

ICAO MID Workshop on GNSS and PBN

Cairo, Egypt | 29 September–1 October 2026

PBN Global
Developments



PBN Global Developments

A Quick Show of Hands

- 1) Who's already comfortable with the core PBN concept (Navigation Application, Navigation Specification, NAVAID Infrastructure)?
- 2) Who has read the Fifth Edition of Doc 9613 cover to cover?

The Policy Mandate : Assembly Resolution A37-11 & the GANP

Titled "Performance-based navigation global goals "adopted by the International Civil Aviation Organization (ICAO) during its 37th Assembly session in 2010, resolves that:

States complete a PBN implementation plan as a matter of urgency to achieve:

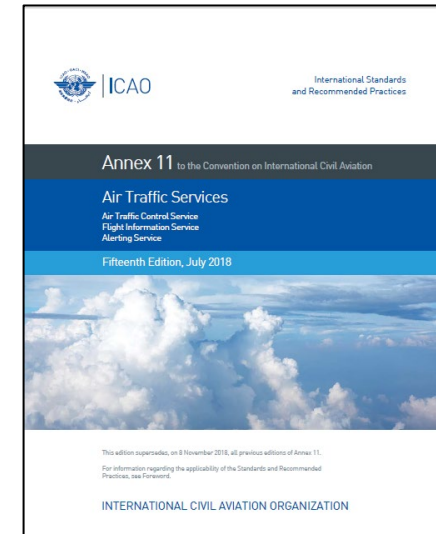
- 1) Implementation of RNAV and RNP operations (where required) for En-route and terminal areas according to established timelines and intermediate milestones; and*
- 2) implementation of approach procedures with vertical guidance (APV) (Baro-VNAV and/or augmented GNSS), including LNAV only minima for all instrument runway ends, either as the primary approach or as a back-up for precision approaches by 2016 with intermediate milestones as follows: 30 per cent by 2010, 70 per cent by 2014; and*
- 3) implementation of straight-in LNAV only procedures, as an exception to 2) above, for instrument runways at aerodromes where there is no local altimeter setting available and where there are no aircraft suitably equipped for APV operations with a maximum certificated take-off mass of 5 700 kg or more.*

ICAO Doc 9750, the Global Air Navigation Plan (GANP) identifies PBN as the "highest priority" and outlines implementation issues involving PBN planning and implementation as part of the Aviation System Block Upgrades (ASBUs).

Why PBN Is a Requirement, Not Just Good Practice

ANNEX 11, § 2.7 — PERFORMANCE-BASED NAVIGATION (PBN) OPERATIONS

- 2.7.1 In applying performance-based navigation, navigation specifications shall be prescribed by States...
- 2.7.2 Recommendation.— PBN operations should be implemented as soon as practicable.
- 2.7.3 The prescribed navigation specification shall be appropriate to the level of communications, navigation and air traffic services provided.



*ICAO Annex 11
Air Traffic Services
15th Edition, July 2018*

Annex 11 sets the requirement (a Standard, plus a Recommendation on timing) — Doc 9613 is the guidance material that tells you how to meet it

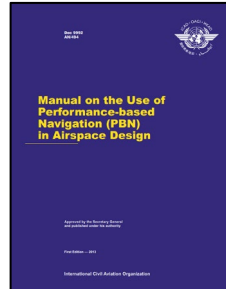
The PBN Document Family



Doc 9613

PBN Manual — 5th ed., 2023

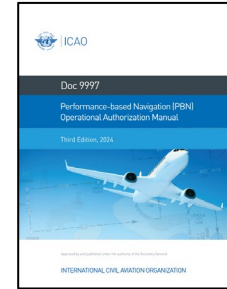
Today's focus: the concept and core implementation guidance



Doc 9992

PBN in Airspace Design — 1st ed., 2013

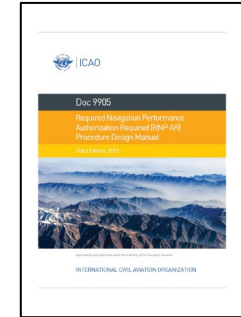
Now the sole home for detailed airspace-design process guidance



Doc 9997

PBN Operational Authorization Manual — 3rd ed., 2024

The operator-authorization process, incl. RNP AR



Doc 9905

RNP AR Procedure Design Manual — 3rd ed., 2021

Design criteria for RNP AR APCH and, new in Ed.5, RNP AR DP

A fifth document, Doc 8168 (PANS-OPS) — the underlying procedure-design criteria.

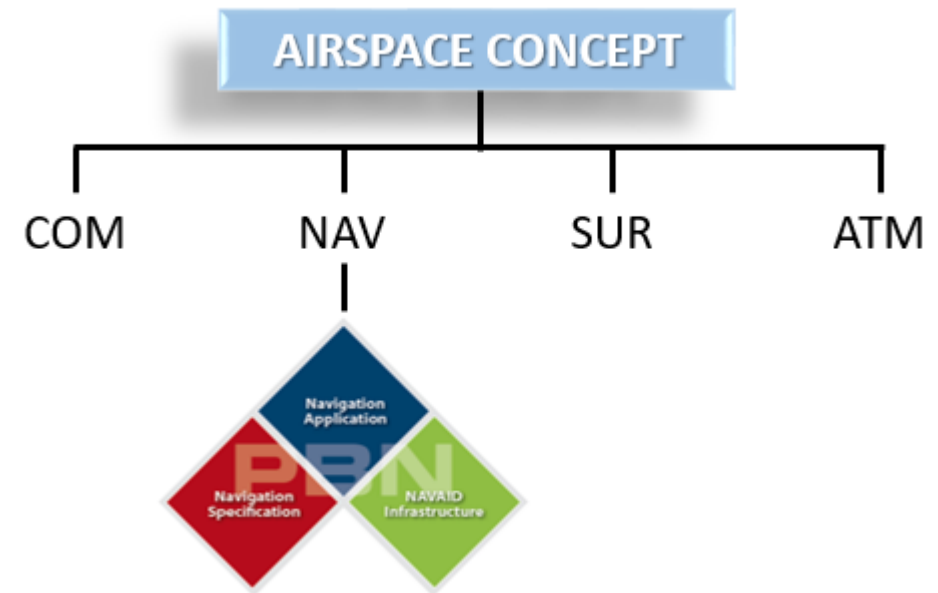
The PBN Concept: Three Components, One Airspace Concept

The three PBN components are:

The **Navigation Application** refers to routes and instrument flight procedures (IFPs) which have navigation performance requirements determined by the needs identified in the Airspace Concept.

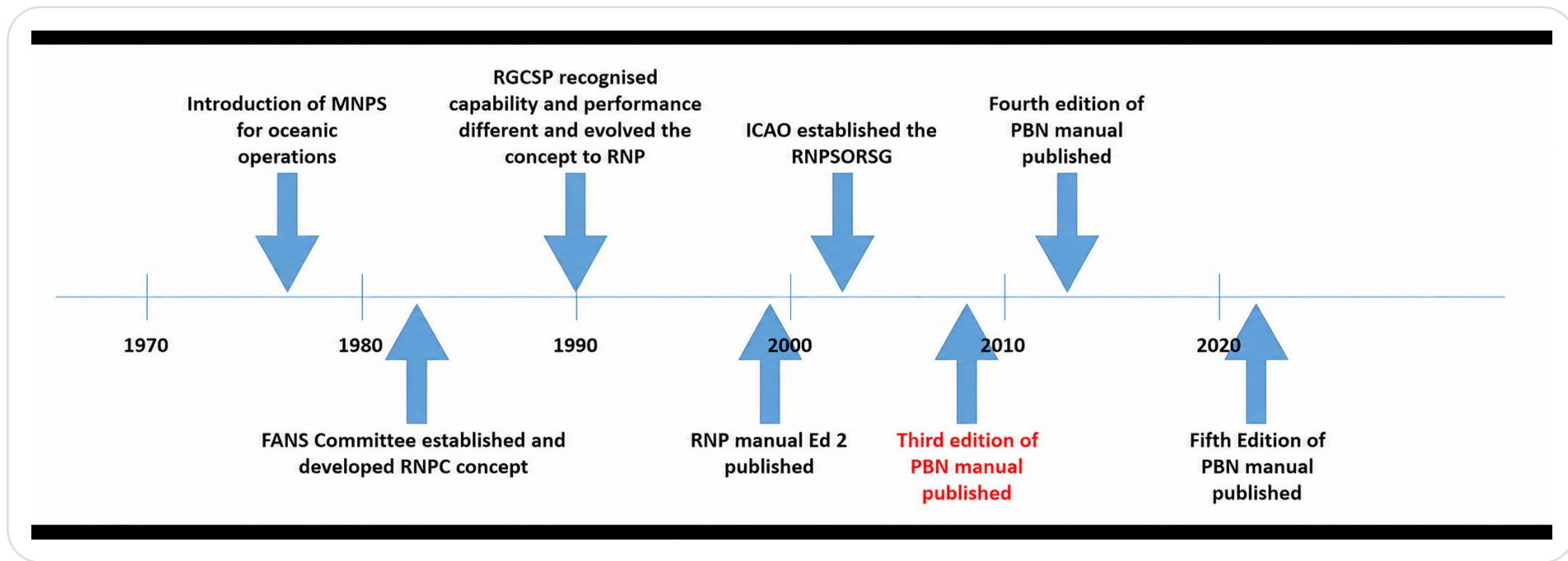
The **NAVAID Infrastructure** refers to ground and space-based navigation aids. The infrastructure provides the aircraft system with range or bearing inputs enabling a position to be computed to the required quality to meet the navigation specification.

The **Navigation Specification** is a technical and operational specification, set at the global level, to ensure interoperability. Navigation Specifications identify the performance and functionality required of the area navigation equipment, avionics and flight crew.



How We Got Here: The PBN Manual's Evolution

From early area-navigation concepts in the 1970s to today's Fifth Edition — PBN has been consolidating for five decades.



Source : Eurocontrol

Doc 9613, Fifth Edition (2023): Where We're Headed Today

Published in 2023, the Fifth Edition is the current global reference for PBN implementation. This manual consists of two volumes: Volume I – Concept and implementation guidance and Volume II – Implementing RNAV and RNP operations

01

Changes to Volume I

Concept and implementation guidance — what was removed, streamlined or clarified

02

Changes to Volume II

Navigation specifications and implementation detail — where the substantive changes live

03

Future work

Active ICAO work, including a live proposal to rethink how procedures get protected: “Real PBN”

01 Changes to Volume I

Concept and
implementation
guidance

Doc 9613

Performance-based Navigation
(PBN) Manual

Fifth Edition, 2023



Structural changes: Two Redundant Sections Retired

Rather than maintaining the same guidance in two places, the Fifth Edition removes two sections that had grown redundant with other, more detailed ICAO manuals.

Part B — Implementation Guidance REMOVED

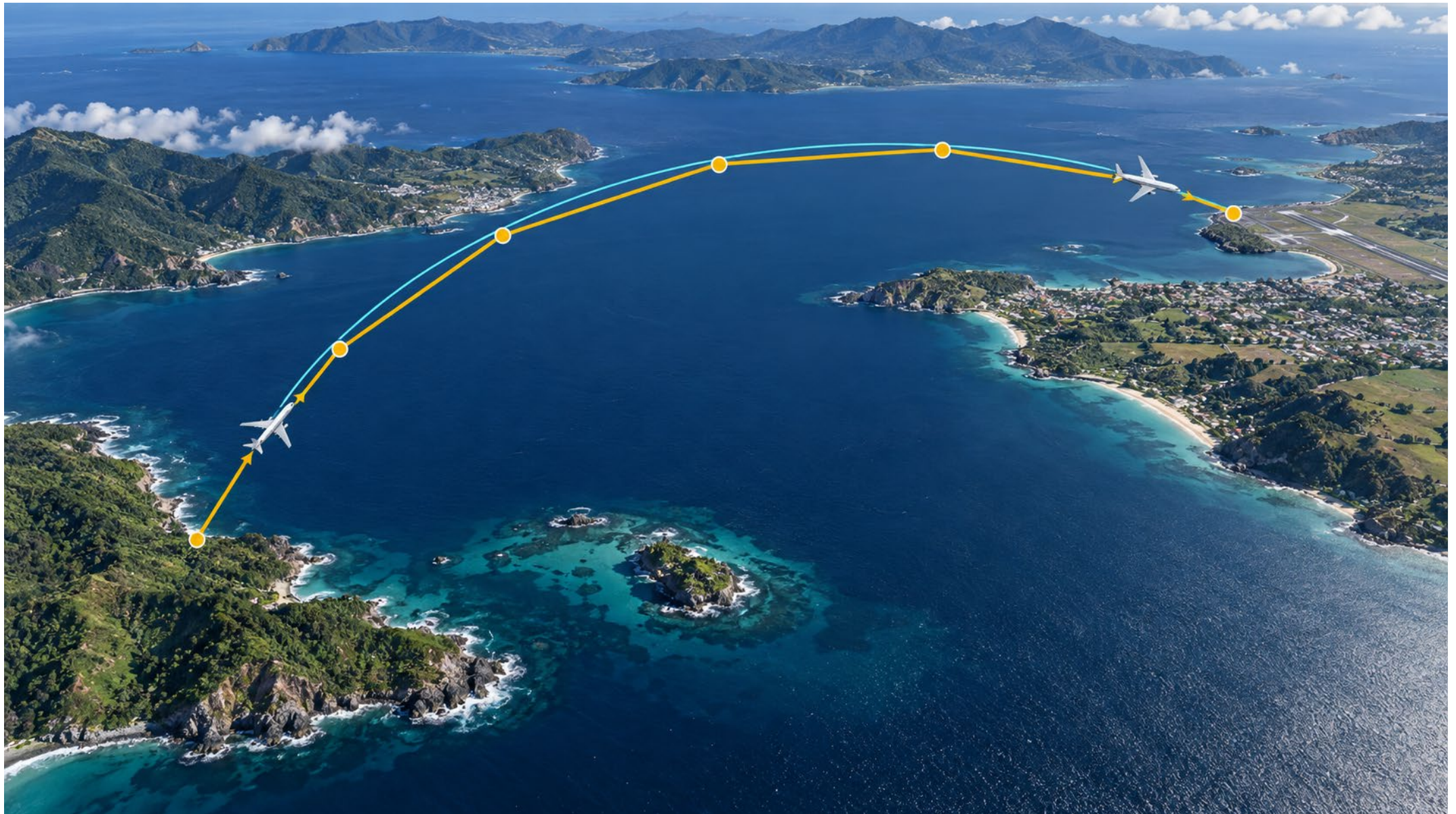


- Duplicated material already in Doc 9992 (Manual on the Use of PBN in Airspace Design)
- The introduction to PBN implementation is retained; the detailed process description is not

Attachment C — Operational Approval REMOVED



- Covered more fully in Doc 9997, the PBN Operational Approval Manual
- Doc 9997's 3rd edition (2024) now includes RNP AR DP



Four Volume I Clarifications Worth Knowing

RNAV OR RNP — YOUR CHOICE

- Fourth Edition guidance leaned toward RNP where surveillance was absent, RNAV where present
- Fifth Edition: choose either specification regardless of surveillance availability

clarification on the definition and the use of holding capabilities

- A-RNP requires RNP holding capability, but no RNP holding design specification is published yet
- In practice: fly a conventional hold manually, or use the system's own RNAV holding function

PBN BEYOND PUBLISHED ROUTES

- Earlier guidance was written mainly around published ATS routes
- Fifth Edition clarifies PBN applies equally in free-route airspace and other non-fixed-route environments

NO PERFORMANCE REQUIREMENT? STILL PBN

- Clarifies expected system behaviour where no navigation performance requirement is prescribed
- All RNAV operations are PBN operations

Consideration of reversion from RNP following loss of GNSS: A New Line in Volume I

RNP performance depends on GNSS positioning staying available for the first time, Volume I explicitly raises what happens when it doesn't.

WHAT THE FIFTH EDITION ADDS

New text considers reversion from RNP following loss of GNSS, a fallback question the Fourth Edition did not raise.

This is a new consideration Volume I raises, not a single prescribed reversion procedure designing the actual fallback stays a State and operator responsibility.

02

Changes to
Volume II

Implementing RNAV
and RNP operations

Doc 9613

Performance-based Navigation
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Fifth Edition, 2023



Structural changes

- **Attachment A Barometric VNAV removed**
 - Attachment did not address other forms of VNAV or the application of VNAV for credit in the Final Approach Segment verses for Advisory purposes
- **Attachment A now refers to Vertical Navigation (VNAV) in the Final Approach Segment**
- **Attachment B Temperature Compensation added**
 - Taken from RTCA/EUROCAE industry standards
- **Attachment D application of Magnetic Variation added**
 - Taken from RTCA/EUROCAE industry standards
- **Attachment E Document References added**
 - latest industry and regulatory reference material used within Vol II Parts B and C

Significant changes

- **Part C, Chapter 4 Implementing Advanced RNP**
 - No scalability, adoption of fixed RNP 0.3 lateral navigation accuracy
 - Missed approach remains at 1 NM
 - Final approach segment is removed
- **Part C, Chapter 6 Implementing RNP with Authorization Required**
 - Development of RNP AR DP nav spec
 - Update of RNP AR APCH based on latest standards and practice

Detailed changes

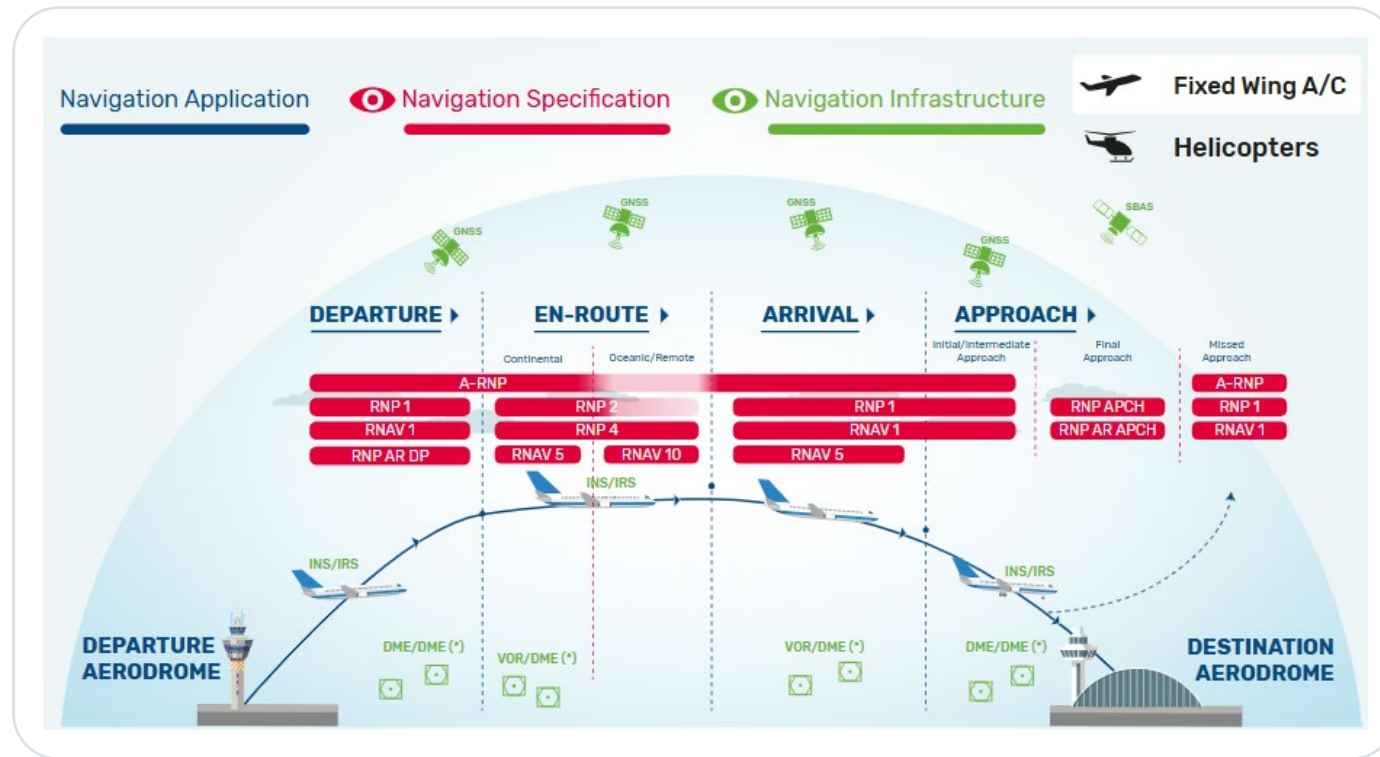
- **On-board performance monitoring and alerting**
 - Text revised and updated for clarity
- **Applicability of nav spec by flight phase**
 - Table IIA-I-I revised
- **Use of Dual Frequency Multi Constellation**
 - Clarification of applicable GNSS elements
- **GNSS monitoring**
- **RNP 0.3 Nav Spec**
 - Identified as helicopter only

No brand-new NAVSPEC in fifth edition, more update of current specification and clarification

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	Departure
RNAV 10	10							
RNAV 5		5	5					
RNAV 2		2	2					2
RNAV 1		1	1	1	1		1	1
RNP 4	4							
RNP 2	2	2						
RNP 1			1	1	1		1	1
A-RNP	2	2 or 1	0.3	0.3	0.3		1	0.3
RNP APCH				1	1	0.3	1	
RNP AR				1-0.1	1-0.1	0.3-0.1	1-0.1	1-0.3
RNP 0.3		0.3	0.3	0.3	0.3		0.3	0.3

Reference: Applicability by Flight Phase, at a Glance

The same navigation specifications from the previous table, mapped visually against flight phase and sensor just a quick-reference companion for procedure designers.



Source: Eurocontrol

Vertical Guidance, Clarified: “For Credit” vs “Advisory”

Attachment A is retitled from “Barometric VNAV” to “Vertical Navigation (VNAV) in the Final Approach Segment” and now draws a clear line between vertical guidance flown “for credit” and guidance that is advisory only, a distinction industry and regulatory practice had already moved past the old text.

Vertical guidance “for credit”

- Required by the procedure — ILS, MLS, GLS
- RNP APCH to LNAV/VNAV or LPV minima
- RNP AR APCH
- Flown to a Decision Altitude (DA)

Advisory vertical guidance

- Not required — RNP APCH to LNAV or LP minima; conventional NDB/VOR/LOC
- Use is left to the flight crew's discretion
- Flown to a Minimum Descent Altitude (MDA)
- Supports a stabilized CDFA but does not lower minima

Three New Attachments

Attachment B

Temperature Compensation

Guidance for RNP APCH and RNP AR APCH operations in non-standard temperature conditions, drawn from RTCA/EUROCAE industry standards

Attachment D

Magnetic Variation

Addresses misalignment between a procedure's design and the aircraft's navigation system, which can otherwise produce misleading lateral guidance also drawn from RTCA/EUROCAE standards

Attachment E

Document References

A compendium of the latest industry and regulatory reference material used throughout Volume II, Parts B and C — for ease of reference

Attachment C: Route Spacing, Refreshed

The Fourth Edition's Attachment B on sample airspace concepts is renumbered Attachment C and its route-spacing values are updated using newer flight-track data.

- Attachment C (previously Attachment B) still covers sample airspace concepts based on navigation specifications
- Route-spacing values refreshed using more recent EUROCONTROL and UK studies of actual aircraft track-keeping performance
- A preview of a theme Part 3 picks up in depth: PBN design criteria increasingly grounded in real flight-track data rather than older, more conservative assumptions

Advanced RNP Gets Simpler: One Fixed Value, No More Scaling

Rather than a continuously scalable value negotiated case by case, A-RNP now fixes terminal-phase accuracy at a single number and drops final approach entirely.

Flight phase	4th Ed. (scalable)	5th Ed. (fixed)
En-route, oceanic / remote continental	2 NM	2 NM (unchanged)
En-route, continental	1 NM	1 NM (unchanged)
Arrival / initial / intermediate / departure	Scalable, 1 – 0.3 NM	Fixed at 0.3 NM
Final approach segment	Within A-RNP scope	Removed — use RNP APCH / RNP AR APCH
Missed approach	1 NM	1 NM; 0.3 NM only exceptionally, with State safety assessment

RNP AR : Departures Join Approaches

A single authorization framework now covers both RNP AR approach and RNP AR departure procedures, gated by a Flight Operational Safety Assessment (FOSA).

RNP AR APCH

- The established capability approach at terrain- or obstacle-constrained airports
- Lateral accuracy 0.1-0.3 NM; vertical error budget covers Baro-VNAV paths
- Fully updated in the 5th Edition to reflect latest standards and practice

RNP AR DP

- New in the 5th Edition departures using the same authorization framework as RNP AR APCH
- Adds detailed climb-performance and take-off data, including one-engine-inoperative (OEI) contingency
- Can be authorized separately from, or combined with, RNP AR APCH

Flight Operational Safety Assessment (FOSA) — confirms the operator's preparation, including OEI climb performance for RNP AR DP, before authorization is granted

RNP 0.3: A Navigation Specification Built for Rotorcraft

A single accuracy value across all phases of flight, now explicitly defined as exclusive to helicopters and rotorcraft in the Fifth Edition.

“This specification is intended for the exclusive use of helicopters and rotorcraft.”

- Reduced protected areas — enabling separation from fixed-wing traffic in dense terminal airspace
- Low-level routes through obstacle-rich, icing-prone environments
- Seamless en-route-to-terminal transitions, incl. point-in-space approaches and departures — including hospital-to-hospital IFR operations
- Not dependent on SBAS — opening RNP 0.3 to States and regions without SBAS coverage (though DME/DME cannot consistently support 0.3 NM either)

03 Future Work

Active ICAO work
the Fifth Edition
doesn't cover yet

Doc 9613

Performance-based Navigation
(PBN) Manual

Fifth Edition, 2023



Four Threads Still Being Worked

None of this is in the Fifth Edition yet. Each is at a different stage, from an identified hazard to a formal working prog.

1

GNSS interference

Jamming (and, increasingly, spoofing) as a growing operational hazard

3

RNP AR APCH with LPV

Could an independent vertical profile replace Baro-VNAV for RNP AR approaches?

2

SID/STAR transitions

A harmonized global approach to transition design, under discussion in IFPP

4

Real PBN

A formal IFPP discussions to rethink how procedures get protected furthest along, and our closing topic

GNSS Interference: From Emerging Risk to Manual Guidance

Jamming and spoofing of GNSS signals have moved from a theoretical concern to a recognized operational hazard with ICAO work under way to turn that recognition into concrete guidance.

WHERE THIS STANDS

- Recognized as a major and growing hazard by ICAO and industry bodies , the Air Navigation Conference recommendation number is being confirmed
- The Navigation Systems Panel (NSP) is leading development of mitigations and operational information, with the Flight Operations Panel (FLTOSP) coordinating operational aspects
- The PBN Operations Study Group is expected to review this material for inclusion as formal GNSS interference guidance in a future Doc 9613

Next Up: A Harmonized Approach to SID/STAR Transitions

Transition design between departures/arrivals and the en-route structure varies more than it probably should across States .

- SID and STAR transition design is reported to be under discussion within the Instrument Flight Procedures Panel (IFPP)
- Goal: a globally harmonized approach to how these transitions are designed and documented
- If adopted, this would likely require corresponding updates to Doc 9613

Could RNP AR Approaches Trade Baro-VNAV for LPV?

Today, RNP AR APCH vertical guidance is Baro-VNAV only. One proposal on the table: add an SBAS-based LPV option with an independent vertical profile.

TODAY — CONFIRMED

- RNP AR APCH vertical guidance is Baro-VNAV based
- Requires a specific airworthiness approval to provide vertical guidance in the final approach segment
- Baro-VNAV has known limitations around temperature and altimeter setting error

PROPOSED

- Add an LPV option using an independent vertical profile (FAS Data Block) — the same mechanism RNP APCH already uses
- Would reduce exposure to Baro-VNAV's temperature/altimeter limitations
- Potential for reduced minima and improved regularity

Real PBN: Why Today's Protection Criteria Don't Add Up

The protected airspace around a PBN procedure isn't sized from accuracy alone , it also depends on which sensor delivers that accuracy. That produces results that don't always make sense.

Today's formula: $\frac{1}{2}$ Area Width = $1.5 \times \text{XTT} + \text{a Buffer Value}$

The Buffer Value comes from a lookup table indexed by aircraft category and phase of flight — one of 22 separate sensor-specific tables spread across Doc 8168, Part III.

THE ANOMALY

A more accurate navigation system can end up needing a LARGER protected area than a less accurate one , the opposite of what a truly “performance-based” concept should mean.

PART III. PERFORMANCE-BASED NAVIGATION PROCEDURES	III-0
Section 1. Underlying principles	III-1-0
Chapter 1. RNAV concepts	III-1-1-1
1.1 General	III-1-1-1
1.2 Flight technical error	III-1-1-4
1.3 Magnetic bearing on a PBN (RNAV or RNP) route segment	III-1-1-4
1.4 Buffer values	III-1-1-4
1.5 Obstacle clearance area	III-1-1-5
1.6 Fixes	III-1-1-6
Chapter 2. GNSS RNAV	III-1-2-1
5/11/20	
<i>Table of Contents (xiii)</i>	
	<i>Page</i>
2.1 General	III-1-2-1
2.2 XTT, ATT and area semi-width	III-1-2-1
Chapter 3. DME/DME RNAV	III-1-3-1
3.1 General	III-1-3-1
3.2 Airborne and ground equipment requirements for DME/DME procedures	III-1-3-1
3.3 DME/DME RNAV system use accuracy	III-1-3-1
3.4 Flight technical tolerance	III-1-3-2
3.5 System computational tolerance	III-1-3-2
3.6 XTT, ATT and area semi-width	III-1-3-2
3.7 Navigation aid coverage	III-1-3-3
3.8 Validation	III-1-3-4
Chapter 4. VOR/DME RNAV	III-1-4-1
4.1 General	III-1-4-1
4.2 Airborne and ground equipment requirements for VOR/DME procedures	III-1-4-1
4.3 VOR/DME RNAV system use accuracy	III-1-4-1
4.4 Flight technical tolerance	III-1-4-2
4.5 System computation tolerance	III-1-4-2
4.6 XTT, ATT and area semi-width	III-1-4-2

Real PBN: One Rule Replaces 22 Tables

IFPP has agreed a single, accuracy-based formula to size every protection area , replacing the old buffer-value tables entirely.

TODAY

$$\frac{1}{2} A/W = 1.5 \times XTT + \text{Buffer Value}$$

- Buffer value looked up by aircraft category and phase of flight
- 22 separate sensor-specific tables across Doc 8168, Part III
- Buffer value assumptions (blunder angle, reaction time, bank angle) predate reliable flight-track data

PROPOSED — REAL PBN

$$\text{Accuracy} \geq 1.0 \text{ NM: } \frac{1}{2} A/W = 2 \times XTT$$

$$\text{Accuracy} < 1.0 \text{ NM: } \frac{1}{2} A/W = 2.5 \times XTT$$

- Based on required accuracy alone not on which sensor delivers it
- Grounded in real flight-track data (Laplace-distributed tails, not Gaussian) rather than 1980s-era assumptions
- No buffer table, no aircraft-category lookup, no sensor chapter

Real PBN: Status and What to Watch

Proposed by ICAO IFPP (Toulouse, March 2025), a draft amendment to Doc 8168 (PANS-OPS), Volume II. Not yet adopted.

- Once adopted, the entire sensor-specific protection-area chapter (Part III, Section 1, Chapter 2 , about 22 tables) is deleted from Doc 8168
- Protected areas become simpler to calculate, easier to explain, and consistent for any sensor that meets the same accuracy requirement
- Published procedures are not changed automatically and any transition follows normal Doc 8168 amendment and State implementation timelines



Thank You!