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Thirty Fourth Workshop/Meeting of the SAM Implementation Group
(SAM/IG/34) – Regional Project RLA/06/901
(Lima, Peru, 24 to 28 August 2026)

Agenda Item 3: Report of activities and deliverables of the GT -Interop and Subgroups

IMPLEMENTATION CHALLENGES OF MON PLAN

(Prepared by Brazil)

SUMMARY

This information paper presents the challenges faced by DECEA in the operationalization of the DME/DME/Inertial Project, part of Brazil's Minimum Operational Network (MON) Plan (PCA 100-5). Given the continuous growth in reliance on Global Navigation Satellite Systems (GNSS) for Performance-Based Navigation (PBN), which has significantly increased civil aviation's vulnerability to radio frequency interference (RFI) such as jamming and spoofing, Brazil developed this comprehensive strategy. The plan encompasses ground infrastructure, operational procedures, and training designed to ensure air navigation resilience and safety against GNSS interruptions. The project aims to provide robust and complementary infrastructure, especially for RNAV 1 operations in High Traffic Density Terminal Areas (TMA) and RNAV 5 operations in the main air traffic flows of the continental upper airways.

References:

- Resolution A42-8C from the 42nd ICAO Assembly;
- Doc 9750, Global Air Navigation Plan (GANP); and
- PCA 100-5, Implementation Plan of the Minimum Operational Network (MON) in Response to GNSS Failure, DECEA - Brazil.

1. Background

1.1 The global aviation community faces increasing challenges due to the growing susceptibility of GNSS signals to various forms of interference. Brazil's proposal, through WP/210 (Implementation of a Minimum Operational Network – MON) at the 42nd ICAO Assembly, contributed to discussions on the need for global guidelines and harmonized criteria to implement a Minimum Operational Network (MON). The document presented Brazil's MON plan and highlighted the absence of international standards for defining strategic aerodromes, airspace volumes, and minimum ground infrastructure requirements, warning about the risks of fragmented and inefficient responses.

1.2 As a result, Resolution A42-8/C incorporated actions reflecting the proposals in WP/210, including encouraging the definition of resilient networks and the harmonization of criteria through international cooperation and Planning and Implementation Regional Groups (PIRGs). These measures aim to ensure consistency in CNS/ATM resilience, promote feasibility studies for MON, and guarantee safe and seamless operations on a global scale.

1.3 Aligned with these global recommendations, Brazil details in this study the implementation of the MON Plan (PCA 100-5) by the Department of Airspace Control (DECEA), published on May 15, 2025. This plan establishes a comprehensive national framework to ensure the continuity and safety of air operations during GNSS interruptions.

1.4 One of the components of this plan is the DME/DME/Inertial Project, an initiative focused on developing a resilient PBN navigation solution based on ground infrastructure in high-demand TMAs and major upper airway flows. To operationalize DME/DME/Inertial RNAV 1 navigation to support SID/STAR procedures in the TMAs covered by the project, DECEA faced several challenges, which will be presented in this paper.

2. **Analysis**

The MON Plan

2.1 PCA 100-5 is a comprehensive plan establishing the framework, procedures, and responsibilities for implementing a Minimum Operational Network (MON). The MON aims to ensure the continuity and safety of air navigation operations in the event of a GNSS failure, using ground navigation infrastructure and conventional procedures such as DME/DME, DME/DME/IRU, VOR/DME, ILS, OMNI SID, and RADAR. The MON structure includes procedures for all phases of flight — departure, en-route, arrival, and approach — ensuring a robust contingency environment.

2.2 The Plan involves several operational and infrastructure factors, such as: National coverage with conventional aids; Integration with PBN and complementary infrastructure; Criteria for strategic aerodromes and airspace; Training and simulation; Continuous maintenance and review; and Revision of Contingency Plans.

2.3 It is important to highlight that the implementation of the plan considers the impacts on airspace capacity and efficiency, especially in portions where the geometry or coverage of the DME/DME network or conventional aids is limited. In the current scenario, DECEA is in the active phase of consolidating technical analyses submitted by the five Regional Centers, ensuring methodological standardization throughout the national territory.

2.4 Simultaneously, dedicated flight inspection flights are being conducted to validate the actual coverage of ground sensors in selected terminal areas, ensuring technical feasibility and safety in the homologation of RNAV 1 procedures strictly based on DME/DME/Inertial sensors.

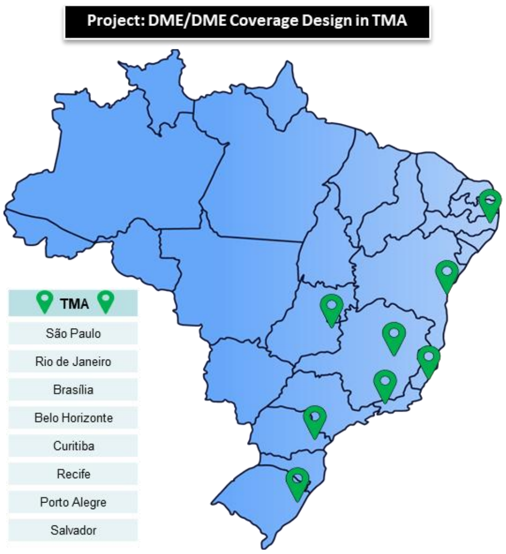
The DME/DME/Inertial Project

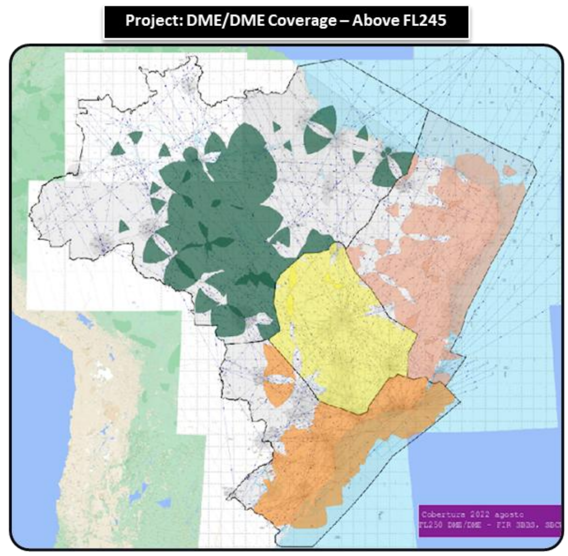
2.5 Based on the ICAO ASBU Block "NAVS-B0/4 – Minimum Operational Navigation Networks (Nav. MON)" and EUROCONTROL best practices, Brazil's DME/DME/Inertial Project aimed to strategically expand ground infrastructure to complement GNSS.

2.6 Due to logistical challenges and the continental dimensions of the Brazilian territory, the operational strategy was designed to leverage on-board inertial systems and fill gaps in DME/DME coverage. Consequently, DME/DME coverage was recently expanded with the installation of 52 independent DME stations.

2.7 The project's scope is to support RNAV 1 (DME/DME/IRU SID/STAR) procedures in high-traffic density terminal areas (TMA) and RNAV 5 (DME/DME/IRU) operations in the main air flows of the upper continental airspace.

2.8 In this strategy, the map on the left shows the terminal areas covered by the project, representing the busiest regions in the country: São Paulo, Rio de Janeiro, Brasília, Belo Horizonte, Curitiba, Recife, Porto Alegre, and Salvador. The map on the right illustrates the projected DME/DME coverage above FL245 after full implementation, elaborated with the EMACS (Electromagnetic Control and Survey) tool, designed to serve the main air traffic flows. The darker areas indicate coverage gaps.





The Challenges of the DME/DME/Inertial Project – Low Altitude Coverage and Procedure Validation Flights

2.9 According to ICAO Annex 10 (Volume I), the DME/DME system can support RNAV 1, RNAV 2, and RNAV 5 operations. However, ensuring DME/DME Only coverage at low altitudes (below 2,000 feet) for use in TMAs is physically challenging and costly.

2.10 To address DME/DME signal gaps in these regions, Annex 10 itself guides States to consider the use of aircraft inertial systems, recommending consultation with the EUROCONTROL Guidelines for RNAV 1 Infrastructure Assessment (EUROCONTROL-GUID-0114) document.

2.11 Following these international regulations and using the United Kingdom's case as an example (Annex B of EUROCONTROL-GUID-0114), DECEA structured its assessment based on the principle that the inertial system (IRS/IRU) can maintain the required precision (navigation error below 0.866 NM) for a period of up to 6.5 minutes after the last position update.

2.12 To validate the operational safety of this model, the Special Flight Inspection Group (GEIV) performs actual evaluations using the laboratory aircraft. During the inspection of departures (SID) and arrivals (STAR), the Inspector Pilot configures the system so that the primary flight solution is GNSS (FMS1), while FMS 2 is forced to receive the DME/DME and other solutions (except GNSS), structuring the most restrictive degradation scenario.

2.13 The crew monitors the exact moment the FMS enters Dead Reckoning (DR) navigation mode, recording coordinates, flight level at signal loss, PBN performance loss alarms, and any lateral deviations to ensure that the gaps respect the tolerable limits of the inertial system. Along the profile, any aural alarm emissions (such as FMS UNABLE RNP) are also recorded if the Estimated Position Uncertainty (EPU/ANP) exceeds the allowable tolerance for PBN performance.

2.14 Inspection flights were conducted throughout this year to assess the most critical segments of the DME/DME/Inertial RNAV 1 STAR procedures at SBBR (Brasília - DF), SBSP (Congonhas – SP), and SBGR (Guarulhos – SP) airports. The results were satisfactory, with some showing DME/DME coverage gaps, which can be complemented by using the inertial systems of properly equipped aircraft.

The Challenges of the DME/DME/Inertial Project – Use of DMEs associated with ILS (Without zero range offset)

2.15 According to ICAO Annex 10, if the DME associated with the ILS uses a zero range offset, this facility should be excluded from RNAV navigation solutions. In this document, it was also noted that some FMS exclude the use of DMEs associated with ILS, making it impossible to guarantee a consistent DME/DME service for all users equipped with this navigation solution.

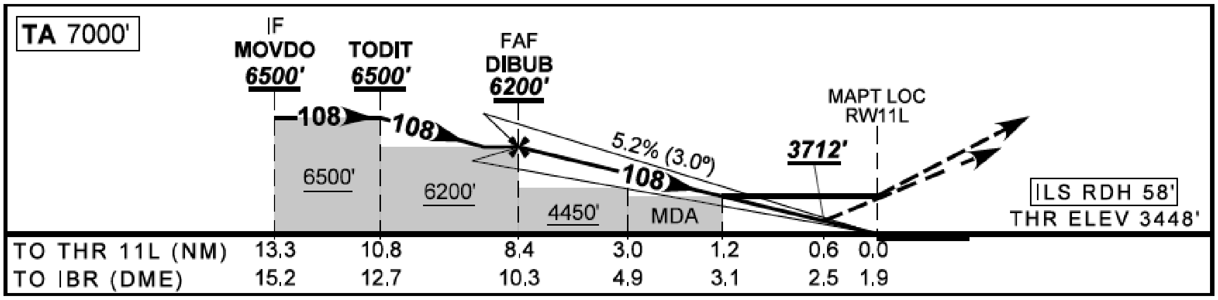
2.16 Additionally, according to ICAO Doc 9613 (PBN Manual), RNAV systems should not use facilities indicated by the State as unsuitable for RNAV 1 and RNAV 2 operations in the AIP or facilities associated with an ILS that use a range offset.

2.17 On the other hand, the EUROCONTROL Guidelines for RNAV 1 Infrastructure Assessment provides justifications for an exception to use DME facilities associated with ILS, despite discouraging their support for RNAV. Their use can be considered if the DME provides adequate omnidirectional coverage, has no range offset, and offers value from a geometric point of view.

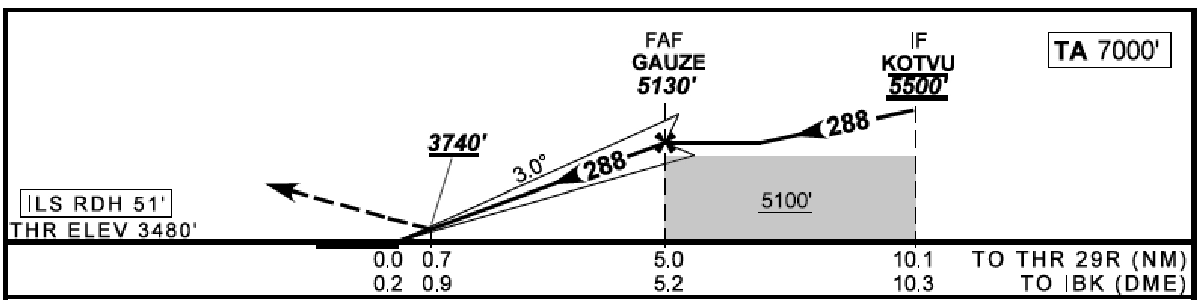
2.18 In the context of the IAC (Instrument Approach Charts) published by the ICA (Institute of Aeronautical Cartography), an organization subordinate to DECEA, two independent distance scales are published to ensure the visual situational awareness required by pilots and, simultaneously, preserve the real spatial geometry needed for FMS calculation.

2.19 Brasília International Airport (SBBR) is given as a practical example of the rejection of using artificial distance offsets (zero range offset) for the IBR and IBK DMEs, both associated with ILS, as described below.

2.20 On the approach chart for runway 11L, operated by ILS/DME IBR (frequency 110.30 MHz), when the aircraft reaches the exact vertical of the threshold (0.0 NM), the system independently reports the true bearing distance of 1.9 NM to the IBR DME antenna, which is geographically close to the LOC antennas.



2.21 In an identical and systemic manner, on the approach for runway 29R, operated by ILS/DME IBK (frequency 109.10 MHz), the 0.2 NM mark to the threshold reflects the exact physical distance to the equipment (DME antenna installed near the GS), attesting that DMEs associated with ILS in Brazil are not offset.



2.22 In this context, although the FMS of some aircraft receive non-offset DMEs associated with ILS, including the GEIV inspection aircraft, it is crucial to emphasize that, currently, these signals are not being considered for DME/DME coverage planning nor for the elaboration of DME/DME RNAV 1 SID/STAR air navigation procedures in Brazil. This decision not to use aids associated with ILS in the current modeling occurs because many FMS summarily exclude the equipment's signal preventively as soon as they identify the tuning on the VHF frequency of the LOC.

3. Suggested Actions

3.1 The Meeting is invited to:

a) Note the information provided regarding the implementation of Brazil's MON Plan and the challenges faced in provisioning the DME/DME/Inertial Project in Terminal Areas; and

b) Encourage States to participate in discussions on these experiences and promote regional collaboration aimed at harmonizing criteria and developing robust and interoperable contingency plans to strengthen CNS/ATM resilience throughout the region.

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