



Mozambique

Performance Based Navigation (PBN) Implementation Plan/Roadmap

ENDORSEMENTS

In 2007 at the 36th International Civil Aviation Organization (ICAO) General Assembly, States agreed to Resolution A36-23, which urges all States to implement routes and airport procedures in accordance with the ICAO PBN criteria. In support of the resolution, ICAO Regional PBN Implementation Task Forces were established to coordinate the regional implementation programs. In Mozambique, the National PBN Roadmap has been written to be in line with the ICAO AFI Region PBN Roadmap.

Given the dynamic nature of the ATM environment the PBN Roadmap will require revision from time to time to reflect the changing situation and to include the contributions of all stakeholders.

The stakeholders whose signatures appear below endorse the plan.

MTC Original Signed _____ IACM Original Signed _____

ADM Original Signed _____ LAM Original Signed _____

MEX Original Signed _____ FAM Original Signed _____

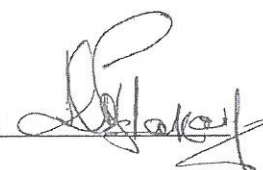
REVISION INDEX SHEET

Version	Revision	Date	Reason for Change	Pages Affected

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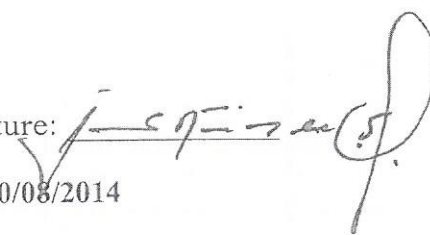
Issued by: National PBN
Programme Manager

Signature: 
Date: 20/08/2014

Authorized by: CEO IACM

Signature:

Date: 20/08/2014

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About the Plan

ICAO Assembly Resolution A37-11 calls for each State to develop a national PBN implementation plan. The "PBN Implementation Plan" is not stand-alone, but part of a broader plan for development of aviation in Mozambique. Mozambique has met its obligation with regard to conversion to the WGS-84 coordinate system; this is included in the plan, as all RNAV and RNP operations are conducted solely with reference to WGS-84 coordinates.

Need for PBN implementation plan.

With RVSM implemented, the main tool for optimizing the airspace structure is the implementation of performance based navigation (PBN), which will foster the necessary conditions for the utilization of RNAV and RNP capabilities by a significant portion of airspace users in the Regions and states.

Current planning by the AFI Regional Planning and Implementation Group is based on the Air Navigation Plans and the AFI Regional CNS/ATM Plans. The AFI Regional Planning and Implementation Group will develop Regional PBN implementation plan. The necessary concurrent and follow-on step is to develop national plans that implement the regional plans at the State level and address PBN implementation strategy at the national level.

In view of the need for detailed navigation planning, it is deemed advisable to call for preparation of a national PBN Implementation Plan, to provide proper guidance and direction to the domestic air navigation service provider(s), airspace operators and users, regulating agency, as well as foreign operators who operate or plan to operate in Mozambique. This guidance should address the planned evolution of navigation, as one of the key systems supporting air traffic management, and describe the, RNAV and RNP navigation applications that should be implemented in at least the medium term, in Mozambique.

Objectives of the PBN Implementation Plan/Roadmap

The PBN implementation plan should meet the following strategic objectives:

-) Provide a high-level strategy for the evolution of the navigation applications to be implemented in the State in the medium term (2013-2017). This strategy is based on the concepts of PBN, Area Navigation (RNAV) and Required Navigation Performance (RNP), which will be applied to aircraft operations involving instrument approaches, standard departure (SID) routes, standard arrival (STAR) routes, and ATS routes in oceanic and continental areas in accordance with the implementation goals in the assembly resolution A37-11;
-) Ensure that the implementation of the navigation portion of the CNS/ATM system is based on clearly established operational requirements;
-) Avoid unnecessarily imposing the mandate for multiple equipment on board or multiple systems on the ground;
-) Avoid the need for multiple airworthiness and operational approvals for intra- and inter-regional operations;
-) Prevent commercial interests from outdoing ATM operational requirements, generating unnecessary costs for the State as well as for airspace users.

Content of the PBN Implementation Plan/Roadmap

The PBN Implementation Plan should be developed by the State together with the stakeholders concerned and is intended to assist the main stakeholders of the aviation community plan a gradual transition to the RNAV and RNP concepts. The main stakeholders of the aviation community that benefit from this roadmap and should therefore be included in the development process are:

- Airspace operators and users
- Air navigation service providers
- Regulating agencies
- National and international organizations

The PBN Implementation Plan is intended to assist the main stakeholders of the aviation community plan the future transition and their investment strategies. For example, airlines and operators can use this implementation plan/ roadmap to plan future equipage and additional navigation capability investments; air navigation service providers can plan a gradual transition for the evolving ground infrastructure. Regulating agencies will be able to anticipate and plan for the criteria that will be needed in the future as well as the future regulatory workload and associated training requirements for their work force.

Principles applied in development of the PBN Implementation Plan/Roadmap.

The implementation of PBN is based on the following principles:

- a) Continued application of conventional air navigation procedures during the transition period, to guarantee availability by users that are not RNAV-and/or RNP-equipped;
- b) Development of airspace concepts, applying airspace modeling tools as well as real-time and accelerated simulations, which identify the navigation applications that are compatible with the aforementioned concept;
- c) Conduct of cost-benefit analyses to justify the implementation of the RNAV and/or RNP concepts in each particular airspace;
- d) Conduct of pre-and post-implementation safety assessments to ensure the application, and maintenance of the established target levels of safety.
- e) Must not conflict with the AFI Regional PBN implementation plan.

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1. INTRODUCTION

1.1. The Mozambique Performance Based Navigation (PBN) Roadmap details the framework within which the ICAO PBN concept will be implemented in Mozambique for the foreseeable future. The Mozambique PBN Roadmap is guided by ICAO Doc. 9613 and relevant SARPS. The primary driver for this plan is to maintain and increase safety, air traffic demand and capacity, and services and technology in consultation with relevant stakeholders. The Mozambique PBN Roadmap also supports national and international interoperability and global harmonization.

1.2. It is the intent of the National PBN Implementation Plan to give effect to Assembly Resolution A36 – 23 as amended by the 37th Session of Assembly is included.

2. BACKGROUND

2.1. The continuing growth of aviation places increasing demands on airspace capacity and emphasizes the need for the optimum utilization of the available airspace.

2.2. Growth in scheduled and general aviation aircraft is expected to increase point-to-point and direct routings. The increasing cost of fuel also presents a significant challenge to all segments of the aviation community. This anticipated growth and higher complexity of the air transportation system could result in increased flight delays, schedule disruptions, choke points, inefficient flight operations, and passenger inconvenience, particularly when unpredictable weather and other factors constrain airport capacity. Without improvements in system efficiency and workforce productivity, the aviation community and cost of operations will continue to increase. Upgrades to the air transportation system must leverage current and evolving capabilities in the near term, while building the foundation to address the future needs of the aviation community stakeholders. These circumstances can be partially alleviated by efficiencies in airspace and procedures through the implementation of PBN concepts.

2.3. In setting out requirements for navigation applications on specific routes or within a specific airspace, it is necessary to define requirements in a clear and concise manner. This is to ensure that both flight crew and ATC are aware of the on-board area navigation (RNAV) system capabilities and to ensure that the performance of the RNAV system is appropriate for the specific airspace requirements.

2.4. The early use of RNAV systems arose in a manner similar to conventional ground-based routes and procedures. A specific RNAV system was identified and its performance was evaluated through a combination of analysis and flight testing. For domestic operations the initial systems used VOR and DME for their position estimation. For oceanic operations, inertial navigation systems (INS) were employed.

2.5. These new systems were developed, evaluated and certified. Airspace and obstacle clearance criteria were developed on the basis of available equipment performance. Requirements specifications were based upon available capabilities and, in some implementations, it was necessary to identify the individual models of equipment that could be operated within the airspace concerned.

2.6. Such prescriptive requirements result in delays to the introduction of new RNAV system capabilities and higher costs for maintaining appropriate certification. To avoid such prescriptive specifications of requirements, the PBN concept introduces an alternative method for defining equipage requirements by specification of the performance requirements. This is termed PBN.

3. PERFORMANCE BASED NAVIGATION

3.1. PBN is a concept that encompasses both area navigation (RNAV) and required navigation performance (RNP) and revises the current RNP concept. PBN is increasingly seen as the most practical solution for regulating the expanding domain of navigation systems.

3.2. Under the traditional approach, each new technology is associated with a range of system-specific requirements for obstacle clearance, aircraft separation, operational aspects (e.g. arrival and approach procedures), aircrew operational training and training of air traffic controllers. However, this system-specific approach imposes an unnecessary effort and expense on States, airlines and air navigation services providers (ANSPs).

3.3. PBN eliminates the need for redundant investment in developing criteria and in operational modifications and training. Rather than build an operation around a particular system, under PBN the operation is defined according to the operational goals, and the available systems are then evaluated to determine whether they are supportive.

3.4. The advantage of this approach is that it provides clear, standardized operational approvals which enable harmonized and predictable flight paths which result in more efficient use of existing aircraft capabilities, as well as improved safety, greater airspace capacity, better fuel efficiency, and resolution of environmental issues.

3.5. The PBN concept specifies aircraft RNAV system performance requirements in terms of accuracy, integrity, availability, continuity and functionality needed for the proposed operations in the context of a particular Airspace Concept. The PBN concept represents a shift from sensor-based to performance-based navigation. Performance requirements are identified in navigation specifications, which also identify the choice of navigation sensors and equipment that may be used to meet the performance requirements. These navigation specifications are defined at a sufficient level of detail to facilitate global harmonization by providing specific implementation guidance for States and operators.

3.6. Under PBN, generic navigation requirements are defined based on the operational requirements. Operators are then able to evaluate options in respect of available

technologies and navigation services that could allow these requirements to be met. The chosen solution would be the most cost effective for the operator, rather than a solution being imposed as part of the operational requirements. Technologies can evolve over time without requiring the operation itself to be revisited, as long as the requisite performance is provided by the RNAV system. As part of the future work of the ICAO it is anticipated that other means for meeting the requirements of the Navigation Specifications will be evaluated and may be included in the applicable Navigation Specifications, as appropriate.

3.7. ICAO's PBN concept aims to ensure global standardization of RNAV and RNP specifications and to limit the proliferation of navigation specifications in use worldwide. It is a new concept based on the use of RNAV systems. Significantly, it is a move from a limited statement of required performance accuracy to more extensive statements for required performance in terms of accuracy, integrity, continuity and availability, together with descriptions of how this performance is to be achieved in terms of aircraft and flight crew requirements.

4. RNAV CURRENT STATUS IN MOZAMBIQUE

4.1. SIDs and STARs were developed for Maputo and Beira airports, 9 Main airports have RNAV approaches and the following RNAV routes have been established

UT 122: ORNAD- VMA- APLAR - SUNIR;

UT 125: ANVAK- VMA;

UT 444: DUTGI- IBKAR- SUNIR;

UT 536: VMA- IMPAM- EROPA;

UT 446: UNPEN-ANTAT- VL;

UT 512: ETLOP- ETKES- VBR;

UT 513: GADNO- GEPAT- VBR;

UT 515: ETLEG- IBMAS- VBR;

UT 516: IMKIB- NETEM- VL

UT 517: IMKIB-IMDIR-VL

UT 518: IXEMA- IBGUT- VL

UT 519: NERUL-UNKER-VL.

4.1.1. **RNAV, ATS routes, SIDs, STARs and approaches** will be developed as shown in the three stages of implementation in accordance with the AFI plan.

4.1.2. **Fleet equipage;** Percentage of aircraft equipage determined through filed flight plans for operations through the Beira Flight information Region (FIR) and nine(9)ATS/AFIS ~~main~~ airports.

	FQ-	MA	BR	NP	PB	VL	TT	IN	CH	LC	MP	QL
Non equipped in%		22	45	33	41	89	67	45	19	07	57	19
RNAVequipped in%		77	55	67	59	11	33	55	81	93	43	81

5. PBN BENEFITS

5.1.PBN offers a number of advantages over the sensor-specific method of developing airspace and obstacle clearance criteria. **These include:**

- a) Reduces the need to maintain sensor-specific routes and procedures, and their associated costs. For example, moving a single VOR ground facility can impact dozens of procedures, as that VOR can be used on routes, VOR approaches, as part of missed approaches, etc. Adding new sensor specific procedures will compound this cost, and the rapid growth in available navigation systems would soon make system-specific routes and procedures unaffordable.
- b) Avoids the need for development of sensor-specific operations with each

new evolution of navigation systems, which would be cost-prohibitive. The expansion of satellite navigation services is expected to contribute to the continued diversity of RNAV systems in different aircraft. The original Basic Global Navigation Satellite System (GNSS) equipment is evolving due to the augmentations of Satellite Based Augmentation System (SBAS), Ground Based Augmentation System (GBAS) and Ground-Based Regional Augmentation System (GRAS), while the introduction of Galileo and modernization of the Global Positioning System (GPS) and Global Orbiting Navigation Satellite System (GLONASS) will further improve performance. The use of GNSS/inertial integration is expanding.

- c) Allows more efficient use of airspace (route placement, fuel efficiency, reduction of CO2 emissions, redress noise abatement).
- d) Clarifies the way in which RNAV systems are used.
- e) Facilitates the operational approval process for operators by providing a limited set of navigation specifications intended for global use.

5.2. RNAV and RNP specifications facilitate more efficient design of airspace and procedures, which collectively result in improved safety, access, capacity, predictability, operational efficiency and environmental effects. Specifically, RNAV and RNP may:

- a) Increase safety by using three-dimensional (3D) approach operations with course guidance to the runway, which reduce the risk of controlled flight into terrain.
- b) Improve airport and airspace access in all weather conditions, and the ability to meet environmental and obstacle clearance constraints.

Enhance reliability and reduce delays by defining more precise terminal area procedures that feature parallel routes and environmentally optimized airspace corridors. Flight management systems (FMS) will then be poised to save operators time and money by managing climb, descent, and engine performance profiles more efficiently.

- d) Improve efficiency and flexibility by increasing use of operator-preferred trajectories airspace-wide, at all altitudes. This will be particularly useful in maintaining schedule integrity when convective weather arises.
- e) Reduce workload and improve productivity of air traffic controllers.

5.3. Performance-based navigation will enable the needed operational improvements by leveraging current and evolving aircraft capabilities in the near term that can be expanded to address the future needs of aviation stakeholders and service providers.

6. STAKEHOLDERS

6.1. Coordination is critical with the aviation community through collaborative forums. This will assist aviation stakeholders in understanding operational goals, determining requirements, and considering future investment strategies. This, in turn, enables the aviation stakeholders to focus on addressing future efficiency and capacity needs while maintaining or improving the safety of flight operations by leveraging advances in navigation capabilities on the flight deck. RNAV and RNP have reached a sufficient level of maturity and definition to be included in key plans and strategies, such as this PBN Roadmap for Mozambique.

6.2. The stakeholders who will benefit from the concepts in the Mozambique PBN Roadmap include airspace operators, air traffic service providers, regulators and standards organizations. As driven by business needs, airlines and operators can use the Mozambique PBN Roadmap to plan future equipage and capability investments. Similarly, air traffic service providers can determine requirements for future

automation systems, and more smoothly modernize ground infrastructure. Finally, regulators and standards organizations can anticipate and develop the key enabling criteria needed for implementation.

6.3. The Mozambique PBN Roadmap also supports other CAA and government-wide planning processes, working on several fronts to address the needs of the aviation community. This Roadmap is a work in progress and will be amended through collaborative efforts with industry and consultations that establish a joint aviation community/government/industry strategy for implementing performance-based navigation. Critical initiative strategies are required to accommodate the expected growth and complexity over the next two decades. These strategies have five key features:

- a) Expediting the development of performance-based navigation criteria and standards.
- b) Introducing airspace and procedure improvements in the near term.
- c) Providing benefits to operators who have invested in existing and upcoming capabilities.
- d) Establishing target dates for the introduction of navigation mandates for selected procedures and airspace, with an understanding that any mandate must be rationalized on the basis of benefits and costs.
- e) Defining new concepts and applications of performance-based navigation for the mid-term and long-term and building synergy and integration among other capabilities toward the realization of the Mozambique PBN goals.

7. CHALLENGES

7.1. Increasing Demands

7.1.1. **En route:** Introducing measures to increase airspace capacity and the number of

aircraft that can be handled by individual controllers without increasing workload.

- Implement RVSM,
- Double tracking of routes,
- Re-structuring the airspace,
- Improve/ gradually implement air traffic management,

Mixed routes of ground-based navigation aids such as VOR and RNAV routes will create complexity for ATC and increased controller workload at specific points.

- Separate flights on the VOR routes and RNAV routes within the RVSMairspace.

Introduce regulations for the flights not PBN equipped to fly at flight level 230 or below

- Introduce routes connecting departure and arrival procedures and medium distance routes by introducing RNAV and RNP routes that allow double tracking.

7.1.2. Terminal Areas (Departures and Arrivals): Flights entering a terminal area should converge onto courses that correspond to landing runways. Introducing RNAV and RNP with navigation performance and functional requirements can increase the airspace capacity in such routes as aircraft can more precisely fly along the published routes and especially inturns.

7.2.Efficient Operations

7.2.1. En route: In order to improve operating efficiency, both en route and terminal operations must be systematically taken into account when developing routes.

RNAV allows for the establishment of routes that are not anchored to the location of ground-based navigation aids, routes for departures and arrivals in terminal areas could be more easily shortened than in en route areas, since departure and arrival routes may involve many turns depending on the location of these navigation aids. Therefore, the development of RNAV within terminal areas should be a priority.

7.2.2. **Terminal Areas:** RNAV departure and arrival routes can be made shorter than routes that use VOR and other ground-based navigation aids. Operations on the published RNAV routes will reduce the amount *R/T* communication between the pilot and the controller and thus reduce their workload, resulting in an improvement in safety while also increasing the airspace capacity. To shorten the routes to the maximum possible extent, arrival routes should be connected directly to the approach phase. To minimize fuel consumption, the routes will be designed so that an optimized profile descent can be made using the aircraft's FMS. For airports without Airport Surveillance, RNAV could be very effective in shortening departure and arrival routes.

7.2.3. **Environment:** With the improvements in operational efficiency that result from shortening published routes, greenhouse gasses (CO₂, etc.) will also be reduced overall routes including en route, terminal, and approach procedures. Departures, arrivals, and approach procedures will be developed to reduce noise exposure by avoiding populated areas and other noise sensitive areas. The implementation of RNAV and RNP operating procedures that take advantage of the more Advanced features of FMS will prevent any increase in noise and is expected to shorten flight distances significantly and increase operational efficiency; CDRs (conditional ATS routes) will be published after discussions with the stakeholders, several such routes do exist and are being used by specific airlines.

7.2.4. **Approach:** The final segment should be conducted in order to improve the flight service rate (runway access) and safety.

8. IMPLEMENTATION STRATEGY

8.1. This Roadmap provides a high-level strategy for the evolution of navigation capabilities to be implemented in three time frames: near term (2008-2012), midterm (2013-2016), and long term (2017 and Beyond). The strategy rests upon two key navigation concepts; RNAV and RNP. It also encompasses instrument approaches, Standard Instrument Departure (SID) and Standard Terminal Arrival (STAR) operations, as well as en route continental, oceanic and remote operations. The section on Long-term initiatives discusses integrated navigation, communication, surveillance and automation strategies.

8.2. To avoid proliferation of new navigation standards, States and other aviation stakeholders in Mozambique should communicate any new operational requirements with ICAO HQ, so that it can be taken into account by the PBN SG.

9. MID TERM (2013-2016) AND LONG TERM (2017 AND BEYOND) KEY TASKS

9.1. The key tasks involved in the transition to performance-based navigation are:

- a) Establish navigation service needs through the Long term that will guide infrastructure decisions and specify needs for navigation system infrastructure, and ensure funding for managing and transitioning these systems.
- b) Define and adopt a national policy enabling additional benefits based on RNP and RNAV.
- c) Identify operational and integration issues between navigation and surveillance, air-ground communications, and automation tools that maximize the benefits of RNP.
- d) Support mixed operations throughout the term of this Roadmap, in particular considering navigation system variations during the near term until appropriate standards are developed and implemented.
- e) To support Civil/Military coordination and develop the policies needed to

accommodate the unique missions and capabilities of military aircraft operating in civil airspace.

- f) Harmonize the evolution of capabilities for interoperability across airspace operations.
- g) Increase emphasis on human factors, especially on training and procedures as operations increase reliance on appropriate use of flight deck systems.
- h) Facilitate and advance environmental analysis efforts required to support the development of RNAV and RNP procedures.
- i) Maintain consistent and harmonized global standards for RNAV and RNP operations.

10. Mid TERM (2013-2016)

10.1. Initiatives, in the mid-term, will focus on investments by operators in current and new aircraft acquisitions and in satellite-based navigation and conventional navigation infrastructure. Key components include wide-scale RNAV implementation and the introduction of RNP for en route, terminal, and approach procedures.

10.2. The mid-term strategy will also focus on expediting the implementation and proliferation of RNAV and RNP procedures. As demand for air travel continues at healthy levels, choke points will develop and delays at the major airports will continue to climb. RNAV and RNP procedures will help alleviate those problems. Continued introduction of RNAV and RNP procedures will not only provide benefits and savings to the operators but also encourage further equipage.

10.3. Operators will need to plan to obtain operational approvals for the planned Navigation Specifications for this period. Operators will also review Regional PBN Implementation Plans from other Regions to assess if there is a necessity for additional Operational approvals.