*International Civil Aviation Organization*

**Seventh Meeting of Performance Based Navigation Sub-Group (PBN SG/7)**

**(Virtual Meeting, 5 - 6 December 2022)**

**Agenda Item 4:** PBN Planning and Implementation in the MID Region

# PBN ROUTE SPACING AND CNS REQUIREMENTS

*(Presented by the Secretariat)*

**SUMMARY**

This paper presents methodologies used to determine spacing between PBN ATS routes and instrument flight procedures to accommodate their strategic de-confliction to achieve the efficiency and safety objectives whilst ensuring a manageable workload for controllers. It also provides the minimum distance or spacing that can exist between two proximate flight procedures when strategic deconfliction is the intended operation.

Action by the meeting is at paragraph 3.

**REFERENCES**

- Procedures for Air Navigation Services — Air Traffic Management (PANS-ATM) (Doc 4444)
- Procedures for Air Navigation Services — Aircraft Operations, (PANS OPS), Volume II, (Doc 8168)
- Performance-based Navigation (PBN) Manual (Doc 9613)
- Manual on Airspace Planning Methodology for the Determination of Separation Minima (Doc. 9689)

## 1. Introduction

1.1 Systemisation of the air traffic flows together with the strategic de-confliction of ATS routes is used to safely improve the efficiency of air traffic operations in a fixed route environment. One of the enablers is the Performance-based Navigation (PBN), which allows the placement of routes independent of ground-based NAVAIDs. An important element of the systemisation concerns the spacing of parallel and non-parallel routes.

1.2 Route Spacing and separation minima are the key indicators for PBN route structures and operations. The spacing between ATS routes may be determined, in part, by the navigation performance of the aircraft that are expected to use them, by anticipated aircraft density, and by the communication and ATS surveillance services that are available to those aircraft.

1.3 This paper presents methodologies used to determine spacing between PBN ATS routes and instrument flight procedures, with a focus on RNAV 5 and RNAV 1, to accommodate their strategic de-confliction to achieve the efficiency and safety objectives whilst ensuring a manageable workload for controllers.

## 2. Discussions

### Route Spacing – ICAO PANS-ATM Doc4444

2.1 There is an important principle described in ICAO PANS-ATM which can be used to determine the appropriate route spacing in the PBN applications:

*"5.4.1.2.1.5 RNAV operations where RNP is specified on parallel tracks or ATS routes. Within designated airspace or on designated routes, where RNP is specified, lateral separation between RNAV-equipped aircraft may be obtained by requiring aircraft to be established on the centre lines of parallel tracks or ATS routes spaced at a distance which ensures that the protected airspace of the tracks or ATS routes does not overlap."*

### PANS OPS Doc 8168, Vol II Obstacle Clearance Area

2.2 The ½ Airway Width (A/W) of the obstacle clearance area in all RNAV and RNP applications (except RNP AR) is based upon the following:

$$½\ W = XTT * 1.5 + BV$$

**Table III-1-1-3. Buffer values**

| *Phase of flight* | *BV for CAT A–E* | *BV for CAT H* |
|---|---|---|
| En-route, SIDs and STARs (greater than or equal to 56 km (30 NM) from departure or destination ARP) | 3 704 m (2.0 NM) | 1 852 m (1.0 NM) |
| Terminal (STARs, initial and intermediate approaches less than 56 km (30 NM) of the ARP; and SIDs and missed approaches less than 56 km (30 NM) of the ARP but more than 28 km (15 NM) from the ARP) | 1 852 m (1.0 NM) | 1 296 m (0.7 NM) |
| Final approach | 926 m (0.5 NM) | 648 m (0.35 NM) |
| Missed approaches and SIDs up to 28 km (15 NM) from the ARP | 926 m (0.5 NM) | 648 m (0.35 NM) |

| *Phase of flight* | *Navigation specification* | *XTT* |
|---|---|---|
| En-route and terminal (>56 km (30 NM) from ARP) | RNAV 5 | 4.65 km (2.51 NM) |
| En-route and terminal (>56 km (30 NM) from ARP) | RNAV 1 and 2 | 3 704 m (2.00 NM) |
| Terminal (<56 km (30 NM) from ARP) to the IAF | RNAV 1 and 2 | 1 852 m (1.00 NM) |

### 2.3 RNAV5

2.3.1 Communications and ATS surveillance requirements

Direct pilot to ATC (voice) communications is required. ATS Surveillance service may be used to assist contingency procedures, to mitigate the effect of blunder errors, and to reduce route spacing.

2.3.2 Route spacing and separation minima

- One regional RNAV 5 implementation adopted a standard route spacing of 16.5 NM for same-

direction traffic and 18 NM for opposite-direction traffic in a ATS Surveillance environment. Moreover, route spacing as low as 10 NM has been used in a radar environment where ATC intervention capability permits.

- Using the method in 2.2 to calculate the route spacing for RNAV5:

*½ W/A = XTT *1.5 + BV=2.51(GNSS)*1.5+2.0=5.77NM. Route spacing for RNAV5 parallel routes could be 11.54NM, roughly 12 NM. However, State should undertake the necessary safety assessments outlined in PANS-ATM (Doc 4444). Furthermore, two aspects are of particular importance: spacing between routes in turns and along track distance between leg changes.*

**2.4 RNAV1**

2.4.1 Communications and ATS surveillance

Direct pilot to ATC (voice) communications is required. ATS Surveillance service may be used to assist contingency procedures, to mitigate the effect of blunder errors, and to reduce route spacing.

2.4.2 Route spacing and separation minima

Route spacing for RNAV 1 depends on the route configuration, air traffic density and the availability of ATS Surveillance to provide intervention capability.

According to ICAO PANS-ATM, 5.4.1.2.1.4.1 Lateral separation of departing and/or arriving aircraft, using instrument flight procedures, will exist:
a) where the distance between any combination of RNAV 1 with RNAV 1, or RNP 1, RNP APCH or RNP AR APCH tracks is not less than 13 km (7 NM); or
b) where the protected areas of tracks designed using obstacle clearance criteria do not overlap and provided operational error is considered.

Route spacing for RNAV 1 on parallel tracks or ATS routes may be calculated the method in 2.2

*½ W = XTT *1.5 + BV=2.0*1.5+2.0=5 NM. Route spacing for RNAV 1 parallel routes could be 10 NM. State should undertake the necessary safety assessments outlined in PANS-ATM (Doc 4444).*

**2.5 Reduction in Separation Minima**

2.5.1 Provided an appropriate safety assessment has shown that an acceptable level of safety will be maintained, and after prior consultation with users, the separation minima may be reduced in the following circumstances:

As determined by the appropriate ATS authority as appropriate:
a) when special electronic or other aids enable the pilot-in-command of an aircraft to determine accurately the aircraft's position and when adequate communication facilities exist for that position to be transmitted without delay to the appropriate air traffic control unit; or
b) when, in association with rapid and reliable communication facilities, information of an aircraft's position, derived from an ATS surveillance system, is available to the appropriate air traffic control unit; or
c) when special electronic or other aids enable the air traffic controller to predict rapidly and accurately the flight paths of aircraft, and adequate facilities exist to verify frequently the actual aircraft positions with the predicted positions; or
d) when RNAV-equipped aircraft operate within the coverage of electronic aids that provide the necessary updates to maintain navigation accuracy.

2.5.2 The ANSP safety case has to demonstrate that PBN routes are tolerably safe. Thereafter, a number of arguments can be made for:

- Operational or 'blunder' errors, e.g. flight crew following an instruction intended for a different aircraft or flying of the incorrect procedure;
- Generic failures leading to intentional deviations, e.g. flight crew avoiding weather without informing ATC, aircraft emergencies, loss of GNSS coverage;
- Technical errors, e.g. navigation system failure;
- Deviations for aircraft operating within their nominal navigation performance.

2.5.3 Moreover, it is important that the Air Navigation Service Provider (ANSP) monitors key assumptions including blunder error rates and controller intervention success rates post implementation. Post implementation lateral navigation performance monitoring would need to confirm the achieved navigation performance.

2.5.4 Regional and national studies have been undertaken to determine the minimum spacing value between strategically de-conflicted routing configurations, which were achieved under specific conditions in particular regional or national environments. None of these examples may be summarily transferred or implemented in a different operating environment without the required implementation safety assessment being undertaken. ICAO Annex 11, Chapter 2 and ICAO Doc 4444 (PANS-ATM) Chapter 2 have unambiguous requirements for specific safety assessments to be undertaken when implementing Airspace changes.

2.5.5 Outlined below are two key points to consider.

- It is emphasized that when route spacing values have been derived for use in a Radar surveillance environment using observed performance, such spacing can never be equal to or less than the prescribed radar separation minima applied in the airspace. This is because a lateral deviation could instantly cause a separation infringement. Sufficient time is needed for the controller to detect and correct a deviation and for the pilot to respond correctly.
- Any published table showing route spacing values determined by particular studies must be seen in this light. No published spacing results for continental application (or study supporting these results) can be considered universal norms. Results are valid only for the assumptions and data used, the particular operating environment and airspace and operational concept envisaged. One key assumption is that aircraft being separated on closely spaced routes are within the same ATC sector. It is also stressed that route spacing values supported by extensive data, statistical analysis, mathematical modelling and airspace design do not ensure that the aircraft will adhere to the route to ensure that the route spacing is maintained. Essential to successful flight operations are proper procedure design, the correct coding of procedures in the aircraft databases and validation of the procedure to check flyability.

## 2.6 PBN Airspace Design Workshop

2.6.1 It is proposed to conduct a workshop, in collaboration with MID FPP, champion States and International Organizations, to provide a thorough understanding of airspace design requirements; focusing on PBN based solutions to ensure an efficient, flexible and dynamic airspace structure that meets Stakeholders requirements in terms of safety, flight efficiency and capacity in a cost-effective manner. The workshop will also be an opportunity to gain insight into lessons learned and/or best practices in the application of PBN in the design of airspace.

2.6.2 In view of the foregoing, the following Draft Conclusion is proposed:

***DRAFT CONCLUSION 7/X: PBN AIRSPACE DESIGN WORKSHOP***

*That:*

*a) a PBN Airspace Design Workshop be organized in 2023, in collaboration with the MID FPP, to provide necessary knowledge about PBN based solutions for airspace design to ensure an efficient, flexible and dynamic airspace structure that meets Stakeholders requirements in terms of safety, flight efficiency and capacity in a cost-effective manner; and*

*b) States and International Organizations are strongly encouraged to participate actively in this Workshop.*

## 3. ACTION BY THE MEETING

3.1. The meeting is invited to:

a) note the information contained in this paper and discuss any relevant matters as appropriate; and

b) endorse the proposed Draft Conclusion at para. 2.6.

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