

PBN – a key step towards airspace modernisation

ICAO is leading a global initiative to introduce performance-based navigation standards that will meet future airspace operational needs. All member states are expected to have an implementation plan for Performance Based Navigation (PBN) by the end of this year, under the Assembly Resolution 36-23 passed in 2007. The long-term aim is to create global harmonisation of navigation specifications so that operators can take advantage of modern avionics to improve both flight efficiency and environmental performance. The introduction of common navigation standards underpins modernisation programmes like SESAR and NEXTGEN, which use precise aircraft navigation concepts to improve airspace safety and capacity.

PBN relies on area navigation systems that include satellite signals with advanced cockpit technology to fly the aircraft without depending on navigation to/from conventional ground-based navigational aids. It requires a shift from ground-based navaids that emit signals to aircraft receivers, to in-aircraft systems that compute the aircraft's position. The result is more direct a flight path that no longer needs to zig-zag between beacons on the ground. Many such navigation systems are already implemented and in daily use, but their ad-hoc development and lack of regulatory requirements has led to prescriptive applications, regional variations, and extra cost.

Under ICAO's PBN initiative, navigation is defined based on operational requirements. Operators then evaluate options in respect of available technology and navigation services. The concept represents a shift from sensor-specific navigation to performance-based navigation. It offers a number of advantages, not least in the way it allows technology to evolve over time without requiring a specific and costly certification process for each new operation. Operators have a limited set of navigation specifications that apply on a global basis. These are designed to support fuel-efficient route profiles, respond to noise abatement programmes, terrain issues, and in the long-term reduce costs associated with conventional ground-based infrastructure.

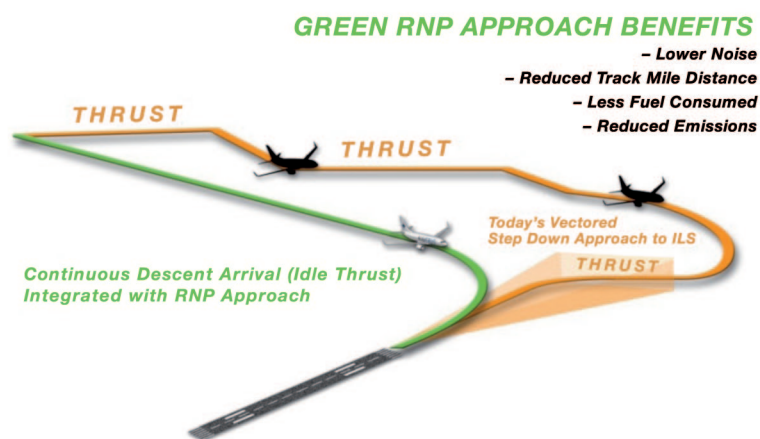
Air traffic management relies on communications, navigation, and

surveillance (CNS) to safely operate the airspace. While PBN refers to the navigation element of CNS, it nevertheless has to operate effectively with the communications and surveillance infrastructure. To encourage states to adopt advanced navigation concepts, ICAO has published an implementation guide, called the PBN Manual (ICAO Document 9613), which details performance requirements for aircraft operators and navigation service providers. It describes the PBN concept; along with RNAV systems performance requirements; safety assessments, and ICAO specifications which are to be used by states as a basis for certification and operational approval.

Area navigation (RNAV) enables aircraft to fly independently of ground-based navaids, within conventional flight

segment airspace design. A defining characteristic of more precise RNP operations is the ability of the aircraft navigation system to monitor the navigation performance it achieves by means of onboard checks and alerting systems.

Navigation specification defines performance required of the RNAV system together with any aircraft and crew requirements. Each navigation specification has a designator: for example RNAV 5, Basic RNP 1, RNP APCH, RNP AR APCH. The number in the designator represents the minimum lateral navigation accuracy in the nm that must be maintained for at least 95 per cent of the time. The detailed airworthiness requirements for RNAV and RNP were developed by the US and European bodies RTCA and



Performance-based navigation offers potential savings in fuel and emissions

Eurocae. These standards specify system accuracy, integrity, continuity and availability requirements for aircraft navigation and flight management systems.

PNB, and in particular the RNP navigation specifications, allow the introduction of precise, curved paths on the aircraft trajectory. It offers advantages during approach phases of flight, where it can support routes that avoid densely populated areas, or difficult terrain. At the most extreme end of the scale, RNP AR (Authorisation Required) criteria are specially customised and require advanced aircraft equipage and training, but yield more in terms of benefits for the operator. For example, RNP AR paths can reduce straight-in segments, typically 7-10 nm from the start of an Instrument Landing System, down to 4nm or less.

ICAO Air Navigation Bureau PBN Task Force leader Erwin Lassoij says: "We are not introducing a new type of navigation. The problem is not equipment onboard the aircraft. The challenge is on the implementation side. There are small pockets where it is in place, but we would like to move the whole world in that direction." He adds there are big efficiency and environmental gains, in addition to the recognised safety benefits, to be gained from implementation. One of the priorities for the Task Force is to communicate these benefits to potential users, and help them understand the path to implementation.

RNAV 5 and B-RNAV routes are already used in en route and continental airspace. The introduction of B-RNAV in Europe contributed to over 20 per cent increase in en route capacity in the late 1990s. In addition to the numerous RNAV 2 routes in the en route environment, the US has introduced hundreds of RNAV 1 routes in terminal airspace that provide alternatives to crowded conventional routes for suitably equipped aircraft.

"People fly RNAV routes, but do not always know what they are flying. They use the equipment and airspace, but in the past it has not been regulated. PBN not only requires the equipment to be onboard, but for the

correct ground infrastructure to be in place as well. So for certain designated RNAV 1 routes, there will be a requirement to have certified Distance Measuring Equipment (DME) on the ground." ICAO joined with FAA and EUROCONTROL to conduct PBN seminars to explain PBN planning processes and navigation specification requirements, visiting every ICAO region. Ten such seminars have been carried out, with more planned.

Lassoij explains that PBN will become easier to implement as satellite navigation services expand. At present, reliance on a single constellation of Global Positioning System (GPS) satellites means aircraft need integrity checks from equipment onboard as well as on the ground. The launch of Europe's Galileo system in the medium term, and an extra L5 bandwidth for GPS, will provide many more independent signals and different frequencies to help mitigate these integrity issues.

For the present, PBN performance requirements support the safety case for implementation, and a number of projects worldwide already demonstrate big gains including reduced fuel use, greener operations, and capacity gain.

Among successful projects, Airservices Australia introduced RNP approach procedures at Brisbane International Airport in 2007. During the first year of operation Qantas carried out over 15,500 procedures including more than 8,000 approaches. The airline achieved a reduction in track miles of 10.7nm

Benefits of PBN implementation

- Fuel savings – reduced track miles
- Fuel savings – continuous descent profiles
- Fewer denied boarding due to payload restrictions
- Increased revenues
- Fewer delays
- Fewer flight diversions
- Lower engine maintenance rates
- Reduced environmental impact
- More effective aircraft utilisation
- More efficient gate utilisation

(average 2 minutes 40 seconds) for each arrival, saving 650,000kg of CO₂ and 200,000 kg of fuel over the year. Airservices worked closely with Naverus Inc, Qantas Airways, Avtech of Sweden and Australia's safety authority CASA to implement six RNP approach procedures and 12 RNP departures based on proprietary criteria.

Brisbane reported additional benefits. In addition to a reduction in aircraft noise impact, non-RNP aircraft experienced reduced delays resulting from shorter arrivals for RNP aircraft. Australia has introduced RNP procedures at close to 15 airports. Naverus Chief Technical Officer Steve Fulton says: "In Australia, the results clearly have shown that RNP is not so much a Next Generation solution as it is a solution available today."

Advanced ideas from ICAO

ICAO's PBN Study Group is concentrating on developing an Advanced RNP navigation specification that will increase benefits without the need for an AR specification. "We hope to have a draft version by the end of the year that will apply to TMA and approach operations," says Lassoij. "Advanced RNP takes into account controlled turns (radius to fix) down to the approach phase, and represents the first steps into 4D navigation with required time of arrival (RTA). We are working together with Eurocontrol and the Europeans to include RF (radius to fix) in the terminal area. It will also incorporate helicopter requirements."

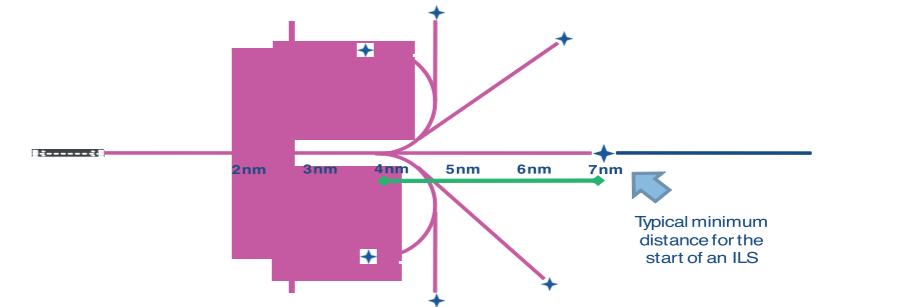
Only a few B737 and A320 aircraft have the capability to downlink 4D trajectory



RNP procedures introduced at Brisbane reduced the 70 dB and 75 dB footprints, and allowed the procedure to be placed over non-residential areas such as the Brisbane River according to AVTECH.

information, as the airlines are reluctant to pay for this option until ATC has the tools to make use of this data. The SESAR Joint Undertaking has launched a co-funded project to demonstrate the environmental benefit that can be derived from using current aircraft capabilities. The Minium Co₂ in TMA with current capabilities (MINT) programme is a consortium of Avtech, LfV, Novair, Airbus and Egis Avia. Avtech Programme Manager Christer Forberg says: "Many commercial aircraft can already support RNP and time-based operation. If RNP is used not only for terrain purposes but also for efficiency in the TMA (ie to shorten the final) then a lot of fuel could be saved. This could start already during the low density periods. Of course peak periods will be more challenging and arrival management needs to set the sequence earlier than today. In peak periods, ATC would issue RTAs to spread out arrival traffic over time, and thereby sequence arrivals in a smooth way instead of arrival peaks. The future support system will be a form of arrival manager, sequencer and/or conformance monitoring tool." The experiences of operations at Brisbane in Australia,

- Unlike RNAV or RNP-APCH, RNP-AR paths can be designed with curves and reduced straight-in segments while still providing precision guidance.
- Reduced track miles translate into reduced flight times, fuel consumption, CO₂ and other emissions... plus money.



Example: 4nm RNP Final (straight-in) versus ILS

Benefits of RNP procedures

Innsbruck in Austria, and several US airports show clearly that RNP operations result in benefits in terms of route efficiency and environmental impact. While the requirements for RNP AR are rigorous, many operators are beginning to discover the benefits can outweigh the costs in instances where terrain and noise issues are at stake. More importantly, the concept of

Performance Based Navigation moves airspace management away from conventional flight segments, towards trajectory-based operations, with the maximum benefit gained through using RNP approach procedures. It is therefore central to helping to meet the industry's long-term capacity and environmental challenges. ➤