SDM Workshop on Performance Based Navigation

Report

19th October, 2017

Executive Summary

On 19th October 2017 SDM organised a Workshop on PBN focused on the deployment perspective. The workshop was attended by approximately 40 stakeholder representatives: ANSPs, Airports, civil and military Airspace Users, manufacturing industry, national regulatory authorities but also the EC. SDM opened the workshop with a brief walkthrough of the relevant section of the PCP IR, its interpretation in the Deployment Programme and a broader background behind the strategy that SDM follows for the implementation of PBN with particular focus on TMA operations using RNP 1. The introduction was complemented by the Eurocontrol representative who discussed the concept of PBN as defined in the ICAO Manual Doc 9613.

To further set the scene, various experts from different stakeholder groups presented their perspectives and experiences, from Airspace User to Air Navigation Service Providers, from Regulators to Manufacturer.

Good examples of successful implementations of RNP in Europe were presented. Pilots confirmed the flyability of RNP procedures and that it is possible to transfer to ILS on very short final. Illustrative recordings from RNP procedures showed in a clear way the advantages of RNP and the capability to tailor procedures to avoid sensitive areas and the repeatability of the flight paths. Importance of early information to local communities was stressed in order to avoid blocking situations at a late stage. It was also highlighted that to take full advantage of RNP, it is necessary to redesign the whole airspace which is a major task. Lack of regulatory supporting material from EASA was identified as a major issue

SDM followed up on the presentations with a brief on recommendations and the participants took the opportunity to engage in a broad exchange of views, questions and answers spanning the final hour of the workshop.

In the closing statement, the stakeholders expressed their shared view that the workshop was productive and useful and that a follow-up gathering in a similar format, perhaps on an annual basis, would be desirable.

A detailed report from the workshop, all presentations and deployment recommendations are published on the SDM Website:

www.sesardeploymentmanager.eu/publications/presentations

Table of contents

Table of figures

1. Introduction to PBN and RNP

Presented by Rick Farnworth, Eurocontrol.

PBN is an operational concept where air navigation is achieved on the basis of demonstrated compliance with performance requirements imposed on the sensor rather than the use of a specific predicated type of sensor.

PBN as a concept is structured in three components:

- Navigation Specification
  - Performance requirements
    - Accuracy
    - Integrity
    - Continuity
    - Availability
  - Functionalities on-board
  - Navigations sensors
  - Flight crew requirements
  - ATCO training requirements
- Navigation infrastructure
  - Ground based navigation aids
  - Space based navigation aids
- Navigation Application
  - The application of a navigation specification and the supporting navigation infrastructure, to routes, procedures, and/or defined airspace volume, in accordance with the intended airspace concept.
  - The navigation application is one element, along with communication, ATS surveillance and ATM procedures which meet the strategic objectives in a defined airspace concept.

Area navigation (RNAV) replaced traditional navigation where routes followed ground based navigation aids. With RNAV it became possible to navigate along any desired flight path that was within coverage range from available positioning sources such as VOR and DME. This offered improved flexibility in airspace design and route planning both horizontally and vertically.

Any published route, STAR, SID or Final Approach procedure that requires the use of an RNAV system is a PBN route.

Flying according to an RNAV specification includes a guarantee that the horizontal flight track error is within a certain tolerance limit for a minimum proportion of time for each flight. For example, flying according to the RNAV5 specification assures that the aircraft is within 5 NM horizontal distance from the desired flight track for at least 95 percent of the total flight time. This puts requirements on the aircraft's navigation performance, hence Performance Based Navigation.

RNAV offers improved navigation safety and improved flight efficiency and environmental impact. For example, it enables the use of Continuous Climb Operations (CCO) and Continuous Descent Operations (CDO).

Required Navigation Performance (RNP) is an evolution of RNAV that includes on-board performance and alerting functions. RNP makes extensive use of Global Navigation Satellite Systems (GNSS) as the navigation source. DME/DME can be used for reversion solution where required.

RNP provides even better benefits beyond those found in RNAV:

- On-board performance monitoring and alerting if performance requirements are not met
- Radius to Fix (RF) path terminators [1]
- Fixed Radius Transitions en-route
- RNP Approaches with vertical guidance (Barometric or Satellite Based Augmentation System (SBAS)
- Connectivity to xLS to continue approach below RNP APCH minima
- Reduces ATC radar monitoring requirements
- Tactical flexibility through the use of parallel offsets
- Higher integrity in navigation

The following figures show examples of benefits from using RF legs in Amsterdam-Schiphol RW24, Riga Airport RW18 and Gothenburg RW21.

In Amsterdam, it can be seen that aircraft flying the RNP RF departure show a much more precise flight path, thereby avoiding noise sensitive areas, see below.

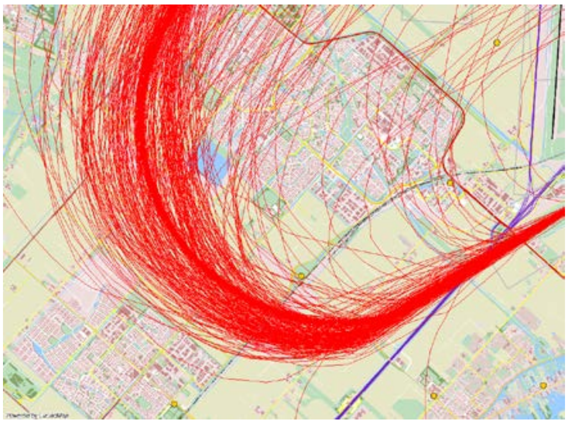


Figure 1 – Schiphol departure tracks RWY24 before RF legs

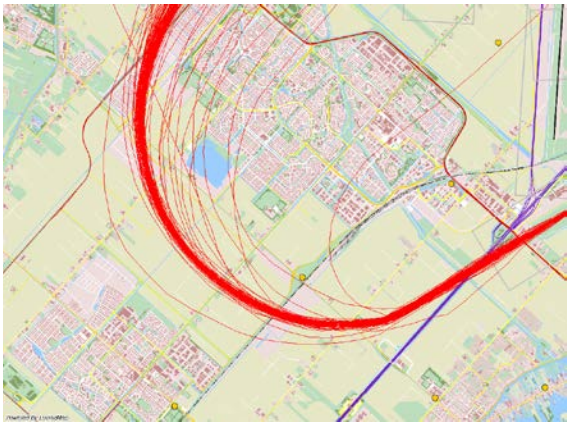


Figure 2 - RF legs in Schiphol departures RWY24

In Gothenburg (GOT) an RNP AR to RW21 shortened the arrival by 11 NM compared to the baseline consisting of RNAV1 STAR followed by an ILS approach, see below.

Figure 3 - GOT arrivals to RWY21 with and without RNP AR

[1] With Radius to Fix path terminators in segments of arrival or departures routes aircraft follow a circular arc with a predefined radius and center point. This is in contrast to RNAV turns where the current ground speed will determine the turn radius resulting in dispersed tracks.

In Riga, the approach to RW18 was shortened by several miles with an RF leg turning onto short final only 1 NM from the runway, see below.

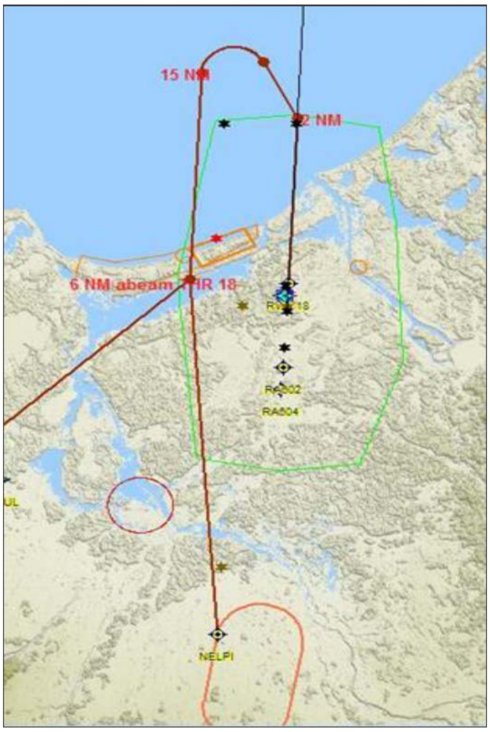


Figure 4 - Riga arrival route RWY18

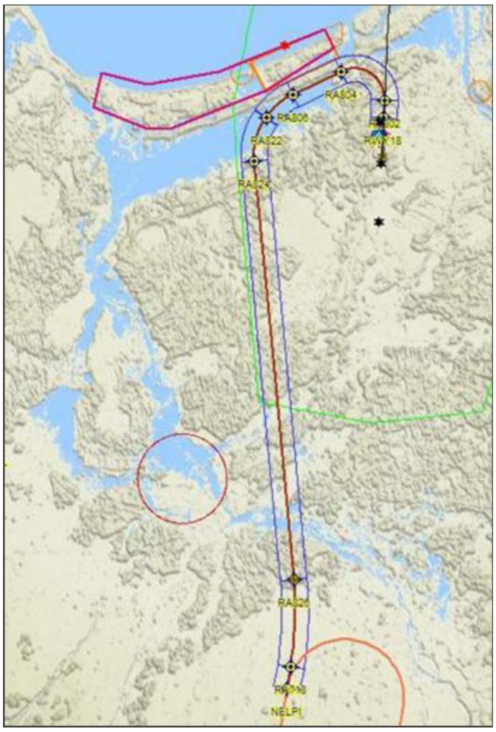


Figure 5 - Riga RNP arrival route RWY18 with RNP AR

RNP Approach procedures can be divided into those with lateral guidance only and those with lateral and vertical guidance according to the following table:

Type of RNP Approach	Guidance provision	Description
LNAV	Lateral only	To be flown as a CDFA approach
LP	Lateral only	SBAS supported
LNAV/VNAV	Lateral and Vertical	Vertical guidance with Baro-VNAV or SBAS
LPV	Lateral and Vertical	SBAS supported Localizer Performance with Vertical guidance. Can be flown down to similar minima as ILS Cat 1.

There has been a general evolution of approach types:

Category	Lateral	Vertical	Sensors
Non-precision Approach (NPA)	Conventional	CDFA	VOR/NDB/DME Localizer
Non-precision Approach (NPA)	RNP APCH	CDFA	GNSS
Approach with Vertical guidance (APV)	APV Baro		GNSS + Baro
Approach with Vertical guidance (APV)	APV SBAS		GNSS + SBAS
Precision Approach (PA)	Conventional		ILS/MLS
Precision Approach (PA)	GBAS Approach		GNSS + GBAS

The benefits with RNP Approaches include the following:

- Safety
    - Vertical guidance allows on-board standard operational procedures
    - Improved situational awareness reduces CFIT risk
    - Reduced pilot work load compared to conventional step-down and CDFA approaches
    - Better obstacle design criteria (low temperature protection in LNAV/VNAV design criteria)
- Low cost
    - No dependence on ground aids
    - EGNOS service free of charge
- Reduced minima
    - Decision Height as low as 200 feet based on SBAS LPV200
    - Potential for straight-in approach where currently offset approach is used

Public consultation of local communities and analysis of environmental impact can be very challenging and make implementation of PBN procedures come to a halt. It is important for implementers to recognize the necessary balance between on one hand social, institutional and economic benefits and on the other hand the environmental impact.

2. PBN in PCP and DP2017

Presented by Larry Johnsson and Jan Stibor, SDM.

The SESAR Deployment Manager has two main roles:

1. Deployment Manager role (as defined by EU Regulation 409/2013, Article 9)
    - Plan – Long term planning, Deployment Programme, CBA and funding mechanism
    - Consult – Stakeholder Consultation Platform Cooperative Arrangements
    - Check – Performance Assessment
    - Deliver – DP Execution synchronization, coordination of performance assessment
2. Coordinator role for the SESAR Framework Partnership Agreement (FPA, article II.1.3)
    - Action Plan – Monitoring and Reporting
    - Payments, Checks and Audits
    - Support – Services to Stakeholders and to the EC, information flow
    - Coordinator – Be Action Coordinator for every Implementation Project

The Pilot Common Project (EU Regulation 716/2014) mandates two PBN specifications to be implemented at 25 airports and in their surrounding airspace as described under ATM Functionality (AF) 1 – "Extended AMAN and PBN in High Density TMAs". This is further defined and specified in the Deployment Programme 2017 in Sub-AF1.2 "Enhanced Terminal Airspace using RNP-based Operations".

The Deployment Programme fulfils several purposes towards SESAR deployment:

- It is the guidance for operational stakeholders to deliver the PCP timely and in a synchronized approach as described in the DP families.
- It represents the blueprint for ATM investment plans of the stakeholders which are impacted by the PCP regulation.
- It serves as reference and provides specifications for proposals under future CEF Calls aiming at implementing SESAR Common Projects.
- It reports on the status of the PCP implementation identifying what remains to be deployed and where and by whom.

The requirements on PBN deployment as found in the PCP are further detailed in the Deployment Programme as seen in the following table:

Requirements category	PCP Regulation (EU 716/2014)	Deployment Programme 2017 (approved by the EC)
Operational & Technical scope	– SID, STAR and transition based on RNP1 including RF – RNP APCH with vertical guidance (LNAV/VNAV and LPV)	– Family 1.2.1 – RNP APCH for all standard landing runways – Family 1.2.3 – RNP1 Operations, RF optional where beneficial
Geographical scope	– 25 airports with surrounding TMAs (not likely to be expanded)	– In practice 24 airports
Stakeholders	– ANSP, NM, Airports	– Family 1.2.4 opens up for Airspace Users to ensure synchronization and capabilities
Target date	– 1 January 2024	– F1.2.1: 1 January 2021 (IOC before 2014) – F1.2.3: 1 January 2024 (IOC 1 January 2015)

In the CEF Call 2017 the following deployment families are prioritized:
- Family 1.2.1 – RNP APCH with vertical guidance
- Family 1.2.3 – RNP1 Operations in high density TMA (ground capabilities)

The ongoing PBN regulation was estimated to be approved by the EC earliest in December 2017, but has been further delayed. It is important to note that the PBN IR and the PCP will be two different but complementing regulations.

One of the main responsibilities of the SDM is to monitor the deployment status for the PCP. The SDM monitoring is based on stakeholders own reporting. When it comes to PBN deployment, it is obvious that Europe is lagging behind in a global perspective. The PCP deployment status is published in the Deployment Programme Monitoring View, which is updated annually.

Other sources for tracking deployment status are for example:
- National AIP
- Eurocontrol "PBN Approach Tool"

It has been noted that there are difficulties in identifying the deployment gaps. Implementing stakeholders are requested to assess implementation status and ensure that PCP gap analysis is correct. Incorrect gap reporting could jeopardize timely and synchronized PCP deployment and prevent CEF funding.

RNP is a cornerstone component to SESAR Time Based and Trajectory Based Operations.

RNP plays an enabling role in several advanced applications in ATM, such as:
- Extended AMAN (DP Family 1.1.2)
- ATC tools (conflict management, conformance monitoring etc.)
- A-CDM (DP Families 2.1.3 and 2.1.4)
- CDO/CCO operations

RNP also brings several benefits in terms of performance:
- Deterministic track keeping allowing aircraft to be flown in automated mode with improvements in flight efficiency and environmental impact.
- Independence from ground based navigation aids allows greater flexibility in procedure design. With it comes the opportunity to rationalize conventional navigation aids.
- RNP APCH with vertical guidance replacing non-precision approach procedures as contingency for ILS outage.
- Additional safety net from on-board performance monitoring and alerting (OPMA)
- Enables procedural lateral separation of 5 NM (PANS-ATM Ed 2016 paragraph 5.4.1.2.1.4.1b)

Although the case for RNP is predominantly positive there exist some issues with RNP deployment that needs to be considered:
- States acceptability of GNSS as navigation reference
  - State liability of space based navigation systems is connected to authorization, approval and acceptance
- Mixed capabilities of aircraft
  - Mixed capabilities can cause problems in handling arrivals and departures in high-density TMAs.

- RNP reversion in case of GNSS outage[2]
  - DME/DME gives RNAV capability only since OPMA is lost[3]
  - There is ongoing work in a EUROCAE working group on defining network requirement for DME/DME as reversionary solution.
- Flight planning
  - Current ICAO flight plan specification is lacking an RF code. Update is ongoing.
  - Flight plan fidelity: air operators may not always file their full PBN capability when there are no RNP procedures along the planned route. This gives ANSP a false view of airborne equipage and in turn discourages implementation planning.
- Lack of EASA RNP1 airworthiness harmonization with the U.S. FAA
  - EASA CS-ACNS NAV and AMC (20-xx) not yet available
- Public consultation of changes in airspace design
  - RNP track concentration can result in locally disproportionate exposure to noise
  - Public opinion can hamper deployment. Early consultation with the public is key.

[2] SBAS/EGNOS coverage in the Spanish Canary Islands is only available about 20 percent of the time.

[3] Airbus reports that all their aircraft types are RNP1 certified and accepted by EASA. They can also fly RNAV based on DME/DME.

3. Conclusions and Recommendations for PBN deployment

Presented by Jan Stibor, SDM.

In order to facilitate an effective deployment of PBN in Europe the SDM offered a number of recommendations for PBN deployment and implementation of the PCP.

First, it is important to identify where to deploy PBN as required by the PCP. This information can be found in the Deployment Programme 2017 Monitoring View. This provides information on remaining PCP gaps in terms of airports and corresponding TMAs where RNP APCH and RNP1 SIDs and STARs have not yet been deployed and published.

The Implementation Partners were made aware that EC INEA grants are only available where there is a gap towards the PCP. The gap analysis contained in the DP Monitoring View is very important with respect to the availability of INEA funding. However, in order to make an informed and correctly timed implementation decision, stakeholders are encouraged to employ other sources of information that the Gap analysis does not provide. Examples would be an assortment of tools available at the Eurocontrol One Sky Online service such as STATFOR and the CNS dashboard.

Considerations should be given to the following:

- Local situation and needs which should be analysed so that the most appropriate solution can be developed and deployed
- The anticipated PBN IR is meant to complement the PCP IR.
- Options for transitioning from existing procedures to RNP1, for example from RNAV1. As an example, Australia introduced RNP with a 2-year transition that can be flown by RNAV aircraft. Are operations with mixed capabilities a requirement?
- SBAS based on EGNOS is now certified for Safety of Life services (SoL). The EGNOS SoL Service Definition document may serve as input to the safety assessment. Monitoring of GNSS availability should probably be done at ANSP level.
- RF legs in SIDs and STARs - this optional concept provides benefits when designing path critical procedures for noise dispersion and terrain avoidance. However, not all aircraft types are possible to upgrade to this capability. In such cases, where the use of RF may indeed give benefits, it is recommended to implement alternative procedures with conventional fly-over or fly-by waypoints. These should be implemented alongside the procedure which includes the RF segment. In many cases it may only be necessary to replace an RF path terminator with a fly-by segment.
- Periodic procedural renewal is generally required every 5 years.
- Aircraft equipment is mature and equipage rates at PCP airports are high and constantly increasing. This brings opportunities for early benefits.

For the deployment of RNP APCH (DP2017 Family 1.2.1):

- The DP2017 states that RNP APCH shall be implemented at all standard landing runways[4] for an airport. It is proposed to include the following text for the PCP-revision: *"RNP APCH shall be implemented at all runway ends, except where local terrain, obstacles and/or environmental regulations preclude implementation."*
- RNP APCH to replace Non-Precision Approach procedures
- It is recommended for applications under the CEF Call 2017 to include:

[4] A standard landing runway was defined as a runway used for arrivals in normal operations.

- Several runways and/or airports and stakeholders as these applications will be given priority.
- A plan for the decommissioning of the legacy infrastructure
- Grants will be limited to 25.000 EUR per approach to which the audience responded that flight testing alone could cost up to 25.000 EUR per approach.

For the deployment of RNP1 SIDs and STARs (DP2017 Family 1.2.3):

- Plan for the deployment of RNP1 SIDs and STARs for all runways. It is proposed include the following text for the PCP-revision: *"RNP1 SIDs and STARs including transitions shall be implemented at all runways in support of principal traffic flows."*
- Include all major stakeholders during development of RNP1 SIDs and STARs.
- Develop a study/plan for the rationalization of legacy nav-aid infrastructure.

Appendix A. Airborne perspective

Presented by Michael Hopp, Lufthansa.

Lufthansa Group is striving to be ready for PBN and future air navigation. Equipage rate is high with RNP APCH in approximately 97 percent of the total fleet. RNP1 and RF capability exists in over 95 percent of the fleet and increases with FMS upgrades. Retrofit is done where possible and where there is a positive business case or major system upgrade of MMS and FMS. A large training program was launched for all pilots in the Lufthansa Airlines Group. This includes theoretical training through CBT and specific simulator training.

Lufthansa Group is participating in several PBN deployment and demonstration projects for trials with respect to PBN and deployment of PBN at Frankfurt, Bremen, Zürich and Vienna Airport. Among these was the SESAR “Augmented Approach to Land” (AAL) large-scale demonstration (EDDF, LSZH). For example, in the AAL demonstration approaches were flown in FRA RWY25L consisting of RNP1 arrival procedures with RF segments, connecting to GLS or ILS on final with 3.0 and 3.2 degrees glide path. It included a descending RF turn onto the final approach ILS.

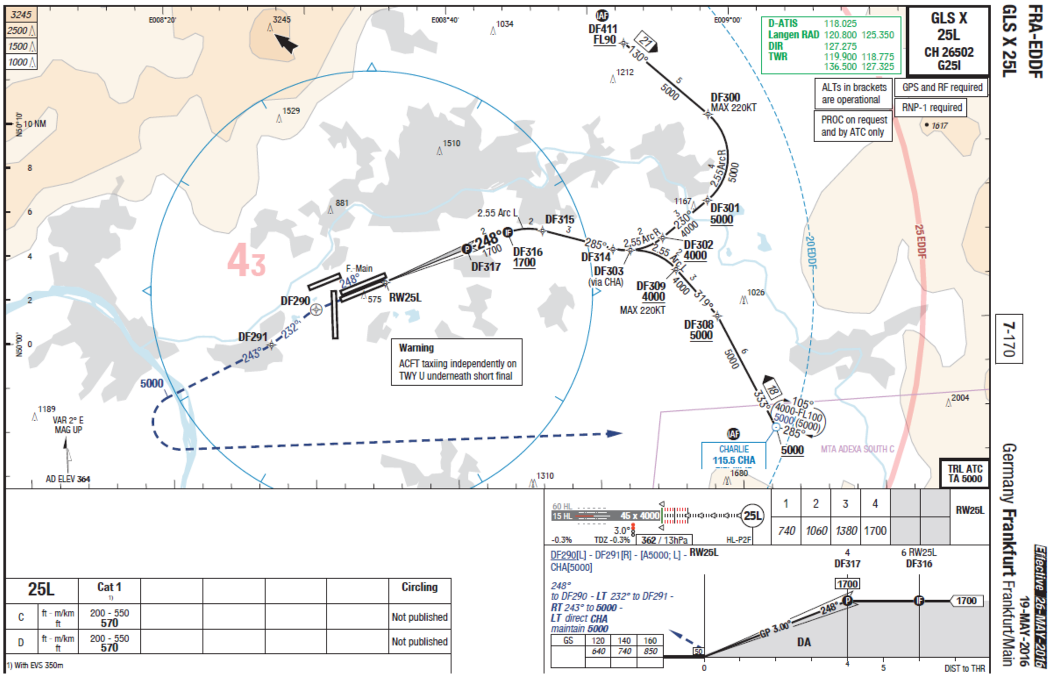


Figure 6 - GLS to ILS approach FRA RWY25L with RF legs

The AAL demonstration showed very good results regarding flyability of RNP to xLS approaches. Technical capability of participating aircraft proved to be suitable, although this type of approach was perceived more demanding for pilots compared to regular radar vectored ILS or GLS approaches with a long final. Specific pilot training is recommended.

One negative impact was that it is challenging for ATC to integrate this approach with other traffic that is radar vectored (mixed mode).

During the deployment project “RNP Based Departure Operations in Frankfurt, Munich, Düsseldorf and Berlin”, a first step was the implementation of FRA RWY25 C/L SIDs, which are now being flown based on RNP1 with two RF segments. This enables better lateral control of noise footprint. However, it was noted that due to speed constraints, imposed by tight turn radius, for example the B747-8 is forced to clean up late, thus causing remarkably increased fuel consumption, in particular at high take off weights, and higher noise impact directly below the flight path relative to the standard RNAV1 SID which includes no RF segments. See below.

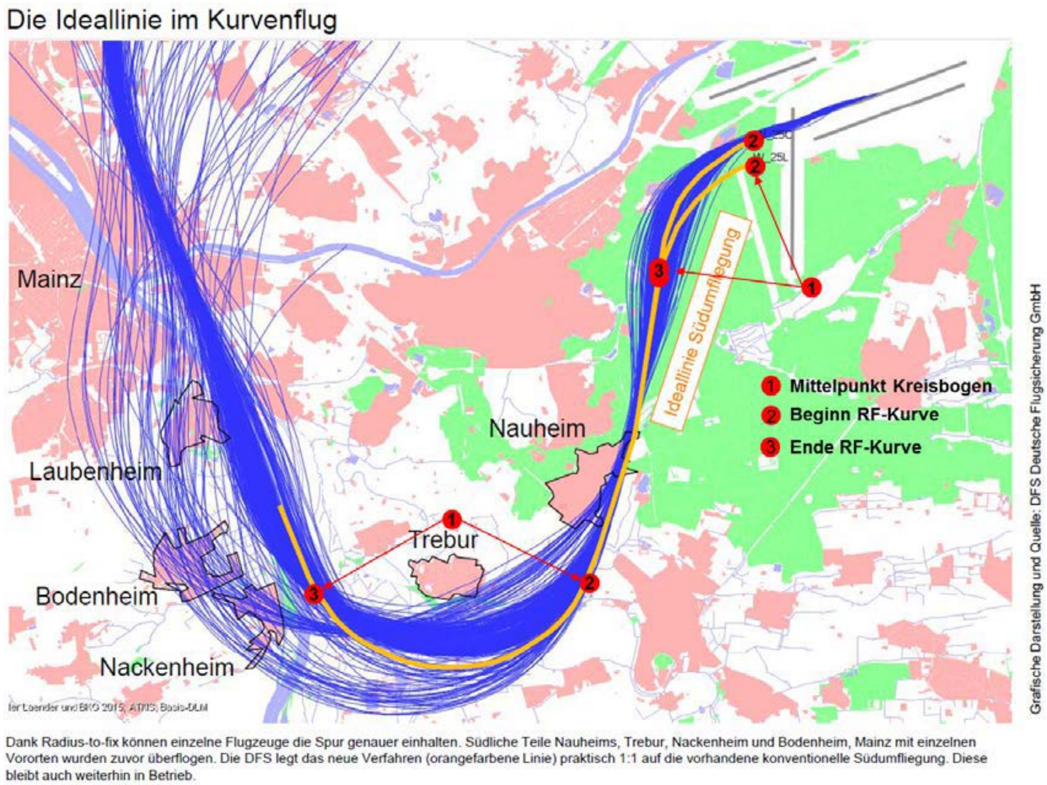


Figure 7 - FRA departure tracks RWY25C

For any PBN deployment project to be successful it is important to note that it should be driven by benefits, not only for the airspace users, but also for ATC and the local communities. These benefits should be identified at the beginning of any PBN project.

Challenges for PBN projects include:

- How to measure benefits for involved parties? A clear definition would help to win buy in from the parties for modernization which would in turn drive innovation.
- High equipage and usage rates by airspace users, who have to invest in training and equipment, are key factors for a successful and timely PBN implementation. How to increase them? A fruitful design of new procedures, leading to benefits on the airspace user side (e.g. more efficient route design for lower fuel consumption) will bring a positive natural momentum and motivation for equipage and usage rates.
- For many historically grown airports, with surrounding airspace designs based on conventional navigation aids, a PBN based redesign would offer a large optimization potential. Experience from recent SESAR projects shows, that nowadays it is extremely challenging to realize a benefit oriented airspace redesign, in particular due to communities being against changes of routes for noise reasons. How can we solve this problem to make PBN implementation a success?
- High usage rate of RNP procedures necessary. How to maximize it?

Conclusions:
A PBN project should bring benefits for all involved stakeholders, including local communities. For example, reduced fuel burn and CO2 emissions, reduced noise impact, simplifying workload for ATCOs and pilots, which in turn enhances safety, and lowering operational costs thereby enabling

reduced charges. The project should identify measures or mechanisms that can compensate disadvantaged stakeholders.

Early and good communication with stakeholders is the basis for a positive momentum. This will generate maximum demand by stakeholders which in turn will drive the initiatives from all sides.

Appendix B. Ground perspective

Presented by Tom Snyers, Belgocontrol.

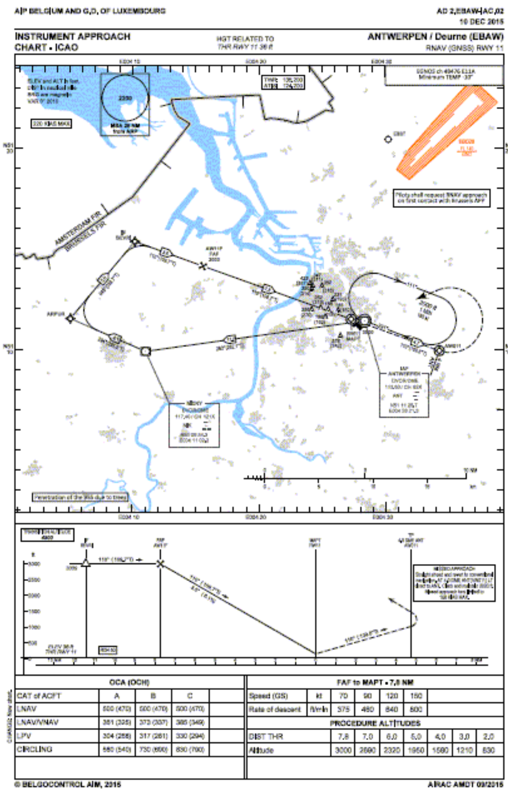
Belgocontrol's main motivation for implementing RNP APCH with vertical guidance is safety. LPV approaches have been published for several runways at Belgian aerodromes allowing lower minima compared to conventional non-ILS approach procedures, both for visibility and minimum descent/decision height. Belgocontrol has published for each approach LPV, LNAV/VNAV and LNAV RNP APCH minima to serve all airspace users.

The deployment aims at optimizing the affected airspace and withdrawing conventional non-precision approaches. This has been endorsed by the Belgian "PBN Implementation Group" representing all aviation stakeholders.

The implementation process consists of many steps, starting from an idea and finally leading to a publication, which represents only the tip of the iceberg. In the process, elaboration of an operational concept, and re-design of the airspace as required, are of paramount importance, but there is also a safety case, in-flight validation, ICAO requirements, obstacle survey, procedure design and validation, controller training and NSA approval. Without changes to the airspace, the implementation period lasts around 8-12 months. Should airspace changes be necessary, this period will likely be much longer.

It is important to note that the NSA approval requires an environmental impact assessment.

An example from Antwerp RWY11 showed a reduction from 550 feet minimum altitude to 330 feet and an RVR reduction from 1900 meters to 900 meters. In this particular project, it was necessary to extend the TMA as more airspace was needed to accommodate the final approach segment which is 12 NM long.



PANS OPS	Standard — STRAIGHT-IN LANDING RWY 11 DA(H) 550′(511′)	ALS out	Max Kts	CIRCLE-TO-LAND MDA(H)	VIS
A	RVR 1500m		100	580′ (541′)	1500m
B			135	730′ (691′)	1600m
C	RVR 1900m	CMV 2400m	180	830′ (791′)	2400m
D	NOT APPLICABLE		D	NOT APPLICABLE	

PANS OPS	LPV DA(H) A: 304′(268′) B: 317′(281′) C: 330′(294′)	LPV ALS out	LNAV/VNAV DA(H) A: 361′(325′) B: 373′(337′) C: 385′(349′)	LNAV/VNAV ALS out	LNAV DA(H) 500′(464′)	LNAV ALS out	Max Kts	CIRCLE-TO-LAND MDA(H)	VIS
A	RVR 900m	RVR 1300m	RVR 1100m	RVR 1500m	RVR 1500m		100	580′ (541′)	1500m
B		RVR 1400m					135	730′ (691′)	1600m
C			RVR 1200m	RVR 1600m	RVR 1800m	CMV 2200m	180	830′ (791′)	2400m
D	NOT APPLICABLE						D	NOT APPLICABLE	

Figure 8 - Antwerp RNP APCH to RWY11

RNP APCH with vertical guidance (LPV or LPV200, LNAV/VNAV, LNAV) at all instrument runway ends at airports where Belgocontrol provides ATS (see the following list) will be deployed by March 2018. Optimisation of the approach transition will also be done.

- Antwerpen
- Brussels-Zaventem
- Charleroi
- Kortrijk (RW24)
- Liège
- Oostende

Charts are named RNAV (GNSS) but will be changed to RNP. A transition phase for this is required by ICAO.

Belgian Defence has also published RNP APCH (LNAV and/or LNAV/VNAV) at their main bases:

- Beauvechain
- Florennes
- Kleine-Brogel

General findings and recommendations from Belgocontrol RNP projects include:

- Knowledge of the ICAO-requirements
- Understand the existing operational environment
- Involve all stakeholders from day 1
- Focus on a revised operational concept well in advance
- Begin your safety case early in the project
- Each procedure has its particularities
- Plan your resources

Appendix C. Regulator perspective

Presented by John Dow, UK CAA.

The **UK Future Airspace Strategy (FAS)** was established as an umbrella organization in support of the European ATM Master Plan. The UK airspace modernization strategy will remain aligned with SESAR deployments and linked to the SESAR 2020 roadmap.

The FAS encompasses several upgrades to the UK airspace system, among them:

- En-route airspace upgrades
    - To remove fixed structures, adding capacity and enabling more direct and free routes
- Terminal airspace upgrades
    - Fundamental redesign of route network taking advantages in technology, especially satellite navigation
- Queue management upgrades
    - To stream traffic using speed control en-route and reduce reliance on holding-stacks in TMA
- Airspace upgrades at lower altitudes
    - Redesign of SIDs and STARs to better accommodate continuous climbs and descents and improve noise impact management
- Airspace information upgrades
    - Provision of accurate traffic data to better manage ground delays and airspace bottlenecks

PBN is an essential enabler in delivering Future Airspace Strategy upgrades. The ideal route to modernization of airspace using PBN includes several components that all need to be in place. These include:

- Airspace concept
    - Definition of new Nav Application, Nav Specification and Nav Infrastructure
- Airspace user equipage and flight crew licensing
- Airspace changes
- Withdrawal of conventional routes and procedures
- Rationalization of navigation aids

For this purpose, a number of UK CAA guidance material has been developed.[5] UK CAA takes a pragmatic approach to RNP AR – basing it on the operators' Safety Management System (SMS). The UK CAA is currently limited in their regulatory capacity due to policy changes and new regulatory processes which include outsourcing of work to coding houses and by the sheer amount of work. Lessons learned include taking early consideration of flyability of procedures to avoid late re-design, and also to include operators and design houses early in the process. Public consultation on environmental impact risks making the whole process costly and time-consuming and may even grind the airspace project to a halt. Therefore, noise respite and/or mitigation has to be part of the airspace design solution.

[5] UK CAA: CAP 1385 – PBN Enhanced Routing Spacing Guidance, and CAP 1378 – PBN Airspace Design Guidance

When it comes to aircraft equipage there are a number of challenges.

- First of all, there is a lack of European regulation on PBN. Currently, the UK CAA use the JAA TGL 10 for RNAV1 operator approvals while awaiting the publication of EASA CS-ACNS. Also, they are relying on FAA criteria for RNP1.[6]
- Secondly, there is no mandate on operators to equip. Retrofitting is mostly driven by airport development which in turn is dependent on fleet renewal. So, there is no incentive for early movers.
- For regional carriers with smaller aircraft types it is a challenging business case. Onboard modifications can be very costly (even higher than airframe worth). Avionics upgrades might not even be available and the timescales for upgrading might be impossible.

The approval of Airspace Users to operate PBN has become simpler with the removal of non-complex PBN from Part-SPA and updates to Air-OPS.[7] New requirements[8] on Flight crew training and certification have been introduced without requirements for aircraft fleet being equipped.

Key developments of PBN in the UK include:

- SESAR deployment, e.g. PCP
- RNAV5 for all routes
- RNAV1 SIDs at London Gatwick, Luton, Birmingham and Bristol
- RNAV1 STARs at Bristol, Hurn sector (SAIP)
- LAMP (London Airspace Management Programme) 1A (London City Point Merge and RNAV1 SIDs)
- RNP1+RF SIDs at London Stansted
- RNAV1 in IoM (Isle of Man)/Antrim en-route airspace supporting closely spaced parallel routes
- FASI (Future Airspace Implementation) North, including Scottish TMA and Northern airports (Manchester etc.)
- FAIS South, including Heathrow R3 and a complete South-East airspace re-design
- Fuel and CO2 savings through SID truncation
- RNP APCH 3D procedures (LNAV/VNAV and LPV)
- GBAS feasibility and options studies
- Navaid (VOR, NDB) rationalization and optimization (DME)

In particular, it is unclear whether a PCP airport has to implement RNP1 SID/STAR for each runway end or whether it is left to the airport to decide. There is a lack of good guidance on this. The UK CAA has taken a pragmatic view that it is up to each airport to decide on the implementation of advanced PBN concept based on business case assessment.

The UK CAA expects that airports will deploy at least one example within the time-frame to deliver operational benefits. RNP1 should be used where RF supports the operational requirements. Otherwise, RNAV1 is sufficient.

---

[6] FAA AC90-105A – "Approval Guidance for RNP Operations and Barometric Vertical Navigation in the U.S. National Airspace System and in Oceanic and Remote Continental Airspace"

[7] Commission Regulation (EU) 2016/1199 of 22 July 2016 amending Regulation (EU) No 965/2012 as regards "Operational approval of performance-based navigation, certification and oversight of data services providers and helicopter offshore operations, and correcting that Regulation"

[8] Commission Regulation (EU) No. 2016/539

Appendix D. Manufacturer perspective

Presented by Thierry Harquin, Airbus.

PBN is an umbrella that includes four RNAV and five RNP specifications, see below.

The main difference between RNAV and RNP is that the latter has additional requirements for Onboard Performance Monitoring and Alerting and guarantees a lateral containment (= Navigation Performance).

Advanced RNP, or A-RNP, is an overarching new specification part of the ICAO PBN Manual that offers the opportunity for operators to achieve a single approval to operate according to all PBN specifications (except RNP AR APCH). A-RNP also offers advanced concepts such as Radius to Fix path terminators and Fixed Radius Transitions.

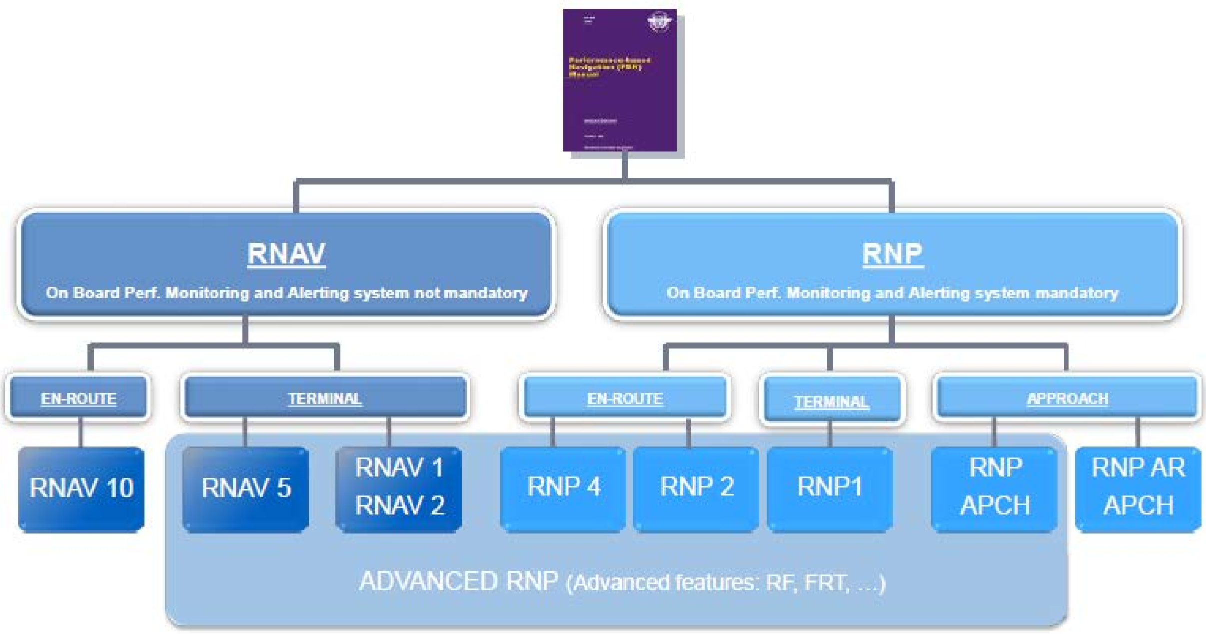


Figure 9 - PBN specifications tree

Airbus aircraft can operate according to most PBN specifications with a few exceptions which can be summarized as follows.

- All Airbus aircraft are capable to fly according to RNAV10 except for A300.
- All Airbus types are RNAV1 capable.
- All Airbus types with GNSS + FANS are RNP4 capable.
- All types with FMS1 or FMS2 plus GNSS are RNP1 capable (91 percent of A320 fleet and 95 percent of A330 fleet).
- All types with FMS2 plus GNSS are RNP APCH (LNAV/VNAV) capable.
- All aircraft with GNSS and FMS2 are capable to at least RNP APCH (LNAV/VNAV) as well as RF legs.
- RNP APCH (LPV) based on SBAS only available on A350. A320 and A330 to come in 2020.
- GBAS Cat I landing system is certified for all Airbus aircraft. For the future, GBAS Cat II/III is pending a synchronized airport deployment which will possibly take place in 2023. For the moment Airbus sees no business case for it. There is an INEA grant under CEF Call 2016 to

develop a new Multi-Mode Receiver (MMR) for SBAS. It may also accommodate GBAS Cat II/III.

The following table gives an overview. There may be differences in equipage configuration between aircraft type families.

Navigation Specification	A320	A330	A340	A380	A350
RNAV 10	YES	YES	YES	YES	YES
RNAV 5	YES	YES	YES	YES	YES
RNP 4	YES	YES	YES	YES	YES
RNP 2	YES	YES	YES	YES	YES
RNAV 1 & 2	YES	YES	YES	YES	YES
RNP 1	YES	YES	YES	YES	YES
RNP APCH (LNAV/VNAV)	YES	YES	YES	YES	YES
SLS (LPV)	Ongoing	Ongoing	no	no	YES
RNP AR 0.3 NM	YES	YES	YES	YES	YES
RNP AR down to 0.1 NM	YES	YES	no	Ongoing	YES
GLS Cat I with Autoland	YES	YES	no	YES	YES

Table 1 - Airbus aircraft PBN capabilities

Appendix E. Experiences from PBN implementations

E.1 Austria

Presented by Daniel Schaad, Austrocontrol.

Austrocontrol sees PBN as a set of tools with several possibilities. These include:
- LNAV/VNAV
- RNP AR Approach
- LPV Approach
- RF legs
- Point-In-Space (PinS) approach for rotorcraft

The story of PBN in Austria started with the implementation of the first European pioneering RNP AR approach in Innsbruck in 2005. The terrain was here the main driver for implementation. New applications such as noise abatement have found their use in Vienna. SBAS/EGNOS provides new opportunities, in particular for General Aviation. In 2013 the first PBN hybrid procedure (Innsbruck) was published.

The issue with mixed equipage in aircraft causes concern among less equipped operators. Austrocontrol aims for downward compatibility with legacy equipment, but the question to what extent that should be maintained is constantly under discussion. Lessons from, for example, GBAS show there is a “chicken and egg” problem. Who should be the early mover?

Introducing PBN imposes some practical problems. For example, PBN has poor awareness amongst stakeholders, the nomenclature is complex and charting titles can be confusing. Training of flight crew may indeed not cover full PBN related functionality in on-board navigation equipment such as geometrical versus barometrical descent paths. The approval process for RNP AR may appear tedious and discourage airline uptake.

However, the expected benefits should in most cases exceed these hurdles. These include higher accessibility, cost-savings for ground-based navigational aids, reduction in track distances and noise exposure, availability of smaller airports which lack ILS installations, higher airspace capacity thanks to tighter route spacing and higher flexibility in route and procedure design thanks to less dependence on ground infrastructure.

In Austria, PBN has been introduced through RNP AR in Innsbruck and Salzburg, RNAV1 SID/STAR in all TMAs, early adoption of LPV and LPV200 in Linz, Graz and Vienna, PinS (Point in Space) procedures for rotorcraft, experimental and planned use of RNP AR and RF legs for departure to reduce noise exposure in Vienna.

More specifically, Vienna, as the only PCP airport in Austria, is planning several PBN solutions:
- LPV200 as an option for General Aviation to achieve Cat 1 approach precision
- RNP AR for short final roll-out curved approach for noise abatement
- RF leg overlay coding for SIDs (flyable at pilot’s discretion).
- Multiple Track Turn (MTT) study to achieve RF emulation for non-RF capable aircraft
- Night SIDs for noise abatement after negotiation with mediation panel
- Redesign of existing LNAV/VNAV procedures according to ICAO Doc 8168 Amdt 6 for better minima

When selling PBN to stakeholders it is important not to promise too much. For example, RNP routes will concentrate noise footprints which might not always be desired. PBN procedures still entail trade-offs between many factors and do not offer a perfect world.

Hybrid procedures have proven a feasible concept where RNP 0.3 is combined with a LLZ approach which offers tighter protection areas the closer the aircraft is to the runway. An early example is found in Innsbruck, see the following graph.

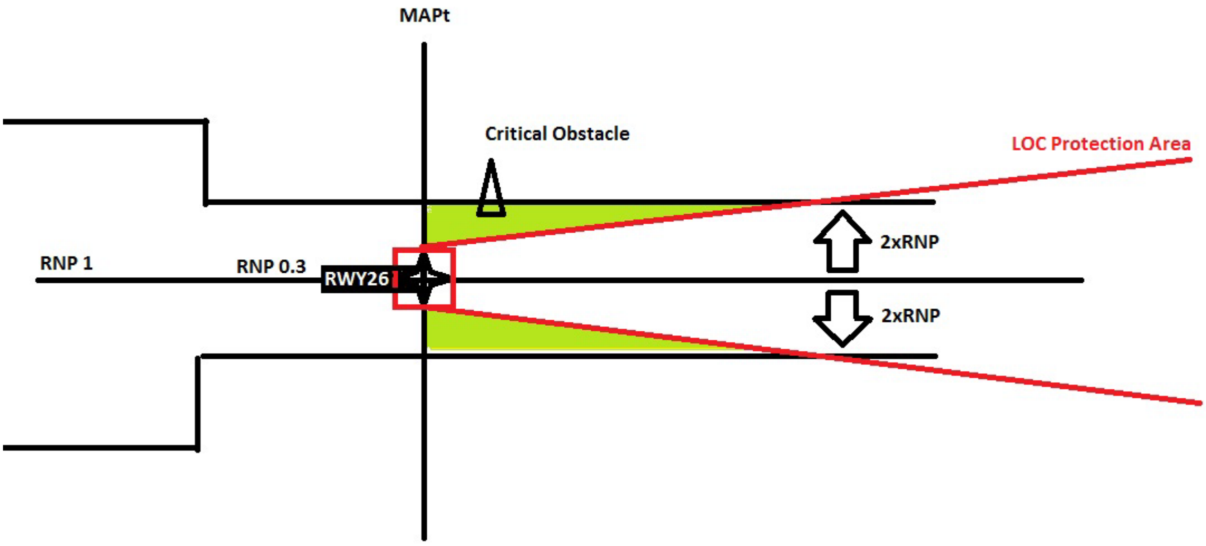


Figure 10 - RNP to LLZ hybrid approach procedure concept

These concepts can offer a bridge between conventional navigation and PBN but is facing technological challenges as there is no standard for avionics mode changes. ICAO has adopted hybrid concepts such as RNP-to-ILS in the latest edition of ICAO Doc 8168 PANS-OPS.

E.2 United Kingdom

Presented by Mark McLaren, NATS.

The Pilot Common Project (PCP) IR identifies four airports in the UK:

- London Heathrow
- Gatwick
- Stansted
- Manchester

NATS applied for and was awarded INEA co-funding for London Airspace Management Programme (LAMP) and the redevelopment of Manchester TMA.

Apart from the PCP airports several other airfields are included in the LAMP programmes, such as Luton, London City, Southend, Biggin Hill, Farnborough and Northolt.


Figure 11 - London TMA

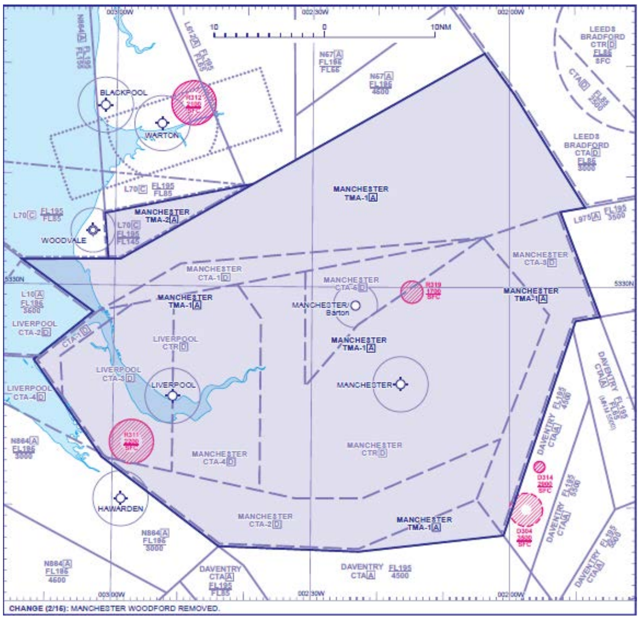


Figure 12 - Manchester TMA

Manchester TMA includes not only Manchester Airport but also Leeds, East Midlands, Birmingham and Liverpool airports.

LAMP is the biggest airspace restructure ever undertaken by NATS. It aims at reducing complexity and tactical intervention while reducing ATCO and pilot workload. It will enable more Continuous Climb and Continuous Descent operations and thereby improving flight efficiency. It will also provide RNAV1 as the minimum navigation capability, capacity to meet future demands while achieving significant savings in CO2 and fuel burn. One of the main goals is to provide improved predictability for airports and airlines.

The LAMP Phase 1A includes several changes:

- Point merge arrivals solutions
- New holding stacks and STARs
- New SIDs to the South
- SIDs converted to RNAV SIDs
- Re-routing of departures from Stansted and Luton
- New RNAV STARs into Gatwick and Southend
- Re-sectorisation of Terminal Control and Area Control sectors in the Southeast of UK
- Lowering of controlled airspace to the South of London TMA

The expected benefits from the above changes include:

- Improvement to the London TMA safety risk index
- CO2 and fuel savings
- Increase use of RNAV
- Much improved predictability of London City airport
- Free flow for Stansted departures
- Increase in CCO/CDO and improved vertical profiles
- Reduction in pilot workload
- Enables future airspace changes for remainder of LAMP

A similar programme is conducted to restructure Manchester TMA. Some highlights of this programme include:

- En-route 3 NM separation below FL285 based on radar control
- RNAV1 routes with 5 NM apart. This is based on a loss-of-separation safety case.
- Introduction of SIDs and STARs for all airfields in Manchester TMA as well as RNAV1 transitions for Liverpool and Leeds Bradford Airports. This will enable decommissioning of DVORs.
- SIDs and STARs procedurally deconflicted by extending SIDs to Flight Level altitudes above Transition Altitude 7000 feet
- Point Merge arrival concept introduced for Manchester Airport
- Revised holding patterns for Birmingham and East Midland Airports

Expected benefits from the Manchester TMA programme include:

- ATCO workload will be reduced
- Increase in capacity and sector monitor values
- CO2 and fuel savings (ca 29000 tonnes per year)
- A systemised airspace
- Removal/rationalisation of old DVORs/DMEs

The programme is also complimentary to the CAA Future Airspace Strategy (FAS) in which it is expected that 43 DVORs will be reduced 22.

E.3 Spanish PBN Implementation Plan

Presented by Ana Bodero, ENAIRE.

The Spanish PBN implementation Plan has several inputs: the PCP, PBN IR, user requirements and the National PBN Regulatory Framework and is targeting 30 airports to have PBN procedures by 2021.

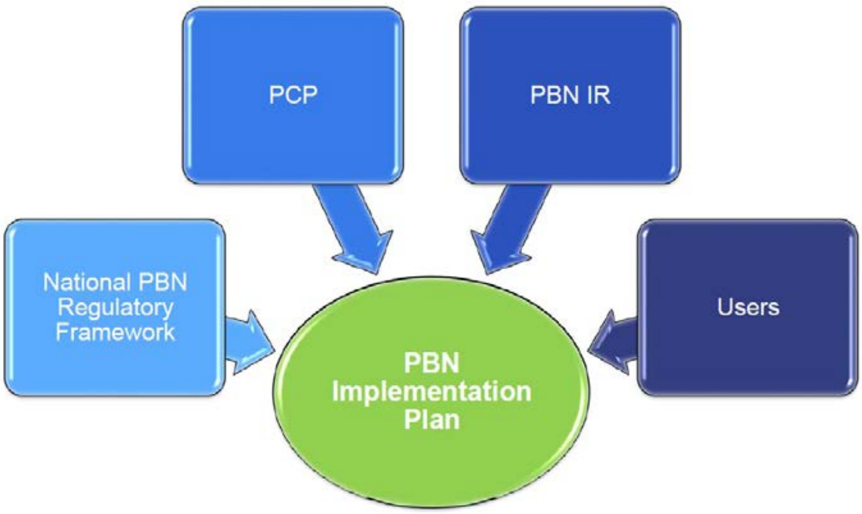


Figure 13 - Spanish PBN Implementation Plan

GNSS was accepted for use in Spanish airspace already in 2011.

ENAIRE is contributing to the PBN IR text for AMC/GM through CANSO.

The National PBN Implementation Plan will result in:

Flight phase	PBN specification	Situation	Date
En-route	RNAV/RNP10 RNAV5	RNAV/RNP10 available in oceanic routes RNAV5 available in FL150 and above	December 2020
TMA	RNAV1/RNP1	RNP1 in high density TMAs (ongoing) RNAV1 available in several TMAs	January2024
Approach	RNP APCH [LNAV, LNAV/VNAV and LPV (APV)]	Santander and Almería available	December 2020 (no PA) January 2024
	RNP AR APCH	Ongoing: La Coruña, Lanzarote	December 2020 (no PA) January 2024
	RNP APCH [LPV (SBAS CAT-I)]	Asturias foreseen mid 2018	December 2020 (no PA) January 2024

Table 2 - Objectives of Spanish PBN Implementation Plan

GBAS is planned for Malaga and Madrid airports. However, GBAS is vulnerable to interference. Ground station detects interference and advises if it affects performance.

PCP status

The Pilot Common Project AF1 identifies three Spanish airports and their surrounding TMAs; Palma de Mallorca, Barcelona and Madrid.

The ENAIRE plan is to gradually introduce RNAV1 SIDs and STARs in these TMAs with the objective to reach full RNP1 deployment by 2021 for Palma and Barcelona and by 2023 for Madrid. RF legs will be optional. Total time for publication is estimated to 12-18 months from project start.

RNP APCH (LNAV/VNAV and LPV) will be deployed for all three airports and main landing runways with publication dates January 2018 for Palma, Q1-2019 for Barcelona and Q4-2019 for Madrid. These will be SBAS enabled.

The Canary Islands with five airports will likely not have SBAS supported RNP APCH since it is only available about twenty percent of the time. LNAV/Baro-VNAV will likely be used here.

Lanzarote may have RNP AR in the future.

E.4 CDG, Paris

Presented by Hervé Marsal and Pascal Collet, Air France.

In 2016 Paris CDG published RNP APCH procedures with vertical guidance to the Southern runways. For RWY 26L (chart title RNAV (GNSS) RWY 26L) it includes the following minima:

- LNAV 470 feet
- LNAV/VNAV 350 feet
- LPV 200 feet

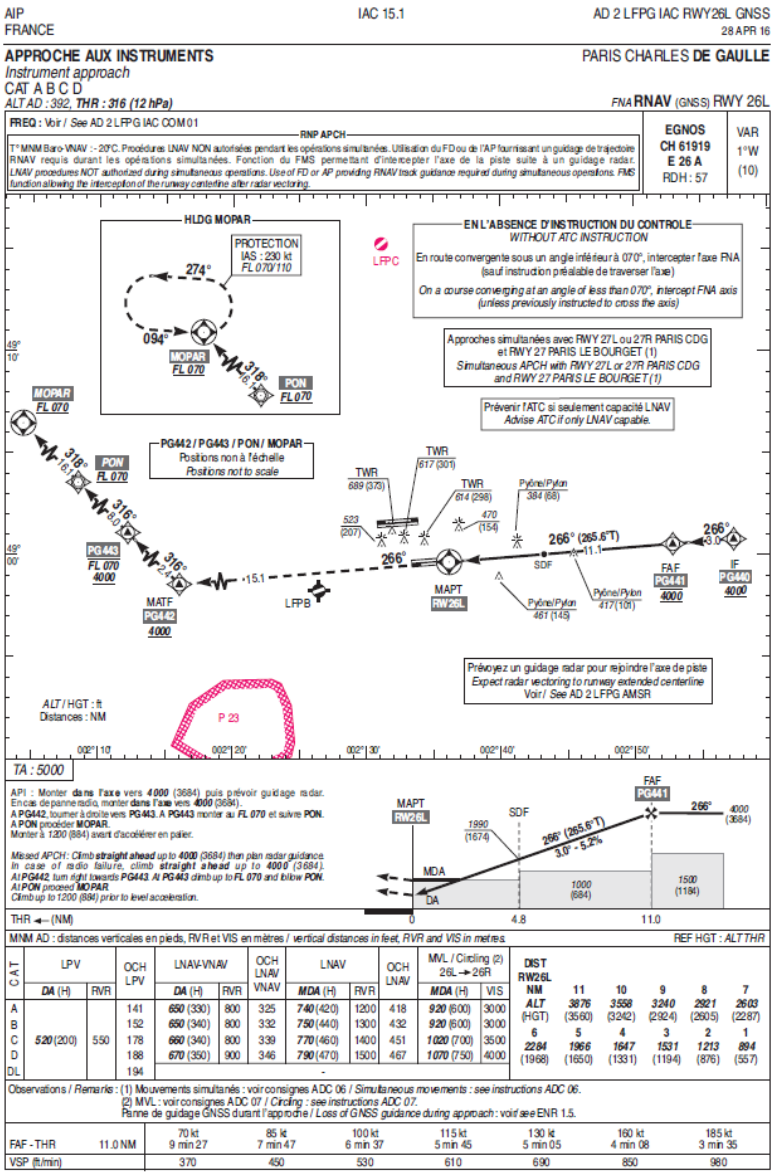


Figure 14 - CDG RNAV(GNSS) RWY 26L

One of the main objectives is to maintain landing capacity at normal levels should the ILS be out of service. Air France has retrofitted 52 Boeing 777 aircraft with LNAV/VNAV capability. The RNP APCH is flown in a very similar way as a normal ILS approach.

CDG uses a combination of RNP APCH and ILS for independent parallel approaches to RWY 26L and 26R.

There was a question regarding how this works in Airbus aircraft. Pascal Collès responded that Airbus uses cross-track error for monitoring. If exceeding 0.3 NM deviation an alarm is given to pilots and a go-around is executed. See also below.

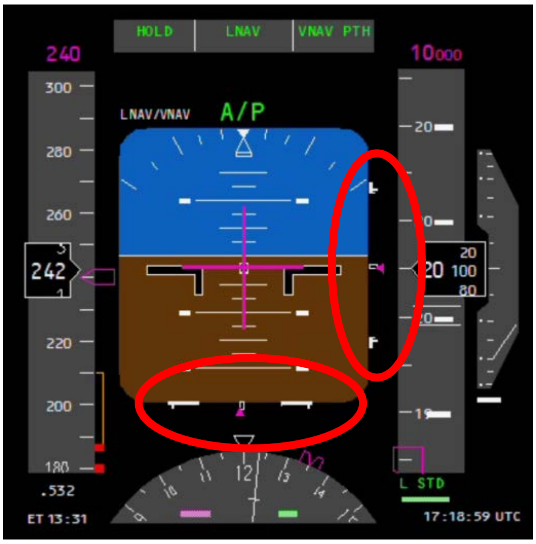


Figure 15 - Primary Flight Display with RNP and ANP indicators

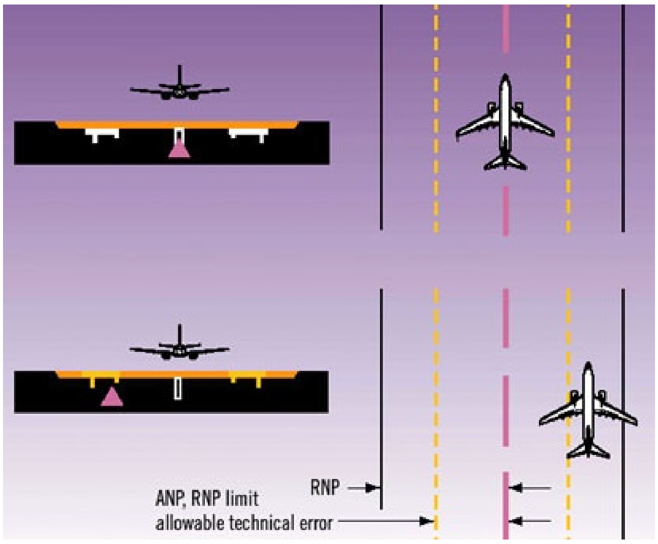


Figure 16 - ANP and RNP indicators

E.5 Germany

Presented by Andre Biestman, DFS.

DFS is planning to publish RNP1 based SIDs in Frankfurt, Munich, Düsseldorf and Berlin as follows:

Task	AIRAC (according to contract)	AIRAC (current planning)	Status
03 - FRA RWY 25	July 20th, 2017	July 20th, 2017	implemented
02 - FRA RWY 07/18*	March 29th, 2018	March 28th, 2019	planned
06 -MUC	May23rd, 2019	May23rd, 2019	planned
04 -DUS	March26th, 2020	March26th, 2020	planned
05-BER*	December 5th, 2019	December 3rd, 2020	planned

At Frankfurt Airport, there are five departure runways with multiple SIDs. Since 2016 several new RNP SIDs including RF legs have been tested for runways 25, 07 and 18. RF legs have been tested for noise abatement as well as for terrain avoidance.

Simulated flights were flown in B748 and A320 full-flight simulators with representatives from the German regulator present. For runway 25 two RF legs were necessary where zero wind and 25 degrees of bank angle were used. See below.

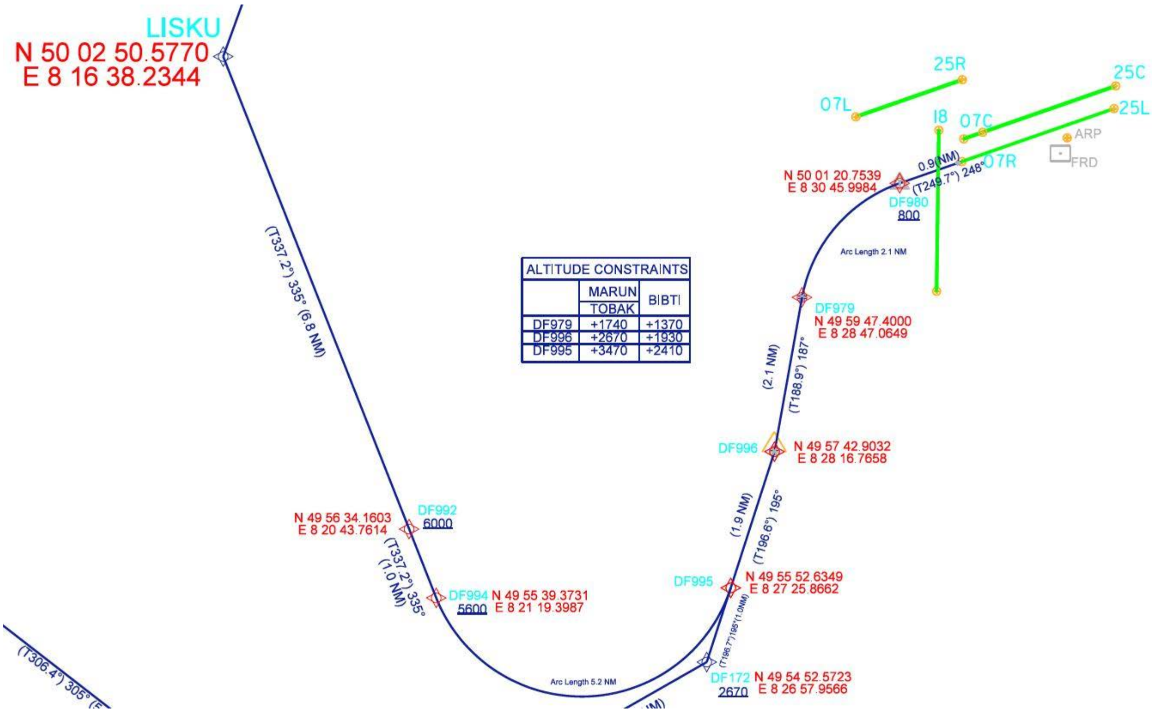


Figure 17 - FRA airport new RNP SID RWY25

Lufthansa also conducted several flight trials with A380, A320, B748 aircraft with more than 7500 flights in operational trials, see the following graph. The local communities are happy with the new departure procedure. The regulator accepted the procedure but required strong monitoring of noise exposure.

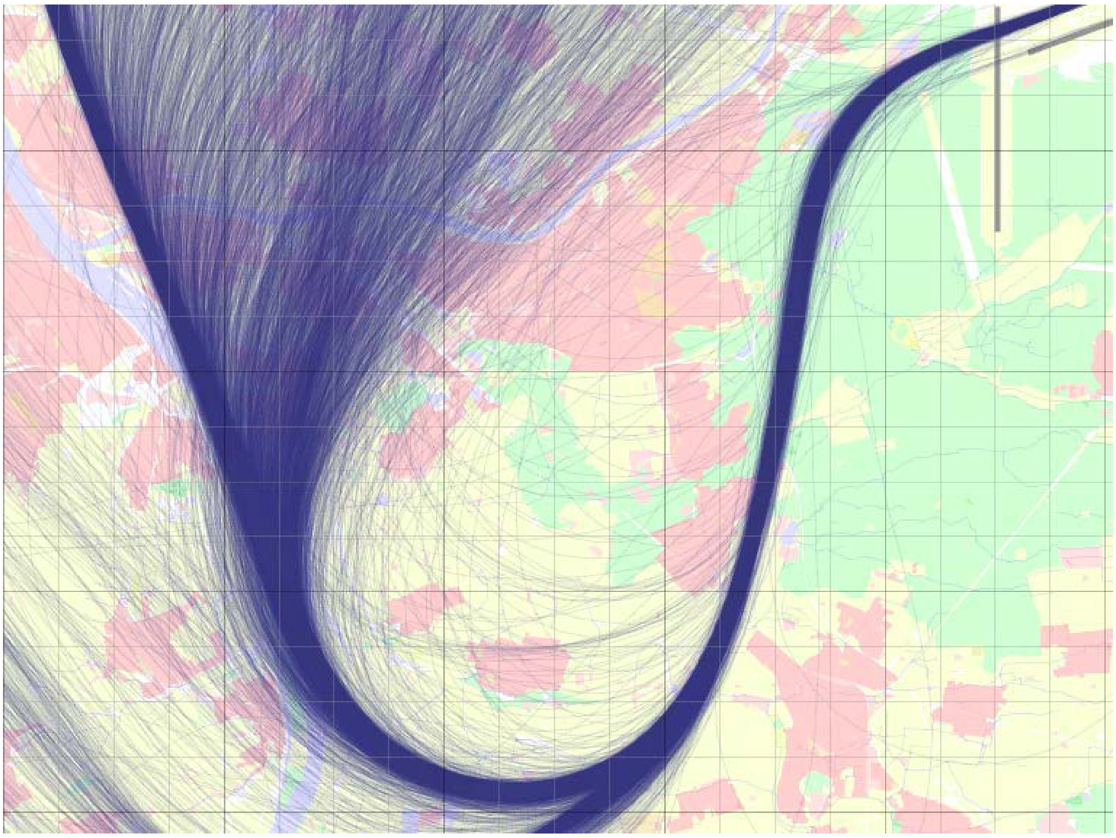


Figure 18 - Lufthansa departure tracks from FRA RWY25C

Expectations for improved capacity and flight efficiency have not been confirmed yet and more analysis is necessary. DFS is now in the planning phase for RNP+RF SIDs for runways 07C, 07R and 18.

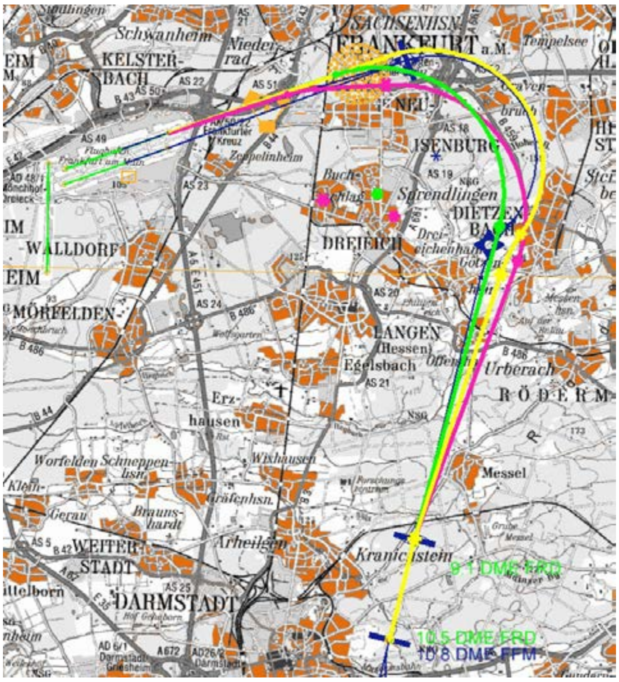


Figure 19 - RNP1+RF SIDs from FRA RWY07C and RWY07R

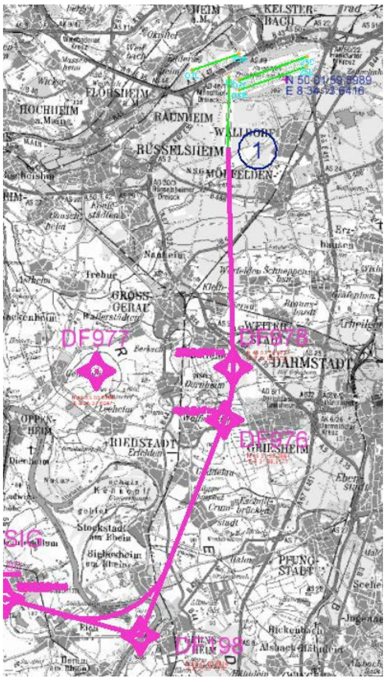


Figure 20 - RNP1+RF SID from FRA RWY18

E.6 Bogota, Colombia

Presented by Xavier Outters, NAVBLUE.

Bogota El Dorado Airport has been one of the fastest growing international airports in Latin America[9] and in need of significant improvements in capacity and efficiency. Traditionally all arrivals had been radar vectored by ATCOs causing a constant high workload and job dissatisfaction. Runways had been inefficiently used with holding patterns and bottlenecks at the surrounding VORs. Because of the high rise in air traffic there was an urgent need to modernize the airspace system.

NAVBLUE was awarded a contract for a project to increase capacity and airspace efficiency through:

- Introduction of PBN
- Reduction in aircraft separation within the TMA
- Implementation of independent and simultaneous parallel runway operations
- Improvements in ground operations
- Updates of regulations and operations manuals
- Enhancements of ATC capability with on-the-job training

NAVBLUE redesigned the TMA, new procedures & independent operations and also re-trained controllers. New RNP procedures have been published with effect from (WEF) 12th October 2017.

[9] Bogota El Dorado experienced more than 60 percent passenger growth and 15 percent increase in traffic in only six years during 2010-2016.

For RWY 13 the following SIDs and STARs and point merge system were introduced:

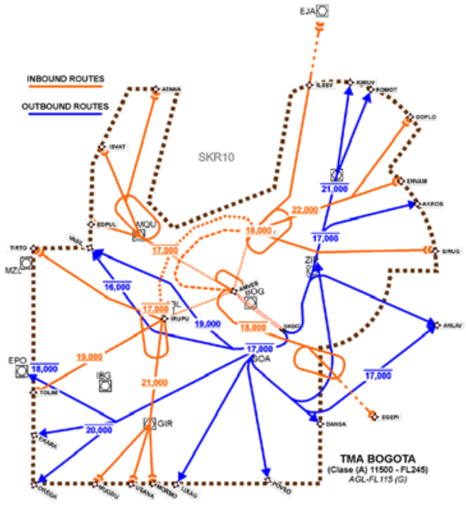


Figure 21 - Bogota SIDs and STARs RWY13

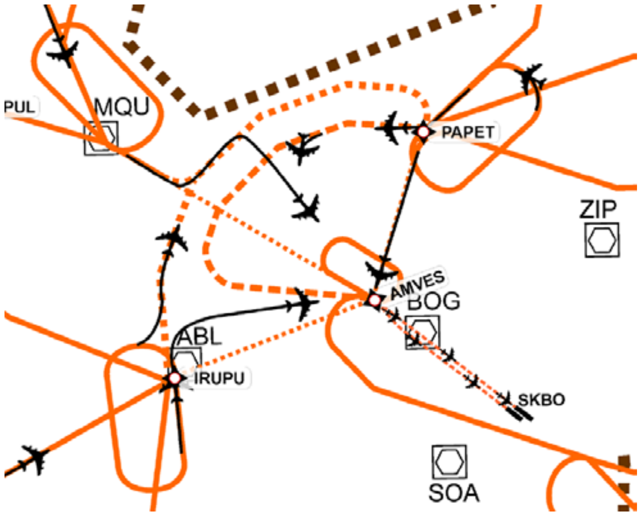


Figure 22 - Bogota Point Merge for RWY13

For RWY 31 the following SIDs and STARs were introduced. RNP AR is available for RWY 31L allowing 68 operations per hour.

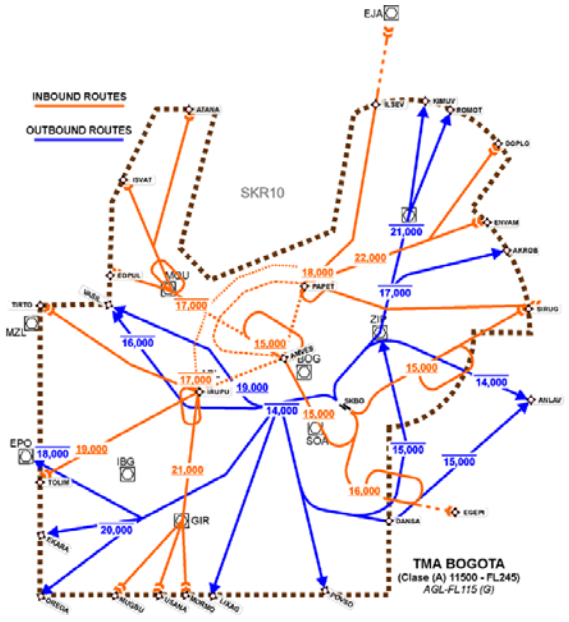


Figure 23 - Bogota SIDs and STARs RWY31

A restructuration of the TMA provided a better balance in workload between sectors and fewer conflicts to manage. ATCO intervention and workload was significantly reduced.

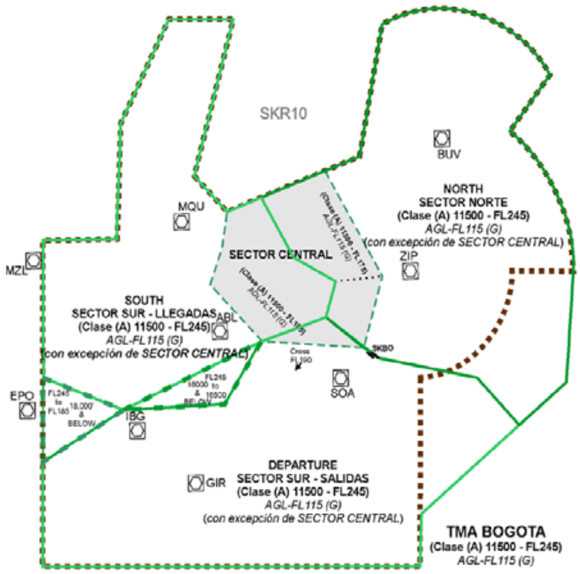


Figure 24 - Bogota new TMA

Challenges and lessons learnt from the Bogota project included:

- Design
  - RWY31 accessible for both RNP capable and non-capable through by keeping RNAV Visual approach procedure
  - Non-RNAV aircraft were given non-RNAV SIDs and STARs at lower altitudes and conventional ILS from BOG VOR.
  - The two-year project was only made possible through the inclusion of all stakeholders from project start
  - Jet and turboprop: routes designed considering fast traffic overtaking slower traffic
- ATCO training
  - ATCO community must be included in project from the start to make it possible to change 20 years old working methods into the new way of working.
  - All ATCOs were given tailored training including simulations and on-the-job training
- Stakeholders
  - Identify “non-believers” and lead them to understand and then “believe”. A must to have commitment from public stakeholders.
  - Discuss design options with each stakeholder. Not possible to realize all wishes, but the design can only get better with a continuous dialog.
- Military Flexible Use of Airspace (FUA)
  - Military users willing to share exclusive airspace when not in use, for the good of overall aviation industry.
  - A military-civilian FUA Letter of Agreement was established for how to share airspace

Appendix F. Questions and answers

Question	Answers
Regarding DP2017 inclusion of RF legs where beneficial, is this part of PCP review process?	SDM: This may be clarified with the revision of the PCP. Awaiting decision from the EC. DP 2017 states this to be a local decision by airspace designers.
How is A-RNP going to be implemented in Europe?	Rick F, EUROCONTROL: The A-RNP is a vague catalogue of specifications. The intention is to allow for a general certification of operators to fly all sorts of PBN procedures. It is still unclear how to achieve certification approval though.
Belgocontrol: The PCP states that RF shall be used in conjunction with RNP1 SIDs and STARs. The DP2017 specifies it as an optional solution. On what grounds should it be implemented and to what extent?	The DP is endorsed by the EC and has similar status as the PCP. It can therefore be referenced in Implementations Projects. RF is an optional solution which can be useful for example in noise mitigation or in advanced design of arrival and departure routes. It is important during design to involve all stakeholders.
The PCP requires the deployment of RNP1 SIDs and STARs but gives no information of when to use them in normal operations. Can SDM give some advice?	This is a fuzzy area. The deployment of RNP1 routes in the TMA must fulfil a purpose, such as more efficient routes and better predictability of the trajectory. It is up to the local implementer to find best possible use of such routes, in particular to find a good balance for use of RNP1 routes between non-capable and capable operators.
Spanish AF: What kind of monitoring and reporting sources can be used to follow PBN status in Europe?	For the scope of the PCP the DP2017 Monitoring View can be used.
Spanish AF: For the Canary Islands and other Spanish islands in the Atlantic, EGNOS service is only available around 20 percent of the time. What options do these airports have for PBN?	It is true that EGNOS is a fully available service in these areas. It is up to the local and Spanish national stakeholders to find the best possible solutions. Refraining from LPV and just use LNAV or LNAV/Baro-VNAV may be a way forward. ENAIRE: work is in progress with IOC date set to 2022.
How should PBN be implemented to provide good service also to operators who are non-PBN capable?	This is a matter of deciding on when to stop being “downwards” compatible. For the PCP airports, there is a high rate of RNP capability already and the trade-off between positive benefits for using RNP routes versus allowing non-capable operators access must remain a local decision.
There is a lack of avionics standards for automatic flight with regards to mode changes, for example on how to execute an RNP to ILS transfer using the autopilot. How does this affect PBN deployment?	SDM recognizes the issue, but is not aware of any ongoing regulatory activities.
Is Air France planning to retrofit fleet with SBAS?	Pascal Collès: not at the moment.
EDA: Why was no civil-military cooperation mentioned in the presentations?	SDM is committed to promoting Civil military coordination. The requirement is well entrenched in the Deployment programme and as of CEF Call

Question	Answers
	2017, submitted IP proposals shall include evidence that CIV-MIL coordination was performed and in what form. A good example was given by NAVBLUE in the Bogota implementation: Military were willing to share exclusive airspace with civilian users. A Letter of Agreement was established for how to share airspace.
Are CEF Calls proposals analysed in terms of cost/benefits before passing them onto INEA?	SDM: Yes, SDM is doing this.
Where is the overall concept? – ATM master plan.	SDM: The overall SESAR concept can be found in the ATM Master Plan.
What is the Lufthansa SBAS & RNP AR equipage?	Michael Hopp: 33 long haul & 6 short haul, only a few CS100 series by Swiss have RNP AR. If 4 miles from the threshold, turn onto FAF is RNP to ILS, if less then it's a RNP AR.
How to cope with interference between DME stations causing degradation of the DME station you are using?	Newer DME stations offer better performance. Guidance is under development in SESAR Pj14 partnership with EUROCAE concerning DME network topology.
Will RNP AR be split into generic and terrain specific areas?	UK CAA: We are looking into this. ILS stabilisation distance has to be minimum 3-4 NM.

Appendix G. Workshop programme

SDM WORKSHOP ON PBN

19 October 2017

Programme

Chair: Larry Johnsson, SDM

Time	Session	Speaker/Presenter
09.00-09.15	Registration and coffee	SRU
09.15-09.30	Welcome	Mariagrazia La Piscopia, SDM
09.30-10.00	Introduction to PBN and RNP	Rick Farnworth, Eurocontrol
10.00-10.45	PBN in PCP and DP • *What is required by PCP?* • *Coming PBN IR* • *GNSS Contingency* • *DP 2017* • *Expected benefits* • *Support to other DP Families* • *Role of SDM*	Larry Johnsson, SDM Jan Stibor, SDM
10.45-11.00	Coffee	
11.00-11.20	Airborne perspective • *Preferred way of flying* • *Aircraft capabilities* • *Retrofit* • *Crew training*	Michael Hopp, Lufthansa
11.20-11.40	Ground perspective (ANSP and airport) • *Airspace capacity/congestion* • *Airspace and procedure design* • *Validation of new procedures* • *Public consultation* • *Mixed mode of operation*	Tom Snyers, Belgocontrol
11.40-12.00	Regulator perspective • *Certification and installation of airborne equipment* • *Approval of airspace users to operate PBN* • *Approval of airspace design*	John Dow, UK CAA
12.00-12.20	Manufacturer perspective • *Navigation equipment on-board aircraft today* • *Future development of navigation capabilities* • *Retrofit of old aircraft*	Thierry Harquin, Airbus
12.20-13.00	Lunch	

Time	Session	Speaker/Presenter
13.00-13.20	Experience from real implementations - slot 1 Vienna, Austrocontrol	Daniel Schaad, Austrocontrol
13.20-13.40	Experience from real implementations - slot 2 London, NATS	Mark McLaren, NATS
13.40-14.00	Experience from real implementations - slot 3 Spain, ENAIRE	Ana Bodero, ENAIRE
14.00-14.20	Experience from real implementations - slot 4 Paris, Air France (with contribution from DSNA)	Hervé Marsal, Air France
14.20-14.40	Experience from real implementations - slot 5 Germany, DFS	André Biestmann, DFS
14.40-15.00	Experience from real implementations - slot 6 Bogota, NAVBLUE	Xavier Outters, NAVBLUE
15.00-15.15	Coffee	
15.15-15.30	Recommendations for deployment	Jan Stibor, SDM
15.30-16.15	Questions	Larry Johnsson, SDM
16.15-16.30	Closure	Larry Johnsson, SDM

Appendix H. List of participants

Name	Organisation
Francois-Xavier Rivoisy	Aeroports de Paris
Hervé Marsal	Air France
Pascal Collet	Air France
Thierry Harquin	Airbus
Daniela Di Febo	Alitalia
Philipp Schaad	Austrocontrol
Tom Snyers	Belgocontrol
Yves Brouwers	Brussels Airport
Jaksa Zizak	Croatia Control
Tomislav Barac	Croatia Control
Andre Biestmann	DFS
Anne Baumgarten	DFS
Laura Piccirillo	EC
Denis Bouvier	EDA
Ian Dryden	EDA
Ana Bodero	Enaire
Peter Eriksen	Eriksen-Aviation / Naviair
Cristina González Rechea	ESSP
Richard Farnworth	Eurocontrol
Clemens Schiebel	Fraport
Sebastian Hentrich	Fraport
Gábor Szlifka	Hungarcontrol
Zoltán Székely	Hungarcontrol
Nieves Rodriguez	Isdefe
Victoriano Garcia	Isdefe
Hakan Fahlgren	LFV
Michael Hopp	Lufthansa
Bart Banning	LVNL
Mark McLaren	NATS
Xavier Outters	NAVBLUE
Jan Stibor	SDM
Larry Jonsson	SDM
Mariagrazia La Piscopia	SDM
Monica Palacios Ituarte	SDM
Nigel Free	SDM
Tomas Paal	SDM
Aleksander Zerjal	Sloveniacontrol
Elena Rodriguez	Spanish Air Force
Luis Peña	Spanish Air Force
Pedro Salatti	Spanish Air Force
Patrick Manzi	Swedavia
Gonçalo Carpinteiro	TAP
Janite Parmanande	TAP
Ricardo Gaspar	TAP
John Dow	UK CAA