PBN Procedure Design Course 2026

ICAO APAC FPP

Beijing,China

(7-25/Sep/2026)

Conceptual Design Nominal Path

Objective of the Course

- Define the conceptual path according to data collected
  - Know how to calculate **minimum length of a segment**
  - Know how to calculate the **descent gradient**
  - Know 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)
  - Know the « draft » coding associated with the path

Objective the Course

1.Standard Instrument Arrival Routes (STARs)

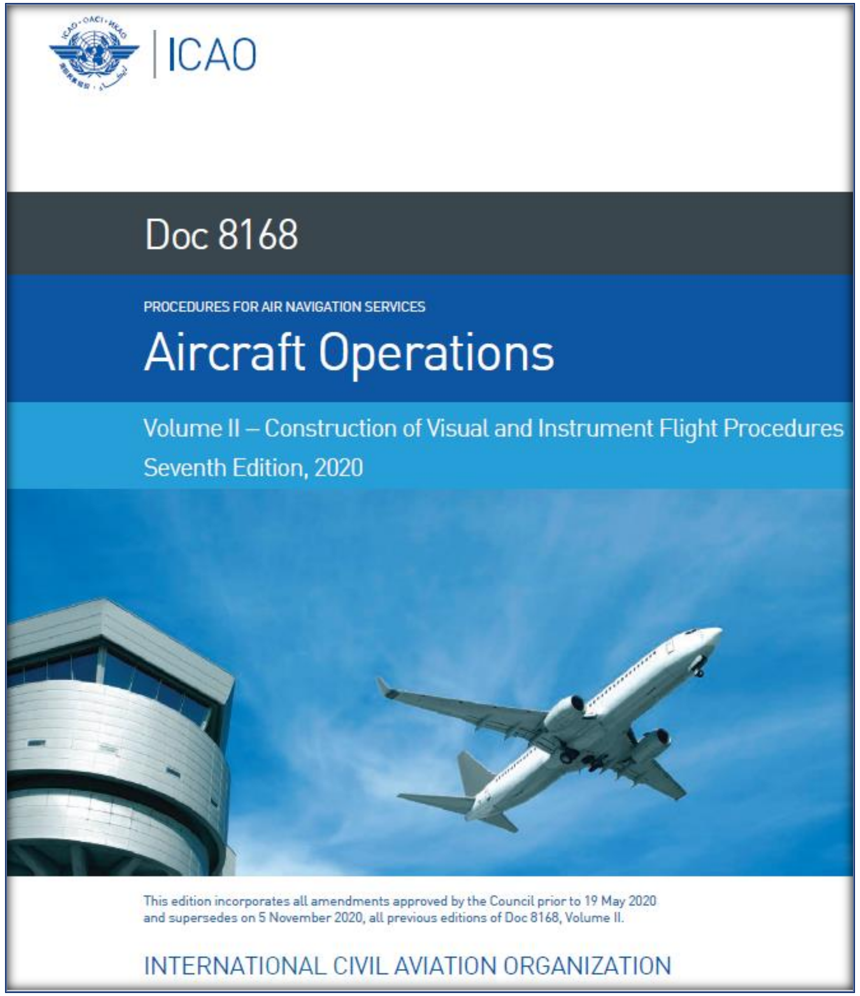
2.Non-precision Approach Procedure (NPA)

3.Approach Procedure with Vertical Guidance(APV) –Baro-VNAV

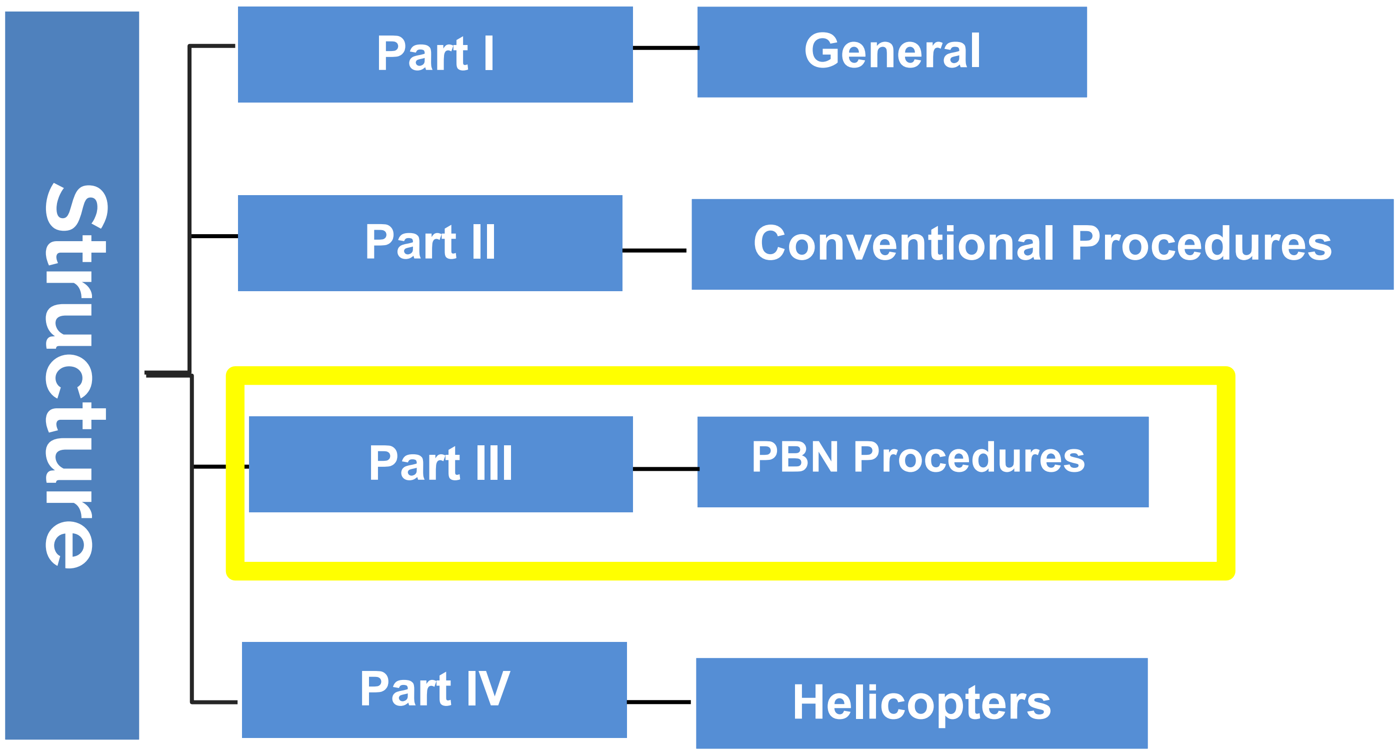
4. Standard Instrument Departure Procedures (SIDs)

Regulatory Reference

- ICAO Regulation
- DOC 8168 – OPS- Volume II
- Procedures for Air Navigation Services – Aircraft Operations (Construction of Visual and Instrument Flight Procedures)
- Doc 8168
- Vol II part I section 4
- Vol II part III section 2 chapters 1,3,5
- ARINC code 424



PANS-OPS Structure



Historical Background

First Edition
1979

Second Edition
1982

Third Edition
1986

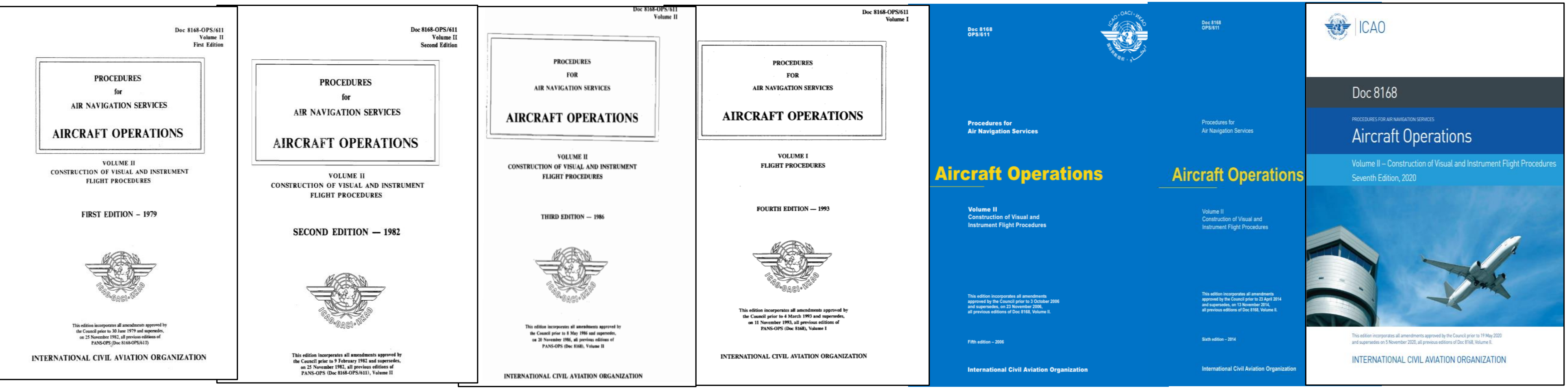
Fourth Edition
1993

Fifth Edition
2006

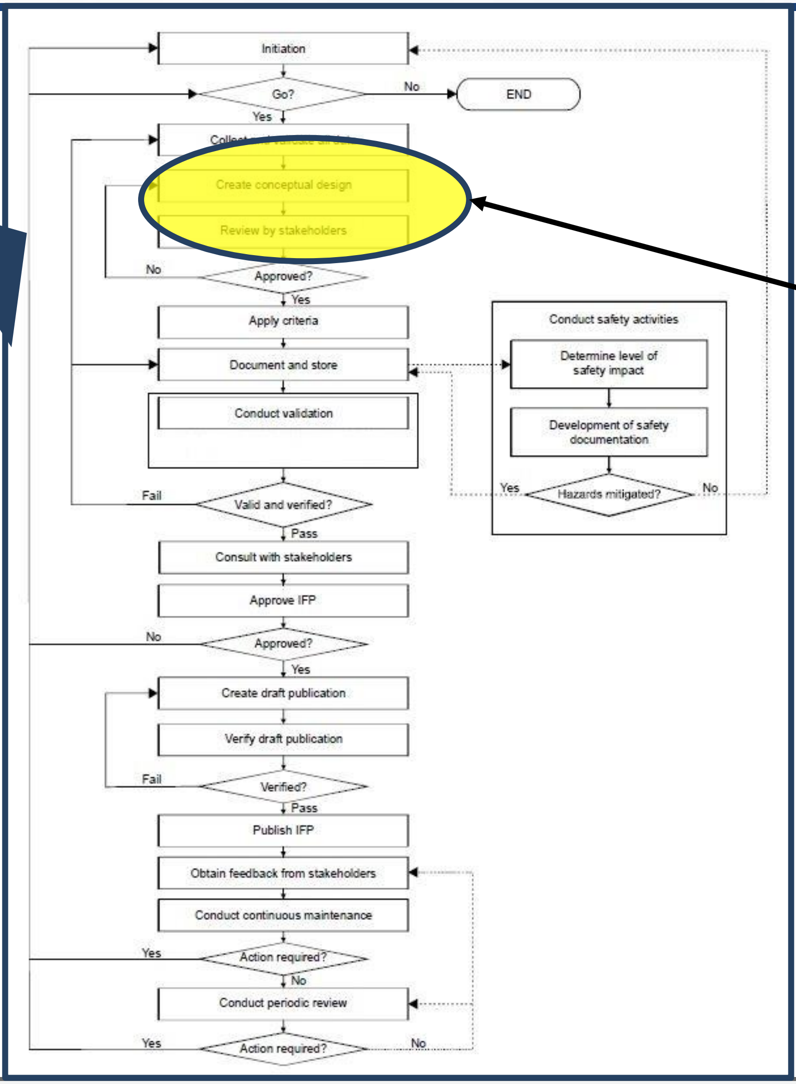
Sixth Edition
2014

Seventh Edition
2020

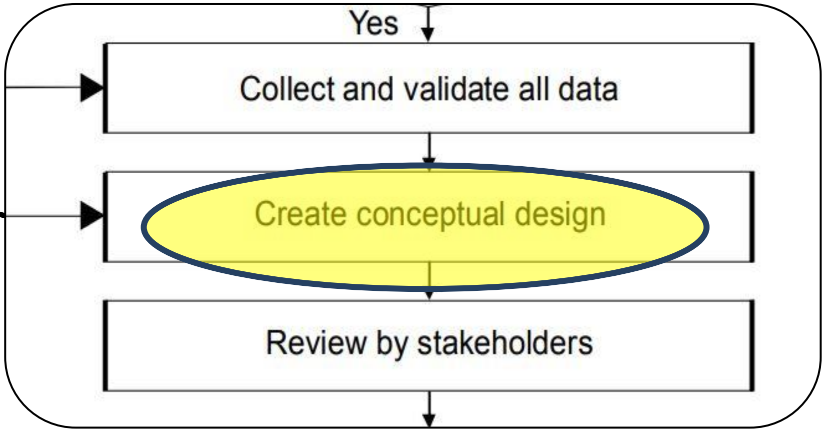
Historical Background



Conceptual Design



Here we are



- A conceptual design is drafted with the key elements considering the overall strategy.

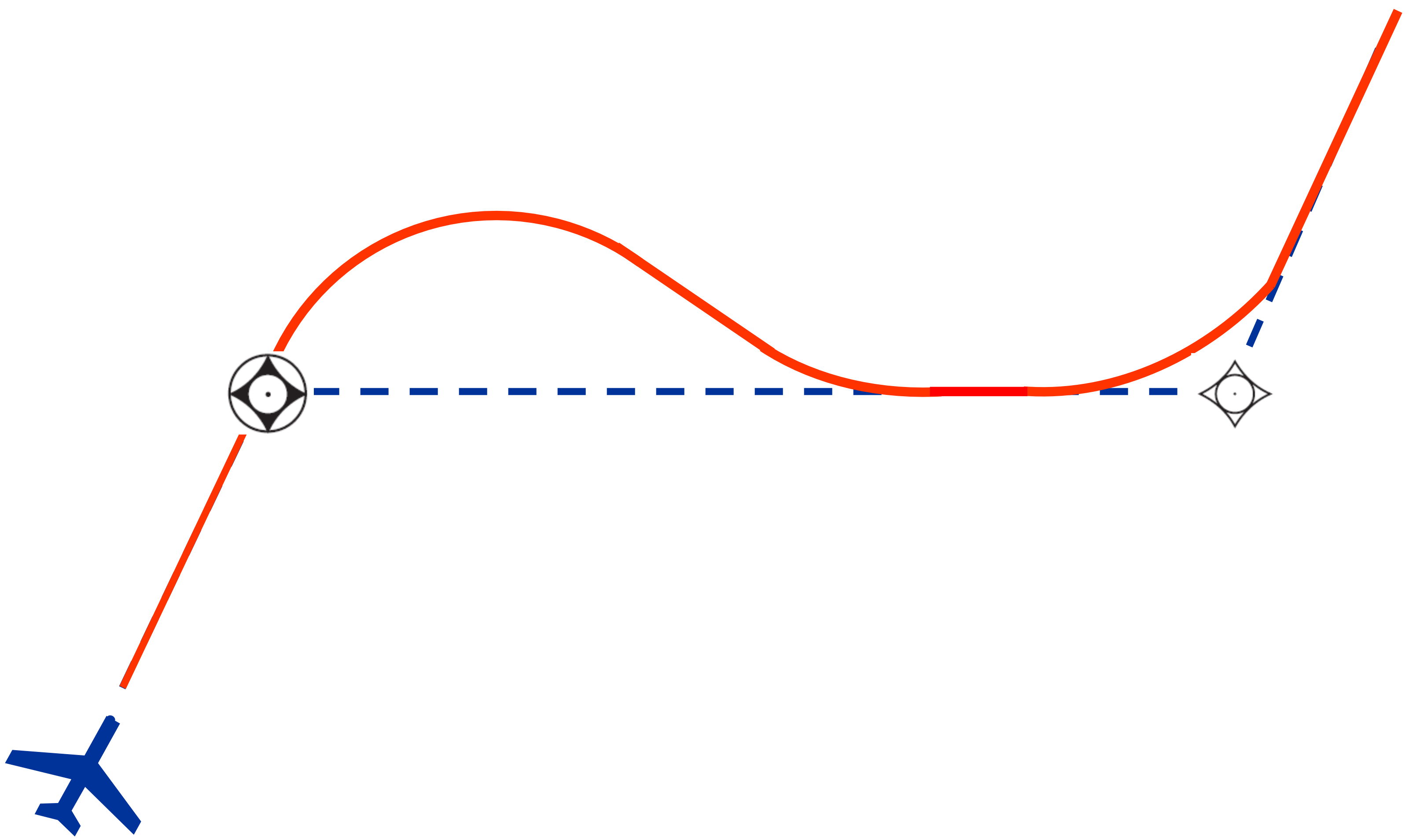
Waypoint

- A path is defined by fixes called waypoints or by specific condition as altitude
- Waypoints **Coordinates** are expressed in **WGS84**

  - **Fly-over waypoint**
    - **Legend :** 
  - **Fly-by waypoint**
    - **Legend :** 

☺ Fly-by waypoint is preferred

WP1 : Fly-Over   WP2 : Fly-by



Type of Waypoints

		
IAF	✓	✓
IF	✓	✓
FAF	✓	✓
MAPt		✓
MAHWP		✓
HWP		✓
AWP	✓	✓
DWP	✓	✓

The acronyms IAWP, IWP , FAWP MAWP have been deleted since amendment 12

MAHWP : Missed Approach Holding Waypoint

HWP : Holding Waypoint

AWP : Arrival Waypoint

DWP : Departure waypoint

Waypoints

- Waypoint are defined to express
  - function e.g. IAF, IF,FAF, MAPT, beginning of a STAR…
  - turning point
  - speed or altitude constraint
  - reporting point for ATC purpose
- Number of waypoints should be limited to a minimum
  - within a straight segment no more than 2 additional waypoints . These additional waypoints are fly-by waypoints.

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 .

Minimum Distance is needed to prevent waypoints being placed so close that RNAV systems are forced to bypass them, a minimum distance between successive waypoints must be taken into account.

Minimum Length

Two types of waypoints are considered:

a)fly-by waypoint

b)Flyover waypoint

Four sequences are possible for a segment limited by two waypoints:

1.Two fly-by waypoints;

2.fly-by waypoint, then flyover waypoint;

3.Two flyover waypoints

4.Flyover waypoint, then fly-by waypoint.

In addition, the particular case of the segment "**DER-first waypoint**" must also be considered.

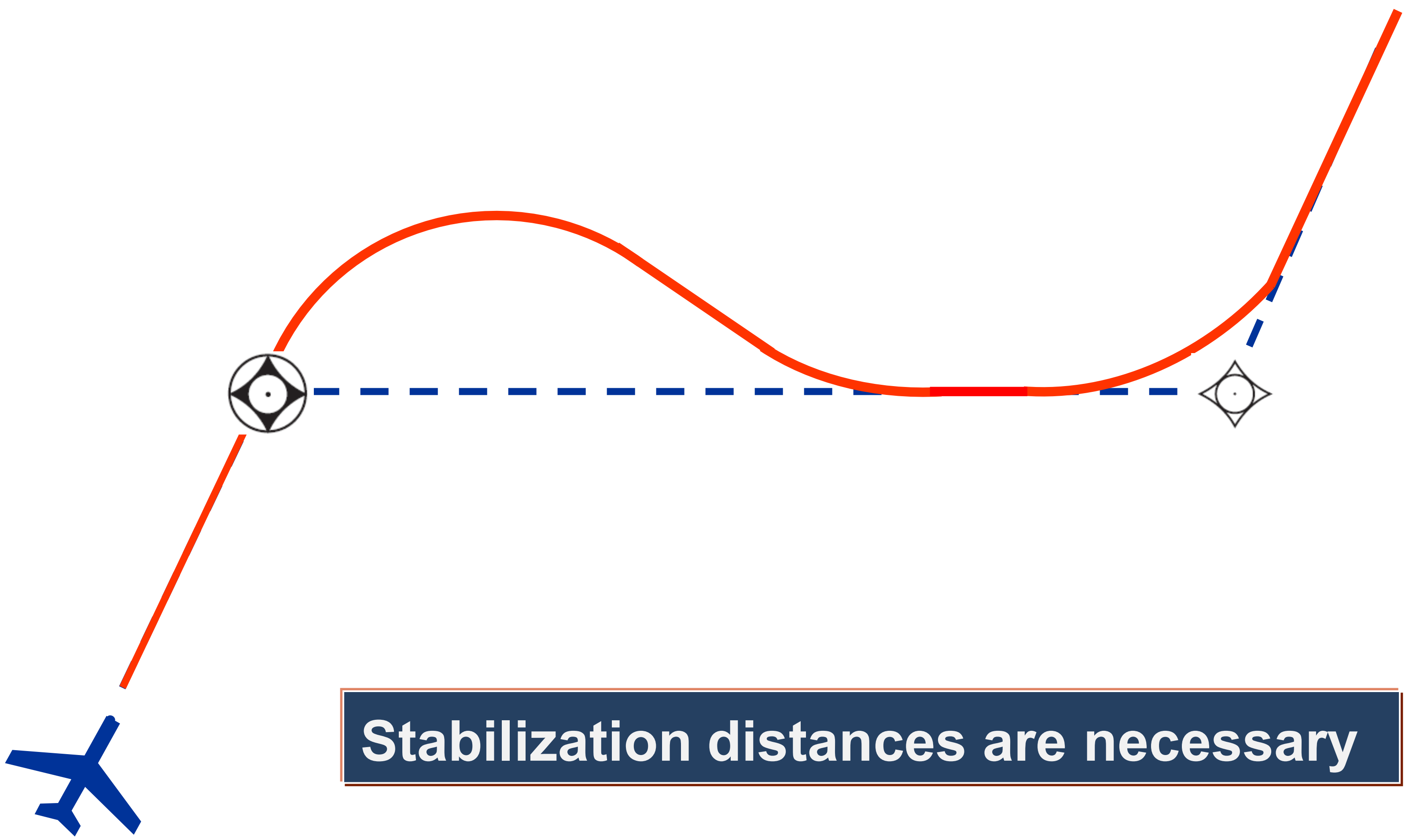
Minimum Length

The aim of the method is **not to determine a protection area**, but to determine a minimum distance between two waypoints on a nominal trajectory. For this reason, **wind effect** and **waypoint tolerances are not taken into account** in the theoretical calculations. When it is necessary, greater values may be chosen.

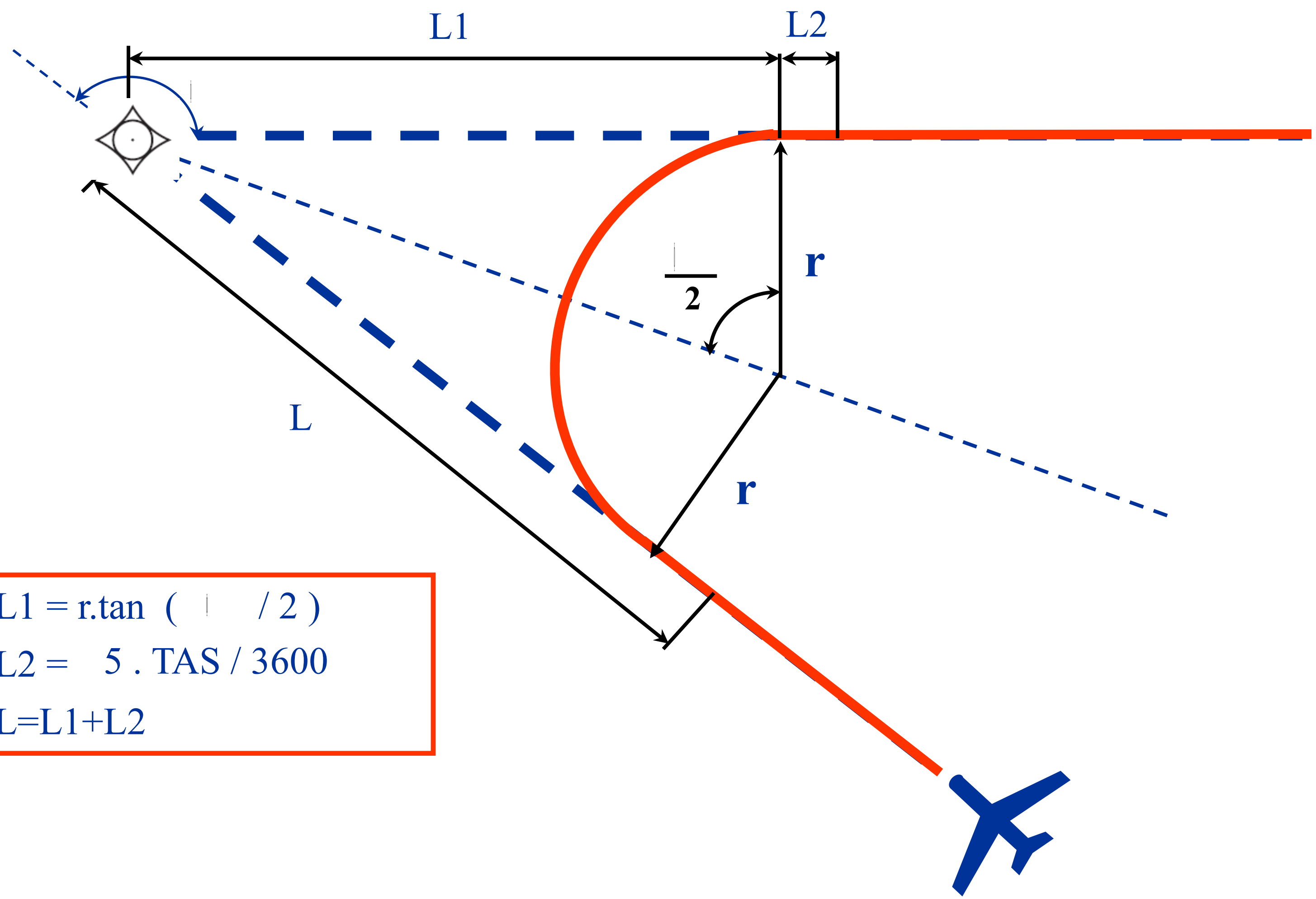
For each waypoint a minimum stabilization distance is determined.

MSD-the distance between the **waypoint** and the point where the **trajectory joins tangentially with the nominal track**.

WP1 : Fly-over   WP2 : Fly-by



Turn Initiation Distance



L1 = r.tan (/ 2)

L2 = 5 . TAS / 3600

L=L1+L2

Fly-by Bank : 25°

Table III-M-9. Minimum stabilization distance between fly-by way-points (Non-SI units, 25° bank angle*)

TAS

Turn angle

No interpolation

Course change** < or = (Degrees)	True airspeed (kt) 130	140	150	160	170	180	190	200	210	220	240	260	280	300	340
50	0.5	0.5	0.6	0.6	0.7	0.7	0.8	0.9	0.9	1.0	1.2	1.3	1.5	1.7	[illegible]
55	0.5	0.6	0.6	0.7	0.7	0.8	0.9	0.9	1.0	1.1	1.3	1.5	1.7	[illegible]	[illegible]
60	0.5	0.6	0.7	0.7	0.8	0.8	0.9	1.0	1.1	1.2	1.4	1.6	1.8	[illegible]	[illegible]
65	0.5	0.7	0.7	0.8	0.8	0.9	1.0	1.1	1.2	1.3	1.5	1.7	[illegible]	[illegible]	2.8
70	0.6	0.7	0.8	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.6	1.8	[illegible]	[illegible]	3.0
75	0.6	0.8	0.8	0.9	0.9	1.0	1.1	1.2	1.3	1.5	1.7	2.0	[illegible]	2.6	3.2
80	0.7	0.8	0.9	0.9	1.0	1.1	1.2	1.3	1.4	1.6	1.8	[illegible]	[illegible]	2.8	3.5
85	0.7	0.9	0.9	1.0	1.1	1.2	1.3	1.4	1.6	1.7	[illegible]	[illegible]	2.6	3.0	3.8
90	0.7	0.9	1.0	1.1	1.1	1.3	1.4	1.5	1.7	1.8	[illegible]	[illegible]	2.8	3.2	4.1
95	0.8	1.0	1.1	1.1	1.2	1.4	1.5	1.6	1.8	2.0	[illegible]	[illegible]	3.1	3.5	4.4
100	0.8	1.1	1.2	1.2	1.3	1.5	1.6	1.8	1.9	2.1	[illegible]	2.9	3.3	3.8	4.8
105	0.9	1.2	1.2	1.3	1.4	1.6	1.7	1.9	2.1	2.3	[illegible]	3.1	3.6	4.1	5.2
110	1.0	1.3	1.3	1.4	1.5	1.7	1.9	2.1	2.3	2.5	2.9	3.4	3.9	4.4	5.6
115	1.1	1.4	1.5	1.6	1.7	1.8	2.0	2.2	2.5	2.7	3.2	3.7	4.2	4.8	6.1
120	1.2	1.5	1.6	1.7	1.8	2.0	2.2	2.4	2.7	2.9	3.5	4.0	4.6	5.3	6.7

*25° or 3°/s

**Use the value of 50° for course changes lower than 50°.

Turn Stabilization Distance

$L1 = r1.\sin$

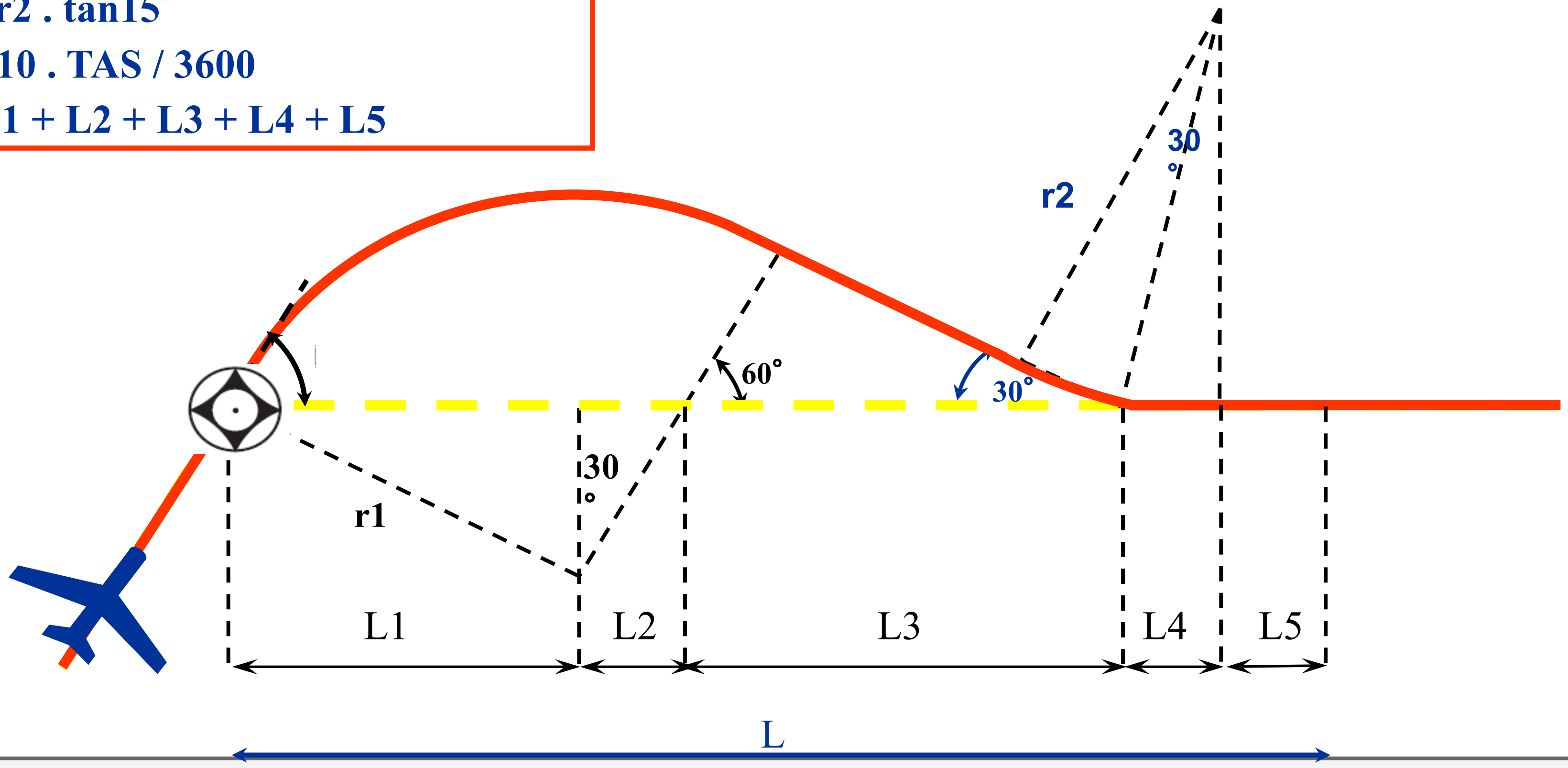
$L2 = r1.\cos \quad .\tan30°$

$L3 = r1\ (1/\sin30° \ - 2\cos \quad / \sin60° \ )$

$L4 = r2\ .\ \tan15°$

$L5 = 10\ .\ TAS / 3600$

$L = L1 + L2 + L3 + L4 + L5$



Fly-over Bank : 25°

Table III-M-12. Minimum stabilization distance between flyover way-points
(Non-SI units, 25° bank angle*)

TAS

Course change** < or = (Degrees)	130	140	150	160	170	180	190	200	210	220	240	260	280	300	340
	True airspeed (kt)														
50	1.7	1.9	2.1	2.2	2.4	2.6	2.9	3.2	3.5	3.8	4.5	5.2	6.0	6.8	8.6
55	1.9	2.0	2.2	2.4	2.5	2.8	3.1	3.4	3.7	4.1	4.8	5.6	6.4	[illegible]	[illegible]
60	2.0	2.2	2.3	2.5	2.7	3.0	3.3	3.6	4.0	4.3	5.1	5.9	6.8	[illegible]	[illegible]
65	2.1	2.3	2.5	2.7	2.9	3.2	3.5	3.9	4.2	4.6	5.4	6.3	7.2	[illegible]	[illegible]
70	2.2	2.4	2.6	2.8	3.0	3.3	3.7	4.1	4.5	4.9	5.7	6.7	[illegible]	[illegible]	11.1
75	2.3	2.5	2.7	3.0	3.2	3.5	3.9	4.3	4.7	5.1	6.0	7.0	[illegible]	[illegible]	11.7
80	2.5	2.7	2.9	3.1	3.3	3.7	4.1	4.5	4.9	5.4	6.3	[illegible]	[illegible]	9.7	12.3
85	2.6	2.8	3.0	3.2	3.5	3.9	4.3	4.7	5.1	5.6	[illegible]	[illegible]	[illegible]	10.1	12.9
90	2.7	2.9	3.1	3.4	3.6	4.0	4.4	4.9	5.4	5.9	6.9	[illegible]	9.3	10.6	13.5
95	2.8	3.0	3.2	3.5	3.7	4.2	4.6	5.1	5.6	6.1	[illegible]	[illegible]	9.6	11.0	14.0
100	2.9	3.1	3.4	3.6	3.9	4.3	4.8	5.2	5.8	6.3	[illegible]	8.6	10.0	11.4	14.5
105	3.0	3.2	3.5	3.7	4.0	4.4	4.9	5.4	5.9	6.5	[illegible]	8.9	10.3	11.7	15.0
110	3.0	3.3	3.6	3.8	4.1	4.5	5.0	5.6	6.1	6.7	7.9	9.2	10.6	12.1	15.4
115	3.1	3.4	3.6	3.9	4.2	4.7	5.2	5.7	6.2	6.8	8.1	9.4	10.8	12.4	15.8
120	3.2	3.4	3.7	4.0	4.3	4.8	5.3	5.8	6.4	7.0	8.2	9.6	11.1	12.6	16.1

Turn angle

No interpolation

*25° or 3°/s
**Use the value of 50° for course changes lower than 50°.

Fly-Over Bank : 15°

Table III-2-1-10. Minimum stabilization distance between flyover waypoints
(Non-SI units, 15° bank angle)

TAS

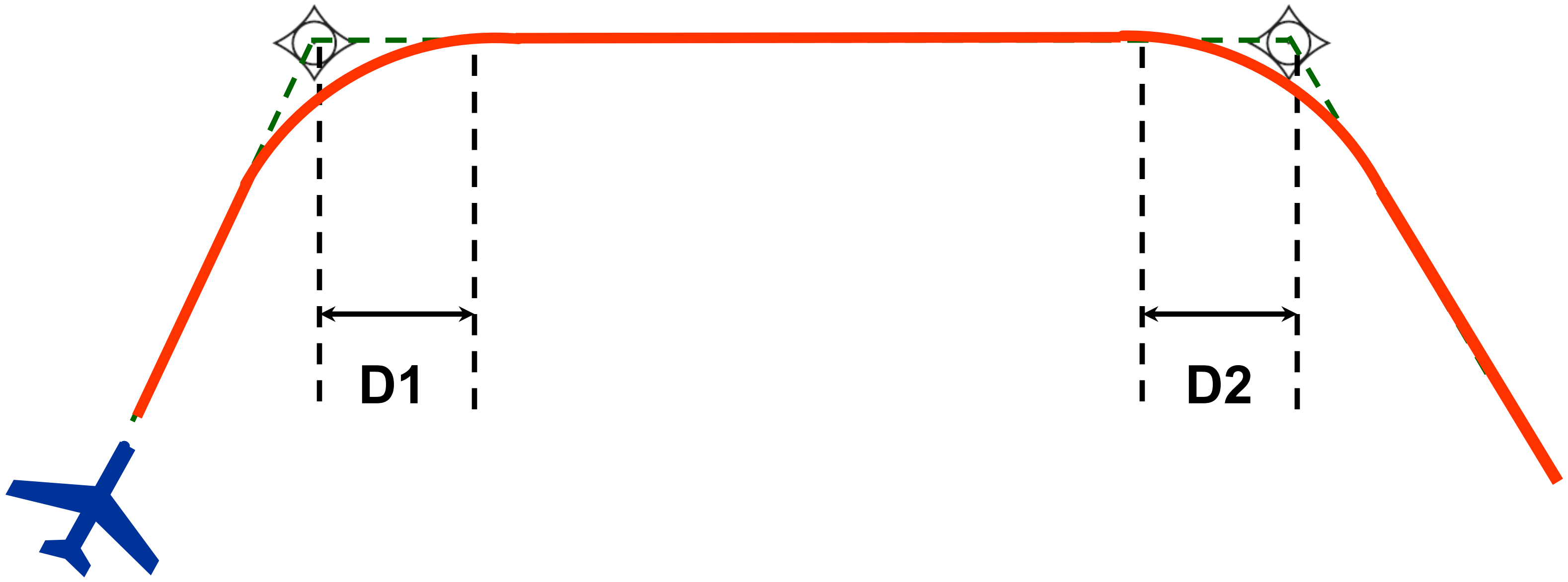
Course change (Degrees)*	*True airspeed (kt)* < or = 130	140	150	160	170	180	190	200	210	220	240	260	280	300	340
50	2.1	2.4	2.8	3.1	3.5	3.9	4.3	4.7	5.2	5.7	6.7	7.8	9.0	10.2	[illegible]
55	2.3	2.6	3.0	3.4	3.8	4.2	4.6	5.1	5.6	6.1	7.2	8.4	9.7	[illegible]	[illegible]
60	2.4	2.8	3.2	3.6	4.0	4.5	5.0	5.5	6.0	6.6	7.8	9.1	10.4	[illegible]	[illegible]
65	2.6	3.0	3.4	3.8	4.3	4.8	5.3	5.9	6.4	7.0	8.3	9.7	[illegible]	[illegible]	[illegible]
70	2.8	3.2	3.6	4.1	4.6	5.1	5.7	6.2	6.9	7.5	8.9	10.3	[illegible]	[illegible]	17.4
75	2.9	3.4	3.8	4.3	4.8	5.4	6.0	6.6	7.3	7.9	9.4	[illegible]	[illegible]	[illegible]	18.5
80	3.1	3.5	4.0	4.6	5.1	5.7	6.3	7.0	7.7	8.4	9.9	[illegible]	[illegible]	15.3	19.5
85	3.2	3.7	4.2	4.8	5.4	6.0	6.6	7.3	8.0	8.8	10.4	[illegible]	[illegible]	16.1	20.5
90	3.4	3.9	4.4	5.0	5.6	6.3	6.9	7.7	8.4	9.2	[illegible]	[illegible]	14.7	16.8	21.5
95	3.5	4.0	4.6	5.2	5.8	6.5	7.2	8.0	8.8	9.6	[illegible]	[illegible]	15.3	17.5	22.4
100	3.6	4.2	4.8	5.4	6.1	6.8	7.5	8.3	9.1	10.0	[illegible]	13.8	15.9	18.2	23.3
105	3.7	4.3	4.9	5.6	6.3	7.0	7.8	8.6	9.4	10.3	[illegible]	14.3	16.5	18.9	24.1
110	3.9	4.4	5.1	5.7	6.4	7.2	8.0	8.8	9.7	10.6	12.6	14.7	17.0	19.4	24.8
115	4.0	4.6	5.2	5.9	6.6	7.4	8.2	9.1	10.0	10.9	12.9	15.1	17.4	20.0	25.5
120	4.0	4.7	5.3	6.0	6.8	7.5	8.4	9.3	10.2	11.1	13.2	15.4	17.8	20.4	26.1

Turn angle

No interpolation

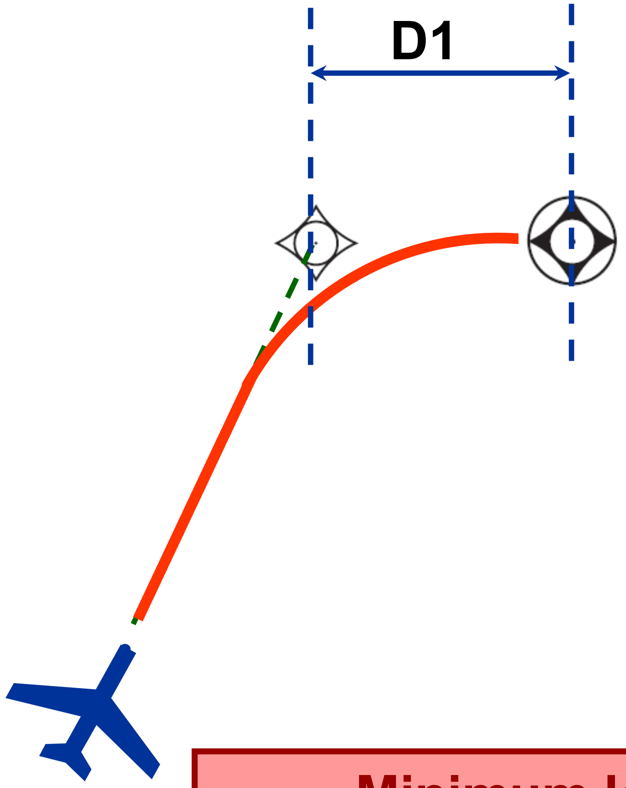
* Use the value of 50° for course changes lower than 50°.

WP1 : Fly-by WP2 : Fly-by



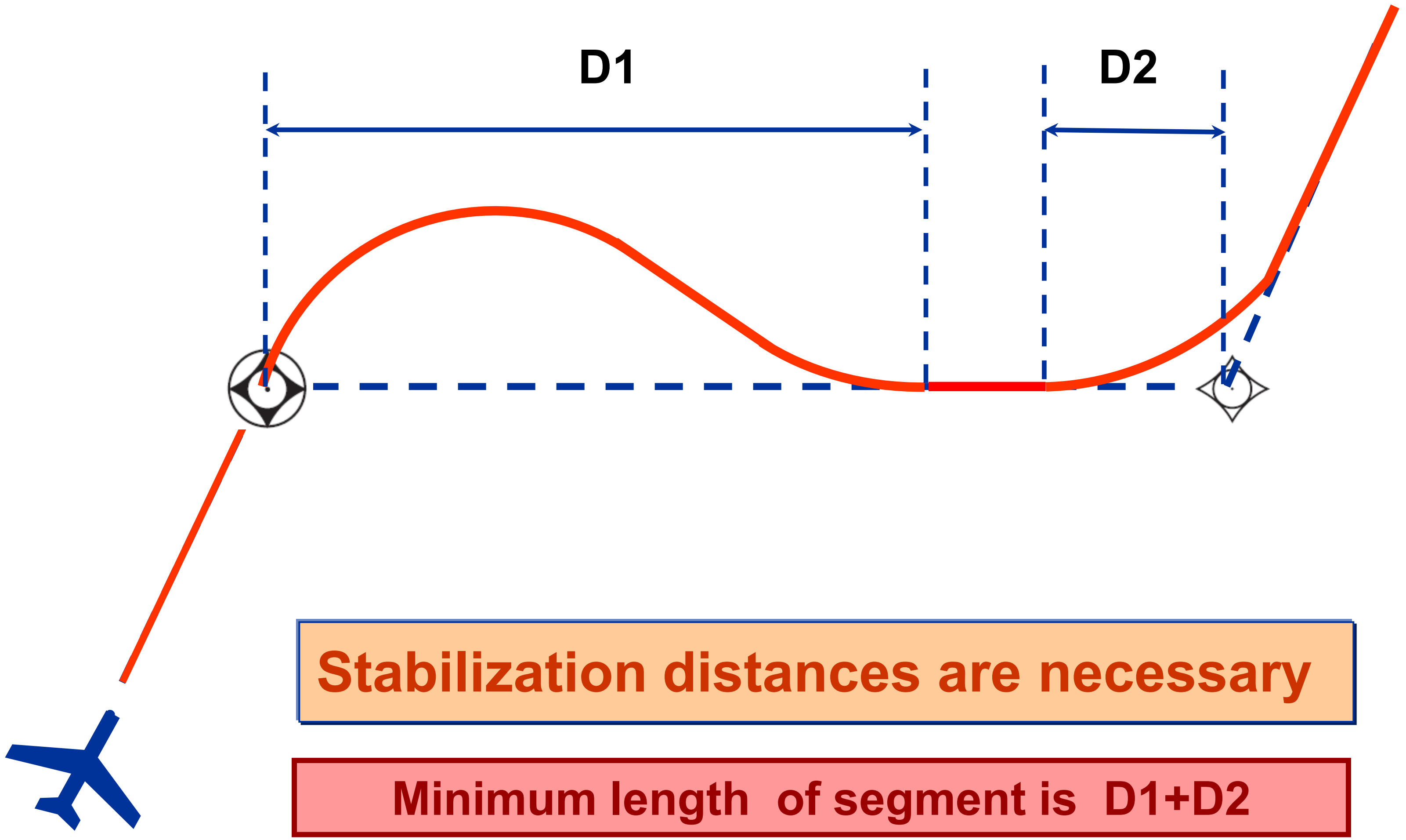
Minimum length of segment is D1+D2

WP1 : Fly-by WP2 : Fly-by



Minimum length of segment is D1

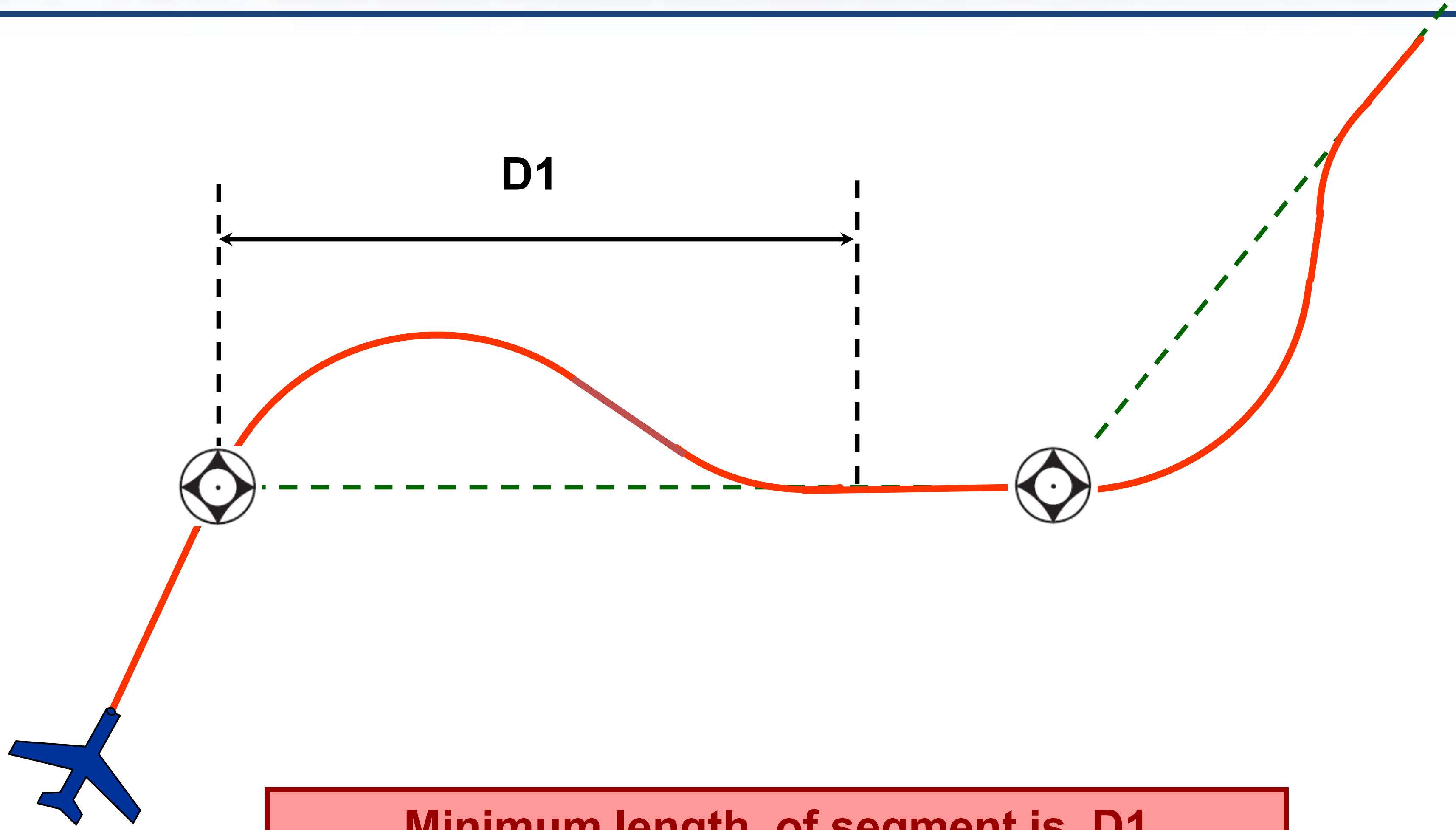
WP1 : Fly-over   WP2 : Fly-by



Stabilization distances are necessary

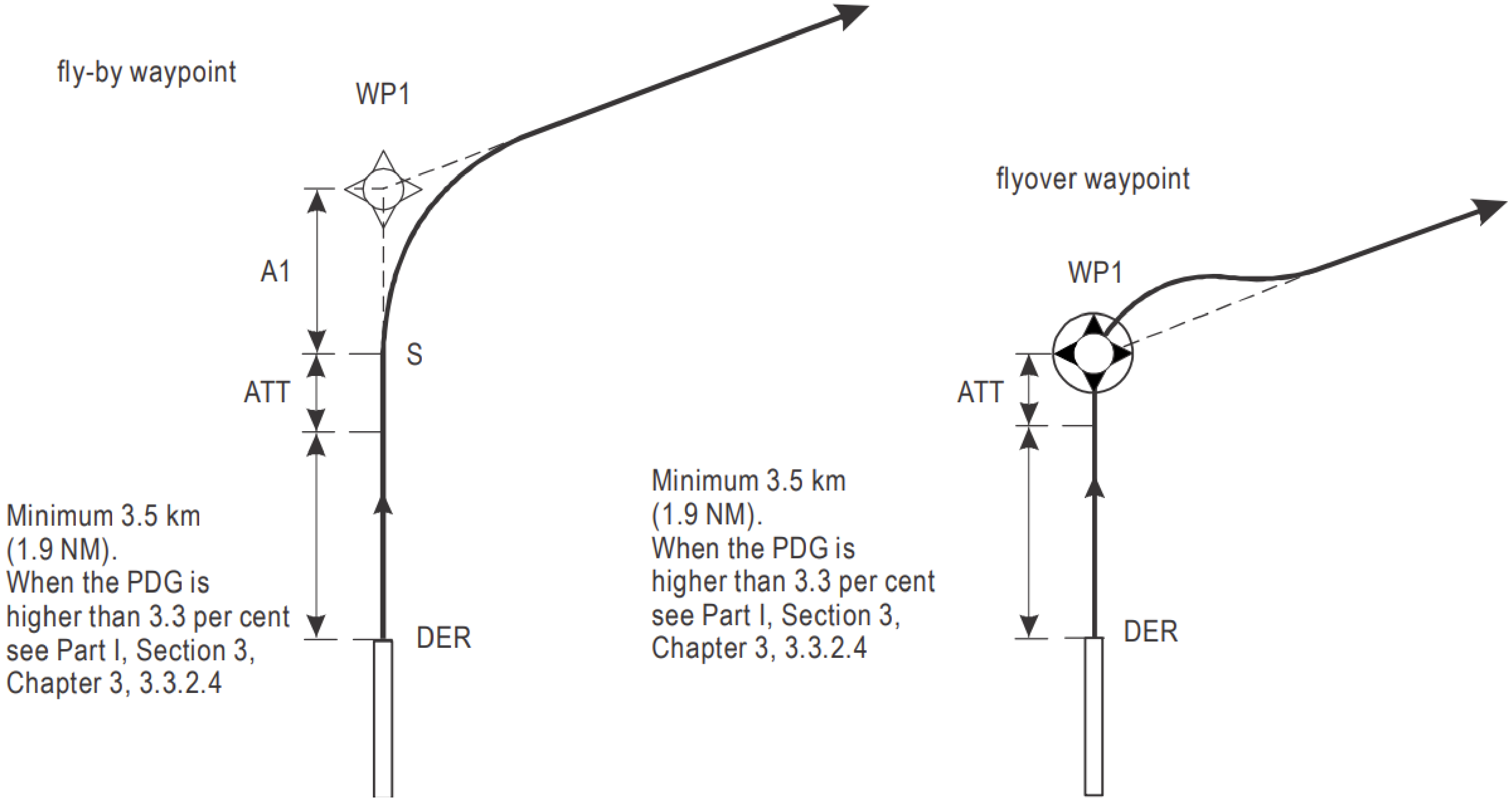
Minimum length of segment is D1+D2

WP1:Fly-over WP2 : Fly-over



Minimum length of segment is D1

MSD-DER-First Waypoint



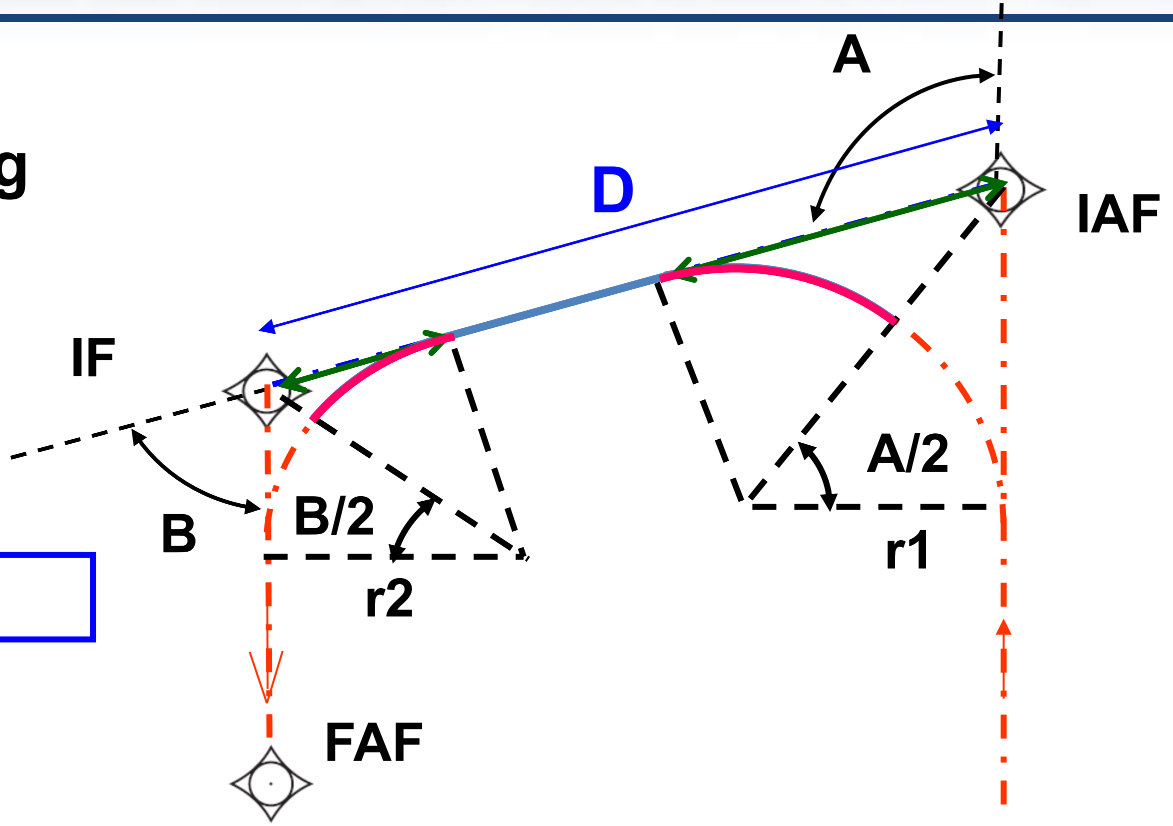
MINIMUM LENGTH OF AN RNAV SEGMENT LIMITED BY AT LEAST ONE WAYPOINT WHICH IS NOT A TURNING WAYPOINT

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

Phase of Flight	D: minimum distance to waypoint *
En-route More than 56 km (30NM)from departure or destination ARP	9.3 km (5.0 Nm)
STARs, Initial within 56 km (30NM) of the ARP	5.6 km (3.0 Nm)
SID within 28 km (15 Nm) ARP and Final Approach	2.8 km (1.5 Nm)
Missed Approaches and SIDs within 56 km (30NM) of the ARP	5.6 km (3.0 Nm)

Descent Gradient Calculation
Track Resultant Distance (TRD)

Aircrafts are descending ABEAM the waypoint

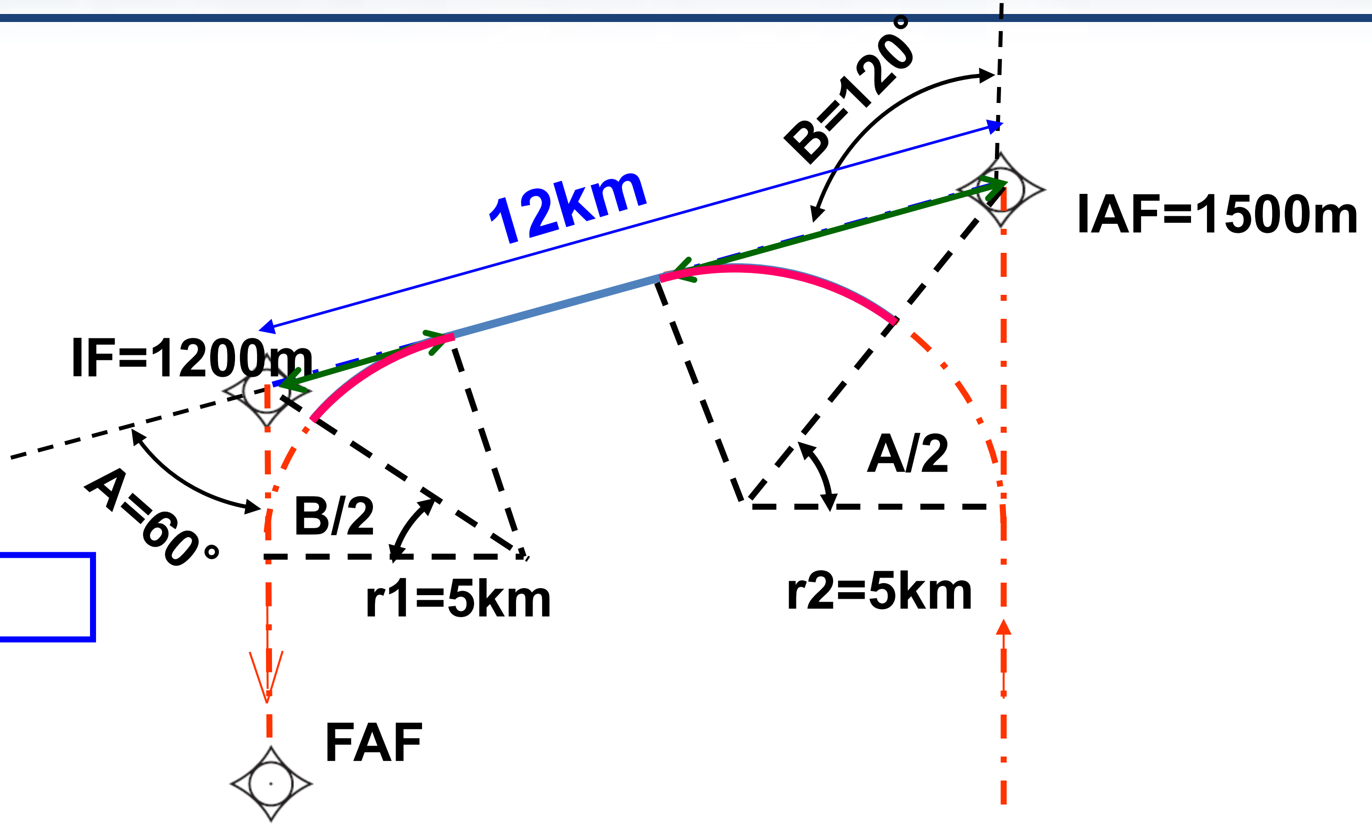


Descent gradient = Δh / TRD

$$TRD = D - (r_1 \times \tan A/2) - (r_2 \times \tan B/2) + (r_1 \times \pi/180 \times A/2) + (r_2 \times \pi/180 \times B/2)$$

A and B expressed in degree

Exercise-1



$$\boxed{\text{Descent gradient} = \Delta h / TRD}$$

$$TRD = D - (r_1 \times \tan A/2) - (r_2 \times \tan B/2) + (r_1 \times \pi/180 \times A/2) + (r_2 \times \pi/180 \times B/2)$$

Key Point 1

Limit the NUMBER of waypoints to a MINIMUM

FLY-BY waypoint are PREFERRED

Minimum length depends on STABILIZATION DISTANCE or a constant value

Aircraft start to descend ABEAM the waypoint.

For descent gradient calculation use TRD

Path Terminator Concept

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

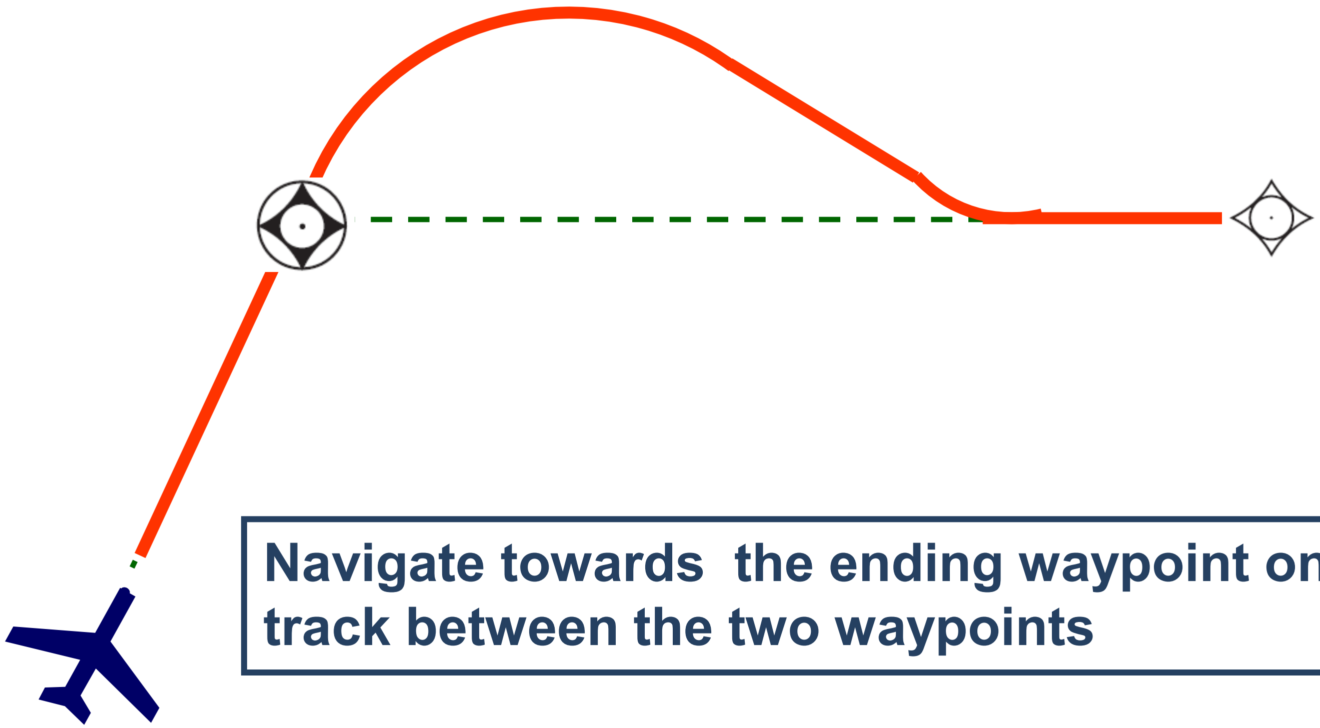
ARINC 424 Path Terminators

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

Table III-2-5-App-1. Initial and final path terminators

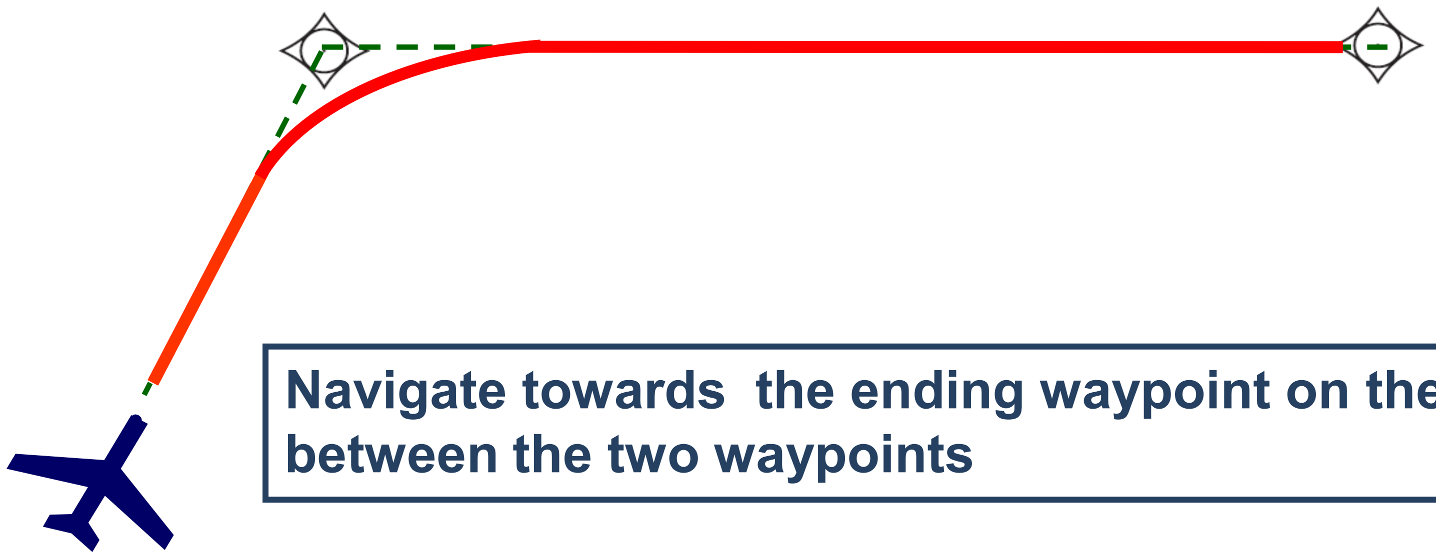
RNAV procedure	*Initial leg*	*Final leg*
SID	CA, CF, VA, VI	CF, DF, FM, RF, TF, VM
STAR	IF	CF, DF, FM, HM, RF, TF, VM
Approach	IF	CF, TF, RF
Missed approach	CA, CF, DF, FA, HM, RF, VI, VM	CF, DF, FM, HM, RF, TF, VM

TF : Track Between Fixes



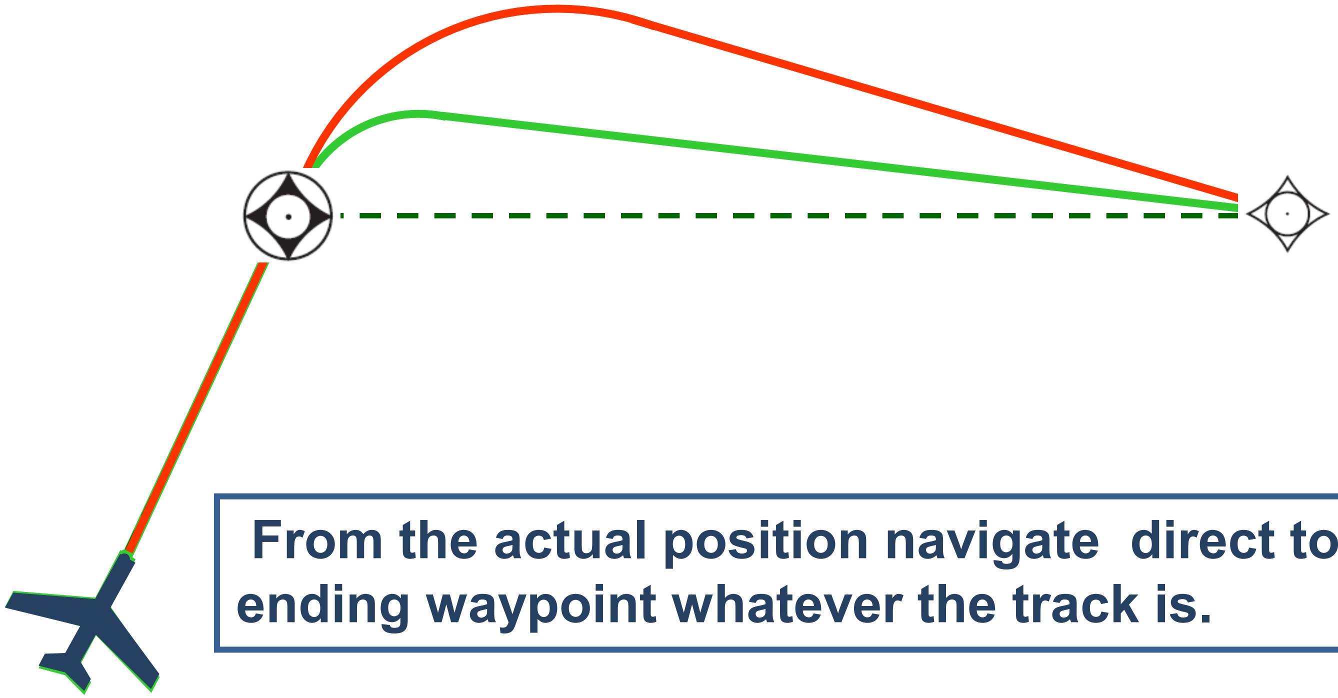
Navigate towards the ending waypoint on the track between the two waypoints

TF : Track Between Fixes



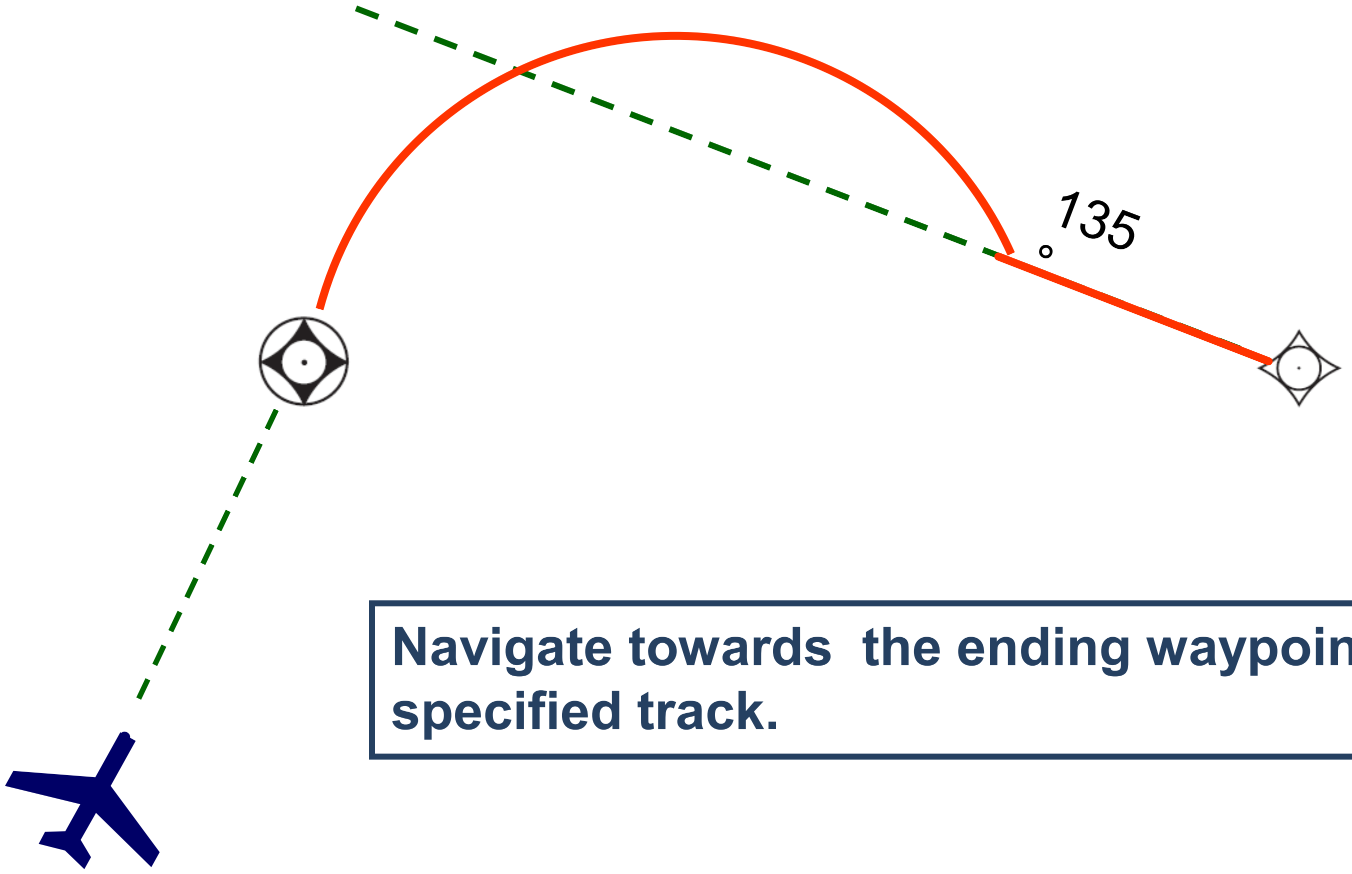
Navigate towards the ending waypoint on the track between the two waypoints

DF : Direct TO Fix



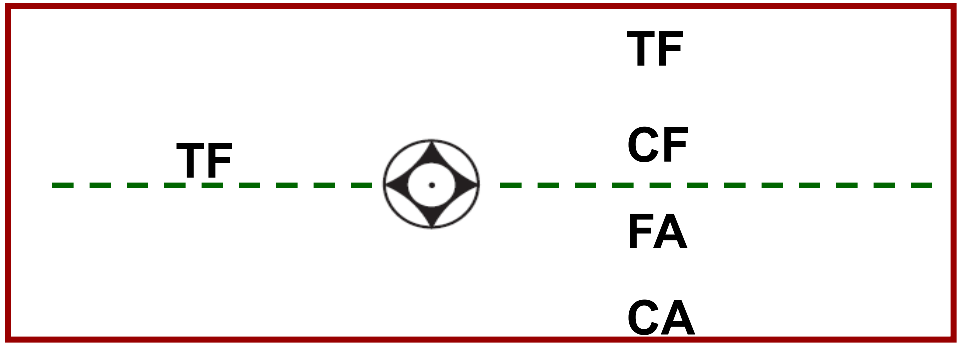
From the actual position navigate direct to the ending waypoint whatever the track is.

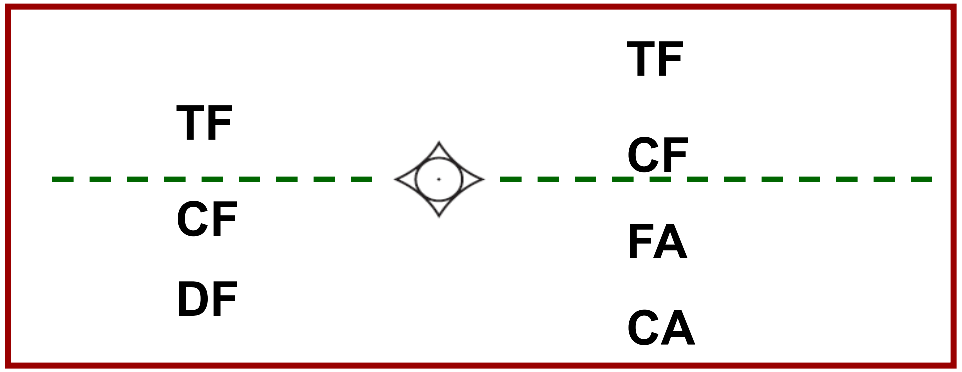
CF : Corse TO Fix

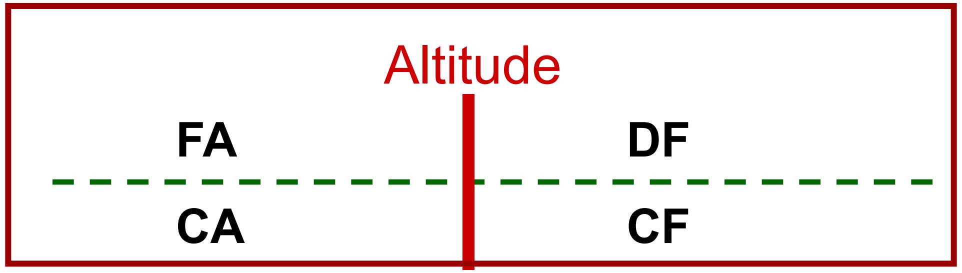


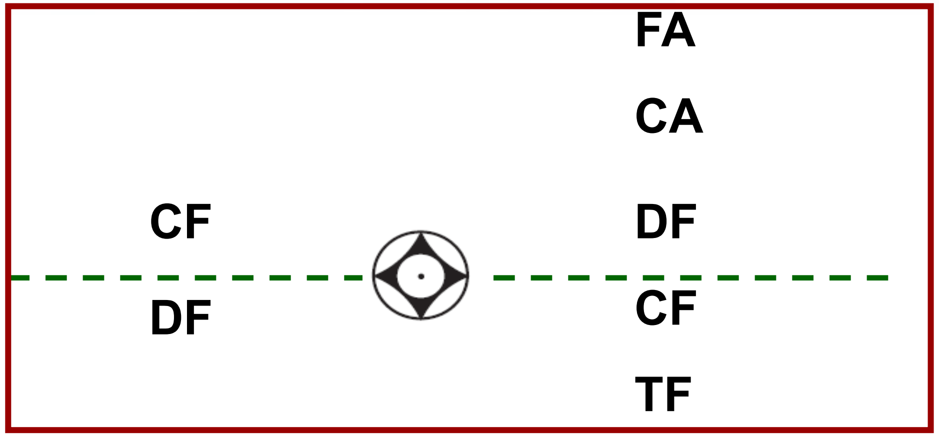
Navigate towards the ending waypoint on a specified track.

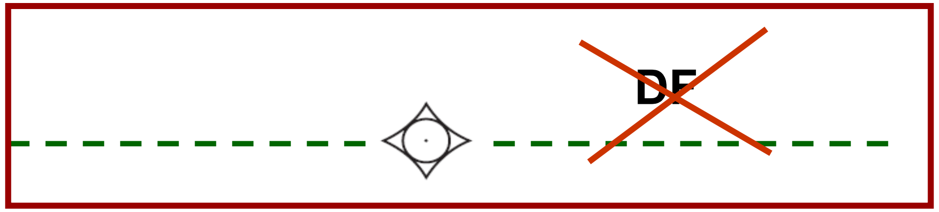
Path Terminators











TF : Track between fixes

CF : course to fix

DF : Direct to fix

FA : Fix to an altitude

CA : Course to an altitude

Key Point

1.Path terminator is associated with the ENDING WAYPOINT of a leg

2.Different rules applied to SEQUENCE legs

3.According to PATH TERMINATOR the route is or not PREDICTABLE

Key Point

Type of waypoint

PATH Terminator

Nominal trajectory

Be aware of coding influence

Real need of COMMUNICATION with coding suppliers

Coding instructions are provided th the procedure chart

Initial Approach Constraints

	Length NM	Turn at IAF °	Turn at IF °	Bank angle °	Descent gradient %	MOC m
Maximum	No limit	120	90	25	8	
Minimum	**(1)**	0	0		-	300
Optimum	**5 Nm** **9.3 Km**	70	70		**4%**	

Depends on the minimum stabilization distances necessary on the segment

IAS-speed table

Intermediate Approach Constraints

	Length NM	Turn at IF °	Turn at FAF °	Bank angle °	Descent gradient %	MOC m
Maximum	15 Nm 28 Km	90	30	25	5.2	300
Minimum	2 Nm + init dist	0	0		-	150
Optimum	10 Nm 19 Km	70	0		Flat	-

The minimum length must guarantee the stabilization distances necessary along the segment

IAS - speed table

Final Approach Constraints

	Axis °	Length NM	Turn at FAF °	Bank Angle °	Descent Gradient %	Turn at MAPt °
Maximum	(1)	10 Nm 19 Km	30	25	6.5 A/B 6.1 C/D/E	No limit
Minimum		(2)	0		5.2	-
Optimum	QFU	5 Nm 9.3 Km	0		5.2	-

(1) Direct approach axis criteria
(2) MAPt position / OCH
IAS cf speed table
MOC : General criteria

Missed Approach Constraints

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

(1) 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 cf speed table

MOC : General criteria

Procedure Altitude Concept

Depiction of Different Type of Altitudes

Always ☒ **Respect MOC**

Sometimes

☒ **Respect Airspace constraint**

☒ **Respect Radionavigation constraint**

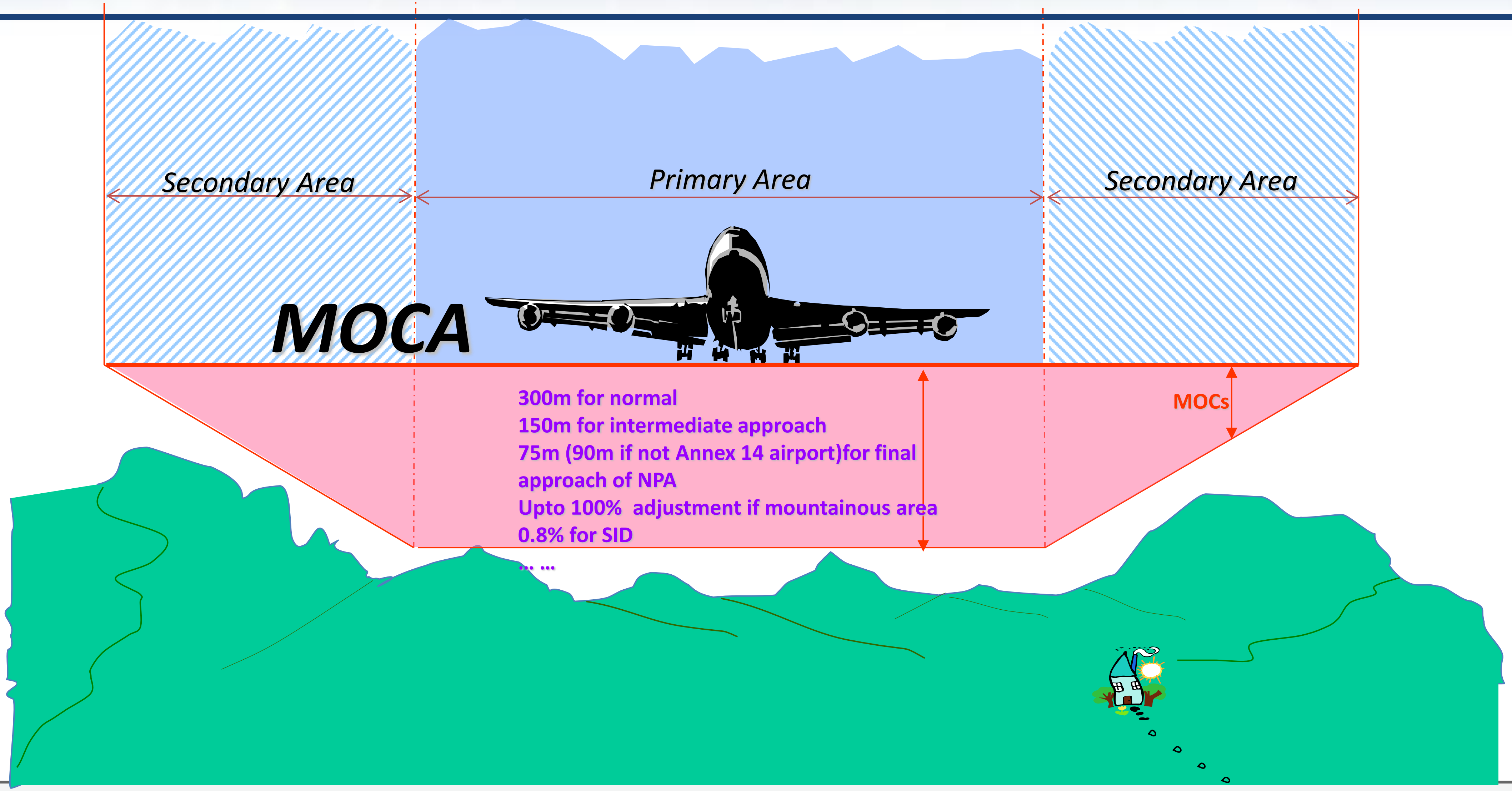
☒ **Respect Environmental constraint**

☒ **Avoid CFIT(stabilized approach)**

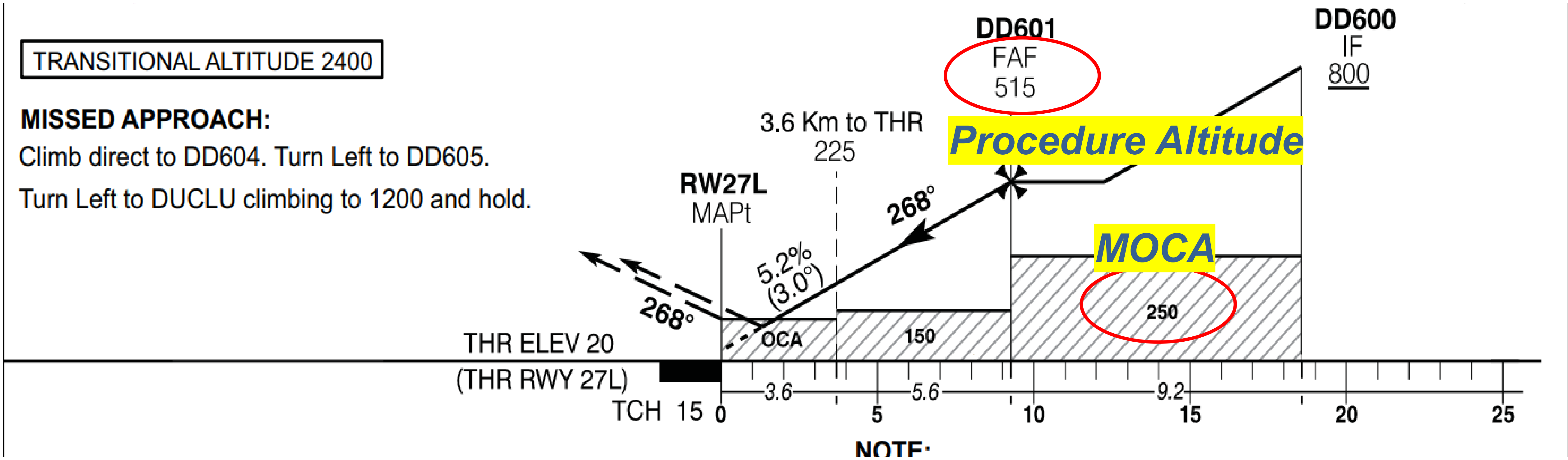
Need to define two types of altitudes

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

Obstacle Clearance



MOCA-Example



MOCA ≤ Procedure Altitude!!!!

Depiction of Different Type of Altitudes

USERS

Operational Altitude

PROCEDURE ALTITUDE

Associated with a WAYPOINT

Minimum Obstacle Clearance Altitude MOCA

Associated with a SEGMENT

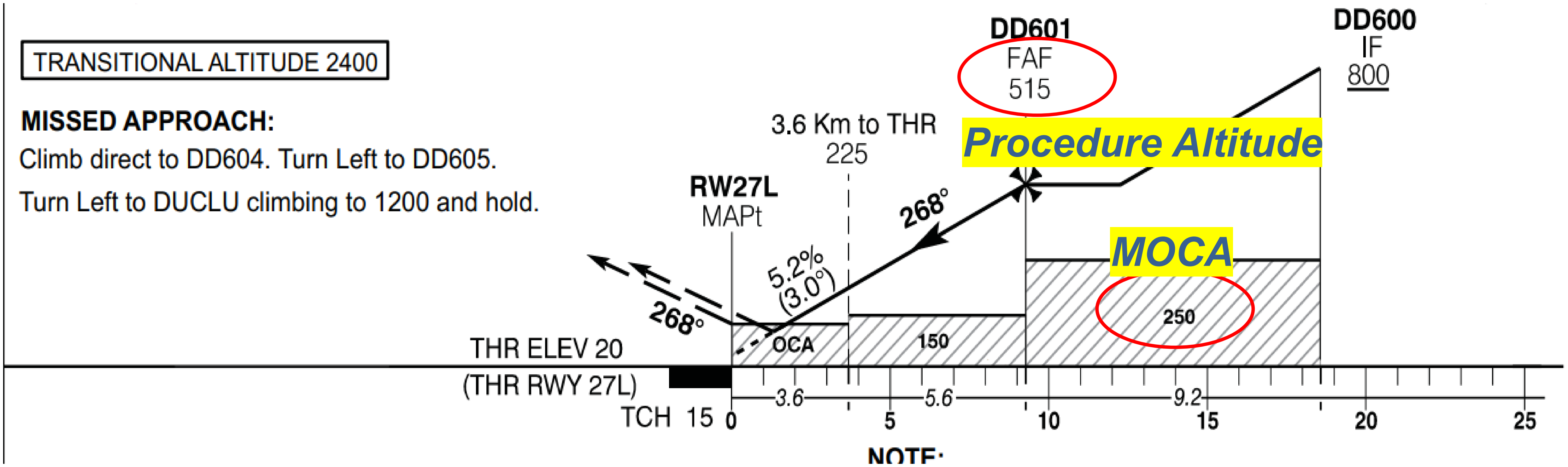
Proedure Altitude / MOCA in Approach Chart

- 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**

MOCA-Example



MOCA ≤ Procedure Altitude!!!!

Let's Focus/Propose/Plan Together