RWANDA AIRPORTS COMPANY

# Performance Based Navigation (PBN) Implementation Plan

# RWANDA

OCTOBER 2020



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| RWANDA AIRPORTS COMPANY LTD | |
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## RECORDS OF AMENDENTS

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## Glossary of /Acronyms/Abbreviations

The following table provides definitions and explanations for terms and acronyms relevant to the content presented within this document.

| Term | Definition |
|---|---|
| AFI Region | Africa Indian Ocean Region |
| ANSP | Air Navigation Service Provider |
| APIRG | AFI Planning and Implementation Regional Group |
| ASBU | Aviation System Block Upgrades |
| ATC | Air Traffic Control |
| CCO | Continuous Climb Operations |
| CDO | Continuous Descend |
| CDR | Coded Departure Route |
| CFIT | Controlled Flight into terrain |
| FMS | Flight Management System |
| GNSS | Global Navigation Satellite System |
| ICAO | International Civil Aviation Organization |
| ILS | Instrument Landing System |
| KIA | Kigali International Airport |
| NBIA | New Bugesera International Airport |
| PBN | Performance Based Navigation |
| RNAV | Area Navigation |
| RF | Radius to Fix |
| RNP | Required Navigation Performance |
| RNP AR | Required Navigation Performance-Authorization Required |
| SID | Standard Instrument Departure |
| STAR | Standard Terminal Arrival Route |
| VOR | Very High Frequency Omni-Directional Range |
| 3D | Three dimensional |



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# EXECUTIVE SUMMARY

This plan describes Rwanda's PBN implementation strategy for the next 5 years including strategic objectives, need or opportunities and challenges which have a direct impact on the existing flight procedures, Implementation strategy, airspace concept to be developed in line with the PBN concept and all the benefits expected from the redesign of the airspace.

Performance Based Navigation was first introduced in 2008 and became the highest air navigation priority of ICAO. Performance Based Navigation is a shift from sensor based navigation to performance based navigation.

Rwanda's air travelling passenger traffic is anticipated to grow by 26% from 2016 to 2023. Rwanda has developed a PBN implementation plan for Kigali FIR to meet this growing demand and also bring about other operational benefits.

As the skies get busier with more aeroplanes, PBN will serve to increase airspace safety, capacity and efficiency. Flight times will also be reduced with optimal flight paths design using PBN specifications resulting in fuel saving and enhanced environmental protection.

Rwanda has set its strategic objectives in accordance with the AFI PBN Plan, ICAO's Global Air Navigation Plan (GANP), the Aviation System Block Upgrades (ASBUs) and other related guidance material.



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# 1. OVERVIEW

## 1.1 Background

The implementation of Performance-Based Navigation (PBN) is presently the global aviation community's highest Air Navigation priority. It is key to the implementation of ICAO's Aviation System Block Upgrades and is an important enabler for Continuous Descent and Continuous Climb operations.

PBN implementation may involve many different stakeholders and processes including airspace and instrument procedure design, operations approvals, airworthiness, and avionics/ database development.

The continuing growth of air traffic in Rwanda will impact today's airspace capacity. Conventional navigation will not meet the increasing demand. As a result of this as well as improvements in technology, new navigation applications are now available to meet future demands.

## 1.2 Requirement for PBN

ICAO Assembly Resolution A36-23 calls for each State to develop a national Performance-Based Navigation (PBN) implementation plan by 2009. This PBN implementation plan is based on ICAO AFI PBN Implementation Plan template developed by the APIRG PBN Task Force. This plan is linked to other State aviation development plans including the conversion of existing coordinates to the WGS-84 coordinate system of which Rwanda has met its obligation as all RNAV and RNP operations are conducted solely with reference to WGS-84 coordinates.

The plan encompasses all future plans relating to PBN implementation in Kigali FIR as regards to; en-route operations (domestic and international), terminal and approach operations including SIDs and STARs.

## 1.3 Purpose

This PBN Implementation Plan is published to provide a roadmap for implementation of the PBN Concept in Kigali FIR. PBN procedures would be implemented in a steady and progressive manner through a 3-phase approach (short, medium and long term).

## 1.4 Strategic Objectives

With the application of the ICAO PBN Concept, Rwanda aims to achieve the following objectives:

a) Enhance Efficiency
   Enhanced reliability, repeatability, and predictability of operations to increase air traffic throughput and smoother traffic flow. RNAV departures result in better climb profiles to optimum en-route altitudes thus reducing fuel burn, and reduced track distances. RNAV arrivals result in continuously descending path with minimum level flight segments to enable smooth aircraft deceleration and configuration prior to landing.



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b) Enhance Capacity

Delays, congestion, and choke points at airports and in crowded airspace may be reduced because of new and parallel offset routes through terminal airspace, additional ingress/egress points around busy terminal areas, more closely spaced procedures for better use of airspace, and reduced or eliminated conflict in adjacent airport flows.

c) Enhance Safety

Lateral and vertical track-keeping is much more accurate and reliable due to new three dimensional guided arrivals, approach, and departure procedures that cannot be defined by conventional navigational aids. PBN also reduces the flight crew's exposure to operational errors.

d) Reduce Environmental Impact:

Utilize PBN to reduce environmental impact from aviation through more efficient operations that result in a less fuel burn and noise emissions. Flying down the middle of a defined flight path means less throttle activity and better avoidance of noise-sensitive areas, so people on the ground perceive less jet noise and are exposed to fewer engine emissions.

## 1.5 Intent

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.



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# 2. Performance Based Navigation (PBN)

## 2.1 PBN Concept

The PBN Concept is based on a shift from sensor-based navigation to performance based. The PBN concept specifies that aircraft area navigation system performance is defined in terms of accuracy, integrity, continuity and functionality. It explains and describes the performance-based RNAV and RNP navigation specifications that can be applied to oceanic, en-route and terminal airspace, to improve safety, efficiency and capacity, as well as reduce the environmental impact. These specifications also detail the navigation sensors and equipment necessary to meet the performance requirement.

The application of a PBN specification depends on many factors – the navigation infrastructure, communications capability, surveillance capability, the operational requirement, the aircraft fleet capability and operational approvals etc. In determining which PBN specification to apply, these factors must be taken into consideration in consultation with all stakeholders.

For Rwanda, the application of the PBN concept is important mainly to enhance airspace safety, capacity and efficiency.

## 2.2 PBN Current status in RWANDA

**High level IFR en-route navigation.**

There are three (3) RNAV 10 routes that have been established and these are;

a) UL432 from ALSAR to GAVDA via KNM.
b) UL442 from BOSAD to BKV via KNM.
c) UY198 from KNM to ETMIX

Two remaining ATS routes are still conventional.

**Low level IFR en-route navigation.**

We have L442 and L432 RNAV routes in the lower airspace.

**Terminal procedures**

Kigali International Airport: There are RNAV1 SIDs for RWY 10 and RNAV1 STARs for RWY 28

**Approach procedures**

There is RNP APCH (with Baro-VNAV) RWY 28 at Kigali International Airport.

## 2.3 Fleet equipage in 2018

Percentage of aircraft equipage determined through filed flight plans for operations through the Kigali flight information region (FIR) and three (3) ATS manned airports



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| | FIR | KIA | KME | GYI |
|---|---|---|---|---|
| **Non-equipped in %** | 9 | 14 | 7 | 99.5 |
| **RNAV equipped in %** | 91 | 86 | 93 | 0.5 |

# 3. Challenges

## 3.1 Increasing Demands

There is increasing demand for the introduction of PBN considering the complexity involved with civil and military operations, increase in international operations (scheduled and non-scheduled flights), increase in general aviation operations, development of new aerodromes, etc.

Also the following challenges are envisaged;

- Mixed fleet / system operations.
- Education and training CAA staff, service provider and aircraft operators.

# 4. Benefits of PBN and global harmonization

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

a) Reduces 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 need for development of sensor-specific operations with each new evolution of navigation systems, which would be cost-prohibitive.

c) Allows more efficient use of airspace (route placement, fuel efficiency, noise abatement).

d) Facilitates the operational approval process for operators by providing a limited set of navigation specifications intended for global use.

e) Clarifies the way in which RNAV systems are used

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:



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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 (CFIT).

b) Improve airport and airspace access in all weather conditions, and the ability to meet environmental and obstacle clearance constraints.

c) 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.

f) 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.

## 5. Stakeholders

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 plan. The stakeholders who will benefit from the concepts in this PBN plan include airspace operations, air traffic service providers, regulations, and standards organizations.

As driven by business needs, airlines and operators can use the 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.

This plan is a work in progress and will be amended through collaborative AFI Region States, industry efforts 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:



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- Expediting the development of performance-based navigation criteria and standards.
- Introducing airspace and procedure improvements in the near term.
- Providing benefits to operators who have invested in existing and upcoming capabilities.
- 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.
- 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 AFI Region PBN goals.

## 6. Efficient Operations

**6.1. 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.

**6.2. Terminal Areas (Departures and Arrivals)**
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 of 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.

At those runway ends where a straight-in precision approach with ILS is not possible, a study for RNP Authorization Required (AR) approaches, which allow the use of an RF turn (a constant radius turn passing through two waypoints) and the application of smaller RNP values in the final segment, should be conducted in order to improve the flight service rate (runway access) and safety.

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

**6.4. Environment**

With the improvements in operational efficiency that result from shortening published routes, greenhouse gases (CO2, etc.) will also be reduced over all routes including en route, terminal, and approach procedures. Departures, arrivals, and approach procedures will be



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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. PBN Implementation Status

### 7.1 General

This plan 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: **Area Navigation (RNAV) and Required Navigation Performance (RNP)**. It also encompasses instrument approaches, Standard Instrument Departure (SID) and Standard Terminal Arrival (STAR) operations, as well as en-route continental operations. The section on Long-term initiatives discusses integrated navigation, communication, surveillance and automation strategies.

To avoid proliferation of new navigation standards, Rwanda will communicate any new operational requirements to ICAO ESAF.

### 7.2. Near term period

In line with the AFI PBN Plan, the time frame for near term implementation was 2008-2012.

In the near-term, Rwanda's initiatives were to develop a National PBN Plan.

### 7.3. Medium term period

In line with the AFI PBN Plan, the time frame for medium term implementation was 2013 – 2016. Rwanda's concept for the PBN implementation in the medium was developed also.

**Below is the summary of what was achieved in regard to PBN implementation in Rwanda from 2008 to 2020.**

| | **2008-2020** | |
|---|---|---|
| | **Planned** | **Achieved** |
| **En route** | RNAV10 | 62.5% |
| **Terminal Area Instrument Runways** | • RNAV1 SIDs/STARs Kigali International Airport | 100% |



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| | | |
|---|---|---|
| **International Airports** | | |
| **Terminal Area For Domestic Airports** | • RNP1 SIDs/STARs Gisenyi Airport<br>• RNP1 SIDs/STARs Kamembe Airport | Design completed at 80%.<br>Design completed at 30% |
| **Approach International Airports** | • RNP APCH (APV with Baro VNAV) Kigali Int'l Airport | 100% |
| **Approach for domestic airports** | • RNP APCH Gisenyi Airport<br>• RNP APCH Kamembe Airport | Design completed at 80%<br>Design completed at 30% |

## BPBN implementation status: Flight Procedures



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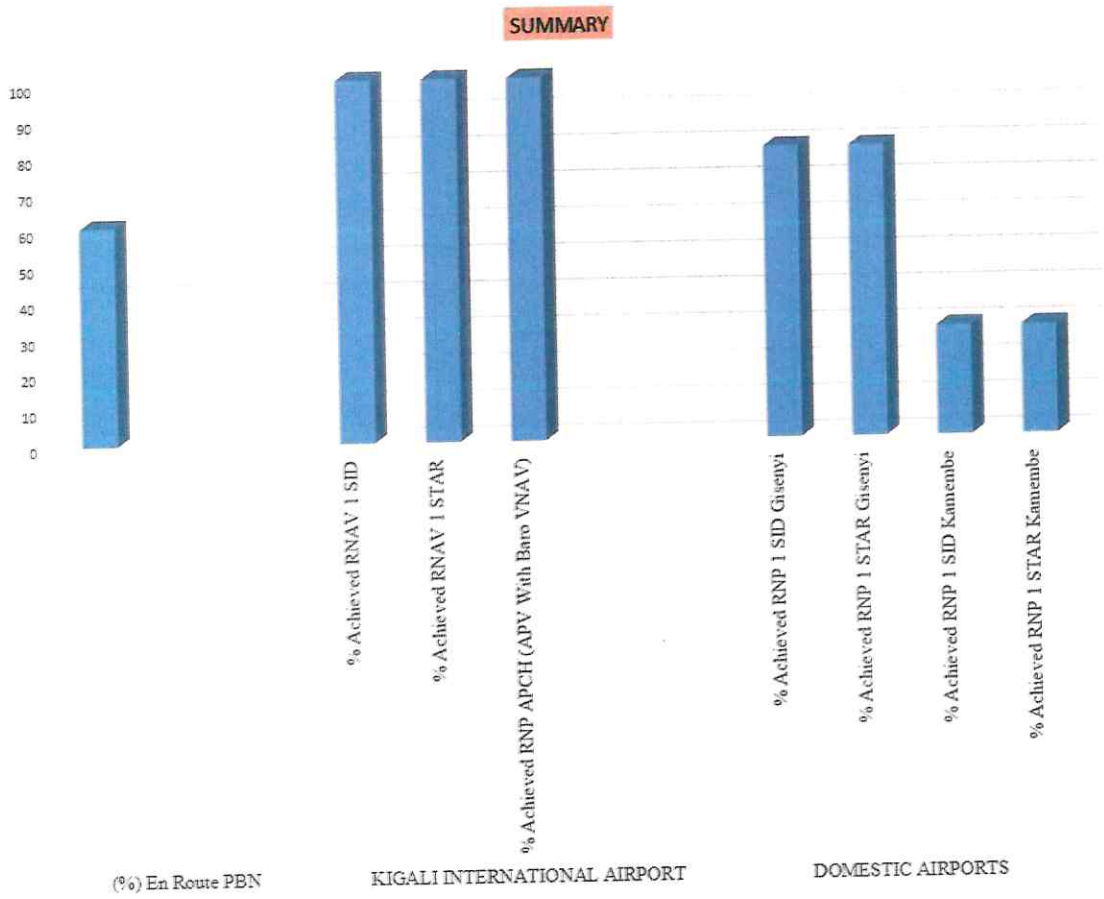


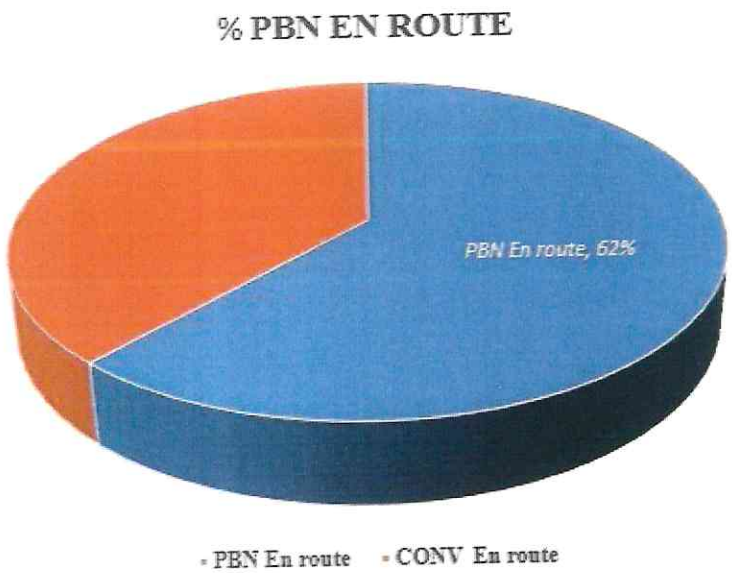


## 8. PBN PLAN 2020 - 2024



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## 8.1. Long term implementation strategy

The Long-term environment will be characterized by continued growth in air travel and increased air traffic complexity. No one solution or simple combination of solutions will address the inefficiencies, delays, and congestion anticipated to result from the growing demand for air transportation. Therefore, Rwanda and key Stakeholders need an operational concept that exploits the full capability of the aircraft in this time frame.

### 8.1.1 Long term (2017 and beyond) Implementation Targets.

GNSS is expected to be a primary navigation infrastructure for PBN implementation. Rwanda's concept for the PBN implementation in the far term for the respective areas is listed as follows:

**Planned PBN Implementation**

| | 2020 | 2021 | 2022 | 2024 |
|---|---|---|---|---|
| **Training** | -ATCOs training on PBN.<br>-On job Training of Flight Procedure Designers. | On job Training of Flight Procedure Designers (cont'd) | Training of Flight Procedure Designers (Theory) | On job Training of Flight Procedure Designers. |
| **PBN legal instruments** | PBN plans Development | Amendment of PBN plans | Airspace Master plan | Amendment of PBN plans |
| **PBN units establishment** | Procedure Design office establishment | PBN oversight office in place. | | |
| **En route** | | | RNAV5and /RNP4 where operational required | |
| **Terminal** | **Kigali Int'l Airport** -Implement CCO/CDOs - Segregate SIDs & STARs where feasible | RNP1 SID & STAR for **KAMEMBE Airport.** | RNP1 SID&STAR for **Gabiro Airport** | RNP1 SIDs & STARs For **BUGESERA Int'l Airport** |
| **Approach** | | RNP APCH for **Gabiro Airport** | RNP APCH for **Kamembe Airport.** | RNP APCH with Baro VNAV for **Bugesera Int'l Airport** |

NOTE: Helicopter PBN procedures will be developed and implemented as may be required.



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**Fig: PBN Plan 2020 - 2024**

| | TASKS | 2020 | 2021 | 2022 | 2023 | 2024 |
|---|---|---|---|---|---|---|
| Training | ATCOs Training on PBN | | | | | |
| | OJT Flight Procedure Designers | | | | | |
| PBN Legal in | Airspace Master Plan | | | | | |
| | Procedure Design Office established | | | | | |
| | PBN units establishment | | | | | |
| En route | RNAV 5/RNAV2/RNP4 | | | | | |
| Terminal | Kigali Int'l Aiport | | | | | |
| | Implementation CCO/CDO | | | | | |
| | segregate SID & STARs where feasible | | | | | |
| | RNP1 SIDS/STARS for NBIA | | | | | |
| Domestic Aerodormes | RNP1 SIDS/STARS for Gabiro Airport | | | | | |
| | RNP1 SID & STAR Kamembe | | | | | |
| Approach | RNP APCH FOR Gabiro Airport | | | | | |
| | RNP APCH FOR Kemembe Airport | | | | | |
| | RNP APCH FOR Bugesera Airport | | | | | |

## 9. PBN Plan Review

The PBN Implementation Plan shall be reviewed on an annual basis. Feedback from stakeholders and users will be considered throughout the implementation plan. Stakeholders includes not only pilots, but where relevant, others such as ATC, neighbouring ANSPs, and others that may be affected by the implementation plan. Feedback will be actively sought and gathered from the relevant regular meetings with stakeholders or through focus group discussions. Other sources to gather feedback includes results (reports) from a consultation (questionnaire), engagement surveys or through the corporate enquiry portal. Feedback from stakeholders will be recorded and documented for traceability.

Elements that generate positive feedback shall be considered for other procedures. Negative feedback shall be evaluated and any problems encountered or implementation issues identified shall be thoroughly assessed by the ANSP so that corrective action can be initiated where appropriate. Feedback and the follow-up action taken shall be documented accordingly.

## 10. Conclusion

PBN Implementation Plan is to meet the objectives of Resolution A37-11. The goal towards building a seamless sky can only be achieved by the active cooperation, collaboration and participation of all aviation stakeholders. Under the ICAO Aviation System Block Upgrades (ASBU) framework, PBN is in Block 0 which includes capabilities or modules that are available currently. This will form the foundations of other future Block Upgrades. For this very reason, Rwanda shall continue to build on existing capabilities and continue to cooperate and engage the other stakeholders to ensure a harmonised and coordinated PBN implementation in the ESAF region.



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