FLAPS

The slats and/or flaps abnormal configuration may be essential due to the following causes:

- dual hydraulic (G + B or G + Y) malfunction,
- dual SFCC (dual channel faults) failure and
- slats and/or flaps jammed (locked by WTB activation).

The consequences of malfunctions as such may be serious since

- a/c handling is affected (flight control reconfiguration law),
- modification of approach attitude references,
- approach speed and landing distances increase and
- frozen high lift devices during go around and diversion, if applicable.

### Consequences in case of SFCC dual channel fault:

- **F/CTL SLATS FAULT (dual SFCC slat channel fault)**
  - ⇒ flight control protections are lost (alternate law and direct law with landing gear extended),
  - ⇒ no characteristic speed calculation available (red SPD LIM flag on PFD). There is no slat position detection available. VAPP is provided by FMGC on the PFD,
  - ⇒ speed is limited to VFE next (corresponding to next slat position),
  - ⇒ aural stall warning and overspeed warning are provided,
  - ⇒ selected speed for landing configuration should be systematically engaged when the malfunction occurs,
  - ⇒ AP, ATTHR and FDs are lost and
  - ⇒ increased VAPP and landing distances may apply (depending upon slat position).
- **F/CTL FLAPS FAULT (dual SFCC flap channel fault)**
  - ⇒ flight controls remain in normal law,
  - ⇒ AP, ATTHR and FDs are lost,
  - ⇒ in order to avoid degraded handling characteristics, flaps full shall not be used,
  - ⇒ abnormal attitude references may apply for approach and landing,
  - ⇒ increased VAPP and landing distances may apply (depending upon flap position) and
  - ⇒ selected speed for landing configuration should be systematically engaged when the malfunction occurs.

In case of slat malfunction caused by dual SFCC slat channel fault, the SFCC slat position information provided to the flight control computers is lost. Thus causing the loss of  $V_{S1G}$  calculation and switching the flight controls to alternate and direct law subsequently. The warnings are actually processed by the FWC specific sensors, which are detecting the real slat position.

Slats/Flaps jammed procedure applies for a/c configuration preparation.

### NOTE:

VSW is not provided in case of dual slat channel fault or in case of dual SFCC fault (all 4 channels have failed). G DOT speed is displayed if the dual SFCC failure has occurred in clean configuration. AP is still available in this case.

**Consequences in case slats/flaps jammed:**

- **F/CTL SLATS/FLAPS LOCKED (by wing tip brake WTB)**
  - ⇒ flight controls in normal law,
  - ⇒ AP, ATHR and FDs are available,
  - ⇒ AP may be used to 500 ft AGL and shall be disconnected upon reaching (procedure),
  - ⇒ VLS on PFD is correct and calculated upon S/F real position,
  - ⇒ VFE is calculated upon VFE next, corresponding to the flaps lever position,
  - ⇒ characteristic speeds are provided on PFD and
  - ⇒ selected speed for a/c configuration should be engaged when the malfunction occurs.

**NOTE:**

For VAPP and landing distance calculation, abnormal attitudes, procedures etc., the same applies as above.

- For **double hydraulic malfunction** refer to chapter 6 of this document. For dealing with the problem, the proposed procedure sequence may be followed.

Obviously the crew reaction will depend upon the moment of the failure.

- If it occurs during take-off with still some configuration remaining, VFE should not be exceeded. Thus selected speed must be used.
- If the origin is the diversion airport, GW should be checked. Depending upon circumstances, a fuel burn off may apply in order to land with GW below MLW or overweight landing may be considered.

In case of diversion whether clean configuration may be selected or the best possible configuration should be kept.

- If the malfunction occurs during approach, usually it is detected upon selecting CONFIG 1 (e.g. in case of WTB activation) whereas with other malfunction (e.g. double hydraulics) it is known early. It may be detected upon selecting CONFIG 2 (flaps jammed). Selected speed should be used and the adapted procedure sequence in chapter 6 of this manual applies.

- The rules for determining VAPP are given in the QRH chapter 2. Finally VLS can always be selected, if applicable.  $\Delta VREF$  and flap lever position should be determined as given in QRH 2.25/2.26/2.27 (e.g. S/F stuck in intermediate position) and taking into consideration the nature of the malfunction, tower wind, use of ATHR, ice accretion etc.

- AP and ATHR may be used, if applicable. The AP should be used as prescribed above and required by the procedure.

If a **cruise to diversion** is envisaged, the clean up will be achieved as follows, pending upon malfunction.

S/F POSITION	ACTION	CONSEQUENCES
Slats at 0	Retract Flaps	normal fuel consumption
Slats > 0	Retract Flaps	205 kt / max FL 200 / Fuel + 40 %
Flaps at 0	Retract Slats	normal fuel consumption
Flaps > 0	Keep CONFIG	MAX SPEED - 10 kt / max FL 200 / Fuel + 100 %
S/F > 0	CONFIG stuck	MAX SPEED - 10 kt / max FL 200 / Fuel + 130 %

MAX SPEED should be extracted whether from ECAM or from QRH 2.06 (table). For additional information upon fuel consumption refer to note underneath the table in QRH 2.06 as well.

## 8 - ZFW ENTRY ERROR (PILOT'S ENTRY)

The a/c gross weight (GW) is an important parameter for the flight.

There are two computer sets supposed to elaborate the GW - FMGC and FAC.

### 1. FMGC (Flight Management and Guidance Computers)

Before engine start, the pilot enters data into INIT B page:

- ZFWCG / ZFW and
- FOB.

These values are memorized in the FMGC.

Once the engines are started, FMGC makes predictions for GW and CG.

**[GW = ZFW + FOB - Estimated Fuel Used]**

NOTE:

When the approach phase is activated, the calculation is updated with the actual fuel used value.

**[GW = ZFW + FOB - Actual Fuel Used]**

Based on this FMGC calculated GW value (displayed on ECAM SD and MCDU FUEL PRED page), the MCDU displays:

- characteristic speeds,
- performance predictions and
- VAPP on PFD.

### 2. FAC (Flight Augmentation Computers)

Each FAC receives AOA (angle of attack) information from 3 AOA probes. It takes an average value from these 3 inputs and calculates the stall speed as a function of:

- AOA,
- speed (EAS),
- load factor (CG) and
- CONFIG.

From this stall speed, according to the a/c configuration, FAC determines the GW.

The characteristic speeds, displayed on the PFD:

- VLS,
- S - speed,
- F - speed and
- G - dot speed

are generated by the FACs.

On ground and up to take-off phase (landing gear extended), the FAC takes the GW parameter from the FMGC (pilot's entry).

Below 14 600 ft and

- speed < 240 kt (255 kt for A321) and
- bank angle < 5° and
- speed brakes retracted and
- no dynamic maneuvers and
- no configuration change (being not in FULL)

GW is calculated by the FAC from the AOA data.

If the conditions above are not satisfied,

**[GW = Last Memorized GW - Fuel Used]**

**Consequences in case of erroneous ZFWCG / ZFW entry:**

**Operational consequences:**

- At take-off, the pitch trim setting might be wrong. This is a minor mistake, since the take-off has been certified in full forward GG with full aft pitch trim and vice versa.
- VS1G and VLS may be slightly affected ( $\pm 2$  kt) as CG is taken into account in their calculation.

**Consequences in case of wrong GW entry upon FMGC initialization**

The error may be twofold:

**a.) Either error on FOB entry**

- As long as the engines are not started, the FMGC GW is wrong as well as resulting FPLN predictions and performance data (on PROG or PERF MCDU pages) whereas the FOB information on Fuel page and ECAM E/W display are correct since they are provided from FQI data.
- Once the engines are started, the FOB information is updated by the FQI - FOB processed out of the fuel gauge readings.

Consequently the FMGC GW, predictions and performance data are updated accordingly, as well as the GW displayed on the permanent display part of ECAM system and status display (S/D).

**b.) Or an error on ZFW entry**

- This ZFW is memorized within the FMGC and leads to a permanent GW error throughout the flight. Furthermore the FAC calculated GW, which is based and initialized on that value, will be updated only once airborne through a specific slow calculation using AOA data information.

The consequences are as follows:

- at take-off, VLS, S, F and G – DOT speeds are erroneous,
- the SRS mode guidance is affected (if VLS > V2 as inserted on PERF take-off page),
- the FMS predictions and performance data are erroneous,
- the data on FUEL PRED page are erroneous except FOB value and
- the GW on ECAM S/D is wrong.

But there are **no consequences** on **V<sub>αprot</sub>** and **V<sub>αmax</sub>** speed calculations nor on flight control laws.

- If FMGC and FAC calculated GW differ by more than:
  - 5 t with FMGC Full Standard and
  - 7 t with FMGC Intermediate Standards,

“**CHECK GW**” amber warning will be displayed on MCDUs.

**If CHECK GW message is displayed:**

Compare the current GW value on FUEL PRED page, with current GW value computed from the load sheet figures, using the Fuel Used values from ECAM.

- If an obvious error is detected on current GW, the correct value must be inserted on FUEL PRED page.

- **If current GW appears to be correct:**
  - characteristic speeds on PFD are erroneous and should be disregarded (AOA sensor problem ?)
  - characteristic speeds should be extracted from QRH chapter 4 (notice forward CG impact).
- **If current GW appears not to be correct, the load sheet being suspected:**
  - FAC and QRH speeds should be compared and
  - the most appropriate apply.

Technical log book must be informed in case CHECK GW message is triggered, with no obvious error.  
If the warning is repetitive during consecutive legs, an AOA probe offset might be suspected.

## 9 - DOUBLE RADIO ALTIMETER FAILURE

The double Radio Altimeter (R/A) failure has various consequences on many systems of the a/c, since the R/A information is used to switch flight control laws or AP - ATHR modes etc. or in auto call outs and warnings. It is clearly materialized by RA red flag on PFD (just underneath the horizon).

The procedure is simple, since the ECAM provides all required information. However, the consequences of such malfunction affect the a/c normal operations in many directions.

### Consequences upon Fly by Wire systems:

Rather than using R/A information, the FBW systems use the LGCIU outputs for most of the logics.

#### a. APPROACH

- The flare law (usually blended in at 50 ft) engages when the landing gear is extended.
- The warning USE MANUAL PITCH TRIM comes up few seconds later on PFD, in order to remind the crew that the remainder of the approach is to be flown in a comfortable direct law (with pitch rate feed back).

#### b. LANDING

- The ground law engages when MLG is compressed and pitch attitude is less than 2.5°.
- The ground spoilers extend using wheel speed information.

#### c. WARNINGS

- The low energy warning is lost in case of double R/A malfunction.

### Consequences for FMGC:

Basically LAND modes do not engage, since it ensures that (for autoland) subsequently FLARE and ROLLOUT will engage which is not possible as the R/A information is missing.

Consequently (landing gear extended):

- FD basic modes available only,
- approach modes are not available (no LOC, no G/S),
- autoland modes are not available (no LAND, no FLARE, no ROLLOUT),
- ATHR remains in speed mode, in approach (no RETARD),
- APs are lost.

### Consequences for GPWS / EGPWS:

Most functions require R/A signal information. Therefore GPWS and EGPWS, if applicable, are lost.

**Consequences for FWC:**

- R/A auto call outs are lost,
- DH / MINIMUM auto call outs are lost (non-modified FWC),
- Retard call out is lost and
- Landing Memo is lost (non-modified FWC).

**NOTE:**

LOC mode is available using the LOC p/b for re-engagement (after landing gear extension). Lateral guidance is not tuned appropriately.

When the R/A is no computed data (NCD), LOC and G/S modes are available using the APPR p/b. CAT I approach is available only till a valid R/A signal is provided through the R/A system. This occurs typically, when ATC clears approach early and systemwise NCD is different from malfunction.

The FWCs do not predict approach conditions but provide proper information and actions in all FWC computed flight phases.

## 10 - UNRELIABLE SPEED/ALTITUDE INDICATION

It is quite a touchy problem to differentiate the cause and the nature of unreliability of those indications. The unreliability maybe caused by pitot or static probe sensor problems, or to radome burst...

The pitot sensors can be blocked due to several causes, such as:

- heavy rain may cause decreasing speed indication and/or temporary fluctuating speed indication and
- severe pitot icing caused by severe icing conditions or pitot heat failures.
  - ⇒ In the first case the measured pressure generally decreases. The IAS decreases and fluctuates during the period of time the icing is severe. ATHR may cause engine thrust fluctuations.
  - ⇒ In the second case, the pitot probe is blocked entirely, including the drain hole. The consequences are similar to the case when the pitot probe is blocked by a foreign object. Thus the measured pressure decreases. IAS remains constant in level flight, increases in climb and decreases in descent. Thus causing abnormal behaviour of AP and FD. Pitch up in climb and pitch down in descent. The Mach number varies like the IAS.

When pitot probe is affected only, ALT, V/S, FPA are correct; FPV is correct.

A non-removed cover may block the static probes, most probably. In such case the static pressure measured remains constant at the airfield value. Consequently:

- the IAS indications are correct during take-off roll,
- the IAS decreases in CLB and increases in descent and
- the altitude remains constant.

When static probes are affected, the altitude, the V/S and FPA, the IAS and Mach number are wrong and the FPV as well.

If some sensors are independently affected, this will cause an ECAM warning since it can be detected.

If all sensors are simultaneously affected, no ECAM warning will be provided since all measured data will vary similarly. This situation may only be detected by the crew who will observe:

- IAS fluctuations,
- jerky and delayed ALT indications,
- abnormal correlation of basic flight parameters (IAS, pitch, thrust, V/S etc.),
- abnormal correlation between ALT and V/S indications,
- abnormal behaviour of AP, FD, ATHR,
- undue stall or overspeed warnings respectively and
- reductions of aerodynamic noise when IAS decreases.

## PROCEDURE

### 1. Safety Recovery

#### THRUST MCT / PITCH 10° ADJUST

ATHR / FD / AP	⇒	OFF
FLAP CONFIG	⇒	MAINTAIN
SPD BRAKE	⇒	RETRACT
REFER TO	⇒	GPS ALTITUDE, if applicable GPS GS, if applicable IRS GS (ND)

2. Check POBE / WINDOW HEAT ON  
Declare emergency and set A7700 on ATC.
3. Check whether altitude is reliable or not.
  - If positive, the BIRD may be used.
  - If negative, the bird is unreliable.
4. Refer to QRH, chapter 5 in order to determine the required, pitch and thrust data.

The following table may assist the crew in determining the nature of the problem and the information that are still valuable:

UNRELIABLE	DISREGARD	USE
ALTITUDE	ALT	GPS ALT* and GPS GS
	IAS / TAS	GS on ND
	WIND	R/A
	V/S - FPA	CAB ALT
SPEED	IAS / TAS	GPS GS
	WIND	BIRD
		WIND reported by other a/c

\* GPS altitude is different from barometric but allows a reasonable use.

The unreliable speed and/or altitude indication may cause the following undue phenomena (but most distracting):

- SPD LIM flag on PFD,
- ALPHA FLOOR activation,
- stall - windshear warnings (due to Mach effect),
- flap auto retraction,
- ALPHA LOCK system activation,
- overspeed warning on ECAM,
- altitude discrepancy warning on ECAM and
- rudder TLU fault on ECAM.

**NOTE:**

Unreliable speed indication procedure is provided in FCOM VOL3 Abnormal and Emergency chapter and in QRH OPS DATA chapter.