# ICAO APAC FPP

# RNP AR Workshop

(2026)

# RNP AR History

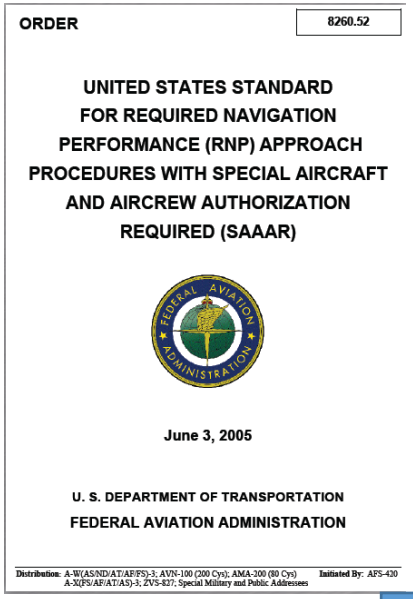
- Juneau airport -the problem (1990s)

# RNP AR History

- Juneau airport -the problem (1990s)

# Public Criteria

- FAA 8260.52 (2005) ICAO 9905 (2009) Third edition(2021)



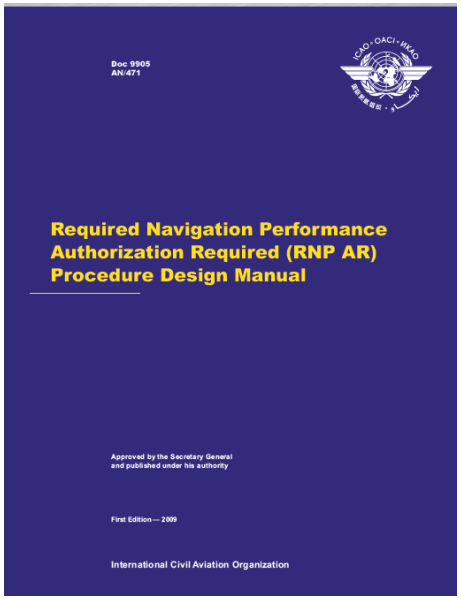
ORDER 8260.52

UNITED STATES STANDARD FOR REQUIRED NAVIGATION PERFORMANCE (RNP) APPROACH PROCEDURES WITH SPECIAL AIRCRAFT AND AIRCREW AUTHORIZATION REQUIRED (SAAAR)

June 3, 2005

U. S. DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

Distribution: A-W(AS/ND/AT/AF/FS)-3; AVN-100 (200 Cys); AMA-200 (80 Cys) Initiated By: AFS-430
A-X(FS/AF/AT/AS)-3; ZVS-827; Special Military and Public Addressees



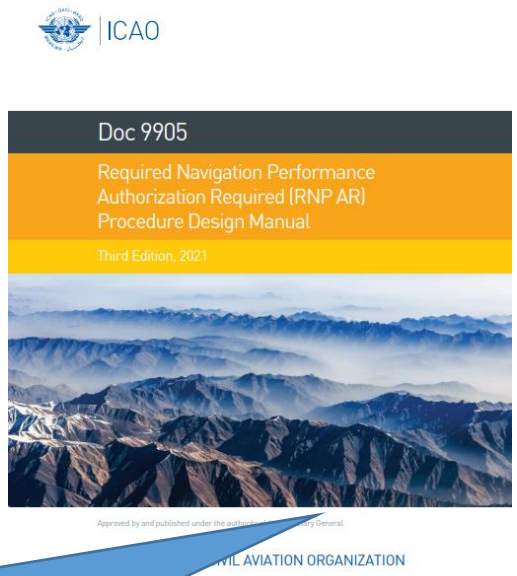
Doc 9905
AN/471

Required Navigation Performance Authorization Required (RNP AR) Procedure Design Manual

Approved by the Secretary General and published under his authority

First Edition — 2009

International Civil Aviation Organization



ICAO

Doc 9905

Required Navigation Performance Authorization Required (RNP AR) Procedure Design Manual

Third Edition, 2021

Approved by and published under the authority of the Secretary General

INTERNATIONAL CIVIL AVIATION ORGANIZATION

RECORD OF AMENDMENTS AND CORRIGENDA

| AMENDMENTS | | |
|---|---|---|
| No. | Date | Entered by |
| | | |
| | | |

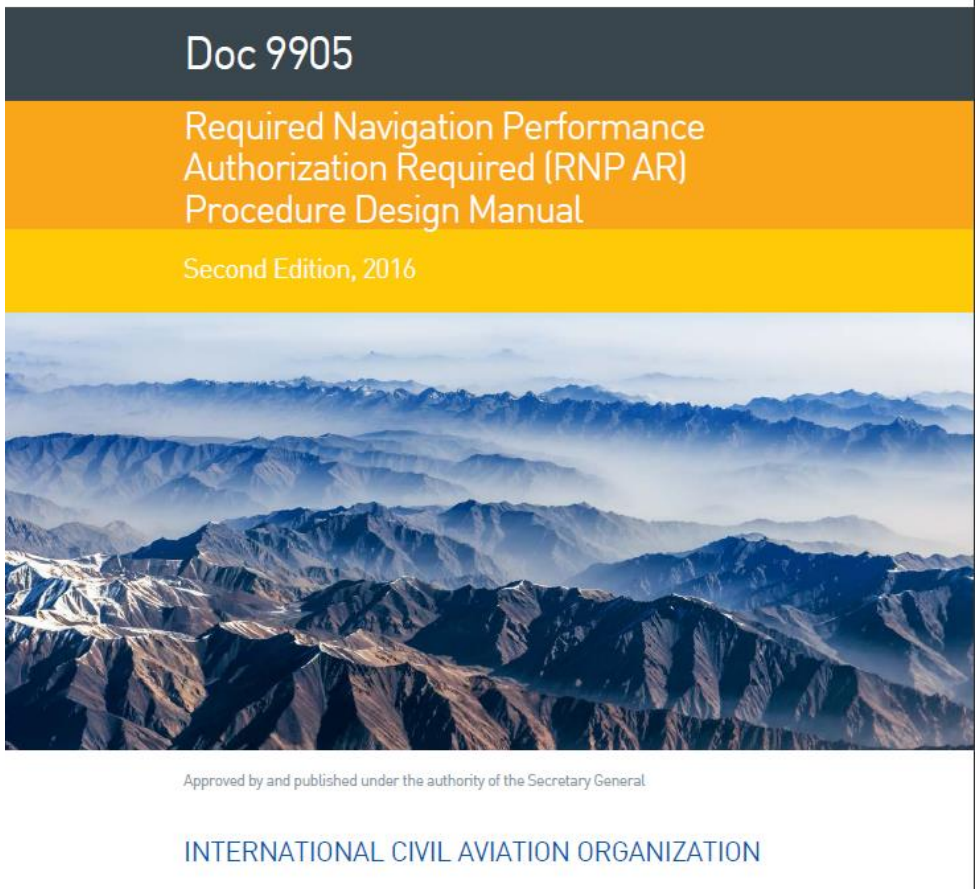
| CORRIGENDA | | |
|---|---|---|
| No. | Date | Entered by |
| 1 | 28/2/24 | ICAO |
| | | |

# Navigation Specification(Doc.9613)

| Area of operation | Applicable navigation specification | | Implementation goal |
|---|---|---|---|
| | RNAV | RNP | |
| Oceanic | RNAV 10 (RNP10) | RNP 4 | Complete State PBN Implementation PLAN by 2009 |
| | | RNP 2 | |
| | | A-RNP | |
| En route/ continental | RNAV 5 | RNP2 | |
| | RNAV 2 | A-RNP | |
| | RNAV 1 | | |
| Terminal area | RNAV2 | RNP1 | |
| | RNAV1 | A-RNP | |
| Approach area (APV/NPA） | N/A | RNP APCH/A-RNP | APV to all Runway by 2016 |
| | | RNP AR APCH | |
| Helicopters | N/A | RNP 0.3（CAT H） | |

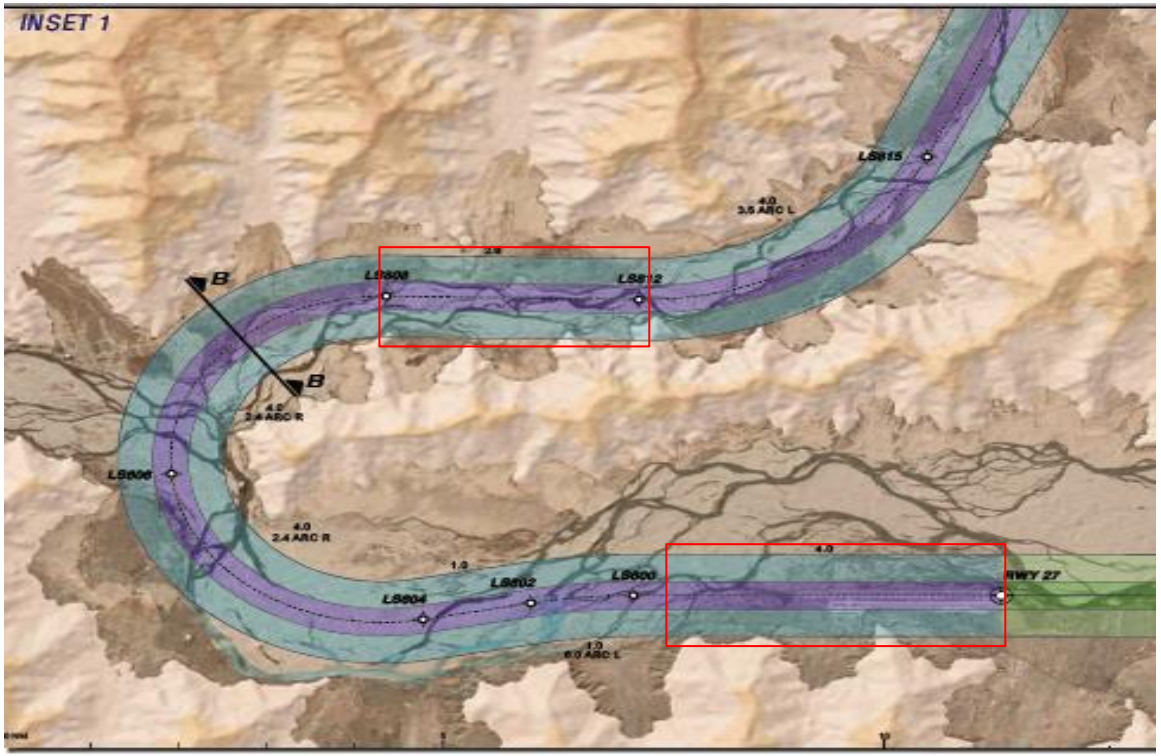
# Navigation Specification

| Part, chapter | Navigation specification | Navigation application, flight phase and RNAV/RNP value (NM) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | ATS or user-defined routeing | | Arrival procedures | Approach procedures | | | | Departure procedures |
| | | En-route oceanic/remote | En-route continental | Arrival | Initial | Intermediate | Final | Missed[1] | Departure |
| B, Ch.1 | RNAV 10 | 10 | | | | | | | |
| B, Ch.2 | RNAV 5[2] | | 5 | 5 | | | | | |
| B, Ch.3 | RNAV 2 | | 2 | 2 | | | | | 2 |
| B, Ch.3 | RNAV 1 | | 1 | 1 | 1 | 1 | | 1 | 1 |
| C, Ch.1 | RNP 4 | 4 | | | | | | | |
| C, Ch.2 | RNP 2 | 2[3] | 2 | | | | | | |
| C, Ch.3 | RNP 1[7] | | | 1 | 1 | 1 | | 1 | 1 |
| C, Ch.4 | Advanced RNP (A-RNP) | 2[3] | 2 or 1 | 0.3 | 0.3 | 0.3 | | 1[9] | 0.3 |
| C, Ch.5 | RNP APCH[4] | | | | 1 | 1 | 0.3[5] | 1[8] | |
| C, Ch.6 | RNP AR | | | | 1-0.1 | 1-0.1 | 0.3-0.1 | 1-0.1 | 1-0.3 |
| C, Ch.7 | RNP 0.3[6] | | 0.3 | 0.3 | 0.3 | 0.3 | | 0.3 | 0.3 |




- Chapter 1 Description of required navigation performance authorization required (RNP AR)
- ……
- 1.3 Aircraft qualification
- ……
- Chapter 2. RNP AR approach procedure design
- 2.1 Underlying principles
- ……
- 2.6 Vertical protection
- Chapter 3. General criteria
- …….

# Example



# Description of RNP AR

- Application
- Aircraft qualification
- Operational qualification
- Procedure construction

# Application

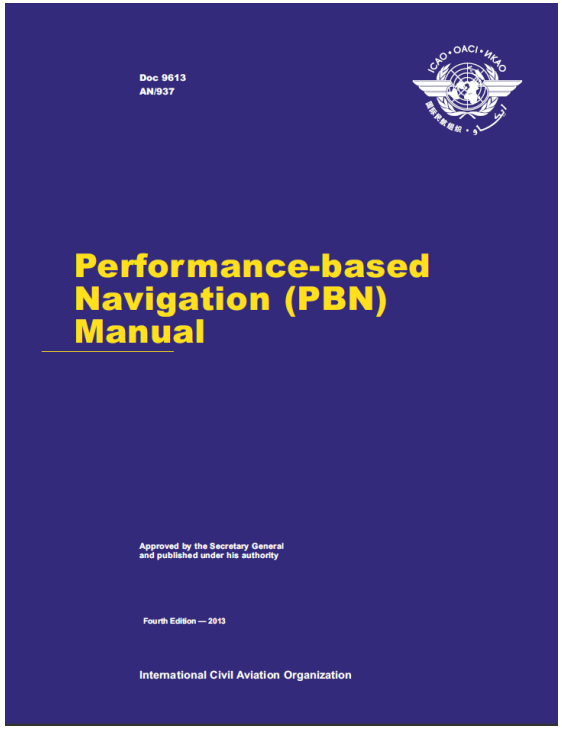
- **Implementation of RNP AR procedures extends beyond procedure design in that an authorization process for aircraft operators is necessary to ensure that other critical dependencies and associated airworthiness and operational procedure approvals are complete prior to implementation.**
  - **Guidance on implementation and operational approval is provided in the PBN Manual.**

*Refer to Doc. 9613 Vol II Part C Chapter 6. "Chapter 6. Implementing RNP with Authorization Required (RNP AR APCH and RNP AR DP)" and Attachment A. "Vertical navigation in the final approach segment", Attachment B "RNP APCH and RNP AR APCH operations in non-standard temperature conditions"*

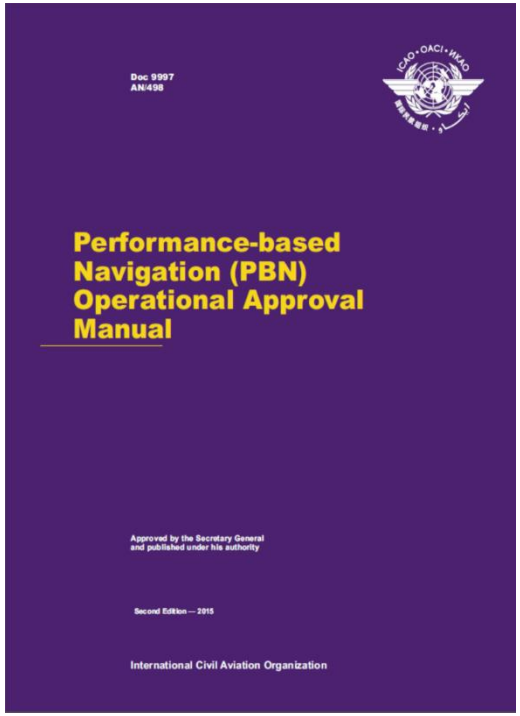
*Doc.9997 Chapter 4. "Navigation specification job aids" 4.12 "RNP AR"*

# Application

## Doc.9613




## Doc.9997



# Approach Type

| Procedure | | Operation | | |
|---|---|---|---|---|
| Chart Identification | Minima Box Label | Type of Operation | Minima | Type (A or B) |
| NDB RWY XX | NDB | 2D<br>3D (CDFA with Positive Guidance) | MDA/H<br>Derived DA | A |
| VOR RWY XX | VOR | 2D<br>3D (CDFA with Positive Guidance) | MDA/H<br>Derived DA | A |
| ILS RWY XX *or* LOC RWY XX | LOC | 2D<br>3D (CDFA with Positive Guidance) | MDA/H<br>Derived DA | A |
| RNP RWY XX | LNAV | 2D<br>3D (CDFA with Positive Guidance) | MDA/H<br>Derived DA | A |
| RNP RWY XX | LP | 2D<br>3D (CDFA with Positive Guidance) | MDA/H<br>Derived DA | A |
| RNP RWY XX | LNAV/VNAV[1] | 3D | DA/H | A |
| RNP RWY XX (AR) | RNP 0.X | 3D | DA/H | A |
| RNP RWY XX | LPV[2] | 3D | DA/H | A or B[3] |
| ILS RWY XX | CAT I<br>CAT II | 3D | DA/H | A or B |

# Application

- RNP AR APCH operations are classified as approach procedures with vertical guidance (APVs)

  This type of operation requires a positive vertical navigation (VNAV) guidance system for the final approach segment (FAS).

  Obstacle clearance is based on a **statistical assessment** of all the component errors referred to as a **vertical error budget (VEB).**

- RNP AR APCH procedures may be designed to support multiple minima for various appropriate RNP

  e.g.RNP 0.3, RNP 0.2, down to RNP 0.1.

# Application

➢**The design criteria in Doc.9905 are applicable to a range of aircraft types and cannot take into account the full capability of some aircraft types.**

➢**If the actual situation can not meet the criteria requirements, alternative design solutions may be derived:**

- Specify aircraft type
- Specific performance parameters:
- Special operating conditions or limitations
- Crew training
- Operational evaluation or other requirements that can be demonstrated to provide an equivalent level of safety

*Refer to Doc.9997 Appendix E.* ***Flight operational safety assessments (FOSAs)***

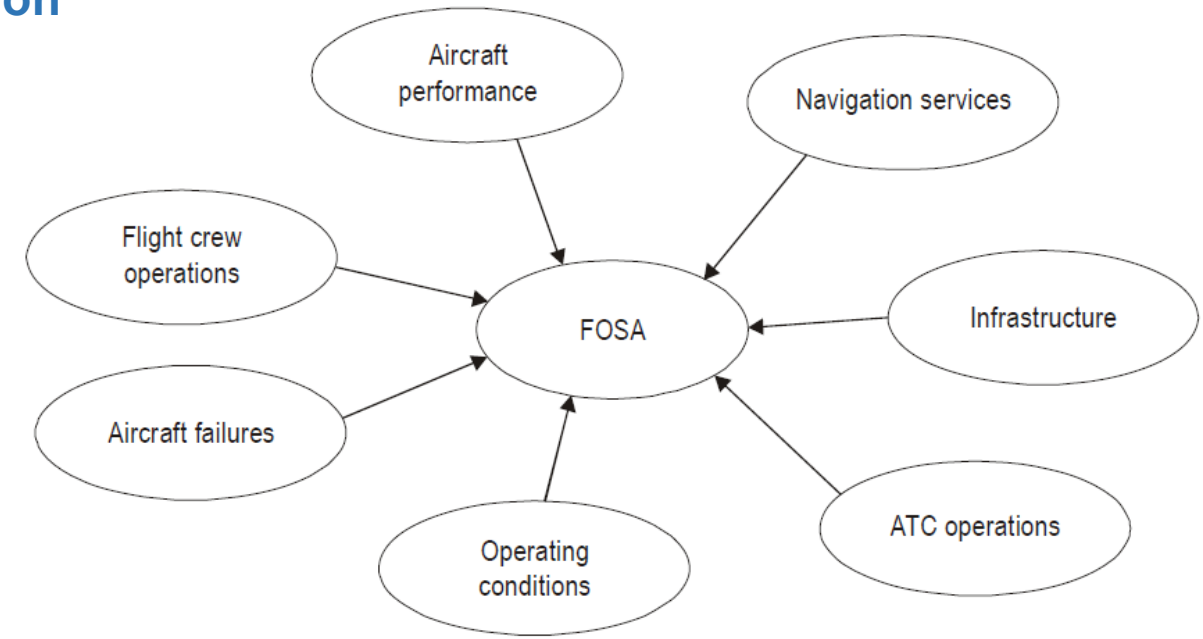
# Application

**Elements to consider in a Flight Operational Safety Assessment:**

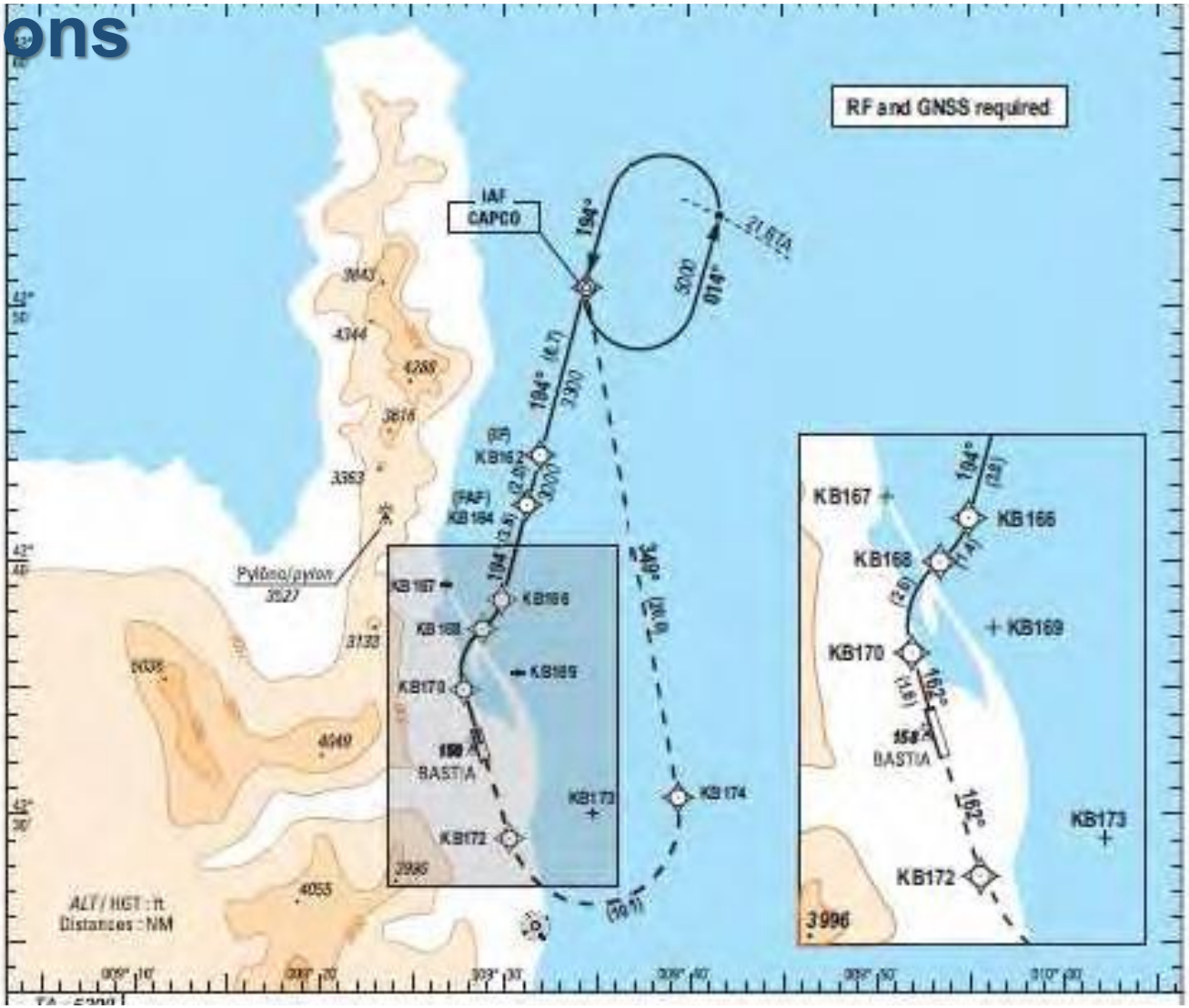
**Aircraft qualification**

**Operational qualification**

**Flight procedure**

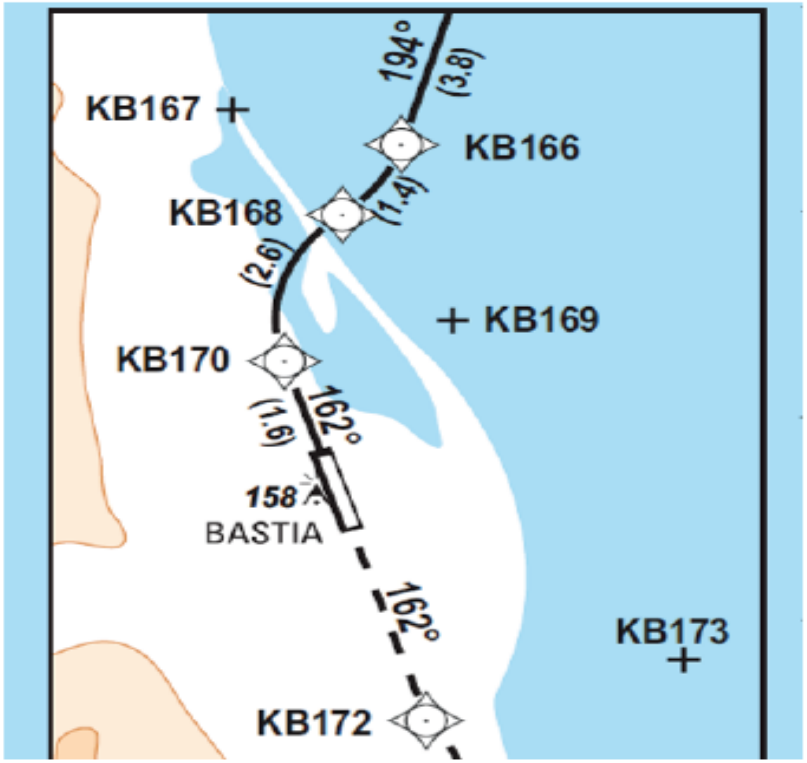


# Early Iterations



# Early Iterations

**Figure:**



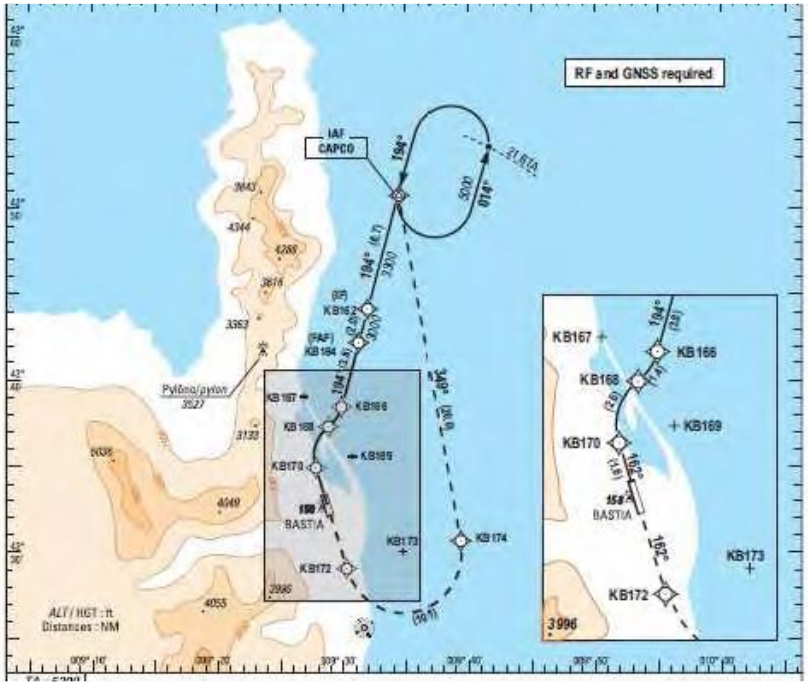

**Issue:** Loss of pilot situational awareness in a Double RF leg (opposite direction, S-approach) when equipment failures occur.

Design allowable under RNP AR Procedure Design Guidance.

**Potential Mitigations/ Solutions:**

- Consider if Double RF leg combinations are absolutely necessary
- Consider Inserting straight segment between 2 legs to allow aircraft to establish wings level
- Training in simulator for such failure events
- Development of contingency procedures

# Early Iterations




BEFORE


AFTER

# Description of RNP AR

- Application
- Aircraft qualification
- Operational qualification
- Procedure construction

# Aircraft Qualification

- Aircraft qualification is integral to the process of authorization for RNP AR operations.
- Only aircraft that have demonstrated performance, capability and functionality can be authorized to conduct RNP AR APCH operations.
- Aircraft must meet the requirements of the RNP AR APCH navigation specification given in the PBN Manual.

# Aircraft Qualification

## AIRPLANE FLIGHT MANUAL

Diamond AIRCRAFT

### DA42 L360

D42L-AFM-002

DIAMOND AIRCRAFT INDUSTRIES INC.
1560 CRUMLIN SIDEROAD, LONDON, ONTARIO
CANADA N5V 1S2



**REV 7**

Re-issue: 18 Aug 10
23 May 12

Reference : Airbus Industrie AI / EV - O 10000



(b) IFR enroute, oceanic and terminal navigation predicated upon the G1000 GPS Receiver is prohibited unless the pilot verifies the currency of the database or verifies each selected way point for accuracy by reference to current approved data.

(c) Instrument approach navigation predicated upon the G1000 GPS Receiver must be accomplished in accordance with approved instrument approach procedures that are retrieved from the GPS equipment database. The GPS equipment database must incorporate the current update cycle.

**NOTE**

Not all published approaches are in the FMS database. The pilot must ensure that the planned approach is in the database.

(1) Instrument approaches utilizing the GPS receiver must be conducted in the approach mode and Receiver Autonomous Integrity Monitoring (RAIM) must be available at the Final Approach Fix.

(2) Accomplishment of ILS, LOC, LOC-BC, LDA, SDF, MLS or any other type of approach not approved for GPS overlay with the G1000 GPS receiver is not authorized.

(3) Use of the G1000 VOR/ILS receiver to fly approaches not approved for GPS require VOR/ILS navigation data to be present on the display.

(4) When an alternate airport is required by the applicable operating rules, it must be served by an approach based on other than GPS or Loran-C navigation, the airplane must have the operational equipment capable of using that navigation aid, and the required navigation aid must be operational.

(5) VNAV information may be utilized for advisory information only. Use of VNAV information for Instrument Approach Procedures does not guarantee step-down fix altitude protection, or arrival at approach minimums in normal position to land.

(6) RNAV (GPS) approaches must be conducted utilizing the GPS sensor.

(7) RNP RNAV operations are not authorized, except as noted in Chapter 1 of this AFM.

# Aircraft Qualification

- Navigation Sensors
- GNSS-updating
- IRS
- US 14 CFR part 121, Appendix G, or equivalent

- a)2 NM per hour drift rate (95 per cent) for flights up to 10 hours

- b)initial drift rate of 8 NM/hour for the first 30 minutes (95 per cent)

# Aircraft Qualification

- Path definition and flight planning
  - Fly-by and fly-over fixes
  - Waypoint resolution error
    - The waypoint resolution error must be <= 60 ft
    - vertical angles (flight path angles) stored to a resolution of hundredths of a degree
  - Capability for a “direct-to” function

# Aircraft Qualification

- RNP AR approaches with RF
  - The RNP system, the flight director system and autopilot must be capable of commanding a bank angle up to 25 degrees above 121 m (400 ft) AGL and up to 8 degrees below 121 m (400 ft) AGL

# Aircraft Qualification

- When the flight crew initiates a go-around (through activation of take-off/go around (TOGA) or other means), the RNP system must provide continuous LNAV guidance to complete an RF leg during the go-around.
  - When continuous LNAV is not available, and the activation of go-around (that is, TOGA) results in disconnecting LNAV guidance (reverting to heading or track-hold flight guidance), the aircraft OEM must define the mitigation necessary to overcome absence of the continuous LNAV function.

# Description of RNP AR

- Application
- Aircraft qualification
- Operational qualification
- Procedure construction

# Operational Qualification

- The authorization process for RNP AR APCH operations includes the approval of operating procedures and crew training in accordance with the RNP AR APCH navigation specification given in the PBN Manual.
- Operating procedures must also take into account any limitations or requirements specified by the procedure designer.

# Operational Qualification

- **Prior to authorization for the conduct of RNP AR APCH operations, an operator must demonstrate to the State regulator that all appropriate elements of the RNP AR APCH operations have been appropriately addressed:**
- a) determination of aircraft qualification;
- b) training e.g. flight crews, dispatch;
- c) MEL, continuing airworthiness;
- d) requirements for operational procedures;
- e) dispatch procedures;
- f) maintenance procedures;
- g) conditions or limitations for approval;
- h) procedure operational validation for each aircraft type; and
- i) conduct of a FOSA.

# Description of RNP AR

- Application
- Aircraft qualification
- Operational qualification
- Procedure construction

# Flight Procedures

- **Users must be familiar with the following aspects associated with RNP AR APCH operations:**

- **RNP capability**.

- Crews must be aware of the aircraft RNP capability documented in the RNP AR authorization appropriate to the aircraft configuration or operational procedures.

- **RNP availability check**.

- Prior to the commencement of an approach, the crew is responsible for ensuring that the appropriate RNP is selected

- The RNP with the least stringent navigation accuracy requirement meeting all the requirements of the approach procedures and consistent with the operating conditions should be selected to reduce the possibility of alerts and consequent missed approaches.

- RNP should not be changed after commencement of the procedure.

# Flight Procedures

- **Users must be familiar with the following aspects associated with RNP AR APCH operations:**
- **Radius to fix (RF) legs.**
- RF legs may be present in all phases of the procedure including the **final segment**
- requirement for RF leg capability will be annotated in the **PBN requirements box** on the approach chart.
- **Minimum equipment**
- At some locations **redundant equipment** may be required.
- **Non-standard speeds or climb gradients**
- Any exceptions to the standard speed and the normal climb gradient must be indicated on the approach procedure, and the operator must ensure they can comply with any published restrictions before conducting the operation.

# Flight Procedures

- **Users must be familiar with the following aspects associated with RNP AR APCH operations:**

- **Non-normal operations.**

- Crews must be competent to contain the aircraft position within tracking tolerances consistent with the selected RNP during all normal and non-normal operations.

- **Vertical flight path tolerances.**

- In the FAS, crews will monitor any vertical deviation from the VNAV path to ensure that the aircraft remains within the tolerances.

- **Coupled autopilot.**

- Use of coupled autopilot is recommended. Operator procedures must specify the conditions for operations without autopilot.

# Library

**ICAO Doc 9905** for procedure design

« *Required Navigation Performance Authorization Required* ***(RNP AR) – Procedure Design Manual*** **»**

**ICAO Doc 9613 PBN Manual** for implementation

Volume II Part C Chapter 6 «Implementing RNP with Authorization Required (RNP AR APCH and RNP AR DP) »

**ICAO Doc 9997** for approval

« Performance Based Navigation (PBN) Operational Approval Manual**»**

***Others:***

**ORDER 8260.58**

Vol 5 TERPS « United States Standard for PBN Instrument Procedure Design » FAA

**AMC 20-26**

« Airworthiness Approval and Operational Criteria for RNP AR Operations » EASA

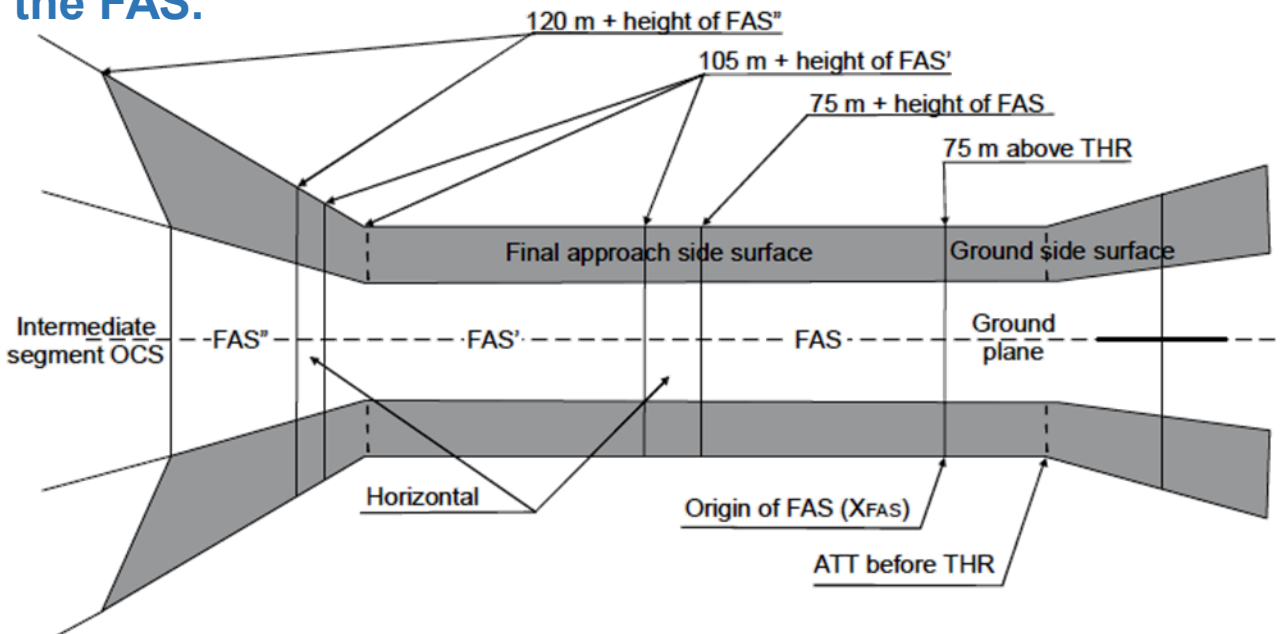
**AMC 20-27**

« Airworthiness Approval and Operational Criteria for RNP APPROACH (RNP APCH) Operations Including APV BAROVNAV Operations »

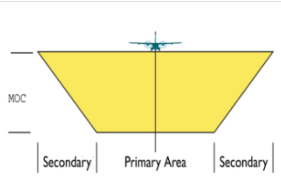
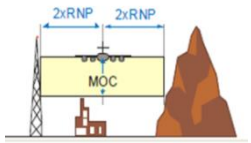
# General Criteria

# General Criteria of Procedure Design

- RNP APCH vs RNP AR APCH
- RNP APCH is defined as an RNP approach procedure that requires a lateral TSE of +/-1 NM in the initial, intermediate and missed approach segments (MAS) and a lateral TSE of ±0.3 NM in the FAS.



# RNP APCH vs RNP AR APCH

| | RNP APCH LNAV/VNAV | RNP AR APCH |
|---|---|---|
| Obstacle Assessment |   |   |
| VNAV | Baro | Baro |
| FAS Vertical | 75m MOC | VEB |
| Lateral | GNSS | GNSS |
| RNP | 0.3 | 0.3 - 0.1 |
| FAS XTK | 0.15NM | 0.15 NM - 0.05 |
| Turn | TF/TF | TF/RF |
| MAS | Terminal mode (RNP 1.0) | RNP 1.0 or lower |
| Initial/Intermediate Segment | Terminal mode (RNP 1.0) | RNP 1.0 - 0.3 |
| Lowest DH | 250ft | 250ft |

# Aircraft Categories

- AIRCRAFT SPEED CATEGORIES
  - Aircraft performance has direct impact on airspace requirement
  - Most significant factor in performance is speed
  - Five categories of aircraft: A - E
  - Four Categories A – D common for civilian use

# Flight Procedures

| Segment | | IAS by aircraft category (CAT) | | | | |
|---|---|---|---|---|---|---|
| | | CAT A | CAT B | CAT C | CAT D | CAT E |
| Maximum airspeed | Initial-, intermediate approach | 150 | 180 | 240 | 250 | 250 |
| | Final approach and intermediate missed approach | 100 | 130 | 160 | 185 | 230 |
| | Missed approach | 110 | 150 | 240 | 265 | 275 |
| Minimum airspeed restriction | Initial-, intermediate approach | 90 | 120 | 160 | 185 | 185 |
| | Final approach | 70 | 85 | 115 | 130 | 155 |
| | Missed approach | 100 | 130 | 160 | 185 | 230 |

# SPEED CONVERSION

$$TAS = IAS \times 171233\,[(288 \pm VAR) - 0.006496H]^{0.5} \div (288 - 0.006496H)^{2.628}$$

**SI:**

$$TAS = IAS \times 171233 \times [(288 + VAR) - 0.006496 \times H]^{0.5} / (288 - 0.006496 \times H)^{2.628}$$

**Non-SI:**

$$TAS = IAS \times 171233 \times [(288 + VAR) - 0.00198 \times H]^{0.5} / (288 - 0.00198 \times H)^{2.628}$$

*VAR = variation from international standard atmosphere (ISA) (standard value +15) or local data for 95 per cent high temperature, if available*

*H = altitude (ft or m, as appropriate)*

OR:

use TAS = IAS * k based on Doc.8168 Table I-2-1-App-1/ I-2-1-App-2

# SPEED CONVERSION

## Doc.8168 Table I-2-1-App-1

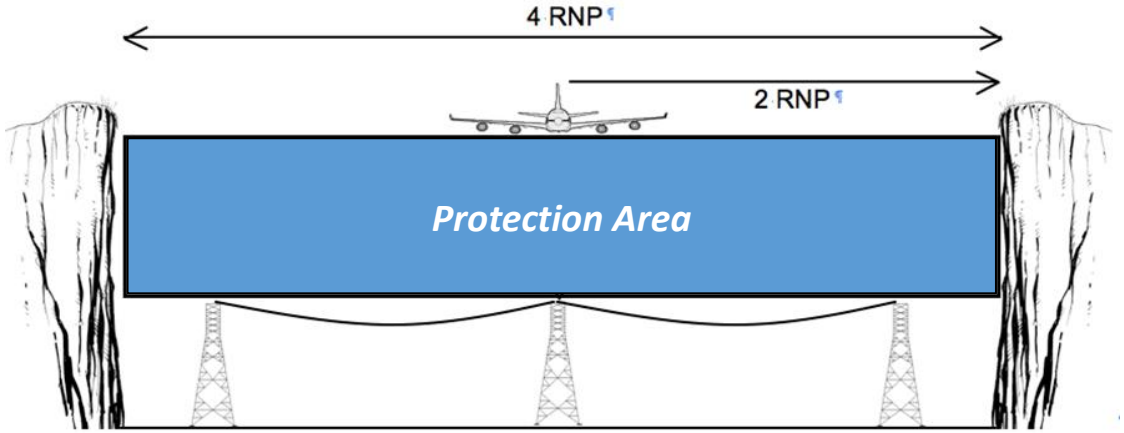
| Altitude (feet) | ISA-30 | ISA-20 | ISA-10 | ISA | ISA+10 | **ISA+15** |
|---|---|---|---|---|---|---|
| 0 | 0.9465 | 0.9647 | 0.9825 | 1.000 | 1.0172 | 1.0257 |
| 1000 | 0.9601 | 0.9787 | 0.9969 | 1.0148 | 1.0324 | 1.0411 |
| 2000 | 0.9740 | 0.9930 | 1.0116 | 1.0299 | 1.0479 | 1.0567 |
| 3000 | 0.9882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

# SPEED CONVERSION

- IAS = 185kts, Alt = 6000’, then TAS = ?
  - TAS =
- IAS = 185kts, Alt = 12000’, then TAS = ?
  - TAS =
- IAS = 185kts, Alt = 9100’, then TAS = ?
  - Use Alt at
  - TAS =

# Lateral Protection

- The semi-width of the primary area is defined as 2 × RNP navigation accuracy requirement.
- There are no buffer or secondary areas.



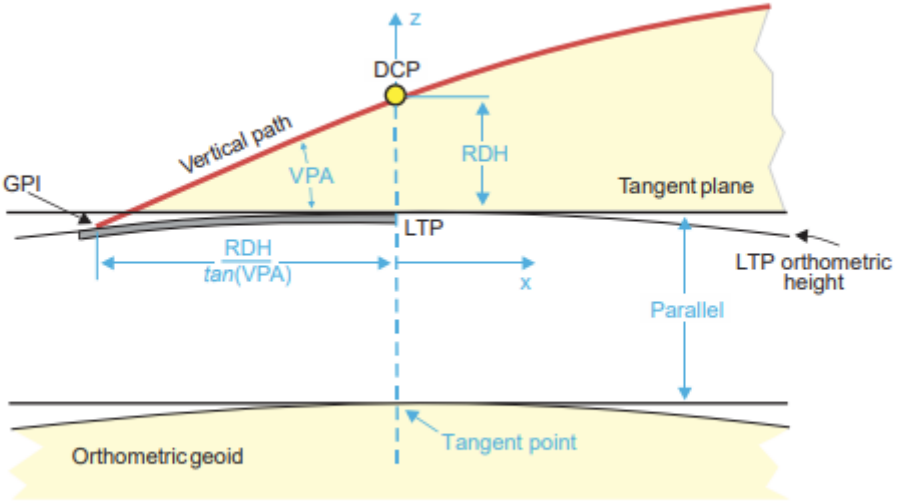
# Procedures Construction

- For each segment, TF legs are considered first, but RF legs may be used for turn path control, procedure simplification, or improved flyability.
- Stepdown fixes are not permitted in RNP AR procedures.
- Procedures shall not be promulgated for use with remote altimeter setting sources.
- The visual segment surface(VSS) must be clear of obstacles.

# Frame of Reference

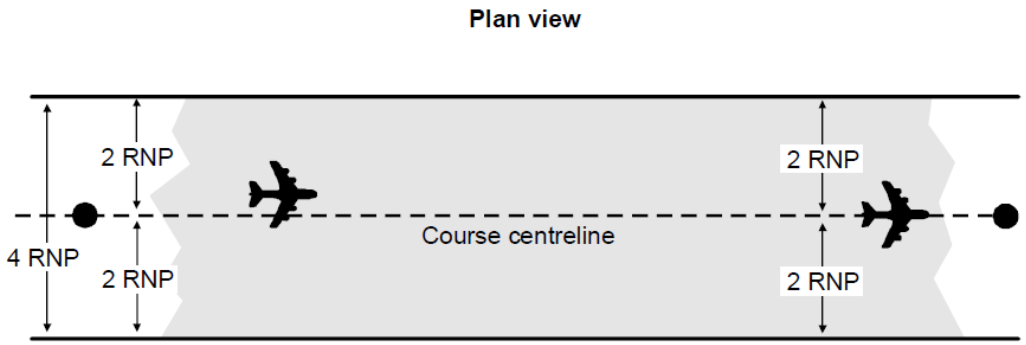
- **Positions of obstacles are related to a conventional x, y, z coordinate system with its origin at LTP and parallel to the world geodetic system (WGS) WGS-84 ellipsoid.**

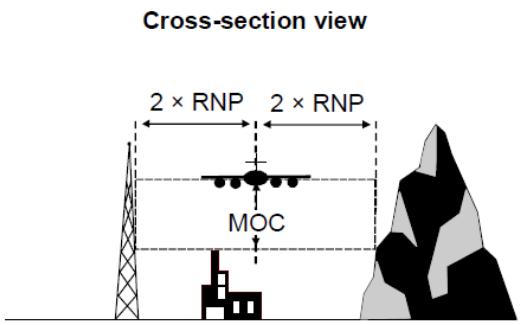
The x-axis is parallel to the final approach track. The y-axis is at right angles to the x-axis. The z-axis is vertical, heights above threshold being positive.



# Protection Area

- Straight protection
- ½ Width = 2*RNP



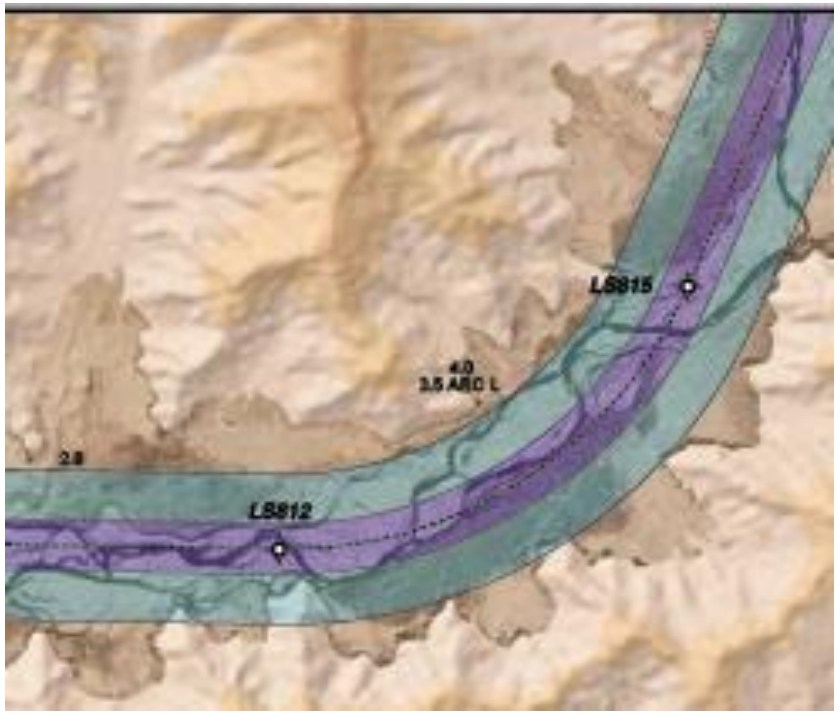



# Lateral Protection

Table 2-1. RNP navigation accuracy requirements

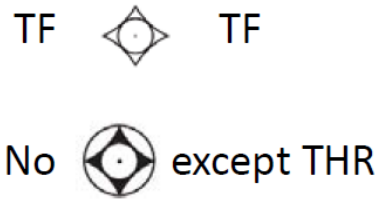
| *Segment* | *RNP AR* | | |
|---|---|---|---|
| | | *Maximum* | *Minimum* |
| Initial | | 1 | 0.1 |
| Intermediate | | 1 | 0.1 |
| Final | | 0.3 | 0.1 |
| Missed approach | | 1.0 | 0.1* |

# Turn



# Turn

- **Fly-over waypoints are not permitted between segments of an RNP AR procedure where there are track changes.**





- **For RNP AR procedures, the turn radius for fly-by and RF turns is calculated using a speed V = TAS + designated tailwind.**
- **And based on a standard bank angle of 25degrees**
- **Using the highest altitude allowed in the turn**

a) For initial and intermediate segments, use the minimum altitude for the fix prior to the turn fix.

b) For the MAS, use the altitude based on 7% with origin at OCA/H –HL.

# Turn

**Calculate the rate of turn (R)（°/s）：**

$R = (6\,355 \tan \alpha)/(\pi \times V)$ SI

or: $R = (3\,431 \tan \alpha)/(\pi \times V)$ Non-SI

note: max R=3°/s; V = (TAS + windspeed)

**Calculate the turn radius (r):**

$r = V/(20 \times \pi \times R)$

# Fly-by Turn

**For initial and intermediate segments, use the minimum altitude for the fix prior to the turn fix**

**Bank angle = 25°**

**V = ICAO standard wind**

**(2h + 47 kts,** h is in 1000 ft above sea level **)**

# Turn Exercise

➢Aircraft Cat A-D, Turn Alt(MSL)=2000m, Turn Height(aerodrome)=500m, Initial Approach Segment, ISA+15°, calculate R and r, draw the arc.

R = (6 355 tan α)/(π×V) ; r = V/(20πR)  DOC 9905

| CAT | IAS | Factor | TAS | W | V | R | r |
|---|---|---|---|---|---|---|---|
| A | | | | | | | |
| B | | | | | | | |
| C | | | | | | | |
| D | | | | | | | |

SI Unit

# Turn Exercise

➢Aircraft Cat A-D, Turn Alt(MSL)=2000m, Turn Height(aerodrome)=500m, Initial Approach Segment, ISA+15°, calculate R and r, draw the arc.

R = (6 355 tan α)/(π×V) ; r = V/(20πR) **DOC 8168**

| CAT | IAS | Factor | TAS | W | V | R | r |
|---|---|---|---|---|---|---|---|
| A | | | | | | | |
| B | | | | | | | |
| C | | | | | | | |
| D | | | | | | | |

SI Unit

# Fly-by Turn

**Missed approach**

**0.3 NM < RNP value < 1.0 NM** (**Whenever the RNP is less than 0.3 NM, the only turn method is RF**)

**The altitude based on 7% with origin at OCA/H –HL**

**Bank angle = 15 °**

**V = ICAO standard wind**

**(2h + 47 kts,** h is in 1000 ft above sea level **)**

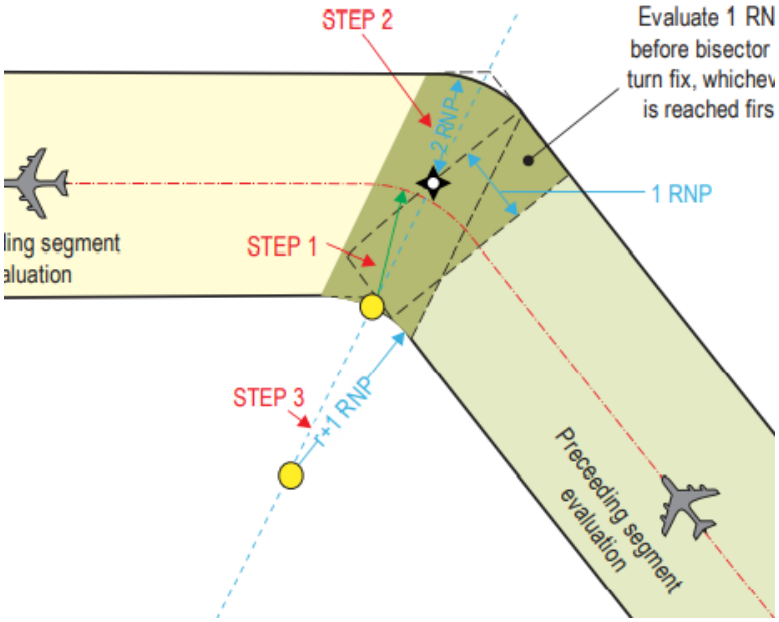
# Fly-by Turn

**MAX Turn angle : 70° above FL 190;**

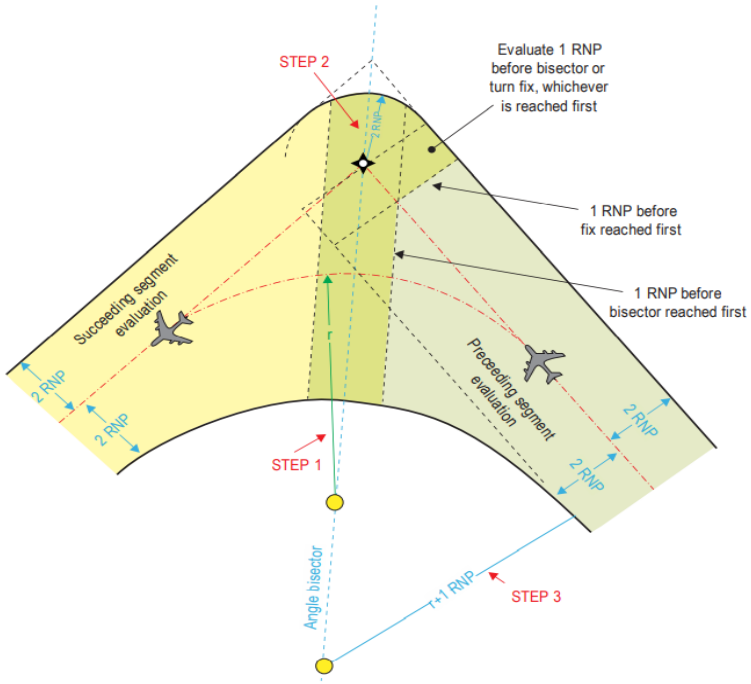
**90 ° at and below FL 190**

- STEP 1: Determine the required ground track. Calculate the turn radius (r). Construct the turning flight path tangent to the inbound and outbound legs. The center will be located on the bisector.
- STEP 2: Construct the outer boundary tangential to the inbound and outbound segment outer boundaries, with a radius of 2 × RNP and center located at the fix.
- STEP 3: Construct the inner turn boundary tangential to the inbound and outbound segment inner boundaries, with radius of (r + 1 RNP). The center is located on the bisector.

# Fly-by Turn




*Small Turn at fly-by fix*




*Large Turn at fly-by fix*

# Fly-by Turn

## RNP navigation accuracy requirement changing

a) on the inner side the area edge splays out **15 degrees from the nominal track** of the succeeding segment, beginning where the area edge of the preceding segment intersects the start of the evaluation of the succeeding segment .

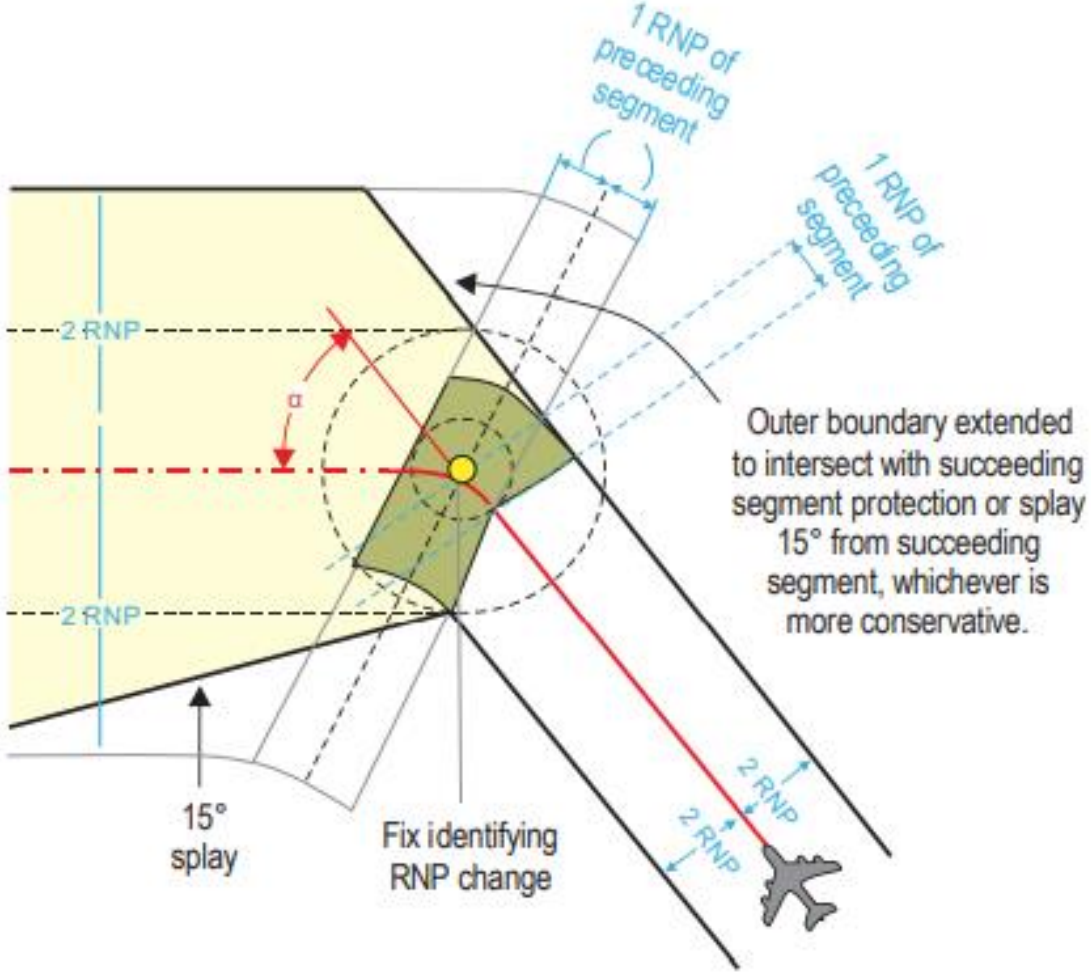
The splay extends until intersecting with the 2 x RNP half width of the succeeding segment, from where the area edge continues with a 2 x RNP constant half width

b) on the outer side the area edge extends parallel to the preceding segment until intersecting with the 2 x RNP half width of the succeeding segment, from where the area edge continues with a 2 x RNP constant half width.

For turns of less than 15 degrees, the area edge splays out 15 degrees from the nominal track of the succeeding segment, beginning where the area edge of the preceding segment intersects the start of the evaluation of the succeeding segment .

The splay extends until intersecting with the **2 x RNP** half width of the succeeding segment, from where the area edge continues with a 2 x RNP constant width.

# Fly-by Turn


1 RNP of preceeding segment
1 RNP of preceeding segment
2 RNP
α
2 RNP
Outer boundary extended to intersect with succeeding segment protection or splay 15° from succeeding segment, whichever is more conservative.
15° splay
Fix identifying RNP change
2 RNP
2 RNP

# Fly-by turns — Distance of turn anticipation (DTA)

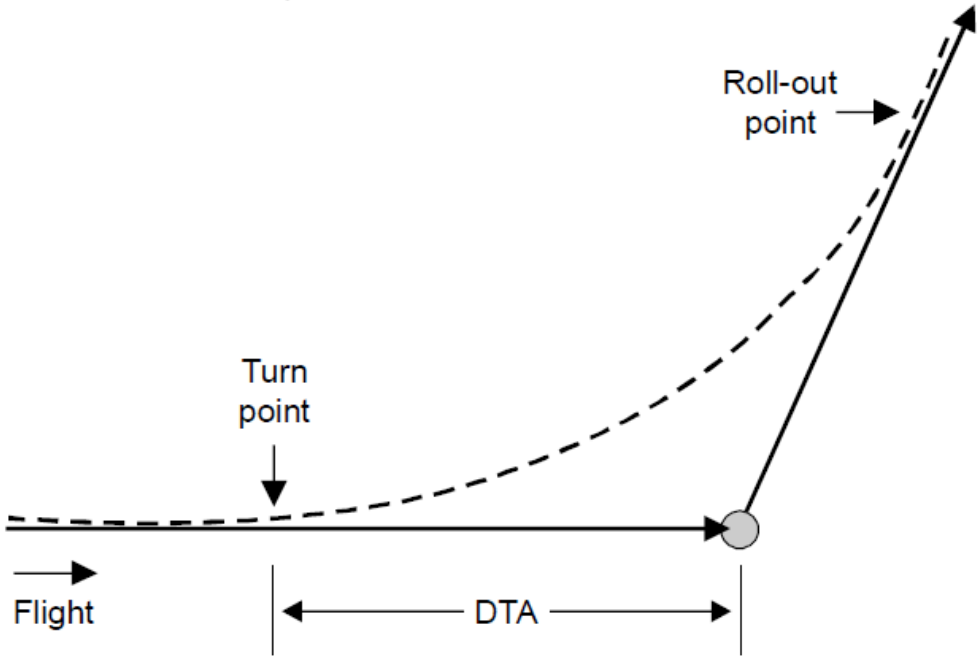
## ➢Fly-by turns — Distance of turn anticipation (DTA)

The minimum length of a segment cannot be less than the sum of the DTAs associated with the start and end fix of the segment.

DTA = r tan(A/2)

2*RNP

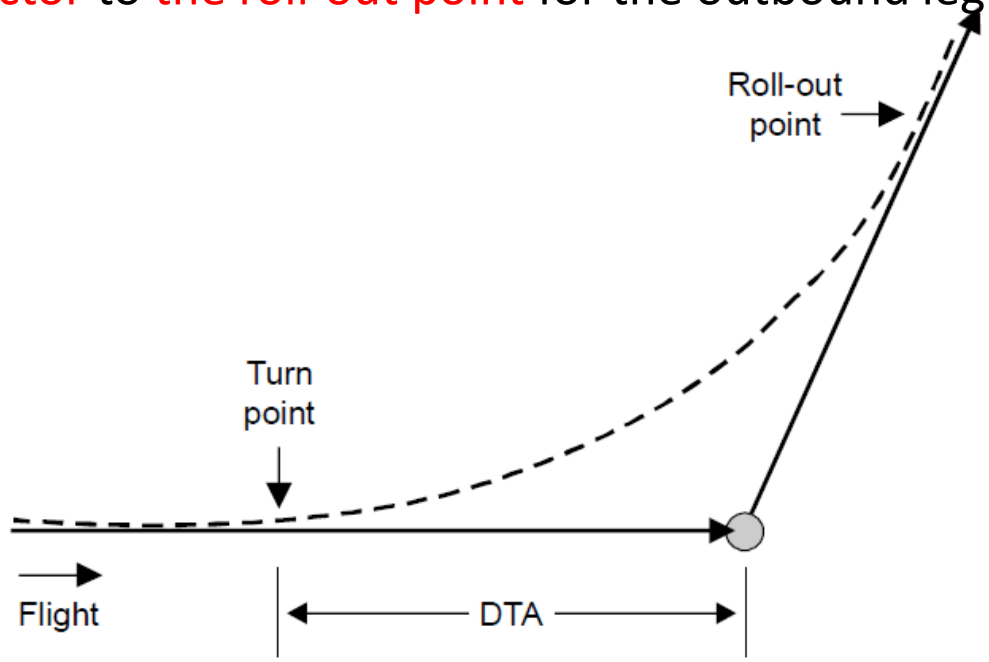
*Note: it is different from PANS-OPS.*



# Fly-by turns — Distance of turn anticipation (DTA)

## ➢Slope and Distance

The nominal distances for calculations of descent gradients are measured along the arc from the turn point to the bisector for the inbound leg component and along the arc length from the bisector to the roll-out point for the outbound leg component.



# RF Turn

**Wind for Missed approach:**

— 19 km/h (10 kt) at or below 152 m (500 ft) above AD elevation

— 37 km/h (20 kt) from 152 m (500 ft) to at or below 305 m (1 000 ft) above AD elevation

— 56 km/h (30 kt) from 305 m (1 000 ft) to at or below 610 m (2 000 ft) above AD elevation

— 74 km/h (40 kt) from 610 m (2 000 ft) to at or below 915 m (3 000 ft) above AD elevation

# RF Turn

**Bank angle:**

**Calculated by radius of turn;**

**Same as Fly-by turns** at or below FL 190;

Above FL 190 bank angle as 15° **should be used**

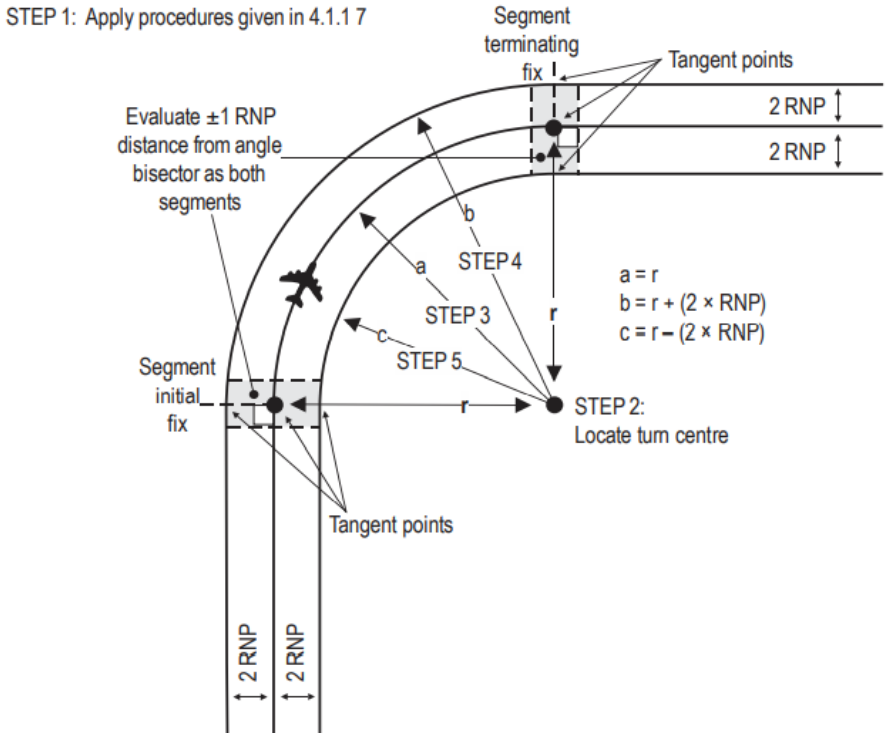
$\alpha = \arctan (TAS + W)^2/(68625 * r)$; given $R = (3431 * \tan \alpha)/[(\pi*(TAS + W)] \leq 3°/sec$

W = tailwind speed; and
r = turn radius.

# RF Turn

- The turn area is bounded by **concentric arcs**. The **minimum turn radius is 2 × RNP**.
- STEP 1: Ground track
- STEP 2: Locate the turn center
  - perpendicular distance “r” from the inbound and outbound segments.
  - This is the **common center** for the nominal turn track, outer boundary and inner boundary arcs.
- STEP 3: Construct the flight path.
  - Draw an arc of radius “r” from the tangent point on the inbound course to the tangent point on the outbound track.
- STEP 4: Construct the outer turn area boundary.
  - Draw an arc of radius (r + 2 RNP) from the tangent point on the inbound segment outer boundary to the tangent point on the outbound track outer boundary.
- STEP 5: Construct the inner turn area boundary.
  - Draw an arc of radius (r – 2 * RNP) from the tangent point on the inbound segment inner boundary to the tangent point on the inner boundary of the outbound track.

# RF Turn


STEP 1: Apply procedures given in 4.1.1 7
Segment terminating fix
Tangent points
2 RNP
2 RNP
Evaluate ±1 RNP distance from angle bisector as both segments
b
a
STEP 4
STEP 3
c
STEP 5
r
a = r
b = r + (2 × RNP)
c = r – (2 × RNP)
Segment initial fix
r
STEP 2: Locate turn centre
Tangent points
2 RNP
2 RNP

# RF Turn

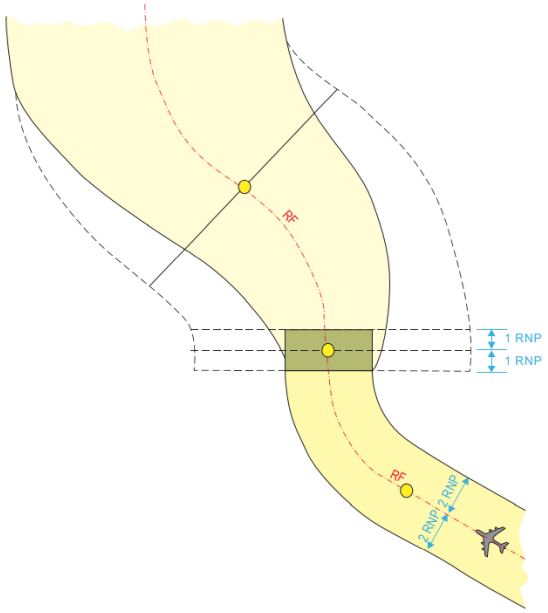
## ➢To determine the height of the surface

➢The height of the surface is constant along a radial line in a manner similar to a **spiral staircase**. To determine the height of the surface:

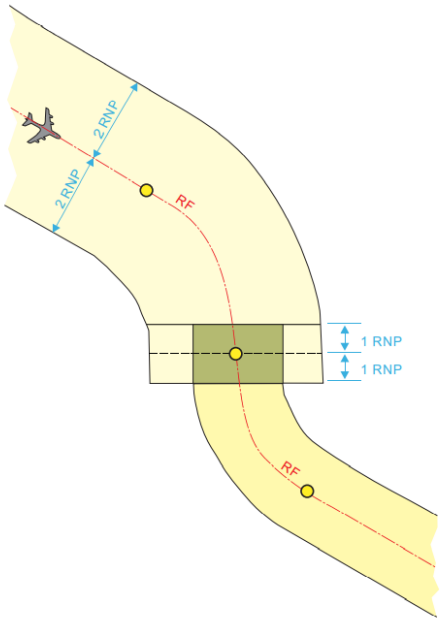
➢For an RF leg in the approach, calculate the height based on the gradient along the nominal track and apply the height across a radial line through the point.

➢For an RF leg in the missed approach, the distance for the gradient is based on an arc length calculated using a radius of (r – 0.1 NM).

# RF Turn




*Change to a less stringent RNP*




*Change to a more stringent RNP*

# Initial & Intermediate Approach Segment

# Initial &Intermediate Approach Segment

- **RNP navigation accuracy requirements**

  1.0nm--------the minimum and the optimum

  0.1nm--------the highest/minimum

# Initial Approach Segment

Segment length:

Sufficient length to

– allow the required descent (as close to the optimum gradient )

– take account of DTA where fly-by turns are required.

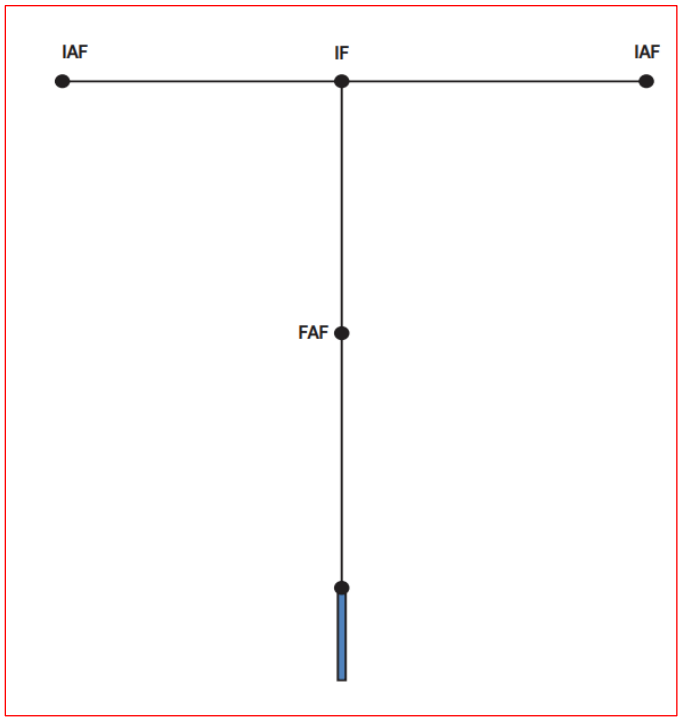
- Minimum straight segment (any segment) length

  2 × RNP* (DTA1+DTA2 for fly-by turn construction).

- Maximum initial segment length = 50 NM

# Initial Approach Segment

- **Initial segment**
- A direct RNP or RNAV route
  - T- Bar
  - turn at IAF > 90 then RF
  - If holding patterns are provided
    - at IAF and align with initial segment.

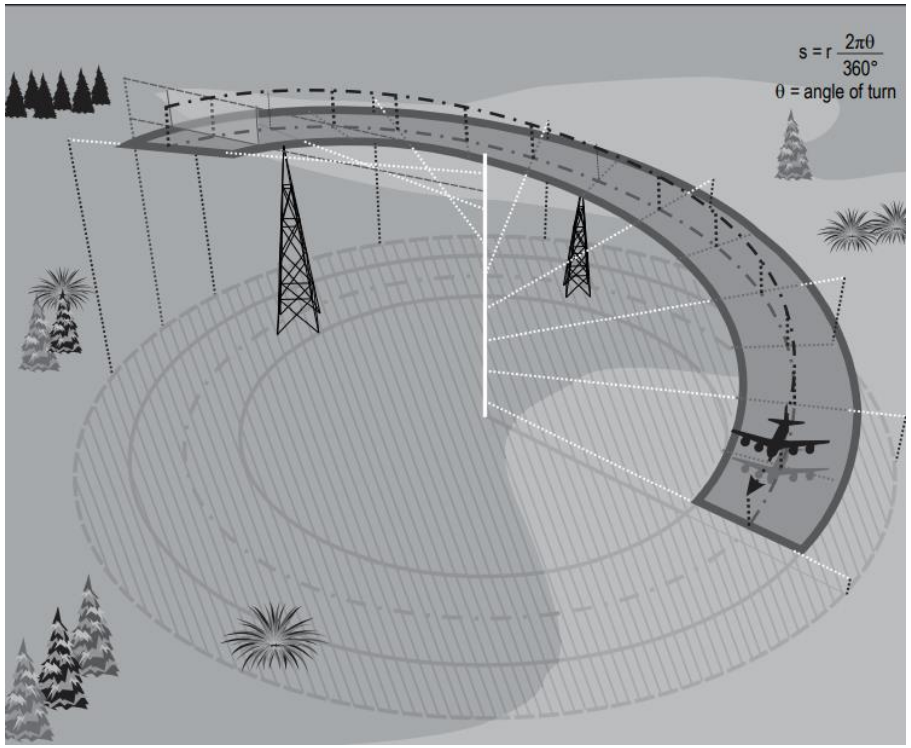


# Descent Gradient

| *Segment* | *Descent gradient* | |
|---|---|---|
| | *Standard* | *Maximum* |
| Initial | 4% (2.4°) | 8% (4.7°) |
| Intermediate | ≤2.5% (1.4°) | Equal to designed final segment gradient |
| Final | 5.2% (3°) | See section 4.4.16 |

# Descent Gradient

- Length of the arc
  - RF
    - r

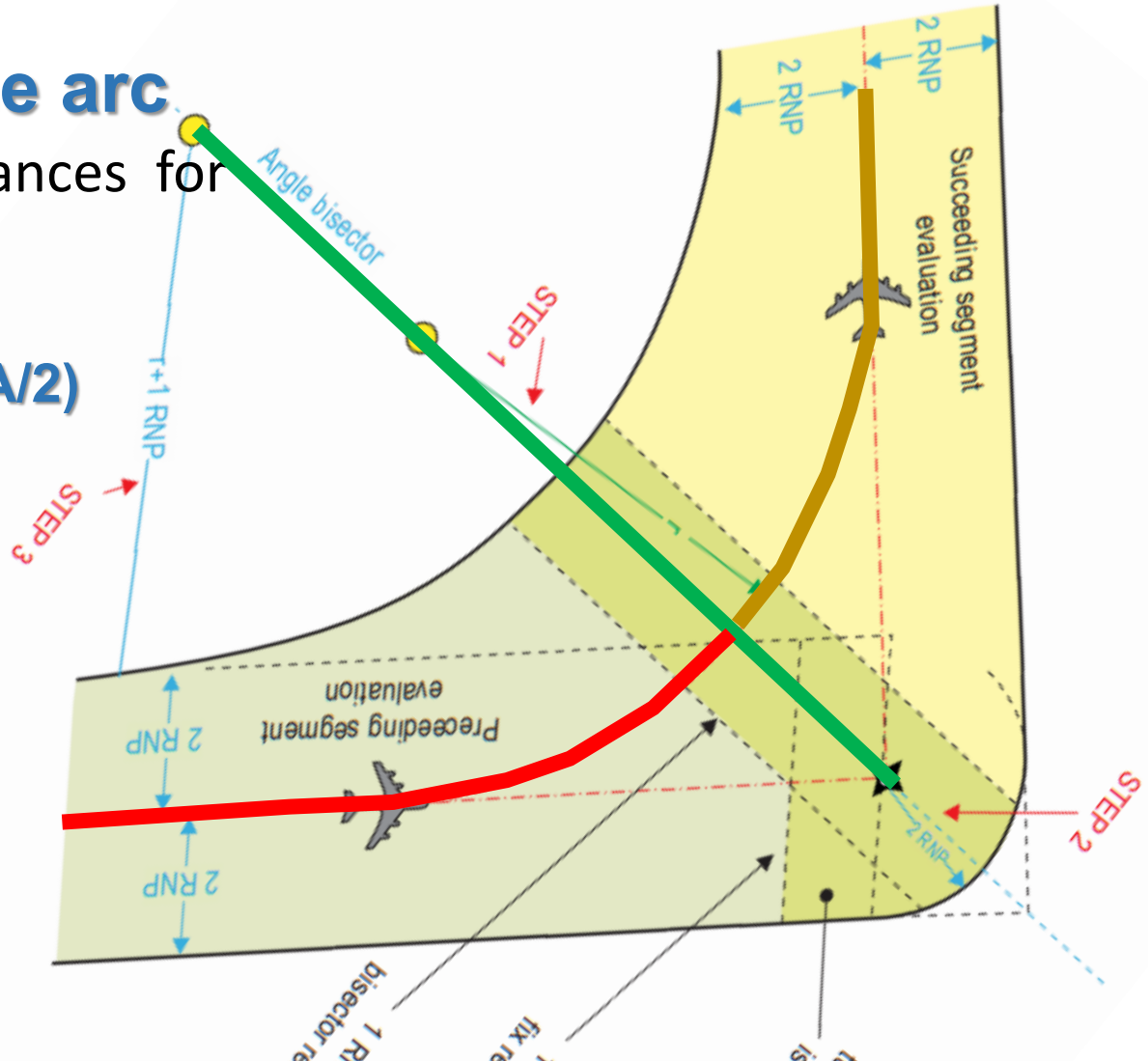



S = r（2π***θ***/360°）

Gradient= (Height changed/S)*100%

# Descent Gradient

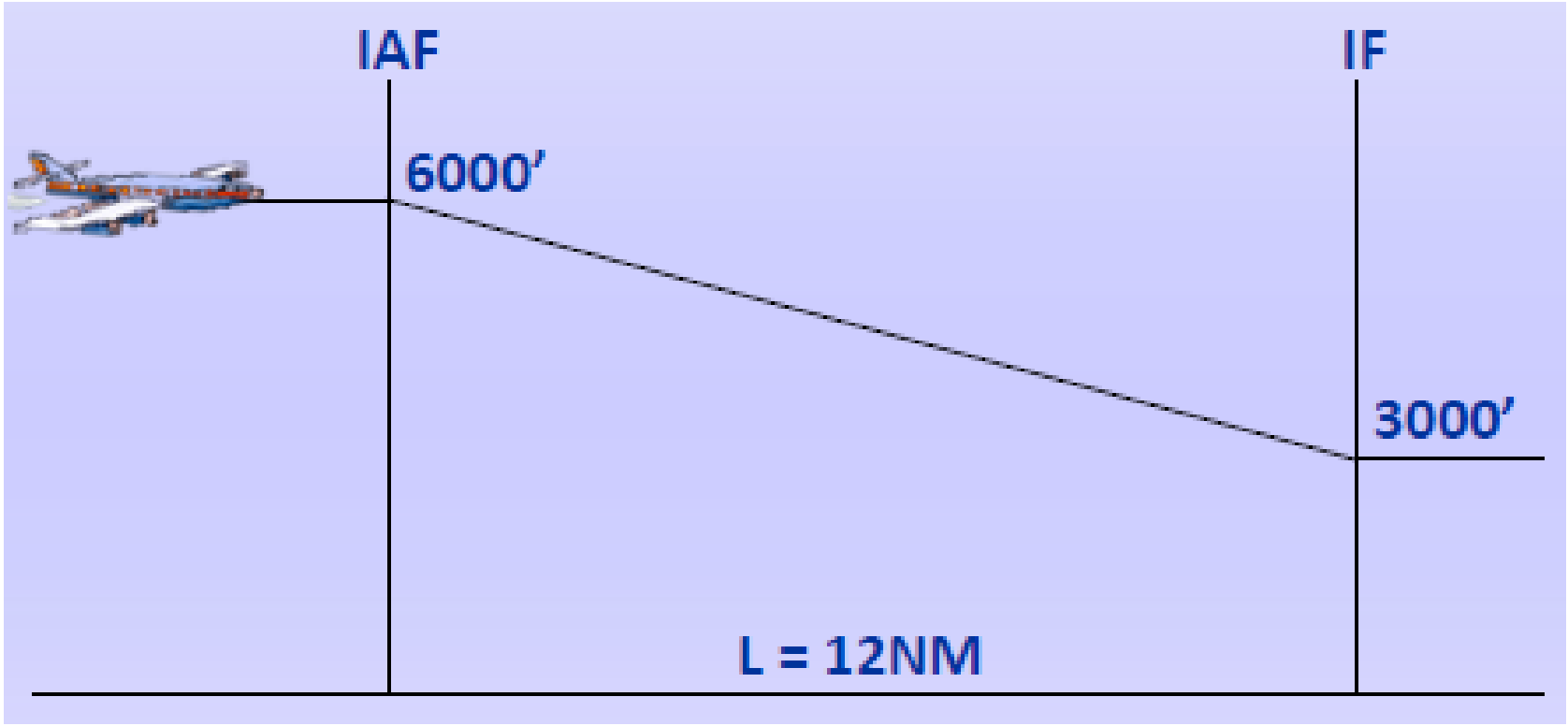
- **Length of the arc**
  - nominal distances for DTA
  - **DTA = r tan(A/2)**



# Descent Gradient

- **Descent gradient:**

（6000-3000）/（12×6076）=4.11%

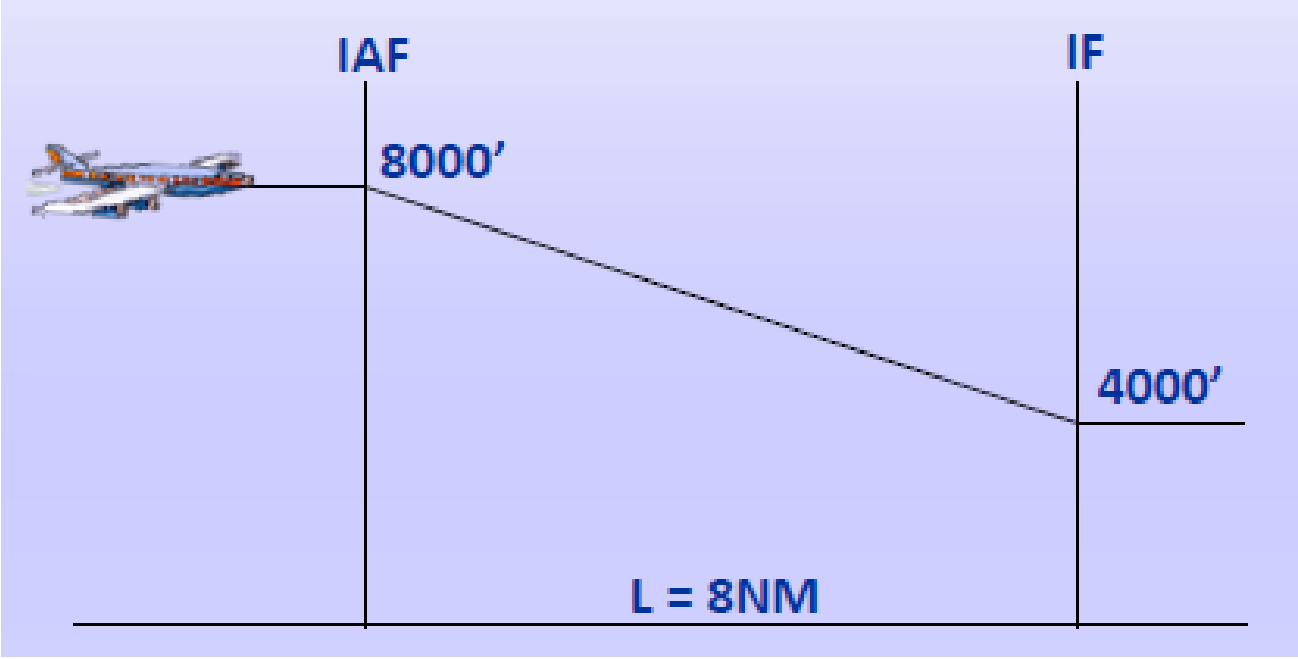


# Descent Gradient

（8000-4000）/（8×6076）=8.23%

（8000-4000）/（？×6076）=4%　　？=16.46

（8000-？）/（8×6076）=4%　　？=6056

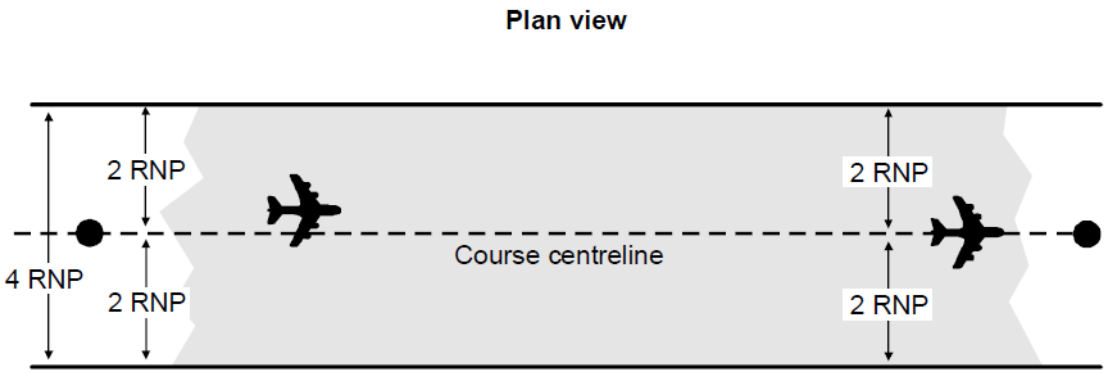


# Initial Approach Segment

- **Protection area:**

½ width = 2*RNP

No secondary area, no buffer zone

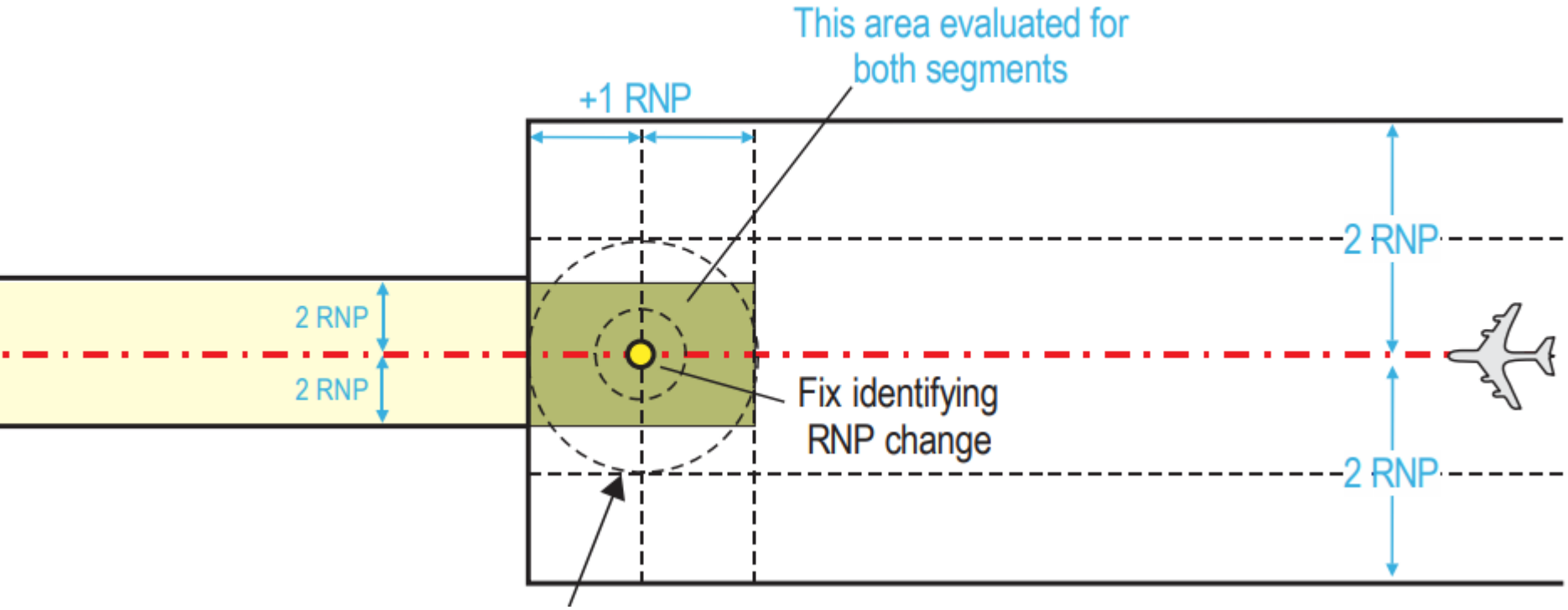


# Initial Approach Segment (RNP reduction)

- **Protection area:**

½ width = 2*RNP

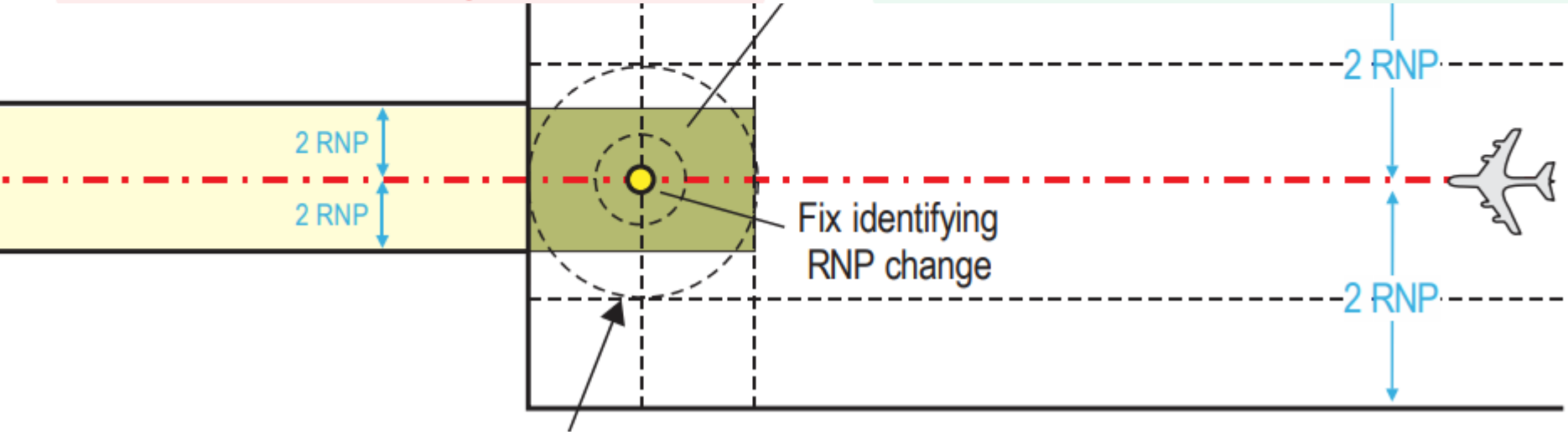
No secondary area, no buffer zone



# CORRIGENDA 28/2/24

## 4-2

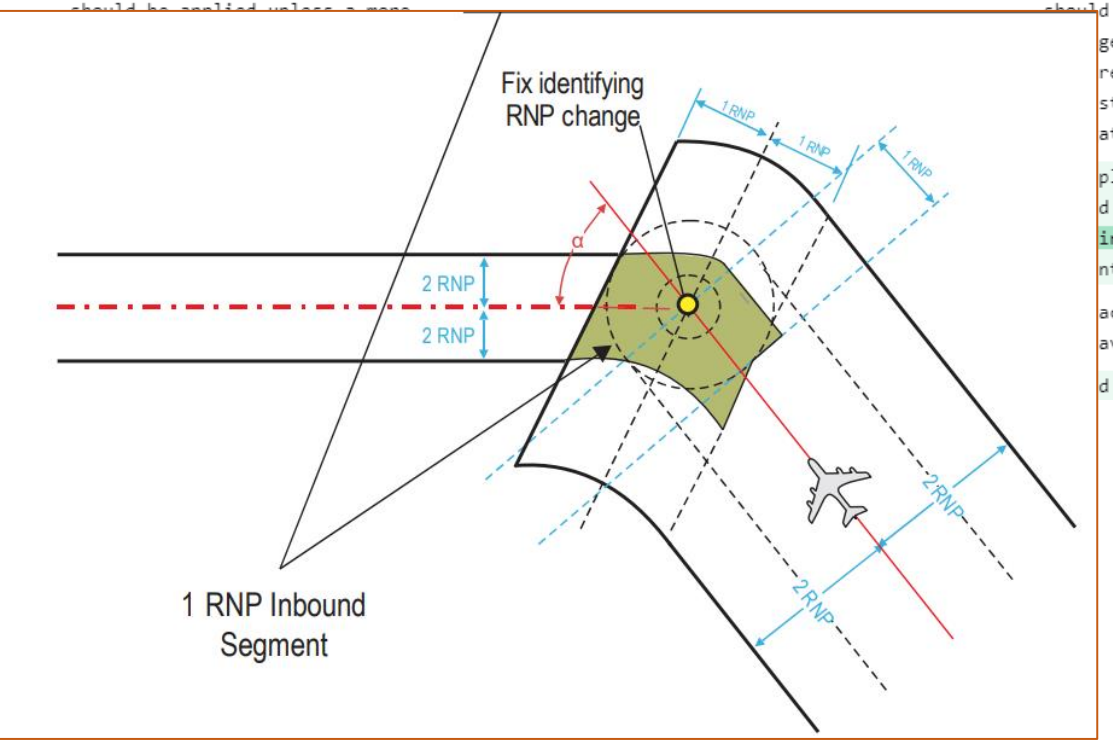
| | |
|---|---|
| 6 4.1.8 The maximum RNP navigation accuracy requirements listed in Table 2-1 should be applied unless a more | 6 4.1.8 The maximum RNP navigation accuracy requirements listed in Table 2-1 should be applied unless a more |
| 7 stringent navigation accuracy requirement is necessary to achieve the required ground track or lowest OCA/H. Once a | 7 stringent navigation accuracy requirement is necessary to achieve the required ground track or lowest OCA/H. Once a |
| 8 more stringent navigation accuracy requirement is applied, a less stringent navigation accuracy requirement should not | 8 more stringent navigation accuracy requirement is applied, a less stringent navigation accuracy requirement should not |
| 9 be applied until the start of the missed approach. The RNP accuracy value should only decrease in the initial and | 9 be applied until the start of the missed approach. The RNP accuracy value should only decrease in the initial, intermediate |
| 10 intermediate approach segments, and only increase in the missed approach segment. For each line of minima, the RNP | 10 and final approach segments, and only increase in the missed approach segment. For each line of minima, the RNP |
| 11 accuracy value must not change within the final segment. The most stringent RNP navigation accuracy requirements are | 11 accuracy value must not change within the final segment. The most stringent RNP navigation accuracy requirements are |
| 12 listed in the “Minimum” column of Table 2-1. | 12 listed in the “Minimum” column of Table 2-1. |



# CORRIGENDA 28/2/24

## 4-2

6 4.1.8 The maximum RNP navigation accuracy requirements listed in Table 2-1




6 4.1.8 The m ble 2-1
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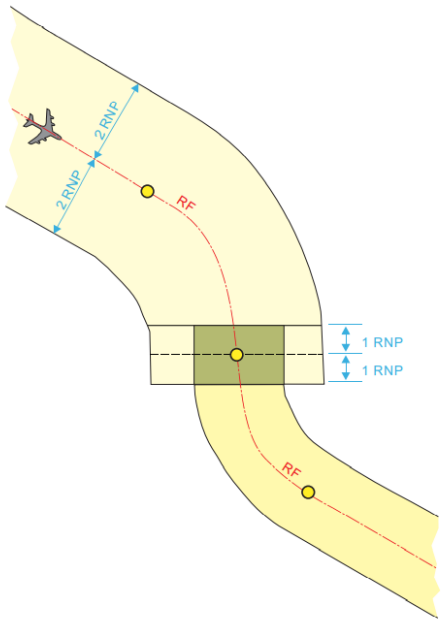


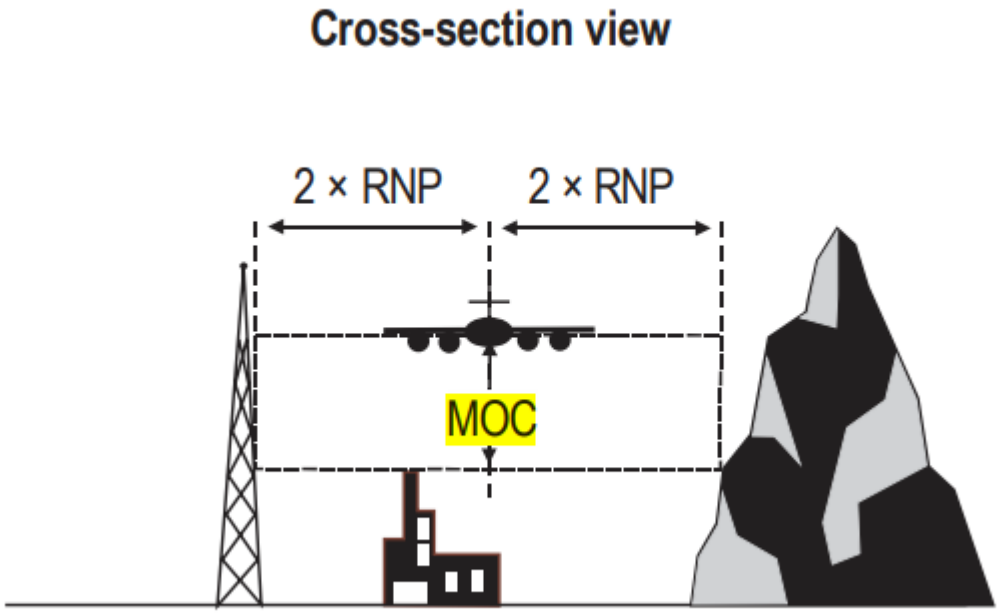
# Initial Approach Segment

## ➢MOC:

MOC = at least 300 m, In mountainous terrain, should be increased by as much as 100 per cent

MOCA ≥ MOCA Intermediate or Final

– Rounded to hundred of ft



# Intermediate Approach egment Segment

Segment length:

Sufficient length to

– allow the required descent (as close to the optimum gradient )

– take account of DTA where fly-by turns are required.

- Minimum straight segment (any segment) length

  2 × RNP* (DTA1+DTA2 for fly-by turn construction).

- ~~Maximum initial segment length – 50 NM~~

# Intermediate Approach Segment
## Descent Gradient

| *Segment* | *Descent gradient* | |
|---|---|---|
| | *Standard* | *Maximum* |
| Intermediate | ≤2.5% (1.4°) | Equal to designed final segment gradient |

# Intermediate Approach Segment Alignment

Aligned with the FAS whenever possible.

- Fly-by turns at FAP limited to 15° *
- Turns of more than 15° =>**RF**

*Note: RF leg should be tangent to FAP*

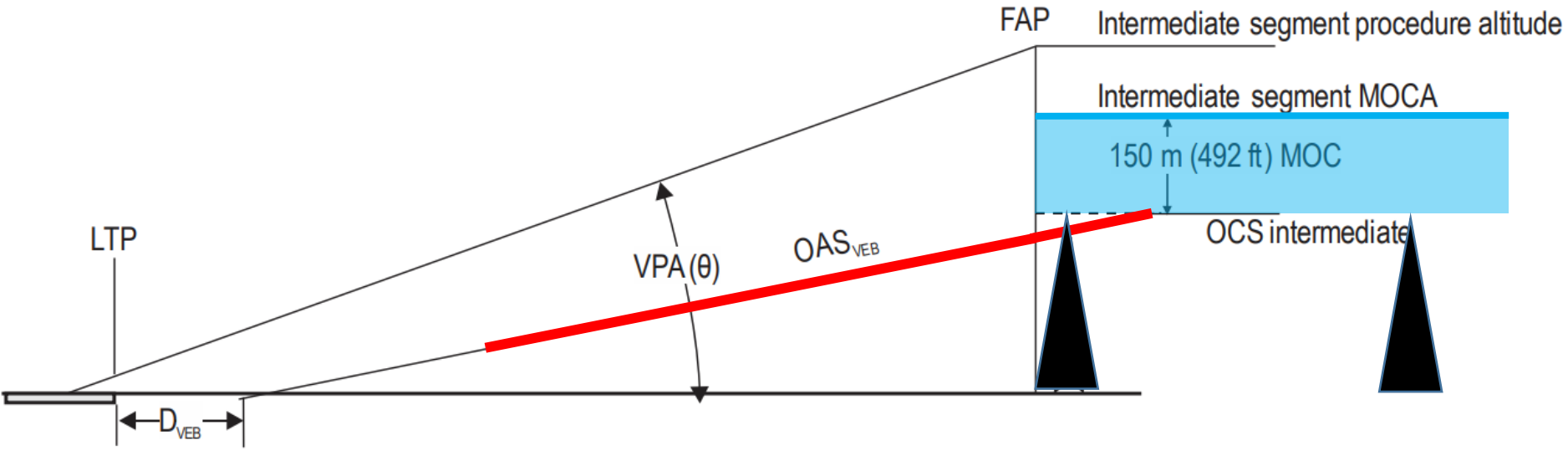
# Intermediate Approach Segment

## MOC

- MOC = at least 150 m
- MOCA Rounded to hundred of ft

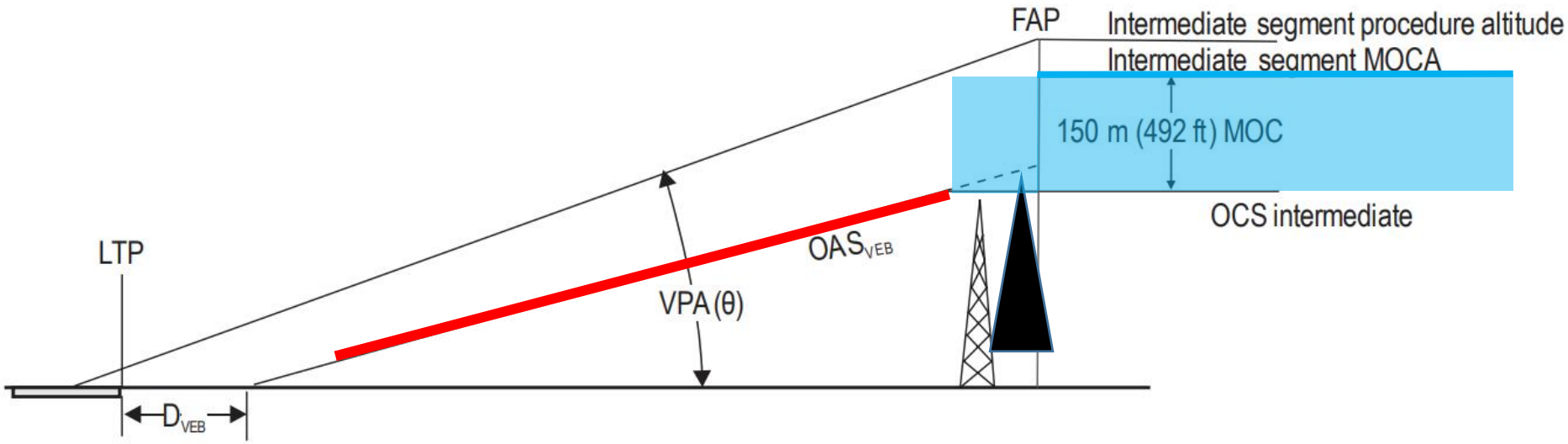
# Intermediate Approach Segment
# $OAS_{VEB}$ Extension

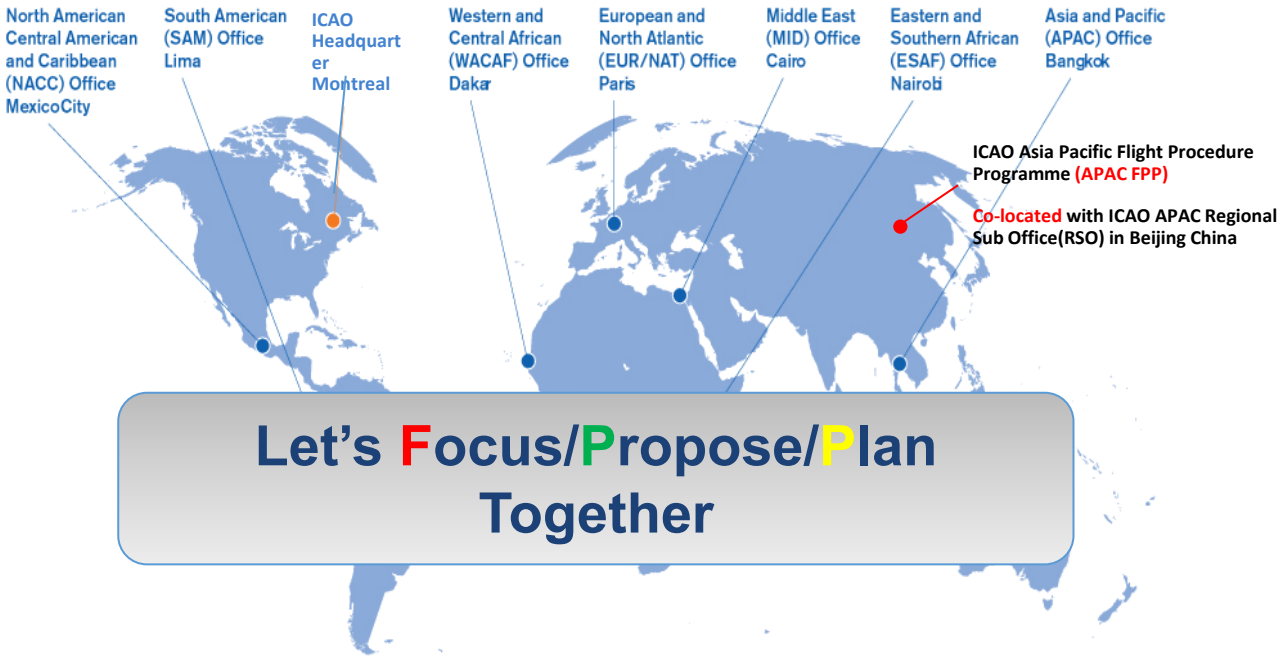
- VEB (OASVEB) extends up to the horizontal obstacle clearance surface (OCS) of the intermediate segment



# Intermediate Approach Segment
# $OAS_{VEB}$ Extension

- VEB (OASVEB) extends up to the horizontal obstacle clearance surface (OCS) of the intermediate segment






# Let's Focus/Propose/Plan Together