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Agenda Item 4: NAM/CAR Regional Safety/Air Navigation Implementation
4.2 Air Navigation Implementation Matters

PBN IMPLEMENTATION IN EU: APPROACH AND CHALLENGES

(Presented by EASA)

EXECUTIVE SUMMARY

This information note aims at sharing the European Union (EU) experience, answering the call of "Connectivity through the Development and Sustainability of Air Transport in the Pan-American Region - Vision 2020-2035" where ICAO member States and all relevant stakeholders were invited to give support in the achievement of this vision.

It is intended to inform the Civil Aviation Authorities of the North American, Central American and Caribbean Region on the EU perspective on the key points for the harmonized implementation of the global plans and objectives set in the Global Aviation Safety Plan (GASP), Global Air Navigation Plan (GANP), as one of the common principles and commitments of the Vision 2020-2035.

PBN implementation is the key factor for modern airspace operations and impacts positively the air navigation services development and airspace performance, representing one of the recommended measures for the CO2 emission reduction.

Within the framework of the EU-LAC APP II project, a project funded by the EU and implemented by EASA with the objective to strengthen the cooperation between Latin America and Europe in civil aviation, activities on Performance Based Navigation (PBN) concepts applicable in the design and validation of flight procedures as well as safety oversight in-flight procedure design organisations (IFPD) are under deployment. EASA considers of strategic importance the sharing of practices, approaches, and challenges to enhance connectivity and join efforts for the environmental sustainability.

Strategic Objectives:	• Strategic Objective 1 – Safety • Strategic Objective 2 – Air Navigation Capacity and Efficiency
References:	• ICAO Annex 10 Volume I • ICAO PBN Manual – Doc. 9613 • GANP ASBU element NAVS

1. Introduction

1.1 The Performance-Based Navigation application is not only an accuracy requirement for aircraft operations but is the key element to achieve future ATM objectives as the implementation of PBN is completely focused on optimising safety, efficiency, and capacity of flight operations.

1.2 The PBN concept represents the move from sensor-based navigation, where navigation requirements are linked directly to the sensor performance, to performance-based navigation where the system performance can be defined in terms of accuracy, integrity, availability, continuity and functionality. Through PBN concept, some of the disadvantages of sensor-based navigation, such as

a. minimum flexibility in routes structure due to the location dependence of land-based navigation aids
b. development of sensor specific operations for each system
c. low airspace efficiency due the lack of trajectory flexibility
d. multiple operational approval processes for operators

are clearly overcome by the advance towards performance-based navigation (PBN) airspace environments mainly based on satellite navigation services, technology, and equipment.

1.3 The requirements to be met by the aircraft (performance and functionality needed) and by the crew are identified in the navigation specifications, associated with the different phases of flight, and classified as RNAV or RNP based on the monitoring and alerting capabilities of the aircraft system.

1.4 The advantages are wide and relevant; the flexibility of the procedure design brings efficiency to the operations and airspace usage, and ground-based infrastructure can be reduced to a Minimum Operation Network (MON) to back up the system, impacting positively the Navigation associated costs.

1.5 However, the transition to a full PBN airspace operation requires a set of technologies, regulations, and coordination from the States that currently are performing at different paces across the Regions.

1.6 In 2018, the European Commission published the Implementing Regulation (EU) 2018/1048 of 18 July laying down airspace usage requirements and operational procedures in relation to PBN (PBN Regulation).

1.7 The Implementing Regulation (EU) 2018/1048 includes the criteria relating to the implementation of the PBN concept in Europe, consistent with the navigation specification and functionalities defined by the ICAO PBN Manual, as well as the actions to be carried out according to a series of established milestones and objectives.

1.8 In this sense, the Regulation frames the transition to the exclusive PBN environment by 2030, relegating the old Conventional Procedures as support, for which it requires each State to draw up its own transition plan approved by the Competent Authority. These Transition Plans are expected to be updated throughout the lifecycle of the Implementing Regulation.

2. Discussion

PBN Implementation Framework

2.1 A common Regional PBN implementation framework must be aligned with the objectives formulated by ICAO in the 'Global Air Navigation Plan' (GANP); and be defined in a strategic reference framework for the implementation of Performance Based Navigation (PBN).

2.2 A key factor to achieve an optimum transition objectives and plan is to set a working group formed by experts to set a common implementation framework. This framework will allow the basis generation of a regional level airspace concept, harmonizing the ICAO navigation specifications and functionalities to support the navigation applications for the different phases of flights, to avoid region fragmentation due State different objectives and implementation deployments. This approach has been proven as highly beneficial for the European Region and has habilitated an industry support to new technology developments and implementations for the air navigation systems.

2.3 Periodic revisions and synchronising of the State plans will allow them to optimise implementation and meet commonly their strategic goals.

2.4 The common framework should be developed by the regional designated authorities in the first instance, undergoing a review and proposed processes internally. Framework implementation may be achieved locally by establishing States' transition plans, where each State is committed to the implemented PBN and consistent with the deadlines set in the common framework. The implementation of the PBN should be led by organisations in charge of the implementation of flight procedures, typically the ANSPs or aerodromes and aerodrome operators, subsequently consulted to all the stakeholders involved in the process: (not limited to) State safety agency, other ATM/ANS providers, operators and the military authorities.

2.5 A PBN Transition Plan, in addition to fulfilling the defined objectives, can serve to lay the foundations for two other vectors of change derived from the implementation of the PBN concept, namely the rationalisation of navaids and the fulfilment of environmental objectives. All this, while trying to ensure that the transition is carried out most efficiently and cost-effectively; however, specific capabilities from aircraft systems are required to enable beneficial PBN implementations being an important factor to be taken into account.

2.6 The PBN transition plan should embrace the definition of the Minimum Operating Network (MON) of legacy Navaids to sustain the system in case of PBN disruption or degraded operations and address the PBN contingency modes.

FPD Certification and Oversight

2.7 Flight Procedure Design (FPD) activities are becoming an additional service provider and are responsible for the design, documentation, validation, maintenance, and periodic review of flight procedures. Since early 2021 under EASA rules, FPD service providers are regulated under certification requirements to ensure an adequate level of service in this area and incentivise the PBN deployment by these units.

2.8 A long and deep experience in flight procedure design requires to focus on continuous training for certified and skilled FP Designers capable of designing, validating, and assessing airspace structures, route networks, and instrument flight procedures with the most reliable and accurate results. The services of an FPD organisation can range from feasibility assessments to the process of designing and specific implementing FP details and include ground and flight validation activities for example.

2.9 The key to efficient design is practically based on planning activities. In this phase, the operational requirements are established, the team is set up with all stakeholders involved, and the project objectives, scope, timelines, and resources are defined. The determination of these aspects is crucial to the success of the project.

2.10 The provision of FPD services by regulated and certified organisations that guarantee the quality and security of the design process is paramount for achieving efficient designs. The training of these FPD organisations in data digitisation, ARINC coding and the use of AIXM data, allows work to be carried out according to airspace design standards that are being implemented in other regions such as Europe.

2.11 Focus on the scarcity of FPD resources should be made when setting the framework to implement PBN at a regional level, as they could suppose a limiting factor with a potential impact delaying the implementations, due the lack of expertise to undertake massive implementations, as FPD services were originally integrated exclusively within ANSP or Civil Aviation units. Private companies, mainly based on Europe and North America, do offer FPD services. Consistent planning on FPD resources is key for a successful PBN transition.

Navigation Specification

2.12 The navigation specification prescribes the performance requirements in terms of accuracy, availability, continuity, and integrity, for proposed operations in a particular airspace. The navigation specification also describes how these performance requirements are to be achieved. Associated with the navigation specification are requirements related to pilot knowledge and training and operational approval. A navigation specification is either an RNAV specification or an RNP specification.

2.13 The main difference between RNAV and RNP are the on-board performance monitoring and alert additional requirements for RNP over RNAV requirements. On board performance monitoring in RNP requires an alert when the system cannot guarantee with sufficient integrity that position meets required accuracy, as example making it more suitable for non-surveillance environments where no ATC corrections can be applied to an aircraft.

2.14 RNAV specifications are currently common in the European and North American Regions as dense continental areas, TMA and high transited airports were and are in the present served with surveillance. However, remote areas as in Alaska benefit from RNP specifications due the low density in terms of traffic and services provided, as in the en-route oceanic structures.

2.15 Nonetheless, benefits for high or medium density volumes are expected from RNP applications, as more trajectories can be condensed due the reduction on trajectory deviations and the key factor for adoption, the increase of equipped aircraft fleets enables positive implementations.

2.16 In terms of approach technologies, the need to be able to move forward with PBN implementations will depend in part on the availability of SBAS coverage or GBAS implementations, otherwise, the only precision procedures available would be ILS. PBN 3D approach systems are key to improve safety and accessibility to airports and optimise airspace operations. For instance, PBN 3D approaches can offer in some situations, guidance to non-precision approach runways or offer straight-in approach procedures at locations where only circling minima exist. However, investment needs and implementation feasibility need to be deeply analysed.

2.17 Due the growing general interest in the advanced RNP specification in the last years, for reference, in Europe the certification basis had been set already in 2019; however, the current operational implementation from the airlines is far from any significance. The operators' interest is not yet envisaged on this type of certification and further developments in the definition of the A-RNP seem to be needed for a more general adoption.

PBN-enabled techniques for optimised operations

2.18 Within the current airspace design environment, there are ATM "practices" or "models" that can be observed in the design of busy terminal airspaces. These models are PBN-enabled and more flexible in the sense that, to avoid aircraft waiting, more dynamic terminal arrival routes are designed for efficient operations.

2.19 In 2006, as an outcome of its R&D activities, the Eurocontrol Experimental Centre developed Point Merge, an innovative sequencing technique to simplify and enhance arrival operations. This technique allows controllers to sequence and merge arrivals without vectoring, while enabling continuous descent operations and maintaining runway throughput, even under high traffic.

2.20 Point Merge has been conceived from a 'blank sheet', relying on modern navigation capabilities but also rethinking the nature of arrival sequencing. Besides, Point Merge is one of the ICAO aviation system block upgrades (ASBU) and is referenced as a technique to support continuous descent operations (CDO - ICAO Doc. 9931).

2.21 After the first Point Merge implementations in Oslo and Dublin, in 2011 and 2012, respectively, the new method spread not only within the ECAC area but also far beyond its borders. As of May 2021, the procedure has been deployed in terminal areas around 30 airports across four continents.

2.22 Point Merge is designed to work in high-traffic loads without radar vectoring, reducing holding patterns by setting the traffic to be ready for instructions to the merge point. It is based on a specific route structure, consisting of a point (the merge point) and pre-defined legs (the sequencing legs) equidistant from this point. The sequencing is achieved with a "direct-to" instruction to the merge point at the appropriate time. The legs are only used to delay aircraft when necessary ("path stretching"); the length of the legs reflects the required delay absorption capacity. This allows the ATCO to fine tune the sequence from far distance from touch down, avoiding unexpected gaps and over-coordination.

2.23 Another innovative airspace design practice is the 'trombone'. These new 'trombone' approach procedures (similar to the oval shape of this musical instrument) consist of a structure of points that allows for optimising the aircraft's trajectory before they land. In other words, a trombone-shaped RNAV (area navigation) procedure consisting of a set of parallel legs composed of multiple equidistant waypoints, where ATCOs can give a shortcut (depending on traffic) to the next leg.

2.24 Both concepts are based on the same basis, being used according to the airspace configuration, restrictions as obstacles near the airports, military or restricted airspace and the airspace volumes availability.

2.25 Currently, trombone procedures are used in several European airports, such as Munich and Frankfurt airports in Germany, Warsaw Chopin airport in Poland, Barcelona-El Prat airport in Spain, Roma Fiumicino in Italy, to mention some within the European Region. Also, Dubai, Doha, Kuala Lumpur, and Qatar airports in the Middle East operate with this type of airspace configurations. Mixed or combined Merge Points with Trombones can be deployed as in Jeddah in KSA.

2.26 Furthermore, at airports with parallel or near-parallel instrument runways, being able to perform independent parallel approaches and/or independent parallel departures maximizes aerodrome capacity if not constrained by ground factors (e.g. Taxiing RWY crossings, high RWY occupancy times). Nevertheless, the safety of parallel runway operations is affected by several factors such as

a) the precision with which aircraft can navigate to the runway,
b) the accuracy of the air traffic service (ATS) surveillance monitoring system,

c) the ability of controllers to intervene when an aircraft deviates from the final approach course or track, and
d) the controller and pilot training and performance capabilities

2.27 A recent example of independent approaches to parallel runways has been implemented at Adolfo Suárez Madrid-Barajas airport in Spain, under the ÁMBAR project (phase II). Approaches have been designed under SOIR (ICAO Doc. 9643) which among the complete requirements, it also considers the SBAS PBN approaches type suitable for this kind of implementation, allowing PBN equivalent scenario benefits.

2.28 The implementation of these techniques as well as independent parallel operations is a complex element that has to be properly addressed through effective training for ATC to achieve the capacity increase objective for which they are designed.

3. **Conclusion**

3.1 PBN implementation is the key factor for modern airspace operations and management and accelerate implementation impacts positively the air navigation services development and airspace performance.

3.2 Common PBN implementation framework in the Region can boost the States' alignment on objective consecution for PBN Transition Plan developments and implementation.

3.3 Updated regulatory framework for ANSPs or private companies providing FPD services can bring more efficient, safe, fast and fit-to-purpose PBN deployments.

3.4 SBAS availability would suppose an enabler on the PBN possibilities for approach services complementing or taking over current conventional approach systems.

3.5 Optimisation strategies enabled by PBN implementations such as Merge Point or Trombone solutions and seek for enhanced modes of operation will certainly bring more capacity and efficiency to the global network.

3.6 Within the framework of the EU-LAC APP II project, a project funded by the EU and implemented by EASA with the objective to strengthen the cooperation between Latin America and Europe in civil aviation, activities on Performance Based Navigation (PBN) concepts applicable in the design and validation of flight procedures as well as safety oversight in flight procedure design organisations (IFPD) are under deployment. EASA considers of strategic importance the sharing of practices, approaches, and challenges to enhance and join efforts for a better connectivity and the environmental sustainability.

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