Airbus – Aircraft Energy management in descent phase using FMS
Airbus fleet performance

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Introduction to descent operations

- In Airbus A/C, the FMS provides a **theoretical descent profile (TDP)** based on a Performance model (PDB) along the **lateral path** defined by a sequence of Waypoints provided by the Navigation Database (NDB). This flight path is used for:
  - Top of Descent (ToD) display
  - Guidance during descent phase
  - Altitude and speed predictions

The use of FMS full managed mode is strongly recommended to achieve an efficient CDO, but requires no ATC intervention.

FMS full managed mode
(lateral, vertical & speed)
Introduction to descent operations

A/C is guided on the TDP by FMS & FG logics

TDP computation uses:
- pilot entered wind and temperature
- Idle thrust
- Clean configuration (no A/B and late S/F extension)

Descent at constant Mach (0.78)
Descent at constant CAS (320kts)
Deceleration from 320kts to 250kts (SPD limit)
Descent at constant CAS (250kts)
Deceleration from 250kts to Vapp

A320 - LW = 58T - ISA - No wind
Introduction to descent operations

- During descent, the A/C continuously loses Energy (kinetic energy + potential energy)
- Descent slope strongly depends on flying objective (maintain speed or deceleration)

**Vertical profile**
- During descent, the A/C continuously loses Energy (kinetic energy + potential energy)
- Descent slope strongly depends on flying objective (maintain speed or deceleration)

**Optimal Descent → the aircraft continuously dissipates energy**

Mean descent slope = -3°

Deceleration requires gentler slopes
Optimum Descent profile sensibility

• Descent profile computation mainly depends on:
  ➢ Aircraft type & Engine type
  ➢ Landing weight
  ➢ Descent speed law
  ➢ Wind

• This sensibility is taken into account by the FMS before descent phase (these conditions will impact the ToD position)

• Procedure design should allow the aircraft to adapt its descent to the current conditions
Optimum Descent profile sensibility: Engine type

CFM idle thrust is higher at high altitude

CFM idle thrust is lower at low altitude
Optimum Descent profile sensibility: weight effect

The lowest weight leads to the shortest descent
Optimum Descent profile sensibility: descent SPD

Low SPD leads to a longer descent (Lift/Drag ratio is better at low descent speed)
Optimum Descent profile sensibility: wind effect

N.B.: The wind shall be entered in the FMS to impact Top of Descent position.
Recommendations for CDO procedure design

• Refer to the document 5.6.2_D03_Airborne Recommendations for CDA Procedure Design recommendations for CDO procedure design provided by Airbus to SESAR project (WP5.6.2)

• Remind of the main recommendations:
  - “Window” ALT constraints shall be preferred compared to “AT”
  - Altitude constraints shall not impose a “too steep” flight path angle to the aircraft (too steep path required the use of Airbrake)
  - The average local wind shall be considered (10kts of tailwind shall decrease the limit slope by 0.1°)
  - A gentle slope (between -1° to -1.5°) shall be allowed before glide slope interception
  - The transition altitude shall be preferably above FL100
  - Speed restrictions below 230kts and far from the FAF shall be avoided (this leads to early S/F extension)
  - The noise level can be reduced by using a SPD Limit at 230kts instead of 250kts
Recommendations for CDO procedure design: limit slopes at constant CAS for the whole Airbus fleet

Example of the steepest slope allowing a constant CAS descent

A318-111-VB11
90% MLW - DISA0° - No WIND - CAS cte

Speed limit [VLS | VLO | VS]
Recommendations for CDO procedure design: limit slopes allowing deceleration for the whole Airbus fleet

Example of the steepest slope allowing a deceleration rate of 4kts/10s
Recommendations for CDO procedure design: Descent capability of Airbus fleet (constant CAS)

SA & LR Results Overview
90% MLW - DISA 0° - No WIND

- CFM [0;5000ft]
- PW [0;5000ft]
- IAE [0;5000ft]
- RR [0;5000ft]
- GE [0;5000ft]
- CFM [5000;10000ft]
- PW [5000;10000ft]
- IAE [5000;10000ft]
- GE [5000;10000ft]
- RR [5000;10000ft]
- CFM 300kt [16000ft]
- IAE 300kt [15000ft]
- PW 300kt [15000ft]
- GE 300kt [15000ft]
- RR 300kt [15000ft]
Recommendations for CDO procedure design: Descent capability of Airbus fleet (deceleration)

SA & LR Results Overview - Slopes for deceleration (-4kts/10s)
90% Max Landing Weight - ISA - No WIND
Fuel burn impact due to early descent

The level off at FL350 costs 50kg

The level off at FL100 costs 78kg

28kg of additional fuel burn due to anticipation of optimum T/D by 10NM
Fuel burn impact due to late descent

The level off at FL350 costs 50kg

The descent segment at Idle thrust without Airbrakes costs 8kg

Airbrakes have to be used to return to optimum profile

42kg of additional fuel burn due to delay of optimum T/D by 10NM
Fuel burn impact due to AT constraints

A320-214 - Impact of AT Constraints

- Vertical Profile - without constraint
- Vertical Profile - with AT cstr at 10NM
- Vertical Profile - with AT cstr at 20NM

21kg of additional fuel burn compared to optimum descent (at iso distance)

34kg of additional fuel burn compared to optimum descent (at iso distance)
Conclusion about Aircraft capabilities in descent

- **An efficient descent** (regarding fuel & noise) consists in flying at **Idle thrust**, in **low drag configuration** → pilots should follow Top of Descent position based on aircraft type, atmospheric conditions and published procedure constraints.

- **Steep slopes** in deceleration phase before G/S intersection (from IAF to FAF) is detrimental for:
  - **Fuel** and particularly **noise** efficiency (due to additive drag)
  - **Safety margins** (increased risk of over-energy, reduction of flight envelope)

- Approach procedures should allow (as far as possible) aircraft to fly a **gentle slope before FAF** in order to decelerate:
  - Limit slope for SA family: -1,3°
  - Limit slope for LR family: -0,9°