GENERAL OVERVIEW

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OBJECTIVE OF THE COURSE

- The trainees should be able to understand the construction of Instrument Flight Procedures based on conventional criteria contained in ICAO Pans-Ops **Doc 8168**
- The trainees shall be able to design:
  - Standard Terminal Arrival Route (**STAR**)
  - Non-precision Approach Procedure (**NPA**)
  - Precision Approach Procedure (**PA**) based on ILS criteria
  - Standard Instrument Departure Procedure (**SID**)

KNOWLEDGE REQUIRED

- Mathematics
  - Algebra
  - Geometry
  - Trigonometry
  - Statistics
- Aviation
  - ATM
  - Navigation
  - Aircraft Performance
  - AIS & Charts
  - Aerodromes
  - Geodesy

CONTENTS

- Instrument Flight Procedures
- Regulations & Structure of PANS-OPS
- Categories of Aircraft
- Obstacle Clearance
- Practical Considerations

INSTRUMENT FLIGHT PROCEDURES - PHILOSPHY

- A process, using navigation, through which an aircraft transits from the en-route phrase of flight to a position, and in a state, from which a normal landing can be initiated (i.e. see the Runway)
- Series of predetermined maneuvers by reference to flight instruments
- Maneuvers based on navigation method for aircraft proceeding according to Instrument Flight Rules
- Obstacle Clearance - the primary safety consideration
- Airspace, Environment, Economy & ATS etc.

FACTORS GOVERNING THE PROCEDURE DESIGN

- Terrain & Obstacles surrounding the aerodrome
- Aircraft to be accommodated (category)
- Aircraft & Pilot ability
- Airspace Management

  - These factors in turn influence the type and siting of the navigational aids
  - Airspace restrictions may also affect the siting of navigation aids

INSTRUMENT FLIGHT PROCEDURES - OBJECTIVES

- **Safety** of aircraft operation
- Regularity of aircraft operation
- Efficiency of aircraft operation
- Air Traffic Services

INSTRUMENT FLIGHT PROCEDURES - OBJECTIVES

- Procedure designed must be:
  - Safe
  - Simple
  - Short (vs CDO)
  - Clear (unambiguous)

TYPES OF PROCEDURES

- En-route Procedures
- Terminal Procedures
  - Arrival Procedures
  - Departure Procedures
- Approach Procedures

✓ Conventional

✓ Area Navigation

CONTENTS

- Instrument Flight Procedures
- Regulations & Structure of PANS-OPS
- Categories of Aircraft
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- Practical Considerations

REGULATIONS

- ICAO Regulation

  DOC 8168 - OPS/611 Volume II

  Procedures for Air Navigation Services – Aircraft Operations (Construction of Visual and Instrument Flight Procedures)

- National regulation
  - US Criteria (TERPS)
  - France
  - Differences from ICAO criteria should be published

HISTORICAL BACKGROUND

- 1951: First regulation by ICAO for Instrument Flight Procedures
- 1961: Operations procedures brought together into single document named as PANS-OPS
- 1966: Obstacle Clearance Panel (OCP) created to update the regulations
- 1979: Rearrangement of regulations into two volumes, one for user and the other for procedure designer
- 2003: Amendment 12 - OCP 13 major revisions on RNAV
- 2006: Complete restructuring of the document to provide a logical layout and more consistency
- 2008: OCP renamed as Instrument Flight Procedure Panel (IFPP)

OTHER RELATED ICAO DOCUMENTATION

- ICAO PANS-OPS Doc 8168 - OPS/611 Volume I
- Aeronautical Chart Manual Doc 8697
- ICAO Manual on the use of Collision Risk Model (CRM) for ILS Operations Doc 9274
- ICAO Template Manual for Holding, Reversal and Racetrack Procedures DOC 9371 - AN/912/2
- ICAO Instrument Flight Procedures Construction Manual Doc 9368
- ICAO Quality Assurance Manual for Flight Procedure Design Doc 9906
- ICAO Required Navigation Performance Authorization Required (RNP AR) Procedure Design Manual Doc 9905

PANS-OPS STRUCTURE

- **Part**
  - Major Subjects, e.g. Part I – General, Part II – Conventional Procedures
- **Section**
  - Main Types of Trajectories, e.g. Section 4 – Arrival and approach procedures
- **Chapter**
  - Segments, e.g. Chapter 5 – Final approach segment, Chapter 6 – Missed approach segment
- **Appendix**
  - Practical Considerations

PANS-OPS STRUCTURE

- Part I: General
- Part II: Conventional Procedures
- Part III: RNAV Procedures and Satellite-based Procedures
- Part IV: Helicopters

CONTENTS

- Instrument Flight Procedures
- Regulations & Structure of PANS-OPS
- Categories of Aircraft
- Obstacle Clearance
- Practical Considerations

AIRCRAFT PERFORMANCE

- Aircraft performance has direct impact on airspace requirement
- Most significant factor in performance is speed
- Five categories of aircraft: A - E
- Provide standardized basis for aircraft manoeuvrability to specific instrument approach procedure
- Four Categories A – D common for civilian use
- Cat H for helicopters

AIRCRAFT CATEGORIES

- Vat: The speed at threshold based on 1.3 times stall speed in the landing configuration at maximum certificated landing mass
- Indicated Air Speed (IAS) for procedure calculation in knots (kt)
- Reference – Table I-4-1-2

Aircraft Category	Vat	Range of Speeds for Initial Approach	Range of Final Approach Speeds	Maximum speeds for Visual manoeuvring	Maximum Speeds for MAP	
					Intermediate	Final
A	<91	90/150(110*)	70/100	100	100	110
B	91/120	120/180(140*)	85/130	135	130	150
C	121/140	160/240	115/160	180	160	240
D	141/165	185/250	130/185	205	185	265
E	165/210	185/250	155/230	240	230	275

AIRCRAFT CATEGORIES

- Category A — less than 91 kt indicated airspeed IAS
- Category B — 91 kt or more but less than 121 kt IAS
- Category C — 121 kt or more but less than 141 kt IAS
- Category D — 141 kt or more but less than 166 kt IAS
- Category E — 166 kt or more but less than 211 kt IAS
- Category H — stall speed does not apply to helicopters

CONTENTS

- Instrument Flight Procedures
- Regulations & Structure of PANS-OPS
- Categories of Aircraft
- Obstacle Clearance
- Practical Considerations

OBSTACLE CLEARANCE

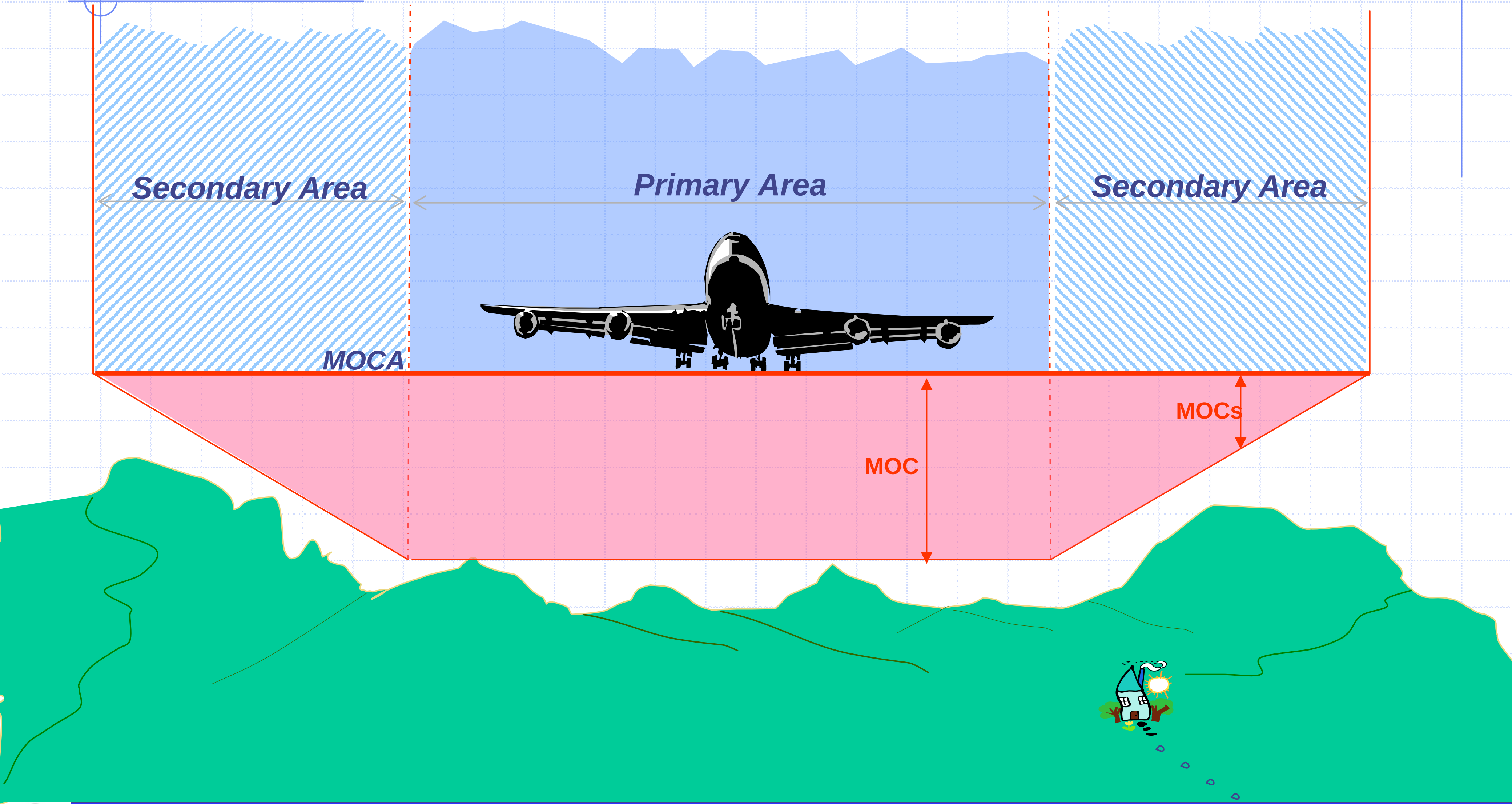
- **Primary Area (MOC)**

  A defined area symmetrically disposed about the nominal flight track in which **full** obstacle clearance is provided

- **Secondary Area (MOCs)**

  A defined area on each side of the primary area located along the nominal flight track in which **decreasing** obstacle clearance is provided.

OBSTACLE CLEARANCE



OBSTACLE CLEARANCE

- An altitude is computed/published for each segment
- Different altitudes:
  - Minimum Obstacle Clearance Altitude (MOCA)
  - Procedure Altitude: Operational Altitude

MOCA $\leqslant$ Procedure Altitude

CONTENTS

- Instrument Flight Procedures
- Regulations & Structure of PANS-OPS
- Categories of Aircraft
- Obstacle Clearance
- Practical Considerations

PREPARATION

- Applicable Regulation
  - ICAO Doc 8168 or National
- Aeronautical Data
  - Runways, Navigation aids, airspace, artificial obstacles etc.
- Suitable Maps
  - Departures, Initial/Intermediate/Final Segments & MAP
- Appropriate Equipment
  - Ruler, 45/30 Triangles, Protractor, Compass, Calculator, Templates etc.

OTHER CONSIDERATIONS

- Use of correct aeronautical data
- Use of appropriate formulas
- Preferable use of same units
- Documentation - worksheets & calculation
- Plotting of plan & profile view

CONVERSION FACTORS

- Conversion from NM to meters : Multiplied by **1852**
- Conversion from meters to feet : Multiplied by **3.2808**
- Conversion from NM to feet : Multiplied by **6076**
- Conversion from knots to m/s : Multiplied by 1852 and divided by 3600
- Conversion from degree to radian : Multiplied by π and divided by 180 (2 π rd are equal to 360°)
- Only the **final result** of computations should be rounded (Up or Down??)

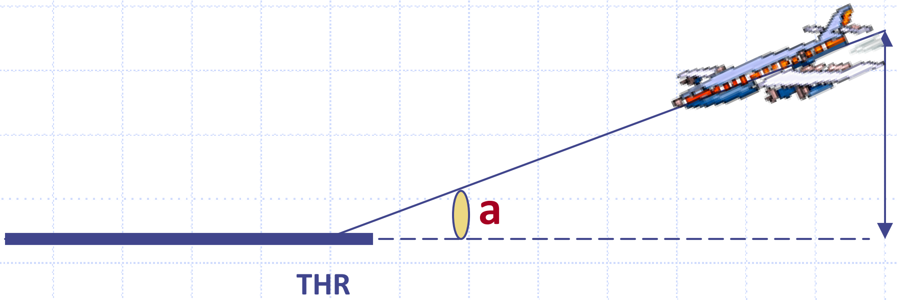
UNIT OF MEASUREMENT

On the Instrument Approach Chart, aeronautical units are normally expressed in:

- **Horizontal distance in nautical mile (NM)**
- **Vertical distance in feet (ft)**
- **Rate of descent in feet per minute (ft/min)**
- **Gradient of slope in percentage (%)**
- **Time in minutes and seconds (min & sec)**
- **Speed in knots (kt)**
- **Angle in degrees (º)**

UNIT OF MEASUREMENT

- Gradient of Slope is normally expressed in Percentage (%)
- For Final Approach, the slope is also calculated by using the Tangent of the Angle between trajectory and the horizontal plane corresponding to Threshold Elevation



Slope in % = Tan a x 100

- Question: For a 3^{o} descent angle, what is the slope in %?

PROCEDURE UPDATE

- Modification of airport infrastructure
- Modification of navaids (type, location….)
- New aircraft category
- Modification of the surrounding environment
- Noise abatement requirements
- Modification of design criteria

SPEED CONVERSION & TURN

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OBJECTIVES

- At the end of the lecture, student is expected to know:
  - Effect of atmosphere condition on True Air Speed (TAS)
  - Conversion of IAS to TAS
  - Radius of Turn
  - Rate of Turn

SPEED CONVERSION

- Indicated Air Speed (IAS) is the speed indicated by the instruments in the cockpit
- True Air Speed (TAS) is the actual speed of an aircraft relative to the outside environment
- Factors having an influence on the value of TAS in aircraft:
  - Altitude
  - Reference Temperature
- TAS is always used in procedure design process

SPEED CONVERSION

- In order to convert IAS into TAS, a conversion table is used. This table can be found in Doc 8168 Volume II Part-1 Section-2 Chapter-1

- TAS = IAS * k

- k depends on Altitude and Temperature. Value of K is given in the conversion table, for a range of altitudes and temperatures. It can also be calculated using a complex formula.

SPEED CONVERSION

International Standard Atmosphere

Reference: Table I-2-1-App-2

Altitude (feet)	ISA-30	ISA-20	ISA-10	ISA	ISA+10	**ISA+15**
0	0.9465	0.9647	0.9825	1.000	1.0172	1.0257
1000	0.9601	0.9787	0.9969	1.0148	1.0324	1.0411
2000	0.9740	0.9930	1.0116	1.0299	1.0479	1.0567
3000	0.9882	1.0076	1.0266	1.0453	1.0637	**1.0728**
4000	1.0027	1.0225	1.0420	1.0611	1.0799	1.0892

The following formula is used for values not listed in the table:

$$TAS = IAS \times 171233\,[(288 \pm VAR) - 0.00198H]0.5 \div (288 - 0.00198H)2.628$$

where: VAR = Temperature variation about ISA in °C, H = Altitude in feet.

SPEED CONVERSION - EXERCISE

- IAS = 185kts, Alt = 6000’, then TAS = ?
  - TAS = 185*1.1231 = 207.7735 = 208kts (↑)

- IAS = 185kts, Alt = 12000’, then TAS = ?
  - TAS = 185*1.2347 = 228.4195 = 229kts (↑)

- IAS = 185kts, Alt = 9100’, then TAS = ?
  - Use Alt at 10000’, then
  - TAS = 185*1.1958 = 221.223 = 222kts (↑)

SPEED CONVERSION

- Instrument Approach Procedure is a process, using navigation, through which an aircraft transits from the en-route phrase of flight to a position, and in a state, from which a normal landing can be initiated

- A procedure may consist of 5 segments:
  - Arrival Segment
  - Initial Segment
  - Intermediate Segment
  - Final Segment
  - Missed Approach Segment

- For the speed in each segment, refer Table I-4-1-2

SPEED CONVERSION - EXERCISE

- CAT D, Initial Segment, Alt = 10000'msl, then TAS = ?
  - TAS = 250*1.1958 = 299kts (↑)
- CAT C, Initial Segment, Alt = 8000'msl, then TAS = ?
  - TAS = 240*1.1586 = 279kts (↑)

Easy?

TURN

- Turn Calculations
  - Rate of Turn (R) in deg/sec
  - Radius of Turn (r) in NM or km
- Parameters
  - TAS (not IAS)
  - Bank Angle (25º, 20º, 15º)
- 3 Bank Angles used in Pans-Ops:
  - 25º - Terminal e.g. Initial
  - 20º - Visual Manoeuvre e.g. Circling
  - 15º - Final, MAP & Departure

TURN

- **Maximum value of bank angle : 25º**
- **Maximum rate of turn : 3º/s**

- *Assuming the value of the IAS, the radius of turn used for the design of the trajectory must always have the maximum value calculated either with the maximum value of bank angle or with maximum value of the rate of turn*

TURN - EXERCISE

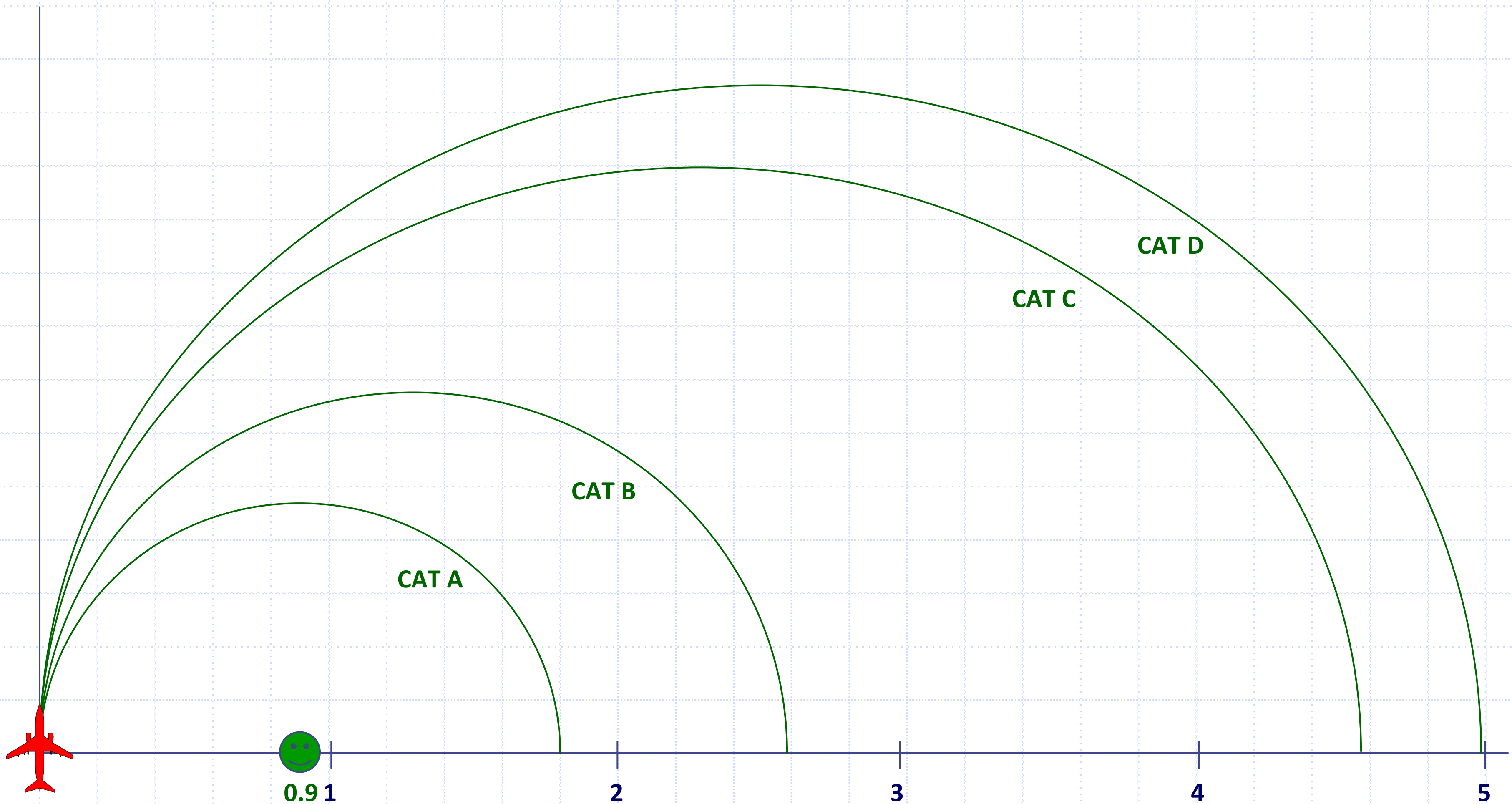
- Formulas (Reference: page I-2-3-2)
  - Rate of Turn: $R = (3431 \tan \alpha) / \pi V$
  - Radius of Turn: $r = V/(20 \pi R)$

- Find R & r for CAT A-D at 6000'msl in Initial Segment, IAS+15:

CAT	IAS	Factor	TAS(V) (whole figure) ↑	R (2 decimals) ↓	r (2 decimals) ↑
A	150	1.1231	169	3.01	0.90
B	180	1.1231	203	2.50	1.30
C	240	1.1231	270	1.88	2.29
D	250	1.1231	281	1.81	2.48

TURN - EXERCISE

- Plotting the tracks: CAT A-D at 6000'msl,



FIX TOLERANCE

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CONTENTS

- Facility & Fix
- Fix Tolerance

FACILITY & FIX

- Facilities may include
  - VOR
  - NDB
  - DME
  - LOC

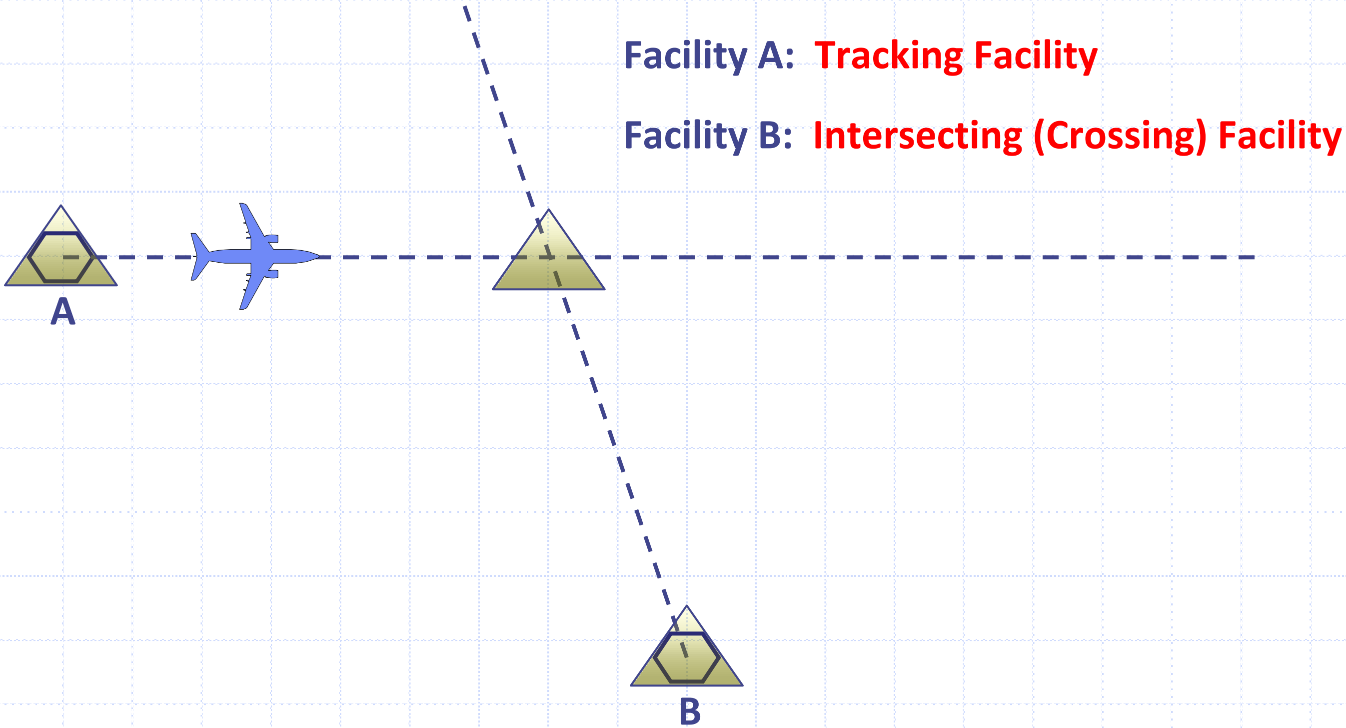
- E.g. VOR provides radials (based on Magnetic North) that can be identified by the aircraft for tracking or crossing
- Aircraft can fly along a radial 'to' or 'from' the facility (Tracking Radial)

FACILITY & FIX

- Fixes are geographical points identified by navigation by the aircraft
- Fixes can be identified by
  - Facility (Fly-over a facility)
  - Intersection of 2 radials or bearings or combo
  - VOR/DME etc...

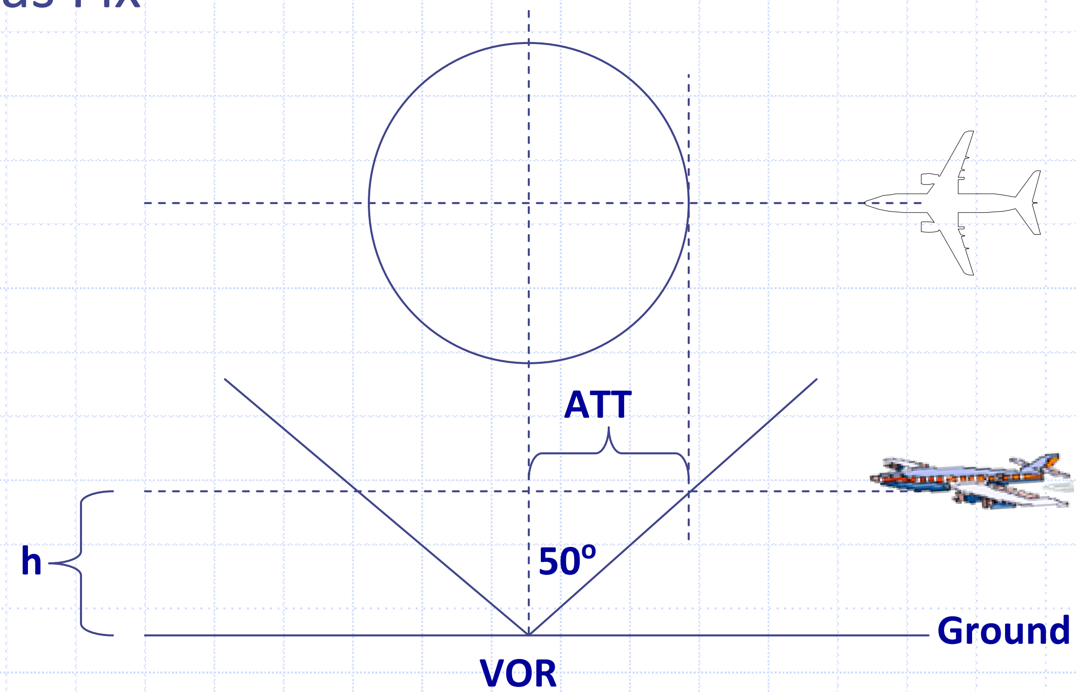
FACILITY & FIX

- Examples of Fixes



FIX TOLERANCE

- Facility as Fix



Along Track Tolerance (ATT) of the Fix = h * Tan50° (↑)

Calculate ATT (in NM) if h=4000ft

ATT = +/-0.79NM (↑)

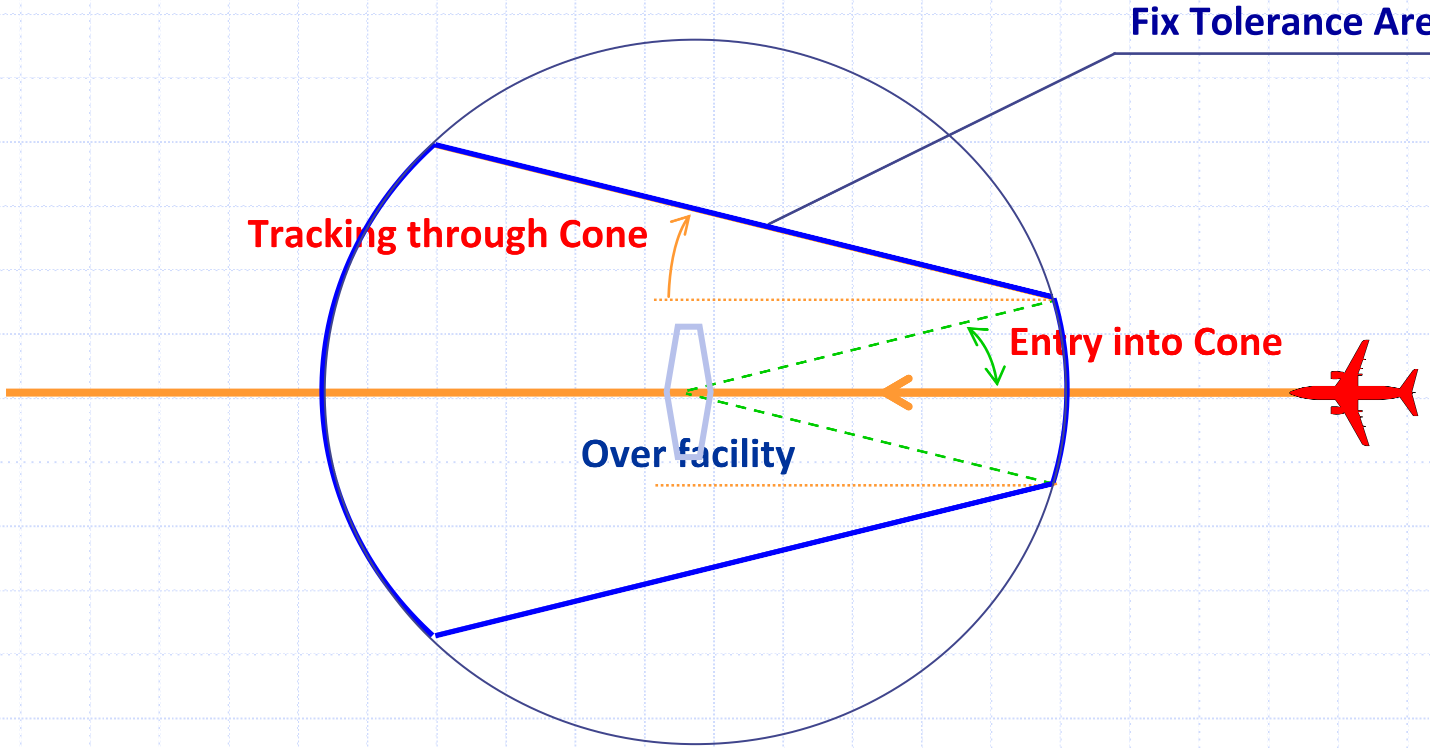
FIX TOLERANCE

- Overhead Facility Tolerances:

	VOR	NDB
Cone Effect Angle	50°	40°
Entry into Cone	+/-5°	+/-15°
Tracking through Cone	+/-5°	+/-5°

FIX TOLERANCE

- Overhead Facility Tolerances:



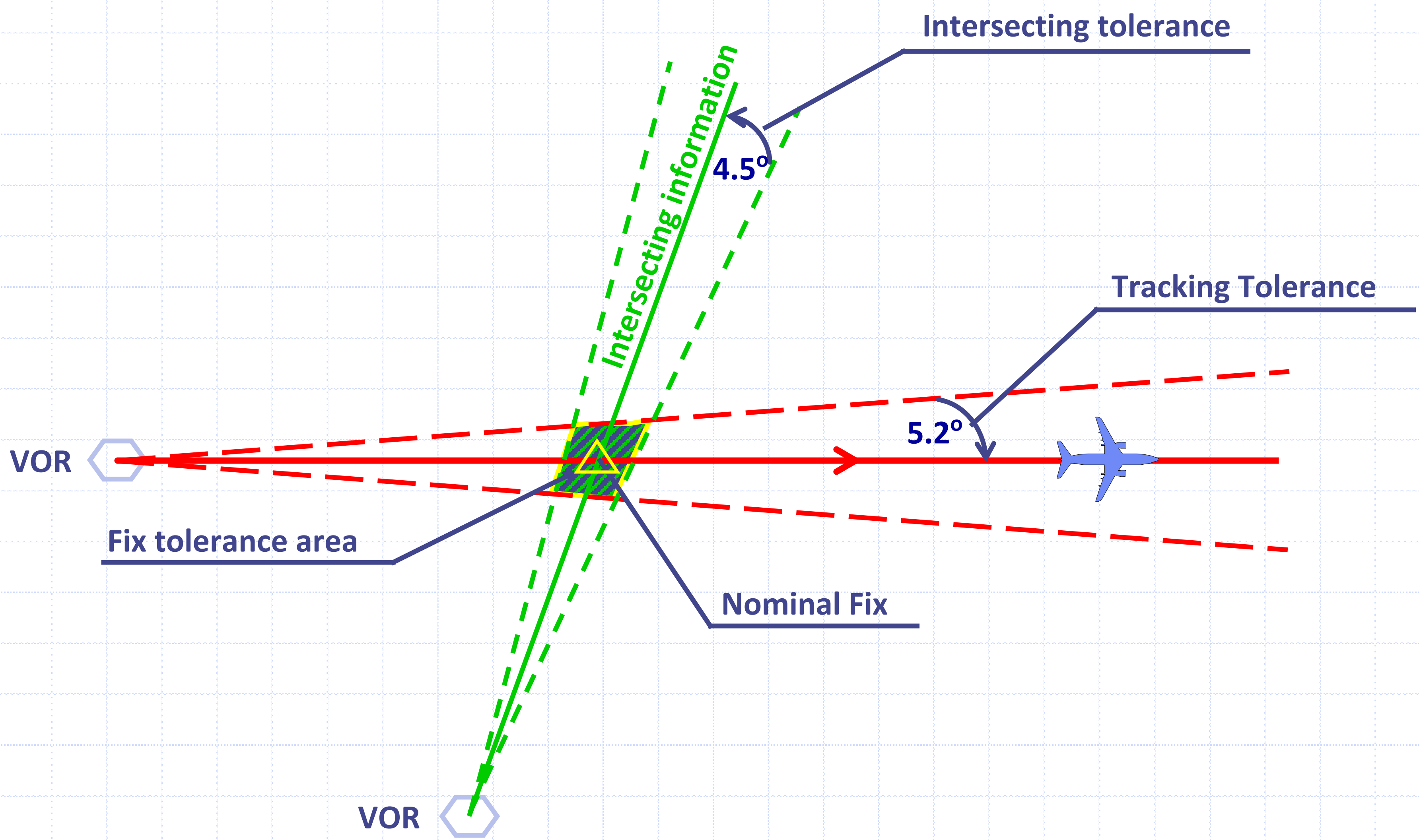
FIX TOLERANCE

- Tracking & Intersecting Fix Tolerances:

	VOR	NDB
Tracking Tolerance	5.2°	6.9°
Intersecting Tolerance	4.5°	6.2°

Reference: Table I-2-2-1

FIX TOLERANCE



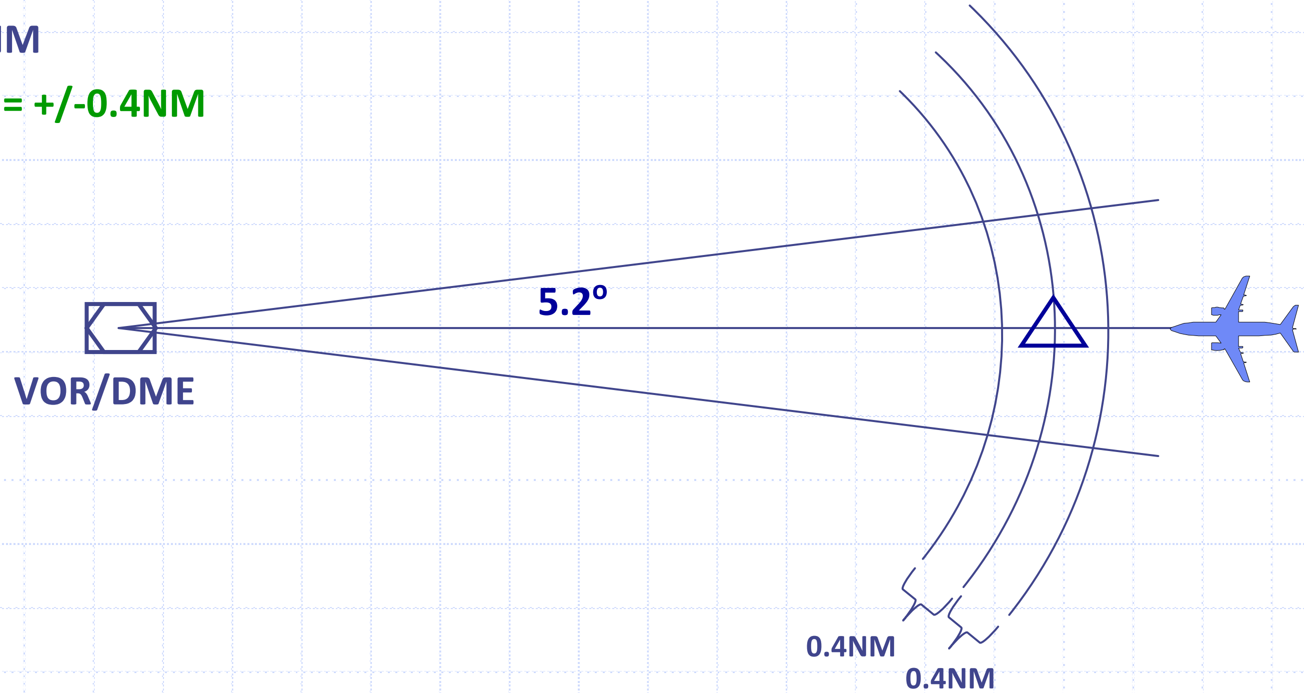
FIX TOLERANCE

- Fix defined by VOR/DME:

DME TOL = 0.25NM + 0.0125*D

If D = 12NM

DME TOL = +/-0.4NM



Note: **When the DME is not co-located with the navigation facility, the maximum angle between the track & a line through the DME facility is 23°**

WIND EFFECT

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CLICK HERE

OBJECTIVES

- At the end of the lecture, student is expected to know:
  - Wind Effect on Aircraft Trajectory
  - How to construct a Wind Spiral
  - How to construct a Bounding Circle

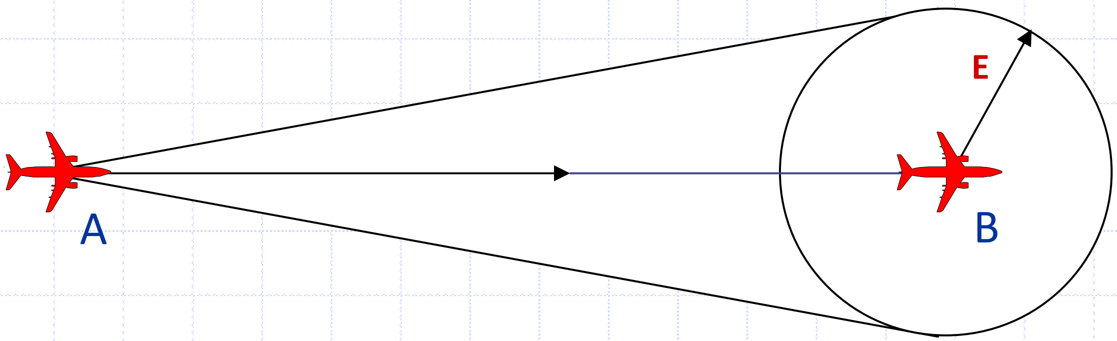
WIND EFFECT

- It is practically impossible to assume how the pilot will correct the effective wind drift. For that reason, it has been decided to take into account the flight paths resulting from a non-corrected wind **drift**.

WIND EFFECT

ALONG A DEAD RECKONING (DR) TRACK

- Wind effect is applied omni-directionally around the position of the aircraft. It gives the maximum deviation around the nominal (theoretical) position

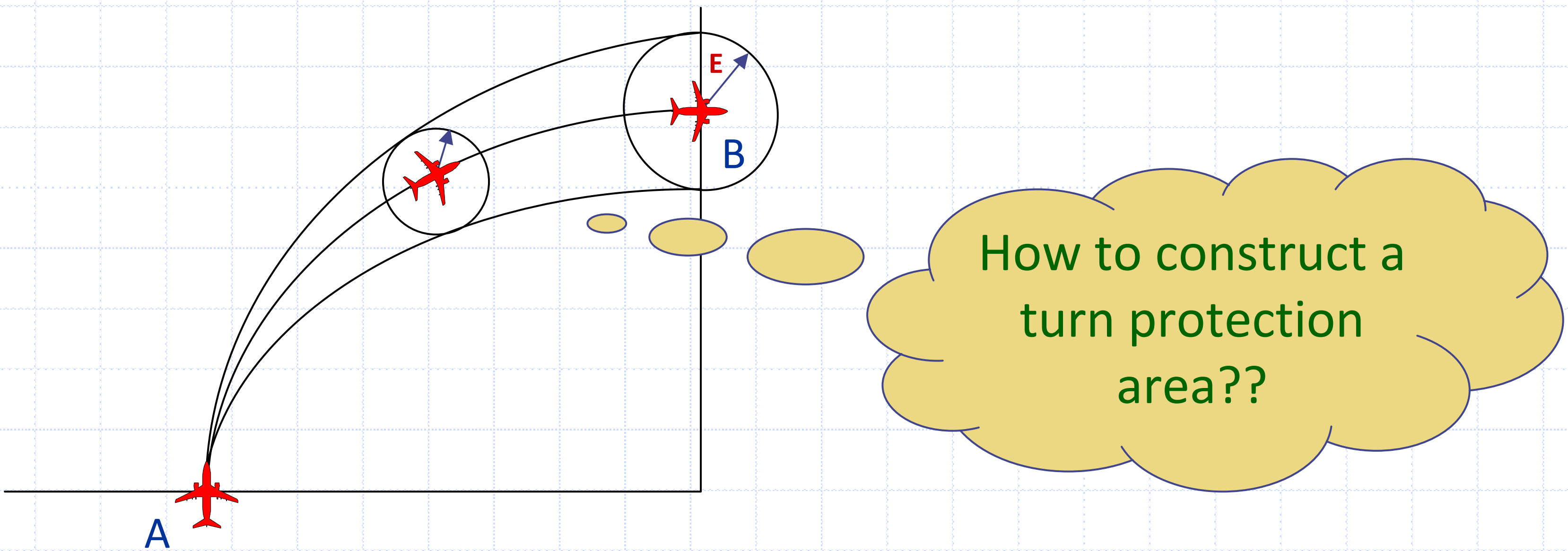


E: Distance the aircraft is blown (Wind Effect)

WIND EFFECT

DURING A TURN

- The outer and inner boundaries of a turn protection area are the spirals resulting from the use of an omni directional wind effect applied along the nominal flight path (path in still air) during the turn



WIND EFFECT

- Wind speed is given by a formula depending on the altitude. It is the result of a general survey conducted all over the world:

$$W = 2h + 47$$

(h: in thousands of ft)

- States which can organize a national survey are allowed to produce their own formulas.

WIND EFFECT

- The wind effect (E) is calculated for each point of the trajectory by multiplying the wind speed by the time of flight from the last checked position
- A checked position is a point along the path where the pilots can precisely check its position e.g. *overflying a navigation facility/fix*

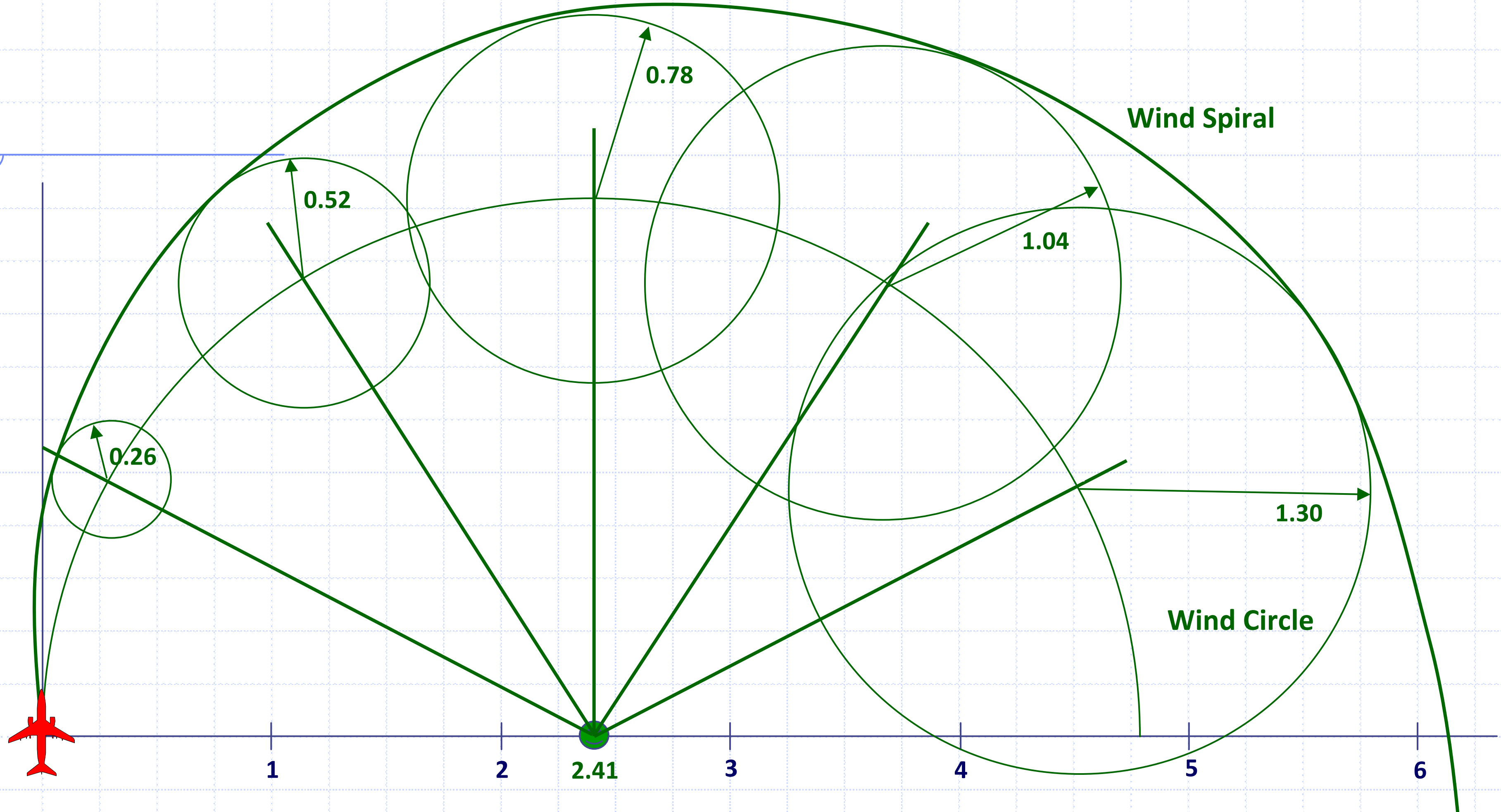
$$E = W \times T$$

- E in m
- T in time of flight in s
- W in m/s

WIND EFFECT – EXERCISE 1

- How to calculate E and construct the turn protection area?
- For a CAT D aircraft turning at 5000' in Initial Segment:
  - IAS =
  - TAS = 250 kts
  - R = 250 * 1.1059 = 277 kts (↑)
  - r = 1.83 °/s (↓)

    2.41NM(↑)



For each 30° Turn Interval:

Time T_{30^o} = D/R = 30°/1.83 = 16.4 sec (↑)

Wind Speed W = 2h + 47 = 57 kts

E_{30^o} = 16.4 * 57/3600 = 0.26NM (↑)

Turn Interval	30º	60º	90º	120º	150º	180º
E	0.26	0.52	0.78	1.04	1.30	…

For smaller Turn Interval…

WIND EFFECT

- Wind Spiral

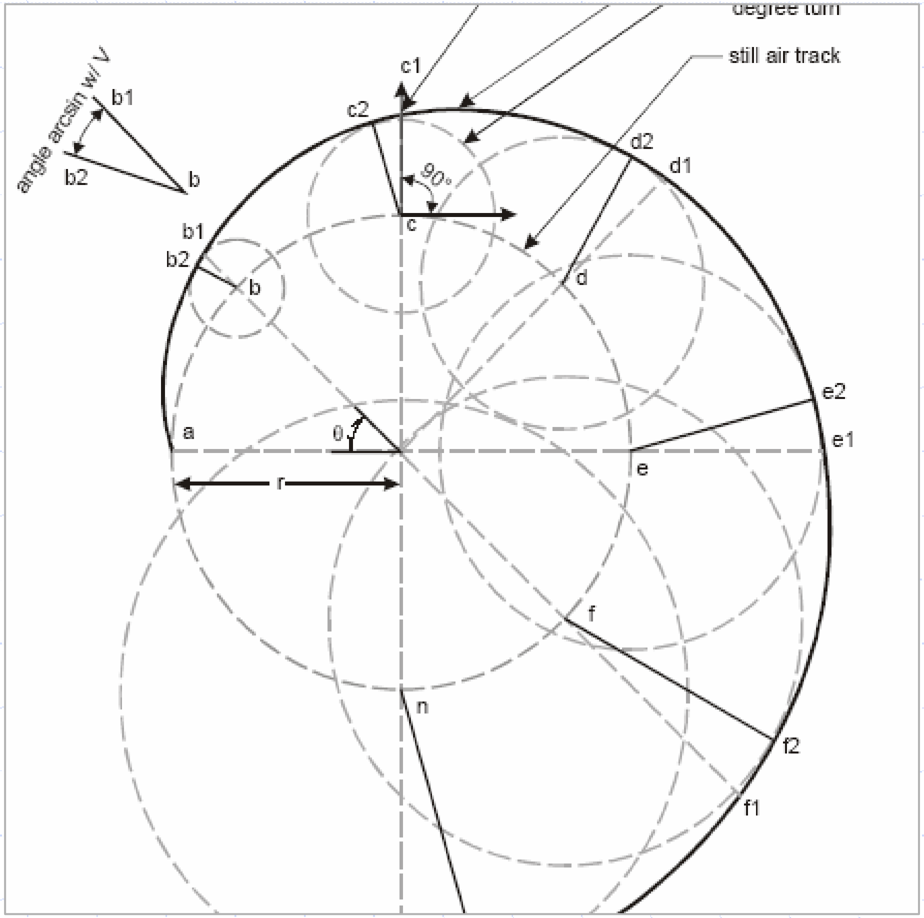


Figure I-2-3-4

WIND EFFECT

- Bounding Circle

Bounding Circles – For Obstacle Consideration

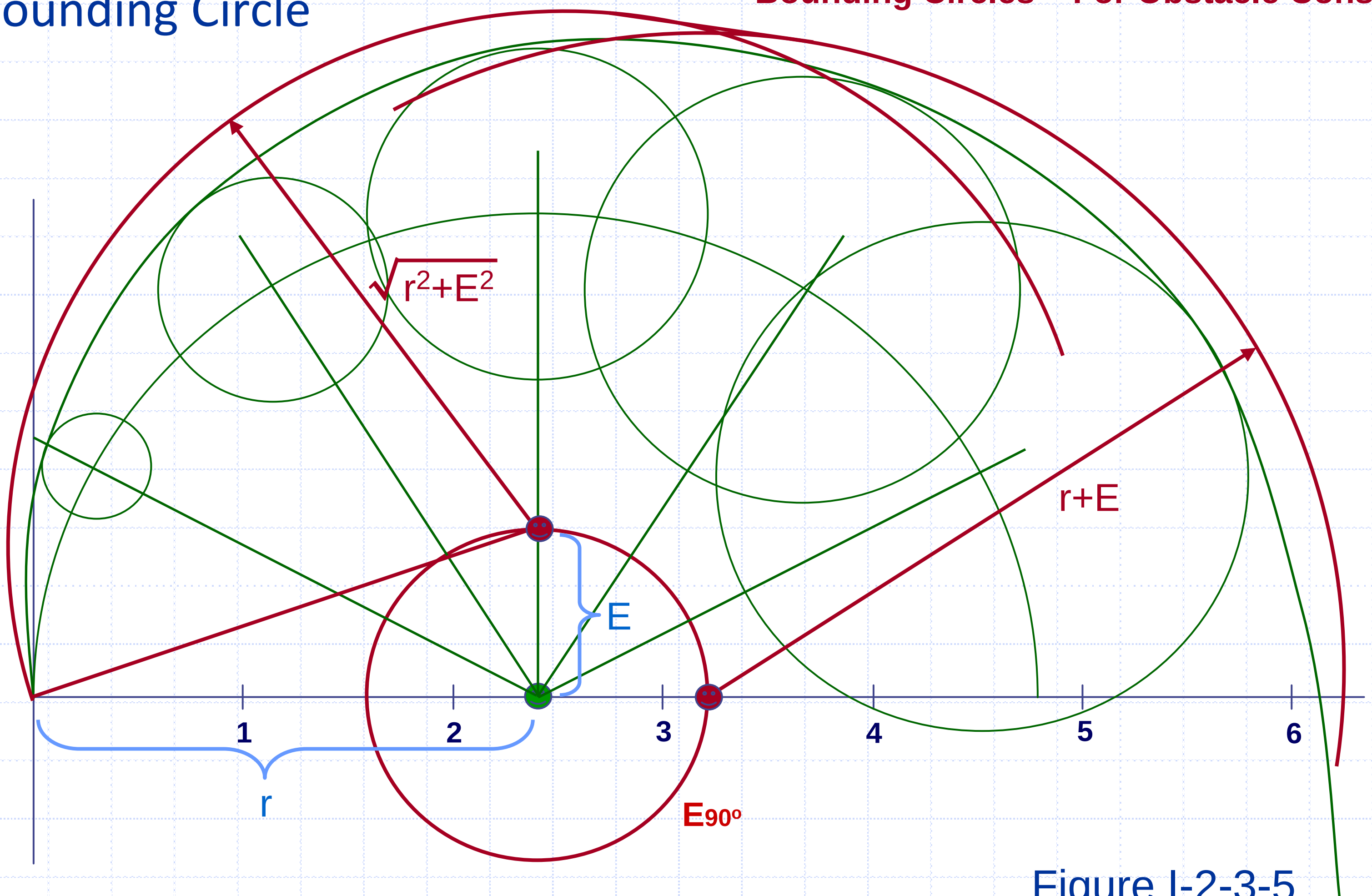


Figure I-2-3-5

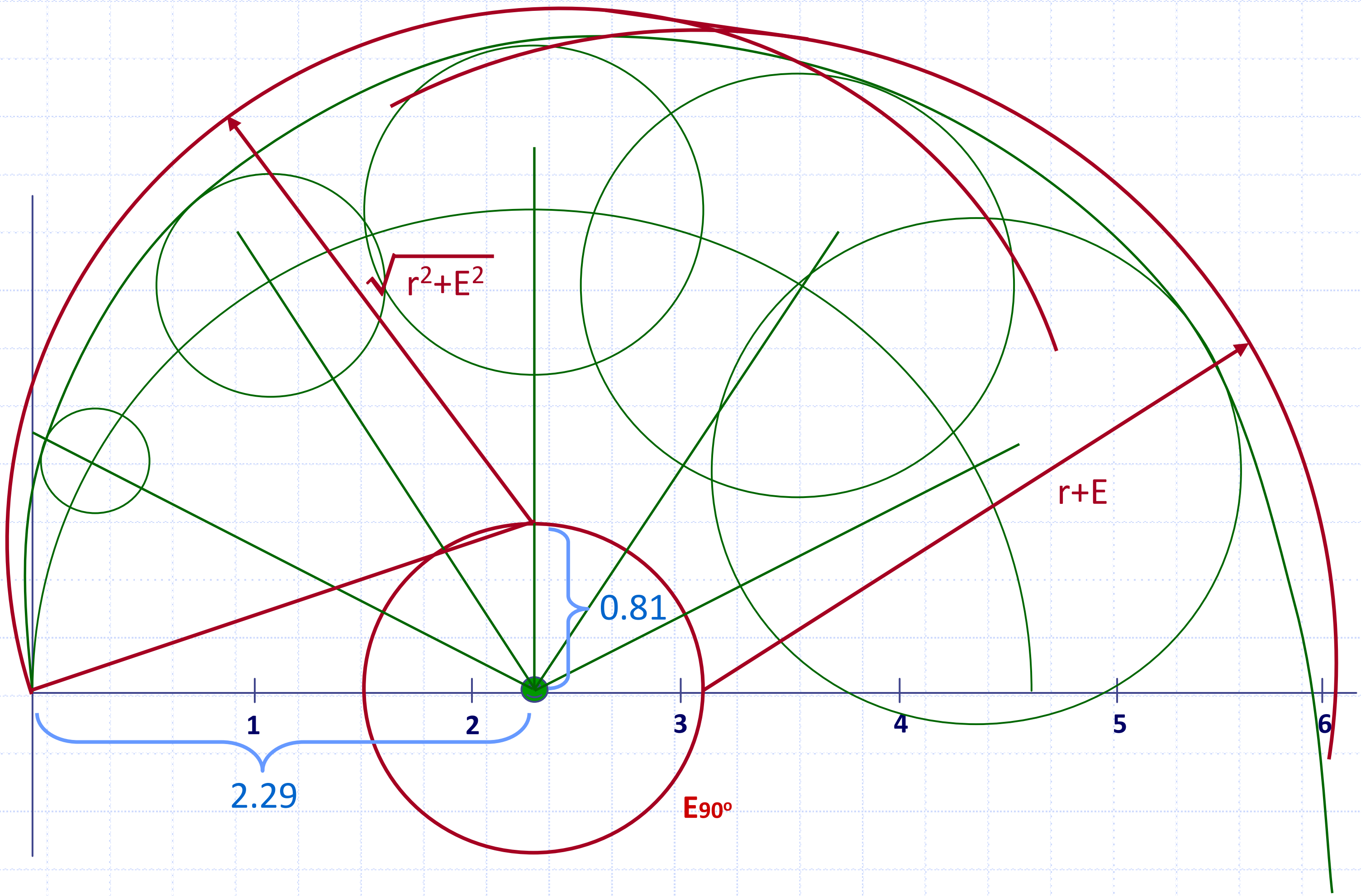
WIND EFFECT – EXERCISE 2

- For CAT C aircraft turning at 6000’ in Initial Segment, Construct Wind Spiral and Bounding Circles:
  - IAS = 240 kts
  - TAS = 240 * 1.1231 = 270 kts (↑)
  - R = 1.88 °/s (↓)
  - r = 2.29NM(↑)
  - Wind = 59 kts
  - T_{30^o} = 30/1.88 = 15.96 (↑)
  - E_{30^o} = 59 * 15.96/3600 = 0.27NM (↑)

Turn Interval	30º	60º	90º	120º	150º	180º
E	0.27	0.54	0.81	1.08	1.35	1.62

  - $\sqrt{r^2+E^2}$ 2.43 (↑)
  - r+E = 3.10 (↑)

WIND EFFECT – EXERCISE 2



NPA INITIAL SEGMENT

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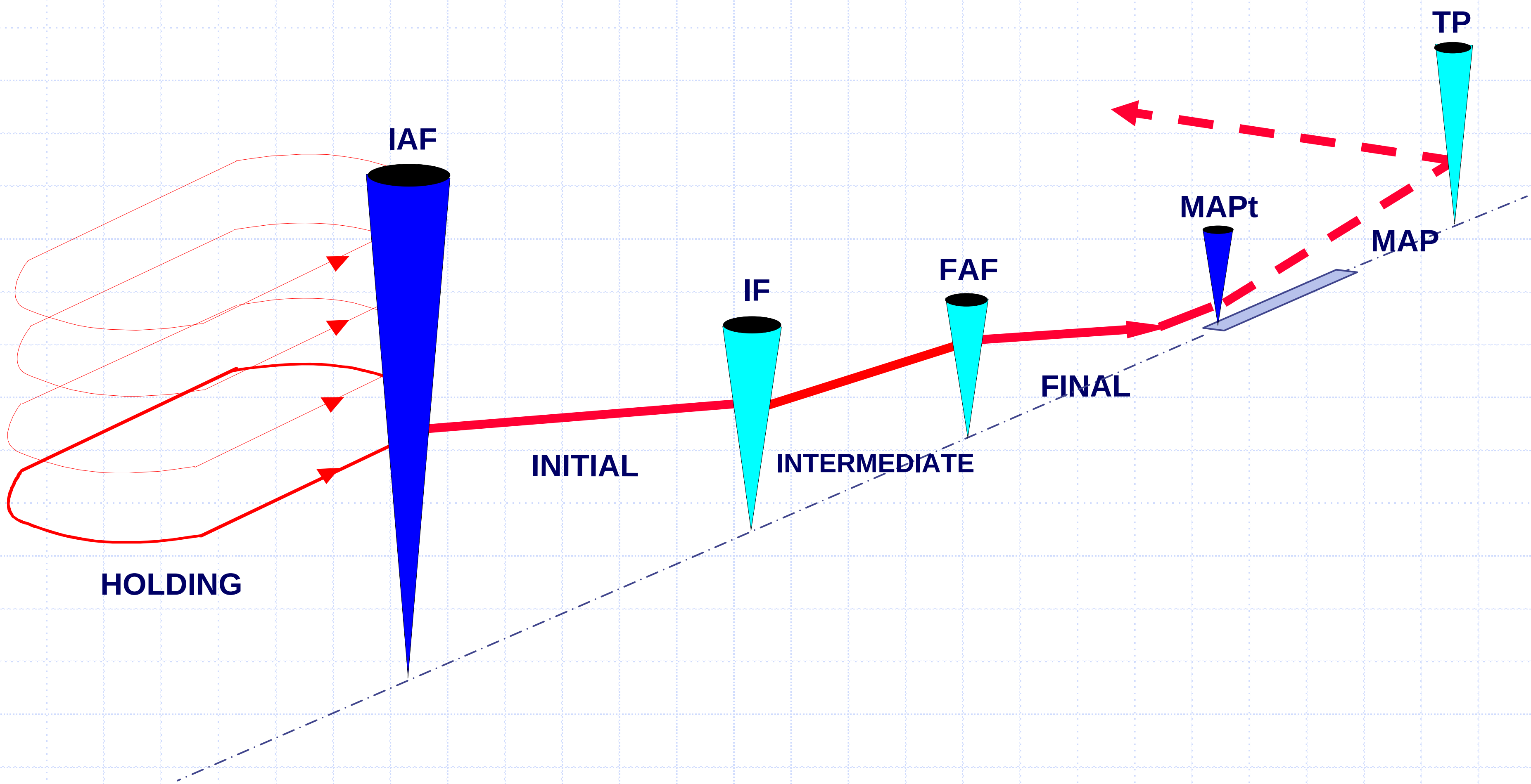
REVIEW

- An Instrument Approach Procedure may consist of 5 segments:
  - Arrival Segment
  - Initial Segment
  - Intermediate Segment
  - Final Segment
  - Missed Approach Segment

REVIEW



PURPOSE

- The aircraft is able to manoeuvre to enter the Intermediate Segment
- It is not mandatory to have the Initial Segment in an Instrument Approach Procedure

INITIAL SEGMENT TRAJECTORIES

- Guided Track:
  - Straight
  - Curve
- Reversal & Racetrack
  - For Turn at IF $\geqslant 120^{o}$
- Dead Reckoning (DR)

CONTENTS

- Segment is defined by 5 Parameters:
  - Alignment
  - Length
  - Descent Gradient
  - Area Width (Semi-width)
  - Minimum Obstacle Clearance (MOC)

ALIGNMENT & LENGTH

- Maximum turn at IAF: **120°** (Recommended ⩽70°)
- Maximum turn within Initial Segment: **120°**

- **No** standard length
- The length shall be sufficient to permit altitude change required by the procedure
- **10NM** is normally good for the Initial Segment

CONTENTS

- Segment is defined by 5 Parameters:
  - Alignment
  - Length
  - Descent Gradient
  - Area Width (Semi-width)
  - Minimum Obstacle Clearance (MOC)

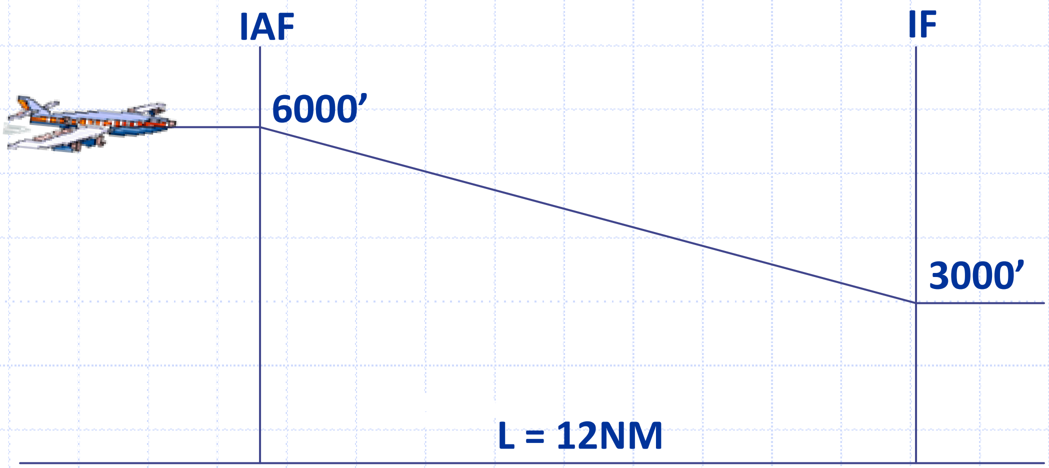
DESCENT GRADIENT

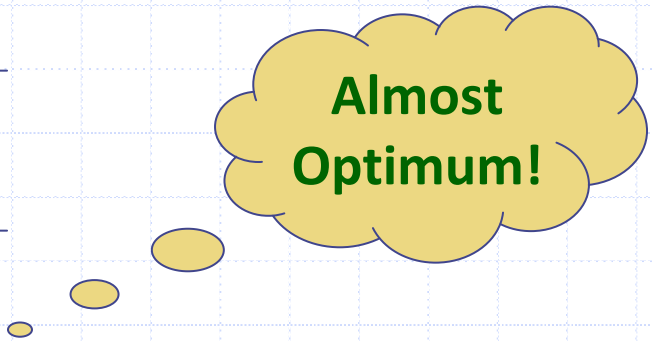
- Gradient = $\frac{\text{Vertical Change}}{\text{Horizontal Change}} = \frac{\text{Rise}}{\text{Run}}$ Tangent
- Tangent * 100 = %
  - E.g. for a Standard GP, 3° = 5.24%
  - Gradient in ft/NM for 5.24% = 5.24% * 6076 = 318 ft/NM
- Maximum: 8%
- Optimum: 4%

DESCENT GRADIENT - EXERCISE

- Descent Gradient = $\dfrac{\text{Change in Altitude}}{\text{Dist. between Nominal Fix Points}} = \dfrac{\triangle \text{ Alt}}{L}$

- **Exercise 1:**

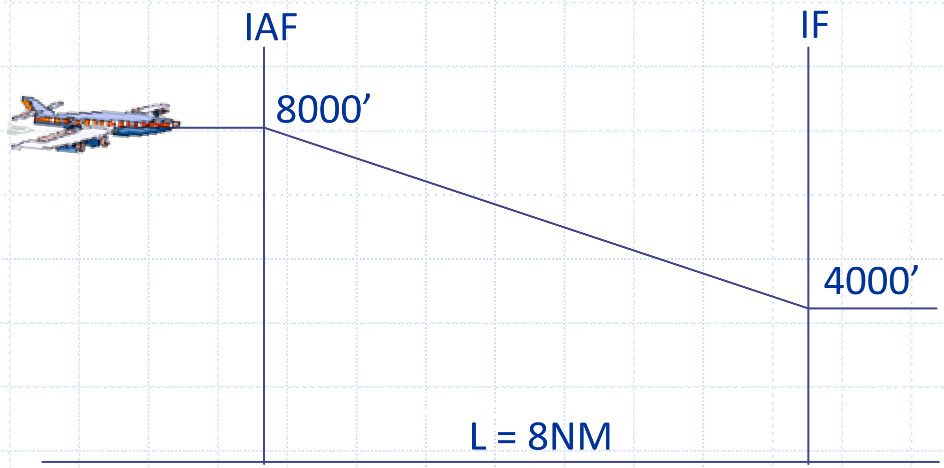




- Descent Gradient = $\dfrac{3000'}{12 * 6076} = 4.11\%$

DESCENT GRADIENT - EXERCISE

- Exercise 2:



Gradient = 8.23%

- How to optimize?

1. Move IAF:

$$L = \frac{\triangle Alt}{Gradient} = \frac{4000'}{4\% * 6076}$$

=16.46NM

2. Increase IF Altitude:

$\triangle$ Alt = L*Gradient = 8*4%*6076 = 1944’

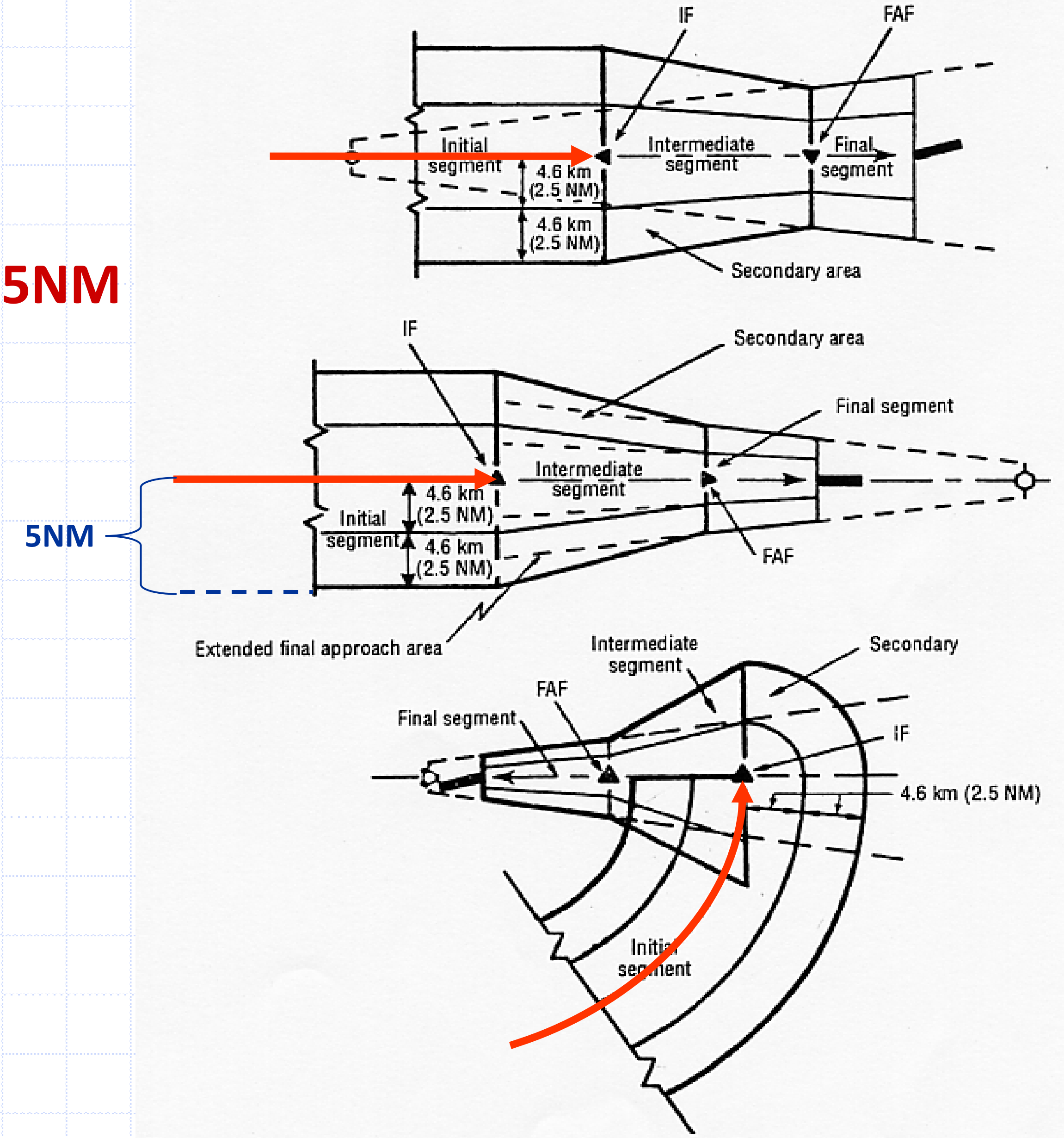
$\therefore$ Altitude of IF = 6056’ $\approx$ 6100’
(100’ or 50m increment)

CONTENTS

- Segment is defined by 5 Parameters:
  - Alignment
  - Length
  - Descent Gradient
  - Area Width (Semi-width)
  - Minimum Obstacle Clearance (MOC)

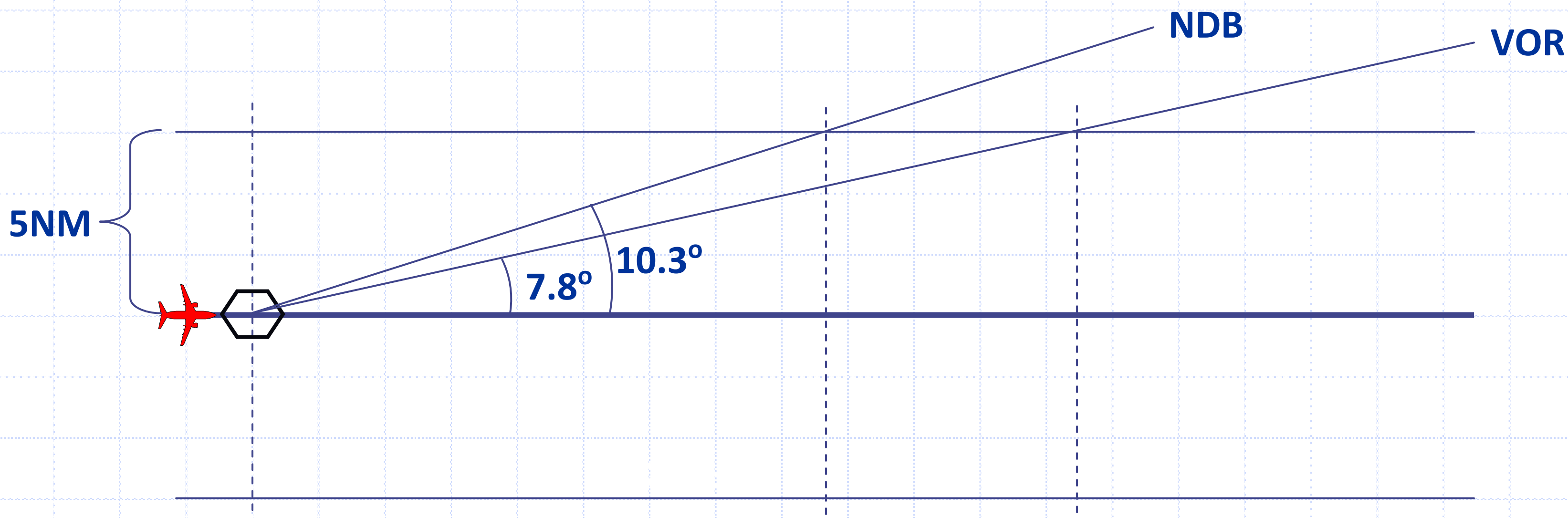
AREA WIDTH

- Semi-width (W/2) = 5NM

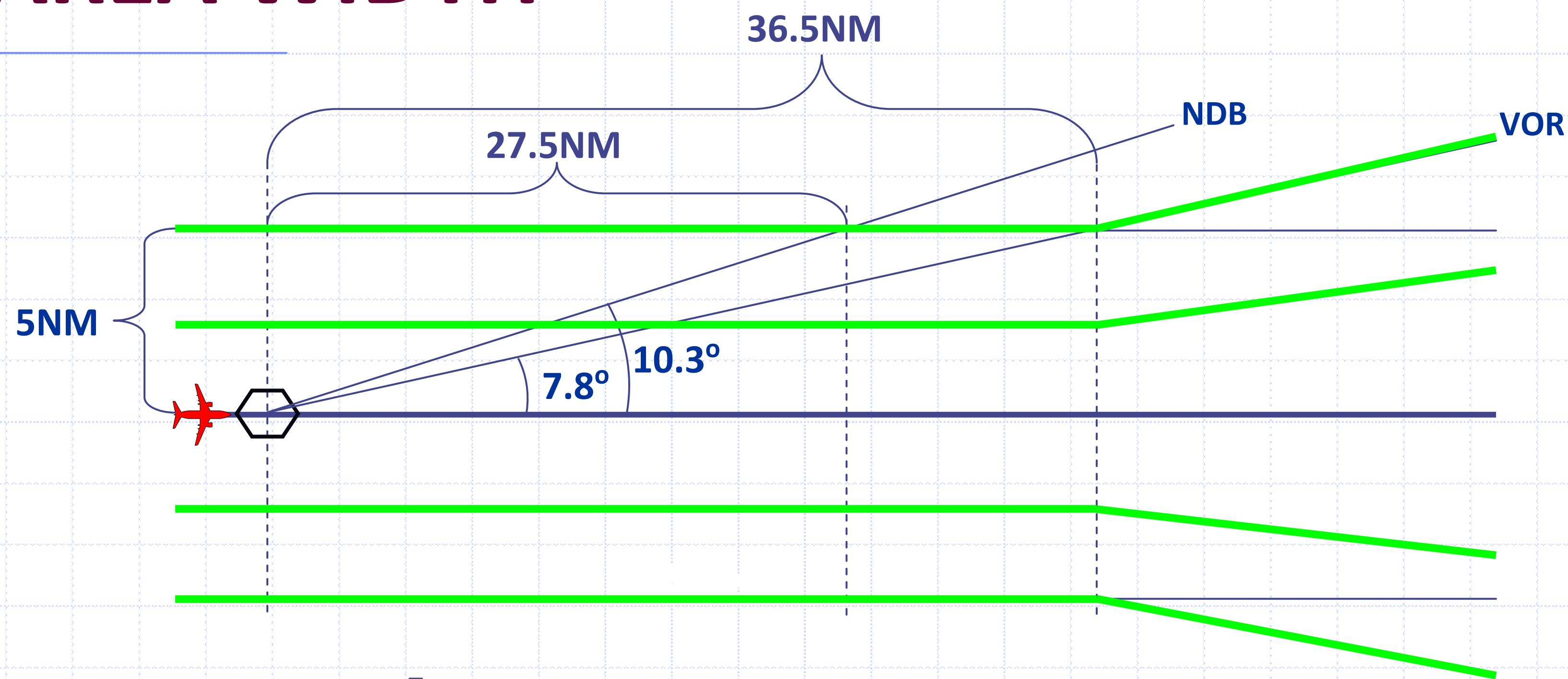


AREA WIDTH

- Semi-width (W/2) = **5NM**
- For a guided track (with **long** segment):
  - VOR: **7.8°**
  - NDB: **10.3°**



AREA WIDTH



$$\text{Dist (VOR)} = \frac{5}{\tan 7.8^\circ} = 36.5\text{NM}$$

$$\text{Dist (NDB)} = \frac{5}{\tan 10.3^\circ} = 27.5\text{NM}$$

- Semi-width is divided equally into Primary & Secondary Areas
- Figure I-4-3-3

AREA WIDTH

- For a particular distance from a facility, area semi-width is given by:
  - For VOR: $w/2 = D * Tan7.8^{o}$ (↑)
  - For NDB: $w/2 = D * Tan10.3^{o}$ (↑)

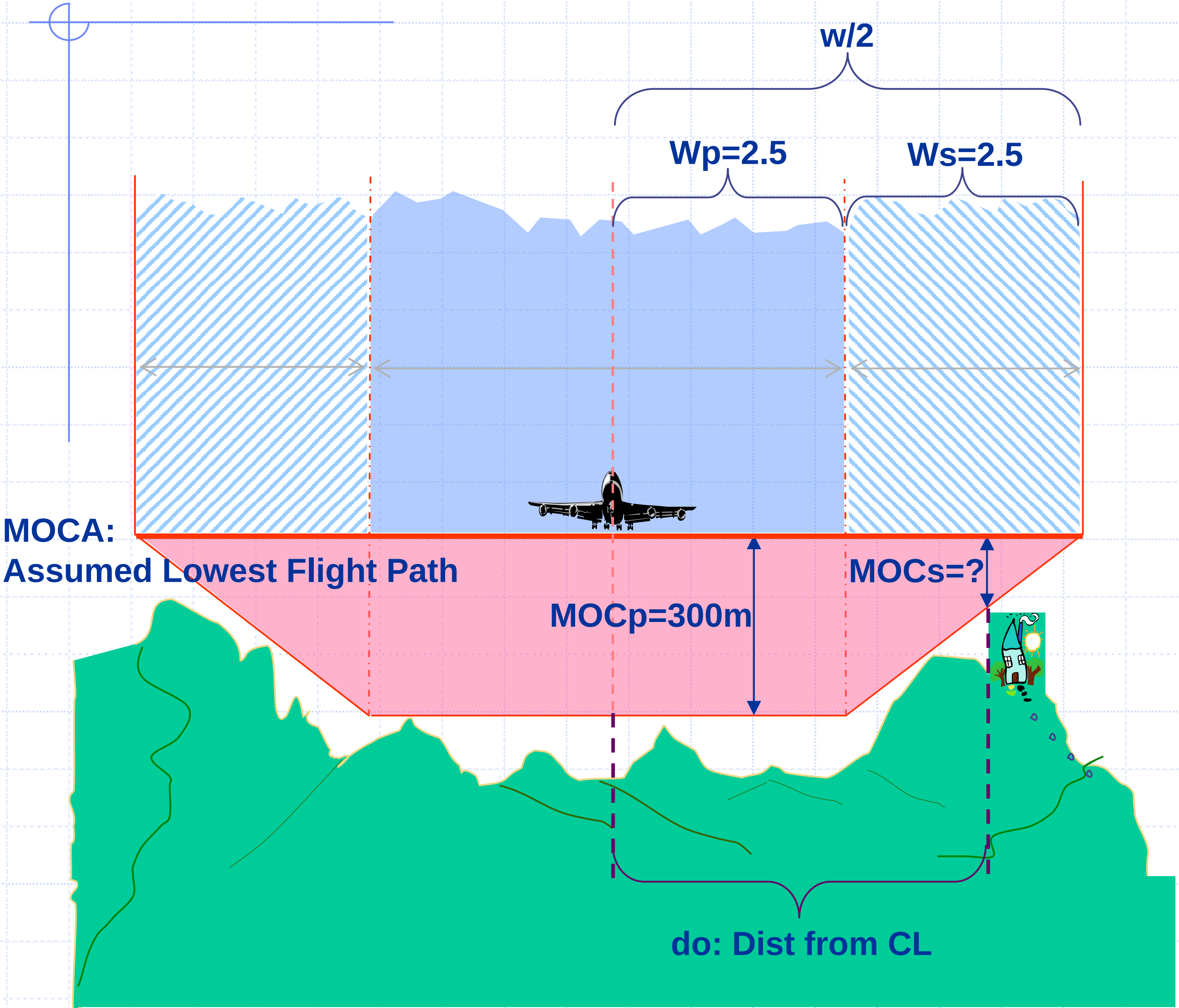
CONTENTS

- Segment is defined by 5 Parameters:
  - Alignment
  - Length
  - Descent Gradient
  - Area Width (Semi-width)
  - Minimum Obstacle Clearance (MOC)

MOC

- MOC: 300m/984ft
- Altitudes are assigned in increments of 100ft or 50m
- Altitude must provide at least 300m (984ft) clearance over all obstacles.
- The area (semi-width) is divided into half, the inner half is Primary and the outer half is Secondary
  - Primary: Full MOC is applied
  - Secondary: The MOC is reduced from full MOC at the inner boundary to zero at the outer boundary

MOC

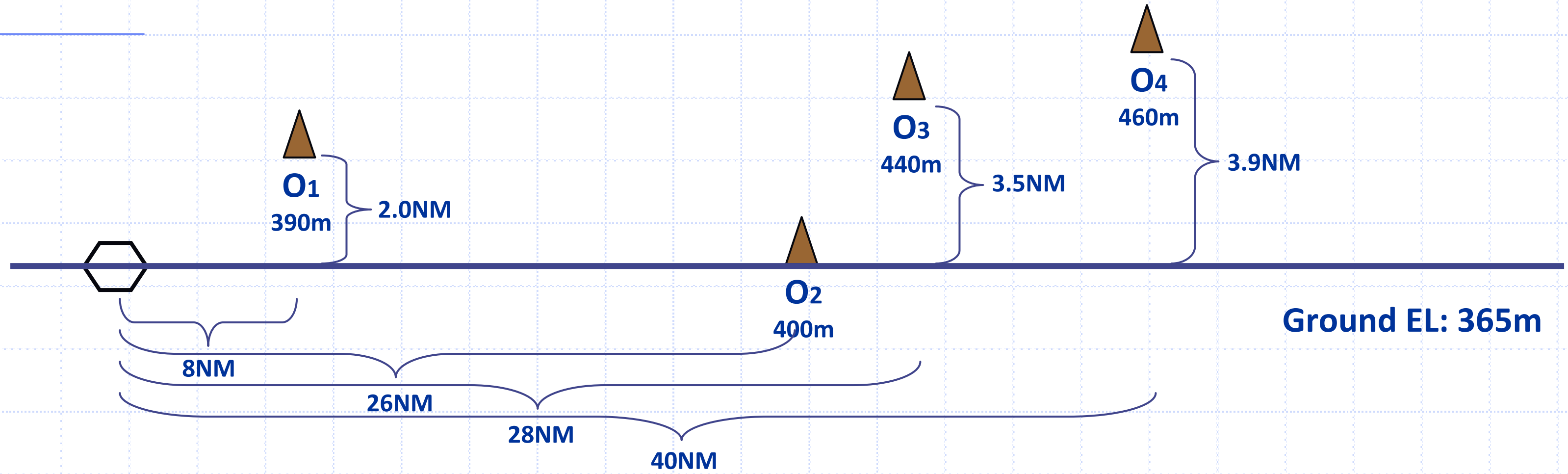


$$MOCs = \frac{w/2 - do}{Ws} MOCp \ (\uparrow)$$

MOCA = GND EL + Ho + MOC (↑)

(with increment of 100ft or 50m)

MOC - EXERCISE



- For each obstacle, calculate MOC and MOCA:

Critical Obstacle?

MOC

O1: 300m

O2: 300m

O3: w/2 = 28*Tan7.8° = 3.84NM (↑ ,SEC)

$$MOCs = \frac{5 - 3.5}{2.5} 300m = 180m$$

O4: w/2 = 40*Tan7.8° = 5.48NM (↑ ,SEC)

$$MOCs = \frac{5.48 - 3.9}{5.48/2} 300m = 173m$$

MOCA

O1: 365 + 390 + 300 = 1055m

O2: 365 + 400 + 300 = 1065m

Rounding?

O3: 365 + 440 + 180 = 985m

O4: 365 + 460 + 173 = 998m

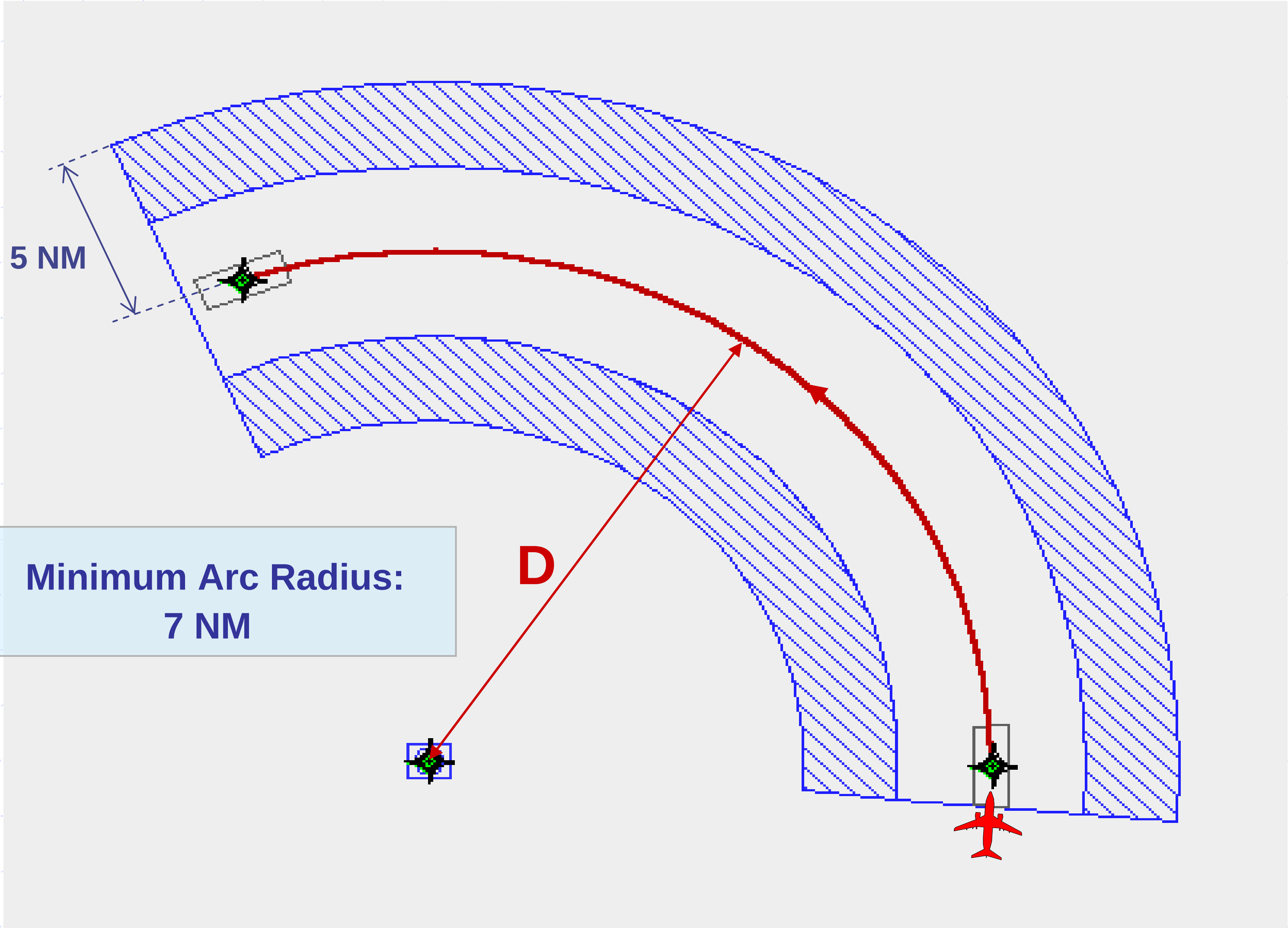
MOCA in this segment: 1100m (↑ to next 50m)

MOCA (in ft): 1065m*3.2808 = 3495' = 3500' (↑ to next 100')

OTHER TRAJECTORIES

- Guided Track:
  - Straight
  - Curve
- Reversal & Racetrack
  - For Turn ⩾ 120°
- Dead Reckoning (DR)

DME ARC



Minimum Arc Radius:
7 NM

NPA INTERMEDIATE SEGMENT

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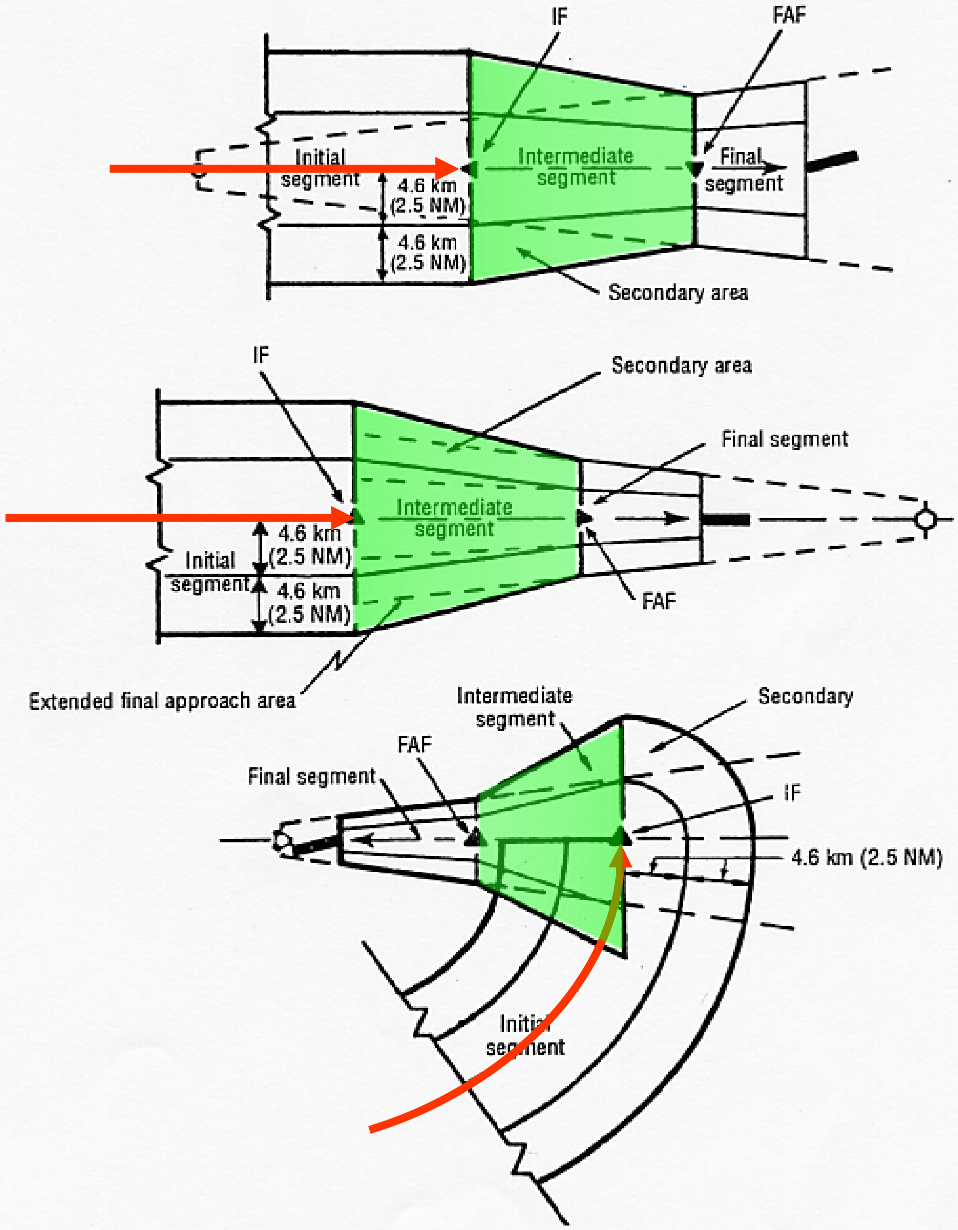
PURPOSE

- To connect the Initial to the Final
- To provide a **level segment** within which the aircraft can be prepared for the final descent (aircraft configuration, speed, etc.)
- **Track guidance** shall be provided

OVERVIEW

- Examples…



CONTENTS

- 5 Parameters:
  - Alignment
  - Length
  - Descent Gradient
  - Area Width (Semi-width)
  - Minimum Obstacle Clearance (MOC)

ALIGNMENT & LENGTH

- Maximum turn at IF: **120°** (Recommended ≤ **70°**)
- If more than 120°, then Reversal

- Length:
  - Minimum: **5NM**
  - Optimum: **10NM**
  - Maximum: **15NM**
- Minimum Length will be increased for a turn great than 90° at IF

Interception Angle	Minimum Length
91-96	6 NM
97-102	7 NM
103-108	8 NM
109-114	9 NM
115-120	10 NM

CONTENTS

- 5 Parameters:
  - Alignment
  - Length
  - Descent Gradient
  - Area Width (Semi-width)
  - Minimum Obstacle Clearance (MOC)

DESCENT GRADIENT

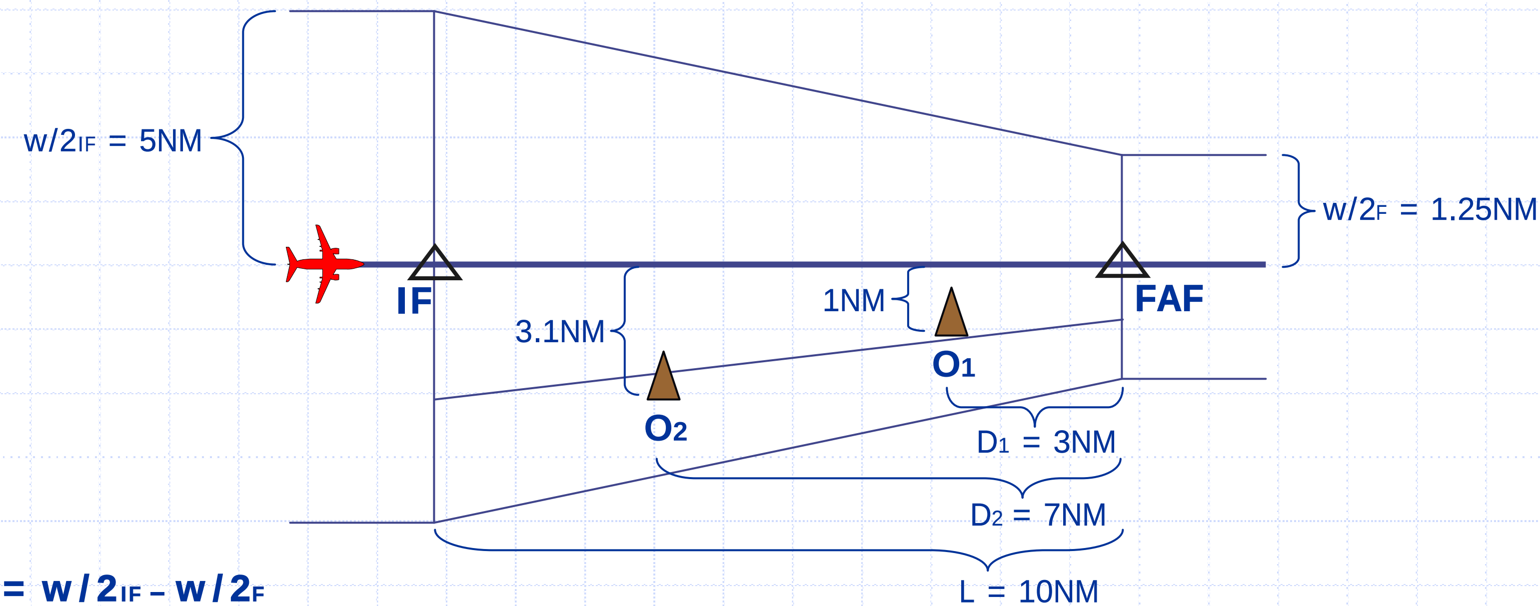
- Optimum: **Flat (i.e. 0%)**
- Maximum: **5.2%**
  - If descent is necessary, a horizontal segment with a minimum length of **1.5NM** should be provided prior to the final approach for CAT C & D aircraft
  - **1NM** for CAT A & B

CONTENTS

- 5 Parameters:
  - Alignment
  - Length
  - Descent Gradient
  - Area Width (Semi-width)
  - Minimum Obstacle Clearance (MOC)

AREA WIDTH

- Join the boundary of the Initial at IF to the boundary of the Final at the FAF
- E.g.



Expansion = $w/2_{IF} - w/2_{F}$

$w/2(O_1) = w/2_F + D_1/L(w/2_{IF} - w/2_F)$ (↑)

= 1.25 + 3/10(5-1.25)

= 2.375NM

∴ O_1 is in PRI

$w/2(O_2)$ = 3.875NM

∴ O_2 is in SEC

CONTENTS

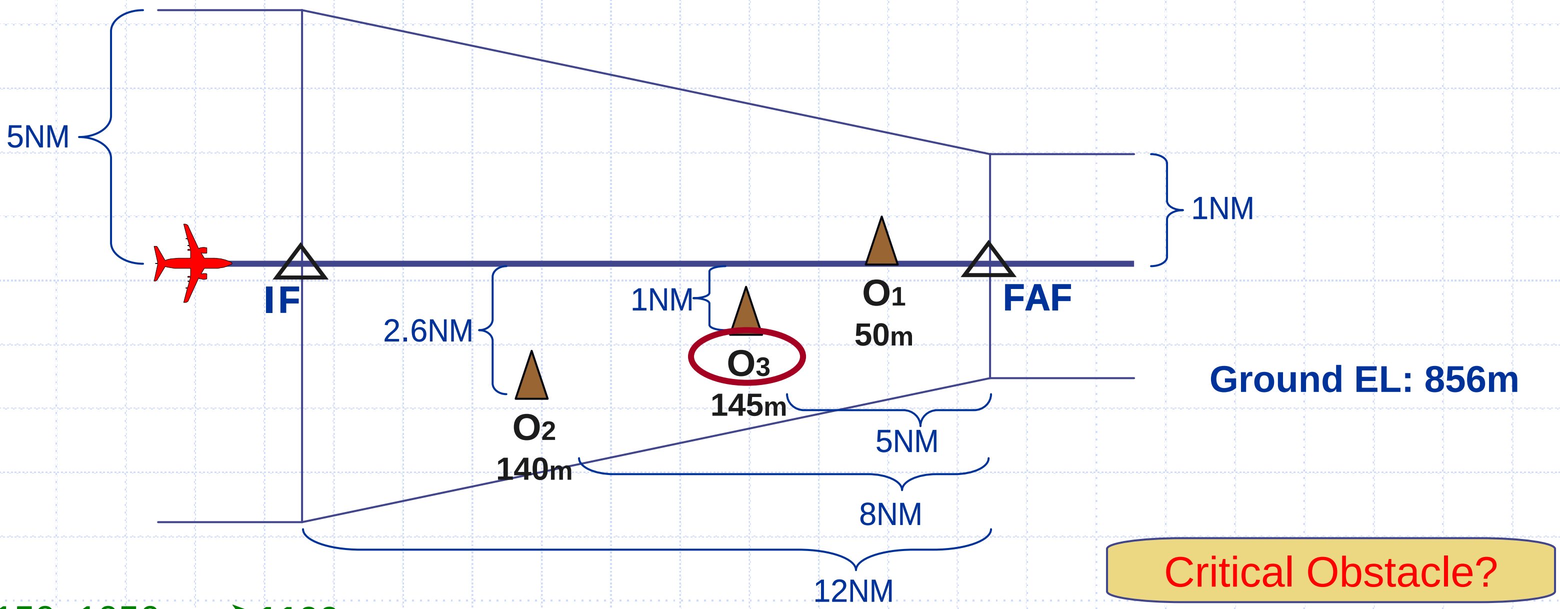
- 5 Parameters:
  - Alignment
  - Length
  - Descent Gradient
  - Area Width (Semi-width)
  - Minimum Obstacle Clearance (MOC)

MOC

- MOC: **150m/492ft**
- Altitudes are assigned in increment of **100ft** or **50m**
- Altitude must provide at least **150m (492ft)** clearance over **all** obstacles.
- The area (semi-width) is divided into half, the inner half is Primary and the outer half is Secondary
  - Primary: Full MOC is applied
  - Secondary: The MOC is reduced from full MOC at the inner boundary to zero at the outer boundary

MOC - EXERCISE

- Calculate MOCA (in m & ft) for O_1, O_2 & O_3:



O_1: 856+50+150=1056m → **1100m**

3465’ → **3500’**

O_2: w/2(O_2) = 1+8/12(5-1) = 3.67 (↑ , SEC)

$$MOCs = \frac{3.67 - 2.6}{3.67/2} 150m = 88m\ (\uparrow)$$

∴856+140+88=1084m → **1100m**

3557’ → **3600’**

O_3: w/2(O_3) = 1+5/12(5-1) = 2.67 (↑ , PRI)

∴856+145+150=1151m → **1200m**

3777’ → **3800’**

NPA FINAL SEGMENT

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PURPOSE

- To deliver the aircraft to a position, and in a state, from which a normal landing can be initiated, or to a position and state from which a Missed Approach Procedure (MAP) can be initiated
- The Final Segment begins at **FAF** and ends at **MAPt**
- It either terminates as: Landing or MAP
- **Track guidance** shall be provided

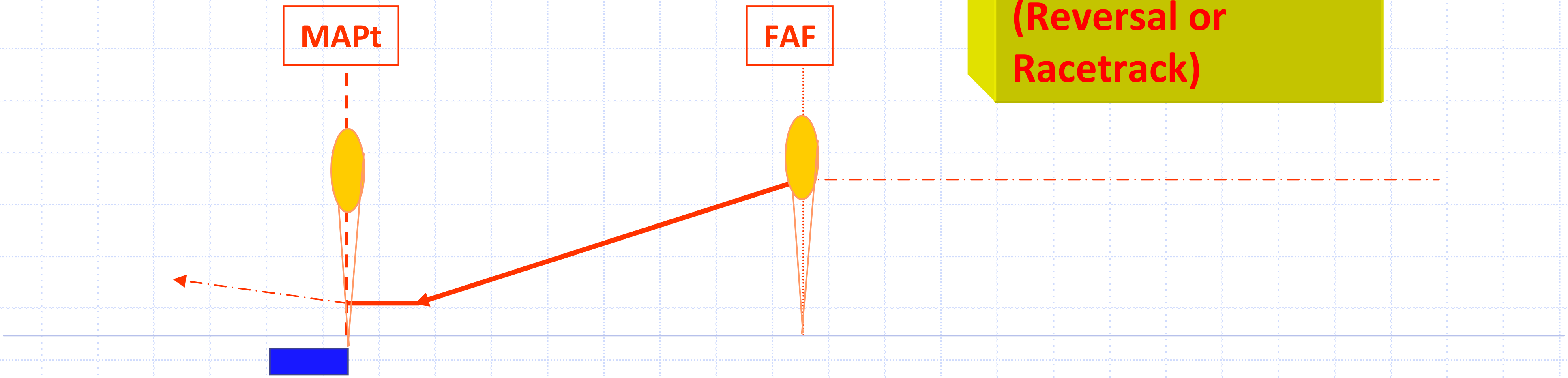
PURPOSE

- Last radio-guided segment before landing

Ends ➢ MAPt

Begins:
- **FAF**

or
- **Inbound Turn (Reversal or Racetrack)**



CONTENTS

- 5 Parameters:
  - Alignment
  - Length
  - Descent Gradient
  - Area Width (Semi-width)
  - Minimum Obstacle Clearance (MOC)

ALIGNMENT

- Final approach may be made:
  - to a runway for a straight-in landing; or
  - to an aerodrome for a circling approach

It should be aligned with the runway whenever possible!

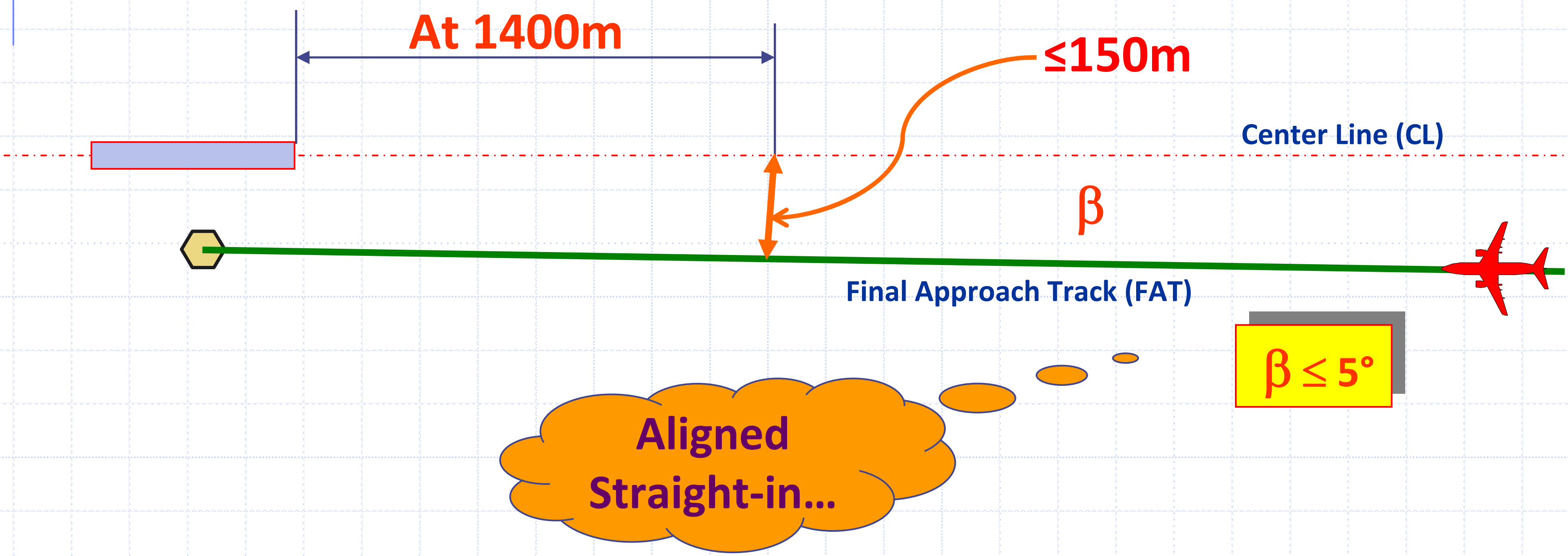
ALIGNMENT

- For STRAIGHT-IN-APPROACH
  - Aligned: $\alpha \leqslant 5^{o}$
  - Non-aligned: $5^{o} < \alpha \leqslant 30^{o}$

- STRAIGHT-IN-APPROACH (2 situations)
  - Final approach with track **not intersecting** the extended runway centre line; and
  - Final approach with track **intersecting** the extended runway centre line.

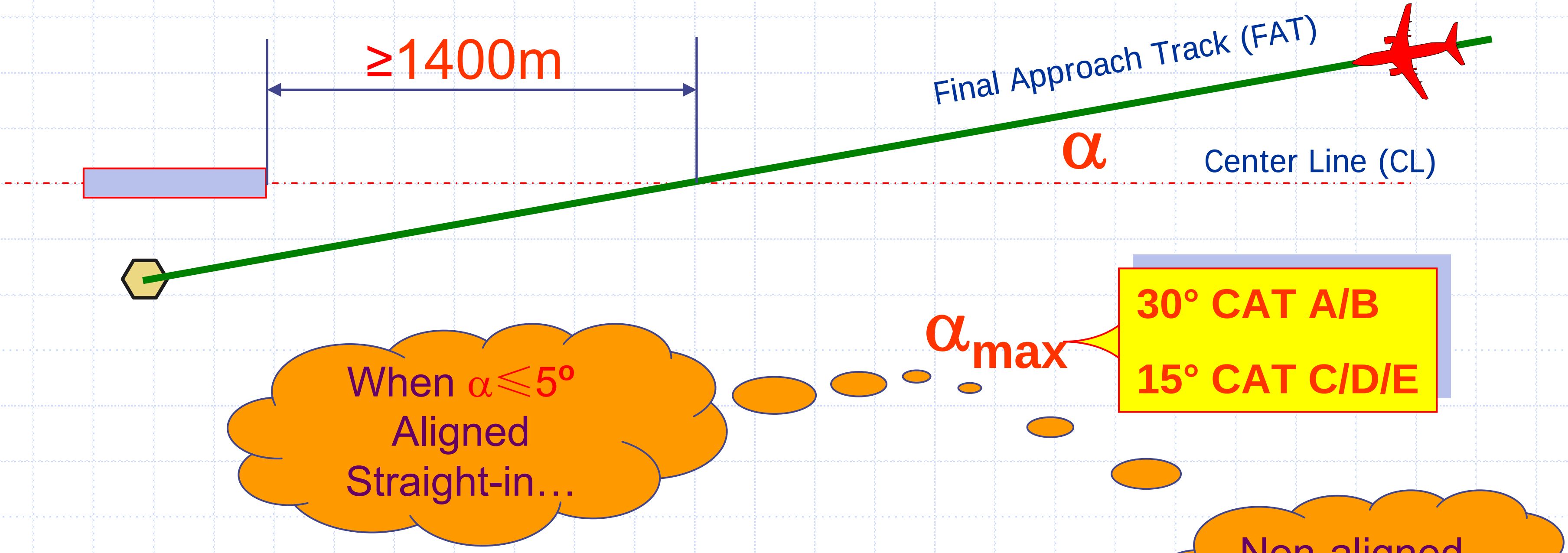
ALIGNMENT

- STRAIGHT-IN-APPROACH (not intersecting)



ALIGNMENT

➢ **STRAIGHT-IN-APPROACH (intersecting)**



if α > 5° ⇒ Lower Limit on OCH (Table I-4-5-3)

ALIGNMENT

- In case of intersecting, for Non-aligned Straight-in-Approach (Angle $\alpha > 5^\circ$)
- Table I-4-5-3

Aircraft Category	Lower Limit on OCH	
	$5^\circ < \theta < 15^\circ$	$15^\circ < \theta < 30^\circ$
CAT A	340	380
CAT B	380	410
CAT C	410	
CAT D	430	
CAT E	480	

ALIGNMENT

- Maximum turn at FAF: 30°
- If criteria cannot be met, then Circling Procedure

Length

- FAF to MAPt (or THR):
  - Minimum: 3NM
  - Optimum: 5NM

CONTENTS

- 5 Parameters:
  - Alignment
  - Length
  - Descent Gradient
  - Area Width (Semi-width)
  - Minimum Obstacle Clearance (MOC)

DESCENT GRADIENT

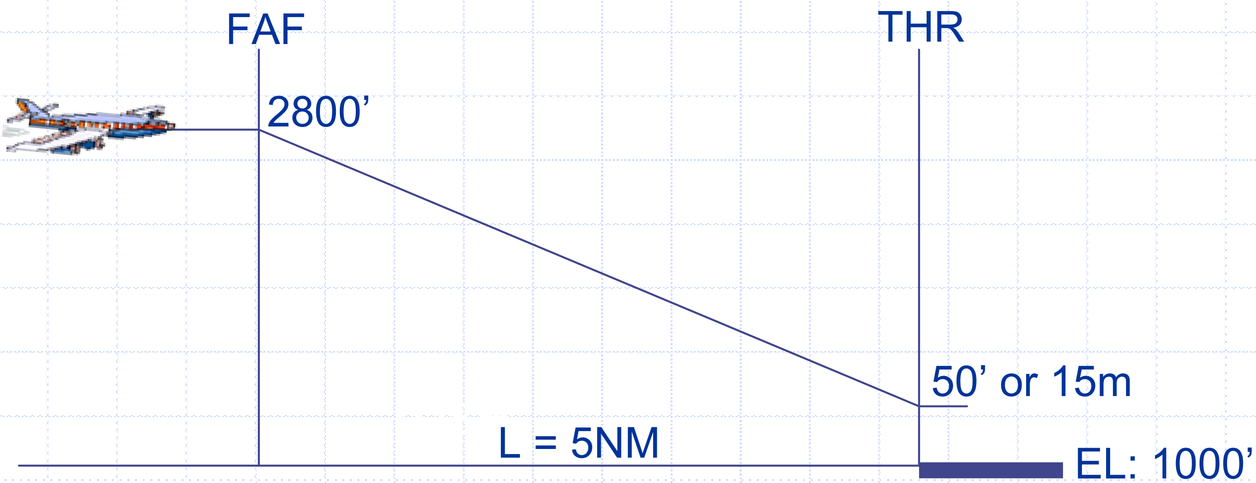
- Final with FAF:
  - Optimum/Minimum: 5.2% (≈3°)
  - Maximum: 6.5% for CAT A/B

    6.1% for CAT C/D/E
- Final without FAF (Table I-4-5-2):

Aircraft CAT	Maximum (ft/min)	Minimum (ft/min)
CAT A/B	655	394
CAT C/D/E	1000	590
CAT H	755	N/A

DESCENT GRADIENT - EXERCISE

- Descent Gradient = $\dfrac{\text{FAF Alt} - \text{THR EL} - (50\text{' or }15\text{m})}{L * 6076}$



$\therefore$ Descent Gradient = $\dfrac{2800-1000-50}{5 * 6076} = 5.76\%$

How to adjust to get the optimum descent gradient?

DESCENT GRADIENT - EXERCISE

1. Lower FAF Alt:

   FAF Alt = 1000 + 50 + 0.052*5*6076 = 2630’

   Then 2600’ or 2700’?

   $\therefore$ Descent Gradient from 2700’ = $\dfrac{2700-1000-50}{5 * 6076}$ = 5.43%

2. If Intermediate altitude cannot be lowered due to obstacles, then move the FAF so as to increase the distance of FAF-THR:

   $\therefore$ L = (2800-50-1000)/6076/5.2% = 5.54NM

   → 5.5NM (0.1NM increment for DME)

Aim: Make the Descent Gradient close to 5.2%

Question: How about when there is a Stepdown Fix (SDF)?

CONTENTS

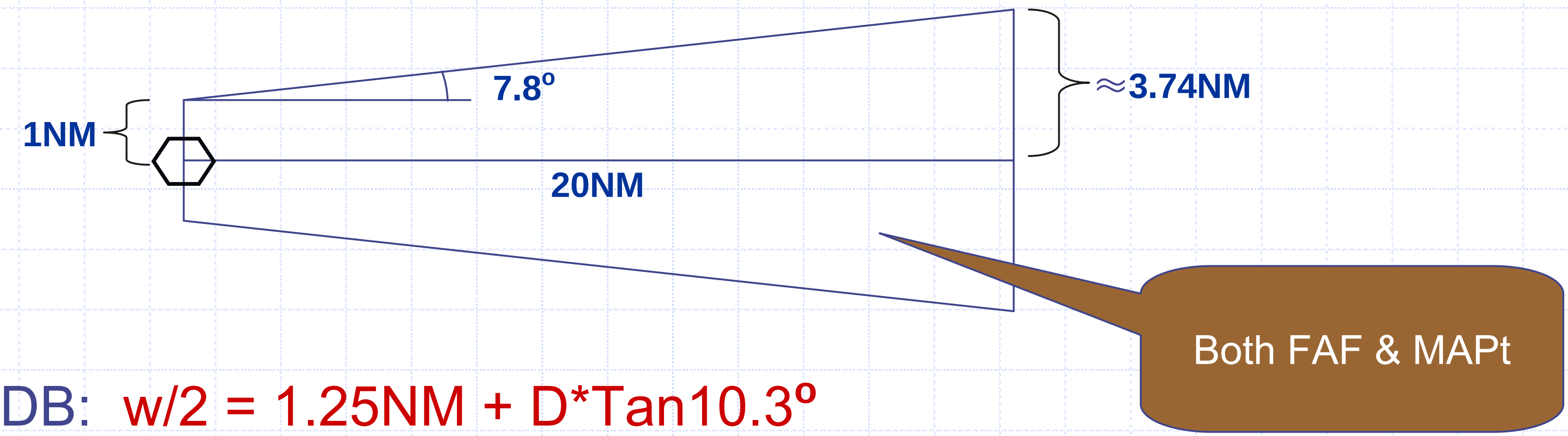
- 5 Parameters:
  - Alignment
  - Length
  - Descent Gradient
  - Area Width (Semi-width)
  - Minimum Obstacle Clearance (MOC)

AREA WIDTH

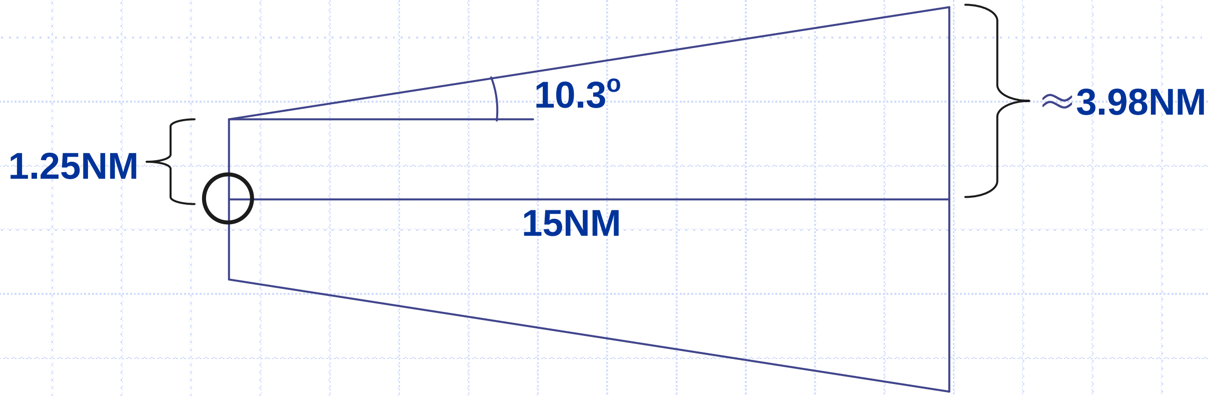
- Depends on:
  - Facility (VOR or NDB)
  - Geometry
- The final approach may be made either ‘from’ or ‘to’ the facility
- VOR: The Final Segment (i.e. from FAF to MAPt) must be contained **within 20NM** of the facility
- NDB: The Final Segment (i.e. from FAF to MAPt) must be contained **within 15NM** of the facility

AREA WIDTH

For VOR: w/2 = 1NM + D*Tan7.8º (D: Distance for the facility)



For NDB: w/2 = 1.25NM + D*Tan10.3º



CONTENTS

- 5 Parameters:
  - Alignment
  - Length
  - Descent Gradient
  - Area Width (Semi-width)
  - Minimum Obstacle Clearance (MOC)

MOC

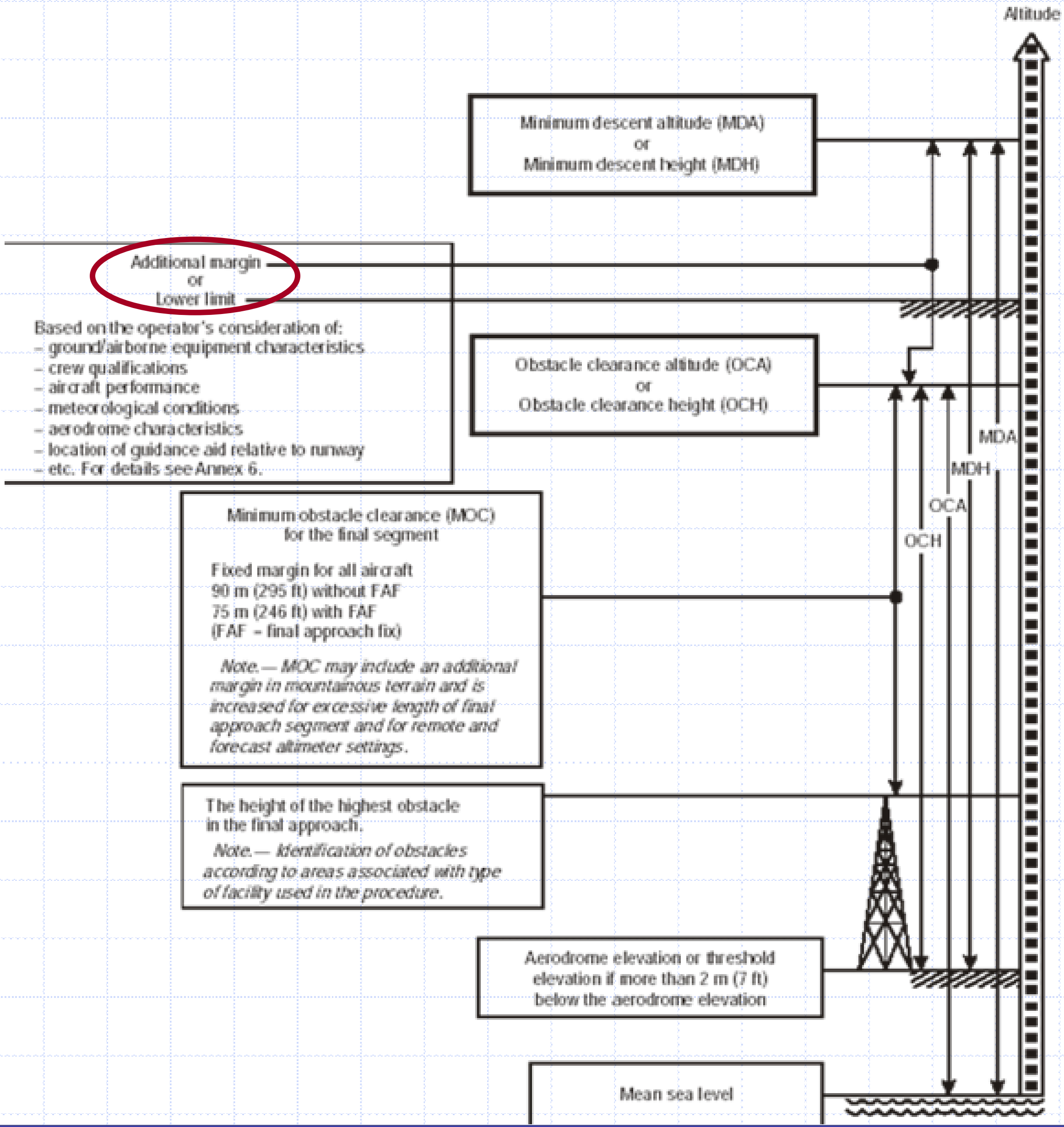
- For Aligned Straight-in Approach (angle between FAT & CL ≤ 5°)
  - With FAF: 75m/246ft
  - Without FAF: 90m/295ft
- Obstacle Clearance Altitude/Height (OCA/H): The lowest altitude/height that provides the minimum obstacle protection
- OCA: Reference to MSL
- OCH: Reference to AD EL
  - or THR EL if more than 7' below
- OCA/H: Round up to next 10' or 5m

MOC

- **Minimum Descent Altitude/Height (MDA/H): A specified altitude/height in a non-precision approach or circling approach below which descent must not be made without the required visual reference.**
- **It is established operationally**
- **With the addition of operators' margin, it must be higher than the OCA/H**

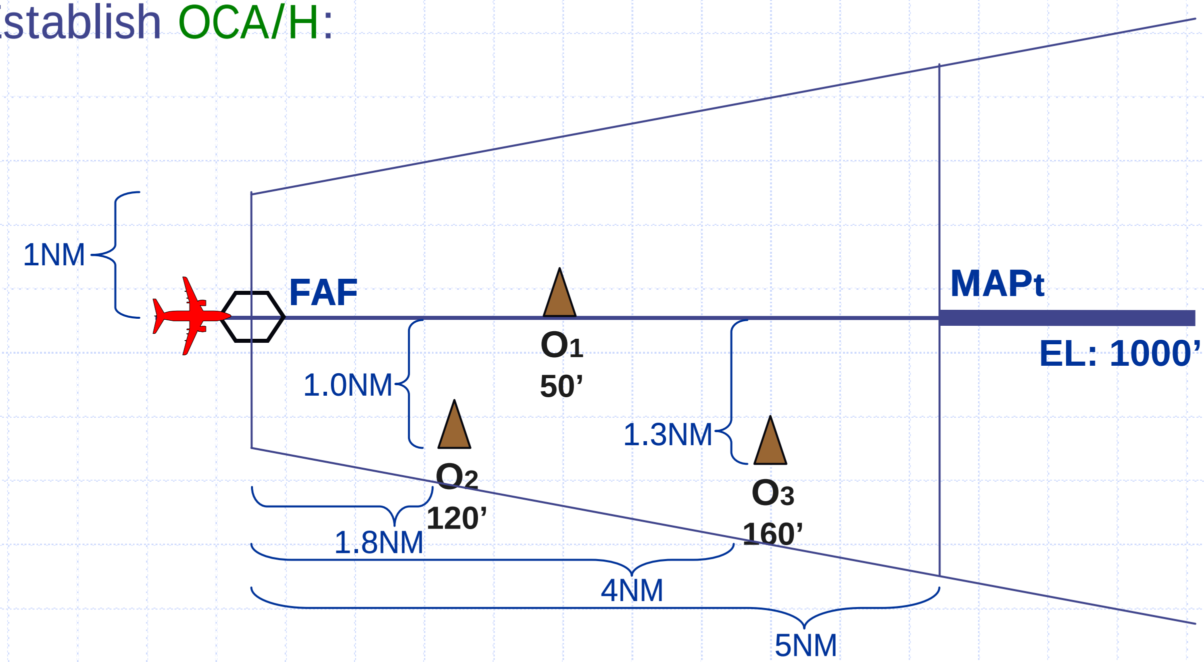
MOC

Relationship between OCA/H - MDA/H for Straight-in approaches



MOC – EXERCISE 1

- Establish OCA/H:



Critical Obstacle?

If α > 5° ⇒
Lower Limit on OCH
(Table I-4-5-3)

O1:

MOC = 246'
OCH = 246+50 = 296'
OCA = 296+1000 = 1296'
∴OCA/H =1300'/300'

α ≤ 5°

O2:

w/2(O2) = 1+1.8*Tan7.8° = 1.25NM (↑ , SEC)

$$MOCs = \frac{1.25 - 1}{1.25/2} 246 = 98.4' \approx 99'$$

OCH = 99+120 = 219'
OCA = 219+1000 = 1219'
∴OCA/H =1220'/220'

O3:

w/2(O3) = 1.55NM (↑ , SEC)
MOCs = 79.4' ≈ 80'
OCH = 80+160 = 240'
OCA = 240+1000 = 1240'
∴OCA/H =1240'/240'

MOC – EXERCISE 1

- Continue with previous question, with the OCA/H of 1300'/300', what is the **height of an additional mast** if it is being built on top of O_2?

  Additional Height = 81'

- Continue with previous question, calculate the **OCA/H** if the VOR is replaced by a NDB:

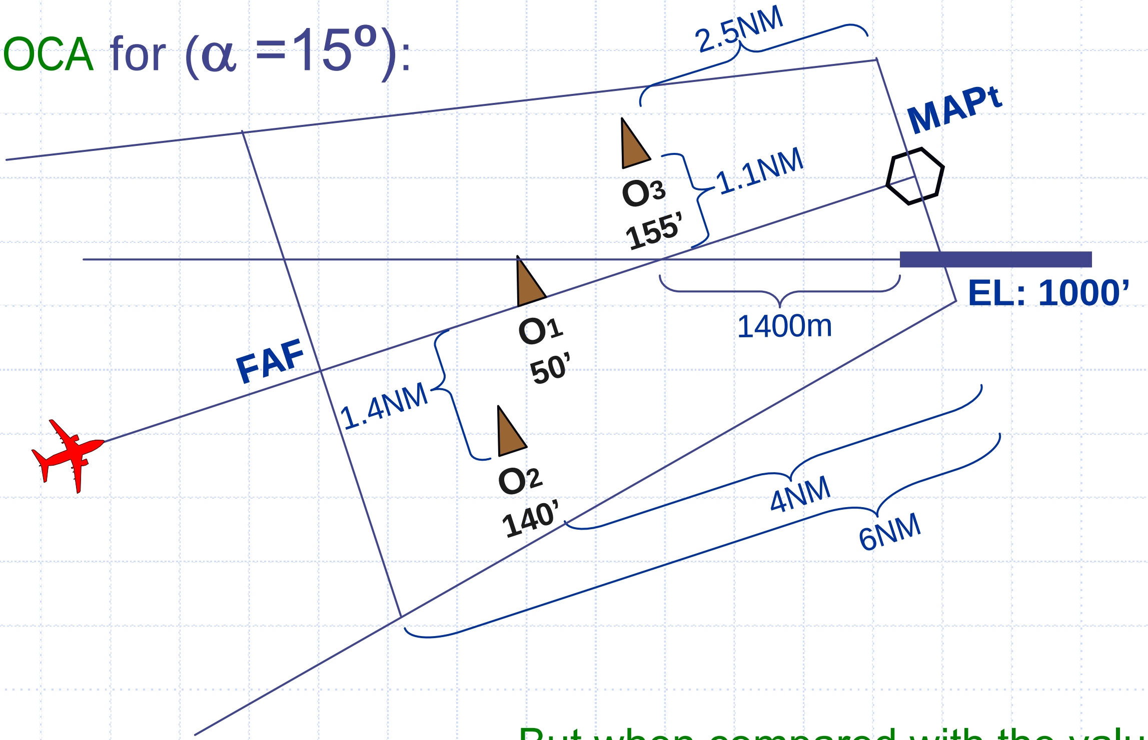
  O_1: OCA/H =1300'/300'

  O_2: OCA/H =1310'/310'

  O_3: OCA/H =1330'/330'

MOC – EXERCISE 2

- Establish OCA for (α =15º):



O1: OCA/H =1300’/300’

O2: OCA/H =1190’/190’

O3: OCA/H =1250’/250’

But when compared with the values in Table I-4-5-3:

CAT A: OCA = 340+1000 = 1340’
CAT B: OCA = 380+1000 = 1380’
CAT C: OCA = 410+1000 = 1410’
CAT D: OCA = 430+1000 = 1430’

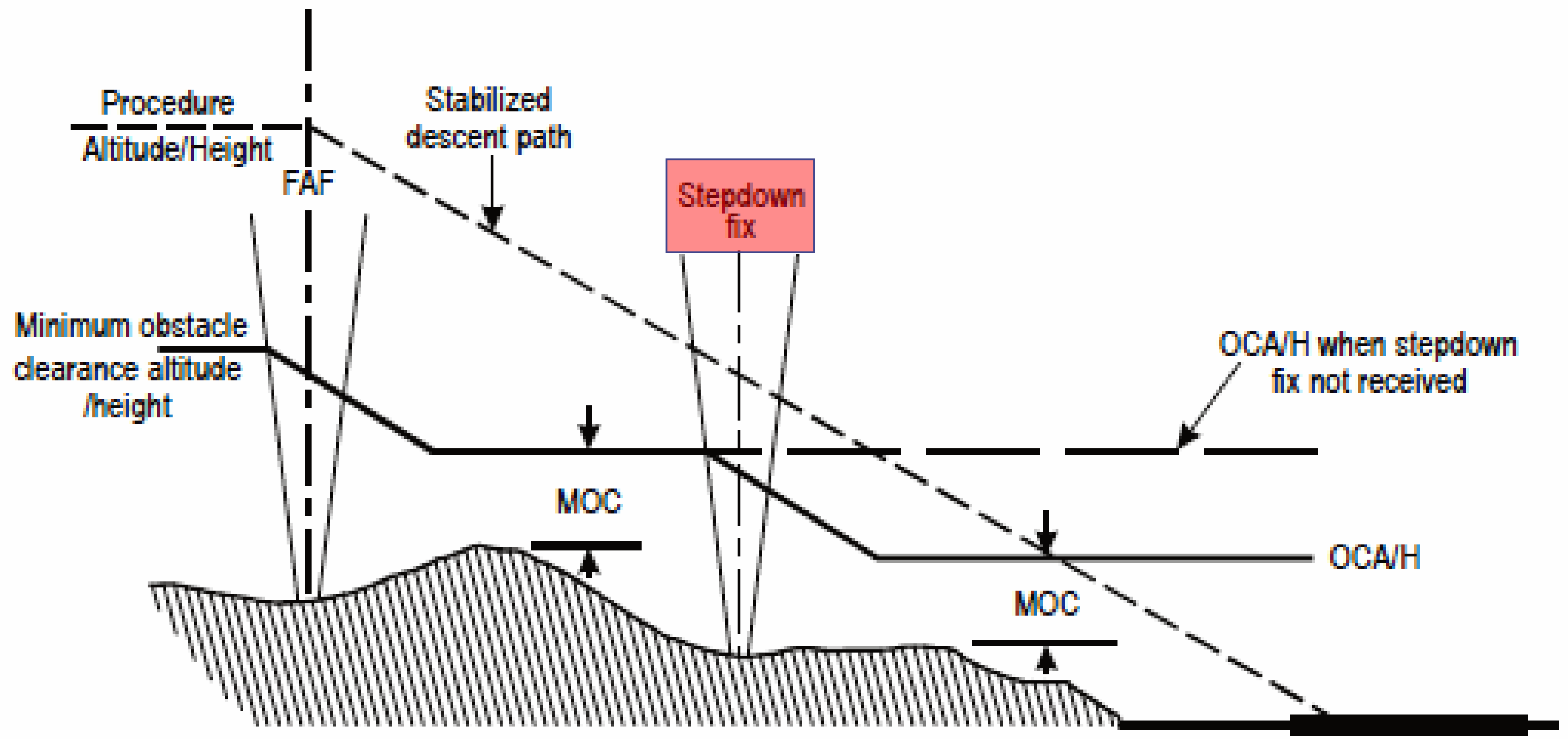
Published Values!!

What's more?

- **Stepdown Fix** – It permits additional descent within a segment by identifying a point at which a controlling obstacle has been safely overflown
  - Used to overfly obstacles
  - Only use it **when necessary** since it may interfere with stabilized approach
  - If used in the Final Segment, normally **one** SDF should be established
  - **Two** could be possible if given by DME distance

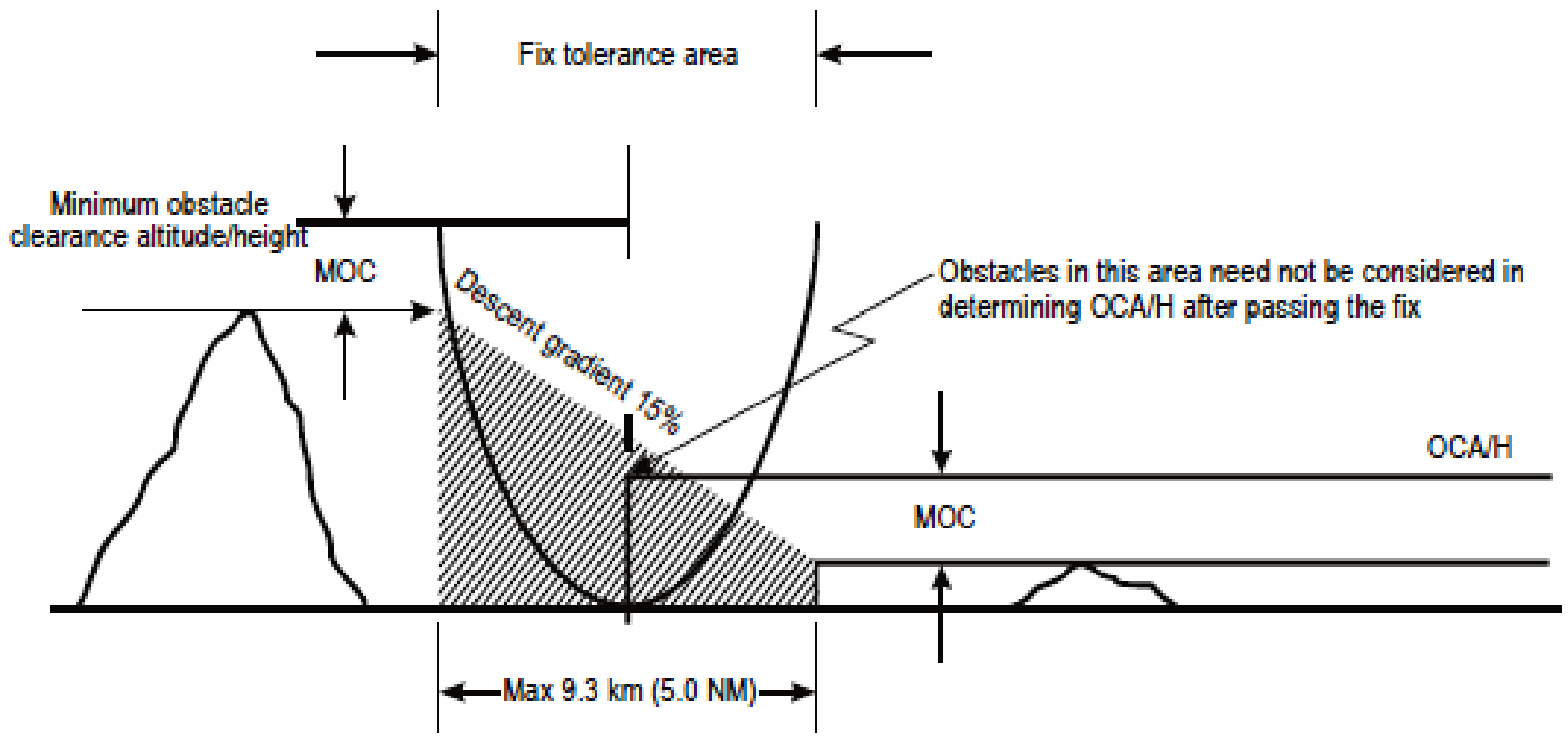
- **Two** descent gradients
- **Two** OCA/H values (with and without SDF)

What's more?



Procedure
Altitude/Height
FAF
Stabilized
descent path
Stepdown
fix
Minimum obstacle
clearance altitude
/height
OCA/H when stepdown
fix not received
MOC
OCA/H
MOC

What's more?



Fix tolerance area
Minimum obstacle clearance altitude/height
MOC
Descent gradient 15%
Obstacles in this area need not be considered in determining OCA/H after passing the fix
OCA/H
MOC
Max 9.3 km (5.0 NM)

What’s more?

- MOC/OCA(H) adjustment
  - Mountainous areas (MOC may be increased)
  - Remote altimeter setting (Buffer: When ＞5NM from THR, add 5’ for each additional NM)
  - Forecast altimeter setting (OCH will be increased)
  - Non-aligned approach (Minimum values of OCH)

VISUAL SEGMENT SURFACE (VSS)

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OVERVIEW

- All straight-in instrument approach procedures shall be protected for obstacles in the visual segment

New Procedures:

VSS shall be applied

Existing Procedures:

Shall be reviewed and VSS shall be applied before15 March 2012

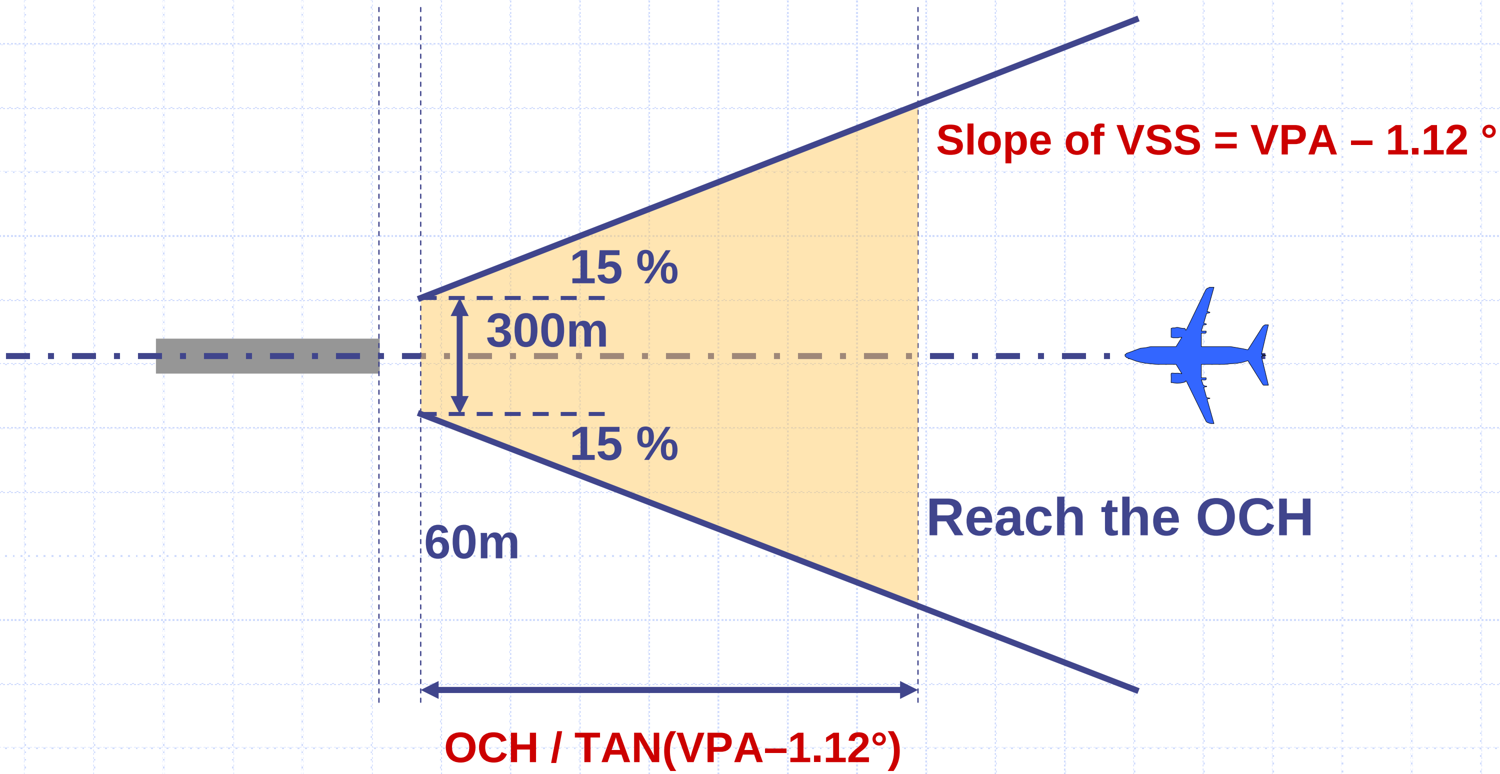
PURPOSE

- Protect the Visual Segment of an approach procedure
- From Runway Threshold (THR) Height up to OCH

AREA

- For NPA
  - Origin at 60m prior to THR
  - Base width of 150m for RWY code 1/2
  - Base width of 300m for RWY code 3/4
  - Splay of 15%
  - End at the point where the height of the surface reaches the OCH
  - Slope of 1.12º less than the promulgated approach procedure angle

AREA

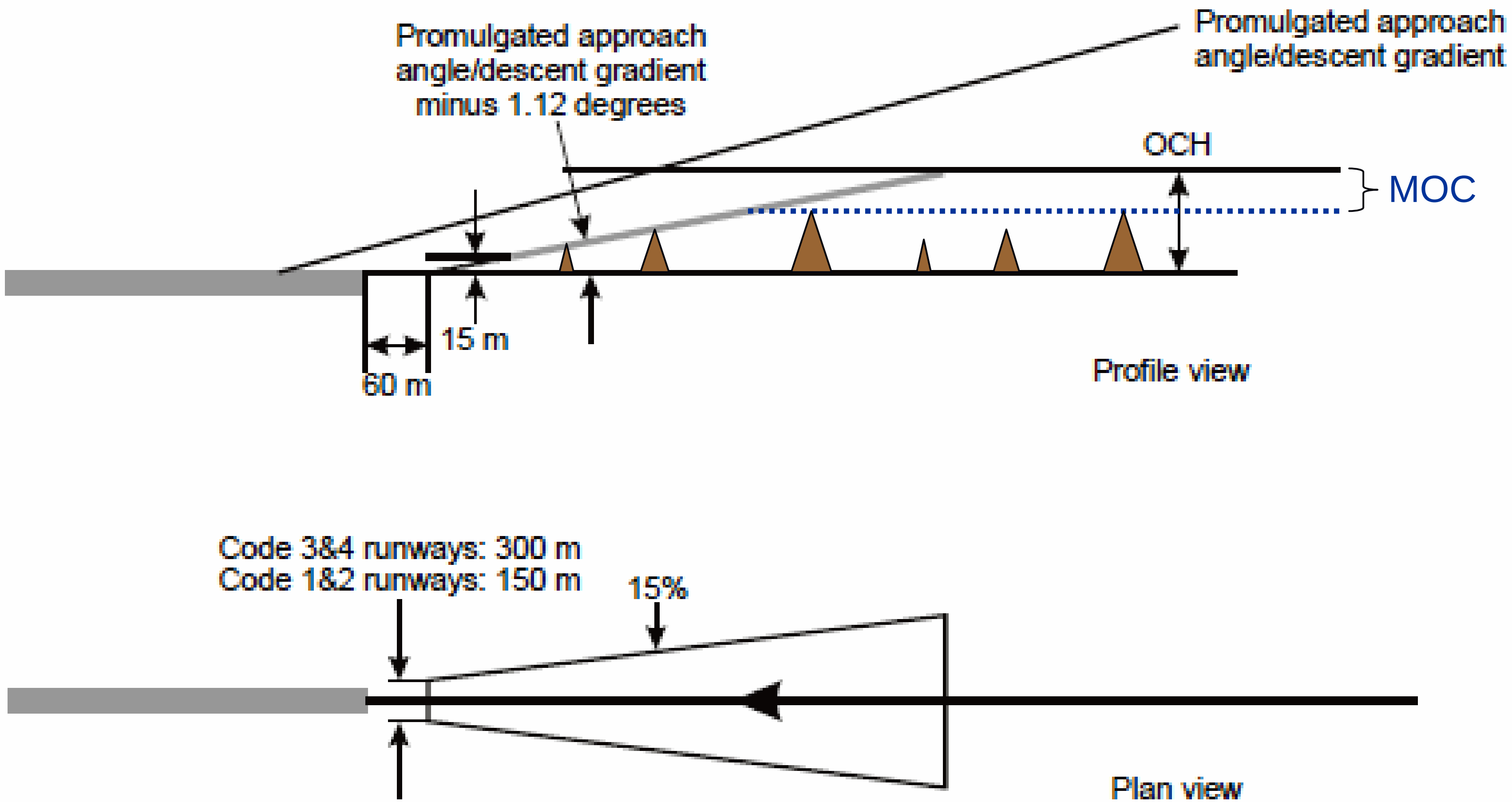

Slope of VSS = VPA – 1.12 °
15 %
300m
15 %
60m
Reach the OCH
OCH / TAN(VPA–1.12°)

AREA

- No obstacle can penetrate except obstacles with height above THR less than 15m
- For example, if a tree of 14m penetrates VSS, it is still acceptable
- Temporary moving obstacles such as aircraft at the holding point are allowed

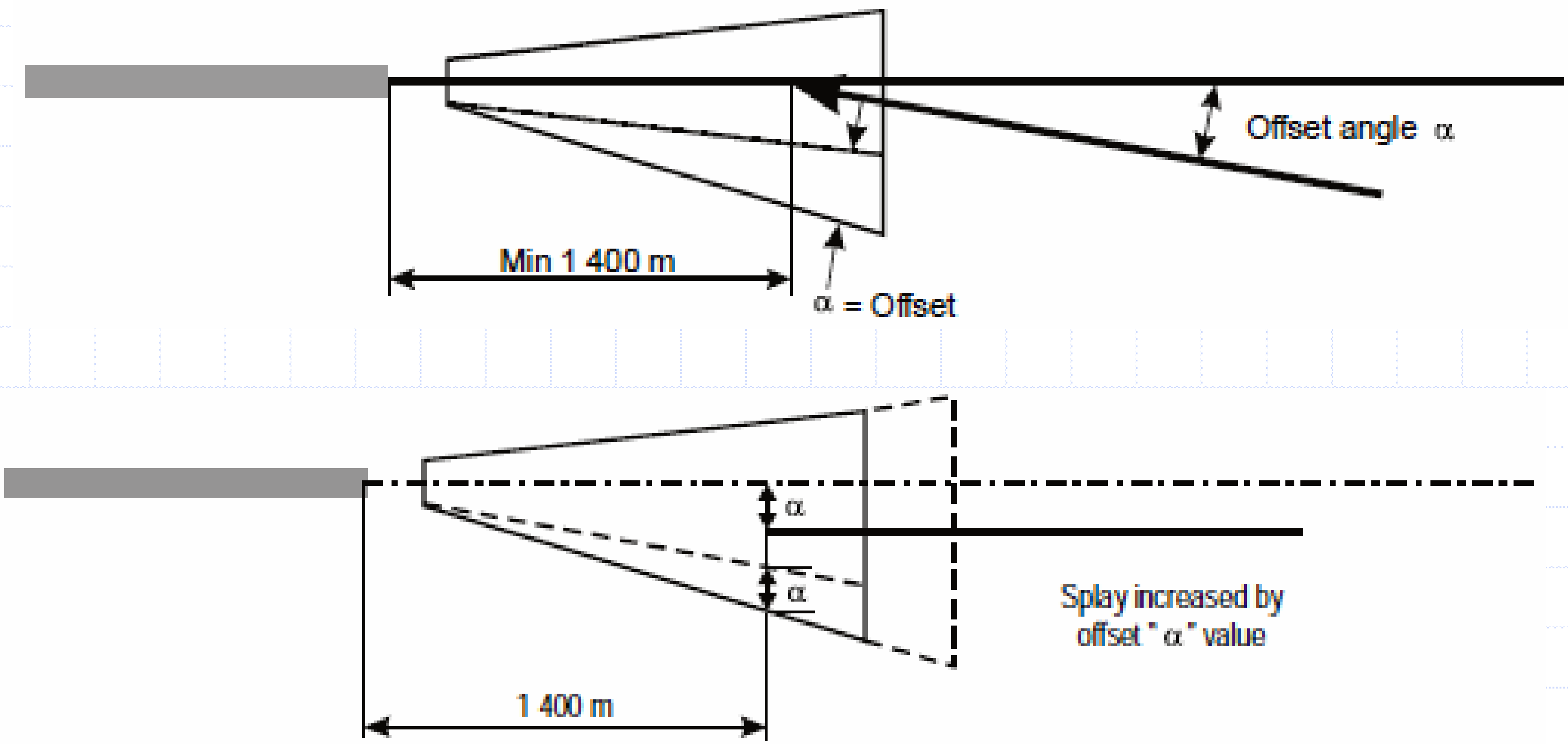
AREA

- VSS for NPA



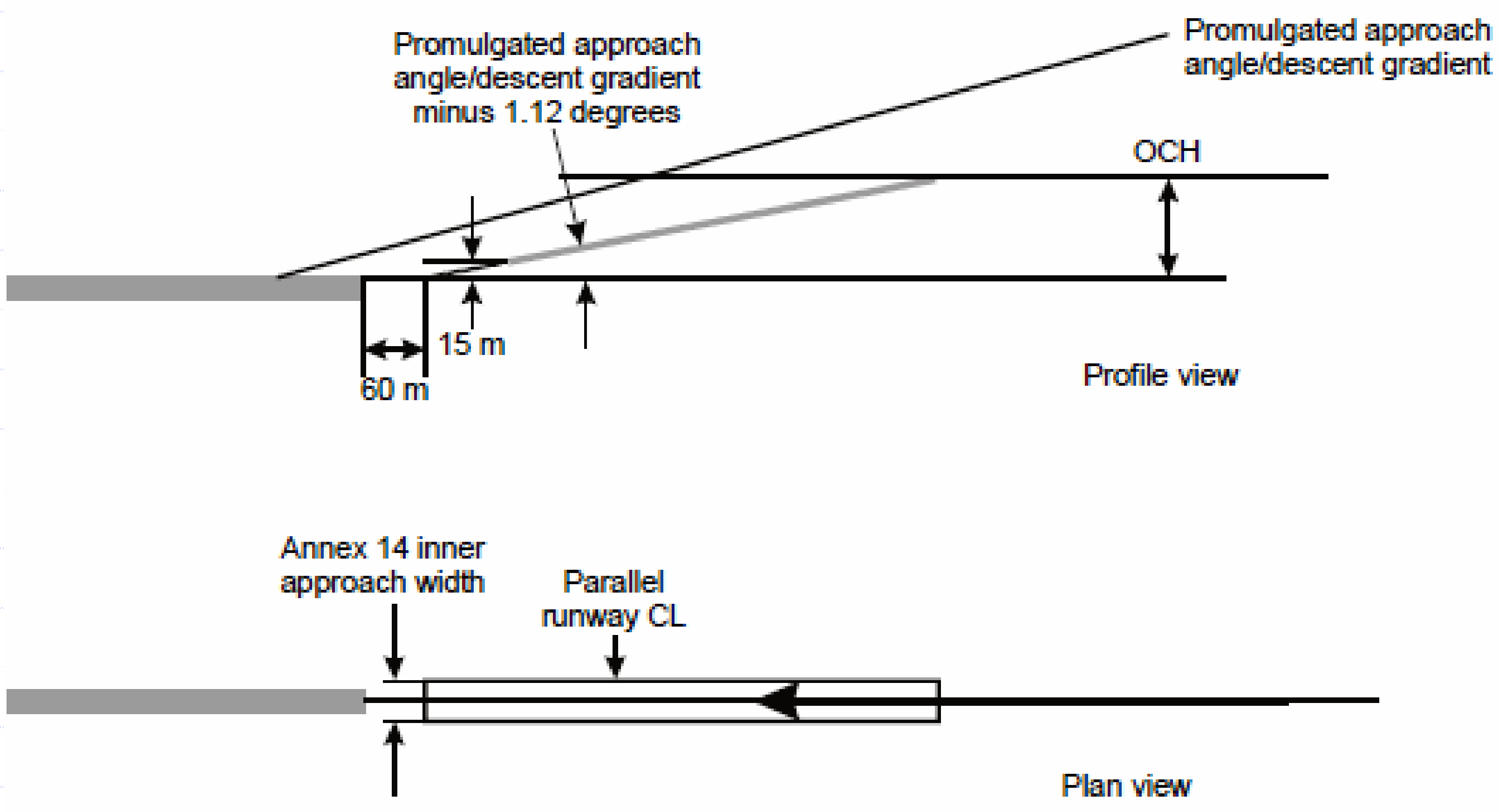
AREA

- ➢VSS for NPA



AREA

- VSS for ILS



PENETRATION

- Penetration of VSS
  - Possible Mitigation
    - Increase the procedure gradient
    - Threshold displacement

MISSED APPROACH PROCEDURE NPA

Doc 8168

Part Ⅰ Section 4 Chapter 6

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CLICK HERE

OBJECTIVE

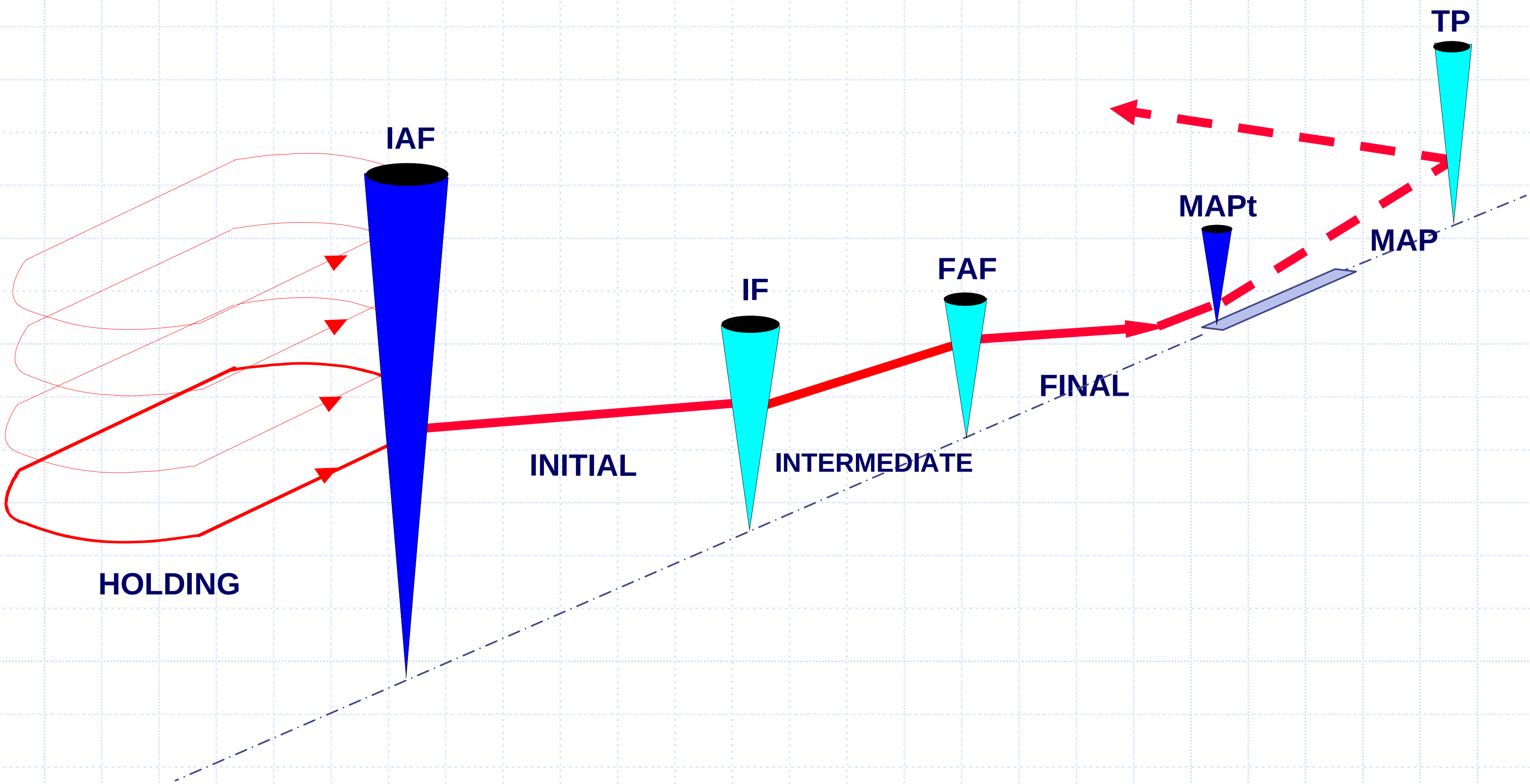
At the end of this lecture, trainee should be able to:

- describe MAPt requirements in different NPAs.
- to compute Missed App Trajectory computation parameters
- construct the protection areas of a straight missed approach.

PURPOSE

- To fly along a safe path in case of an unsuccessful attempt for an approach to land.

OVERVIEW



REQUIREMENT

- A Missed Approach Procedure shall be established for each instrument approach.
- It shall specify a point where the procedure begins and a point where it ends.

START

- Missed approach is initiated at
  - at the decision altitude height (DA/H) in precision approach procedures or approach with vertical guidance (APV); or
  - at the missed approach point (MAPt) in non-precision approach procedures.

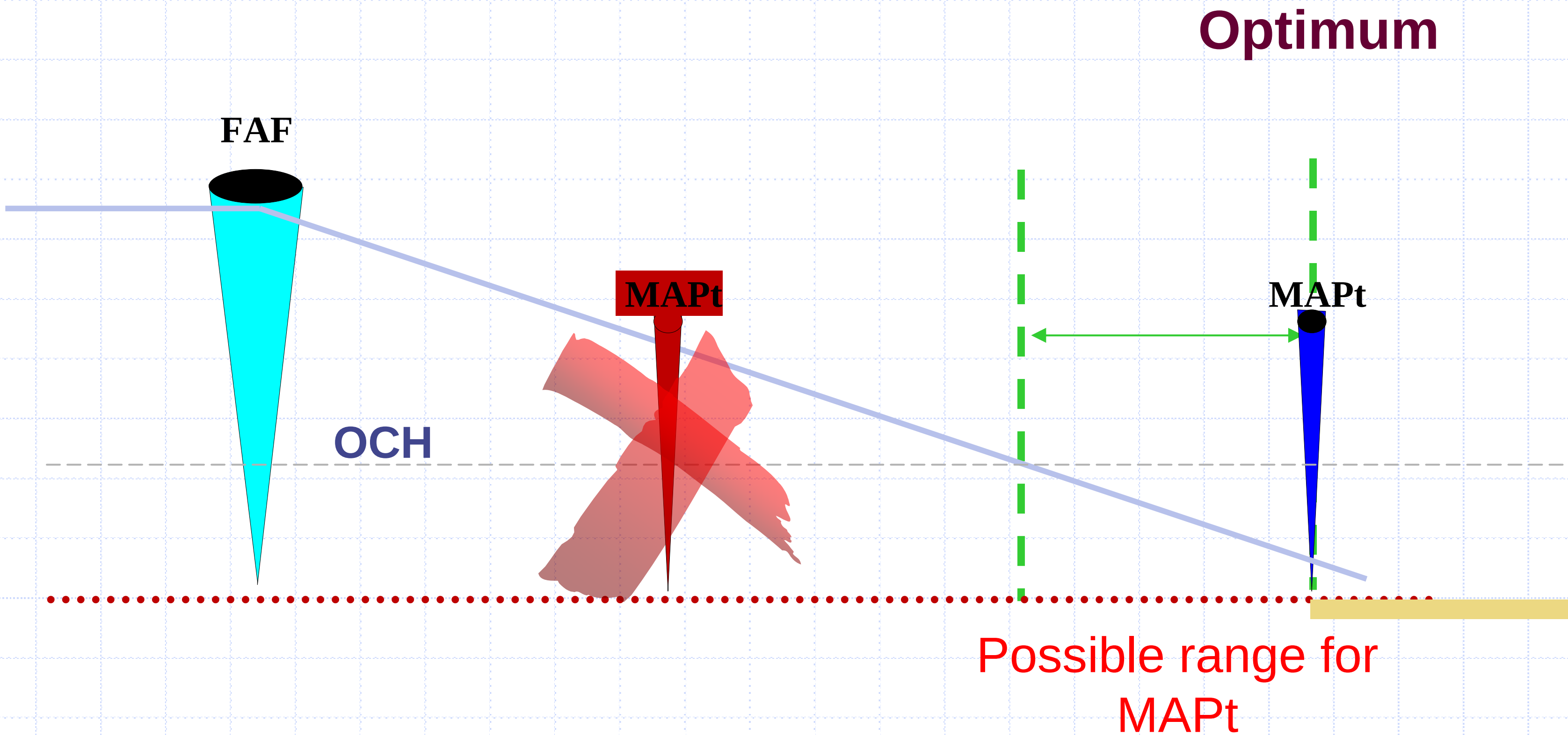
May be initiated earlier

END

- Missed approach shall terminate at an altitude/ height sufficient to permit
  - initiation of another approach; or
  - return to a designated holding pattern; or
  - resumption of en-route flight.

OVERVIEW

- MAPt Location



TYPES of MAPt

- Procedures without FAF – by a facility or fix at MAPt
- Procedures with FAF
  - by a facility or fix at MAPt
  - flight distance from nominal FAF (timings)

If operational advantage, both can be published

TYPES of MAP

- Straight MAP: FAT & MAP track differ by ≤ 15°
- Turning MAP: FAT & MAP track differ by > 15°

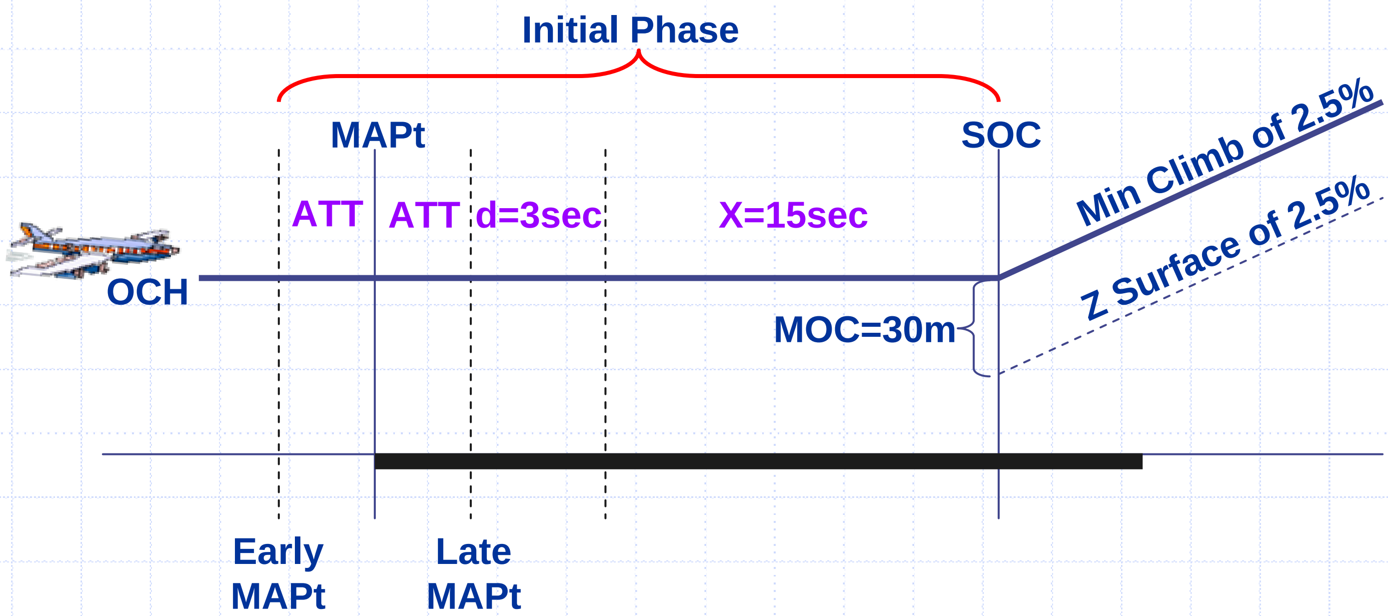
CONTENTS

- 3 Phases:
  - Initial Phase – From the Earliest MAPt to the Start of Climb (SOC)
  - Intermediate Phase – Period of straight stable climb with 30m/98’ MOC
  - Final Phase – Begins when 50m/164’ MOC is achieved or a Turn is specified; and ends at e.g. Holding Fix

INITIAL PHASE

- It is a level transition segment during which the aircraft accelerates and configure to achieve 2.5% climb
- From: Early MAPt
- To: SOC (It is not a fix and it is never displayed on chart)
- 3 Components in the Initial Phase:
  - Early & Late ATT NAV Tolerance of the MAPt (No NAV TOL if the MAPt is over a facility)
  - Pilot Reaction (d=3 sec)
  - Aircraft Transition (x=15 sec)

INITIAL PHASE



- Parameters for Calculation:
  - Final Approach IAS converted to TAS at AD EL
  - Plus 10kts Tail Wind

INITIAL PHASE – EXERCISE 1

- Calculate the Distance (MAPt-SOC) for CAT C aircraft with AD EL of 2000’ and NAV ATT of +/-0.3NM:

  IAS (Final Approach) = 160kts

  TAS (at 2000’) = 160*1.0567 = 170kts

  170kts + 10kts Tail Wind = 180kts

  (d+x) = 180kts*18sec/3600 = 0.9NM

  ∴ **MAPt-SOC = 0.3+0.9 = 1.2NM**

- For the same RWY, calculate MAPt-SOC for CAT D:

  ∴ **MAPt-SOC = 0.3+1.03 = 1.33NM**

INITIAL PHASE – EXERCISE 2

- Calculate MAPt-SOC for CAT C aircraft with AD EL of 3000' Early ATT=0.75NM and Late ATT = 0.66NM:

∴ MAPt-SOC = 0.91+0.66 = 1.57NM

For the same MAPt in a procedure, MAPt-SOC is different for different CAT of aircraft.

But bear in mind that SOC is not a fix and it is never displayed on chart...

INITIAL PHASE

Protection Area :

- Continuation from guidance on Final Segment
  - No change in track guidance allowed

- Continuation of final approach protection area

INITIAL PHASE

MOC:

- MOC of Final Segment
- May be reduced backward from Intermediate segment extension in transitional distance

CONTENTS

- 3 Phases:
  - Initial Phase
  - Intermediate Phase
  - Final Phase

INTERMEDIATE PHASE

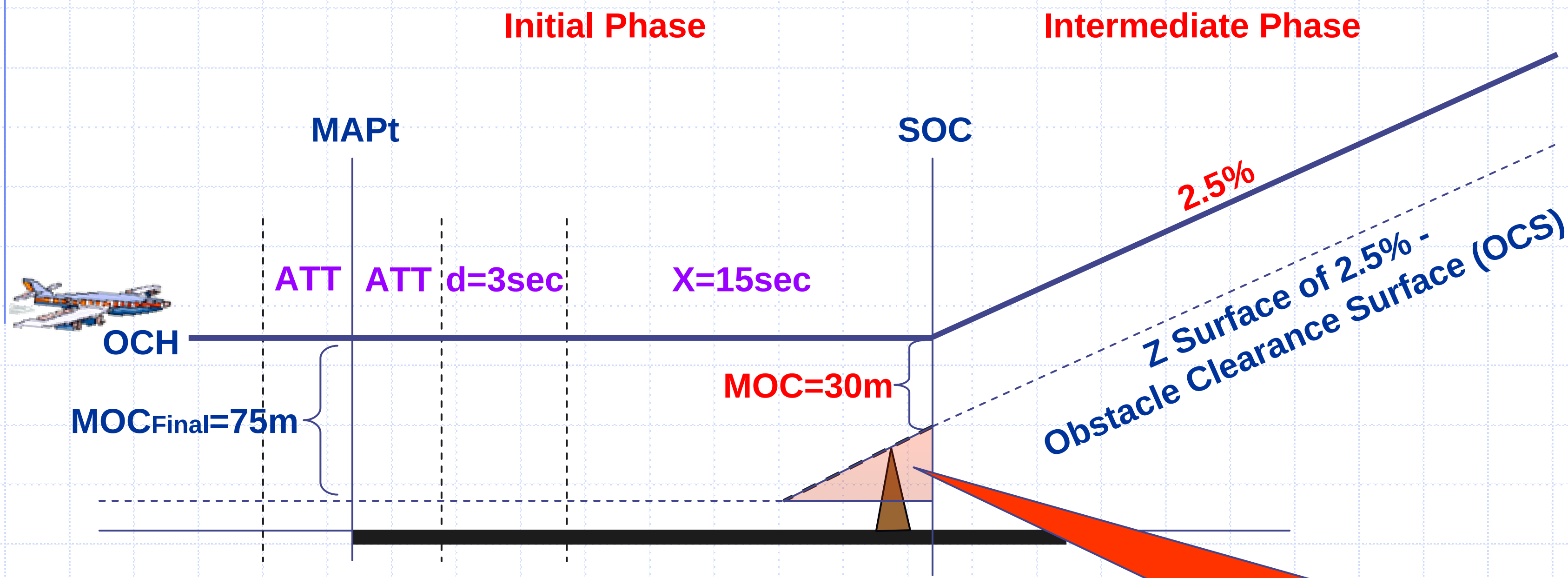
- It is a stable and straight climb segment with minimum gradient of 2.5% (Max: 5%)
- Track can be changed by maximum of 15^{o}
- Protection area based on track guidance from Final Approach Segment or from other suitable facilities

- Operational advantage may be obtained using suitably located facilities to reduce the dimensions.

INTERMEDIATE PHASE

- MOC: 30m/98'
- Begins: SOC
- Ends: A point where 50m/164' MOC is achieved & thereafter maintained and/or where a turn is designated (50m MOC is also required to designate a turn)

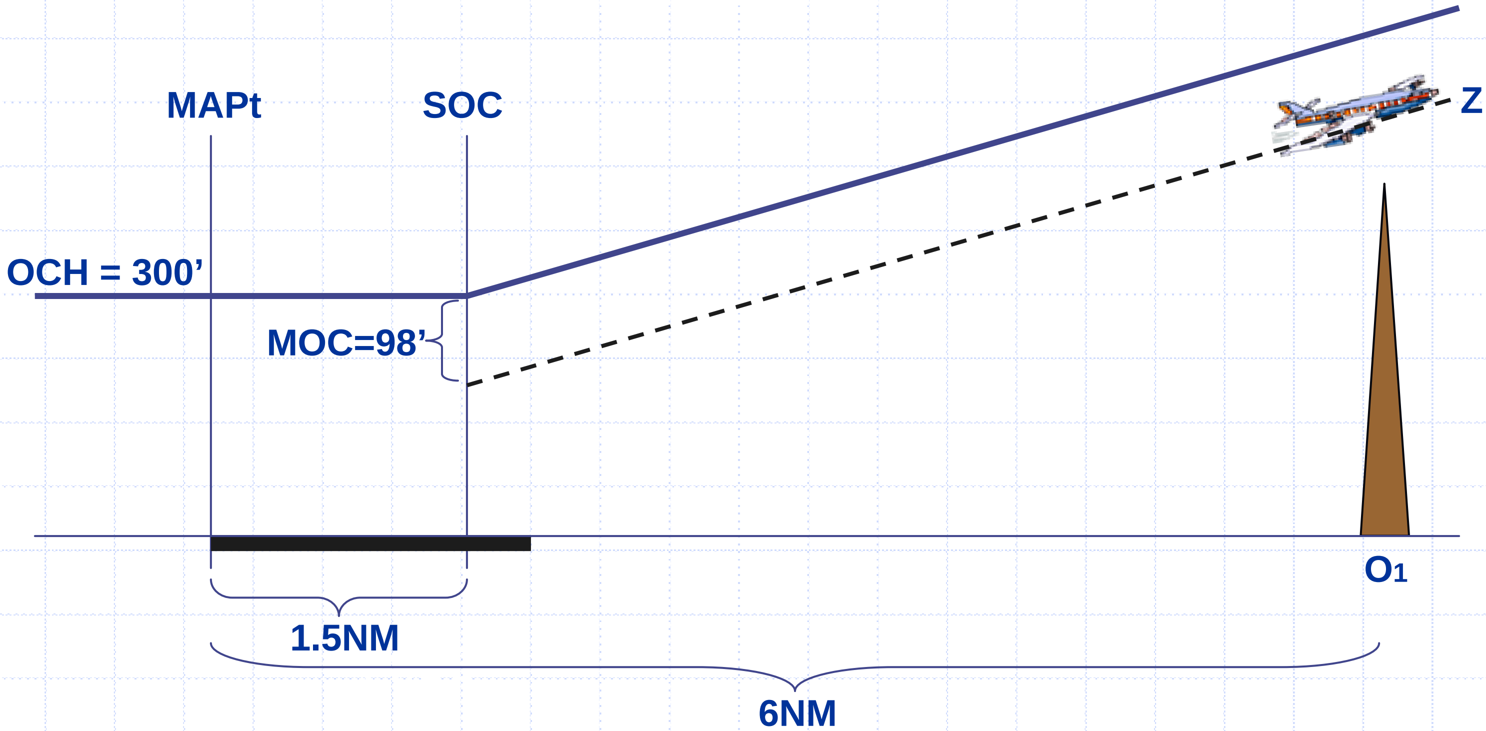
INTERMEDIATE PHASE



OCS for the Intermediate Phase may be extended back into the Initial, but not further than the nominal MAPt

INTERMEDIATE PHASE – EXERCISE 1

- What is the maximum height of O_1 (H_{max})?



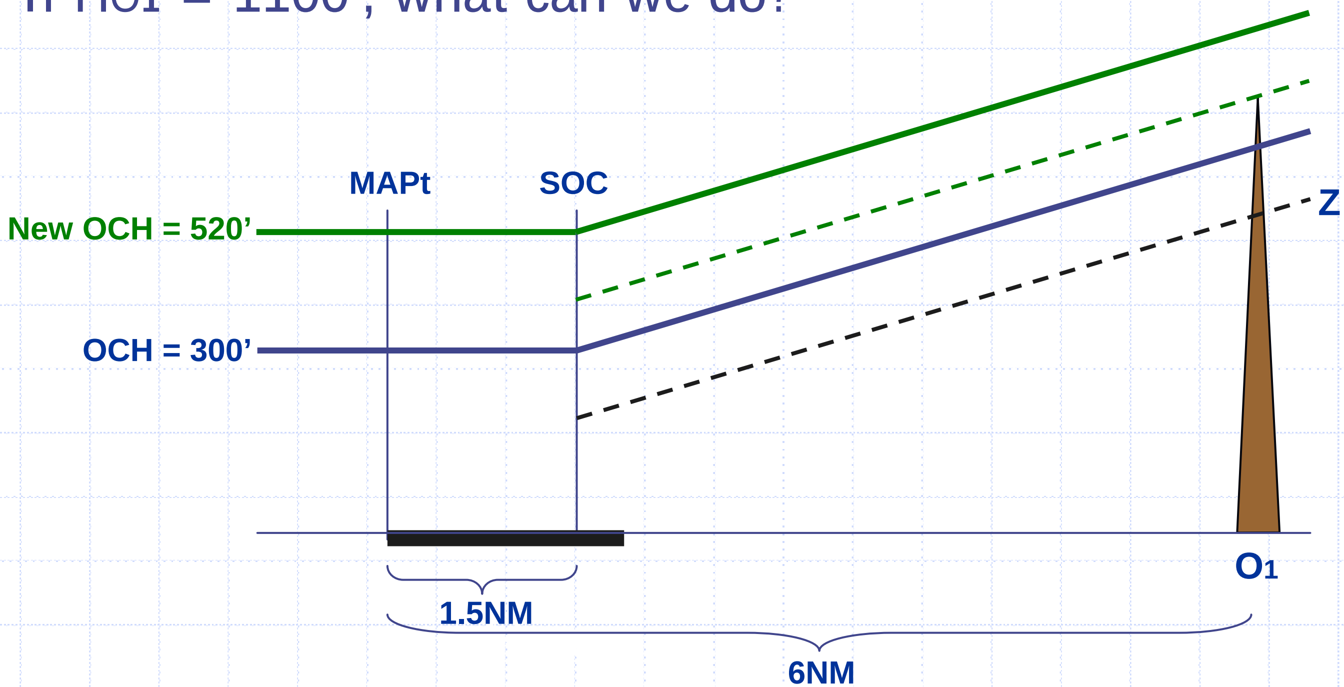
- Hint: Find the height of Z-Surface over O_1

  $Z_z = 202 + 683 = 885'$

  $\therefore H_{max} = 885'$

INTERMEDIATE PHASE – EXERCISE 1

- If H_{O1} = 1100’, what can we do?



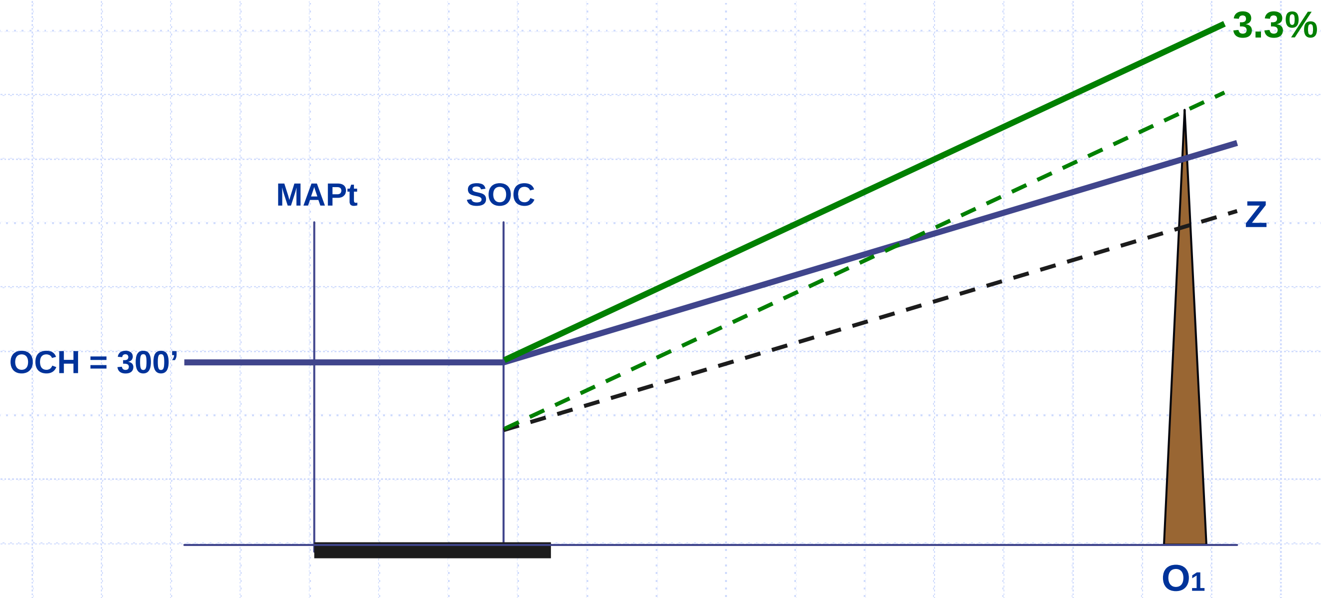
- Penetration: 1100-885 = 215’

Method 1:

New OCH = 300 + 215 = 515’ ≈ 520’ (↑)

Rare!
Not Preferable

INTERMEDIATE PHASE – EXERCISE 1



Method 2: Establish a new Climb Gradient

Hint: MAP Climb Gradient = ($RH_{A/C}$–OCH)/DIST

New Gradient = 3.3% (↑)

Publish: OCH for 2.5% = 520’

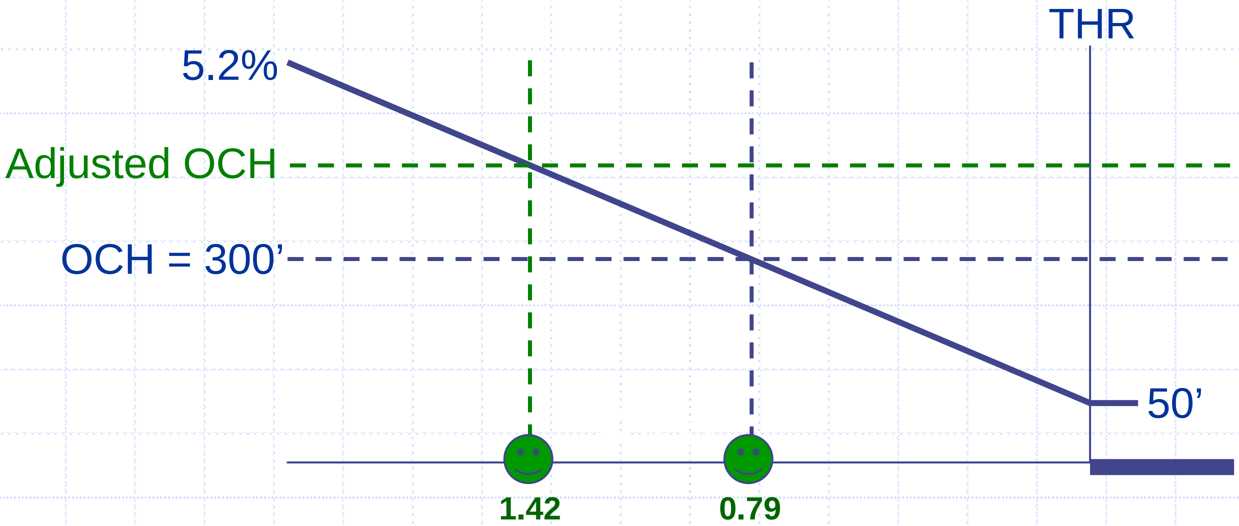
OCH for 3.3% = 300’ (until passing 1198’..)

INTERMEDIATE PHASE – EXERCISE 1

Method 3: Move the MAPt

By 1.42NM (↑)

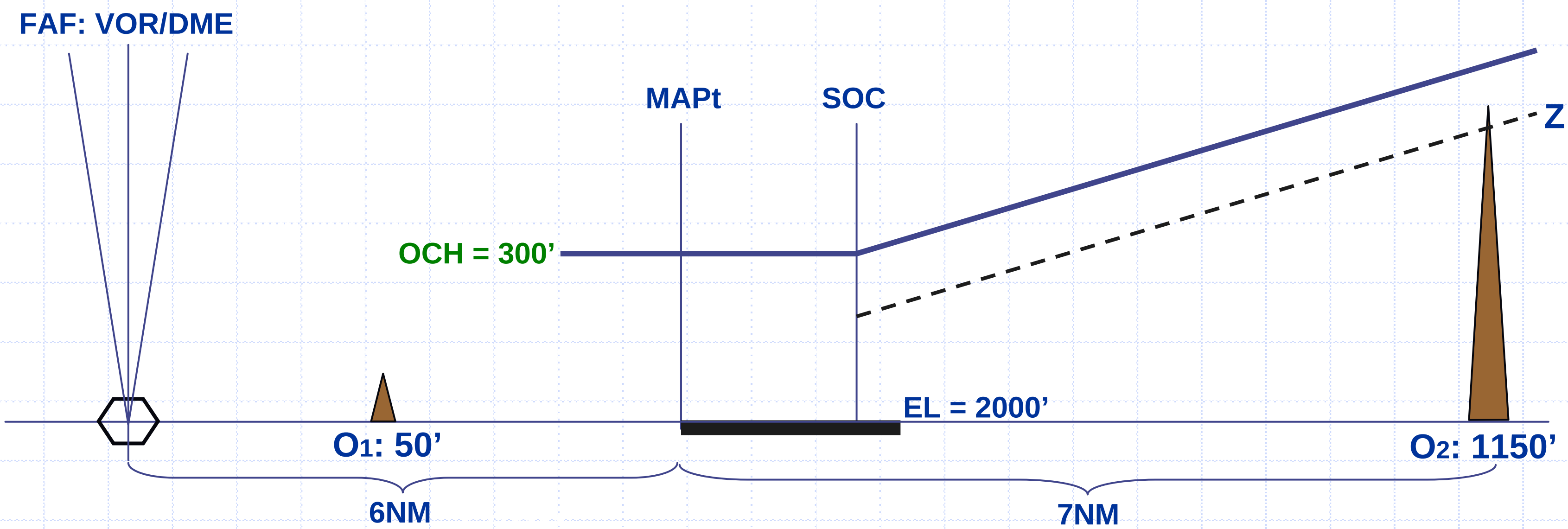
Earliest Location of MAPt?



∴ Earliest Location of MAPt = 0.79NM (↓)

INTERMEDIATE PHASE – EXERCISE 2

- Calculate OCH for CAT C:



Hint: Calculate OCA/H for Final

Calculate OCA/H in MAP

If penetration, use methods 1-3 of Exercise 1

For O1: OCA/H = 300’/2300’

INTERMEDIATE PHASE – EXERCISE 2

TAS (+10kts Tail Wind) = 180kts (↑)

DME TOL = 0.25 + 0.0125*d
= 0.325NM

MAPt to SOC = 1.23NM (↑)

Calculate Hmax for O2: H_{max} = 1078’ (↓)

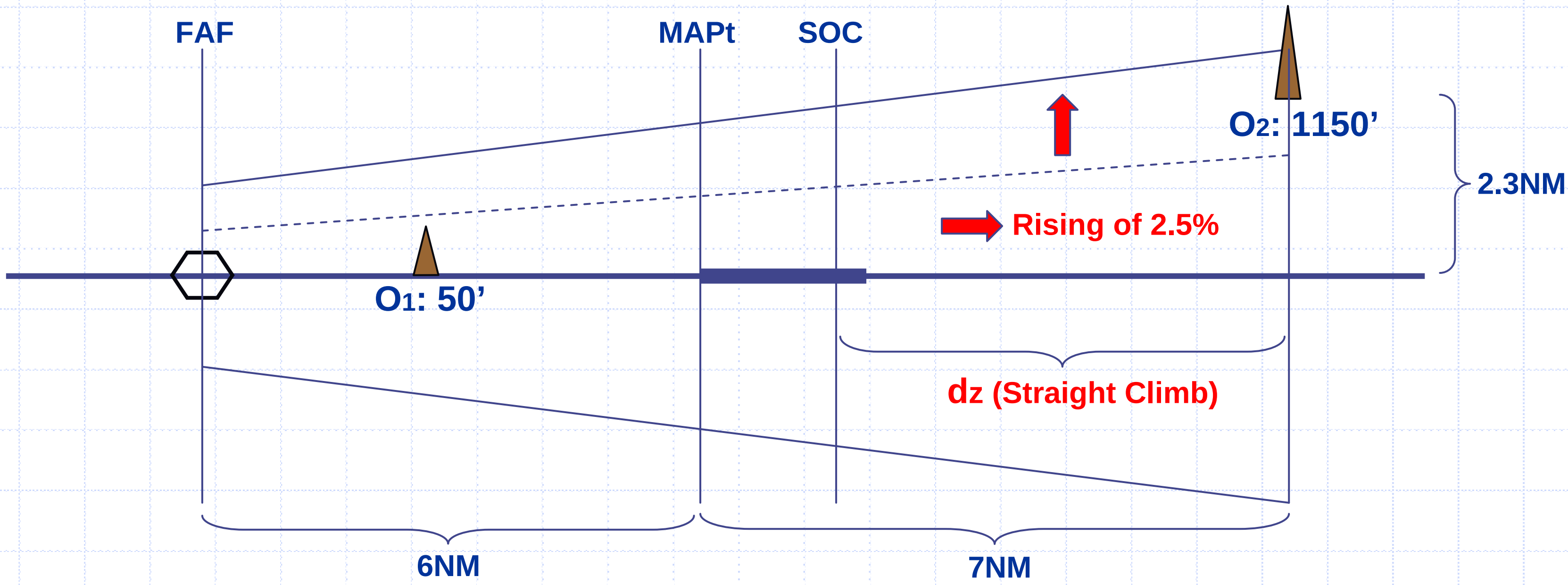
Method 1: Penetration = 72’

Method 2: New Gradient = 2.8% (↑)

Method 3: Move MAPt to DME 5.5NM

INTERMEDIATE PHASE – EXERCISE 2

- If O_2 is offset the CL by 2.3NM, any penetration?



w/2 at O_2 = 2.79NM

MOCs at O_2 = 35’

Penetration = 9’

CONTENTS

- 3 Phases:
  - Initial Phase
  - Intermediate Phase
  - Final Phase

FINAL PHASE

- Begins when:
  - 50m/164’ MOC is achieved
  - Or a Turn is specified
- Ends at:
  - Holding pattern
  - New approach
  - En-route

FINAL PHASE

- Turn is required to
  - avoid obstacle in the direction of straight MAP
  - reach another trajectory
- Turning MAP
  - Track change from Final to MAP **> 15º**

FINAL PHASE

- Turn at a designated altitude/height
  - TNA/H
- Turn at a designated turning point
  - "TP"
- Turn over the MAPt

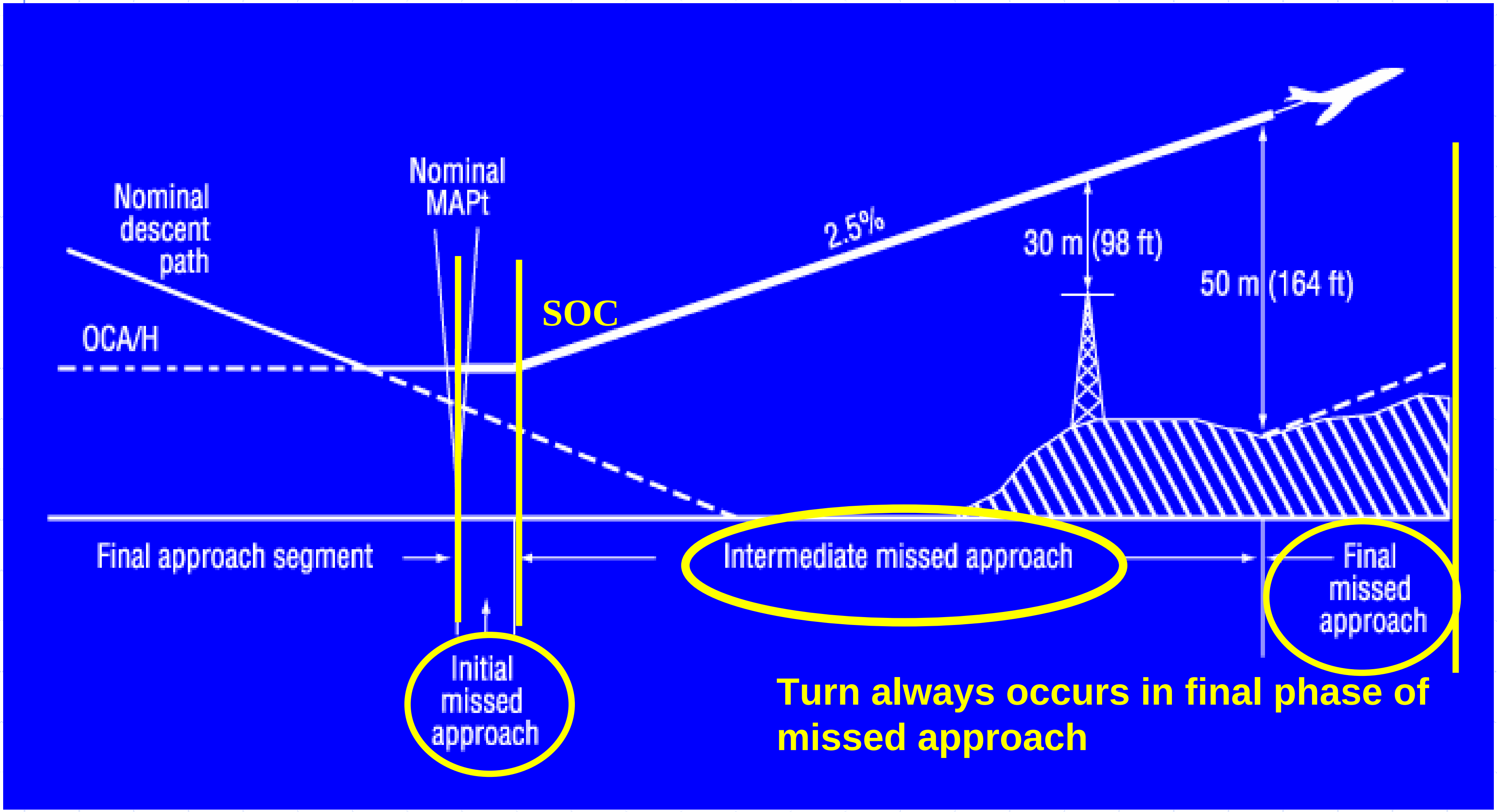
- To obtain the minimum OCA/H it may be necessary to adjust the designated turn altitude or turning point (TP).
- The number of variables is such that this may involve a trial and error process.

FINAL PHASE

Parameters:

- IAS: Final MAP Speed (may be reduced to Intermediate MAP Speed)
- Altitude: AD EL + 1000' (300m) or Defined TNA
- Temperature: ISA +15º
- Wind: 30 kts
- Pilot Reaction Time: 3 sec
- Bank Establishment Time (15º Bank Angle): 3 sec
- MOC: 50 m / 164 ft

MISSED APPROACH PHASES - REVIEW



FINAL PHASE – TNA/H

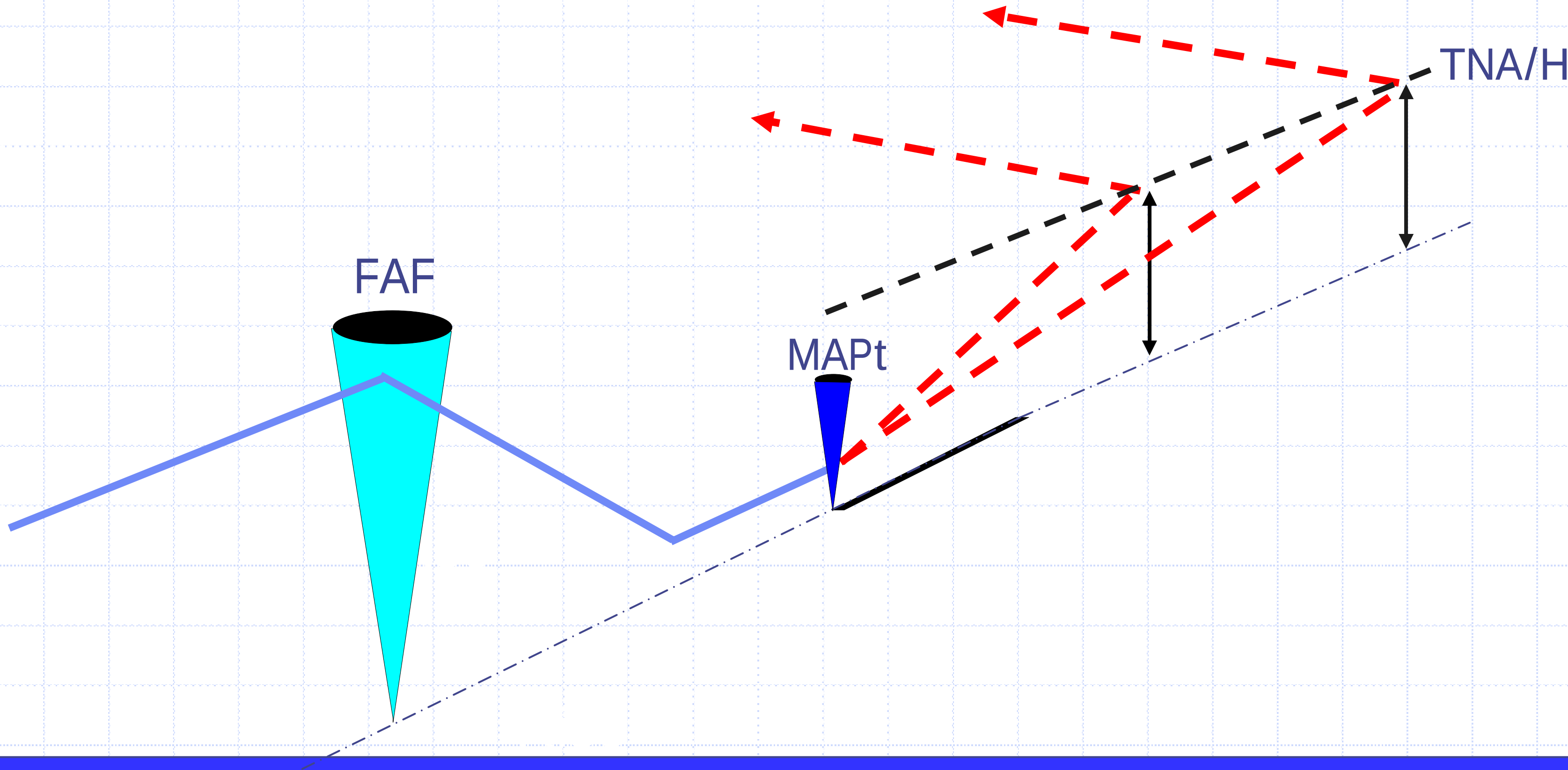
- Turn at Altitude/Height (TNA/H)
  - Aircraft continues on the Final Track until reaching a specified Altitude/Height (TNA/H), then to a specified track
- Early Turn Point
  - Early MAPt Tolerance
  - It is the early ATT for the FAF unless a statment on the Approach Chart that prohibits turns prior to the MAPt is included (‘No turn prior to MAPt’)
- Late Turn Point
  - Point (Distance) where the aircraft climb gradient reaches the TNA/H, plus ‘C’ (6 sec)

FINAL PHASE – TNA/H

- Turn Initiation Area (TIA) is bounded by:
  - Early TP (Early MAPt or FAF)
  - Point where the aircraft climb gradient reaches the TNA/H
  - On the sides by the trapeziod for the NAV guidance

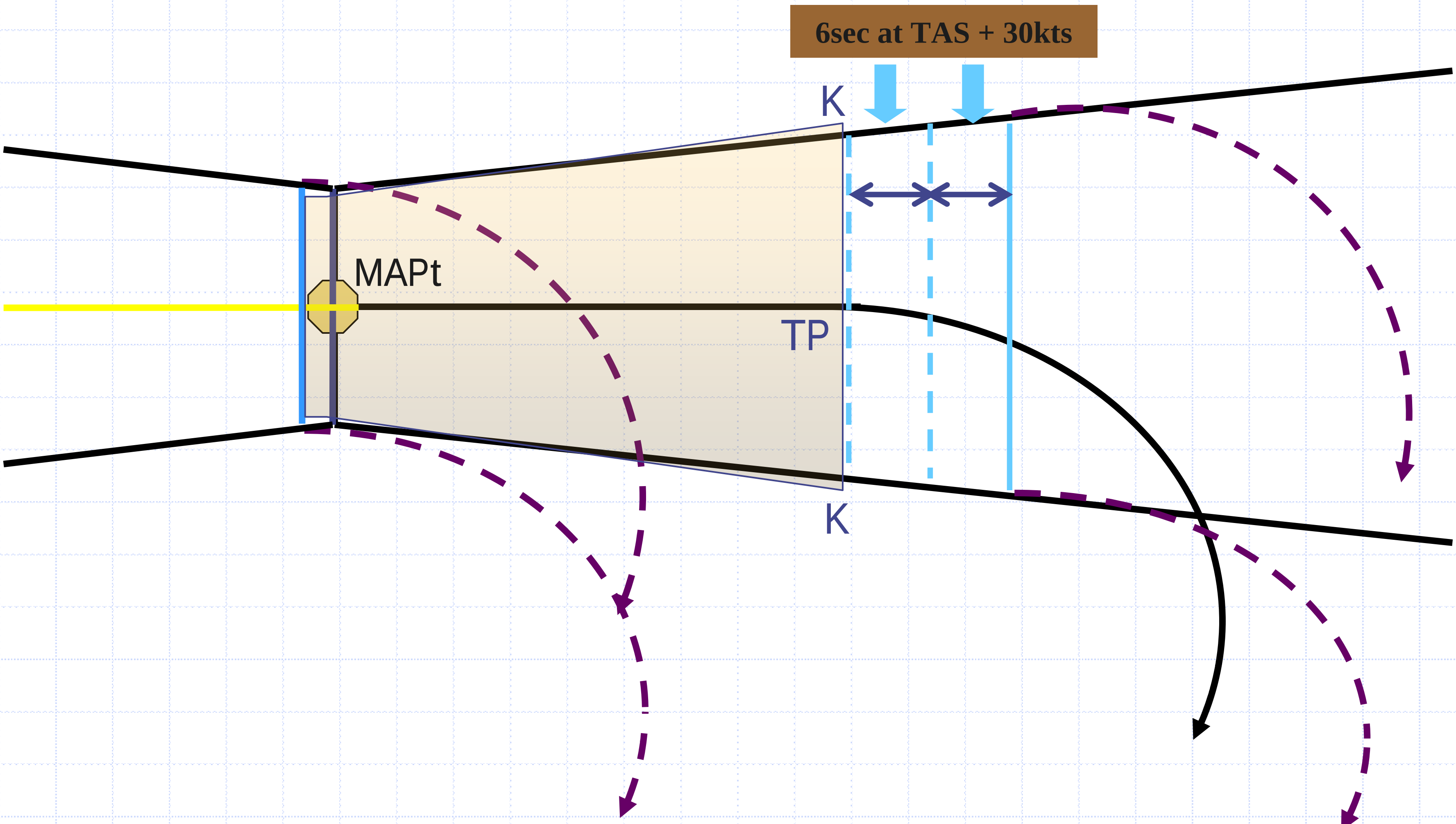
FINAL PHASE – TNA/H

- Turning at Altitude/Height (TNA/H)
  - E.g. At 1000' turn left to ... & no turn before the MAPt



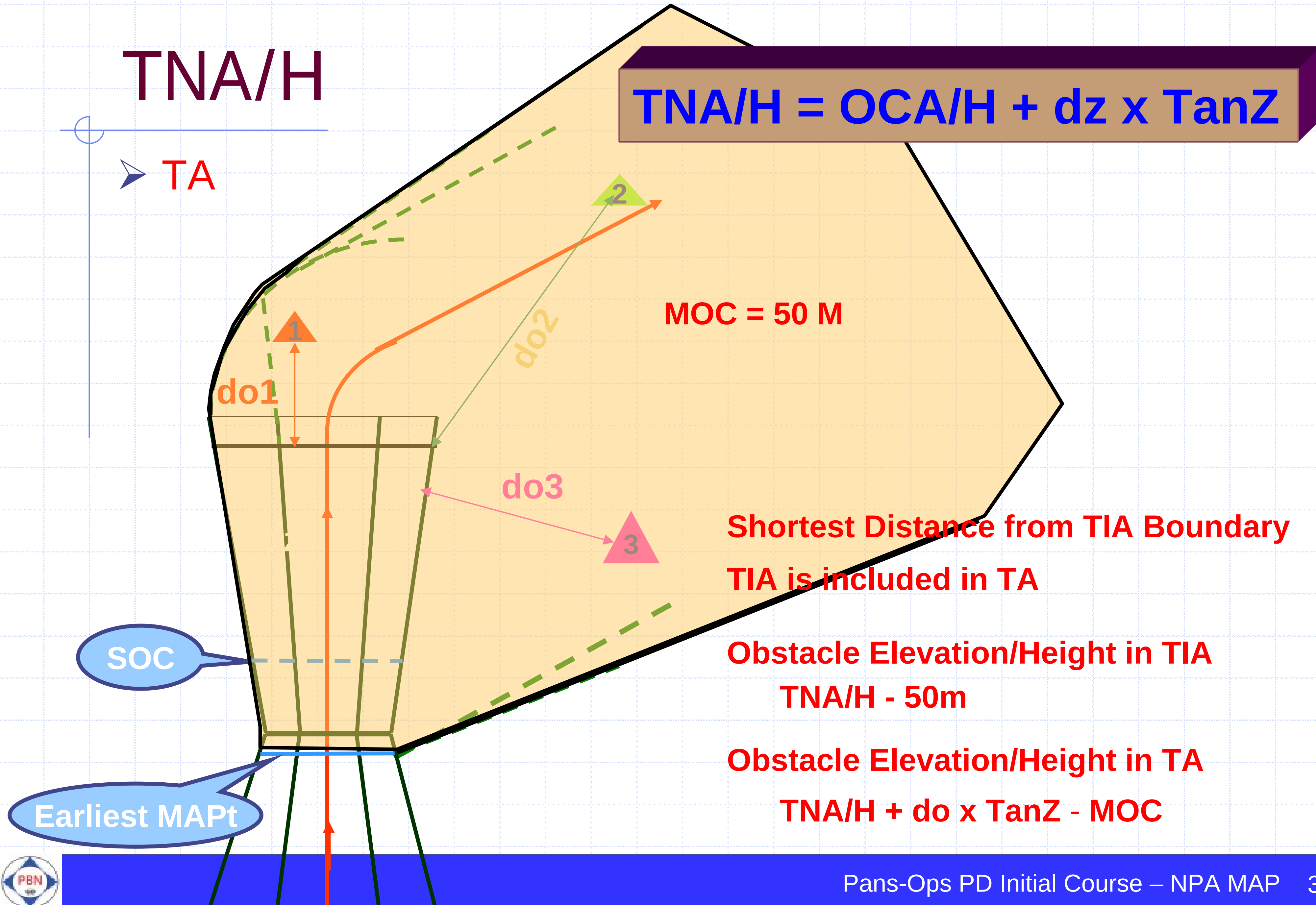
FINAL PHASE – TNA/H

- TIA: All points where turn can be initiated



TNA/H

- TA



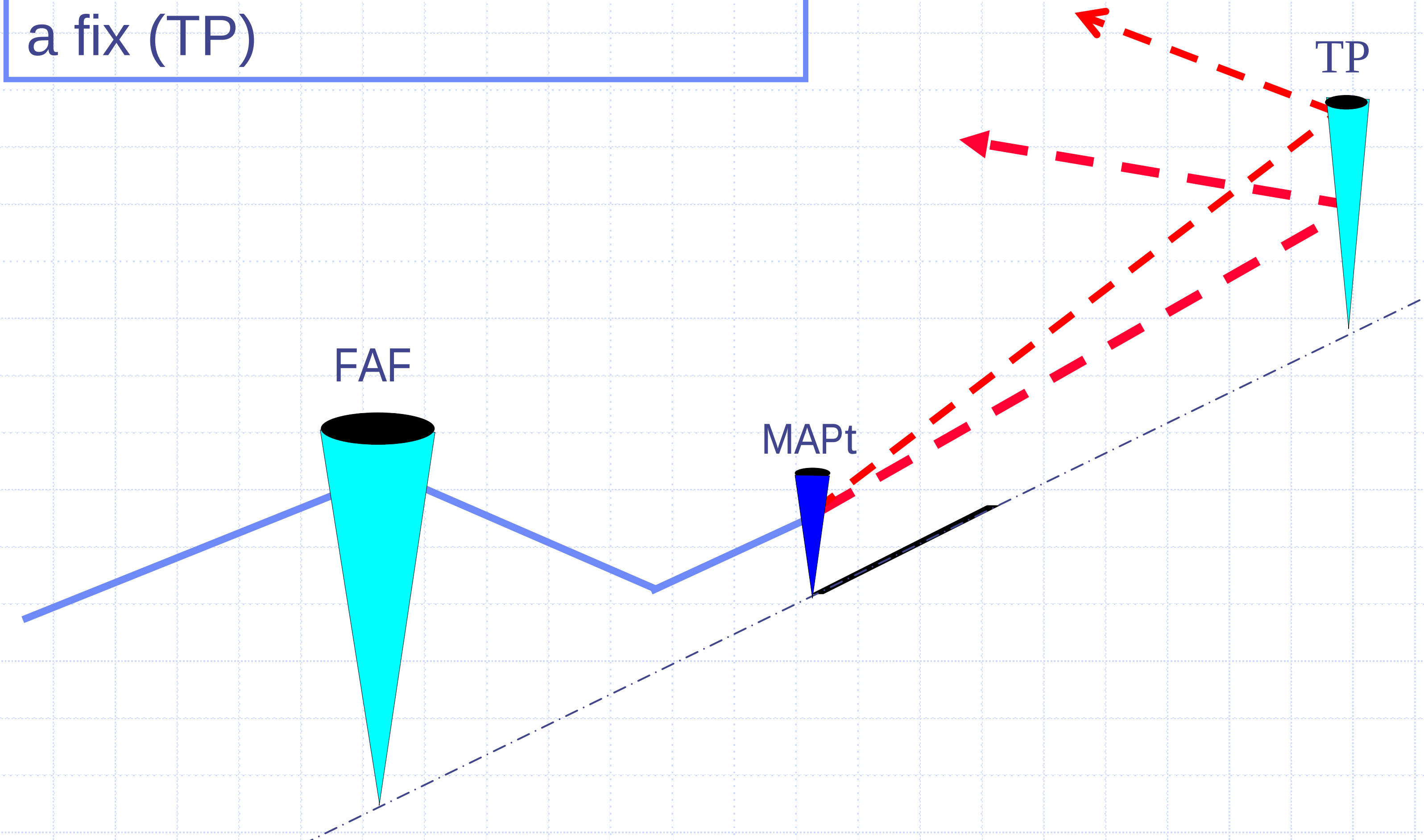
TNA/H = OCA/H + dz x TanZ
MOC = 50 M
2
1
do1
do2
do3
3
SOC
Earliest MAPt
Shortest Distance from TIA Boundary
TIA is included in TA
Obstacle Elevation/Height in TIA
TNA/H - 50m
Obstacle Elevation/Height in TA
TNA/H + do x TanZ - MOC

TNA/H ADJUSTMENTS

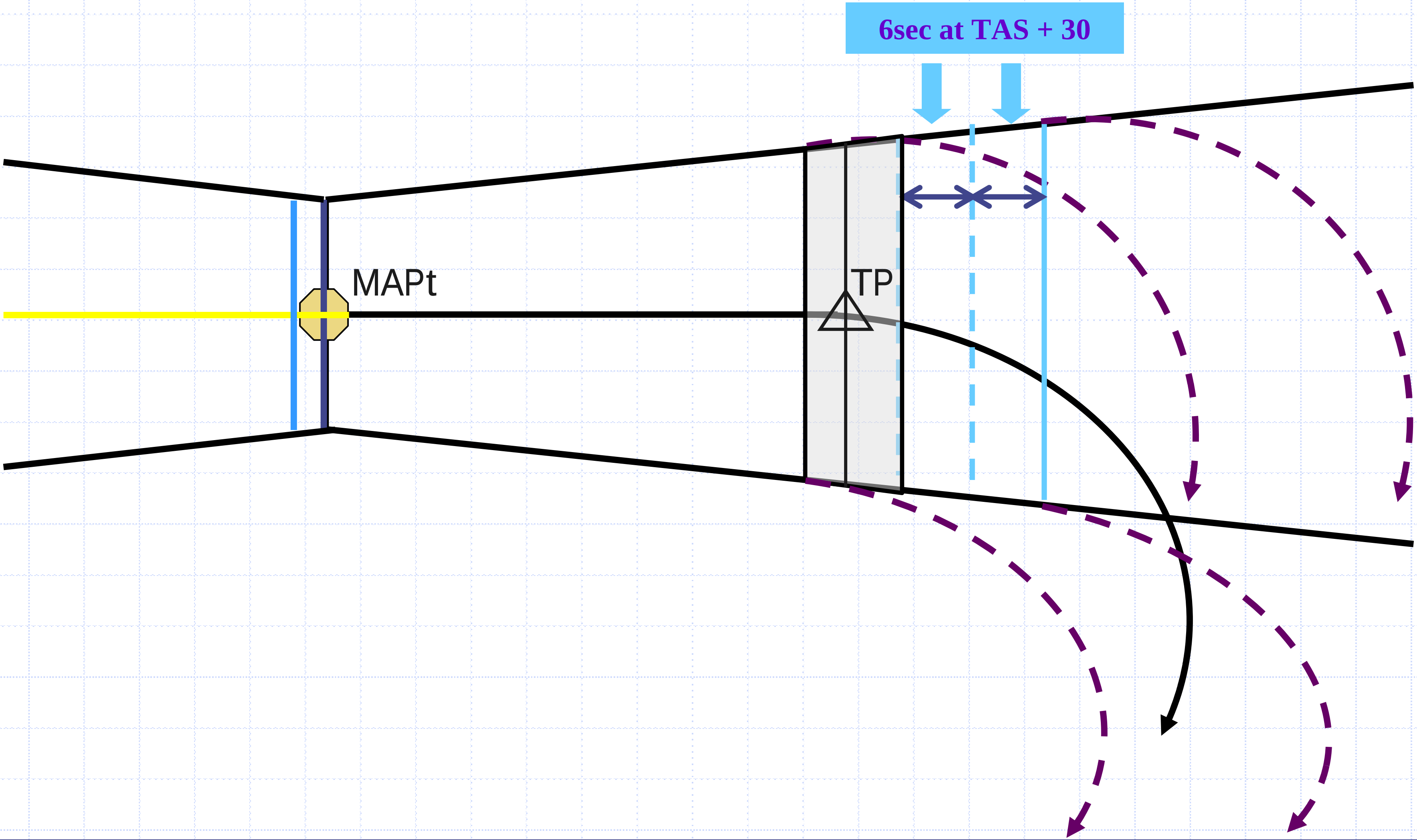
- Without changing OCA/H. Latest TP will be moved and the areas redrawn accordingly;
- move SOC back to increase dz. MAPt and consequently earliest TP will be moved and the turn areas extended accordingly; and
- increase OCA/H.

FINAL PHASE – TP

Aircraft turns when flying over a fix (TP)

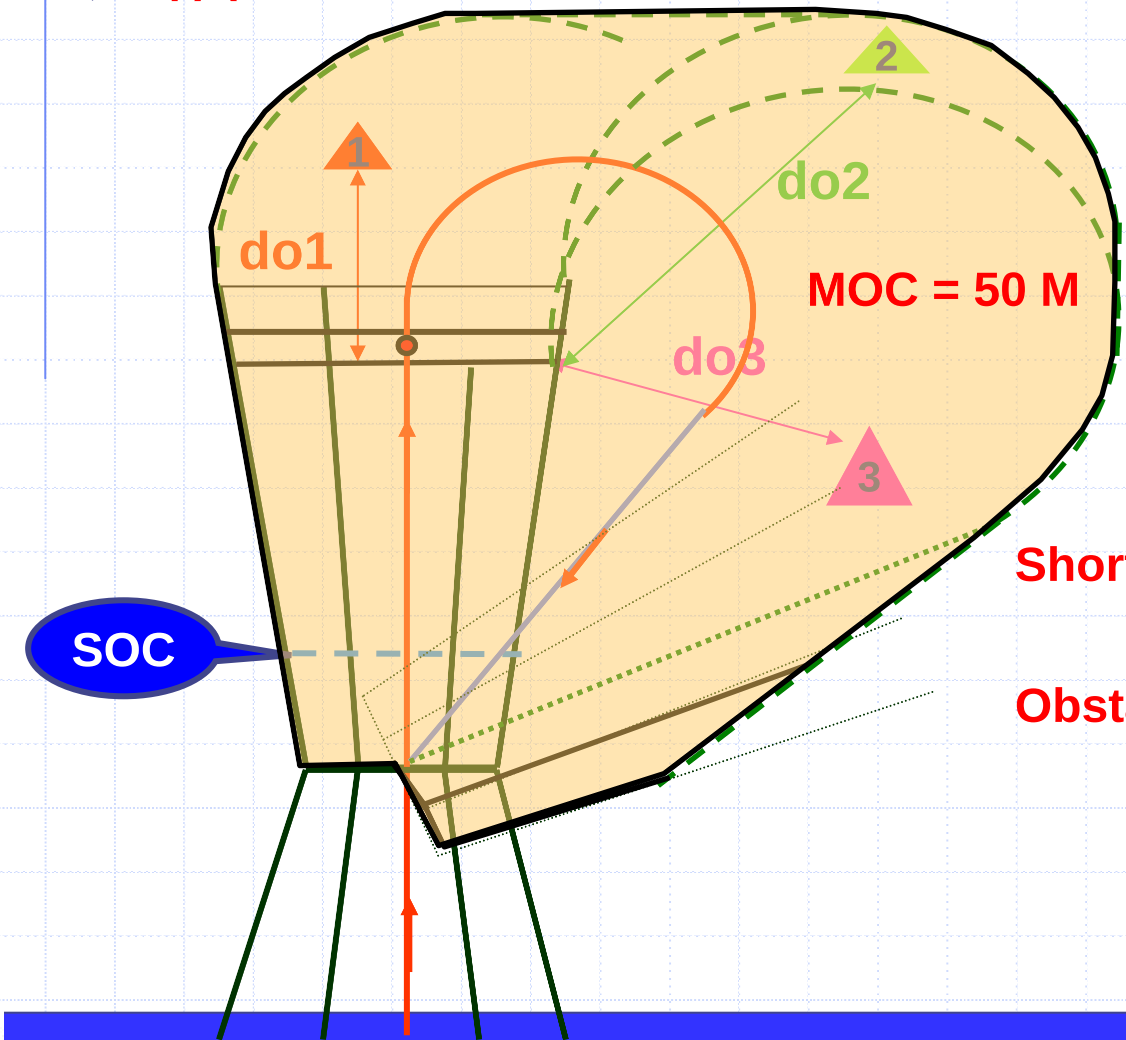


FINAL PHASE – TP



TP

- TA



Shortest Distance from KK Line(ETP)

Obstacle Elevation/Height in TA

OCA/H + (dz + do) x TanZ - MOC

FINAL PHASE – EXERCISE

- MAP: Turn at Altitude

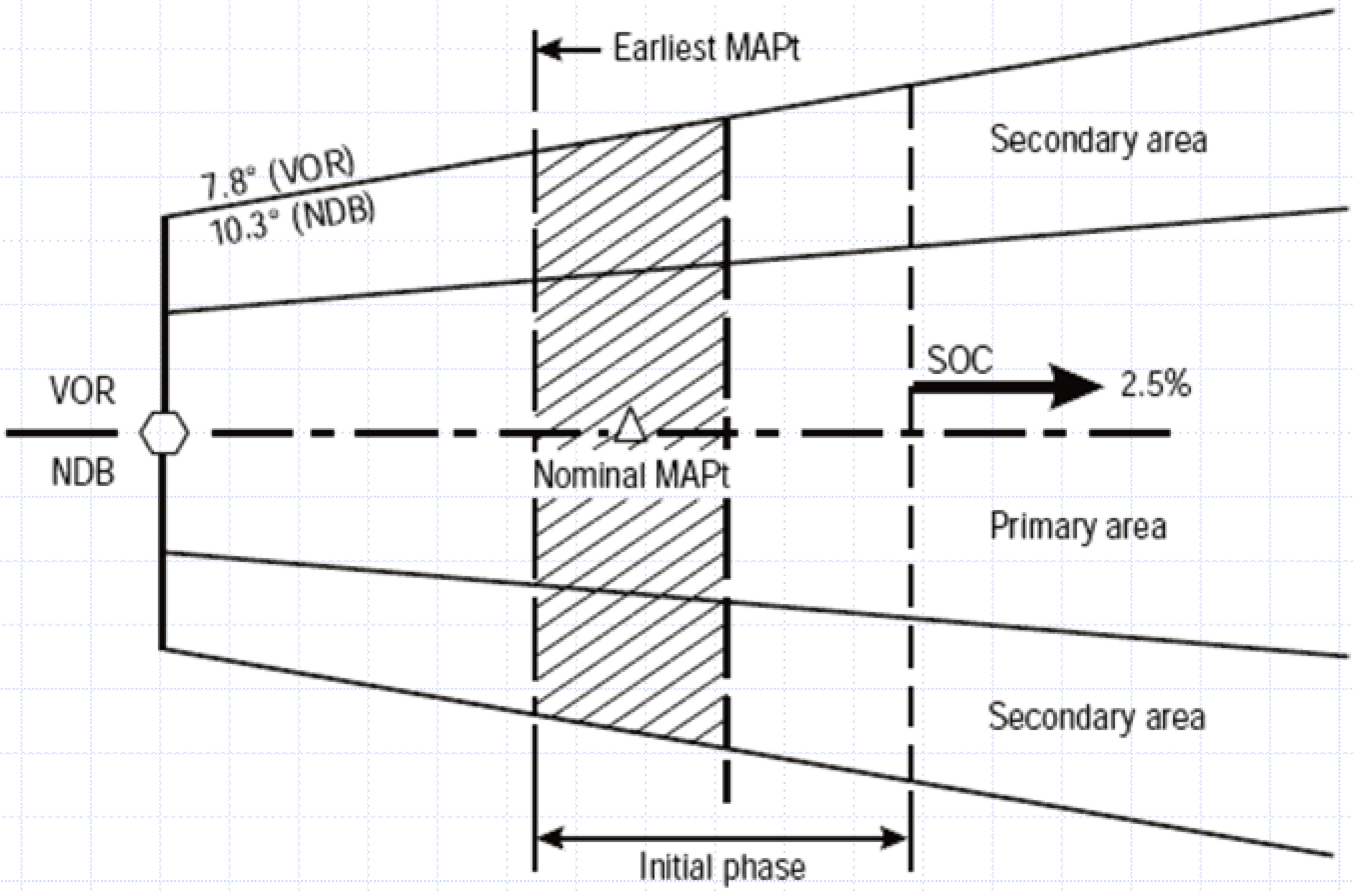
Missed Approach Procedure

The procedure to be followed if the approach cannot be continued.

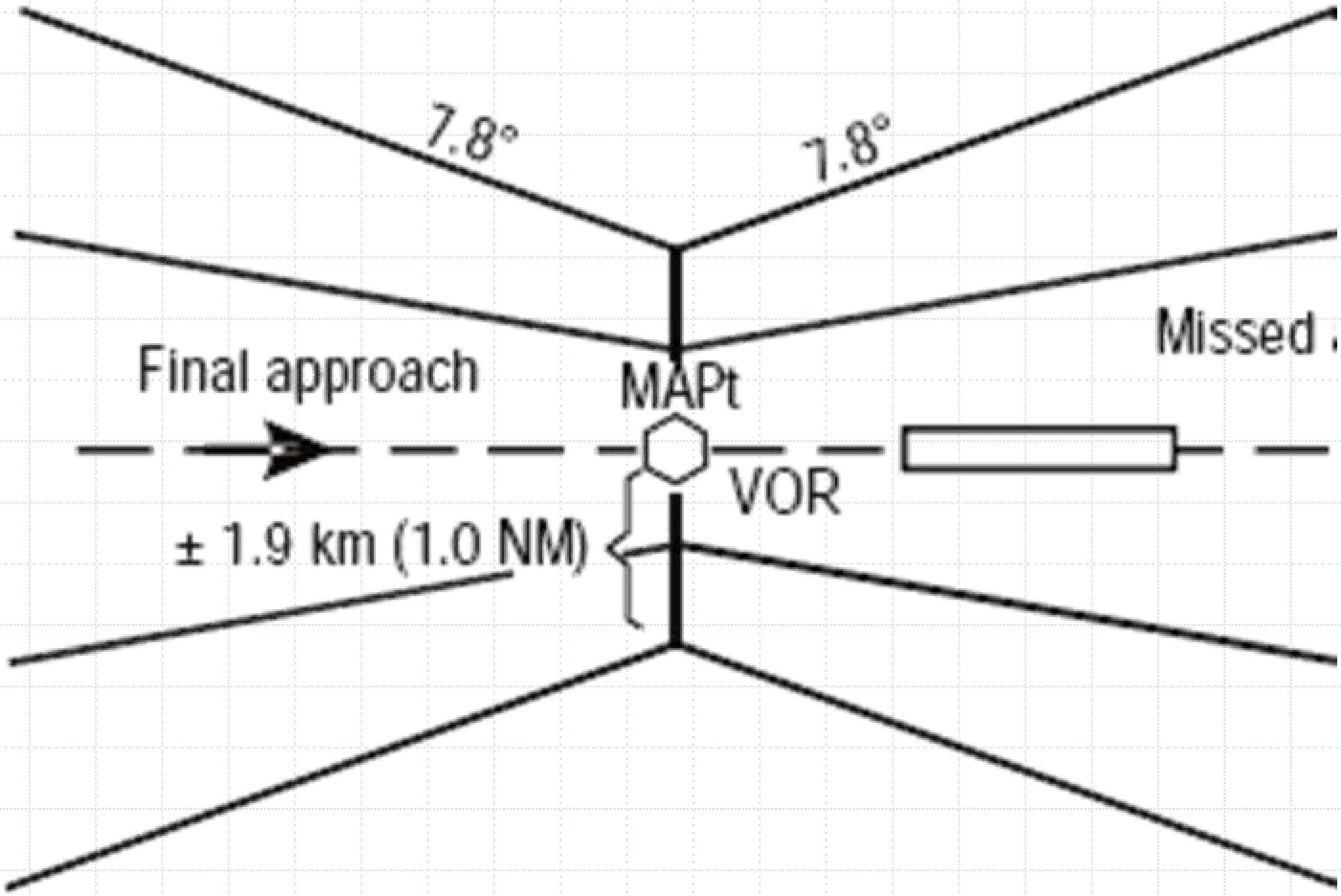
Missed approach point (MAPt).

That point in an instrument approach procedure at or before which the prescribed missed approach procedure must be initiated in order to ensure that the minimum obstacle clearance is not infringed.

CONTINUATION OF GUIDANCE MAPt-FIX



CONTINUATION OF GUIDANCE MAPt-FACILITY



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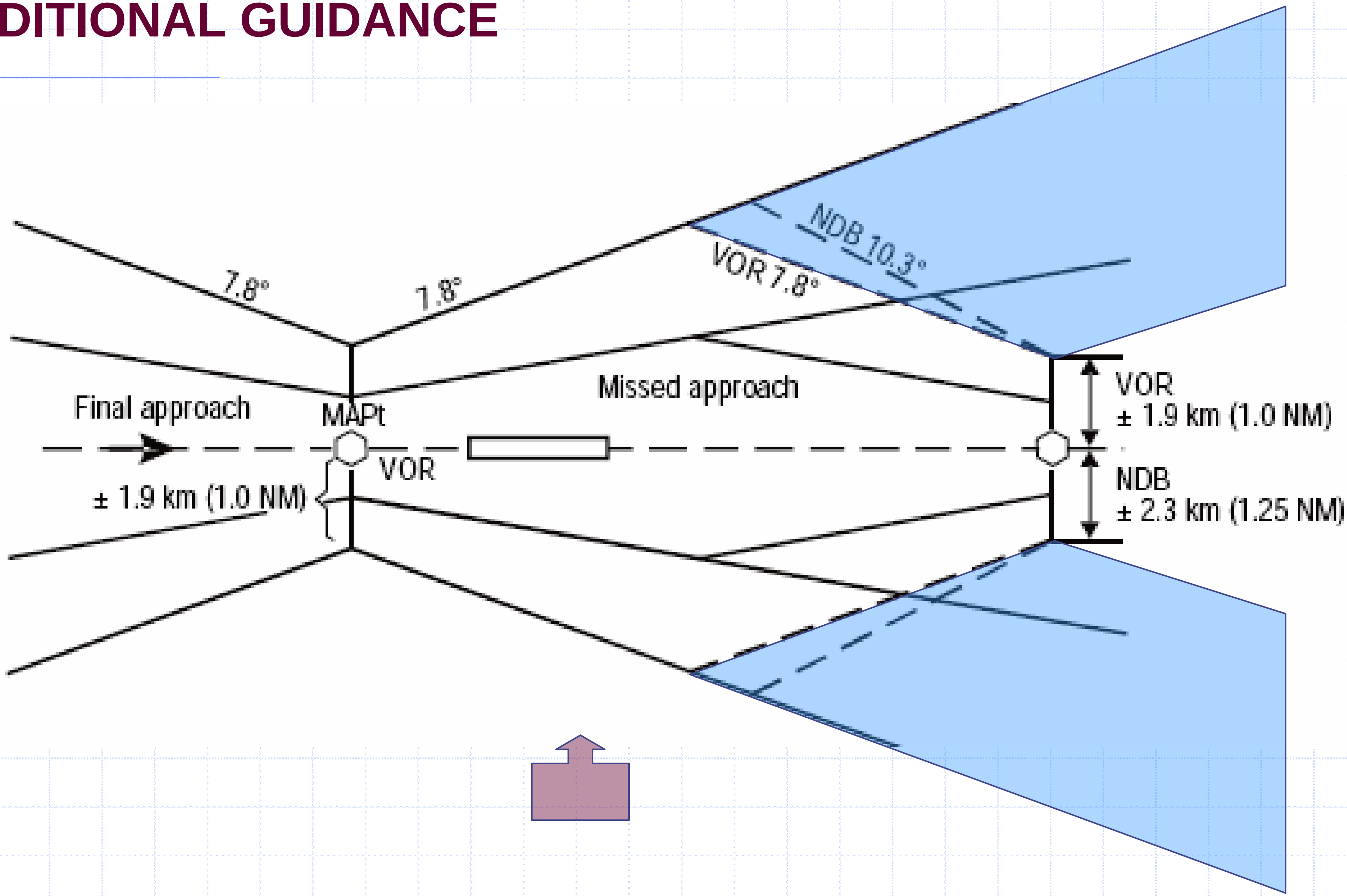
ADDITIONAL GUIDANCE



CONTINUOUS DESCENT OPERATIONS (CDO)

ICAO FPP

Beijing, China

CLICK HERE

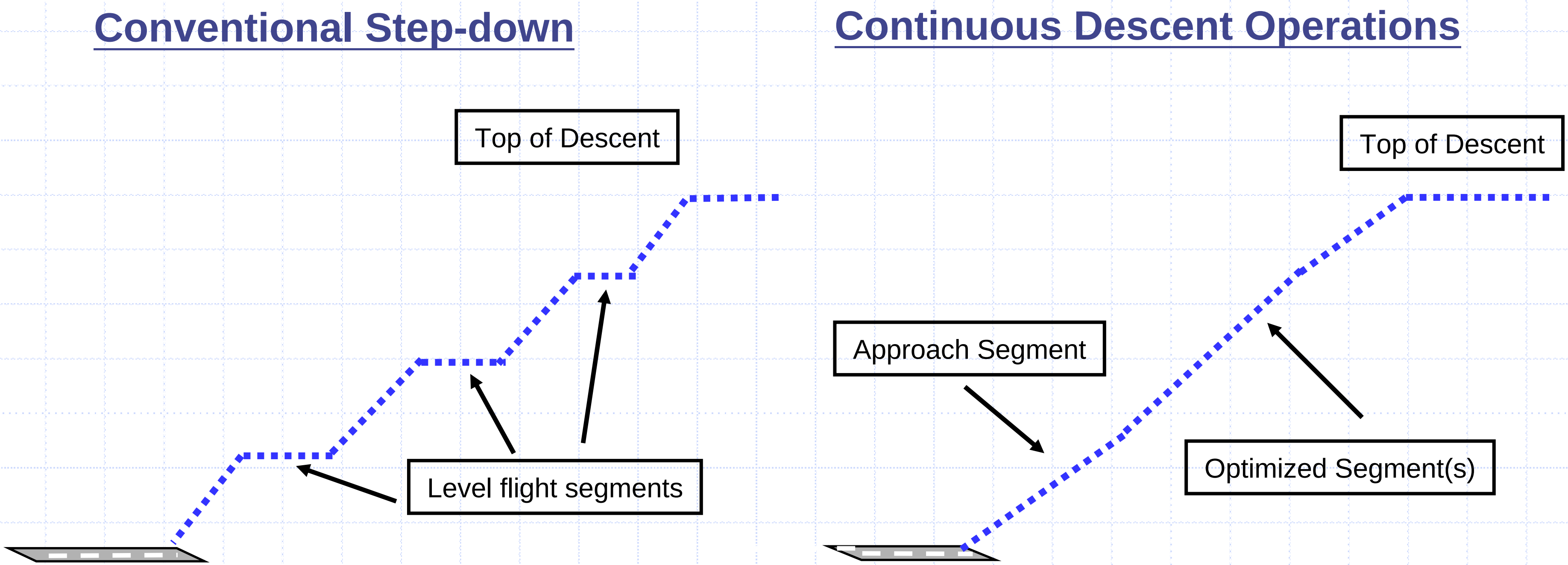
CONTENTS

- General Overview
- Optimum Vertical Path
- Benefits
- Design
- CCO
- Example

GENERAL OVERVIEW

- CDO should always be considered by airspace designers and procedure designers especially when implementing new Arrivals (STAR) and Approaches
- CDO: Where aircraft descends continuously, employs minimum engine thrust in a low drag configuration
- Usable by 85% of the aircraft, 85% of the time

GENERAL OVERVIEW



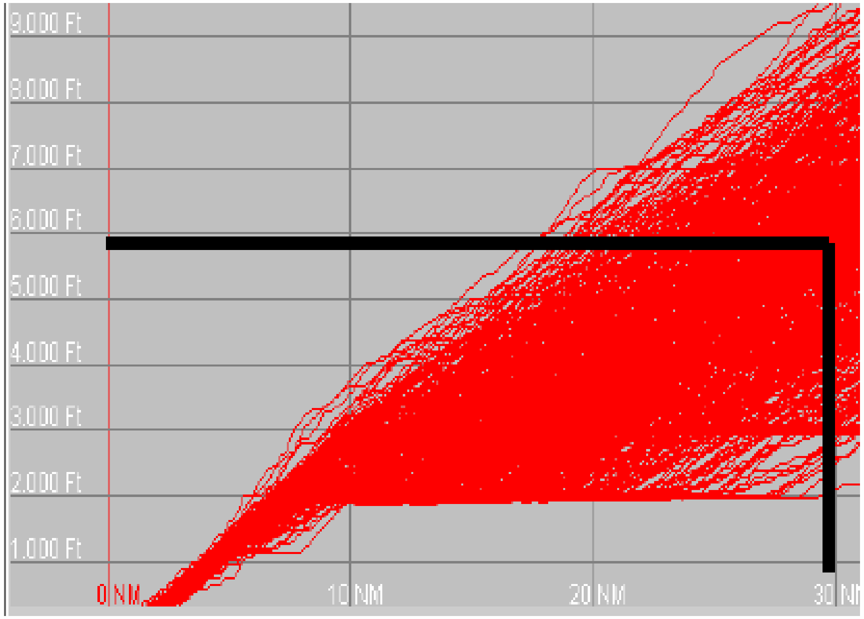
OPTIMUM VERTICAL PATH

The optimum vertical path angle will vary depending on:

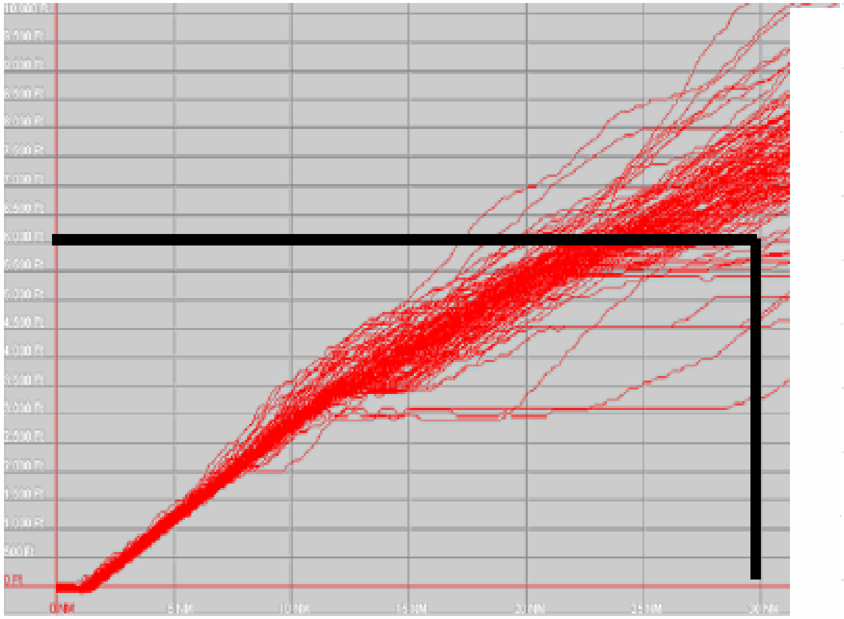
- type of aircraft
- its actual weight
- the wind
- air temperature
- atmospheric pressure
- icing conditions
- and other dynamic considerations

The maximum benefit is achieved by keeping the aircraft as high as possible until it reaches the optimum descent point determined by the onboard flight management computer.

OPTIMUM VERTICAL PATH



Flight tracks before CDO



Flight tracks after CDO

BENEFITS

An optimum CDO starts from the Top of Descent:

Reducing-

- segments of level flight
- noise
- fuel burn
- emissions
- ATC/Pilot communication and workload

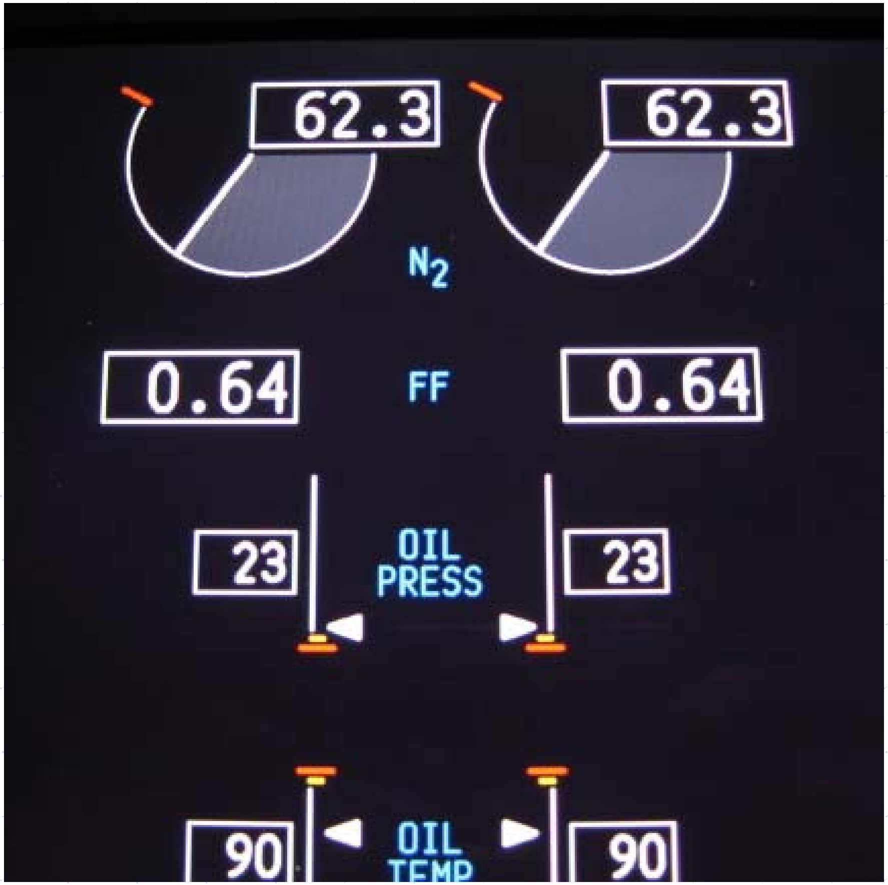
While Increasing:

- predictability to ATC/Pilots
- flight stability
- consistency flight path

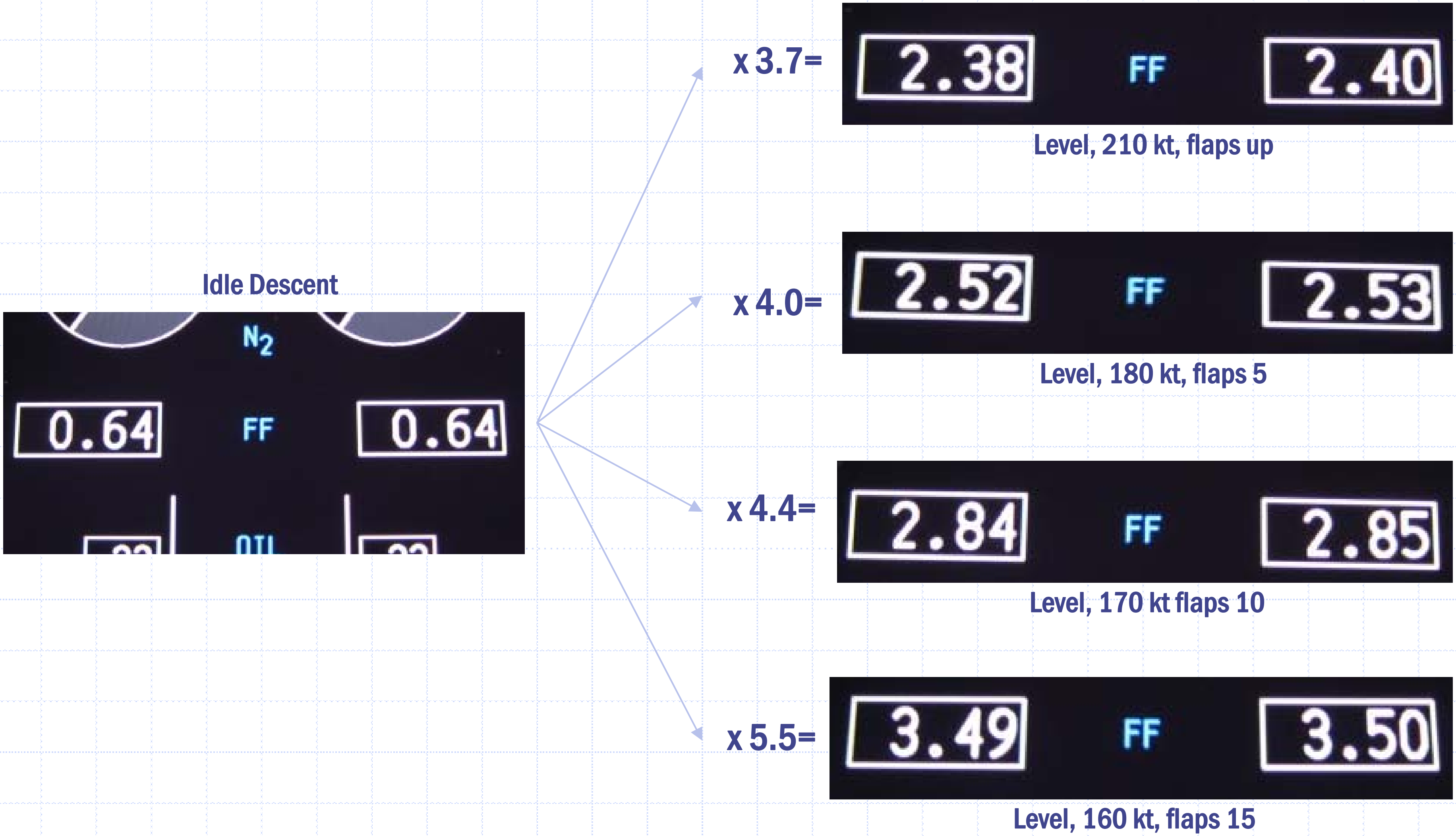
BENEFITS

Importance of an Idle Descent

- Idle Descent
- 640 lbs/hr/engine
- 1280 lbs/hr
- 3.2 gal/min



BENEFITS


Idle Descent
N2
0.64
FF
0.64
OIL
x 3.7=
2.38
FF
2.40
Level, 210 kt, flaps up
x 4.0=
2.52
FF
2.53
Level, 180 kt, flaps 5
x 4.4=
2.84
FF
2.85
Level, 170 kt flaps 10
x 5.5=
3.49
FF
3.50
Level, 160 kt, flaps 15

DESIGN OF CDO

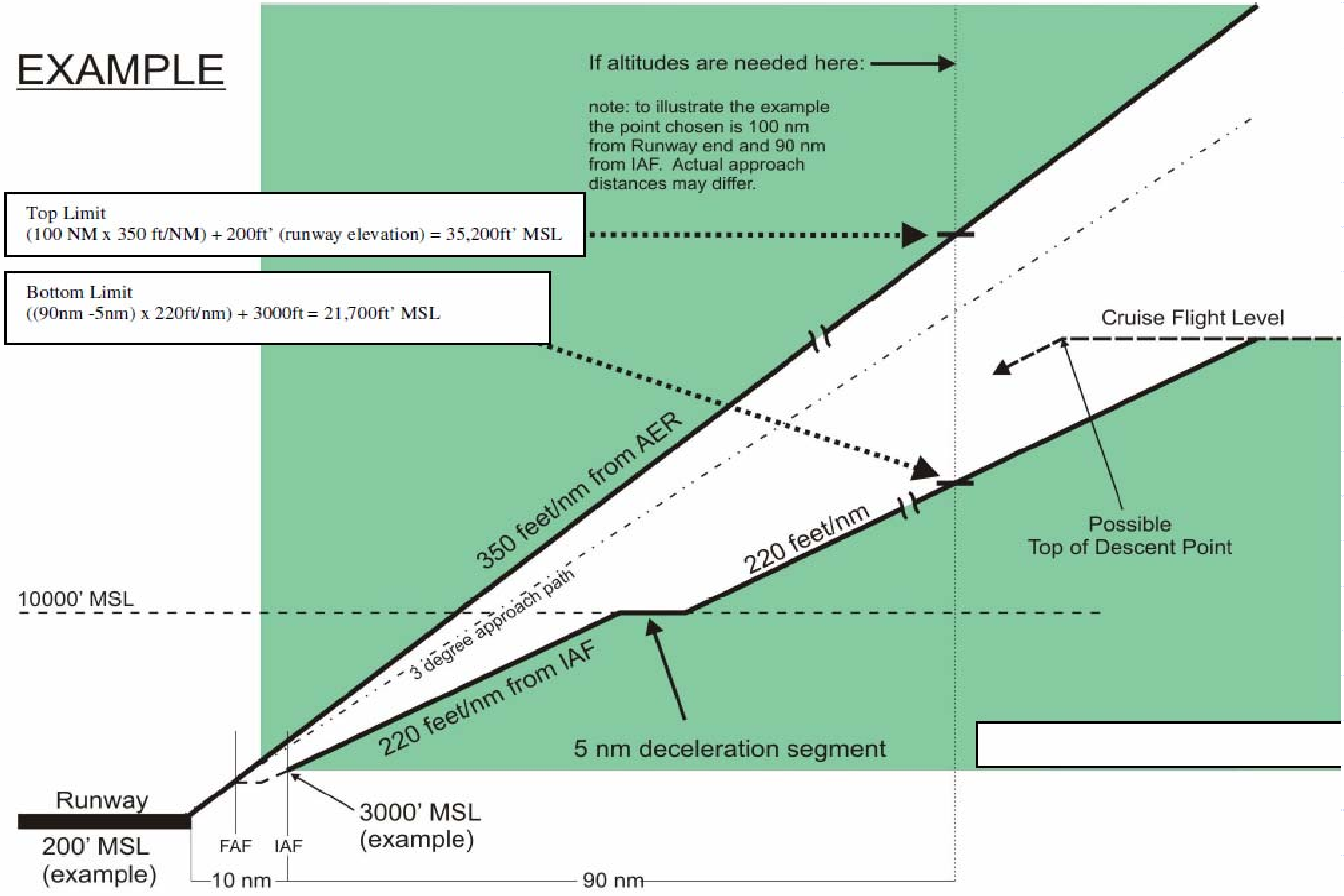
CDO facilitation methods should be selected and designed with the goal of allowing the highest percentage of use during the broadest periods of air traffic operations

DESIGN OF CDO

- Accurate planning for an optimum descent path is facilitated by the pilot and/or the FMS knowing the flight distance to the runway, and the level above the runway from which the CDO is to be initiated
- This will allow an accurate calculation of flight descent path
- Although CDO are optimized by using vertical navigation (VNAV) systems, these types of systems are not a prerequisite.

DESIGN OF CDO

- The lateral flight track is pre-defined up to and including the Final Approach Fix
- The exact distance to runway is precisely known
- The procedure may be published with crossing levels, level windows and/or speed constraints
- An example of a CDO is a STAR terminating at a point that defines a part of an instrument approach and is thus directly linked to an approach procedure


EXAMPLE
If altitudes are needed here:
note: to illustrate the example the point chosen is 100 nm from Runway end and 90 nm from IAF. Actual approach distances may differ.
Top Limit
(100 NM x 350 ft/NM) + 200ft' (runway elevation) = 35,200ft' MSL
Bottom Limit
((90nm -5nm) x 220ft/nm) + 3000ft = 21,700ft' MSL
Cruise Flight Level
350 feet/nm from AER
3 degree approach path
220 feet/nm
Possible
Top of Descent Point
10000' MSL
220 feet/nm from IAF
5 nm deceleration segment
Runway
200' MSL
(example)
FAF
IAF
3000' MSL
(example)
10 nm
90 nm

CONTINUOUS CLIMB OPERATIONS (CCO)

Arriving and departing traffic are usually interdependent and the airspace design supporting CDO should ensure that both arriving and departing flights can achieve fuel efficient profiles. Balancing the demands of capacity, efficiency, access and the environment within the overall requirement for safe operations, is the most demanding task when developing an airspace design