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ICAO Heading for Performance based Navigation

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INTRODUCTION

The International Civil Aviation Organization (ICAO) is in the process of revising the current ICAO concept of required navigation performance (RNP) in order to meet current and future demands of aircraft operators and air navigation service providers for implementing performance-based navigation (PBN). PBN encompasses Area Navigation (RNAV) and Required Navigation Performance (RNP).
The growing focus on performance based navigation reflects the fact that PBN is increasingly seen as the most practical solution for the regulation of the ever continuing expansion of new navigation systems technology. ,Under the traditional, system-specific operational context, each new navigation system technology (such as DME/DME, IRU, GPS, GLONASS, SBAS GBAS, GRAS and Galileo) would be associated with new range of system specific requirements such as obstacle clearance criteria, separation criteria, operations (e.g. SBAS arrival procedures), aircrew operational training, and new air traffic controller training. This system-specific approach imposes an increasing significant investment on the part of ICAO and implementing States, airlines and air navigation service providers.
Performance-Based Navigation eliminates the need for redundant investment in criteria, operations and training. Rather than developing an operation around a particular system, under PBN the operation is defined based on the operational goals and the available system(s) are evaluated to determine if they support that operation. This will enable harmonized, predictable flight paths, resulting in more efficient use of existing aircraft capabilities, increased safety, airspace capacity and fuel efficiency, and facilitating the resolution of noise issues.

THE ORIGINAL ICAO RNP CONCEPT

The original ICAO RNP concept as defined by ICAO , was a supporting element of the Future Air Navigation Systems (FANS) concept. Its purpose was to introduce more flexibility and adaptability to change into global aviation operations by better exploiting the C,N and S capability of the aircrafts on board systems. It was developed to allow airspace planners to increase airspace capacity by specifying airspace and aircraft operational requirements based on the existing capabilities of the aircraft fleet, rather than relying on the normally lengthy process required for industry to comply with sensor-dependent specifications.

INDUSTRY DEVELOPMENT

The ICAO concept was widely acknowledged and well received. However it was perceived by industry as not detailed enough to be of practical use, especially in terminal airspace. Industry then developed the so called RNP/RNAV concept, a derivative of the ICAO RNP concept, which provided a more comprehensive technical support for performance, design, development, implementation, and qualification of aircraft navigation systems. An integral part of the industry concept was the specification of requirements for on-board performance and monitoring and alerting requirement. These specifications were specified, so as to be measurable, demonstrable and essential to enable improvements in airspace design and management, e.g. closer route spacing, reduced separation and obstacle clearance, etc.

RECOGNITION OF THE PROBLEM

As aircraft system capabilities evolved, it became apparent that the original guidance provided by ICAO provisions was insufficient to meet all industry demands , and unable to prevent the development of partially divergent industry specifications. As a result different types of RNP and/or RNAV were implemented based on the needs in different regions (e.g. RNP 5, P-RNAV, USRNAV etc.), see figure 1. These implementations fulfilled the requirements in these regions, but their development implied that the RNP concept that was designed to address the proliferation of new technology, was facing its own potential proliferation. This raised concerns in the international aviation community. Aircraft operators were and are still facing the increasing burden of regulatory compliance necessary to operate in the various regions, each having a different approval requirement. Potential safety risks were also identified, as operators and flight crews attempted to comply with all the pertinent regulations in an environment where the rules changed from region to region.

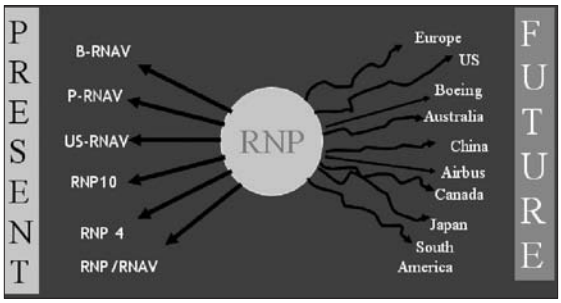

Figure 1. World wide divergence in implementation of RNP

ICAO recognized this undesirable situation and formed a new group, called the Required Navigation Performance Special Operational Requirements Study Group (RNPSORSG) to address the issues and make recommendations on how to proceed.

SOLUTION

The ICAO study group, consisting of participants from several States who are front-runners in RNAV and RNP implementation, as well as aircraft manufacturers, airlines and pilot associations, came to the conclusion that it was feasible to develop a globally harmonized concept that would meet current operational requirements and yet be flexible enough to also meet future requirements. The group recognized that the industry developments in the area of on-board performance monitoring and alerting requirements were valuable, and even of critical need in some cases, such as in the final approach phase (where on-board performance monitoring and alerting is critical to meet exacting obstacle clearance requirements).
At the same time, the group recognized that these capabilities would not necessarily be required to satisfy the operational requirements in all types of airspace, or in every application within a given airspace and would not always be cost-beneficial. It was therefore concluded that a concept focused on performance-based navigation and harmonizing elements of the industry concept and of the current ICAO concept would best answer the need. This concept includes all segments of flight, including en-route terminal area and final approach where RNP will be used as a basis for obstacle clearance.
It is expected that the revised concept will harmonize the currently available area navigation (RNAV) and RNP- designated performance-based navigation applications, particularly in the terminal area, where a divergence in implementations has been noticed.
One of the essential elements of the concept is the recognition that a clear distinction must be made in the designation of operations, between those operations that require onboard performance monitoring and alerting and those that do not. It was agreed that navigation specifications for operations that do not require on-board performance monitoring and alerting should be designated RNAV-X, while for operations that do require these capabilities, the navigation specification would be designated as RNP-X. The "X" in the designation identifies the lateral navigation accuracy in nautical miles that is required during at least 95 per cent of the flight time.
The specifications associated with each designation meet current operational requirements, while allowing global harmonization, leading to greater efficiency and lower costs for aircraft operators, and ensuring enhanced safety. Furthermore, they are fully compatible with existing implementations. For instance aircraft meeting the RNAV-1 navigation

specification developed by the study group can fly in both P-RNAV and USRNAV type-B airspace.

Thus far the group has identified nine different navigation specifications (See table 1) for which there is a current operational need. They are listed in table 1 together with the applicable type of operation. Some of the specifications were already in existence, whereas other have been developed by the group. For existing specifications, a mapping between the current designation and the designation based on the new designation scheme is provided in the table.

In order to avoid future proliferation of regional navigation specifications in the future, the group also developed a process to develop a global navigation specification to address in a harmonized fashion any emerging regional requirements that could not be met by specifications listed in Table 1.

The RNAV 10, RNP 4, RNAV 5, RNAV 2 and RNAV 1 navigation specifications are either existing specifications or modified specifications based on existing regional implementations.

New RNP 1 and 2 specifications are currently under review by the RNPSORSG and designed for applications airspace that does not necessarily require radar monitoring and enhanced functionalities, such as RF turns, time of arrival control etc. These new specifications will enable enroute and terminal operations outside the coverage of ground navigation aids through the use of GNSS.

A new RNP 0.3 approach specification would provide a single, harmonized standard that accommodates Basic GNSS equipment as well as RNP-certified aircraft, and SBAS navigation equipment. This will eliminate the need for sensor-specific multiple approaches designed for different aircraft configurations but very similar performance characteristics.

ICAO is also addressing performance-based navigation in the approach phase through development of the relevant approach procedures. These procedures are designated as "RNP 0.3-0.1", reflecting the fact that the accuracy requirement is "scaleable" from 0.3 down to 0.1 NM depending on the procedure requirement. They require specific aircraft and aircrew authorization similar to that required for ILS Category II and III operations. The authorization is required pre-dominantly due to the reduced obstacle clearance surfaces in comparison to conventional RNP 0.3 approaches. The goal is that the criteria be equivalent to the US RNP/Special Aircraft and Aircrew Authorization Required (SAAAR) criteria. Their introduction will ensure that for this particular type of operation there will be complete global harmonization of flight procedure design, aircraft and operational criteria, resulting in significant safety and efficiency benefits.

The performance-based navigation concept that allows for RNAV-X and RNP-X operations will also need to be flexible enough to accommodate future operations, such as a potential requirement for 4-D navigation. An overview of the PBN concept showing how this all fits together is depicted in figure 2.

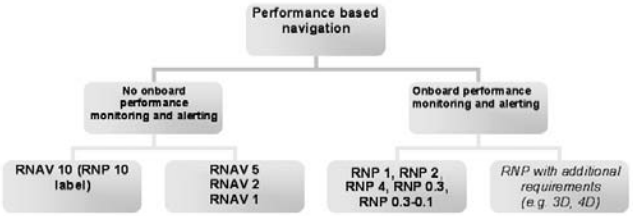

Figure 2. Performance based navigation concept. In bold, navigation specifications that already have an operational requirement or that are in development. Navigation specification in italic are examples of potential expansion after assessment of performance objective.

ICAO DOCUMENTATION

The new guidance material under development by RNPSORSG will be published as an ICAO Manual to provide implementation guidance for States, aircraft operators and air navigation service providers.. This manual will also contain a compendium of navigation specifications, including the applicable approval and aircraft qualification requirements. Related terminology in ICAO international Standards and Recommended Practices will also be aligned to the new designation scheme.

It is envisaged that the PBN manual will be available in draft on the ICAO-net by September this year, while the SARPs updates will be applicable in November 2008. This package of material will provide States a common international framework for implementation of performance-based navigation ensuring regulatory harmonization with minimum impact on aircraft equipage and safety oversight.

THE ROAD AHEAD

The above described documentation is only an initial basis to obtain successful world-wide implementation. Successful and timely implementation of performance-based navigation will require that ICAO provide consistent policy and guidance across the many disciplines touched by this programme. The RNPSORSG is nearing the completion of its initial goals and a few issues still need resolving:

Performance monitoring and alerting requirements

The RNPSORSG is considering the TSO C129 receiver as a sensor that would be suitable for RNP 1 and 2 operations that require performance monitoring and alerting. An issue that still need to be resolved in this respect is whether the level of performance monitoring and alerting provided by the TSO-C129 receiver is adequate.

RNP and RNAV designation

One aspect of the RNP and RNAV designation issue is not fully resolved yet. As there might be a need in the future for two different operations, both with "X" accuracy requirement but with different functional requirements, a method needs to be found to distinguish those types of operations. This could be done either by adding a suffix (e.g. RNP-1A) or by charting (e.g. note on the chart specifying additional functional requirements).

Area of application	Navigation accuracy (NM)	Navigation specification (current)	Navigation specification (new)	Requirement for performance monitoring and alerting
Oceanic/remote	10	RNP 10	RNAV 10 (RNP 10 label)	no
	4	RNP 4	RNP 4	yes
Enroute continental	5	B-RNAV RNP 5	RNAV 5	no
Enroute continental/Terminal	2	USRNAV type A	RNAV 2	no
	2	--	RNP 2	yes
Terminal	1	USRNAV type B and P-RNAV	RNAV 1	no
	1	--	RNP 1	yes
Approach	0.3	RNP 0.3	RNP 0.3	yes
	0.3 - 0.1	RNP/SAAAR	RNP 0.3 - 0.1 (RNP/AR)	yes

Table 1. Mapping between existing navigation specifications and new navigation specifications

Approach performance

At the moment PBN is focussed on linear performance criteria (supporting rectangular obstacle clearance areas). Discussions are ongoing on whether and how angular performance criteria (supporting trapezoidal obstacle clearance areas,such as with GBAS and SBAS) should be included in the concept of Performance based navigation. Another matter to be resolved is the requirement for Radius to fix (RF) legs and VNAV for RNP 0.3 approaches.

After finalization of the work of the RNPSORSG, it will be required that all related ICAO technical provisions be updated by expert groups in a coordinated manner. Therefore ICAO is in the process of establishing a long-term multi-disciplinary programme to coordinate the development and maintenance of ICAO provisions (such as route spacing, procedure design, charting, aeronautical databases, flight planning, radio navigation aids etc.) and to assist implementation of the PBN concept in the regions and States.

One important element of the multi-disciplinary programme that should not be overlooked in the introduction of the PBN approach is that of flight inspection of PBN procedures. Flight inspection is required to ensure that the procedure definition is correct, provides safe obstacle clearance and is supported by an adequate navaid infrastructure that is consistent with the target performance.

For instance, the new RNAV-1 and RNAV-2 navigation specifications can be supported by GNSS or by a DME-DME infrastructure. Provisions for flight-testing/inspection of GNSS (including augmentations) have already been developed (volume II of Doc 8071 + amendment to be published).

Flight inspection of DME-DME infrastructure (to ensure that it provides adequate accuracy and coverage) are being addressed within ICAO by the Navigation Systems Panel (NSP). This is a process that would typically involve several steps. Following the definition of the desired route on the basis of operational needs, an initial assessment of route feasibility is conducted to identify the candidate DMEs that could support the procedure on the basis of their anticipated coverage. The assessment can be conducted using software tools including a terrain model. Flight inspection is then performed to ensure that sufficient DME signal strength is available throughout the required route and to check for electromagnetic interference, obstructions and multipath effects. This involves a number of technical challenges for the flight inspection equipment to ensure a measurement accuracy enabling meaningful error measurements, and to provide an efficient approach to the measurement of multiple candidate DME (one run along the route instead of multiple runs). Following the inspection a final feasibility assessment will confirm if the infrastructure can support the route and will determine if any critical DMEs exist or if any DME will need to be deselected for the route due to excessive errors (to be identified in the relevant AIP). Critical DMEs may require specific adjustment to maintenance procedures and maintenance frequency. Work is currently underway within the NSP to develop material for inclusion in Doc 8071 and/or other ICAO document.

Other aspects of PBN that will need to be addressed from a flight inspection standpoint include the future development of navigation specifications based on advanced functional requirements (eg support of Radius to Fix legs, Time of Arrrival Control etc), which may need to be supported by flight inspection aircraft.

While the initial concept of RNP as envisaged by the FANS Committee many years ago, has served the aviation community well with implementation or RNP 10 and 4 in remote and oceanic airspace, aircraft navigation capabilities and ATM automation and concepts have advanced rapidly over the years. , The international civil aviation community is now at a turning point in the way that airspace is designed and ATM provided, on the basis of aircraft navigation performance. Major advances in safety, accessibility, efficiency and airspace capacity are expected from this effort.. To assist planners and regulatory authorities in taking advantage of these advances, ICAO, with the aid of an internationally recruited study group and the establishment of a performance based navigation programme, has stepped up to the challenge.

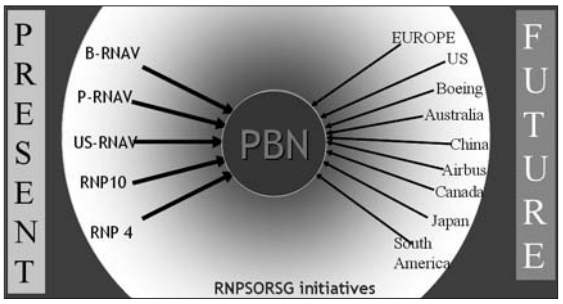

Figure 3. PBN convergence