PANS-OPS Flight Procedure Design Training for CAAs

23 August – 03 September 2021

02 – Nominal Path

(Doc. 8168, Vol. 2, Part III, Section 2)

Outlines

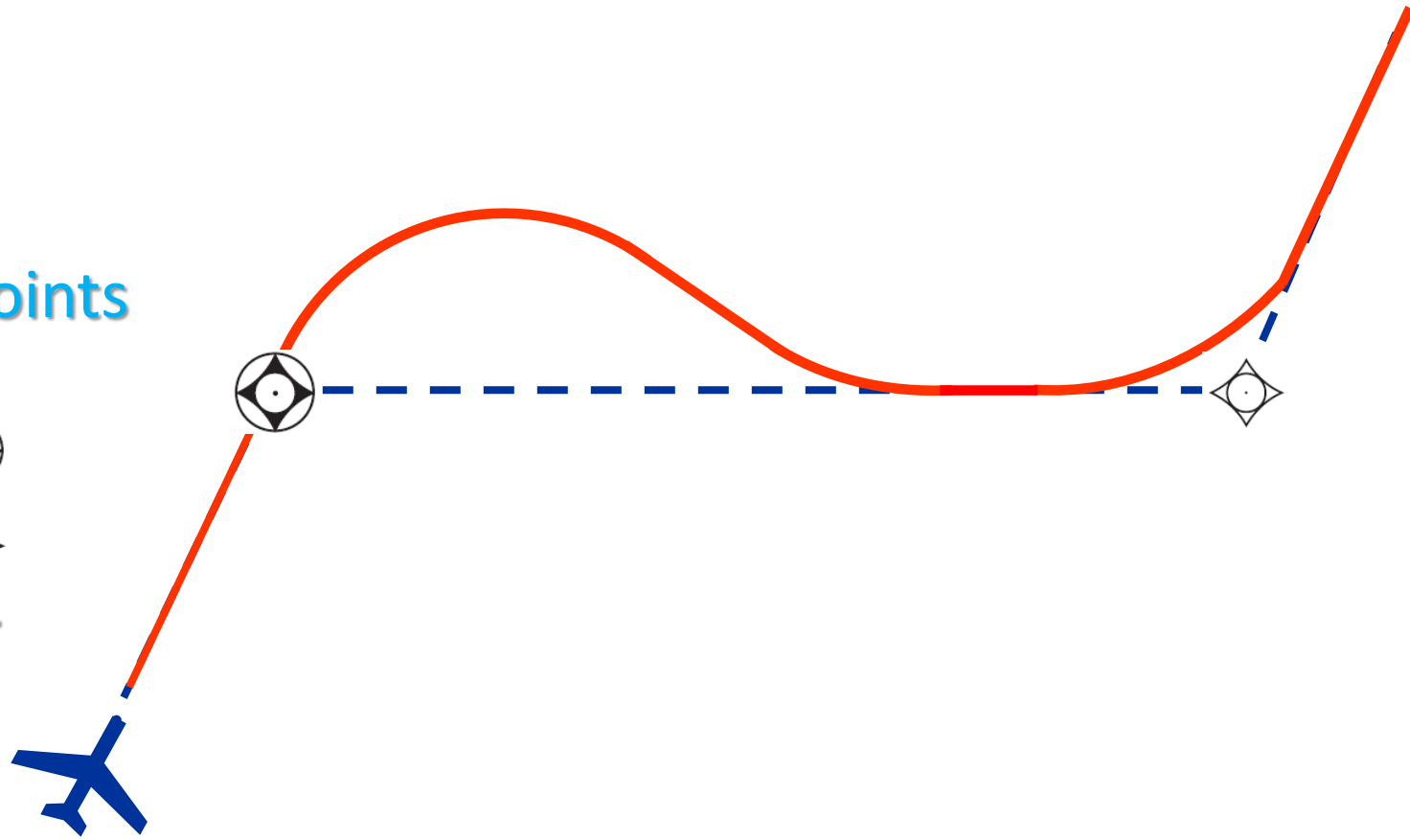
1. Objective
2. Limits of segments
3. Minimum length
4. Descent gradient calculation
5. ARINC 424 coding
6. Initial approach constraints
7. Intermediate approach constraints
8. Final approach constraints
9. Missed approach constraints
10. Procedure altitude concept

Objective

- Define the conceptual path according to data collected
- Know how:
  - To calculate minimum length of a segment;
  - How to calculate the descent gradient;
  - The different constraints associated to each segment:
    - Speed;
    - Turn angle;
    - Bank angle;
    - MOC.
- Define procedure altitude at a Waypoint;
- Know:
  - How to calculate MOCA (Minimum Obstacle Clearance Altitude);
  - The “draft” coding associated with the path .

Limits of segments

- A path is bounded by:
  - Specific conditions:
    - Altitude, radial, etc.
  - Fixes called “waypoints”:
- Two types of waypoints (mainly):
  - Fly-over waypoint
  - Fly-by waypoint:
    - Preferred and most used.



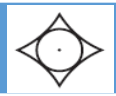
Limits of segment

Waypoints

- Define:
  - Function e.g. IAF, IF,FAF, MAPT, beginning of a STAR…
  - Turning point;
  - Speed or altitude constraint;
  - Reporting point for ATC purpose.
- Number of waypoint should be limited to a minimum:
  - within a straight segment no more than 2 additional waypoints:
    - These additional waypoints are fly-by waypoints.

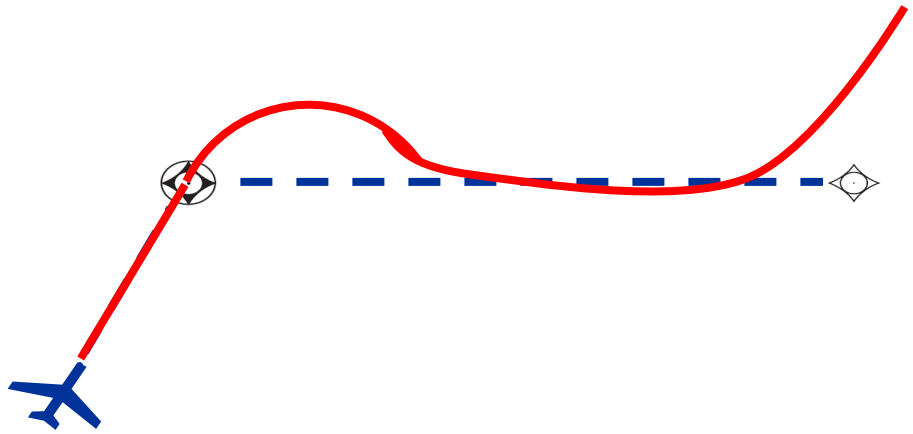
Limits of segment

Waypoints

Type	Full name	Fly-by 	Fly-over 
IAF	Initial Approach Fix	☑	☑
IF	Intermediate Approach Fix	☑	☑
FAP/FAF	Final Approach Point/Fix	☑	☑
MAPt	Missed Approach Point		☑
MAHF	Missed Approach Holding Fix		☑
HF	Holding Fix		☑
AWP	Arrival WayPoint	☑	☑
DWP	Departure WayPoint	☑	☑

Minimum length

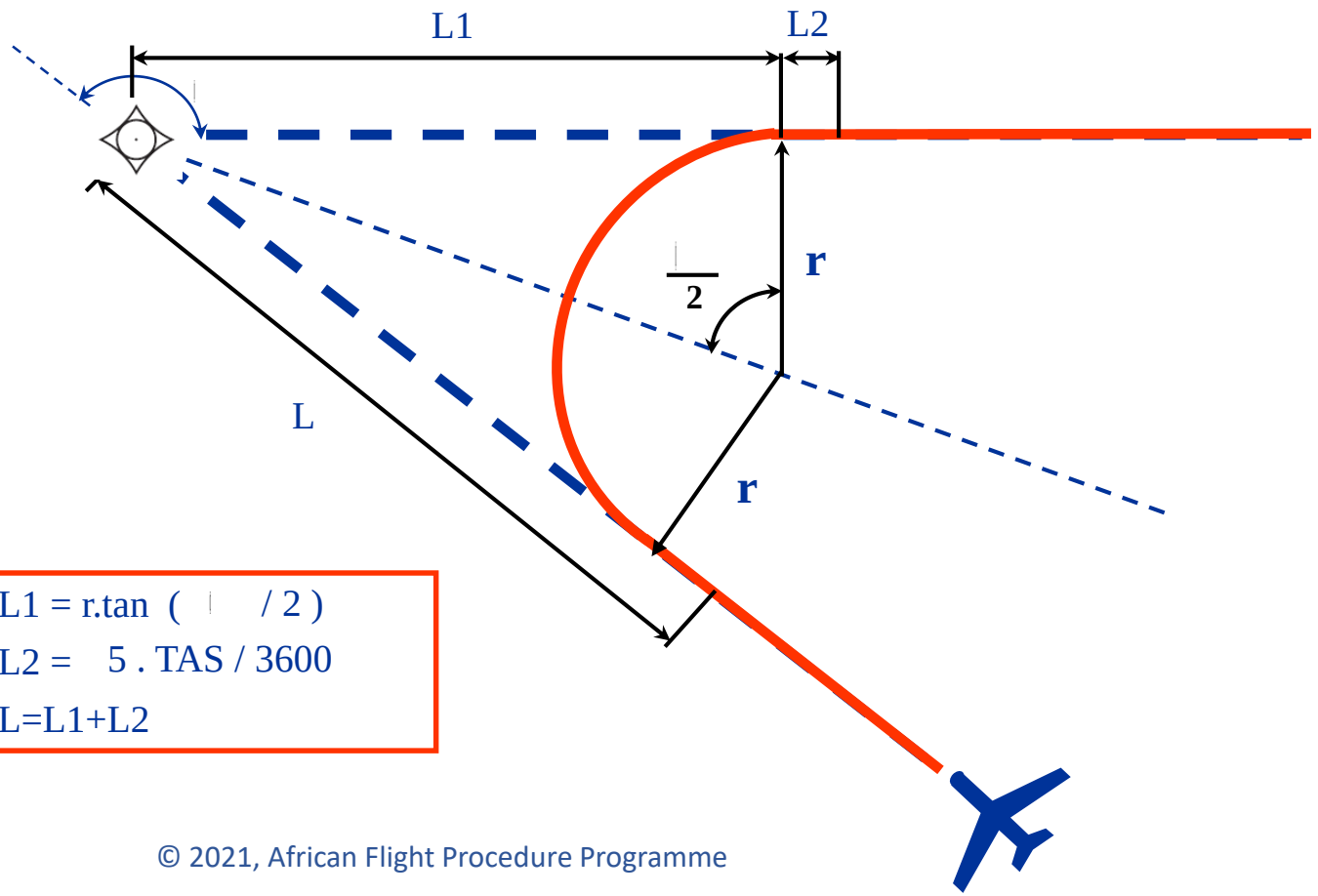
- Segment shall be long enough:
  - To allow aircraft to perform turn and stabilization:
    - Turn stabilization distance.
  - Where no turn is required, to achieve the constraint at the waypoint.



Stabilization distances are necessary

Minimum length

Turn initiation distance



L1 = r.tan (/ 2)

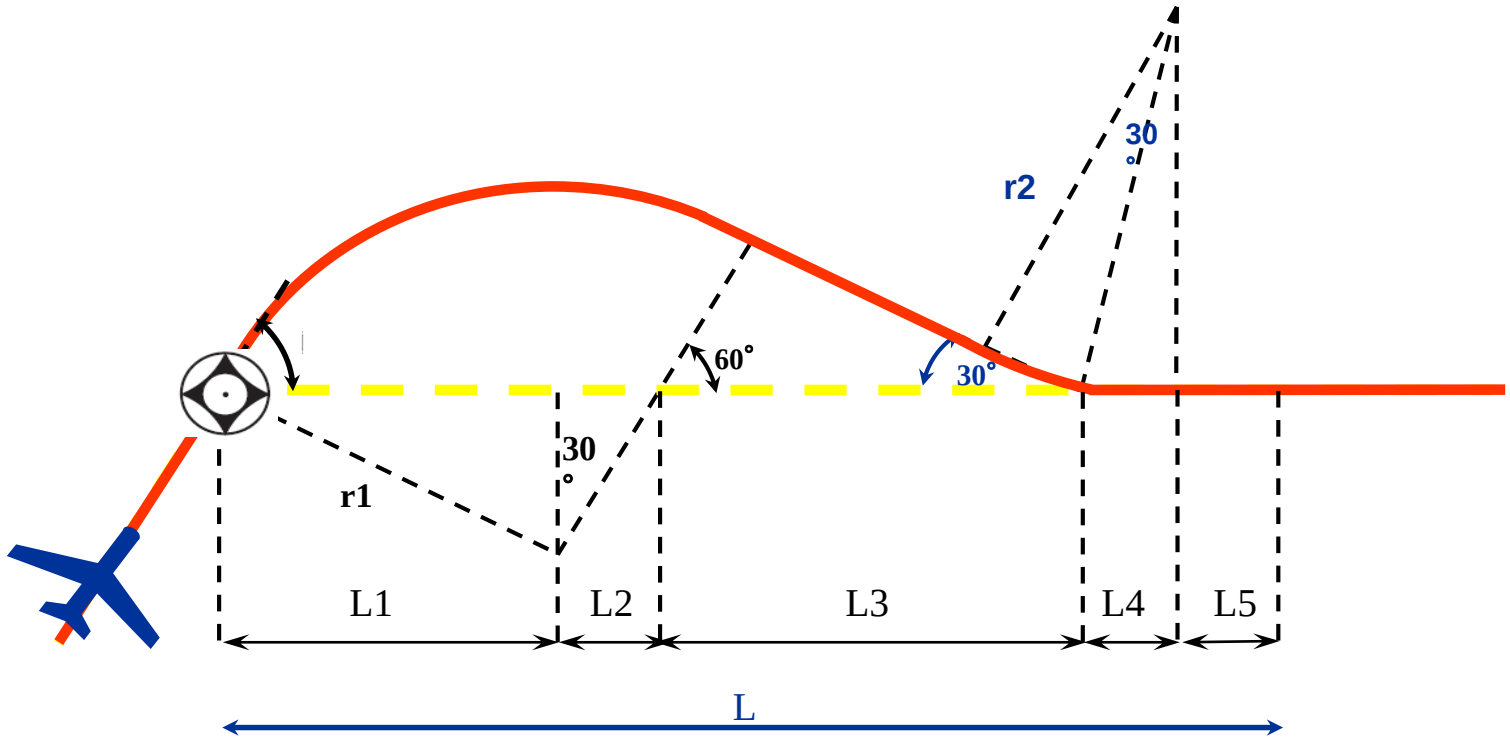
L2 = 5 . TAS / 3600

L=L1+L2

Minimum length

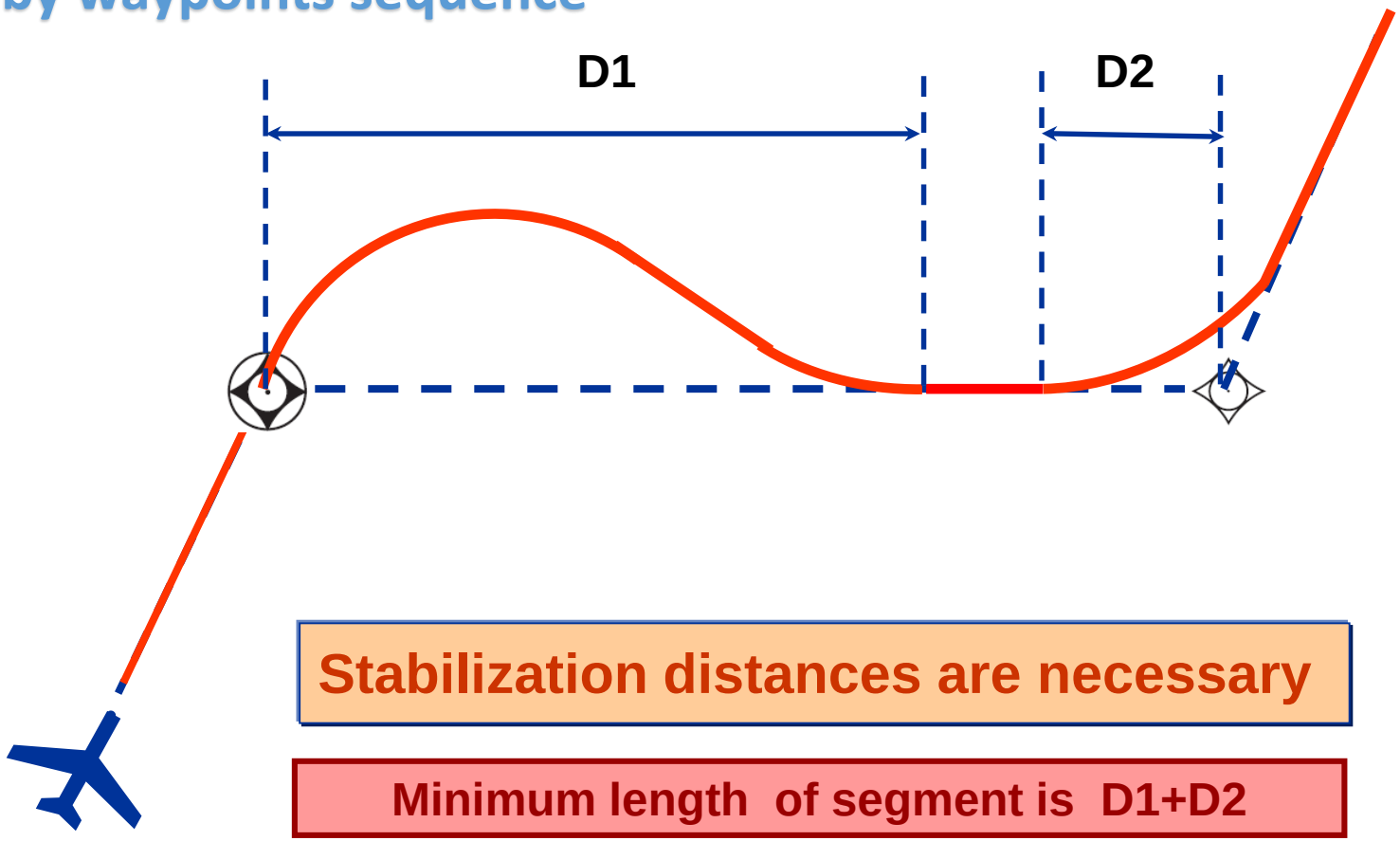
Minimum Stabilization Distance (MSD)

L1= r1.sin
L2= r1.cos .tan30°
L3 = r1 (1/sin30° - 2cos / sin60°)
L4 = r2 . tan15°
L5 = 10 . TAS / 3600
L = L1 + L2 + L3 + L4 + L5



Minimum lengthn

MSD fly-over fly-by waypoints sequence

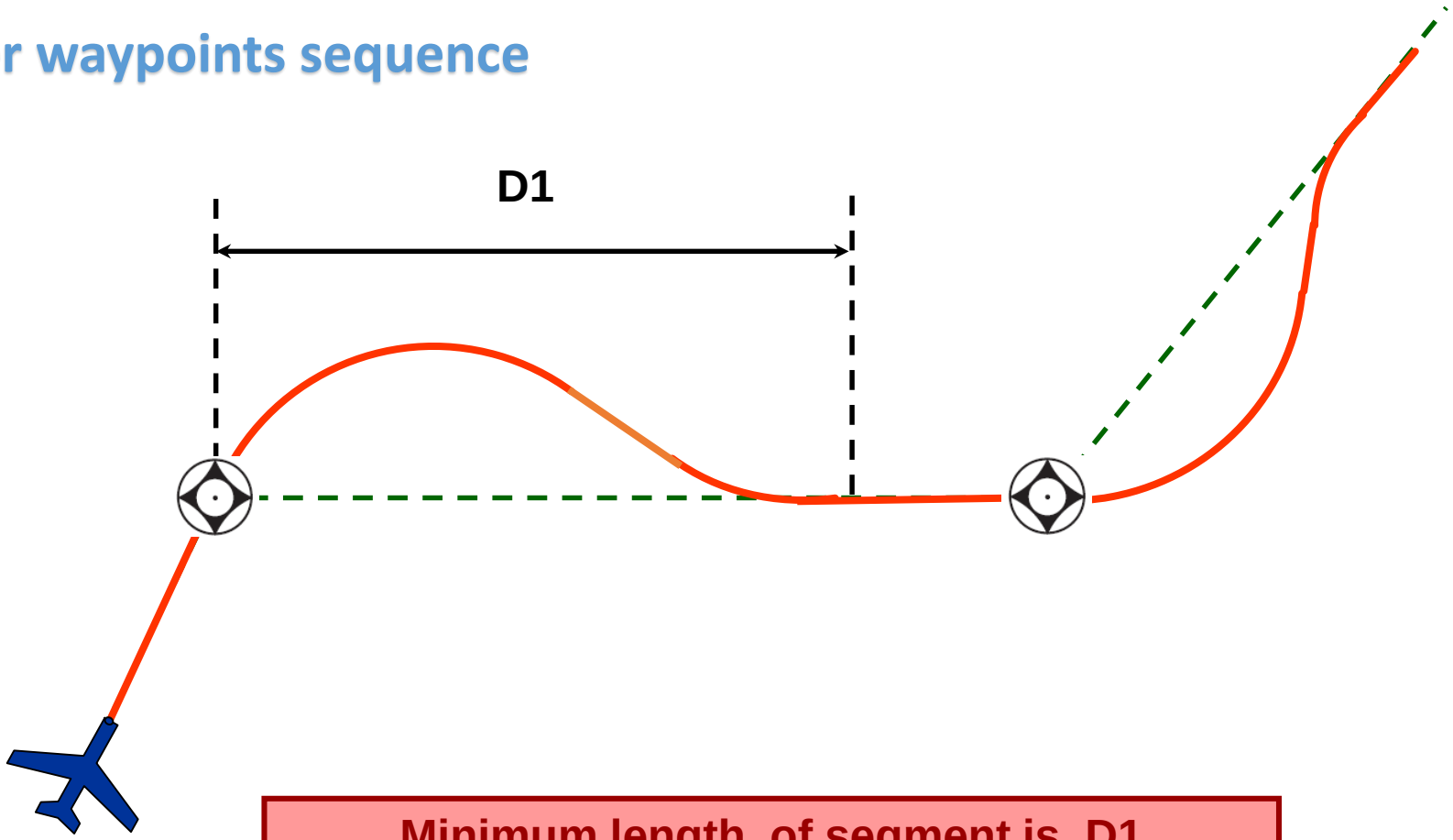


Stabilization distances are necessary

Minimum length of segment is D1+D2

Minimum length

MSD fly-over fly-over waypoints sequence



Minimum length of segment is D1

Minimum length

Table III-2-1-4. Minimum stabilization distance between flyover waypoints (SI units, 15° bank angle)

*Course change**	*True airspeed (km/h)*														
(Degrees)	*< or = 240*	*260*	*280*	*300*	*320*	*340*	*360*	*380*	*400*	*440*	*480*	*520*	*560*	*600*	*640*
50	3.9	4.5	5.2	5.9	6.7	7.5	8.3	9.2	10.1	12.1	14.3	16.7	19.2	22.0	24.9
55	4.2	4.9	5.6	6.4	7.2	8.0	9.0	9.9	10.9	13.1	15.5	18.1	20.8	23.8	27.0
60	4.5	5.2	6.0	6.8	7.7	8.6	9.6	10.7	11.8	14.1	16.7	19.4	22.4	25.6	29.1
65	4.8	5.6	6.4	7.3	8.2	9.2	10.3	11.4	12.6	15.1	17.9	20.8	24.0	27.5	31.1
70	5.1	5.9	6.8	7.7	8.8	9.8	11.0	12.1	13.4	16.1	19.0	22.2	25.6	29.3	33.2
75	5.4	6.3	7.2	8.2	9.3	10.4	11.6	12.9	14.2	17.1	20.2	23.6	27.2	31.1	35.3

Minimum length

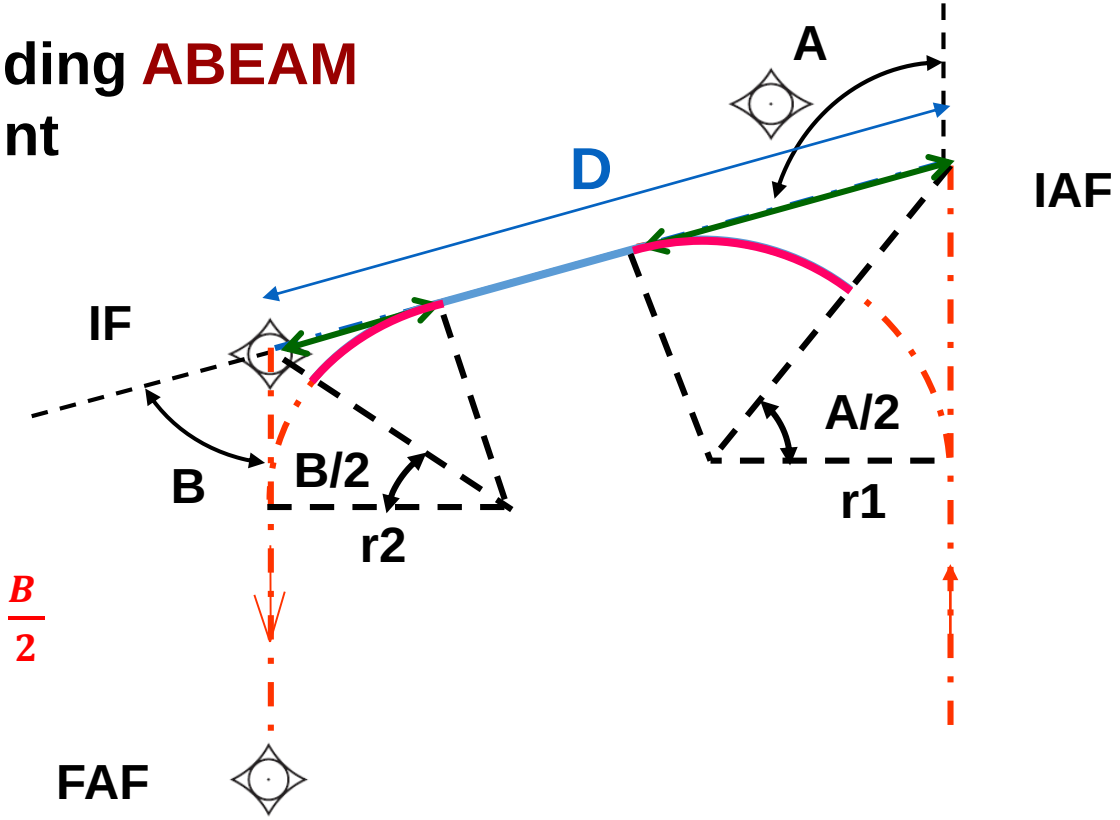
Phase of flight	Minimum Distance to waypoint (D)*
En-route More than 30 NM ARP	5.0 NM
STARs, initial within 30 NM ARP	5.0 NM
SIDs, initial within 15 NM ARP and final approach	1.5 NM
Missed approaches and SIDs within 30 NM ARP	3.0 NM

*When the stabilization distance is greater than D, D is equal to the stabilization distance.

Descent gradient calculation

Descent gradient calculation: Track Resultant distance (TRD)

- Aircrafts are descending **ABEAM** the waypoint



Descent gradient = ∆h / TRD

$$TRD = D - r_1\tan\left(\frac{A}{2}\right) - r_2\tan\left(\frac{B}{2}\right) + r_1\left(\frac{\pi}{180}\right)*\frac{A}{2} + r_2\left(\frac{\pi}{180}\right)*\frac{B}{2}$$

A and B in degree

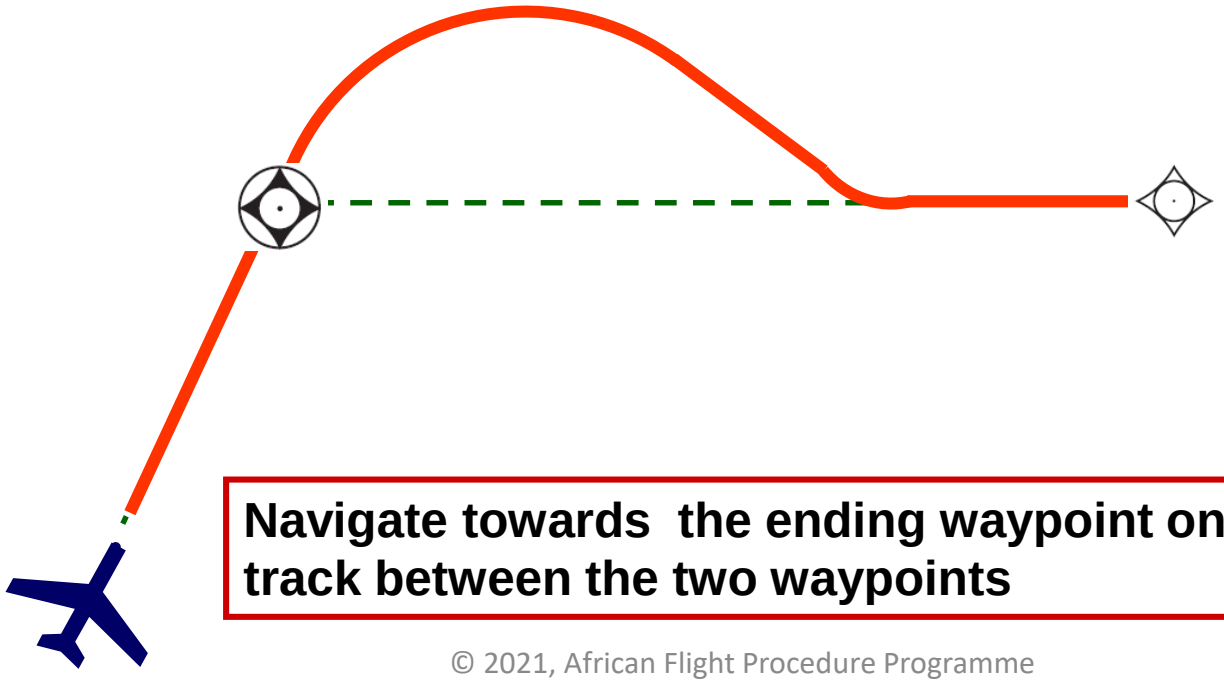
Path Terminator concept

- Transform procedures into coded flight path
- Path terminator:
  - ☞Set of two alphabetic characters;
  - ☞PT instructs how to navigate from a starting point or condition:
    - to a specific point;
    - or terminating condition.
- ONLY ONE path terminator associated with a WP;
- BUT possible additional constraints (altitude or speed).

ARINC 424 PATH TERMINATOR

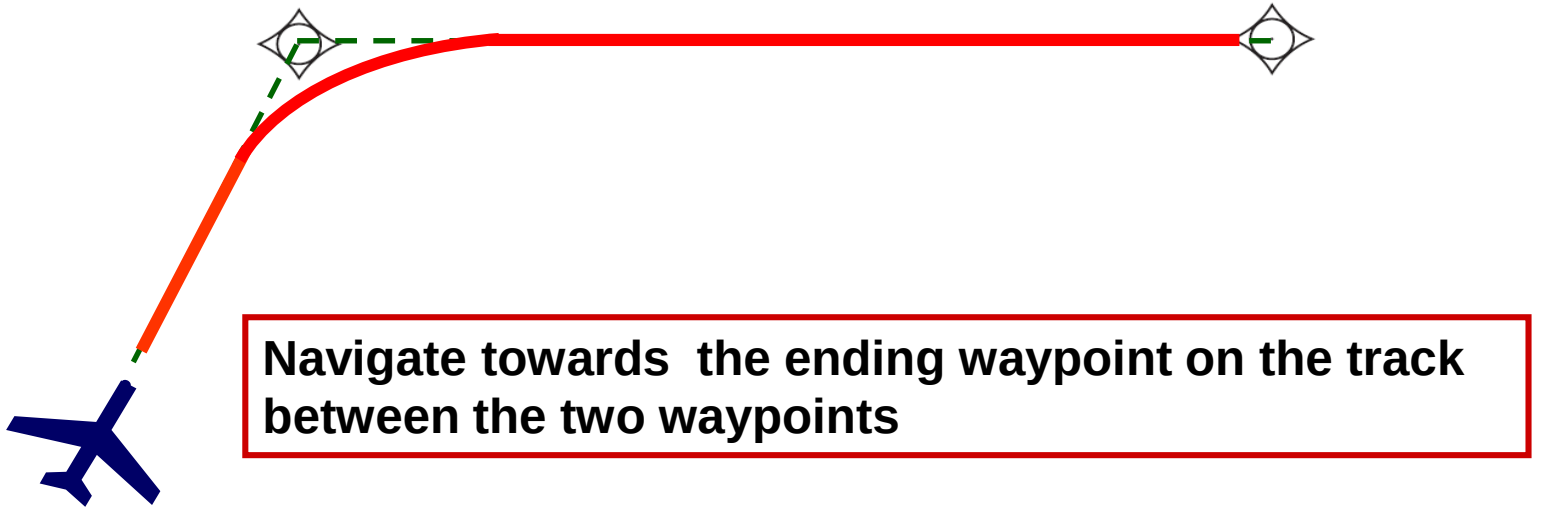
IF	Initial Fix
TF	Track between fix
RF	Radius to fix
DF	Direct to fix
FA	Fix to an altitude
CF	Course to fix
HF	Hold to fix
HA	Hold to altitude
HM	Hold for clearance
PI	Procedure turn to intrecept
CA	Course to altitude
CI	Course to intercept
CD	Course to dme arc
CR	Course to VOR radial
FC	Course from fix
FD	Fix to DME arc
FM	Vectors from fix
AF	DME Arc to fix
VD	Heading to DME Arc
VA	Heading to altitude
VM	Heading (vectors)
VI	Heading to intercept
VR	Heading to VOR Radial

TF : Track between Fixes



Navigate towards the ending waypoint on the track between the two waypoints

TF : Track between Fixes



Initial approach constraints

	Length (NM)	Turn at IAF (°)	Turn at IF (°)	Bank angle (°)	Descent gradient(%)	MOC(m)
Minimum	(1)	0	0	25	0	300
Optimum	5	70	70		4	
Maximum	No limit	120	90		8	

(1) Depends on the minimum stabilization distances necessary on the segment

(2) IAS see speed table

Intermediate approach constraints

	Length (NM)	Turn at IF (°)	Turn at FAF (°)	Bank angle (°)	Descent gradient (%)	MOC (m)
Minimum	2 + MDS	0	0	25	-	150
Optimum	5	70	0		Flat	0
Maximum	15	90	30		5.2 + Flat segment	300

(1) Depends on the minimum stabilization distances necessary on the segment

(2) IAS see speed table

Final approach constraints

	Length (NM)	Turn at FAF (°)	Bank angle (°)	Descent gradient (%)	MOC (m)
Minimum	3	0	25	5.2	0
Optimum	5	0		5.2	0
Maximum	10	30		6.5 (AB) & 6.1 (CD)	75

- Depends on the minimum stabilization distances necessary on the segment
- MAPt position
- IAS see speed table

Missed approach constraints

	Length (NM)	Turn at MAPt (°)	Turn at MATF	Bank angle (°)	Climb gradient (%)
Minimum	(1)	0	0	15	2.5
Maximum	-	No limit	120 (2)		-

(1) Depends The length necessary to reach the minimum holding altitude and to guarantee minimum stabilization distances .

(2) No limit when turn is followed by DF.

IAS see speed table

Procedure altitude concept

- Need of depiction of different types of altitude:
  - ☞MOCA (always) and sometimes constraints:
    - Airspace;
    - Radio navigation;
    - Environment;
    - Avoid CFIT.

Need to define two types of altitudes

- **MOCA: Minimum Obstacle Clearance Altitude**
- **Procedure Altitude**
- **💣 Procedure altitude is ALWAYS ≥ MOCA**

Procedure altitude concept

USERS

Operational Altitude

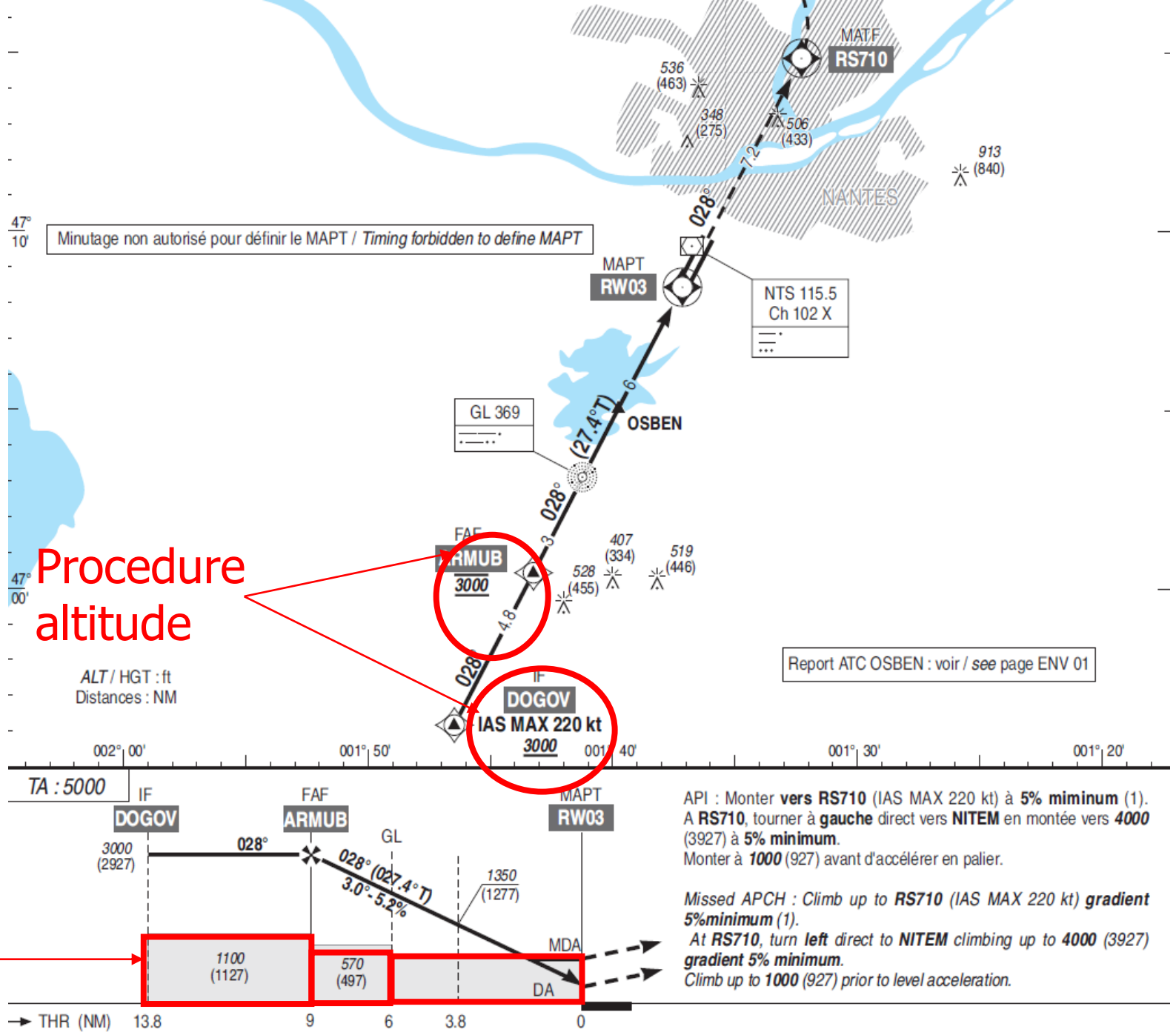
PROCEDURE ALTITUDE

Associated with a WAYPOINT

Minimum Obstacle Clearance Altitude MOCA
Associated with a SEGMENT

Procedure altitude concept

- To support CFIT prevention initiative, procedure altitude should be defined for all NPA;
- Arrival and departure procedure altitude are developed to separate arriving and departing traffic;
- Depiction of procedure altitude / MOCA in NPA approach charts:
  - Procedure altitude is provided in the profile view (ref § 11.10.6.3 annex 4);
  - Minimum altitude (MOCA) or a ground profile is RECOMMENDED to be depicted (ref § 11.10.6.5 annex 4);
  - MOCA in intermediate and final segment are depicted with **SHADED BLOCKS.**


MATF
RS710
536
(463)
348
(275)
506
(433)
913
(840)
NANTES
7.2
028°
47° 10'
Minutage non autorisé pour définir le MAPT / Timing forbidden to define MAPT
MAPT
RW03
NTS 115.5
Ch 102 X
GL 369
(27.4°T)
6
OSBEN
028°
3
FAF
ARMUB
3000
407
(334)
519
(446)
528
(455)
4.8
028°
IF
DOGOV
IAS MAX 220 kt
3000
47° 00'
Procedure altitude
ALT / HGT : ft
Distances : NM
Report ATC OSBEN : voir / see page ENV 01
002° 00'
001° 50'
001° 40'
001° 30'
001° 20'
TA : 5000
IF
DOGOV
FAF
ARMUB
MAPT
RW03
GL
3000
(2927)
028°
028° (027.4°T)
3.0° - 5.2%
1350
(1277)
MDA
DA
1100
(1127)
570
(497)
THR (NM)
13.8
9
6
3.8
0
API : Monter vers RS710 (IAS MAX 220 kt) à 5% miminum (1).
A RS710, tourner à gauche direct vers NITEM en montée vers 4000 (3927) à 5% minimum.
Monter à 1000 (927) avant d'accélérer en palier.
Missed APCH : Climb up to RS710 (IAS MAX 220 kt) gradient 5%minimum (1).
At RS710, turn left direct to NITEM climbing up to 4000 (3927) gradient 5% minimum.
Climb up to 1000 (927) prior to level acceleration.

MOCA

Questions:

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