

Presented by:



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Use of FMS for CDA profiles

Review of Flight Management Systems characteristics
in relation with Continuous Descent Approach procedures



AIRBUS

Content

- Main Characteristics of CDA profiles
- Computation of FMS profile
- Effect of altitude and speed constraints
- Examples and cockpit displays
- Conclusion

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How to benefit from CDA

- A successful Continuous Descent Approach (idle thrust) requires a large flexibility of the vertical profile, depending on:
 - ▶ Performance of the A/C and engine type,
 - ▶ Wind and temperature profile,
 - ▶ Speed profile,
 - ▶ Operational weight of the A/C
- Current FMS can already provide optimized profile
 - ▶ Particularly when no constraint exists in the F-PLN
 - ▶ When wind data are correctly entered
- FMS profile indeed corresponds to the CDA objectives, with the exception of deceleration level-off

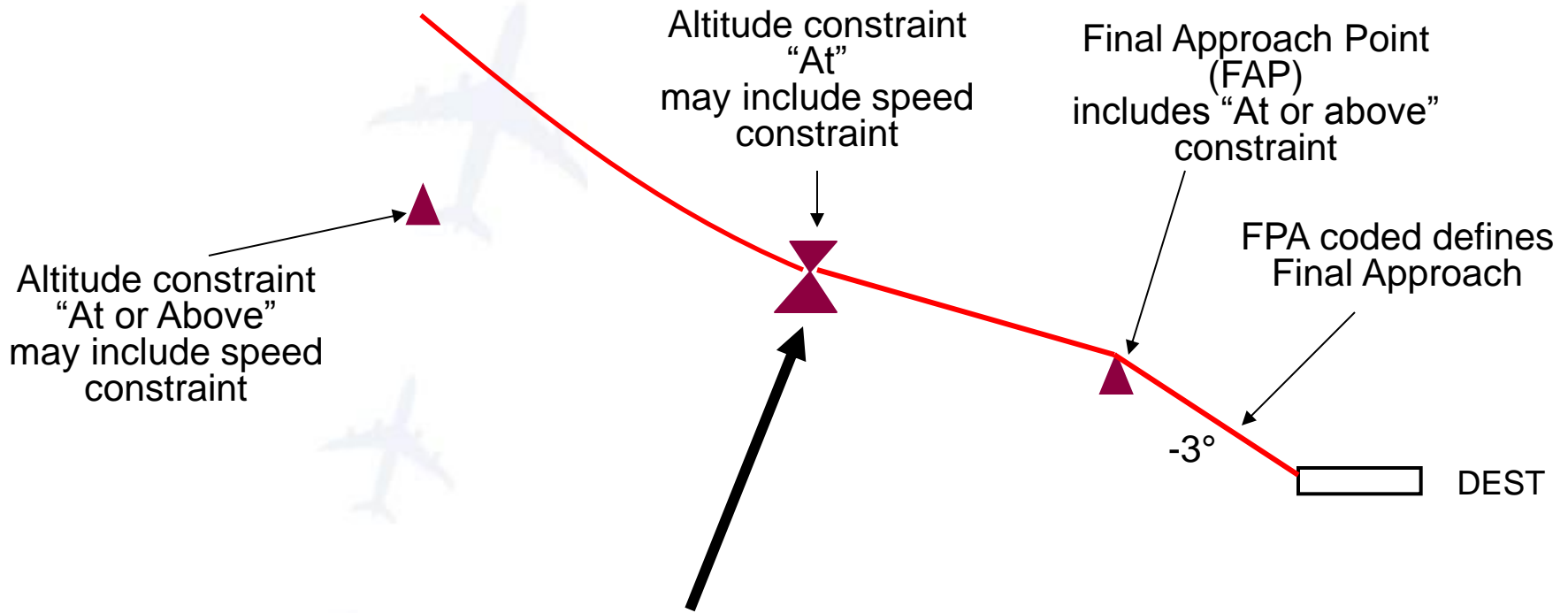
How to benefit from CDA

- Optimizing Continuous Descent Approaches obviously conflicts with traffic management in dense airspace
 - ▶ “Full” CDA (with fixed lateral path and optimized speed profile) may rather apply for night operations
 - ▶ CDA profile may still be used as a reference by ATC at peak hours (e.g. for vectoring)
- To really benefit from CDA concept, a compromise must be determined with airspace planners, taking into account:
 - ▶ All previous variables (affecting descent performance)
 - ▶ Main traffic flows

CDA implementation

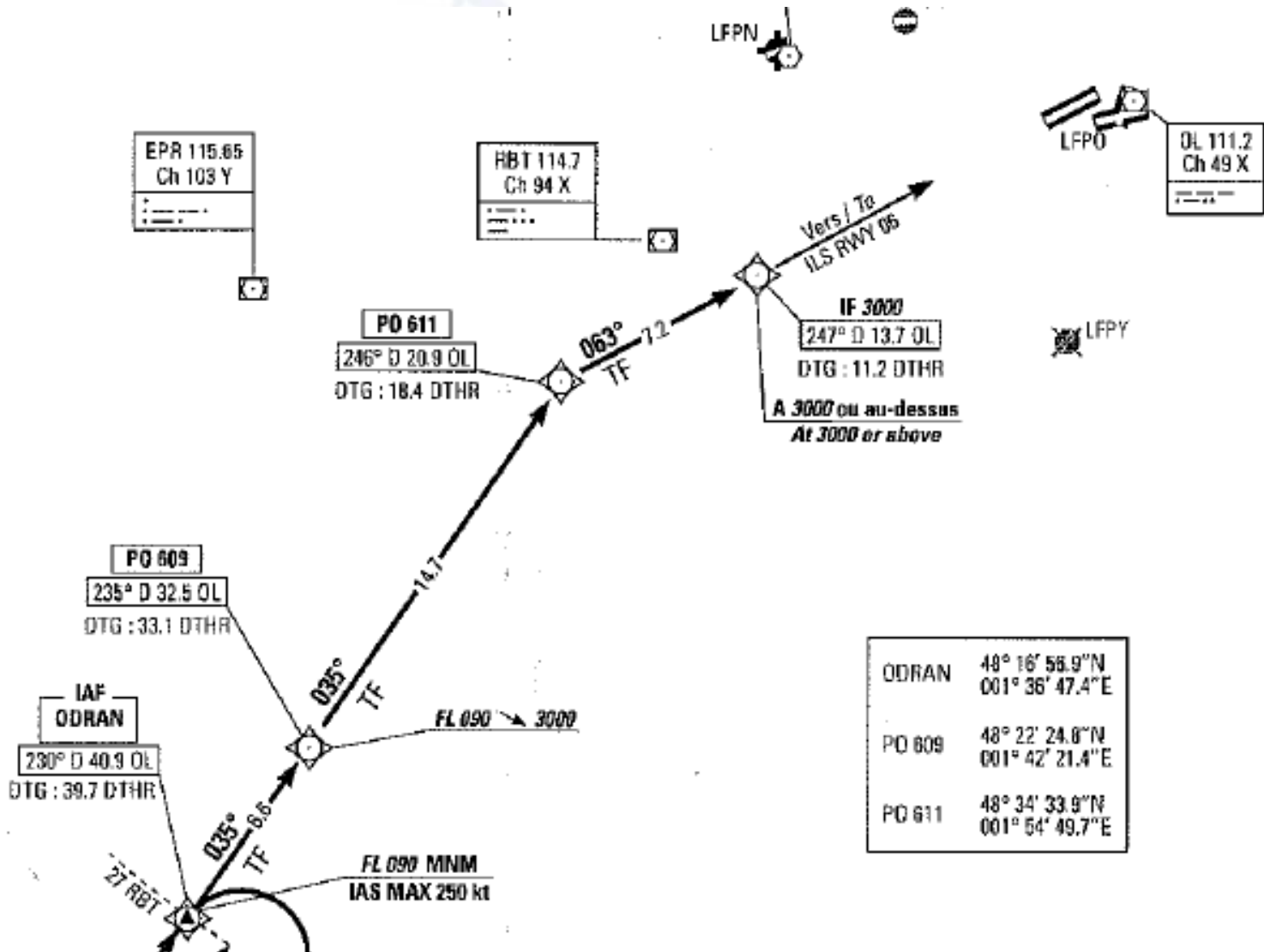
- Published Continuous Descent Approach procedures have the following characteristics:
 - ▶ Altitude constraints (higher trajectories)
 - ▶ Speed constraints (earlier deceleration)
- Main benefit is for ATC, with an almost harmonized A/C behavior, less dependant on A/C type and loading or actual wind and temperature conditions
- However path optimization will not be possible for each set of A/C type, loading, or weather conditions

Typical CDA procedure



Fixed altitude or speed constraints help ATC to expect the A/C behavior, but generally affect FMS optimization

Typical CDA : LFPO ODRAN 1A



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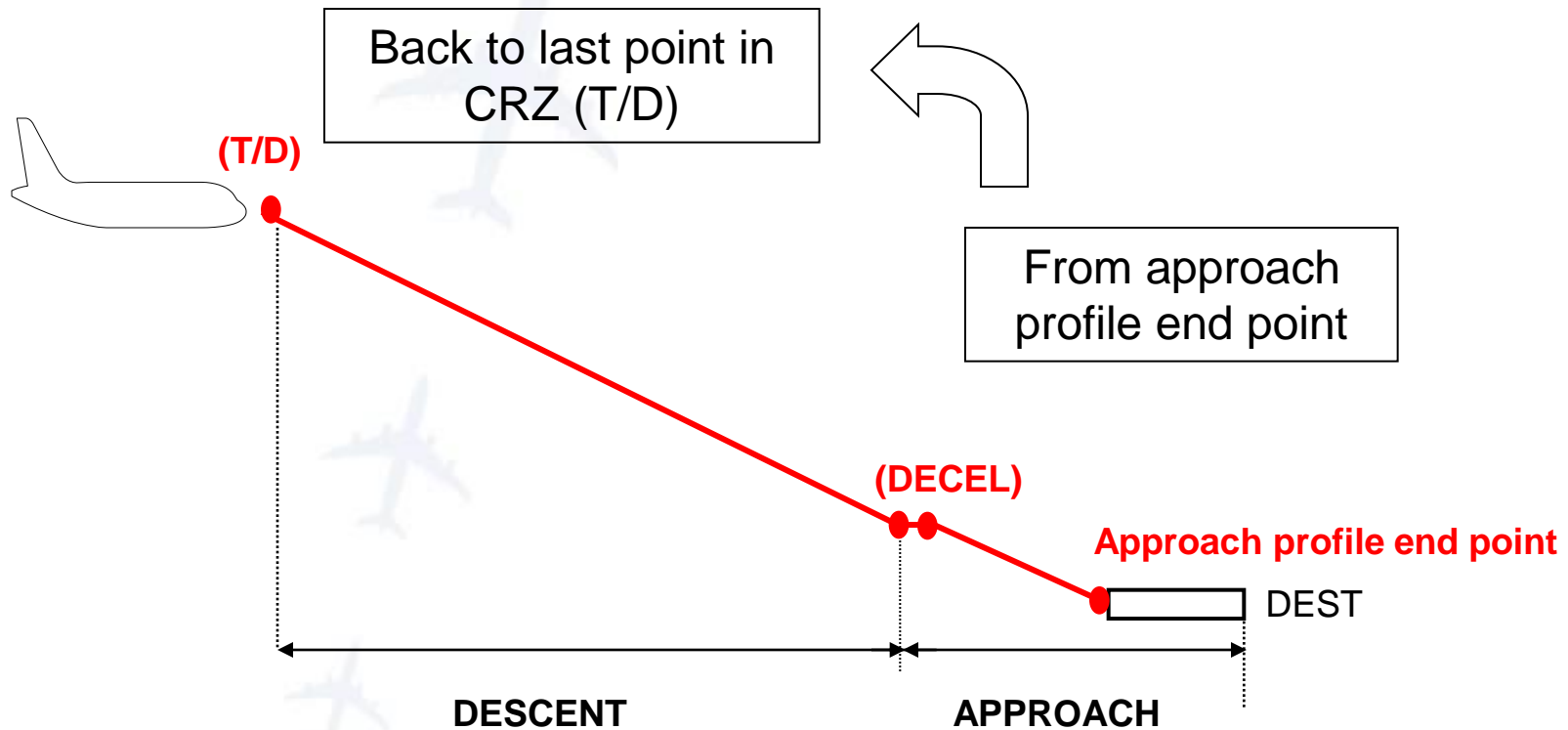
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Close to CDA objectives... however

- Current FMS profile is fully optimized with no (altitude or speed) constraint
 - Alt / Speed constraints in the procedure may be detrimental to the CDA objectives
- Current FMS build level segments for deceleration to approach
 - May affect the expected local noise benefits

FMS profile is always constructed backwards

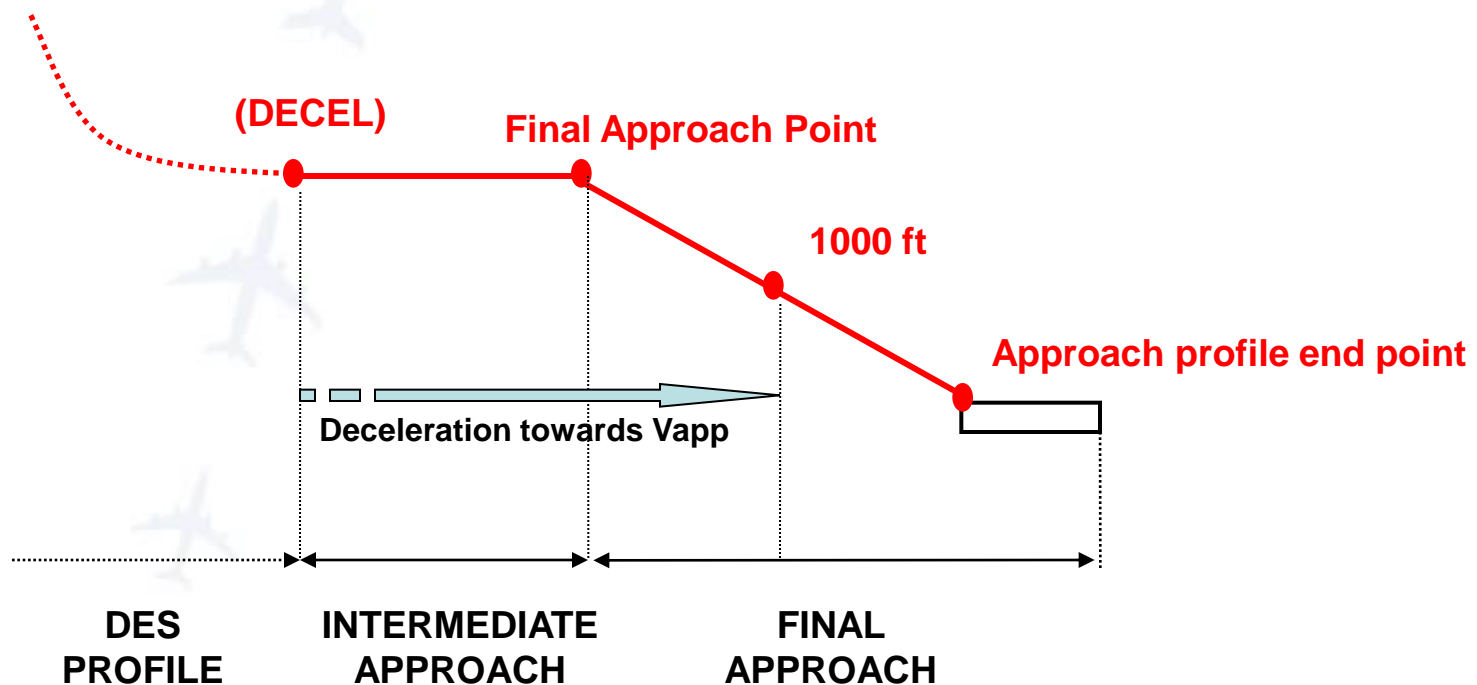


- (DECEL) pseudo sets the limit of DES and APP profiles

Note: (DECEL) altitude is limited to 7200 or 9500 ft above airport elevation (depending on FMS or A/C type)

FMS approach profile is made of (backwards):

- The final approach profile (deceleration on the published FPA)
- An intermediate approach profile = **level** deceleration
- Total deceleration (level + FPA) allows to reach V_{app} at 1000ft



Summary of basic FMS hypothesis for approach profile

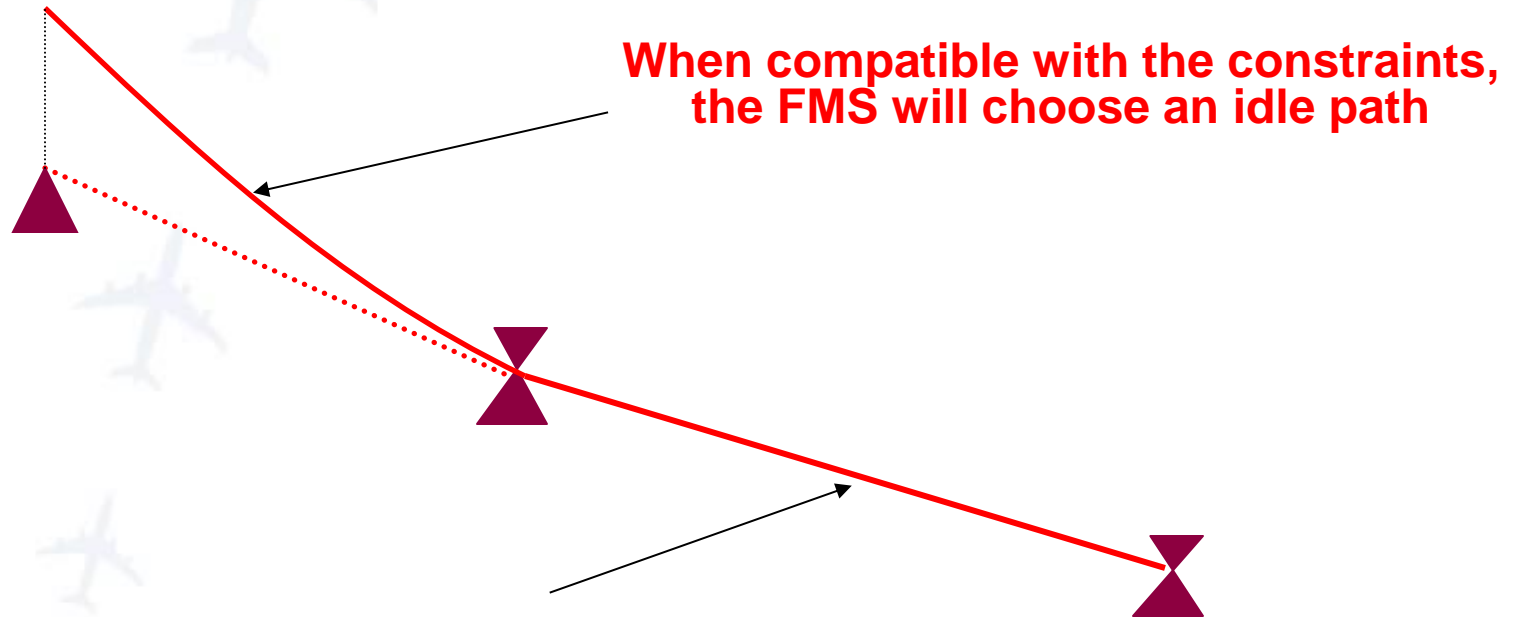
- Deceleration starts at DECEL **on a level segment**
- DECEL is sequenced in conf. Clean
 - usually at 250 kt (below speed limit)
 - at a lower speed if speed constraint exists before DECEL point
- Slats / Flaps and Gear are extended according to a fixed plan
 - Next Flaps extended close to manoeuvring speed of current configuration
- 1000 ft will be reached at V_{app} in landing conf.

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Successive altitude constraints

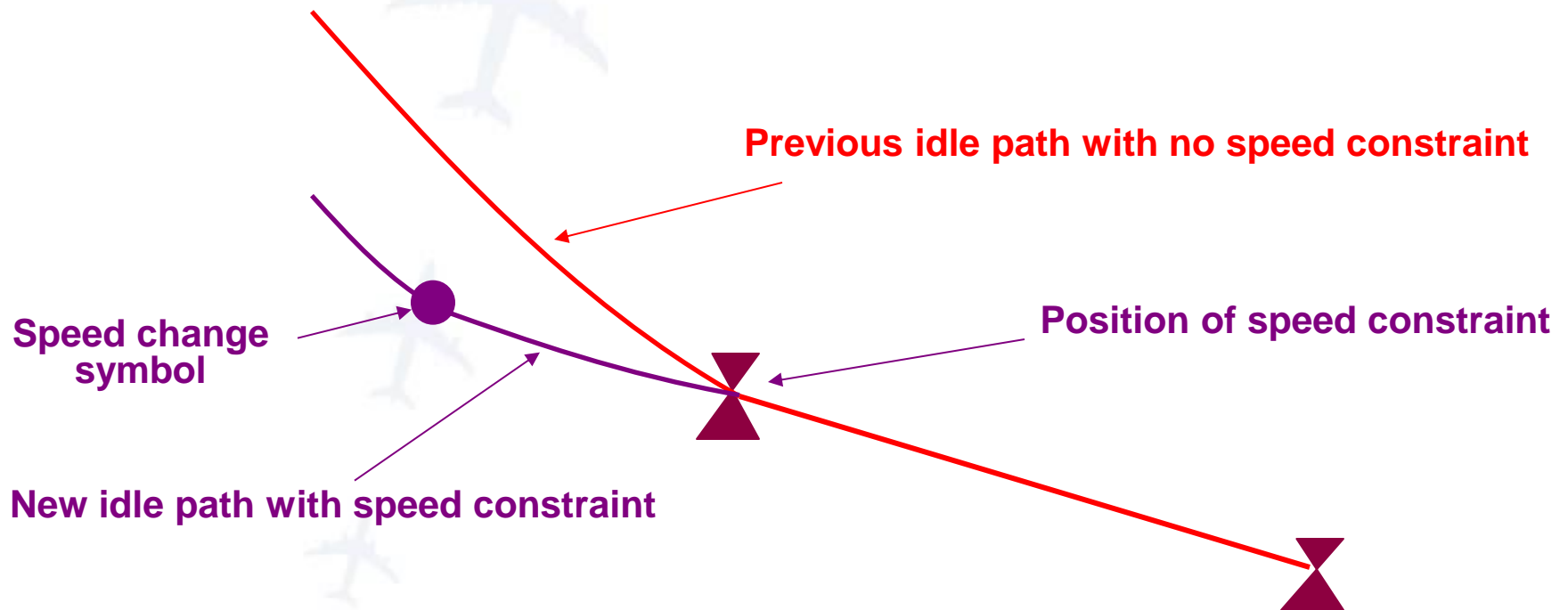
2 successive altitude constraints usually define a geometric path



The geometric path is the solution that the FMS selects when an idle path cannot respect the constraints

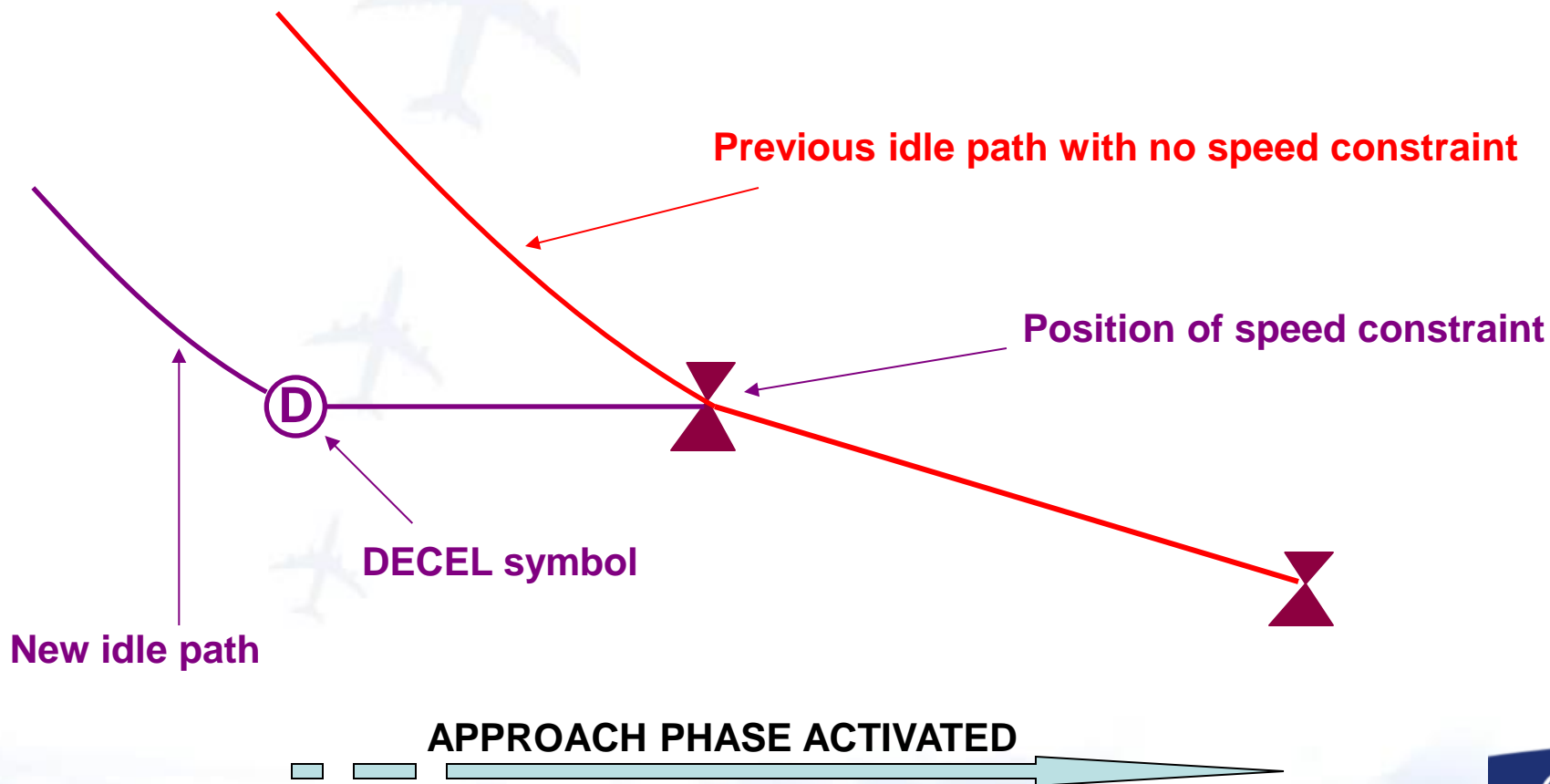
Speed constraint > Green Dot

- leads to deceleration on path:
 - on an existing geometric path, and/or,
 - on the idle path (energy sharing concept => idle path becomes more shallow)



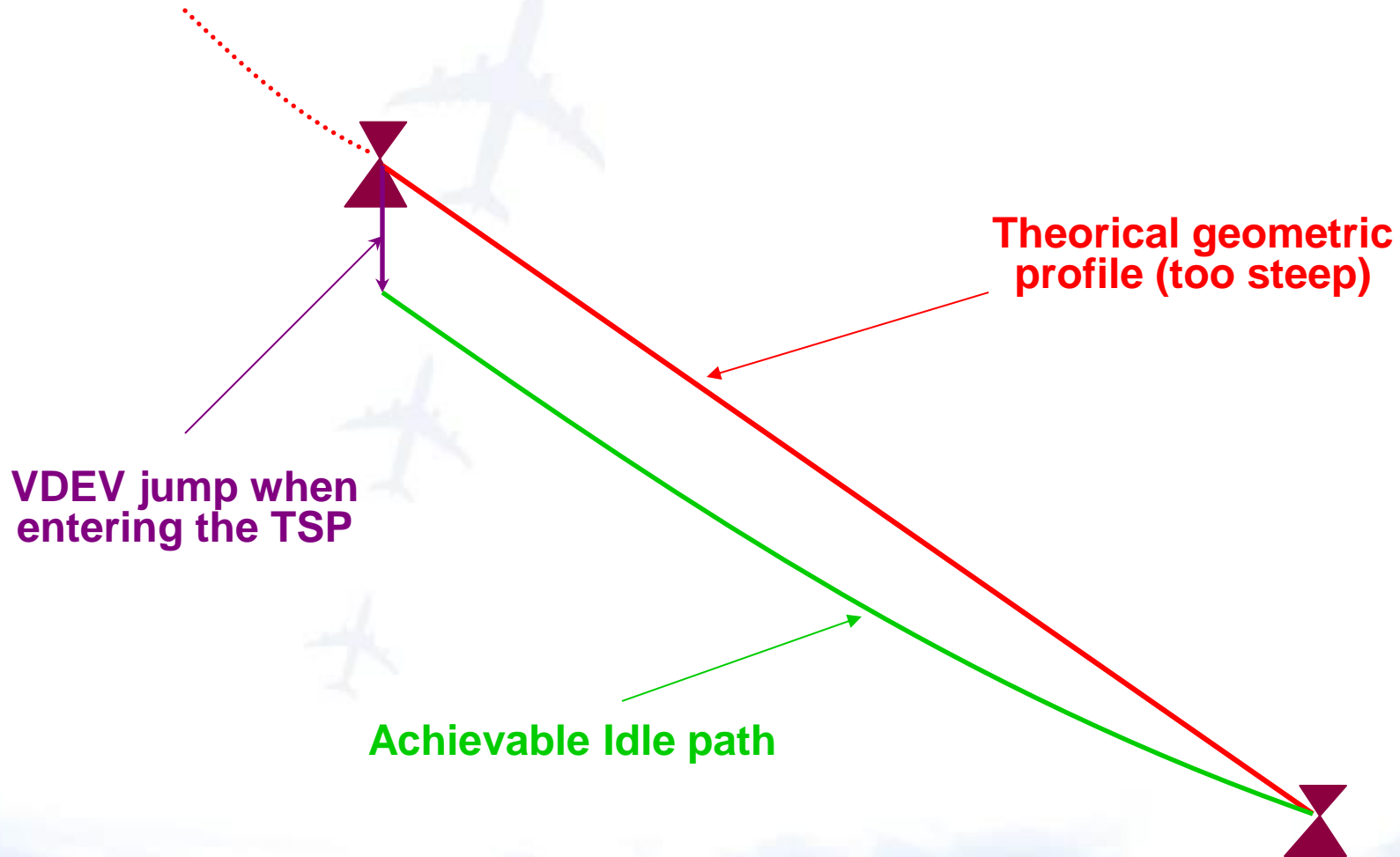
Speed constraint < Green Dot

- leads to computation of a DECEL pseudo, with level deceleration as soon as compatible with the altitude constraints (and activation of FMS approach phase):



FMS considerations

FMS may consider that a path is TOO STEEP (too steep to be flown at constant speed, with idle thrust, and half speed-brakes)



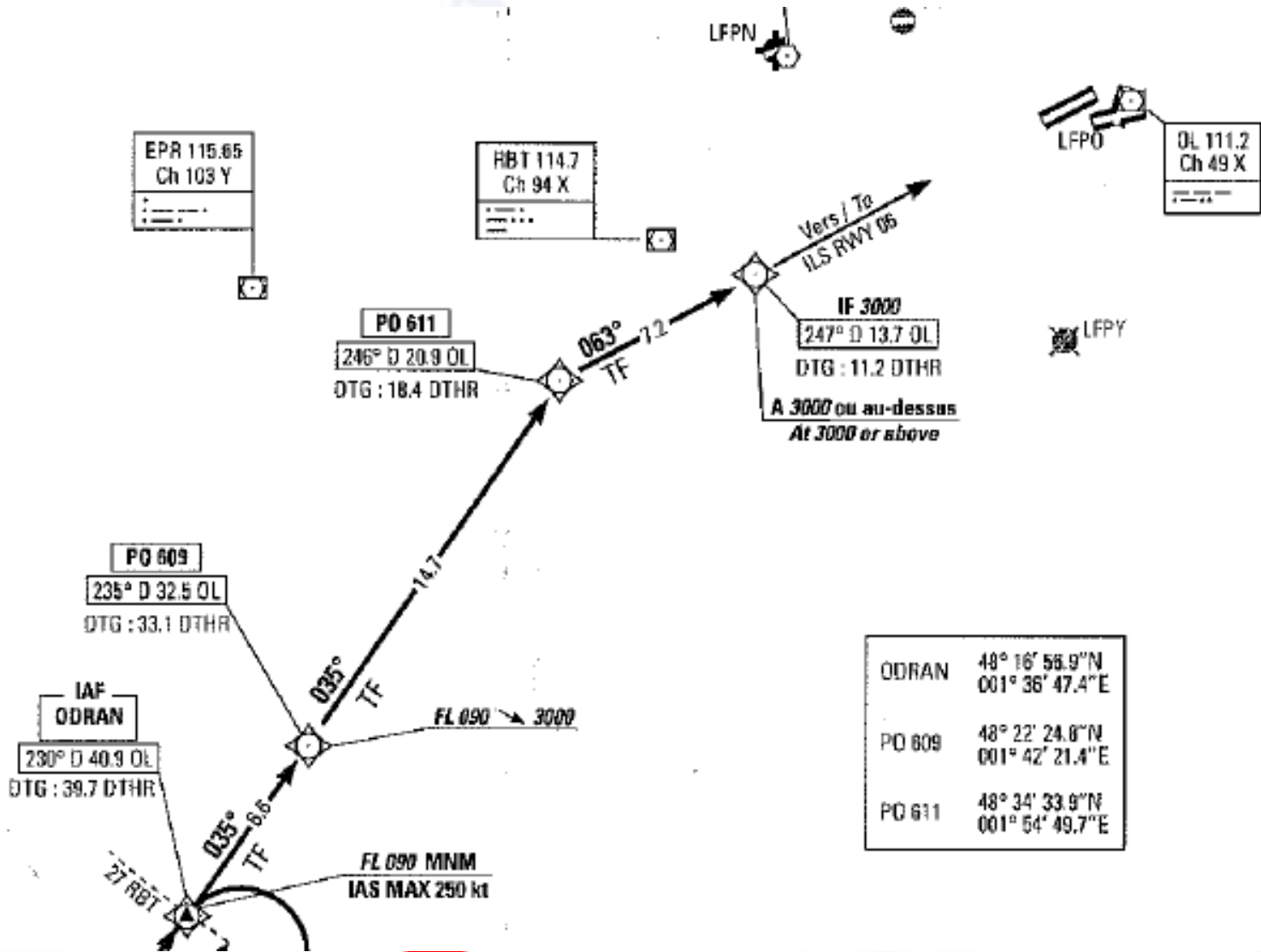
Summary: Effect of altitude and speed constraints

- Idle profile is first FMS priority for the profile computation
- Altitude constraints generally create geometric path
- Some altitude constraints may lead to a Too Steep Path
- Speed constraints increase risk of Too Steep Path
- Speed constraint below GD creates a DECEL
 - level segment
 - activation of approach phase

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LFPO ODRAN 1A



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LFPO ODRAN 1A

SPEED LIMIT : 250kt AT FL100

ODRAN PREDICTED 250kt / FL93

**DECEL CREATES A LEVEL
SEGMENT AT FL90**

PO609 PREDICTED 190kt/ FL90

CI06 (FAP) PREDICTED 190kt/ FL90

ON THIS EXAMPLE:

- **NO TOO STEEP PATH**
- **NOT ENOUGH DECEL ON PATH
=> DECEL SEGMENT AT FL90**
- **MANAGED SPEED PROFILE
PROBABLY NOT SUITABLE FOR ATC**



LFPO ODRAN 1A



VERTICAL DISPLAY MAY HELP THE CREW TO IDENTIFY THE FMS PROFILE



LFPO ODRAN 1A

F-PLN PAGE DOES NOT DISPLAY THE CONSTRAINTS:

➤ REVIEW OF CONSTRAINT PAGE NECESSARY
(THROUGH VERT REV ON SA/LR)

RTA SPD CMS ALT STEP ALTs

DES ALT CSTR AT ODRAN ▼

AT

AT OR ABOVE

AT OR BELOW

FL 090

DELETE ALT CSTR *

RTA SPD CMS ALT STEP ALTs

DES ALT CSTR AT P0609 ▼

AT

AT OR ABOVE

AT OR BELOW

FL 090

DELETE ALT CSTR *

RTA SPD CMS ALT STEP ALTs

DES ALT CSTR AT CI06 ▼

AT

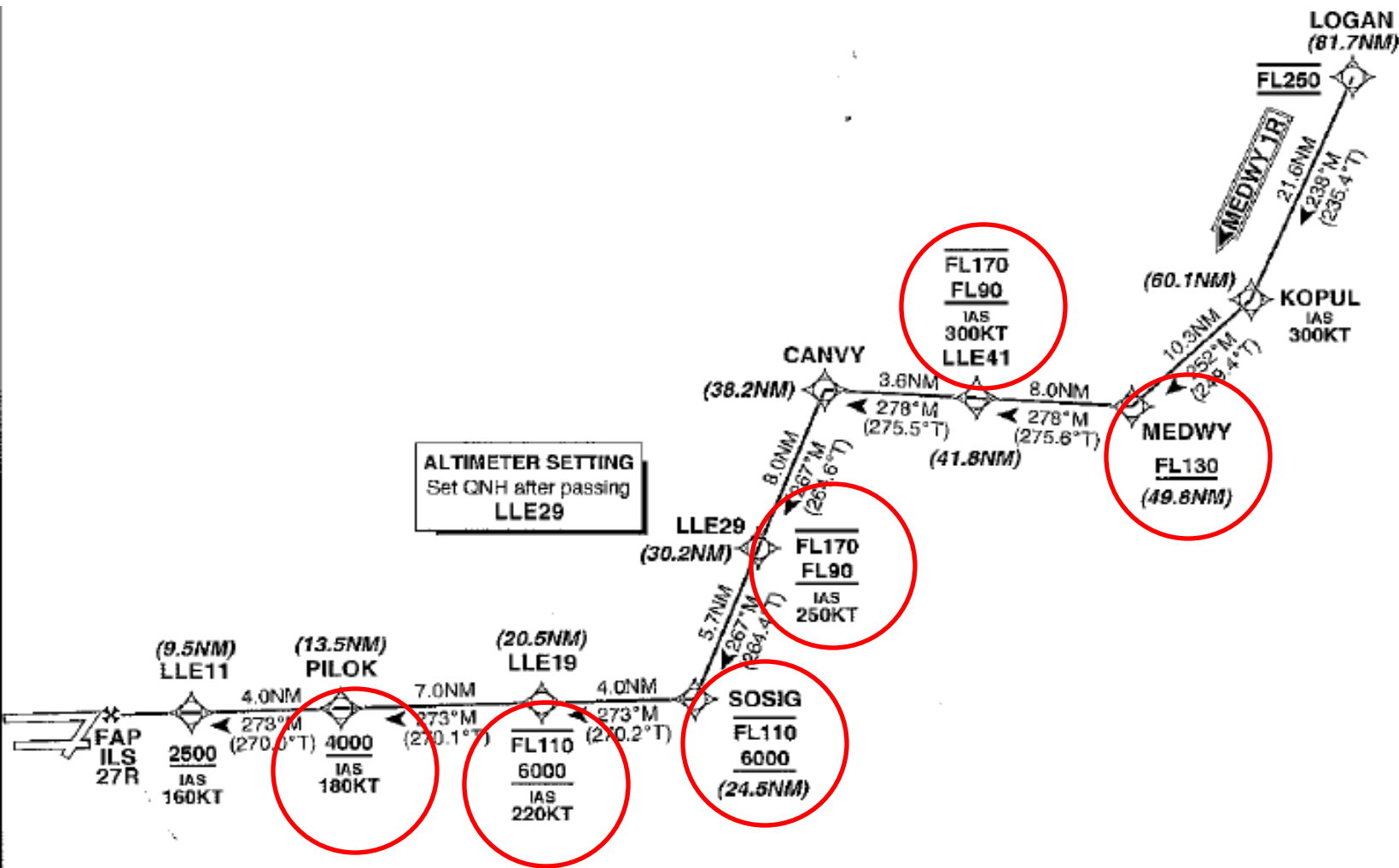
AT OR ABOVE

AT OR BELOW

3000 FT

DELETE ALT CSTR *

EGLL MEDWY 27R



EGLL MEDWY 27R

T-P	12:57	FL089		
LOGAN	13:12	217 *13000	82°	46
- - - - - TOO STEEP PATH - - - - -				
MED1R			237°	22
KOPUL	13:17	*160 13000		
MED1R			251°	10
MEDWY	13:21	*13000		
MED1R			278°	8
LLE41	13:23	*160 *11370		
MED1R			277°	4
CANVY	13:24	*10630		
				3
(SPDLIM)	13:25	*160 10000		
MED1R			267°	5
LLE29	13:27	*160 *9000		

SOSIG	13:28	160 *7230		
MED1R			272°	4
LLE19	13:29	*160 *6000		
MED1R			272°	7
PILOK	13:31	*160 *4000		
MED1R			272°	4
LLE11	13:33	*160 *2930		
C272°			272°	1
CI27R	13:33	" *2530		
C272°			272°	4-3.0
FI27R	13:35	" 1420		
C272°			272°	4-3.0
EGLL27R	13:36	151 140		
C272°				2
1580	--:--	---		
C319°				2
3000	--:--	---		

PROCEDURE LOOKS ALREADY LONG AND COMPLEX ON F-PLN PAGES...

EGLL MEDWY 27R



**COMPLEX PROCEDURES
ADD CLUTTER TO THE
DISPLAYS AND ARE MORE
DIFFICULT TO MONITOR**

EGLL MEDWY 27R

The image displays four screenshots of an aircraft's flight deck interface, arranged in a 2x2 grid. Each screenshot shows a different step in the process of reviewing and deleting constraints for a specific leg (MEDWY).

- Top Left Screenshot:** Shows the 'DES ALT CSTR AT' menu with 'LLE41' selected. The 'AT OR ABOVE' option is selected. A 'DELETE ALT CSTR' button is visible.
- Top Right Screenshot:** Shows the 'DES ALT CSTR AT' menu with 'MEDWY' selected. The 'AT OR ABOVE' option is selected. A '13000 FT' constraint is displayed. A 'DELETE ALT CSTR' button is visible.
- Bottom Left Screenshot:** Shows the 'DES ALT CSTR AT' menu with 'LLE29' selected. The 'AT OR ABOVE' option is selected. A 'DELETE ALT CSTR' button is visible.
- Bottom Right Screenshot:** Shows the 'DES SPD CSTR AT' menu with 'LLE41' selected. A '300 KT' constraint is displayed. A 'DELETE SPD CSTR' button is visible.

REVIEWING ALT AND SPEED CONSTRAINTS MAY REQUIRE A LOT OF KEY STROKES !

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Conclusion

- CDA procedures are likely to develop for environmental aspects, either as full CDA or combined with radar vectors
- CDA optimization requires a flexible vertical path
 - ▶ Multiple altitude or speed constraints may be detrimental to the objectives of CDA... and sometimes lead to unexpected FMS behavior
- Each new CDA procedure should be reviewed and tested
 - ▶ Training simulators are a suitable tool
- Discussions must take place with procedure designers
 - ▶ Importance of trial phases
- Reporting to Airbus is useful as it will benefit to new designs