*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**

# INFRASTRUCTURE ASSESSMENTS FOR PBN IMPLEMENTATION

*(Presented by the Secretariat)*

**SUMMARY**

This paper presents the methods and processes that should be used to evaluate if a specific navigation infrastructure is suitable to support aircraft flying PBN (RNAV1) application based on infrastructure requirements and corresponding navigation specifications as defined in the Performance Based Navigation Manual, ICAO Doc 9613.

Action by the meeting is at paragraph 3.

**REFERENCES**

- Performance-based Navigation (PBN) Manual (Doc 9613)
- EUROCONTROL Guidelines for RNAV 1 Infrastructure Assessment

## 1. INTRODUCTION

1.1 Air Navigation Service Providers (ANSP) have a responsibility to provide infrastructure (e.g., navigation aids) that is "sufficient" to support all procedures, including PBN. This generic provision responsibility and the demand for "sufficiency" are documented as follows:

*Convention on International Civil Aviation (ICAO Doc 7300/9 Article 28): "Each … state undertakes … to provide … radio services … and other navigation facilities to facilitate international air navigation …"*

*ICAO Annex 11, Air Traffic Services (RNP Routes, Attachment B), "…infrastructure must be provided sufficient to support …"*

1.2 These standards define the responsibility of States (ANSPs) to ensure that the navigation, surveillance and communications infrastructure has the capabilities needed to support the intended PBN operation.

1.3 This paper provides guidance for ANSP to conduct navigation infrastructure assessments in order to satisfy the requirements of RNAV 1 NAVSPEC.

1.4 The NAVAID Infrastructure includes all NAVAIDs permitted by PBN, be they ground or space-based.

## 2. DISCUSSIONS

2.1 PBN provides procedures that can be flown with a variety of navigation aids and airborne sensors. Each navigation specification stipulates which positioning sensor may be used for a particular navigation application as indicated in the PBN Manual Doc 9613, Volume II table (II-A-1-4).

2.2 The RNAV 1 specification in Volume II of PBN manual shows that any of the following navigation sensors can meet its performance requirements: GNSS or DME/DME/IRU or DME/DME.

2.3 As such, each combination of navigation aid and sensor needs to be assessed to see if the requirements to support a specific procedure are met. Consequently, an ANSP can declare which navigation infrastructures are available to support the navigation specification in a given airspace.

2.4 Note that one of the goals of the infrastructure assessment is to provide evidence to the corresponding safety assessment that the navigation service supporting a certain procedure complies with the safety requirements.

***Conventional infrastructure: DME/DME infrastructure assessment process***

2.5 DME/DME is the only non-GNSS infrastructure suitable to support aircraft using RNAV 1 procedures.

2.6 These following steps should be followed in order to assess whether DME/DME RNAV infrastructure meets the requirements as per Doc 9613.

**Step 1**: Collect Necessary Data: The CNS provider should receive all the necessary information from the procedure design and airspace planning office. This includes all waypoint coordinates, path terminators and any vertical profile restrictions (minimum climb gradients, minimum crossing altitudes, speed categories etc.), offset, direct-to or other operational requirements, as well as the outer boundaries of the secondary protection surfaces.

**Step 2:** Identify Individual Qualifying DME Facilities : Using a terrain modelling tool, determine which DME facilities are within line of sight to each point of the procedure service volume and are usable by all FMS's (range more than 3 NM & less than 160 NM, elevation angle less than 40 degrees).

*Note : As it is not possible to know which DME facilities the airborne system will use for a position update, a theoretical viability check should be made of the route to ensure that there is appropriate DME coverage available at any point along the proposed route, based upon at least two selected facilities (the coverage of DME stations is given in Appendix A).*

**Step 3**: Establish Supporting DME Pairs: Define sufficient possible combinations of pairs of DMEs at each point within the procedure service volume, based on the list of suitable facilities identified in the previous step.

**Step 4:** Identify Specific Issues: If only one valid pair of supporting DME exists, both DME facilities are considered critical to the procedure. If a particular DME is common to the list of all supporting DME pairs, that DME is critical as well. A DME is critical when an outage will disable RNAV positioning (using DME/DME only). The infrastructure assessment needs to identify the number of critical DME facilities that support a procedure.

Step 5: Prepare and Conduct Flight Inspection : Prepare the list of DME facilities to be flight inspected and communicate any findings (such as incomplete coverage of entire procedure volume) to the flight inspection organisation, including any specific factors to be considered. Conduct flight inspection to confirm signal in space compliance with ICAO Annex 10, e.g. coverage (availability) and accuracy of individual DME facilities supporting RNAV.

**Step 6**: Finalise Assessment and Implementation Measures: The CNS provider should assess the flight inspection report to see if the assumptions in the initial assessment have been confirmed or if any unforeseen effects have been discovered and take the appropriate action for remedy. If any DME facilities are identified as being deleterious to the navigation solution, they need to be removed from the list of supporting DMEs and corresponding pairs (if applicable).

*Note1: steps 2, 3, 4 and 6 are best conducted with the support of software tools. More information on the use of tools is contained in para below.*

*Note: More guidance for RNAV 1 Infrastructure Assessment is contained Doc EUROCONTROL- -GUID-114 accessible through the link : https://www.eurocontrol.int/sites/default/files/2021-07/eurocontrol-guidelines-rnav-1-infrastructure-assessment-20.pdf.*

2.7 Appropriate tools should be used to assess navigation infrastructure. While the assessment could be conducted using manual analysis and flight inspection, the use of a software tool is recommended in order to make the assessment more efficient. The software tool should be tailored to allow evaluating the infrastructure in light of the requirements imposed by a specific navigation specification.

2.8 In general, RNAV assessment tools should include a 3D terrain model with sufficient resolution and accuracy to allow predicting the line of sight visibility of NAVAIDS along a procedure service volume, including an analysis of their respective subtended angles and a variety of other geometric constraints.

2.9 VOR/DME assessments for RNAV 5 are simply a matter of generating cumulative coverage estimations, because geometry constrains do not have to be taken into account (such as in DME/DME).

***Global Navigation Satellite System (GNSS)***

2.10 PBN procedures should always allow the use of GNSS.

2.11 Because GNSS is available on a worldwide basis, infrastructure assessment for GNSS differs significantly from terrestrial navigation aids. Relevant aspects such as safety assessment and GNSS performance assessment are described in the GNSS Manual, ICAO Doc 9849 (2017 edition, especially chapters 7.5 and 7.8.2). In addition to considering constellation performance, the ANSP should assess that the space weather and radio frequency interference environment is satisfactory for the planned procedures, and implement vulnerability mitigation measures, if appropriate (chapter 5 and appendix F of the GNSS Manual). Further guidance on assessing and measuring GNSS interference is contained in ICAO Doc 8071, Testing of Radio Navigation Aids. During outages of GNSS and depending on available NAVAID facilities, ANSPs may find it useful to consider suspending planned routine maintenance activities to ensure the availability of an alternate source of navigation.

***Publication***

2.12 The State AIP should clearly indicate whether the navigation application is RNAV 1. The available NAVAID infrastructure should be clearly designated on all appropriate charts (e.g. GNSS, DME/DME or DME/DME/Inertial).

2.13 Any DME facilities that are critical to RNAV 1 operations should be identified in the relevant publications.

2.14 Where holding patterns are established, they are to comply with the criteria and publication requirements in PANS OPS Volume II, Part 3, Section 3, Chapter 7. For the content of the PBN Requirement Box published on the chart, see also PANS OPS Volume II, Part 3, Section 5, Chapter 1.

2.15 Since RNAV systems conducting DME/DME navigation should only use DME facilities identified in State AIPs, the State should indicate facilities inappropriate for RNAV 1 operations in their AIP and Where temporary restrictions occur, the publication of restrictions on the use of a DME facility should be accomplished by use of a NOTAM to identify the need to exclude that specific DME facility.

## 3. ACTION BY THE MEETING

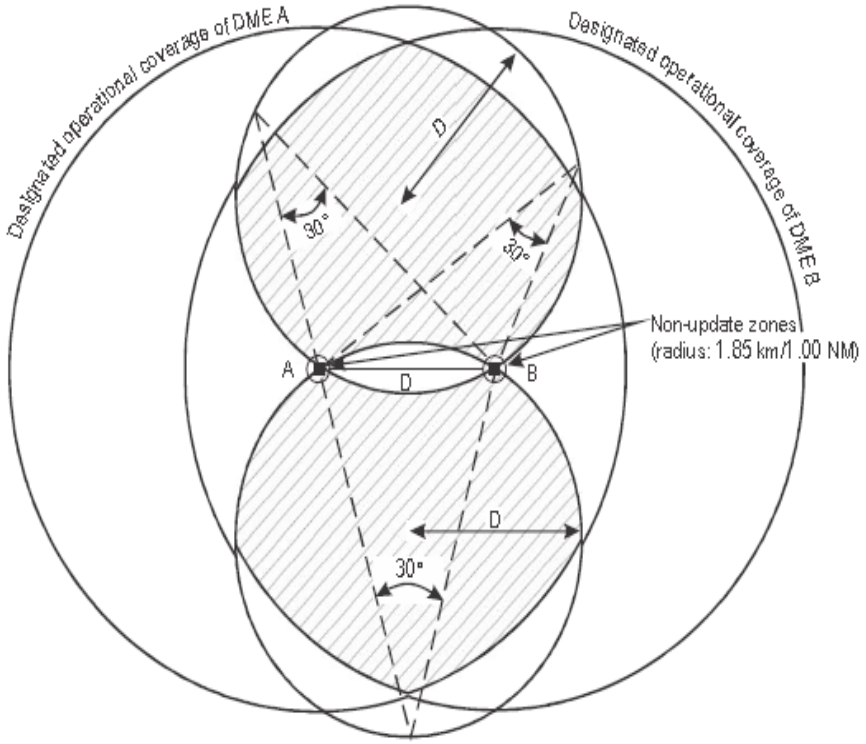
3.1. The meeting is invited to:

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

b) encourage States that have not yet done so, to conduct a complete assessment of the CNS infrastructure to ensure PBN implementation. CNS infrastructure assessment should be integrated in the State national PBN plan.

– END –

**Appendix A**
**Maximum update area of two DME stations A and B**




Update-area where the 30°/150° rule is applicable

**DME/DME UPDATE AREA FOR 2 DME STATIONS LOCATED AT A DISTANCE 'D' APART**

**Step 1 —** A circle centred on each station with a radius equal to the Designated Operational Coverage (DOC) with a maximum of 370.4 km (200.0 NM) must be drawn.

**Step 2 —** The 30–150° DME intercept circles with a radius equal to the distance 'D' on either side of both DME stations must be drawn.

**Step 3 —** Then the no-update zone circles of 1.85 km (1.00 NM) centred on both DME stations are drawn.

The area with dual DME update is comprised within an area where both the following conditions exist:

1. the area within the DOC/370.4 km (200.0 NM) and
2. the area of the 30/150 degrees intersect angle.

Excluded from DME/DME coverage is the area comprised within:

1. the no update zone circles and
2. the area between the two DME stations.