International Civil Aviation Organization

Tenth Meeting of the Performance Based Navigation Sub-Group (PBN SG/10)

(Amman, Jordan, 10 - 11 December 2025)

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

FEASIBILITY OF DME/DME RNAV: A CASE STUDY FOR AQABA AND AMMAN TMAS

(Presented jointly by Oman and Jordan)

SUMMARY

This paper presents the results of a detailed DME/DME RNAV feasibility and performance study conducted for the terminal airspaces of Aqaba and Amman within the Amman FIR. The study evaluates the adequacy of existing and proposed DME infrastructure to support RNAV 1 terminal operations and assesses the viability of DME/DME as a resilient backup to GNSS-based navigation during contingency or GNSS-degraded scenarios.

Action by the meeting is at paragraph 3.

REFERENCES

- PANS OPS, Doc 8168, Vol. II, 7th Edition 2020
- PBN Manual, Doc 9613, 5th Edition, 2023
- DEMETER User Manual, Version 3.0, 2023
- Report of ICAO MID PBN SG/9 Meeting, December 2024
- MIDANPIRG ATM SG-11 Report, October 2025

1. INTRODUCTION

1.1 In line with the collaborative direction highlighted at the PBNSG/9 meeting and with the facilitation of the ICAO MID Regional Office, a virtual meeting between Oman and Jordan was held in March 2025 to advance the joint efforts supporting Jordan's initiatives in DME/DME integration.

1.2 As an outcome of the meeting, Oman committed to contributing technical expertise to assist Jordan in evaluating DME/DME performance within the Aqaba and Amman TMAs as a contingency navigation solution in the event of GNSS outages or degradation. ICAO MID encouraged this collaboration in line with the MID Region PBN implementation objectives.

1.3 Following the Oman–Jordan understanding, a joint technical team conducted a comprehensive feasibility study using the airspace, IFP procedure, terrain, and DME data provided by Jordan.

1.4 The DME/DME RNAV feasibility study was completed over approximately two months, during which it required sustained coordination, analytical effort, and technical focus from the involved team members, reflecting their professional commitment and dedication to supporting regional PBN initiatives.

1.5 The study result represents a shared regional effort between Oman, Jordan, and ICAO MID, and is presented with the aim of promoting continued cooperation and harmonized implementation of RNAV operations across MID States.

2. DISCUSSION

2.1 The study was successfully completed in May 2025 using DEMETER tool for both the Aqaba and Amman TMAs, reflecting effective regional cooperation and contributing to strengthened navigation resilience across the MID Region.

2.2 The DEMETER is a EUROCONTROL-developed tool and is used primarily for the planning and assessment of NAVAID infrastructure and for evaluating the performance of DME/DME and VOR/DME for RNAV operations by analysing VOR and DME geometry, line-of-sight conditions, and signal availability.

Applied Methodology

2.3 In order to conduct the DME/DME coverage study and analysis, the following methodology was applied:

a) Data collection and assessment, including DME siting data, terrain data, and TMA airspace and terminal flight procedure data provided by the Jordan ANSP;

b) Conversion of KML datasets into ArcGIS Shapefiles compatible with the DEMETER tool;

c) Assessment of the suitability of existing and proposed DME infrastructures within and around Aqaba and Amman TMAs;

d) Analysis of the desirable airspace to be covered by DME/DME infrastructure for terminal operations;

e) Terrain analysis at existing and proposed DME sites to assess the impact of surrounding topography on coverage;

f) Selection and evaluation of different combinations of DME stations to determine the optimum configuration that provides maximum coverage and redundancy with a minimum number of stations;

g) Using the DEMETER NAVAID siting tool to identify appropriate DME locations, with consideration for potential future installations;

h) DME/DME coverage simulations using DEMETER tool with different combinations of DME stations and at different levels; and

i) Verification of compliance with relevant criteria contained in ICAO Doc 9613 and Doc 8168, Vol. II, for RNAV 1 terminal operations using DME/DME as a navigation sensor.

Data used for the Study

2.4 The following data were used during the study:

a) DME Siting Data used for DME/DME Performance Evaluation: Siting data of 25 DME stations (existing + proposed) (Source: Jordan ANSP)

b) Terrain Data used for DME/DME Performance Evaluation: SRTM data (Source: Jordan ANSP) and GTOPO30 data (Source: DEMETER in-built)

c) Flight Procedure Data (Source: Jordan ANSP)

System Parameters

2.5 The following System Parameters are used in DME/DME Performance Evaluation:

- Min/Max DME Intersection angle 30° - 150°
- Min/Max DME Facility Range 3 NM – 160 NM
- DME Cone of Silence 50°
- Max Elevation Angle 40°

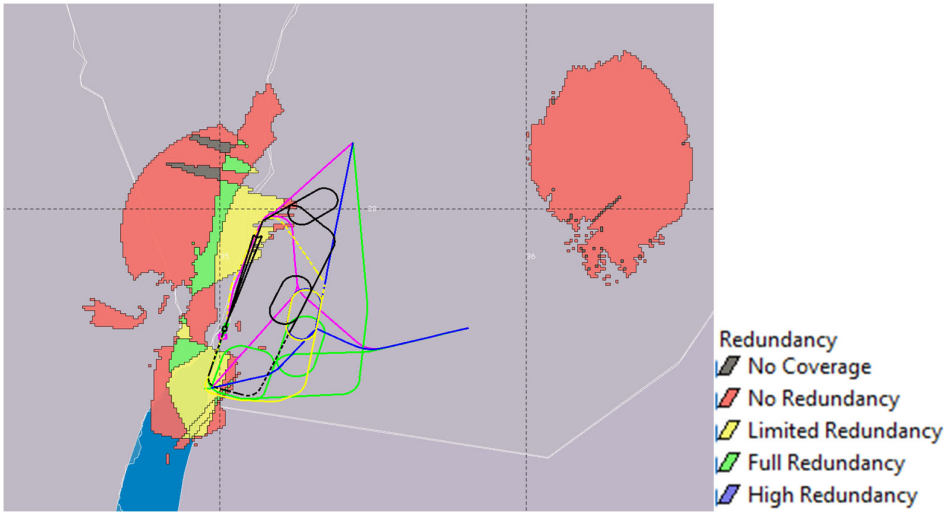
Coverage Assessment

2.6 The DME/DME coverage has been assessed using DEMETER tool at specified levels and DME configurations in 500-ft increments, using a set of selected DME stations in case of both Aqaba and Amman TMAs, as stated below:

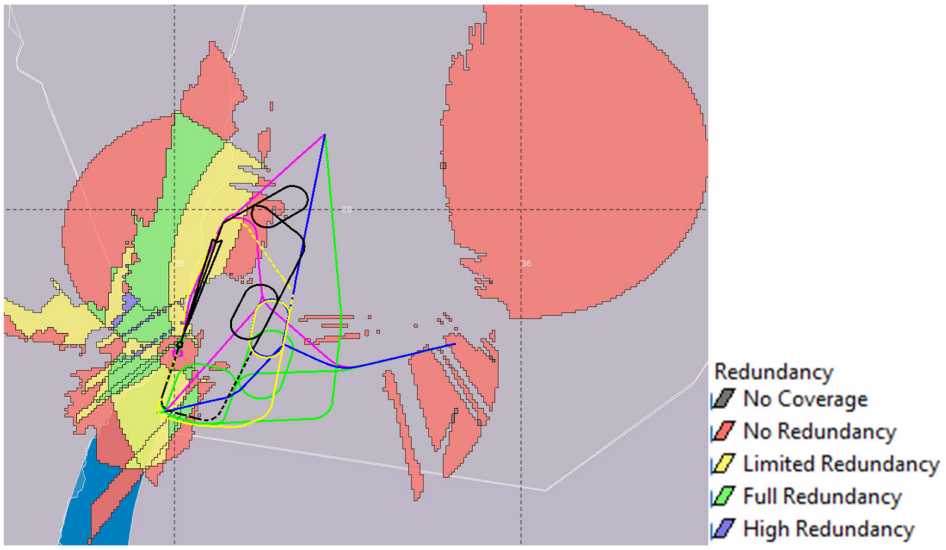
- from 8000 ft down to 3000 ft in case of Aqaba TMA
- from 5000 ft down to 3500 ft in case of Amman TMA

Aqaba DME-DME RNAV Performance Simulation (Tool: EUROCONTROL DEMETER)

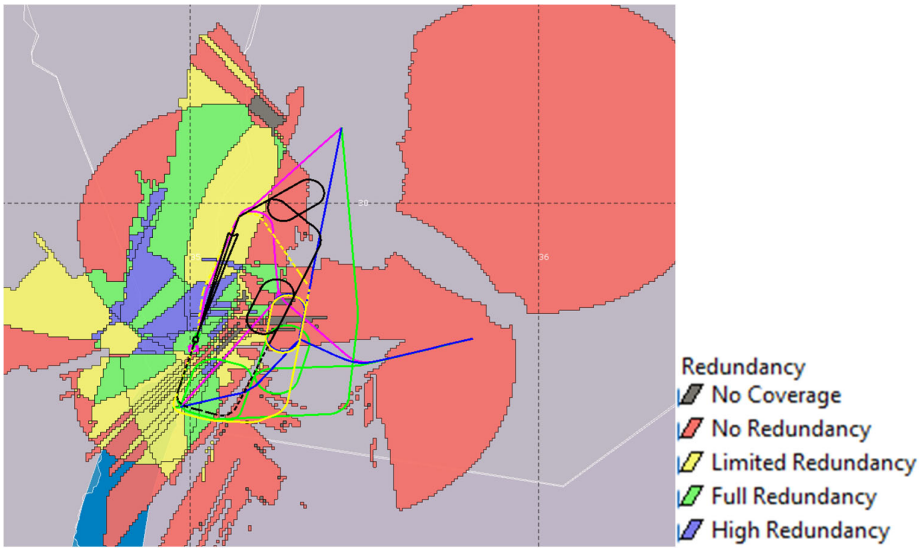
At 3000 ft



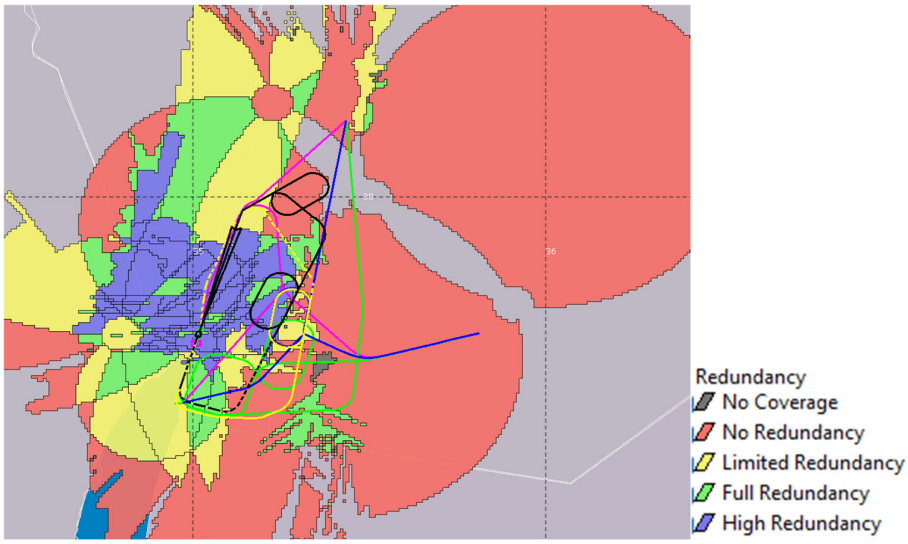
At 4000 ft



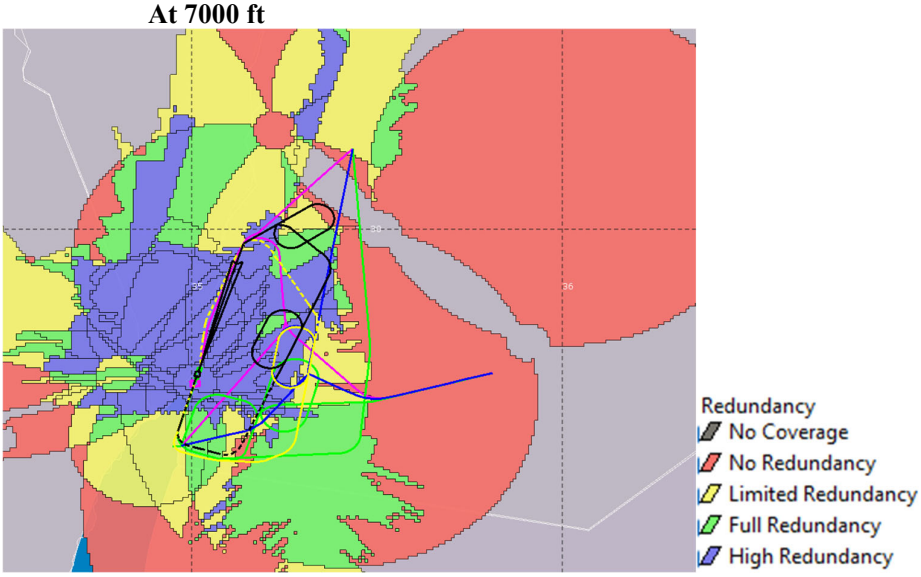
At 5000 ft



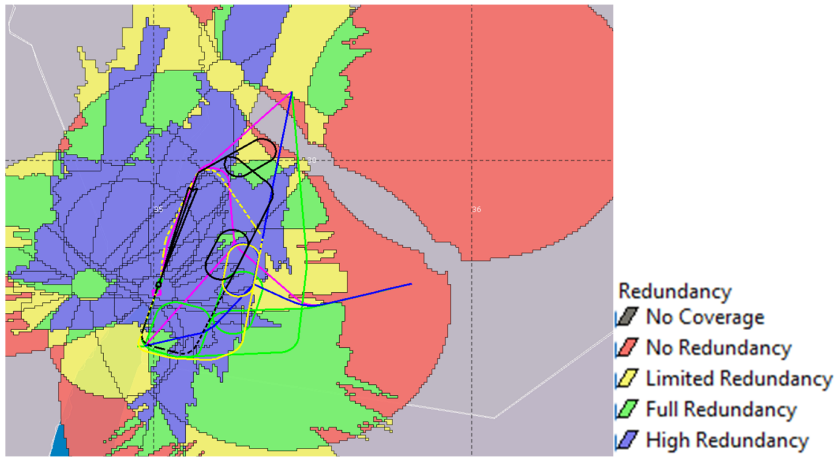
At 6000 ft



At 7000 ft

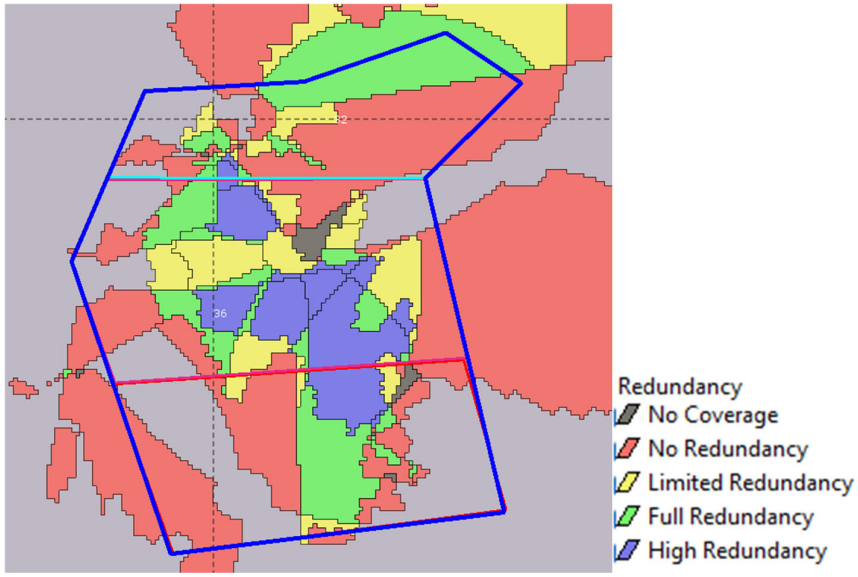


At 8000 ft

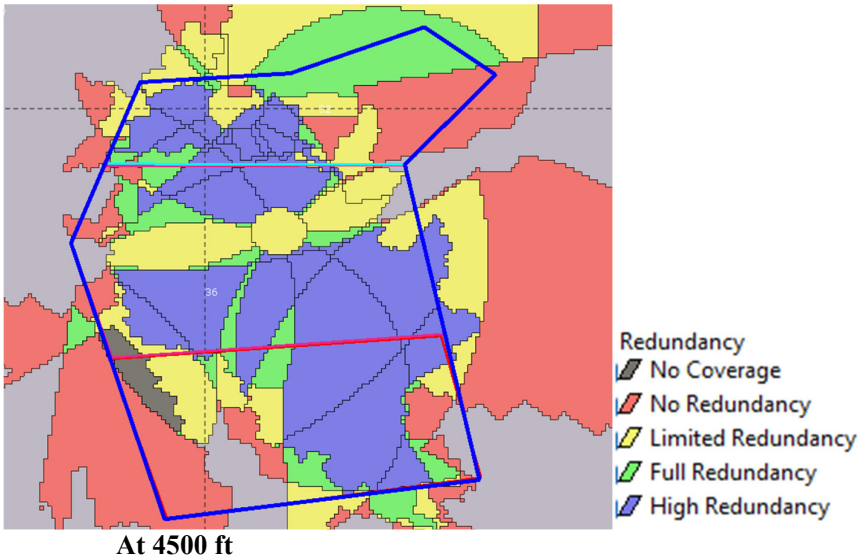


Amman DME-DME RNAV Performance Simulation (Tool: EUROCONTROL DEMETER)

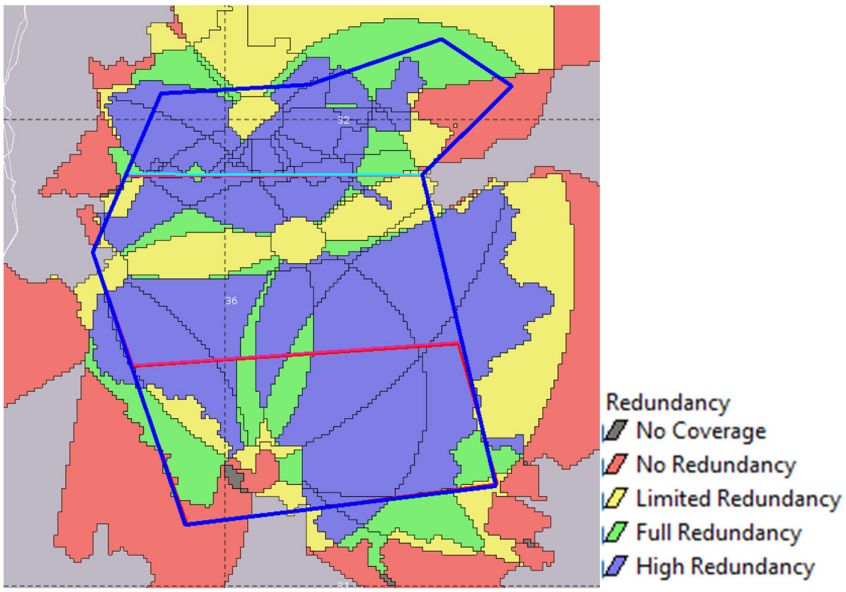
At 3500 ft



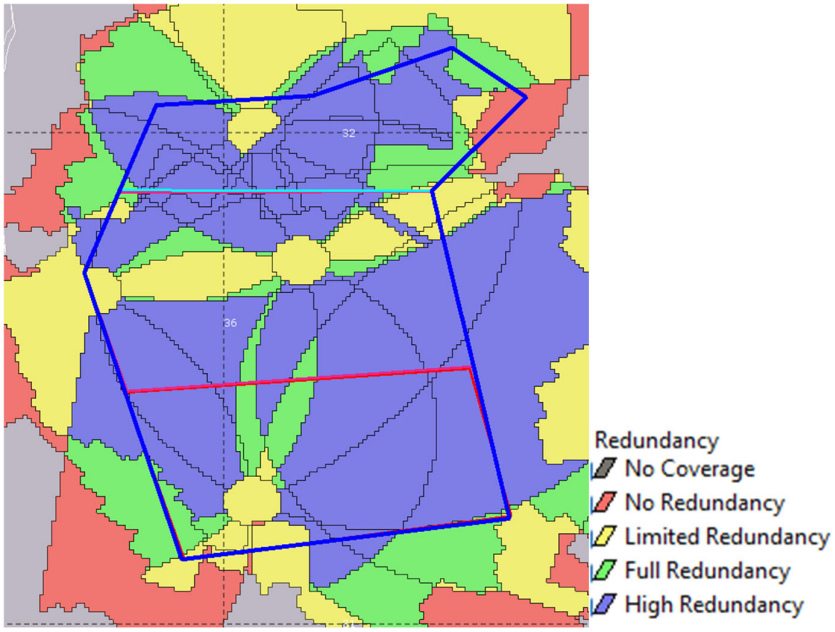
At 4000 ft



At 4500 ft



At 5000 ft



2.7 The purpose of the assessment was to determine whether DME-DME update could be maintained along typical SID, STAR, holding, and approach paths.

2.8 The assessment showed that coverage is generally satisfactory at intermediate and higher altitudes, where DME geometry and line-of-sight conditions allow consistent DME-DME updating suitable for RNAV 1 operations. However, at lower altitudes, some gaps were identified due to terrain and the geometric limitations inherent to ground-based navigation aids, which can be mitigated by introducing additional appropriately located DME site(s), as needed.

2.9 The study concludes that DME/DME-based RNAV 1 NAVSPEC is feasible within the assessed terminal airspaces, with some terrain-driven limitations that remain manageable through appropriate mitigations.

2.10 The evaluated configuration of existing and proposed DME stations provides sufficient geometric strength to support RNAV 1 operations, with some identified gaps falling within the permitted tolerance, with some exceptions in Aqaba TMA.

2.11 Overall, DME/DME RNAV offers a reliable multi-sensor backup to GNSS-based terminal operations, particularly in contingency or GNSS-degraded scenarios.

Limitations of the Study

2.12 The study confirms the feasibility of implementing DME/DME RNAV operations within Aqaba and Amman TMAs; however, the following limitations were identified:

a) Combination of only a limited number of DME stations (5 in number) out of 25 existing and proposed sites were considered for the study, in order to minimise the cost of installation and maintenance;

b) DME/DME coverage at lower altitudes is constrained by the terrain, (particularly below 3000 ft in Aqaba and 3500 ft in Amman), which limits line-of-sight to DME stations;

c) Existing and proposed DME sites within the Aqaba TMA did not provide sufficient DME/DME geometry to fully support RNAV 1 operations especially along initial and intermediate approach phases requiring some other optimum solutions; and

d) The scope of the study was restricted to the terminal airspace only, and did not include en-route segments or adjacent FIR interface areas.

Recommendations of the Study

2.13 RNAV 1 procedures, if developed, be published with clear PBN requirement boxes in accordance with Doc 8168, explicitly stating the navigation specification and sensor requirements (e.g. RNAV 1, GNSS and DME/DME/IRU required, as applicable);

2.14 States and air navigation service providers (ANSPs) coordinate with aircraft operators to ensure fleet equipage with RNAV 1 capability, including GNSS and DME/DME/IRU multi-sensor receivers, in order to fully benefit from the redundancy provided by DME/DME; and

2.15 Where existing and proposed national DME sites do not provide an optimum RNAV 1 solution, States consider the use of appropriately located cross-border DME facilities, subject to bilateral agreement, as this could provide an improved cost-effective solution and serve as a model of regional collaboration and excellence.

2.16 States in the MID Region are encouraged to consider similar feasibility studies, where appropriate, as part of their PBN implementation plans, particularly with a view to enhancing navigation resilience against GNSS vulnerabilities in the Region.

3. ACTION BY THE MEETING

3.1 The meeting is invited to:

a) review and discuss the information presented in this Working Paper;

b) encourage MID States to consider and promote the use of multi-sensor (GNSS, DME/DME and DME/DME/IRU) environments to increase the resilience and continuity of terminal navigation operations;

c) encourage cross-border utilization and sharing of ground-based navigation aids (NAVAIDs) infrastructure between adjacent States;

d) promote regional collaboration, particularly where cross-border DME infrastructure is required to support terminal operations; and

e) encourage mutual technical cooperation among MID States, particularly where specialized tools or resources are limited.

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