



**INTERNATIONAL CIVIL AVIATION ORGANIZATION**

*A United Nations Specialized Agency*

## **PBN Airspace Design Workshop**

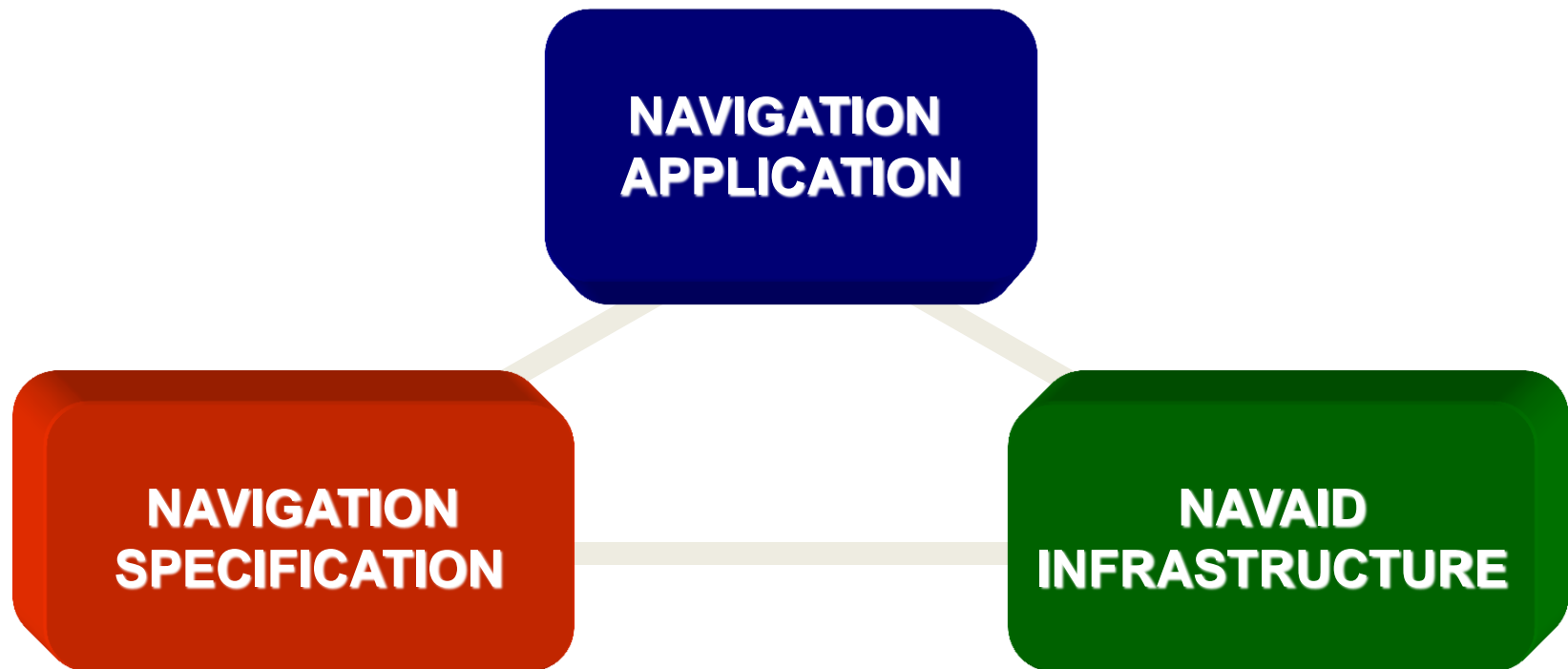
# **Overview of PBN NavSpecs**

**Asia and Pacific Regional Sub-Office  
Beijing, China**

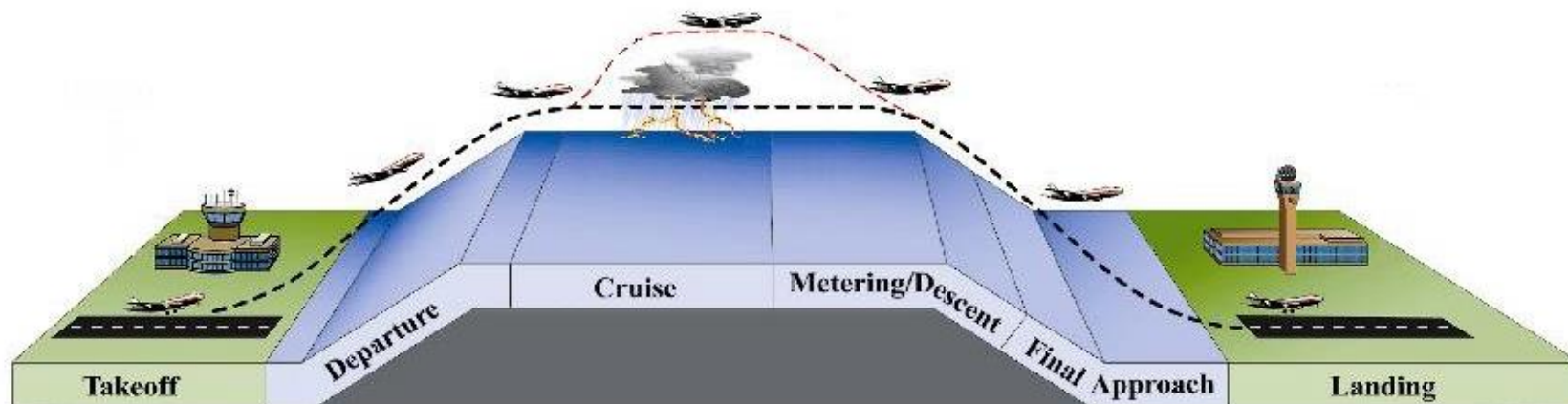
# Learning Objectives

- ❖ **By the end of this presentation, you will:**
  - Know where to find details of the Navigation Specifications (NavSpecs)
  - Appreciate how the different NavSpecs relate to phases of flight
  - Identify which sensor can support every NavSpecs
  - Explain the aim of Advanced RNP (A-RNP)
  - State which NavSpecs support the approach phase of flight
  - Explain how, within PBN, vertical guidance can be provided for approach operations

# Components of PBN Concept



# Application of NavSpecs. by Phase of Flight



Part Chapter	Navigation specification	Flight phase							
		En-route oceanic/remote	En-route continental	Arrival	Approach				DEP
					Initial	Intermediate	Final	Missed <sup>1</sup>	
B, Ch.1	RNAV 10	10							
B, Ch.2	RNAV 5 <sup>2</sup>		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	2						
C, Ch.3	RNP 1 <sup>3</sup>			1	1	1		1	1
C, Ch.4	Advanced RNP (A-RNP) <sup>4</sup>	2 <sup>5</sup>	2 or 1	1	1	1	0.3	1	1
C, Ch.5	RNP APCH <sup>6</sup>				1	1	0.3 <sup>7</sup>	1	
C, Ch.6	RNP AR APCH				1-0.1	1-0.1	0.3-0.1	1-0.1	
C, Ch.7	RNP 0.3 <sup>8</sup>		0.3	0.3	0.3	0.3		0.3	0.3

# Application of NavSpecs. by Phase of Flight

- ❖ PBN Manual includes airworthiness, operational and training guidance

Doc 9613 Part / Chapter	Navigation Specification	Flight phase							DEP
		En-route oceanic/remote	En-route continental	Arrival	Approach				
					Initial	Intermediate	Final	Missed <sup>1</sup>	
B Ch.1	<b>RNAV 10</b>	<b>10</b>							
B Ch.2	<b>RNAV 5<sup>2</sup></b>		<b>5</b>	<b>5</b>					
B Ch.3	<b>RNAV 2</b>		<b>2</b>	<b>2</b>					<b>2</b>
B Ch.3	<b>RNAV 1</b>		<b>1</b>	<b>1</b>	<b>1</b>	<b>1</b>		<b>1</b>	<b>1</b>
C Ch.1	<b>RNP 4</b>	<b>4</b>							
C Ch.2	<b>RNP 2</b>	<b>2</b>	<b>2</b>						
C Ch.3	<b>RNP 1<sup>3</sup></b>			<b>1</b>	<b>1</b>	<b>1</b>		<b>1</b>	<b>1</b>
C Ch.4	<b>Advanced RNP<sup>4</sup></b>	<b>2<sup>5</sup></b>	<b>2 or 1</b>	<b>1</b>	<b>1</b>	<b>1</b>	<b>0.3</b>	<b>1</b>	<b>1</b>
C Ch.5	<b>RNP APCH<sup>6</sup></b>				<b>1</b>	<b>1</b>	<b>0.3<sup>7</sup></b>	<b>1</b>	
C Ch.6	<b>RNP AR APCH</b>				<b>1-0.1</b>	<b>1-0.1</b>	<b>0.3-0.1</b>	<b>1-0.1</b>	
C Ch.7	<b>RNP 0.3<sup>8</sup></b>		<b>0.3</b>	<b>0.3</b>	<b>0.3</b>	<b>0.3</b>		<b>0.3</b>	<b>0.3</b>

# Avionics Supporting Specifications



	Permitted Sensors					Aircraft Requirement
	GNSS	IRU	D/D	D/D/I	VO/D	AP/FD
RNAV-10	X	X				FTE may be manually controlled by the pilot remaining within ½ full scale deflection of CDI with corrected scaling for phase of flight
RNAV-5	X	X	X	X	X	
RNAV -1 & RNAV -2	X		X	X		
RNP-4	X					
RNP-2 <sup>1</sup>	X					
RNP-1	X		X <sup>3</sup>			
Advanced RNP <sup>1</sup>	X		X <sup>3</sup>			X <sup>2</sup>
RNP APCH	X		X <sup>3</sup>	X <sup>3</sup>		X <sup>3</sup>
RNP AR APCH	X					X
RNP 0.3	X					X

1. For Oceanic/Remote Continental operations, dual independent LRNS (providing Higher Continuity) are required
2. Although the A-RNP NavSpec does not explicitly state AP/FD, the RF appendix does and RF is a requirement for A-RNP
3. Only when authorized by a specific State based on an available DME infrastructure and appropriate aircraft capability

# Long Range Operations

## ❖ Navigation Specifications

- RNAV 10
- RNP 4
- RNP 2 (with limitations)

# Long Range Operations

## ❖ RNAV 10

- Currently authorised as RNP 10
- PBN NavSpec is RNAV 10
- **No change in principle - Only a name change**
- Existing RNP 10 approvals may continue
- New approvals RNP 10
- Requires two Long Range Navigation Systems
  - INS or IRS
  - GNSS
- Common installations
  - Dual IRS with radio updating
  - IRS/GNSS
  - Dual GNSS

# Long Range Operations

## ❖ RNAV 10 Limitations

### ➤ Inertial only

- Position confidence degrades with time
- Limitation on time between updates

### ➤ Time limitations

- Standard case 6.2 hours
- Based on assumed drift rate
- Assumed drift rate 2.0 NM/hr (radial position)/95%
- $XTK = 0.8 * \text{radial drift (Rayleigh distribution)}$

✓  $0.8 * 2.0 = 1.6 \text{ NM/HR}$

✓  $10\text{NM} \div 1.6 = 6.2 \text{ hrs}$

### ➤ Time limit extension

- Dual INS/IRS
- Demonstrated reduced drift rate  $< 2.0$

# Long Range Operations

## ❖ RNAV 10 Limitations (Cont')

- En-route update (FAA Order 8400.12A para 12.e)
  - Automatic updating using DME/DME : Baseline – 0.3h
  - Automatic updating using VOR/DME : Baseline – 0.5h
  - Manual updating : Baseline – 1h
  
- GNSS
  - IRS+GNSS or dual GNSS
  - No maximum time limitation
  - FDE required
    - ✓ Basic TSO C129a not FDE capable
  - 34 minute FDE loss limitation

# Long Range Operations

## ❖ RNP 4

- GNSS
- Two Long Range Navigation Systems
  - At least one GNSS
  - Navigation database
- Common installations
  - 2 x IRS/GNSS
  - 2 x GNSS

## ❖ RNP 4 Limitations

- Time limitations
  - Dual GNSS only: 25 min FDE loss max
  - IRS/GNSS (multi-sensor): No limitations

# Long Range Operations

## ❖ RNP 2

### ➤ GNSS Required

- Oceanic/Remote requires additional continuity
- Advanced RNP qualifies

### ➤ Suitable GNSS

- TSO C129a Class B or C or TSO C145() (FMS systems)
- TSO C129a Class A1 or TSO C146() (stand-alone)

### ➤ Continuity

- For oceanic/remote loss of function is major failure
- TSO C129a Class B or C or TSO C145() (FMS systems)
- TSO C129a Class A1 or TSO C146() (stand-alone)

## ❖ RNP 2 Limitations

### ➤ Time limitations

- Predicted loss of integrity  $\leq 5$  mins

### ➤ Continuity

- Duplicated equipment
- FDE

# En-route/Terminal Area Operations

## ❖ Navigation Specifications

- RNAV 5
- RNAV 1 and RNAV 2
- RNP 2
- RNP 1 (previously Basic RNP 1)
- Advanced RNP (A-RNP)
- RNP 0.3

# En-route/Terminal Area Operations

## ❖ RNAV 5

- Replaces B-RNAV
- **Automatic transition B-RNAV to RNAV 5**
  - Doc 9613, Vol. II Part B Ch. 2, 2.3.2.3
  - Doc 9997 Ch. 4, 4.4.1.1
- “Basic” RNAV
- Routes dependent on ground aids
- Single RNAV system
- Navigation database not required
- Storage of 4 waypoints required
- Manual data entry permitted
- Human factors issues?

# En-route/Terminal Area Operations

## ❖ RNAV 5 (Cont')

### ➤ Common Installations

- IRS with radio updating
- IRS with GNSS updating
- Stand-alone GNSS (en-route mode)

## ❖ RNAV 5 Limitations

### ➤ INS/IRS without automatic radio updating

- 2hrs from ground update (take-off)

### ➤ GNSS

- Predicted loss of FD < 5 mins
- Revised flight plan

# En-route/Terminal Area Operations

## ❖ RNAV 1 and RNAV 2

- Replaces P-RNAV and US-RNAV
- P-RNAV/US RNAV Transition conditions
  - Doc 9613. Vol II, Part B, Ch. 3, 3.3.2.4
- Routes dependent on ground aids
- Single ops approval for RNAV 1 and RNAV 2
- RNAV 1 and RNAV 2 routes
  - Designated by ANSP
  - Based on ground navaid infrastructure
  - NOT an ops approval condition
- Applicable to SID/STAR
- Can apply to an approach up to FAF
- Single RNAV system
- Navigation database required

# En-route/Terminal Area Operations

## ❖ RNAV 1 and RNAV 2 (Cont')

### ➤ SID/STAR

- Extracted from database
- Waypoints may be added/deleted
- **Manual entry of waypoint data prohibited**

### ➤ Common Installations

- IRS with radio updating
- IRS with GNSS updating
- Stand-alone GNSS (terminal mode)

## ❖ RNAV 1 and RNAV 2 Limitations

### ➤ GNSS

- Predicted loss of FD < 5 mins
- **Revise flight plan**

# En-route/Terminal Area Operations

## ❖ RNP 2

- GNSS Required
- Loss of continuity minor failure condition
  - Provided alternative nav system available
- Navigation database required
- Routes
  - Extracted from database
  - Approval may be given for pilots to construct routes
    - ✓ Using waypoints in the nav database
  - For flexible routes lat/long entry may be permitted

## ❖ RNP 2 Limitations

- GNSS
  - Predicted Loss of integrity  $\leq 5$  mins
- Continuity
  - Approval limited to domestic ops
    - ✓ Unless continuity addressed

# En-route/Terminal Area Operations

## ❖ RNP 1

- Same as RNAV 1 and RNAV 2 with GNSS but some minor differences
- Previously called Basic RNP 1
- Minimum single GNSS system
- Navigation database required
- SID/STAR
  - Extracted from database
  - Waypoints may be added/deleted
  - **Manual entry of waypoint data prohibited**

## ❖ RNP 1 Limitations

- GNSS
  - Loss of FD < 5 mins

# En-route/Terminal Area Operations



## ❖ RNP 1 Operations

### ➤ Stand-alone GNSS

- **Automatic mode switching**
- Departures **require ARP** in flight plan
- Arrivals **require ARP** in flight plan
- **Scaling changes at 30NM ARP**
- **Limited ARINC 424 functionality**
- **VNAV capability not standard**

### ➤ FMS aircraft

- **No automatic mode switching**
- **Normally integrated with VNAV capability**
- **RNP 1 selection/confirmation required**

# En-route/Terminal Area Operations

## ❖ FTE Limits

- RNAV 5 2.5NM
- RNAV 1 0.5NM
- RNAV 2 1.0NM
- RNP 2 1.0NM
- RNP 1 0.5NM

## ❖ Control System Requirement

- RNAV 5 CDI/FD/AP/MAP, CDI scale +/- 5NM
- RNAV 1 CDI/FD/AP, CDI scale +/- 1NM
- RNAV 2 CDI/FD/AP/MAP, CDI scale +/- 1NM (Terminal mode)
- RNP 2 CDI/FD/AP/MAP,  
CDI scale +/- 2NM or +/-5NM (Stand-alone)
- RNP 1 CDI/FD/AP, CDI scale +/- 1NM

# En-route/Terminal Area Operations

## ❖ Advanced RNP (A-RNP)

- Single operational approval allows aircraft to fly **oceanic, en-route, terminal area, and approach** phase of flight
- Reduced individual assessments
- A-RNP Navigation Specification
  - Authorises RNP Operations with Nav Accuracies 0.3 on final approach and 1, 2, 5 NM for other phases of flight
  - Relies solely on the RNP system without recourse to conventional aids ( Refer para 4.1.3.1)
  - **RF Radius to Fix capability is required**
- **For existing approvals**, re-examination not required
  - Only need to comply with A-RNP Navspec
- **For future approvals**, aircraft will be documented to meet A-RNP

# En-route/Terminal Area Operations



## ❖ Advanced RNP (A-RNP) (Cont')

### ➤ Aircraft Requirements

- **RF**
- Parallel Offsets
- RNAV holding
- **Scalability** (Selection RNP in 1/10NM 0.1 to 1.0)
- Higher continuity (for some ops)
- Fixed Radius Transitions (optional)
- Time of Arrival Control (optional)
- Automatic selection of RNP (from database)



### ➤ Radio Updating

- **GNSS dependent**
- DME updating may be approved by State
- VOR updating NOT permitted

# En-route/Terminal Area Operations

## ❖ RNP 0.3

- Intended to support short range helicopter operations
- Not limited to helicopters
- RNP 0.3 required for all segments
- Capable nav system required
- RNP selectability



# En-route/Terminal Area Operations



## ❖ RNP 0.3 (Cont')

### ➤ Aircraft Equipment Requirement

- Typically TSO C145/146 receiver
- FMS
- RNP 0.3 selection
- Loss of function a major failure for remote/offshore ops
  - ✓ Duplicated independent nav systems may be required
- CA path terminator capability required
  - ✓ Implies VNAV requirement

**Note: Stand-alone receivers typically cannot operate RNP 0.3 unless in approach mode**

## ❖ RNP 0.3 Operations

- Integrity prediction required
- Loss of integrity  $\leq 5$  minutes
- Loss of GNSS capability must be considered

# PBN Approaches

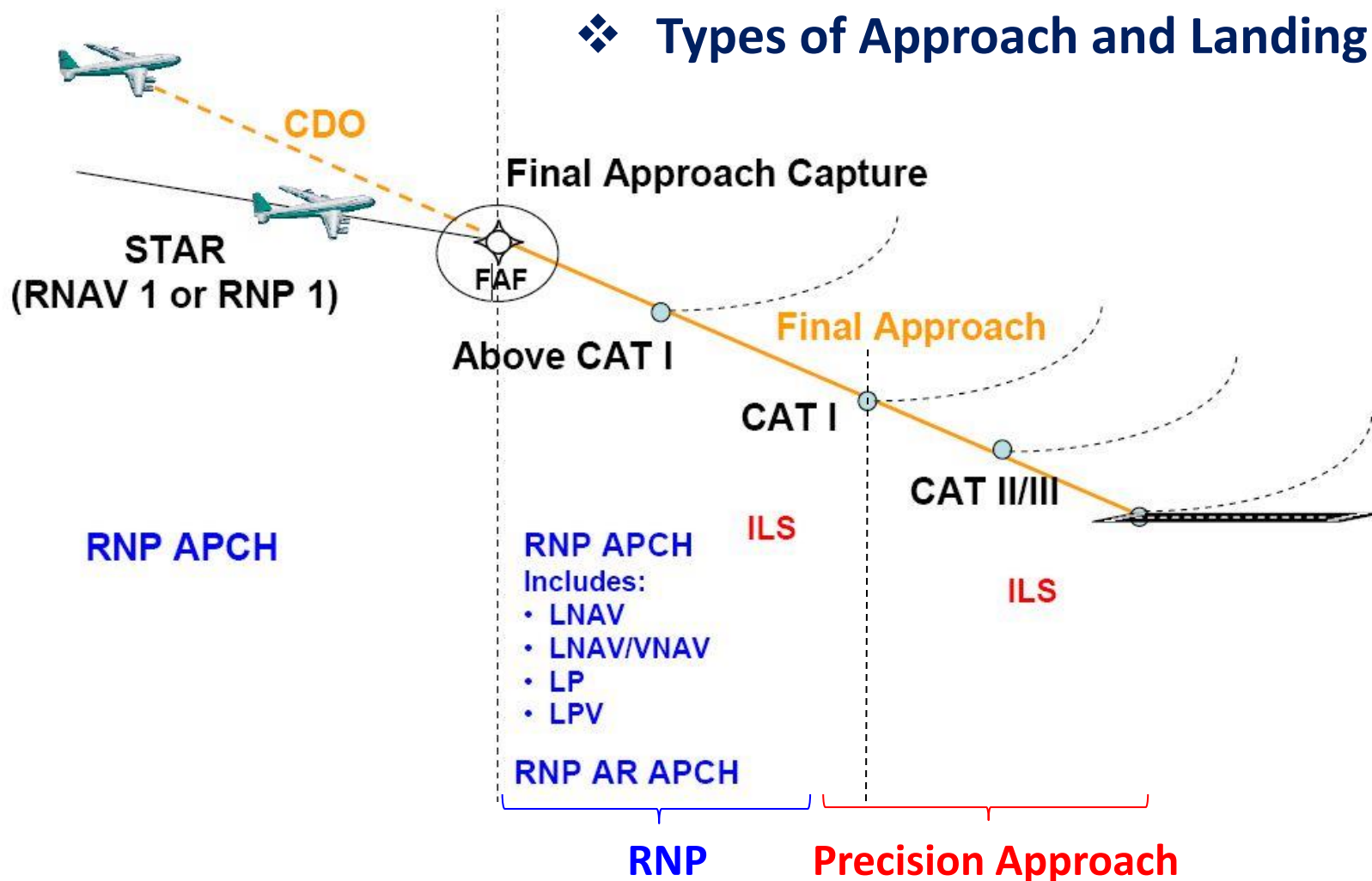
## ❖ Navigation Specifications

➤ RNP APCH

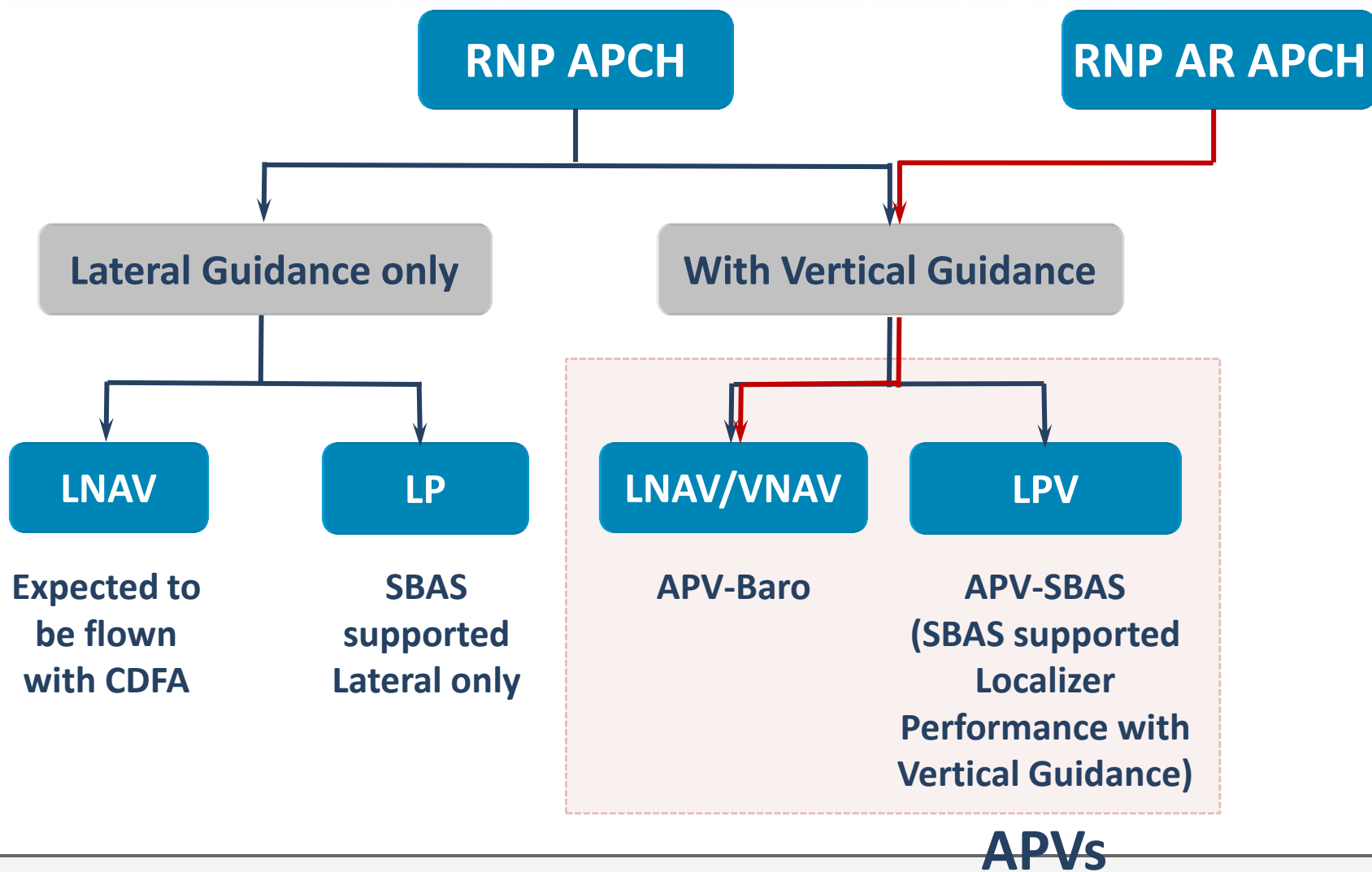
➤ RNP AR APCH

# PBN Approaches

## ❖ Types of Approach and Landing



# PBN Approaches



# PBN Approaches

## ❖ RNP APCH

- Flown to **LNAV minima**

## ❖ RNP APCH with Baro-VNAV

- Flown to **LNAV/VNAV minima**
- Also called **APV Baro**

## ❖ RNP AR (Authorization Required) APCH

- Flown to **LNAV/VNAV minima but reduced terrain clearance**

## ❖ RNP APCH using SBAS augmentation

- Flown to **LPV minima**
- Called an **APV SBAS**
- Potentially to DA/H of 200ft if airport is equipped for ILS CAT I operations

# PBN Approaches

## ❖ RNP APCH LNAV

- Charted as **RNAV (GNSS) or RNP** (from 1 Dec 2022)
- Under PBN Concept classified as RNP APCH (LNAV)
- GNSS provides PMA capability
- Minima shown as **LNAV**
- No change to operations and design of approaches
- Based on GA type stand-alone receivers
- Re-issue approvals as **RNP APCH LNAV**

## ❖ RNP APCH LNAV/VNAV

- RNP APCH LNAV + Baro-VNAV (called as APV Baro)
- Minima shown as **LNAV/VNAV**
- Operational approval as **RNP APCH LNAV/VNAV**
- Available **APVs**
  - RNP AR APCH (Vol II Part C Chapter 6)
  - RNP APCH LNAV/VNAV (Vol II Part C Chapter 5 Section A)
  - RNP APCH LPV (Vol II Part C Chapter 5 Section B)

# PBN Approaches

## ❖ RNP APCH Characteristics

### ➤ Avionics Requirements

- LNAV only
  - ✓ Stand-alone GNSS receiver : TSO C129(), TSO C146(), or
  - ✓ FMS RNP 0.3 capability
    - Provides equivalent approach navigation performance
- LNAV/VNAV
  - ✓ **FMS required**
  - ✓ Approved Baro-VNAV system (FAA AC 20-129)

### ➤ FTE (XTK) Considerations

- CDI or MAP, but MAP displays may be limited
- Autopilot/FD may be used to limit XTK deviation
- **Normal operating standards**
  - ✓  $\frac{1}{2}$  navigation accuracy for segment ( **$\frac{1}{2}$  RNP**)
  - ✓ Allowance for turns
- Go-round requirement
  - ✓ 1 x navigation accuracy (refer para Ch5, Sec. A, 5.3.4.4.8)
- Not normally a pilot qualification/skill issue
- Autopilot/FD accuracy is well documented

# PBN Approaches

## ❖ RNP APCH Characteristics (Cont')

### ➤ Lateral Control

- CDI/HSI or MAP
- **CDI scaling +/- 0.3 on approach, +/- 1.0 initial**
- MAP display must have equivalent functionality
- FD or AP not required, unless necessary to limit XT

### ➤ Cockpit Display

- CDI or HSI required for stand-alone installations
  - ✓ Automatic CDI scaling
  - ✓ Initial/intermediate 1.0NM (terminal)
  - ✓ Final 0.3NM (approach)
  - ✓ Missed approach 1.0NM (terminal)
- FMS
  - ✓ CDI not normally installed
  - ✓ XTK pointer available as option
  - ✓ MAP display standard
  - ✓ Numerical XTK deviation on MAP; or
  - ✓ Numerical XTK deviation on CDU

# PBN Approaches

## ❖ RNP APCH Characteristics (Cont')

### ➤ Vertical Navigation - LNAV Only

- Non-precision approach procedures apply
- **Descent to MDA**
- Descent to DA at MDA + margin
- Use of MDA as DA
- Step-down fix limitations apply
- VNAV path may be coded
- **VNAV advisory only**

### ➤ Vertical Navigation – LNAV/VNAV

- **Descent to DA**
- Step-down fix limitations do not apply
- Adherence to vertical path required
- V FTE +/- 75 ft
- Correct VNAV mode

**Note : Difference between VNAV advisory vs. VNAV guidance**

# PBN Approaches

## ❖ RNP AR APCH

- **Authorization Required** for operators, aircraft and flight crews satisfying accurate operational requirements
- Charted as **RNAV (RNP) or RNP RWY XX (AR)** (from 1 Dec 2022)
- GNSS provides PMA capability
- Minima shown as LNAV/VNAV with RNP accuracy
- Re-issue approvals as **RNP AR APCH**
- Typical Configurations
  - 2 FMS
  - 2 or 3 IRS
  - 2 GNSS
  - 2 FD
  - 2 AP
  - Duplicated primary flight displays
  - Duplicated navigation displays
  - 2 RADALT
  - TAWS

# PBN Approaches

## ❖ RNP AR Operations

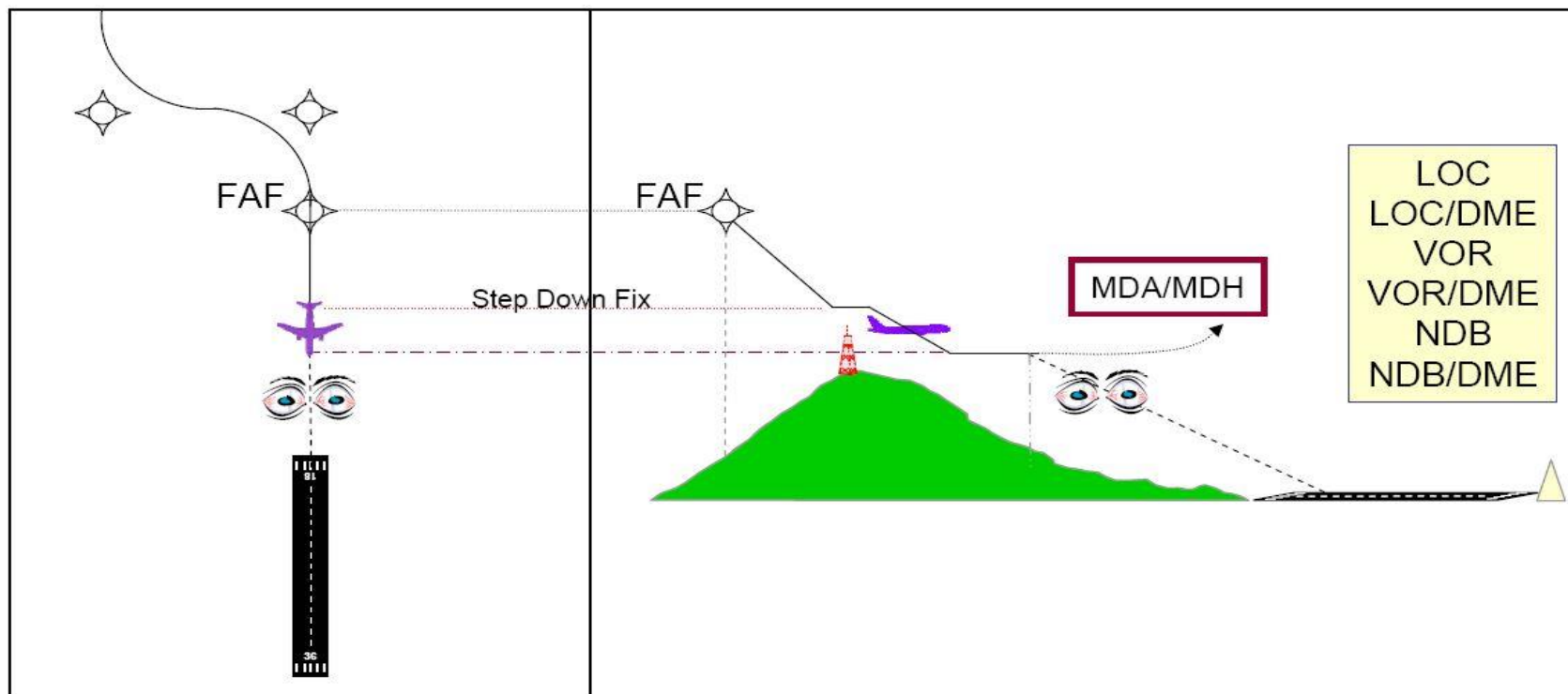
- **Reduced obstacle clearance 2 x RNP without buffers**
- **Vertical guidance mandatory**
- **Baro VNAV obstacle clearance using VEB**
- **Supports RNP less than 0.3, DA up to 250ft**
- **Supports use of RF legs**
- **Supports reduced tolerances in missed approach**
- **Identified by AUTHORISATION REQUIRED on chart**
- **Benefits**
  - **Designed to take advantage of available capability**
  - **Extract the maximum benefit from installed equipment**
  - **Improved safety**
  - **Improved efficiency**



# Conventional NPA

## LATERAL

## VERTICAL

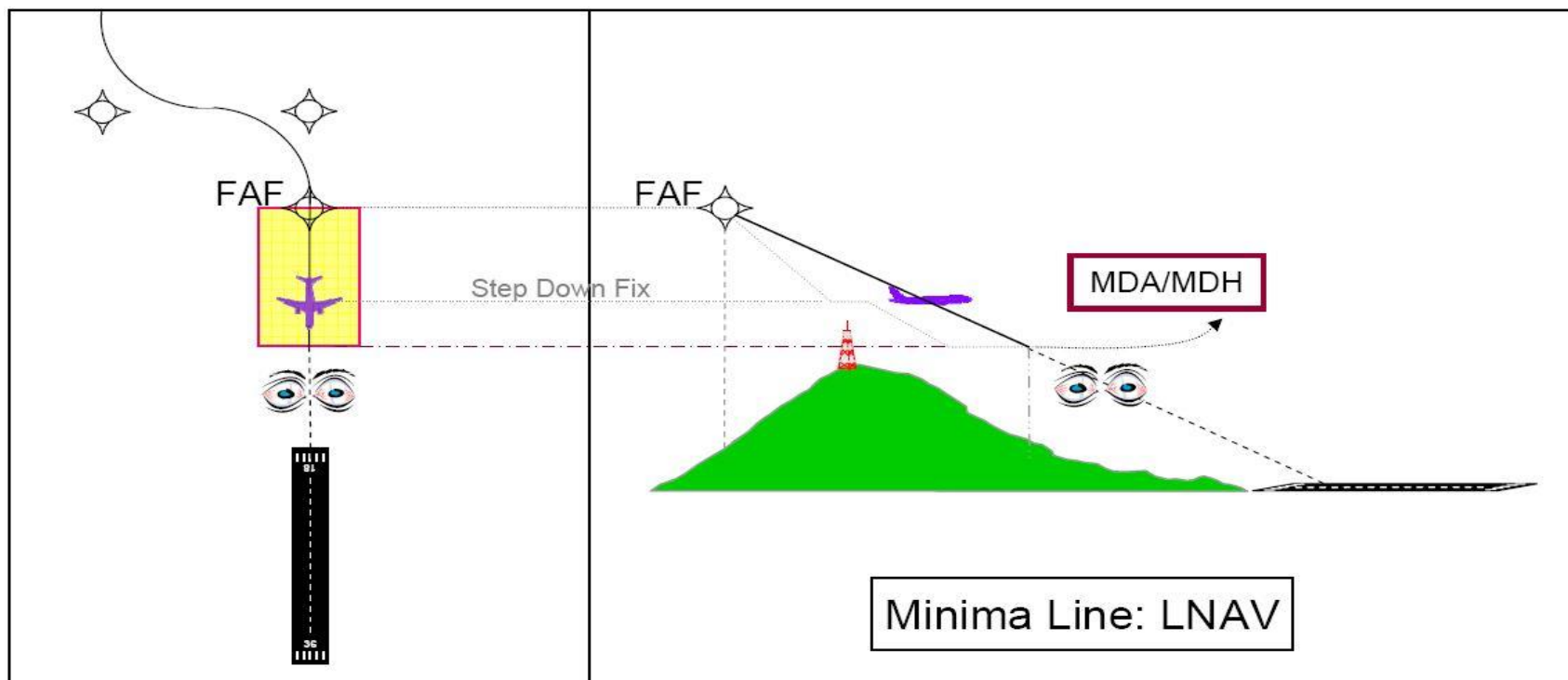


Description	System	Performance
<ul style="list-style-type: none"> <li>• Approach conducted to a MDA/MDH</li> <li>• Lateral Guidance based on ground based NAVAIDs</li> </ul>	As Displayed	/

# RNP APCH with CDFA

## LATERAL

## VERTICAL

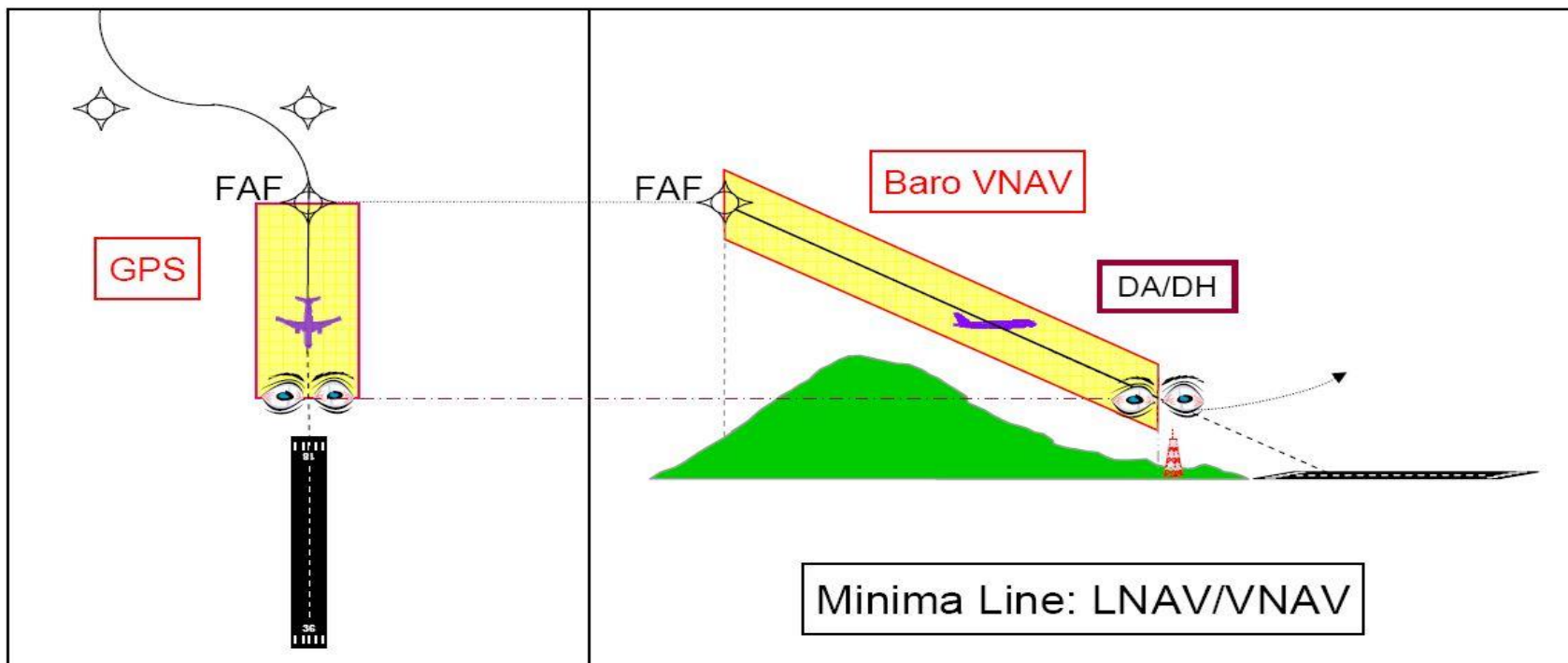


Description	System	Performance
<ul style="list-style-type: none"> <li>• Approach conducted to a MDA/MDH</li> <li>• Lateral Guidance only based on GPS (with RAIM)</li> </ul>	GPS RAIM	0.3NM (95%)

# APV Baro Approach

## LATERAL

## VERTICAL

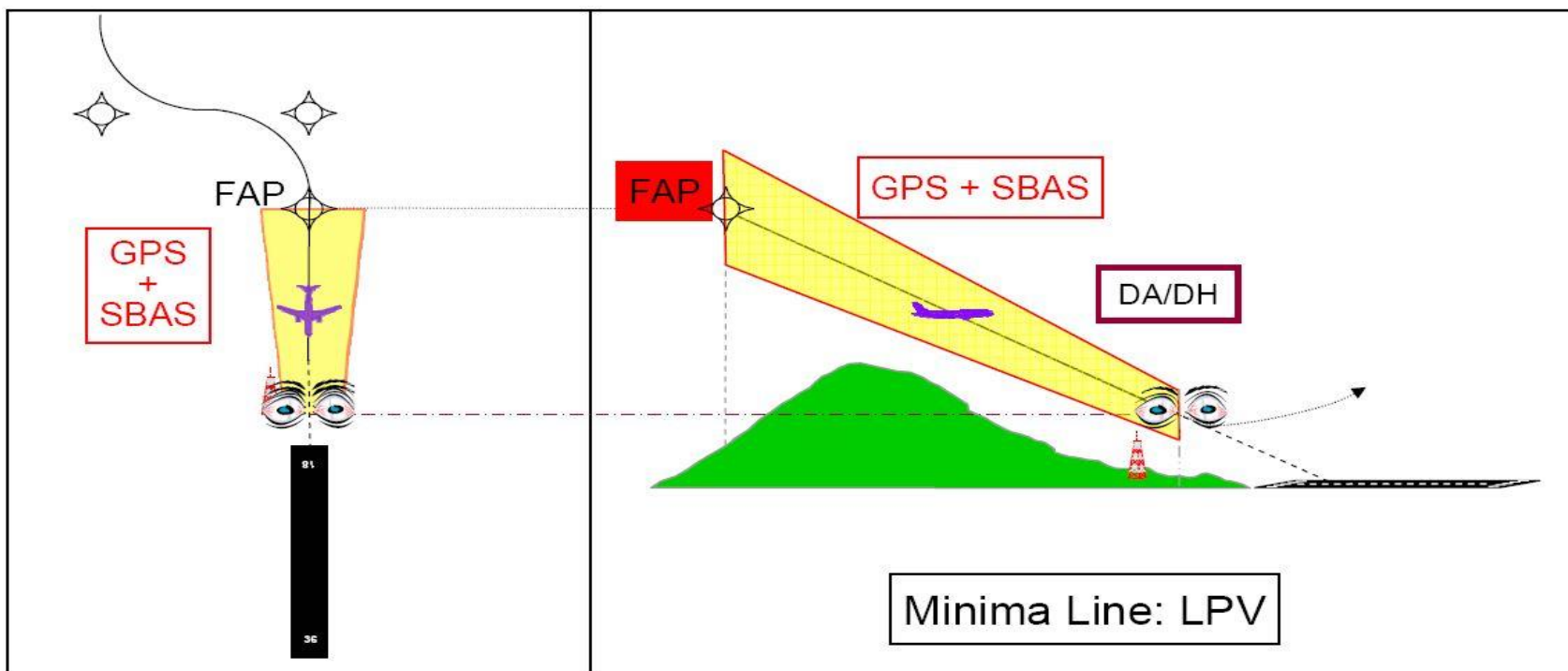


Description	System	Performance
<ul style="list-style-type: none"> <li>Approach conducted to a DA/DH</li> <li>Lateral Guidance only based on GPS (with RAIM) and Vertical Guidance based on Baro</li> </ul>	GPS RAIM & Barometric altimetry	0.3NM (95%) VNAV: $\pm 22\text{m}/\pm 75\text{ft}$

# APV SBAS Approach

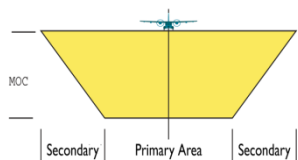
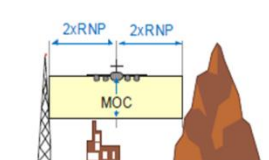
## LATERAL

## VERTICAL



Description	System	Performance
<ul style="list-style-type: none"> <li>• Approach conducted to a DA/DH</li> <li>• Lateral and Vertical Guidance based on SBAS</li> </ul>	GPS + SBAS	HAL : 40m VAL : 50m/ 35m (DA 200ft)

# RNP APCH vs. RNP AR APCH

	RNP APCH LNAV/VNAV	RNP AR APCH
Obstacle Evaluation		
VNAV	Baro	Baro
FAS Vertical	75m MOC	Vertical Error Budget
Lateral Accuracy	GNSS	GNSS
RNP	0.3 equivalent	0.3 to 0.1
Final XTK	0.15NM	0.15 NM to 0.05
Turns	TF/TF	TF/RF
Missed Approach	Terminal Mode (RNP 1.0)	RNP 1.0 or less
Initial/Intermediate	Terminal Mode (RNP 1.0)	RNP 1.0 to 0.3
Lowest DH	250ft	250ft
Equipment	Single	Duplicated standard
Safety Assessment	Vol II A3	FOSA

# PBN-in-a-page



## PBN NavSpecs and Route Spacing (PBN Manual Doc 9613 Volume II, Attachment B & PANS-OPS Doc 8168 Volume II, Part III)

Nav Specs	Flight Phase								Supporting Nav. Infrastructure	Route Spacing (NM)	Additional Functionality (Required or Optional)					Operational Requirements					
	En-route Remote	En-route Continental	Arrival	Approach				Departure			RF	FRT	TOAC <sup>2)</sup>	Baro VNAV	Nav DB	Communication	Navigation	Surveillance	Others		
				Initial	Intermediate	Final	Missed <sup>1)</sup>														
RNAV 10	10								Not require ground-based Naviad Dual LRNS (INS, IRS FMS, GNSS)	50					O	Voice com through 3rd party, DCPC in some areas	RNAV 10 (RNP 10) Approval, lateral deviation less than 7NM (same direction)/6NM (opposite direction)	Procedural pilot position reports	System safety must be monitored, TLS 5X10 <sup>-9</sup> accident per flight hour		
RNAV 5		5	3) 5)						VOR/DME DME/DME INS or IRS GNSS	16.5 - straight unidirectional tracks (same direction route-ECAC) 18 - straight bidirectional tracks (opposite direction route- ECAC) 10 - ATC intervention capability (ECAC) 30 - No ATS Surveillance in high traffic density (ECAC)					O	DCPC- VHF	RNAV 5/RNP 5 OPS Approval (BRNAV)	Procedural pilot position report (RNP 5) Radar surveillance (RNAV 5)			
RNAV 2		2	2					2	GNSS DME/DME DME/DME/IRU	8 to 9 - straight tracks in high traffic density (en-route) (FAA)					R	DCPC- VHF	RNAV 2 OPS Approval (PRNAV, US RNAV AC 90-100)	Radar surveillance			
RNAV 1		1	1	1	1			1	GNSS DME/DME DME/DME/IRU	8 - straight tracks in high density (terminal, Eurocontrol) 7 for SIDs/STARs (PANS-ATM)					R	DCPC- VHF	RNAV 1 OPS Approval (PRNAV, US RNAV AC 90-100)	Radar surveillance			
RNP 4	4								Not require ground-based Naviad GNSS	30 (part of the Pacific airspace) 50 or 30 * (PANS-ATM) *23NM proposed by SASP (applicable date : 10 November 2016)					R	DCPC or CPDLC	RNP 4 OPS Approval	ADS with a lateral deviation contract having 5NM	System verification assuring lateral deviation less than 15NM		
RNP 2	2	2							GNSS	50, 30 or 15 (PANS-ATM) 7 for climb/descend through other aircraft with VHF DCPC 20 for climb/descend through other aircraft with other type of com.					R	Depend on operational considerations (route spacing, traffic density, complexity, contingency procedures)	RNP 2 OPS Approval (Oceanic/Remote/continental)	Not required except reduced route spacing			
RNP 1			1	1	1			1	GNSS	5 for SIDs/STARs (PANS-ATM)					R	DCPC (RNP 1 SIDs/STARs)	RNP 1 OPS Approval	Not required except reduced route spacing			
A RNP <sup>4)</sup>	2	2 or 1	1 - 0.3	1 - 0.3	1 - 0.3	0.3	1 - 0.3	1 - 0.3	GNSS Multi-DME may be provided	7 - straight and turning tracks (<90°) in high traffic density (en-route, Terminal, Eurocontrol) 6 to 7 NM with an RNP 0.5 (terminal, Eurocontrol)					R	DCPC- VHF	A-RNP OPS Approval (Navigation accuracy at least ±1NM, 95% of the flight time)	Radar surveillance (may not be required to certain navigation application)			
RNP APCH (Part A) <sup>5)</sup>				1	1	0.3	1		GNSS (Missed App - RNAV or Conv.)	5 for SIDs/STARs (PANS-ATM)					R	Not required	RNP APCH OPS Approval	Not required			
RNP APCH (Part B) <sup>5)</sup>				1	1	Angular	1 or 0.3 (Initial Straight MISAP)		GNSS	5 for SIDs/STARs (PANS-ATM)					R	Not required	RNP APCH OPS Approval	Not required			
RNP AR APCH			1 - 0.1	1 - 0.1	0.3 - 0.1	1 - 0.1			GNSS (DME/DME may be authorized)	5 for SIDs/STARs (PANS-ATM)					R <sup>6)</sup>	TBD	R <sup>6)</sup>	R	Not required	RNP AR APCH OPS Approval	Not required
RNP 0.3		0.3	0.3	0.3	0.3		0.3	0.3	GNSS	5 for SIDs/STARs (PANS-ATM)					R	Not required	RNP 0.3 OPS Approval	Not required			

1) RNP requirements do not apply to initial and intermediate missed approach segments.

2) TOAC (Time of Arrival Control), TBD (To Be Determined)

3) RNAV 5 may be used for initial parts of STARs outside 30 NM from the ARP.

4) Advanced RNP core requirements are limited to RNP 1 in all flight phases except final approach (RNP 0.3) and RNP 2 in oceanic/remote and en-route continental. A scaleability option will allow accuracy values between 0.3 and 1.0, in 0.1 NM increments, in all flight phases except oceanic/remote/en-route continental (RNP 1 and RNP 2) and final approach (RNP 0.3).

5) Part A and B refer to the Performance-based Navigation (PBN) Manual (Doc 9613), Volume II, Part C, Chapter 5, Part A — RNP APCH operations down to LNAV and LNAV/VNAV minima and Part B — RNP ARH operations down to LP and LPV minima, respectively.

6) Specific requirement for RF and VNAV



# PBN-in-a-page



## PBN NavSpecs and Route Spacing (PBN Manual Doc 9613 Volume II, Attachment B & PANS-OPS Doc 8168 Volume II, Part III)

Nav Specs	En-route Remote	En-route Continental	Arrival	Flight Phase				Departure	Supporting Nav. Infrastructure	Route Spacing (NM)	Additional Functionality (Required or Optional)					Operational Requirements				
				Initial	Intermediate	Final	Missed <sup>1)</sup>				RF	FRT	TOAC <sup>2)</sup>	Baro VNAV	Nav DB	Communication	Navigation	Surveillance	Others	
RNAV 10	10								Not require ground-based Naviad Dual LRNS (INS, IRS FMS, GNSS)	50			TBD <sup>2)</sup>		O	Voice com through 3rd party, DCPC in some areas	RNAV 10 (RNP 10) Approval, lateral deviation less than 7NM (same direction)/6NM (opposite direction)	Procedural pilot position reports	System safety must be monitored, TLS 5X10 <sup>-9</sup> accident per flight hour	
RNAV 5		5	5 <sup>3)</sup>						VOR/DME DME/DME INS or IRS GNSS	16.5 - straight unidirectional tracks (same direction route-ECAC) 18 - straight bidirectional tracks (opposite direction route- ECAC) 10 - ATC intervention capability (ECAC) 30 - No ATS Surveillance in high traffic density (ECAC)			TBD		O	DCPC- VHF	RNAV 5/RNP 5 OPS Approval (BRNAV)	Procedural pilot position report (RNP 5) Radar surveillance (RNAV 5)		
RNAV 2		2	2					2	GNSS DME/DME DME/DME/IRU	8 to 9 - straight tracks in high traffic density (en-route) (FAA)			TBD		R	DCPC- VHF	RNAV 2 OPS Approval (PRNAV, US RNAV AC 90-100)	Radar surveillance		
RNAV 1		1	1	1	1		1	1	GNSS DME/DME DME/DME/IRU	8 - straight tracks in high density (terminal, Eurocontrol) 7 for SIDs/STARs (PANS-ATM)			TBD		O	R	DCPC- VHF	RNAV 1 OPS Approval (PRNAV, US RNAV AC 90-100)	Radar surveillance	
RNAV 5			5						VOR/DME DME/DME INS or IRS GNSS	16.5 - straight unidirectional tracks (same direction route-ECAC) 18 - straight bidirectional tracks (opposite direction route- ECAC) 10 - ATC intervention capability (ECAC) 30 - No ATS Surveillance in high traffic density (ECAC)							DCPC- VHF	RNAV 5/RNP 5 OPS Approval (BRNAV)	Procedural pilot position report (RNP 5) Radar surveillance (RNAV 5)	
RNP 1			1	1	1		1	1	GNSS	5 for SIDs/STARs (PANS-ATM)			O		R	DCPC (RNP 1 SIDs/STARs)	RNP 1 OPS Approval	Not required except reduced route spacing		
A RNP <sup>4)</sup>	2	2 or 1	1-0.3	1-0.3	1-0.3	0.3	1-0.3	1-0.3	GNSS Multi-DME may be provided	7 - straight and turning tracks (<90°) in high traffic density (en-route, Terminal, Eurocontrol) 6 to 7 NM with an RNP 0.5 (terminal, Eurocontrol)			R	O	TBD	O	R	DCPC- VHF	A-RNP OPS Approval (Navigation accuracy at least ±1NM, 95% of the flight time)	Radar surveillance (may not be required to certain navigation application)
RNP APCH (Part A) <sup>5)</sup>				1	1	0.3	1		GNSS (Missed App - RNAV or Conv.)	5 for SIDs/STARs (PANS-ATM)			O		TBD	O	R	Not required	RNP APCH OPS Approval	Not required
RNP APCH (Part B) <sup>5)</sup>				1	1	Angular	1 or 0.3 (Initial Straight MISAP)		GNSS	5 for SIDs/STARs (PANS-ATM)			O		TBD		R	Not required	RNP APCH OPS Approval	Not required
RNP AR APCH			1-0.1	1-0.1	0.3-0.1	1-0.1			GNSS (DME/DME may be authorized)	5 for SIDs/STARs (PANS-ATM)			R <sup>6)</sup>		TBD	R <sup>6)</sup>	R	Not required	RNP AR APCH OPS Approval	Not required
RNP 0.3		0.3	0.3	0.3	0.3		0.3	0.3	GNSS	5 for SIDs/STARs (PANS-ATM)			O		TBD	O	R	Not required	RNP 0.3 OPS Approval	Not required

1) RNP requirements do not apply to initial and intermediate missed approach segments.

2) TOAC (Time of Arrival Control), TBD (To Be Determined)

3) RNAV 5 may be used for initial parts of STARs outside 30 NM from the ARP.

4) Advanced RNP core requirements are limited to RNP 1 in all flight phases except final approach (RNP 0.3) and RNP 2 in oceanic/remote and en-route continental. A scaleability option will allow accuracy values between 0.3 and 1.0, in 0.1 NM increments, in all flight phases except oceanic/remote/en-route continental (RNP 1 and RNP 2) and final approach (RNP 0.3).

5) Part A and B refer to the Performance-based Navigation (PBN) Manual (Doc 9613), Volume II, Part C, Chapter 5, Part A — RNP APCH operations down to LNAV and LNAV/VNAV minima and Part B — RNP ARH operations down to LPV and LPV minima, respectively.

6) Specific Requirement for RNP and VNAV

# PBN-in-a-page



PBN NavSpecs and Route Spacing (PBN Manual Doc 9613 Volume II, Attachment B & PANS-OPS Doc 8168 Volume II, Part III)

Nav Specs	Flight Phase								Supporting Nav. Infrastructure	Route Spacing (NM)	Additional Functionality (Required or Optional)				Operational Requirements						
	En-route Remote	En-route Continental	Arrival	Approach				Departure			RF	FRT	TOAC <sup>2)</sup>	Baro VNAV	Nav DB	Communication	Navigation	Surveillance	Others		
				Initial	Intermediate	Final	Missed <sup>1)</sup>														
RNAV 10	10								Not require ground-based Naviad Dual LRNS (INS, IRS FMS, GNSS)	50					O	Voice com through 3rd party, DCPC in some areas	RNAV 10 (RNP 10) Approval, lateral deviation less than 7NM (same direction)/6NM (opposite direction)	Procedural pilot position reports	System safety must be monitored, TLS 5X10 <sup>-9</sup> accident per flight hour		
RNAV 5		5	3) 5)						VOR/DME DME/DME INS or IRS GNSS	16.5 - straight unidirectional racks (same direction route-ECAC) 18 - straight bidirectional tracks (opposite direction route- ECAC) 10 - ATC intervention capability (ECAC) 30 - No ATS Surveillance in high traffic density (ECAC)					O	DCPC- VHF	RNAV 5/RNP 5 OPS Approval (BRNAV)	Procedural pilot position report (RNP 5) Radar surveillance (RNAV 5)			
RNAV 2		2	2					2	GNSS DME/DME DME/DME/IRU	8 to 9 - straight tracks in high traffic density (en-route) (FAA)					R	DCPC- VHF	RNAV 2 OPS Approval (PRNAV, US RNAV AC 90-100)	Radar surveillance			
RNAV 1		1	1	1	1			1	GNSS DME/DME DME/DME/IRU	8 - straight tracks in high density (terminal, Eurocontrol) 7 for SIDs/STARs (PANS-ATM)					R	DCPC- VHF	RNAV 1 OPS Approval (PRNAV, US RNAV AC 90-100)	Radar surveillance			
RNP 4	4								Not require ground-based Naviad GNSS	30 (part of the Pacific airspace) 50 or 30* (PANS-ATM) *23NM proposed by SASP (applicable date - 10 November 2020)					R	DCPC or CPDLC	RNP 4 OPS Approval	ADS with a lateral deviation contract having 5NM	System verification assuring lateral deviation less than 15NM		
RNP 2	2	2							GNSS	50, 30 or 15 (PANS-ATM) 7 for climb/descend through other aircraft with VHF DCPC 20 for climb/descend through other aircraft with other type of com.					R	Depend on operational considerations (route spacing, traffic density, complexity, contingency procedures)	RNP 2 OPS Approval (Oceanic/Remote/continental)	Not required except reduced route spacing			
RNP 1			1	1	1			1	GNSS	5 for SIDs/STARs (PANS-ATM)					R	DCPC (RNP 1 SIDs/STARs)	RNP 1 OPS Approval	Not required except reduced route spacing			
A RNP <sup>6)</sup>	2	2 or 1	1-0.3	1-0.3	1-0.3	0.3	1-0.3	1-0.3	GNSS Multi-DME may be provided	7 - straight and turning tracks (<90°) in high traffic density (en-route, Terminal, Eurocontrol) 6 to 7 NM with an RNP (terminal, Eurocontrol)					R	DCPC- VHF	A-RNP OPS Approval (Navigation accuracy at least ±1NM/90% of the flight time)	Radar surveillance (may not be required to certain navigation application)			
RNP 2	2	2							GNSS	50, 30 or 15 (PANS-ATM) 7 for climb/descend through other aircraft with VHF DCPC 20 for climb/descend through other aircraft with other type of com.					R	Depend on operational considerations (route spacing, traffic density, complexity, contingency procedures)	RNP 2 OPS Approval (Oceanic/Remote/continental)	Not required except reduced route spacing			
RNP 0.3		0.3	0.3	0.3	0.3			0.3	GNSS						O	TBD	O	R	Not required	RNP 0.3 OPS Approval	Not required

1) RNP requirements do not apply to initial and intermediate missed approach segments.

2) TOAC (Time of Arrival Control), TBD (To Be Determined)

3) RNAV 5 may be used for initial parts of STARs outside 30 NM from the ARP.

4) Advanced RNP core requirements are limited to RNP 1 in all flight phases except final approach (RNP 0.3) and RNP 2 in oceanic/remote and en-route continental. A scaleability option will allow accuracy values between 0.3 and 1.0, in 0.1 NM increments, in all flight phases except oceanic/remote/en-route continental (RNP 1 and RNP 2) and final approach (RNP 0.3).

5) Part A and B refer to the Performance-based Navigation (PBN) Manual (Doc 9613), Volume II, Part C, Chapter 5, Part A — RNP APCH operations down to LNAV and LNAV/VNAV minima and Part B — RNP ARH operations down to LP and LPV minima, respectively.

6) Specific requirement for RF and VNAV

# PBN-in-a-page



PBN NavSpecs and Route Spacing (PBN Manual Doc 9613 Volume II, Attachment B & PANS-OPS Doc 8168 Volume II, Part III)

Nav Specs	Flight Phase								Supporting Nav. Infrastructure	Route Spacing (NM)	Additional Functionality (Required or Optional)					Operational Requirements			
	En-route Remote	En-route Continental	Arrival	Approach				Departure			RF	FRT	TOAC <sup>2)</sup>	Baro VNAV	Nav DB	Communication	Navigation	Surveillance	Others
RNAV 10	10								Not require ground-based Naviad Dual LRNS (INS, IRS FMS, GNSS)	50					O	Voice com through 3rd party, DCPC in some areas	RNAV 10 (RNP 10) Approval, lateral deviation less than 7NM (same direction)/6NM (opposite direction)	Procedural pilot position reports	System safety must be monitored, TLS 5X10 <sup>-9</sup> accident per flight hour
RNAV 5		5	3) 5)						VOR/DME DME/DME INS or IRS GNSS	16.5 - straight unidirectional racks (same direction route-ECAC) 18 - straight bidirectional tracks (opposite direction route- ECAC) 10 - ATC intervention capability (ECAC) 30 - No ATS Surveillance in high traffic density (ECAC)					O	DCPC- VHF	RNAV 5/RNP 5 OPS Approval (BRNAV)	Procedural pilot position report (RNP 5) Radar surveillance (RNAV 5)	
RNAV 2		2	2					2	GNSS DME/DME DME/DME/IRU	8 to 9 - straight tracks in high traffic density (en-route) (FAA)					R	DCPC- VHF	RNAV 2 OPS Approval (PRNAV, US RNAV AC 90-100)	Radar surveillance	
RNAV 1		1	1	1	1			1	GNSS DME/DME	8 - straight tracks in high density (terminal, Eurocontrol)					R	DCPC- VHF	RNAV 1 OPS Approval (PRNAV, US RNAV AC 90-100)	Radar surveillance	
<b>A RNP<sup>4)</sup></b>	<b>2</b>	<b>2 or 1</b>	<b>2 or 1</b>	<b>GNSS Multi-DME may be provided</b>				<b>7 - straight and turn density (en-route) 6 to 7 NM with an R</b>	<b>DCPC- VHF</b>	<b>A-RNP OPS Approval (Navigation accuracy at least ±1NM, 95% of the flight time)</b>	<b>Radar surveillance (may not be required to certain navigation application)</b>								
RNP 2	2	2							GNSS	50, 30 or 15 (PANS-ATM) 7 for climb/descent through other aircraft with VHF DCPC 20 for climb/descent through other aircraft with other type of com.					R	operational considerations (route spacing, traffic density, complexity, contingency procedures)	RNP 2 OPS Approval (Oceanic/Remote/continental)	Not required except reduced route spacing	
RNP 1			1	1	1			1	GNSS	5 for SIDs/STARs (PANS-ATM)					R	DCPC (RNP 1 SIDs/STARs)	RNP 1 OPS Approval	Not required except reduced route spacing	
<b>A RNP<sup>4)</sup></b>	<b>2</b>	<b>2 or 1</b>	<b>1 - 0.3</b>	<b>1 - 0.3</b>	<b>1 - 0.3</b>	<b>0.3</b>	<b>1 - 0.3</b>	<b>1 - 0.3</b>	<b>GNSS Multi-DME may be provided</b>	<b>7 - straight and turning tracks (&lt;90°) in high traffic density (en-route, Terminal, Eurocontrol) 6 to 7 NM with an RNP 0.5 (terminal, Eurocontrol)</b>					R	<b>DCPC- VHF</b>	<b>A-RNP OPS Approval (Navigation accuracy at least ±1NM, 95% of the flight time)</b>	<b>Radar surveillance (may not be required to certain navigation application)</b>	
RNP APCH (Part A) <sup>5)</sup>				1	1	0.3	1		GNSS (Missed App - RNAV or Conv.)	5 for SIDs/STARs (PANS-ATM)					R	Not required	RNP APCH OPS Approval	Not required	
RNP APCH (Part B) <sup>5)</sup>				1	1	Angular	1 or 0.3 (Initial Straight MISAP)		GNSS	5 for SIDs/STARs (PANS-ATM)					R	Not required	RNP APCH OPS Approval	Not required	
RNP AR APCH			1 - 0.1	1 - 0.1	0.3 - 0.1	1 - 0.1			GNSS (DME/DME may be authorized)	5 for SIDs/STARs (PANS-ATM)		R <sup>6)</sup>			R	Not required	RNP AR APCH OPS Approval	Not required	
RNP 0.3		0.3	0.3	0.3	0.3		0.3	0.3	GNSS	5 for SIDs/STARs (PANS-ATM)					R	Not required	RNP 0.3 OPS Approval	Not required	

1) RNP requirements do not apply to initial and intermediate missed approach segments.

2) TOAC (Time of Arrival Control), TBD (To Be Determined)

3) RNAV 5 may be used for initial parts of STARs outside 30 NM from the ARP.

4) Advanced RNP core requirements are limited to RNP 1 in all flight phases except final approach (RNP 0.3) and RNP 2 in oceanic/remoted and en-route continental. A scaleability option will allow accuracy values between 0.3 and 1.0, in 0.1 NM increments, in all flight phases except oceanic/remoted/en-route continental (RNP 1 and RNP 2) and final approach (RNP 0.3).

5) Part A and B refer to the Performance-based Navigation (PBN) Manual (Doc 9613), Volume II, Part C, Chapter 5, Part A — RNP APCH operations down to LNAV and LNAV/VNAV minima and Part B — RNP ARH operations down to LP and LPV minima, respectively.

6) Specific requirement for RNP and VNAV



North American  
Central American  
and Caribbean  
(NACC) Office  
Mexico City

South American  
(SAM) Office  
Lima

ICAO  
Headquarters  
Montreal

Western and  
Central African  
(WACAF) Office  
Dakar

European and  
North Atlantic  
(EUR/NAT) Office  
Paris

Middle East  
(MID) Office  
Cairo

Eastern and  
Southern African  
(ESAF) Office  
Nairobi

Asia and Pacific  
(APAC) Office  
Bangkok

Asia and Pacific  
Regional Sub-Office  
Beijing (APAC RSO)

**Questions?**



North American  
Central American  
and Caribbean  
(NACC) Office  
Mexico City

South American  
(SAM) Office  
Lima

ICAO  
Headquarters  
Montreal

Western and  
Central African  
(WACAF) Office  
Dakar

European and  
North Atlantic  
(EUR/NAT) Office  
Paris

Middle East  
(MID) Office  
Cairo

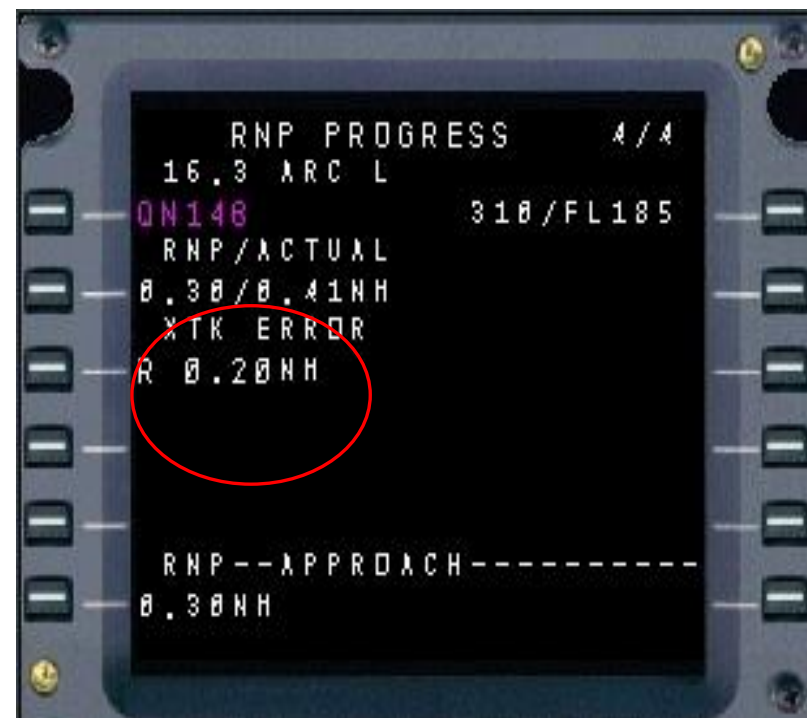
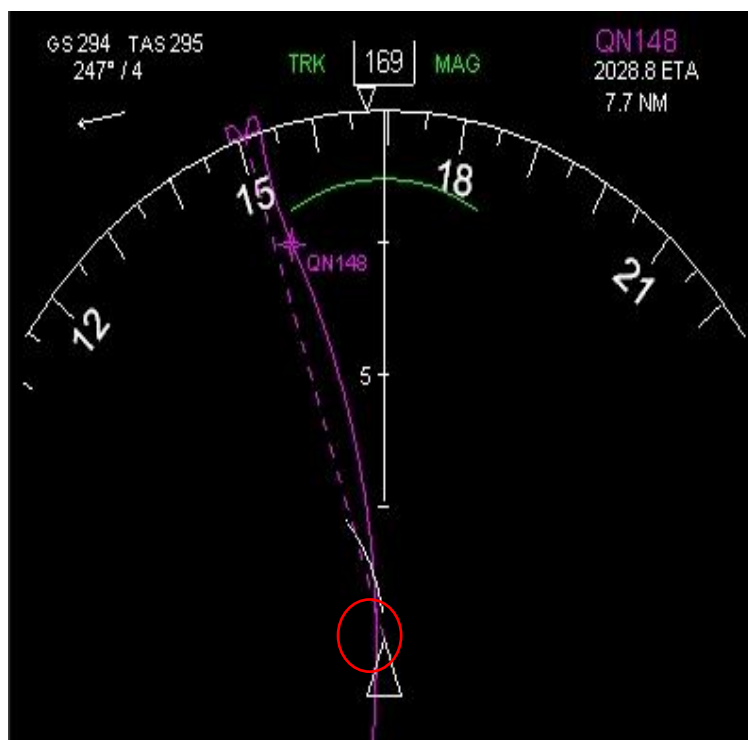
Eastern and  
Southern African  
(ESAF) Office  
Nairobi

Asia and Pacific  
(APAC) Office  
Bangkok

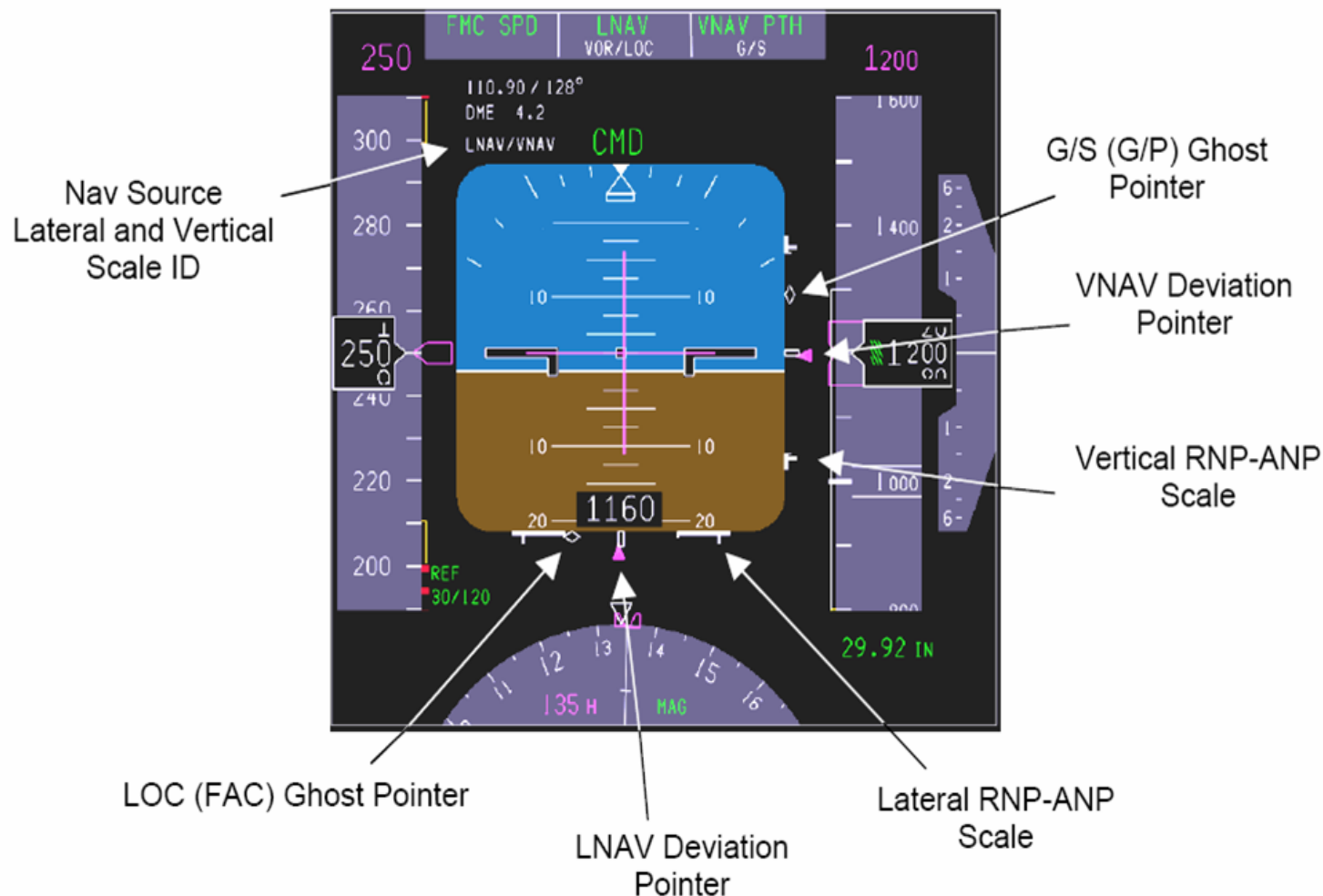
Asia and Pacific  
Regional Sub-Office  
Beijing (APAC RSO)

**Thank You**

# STANDARD BOEING 737NG DISPLAY

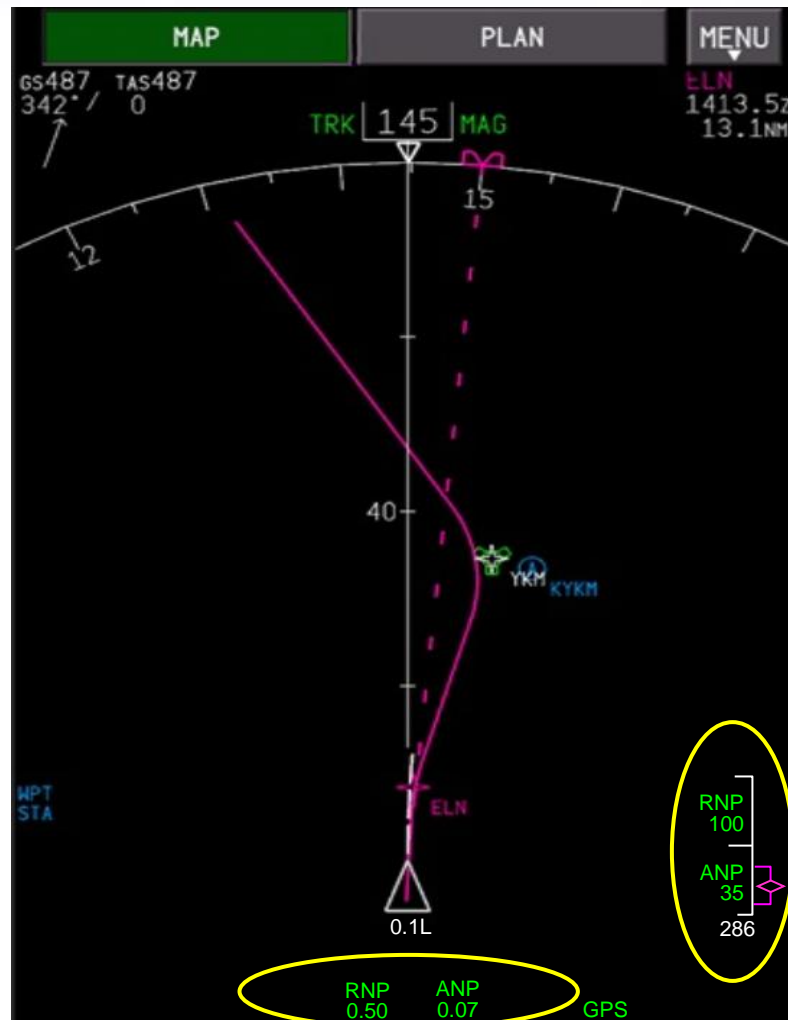


# BOEING PFD WITH NPS OPTION



# BOEING ND WITH NPS OPTION

XTK  
deviation in  
1/100<sup>th</sup> NM



# AIRBUS ND WITHOUT L/DEV SCALES

Standard display in 1/10<sup>th</sup> NM  
Initial indication 0.2NM at XTK  
0.15NM

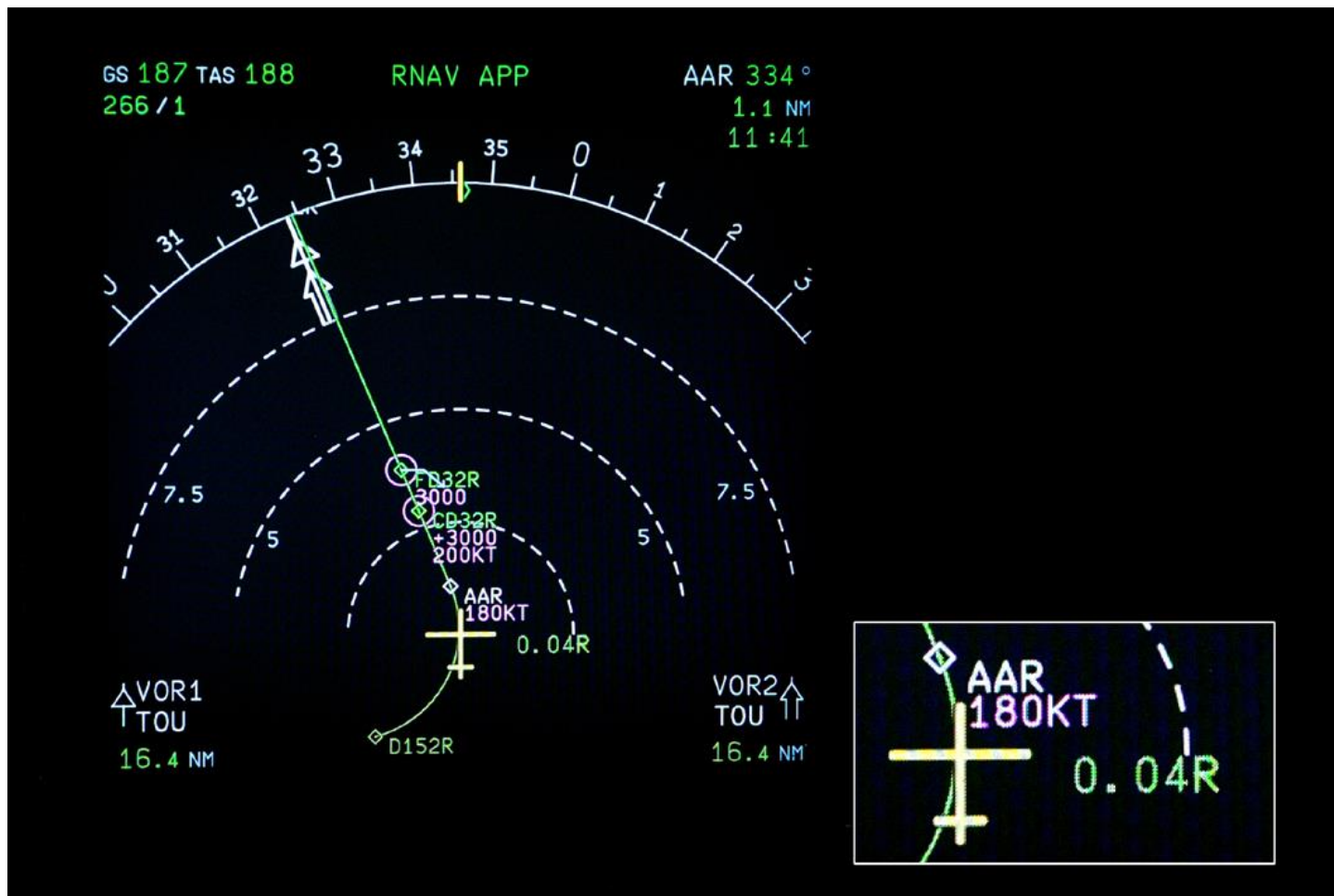


# AIRBUS PFD WITH L/DEV OPTION



L/DEV Scale 0.2NM

# AIRBUS ND WITH L/DEV OPTION



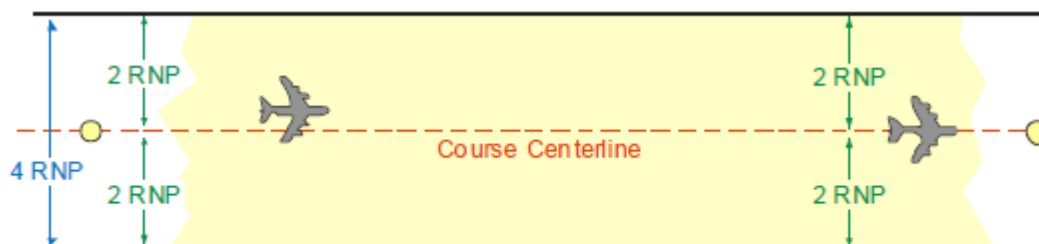
# RNP AR APCH

2 x RNP

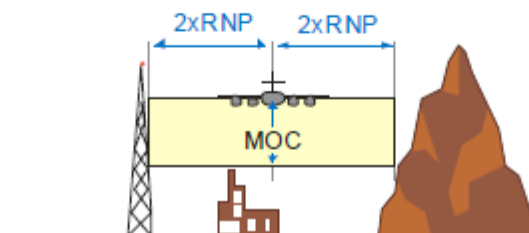
Parallel Obstacle Evaluation Area (OEA)

Rectangular cross-section

PLAN VIEW



CROSS SECTION VIEW



# RNP AR APCH

## VERTICAL ERROR BUDGET

Reduced vertical obstacle clearance

