International Civil Aviation Organization

THE TENTH MEETING OF PERFORMANCE BASED NAVIGATION IMPLEMENTATION COORDINATION GROUP (PBNICG/11)

Bangkok, Thailand, 27-29 March 2024

Agenda Item 4: States' PBN Implementation Progress and the challenges faced by the States and lessons learnt.

IMPLEMENTATION OF PBN SEPARATION ACROSS FIR BOUNDARIES

(Presented by Airservices Australia)

SUMMARY

This paper presents an overview of issues encountered when implementing PBN separation, particularly RNP standards, across FIR boundaries.

1. INTRODUCTION

1.1 Several issues exist when aircraft are transitioning to and from different types of airspace, such as an oceanic-like region with RNP routes and a surveillance environment (such as ADS-B and VHF-voice communications).

1.2 Appendix 2 describes some of the situations in more detail, but Figure 1 below summarises one issue. The figure shows pairs of aircraft in RNP oceanic airspace approaching an FIR with surveillance (non-RNP). When both aircraft are in the RNP airspace the longitudinal separation could be 30 NM (for example). When both aircraft are in surveillance airspace, separation can be 5 NM. But when the aircraft pair straddle the boundary, one aircraft is no longer in RNP airspace, and a 10-minute (~80 NM) standard must be applied. This is counterintuitive and is an issue for controllers and seamless operation across FIR boundaries.

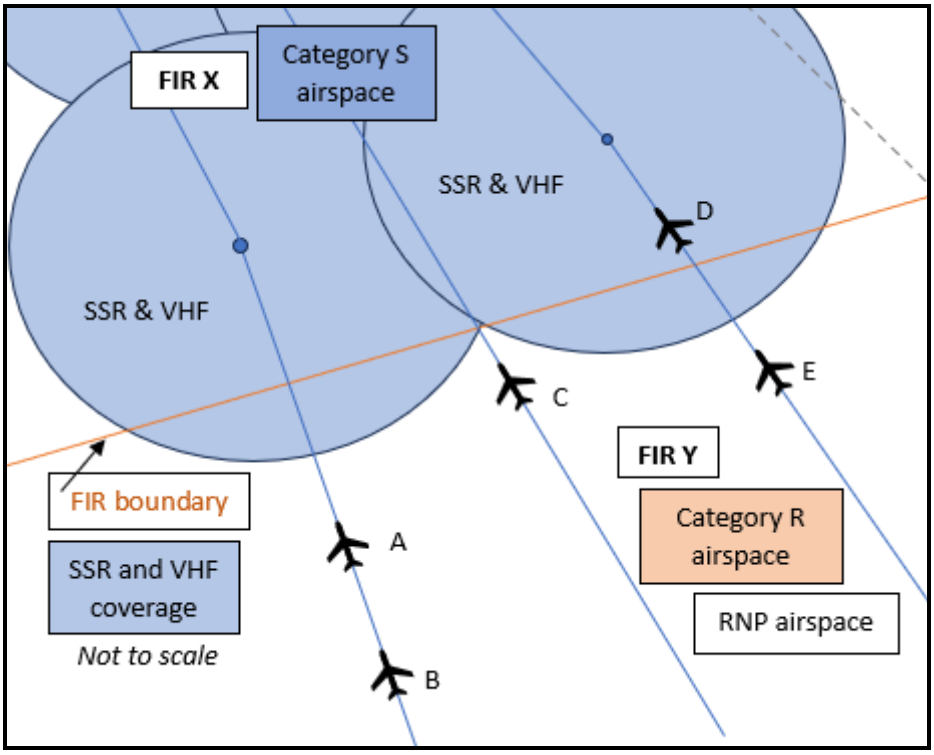

Figure 1: *Example of one issue. Here Aircraft A and B are in oceanic RNP airspace and can be separated by 30 NM. Aircraft D has entered surveillance airspace in a second FIR which is not an RNP airspace. Hence aircraft E and D must be separated by 10 minutes longitudinally (~80 NM), despite Aircraft D now under more surveillance and having better communication. As soon as Aircraft E enters the surveillance airspace the separation between E and D can be 5 NM.*

1.3 Airspace concepts are used to describe the intended operations within an airspace and are developed to satisfy strategic objectives such as to improve or maintain safety, to increase air traffic capacity, improve efficiency, provide more accurate flight paths and to mitigate environmental impacts.

1.4 Airspace concepts also include details of the practical organisation of the airspace and its users based on varying combinations of communications, navigation, and surveillance (CNS)/air traffic management (ATM) assumptions. In developing overall airspace concepts, these enablers are considered holistically.

1.5 Four main airspace concepts are described in Doc 9613 - Performance Based Navigation (PBN) Manual. Each concept provides a different combination of CNS/ATM enablers to address the strategic outcomes of the areas of operation:

- Oceanic and remote continental,
- Continental en-route,
- Terminal airspace: arrival and departure, and
- Approach.

1.6 By separating airspace into these concepts, simpler sets of CNS/ATM requirements can be developed and implemented by ANSPs and Aircraft Operators, depending on where they operate.

Regional agreements

1.7 The APAC Seamless ANS Plan[1] does not use 'continental', 'remote' and 'oceanic' areas and instead categorises airspace in accordance with the concept that air navigation services should be provided commensurate with the capability of the CNS equipment as follows:

Category	Descriptor (CNS requirements)
Category R	Remote en-route airspace with: • Air Traffic Services (ATS) • HF or CPDLC communications, and • outside the coverage of ground-based surveillance coverage.
Category S	Serviced (or potentially serviced) en-route airspace with: • Air Traffic Services (ATS) • direct ATS communications*, and • surveillance
Category T	Terminal operations with: • Air Traffic Services (ATS) • direct ATS communications* and • surveillance

** Direct ATS communications are not dependent on a Communication Service Provider (CSP)*

1.8 The Asia/Pacific Air Navigation Plan (APAC ANP)[2] specifies navigation targets either generically or based on these categories e.g.

a) APAC ANP Vol II (regional agreement for PBN implementation):

3.8 GNSS-enabled area navigation systems for all RNP navigation specifications are adopted as minimum requirement in the ASIA/PAC Region. [APANPIRG/22, Conc. 22/22]

and

b) APAC ANP Vol III:

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Objectives						Priorities and targets			
Block	ASBU modules and elements and enablers	Performance Improvement Area	Applicable or not in APAC (yes/no)	Regional planning elements		Priority in APAC	Target(s) in APAC	Indicator(s) / Metric(s)	Reference
0	B0-FRTO	4- Efficient Flight Path	Yes	140	Performance-based Navigation (PBN) Routes	2	All ATS routes should be designated with a navigation performance specification for category R airspace RNP 4 or RNP 10 (RNAV 10) or RNP 2 oceanic; and for Category S airspace RNAV 2 or RNP 2	% of ATS routes designated as PBN routes in accordance with Seamless ATM Phase 1	ANRF to be developed
0	Regional	4- Efficient Flight Path	Yes	150	Performance-based Navigation (PBN) Airspace	2	All Category R and S upper controlled airspace, and Category T airspace supporting high density aerodromes should be designated as non-exclusive or exclusive PBN airspace as appropriate.	Are all your Category R and S upper controlled airspace, and Category T airspace supporting high density aerodromes designated as non-exclusive or exclusive PBN airspace as appropriate.? (1- yes, 0-no)	Seamless Plan V2R0

Note that the Asia Pacific Air Navigation Plan (APAC ANP) uses the terms 'PBN airspace' and 'PBN routes' which differs to 'RNP airspace' and 'RNP routes' used by PANS ATM.

[1] Asia/Pacific Seamless ANS Plan V3.0 Scope 1.4
[2] Asia/Pacific Air Navigation Plan Vol II and Vol III

Seamless ATS plans

1.9 However, as many flight operations must transition between airspace concepts – these varying airspace requirements can create artificial barriers between adjoining airspaces. When the transition involves an FIR boundary, or multiple rapid transitions, the complexity of flight transitions is increased.

1.10 Examples of transitioning flight scenarios include:

- simple transition - a domestic flight transitioning from continental en-route to remote continental, or
- complex transition - an international flight transitioning from oceanic airspace and crossing an FIR boundary into either continental en-route or directly into terminal airspace. Airspace may be designated RNP or not, exclusive or non-exclusive.

1.11 A major goal of airspace concepts (and the corresponding CNS/ATM requirements) is to also create a seamless air navigation system where the transition requirements of aircraft operations across artificial boundaries are minimised.

1.12 The APAC Seamless ANS Plan V3.0 provides related requirements under this objective: *The objective of Seamless ATM is the safe and interoperable provision of harmonized and **consistent air traffic management service provided to a flight, appropriate to the airspace category and free of transitions** due to a change in the air navigation service provider or Flight Information Region.* See Appendix 1 for a summary of CNS enablers from the plan.

1.13 These targets provide a seamless result when States with adjoining common airspace concepts implement the same RNP separation solutions. However, States with different airspace concepts across adjoining boundaries can still encounter artificial barriers to aircraft transition.

1.14 This paper discusses some of these transitional issues and potential solutions.

2. DISCUSSION

Navigation requirements

2.1 Prior to the implementation of a reduced separation minimum, an assessment to demonstrate an acceptable level of safety must be conducted[1]. In addition, the application of RNP separation requires the designation either RNP routes or RNP airspace where RNP separation may be applied[2]. However, the requirements to designate RNP routes or airspace are not clear, may be costly and seen as unnecessary.

2.2 CIR 341[3] and CIR 343[4] provide implementation guidance on lateral separation and performance-based longitudinal separation, airspace modelling and monitoring requirements for RNP separation standards. However:

- CIR 341 and 343 are not referenced in Doc 4444 PANS-ATM nor Doc 9613 PBN Manual.

[1] ICAO Doc4444 PANS-ATM 2.6.1.1 and 2.6.1.2
[2] ICAO Doc 4444 - PANS ATM, and Doc 9613 - Performance Based Navigation (PBN) Manual
[3] Cir 341: Guidelines for the Implementation of Lateral Separation Minima
[4] Cir 343: Guidelines for the Implementation of Performance-based Longitudinal Separation Minima

- CIR 341 and 343 limit the scope of application to procedural environments. No provision is made for the RNP designation of Category S or T airspace, or for RNP standards transitioning from Category R airspace (procedural) to a Category S or T (surveillance/ VHF) environment.
- CIR 341 and 343 specify that RNP standards should be supported by monitoring programs which may be complicated and costly. States may not be willing or able to implement these programs where there is no direct benefit.

2.3 States may not recognise a need to designate airspace as RNP where the category of operations is based on VHF and ATS surveillance (Category S or T) ie RNP separation is not needed because day-to-day separation is achieved through an ATS surveillance system.

2.4 It is not clear how the different designations of either routes or airspace affects RNP operations. For instance, where certain routes are designated RNP and aircraft deviate from that route, e.g. to avoid weather, do the modelling assumptions for the routes remain valid and therefore, do the RNP standards remain available for use?

2.5 Continuity issues arise when the aircraft pairs are positioned with one aircraft on either side of a boundary and there is either:

- no RNP designation on one side of the boundary (e.g. Category S or T), or
- States use different methods in the designation of RNP (either routes or airspace) or not all routes are designated RNP.

2.6 Alternatively, one State may need to rely on overlapping surveillance coverage from the other State, in order to ensure the continuity of separation standards during transition, creating complicated separation establishment and monitoring requirements for both States. Additionally, the sharing of surveillance data may not meet the technical requirements to apply ATS surveillance separation standards, eg low quality ADS-B.

2.7 When RNP is not seamless, transition standards are reduced to a few standards common to both States, such as 10 or 15 minutes longitudinal spacing, or vertical solutions, reducing efficiency.

Communication and surveillance requirements

2.8 A similar barrier can occur when the communication or surveillance context changes for an aircraft pair. There is no doubt that a degradation in either of these elements will impact the validity and continuity of a separation standard, however transition to a ‘superior’ form of communication or surveillance (more accurate, more reliable, faster response times) should not remove the ability to apply an RNP standard.

2.9 For example, RCP240 (CPDLC) and RSP180 (ADS-C) are required for some lateral and longitudinal RNP standards:

- The 50NM lateral standard requires “Types of communication other than direct controller pilot VHF voice”, however VHF voice provides a superior form of communication and does not degrade the application of the standard.
- Similarly, where “Conformance monitoring shall be ensured by establishing an ADS-C event contract specifying a lateral deviation change event with a maximum of 5 NM threshold and a waypoint change event”, use of an ATS surveillance system, such as radar or ADS-B, for one aircraft would provide a more accurate and higher surveillance update rate than ADS-C.

ATS systems

2.10 Some ATS systems provide a hierarchy for the display and processing of surveillance information related to a flight. This provides the Air Traffic Controller (ATC) with the best available position source information available for any flight. An example hierarchy from lowest to highest is:

1) No surveillance

2) ADS-C

3) ADS-B (low quality)

4) ATS Surveillance systems including radar, ADS-B (high quality), MLAT.

2.11 This hierarchy means that some ATS systems may 'suppress' ADS-C information when ATS surveillance system (radar/ ADS-B) is also being received for the same aircraft. Upon entering surveillance coverage, some ATS systems may also automatically change the contracted reporting rate to a lower rate than that required for application of the RNP standard. This provides efficiencies for aircraft operators when the ADS-C information is not considered the primary surveillance source but places the validity of the separation standard in doubt.

2.12 Inefficiencies occur for both ATC and operators when ATC manually increases the ADS-C reporting rate of a radar identified aircraft, to facilitate technical compliance for continued use of an RNP standard during transition.

3. CONCLUSIONS AND OPTIONS

3.1 Although there are a large number of supporting documents for PBN implementation, some additional areas of improvement could assist adjacent States to achieve the seamless efficiencies envisioned by the APAC plans.

Improved requirements for RNP designation

3.2 More information regarding the RNP designation of routes or airspace could assist the appropriate implementation of RNP. More flexibility and appropriate application of PBN requirements could also improve the uptake of PBN implementation:

- Consider a review of RNP modelling to remove the requirement for RNP designation of air routes or airspace, or provide alternative methods of compliance.

- Provide more information to States about when and how RNP designation of airspace or air routes can and should be done, and times when the designation is not required. Information about the implications of different designations would also assist.

- Review Doc 4444 PANS-ATM and Doc 9613 PBN Manual to include reference to CIR 341 and 343.

- Review whether the safety outcome provided by monitoring of PBN performance may be achieved by a different means, for example, exception reporting, or whether it is required at all in some airspaces, such as Category S and T.

Separation standard transition between airspaces

3.3 When considering the CNS modelling parameters used to establish the safety of RNP separation, it is logical that an aircraft pair subject to RNP separation would continue to be separated when one aircraft moves into an area of improved surveillance or communication.

3.4 To further this, a review the application of RNP separation to include transitioning allowances within Doc 4444 PANS-ATM would improve the seamless nature of boundaries. Considerations may include:

- The removal of RNP designation requirements,
- The addition of RNP equivalence to remove the requirement for some airspaces to be designated as RNP, such as category S and T,
- Clarity in the application of RNP separation with differing designation - routes or airspace - including off track operations,
- Determining whether RNP standards dependent upon a particular communication or surveillance source can also include other communication and surveillance sources,
- Determining whether the transition from any procedural standard to a more superior environment e.g. ATS surveillance and VHF, can be supported holistically.

4. ACTION REQUIRED BY THE MEETING

4.1 The meeting is invited to:

a) note the information contained in this paper;

b) discuss any relevant matters as appropriate; and

c) determine what further actions could or should be taken.

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References

1) Circular 341: Guidelines for the implementation of lateral separation minima
2) Circular 343: Guidelines for the implementation of of Performance-based Longitudinal Separation Minima
3) ICAO Doc 4444 - PANS ATM

Appendix 1

Summary of CNS enablers – APAC Seamless Plan V3.0

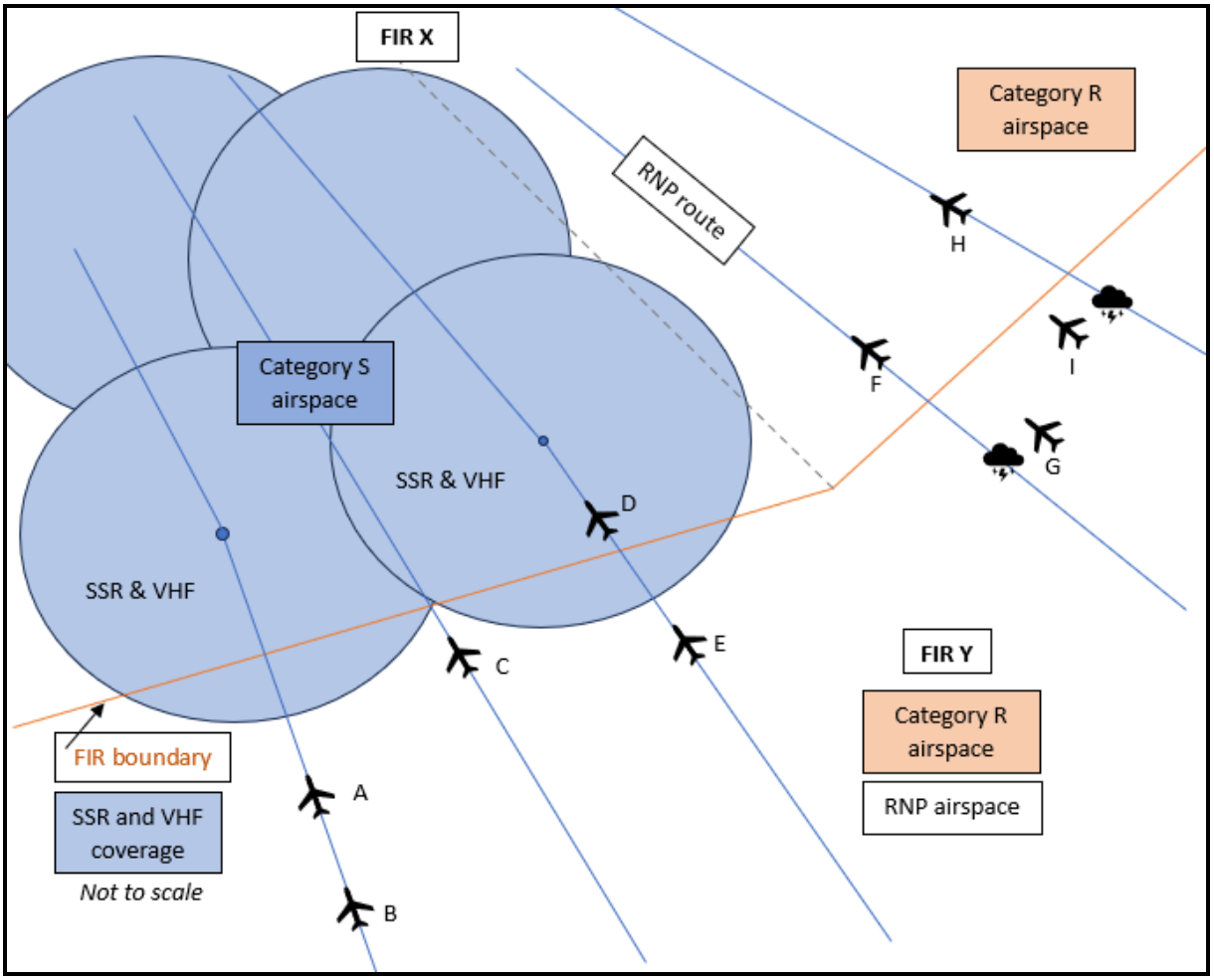
Airspace category		**Airspace** *APAC Seamless ANS Plan 7.10 – 7.13*	**PBN** *APAC Seamless ANS Plan 7.4 – 7.15*	**PBC** *APAC Seamless ANS Plan 7.24 – 7.26*	**PBS** *APAC Seamless ANS Plan 7.27 – 7.31*
Terminal	Terminal (T)	Should be designated PBN to facilitate seamless operations and off-track events.	• RNAV1/RNP1 • SBAS/GBAS • RNP APCH with Baro-VNAV or SBAS.	Where surveillance is provided: Direct speech circuits or digital voice communications.	• ADS-B or Radar. • Mode S Radar required at international airports.
En Route	Serviced (S)	Should be designated PBN to facilitate seamless operations and off-track events.	New routes should be designated RNAV 2 or RNP 2.	Where surveillance is provided: Direct speech circuits or digital voice communications.	• ADS-B or Mode S Radar. • Requirement for aircraft to equip where Mode S is provided.
	Remote (R)	Should be designated PBN to facilitate seamless operations and off-track events.	New routes should be designated: • RNP 4, RNP 10 (RNAV 10) or RNP2 Oceanic • RPAS - RNP 2 Oceanic or RNP4.	CPDLC enabled.	• ADS-C enabled. • Requirement to equip with Mode S where provided.

Summary of airspace category descriptors – APAC Seamless Plan V3.0

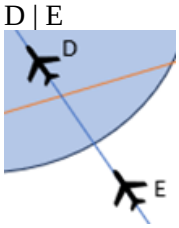
Category	**Descriptor (CNS requirements)**
Category R	Remote en-route airspace with: • Air Traffic Services (ATS) • HF or CPDLC communications, and • outside the coverage of ground-based surveillance coverage.
Category S	Serviced (or potentially serviced) en-route airspace with: • Air Traffic Services (ATS) • direct ATS communications*, and • surveillance
Category T	Terminal operations with: • Air Traffic Services (ATS) • direct ATS communications* and • surveillance

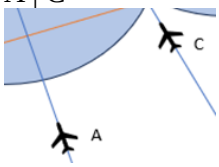
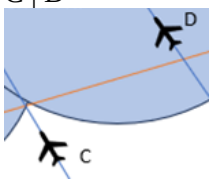
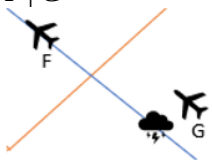
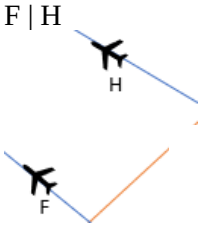
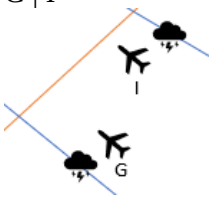
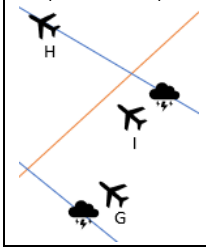
Appendix 2

Example airspace depicting complex transitional issues



Description of scenarios depicted in the above diagram:

Aircraft pair	Separation issue
A | B 	Both aircraft A and B are RNP approved, in RNP airspace. 30NM RNP longitudinal separation is applied.
D | E 	*Progression of scenario above* Both aircraft are RNP approved. Aircraft D is in VHF and surveillance coverage but is no longer eligible for RNP standards as the airspace or route is not designated RNP. Aircraft E is in RNP airspace. Required separation is 10 or 15 minutes longitudinal (or vertical separation).

A | C 	Both aircraft are RNP approved, in RNP airspace. 30NM RNP lateral separation is applied.
C | D 	*Progression of scenario above* Both aircraft are RNP approved. Aircraft D is in VHF and surveillance coverage but is no longer eligible for RNP standards as the airspace or route is not designated RNP. Aircraft C is in RNP airspace. GNSS-GNSS lateral separation for RNP 4 aircraft (PANS-ATM 5.4.1.2.1.2) or another locally agreed standard could be applied.
F | G 	Both aircraft F and G are RNP approved, in RNP airspace (G) or on an RNP route (F). 30NM longitudinal separation is applied and will exist until aircraft G crosses into FIR X. At that point, aircraft G is no longer eligible for RNP standards as the aircraft is not on the designated RNP route.
F | H 	Both aircraft F and H are RNP approved. Aircraft F is on an RNP route, aircraft H is not on an RNP route. RNP standards are not able to be applied as aircraft H is not on a designated RNP route. GNSS-GNSS lateral separation may apply if both aircraft are RNP 4 approved.
G | I 	Both aircraft G and I are RNP approved, in RNP airspace. In addition, both aircraft are deviating around weather. In FIR X, aircraft F will be planned on an RNP route, aircraft H will not be on an RNP route. RNP standards are not able to be applied when one aircraft leaves RNP airspace - vertical separation will be required by the time the first aircraft crosses into FIR X.
H | I and H | G 	Where a longitudinal RNP standard may have existed between aircraft H and I, or a lateral RNP standard between aircraft H and G, when the aircraft were in FIR Y, and alternate standard (such as 10 or 15 minutes longitudinal separation, or vertical separation) must be applied from the time H crosses into FIR X.