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PERFORMANCE-BASED NAVIGATION (PBN) OPERATIONAL APPROVAL MANUAL

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(Advance unedited version)

FOREWORD

The purpose of this manual is to provide guidance on the operational approval process in the context of performance-based navigation (PBN). It is intended for flight operations inspectors and others involved in the regulation of PBN operations.

This manual is intended to supplement the existing guidance material on certification and operational approval found in the *Manual of Procedures for Operations Inspection, Certification and Continued Surveillance* (Doc 8335).

Future developments

Comments on this manual would be appreciated from all parties involved in the regulation of and issuance of approvals for PBN applications. These comments should be addressed to:

The Secretary General
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Montréal, Quebec, Canada H3C 5H7

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REFERENCES

ICAO documents

- *Manual of Procedures for Operations Inspection, Certification and Continued Surveillance* (Doc 8335)
- *Performance-based Navigation (PBN) Manual* (Doc 9613)
- *Required Navigation Performance Authorization Required (RNP AR) Procedure Design Manual* (Doc 9905)

Aeronautical Radio Inc (ARINC) documents

- Navigation System Data Base (ARINC Specification 424)

RTCA Inc

- Standards for Processing Aeronautical Data (DO200A)

European Organization for Civil Aviation Equipment (EUROCAE)

- Standards for Processing Aeronautical Data (ED76)

European Aviation Safety Agency

- Airworthiness Approval and Operational Criteria for the use of Navigation Systems in European Airspace designated for Basic RNAV Operations (AMC 20-4)
- Recognition of FAA Order 8400.12a for RNP 10 Operations (AMC 20-12)
- Airworthiness Approval and Operational Criteria for RNP APPROACH (RNP APCH) Operations (AMC 20-26)
- Airworthiness Approval and Operational Criteria for RNP Authorization Required (RNP AR) Operations (AMC 20-27)
- Airworthiness Approval and Operational Criteria for RNAV GNSS approach operation to LPV minima using SBAS (AMC 20-28)
- Airborne Supplemental Navigation Equipment using the Global Positioning System (GPS) (ETSO-C129a)
- Airborne Navigation Sensors using the Global Positioning System (GPS) Augmented by the Wide Area Augmentation System (WAAS) (ETSO-C145)
- Stand-Alone Airborne Navigation Equipment using the Global Positioning System (GPS) Augmented by the Wide Area Augmentation System (WAAS) (ETSO-C146)

Federal Aviation Agency

- Airworthiness Approval of Vertical Navigation (VNAV) Systems for use in the U.S. National Airspace system (NAS) and Alaska (AC 20-129)

- Airworthiness Approval of Global Navigation Satellite System (GNSS) Equipment (AC 20-138)
- Acceptance of Aeronautical Data Processes and Associated Databases (AC 20-153)
- Approval of US Operators and Aircraft to Operate under Instrument Flight Rules (IFR) in European Airspace Designated for Basic Area Navigation (B-RNAV/RNAV 5 and Precision Area Navigation (P-RNAV) (AC 90-96)
- US Terminal and En-route Area Navigation (RNAV) Operations (AC 90-100)
- Approval Guidance for RNP Procedures with SAAAR (AC 90-101)
- Approval Guidance for RNP Operations and Barometric Vertical Navigation in the U.S. National Airspace System (AC 90-105)
- Guidance for Localizer Performance with Vertical Guidance and Localizer Performance without Vertical Guidance Approach operations in the US National Airspace System (AC 90-107)
- Required Navigation Performance 10 (RNP 10) Operational Authorization (Order 8400.12)
- Procedures for Obtaining Authorization for Required Navigation Performance 4 (RNP 4) Oceanic and Remote Area Operations (Order 8400.33)
- Distance Measuring Equipment (DME) Operating within the Radio Frequency Range of 960-1215 Megahertz (TSO-C66c)
- Airborne Supplemental Navigation Equipment using the Global Positioning System (GPS) (TSO-C129)
- Airborne Supplemental Navigation Equipment using the Global Positioning System (GPS) (TSO-C129a)
- Airborne Navigation Sensors using the Global Positioning System Augmented by the Satellite Based Augmentation System (TSO-C145)
- Stand-Alone Airborne Navigation Equipment using the Global Positioning System (GPS) Augmented by the Satellite Based Augmentation System (TSO-C146)

ABBREVIATIONS

AAIM	Aircraft autonomous integrity monitoring
AC	Advisory circular
AFM	Aircraft flight manual
AHRS	Attitude and heading reference system
AIP	Aeronautical information publication
AIRAC	Aeronautical information regulation and control
AMC	Acceptable means of compliance
AMM	Aircraft maintenance manual
ANPE	Actual navigation performance error
ANSP	Air navigation service provider
AOC	Air operator's certificate
AP	Auto pilot
ARP	Aerodrome reference point
ASE	Altimetry system error
ATC	Air traffic control
ATIS	Automatic terminal information service
B-RNAV	Basic RNAV
BG	Body geometry
CAA	Civil aviation authority
CDI	Course deviation indicator
CDU	Control display unit
DA	Decision altitude
DGCA	Directorate general for civil aviation
DME	Distance measuring equipment
DOP	Dilution of precision
DR	Dead reckoning
EASA	European Aviation Safety Agency
EPE	Estimated position error
ETSO	European TSO
EUROCAE	European Organization for Civil Aviation Equipment
FAA	Federal Aviation Administration
FAF	Final approach fix
FAP	Final approach point
FD	Fault detection
FD	Flight director
FDE	Fault detection and exclusion
FMS	Flight management system
FOSA	Flight operational safety assessment
FRT	Fixed radius transition
FSD	Full scale deflection
FTE	Flight technical error
GNSS	Global navigation satellite system
GPS	Global positioning system
HAL	Horizontal alert limit
HFOM	Horizontal figure of merit
HIL	Horizontal integrity limit
HIS	Horizontal situation indicator
HPL	Horizontal protection limit
IFR	Instrument flight rules
INS	Inertial navigation system

IRU	Inertial reference unit
ISAD	ISA deviation
L/DEV	Lateral deviation
LCD	Liquid crystal display
LNAV	Lateral navigation
LOA	Letter of authorization
LP	Localiser performance
LPV	Localiser performance with vertical guidance
LRNS	Long range navigation system
MAPt	Missed approach point
MASPS	Minimum aviation system performance standard
MDA	Minimum descent altitude
MEL	Minimum equipment list
MEL	Minimum equipment list
MMEL	Master MEL
MOC	Minimum obstacle clearance
MOPS	Minimum operational performance standards
NAS	National airspace system (USA)
NAVAID	Navigation aid
NM	Nautical mile
NPS	Navigation performance scales
NSE	Navigation system error
OEI	One engine inoperative
OEM	Original equipment manufacturer
OM	Operations manual
P-RNAV	Precision RNAV
PBN	Performance-based navigation
PDE	Position definition error
PM	Pilot monitoring
RAIM	Receiver autonomous integrity monitoring
RF	Radius to fix
RNAV	Area navigation
RNP	Required navigation performance
RNP APCH	RNP approach
RNP AR	RNP authorization required
RSS	Root sum squared
RVSM	Reduced vertical separation minimum
SAAAR	Special aircraft and aircrew authorization required
SB	Service bulletin
SBAS	Space-based augmentation system
SID	Standard instrument departure
SOP	Standard operating procedure
STAR	Standard arrival route
STC	Supplemental TC
TC	Type certificate
TGL	Temporary guidance leaflet
TOGA	Take-off/go around
TSE	Total system error
TSO	Technical standard order
V/DEV	Vertical deviation
VAE	Vertical angle error
VEB	Vertical error budget

VHF	Very high frequency
VMC	Visual meteorological conditions
VNAV	Vertical navigation
VOR	VHF omnidirectional range
WAAS	Wide area augmentation system
WDM	Wiring diagram manual
WPR	Waypoint resolution error
WPT	Waypoint

CHAPTER 1. PERFORMANCE BASED NAVIGATION

1.1 INTRODUCTION

1.1.1 Conventional navigation is dependent upon ground-based radio navigation aids. It has been the mainstay of aviation for the last seventy years and pilots, operators, manufacturers and ANSPs are all familiar with the associated technology, avionics, instrumentation, operations, training and performance.

1.1.2 Performance Based Navigation (PBN) detailed in Doc 9613, The Performance Based Navigation Manual, is based upon area navigation principles. While various methods of area navigation have been in existence for many years, the widespread use of area navigation as a primary navigation function is a more recent phenomenon. The PBN concept is intended to better define the use of area navigation systems and is expected to replace much of the existing conventional navigation routes within the next twenty years.

1.1.3 The fundamentals of PBN operations are relatively straightforward, and operational approval need not be a complicated process for either applicant or regulator. However the transition to new technology, new navigation and new operational concepts and the dependence on data driven operations requires careful management. The PBN Operational Approval process is intended to ensure that the appropriate level of oversight is provided for all PBN operations in an environment where there are currently many variables, in terms of State regulations as well as experience in the related equipment, engineering and operational issues. In this way, the benefits of PBN will be achieved consistently and safely.

1.1.4 The key to successful PBN implementation is knowledge and experience. For many States, both operators and regulators lack both and this manual is intended to assist in improving this level of knowledge.

1.2 PBN OVERVIEW

1.2.1 Area navigation systems evolved in a manner similar to conventional ground-based routes and procedures. The early systems used very high frequency omnidirectional radio range (VOR) and distance measuring equipment (DME) for estimating their position in domestic operations and inertial navigation systems (INS) were employed in oceanic operations. In most cases a specific area navigation system was identified and its performance was evaluated through a combination of analysis and flight testing. In some cases, it was necessary to identify the individual models of equipment that could be operated within the airspace concerned. Such prescriptive requirements resulted in delays to the introduction of new area navigation system capabilities and higher costs for maintaining appropriate certification. The PBN concept was developed with globally-applicable performance requirements, detailed in accompanying navigation specifications, in order to avoid these high costs and delays.

1.2.2 The PBN concept requires that the aircraft area navigation system performance is defined in terms of the accuracy, integrity, availability, continuity and functionality necessary to operate in the context of a particular airspace concept. Appropriate positioning sensors are also identified, these may include VOR/DME, DME/DME, GNSS and/or Inertial systems. The performance is detailed in a navigation specification at sufficient level of detail to facilitate global harmonisation. The navigation specification not only lays out the aircraft system performance requirements but also the aircrew requirements, in terms of crew procedures and training, as well as any appropriate maintenance requirements, such the provision of navigation databases.

1.2.3 Area navigation systems are described in more detail in Annex A.

1.3 RNAV AND RNP

1.3.1 RNAV specifications have been developed to support existing capabilities in aircraft equipped with area navigation systems which, in the general case, were not designed to provide on-board performance monitoring and alerting. RNAV specifications are similar to RNP specifications but do not require an on-board performance monitoring and alerting capability.

1.3.2 RNP specifications have been developed from a need to support operations that require greater integrity assurance, where the pilot is able to detect when the navigation system is not achieving, or cannot guarantee with appropriate integrity, the navigation performance required for the operation. Such systems are known as RNP systems. RNP systems provide greater assurance of integrity and, hence, can offer safety, efficiency, capacity and other operational benefits.

1.4 NAVIGATION SPECIFICATIONS

1.4.1 The following navigation specifications have been published to date:

Flight Phase								
Navigation Specification	En-route Oceanic/ remote	En-route continental	Arrival	Approach				Departure
				Initial	Intermediate	Final	Missed	
RNAV 10	10							
RNAV 5[a]		5	5					
RNAV 2		2	2					2
RNAV 1		1	1	1	1		1[b]	1
RNP 4	4							
RNP 2	2	2						
Advanced RNP[f]	2	2 or 1	1	1	1	0.3	1[b]	1
RNP 1			1[d]	1	1		1[b]	1[d]
RNP 0.3[e]		0.3	0.3	0.3	0.3	-	0.3[b]	0.3
RNP APCH				1	1	0.3[g]	1[b] or 0.3[c]	
RNP AR APCH				1-0.1	1-0.1	0.3-0.1	1-0.1[f]	

Notes:

a. RNAV 5 is an en-route navigation specification which may be used for the initial part of a STAR outside 30 NM and above MSA.

b. Only applies once 50m (40m Cat H) obstacle clearance has been achieved after the start of climb.

c. RNP APCH is divided into two parts. This value applies during the initial straight ahead segment in RNP APCH Part B (SBAS LPV) approaches.

d. Beyond 30 NM from the airport reference point (ARP), the accuracy value for alerting becomes 2 NM.

e. The RNP 0.3 specification is primarily intended for helicopter operations.

f. If <RNP 1 is required in missed approach, the reliance on inertial to cater for loss of GNSS in final means that accuracy will slowly deteriorate and any accuracy value equal to that used in final can only be applied for a limited distance.

g. RNP APCH is divided into two parts. RNP 0.3 is applicable to RNP APCH Part A . Different angular performance requirements are applicable to RNP APCH Part B only.

1.5 PBN APPLICATIONS

1.5.1 A navigation application uses a navigation specification and the associated navigation infrastructure to support a particular airspace concept. This is illustrated in Figure 1

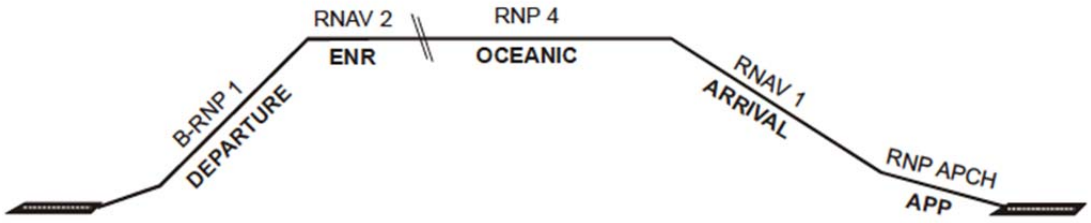


Figure 1.— Navigation specifications for airspace concept

CHAPTER 2. CERTIFICATION AND OPERATIONAL APPROVAL

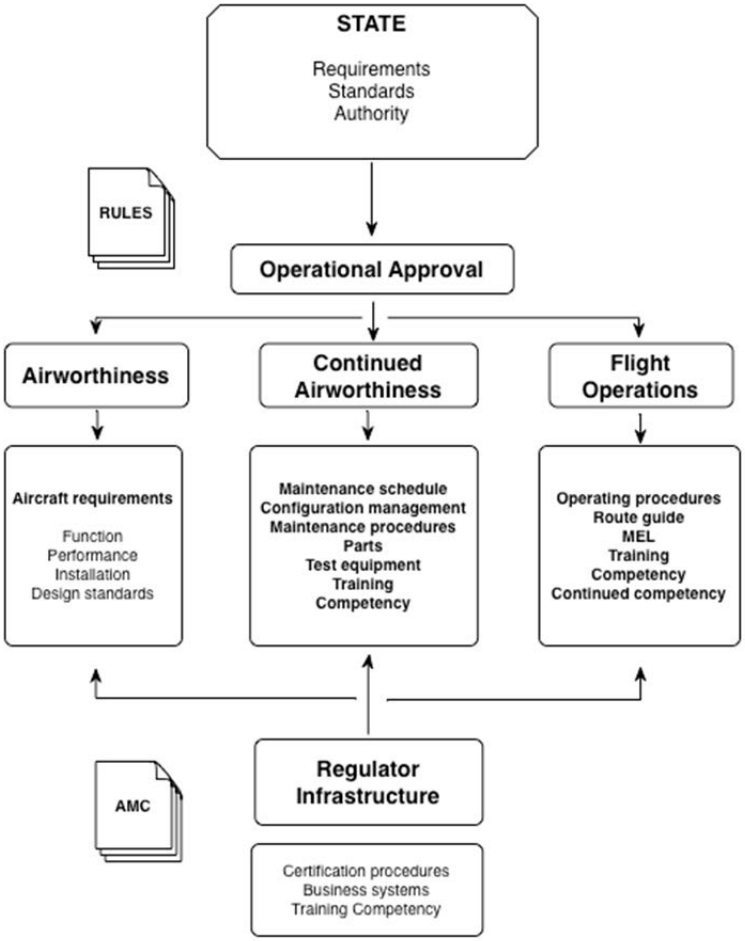
2.1 OVERVIEW

2.1.1 The PBN concept requires that the aircraft meets certain airworthiness certification standards, including the necessary navigation system performance and functionality, to be eligible for a particular application and that the operator has operational approval from an appropriate regulatory body before the system can be used. A PBN navigation specification operational approval is an approval that authorises an operator to carry out defined PBN operations with specific aircraft in designated airspace. The operational approval for an operator may be issued when the operator has demonstrated to the State of Registry/Operator regulatory authority that the specific aircraft are in compliance with the relevant airworthiness standard, and that the continued airworthiness and flight operations requirements are satisfied.

- The airworthiness element ensures that the aircraft meets the aircraft eligibility and safety requirements for the functions and performance defined in the navigation specifications (or other referenced certification standards) and the installation meets the relevant airworthiness standards e.g. US 14 CFR / EASA CS-25 and the applicable AC/AMC. The AC/AMC may also include other non-navigation equipment required to conduct the operation such as communications and surveillance equipment.

- The continued airworthiness element of the operational approval is not directly addressed in the PBN Manual since it is inherent in the aircraft airworthiness approval through the airworthiness requirements i.e. US 14 CFR / EASA CS-25.1529 but the operator is expected to be able to demonstrate that the navigation system will be maintained compliant with the type design. For navigation system installations there are few specific continued airworthiness requirements other than database and configuration management, systems modifications and software revisions but the element is included for completeness and consistency with other CNS / ATM operational approvals e.g. RVSM.

- The flight operations element considers the operator's infrastructure for conducting PBN operations and flight crew operating procedures, training and competency demonstrations. This element also considers the operator's MEL, Operations Manual, checklists, instrument flight procedure approval processes, navigation database validation procedures, dispatch procedures, etc.



2.2 STATE REGULATORY RESPONSIBILITIES

2.2.1 Individual States must develop national regulatory material which addresses the PBN applications relevant to their airspace or relevant to operations conducted in another State by the operators and aircraft registered in their State. Responsibility for all, or part of this activity may be delegated to Regional Safety Oversight Organisations. In line with current practice, small or less capable States may elect to adopt or even adapt the national regulatory material of the certification States with a relevant developed regulatory framework as an acceptable means of compliance.

2.2.2 There may be up to three different States and regulatory agencies involved in operational approval:

- State of Design / Manufacture: The organisation which has designed the aircraft applies for a Type Certificate (TC) from the State of Design. The State of Design also approves the Master Minimum Equipment List (MMEL), the mandatory maintenance tasks and intervals, and the Aircraft Flight Manual (AFM) and its amendments, which determine the PBN capabilities and limitations of the aircraft. A State of Design, which may be different from the State which issued the original TC, may

issue a design change approval for an aircraft as a Supplemental Type Certificate (STC).

- State of Registry: The State of Registry is the State in which the aircraft is registered. The State of Registry is responsible for the airworthiness of the aircraft. It approves the aircraft maintenance programme, in accordance with its regulations, and issues the Certificate of Airworthiness. It also approves aircraft repairs and modifications (as standalone modifications or as STCs). For General Aviation, the State of Registry approves the Minimum Equipment List (MEL) aircraft and the conduct of specified PBN operations.

- State of the Operator: The State of the Operator (which may be different from the State of Registry for commercial air transport operators) accepts the aircraft maintenance programme and approves the MEL, the flight crew training programmes and the conduct of specified PBN operations, in accordance with its regulations.

2.2.3 States should not re-approve technical data approved by another State; re-approving already approved technical data effectively transfers the regulatory responsibility for that data to the State re-approving the data with respect to aircraft registered under its jurisdiction. Where a State wishes to use technical data approved by another State, the State should review the data and determine that the data is acceptable for use in the State and formally accept the data; in this way, the regulatory responsibility remains with the State that originally approved the data. An example of regulatory text is provided in Annex C.

2.3 OPERATIONAL APPROVAL

2.3.1 Operational approval is usually the responsibility of the regulatory authority of the State of the Operator for commercial air transport operations and the State of Registry for general aviation operations.

2.3.2 The following factors can influence a State decision to require a formal operational approval process and specific documentation of approval:

a) the degree of linkage to the basis for aircraft/avionics certification, i.e. does the aircraft, including its RNAV or RNP navigation system, have an airworthiness approval covering the type of envisaged PBN operations;

b) the complexity of the PBN operation and the level of associated challenges to operators and regulators;

c) the maturity of the related operational concept and systems and, specifically, whether the issues are well understood and relatively stable;

d) the risk associated with improper conduct of operation and operator-specific safety expectations, as well as those of third parties in the air and on the ground;

e) the availability of appropriate training, checking standards and procedures for the respective type of PBN operations (mainly for pilots but also for maintenance and dispatcher personnel, as appropriate); and

f) the promulgation of information from holders of Type Certificates (TC) to air operators (e.g. MMEL and training requirements), throughout the life cycle of the aircraft.

2.3.3 State decisions in this area should be based upon balancing the efficient use of available regulatory resources, to ensure proper initial operator compliance and to promote ongoing operational safety, while also enabling the use of new technologies and operations in the interest of enhanced safety and efficiency.

2.3.4 In order to facilitate expedited approvals, provided all airworthiness and operational requirements are satisfied, States may "bundle" certain operations, particularly by flight phase, thereby allowing for leveraging of an operator's higher-level capabilities (see Figure 2). For example, an operator approved for RNP 1 operations might be readily approved for RNAV 1 operations provided State guidance is in place. States may also approach certain operations, such as those in the shaded area of Figure 2, as having less operational risk if adequate control mechanisms are implemented overall.

2.3.5 General aviation operators may not be required to follow the same authorization model as commercial operators although a State may determine that an LOA is also necessary for GA. Alternatively, a State may determine that a GA aircraft may operate on a PBN route/procedure provided that the operator has ensured that the aircraft has suitably approved equipment (is eligible), the navigation database is valid, the pilot is suitably qualified and current with respect to the equipment and adequate procedures (and checklists) are in place. Another consideration may be the ability for certain operators to document home State approval(s) for international operations. As such, issuance of a formal, specific approval may also be appropriate if only as an option to facilitate recognition by foreign States.

2.3.6 See www.xxx.xxx.xxx for example approaches to operational approvals for commercial air transport (CAT) and general aviation (GA) operators.

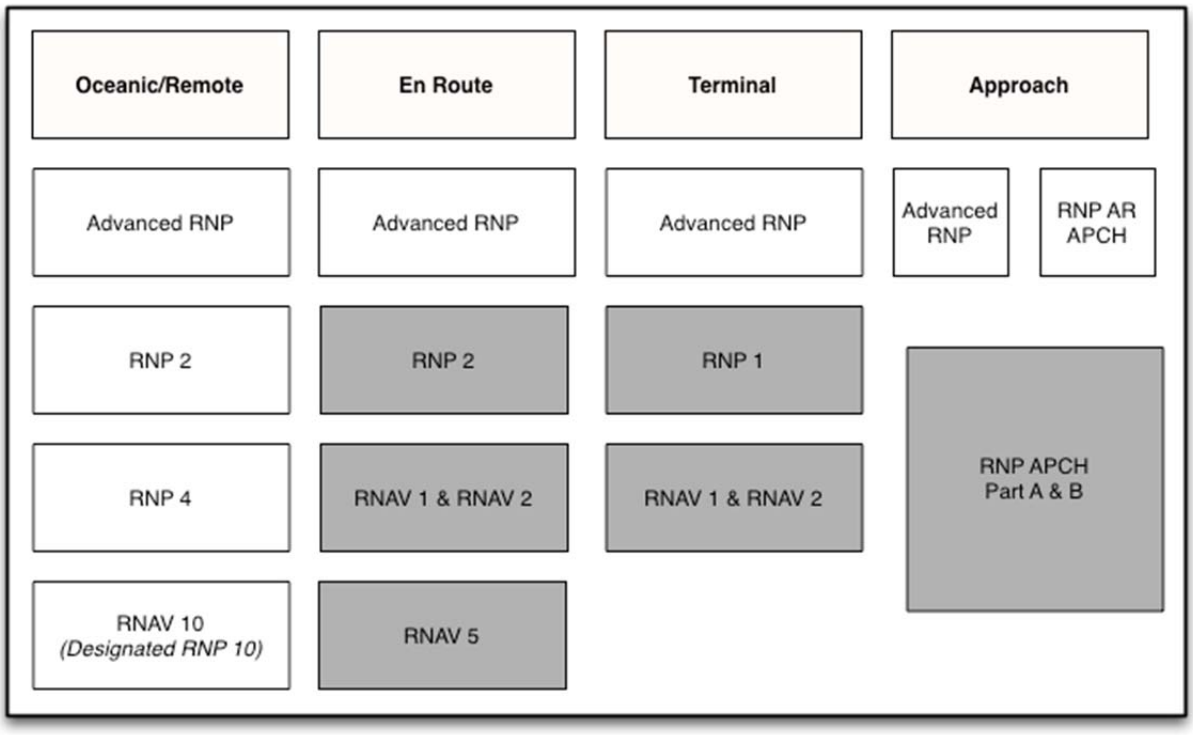


Figure 2 – Hierarchy of Navigation Specifications

Note1.— RNP 0.3 not included as it primarily deals with helicopter operations with specific applications.

Note 2.— RNP 4 navigation specification contains additional requirements beyond navigation.

2.3.7 The operational approval assessment must take account of the following:

a) aircraft eligibility and airworthiness compliance (any limitations, assumptions or specific procedures considered in the framework of the airworthiness approval must be addressed);

b) operating procedures for the navigation systems used;

c) control of operating procedures (documented in the operations manual);

d) flight crew initial training and competency requirements and continuing competency requirements;

e) dispatch training requirements; and

f) control of navigation database procedures. Where a navigation database is required, operators need to have documented procedures for the management of such databases. These procedures will define the sourcing of navigation data from approved suppliers, data validation procedures for navigation databases and the installation of updates to databases into aircraft so that they remain current with the AIRAC cycle. (For RNP AR applications, the control of the terrain database used by TAWS must also be addressed).

2.3.8 **Aircraft eligibility**

2.3.8.1 An aircraft is eligible for a particular PBN application provided there is clear statement in:

a) the TC; or

b) the STC; or

c) the associated documentation – AFM or equivalent document; or

d) a compliance statement from the manufacturer that has been approved by the State of Design and accepted by the State of Registry or the State of the Operator, if different.

The operator must have a configuration list detailing the pertinent hardware and software components and equipment used for the PBN operation.

2.3.8.2 The TC is the approved standard for the production of a specified type/series of aircraft. The aircraft specification for that type/series, as part of the TC, will generally include a navigation standard. The aircraft documentation for that type/series will define the system use, operational limitations, equipment fitted and the maintenance practices and procedures. No changes (modifications) are permitted to an aircraft unless the CAA of the State of Registry either approves such changes through a modification approval process, STC or accepts technical data defining a design change that has been approved by another State.

2.3.8.3 Alternate methods of achieving the airworthiness approval of the aircraft for PBN operations is for the aircraft to be modified in accordance with approved data (e.g. STC, minor modification, 8110-3)

2.3.8.4 One means of modifying an aircraft is the approved service bulletin (SB) issued by the aircraft manufacturer. The SB is a document approved by the State of Design to enable changes to the specified aircraft type and the modification then becomes part of the type design of the aircraft. Its applicability will normally be restricted by airframe serial number. The SB describes the intention of the change and the work to be done to the aircraft. Any deviations from the SB require a design change approval; any deviations not approved will invalidate the SB approval. The State of Registry accepts the application of a SB and changes to the maintenance programme, while the State of the Operator accepts changes to the maintenance programme and approves changes to the MEL, training programmes and operations specifications. An OEM SB may be obtained for current production or out of production aircraft.

2.3.8.5 For recently manufactured aircraft, where the PBN capability is approved under the TC, there may be a statement in the AFM limitations section identifying the operations for which the aircraft is approved. There is also usually a statement that the stated approval does not itself constitute an approval for an operator to conduct those operations.

2.3.8.6 In many cases for legacy aircraft, while the aircraft is capable of meeting all the airworthiness requirements of a PBN navigation specification, there may be no clear statement in the applicable TC or STC or associated documents (AFM or equivalent document). In such cases, the aircraft manufacturer may elect to issue an SB with appropriate AFM update or instead may publish a compliance statement in the form of a letter, for simple changes, or a detailed aircraft type specific document for more complex changes. The State of Registry may determine that an AFM change is not required if it accepts

the OEM documentation. Table 1 lists the possible scenarios facing an operator who wishes to obtain approval for a PBN application, together with the appropriate courses of action.

Scenario	Aircraft Certification Status	Actions by Operator/Owner
1	Aircraft designed and type certificated for PBN application. Documented in AFM, TC or the STC.	No action required, aircraft eligible for PBN application.
2	Aircraft equipped for PBN application but not certified. No statement in AFM. SB available from the aircraft manufacturer.	Obtain SB (and associated amendment pages to the AFM) from the aircraft manufacturer.
3	Aircraft equipped for PBN application. No statement in AFM. SB not available. Statement of compliance available from the aircraft manufacturer.	Establish if the statement of compliance is acceptable to the regulatory authority of the State of Registry of the aircraft.
4	Aircraft equipped for PBN application. No statement in AFM. SB not available. Statement of compliance from the aircraft manufacturer not available.	Develop detailed submission to State of Registry showing how the existing aircraft equipment meets the PBN application requirements. OEM support should be solicited where possible.
5	Aircraft not equipped for PBN application	Modify aircraft in accordance with the aircraft manufacturer SB or develop a major modification in conjunction with an approved design organization in order to obtain an approval from the State of Registry (STC).

Table 1.— Approval scenarios

Note.— The European Aviation Safety Agency (EASA) publishes the criteria required for airworthiness certification and operational approval to conduct PBN operations and member States apply these criteria. In the context of PBN, the EASA acceptable means of compliance (AMC) series is currently the repository for such criteria (in some cases, a Temporary Guidance Leaflet (TGL) is used). The Federal Aviation Administration (FAA), similarly, publishes Advisory Circulars (AC) and Orders for operations in US airspace. The ACs, Orders and AMCs usually reference appropriate Technical Standard Orders (TSO) and European TSOs (ETSO). TSO/ETSOs are also the responsibility of the FAA and EASA and provide technical and performance requirements for specific parts or items of equipment. A design organization, typically the aircraft manufacturer, may require a vendor to produce a TSO/ETSO approval before including such equipment into a system design. The ACs and AMCs may also reference industry standard documents such as the Minimum Aviation System Performance Standards (MASPS) or the Minimum Operational Performance Standards (MOPS), which are usually developed under the aegis of the RTCA and EUROCAE, and specific interoperability and interface standards such as those published by ARINC. The airworthiness certification requirements in the USA and in the European Union are largely 'harmonised' in order to reduce the costly and time-consuming work by OEMs and equipment vendors to gain approval from two different authorities with the same safety objectives. Some States have imposed additional constraints which are highlighted in Chapter 4. Table 2 lists the certification standards

published by EASA and the FAA for PBN applications (each document may reference additional standards including ACs, TSOs and RTCA/EUROCAE documents).

Navigation Specification	EASA	FAA
RNAV 10	AMC 20-12	Order 8400.12()
RNAV 5	AMC 20-4	AC 90-96()
RNAV 1 & RNAV 2	TGL 10 expected to change to a CS	AC 90-100()
RNP 4	Expected 2015	Order 8400.33
RNP 2	Expected 2015	tba
RNP 1	Expected 2015	AC 90-105
Advanced RNP	Expected 2015	tba
RNP 0.3	Expected 2015	tba
RNP APCH (LNAV)	AMC 20-27	AC 90-105
RNP APCH (LNAV/VNAV)	AMC 20-27	AC 90-105
RNP APCH (LPV)	AMC 20-28	AC 90-107
RNP AR APCH	AMC 20-26	AC 90-101
RF Attachment	Expected 2015	AC 90-105

Table 2.— EASA and FAA Certification Standards

2.3.9 **Operating procedures**

2.3.9.1 Standard operating procedures (SOP) must be developed to cover both normal and non-normal (contingency) procedures for the systems used in the PBN operation. The SOPs must address:

a) pre-flight planning requirements including the MEL and, where appropriate, RNP/RAIM prediction;

b) actions to be taken prior to commencing the PBN operation;

c) actions to be taken during the PBN operation; and

d) actions to be taken in the event of a contingency, including the reporting to the operator and to the CAA of significant incidents such as:

i) navigation errors not associated with transitions from an inertial navigation mode to a radio navigation mode;

ii) unexpected deviations in lateral or vertical flight path attributed to incorrect navigation data;

iii) significant misleading information without failure warning;

iv) total loss or multiple failures of the PBN navigation equipment ; or

v) problems with ground navigational facilities leading to significant navigation errors.

2.3.9.2 When operating procedures contribute directly to the airworthiness demonstration (e.g. in RNP AR) they should be documented in the AFM or an equivalent document (e.g. FCOM) approved by the State of Registry.

2.3.9.3 General aviation pilots must ensure that they have suitable procedures/checklists covering all these areas.

2.3.10 **Control of operating procedures**

The SOPs must be adequately documented in the operations manual (OM) for commercial air operators and for general aviation operators of large or turbojet aircraft. For general aviation operators where an OM is not required, the PBN operating procedures must still be documented.

2.3.11 **Flight crew and dispatch training and competency**

A flight crew and, if applicable, dispatcher training programme must cover all the tasks associated with the PBN operation as well as providing sufficient background to ensure a comprehensive understanding of all aspects of the operation.

2.3.12 **Control of navigation database procedures**

Navigation databases are required for all PBN navigation specifications except RNAV 10 and RNAV 5. The procedures for maintaining currency, checking for errors and reporting errors to the navigation database supplier must be documented in the operations and maintenance manual. Moreover, the suppliers of the navigation data are usually required to comply with FAA AC 20-153 or to be issued with a Letter of Authorization in accordance with EASA opinion Nr 01/2005.

2.3.6 **Performance record**

Navigation error reports should be recorded and analyzed to determine the need for any remedial action. Such action may involve the replacement of, or modifications to, the navigation equipment or changes to the operational procedures. All corrective action taken should be documented.

2.4 DOCUMENTATION OF OPERATIONAL APPROVAL

2.4.1 Operational approval may be documented through:

a) an amendment to the operations manual (OM), if it is required; and

b) an operations specification (Ops Spec), associated with the air operator’s certificate (AOC); or

c) a letter of authorization (LOA) for general aviation aircraft.

Example entries are provided at Annex B.

2.4.2 During the validity of the operational approval, the CAA should consider any anomaly reports received from the operator or other interested party. Repeated navigation error occurrences attributed to a specific piece of navigation equipment may result in restrictions on use or cancelation of the approval for use of that equipment. Information that indicates the potential for repeated errors may require modification of an operator's procedures and training programme. Information that attributes multiple errors to a particular pilot or crew may necessitate remedial training and checking or a review of the operational approval.

2.5 STATE REGULATORY MATERIAL

2.5.1 Individual States must publish national regulatory material which addresses the PBN applications relevant to their airspace or relevant to operations conducted in another State by the State's operators or by aircraft on their Registry. The regulations may be categorized by operation, flight phase, area of operation and/or navigation specification. Approvals for commercial operations should require specific authorization. Example regulatory text is provided at Annex C.

Note.— The EASA AMCs and the FAA ACs mentioned above also address operational approval. The ICAO South American Office (SAM) has published a set of PBN Advisory Circulars covering operational approval for PBN applications for use within the region. Many other States publish similar ACs or refer to existing ACs or AMCs in their national regulations. Table 3 lists the operational approval material published by ICAO (SAM) and Australia for PBN applications (each document may reference additional standards including ACs, TSOs and RTCA/EUROCAE documents):

Navigation Specification	ICAO (SAM)	Australia	NZ	Canada
RNAV 10	AC 91-001	AC 91U-2()		
RNAV 5	AC 91-002	CAAP B-RNAV-1		AC700-015
RNAV 1 & RNAV 2	AC 91-003	AC 91U-II-3-B		
RNP 4	AC 91-004	AC 91U - 3	AC 91-10	
RNP 1	AC 91-006	AC 91U-II-C-3		
A-RNP	-	-		
RNP 0.3	-	-		
RNP APCH (LNAV)	AC 91-008	AC 91U-II-C-5		
RNP APCH (LNAV/VNAV)	AC 91-010	AC 91U-II-Attachment-		
RNP APCH (LPV)	AC 91-011	-		
RNP AR APCH	AC 91-009	AC 91U-II-C-6		
RF Attachment		-		

Table 3.— Operational approval material

2.6 APPROVAL PROCESS

2.6.1 Since each operation may differ significantly in complexity and scope, the project manager and the operational approval team need considerable latitude in taking decisions and making recommendations during the approval process. The ultimate recommendation by the project manager and decision by the CAA, regarding operational approval should be based on the determination of whether or not the applicant:

a) meets the requirements established by the State in its air navigation regulations;

b) is adequately equipped; and

c) is capable of conducting the proposed operation in a safe and efficient manner.

2.6.2 The complexity of the approval process is based on the inspector's assessment of the applicant's proposed operation. For simple approvals, some steps can be condensed or eliminated. Some applicants may lack a basic understanding of what is required for approval. Other applicants may propose a complex operation, but be well prepared and knowledgeable. Because of the variety in proposed operations and differences in applicant knowledge, the process must be thorough enough and flexible enough to apply to all possibilities.

2.6.3 The approval process should consist of the following phases:

2.6.3.1 *Step 1 – Pre-application phase*

The operator initiates the approval process by reviewing the requirements; establishing that the aircraft, the operating procedures, the maintenance procedures and the training meet the requirements; and developing a written proposal to the regulator. A number of regulators have published “job aids” to assist the operator in gathering the necessary evidence to support the approval application. At this stage, a pre-application meeting with the regulator can also be very beneficial. If the proposed application is complex, the operator may need to obtain advice and assistance from OEMs or other design organizations, training establishments, data providers, etc.

2.6.3.2 *Step 2 – Formal application phase*

The operator submits a formal, written application for approval to the CAA, which appoints a project manager (either for the specific approval or generally for PBN approvals).

Note.— An example application form is contained in Annex D.

2.6.3.3 *Step 3 – Document evaluation phase*

The CAA project manager evaluates the formal, written application for approval to determine if all the requirements are being met. If the proposed application is complex, the project manager may need to obtain advice and assistance from other organizations such as regional agencies or experts in other States.

2.6.3.4 *Step 4 – Demonstration and inspection phase*

During a formal inspection by the project manager (assisted as necessary by a CAA team), the operator demonstrates how the requirements are being met.

2.6.3.5 *Step 5 – Approval phase*

Following a successful formal inspection by the CAA, approval is given via:

a) an amendment to the operations manual (OM); and

b) an operations specification (Ops Spec), associated with the air operator's certificate (AOC); or

c) a letter of authorization (LOA).

Note 1.— The approval procedure described above consists of a simplified process of the certification guidance contained in Part III of the Manual of Procedures for Operations Inspection, Certification and Continued Surveillance *(Doc 8335).*

Note 2.— The demonstration and inspection phase may not be required depending upon the area navigation system used, the type of operation and the supporting State regulatory structure. An aircraft equipped with standalone E/TSO-C129a (or higher) equipment and operated by an IFR qualified and current pilot may be "deemed" to hold a PBN operational approval for RNAV 5, for example.

2.7 INTERNATIONAL OPERATIONS

2.7.1 A State undertakes, in accordance with Article 12 to the Convention, to insure that every aircraft flying over or manoeuvring within its territory shall comply with the rules and regulations relating to the flight and manoeuvre of aircraft there in force. Article 33 to the Convention provides that certificates of airworthiness and certificates of competency and licences issued, or rendered valid, by the State in which an aircraft is registered, shall be recognized by other States, provided that the requirements under which such certificates or licences were issued or rendered valid are equal to or above the minimum standards which may be established by ICAO. This requirement for recognition is now extended by Annex 6, Part I and Part III, Section II, such that Contracting States shall recognize as valid an AOC issued by another Contracting State, provided that the requirements under which the certificate was issued are at least equal to the applicable Standards specified in Annex 6, Part I and Part III.

2.7.2 States should establish procedures to facilitate the application by foreign commercial air operators for acceptance to operate into their territory. States should be careful in their requirements for applications, to request only details relevant to the evaluation of the safety of the operations under consideration and their future surveillance. Guidance for evaluating an application by an operator from another State to operate within the territory of a State is contained in Part VI of the *Manual of Procedures for Operations Inspection, Certification and Continued Surveillance* (Doc 8335). Such evaluation is necessary in order for the State, in the terms of Article 33 to the Convention, to have confidence in the validity of the certificates and licences associated with the operator, its personnel and aircraft, in the operational capabilities of the operator and in the level of certification and oversight applied to the activities of the operator by the State of the Operator.

2.7.3 The operator will need to make applications to each State into or over which it is intended to operate. The operator will also need to keep its own CAA, as the authority of the State of the Operator, informed of all applications to operate into other States. Applications should be made direct to the CAAs of the States into which it is intended to operate. In some cases it will be possible to download information and both the instructions for making an application and the necessary forms, from a website maintained by the CAA in question.

CHAPTER 3. OPERATIONAL APPROVAL GUIDELINES

3.1 AIRCRAFT ELIGIBILITY

3.1.1 The first step in assessing an application for PBN operational approval is to establish that the aircraft and its systems are suitable for the specific operation.

3.1.2 The PBN Manual and the associated State regulatory material have only recently been issued and this means that there are many aircraft whose TC, STC and associated documentation (AFM) do not include references to PBN.

3.1.3 However, a lack of specific airworthiness certification does not necessarily mean a lack of PBN capability. If the aircraft is suitably equipped, it will be necessary to demonstrate this and that the aircraft is capable of the specific PBN operation. It is not meant to imply that additional certification is required to obtain approval although it is important that appropriate OEM input is obtained to support any claims of capability that is not part of the existing certification.

3.1.4 The aircraft eligibility assessment process needs to consider the capability, functionality and performance characteristics of the navigation and other relevant flight systems against the requirements of the particular PBN operation. In some cases operational mitigations and alternative means of meeting the PBN requirements may need to be considered. Considerable additional evaluation may be necessary before an aircraft is determined to be eligible for the issue of an operational approval, particularly for advanced navigation specifications such as RNP AR or A-RNP. While a large number of aircraft may never be considered to be eligible for RNP operational approval, for engineering, economical or practical reasons, many older aircraft have been certified to, or will be able to be approved for, RNAV operational approvals such as RNAV 10, RNAV 5, RNAV 2 and RNAV 1.

3.1.5 Operating mitigations are normally required to address deficiencies in the required aircraft qualification to undertake a particular operational procedure. These deficiencies could be items related to aircraft performance or information displays or availability.

3.1.6 The Operator should discuss the proposed changes and mitigations with their regulatory authority as early as possible.

3.1.7 In order to develop possible operational mitigations the operators should:

a) assess the aircraft qualification standard and fully understand the associated short-fall in navigation specification qualification;

b) assess the procedures that have been established by the State with respect to the area of operations. This review should identify the complexity of the proposed operation and the hazards associated with that operation.

3.1.8 Following the identification of the above, the operator should review their operational procedures and identify possible changes or additional requirements procedures/requirements that could mitigate the identified deficiencies and hazards. The proposed changes should be presented to their regulatory authority for authorisation/approval.

3.1.9 The operator should ensure that subsequent operations are conducted in accordance with any restriction or limitation specified by the regulatory authority.

3.1.10 A number of manufacturers have obtained, or are in the process of obtaining, airworthiness certification for specific PBN operations. In such cases the aircraft eligibility assessment can be greatly simplified. In the future it is anticipated that all manufacturers will seek appropriate PBN airworthiness certification for new aircraft.

3.1.11 The AFM may include a statement of RNAV or RNP capability without any reference to PBN. In many of these cases, the basis upon which a statement is included in an AFM is not consistent with the PBN Manual, as many of the terms, requirements, operating practices and other characteristics either differed or did not exist at the time the AFM was issued. Consequently, unless the AFM specifically references the relevant State regulatory documents consistent with PBN, additional information will need to be obtained to evaluate the relevance of the AFM statement.

3.1.12 In order to enable PBN operational approval a number of original equipment manufacturers (OEMs) provide additional information to support claims of PBN compliance and capability. Such supporting documentation may or may not be approved or endorsed by the State of manufacture, and it may be necessary to contact the relevant authority to validate the manufacturer's claims.

3.1.13 Where there is insufficient evidence of airworthiness certification, the aircraft capability assessment must include an evaluation of the navigation functionality as well as control, display, and alerting functions. Area navigation systems that were designed and installed before PBN implementation may not meet the minimum requirements, and avionics upgrades may be necessary.

3.2 OPERATING PROCEDURES

3.2.1 Standard operating procedures (SOP) must be developed to cover both normal and non-normal (contingency) procedures for the systems used in the PBN operation. Where possible, the practices and procedures should follow those laid down by the manufacturer and the air navigation service provider (ANSP) in whose airspace the PBN operations occur. The SOPs must be adequately documented in the operations manual (OM).

3.2.2 *Pre-flight planning requirements*

a) The flight plan should contain the appropriate statements of capability applicable to the PBN operations anticipated during the flight.

b) The on-board navigation database, where applicable, must be current and must contain the appropriate procedures, routes, waypoints and NAVAIDs.

c) A check must be carried out on the availability of appropriate NAVAIDs, including, where appropriate, RNP or RAIM prediction. Any relevant NOTAMS must be addressed.

d) An alternate approach must be identified, in the event of a loss of PBN capability.

e) The appropriate installed equipment must be serviceable.

3.2.3 Prior to commencing the PBN operation,:

a) if all the criteria are not met, the PBN procedure must not be requested;

b) if offered a clearance for a procedure whose criteria cannot be met, ATC must be advised “UNABLE ...”;

c) the loaded procedure must be checked against the chart;

d) it must be confirmed that the correct sensor has been selected and any NAVAID de-selection is complete, if required;

e) it must be confirmed that a suitable RNP value has been selected, if appropriate, and the navigation performance is adequate for procedure;

f) the contingency procedures must be reviewed.

3.2.4 During the PBN operation, the:

a) manufacturer’s instructions/procedures must be adhered to;

b) appropriate displays must have been selected;

c) lateral and, where appropriate, vertical deviation must not exceed prescribed values;

d) altitude and speed constraints must be observed;

e) procedure must be discontinued if there are integrity alerts, if the navigation display is flagged as invalid or if the integrity alerting function is not available.

3.2.5 In the event of a contingency:

a) ATC must be advised of any loss of PBN capability and proposed course of action;

b) where possible, documented procedures should be followed for:

i) navigation errors not associated with transitions from an inertial navigation mode to a radio navigation mode;

ii) unexpected deviations in lateral or vertical flight path attributed to incorrect navigation data;

iii) significant misleading information without failure warning;

iv) total loss or multiple failures of the PBN navigation equipment; or

v) problems with ground navigational facilities leading to significant navigation errors;

vi) communications failure.

3.2.6 *After-flight procedures*

The required reporting of navigation errors or malfunctions should be completed as applicable.

3.3 TRAINING

3.3.1 General

3.3.1.1 The navigation specifications cover a wide range of operations and training needs to be appropriate to the particular circumstances. Moreover, although each navigation specification includes guidance on flight crew training, the guidance is not consistent, in detail or scope, across the range of navigation specifications and there is much duplication. The amount and type of training required for flight crews varies significantly depending upon a number of factors including:

a) previous training and experience;

b) complexity of operations;

c) aircraft equipment.

It is therefore not possible to specify, for each of the navigation specifications, the particular training that will be required.

3.3.1.2 For en-route operations, ground training is usually sufficient to provide crews with the necessary knowledge. Delivery methods will vary, but classroom training, computer based training or, in some cases, desk-top simulation training is normally sufficient. Arrival and departure operations and approach operations, in particular, also require flight simulation training device use in addition to ground training and briefings.

3.3.1.3 Dispatcher training, as applicable, should be implemented to achieve the necessary competency in dispatch procedures related to PBN operations.

3.3.1.4 Consideration should also be given to the need for flight crews to demonstrate that competency standards are achieved and maintained, and the means by which the operator documents the qualification.

3.3.2 Knowledge requirements

3.3.2.1 The following knowledge requirements apply to all PBN operations, although the content and complexity will vary, depending upon the particular operations.

3.3.2.2 *Area navigation principles*

Area navigation is the basis for all PBN operations, and the same general knowledge is applicable to all navigation specifications. Pilots with previous experience of area navigation operations may not be familiar with some of the more advanced features such as radius to fix legs (RF), fixed radius transitions, required time of arrival (RTA) or the application of vertical navigation.

3.3.2.3 *Navigation system principles*

Flight crews should have a sound knowledge of the navigation system to be used. The relevance of the navigation system to the particular PBN operation should be clearly established. For example, knowledge of inertial navigation and updating is relevant to requirements for some oceanic and remote navigation specifications, as is the knowledge of GNSS for RNP APCH operations.

3.3.2.4 *Equipment operation and functionality*

Considerable variation exists in the operation of navigation equipment, cockpit controls, displays and functionality. Crews with experience on one type of installation or aircraft may require additional training on another type of equipment. Special attention should be paid to the differences between stand-alone GNSS equipment and flight management systems with GNSS updating and degraded modes of operation such as loss of integrity or loss of GNSS.

3.3.2.5 *Flight planning*

Knowledge of the relevant aspects of each of the navigation specifications that relate to flight planning is required.

3.3.2.6 *Operating procedures*

The complexity of operating procedures varies considerably between different PBN operations. RNP APCH and RNP AR APCH require a detailed knowledge of standard operating procedures for both normal and non-normal operations.

3.3.2.7 *Monitoring and alerting*

Flight crew responsibilities with respect to performance monitoring and alerting provided by the navigation system must be clearly understood.

3.3.2.8 *Limitations*

Operating limitations (e.g. time limits, minimum equipment) vary both between and within the navigation specifications and flight crews need to be able to recognize this and plan accordingly. Alternative means of navigation or other contingency procedures must be addressed. Flight crews need to be aware of the ATC procedures that may be applicable to the particular PBN operation.

3.3.3 Flight training requirements

3.3.1 Arrival, approach and departure operations require flight training and the demonstration of flight crew competency. The amount of flight training required varies with the anticipated operation, previous training and experience. In the course of operational approval evaluation all relevant circumstances need to be considered and the training assessed for completeness and effectiveness. Ongoing and recurrent training should also be considered.

3.3.2 The following guidelines are intended to aid the assessment of the extent of training that might be required. These guidelines assume that flight crews have previous relevant experience, and have completed knowledge training curriculum.

3.3.2.1 *En-route (oceanic, remote and continental)*

In general flight training is not required for en-route operations.

3.3.2.2 *Arrival and departure*

As departure and arrival operations require strict adherence to track during periods of higher workload and may be associated with minimum terrain clearance and reduced route spacing, crews need to be fully conversant with the operation of the navigation system. Consequently, unless crews have significant appropriate operational experience, simulator or flight training must be provided. Particular care should be taken when this type of operation is conducted with stand-alone GNSS equipment where functional limitations require crew intervention.

3.3.2.3 *RNP APCH*

Flight training for RNP APCH can be considered under two headings – stand-alone GNSS equipment and FMS equipment:

a) the training for RNP APCH operations using stand-alone GNSS equipment, particularly in a single-pilot aircraft, normally requires multiple in-flight exercises, each with pre-flight and post-flight briefing. Considerable attention should be given to the programming and management of the navigation system, including in-flight re-programming, holding, multiple approaches, mode selection and recognition, human factors and the navigation system functionality;

b) approaches conducted in FMS equipped aircraft, are generally much easier to manage as aircraft are usually equipped with map displays which aid situational awareness. Normal operations are quite simple and competency can be achieved with one or two approaches. Additional training should be provided to ensure familiarity and competency in operations which involve changes to the planned approach, system alerting and missed approaches. Attention should also be given to the method of vertical navigation to LNAV minima, to LNAV/VNAV minima and to LPV minima. Crews with previous relevant GNSS and area navigation experience can usually achieve competency during one full flight simulator training session with associated pre-flight and post flight briefing.

3.3.2.4 *RNP AR APCH*

RNP AR APCH operations require that all aspects of the operation are carefully addressed and appropriate attention is given to training. The safety of the RNP AR operation is often predicated upon the fact that the crew procedures provide a significant mitigation for a number of the hazards associated with the procedure. However, the mitigations vary widely depending upon the cockpit displays and the RNP system functionality. Accordingly training for RNP AR APCH operations should be extremely thorough and should ensure that crews are able to manage all operations, including non-normal operations, safely. As a guide, crews without previous relevant experience (e.g. RNP APCH with Baro-VNAV), may require a course of ground training plus simulator flight training in order to achieve competency.

3.4 NAVIGATION DATABASES

3.4.1 The packed navigation databases should be delivered to the operator at least one week prior to the AIRAC effective date. The operator should have procedures in place for ensuring:

a) the correct version of the navigation database is loaded on the aircraft;

b) any database errors/omissions reported by the suppliers are addressed expeditiously by flight crew briefing/removal of procedures etc.;

c) any database errors/omissions reported by the flight crew are addressed expeditiously by flight crew briefing/removal of procedures and reported back to the database suppliers;

d) the version of the loaded navigation database is checked for validity by the flight crew prior to departure;

e) prior to use, after loading into the area navigation system, the procedure is checked against the chart, by the flight crew, for waypoint sequence, waypoint transition, leg length, magnetic bearing, altitude constraint and speed constraint.

CHAPTER 4. NAVIGATION SPECIFICATIONS

4.1 RNAV 10

4.1.1 General

4.1.1.1 RNAV 10 supports 50NM lateral and 50NM longitudinal distance-based separation minima in oceanic or remote area airspace. Prior to the development of the PBN concept, RNAV 10 operations were authorized as RNP 10 operations. An RNAV 10 operational approval does not change any requirement nor does it affect operators that have already obtained an RNP 10 approval.

4.1.1.2 RNP 10 was developed and implemented at a time when the delineation between RNAV and RNP had not been clearly defined. As the requirements for RNP 10 did not include a requirement for on-board performance monitoring and alerting, it is more correctly described as an RNAV operation and hence the inclusion in the PBN Manual as RNAV 10.

4.1.1.3 Recognizing that airspace, routes, airworthiness and operational approvals have been designated as RNP 10, further declaration of airspace, routes, and aircraft and operator approvals may continue to use the term RNP 10, while the PBN Manual application will be known as RNAV 10.

4.1.1.4 RNAV 10 is applicable to operations in oceanic and remote areas and does not require any ground-based navigation infrastructure or assessment.

4.1.2 System requirements

4.1.2.1 RNAV 10 is intended for use in oceanic and remote areas and the navigation specification is based on the use of Long Range Navigation Systems. A minimum of two LRNSs is required for redundancy.

4.1.2.2 The most common combinations of dual LRNSs are:

a) dual INS;

b) dual IRS;

c) dual GNSS;

d) GNSS/IRS (IRS updated by GNSS).

4.1.2.3 Inertial systems (unless updated by GNSS) are subject to a gradual loss of position accuracy with time (drift rate) and their use is time-limited in order to meet the RNAV 10 accuracy requirement. The basic time limit is 6.2 hrs, but this may be extended by updating or by demonstration of reduced drift rate (<3.7km/2NM per hr.)

4.1.2.4 GNSS position is continuously updated and not subject to any time limit.

4.1.2.5 In order to be approved for oceanic and remote applications a GNSS receiver must be capable of excluding a faulty satellite from the solution (fault detection and exclusion (FDE)) so that continuity of navigation can be provided. FDE is standard for TSO C145A/146A GNSS receivers and is

available as an option or modification on some TSO C129( ) receivers. Consequently, where a TSO C129 ( ) GNSS is used to satisfy the requirement for one or both of the LRNSs it must be capable of FDE and approved for oceanic/remote operations.

4.1.2.6 The FDE requirement notwithstanding, the satellite constellation may be such that there are not sufficient satellites for the FDE computation and in such situations FDE is not available. In order to limit the exposure to the potential loss of a navigation solution due to unavailability of FDE, a prediction of satellite availability is required. The maximum period during which FDE may be predicted to be unavailable is 34 minutes. The same time limit applies to an IRS/GNSS system.

4.1.2.7 These time limitations mean that an RNAV 10 operational approval is not universal for aircraft without GNSS where the operator must evaluate the route(s) to be flown to determine if the RNAV 10 requirement can be satisfied. Moreover, for aircraft with INS or IRS only, attention must be paid to radio updating. Aircraft equipped with a Flight Management System normally provide automatic radio updating of inertial position. Automatic updating is normally considered adequate in such circumstances, provided the aircraft is within a reasonable distance of the radio aids at the point at which the last update is expected. If any doubt exists then the operator should be required to provide an analysis of the accuracy of the update. Manual updating is less common, and the operational approval needs to be based on a more detailed examination of the circumstances.

4.1.3 Operating procedures

4.1.3.1 The standard operating procedures adopted by operators flying on oceanic and remote routes should normally be generally consistent with RNAV 10 operations, although some additional provisions may need to be included. A review of the operator's procedure documentation against the requirements of the PBN Manual and the [State] regulatory requirements should be sufficient to ensure compliance.

4.1.3.2 The essential elements to be evaluated are:

a) the aircraft is serviceable for RNAV 10 operations;

b) RNAV 10 capability is indicated on the flight plan;

c) route limitations are defined and observed (e.g. time limits);

d) en-route loss of capability is identified and reported;

e) procedures for alternative navigation are described.

4.1.3.3 GNSS based operations also require the prediction of FDE availability. Many stand-alone GNSS service prediction programs are based on a prediction at a destination and do not generally provide predictions over a route or large area. RNAV 10 specific route prediction services are available from commercial sources.

4.1.4 Pilot knowledge and training

4.1.4.1 Unless the operator is inexperienced in the use of area navigation, flight crews should possess the necessary skills to conduct RNAV 10 operations with minimal additional training.

4.1.4.2 Where GNSS is used, flight crews must be familiar with GNSS principles related to en-route navigation.

4.1.4.3 Where additional training is required, this can normally be achieved by bulletin, computer-based training or classroom briefing. Flight training is not normally required.

RNAV 10 (DESIGNATED AND AUTHORIZED AS RNP 10) JOB AID

APPLICATION TO CONDUCT RNP 10 OPERATIONS

1. Introduction

RNAV 10 maintains the designation RNP 10, as specified in the ICAO document *Performance-based Navigation (PBN) Manual* (Doc 9613).

2. Purpose of the job aid

a) To provide information on the relevant reference documents.

b) To provide a record of the operator application, the inspector comments and the operator follow-up action for each relevant paragraph in the reference document(s).

3. Actions recommended for the inspector and operator

a) At the pre-application meeting, the operator and the inspector review the approval process events and establish the form and content of the approval application.

b) The operator records references to material in company documents for each relevant paragraph in the job aid.

c) The operator submits the completed job aid with the application to the inspector.

d) The inspector records his findings for each relevant paragraph in the job aid indicating compliance or necessary corrective action.

e) The inspector informs the operator as soon as possible when a corrective action is required.

f) The operator provides the inspector with the revised material when so requested.

g) The CAA provides the operator with the operational specifications (OpSpecs) or a letter of authorization (LOA), as applicable, when the tasks and documents have been completed.

4. **Reference documents**

Publisher	Reference	Title
ICAO	Annex 2	Rules of the Air
	Annex 6	Operation of Aircraft
	Doc 4444	PANS-ATM Air Traffic Management
	Doc 7030	Regional Supplementary Procedures
	Doc 9613	Manual on Performance Based Navigation
FAA	Order 8400.12A	Required Navigation Performance 10 (RNP 10) Operational Approval
	AC 20-130	Airworthiness Approval of Multi-sensor Navigational Systems for Use in the US National Airspace System.
	AC 20-138A	Airworthiness Approval of Global Navigation Satellite System (GNSS) equipment
	14 CFR Part 121 Sub-part G	Manual Requirements
EASA	AMC 20-12	Recognition of FAA Order 8400.12A for RNP 10 operations
CASA	(AC) 91U-2(0)	Required Navigation Performance 10 (RNP 10) Operational Approval
ICAO (SAM)	AC 91-001	Aircraft and Operators Approval for RNAV 10 Operations (Designated and Authorized as RNP 10)

PART 1. GENERAL INFORMATION

BASIC EVENTS OF THE APPROVAL PROCESS

	Action by Operator	Action by Inspector
1	Establish the need for the authorization	
2	Review AFM, AFM Supplement, TC Data Sheet, other appropriate documents (e.g. STCs, SB, SLs) to determine aircraft eligibility if necessary contact aircraft and/or avionics OEM to confirm eligibility.	
3	Schedule pre-application meeting with inspector	
4		During pre-application meeting establish: Form and contents of application Documents required to support application Target date of application submission Requirement for flight validation
5	Submit application at least XX days prior to start-up of planned operations	
6		Review submission
7	Ensure amendments to manuals, programmes and other relevant documents are complete; provide training to flight crews, flight dispatchers and maintenance personnel; if required, conduct validation flight	If required, participate in validation flight
8		Once requirements have been met, issue operational approval

PART 2. IDENTIFICATION OF AIRCRAFT AND OPERATORS

Name of Operator: _____

Aircraft manufacturer, model and series	Registration number	Serial number	Long range navigation systems manufacturer, model and number	PBN specification

Date of pre-application meeting: _____

Dare when application received by CAA: _____

Date when operator intend to begin RNAV 10 operations: _____

CAA notification date appropriate? Yes _____ No _____

PART 3. OPERATOR APPLICATION

Annex	Title	Inclusion by Operator	Comments by Inspector
A	**Request for Authorization**		
B	**Aircraft Group** Statement by the operator as to whether aircraft/LRNS combinations belong to a group of aircraft.		
C	**Aircraft Eligibility – Airworthiness** AFM, AFM Revision, AFM supplement, TCDS showing aircraft RNAV systems are eligible.		
D	**Aircraft Eligibility- Modifications (if applicable)** Maintenance records documenting installation or modification of aircraft systems to achieve eligibility		
E	**RNP 10 Time Limit and Area of Operations (if applicable)** For aircraft equipped with INS/IRU only, details of time limit and area of operations/routes for which aircraft is eligible.		
F	**Maintenance** For aircraft with established LRNS maintenance practices, the references to the maintenance document/programme. For recently installed LRNSs, details of the full maintenance practices.		
G	**Minimum Equipment List** Showing provisions for LRNS		
H	**Training** **xxx91 / GA operators or equivalent:** Course completion records. **xxx121 / xxx135 / CAT operators or equivalent:** Training programmes for flight crew, flight dispatchers and maintenance personnel.		

Annex	Title	Inclusion by Operator	Comments by Inspector
J	**Operating Policies and Procedures** **xxx91 / GA operators or equivalent:** Extracts from Operations Manual corresponding to application **xxx121 / xxx135 / CAT operators or equivalent:** Operations Manual and Checklists.		
K	**Performance Record** Evidence of previous problems, incidents or path-keeping errors, together with corrective action applied.		
L	**Withdrawal of Approval** The need for follow-up action on navigation error reports, with possibility of removal of approval.		
M	**Validation Flight Plan** As required.		

CONTENTS OF THE APPLICATION TO BE SUBMITTED BY THE OPERATOR

- Compliance documentation of the aircraft/navigation systems
- Operating procedures and policies
- Sections of the maintenance manual related to LRNS (if not previously reviewed).

Note.— Documents may be grouped in a single binder or may be submitted as individual document.

PART 4. CONTENTS OF OPERATOR APPLICATION

#	Topic	Specific ICAO Doc 9613 reference *(ICAO Doc 9613, Vol. II, Part B, Chap. 1)*	Specific State guidance reference *(AC/AMC/CA etc.)*	Operator compliance description *(Document reference/ method)*	Inspector disposition/ comments *(Accepted/not accepted)*	Follow-up by inspector (Optional) *(Status and date)*
1	**Authorization request** Statement of intent to obtain authorization	1.3.3.2				
2a	**Aircraft/navigation system eligibility** Documents that establish the eligibility. For RNP 10, the eligibility method(s) used and a list of the airframes included in each method	1.3.3.1 & 1.3.3.2.1				
2b	**Dual LRNS** At least 2 LRNS with displays and functions suitable for oceanic operations	1.3.4				
3	**Time limit for aircraft equipped with INS/IRU and no GNSS**	1.3.4.2.2 & 1.3.9.6				
4	**Area of operation for aircraft equipped with INS/IRU and no GNSS**	1.3.9.6				
5	**Training** Details of courses completed (xxx91 operators) Details of training programmes (xxx121 and xxx135 operators)	1.3.3.2.2.2 & 1.3.10				

#	Topic	Specific ICAO Doc 9613 reference *(ICAO Doc 9613, Vol. II, Part B, Chap. 1)*	Specific State guidance reference *(AC/AMC/CA etc.)*	Operator compliance description *(Document reference/ method)*	Inspector disposition/ comments *(Accepted/not accepted)*	Follow-up by inspector (Optional) *(Status and date)*
6	**Operating Policies and Procedures** Extracts from Operations Manual or other documentation (xxx91 operators) Operations Manual and checklists (xxx121 and xxx135 operators)	1.3.3.2.2.3 & 1.3.5				
7	**Maintenance Practices** Document references for established LRNS maintenance practices Complete copy of appropriate maintenance practices for new LRNS installations	1.3.3.2.2.5 & 1.3.11				
8	**MEL update** Only applicable to operations requiring an MEL	1.3.3.2.2.4				
9	**Past Performance** Record of operating history, including problems, incidents, track-keeping errors and corrective actions	1.3.3.2.5				
10	**Withdrawal of RNP 10 Authority**	1.3.12				
11	**Validation Flight Plan** If required.					

PART 5. OPERATING PROCEDURES

#	Topic	Specific ICAO Doc 9613 reference *(ICAO Doc 9613, Vol. II, Part B ,Chap 1)*	Specific State guidance reference *(AC/AMC/CA etc.)*	Operator compliance description *(Document reference/ method)*	Inspector Disposition/ Comments *(Accepted/not accepted)*	Follow-up by Inspector (Optional) *(Status and date)*
1	**Flight Planning**					
1a	Verify aircraft is approved for RNP 10 operations	1.3.7				
1b	Verify two LRNS operational	1.3.6				
1c	Verify RNP 10 time-limit taken into account (INS/IEU only)	1.3.5.2				
1d	Verify FDE available (GNSS only)	1.3.5.2 & 1.3.8				
1e	Verify FPL: 'R' in field 10 PBN/A1 in field 18	1.3.7				
1f	Verify operational restrictions as appropriate	1.3.5.2				
1g	Verify flight-planned route including diversions	1.3.7				
2	**Pre-flight**					
2a	Verify equipment conditions: Review flight technical records Confirm maintenance actions complete	1.3.5.3				
2b	Check condition of navigation antennae and surrounding fuselage skin	1.3.5.3				
2c	Review emergency procedures for RNP 10 operations	1.3.5.3				
3	**En-route**					
3a	Both LRNSs RNP 10 capable at Oceanic point of entry	1.3.9.1				
3b	Prior to Oceanic point of entry aircraft position independently checked and updated if necessary	1.3.9.2				
3c	Other mandatory navigation cross-checks	1.3.9.3				

#	Topic	Specific ICAO Doc 9613 reference *(ICAO Doc 9613, Vol. II, Part B ,Chap 1)*	Specific State guidance reference *(AC/AMC/CA etc.)*	Operator compliance description *(Document reference/ method)*	Inspector Disposition/ Comments *(Accepted/not accepted)*	Follow-up by Inspector (Optional) *(Status and date)*
3d	ATC notified if unable RNP or deviation required for contingency	1.3.9.4				
3e	Follow route centre-line within 5NM.	1.3.9.5				
4	**Update LRNS position**	1.3.9.7				

PART 6. CONTINGENCY PROCEDURES

#	Topic	Specific ICAO Doc 9613 reference	Specific State guidance reference *(AC/AMC/CA etc.)*	Operator compliance description *(Document reference/ method)*	Inspector disposition/ comments *(Accepted/not accepted)*	Follow-up by inspector (Optional) *(Status and date)*
1	Contingencies	(Doc 4444, Chapter 5, 15.2.1 and 15.2.2)				
1a	Inability to comply with ATC clearance due meteorological conditions, aircraft performance or pressurization failure	(Doc 4444, Chapter 5, 15.2.1.1)				
1b	Weather deviation	(Doc 4444, Chapter 5, 15.2.3)				
1c	Air-Ground comms failure	5.4.2.6.3.2 (Doc 4444, Chapter 5, 15.3)				

4.2 RNAV 5

4.2.1 General

4.2.1.1 RNAV 5 supports continental en-route operations using a range of different positioning sensors. Prior to the introduction of PBN, basic RNAV (B-RNAV) was introduced in Europe and the Middle East. The RNAV 5 requirements are based upon B-RNAV and any B-RNAV approval meets the requirements of RNAV 5 without further examination.

4.2.1.2 RNAV 5 is intended for en-route navigation where the airspace users are not all equipped with GNSS and where there is adequate coverage of ground-based radio navigation aids permitting DME/DME or VOR/DME area navigation operations.

4.2.1.3 An RNAV 5 route is dependent upon an analysis of the supporting NAVAID infrastructure. This analysis is the responsibility of the air navigation service provider.

4.2.2 System requirements

4.2.2.1 The RNAV 5 system requirements are not complex:

a) one single area navigation system is required;

b) the following sensors may be used:

i) VOR/DME;

ii) DME/DME;

iii) INS/IRS – if automatic radio updating is not carried out, a time limit of 2 hours usually applies from the last on ground position update;

iv) GNSS – receivers must be approved in accordance with ETSO C129(a), FAA TSO C129 (a) or later. (ETSO C129 or FAA TSO C129 is also applicable provided they include pseudo-range step detection and health word checking functions);

c) storage of a minimum of four waypoints is required. Manual data entry is permitted and a navigation database is not required;

d) area navigation system failure indication is required;

e) continuous indication of aircraft position relative to track to be displayed to the pilot flying (and the pilot not flying) on a navigation display situated in the primary fields of view;

f) display of distance and bearing to the active (To) waypoint;

g) display of ground speed or time to the active (To) waypoint;

h) lateral deviation display must have scaling and FSD $\leqslant \pm$ 5NM for RNAV 5 – the maximum FTE permitted is 2.5NM (½ FSD).

4.2.3 Operating procedures

4.2.3.1 Normal area navigation operating procedures will usually meet the requirements of RNAV 5.

The essential elements to be evaluated are that the operator's procedures ensure that:

a) the aircraft is serviceable for RNAV 5;

b) RNAV 5 capability is indicated on the flight plan;

c) en-route loss of capability is identified and reported;

d) procedures for alternative navigation are addressed.

If the navigation system does not use a navigation database manual waypoint entry significantly increases the potential for navigation errors. Operating procedures need to be robust to reduce the incidence of human error, including cross-checking of entry, checking of tracks/distances/bearings against published routes and general situational awareness and checking for reasonableness.

4.2.3.2 As RNAV 5 operations are typically conducted in areas of adequate NAVAID coverage, contingency procedures will normally involve reversion to conventional radio navigation using VOR/DMEs, VORs and NDBs.

4.2.3.3 GNSS based operations also require the prediction of FDE availability. Many stand-alone GNSS service prediction programs are based on a prediction at a destination and do not generally provide predictions over a route or large area. RNAV 5 specific route prediction services are available from commercial sources.

4.2.4 Pilot knowledge and training

4.2.4.1 Unless the operator is inexperienced in the use of area navigation, flight crews should possess the necessary skills to conduct RNAV 5 operations with minimal additional training.

4.2.4.2 Where GNSS is used, flight crews must be familiar with GNSS principles related to en-route navigation. Where additional training is required, this can normally be achieved by bulletin, computer-based training or classroom briefing. Flight training is not normally required.

4.2.5 Operational approval

4.2.5.1 The operational approval process for RNAV 5 is generally straightforward, given that most aircraft are equipped with area navigation systems which exceed the minimum requirements for RNAV 5.

4.2.5.2 In most cases the AFM will document RNAV 5 capability, failing that, many OEMs have issued statements of compliance and only occasionally will it be necessary to conduct an evaluation of aircraft capability.

4.2.5.3 With the exception of an amendment to the operations manual, a State may decide that there is no further requirement for any additional documentation of RNAV 5 approval.

RNAV 5 JOB AID

APPLICATION TO CONDUCT RNAV 5 OPERATIONS

1. **Purpose of the job aid**

a) To provide information on the relevant reference documents.

b) To provide a record of the operator application, the inspector comments and the operator follow-up action for each relevant paragraph in the reference document(s).

2. **Actions recommended for the inspector and operator**

a) At the pre-application meeting, the operator and the inspector review the approval process events and establish the form and content of the approval application.

b) The operator records references to material in company documents for each relevant paragraph in the job aid.

c) The operator submits the completed job aid with the application to the inspector.

d) The inspector records his findings for each relevant paragraph in the job aid indicating compliance or necessary corrective action.

e) The inspector informs the operator as soon as possible when a corrective action is required.

f) The operator provides the inspector with the revised material when so requested.

g) The CAA provides the operator with the operational specifications (OpSpecs) or a letter of authorization (LOA), as applicable, when the tasks and documents have been completed.

3. Reference documents

Publisher	Reference	Title
ICAO	Annex 2	Rules of the Air
	Annex 6	Operation of Aircraft
	Doc 4444	PANS-ATM Air Traffic Management
	Doc 7030	Regional Supplementary Procedures
	Doc 9613	Manual on Performance Based Navigation
FAA	AC 90-45()	Approval of Area Navigation Systems for use in the US National Airspace System
	AC 20-15	Approval of FMS in Transport Category Airplanes
	AC 25-4	Inertial Navigation Systems
	14 CFR Part 121 Sub-part G	Manual Requirements
EASA	AMC 20-4	Airworthiness Approval and Operational Criteria for the use of Navigation Systems in European Airspace designated for Basic RNAV Operations.
	AMC 20-5	Airworthiness Approval and Operational Criteria for the use of NAVSTAR global positioning system.
CASA	CAAP B-RNAV-1	Approval of Australian Operators and Aircraft to Operate under Instrument Flight Rules in European Airspace Designated for Basic Area Navigation
ICAO (SAM)	AC 91-002	Aircraft and Operators Approval for RNAV 5 Operations

PART 1. GENERAL INFORMATION

BASIC EVENTS OF THE APPROVAL PROCESS

	Action by Operator	Action by Inspector
1	Establish the need for the authorization	
2	Review AFM, AFM Supplement, TC data sheet, other appropriate documents (e.g. STCs, SB, SLs) to determine aircraft eligibility if necessary contact aircraft and/or avionics OEM to confirm eligibility.	
3	Schedule pre-application meeting with inspector	
4		During pre-application meeting establish: ▪ Form and contents of application ▪ Documents required to support application ▪ Target date of application submission ▪ Requirement for flight validation
5	Submit application at least XX days prior to start-up of planned operations	
6		Review submission
7	Ensure amendments to manuals, programmes and other relevant documents are complete; provide training to flight crews, flight dispatchers and maintenance personnel; if required, conduct validation flight	If required, participate in validation flight
8		Once requirements have been met, issue operational approval

PART 2. IDENTIFICATION OF AIRCRAFT AND OPERATORS

Name of Operator: _____

Aircraft manufacturer, model and series	Registration number	Serial number	Navigation systems manufacturer, model and number	RNP specification

Date of pre-application meeting: _____

Dare when application received by CAA: _____

Date when operator intend to begin RNAV 5 operations: _____

CAA notification date appropriate? Yes _____ No _____

PART 3. OPERATOR APPLICATION

Annex	Title	Inclusion by Operator	Comments by Inspector
A	**Request for authorization**		
B	**Aircraft eligibility – Airworthiness** AFM, AFM Revision, AFM supplement, TCDS showing aircraft RNAV systems are eligible.		
C	**Aircraft eligibility – Modifications (if applicable)** Maintenance records documenting installation or modification of aircraft systems to achieve eligibility		
D	**Maintenance** For aircraft with established maintenance practices, the references to the maintenance document/programme. For recently installed systems, details of the full maintenance practices.		
E	**Minimum equipment list**		
F	**Training** **xxx91 / GA operators or equivalent**: Course completion records. **xxx121 / xxx135 / CAT operators or equivalent:** Training programmes for flight crew, flight dispatchers and maintenance personnel.		
G	**Operating policies and procedures** **xxx91 / GA operators or equivalent:** Extracts from Operations Manual corresponding to application **xxx121 / xxx135 / CAT operators or equivalent:** Operations Manual and Checklists.		

CONTENTS OF THE APPLICATION TO BE SUBMITTED BY THE OPERATOR

- Compliance documentation of the aircraft/navigation systems
- Operating procedures and policies
- Sections of the maintenance manual related to navigation databases (if applicable)

Note.— Documents may be grouped in a single binder or may be submitted as individual document.

PART 4. CONTENTS OF OPERATOR APPLICATION

#	Topic	Specific ICAO Doc. 9613 reference *(ICAO Doc. 9613, Vol. II, Part B, Chap 2)*	Specific State guidance reference *(AC/AMC/CA etc.)*	Operator compliance description *(document reference/ method)*	Inspector disposition/ comments *(Accepted/not accepted)*	Follow-up by inspector (Optional) *(Status and date)*
1	**Authorization request** Statement of intent to obtain authorization					
2	**Aircraft/navigation system eligibility** Documents that establish the eligibility.	2.3.2.1 & 2.3.2.2.1				
3	**Training** Details of courses completed (xxx91 operators) Details of training programmes (xxx121 and xxx135 operators)	2.3.2.2.2 & 2.3.5				
4	**Operating Policies and Procedures** Extracts from operations manual or other documentation (xxx91 operators) Operations manual and checklists (xxx121 and xxx135 operators)	2.3.2.2.3				
5	**Maintenance Practices** Document references for navigation database maintenance practices	2.3.2.2.5 & 2.3.6				
6	**MEL update**	2.3.2.2.4				

PART 5. OPERATING PROCEDURES

#	Topic	Specific ICAO Doc 9613 reference *(ICAO Doc 9613, Vol. II, Part B, Chap. 2)*	Specific State guidance reference *(AC/AMC/CA etc.)*	Operator compliance description *(Document reference/ method)*	Inspector disposition/ comments *(Accepted/not accepted)*	Follow-up by inspector (Optional) *(Status and date)*
1	**Flight planning**					
1a	Verify aircraft is approved for RNAV 5 operations	2.3.4.2.2				
1b	Verify RAIM available (GNSS only)	2.3.4.3				
1c	Verify navaids available (non-GNSS)	2.3.4.2.4				
1d	Verify navigation database current and appropriate for region (if carried)	2.3.4.2.3				
1e	Verify FPL: 'R' in field 10 PBN/B1-B5 (as appropriate) in field 18	2.3.4.2.1				
1f	Verify operational restrictions as appropriate	2.3.4.4.3				
1g	Verify flight-planned route including diversions	2.3.4.4.1				
2	**General operating procedures**					
2a	Advise ATC if unable	2.3.4.4.1				
2b	Confirm navigation database up to date (if appropriate)	2.3.4.4.4				
2c	Cross-check chart with RNAV system display	2.3.4.4.5				
2d	Cross-check with conventional navaids to monitor navigational reasonableness	2.3.4.4.6				
2e	Follow route centre-line within 2.5NM.	2.3.4.4.8				
2f	Do not modify flight plan in RNAV system after ATC heading assignment until clearance to rejoin route or new clearance.	2.3.4.4.9				

PART 6. CONTINGENCY PROCEDURES

#	Topic	Specific ICAO Doc 9613 Reference *ICAO Doc 9613 Vol. II, Part B, Chap 2*	Specific State Guidance Reference *(AC/AMC/CA etc.)*	Operator Compliance Description *(Document reference/ method)*	Inspector Disposition/ Comments *(Accepted/not accepted)*	Follow-up by Inspector (Optional) *(Status and date)*
1	**Contingencies**					
1a	Advise ATC if unable RNAV 5	2.3.4.5.1				
1b	Air-Ground Comms Failure	2.3.4.5.2 (Doc 4444 Chapter 5 - 15.3)				
1c	GNSS RAIM Alert or Loss of RAIM	2.3.4.5.3				

4.3 RNAV 1 AND RNAV 2

4.3.1 General

4.3.1.1 RNAV 1 and RNAV 2 support operations in continental en-route, SIDs, STARs and Approach transitions using GNSS or DME/DME positioning. The RNAV 1 and RNAV 2 specifications represent an attempt at the harmonization of European Precision RNAV (P-RNAV) and United States RNAV (US-RNAV) requirements.

4.3.1.2 The RNAV 1 and RNAV 2 specifications apply to:

a) all ATS routes, including en-route;
b) standard instrument departures and arrivals (SID/STAR); and
c) instrument approach procedures up to the final approach fix (FAF)/final approach point (FAP).

4.3.1.3 As RNAV 1 and RNAV 2 operations can be based on DME/DME or DME/DME IRU, the NAVAID infrastructure must be assessed to ensure adequate DME coverage. This is the responsibility of the ANSP and is not part of the operational approval.

4.3.1.4 A single RNAV 1 and RNAV 2 approval is issued. An operator with an RNAV 1 and RNAV 2 approval is qualified to operate on both RNAV 1 and RNAV 2 routes. RNAV 2 routes may be promulgated in cases where the NAVAID infrastructure is unable to meet the accuracy requirements for RNAV 1.

4.3.2 Operational approval

4.3.2.1 For operators holding either a P-RNAV approval or a US-RNAV approval, the operational approval is relatively simple and minimal regulatory effort is required. Operators holding both P-RNAV and US-RNAV approvals should qualify for an RNAV 1 and RNAV 2 operational approval without further examination. There are some small differences between the P-RNAV and US-RNAV, and migration to RNAV 1 and RNAV 2 approval is not automatic unless the operator holds both US and European approvals.

4.3.2.2 For operators holding only a P-RNAV approval, or a US-RNAV approval, it is necessary to ensure that any additional requirements for RNAV 1 and RNAV 2 are met as laid down in the PBN Manual (Part B, Chapter 3 para 3.3.2.7)

4.3.2.3 Operators not holding a P-RNAV or US-RNAV approval need to be evaluated to determine that they meet the requirements for RNAV 1 and RNAV 2.

4.3.2.4 There is no obligation to obtain an RNAV 1 and RNAV 2 approval or to migrate an existing approval to RNAV 1 and RNAV 2 if the existing approval is applicable to the area of operation. Operators that operate only in P-RNAV airspace or only in US-RNAV airspace can continue to do so in accordance with a P-RNAV or US-RNAV approval respectively.

4.3.3 System requirements

4.3.3.1 The RNAV 1 and RNAV 2 system requirements are as follows:

a) a single area navigation system;

b) the following sensors may be used:

   i) DME/DME – accuracy is based upon TSO-C66c, system must be capable of auto-tuning multiple DME facilities, obtaining a position update within 30 seconds of tuning, maintaining continuous updating and performing reasonableness checks;

   ii) DME/DME/IRU – IRU performance in accordance with US 14 CFR Part 121 Appendix G, automatic position updating from the DME/DME position and must not allow VOR inputs to affect position accuracy;

   iii) GNSS – receivers must be approved in accordance with ETSO C129(a), FAA TSO C129 (a) or later. (ETSO C129 or FAA TSO C129 are also applicable provided they include pseudo-range step detection and health word checking functions);

c) a navigation database containing the routes and procedures;

d) area navigation system failure indication is required;

e) continuous indication of aircraft position relative to track to be displayed to the pilot flying (and the pilot not flying) on a navigation display situated in the primary fields of view;

f) display of distance and bearing to the active (To) waypoint;

g) display of ground speed or time to the active (To) waypoint;

h) display of active navigation sensor type;

i) lateral deviation display must have scaling and FSD of ⩽± 1NM for RNAV 1 or ⩽±2NM for RNAV 2 – the maximum FTE permitted is:

   i) 0.5NM for RNAV 1;

   ii) 1.0 NM for RNAV 2;

   Note.— Some States have authorized TSO-C129() equipment with FSD of ± 5NM on RNAV 2 routes.

j) automatic leg sequencing and fly-by or fly-over turn functionality;

k) execution of leg transitions and maintenance of tracks consistent with ARINC 424:

   i) CA
   ii) CF
   iii) DF
   iv) FM
   v) IF

vi) TF
vii) VA
viii) VI
ix) VM

4.3.3.2 For the majority of air transport aircraft equipped with FMS, the required functionalities, with the exception of the provision of a non-numeric lateral deviation display are normally available. For this category of aircraft lateral deviation is displayed on a map display, usually with a numeric indication of cross-track error in 1/10th NM. In some cases a numeric indication of cross-track error may be provided outside the primary field of view (e.g. CDU). Acceptable lateral tracking accuracy for both RNAV 1 and RNAV 2 routes is usually adequate provided the autopilot is engaged or the flight director is used.

4.3.3.3 Aircraft equipped with stand-alone GNSS navigation systems, should have track guidance provided via a CDI or HSI (a navigation map display may also be used for RNAV 2 routes). A lateral deviation display is often incorporated in the unit, but is commonly not of sufficient size nor suitable position to allow either pilot to manoeuvre and adequately monitor cross-track deviation.

4.3.3.4 Caution should be exercised in regard to the limitations of stand-alone GNSS systems with respect to ARINC 424 path terminators. Path terminators involving an altitude termination are not normally supported due to a lack of integration of the lateral navigation system and the altimetry system. For example, a departure procedure commonly specifies a course after takeoff until reaching a specified altitude (CA path terminator). Using a basic GNSS navigation system it is necessary for the flight crew to manually terminate the leg on reaching the specified altitude and then navigate to the next waypoint, ensuring that the flight path is consistent with the departure procedure. This type of limitation does not preclude operational approval (as stated in the PBN Manual functional requirements) provided the operator's procedures and crew training are adequate to ensure that the intended flight path and other requirements can be met for all SIDs and STAR procedures.

4.3.4 Operating procedures

4.3.4.1 Operators with en-route area navigation experience will generally meet the basic requirements of RNAV 1 and RNAV 2 and the operational approval should focus on procedures associated with SIDs and STARs.

4.3.4.2 Particular attention should be placed on the selection of the correct procedure from the database, review of the procedures, connection with the en-route phase of flight and the management of discontinuities. Similarly an evaluation should be made of procedures management, selection of a new procedure, including change of runway, and any crew amendments such as insertion or deletion of waypoints.

4.3.4.3 GNSS based operations also require the prediction of Fault Detection (FD) RAIM availability. Many stand-alone GNSS service prediction programs are based on a prediction at a destination and do not generally provide predictions over a route or large area. RNAV 1 and RNAV 2 specific route prediction services are available from commercial sources.

4.3.4.4 RNAV 1 and RNAV 2 operations are typically conducted in areas of adequate NAVAID coverage, contingency procedures will normally involve reversion to conventional ground-based radio navigation.

4.3.5 Pilot knowledge and training

4.3.5.1 Most crews will already have some experience area navigation operations and much of the knowledge and training will have been covered in past training. Particular attention should be placed on the application of this knowledge to the execution of RNAV 1 and RNAV 2 SIDs and STARs, including connection with the en-route structure and transition to final approach. This requires a thorough understanding of the airborne equipment, and its functionality and management.

4.3.5.2 Particular attention should be placed on:

- The ability of the airborne equipment to fly the designed flight path. This may involve pilot intervention where the equipment functionality is limited.
- Management of changes.
- Turn management (turn indications, airspeed & bank angle, lack of guidance in turns).
- Route modification (insertion/deletion of waypoints, direct to waypoint).
- Intercepting a route from radar vectors.

4.3.5.3 Flight training for RNAV 1 and RNAV 2 is not normally required, and the required level of competence can normally be achieved by classroom briefing, computer based training, desktop simulator training, or a combination of these methods. Computer based simulator programs are available from a number of GPS manufacturers which provide a convenient method for familiarity with programming and operation of stand-alone GNSS systems.

4.3.5.4 Where VNAV is used for SIDs and STARs, attention should be given to the management of VNAV and specifically the potential for altitude constraints to be compromised in cases where the lateral flight path is changed or intercepted.

RNAV 1/2 JOB AID

APPLICATION TO CONDUCT RNAV 1/2 OPERATIONS

1. **Purpose of the job aid**

a) To provide information on the relevant reference documents.

b) To provide a record of the operator application, the inspector comments and the operator follow-up action for each relevant paragraph in the reference document(s).

2. **Actions recommended for the inspector and operator**

a) At the pre-application meeting, the operator and the inspector review the approval process events and establish the form and content of the approval application.

b) The operator records references to material in company documents for each relevant paragraph in the job aid.

c) The operator submits the completed job aid with the application to the inspector.

d) The inspector records his findings for each relevant paragraph in the job aid indicating compliance or necessary corrective action.

e) The inspector informs the operator as soon as possible when a corrective action is required.

f) The operator provides the inspector with the revised material when so requested.

g) The CAA provides the operator with the operational specifications (OpSpecs) or a letter of authorization (LOA), as applicable, when the tasks and documents have been completed.

3. **Reference Documents**

Publisher	Reference	Title
ICAO	Annex 2	Rules of the Air
	Annex 6	Operation of Aircraft
	Doc 4444	PANS-ATM Air Traffic Management
	Doc 7030	Regional Supplementary Procedures
	Doc 9613	Manual on Performance Based Navigation
FAA	AC 90-100()	US Terminal and En Route Area Navigation (RNAV) Operations
	14 CFR Part 121 Sub-part G	Manual Requirements
EASA	TGL No 10	Airworthiness and Operational Approval for Precision RNAV Operations in Designated European Airspace.
	AMC 20-5	Airworthiness Approval and Operational Criteria for the use of NAVSTAR global positioning system.
CASA	AC 91U-II-3-B (draft)	Navigation Authorizations – RNAV 1 and RNAV 2
ICAO (SAM)	AC 91-003	Aircraft and Operators Approval for RNAV 1 and RNAV 2 Operations

PART 1. GENERAL INFORMATION
BASIC EVENTS OF THE APPROVAL PROCESS

	Action by Operator	**Action by Inspector**
1	Establish the need for the authorization	
2	Review AFM, AFM Supplement, TC Data Sheet, other appropriate documents (e.g. STCs, SB, SLs) to determine aircraft eligibility if necessary contact aircraft and/or avionics OEM to confirm eligibility.	
3	Schedule pre-application meeting with inspector	
4		During pre-application meeting establish: Form and contents of application Documents required to support application Target date of application submission Requirement for flight validation
5	Submit application at least XX days prior to start-up of planned operations	
6		Review submission
7	Ensure amendments to manuals, programmes and other relevant documents are complete; provide training to flight crews, flight dispatchers and maintenance personnel; if required, conduct validation flight	If required, participate in validation flight
8		Once requirements have been met, issue operational approval

PART 2. IDENTIFICATION OF AIRCRAFT AND OPERATORS

Name of Operator: _____

Aircraft manufacturer, model and series	Registration number	Serial number	Navigation systems manufacturer, model and number	RNP specification

Date of pre-application meeting: _____

Dare when application received by CAA: _____

Date when operator intend to begin RNAV 1/2 operations: _____

CAA notification date appropriate? Yes _____ No _____

PART 3. OPERATOR APPLICATION

Annex	Title	Inclusion by Operator	Comments by Inspector
A	**Request for Authorization**		
B	**Aircraft Eligibility – Airworthiness** AFM, AFM Revision, AFM supplement, TCDS showing aircraft RNAV systems are eligible.		
C	**Aircraft Eligibility- Modifications (if applicable)** Maintenance records documenting installation or modification of aircraft systems to achieve eligibility		
D	**Maintenance** Navigation database maintenance practices.		
E	**Minimum Equipment List**		
H	**Training** **xxx91 / GA operators or equivalent:** Course completion records. **xxx121 / xxx135 / CAT operators or equivalent:** Training programmes for flight crew, flight dispatchers and maintenance personnel.		
J	**Operating Policies and Procedures** **xxx91 / GA operators or equivalent:** Extracts from Operations Manual corresponding to application **xxx121 / xxx135 / CAT operators or equivalent:** Operations Manual and Checklists.		

CONTENTS OF THE APPLICATION TO BE SUBMITTED BY THE OPERATOR

- Compliance documentation of the aircraft/navigation systems
- Operating procedures and policies
- Sections of the maintenance manual related to navigation databases

Note.— Documents may be grouped in a single binder or may be submitted as individual document.

PART 4. CONTENTS OF OPERATOR APPLICATION

#	Topic	Specific ICAO Doc 9613 reference *(ICAO Doc 9613 Vol. II, Part B, Chap. 3)*	Specific State guidance reference *(AC/AMC/CA etc.)*	Operator compliance description *(Document reference/ method)*	Inspector disposition/ comments *(Accepted/not accepted)*	Follow-up by inspector **(Optional)** *(Status and date)*
1	**Authorization request** Statement of intent to obtain authorization	3.3.2.1				
2	**Aircraft/navigation system eligibility** Documents that establish the eligibility.	3.3.2.2 & 3.3.2.3.1				
3	**Training** Details of courses completed (xxx91 operators) Details of training programmes (xxx121 and xxx135 operators)	3.3.2.3.2 & 3.3.5				
4	**Operating Policies and Procedures** Extracts from Operations Manual or other documentation (xxx91 operators) Operations Manual and checklists (xxx121 and xxx135 operators)	3.3.2.3.3				

#	Topic	Specific ICAO Doc 9613 reference *(ICAO Doc 9613 Vol. II, Part B, Chap. 3)*	Specific State guidance reference *(AC/AMC/CA etc.)*	Operator compliance description *(Document reference/ method)*	Inspector disposition/ comments *(Accepted/not accepted)*	Follow-up by inspector (Optional) *(Status and date)*
5	**Maintenance Practices** Document navigation database maintenance practices	3.3.2.3.5 and 3.3.6				
6	**MEL update**	3.3.2.3.4				

PART 6. OPERATING PROCEDURES

#	Topic	Specific ICAO Doc 9613 reference *(ICAO Doc 9613 Vol. II, Part B, Chap. 3)*	Specific State guidance reference *(AC/AMC/CA etc.)*	Operator compliance description *(Document reference/ method)*	Inspector disposition/ comments *(Accepted/not accepted)*	Follow-up by inspector (Optional) *(Status and date)*
1	**Flight Planning**					
1a	Verify aircraft is approved for RNAV 1/2 operations	3.3.4.1				
1b	Verify RAIM available (GNSS only)	3.3.4.2.3 & 3.3.4.2.4				
1c	Verify navaids available (non-GNSS)	3.3.4.2.3 & 3.3.4.2.5				
1d	Verify navigation database current and appropriate for region (if carried)	3.3.4.2.2 & 3.3.4.3.3				
1e	Verify FPL: 'R' in field 10 PBN/C1-D4 (as appropriate) in field 18	3.3.4.2.1				

#	Topic	Specific ICAO Doc 9613 reference *(ICAO Doc 9613 Vol. II, Part B, Chap. 3)*	Specific State guidance reference *(AC/AMC/CA etc.)*	Operator compliance description *(Document reference/ method)*	Inspector disposition/ comments *(Accepted/not accepted)*	Follow-up by inspector (Optional) *(Status and date)*
2	**General Operating Procedures**					
2a	Verify flight-planned route	3.3.4.3.3				
2b	Advise ATC if unable	3.3.4.3.2				
2c	Confirm navigation database up to date	3.3.4.3.3				
2d	Only retrieve SIDs/STARs from database	3.3.4.3.4				
2e	Cross-check chart with RNAV system display	3.3.4.3.3 & 3.3.4.3.6				
2f	Cross-check with conventional navaids to monitor navigational reasonableness	3.3.4.3.7				
2g	Use appropriate display	3.3.4.3.8 & 3.3.4.3.9				
2h	Use appropriate scaling	3.3.4.3.10				
2i	Follow route centre-line within 1 or 0.5NM.	3.3.4.3.11				

#	Topic	Specific ICAO Doc 9613 reference *(ICAO Doc 9613 Vol. II, Part B, Chap. 3)*	Specific State guidance reference *(AC/AMC/CA etc.)*	Operator compliance description *(Document reference/ method)*	Inspector disposition/ comments *(Accepted/not accepted)*	Follow-up by inspector (Optional) *(Status and date)*
2j	Do not modify flight plan in RNAV system after ATC heading assignment until clearance to rejoin route or new clearance.	3.3.4.3.12				
3	**RNAV SID Requirements**					
3a	Prior take-off check RNAV system, loaded aerodrome and procedure and displayed position	3.3.4.4.1				
3b	Engage LNAV no later than 500ft above aerodrome elevation	3.3.4.4.2				
3c	If DME/DME only, no use of RNAV until within adequate DME coverage	3.3.4.4.4				
3d	If DME/DME/IRU only, confirm navigation position within 0.17NM before start of take-off roll	3.3.4.4.5				
3e	If GNSS, signal acquired before start of take-off roll	3.3.4.4.6				
4	**RNAV STAR Requirements**					

#	Topic	Specific ICAO Doc 9613 reference *(ICAO Doc 9613 Vol. II, Part B, Chap. 3)*	Specific State guidance reference *(AC/AMC/CA etc.)*	Operator compliance description *(Document reference/ method)*	Inspector disposition/ comments *(Accepted/not accepted)*	Follow-up by inspector (Optional) *(Status and date)*
4a	Verify correct STAR loaded and displayed	3.3.4.5.1				
4b	Contingency preparations	3.3.4.5.3				
4c	Procedure modification in response to ATC instructions	3.3.4.5.4				
4d	Observance of speed and altitude constraints	3.3.4.5.6				

PART 7. CONTINGENCY PROCEDURES

#	Topic	Specific ICAO Doc 9613 reference *ICAO Doc 9613 Vol. II, Part B, Chap. 3*	Specific State guidance reference *(AC/AMC/CA etc.)*	Operator compliance description *(Document reference/ method)*	Inspector disposition/ comments *(Accepted/not accepted)*	Follow-up by inspector (Optional) *(Status and date)*
1	**Contingencies**					
1a	Advise ATC if unable RNAV 1/2	3.3.4.6.1				
1b	Air-Ground Comms Failure	3.3.4.6.2 (Doc 4444 Chapter 5 - 15.3)				

4.4 RNP 4

4.4.1 General

4.4.1 RNP 4 supports 30NM lateral and 30NM longitudinal distance-based separation minima in oceanic or remote area airspace. Operators holding an existing RNP 4 operational approval do not need to be re-examined as the navigation specification is based upon US Order 8400.33.

4.4.2 System requirements

4.4.2.1 The RNP 4 system requirements are as follows:

a) two long range navigation systems;

b) at least one GNSS receiver with FDE;

c) a navigation database containing the routes and procedures;

j) area navigation system failure indication is required;

e) continuous indication of aircraft position relative to track to be displayed to the pilot flying (and the pilot not flying) on a navigation display situated in the primary fields of view;

f) display of distance and bearing to the active (To) waypoint;

g) display of ground speed or time to the active (To) waypoint;

h) display of active navigation sensor type;

i) lateral deviation display must have scaling and FSD of ± 4NM – the maximum FTE permitted is 2 NM;

j) automatic leg sequencing and fly-by turn functionality;

k) parallel off-set;

l) ability to fly direct to a fix;

m) ability to fly a course to a fix.

4.4.2.2 For the majority of air transport aircraft equipped with FMS, the required functionalities, with the exception of the provision of a non-numeric lateral deviation display are normally available. For this category lateral deviation is not normally displayed on a CDI or HSI, but is commonly available on a map display, usually with a numeric indication of cross-track error in $1/10^{th}$ NM. In some cases a numeric indication of cross-track error may be provided outside the primary field of view (e.g. CDU).

4.4.2.3 Aircraft equipped with stand-alone GNSS navigation systems should provide track guidance via a CDI, HSI, or a navigation map display. The CDI/HSI must be coupled to the area navigation route providing a direct indication of lateral position reference the flight planned track. This type of unit in en-route mode (nominally outside 30NM from departure and destination airports) defaults

to a CDI/HSI full-scale display of ±5NM, with RAIM alerting defaulting to 2NM; which is adequate for RNP 4. A lateral deviation display is often incorporated in the unit, and may be suitable if of sufficient size and position to allow either pilot to manoeuvre and monitor cross-track deviation.

4.4.2.4 The default method for area navigation systems to manage turns at the intersection of "straight" route segments, is to compute, based on groundspeed and assumed angle of bank, a position at which the turn should commence so that the resulting radius will turn inside the angle created by the two consecutive segments. For aircraft fitted with a stand-alone GNSS system or an FMS, fly-by transitions are a standard function and should not require specific evaluation. However a stand-alone GNSS receiver may require a pilot action to initiate the turn. All turns are limited by the physical capability of the aircraft execute a turn of suitable radius. In normal cases where the angle between track is small there is seldom a problem, but operators need to be aware that large angle turns, particularly at high altitude where TAS is high and bank angle is commonly limited can be outside the aircraft capability. While this condition is rare, flight crews need to be aware of the aircraft and avionics limitations.

4.4.3 Operating procedures

4.4.3.1 Some additional provisions may need to be added to the standard operating procedures to specifically address RNP 4 operations.

4.4.3.2 A review of the operator's procedure documentation against the requirements of the PBN Manual and the [State] regulatory requirements should be sufficient to ensure compliance.

4.4.3.3 The essential elements to be evaluated are that the operator's procedures ensure that:

a) the aircraft is serviceable for RNP 4 ops;

b) RNP 4 capability is indicated on the flight plan;

c) en-route loss of capability is identified and reported;

d) procedures for alternative navigation are described.

4.4.3.4 GNSS based operations also require the prediction of FDE RAIM availability. The maximum period during which FDE may be predicted to be unavailable is 25 minutes. Many stand-alone GNSS prediction programs are based on a prediction at a destination and do not generally provide predictions over a route or large area. RNP 4 specific route prediction services are available from commercial sources.

4.4.4 Pilot knowledge and training

4.4.4.1 Unless the operator is inexperienced in the use of area navigation, flight crews should possess the necessary skills to conduct RNP 4 operations with minimal additional training.

4.4.42 Where additional training is required, this can normally be achieved by bulletin, computer based training or classroom briefing. Flight training is not normally required.

RNP 4 JOB AID
APPLICATION TO CONDUCT RNP 4 OPERATIONS

1. **Purpose of the job aid**

a) To provide information on the relevant reference documents.

b) To provide a record of the operator application, the inspector comments and the operator follow-up action for each relevant paragraph in the reference document(s).

2. **Actions recommended for the inspector and operator**

a) At the pre-application meeting, the operator and the inspector review the approval process events and establish the form and content of the approval application.

b) The operator records references to material in company documents for each relevant paragraph in the Job Aid.

c) The operator submits the completed Job Aid with the application to the inspector.

d) The inspector records his findings for each relevant paragraph in the Job Aid indicating compliance or necessary corrective action.

e) The inspector informs the operator as soon as possible when a corrective action is required.

f) The operator provides the inspector with the revised material when so requested.

g) The CAA provides the operator with the operational specifications (OpSpecs) or a letter of authorization (LOA), as applicable, when the tasks and documents have been completed.

3. **Reference documents**

Publisher	Reference	Title
ICAO	Annex 2	Rules of the Air
	Annex 6	Operation of Aircraft
	Doc 4444	PANS-ATM Air Traffic Management
	Doc 7030	Regional Supplementary Procedures

Publisher	Reference	Title
	Doc 9613	Manual on Performance Based Navigation
FAA	Order 8400.33	Procedures for Obtaining Authorization for Required Navigation Performance 4 (RNP 4) Oceanic and remote Area Operations
	AC 20-130	Airworthiness Approval of Multi-sensor Navigational Systems for Use in the US National Airspace System.
	AC 20-138A	Airworthiness Approval of Global Navigation Satellite System (GNSS) equipment
	Order 7110.82	Monitoring of Navigation/Altitude Performance in Oceanic Airspace
	14 CFR Part 121 Sub-part G	Manual Requirements
EASA	tba	tba
CASA	(AC) 91U-3(0)	Required Navigation Performance 4 (RNP 4) Operational Authorization
ICAO (SAM)	AC 91-004	Aircraft and Operator Approval for RNP 4 Operations

PART 1. GENERAL INFORMATION
BASIC EVENTS OF THE APPROVAL PROCESS

	Action by Operator	**Action by Inspector**
1	Establish the need for the authorization	
2	Review AFM, AFM Supplement, TC Data Sheet, other appropriate documents (e.g. STCs, SB, SLs) to determine aircraft eligibility if necessary contact aircraft and/or avionics OEM to confirm eligibility.	
3	Schedule pre-application meeting with inspector	
4		During pre-application meeting establish: Form and contents of application Documents required to support application Target date of application submission Requirement for flight validation
5	Submit application at least XX days prior to start-up of planned operations	
6		Review submission
7	Ensure amendments to manuals, programmes and other relevant documents are complete; provide training to flight crews, flight dispatchers and maintenance personnel; if required, conduct validation flight	If required, participate in validation flight
8		Once requirements have been met, issue operational approval

PART 2. IDENTIFICATION OF AIRCRAFT AND OPERATORS

Name of Operator: _____

Aircraft Manufacturer, Model and Series	Registration Number	Serial Number	Long Range Navigation Systems Manufacturer, Model and Number	RNP Specification

Date of pre-application meeting: _____

Dare when application received by CAA: _____

Date when operator intend to begin RNP 4operations: _____

CAA notification date appropriate? Yes _____ No _____

PART 3. OPERATOR APPLICATION

Annex	Title	Inclusion by Operator	Comments by Inspector
A	**Request for Authorization**		
B	**Aircraft Group** Statement by the operator as to which group the aircraft/RNP system combinations belong.		
C	**Aircraft Eligibility – Airworthiness** AFM, AFM Revision, AFM supplement, TCDS showing aircraft RNP systems are eligible.		
D	**Aircraft Eligibility- Modifications (if applicable)** Maintenance records documenting installation or modification of aircraft systems to achieve eligibility		
F	**Maintenance** References to the RNP 4 maintenance document/programme.		
G	**Minimum Equipment List**		
H	**Training** **xxx91 / GA operators or equivalent:** Course completion records. **xxx121 / xxx135 / CAT operators or equivalent:** Training programmes for flight crew, flight dispatchers and maintenance personnel.		

Annex	Title	Inclusion by Operator	Comments by Inspector
J	**Operating Policies and Procedures** **xxx91 / GA operators or equivalent:** Extracts from Operations Manual corresponding to application **xxx121 / xxx135 / CAT operators or equivalent:** Operations Manual and Checklists.		
M	**Validation Flight Plan** As required.		

CONTENTS OF THE APPLICATION TO BE SUBMITTED BY THE OPERATOR

- Compliance documentation of the aircraft/navigation systems
- Operating procedures and policies
- Sections of the maintenance manual related to RNP system

Note.— Documents may be grouped in a single binder or may be submitted as individual document

PART 4. CONTENTS OF OPERATOR APPLICATION

#	Topic	Specific ICAO Doc 9613 reference *(ICAO Doc 9613, Vol. II, Part C, Chap. 1)*	Specific State guidance reference *(AC/AMC/ CA etc.)*	Operator compliance description *(Document reference/ method)*	Inspector disposition/ comments *(Accepted/not accepted)*	Follow-up by inspector (Optional) *(Status and date)*
1	**Authorization request** Statement of intent to obtain authorization					
2	**Aircraft/navigation system eligibility** Documents that establish the eligibility. For RNP 4, the eligibility groups(s) used and a list of the airframes included in each group	1.3.2.2				
3	**Training** Details of courses completed (xxx91 operators) Details of training programmes (xxx121 and xxx135 operators)	1.3.2.3.2 & 1.3.5				
4	**Operating Policies and Procedures** Extracts from Operations Manual or other documentation (xxx91 operators) Operations Manual and checklists (xxx121 and xxx135 operators)	1.3.2.3.3				

#	Topic	Specific ICAO Doc 9613 reference *(ICAO Doc 9613, Vol. II, Part C, Chap. 1)*	Specific State guidance reference *(AC/AMC/ CA etc.)*	Operator compliance description *(Document reference/ method)*	Inspector disposition/ comments *(Accepted/not accepted)*	Follow-up by inspector (Optional) *(Status and date)*
5	**Maintenance Practices** Document references for RNP 4 maintenance practices	1.3.2.3.5				
6	**MEL update**	1.3.2.3.4				

PART 5. OPERATING PROCEDURES

#	Topic	Specific ICAO Doc 9613 reference *(ICAO Doc 9613, Vol. II, Part C, Chap 1)*	Specific State guidance reference *(AC/AMC/ CA etc.)*	Operator compliance description *(Document reference/ method)*	Inspector disposition/ comments *(Accepted/not accepted)*	Follow-up by inspector (Optional) *(Status and date)*
1	**Flight Planning**					
1a	Verify aircraft is approved for RNP 4 operations	1.3.4.1				
1b	Verify navigation database current	1.3.4.2.1				
1c	Verify FDE available	1.3.4.3				
1d	Verify FPL: 'R' in field 10 PBN/L1 in field 18	1.3.4.2.1				
1e	Verify equipment conditions: Review flight technical records Confirm maintenance actions complete	1.3.4.2.2				
2	**En-route**					
2a	Both LRNSs RNP 4 capable at Oceanic point of entry	1.3.4.4.1				

#	Topic	Specific ICAO Doc 9613 reference *(ICAO Doc 9613, Vol. II, Part C, Chap 1)*	Specific State guidance reference *(AC/AMC/ CA etc.)*	Operator compliance description *(Document reference/ method)*	Inspector disposition/ comments *(Accepted/not accepted)*	Follow-up by inspector (Optional) *(Status and date)*
2b	Other mandatory navigation cross-checks	1.3.4.4.2				
2c	ATC notified if unable RNP or deviation required for contingency	1.3.4.4.3				
2d	Follow route centre-line within 2NM.	1.3.4.4.4				

PART 6. CONTINGENCY PROCEDURES

#	Topic	Specific ICAO Doc 9613 reference *(ICAO Doc 9613, Vol. II, Part C, Chap. 1)*	Specific State guidance reference *(AC/AMC/ CA etc.)*	Operator compliance description *(Document reference/ method)*	Inspector disposition/ comments *(Accepted/not accepted)*	Follow-up by inspector (Optional) (Status and date)
1	**Contingencies**					
1a	Inability to comply with ATC clearance due meteorological conditions, aircraft performance or pressurization failure.	- (Doc 4444 Chapter 5 - 15.2.1.1)				
1b	Weather deviation	- (Doc 4444 Chapter 5 - 15.2.3)				
1c	Air-Ground Comms Failure	- (Doc 4444 Chapter 5 - 15.3)				

4.5 RNP 1

4.5.1 General

4.5.1.1 RNP 1 is intended to support arrival and departure procedures using GNSS positioning only.

4.5.1.2 Other than the sole requirement for GNSS there is no significant difference between the RNAV 1 and RNAV 2 specification and RNP 1.

4.5.2 Maintaining 1NM scaling

4.5.2.1 **Stand-alone basic GNSS receiver**

4.5.2.1.1 The most basic qualifying system is a stand-alone GNSS receiver (TSO C129(a) or equivalent) which should coupled to a CDI or HSI display providing course guidance and cross-track deviation indications. The receiver normally incorporates a self-contained control and display unit but the interface may also be provided by a separate CDU.

4.5.2.1.2 In this arrangement the RNP 1 capability is provided when in terminal mode. In terminal mode:

a) Across track deviation display scaling is automatically set at ± 1NM full scale deflection
b) Alert is automatically set to 1 NM (RAIM alert limit)

4.5.2.1.3 In the default mode (en-route) CDI scaling increases to ±5NM and HAL increases to 2NM. Terminal mode cannot be manually selected but will be system selected provided certain conditions exist.

4.5.2.1.4 For departure, provided the current flight plan includes the departure airport (usually the ARP) terminal mode will be active and annunciated. In the general case terminal mode will automatically switch to en-route mode at 30NM from the departure ARP. If the RNP 1 SID extends past 30NM, the CDI scaling will no longer be adequate to support the required FTE limit (±0.5NM), and flight crew action is necessary to manually select ±1NM CDI scaling.

4.5.2.1.5 On arrival, provided the current flight plan route includes the destination airport (ARP) the receiver will automatically switch from en-route to terminal mode at 30NM from the ARP. If the STAR commences at a distance greater than 30NM radius from the destination, then en-route CDI scaling of ±5NM is inadequate for RNP 1 and must be manually selected to ±1NM.

Note 1.— Manual selection of ±1NM CDI scale (terminal scaling) does not change the mode, and en-route RAIM alert limits apply.

Note 2.— If manual selection of ± 1NM is not available, crew procedures to maintain FTE at ± 0.5NM may be considered an acceptable means of compliance.

4.5.2.2 **FMS systems**

4.5.2.2.1 Aircraft equipped with an FMS normally integrate positioning from a number of sources (radio NAVAIDs and GNSS) with the IRS.

4.5.2.2.2 In such systems, the navigation capability, alerting and other functions are based upon an RNP value, which may be a default value for a given operation, a pilot selected value or a value extracted from the navigation database.

4.5.2.2.3 There is normally no automatic mode switching (as in the case of a stand-alone receiver), although the default RNP may vary with the phase of flight and numerical across-track deviation displays may be deemed acceptable.

4.5.3 De-selection of radio updating

4.5.3.1 There is a possibility of position errors caused by the integration of GNSS data with other positioning data and the potential need for de-selection of other navigation sensors. While it is unlikely that any reduction in positioning accuracy will be significant in proportion to the required RNP 1 navigation accuracy, this should be confirmed. Otherwise, a means to deselect other sensors should be provided and the operating procedures should reflect this.

RNP 1 JOB AID

APPLICATION TO CONDUCT RNP 1 OPERATIONS

1. **Purpose of the job aid**

a) To provide information on the relevant reference documents.

b) To provide a record of the operator application, the inspector comments and the operator follow-up action for each relevant paragraph in the reference document(s).

2. **Actions recommended for the inspector and operator**

a) At the pre-application meeting, the operator and the inspector review the approval process events and establish the form and content of the approval application.

b) The operator records references to material in company documents for each relevant paragraph in the Job Aid.

c) The operator submits the completed Job Aid with the application to the inspector.

d) The inspector records his findings for each relevant paragraph in the Job Aid indicating compliance or necessary corrective action.

e) The inspector informs the operator as soon as possible when a corrective action is required.

f) The operator provides the inspector with the revised material when so requested.

g) The CAA provides the operator with the operational specifications (OpSpecs) or a letter of authorization (LOA), as applicable, when the tasks and documents have been completed.

3. **Reference Documents**

Publisher	Reference	Title
ICAO	Annex 2	Rules of the Air
	Annex 6	Operation of Aircraft
	Doc 4444	PANS-ATM Air Traffic Management
	Doc 7030	Regional Supplementary Procedures
	Doc 9613	Manual on Performance Based Navigation

Publisher	Reference	Title
FAA	AC 90-105()	US Terminal and En Route Area Navigation (RNAV) Operations
	14 CFR Part 121 Sub-part G	Manual Requirements
EASA	Expected 2015	
	AMC 20-5	Airworthiness Approval and Operational Criteria for the use of NAVSTAR global positioning system.
CASA	AC 91U-II-C-3 (draft)	Navigation Authorizations – RNP 1
ICAO (SAM)	AC 91-006	Aircraft and Operator Approval for RNP 1 Operations

PART 1. GENERAL INFORMATION
BASIC EVENTS OF THE APPROVAL PROCESS

	Action by Operator	Action by Inspector
1	Establish the need for the authorization	
2	Review AFM, AFM Supplement, TC Data Sheet, other appropriate documents (e.g. STCs, SB, SLs) to determine aircraft eligibility if necessary contact aircraft and/or avionics OEM to confirm eligibility.	
3	Schedule pre-application meeting with inspector	
4		During pre-application meeting establish: Form and contents of application Documents required to support application Target date of application submission Requirement for flight validation
5	Submit application at least XX days prior to start-up of planned operations	
6		Review submission
7	Ensure amendments to manuals, programmes and other relevant documents are complete; provide training to flight crews, flight dispatchers and maintenance personnel; if required, conduct validation flight	If required, participate in validation flight
8		Once requirements have been met, issue operational approval

PART 2. IDENTIFICATION OF AIRCRAFT AND OPERATORS

Name of Operator: _____

Aircraft Manufacturer, Model and Series	Registration Number	Serial Number	Navigation Systems Manufacturer, Model and Number	RNP Specification

Date of pre-application meeting: _____

Dare when application received by CAA: _____

Date when operator intend to begin RNP 1 operations: _____

CAA notification date appropriate? Yes _____ No _____

PART 3. OPERATOR APPLICATION

Annex	Title	Inclusion by Operator	Comments by Inspector
A	**Request for Authorization**		
B	**Aircraft Eligibility - Airworthiness** AFM, AFM Revision, AFM supplement, TCDS showing aircraft RNAV systems are eligible.		
C	**Aircraft Eligibility- Modifications (if applicable)** Maintenance records documenting installation or modification of aircraft systems to achieve eligibility		
D	**Maintenance** Navigation database maintenance practices.		
E	**Minimum Equipment List**		
H	**Training** **xxx91 / GA operators or equivalent:** Course completion records. **xxx121 / xxx135 / CAT operators or equivalent:** Training programmes for flight crew, flight dispatchers and maintenance personnel.		
J	**Operating Policies and Procedures** **xxx91 / GA operators or equivalent:** Extracts from Operations Manual corresponding to application **xxx121 / xxx135 / CAT operators or equivalent:** Operations Manual and Checklists.		

CONTENTS OF THE APPLICATION TO BE SUBMITTED BY THE OPERATOR

- Compliance documentation of the aircraft/navigation systems
- Operating procedures and policies
- Sections of the maintenance manual related to navigation databases

Note.— Documents may be grouped in a single binder or may be submitted as individual document

PART 4. CONTENTS OF OPERATOR APPLICATION

#	Topic	Specific ICAO Doc 9613 reference *(ICAO Doc 9613, Vol. II, Part C, Chap. 3)*	Specific State guidance reference *(AC/AMC/CA etc.)*	Operator compliance description *(Document reference/ method)*	Inspector disposition/ comments *(Accepted/not accepted)*	Follow-up by inspector (Optional) *(Status and date)*
1	**Authorization request** Statement of intent to obtain authorization					
2	**Aircraft/navigation system eligibility** Documents that establish the eligibility.	3.3.2.2 & 3.3.2.3.1				
3	Training Details of courses completed (xxx91 operators) Details of training programmes (xxx121 and xxx135 operators)	3.3.2.3.2 & 3.3.6				
4	Operating Policies and Procedures Extracts from Operations Manual or other documentation (xxx91 operators) Operations Manual and checklists (xxx121 and xxx135 operators)	3.3.2.3.3				
5	Maintenance Practices Document navigation database maintenance practices	3.3.2.3.5 & 3.3.7				
6	MEL update	3.3.2.3.4				

PART 6. OPERATING PROCEDURES

#	Topic	Specific ICAO Doc 9613 reference *(ICAO Doc 9613, Vol. II, Part C, Chap. 3)*	Specific State guidance reference *(AC/AMC/ CA etc.)*	Operator compliance description *(Document reference/ method)*	Inspector disposition/ comments *(Accepted/not accepted)*	Follow-up by inspector (Optional) *(Status and date)*
1	**Flight planning**					
1a	Verify aircraft and crew approved for RNP 1 operations	3.3.5.1				
1b	Verify RAIM available	3.3.5.2.3 & 3.3.5.3				
1c	Verify navigation database current	3.3.5.2.2				
1d	Verify FPL: 'R' in field 10 PBN/O2 in field 18	3.3.5.2.1				
2	**General operating procedures**					
2a	Comply with manufacturer's instructions/procedures	3.3.5.4.1				
2b	Advise ATC if unable	3.3.5.4.2				
2c	Verify aircraft position and entry of assigned route	3.3.5.4.3				
2d	Only retrieve SIDs/STARs from database	3.3.5.4.4				
2e	Cross-check chart with RNAV system display	3.3.5.4.5				
2f	Cross-check with conventional navaids to monitor navigational reasonableness	3.3.5.4.6				
2g	Use appropriate display	3.3.5.4.7				
2h	Use appropriate scaling	3.3.5.4.7				
2i	Follow route centre-line within 0.5NM.	3.3.5.4.8				

#	Topic	Specific ICAO Doc 9613 reference *(ICAO Doc 9613, Vol. II, Part C, Chap. 3)*	Specific State guidance reference *(AC/AMC/ CA etc.)*	Operator compliance description *(Document reference/ method)*	Inspector disposition/ comments *(Accepted/not accepted)*	Follow-up by inspector (Optional) *(Status and date)*
2j	Do not modify flight plan in RNAV system after ATC heading assignment until clearance to rejoin route or new clearance.	3.3.5.4.9				
2k	If RNP input required, select RNP 1 or lower	3.3.5.5				
3	**RNP 1 SID requirements**					
3a	Prior take-off check RNAV system, loaded aerodrome and procedure and displayed position	3.3.5.6.1				
3b	Engage LNAV no later than 500ft above aerodrome elevation	3.3.5.6.2				
3c	Used authorized method to achieve RNP 1 (AP/FD/Map/LatDev Indicator)	3.3.5.6.3 & 3.3.5.6.5				
3e	If GNSS, signal acquired before start of take-off roll	3.3.5.6.4				
4	**RNP 1 STAR Requirements**					
4a	Verify correct STAR loaded and displayed	3.3.5.7.1				
4b	Contingency preparations	3.3.5.7.3				
4c	Procedure modification in response to ATC instructions	3.3.5.7.4				

#	**Topic**	**Specific ICAO Doc 9613 reference** *(ICAO Doc 9613, Vol. II, Part C, Chap. 3)*	**Specific State guidance reference** *(AC/AMC/ CA etc.)*	**Operator compliance description** *(Document reference/ method)*	**Inspector disposition/ comments** *(Accepted/n ot accepted)*	**Follow-up by inspector (Optional)** *(Status and date)*
4d	Verify correct operation of navigation system, correct procedure, transition and runway loaded	3.3.5.7.5				
4e	Observance of speed and altitude constraints	3.3.5.7.6				
4f	If procedure >30NM from ARP use FD/AP or set FSD to 1NM	3.3.5.7.7				

PART 7. CONTINGENCY PROCEDURES

#	Topic	Specific ICAO Doc 9613 reference (ICAO Doc 9613, Vol. II, Part C, Chap. 3)	Specific State guidance reference (AC/AMC/C A etc.)	Operator compliance description (Document reference/ method)	Inspector disposition/ comments (Accepted/not accepted)	Follow-up by inspector (Optional) (Status and date)
1	Contingencies					
1a	Advise ATC if unable RNP 1	3.3.5.8.1				
1b	Air-Ground Comms Failure	3.3.5.8.2 (Doc 4444 Chapter 5 - 15.3)				

4.6 RNP APCH

4.6.1 General

4.6.1.1 RNP APCH is the general designator for PBN approach procedures that are not Authorization Required operations.

4.6.1.2 GNSS is used for all RNP APCH applications as follows:

a) RNP APCH – LNAV - lateral positioning with GNSS (Basic constellation);

b) RNP APCH – LNAV/VNAV - lateral positioning with GNSS, vertical positioning with Barometric inputs;

c) RNP APCH – LPV (Localiser Performance with Vertical Guidance) - lateral and vertical positioning with SBAS;

d) RNP APCH – LP (Localiser Performance) - lateral positioning with SBAS.

4.6.1.3 The current version of the PBN Manual only addresses LNAV and LNAV/VNAV procedures, the next version will include LP and LPV procedures.

4.6.1.4 The published RNP APCH OCA/H are treated as:

a) MDA/H for LNAV and LP minima;

b) DA/H for LNAV/VNAV and LPV minima

Operators currently approved to conduct RNAV $_{(GNSS)}$ approaches should qualify for RNP APCH – LNAV without further examination.

4.6.2 System requirements

4.6.2.1 The RNP APCH system requirements are as follows:

a) a single area navigation system;

b) GNSS sensor only - receivers must be approved in accordance with ETSO C129(a), FAA TSO C129 (a) or later;

c) a navigation database containing the approach procedures;

d) continuous indication of aircraft position relative to track to be displayed to the pilot flying (and the pilot not flying) on a navigation display situated in the primary fields of view;

e) identification of active waypoint;

f) display of distance and bearing to the active (To) waypoint.;

g) display of ground speed or time to the active (To) waypoint;

h) lateral deviation display must have scaling and FSD suitable for RNP APCH - the maximum FTE permitted is:

i) 0.5NM for initial, intermediate and missed approach
ii) 0.25 NM for final approach

Note.— Angular display systems may be considered.

i) Automatic leg sequencing and fly-by or fly-over turn functionality.

j) Execution of leg transitions and maintenance of tracks consistent with ARINC 424:

i) CA/FA
ii) CF
iii) DF
iv) HM
v) IF
vi) TF

k) area navigation system failure indication;

l) indication when NSE alert limit exceeded.

4.6.3 RNP APCH systems

There are two categories of RNP APCH system. Although both types of navigation systems have similar capabilities there are significant differences in functionality, cockpit displays, and flight crew procedures:

4.6.3.1 **Stand-alone systems**

4.6.3.1.1 This type of system is commonly represented by a panel-mounted self-contained unit comprising a GNSS receiver incorporating a control unit, a lateral deviation indicator and an annunciator panel. In some cases the unit may also include a map display.

4.6.3.1.2 Mode switching from en-route, to terminal and to approach is automatic, provided a suitable flight plan is loaded which enables the receiver to identify the destination airport. CDI scaling automatically reduces from ±5NM en-route mode scaling to ±1NM terminal mode scaling at 30NM from the ARP. The RAIM alert limit reduces similarly from 2NM en-route mode to 1NM terminal mode.

4.6.3.1.3 At 2NM from the FAF, the receiver checks that approach RAIM will be available and the CDI scaling gradually reduces to ±0.3NM. Any off track deviation as the FAF is approached will be exaggerated as CDI scaling changes, and the flight crew can be mislead if the aircraft is not flown accurately or if the effect of scale change is not understood.

4.6.3.1.4 If ‘approach’ is not annunciated before crossing the FAF the approach must be discontinued.

4.6.3.1.5 During the approach, distance to run is given to the ‘Next WPT’ in the flight plan, and not to the runway. Minimum altitudes are commonly specified at a waypoint, or at a distance from a

waypoint. Situational awareness can be difficult and it is not uncommon for pilots to confuse the current segment and descend prematurely.

4.6.3.1.6 Cross-track deviation should be limited to ½ scale deflection (0.5NM) on initial/intermediate/missed approach segments and 0.25NM on final. A missed approach should be conducted if these limits are exceeded.

4.6.3.1.7 At the MAPt, which is commonly located at the runway threshold, waypoint sequencing is inhibited, on the assumption that the aircraft is landing. If a missed approach is conducted, pilot action is normally required to sequence to the missed approach. Depending on the procedure design, track guidance may not be provided in the missed approach. Crews need to understand the navigation indications that are provided and the appropriate technique for managing the missed approach.

4.6.3.1.8 The receiver automatically reverts to terminal mode when the missed approach is sequenced.

4.6.3.2 **FMS LNAV systems**

4.6.3.2.1 Positioning data, including GNSS, is commonly combined with IRS and radio position to compute an FMS position. The GNSS receiver, which may be separate or part of a multi-mode receiver, provides position data input but does not drive automatic mode switching or CDI scaling. Navigation system integrity may be based on RAIM, but more commonly is provided by a hybrid IRS/GNSS system, which can provide significantly improved integrity protection and availability.

4.6.3.2.2 Most FMS aircraft are not equipped with a CDI type non-numerical lateral deviation indicator, although some manufacturers offer a lateral deviation indicator as an option. Where a lateral deviation indicator is provided, the scaling is determined by the manufacturer and may be either a fixed scale or a non-scaled system. Lateral deviation scales may only be available (either automatic or selectable) for certain phases of flight. Automatic scaling similar to stand-alone systems is not provided.

4.6.3.2.3 Lateral deviation in this type of system is commonly displayed as a digital cross-track deviation on a map display. Digital cross-track deviation is normally displayed in 1/10th NM, although 1/100th is often available as an option. Digital cross-track deviation may also be subject to rounding. For example where the display threshold is set at 0.15NM on a display capable of only 1 decimal place, the first digital indication of cross-track deviation is displayed as 0.2NM. In the same example, as cross-track deviation is reduced, the lowest value displayed is 0.1NM rounded down when the actual deviation reaches 0.15NM.

4.6.3.2.4 Monitoring of deviations within the limits of the navigation specification (0.15NM on final approach) using digital cross-track indications alone can be difficult in some cases. In the example in the previous paragraph the first digital indication of cross-track error is displayed at 0.2NM (although this indication is initiated at 0.15). However, a relative or graphical indication of cross-track error can be derived from the relative position of the aircraft symbol to the flight plan track on the navigation display. For this method to be satisfactory, the size and resolution of the map display needs to be sufficient, and a suitable map scale must be selected.

4.6.3.2.5 A go-round should be conducted if the cross-track error reaches 1 x RNP unless the pilot has the visual references, required to continue the approach, in sight.

4.6.3.2.6 Modern large screen (10inch) multi-function displays at 10NM range are generally satisfactory and small deviations can be estimated sufficiently accurately to provide good initial

indication of track divergence. Older and smaller displays, including LCD type displays can be less effective and subject to variation (jumping) in displayed position.

4.6.3.2.7 Additional cross-track deviation information may also be available on the CDU/MCDU which although outside the normal field of view can be monitored by the PM. In such cases the evaluation of cockpit displays must also take into consideration the crew operation procedures, callouts etc.

4.6.3.2.8 In the evaluation cross-track deviation monitoring, it should be noted that use of autopilot or flight director for normal operations results in little or no cross-track deviation. The evaluation should therefore concentrate on determining whether the crew has sufficient indications to detect and manage any deviation, in that unlikely event.

4.6.3.2.9 Navigation system alerting varies between aircraft systems and, unlike stand-alone systems, is driven by logic determined by the OEM. The basics of the alerting system must be understood and the operator's flight crew procedures and training must be consistent with the particular aircraft system.

4.6.3.2.10 The most common method to manage RNP is to select RNP 0.3 prior to the IAF, and retain that selection throughout the approach and missed approach. In some cases a default RNP for approaches may apply, and it is sufficient that the crew confirms the correct RNP is available. In other cases crew selection of RNP 0.3 prior to commencement of the approach will be necessary. Changing the RNP after passing the IAF is not recommended as it increases crew workload, introduces the opportunity for error (forgetting to change the RNP), and provides little or no operational advantage. For RNP 0.3 operations, availability is normally close to 100% and although RNP 0.3 may not be required for the majority of the approach (initial/intermediate segments), the probability of an alert due to the selection of a lower than necessary RNP is extremely low, especially as prediction for RNP 0.3 availability is required to conduct an approach.

4.6.3.2.11 Some systems allow the RNP to be automatically extracted from the navigation database.

4.6.3.3 **FMS LNAV/VNAV systems**

4.6.3.3.1 Barometric VNAV (Baro-VNAV) is commonly available on FMS equipped aircraft. SBAS equipment can also provide a VNAV functionality. Aircraft in the general aviation, commuter and light airline categories are generally not equipped with an integrated LNAV/VNAV system.

4.6.3.3.2 Most RNP APCH LNAV approach procedures are published with an optimum approach gradient (normally 3°) which clears all minimum obstacle clearance altitudes. Navigation database coding normally supports a flight path angle where identified on the instrument approach chart. It is recommended that VNAV is used, where available, as a vertical advisory to manage the approach and assist in flying a stabilised constant descent final approach.

4.6.3.3.3 Use of VNAV in this way does not absolve the crew from the responsibility to ensure obstacle clearance is maintained through the strict adherence to minimum attitudes by use of the pressure altimeter. Descent is made to the LNAV minima which is an MDA.

4.6.3.3.4 Where an LNAV/VNAV minimum is published, the procedure has been designed as a vertically guided approach and shall only be flown by approved LNAV/VNAV equipped aircraft. Descent is made to the LNAV/VNAV minimum which is a DA.

4.6.3.3.5 RNP APCH LNAV/VNAV procedures are currently based upon the use of Baro-VNAV. If the design is suitable for SBAS equipped aircraft it will be annotated on the chart.

4.6.3.3.6 The design of the vertical flight path takes account of the cold temperature effects on barometric altimetry as well as the effect of any along-track error in the determination of the vertical path (horizontal coupling effect). The minimum temperature for which the procedure has been designed is promulgated on the chart.

4.6.3.3.7 Temperature compensated VNAV systems, which enable the designed vertical flight path to be flown irrespective of temperature, do exist but such equipment is not widespread.

4.6.3.3.8 When conducting an LNAV/VNAV approach adherence to the vertical flight path within reasonable tolerance is required. Vertical deviations from the defined path should be limited to ±75ft, transient deviations above +75ft, associated with aircraft configuration changes are acceptable, however any deviation below -75ft on final approach requires an immediate go-around unless the pilot has in sight the visual references required to continue the approach.

4.6.3.3.9 The operational approval needs to carefully examine the aircraft capability, VNAV functionality, mode selection and annunciation, mode reversion, operating procedures and crew knowledge and training. As the flight path guidance provided by a barometric VNAV system is directly affected by the barometric pressure subscale setting, particular attention needs to be paid to pressure setting procedures and associated aircraft systems.

4.6.4 GNSS availability prediction

4.6.4.1 The availability of RNP APCH operations depends upon the availability of FD RAIM with 0.3NM HPL. The prediction should be based on the latest satellite health data, which is readily available, and may take into account other factors such as high terrain. On board prediction programs are generally unsatisfactory in that they are unable to take account of satellite NOTAMS. Prediction services are available from commercial sources.

4.6.4.2 An operation is not available, or should be discontinued when an alert is displayed to the flight crew. While satellite prediction services are normally accurate and reliable it should be noted that an unpredicted loss of service can occur at any time.

4.6.5 Radio updating

4.6.5.1 The navigation specification permits the integration of other navigation sensor information with GNSS provided the TSE is not exceeded. Where the effect of radio updating cannot be established, inhibiting of radio updating is required.

4.6.5.2 If it can be determined that radio updating has no detrimental effect on the accuracy of the computed position, then no action is required.

4.6.7 Operating procedures

Most manufacturers have developed recommended procedures for $RNAV_{(GPS)}$/$RNAV_{(GNSS)}$ procedures. Although the manufacturer recommendations should be followed, the operational approval should include an independent evaluation of the operator’s proposed procedures.

RNP APCH operating procedures should be consistent with the operator's normal procedures where possible in order to minimise any human factors elements associated with the introduction of PBN operations.

4.6.7.1 **Procedure selection and review**

4.6.7.1.1 Operating procedures should address the selection of the approach from the navigation database and the verification and review of the displayed data.

4.6.7.1.2 The instrument approach chart will contain, for example, $RNAV_{(GNSS)}$z RW20R in the title and the clearance issued will be to RNAV z RWY20R. Due to avionics limitations the available approaches may be displayed in an abbreviated format e.g. RNVZ. In some cases the multiple indicators (x, y, and z) may not be supported. Flight crew procedures must take these limitations into account to ensure that the correct procedure is selected and then checked.

4.6.7.2 **Use of autopilot and flight director**

The manufacturer's guidance will normally provide recommendations on the use of auto-pilot and/or flight director.

4.6.7.3 **GNSS updating**

4.6.7.3.1 RNP APCH procedures are dependent on GNSS positioning, and the availability of GNSS, (as well as the available level of RNP) should be checked prior to commencement of an approach.

4.6.7.3.2 The failure of a GNSS receiver (i.e. an equipment failure) should be annunciated. Where dual GNSS receivers are installed, the approach can continue normally using the serviceable receiver.

4.6.7.3.3 A loss of GNSS updating due to a loss of signal may occur at any time, but an alert will not normally be generated immediately. Where position integrity can be maintained following the loss of GNSS a valid position will continue to be displayed.

4.6.7.3.4 When the required performance cannot be sustained, an alert will be generated. A go-around should be initiated unless the approach can be completed visually.

4.6.7.3.5 Inspectors should be familiar with the alerting system applicable to the specific aircraft under consideration to ensure that operating procedures and crew knowledge and training is consistent with the system functionality.

4.6.8 Flight crew knowledge and training

Successful RNP APCH LNAV and LNAV/VNAV approach operations depend on sound flight crew knowledge and training.

The type of navigation system has a significant effect on the conduct of this type of procedure and flight training must take this factor into account.

Crews operating aircraft equipped with basic stand-alone systems typically require significantly more flight training than crews operating FMS equipped aircraft. The amount of training will vary depending on the flight crew's previous area navigation experience, however the following is provide as a guide:

4.6.8.1 **Ground training**

Ground training, including computer-based training and classroom briefings, should comprise all elements of the syllabus stated in the PBN manual.

4.6.8.2 **Simulator training**

Simuator training shall include all new elements required for the intended operation. For FMS systems operated by crews with experience in the use of the FMS for the conduct of conventional approach procedures, a pre-flight briefing session and one 2 - 4 hours simulator session per crew may be sufficient. For operators of stand-alone systems, simulator or flight training may require 2 or more training sessions. Proficiency may be achieved in normal uncomplicated operations in a short period of time however additional flight time needs to be scheduled to ensure competency in the management of approach changes, go-round, holding and other functions, including due consideration of human factors. Where necessary initial training should be supplemented by operational experience in VMC or under supervision.

4.6.9 Navigation database

4.6.9.1 RNP APCH operations are critically dependent on valid data.

4.6.9.2 Although the navigation database should be obtained from a qualified source, operators must also have procedures in place for the management of data. Experienced area navigation operators who understand the importance of reliable data will normally have such procedures established, however less experienced operators may not fully understand the need for comprehensive management procedures and may need to develop or improve existing procedures.

4.6.9.3 It should be noted that despite the requirement for the database supplier to comply with RTCA DO200A/EUROCAE ED 76, data errors will still occur.

RNP APCH (Part A) JOB AID

APPLICATION TO CONDUCT RNP APCH OPERATIONS

1. **Purpose of the job aid**

a) To provide information on the relevant reference documents.

b) To provide a record of the operator application, the inspector comments and the operator follow-up action for each relevant paragraph in the reference document(s).

2. **Actions Recommended for the inspector and operator**

a) At the pre-application meeting, the operator and the inspector review the approval process events and establish the form and content of the approval application.

b) The operator records references to material in company documents for each relevant paragraph in the job aid.

c) The operator submits the completed job aid with the application to the inspector.

d) The inspector records his findings for each relevant paragraph in the job aid indicating compliance or necessary corrective action.

e) The inspector informs the operator as soon as possible when a corrective action is required.

f) The operator provides the inspector with the revised material when so requested.

g) The CAA provides the operator with the operational specifications (OpSpecs) or a letter of authorization (LOA), as applicable, when the tasks and documents have been completed.

3. **Reference documents**

Publisher	Reference	Title
ICAO	Annex 2	Rules of the Air
	Annex 6	Operation of Aircraft
	Doc 4444	PANS-ATM Air Traffic Management
	Doc 7030	Regional Supplementary Procedures

Publisher	Reference	Title
	Doc 9613	Manual on Performance Based Navigation
FAA	AC 90-105()	US Terminal and En Route Area Navigation (RNAV) Operations
	14 CFR Part 121 Sub-part G	Manual Requirements
EASA	AMC 20-27	Airworthiness and Operational Criteria for RNP APPROACH (RNP APCH) Operations including APV BARO-VNAV Operations.
CASA	AC 91U-II-C-5 (draft) AS 91U-II-Attachment (draft)	Navigation Authorizations – RNP APCH Navigation Authorizations – APV BARO-VNAV
ICAO (SAM)	AC 91-008 AC 91-010	Aircraft and Operators Approval for RNP Approach (RNP APCH) Operations Aircraft and Operators Approval for Approach Operations with Vertical Guidance/Barometric Vertical Navigation (APV/baro VNAV)

PART 1. GENERAL INFORMATION
BASIC EVENTS OF THE APPROVAL PROCESS

	Action by Operator	Action by Inspector
1	Establish the need for the authorization	
2	Review AFM, AFM Supplement, TC Data Sheet, other appropriate documents (e.g. STCs, SB, SLs) to determine aircraft eligibility if necessary contact aircraft and/or avionics OEM to confirm eligibility.	
3	Schedule pre-application meeting with inspector	
4		During pre-application meeting establish: Form and contents of application Documents required to support application Target date of application submission Requirement for flight validation
5	Submit application at least XX days prior to start-up of planned operations	
6		Review submission
7	Ensure amendments to manuals, programmes and other relevant documents are complete; provide training to flight crews, flight dispatchers and maintenance personnel; if required, conduct validation flight	If required, participate in validation flight
8		Once requirements have been met, issue operational approval

PART 2. IDENTIFICATION OF AIRCRAFT AND OPERATORS

Name of Operator: _____

Aircraft Manufacturer, Model and Series	Registration Number	Serial Number	Navigation Systems Manufacturer, Model and Number	RNP Specification

Date of pre-application meeting: _____

Dare when application received by CAA: _____

Date when operator intend to begin RNP APCH operations: _____

CAA notification date appropriate? Yes _____ No _____

PART 3. OPERATOR APPLICATION

Annex	Title	Inclusion by Operator	Comments by Inspector
A	**Request for authorization**		
B	**Aircraft eligibility - Airworthiness** AFM, AFM Revision, AFM supplement, TCDS showing aircraft RNAV systems are eligible.		
C	**Aircraft eligibility- Modifications (if applicable)** Maintenance records documenting installation or modification of aircraft systems to achieve eligibility		
D	**Maintenance** Navigation database maintenance practices.		
E	**Minimum equipment list**		
H	**Training** **xxx91 / GA operators or equivalent:** Course completion records. **xxx121 / xxx135 / CAT operators or equivalent:** Training programmes for flight crew, flight dispatchers and maintenance personnel.		
J	**Operating policies and procedures** **xxx91 / GA operators or equivalent:** Extracts from Operations Manual corresponding to application **xxx121 / xxx135 / CAT operators or equivalent:** Operations Manual and Checklists.		

CONTENTS OF THE APPLICATION TO BE SUBMITTED BY THE OPERATOR

- Compliance documentation of the aircraft/navigation systems
- Operating procedures and policies
- Sections of the maintenance manual related to navigation databases

Note.— Documents may be grouped in a single binder or may be submitted as individual document.

PART 4. CONTENTS OF OPERATOR APPLICATION

#	Topic	Specific ICAO Doc 9613 reference *(ICAO Doc 9613, Vol. II Part C, Chap. 5)*	Specific State guidance reference *(AC/AMC/CA etc.)*	Operator compliance description *(Document reference/ method)*	Inspector disposition/ comments *(Accepted/not accepted)*	Follow-up by Inspector (Optional) *(Status and date)*
1	Authorization request Statement of intent to obtain authorization					
2	Aircraft/navigation system eligibility Documents that establish the eligibility.	A.5.3.2.2 & A.5.3.2.3.1				
5	Training Details of courses completed (xxx91 operators) Details of training programmes (xxx121 and xxx135 operators)	A.5.3.2.3.2 & A.5.3.5				
6	Operating Policies and Procedures Extracts from Operations Manual or other documentation (xxx91 operators) Operations Manual and checklists (xxx121 and xxx135 operators)	A.5.3.2.3.3				
7	Maintenance Practices Document navigation database maintenance practices	A.5.3.2.3.5 & A.5.3.9				
8	MEL update	A.5.3.2.3.4				

PART 6. OPERATING PROCEDURES

#	Topic	Specific ICAO Doc 9613 reference *(ICAO Doc 9613, Vol. II, Part C, Chap. 5)*	Specific State guidance reference *(AC/AMC/ CA etc.)*	Operator compliance description *(Document reference/ method)*	Inspector disposition/ comments *(Accepted/not accepted)*	Follow-up by Inspector (Optional) *(Status and date)*
1	**Flight planning**					
1a	Verify aircraft and crew approved for RNP APCH operations to LNAV or LNAV/VNAV minima	A.5.3.4				
1b	Verify RAIM available	A.5.3.4.1.3 & A.5.3.4.2				
1c	Verify navigation database current	A.5.3.4.1.1 & A.5.3.4.1.2 a)				
1d	Verify FPL: 'R' in field 10 PBN/S1 in field 18	A.5.3.4.1.1				
2	**Prior to commencing procedure**					
2a	Verify correct procedure loaded	A.5.3.4.3.1				
2b	Cross-check chart with RNAV system display	A.5.3.4.3.2				
2c	Verify GNSS sensor in use (only multi-sensor systems)	A.5.3.4.3.3				
2d	Input Baro altimeter setting (only ABAS requiring Baro input)	A.5.3.4.3.4				
2e	RAIM check 15 minutes prior ETA if ETA>FPL ETA±15minutes (only ABAS)	A.5.3.4.3.5				
2f	Do not modify flight plan in RNAV system after ATC heading assignment until clearance to rejoin route or new clearance. Direct to up to IF provided track change at IF≤45º	A.5.3.4.3.6				
2g	Do NOT modify final approach segment	A.5.3.4.3.7				

#	Topic	Specific ICAO Doc 9613 reference *(ICAO Doc 9613, Vol. II, Part C, Chap. 5)*	Specific State guidance reference *(AC/AMC/ CA etc.)*	Operator compliance description *(Document reference/ method)*	Inspector disposition/ comments *(Accepted/not accepted)*	Follow-up by Inspector (Optional) *(Status and date)*
3	**During procedure**					
3a	Establish on final approach course before starting descent	A.5.3.4.4.1				
3b	Verify approach mode activated 2Nm prior FAF	A.5.3.4.4.2				
3c	Use appropriate display	A.5.3.4.4.3				
3d	Discontinue approach if: Nav display flag invalid Loss of integrity alert Loss of integrity alerting function prior to the FAF FTE excessive	A.5.3.4.4.4				
3e	Do not use RNP system in missed approach if: RNP system not operational or, Missed approach not loaded from database	A.5.3.4.4.5				
3f	Follow route centre-line within 0.5/0.15/0.5NM.	A.5.3.4.4.6				
3g	If Baro VNAV used, follow vertical path ±75ft	A.5.3.4.4.7				
3h	Execute missed approach if lateral or vertical deviations exceed limits in 3f) and 3g) above.	A.5.3.4.4.8				
4	**General operating procedures**					
4a	Advise ATC if unable	A.5.3.4.5.1				
4b	Comply with manufacturer's instructions/procedures	A.5.3.4.5.2				

#	Topic	Specific ICAO Doc 9613 reference *(ICAO Doc 9613, Vol. II, Part C, Chap. 5)*	Specific State guidance reference *(AC/AMC/ CA etc.)*	Operator compliance description *(Document reference/ method)*	Inspector disposition/ comments *(Accepted/not accepted)*	Follow-up by Inspector (Optional) *(Status and date)*
4c	If missed approach based on conventional means, appropriate navigation equipment installed and serviceable.	A.5.3.4.5.3				
4d	Use FD or AP if available	A.5.3.4.5.4				

PART 7. CONTINGENCY PROCEDURES

#	Topic	Specific ICAO Doc 9613 reference *(ICAO Doc 9613, Vol. II, Part C, Chap. 5)*	Specific State guidance reference *(AC/AMC/CA etc.)*	Operator compliance description *(Document reference/ method)*	Inspector disposition/ comments *(Accepted/not accepted)*	Follow-up by inspector (Optional) *(Status and date)*
1	Contingencies					
1a	Advise ATC if unable RNP APCH	A.5.3.4.6.1				
1b	Air-Ground Comms Failure	A.5.3.4.6.2 (Doc 4444 Chapter 5 - 15.3)				

4.7 RNP AR OPERATIONS

4.7.1 General

4.7.1.1 RNP AR APCH is the designator for PBN approach procedures that require additional levels of scrutiny, control and authorization. RNP AR APCH applications can range from simple straight in approaches, with a minimum track-keeping accuracy requirement of RNP 0.3 in final approach and RNP 1 at all other times, to complex curved approaches with RF legs used in the final and the missed approach and minimum track-keeping accuracies as low as RNP 0.1. Moreover, in addition to the RNP AR APCH procedures designed according to ICAO Doc 9905, there are a number of RNP AR APCH procedures in commercial use which have been designed according to private, proprietary, criteria.

4.7.1.2 GNSS, an inertial reference system and a VNAV system is required for all RNP AR APCH applications. DME/DME updating may be used as a reversionary system if the required navigation accuracy can be maintained in a specific operation, although explicit authorization is required. VOR updating shall not be used.

4.7.1.3 The published RNP AR APCH OCA/H is treated as DA/H.

4.7.2 System requirements

4.7.2.1 The RNP AR APCH system requirements are as follows:

a) sufficient area navigation systems to meet the requirement that the probability of the aircraft exiting the lateral and/or vertical extent of the obstacle clearance volume does not exceed 10-7. Loss of lateral guidance is a major failure. Loss of vertical guidance is a minor failure. Display of misleading lateral or vertical guidance is a severe-major failure for navigation accuracy <RNP 0.3;

b) GNSS sensors must be approved in accordance with AC 20-138() or AC 20-130 A. In the event of a latent satellite failure, the probability that the aircraft remains within the obstacle clearance volume used to evaluate the procedure must be greater than 95% (both laterally and vertically);

c) inertial reference systems must meet the criteria of US 14 CFR Part 121 Appendix G; OEMs may demonstrate, and get credit for, improved performance;

d) Class A terminal awareness warning system (TAWS) operating independently of the captain’s altimeter sub-scale setting;

e) 95% lateral system error (across track and along track) < applicable accuracy value (0.1NM – 1NM);

f) for RNP < 0.3 (optional) and/or missed approach<1 (optional), dual GNSS, dual FMS, dual ADS, dual AP and at least one IRU required; loss of display is hazardous (severe/major) condition; loss of vertical or lateral guidance is a major failure; flight guidance to stay in LNAV at go-around initiation; must be able to couple AP/FD by 400ft AGL; must automatically revert to another means of navigation that complies with nav accuracy on go-around following loss of GNSS;

g) final approach vertical paths defined by flight path angle to a fix and altitude;

h) 99.7% vertical system error < defined vertical error budget (VEB); where temperature compensated systems are used, VNAV guidance must comply with RTCA/DO-236B;

i) a navigation database containing the approach procedures, with resolution error for waypoints ≤ 60ft and vertical angles ≤0.01º;

j) altitude and speed constraints for a procedure extracted from the database;

k) magnetic variation for CF and FA legs extracted from the procedure in the database;

l) capability to define vertical path by flight path angle to a fix and between altitude constraints at two sequential fixes;

m) capability to display flight path angles and altitude restrictions to the pilot;

n) capability to define a path from current position to a vertically constrained fix;

o) continuous indication of aircraft position (lateral and vertical) relative to track to be displayed to the pilot flying (and the pilot not flying) on a navigation display situated in the primary fields of view;

p) identification of active waypoint;

q) display of distance and bearing to the active (To) waypoint;

r) display of ground speed or time to the active (To) waypoint;

s) non-numeric lateral and vertical deviation displays which must have FSDs which are suitable for the lateral navigation accuracy and the 75ft vertical accuracy – the pilot must be able to distinguish excursions beyond 1xRNP and 75 ft;

t) numeric display of vertical and lateral deviation; resolution 10ft vertically, 0.1NM for RNP≥0.3, 0.01 for RNP<0.3. Numeric display without a deviation indicator is not normally accepted for RNP<0.3;

u) display of barometric altitude from two independent altimetry sources, one each in the primary field of view;

v) display of current navigation sensor in use;

w) automatic leg sequencing and fly-by or fly-over turn functionality;

x) execution of leg transitions and maintenance of tracks consistent with ARINC 424:

i) FA
ii) CF
iii) DF
iv) IF

v) RF (optional) – electronic map display required; AP/FD command bank angle of up to 8º below 400ft AGL and up to 25º above 400ft AGL; flight guidance to stay in LNAV at go-around initiation.

vi) TF

y) changes in alert from one navigation accuracy value to a smaller value, achieved by the time the fix is reached;

z) area navigation system failure indication;

aa) indication when NSE alert limit exceeded.

4.7.3 RNP AR APCH operations

4.7.3.1 **Pre-flight**

4.7.3.1.1 Most manufacturers have developed recommended procedures for RNP AR APCH procedures. Although the manufacturer recommendations should be followed, the operational approval should include an independent evaluation of the operator's proposed procedures. RNP AR APCH operating procedures should be consistent with the operator's normal procedures where possible in order to minimise any human factors elements associated with the introduction of PBN operations.

4.7.3.1.2 RNP AR APCH procedures are designed as vertically guided approaches and shall only be flown by suitably qualified aircraft and approved crews. The MEL shall clearly identify the required equipment which may include dual GNSS, dual FMS, dual ADS, dual AP; at least one IRU and a Class A TAWS.

4.7.3.1.3 A pre-flight prediction of the anticipated RNP availability at the destination aerodrome is required. The prediction should be based on the latest satellite health data and a mask angle of at least 5º, which should be increased, as necessary, to cater for high terrain.

4.7.3.1.4 Crew procedures must be established to exclude NAVAID facilities in accordance with NOTAMS.

4.7.3.1.5 The navigation database must be current and the procedure must have been validated for use by the operator.

4.7.3.2 **Procedure selection and review**

4.7.3.2.1 Operating procedures should address the selection of the approach from the navigation database and the verification and review of the displayed data.

4.7.3.2.2 The instrument approach chart will contain, for example, $RNAV_{(RNP)}$z RW20R in the title and the clearance issued will be to RNAV z RWY20R. Due to avionics limitations the available approaches may be displayed in an abbreviated format e.g. RNVZ. In some cases the multiple indicators (x, y, and z) may not be supported. Flight crew procedures must take these limitations into account to ensure that the correct procedure is selected and then checked. Attention should also be paid to the desired navigation accuracy – if the RNP is not automatically extracted from the database, there should be a crew procedure for entering it manually. The minimum navigation accuracy set must be compatible with the aircraft/crew qualification and briefed Decision Altitude.

4.7.3.2.3 The lateral path of the procedure shall not be modified with the exception of direct to clearances to waypoints prior to the FAF that are not the start of an RF leg. Altitude and speed constraints may be altered to comply with ATC instructions.

4.7.3.3 **GNSS updating**

4.7.3.3.1 RNP AR APCH procedures are dependent on GNSS positioning, and the availability of GNSS, (as well as the available level of RNP) should be checked prior to commencement of an approach.

4.7.3.3.2 The failure of a GNSS receiver (i.e. an equipment failure) should be annunciated. Where dual GNSS receivers are installed, the approach can usually continue normally using the serviceable receiver.

4.7.3.3.3 A loss of GNSS updating due to a loss of signal may occur at any time, but an alert will not normally be generated immediately. Where position integrity can be maintained following the loss of GNSS a valid position will continue to be displayed.

4.7.3.3.4 When the required performance cannot be sustained, an alert will be generated. A go-around should be initiated unless the approach can be completed visually.

4.7.3.3.5 Inspectors should be familiar with the alerting system applicable to the specific aircraft under consideration to ensure that operating procedures and crew knowledge and training is consistent with the system functionality.

4.7.3.4 **Radio updating**

4.7.3.4.1 Although RNP AR APCH are based upon GNSS positioning, it may be possible to use DME/DME as a reversionary system if there is adequate cover and the aircraft is qualified. VOR updating is not authorized and may need to be inhibited.

4.7.3.5 **Track deviation monitoring**

4.7.3.5.1 Lateral deviation shall be limited to ½ RNP on straight legs and RF legs, brief deviations up to a maximum of 1xRNP are allowed during fly-by and fly-over turns. The pilot must ensure that the appropriate scaling is selected in the lateral deviation indicator when the means for selection is available.

4.7.3.5.2 Vertical deviations from the defined path should be limited to ±75ft, transient deviations above +75ft, associated with aircraft configuration changes are acceptable, however, with the exception of vertical fly-bys, any deviation below -75ft on final approach requires an immediate go-around unless the pilot has in sight the visual references required to continue the approach. Vertical fly-by guidance at a fix may result in momentary deviations of up to 100ft.

4.7.3.5.3 For RNP<0.3, the pilot must check that the lateral and vertical guidance is consistent with other independent data sources.

4.7.3.5.4 If the deviation exceeds 1xRNP, or -75ft, and the pilot does not have adequate visual references in sight, a missed approach must be executed.

4.7.3.5.5 The design of the vertical flight path takes account of the cold temperature effects on barometric altimetry as well as the effect of any along-track error in the determination of the vertical path (horizontal coupling effect). The minimum temperature for which the procedure has been designed is promulgated on the chart.

4.7.3.5.6 Temperature compensated VNAV systems and systems using GNSS for vertical navigation (SBAS and GBAS) enable the designed vertical flight path to be flown irrespective of temperature. The pilot must be aware of the effects of cold temperature correction on intercepting the compensated path.

4.7.3.6 **Altimeter settings**

4.7.3.6.1 Current local QNH must be set prior to the FAF. A cross-check between the two pilots' altimeters, prior to the FAF but no earlier than the IAF, must agree within 100ft. If the cross-check fails the procedure must be abandoned. A manual cross-check is not required if this is performed automatically by the system.

4.7.3.7 **Airspeed**

4.7.3.7.1 Pilots must not exceed the maximum airspeed promulgated for the aircraft category or published with the procedure. This is particularly important when flying RF legs and/or low RNP legs.

4.7.3.8 **Missed approach**

4.7.3.8.1 In aircraft where LNAV disengages at TOGA activation, the pilot shall ensure that LNAV is reengaged as soon as possible thereafter. The operator should demonstrate that crew detection and reaction times ensures that the lateral excursion is contained within 1xRNP wherever the Go Around is initiated (this should be demonstrated in particular in the most stringent RF leg of the intended procedures)

4.7.4 Flight crew knowledge and training

Successful RNP AR APCH operations depend on sound flight crew knowledge and training.

The type of navigation system has a significant effect on the conduct of this type of procedure and flight training must take this factor into account.

The amount of training will vary depending on the flight crew's previous area navigation experience, however the following is provide as a guide:

4.7.4.1 **Ground training**

Ground training including computer-based training and classroom briefings shall include all required elements of the syllabus detailed in the PBN Manual.

4.7.4.2 **Simulator training**

Briefings and simulator sessions should cover all elements of the intended operation, or the minimum number of approaches stipulated in the PBN Manual. Proficiency may be achieved in normal uncomplicated operations in a short period of time however additional flight time needs to be scheduled to ensure competency in the management of approach changes, go-round, holding and other functions, including due consideration of human factors. Where necessary initial training should be supplemented by operational experience in VMC or under supervision. The minimum functionality of the Flight Simulation Training Device used for RNP AR simulator training is listed in Appendix 1.

4.7.5 Navigation Database

4.7.5.1 RNP AR APCH operations are critically dependent on valid data.

4.7.5.2 Any RNP AR APCH in the database must first be validated formally by the operator by:

a) comparing the data in the database with the procedure published on the chart;

b) flying the entire procedure either in a simulator or in the actual aircraft in VMC to ensure that there is complete consistency and there are no disconnects;

c) subsequent database updates must be compared with the validated master to ensure that there are no discrepancies.

4.7.5.3 The navigation database shall be obtained from a qualified source and operators must also have procedures in place for the management of data.

4.7.5.4 Even qualified database suppliers who comply with RTCA DO200A/EUROCAE ED 76 cannot guarantee that the databases will be error-free. Operators must have procedures in place to ensure, for every AIRAC, that the RNP AR procedure in the database is exactly the same as the RNP AR procedure that was initially validated.

4.7.6 Safety assessments

4.7.6.1 The ICAO Doc 9905 RNP AR procedure design criteria assume that any event leading the aircraft to exit the lateral (2xRNP) or vertical (VEB) extent of the obstacle clearance volume may have hazardous repercussions. In order to ensure that the TLS of the intended operation is met, the acceptability of the repercussions of aircraft failures with respect to the RNP AR application must be addressed. (PBN Manual, Vol 2, RNP AR Nav Spec paras 6.3.3.2.7 and 6.3.3.4.1.2.)

4.7.6.2 Demonstration of compliance with those requirements may be part of the aircraft qualification criteria assessed during the airworthiness approval, or may be the subject of a demonstration as part of the operational approval.

4.7.6.3 Whatever the methodology followed, operational approval stakeholders should ensure that aircraft documented compliance in the airworthiness approval or the demonstrated comopliance performed during the operational approval properly satisfies the 10^{-7} RNP AR lateral and vertical airspace containment limits. The applicant should demonstrate that any contingency procedures and operational limitations used to satisfy this objective are well understood and are applied by the applicant's flight crews. Furthermore, when States have decided to implement a "State-wide" RNP AR operational approval process, stakeholders should ensure that any demonstration is representative and is applicable to all public RNP AR procedures, including the most challenging ones.

4.7.6.4 The CAA should ensure that a clear statement is available from the applicant as to whether the aircraft State of Design approval has included the demonstration of compliance within the airworthiness approval of the aircraft or whether the demonstration will be an operator's responsibility to be satisfied during the operational approval.

a) If the published RNP AR value in the applicant's AFM includes the potential degradation of performance under aircraft failures and if the RNP AR level at which the aircraft has been qualified satisfies the RNP AR level required by the intended application, no additional failure demonstration should be required during the

operational approval process provided the applicant is able to give evidence through the documentation obtained from the aircraft manufacturer qualification dossier.

b) If the published RNP AR value in the applicant's AFM does not include the potential degradation of performance under aircraft failures or if the RNP AR level at which the aircraft has been qualified does not satisfy the RNP AR level required by the intended application, the CAA must require a demonstration from the applicant, additional to the RNP AR aircraft qualification, that the containment criteria are satisfied (including consideration of engine failure in addition to system failures) for the intended application. To do so, the applicant needs to obtain from the aircraft manufacturer the detailed list of failures that may degrade the RNP AR performance. The applicant then has to assess the effect of those failures with respect to the intended operation using simulation means qualified as representative of the aircraft configuration approved for RNP AR.

In both cases, all contingency procedures and operational limitations required to support the demonstration that the TLS of the intended application is satisfied must be applied during the training program.

4.7.6 Flight Operational Safety Assessment (FOSA)

4.7.6.1 In certain circumstances, such as for RNP<0.3 applications, approaches in areas of high terrain and other difficult conditions, or approaches in complex high traffic density environments, a Flight Operational Safety Assessment (FOSA) may need to be completed. Further guidance on how to conduct a FOSA is provided at Annex E.

4.7.7 Documentation supporting the application for approval

4.7.7.1 Support data and information collated during the AR qualification and compliance assessment may include inputs from one or all of the following: aircraft manufacturer, avionics supplier, and operator.

4.7.7.2 Support documentation will vary in form and location of content depending on the governing regulations, business processes and procedures, and other practices that may apply. Each is an acceptable means of compliance. The result is there will not be a 1 for 1 correlation between one manufacturer's documentation and another's, or one operator and another. However, what should be clear from any documentation set is what is relevant and applicable to the PBN application and the associated operational approval e.g. this could range from a single document whose content clearly addresses RNP AR requirements only for regulatory approval, to a documentation set comprised of multiple documents with clearly identified sections for RNP AR indexed to the application requirements.

APPENDIX 1 TO CHAPTER 4

FLIGHT SIMULATION TRAINING DEVICE FUNCTIONALITY AND QUALIFICATION FOR RNP AR APCH

A Statement of Compliance is required that attests to the fact that the simulation of the navigation systems (i.e. EGPWS, GPS, IRS, FMS) and flight guidance systems accurately replicate the operator's equipment and is based on original equipment manufacturer's (OEM) or aircraft manufacturer's design data. A Statement of Compliance template, should be made available by the regulatory authority.

While there are no requirements for airport specific models (e.g. FAA Part 60 Class I or Class II models) to be used in the qualification of a Flight Simulation Training Device (FTSD) for RNP AR APCH training, any visual model must employ real-world terrain modelling. Furthermore, approved RNP AR APCH applications must be used. Generic airport models may be approved for use in training where airport recognition in the visual segment portion of the RNP/AR approach is not critical to completion of the training task. In these cases, a generic airport with a real world visual terrain model may be utilized. In addition, any terrain awareness and warning system (TAWS/EGPWS) must provide correct terrain feedback (Class A terrain display) and warnings consistent with the specific approach being trained.

Evidence must be provided that the FSTD is equipped and operated in accordance with a valid aircraft cockpit configuration and complies with all applicable software versions or limitations. The operator should ensure that the simulator has the capabilities to support the simulation of any manufacturer required, or operator adapted, normal and non-normal procedures including appropriate aircraft/system specific failures and relevant operating conditions (obtained from the appropriate OEM or vendor), for inclusion in the flight training program.

The following items should be addressed in the Statement of Compliance:

Simulator PBN RNP AR capability

- Airframe
  - Model
  - Engines
  - Winglets
  - Other airframe unique options
- Flight Guidance and Flight Management System
  - Part numbers for all software and hardware components
- Autoflight Options
- Autothrust
- Air Data system
- PFD
- Flight Mode Annunciation
- TAWS
  - GPS position as a direct input to keep terrain on Nav Display
  - Peaks and obstacle function
  - Database currency

Operator and Crew Policies and Procedures

- AFM or equivalent documentation providing all training assumptions taken in the framework of RNP AR qualification of the aircraft
- FCOMs
- QRH
- Checklist

Ability to generate failures and degradation

- GPS faults
- CDU faults and failures
- Display Unit failures
- Flight Guidance System failures
- Loss of NAV or Approach modes
- Loss of deviation or performance information
- Loss of TAWS data or display
- TAWS terrain discrepencies
- Dual loss of GPS sensors
- FMS/GPS position disagreements
- FMS failures or downgrades

Visuals

- Ability to add airports to visual database
- Use of Generic Airport with TAWS (possibility to set a generic visual with "flat terrain" in a way to avoid spurious GPWS warning or crash simulator generated by an inaccurate generic visual terrain)
- Runway coordinates must match AIP
- Visual terrain is accurate and doesn't cause spurious TAWS alerts (or flat terrain option in visual settings)

Navigation Database considerations

- Procedure service provider/developer test DBs and loading media.
- Coordination required with multiple parties associated with process
  - Aircraft OEM
  - FMS/FGS vendor
  - Operator
  - FSTD vendor
  - Nav Database packing service provider
  - Flight Training provider

Evaluation Criteria:

- Normal Performance and Functionality:
  - Up-to-date database with display of validity period
  - Operable Class A Terrain Awareness Warning System (TAWS) identical to the aircraft.
  - Dual FMSs, dual GPSs, dual autopilots, and at least a single inertial reference unit (IRU). All must be operable.
  - Statement of Compliance with the OEM systems included in the eligible configuration of RNP AR A/C qualification.
  - Ability to load the entire RNP/AR approach procedure to be flown from the onboard navigation database.
  - Ability to verify the RNP/AR procedure to be flown through a review of the individual waypoints.
  - Either an equipment capability or an operational procedure to provide a direct means of inhibiting sensor updating (VOR/DME), if required.
  - FSTD autopilot/flight director able to fly a RF leg, comply with the aircraft's bank angle limits, able to maintain lateral track navigation without exceeding the RNP value while encountering strong tailwinds.
  - Upon initiating a go-around or missed approach (through activation of TOGA or other means), the lateral flight guidance mode should remain in LNAV/NAV1. If the aircraft cannot remain in LNAV/NAV after TOGA is selected, then procedures to re-engage LNAV/NAV while remaining

within 1 x RNP must be demonstrated and verified in the FSTD. The FSTD must permit re-engagement of LNAV/NAV by 400 ft AGL.

- Non-normal Performance and Functionality:
  - Navigation system must have the ability to monitor the achieved navigation performance and to alert the pilot when the RNP requirements are not being met (i.e. “UNABLE RNP”).
  - The Instructor’s Operating Panel must have the capability to induce the malfunction of an “UNABLE RNP” alert or other alert message that would cause a missed approach during a RNP AR APCH (e.g. FMS failure, GPS failure, AP failure, loss of guidance, loss of FD/FDE, engine failure, extreme wind/turbulence, etc). The malfunction must appear realistic to the pilots.
- Demonstration mode

The ability to demonstrate cockpit effects induced by remote or very remote failure combinations at a faster rate than real time would be advantageous. The objective being to illustrate and consolidate the theoretical knowledge received during the ground course. The FTSD should clearly indicate that the training situation is not real time. (“Demo Mode” displayed in front of the visual scene) Example effects could include:

- FMS / GPS position disagree
- FMS 1 / FMS 2 position disagree
- Inconsistency between the terrain display and one or both FMS FPL displays
- Effect of position RAD NAV update
- High / Low temperature impact on non compensated baro-VNAV FPA
- Loss of GPS, GPS primary lost, NAV ACCUR downgraded
- IRS drift effect

RNP AR APCH JOB AID

APPLICATION TO CONDUCT RNP AR APCH OPERATIONS

1. **Purpose of the job aid**

a) To provide information on the relevant reference documents.

b) To provide a record of the operator application, the inspector comments and the operator follow-up action for each relevant paragraph in the reference document(s).

2. **Actions recommended for the inspector and operator**

a) At the pre-application meeting, the operator and the inspector review the approval process events and establish the form and content of the approval application.

b) The operator records references to material in company documents for each relevant paragraph in the job aid.

c) The operator submits the completed job aid with the application to the inspector.

d) The inspector records his findings for each relevant paragraph in the job aid indicating compliance or necessary corrective action.

e) The inspector informs the operator as soon as possible when a corrective action is required.

f) The operator provides the inspector with the revised material when so requested.

g) The CAA provides the operator with the operational specifications (OpSpecs) or a letter of authorization (LOA), as applicable, when the tasks and documents have been completed.

3. **Reference documents**

Publisher	Reference	Title
ICAO	Annex 2	Rules of the Air
	Annex 6	Operation of Aircraft
	Doc 4444	PANS-ATM Air Traffic Management
	Doc 7030	Regional Supplementary Procedures
	Doc 9613	Manual on Performance Based Navigation
FAA	AC 90-101()	Approval Guidance for RNP Procedures with SAAAR
	14 CFR Part 121 Sub-part G	Manual Requirements
EASA	AMC 20-26	Airworthiness Approval and Operational Criteria for RNP Authorization Required (AR) Operations
CASA	AC 91U-II-C-5 (draft)	Navigation Authorizations – RNP AR Operations
ICAO (SAM)	AC 91-009	Aircraft and Operators Approval for RNP Authorization Required Approach (RNP AR APCH) Operations

PART 1. GENERAL INFORMATION
BASIC EVENTS OF THE APPROVAL PROCESS

	Action by Operator	**Action by Inspector**
1	Establish the need for the authorization	
2	Review AFM, AFM Supplement, TC Data Sheet, other appropriate documents (e.g. STCs, SB, SLs) to determine aircraft eligibility if necessary contact aircraft and/or avionics OEM to confirm eligibility.	
3	Schedule pre-application meeting with inspector	
4		During pre-application meeting establish: Form and contents of application Documents required to support application Target date of application submission Requirement for flight validation
5	Submit application at least XX days prior to start-up of planned operations	
6		Review submission
7	Ensure amendments to manuals, programmes and other relevant documents are complete; provide training to flight crews, flight dispatchers and maintenance personnel; if required, conduct validation flight	If required, participate in validation flight
8		Once requirements have been met, issue operational approval

PART 2. IDENTIFICATION OF AIRCRAFT AND OPERATORS

Name of Operator: _____

Aircraft Manufacturer, Model and Series	Registration Number	Serial Number	Navigation Systems Manufacturer, Model and Number	RNP Specification

Date of pre-application meeting: _____

Date when application received by CAA: _____

Date when operator intend to begin RNP APCH operations: _____

CAA notification date appropriate? Yes _____ No _____

PART 3. OPERATOR APPLICATION

Annex	Title	Inclusion by Operator	Comments by Inspector
A	**Request for Authorization**		
B	**Aircraft Eligibility - Airworthiness** AFM, AFM Revision, AFM supplement, TCDS showing aircraft RNAV systems are eligible.		
C	**Aircraft Eligibility- Modifications (if applicable)** Maintenance records documenting installation or modification of aircraft systems to achieve eligibility		
D	**Maintenance** Navigation database and RNP AR APCH system maintenance practices.		
E	**Minimum Equipment List**		
F	**Training** **xxx91 / GA operators or equivalent:** Course completion records. **xxx121 / xxx135 / CAT operators or equivalent:** Training programmes for flight crew, flight dispatchers and maintenance personnel.		
G	**Operating Policies and Procedures** **xxx91 / GA operators or equivalent:** Extracts from Operations Manual corresponding to application **xxx121 / xxx135 / CAT operators or equivalent:** Operations Manual and Checklists.		
H	**Navigation Database** Validation programme and procedures		
I	**Withdrawal of Approval** Possibility of withdrawal of approval following navigation error reports.		
J	**Validation flights** Formal plan to validate proposed operation		
K	**Monitoring Programme** Data collection plan		
L	**Flight Operational Safety Assessment (FOSA)** AN established methodology for a formal safety assessment of the proposed operation		

CONTENTS OF THE APPLICATION TO BE SUBMITTED BY THE OPERATOR

- COMPLIANCE DOCUMENTATION OF THE AIRCRAFT/NAVIGATION SYSTEMS
- OPERATING PROCEDURES AND POLICIES
- SECTIONS OF THE MAINTENANCE MANUAL RELATED TO NAVIGATION DATABASES

Note.— Documents may be grouped in a single binder or may be submitted as individual document.

PART 4. CONTENTS OF OPERATOR APPLICATION

#	Topic	Specific ICAO Doc 9613 reference *(ICAO Doc 9613, Vol. II, Part C, Chap. 6)*	Specific State guidance reference *(AC/AMC/CA etc.)*	Operator compliance description *(Document reference/ method)*	Inspector disposition/ comments *(Accepted/not accepted)*	Follow-up by inspector (Optional) *(Status and date)*
1	**Authorization request** Statement of intent to obtain authorization					
2	**Aircraft/navigation system eligibility** Documents that establish the eligibility.	6.3.2.5				
5	**Training** Details of courses completed (xxx91 operators) Details of training programmes (xxx121 and xxx135 operators)	6.3.2.6.2 & 6.3.5				
6	**Operating Policies and Procedures** Extracts from Operations Manual or other documentation (xxx91 operators) Operations Manual and checklists (xxx121 and xxx135 operators)	6.3.2.6.3				
7	**Maintenance Practices** Document navigation database maintenance practices	6.3.2.6.5 & 6.3.6				
8	**MEL update**	6.3.2.6.4				

PART 6. OPERATING PROCEDURES

#	Topic	Specific ICAO Doc 9613 reference *(ICAO Doc 9613, Vol. II, Part C, Chap. 6)*	Specific State guidance reference *(AC/AMC/CA etc.)*	Operator compliance description *(Document reference/ method)*	Inspector disposition/ comments *(Accepted/not accepted)*	Follow-up by inspector (Optional) *(Status and date)*
1	Flight Planning					
1a	Verify aircraft and crew approved for RNP AR operations	6.3.4				
1b	Verify MEL and AP/FD availability	6.3.4.1.1 & 6.3.4.1.2				
1c	Verify RNP available	6.3.4.1.3				
1d	Verify procedures for NAVAID exclusion	6.3.4.1.4				
1e	Verify navigation database current	6.3.4.1.5				
1f	Review contingency procedures/options	6.3.4.2.20 & 6.3.4.2.21				
1g	Verify FPL: 'R' in field 10 PBN/T1 or T2 in field 18					
2	Prior to Commencing Procedure					
2a	Verify correct procedure loaded	6.3.4.2.1 & 6.3.4.2.6				
2b	Verify correct RNP accuracy requirements	6.3.4.2.3				
2c	Cross-check chart with RNAV system display	6.3.4.2.1 & 6.3.4.2.6				
2d	Verify GNSS sensor in use (only multi-sensor systems)	6.3.4.2.4				
2e	Inhibit specific NAVAIDS as required	6.3.4.2.5				
2f	Only modify to accept direct to waypoint before FAF and not preceding an RF leg or to change altitude/speed constraints in initial, intermediate or missed approach segments	6.3.4.2.1				
2g	Confirm aircraft capable of complying with missed approach climb gradient	6.3.4.2.16				

#	Topic	Specific ICAO Doc 9613 reference *(ICAO Doc 9613, Vol. II, Part C, Chap. 6)*	Specific State guidance reference *(AC/AMC/CA etc.)*	Operator compliance description *(Document reference/ method)*	Inspector disposition/ comments *(Accepted/not accepted)*	Follow-up by inspector (Optional) *(Status and date)*
3	During procedure					
3a	Maintain centreline; monitor track deviation; lateral deviation limited to ± ½ navigation accuracy (up to 1xRNP in fly-by turns) Execute missed approach if 1xRNP exceeded	6.3.4.2.7				
3b	Maintain vertical path; monitor vertical deviation – limited to ± 75ft. Execute missed approach if ± 75 ft exceeded	6.3.4.2.8				
3c	For RNP<0.3, cross-check lateral and vertical guidance against other data sources.	6.3.4.2.10				
3d	Do not exceed aircraft category speeds in RF turns	6.3.4.2.11				
3e	Apply temperature compensation as appropriate	6.3.4.2.12				
3f	Ensure local QNH set before FAF	6.3.4.2.13				
3g	Cross check altimeters after IAF and before FAF (±100ft)	6.3.4.2.14				
3h	Do not exceed ±100ft vertical deviation at VNAV capture	6.3.4.2.15				
3i	If LNAV disengaged at TOGA, reengage as quickly as possible	6.3.4.2.18				
3j	Manage speed to maintain track in any go-around	6.3.4.2.19				
3k	Comply with manufacturer's instructions/procedures	A.3.4.5.2				
3l	Use FD and/or AP	6.3.4.2.7				

PART 7. CONTINGENCY PROCEDURES

#	Topic	**Specific ICAO Doc 9613 reference** *(ICAO Doc 9613, Vol. II, Part C, Chap. 6)*	**Specific State guidance reference** *(AC/AMC/CA etc.)*	**Operator compliance description** *(Document reference/ method)*	**Inspector disposition/ comments** *(Accepted/not accepted)*	**Follow-up by inspector (Optional)** *(Status and date)*
1	Contingencies					
1a	Advise ATC if unable RNP APCH	(Doc 4444 Chapter 5 - 15.2.1.1				
1b	Air-Ground Comms Failure	- (Doc 4444 Chapter 5 - 15.3)				

ANNEX A
AREA NAVIGATION SYSTEMS
OVERVIEW

An area navigation system automatically accepts inputs from various positioning sources. These can be ground-based NAVAIDs, satellite or airborne systems e.g. VOR, DME, INS or GNSS. The quality of the available NAVAID infrastructure directly impacts the accuracy of the navigation solution. The area navigation system computes aircraft position, velocity, track angle, vertical flight path angle, drift angle, magnetic variation, barometric-corrected altitude, estimated time of arrival and wind direction and magnitude. It may also perform automatic radio NAVAID tuning as well as support manual tuning. While navigation can be based upon a single navigation signal source (e.g. GNSS), most systems are multi-sensor area navigation systems. Such systems use a variety of navigation sensors including GNSS, DME, VOR and IRS, or AHRS, to compute the position and velocity of the aircraft. While the implementation may vary, the system will typically base its calculations on the most accurate positioning sensor available.

The area navigation system will confirm the validity of the individual sensor data and, in most systems, will also confirm the consistency of the computed data before they are used. GNSS data are subjected to rigorous integrity and accuracy checks prior to being accepted for navigation position and velocity computation. DME and VOR data are typically subjected to a series of reasonableness checks prior to being accepted for radio updating. This difference in rigour is due to the capabilities and features designed into the navigation sensor technology and equipment. For multi-sensor area navigation systems, if GNSS is not available for calculating position/velocity, then the system may automatically select a lower priority update mode such as DME/DME or VOR/DME. If these radio update modes are not available or have been deselected, then the system may automatically revert to inertial coasting (i.e. navigation with reference to INS information or AHRS DR). For single-sensor systems, sensor failure may lead to a dead reckoning mode of operation. If the area navigation system is using ground NAVAIDs, it uses its current estimate of the aircraft's position and its internal database to automatically tune the ground stations in order to obtain the most accurate radio position.

Area navigation enables the aircraft to fly a path, or 'leg', between points, called 'waypoints', which are not necessarily co-located with ground-based navigational aids. If a navigation data base is included in the area navigation system then the data in the database is specific to an operator’s requirements. This data is taken from the States‘ Aeronautical Information Publications (AIPs) in the form of route structures, instrument flight procedures, runways and NAVAIDs. The intended flight path is programmed into the area navigation system by selection or input of a series of waypoints, or by loading a complete route or procedure description from the navigation database. If there is no database the pilot must insert all waypoint data.

The intended flight path is displayed to the pilot. Lateral and, where available, vertical guidance is provided to the pilot on displays in the primary field of view. Area navigation systems are generally coupled, or capable of being coupled, directly to the auto-flight system (autopilot).

More advanced area navigation systems include a capability for performance management where aerodynamic and propulsion models are used to compute vertical flight profiles matched to the aircraft and able to satisfy the constraints imposed by the procedure. A performance management function can be complex, utilising fuel flow, total fuel, flap position, engine data and limits, altitude, airspeed, Mach, temperature, vertical speed, progress along the flight plan and pilot inputs to determine the optimum path. Area navigation systems routinely provide flight progress information for the waypoints en-route, for terminal and approach procedures, and the origin and destination. The information includes estimated time of arrival, and distance-to-go which are both useful in tactical and planning coordination with ATC.

GUIDANCE AND CONTROL

An area navigation system provides lateral guidance, and in many cases, vertical guidance. The lateral guidance function compares the aircraft‘s position generated by the navigation function with the desired lateral flight path and then generates steering commands to fly the aircraft along the desired path. Geodesic or great circle paths join the flight plan waypoints and circular transition arcs between these legs are calculated by the area navigation system. The flight path error is computed by comparing the aircraft‘s present position and direction with the reference path. Roll steering commands to track the reference path are based upon the path error. These steering commands are output to a flight guidance system, which either controls the aircraft directly or generates commands for the flight director. The vertical guidance function, where included, is used to control the aircraft along the vertical profile within constraints imposed by the flight plan. The outputs of the vertical guidance function are typically pitch commands to a display and/or flight guidance system, and thrust or speed commands to displays and/or an auto-thrust function.

Display and system controls provide the means for system initialization, flight planning, computation of path deviations, progress monitoring, active guidance control and presentation of navigation data for flight crew situational awareness.

NAVIGATION DATABASE

Operators purchase the navigation data from third party companies known as data-houses who compile the navigation information from each State to support the operator’s requirement. These data houses produce the datasets which are packaged and shipped in ARINC 424 format to the Original Equipment (area navigation system) Manufacturers (OEMs). The OEMs, known as 'data packers', code the datasets for the appropriate (target) area navigation systems. The data bases are updated and validated in accordance with the ICAO AIRAC. Each area navigation system uses its own proprietary binary database format. Furthermore, each operator has a specific requirement for navigation data.

If the data in the dataset is incorrect, the data in the database will be incorrect and the pilot may not be aware of this. Each navigation specification includes requirements to ensure that the navigation database integrity is maintained and to ensure that only valid databases are used. The flight path extracted from the database should also be checked for accuracy and consistency against the chart information before and during every area navigation operation.

When using an area navigation system with a database, the pilot will select the route/procedure or the waypoints defining the flight planned route from the database to create a route in the area navigation system. For area navigation systems without a database, the pilot will manually insert the waypoints (key in the coordinates of each waypoint required) to define the route.

RNAV WAYPOINTS

A significant point is defined as a specified geographical location used to define an area navigation route or the flight path of an aircraft employing area navigation. There are three categories of significant points: ground-based navigation aid, intersection and waypoint. An intersection is a significant point expressed as radials, bearings and/or distances from ground-based navigation aids. area navigation systems only use significant points that are defined by geographic coordinates in WGS84 and data-houses convert fixes into ‘Computer Navigation Fixes’ with associated co-ordinates. Fixes are only associated with conventional navigation and are not used in PBN. All significant points are treated as ‘waypoints’ within the area navigation system. Significant points are identified as follows:

a) by a five letter unique name code, e.g. BARNA,

b) by the three letter ICAO identifier for the NAVAID, e.g. OTR,
c) by an alphanumeric name code if used in Terminal Airspace only, e.g. DF410.

Area navigation routes/procedures can specify a path laterally, longitudinally and vertically. The waypoints are used to indicate a change in direction (track), speed and/or height. In SIDs and Missed Approaches, turns may be predicated on altitude rather than waypoint location. The area navigation system will fly routes and procedures in a consistent manner but the actual track will depend upon the waypoint transition and, in terminal procedures, on the leg types‘ used to define the procedure. Waypoint transition may be:

a) Fly-over
b) Fly-by
c) Fixed radius

A fly over waypoint requires that the turn is initiated when the aircraft passes overhead the waypoint. All area navigation systems are capable of a fly-over turn followed by a manoeuvre to recapture the next leg. A fly by waypoint requires the area navigation system to calculate a turn anticipation before the aircraft reaches the waypoint to allow interception of the next segment without the aircraft passing overhead the waypoint. The turn anticipation distance depends on aircraft ground speed and the angle of bank applied in the turn. Turn anticipation does not provide track guidance during the turn and cross-track error cannot be monitored until the aircraft is established on the subsequent leg,. The effectiveness of the turn anticipation algorithm is limited by variation in groundspeed during the turn (e.g. headwind to tailwind) and the achieved bank angle. Undershooting or overshooting of the turn can occur and crew intervention may be required. Fly-by functionality is called up in many navigation specifications but is not always available on older and less capable area navigation systems.

A fixed radius turn is defined differently in en-route and on terminal procedures. In the former, which is known as a Fixed Radius Transition (FRT), a fixed radius value is associated with a waypoint and the area navigation system is required to fly-by that waypoint using the same turn radius regardless of the aircraft ground speed. In the latter case, the ground track is defined in the database with a waypoint at the start and end of the turn and the leg type specified as a radius to fix (RF) leg. In both cases the turn is a fixed circular track over the ground with tangential inbound and outbound legs. The area navigation system monitors cross track error during the turn and provides guidance to maintain the circular track. RF and FRT functionality is not available on many older RNAV systems.

RNAV PERFORMANCE

PBN requirements are specified in terms of lateral, vertical and 4D accuracy; integrity; continuity; availability and functionality. (Only one navigation specification to date addresses ‘time of arrival’ (4D) requirements)

Accuracy

The accuracy achieved by an area navigation system depends on the position and timing sources, the RNAV system, the flight guidance and the navigation database. The Total System Error (TSE) is usually computed as a root sum square of the Navigation System Error (NSE), the Flight technical Error (FTE) and the Position Definition Error (PDE):

The lateral track accuracy is based upon the path that has been defined by the area navigation system, the navigation sensor used to estimate the position, and the ability of the pilot and aircraft guidance system to fly the defined path. Each navigation specification identifies the 95% accuracy requirement and may place additional constraints on certain of the error sources. For example, the FTE requirement is usually

set at ½ Full Scale Deflection (FSD), where FSD = the 95% accuracy requirement. Positioning sources may be limited, for example to DME/DME and GNSS only. Additional data integrity checks may be required to limit the potential for path definition error.

$$TSE = \sqrt{NTE^2 + FTE^2 + PDE^2}$$

Position estimation accuracy is related to the type of navigation sensor used and the associated NSE. The NSE depends upon the signal in space and the dilution of precision (DOP) resulting from the relative angle that the signals subtend at the antenna.

Some sensors are better suited to PBN operations than others:

a) NDB is not suitable for any area navigation systems.
b) VOR accuracy deteriorates with range and is only appropriate for RNAV 5 applications.
c) DME/DME requires there to be sufficient stations with appropriate geometry in order to support some PBN applications in continental en-route and terminal airspace. A position estimation accuracy sufficient for ±1NM accuracy requires that the signals from a pair of DME stations subtend more than 30° but less than 150° at the aircraft antenna.
d) GNSS is the most accurate PBN positioning source and can be used in all PBN applications.

Vertical profile accuracy is, similarly, based upon the vertical path defined by the area navigation system, the sensor used to estimate the altitude, the vertical component of any along track error and the ability of the pilot and aircraft guidance system to fly the defined profile. At present there are two vertical sensor sources for area navigation systems: barometric altimetry and SBAS.

Integrity

Integrity is the degree of confidence that can be placed in the guidance provided by the area navigation system. Any malfunction of the area navigation system or associated equipment (e.g. sensors) must not occur more than once in 100,000 flight hours. The pilot must be alerted if the system malfunctions.

In RNP systems, the pilot must also be alerted if the probability that the Total System Error (TSE) is greater than the 95% accuracy requirement exceeds 10^{-5}. In GNSS-equipped area navigation systems this is usually achieved using the Receiver Autonomous Integrity Monitoring (RAIM) function or the Aircraft Autonomous Integrity Monitoring (AAIM) function. SBAS also provides an integrity monitoring function.

The RAIM function in the GNSS receiver compares a series of position estimations using the available satellite signals and generates an alert if one of the position estimations exceeds a preset threshold value (Horizontal Alarm Limit (HAL)). This is known as Fault Detection (FD) and requires a minimum of 5 satellites in view, although a barometric input may be used instead of one satellite. More recent RAIM versions detect the fault and exclude the faulty satellite from the positioning solution without necessarily generating any alert. This is known as Fault Detection and Exclusion (FDE) and requires a minimum of 6 satellites in view. RAIM availability is determined by calculating the radius of a circle, as a function of the RAIM threshold and the satellite geometry at the time of the measurements, which is centered on the GPS position solution and is guaranteed to contain the true position. If this radius is less than HAL, RAIM is available. The AAIM function compares the GNSS position estimation with the on-board inertial navigation position and generates an alert if the preset threshold values are breached. SBAS detects GPS satellite signal errors and broadcasts corrections to all users.

Availability and continuity

In order to perform a specific navigation application, both the signals-in-space and the aircraft systems must meet the required accuracy and integrity for that operation. Availability is a measure of the probability that this will be the case when the operation is to be performed. Continuity is a measure of the probability that it will continue to be the case for the duration of the operation. The Service Provider is responsible for ensuring that the signal is available and continues to be available. However, the navigation specifications do not specify a measure of availability and operators are required to check the availability prior to departure and again prior to commencing an operation. The navigation specifications all require that the airborne systems meet a continuity of 10^{-4} per flight hour This is often achieved through redundancy (additional capability to handle failures), or by the carriage of additional systems (e.g. IRS/IRU). The probability of failure and therefore being unable to complete an operation must be acceptably low.

On-board Performance Monitoring and Alerting

RNP systems do not necessarily provide the pilot with a warning when the lateral accuracy limits have been exceeded. Most RNP specifications require that the area navigation system, or the area navigation system and pilot in combination, provide an alert if the accuracy requirement is not met, or if the probability that the lateral TSE exceeds a specified value is greater than 10^{-5}. RNP systems typically have a NSE monitoring and alerting algorithm, which generates an alert, and display FTE via a lateral deviation indicator, which is monitored by the crew.

Functionality

The following system functions are the minimum required to conduct area navigation operations:

a) Continuous indication of aircraft position relative to track to be displayed to the pilot flying (and the pilot monitoring) on a navigation display situated in the primary fields of view.
b) Display of distance and bearing to the active (To) waypoint.
c) Display of ground speed or time to the active (To) waypoint.
d) Navigation data storage (usually a navigation database).
e) Appropriate failure indication of the area navigation system, including failed sensors or degraded mode of performance.

Each navigation specification identifies additional functionalities which may include:

a) Non-numeric lateral and vertical deviation displays in the primary field of view, automatically slaved to the area navigation computed path and with full scale deflection based upon the required TSE. (See para 1.10.6)
b) Map displays with appropriate scales.
c) The means to retrieve and display data, including entire area navigation routes/procedures, from a navigation database.
d) Display active sensor type.
e) Execute ‘direct to’ function.
f) Automatically sequence legs and display the sequencing (fly-by, fly-over, turn at altitude).
g) Execute leg transitions and maintain tracks consistent with ARINC 424[1] path terminators (CA, CF, DF, FA, FM, HA, HF, HM, IF, RF, VA, VI and VM).

[1] ARINC 424 is a de facto industrial standard for navigation databases developed for use in airborne area navigation systems and is referenced in a number of ICAO documents.

h) Define a vertical path by altitude constraints at two waypoints or by vertical path angle at a waypoint.
i) Provide guidance to a vertically constrained waypoint.
j) Display altitude restrictions and vertical path angles.
k) Execute fixed radius transitions.
l) Automatic reversion to alternate sensor when primary sensor fails.
m) Execute parallel offset.
n) Maintain continuous track guidance upon initiation of missed approach/go-around.
o) Ensure that lower navigation accuracy is achieved by the waypoint which marks the start of the leg with the lower accuracy requirement.
p) Appropriate alert when the NSE limit cannot be assured.

Deviation Display

There are a number of different ways in which lateral deviation can be displayed: the Course Deviation Indicator (CDI) and the Horizontal Situation Indicator (HSI) are both avionic instruments that display deviation from track by means of pointers; Navigation Performance Scales (NPS) and also L/DEV & V/DEV provide a graphical representation of the achieved lateral and vertical performance, together with an indication of available flight technical error remaining; numeric displays of achieved navigation performance and, finally the navigation map display. In general, a map display, or a numeric indicator is considered to be adequate for RNP 2 and higher, while deviation indicators such as CDI and HSI are required for lower RNP accuracy values and NPS or L/DEV & V/DEV, together with FD and/or AP, are required for low RNP accuracy values.

ANNEX B
EXAMPLE OPS SPEC ENTRIES
The PBN approval is detailed within the Ops Spec:

OPERATIONS SPECIFICATIONS
(subject to the approved conditions in the operations manual)

ISSUING AUTHORITY CONTACT DETAILS[1]

Telephone: _____ Fax: _____ E-mail: _____

AOC#[2]: _____ Operator name[3]: _____ Date[4]: _____ Signature: _____

Dba trading name: _____

Aircraft model[5]:

Types of operation: Commercial air transportation ☐Passengers ☐ Cargo ☐ Other[6]: _____

Area(s) of operation[7]:

Special limitations[8]:

SPECIAL AUTHORIZATIONS	YES	NO	SPECIFIC APPROVALS[9]	REMARKS
Dangerous goods	☐	☐		
Low visibility operations				
Approach and landing	☐	☐	CAT[10]: ____ RVR: ____ m DH: ____ ft	
Take-off	☐	☐	RVR[11]: ____ m	
RVSM[12] ☐ N/A	☐	☐		
ETOPS[13] ☐ N/A	☐	☐	Maximum diversion time[14]: ____ minutes	
Navigation specifications for PBN operations[15]	☐	☐		[16]
Continuing airworthiness	X	X	[17]	
Other[18]	☐	☐		

Notes.—

1. *Telephone and fax contact details of the authority, including the country code. E-mail to be provided if available.*
2. *Insert the associated AOC number.*
3. *Insert the operator's registered name and the operator's trading name, if different. Insert "dba" before the trading name (for "doing business as").*
4. *Issuance date of the operations specifications (dd-mm-yyyy) and signature of the authority representative.*
5. *Insert the Commercial Aviation Safety Team (CAST)/ICAO designation of the aircraft make, model and series, or master series, if a series has been designated (e.g. Boeing-737-3K2 or Boeing-777-232). The CAST/ICAO taxonomy is available at: http://www.intlaviationstandards.org/.*

Example entries are illustrated below:

SPECIAL AUTHORIZATIONS	YES	NO	SPECIFIC APPROVALS	REMARKS
Navigation specifications for PBN operations				
RNAV 10		✗		Primary sensor GNSS
RNAV 5		✗		Approval based upon GNSS and DME/DME
RNP 1		✗		Authorised for RF legs
RNP APCH		✗	LPV	Approval based upon SBAS. Authorised for approaches to LPV, LNAV/VNAV or LNAV minima.
RNP AR APCH	✗		RNP 0.15	Authorised for RF legs, RNP 0.2 in missed approach AP required Dual FMS/IRS required

ANNEX C
EXAMPLE REGULATORY TEXT

XXX.001 APPLICATION FOR A SPECIFIC APPROVAL

a) An applicant for the initial issue of a specific approval shall provide the [Competent Authority] with the documentation required, as detailed on the application form, and the following information:

   i) the official name, address and mailing address of the applicant; and
   ii) a description of the intended operation.

b) An applicant for a specific approval shall provide evidence to the [Competent Authority] that:

   i) the applicant complies with the requirements;
   ii) the aircraft and required equipment fulfil the applicable airworthiness requirements, are maintained according to the approved maintenance programme and are approved when required;
   iii) a training programme has been established for flight crew and, as applicable, personnel involved in these operations; and
   iv) operating procedures in accordance with the requirements have been documented. Operating procedures should be documented in the operations manual. If an operations manual is not required, operating procedures may be described in a procedures manual.

c) An operator shall retain records relating to the requirements of (a) and (b) above at least for the duration of the operation requiring the specific approval.

XXX.002 PRIVILEGES OF AN OPERATOR HOLDING A SPECIFIC APPROVAL

The scope of the activity that the operator is approved to conduct shall be documented and specified:

a) for commercial operators, in the operations specifications associated to the air operator certificate; and

b) for non-commercial operators, in the list of specific approvals.

XXX.003 CHANGES TO OPERATIONS SUBJECT TO A SPECIFIC APPROVAL

In case of a change that affects the conditions of a specific approval, the operator shall provide the relevant documentation to the competent authority and obtain prior approval for the change to operation, documented by an amendment to the approval document of XXX.003.

XXX.004 CONTINUED VALIDITY OF A SPECIFIC APPROVAL

Specific approvals shall be issued for an unlimited duration. They shall remain valid subject to the operator remaining in compliance.

XXX.PBN.001 PBN OPERATIONS

An aircraft shall only be operated in designated airspace, on routes or in accordance with procedures where compliance with Performance-Based Navigation (PBN) specifications is required, if the operator has been approved by the competent authority.

Guidance material for the global performance specifications, approval process, aircraft requirement (e.g. generic system performances, accuracy, integrity, continuity, signal-in-space, RNP specifications required for the on-board performance monitoring and alerting system), requirements for specific sensor technologies, functional requirements, operating procedures, flight crew knowledge and training and navigation databases integrity requirements can be found in ICAO Doc 9613 *Performance-Based Navigation (PBN) Manual* and the applicable documents listed in the table below.

Flight Phase									Applicable Documents	Complementary guidance material
	En-route		STAR	Approach				SID		
	Oceanic/Remote	Continental		Initial	Intermediate	Final	Missed			
RNAV 10	X								AC 91-001	EASA AMC 20-12 FAA 8400.12
RNAV 5		X							AC 91-002	EASA AMC 20-4 FAA 90-96()
RNP 4	X								AC 91-004	FAA 8400.33
RNP 2		X	X						tbd	tba
RNAV 2		X	X						AC 91-003	EASA TGL 10 FAA AC 90-100()
RNP 1			X	X	X		X	X	AC 91-006	EASA TGL 10 FAA AC 90-105
RNAV 1			X	X	X		X	X	AC91-003	EASA TGL 10 FAA AC 90-100()
A-RNP		X	X	X	X	X	X	X	tbd	tba
RNP APCH (LNAV)				X	X	X	X		AC 91-008	EASA AMC 20-27 FAA AC 90-105
RNP APCH (LNAV/VNAV)				X	X	X	X		AC 91-010	
RNP APCH (LP/LPV)						X	X		tbd	EASA AMC 20-28 FAA AC 90-107
RNP AR			X	X	X	X	X	X	AC 91-009	EASA AMC 20-26 FAA AC 90-101
RF			X	X	X		X	X	tbd	FAA AC 90-105
Electronic Data Management		X	X	X	X	X	X	X	tbd	EASA IR 21 subpart G FAA AC 20-153

XXX.PBN.002 PBN OPERATIONAL APPROVAL

To be issued a PBN operational approval by the [Competent Authority], the operator shall provide evidence that:

a) the relevant airworthiness approval of the RNAV system has been obtained;

b) a training programme for the flight crew involved in these operations has been established; and

c) operating procedures have been established specifying:

i) the equipment to be carried, including its operating limitations and appropriate entries in the Minimum Equipment List (MEL);
ii) flight crew composition and experience requirements;
iii) normal procedures;
iv) contingency procedures;

v) monitoring and incident reporting; and
vi) electronic navigation data management.

XXX.PBN.003 ELECTRONIC NAVIGATION DATA MANAGEMENT

Electronic navigation data products that have been processed for application in the air and on the ground shall only be used once the [Competent Authority] has approved the operator's procedures for:

a) ensuring acceptable standards of data integrity and compatibility with the intended function;

b) continual monitoring of the related data processes and the products; and

c) ensuring the timely distribution and insertion of electronic navigation data.

ANNEX D
EXAMPLE APPLICATION FORM

APPLICATION FOR XXXX OPERATIONAL APPROVAL OR RENEWAL

Please complete the form in BLOCK CAPITALS using black or dark blue ink.

This form is designed to elicit all the required information from those operators requiring [Insert PBN Type] operations approvals. The completed form and supporting documentation should be submitted to [Insert Name of Authority] at the address listed below:

Xxxx
Xxxx
Xxxx
Xxxx

Section I **Operator/Airframe Details (completion is mandatory)**
Section II **Notes For Completion**
Section III **Signature Block (completion is mandatory)**
Section IV **Operator's Submissions Matrix (completion is mandatory)**

SECTION I OPERATOR/AIRFRAME DETAILS

1 Applicant Details		
Provide official name, address, mailing address, e-mail address and contact telephone /fax number.		
2 Aircraft Details Aeroplane type(s), series and registration mark(s)		
Aeroplane Type	Aeroplane Series	Registration

SECTION II NOTES FOR COMPLETION

1 Applicability
[General description of operation with references to appropriate standards and guidance material]
2 Operator's Submissions Matrix
Section IV of this application form is the Operator's Submissions Matrix. All applicants should complete Column 4 of this matrix in full. If more than one type of aircraft/fleet is included in a single application a completed matrix should be included for each aircraft/fleet. FAILURE TO COMPLETE THE SUBMISSIONS MATRIX MAY RESULT IN A DELAY IN PROCESSING THE APPLICATION.
3 Documents to be included with the submission
Copies of all documents referred to in Column 4 of the Operator's Submissions Matrix should be included when returning the completed application form to the [Insert Name of Authority]. Original documents should not be sent, photocopies are sufficient. Do not send complete manuals, only the relevant sections/pages. FAILURE TO INCLUDE ALL RELEVANT DOCUMENTATION MAY RESULT IN A DELAY IN PROCESSING THE APPLICATION.
4 Submissions and enquiries
[Address for submissions and contact details for enquiries]

SECTION III SIGNATURE

Signature:…… Name (Block Letters):…… Title:…….. Date:……

SECTION IV OPERATOR'S SUBMISSIONS MATRIX

Reference Documents	Submission based upon current regulatory material Compliance statement should show how criteria have been satisfied.	List of appropriate documents
Airworthiness Navigation System Capability Compliance Statement	Specify to what standards the Navigation System complies.	List of applicable standards/TSOs/guidance material
Aircraft Flight Manual	Copy of extract from AFM showing certification standard for PBN operation.	

Navigation System FMS/Autopilot Interface Capability	Full details of Navigation System, FMS and Autopilot including type, number, software version.	
Navigation Accuracy	Statement of certified navigation accuracy.	
Navigation Database	Details of supplier of navigation database, supplier's approval status and, where necessary, additional quality assurance/data integrity checks applied by the operator or the supplier.	
Maintenance	Details of maintenance procedures applicable to Navigation System and associated databases.	
Charts	Details of supplier of charts, supplier's approval status and, where necessary, additional quality assurance/data integrity checks applied by the operator or the supplier	
Error Reporting	Outline of error reporting process and procedures for error analysis, prevention and correction, including feedback to the CAA, navigation database and chart suppliers, as well as OEMs.	
Standard Operating Procedures	Details of applicable operating procedures. It is recommended that manufacturer's procedures are used as a starting point.	
Operations Manual	Details of dispatch requirements (nav accuracy, MEL, RAIM, NOTAMS); RTF phraseology; SOPs; crew authorization requirements; training and testing requirements.	
Any Further Comments		

ANNEX E
FLIGHT OPERATIONAL SAFETY ASSESSMENTS (FOSA)

FOSA OVERVIEW

Why is a FOSA needed?

In some cases, the operational needs of stakeholders lead to procedure designs which may or may not comply with ICAO Doc 9905 but which require the aircraft to be operated in a manner that was not considered in its airworthiness approval.

A FOSA is intended to address this nominal mismatch.

When RNP AR APCH is being implemented it is for a specific reason e.g. improved access, safety, efficiency, etc. The FOSA process helps to ensure that the operational needs, the limits of safe and efficient aircraft performance, the means of assuring repeatable and predictable flight operations, the means of safe flight operations when faced with aircraft failures and hazardous conditions, etc. are understood by all relevant stakeholders. As a result the aircraft operations, procedure design, contingency arrangements, training and maintenance will all be at the level necessary for flight and operational safety.

When should a FOSA be conducted?

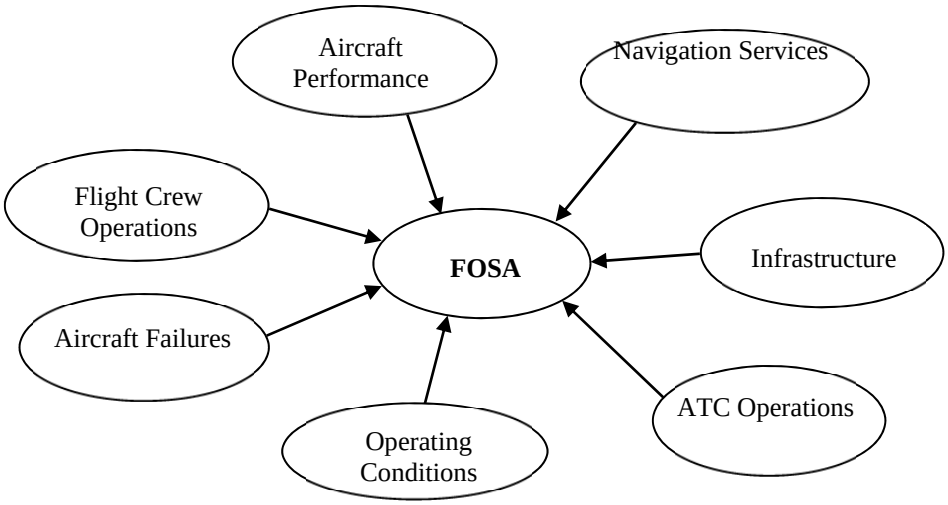
A FOSA should be conducted for each RNP AR approach procedure where the more stringent aspects of the nominal procedure design criteria (as per ICAO Doc 9905) are applied (i.e. RF legs after the FAF, RNP missed approaches less than 1.0, RNP final approaches less than 0.3) or where the application of the default procedure design criteria is in an operating environment with special challenges or demands.

How should a FOSA be carried out?

The FOSA should ensure that for each specific set of operating conditions, aircraft and environment, all failure conditions are assessed and, where necessary, mitigations are implemented to meet the safety criteria. The assessment should give proper attention to the inter-dependence of the elements of procedure design, aircraft capability, crew procedures and operating environment.

The functional areas presented in the figure below have been identified as elements to assess collectively in a typical FOSA. The FOSA should act as the ‘glue’ to combine and analyse the risks associated with the RNP AR system.

Elements to Consider in a FOSA



REQUIRED DEPTH OF FOSA

The level of depth and the associated level of resources for a FOSA are very important issues for stakeholders. Three factors that influence the required depth of a FOSA are:

i. How challenging the proposed procedure design is relative to the airworthiness approval/ qualification;
ii. The operational and obstacle environment; and
iii. The previous experience of stakeholders and the availability of appropriate previous safety assessments.

Airworthiness Approval/Qualification

In order to meet the RNP AR eligibility requirements (Doc 9613 Vol II Part C Para 6.3.3) the manufacturer needs to establish that the criteria for assessing probable failures during the aircraft qualification demonstrated that the aircraft trajectory is maintained:

- within 1xRNP of the lateral track, 95% of flight time, and
- within $\sqrt{((6076.115)(1.225)RNP\tan\theta)^2 + (60\tan\theta)^2 + 75^2 + ASE^2}$ of the vertical path, 99.7% of flight time. ($ASE = -8.8 * 10^{-8} * H^2 + 6.5 * 10^{-3} * H + 50$)

Proper documentation of this demonstration in the aircraft flight manual (AFM), AFM extension, or appropriate aircraft operational support document, alleviates the operational evaluations.

RNP-significant improbable failure cases should also be assessed to show that, under these conditions, the aircraft can be safely extracted from the procedure. Failure cases may include dual system resets, flight control surface runaway and complete loss of flight guidance function.

The aircraft performance demonstration during the operational evaluations can be based on a mix of analyses and flight technical evaluations using expert judgment.
The aircraft performance in the event of failures, as well as normal conditions, should therefore be available in the AFM or an equivalent document.

Operational and obstacle environment

If the procedure is being introduced for noise alleviation purposes and there are no obstacles close to the route (within 2*RNP), a less detailed FOSA may be appropriate. No FOSA is required if the default RNP values of 1, 1, 0.3 and 1 are used for the procedure.

If a very complex and challenging procedure is being introduced for better access to a runway surrounded by challenging terrain/ obstacles, a more detailed FOSA may be considered advisable (if no prior examination/ assessment is found to be applicable – see below).

Previous experience of stakeholders and availability of appropriate previous FOSAs

The specific history and circumstances of the RNP AR APCH implementation and the associated stakeholders will affect the depth of the FOSA.

Important factors include whether:

i. A new procedure is being developed, or one already exists flown by other carriers and/or by other aircraft types.
ii. Relevant FOSAs exist for the procedure or for other similar applications.
iii. A carrier with an RNP certified aircraft already has the manufacturers AFM, operations manual, crew procedures, dispatch guidance, minimum equipment criteria for RNP, compliance assessments, etc. that were considered valid from a previous similar RNP AR application.
iv. The ANSP and regulator(s) have previous experience of RNP AR approaches and FOSA at this airport or similar locations.

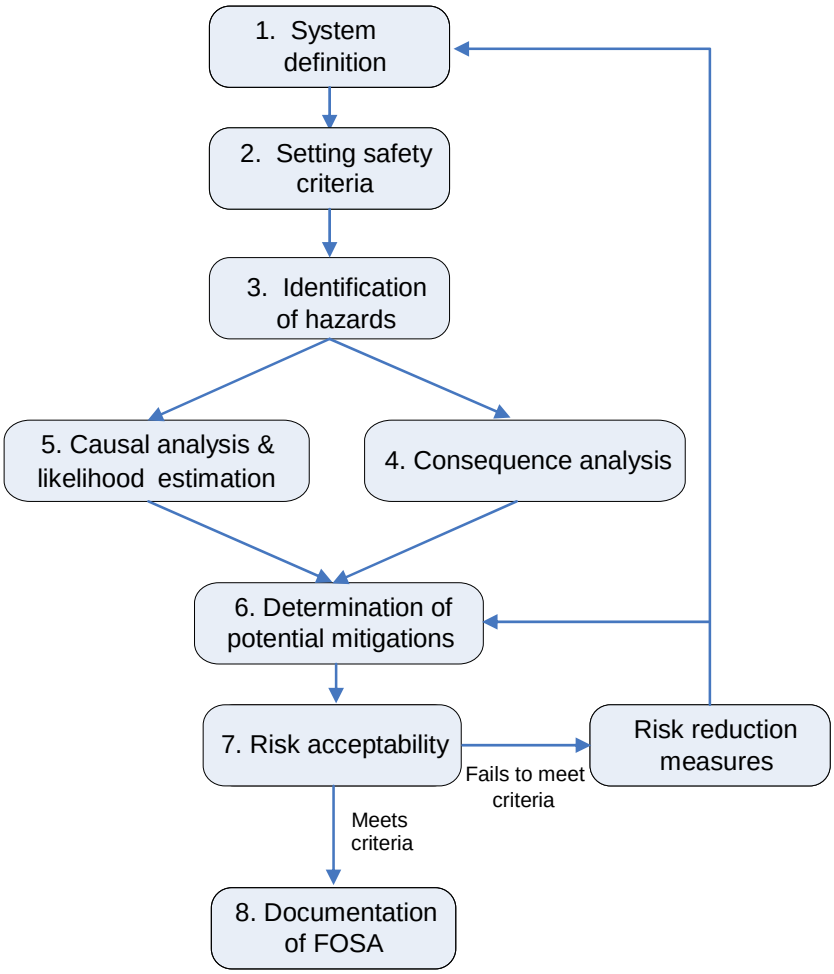
When it is determined that no FOSA has to be performed, a rationale should be provided e.g. “not applicable as covered by basic aircraft certification and/or prior operational approvals and FOSA”.

A. HOW TO CONDUCT A FOSA

OVERVIEW OF MAIN STEPS

Within aviation a number of safety assessment methodologies are in use. There is usually a large degree of commonality between them and it is difficult to identify one as clearly the best in all situations. The method illustrated in the figure below has been developed to be consistent with previous FOSA material and more general safety assessment material. It is likely that many organizations planning RNP AR approaches will already have their own safety assessment processes in place. It is expected that the steps below will be represented within these processes.

Main Steps in FOSA



DETAILS OF EACH STEP

Step 1 - System Definition

The following information should be gathered with respect to the proposed RNP AR APCH procedure:

- The proposed procedure design and details of the proposed operations including FMS coding issues;
- Aircraft information, e.g. compliance documents against applicable States' regulations, in particular the aircraft RNP system performance under operational, rare normal and non normal conditions which should be documented to support the FOSA exercise;
- Flight crew procedures and training;
- Dispatch procedures and training;
- Proposed Minimum Equipment List (or RNP AR required equipment list);
- Any special maintenance requirements;
- Airport and airspace environment;
- Navigation infrastructure;

- ATC facilities (including SUR and COMMS), procedures and intended training with respect to RNP AR operations; and
- Monitoring programme.

This should be used to put together a system description which is suitable and sufficient to conduct the FOSA. It should be ensured that all relevant elements are included, i.e. not just equipment hardware but human aspects, procedures, software, firmware and environmental aspects. As part of this step, assumptions made in AR guidance documents will need to be checked and validated.

With the system defined it is recommended that a small group of experts spend a short amount of time to identify the difficult elements of the approach, any human factors issues and any key hazards. This information will help to understand the exact requirements and necessary outcomes of the FOSA process. Subsequently an estimation of the depth of analysis required and the effort needed to complete the FOSA can be made.

Step 2 - Setting Safety Criteria

Safety criteria can be quantitative or qualitative. The PBN manual notes that a FOSA is likely to use a mix of quantitative and qualitative analysis so it would be expected that the safety criteria reflect this. The following criteria have been found to be useful and practical:

- **Quantitative safety objective criteria**. Quantitative criteria work best in the airworthiness domain where relevant data on equipment failure rates are available and where consequences can be precisely defined. It should be noted that conversions between different units (e.g. per flight hour to per approach) need to take account of exposure times.

  In the flight operations domain, human factors and the influence of procedures and training make it much more difficult to derive meaningful quantitative criteria. Hence qualitative criteria such as the following are generally more useful.

- **Risk reduced As Far As Reasonably Practicable (AFARP).** This criterion is commonly in aviation. It is sometimes referred to as the ALARP criterion, reducing risk As Low As is Reasonably Practicable. It is generally used in a qualitative manner although it can be used quantitatively via Cost Benefit Analysis. In the context of the FOSA it can be applied globally to the system, i.e. has the system as a whole reduced risk AFARP, and it can also be applied hazard by hazard.

  Risk reduced AFARP / ALARP is a flexible criterion suited to the mixture of techniques used in a FOSA. It has been found to be readily accepted by stakeholders in RNP AR case studies and has helped to define what extra risk reduction measures were needed by the AO and ANSP.

- **Risk no greater than current operations.** In a safety conscious industry such as aviation great care is taken to ensure that operations do not become riskier; rather there is a drive to continue the downward trend in accident rates. This is potentially a useful criterion to apply hazard by hazard to check that there are adequate mitigations in place to ensure no risk increase. Potential difficulties with this relative criterion are:

  - Sometimes it is very difficult even for aviation experts to compare the risks from different approach types.
  - There is a range of risk associated with current approach operations (historically Non-Precision Approaches are significantly higher risk than Precision Approaches). Hence the conclusions from use of this criterion will depend on what is being compared.

- Some regulations require that ATM risk decreases in the future as traffic rises. Being as safe as today may not be good enough.

Therefore some care needs to be taken with this "no risk increase" criterion. On its own it will probably not be sufficient, but together with the other criteria above it can be part of a practical package. If a relative criterion is used, the other approach type for comparison needs to be defined in the same level of detail as described above in Step 1 for the RNP AR approach.

The choice of safety criteria is very important. It is advisable for AOs to consult with their regulators before undertaking a FOSA. Some regulators may be wary of an RNP AR approach that increases risk compared to an existing PA, for example, even if the new procedure meets an AO's existing risk tolerability matrix. This could prevent an operational approval being granted. The AFARP/ ALARP principle is likely to be an important and possibly the most practical part of the criteria used in a FOSA.

Step 3 - Identification of Hazards

There are a range of techniques that have been used in aviation to identify hazards[2]. Some of these are based on analysis by a single person and others use a group of experts working as a team. Given the need for a FOSA to make use of a mix of disciplines a group based approach is likely to be the most successful.

The following points can help maximise the effectiveness of group based hazard identification:

- Ensure use of an experienced facilitator to guide the group.
- Gather the required mix of skills and knowledge, i.e.:

  - Procedure designers;
  - Aircraft and avionics manufacturers, if available;
  - Technical support experts;
  - Pilots (from relevant aircraft operators and test pilots if available);
  - AIM experts;
  - ATCOs and ATC representatives with knowledge of airspace planning, technical facilities; and
  - Regulators.

Other disciplines which could be useful in a FOSA include flight operations representatives, dispatch, maintenance, and safety and quality representatives. Running an effective group session involves obtaining a balance of skills but also having a manageable size of group.

Step 4 - Consequence Analysis and Severity Evaluation

The manner in which the consequences[3] of hazards are analysed will depend on the hazards. Aircraft failures will use the failure condition effects and severity classification detailed in the national advisory circulars/acceptable means of compliance and will have to satisfy the quantitative safety objectives set

[2] The term hazard is used in this document to refer to events that form convenient pinch points between sets of consequences and causes. Hazard can be defined as "Any condition, event or circumstance which could induce an accident". This broader definition is covered by the full set of hazards, causes and consequences that would be generated in a FOSA.

[3] Termed "effects" in some safety assessment methods

forth in the PBN manual and related documents. In this context, consequences are related to quantitative lateral and vertical excursions and, in the case of excursion beyond the 2 x RNP lateral corridor, whether or not the aircraft remains manoeuvrable and able to make a safe extraction. To assess consequences in this manner will require simulations. Where relevant analysis already exists from RNP certification activity this should be used and not duplicated.

For hazards in many of the other FOSA functional areas, human failures and procedural issues have a dominant effect. It is very difficult to assign a single severity level or determine a quantified excursion for such hazards. Thus the consequences are better described qualitatively for most of these other hazards. This information can then be used in the decision making process concerning whether mitigations are sufficient to control risk to an acceptable level.

Step 5 - Causal Analysis and Likelihood Estimation

The likelihood of aircraft equipment failures will already have been analysed in the existing aircraft System Safety Assessment (SSA) documents. These often employ techniques that can model complex trees/ chains linking multiple causes to the hazard. Data generally exists to populate these models and enable robust quantification of the hazard likelihood. This enables a check to be made that the safety objectives can be met. This work will already have been done during RNP AR certification activities and it should not be necessary for the manufacturer to supply detailed technical analyses. Details of the hazards considered and their likelihood category should be sufficient for the FOSA.

For most of the other functional areas, where human failures and procedural issues have a dominant effect, such detailed quantification either may not be possible or may not be useful. A possible qualitative method used in the case studies was:

- Identify and document the relevant causes of the hazard.
- Map the causal mitigations (see step 6) to these causes.
- Consider the likelihood of these causes implicitly when judging whether the mitigations are sufficient.

At the end of Step 5, potential combinations and sequences of causes leading to hazards and subsequent sequences of events to various consequences (from Step 4) will be apparent. It is important that Common Cause Failures (CCFs) within these combinations and sequences are identified and their importance assessed. Critical CCFs that can significantly increase risk levels will need additional mitigations.

Step 6 – Determination of Mitigations

Mitigations that reduce the chance of a hazard occurring (causal mitigations) and mitigations that reduce the severity of hazard consequences/ effects should be considered and documented. Splitting out the potential causes and consequences can help this process.

As part of the analysis of consequential mitigations it would be expected that contingency procedures would be fully worked out covering a range of challenging hazards (e.g. double FMS loss, loss of GNSS, etc.) occurring at various critical locations (e.g. in RF leg, early in procedure potentially requiring long extraction, at DA/ DH, etc.)

It is usually helpful to identify mitigations that are in place already or planned and then to allow the FOSA group time to also identify potential extra mitigations. Some of these potential extra mitigations may later be rejected as not needed or not practicable. However, this part of the process is a key stage in demonstrating that risk has been reduced AFARP.

Step 7 – Determination of Risk Acceptability

For Aircraft Failure hazards, the normal airworthiness criteria from 25.1309 will be used together with PBN Manual section 6.3.3, i.e.:

a) Criteria for assessing probable failures during the aircraft qualification will demonstrate that the aircraft trajectory is maintained within a 1xRNP corridor, and 22 m (75 ft) vertical. Proper documentation of this demonstration in the aircraft flight manual (AFM), AFM extension, or appropriate aircraft operational support document, alleviates the operational evaluations.

b) RNP-significant improbable failure cases should be assessed to show that, under these conditions, the aircraft can be safely extracted from the procedure. Failure cases might include dual system resets, flight control surface runaway and complete loss of flight guidance function.

c) The aircraft performance demonstration during the operational evaluations can be based on a mix of analyses and flight technical evaluations using expert judgment.

For most of the other hazards the most direct way to determine risk acceptability is for the expert group to look at the mitigations and decide if residual risk is acceptable. In making this decision the group will be making sure that risk is not going to be higher than current operations and that it has been reduced AFARP.

If the safety criteria are not satisfied, the FOSA Steps figure shows the need to consider further risk reducing measures either feeding back to Step 6 or potentially to a system re-design, e.g. updated procedure design, in Step 1.

Step 8 – Documentation of FOSA

Expected contents for a FOSA document include:

- Introduction (including justification for introduction of an RNP AR APCH, benefits etc.);
- Description of the system;
- Overview of safety assessment process and safety criteria used;
- Analysis of procedure, including airport environment and procedure design
- Identification of relevant hazards, causes and consequences;
- Documentation of relevant mitigations and determination of risk acceptability for RNP AR operations;
- Key issues to be monitored in trials and in operations;
- Assumptions and open items to be validated and closed out;
- Conclusions/ recommendations;
- Appendices with supporting information, i.e. minutes from group sessions, hazard identification tables, hazard logs with action tracking, etc.

HUMAN FACTORS ISSUES

Normal Operating Procedures

The PBN manual contains guidance and requirements concerning:

- Revision of the Minimum equipment list (MEL) to address RNP AR requirements
- Use of autopilot and flight director
- Dispatch RNP assessment
- Navaid exclusion
- Navigation database currency
- In-flight considerations including required equipment to start RNP AR approaches, RNP management, lateral and vertical deviation monitoring, special go-around procedures, altimeter setting and cross-checking and several others.

These have been developed based on the accumulated knowledge of RNP AR/ SAAAR approaches conducted to date. An AO will need to develop a compliance checklist against these procedures in developing the system description.

Abnormal and Contingency Procedures

The PBN manual also contains guidance on procedures for flight crew reacting to a variety of possible equipment failures including:

- Engine failure during approach or missed approach
- Loss of GNSS updates
- Degradation of external signal in space
- Failures of the RNP system components (e.g. failures of a GPS sensor, the flight director or automatic pilot, etc.)

Manufacturers will be able to supply detailed lists of equipment failures for which procedures should be available, e.g.:

- Loss of one Auto-Pilot (AP)
- Loss of both AP
- Loss of NAV mode, before or during approach
- Loss of GPS as primary navigation (on one side)
- Loss of GPS as primary navigation (on both sides)
- Navigation accuracy downgrade (on one side)
- Navigation accuracy downgrade (on both sides)
- GPS position disagree with the FMS
- Etc.

Training Requirements

The PBN manual contains guidance and requirements concerning training for flight crew and dispatchers. For flight crew there is detailed guidance on the contents of ground training segments and flight training segments plus how these should be evaluated. The training covers the normal procedures and abnormal/ contingency procedures listed above. Each pilot must complete at least two RNP approach procedures that employ the unique RNP AR APCH characteristics of the operator’s approved procedures, one procedure culminating in a landing and one in a missed approach.

Manufacturers may supply additional training guidance specific to the relevant aircraft types.

Recurrent Training

The PBN manual also contains guidance on recurrent training. An AO should incorporate recurrent RNP training that employs the unique (AR) approach characteristics of the operator's approved procedures as part of the overall programme. A minimum of two RNP AR APCHs must be flown by each pilot for each duty position (pilot flying and pilot monitoring), with one culminating in a landing and one culminating in a missed approach, and may be substituted for any required "precision-like" approach.

FOSA and HF Issues

Having used the information in the previous sections to establish what is proposed, the subsequent FOSA steps establish the adequacy of the procedures and training for the specific RNP AR procedure.

The simple approach adopted in the case studies was to involve groups with knowledge of the proposed procedures and training and of the specific hazards to directly determine the adequacy of the procedures and training. Where potential improvements were identified these were listed for further consideration under steps 6 and 7 of the FOSA.

B. FOSA AND ANSP CONSIDERATIONS

ANSP'S ROLE IN A FOSA

The personnel from an ANSP may be asked to participate in a FOSA, particularly in the case of a new RNP AR procedure being implemented.

An ANSP may fulfil the following roles:

- Providing relevant information in step 1, "System Definition", of the FOSA including the proposed procedure design, ATC facilities, procedures, intended controller training and navigation infrastructure.
- Participating in safety workshops addressing hazard identification, consequence and causal analysis and helping to determine appropriate risk mitigations (steps 3-6 of the FOSA).
- Reviewing and providing comments on the FOSA documentation.

Typically an ANSP will supply procedure designers, controllers, ATC engineers, AIM experts and airspace planners to carry out these roles.

In addition to participating in these formal steps of the FOSA, it is likely that the procedure designer will also liaise at an early stage with the AO to understand the key operational needs for the RNP AR APCH.

HOW AN ANSP CAN USE FOSA OUTPUTS

There will be many outputs from the AO's FOSA that the ANSP can use. For an RNP AR APCH where the main safety issues relate to separation from terrain, typically in low traffic density situations, FOSA outputs of use to the ANSP will include the following:

- The impact of the procedure design on the flight crew. The procedure may be compliant with ICAO's RNP AR procedure design guidance but could still lead to unacceptable or

unnecessary increases in pilot workload. Feedback from the FOSA could lead to the ANSP's procedure designer needing to make changes.

- Adequacy of ATC phraseology including clearance for the RNP AR APCH.
- Adequacy of ATC procedures relating to constraints on any vectoring or "Direct To"s, provision of local pressure data, any changes in monitoring and in the event of RNP related aircraft failures.
- Adequacy of ATC training given the hazard identification and analysis performed for the FOSA.

For an RNP AR APCH where the main safety issues relate to separation from other traffic, perhaps in a busy terminal/ airport environment, additional useful FOSA outputs could include analysis of the:

- Adequacy of ATC procedures to handle mixed mode traffic (RNP AR and other approach types) including how to identify aircraft with different approach capabilities and how to handle potentially different missed approach paths.
- Adequacy of existing monitoring systems, e.g. Non-Transgression Zones.
- Impact of wide area GNSS failure on multiple aircraft.

It is anticipated that more detailed guidance with respect to traffic separation safety issues will be provided in a subsequent version of this document.

These and similar outputs can be brought into the ANSP safety assessment and analysed using the existing ANSP safety assessment processes.

ADDITIONAL ISSUES TO INCLUDE IN AN ANSP SAFETY CASE

Within an ANSP safety case, as well as documenting the safety assessment of the ATM aspects of a new RNP AR APCH, an ANSP may also need to cover the following safety assurance activities:

- Demonstration that the revised ATM system operates correctly and safely through ATC simulations. If, for example, a new RNP AR APCH procedure is being introduced for closely spaced parallel approaches this could represent a significant ATM change with implications for controller workload. A consideration of the dynamics via fast and/ or real time simulation may be required evidence from a regulator. Real time simulations can also be used to investigate controller reaction to hazards identified in the FOSA. When a new RNP AR APCH involves only minimal ATC changes, such ATC simulations would not be required.
- Flight trials under controlled conditions to ensure that the initial implementation is safely managed. An ANSP will be involved in the co-ordination between AO and the regulator to ensure that flight trials occur initially only in VMC conditions, or only with a limited sub-set of aircraft and crews, for example. The ANSP will sometimes also collect data, e.g. radar track data, during these trials and early operations to provide evidence to support the safety case.
- An RNP monitoring programme to record and investigate any ATM significant events.

In addition, an ANSP safety case will need to demonstrate how ATM assumptions and open issues from the FOSA have been closed out, e.g. testing for GNSS interference prior to implementation, investigation of terrain masking, checks on accuracy of obstacle and terrain survey data, etc.

C. SIMULATIONS, TRIALS AND MONITORING

SIMULATIONS AND TRIALS

Simulations (additional to those carried out during the airworthiness approval) can provide valuable support to the safety assessment. Reasons for conducting simulations could be:

- To help evaluate alternative procedure designs.
- To evaluate the significance of a hazard for the proposed procedure design in a specific operating environment.
- To familiarise a carrier new to RNP AR APCH with some of the key safety issues.

In the absence of any failures, simulations may investigate:

- Varying cross winds;
- Increasing aircraft speeds above the recommended values on final approach and missed approach to study the impact on guidance in the RF legs; and
- Guidance in heavy tail winds (well beyond what would realistically be flown).

In addition, the following failures may be simulated:

- One Engine Inoperable in cross wind during RF leg;
- Manually steering away from centreline to observe what indications are provided to crew;
- 10 HPa pressure setting error to observe the TAWS alert parameters;
- Map shift; and
- Autopilot disconnect just before the RF leg.

Note.— Aircraft Operators' simulators are unlikely to be able to model as wide a range of failures as the development simulators used by aircraft manufacturers. Therefore assistance from aircraft manufacturers may be required. From a safety perspective simulations must reflect real situations as accurately as possible. There is a need to be able to judge how close the reality is to the simulation. Additional hazards and risks can be introduced if simulations do not reflect real world circumstances

Trials can also be used to address safety issues, for example:

- Initial flights can be conducted in VMC to check the navigation database.
- A carrier new to RNP AR APCH might elect for an extended trial period in order to train flight crew, dispatchers etc. and to check that the operational procedures are robust. This can help provide a smoother transition to full operations.
- FOSA data can be collected to help convince regulators.

Trials may have extra mitigations associated with them which would not be subsequently used in full operations, e.g. VMC conditions, compulsory use of autopilot, etc.

Some States operate a process of "Interim Authorisation", where for the first 90 days and at least 100 AR approaches in each aircraft type, the operator will be authorised to conduct RNP approaches with AR using minima associated with RNP 0.3. For approach procedures with no line of minima associated with RNP 0.3, the procedure must be flown in VMC. The interim authorisation is removed after completion of the applicable time period and number of approaches and upon a review of the reports from the RNP AR monitoring programme by the regulator.

In certain circumstances it has been possible to use flight evaluation to determine if an operation is possible.

MONITORING PROGRAMME

The PBN manual notes the requirement for an RNP monitoring programme.

In the context of this FOSA guidance material it should be highlighted that:

- One of the outputs of a FOSA should be an identification of key safety performance indicators that will be part of the RNP monitoring programme. Some likely candidates for safety performance indicators are already listed the PBN manual; however, a local FOSA may identify certain hazards as the main risk drivers and therefore monitoring the precursors to these hazards will be important to controlling risk during the operational phase.
- A FOSA may also identify key assumptions or open issues which are difficult to validate without operational data. Again these should be fed forward to the monitoring programme.

Compared to other types of approach (e.g. ILS approaches) there are still relatively few RNP AR approaches worldwide. Thus it is important to pool information from monitoring programmes to see whether the predictions from FOSAs (e.g. on deviation frequencies) are realistic.

– END –