

Performance-Based Navigation for ANSPs: Concept 2030

Acknowledgements

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Foreword

Performance-based navigation (PBN) is, rightly, the highest air navigation priority of the International Civil Aviation Organization and is a key element of the ICAO Aviation System Block Upgrades (ASBU). PBN has been instrumental in improving the efficiency of airspace across the globe for many years. Nevertheless, implementation has fallen behind ICAO targets.

PBN is an important priority for CANSO Members and this is reflected in the specific activities and deliverables on PBN in the Work Plan of Vision 2020, CANSO's strategic framework for the air traffic management industry. These include training, seminars and guidance in publications such as Performance-Based Navigation Best Practice Guide for ANSPs. That document provides practical guidance on performance-based navigation (PBN) as it applies primarily to the terminal and approach environments.

CANSO's efforts on PBN are complemented by a wide range of PBN material and training that is available publicly, particularly from the International Civil Aviation Organization (ICAO), and Airports Council International (ACI). While

these deal with the implementation of PBN today, CANSO ANSPs have highlighted the need for greater support to plan for the future, looking ahead across the 15 year replacement life cycle. ANSPs also want to address ANSP-specific PBN implementation issues, such as knowledge and resourcing.

CANSO has therefore produced this document, Performance-Based Navigation for ANSPs: Concept 2030, to support Member ANSPs as they prepare for, or continue with, PBN implementation. This document identifies current and future PBN-related technologies and services that are expected to impact ANSPs, and then identifies potential impediments to successfully implementing PBN, highlighting capabilities and resources which ANSPs might consider.

By determining the future state of PBN, this document will assist CANSO Members with their strategic planning, helping them prepare for the PBN environment of 2030. It will help them make the right decisions; earmark the appropriate resources; identify requirements for collaboration; target areas to exert influence; and allocate funding now to prepare for the future.



Source: Boeing

Executive Summary

This report provides a vision of performance-based navigation (PBN), from an air navigation service provider's (ANSP) perspective, to the year 2030. The CANSO ANSP's outlook for PBN is important because PBN is an integral component of the 'perfect flight' concept and is closely linked to associated communication, navigation, surveillance and air traffic management (CNS/ATM) elements. In determining the likely direction, rate of progress and future state of PBN, we aim to assist CANSO Members with their own strategic planning, helping to identify potential impediments to the successful implementation of PBN, and highlighting capabilities and resources that may benefit from ANSP investment.

PBN provides numerous safety and efficiency benefits, and is an enabler for other techniques and operations such as continuous climb/descent operations (CCO/CDO) and flow management. Optimised ATM routings combined with efficient air traffic flow management (ATFM) contribute to the whole system – from curb to curb – operating to plan, giving all stakeholders the opportunity to optimise their operations. For this reason, PBN is the International Civil Aviation Organization's (ICAO) highest air navigation priority and is a key element of ICAO's Aviation System Block Upgrades (ASBUs). However, the global rate of PBN implementation has slipped behind ICAO targets, even though these targets have been beneficial to implementation progress. Performance-Based Navigation for ANSPs: Concept 2030 will provide some confidence to ANSPs that their planning and investment strategies are sound, and may encourage investment in people, technologies and processes to further progress PBN implementation rates.

A range of resources has been drawn on to develop Performance-Based Navigation for ANSPs: Concept 2030. ICAO's Global Air Navigation Plan (GANP) and regional navigation strategies,

International Air Transport Association (IATA) and airline feedback, and Single European Sky ATM Research (SESAR) and NextGen papers all provide strong leads as to where PBN should be heading.

The document considers inter-related and individual CNS/ATM components, existing and future infrastructure, air traffic control (ATC) and fleet technologies and processes, and anticipated levels of ANSP service.

It should be noted that many technologies require considerable investment from ANSPs and operators, and that a 15-year replacement life cycle is common in the aviation industry. Hence, the time horizon for this vision document; while some legacy equipment will still be in use, a large percentage of technology will require replacement before 2030. It should also be noted that there are a wide range of ANSP needs and capabilities; some ANSPs have been on the PBN path for many years, and are well ahead of ASBU targets; others have not been in a position to complete a State PBN implementation plan or strategy, let alone to commence PBN implementation.

CANSO Members are invited to contribute their own perspectives and suggestions relating to the vision, to the CANSO PBN Workgroup. Given the long-term 'white paper' nature of this document, a full review should not be required for several years.

Introduction

CANSO provides value to its Members by demonstrating thought leadership about future operational concepts of the global air traffic management (ATM) system. ANSPs will better serve their customers by looking to future technological improvements that enhance operational efficiency and capacity while maintaining the highest level of safety.

The purpose of this document is to present the CANSO performance-based navigation (PBN) vision for the year 2030. The content will provide ANSPs with a projected 2030 state of PBN operations. This information will be helpful in considering coordinated investment opportunities and potential improvements in infrastructure to realise operational cost benefits. This document is not a detailed PBN implementation guide, but rather a vision of strategic possibilities that provide opportunities for systemic operational improvements.

The information provided is aligned with the ICAO Global Air Navigation Plan (GANP) and uses concepts contained in the ICAO Aviation System Block Upgrades (ASBU) relating to PBN as a general guide. CANSO has also used information provided by other industry partners, such as IATA, International Federation of Air Line Pilots' Associations (IFALPA), and ACI. CANSO will regularly review and evaluate the plans and progress of current regional programmes like SESAR, NextGen, and others to ensure alignment of high-level aspirations to exploit PBN capabilities. The vision that this document provides is primarily focused on PBN but it also includes other interrelated aspects in the consideration of the evolutionary benefits of our industry's global transition from tactical air

traffic control to performance-based air traffic management.

CANSO's Performance-Based Navigation for ANSPs: Concept 2030 will also help to drive alignment in current and future development of industry standards through organisations such as; ICAO, RTCA, and European Organisation for Civil Aviation Equipment (EUROCAE). Harmonisation of standards is essential to globally interoperable solutions that need to be supported by responsive regulatory environments meeting industry needs and objectives. Coordinated efforts in these areas will better prepare our industry and its partners for the future and ensure that operational benefits are realised in the most cost effective manner possible. This vision must be driven by operational needs through processes that will withstand a rigorous cost benefit analysis.

There are many challenges facing our industry as we move into the next decade and beyond. Constrained resources, increasing cost of improvements, varying stakeholder priorities, and most importantly, environmental issues, must be handled in ways that promote robust integrated solutions. An ANSP's success will depend on addressing and investing in a common understanding of the needs and expectations of all public and industry stakeholders. A shared vision and a dedication to intense collaboration will ensure that we make the right decisions at the appropriate times. We believe that this document will be beneficial in helping to shape our collective future and progress PBN as a major driving force in operational safety, efficiency, and capacity.

¹ Hyperlinks have been included to provide quick and easy access to relevant PBN information when viewed online. The information in this document focusses on the ANSP perspective and is intended to supplement, not replace, the excellent PBN guidance material that is already provided by CANSO partner organisations—ICAO, IATA, and ACI. Sources for the information used in this publication have been referenced where possible, but some of the guidance material provided originates from CANSO Member organisations and so may not be publicly available. Every effort has been made to acknowledge the original author and to confirm the validity of the content of this document.

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Operational Vision

The use of navigation performance as an enabler of improved airspace efficiency and capacity will be commonly applied across flight information region (FIR) boundaries. In all cases, navigation performance in lateral, vertical or time will complement the required communication, surveillance and air traffic infrastructure to support the desired airspace concept. Aircraft separation standards will evolve in a systemised manner, influenced by new design separation criteria.

At its core, the transition to performance-based navigation reduces dependence on conventional ground-based navigation aid systems and represents a move from traditional structured route navigation utilising ground-based navigation aids to more flexible point-to-point area navigation.

The target operational navigation environment and associated navigation specifications will include

- Oceanic/Remote Continental – RNP 2
- En route – RNP 2 or RNP 1 and/or A-RNP
- Terminal – RNP 1 or RNP AR DP² and/or A-RNP
- Approach – RNP APCH, RNP AR APCH, or A-RNP

The application of these ICAO Navigation Specifications will be applied against both individual route segments and/or within volumes of en route or terminal airspace.

Oceanic/Remote Continental

Navigation in oceanic and remote regions will take advantage of the high availability of en route integrity and accuracy from multiple satellite constellations. Navigation performance will enable less restrictive separation standards to be applied with the availability of enhanced surveillance

and communication technology to mitigate risks. User-preferred trajectories will be commonly used, in addition to structured flightpaths between specific waypoints or nav aids. The minimum defined performance requirements for the navigation specification will be required navigation performance (RNP) 2 and will enable the removal of RNP 4 and area navigation (RNAV) 10 subject to separation, dependent on communication and surveillance requirements, and the need to cater for legacy traffic. It is expected that airspace capacity in oceanic and remote regions will be transitioning to match that available in today's continental airspace. Space-based surveillance and communications will be in place and, where used, will improve trajectory modelling, conflict prediction and probing, and provide potential for surveillance based separation to be applied in oceanic or remote airspace.

En Route

Upper airspace structures will be unconstrained by ground infrastructure. Defined PBN ATS route structures will exist only where necessary, and it is assumed that user-preferred



Source: canaryluc/shutterstock.com

² RNP AR departure procedures expected to be added to ICAO PANS OPS.

trajectory will be the baseline capability where a structured route network is not required. Determinations for route structure should be data-driven and based on factors such as traffic demand, airspace utilisation and constraints, ATC task complexity, and potential operational efficiency gains that benefit aviation users.

Given the lateral precision associated with PBN, and where published route structures are needed to increase airspace capacity, RNP assurance should provide optimised separation standards between routes with less than today's procedural separation requirements. Furthermore, predictable flight paths encourage the development of ATM solutions and automation aids, and support the migration from tactical ATC to strategic ATM.

User-preferred trajectories will be utilised as the primary method of navigation. The transition to PBN provides airspace users with increased options for flight planning to take advantage of optimised routing. ATC will retain the ability to collaboratively develop and disseminate trajectory options to organise traffic - when required or at the request of airspace users in flight (e.g. Dynamic Airborne Reroute Procedure³).

Advanced-RNP⁴ (A-RNP), with an RNP 2 or RNP 1 navigational specification in upper airspace, will be in use for continental PBN route structures outside terminal control areas (TMA). Predictable turn performance inherent to A-RNP through the

optional fixed radius transition (FRT) capability will permit more closely spaced parallel route structures.

Terminal

All terminal operations will be based on PBN, and largely on satellite-based navigation. Standard arrival routings (STARs), standard instrument departures (SIDs), and transitions to and from the en route airspace will have defined vertical and lateral paths taking advantage of RNP performance to provide both precise trajectories as well as opportunities for increased airspace and airport capacity through reduced aircraft separation.

RNP 1 will be the basic design standard for STARs and SIDs, with the possibility of reverting to a contingency or fail-down mode that allows the continued operation of non-global navigation satellite system (GNSS) aircraft flying the same procedures but using RNAV 1. Scalable A-RNP capabilities may be required on some segments.

SIDs will utilise RNP performance and allow for more design options for departures with parallel RF (constant radius arc to a fix) turns, particularly applicable for multiple runway operations. Vertical path constraints on both arrival and departure will be utilised to provide separation assurance between multiple traffic streams.

The use of geometric path⁵ adherence rather than barometric vertical navigation (Baro-VNAV) between vertical crossing points may be required

³ Dynamic Airborne Reroute Procedure is a regional initiative, used by ASPIRE members.

⁴ A-RNP navigation specification provides for a single assessment of aircraft eligibility applied to one or more than one navigation accuracy requirement and across multiple applications and all phases of flight. Doc9613 4.1.2.1

⁵ Geometric path refers to a point-to-point vertical path with a defined flight path angle as determined by two three-dimensional waypoints with a common reference system, and their associated altitude constraints. Currently applied only to final approach, but may also be applied to climb and descent segments of flight and may enable closer separations.

in high-density terminal operations. Where high accuracy and integrity is needed in these path definitions there may be a requirement for GNSS augmentation (satellite-based augmentation system (SBAS), ground-based augmentation system (GBAS) or horizontal advanced receiver autonomous integrity monitoring (H-ARAIM)) . Effective use of airspace utilising precise lateral paths will require broad use of RF leg type construction. Time of arrival control (TOAC) and time-based separation will be available to support arrival sequencing (flow control management) with a resolution that matches current terminal spacing as achieved by ATC vectoring.

Improved airport and airspace access in all weather conditions and the ability to meet environmental and obstacle clearance constraints is expected. RNP 1 will ensure the necessary throughput and access, as well as reduced controller workload, while maintaining safety standards.

Approach

Approach operations will take into consideration the requirements for the safety and efficiency of both airborne and surface movements while balancing the demands for delivery of environmental and community outcomes (refer to Environmental section). The use of RNP as a means to manoeuvre to the final approach segment will be the common practice. A specific procedure and RNP value will be driven by the obstacle and traffic environments, but will be one nautical mile (NM) or less.

During times of high capacity, demand or complex operations at an airport there may be elevated terminal entry requirements either for the entire terminal or for specific runways. At these times, there would be an advertised requirement for capabilities. States would have facilitated this requirement through appropriate mandates. For



example, airport XXXX may specify RNP AR-only operations during peak periods of demand – with peak times and applicable procedures advertised on the ATIS and specified in the AIP (similar to today's poor-weather operations, where a NOTAM may be issued advising that only Category III capable aircraft can be accommodated for a period).

Three classes of approach capability will be available: Non Precision Approach (NPA), Approach with vertical Guidance (APV) and Precision Approach (PA).

Non-Precision Approach

Two-dimensional non-precision approaches (NPA), such as conventional VOR/DME or RNP APCH (2D), will remain available but are not preferred. They are expected to be retained for recovery purposes only in the event of the unavailability of the RNP based approach and based on a resilience business case. The use of circling approaches is highly discouraged and wherever possible final approach segments will be runway aligned.

Typical applications of NPA will be at locations without suitable GNSS augmentation

⁶ H-ARAIM may be available in 2025 with improved receiver performance; V-ARAIM will be available post-2030.

⁷ Comparative analysis presented to Institute of Navigation (ION) as far back as 2000 shows vertical accuracy/integrity of un-augmented GPS is almost as good as Baro-VNAV. By 2030 the case may be made, even when not MCDF.

to enable the use of APV, or to accommodate contingency navigation/aircraft equipment capability.

Approach with Vertical Guidance

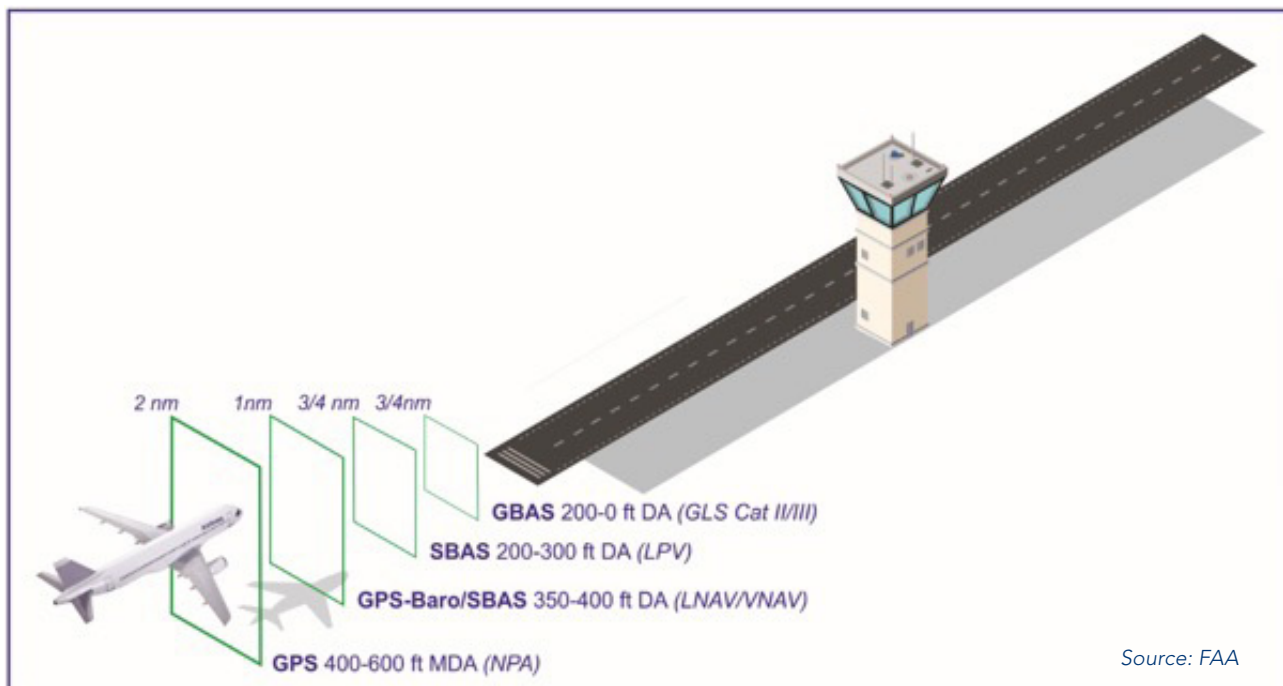
By 2030 full implementation of APV, consistent with ICAO Resolution A37-11, will be in place with APV the baseline approach capability wherever suitable GNSS augmentation (SBAS, GBAS or ABAS/Baro-VNAV) is available. SBAS localizer performance with vertical guidance (LPV) 200 (decision height) capability will be widely available⁸. The optional use of RF legs in combination with RNP APCH (APV) will enable more accurate positioning of flight paths and containment of turns. RNP AR APCH will be deployed where the specific outcomes desired at the location cannot be achieved using the less onerous RNP APCH (APV) specifications. Some examples of RNP AR APCH necessity would include use in obstacle rich environments, and application in multi-runway operations at the same or close proximity airports with specific opportunities

for increasing capacity during parallel runway operations. Increasingly RNP AR APCH will be used for environmental reasons.

APV enhances safety levels by providing three-dimensional (3D) approach operations with lateral and vertical guidance to the runway, reducing the risk of controlled flight into terrain (CFIT). The inclusion of vertical guidance is not necessarily intended to improve the landing minima, although it may in some cases. Safety is the fundamental driver, and mitigation of the CFIT threat is improved through the significant gains in pilot situational awareness and cockpit workload reduction resulting from a runway aligned, vertically guided, stabilised approach.

Precision Approach

Instrument landing system (ILS) remains the dominant precision approach capability although, following cost benefit analysis, many airports



⁸ More satellites will be available globally, and correction signals will be broadcast from positioning satellites within the core constellation, not just from geo-stationary SBAS-specific satellites.

will deploy GBAS/GLS (GBAS landing system) approaches and / or RNP AR with equal or better minima. Although ILS is not identified as a PBN component, the hybrid approach construction of using radius-to-fix (RF) or track-to-fix (TF) legs as transitions to an ILS final will be commonplace. Missed approach paths from ILS approaches using RNP application will be the norm.

Airliner and business jet fleets will be equipped with satellite precision approach receivers as part of the baseline avionics capability. GBAS applications will extend beyond the simple replication of straight-in CAT I ILS procedures to 'value added' GLS applications. Aerodrome authorities will identify unique satellite precision approach versus ILS benefits in operational applications. Pros and cons such as reduction of ILS critical and sensitive areas versus GLS signal interference risk will be among the issues considered.

Shifts in equipage levels by customers will result in new demands and will affect investment decisions about where, when or if new ILS

installations are deployed or ageing systems renewed.

SBAS today is able to provide equivalent to CAT I Precision Approach capabilities, and SBAS multi constellation dual frequency (MCDF) in the future will enhance system robustness, and may fill some of the SBAS space for positioning accuracy, integrity and continuity requirements.

Surface

With significant traffic using RNP AR, GLS or LPV for final approach guidance there will be reduced need to manage the surface to protect ILS LOC and GP areas. Spacing will improve between arrivals and departures, and decisions regarding dedicated arrival or departure runways may change.

RNP operations will cover the full gate-to-gate cycle. Existing PBN-related avionics capabilities will be used to provide uninterrupted safe and accurate movements on runways and airport manoeuvring areas. GNSS augmentation may be needed to support advanced surface movement capabilities.



Source: FAA

2

PBN Navigational Infrastructure

Navigational infrastructure includes items that are applicable to all phases of flight, as described in the Operational Vision section. Specific PBN infrastructure requirements are dealt with above. (Source: Federal Aviation Administration)

GNSS Core Satellite Constellations

There will be at least four core Global Navigation Satellite System constellations in use – GPS, GLONASS, Galileo and BeiDou⁹.

MCDF

To achieve maximum benefits from GNSS and provide a sustainable level of availability for worldwide GNSS, MCDF capabilities will be available for PBN services. To mitigate errors introduced by ionospheric delays and take maximum advantage of this improved resilience, ANSPs will work with regulators to ensure that state approvals are in place as MCDF systems become available.

Continued development of new contingency solutions and improved resilience of the GNSS signal in space mean that, in time, terrestrial navigation infrastructure may be eliminated. SBAS and GBAS will take advantage of the MCDF signals and continue providing services beyond 2030.

SBAS

Satellite-Based Augmentation System (SBAS)¹⁰ is viewed as regional infrastructure; implementation is a decision made by individual States with benefits extending beyond aviation. SBAS represents a valid safe and economic option for airports where up to ILS Cat I performance is required, enabling also airport accessibility and reduction of CFIT. One of the key advantages of SBAS (particularly in the approach domain) is geometric vertical guidance, which mitigates extreme temperature conditions.

By 2030, dual frequency (DF) SBASs should be achieving initial operational capability in North



WAAS Architecture – Global View

⁹ There will also be regional constellations, e.g. Japan’s QZSS, and India’s IRNSS.

¹⁰ For example, US WAAS, European EGNOS, Indian GAGAN, Japanese MSAS, and Russian SDCM.

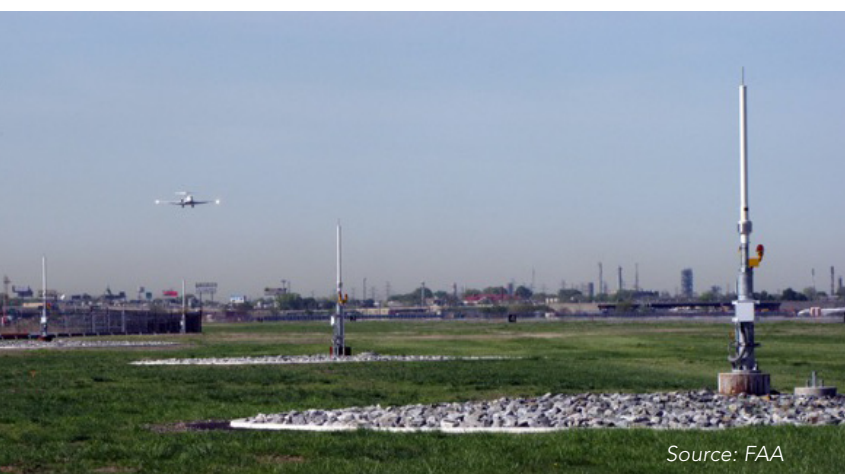
America and Europe. Aircraft should be in the process of transitioning to DF SBAS capability. DF SBAS will enable expansion of existing SBASs (i.e., wide area augmentation and European geostationary navigation overlay service) into South America and Africa, respectively, utilising the same geostationary satellites if agreements can be reached to design the new MCDP SBAS standards and install a limited number of reference stations. DF SBAS will improve accuracy/integrity performance enabling CAT I minima to be extended beyond single frequency coverage areas.

GBAS

Ground-Based Augmentation System (GBAS) and GLS approach criteria will be available for CAT I, II, and III operations. The availability of GBAS systems will be based on airport investment decisions. Widespread GBAS service will be available with extended service volume. We can expect DF and multi-constellation GBAS to be available in 2030.

ABAS

Aircraft-Based Augmentation System (ABAS), in the form of RAIM and Baro-VNAV¹¹, will continue to be used in areas where SBAS or GBAS is unavailable. H-ARAIM may also be available in this timeframe.



Source: FAA

GBAS Antennas - Newark Liberty International Airport (EWR)

Data Management

Data accuracy and integrity issues will have been improved. System Wide Information Management (SWIM) will be in place whereby systems globally will share data in near real-time using open data standards such as the aeronautical information exchange model (AIXM), flight information exchange model (FIXM), and weather information exchange model (WXXM) to reduce compatibility errors and give assurance of database integrity. Harmonisation of flight procedure coding by data-house aggregators and data-flight management system (FMS) suppliers will be progressing. Legacy FMS applications are able to operate with a wider variance in existing waypoint data standards; however, newer avionics require more up to date accuracy standards.

Frequency Interference and Protection

ANSPs have observed an increasing number of electromagnetic signals interfering with the aviation-protected spectrum. These include portions dedicated to aeronautical mobile and fixed services, as well as GNSS-dedicated bands. Interference is caused by the increasing demand from mobile phone and mobile network providers, for whom mobile internet connectivity is an increasingly important business. Intentional or inadvertent interference is also an issue, for example from personal privacy devices, such as GNSS jammers.

The International Telecommunications Union (ITU) protects aeronautical radio navigation services (ARNS) aviation bands, and it is assumed that neighbouring band interference will have been addressed by 2030.

Contingency Navigation Network

States set the level of network capacity and contingency capability required in the event of GNSS disruption, and will determine the complexity and appropriate level of contingency network that must be provided. States may require that some terrestrial infrastructure, route networks and terminal procedures are maintained or developed specifically

¹¹ LNAV/VNAV minima may be flown using SBAS receivers in some States.

for contingency operations¹². Some ANSPs will not have access to a robust ground-based infrastructure, and subject to individual States' business case for continuity of service, will use other means¹³ to address GNSS service disruptions.

Communication, Surveillance and ATMS

Communication - will be primarily via controller-pilot data link communication (CPDLC) in oceanic airspace, and there will be reduced reliance on voice communication in domestic environments. Enhanced-Mode S will reduce ATC workload in areas where voice remains in use. Oceanic navigation specifications will be tied to communication capabilities.

Surveillance - will be via an appropriate mix of automatic dependent surveillance broadcast (ADS-B), with Mode S secondary surveillance radar (SSR) and multilateration (MLat). States and ANSPs will have surveillance strategies that address State needs and appropriate levels of surveillance and resilience. Primary Surveillance Radar (PSR) will also provide support and intruder protection at major aerodromes. However, in the event of a loss of GNSS positioning capability by aircraft, ATC will lose ADS-B position reporting with the integrity required for ATC surveillance separation.

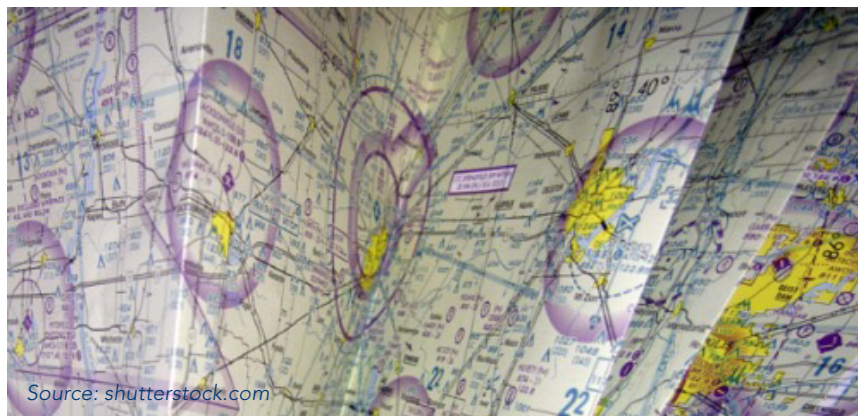
Air traffic management systems (ATMS) will provide auto-allocation of flight procedures based on flight-planned PBN capabilities. ICAO flight planning will be via FIXM standards. Flight plan suffixes will be harmonised and minimised¹⁴ to support ATC/pilot PBN needs. ATMS will provide trajectory management and conflict resolution capabilities.

Air Traffic Flow Management

Aircraft position and intent information directed to automated, ground-based ATMS will enable strategic and tactical flight deck-based separation assurance in selected situations, such as conflict



VHF omnidirectional radio range (VOR)



detection and resolution; in-trail procedures (ITP); trajectory-based operations (TBO); and CCO/CDO.

Regulations

Regulatory support and guidance relating to PBN will cover PBN mandates, operator approvals, noise and environmental requirements, community engagement, contingency, security and resilience and GNSS elements approval by States.

¹² Some states are considering DME as the backup to GNSS, as this navigation service is currently capable of supporting RNAV routes/procedures (and aircraft equipment failures), and may be capable of supporting RNP services in 2030.

¹³ Surveillance ATC vectoring, or Dead Reckoning extraction to alternate aerodrome with ground-based navaid.

¹⁴ Retire unused Navigation Specifications, e.g. RNP 4, RNAV 10, RNAV 5.

3

Safety

States are implementing PBN approach (RNP APCH) procedures with vertical guidance (APV) to all runway ends serving aircraft with a maximum certificated take-off mass of 5,700 kilograms (kg) or more, as far as practicable, in accordance with Assembly Resolution A37-11. RNP approaches support a reduction in the number of operational disruptions during periods of bad weather, or where ILS is unavailable. An operational disruption is an event affecting the movements of an airport and can include delay, diversion or cancellation of aircraft landings. This may occur at airports without ILS capability or where the ILS is out of service. The improvement in operational minima enabled



by a RNP approach can allow aircraft to land at an airport where they would otherwise encounter a disruption. Disruptions typically occur when a combination of low cloud ceiling or reduced runway visibility and current published minima result in a failure by the pilot to see the runway in advance of the missed approach point.

PBN continues to be an enabler for straight-in and 3-dimensional approaches at all aerodromes, providing significant safety benefits¹⁵.

Navigation specifications, flight procedures design criteria, new separation standards, new ATM procedures, contingency and emergency procedures (etc.) have led to developments in safety processes, such as safety initiatives across sovereign borders or across FIR boundaries.

Safety management system (SMS) processes between regulators, ANSPs and operators are more collaborative, and include sharing safety case analyses that enable timely approvals and reduce duplication.

Unique safety cases will not be required for many new operations; performance-based regulation will be the standard. The combination of aircraft certifications, ICAO navigation specifications, approved procedure design criteria, separation standards should allow "select from menu" for operations to enable use.

¹⁵ ICAO CFIT data: straight-in approaches are 25 times safer than circling approaches. Approaches with vertical guidance are 8 times safer than step-down final approach segment approaches.

4

Environmental and Community Considerations

Delivering environmentally responsible PBN flight procedures requires consideration of the impact of aircraft noise in specific noise-sensitive locations. Such locations may include residential, educational, health facilities, religious sites, historic locations, parks, recreational areas and wilderness sites among others. As part of an ANSP's (and airport authority's) accountability to the general public and all stakeholders, the importance of developing and maintaining a strong strategy for supporting and promoting community involvement in developing and deploying new routes is the key to successful PBN implementation.

ANSPs and airport operators will have State level guidance on the appropriate level of public consultation and engagement for PBN deployment differentiating between the level of engagement needed at lower, for example SID, altitudes, and other TMA and en-route deployments.

Aircraft noise impacts associated with creating or modifying PBN flight procedures is expected primarily to focus on concentrated flight paths resulting from the accuracy of PBN procedures. Addressing public concerns will involve countering misinformation, demonstrating how community input improved decision-making and a willingness to accept trade-offs between efficiency and environmental impact. It must be highlighted that civil aviation is an integral part of everyday life and commerce, and that it will continue to provide an essential foundation for the economic growth and vitality of the community.

In common practice, ANSPs will use guiding principles to ensure community involvement in instrument flight procedure projects. There will be early engagement with the community and clear and transparent communication between all parties.

Community involvement will be part of the standard change management processes established to ensure noise-sensitive areas are identified and appropriately accounted for in procedure design to the degree that this is practical. ANSPs should strive to establish a standard, repeatable process to ensure productive and effective community involvement when proposing PBN flight procedures. The outcome of such processes will inform and influence ANSP decision-making beyond that required by regulation.

5

RPAS and UAS

Integration of remotely piloted aircraft systems (RPAS) and unmanned aircraft systems (UAS)¹⁶ into controlled airspace will have reached a varying level of maturity for individual States, but the presence of these vehicles is certain.

It is expected that very low-level operations, those below 500 feet above ground level (AGL) and operations not in the vicinity of aerodromes, by smaller RPAS will be discounted from consideration within the ATM system. Instead they will potentially be managed by UAS traffic management (UTM) system, which interfaces with the 'conventional' ATM system as appropriate.

The nature of small to medium and military RPAS means that their navigation capability is unlikely to be capable of achieving technical standard order (TSO) certification by 2030 and will struggle to demonstrate the required performance to satisfy PBN approval criteria. Larger RPAS may have the ability to accommodate TSO certified equipment, but they still face the same size, weight and power (SWaP) trade-offs as smaller vehicles. One particular challenge is the use of barometric altimetry used for vertical separation by ATC today, which is an equipage issue for smaller vehicles. ANSPs and regulators will exclude non-compliant vehicles from certain airspaces or utilise tools that accept lower integrity data and accommodate them within controlled airspace.

¹⁶ Remotely-piloted aircraft systems (RPAS) are a set of configurable elements consisting of a remotely-piloted aircraft, its associated remote pilot station(s), the required command and control links and any other system elements as may be required, at any point during flight operation. Unmanned aircraft systems (UAS) are an aircraft and its associated elements, which are operated with no pilot on board.

6

Conclusions

As ANSPs look to the future, it is clear that PBN will make continued progress and impact on airspace efficiencies, capacity and safety. This vision document is intended to be a source of information to assist Members in their strategic planning, investment decisions and operational benefits that may be realised. This projected state of PBN operations in 2030 will help ANSPs who may be struggling with PBN planning, implementation and decisions to gain insight into the potential capabilities they may secure for their stakeholders.

As we continue to progress PBN with our ICAO, IATA, and ACI partners, updates to this vision may occur. We invite our Members to consider this document as a supplementary publication, not a replacement, for the excellent PBN material already provided by our partner organisations.



Source: Antonio Guillem/shutterstock.com

Acronyms

AC	Advisory circular
ACC	Area control centre or area control
ACI	Airports Council International
ADS-B	Automatic dependent surveillance - broadcast
AGL	Above ground level
AIC	Aeronautical information circular
AIM	Aeronautical information management
AIRAC	Aeronautical information regulation and control
ANSP	Air navigation service provider
APCH	Approach
APV	Approach procedures with vertical guidance
A-RNP	Advanced RNP (PBN navigation specification)
ATC	Air traffic control
ATCO	Air traffic control officer
ATFM	Air traffic flow management
ATM	Air traffic management
ATS	Air traffic services
BARO-VNAV	Barometric vertical navigation
CAA	Civil aviation authority (regulator)
CANSO	Civil Air Navigation Services Organisation
CCO	Continuous climb operations
CDO	Continuous descent operations
CFIT	Controlled flight into terrain
CNS/ATM	Communications, navigation and surveillance / air traffic management
CPDLC	Controller-pilot data link communication
DH	Decision height
DME	Distance measuring equipment
EUROCAE	European Organisation for Civil Aviation Equipment
FDR	Flight data recorder
FMC	Flight management computer
FMS	Flight management system
FRP	Fixed radius path
FRT	Fixed radius transition
FTE	Flight technical error
GBAS	Ground-based augmentation system
GLS	Ground-based augmentation landing system
GNSS	Global navigation satellite system (e.g. GPS, GLONASS)

GPS	Global positioning system
H-ARAIM	Horizontal advanced receiver autonomous integrity monitoring
IATA	International Air Transport Association
ICAO	International Civil Aviation Organization
IAP	Instrument approach procedure
IAS	Indicated airspeed
IFP	Instrument flight procedure
ILS	Instrument landing system
IMC	Instrument meteorological conditions
IRS	Inertial reference system
ITP	In trail procedures
KT	Knots
LNAV	Lateral navigation
LPV	Localizer performance with vertical guidance
MAPT	Missed approach point
MASPS	Minimum aviation system performance standards
MCDF	Multi constellation dual frequency
MDH	Minimum decision height
MLAT	Multilateration
MOPS	Minimum Operational Performance Standards
NAVAID	Navigation(al) aid
Nav-spec	Navigation specification
NextGen	Next generation Air Transportation System (United States)
NDB	Non-directional radio beacon
NM	Nautical mile
NSE	Navigation system error
PBN	Performance-based navigation
PDE	Path definition error
PSR	Primary Surveillance Radar
RF	Constant radius arc to a fix
RNAV	Area navigation
RNP	Required navigation performance
RNP AR	RNP authorisation required (approach)
RPAS	Remotely piloted aircraft systems
RTF	Radiotelephone
SBAS	Satellite-based augmentation system (GNSS augmentation)
SESAR	Single European Sky ATM Research

SID	Standard instrument departure
SME	Subject matter expert
SMS	Safety management system
SSR	Secondary surveillance radar
STAR	Standard instrument arrival
SWaP	Size, weight and power
TBO	Trajectory based operations
TF	Track-to-fix
TMA	Terminal control area
TOAC	Time of arrival control
TSO	Technical standard order (minimum performance standard)
UAS	Unmanned aircraft systems
UTM	UAS traffic management
VOR/DME	VHF omnidirectional range / distance measuring equipment
VNAV	Vertical navigation

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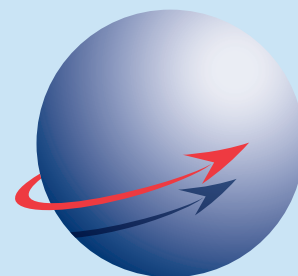
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