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AN/498



Performance-based Navigation (PBN) Operational Approval Manual

Approved by the Secretary General
and published under his authority

First Edition — 2013

International Civil Aviation Organization

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AMENDMENTS

Amendments are announced in the supplements to the *Catalogue of ICAO Publications*; the Catalogue and its supplements are available on the ICAO website at www.icao.int. The space below is provided to keep a record of such amendments.

RECORD OF AMENDMENTS AND CORRIGENDA

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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).

This edition includes job aids for the navigation specifications detailed in the first edition of the *Performance-based Navigation Manual* (Doc 9613). The new navigation specifications detailed in the second edition of Doc 9613 will be addressed in a future edition of this manual.

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

The Secretary General
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GLOSSARY

ABBREVIATIONS/ACRONYMS

AAIM	Aircraft autonomous integrity monitoring
AC	Advisory circular
ACCUR	Accuracy
AFARP	As far as reasonably practical
AFM	Aircraft flight manual
AGL	Above ground level
AHRS	Attitude and heading reference system
AIP	Aeronautical information publication
AIRAC	Aeronautical information regulation and control
ALARP	As low as reasonably practical
AMC	Acceptable means of compliance
AMM	Aircraft maintenance manual
ANPE	Actual navigation performance error
ANSP	Air navigation service provider
AO	Air operator
AOC	Air operator certificate
AP	Auto pilot
AR	Authorization required
A-RNP	Advanced RNP
ARP	Aerodrome reference point
ASE	Altimetry system error
ATC	Air traffic control
ATCO	Air traffic controller
ATIS	Automatic terminal information service
Baro-VNAV	Barometric VNAV
B-RNAV	Basic RNAV
BG	Body geometry
CA	Certificating authority
CAA	Civil aviation authority
CAAP	Civil aviation advisory publication
CASA	Civil Aviation Safety Authority (Australia)
CCF	Common cause failure
CDI	Course deviation indicator
CDU	Control display unit
CS	Certification specification
DA	Decision altitude
DA/H	Decision altitude/height
DF	Direct to a fix
DGCA	Directorate General of Civil Aviation
DME	Distance measuring equipment
DOP	Dilution of precision
DR	Dead reckoning
EASA	European Aviation Safety Agency
EGPWS	Enhanced ground proximity warning system

ENR	En-route
EPE	Estimated position error
ETSO	European Technical Standards Order
EUROCAE	European Organization for Civil Aviation Equipment
FA	Fix to an altitude
FAA	Federal Aviation Administration
FAF	Final approach fix
FAP	Final approach point
FCOM	Flight crew operations manual
FD	Flight director
FDE	Fault detection and exclusion
FGS	Flight guidance system
FM	Fix to a manual termination
FMS	Flight management system
FOSA	Flight operational safety assessment
FPA	Flight path angle
FPL	Flight plan
FRT	Fixed radius transition
FSD	Full-scale deflection
FSTD	Flight simulation training device
FTE	Flight technical error
GA	General aviation
GNSS	Global navigation satellite system
GPS	Global positioning system
HA	Holding/racetrack to an altitude
HAL	Horizontal alert limit
HF	Holding/racetrack to a fix
HFOM	Horizontal figure of merit
HIL	Horizontal integrity limit
HM	Holding/racetrack to a manual termination
HPL	Horizontal protection limit
HSI	Horizontal situation indicator
IAF	Initial approach fix
IF	Initial fix
IFR	Instrument flight rules
INS	Inertial navigation system
IRS	Inertial reference system
IRU	Inertial reference unit
ISAD	ISA deviation
L/DEV	Lateral deviation
LCD	Liquid crystal display
LNAV	Lateral navigation
LOA	Letter of authorization
LP	Localizer performance
LPV	Localizer performance with vertical guidance
LRNS	Long range navigation system
MAPt	Missed approach point
MASPS	Minimum aviation system performance standard
MCDU	Multifunction control display unit
MDA	Minimum descent altitude
MDA/H	Minimum descent altitude/height
MEL	Minimum equipment list
MMEL	Master minimum equipment list



MOC	Minimum obstacle clearance
MOPS	Minimum operational performance standards
MSA	Minimum sector altitude
NAS	National airspace system (USA)
NAV	Navigation
NAVAID	Navigation aid
NDB	Non-directional radio beacon
NM	Nautical mile
NOTAM	Notice to airmen
NPS	Navigation performance scales
NSE	Navigation system error
OCA/H	Obstacle clearance altitude/height
OEI	One-engine inoperative
OEM	Original equipment manufacturer
OM	Operations manual
OPS-SPEC	Operations specification
PA	Precision approach
PBN	Performance-based navigation
PDE	Position definition error
PFD	Primary flight display
PM	Pilot monitoring
P-RNAV	Precision RNAV
QRH	Quick reference handbook
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
SAM	South American
SB	Service bulletin
SBAS	Space-based augmentation system
SID	Standard instrument departure
SL	Service letter
SOP	Standard operating procedure
STAR	Standard arrival route
STC	Supplemental type certificate
TAS	True airspeed
TAWS	Terrain awareness warning system
TC	Type certificate
TCDS	Type certificate data sheets
TF	Track to a fix
TGL	Temporary guidance leaflet
TLS	Target level of safety
TOGA	Take-off/go-around
TSE	Total system error
TSO	Technical standard order
US-RNAV	United States RNAV
VA	Heading to an altitude
VAE	Vertical angle error

V/DEV	Vertical deviation
VEB	Vertical error budget
VHF	Very high frequency
VI	Heading to an intercept
VM	Heading to a manual termination
VMC	Visual meteorological conditions
VNAV	Vertical navigation
VOR	VHF omnidirectional radio range
WAAS	Wide area augmentation system
WDM	Wiring diagram manual
WPR	Waypoint resolution error
WPT	Waypoint

PUBLICATIONS

(referred to in this manual)

ICAO DOCUMENTS

Convention on International Civil Aviation (Doc 7300)

Annexes to the Convention on International Civil Aviation

Annex 6 — *Operation of Aircraft*

Part I — *International Commercial Air Transport — Aeroplanes*

Part III — *International Operations — Helicopters*

Procedures for Air Navigation Services

ATM — Air Traffic Management (PANS-ATM, Doc 4444)

Regional Supplementary Procedures (Doc 7030)

Manuals

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)

Regional Safety Oversight Cooperation System (SRVSOP) Advisory Circulars

AC 91-001	Aircraft and Operators Approval for RNAV 10 Operations (Designated and Authorized as RNP 10)
AC 91-002	Aircraft and Operators Approval for RNAV 5 Operations
AC 91-003	Aircraft and Operators Approval for RNAV 1 and RNAV 2 Operations
AC 91-004	Aircraft and Operator Approval for RNP 4 Operations
AC 91-006	Aircraft and Operator Approval for Basic-RNP 1 Operations
AC 91-008	Aircraft and Operators Approval for RNP Approach (RNP APCH) Operations
AC 91-009	Aircraft and Operators Approval for RNP Authorization Required Approach (RNP AR APCH) Operations

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AC 91-010	Aircraft and Operators Approval for Approach Operations with Vertical Guidance/ Barometric Vertical Navigation (APV/baro-VNAV)
AC 91-011	Aircraft and Operators Approval for RNP APCH Operations Down to LP and LPV Minima Using GNSS Augmented by SBAS

DOCUMENTS OF OTHER STATES/ORGANIZATIONS

Australia

CAAP B-RNAV-1	Approval of Australian Operators and Aircraft to Operate Under Instrument Flight Rules in European Airspace Designated for Basic Area Navigation
AC 91U-II-Attachment(0)	Navigation Authorisations — APV baro-VNAV
AC 91U-II-B-3(0)	Navigation Authorisations — RNAV 1 and RNAV 2
AC 91U-II-C-3(0)	Navigation Authorisations — RNP 1
AC 91U-II-C-5(0)	Navigation Authorisations — RNP APCH
AC 91U-II-C-6(0)	Navigation Authorisations — RNP AR Operations
AC 91U-2(0)	Required Navigation Performance 10 (RNP 10) Operational Authorisation
AC 91U-3(0)	Required Navigation Performance 4 (RNP 4) Operational Authorisation

ARINC

ARINC Specification 424-13	Navigation System Data Base
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Canada

AC 700-015	En Route Area Navigation Operations RNAV 5 (Formerly B-RNAV)
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European Aviation Safety Agency (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 the NAVSTAR Global Positioning System (GPS)
AMC 20-12	Recognition of FAA Order 8400.12a for RNP 10 Operations
AMC 20-26	Airworthiness Approval and Operational Criteria for RNP Authorisation Required (RNP AR) Operations
AMC 20-27	Airworthiness Approval and Operational Criteria for RNP APPROACH (RNP APCH) Operations Including APV BARO-VNAV Operations

AMC 20-28	Airworthiness Approval and Operational Criteria Related to Area Navigation for Global Navigation Satellite System Approach Operation to Localiser Performance with Vertical Guidance Minima Using Satellite Based Augmentation System
CS-25	Certification Specifications for Large Aeroplanes
CS-25.1529	Instructions for Continued Airworthiness
EASA Part-21 Subpart G	Production Organisation Approval
ETSO-C129a	Airborne Supplemental Navigation Equipment Using Global Positioning System (GPS)
ETSO-C145	Airborne Navigation Sensors Using the Global Positioning System (GPS) Augmented by the Wide Area Augmentation System (WAAS)
ETSO-C146	Stand-Alone Airborne Navigation Equipment Using the Global Positioning System (GPS) Augmented by the Wide Area Augmentation System (WAAS)
TGL No. 10	Airworthiness and Operational Approval for Precision RNAV Operations in Designated European Airspace

European Organization for Civil Aviation Equipment (EUROCAE)

ED-76	Standards for Processing Aeronautical Data
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New Zealand

AC 91-10	Required Navigational Performance 4 (RNP 4) Operational Approval
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RTCA

DO-200A	Standard for Processing Aeronautical Data
DO-236()	Minimum Aviation System Performance Standards: Required Navigation Performance for Area Navigation

United States Federal Aviation Administration (FAA)

AC 20-130	Airworthiness Approval of Navigation or Flight Management Systems Integrating Multiple Navigation Sensors
AC 20-138	Airworthiness Approval of Global Navigation Satellite System (GNSS) Equipment
AC 20-153	Acceptance of Data Processes and Associated Databases
AC 25-4	Inertial Navigation System (INS)
AC 25-15	Approval of Flight Management Systems in Transport Category Airplanes

AC 90-45	Approval of Area Navigation Systems for Use in the U.S. National Airspace System
AC 90-96	Approval of U.S. Operators and Aircraft to Operate under Instrument Flight Rules (IFR) in European Airspace Designated for Basic Area Navigation (B-RNAV/RNP-5)
AC 90-100	U.S. Terminal and En Route Area Navigation (RNAV) Operations
AC 90-101	Approval Guidance for RNP Procedures with SAAAR
AC 90-105	Approval Guidance for RNP Operations and Barometric Vertical Navigation in the U.S. National Airspace System
AC 90-107	Guidance for Localizer Performance with Vertical Guidance and Localizer
FAA Form 8110-3	Statement of Compliance with Airworthiness Standards
Order 7110.82	Monitoring of Navigation/Altitude Performance in Oceanic Airspace
Order 8400.12	Required Navigation Performance 10 (RNP 10) Operational Approval
Order 8400.33	Procedures for Obtaining Authorization for RNP-4 Oceanic and Remote Area Operations
TSO-C66c	Distance Measuring Equipment (DME) Operating within the Radio Frequency Range of 960-1215 Megahertz
TSO-C129	Airborne Supplemental Navigation Equipment Using the Global Positioning System (GPS)
TSO-C145	Airborne Navigation Sensors Using the Global Positioning System (GPS) Augmented by the Satellite Based Augmentation System
TSO-C146	Stand-Alone Airborne Navigation Equipment Using the Global Positioning System (GPS) Augmented by the Satellite Based Augmentation System
14 CFR 25.1309	Equipment, Systems, and Installations
14 CFR 25.1529	Instructions for Continued Airworthiness
14 CFR 60	Flight Simulation Training Device Initial and Continuing Qualification and Use
14 CFR 121, Subpart G	Manual Requirements
14 CFR 121, Appendix G	Doppler Radar and Inertial Navigation System (INS): Request for Evaluation; Equipment and Equipment Installation; Training Program; Equipment Accuracy and Reliability; Evaluation Program

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 (PBN) 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 many 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 require 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. In many States, 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 in 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 be 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. Performance is detailed in a navigation specification in sufficient detail to facilitate global harmonization. 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 as the provision of navigation databases.

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

1.3 RNAV AND RNP

1.3.1 RNAV specifications were 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 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

The navigation specifications in Table 1-1 have been published to date.

Table 1-1. Navigation specifications 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 ^c	2 ^d	2 or 1	1	1	1	0.3	1 ^b	1
RNP 1			1 ^e	1	1		1 ^b	1 ^e
RNP 0.3 ^f		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 ^h	
RNP AR APCH				1-0.1	1-0.1	0.3-0.1	1-0.1 ⁱ	

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) Applies only once 50 m (40 m Cat H) obstacle clearance has been achieved after the start of climb.
- c) A-RNP also permits a range of scalable RNP lateral navigation accuracies.
- d) Optional; requires higher continuity.
- e) Beyond 30 NM from the airport reference point (ARP), the accuracy value for alerting becomes 2 NM.
- f) The RNP 0.3 specification is primarily intended for helicopter operations.
- g) RNP APCH is divided into two parts. This value applies during the initial straight ahead segment in RNP APCH Part B (SBAS LPV) approaches.
- h) 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.
- i) If less than RNP 1 is required in the 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 be applied only for a limited distance.

1.5 PBN APPLICATIONS

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

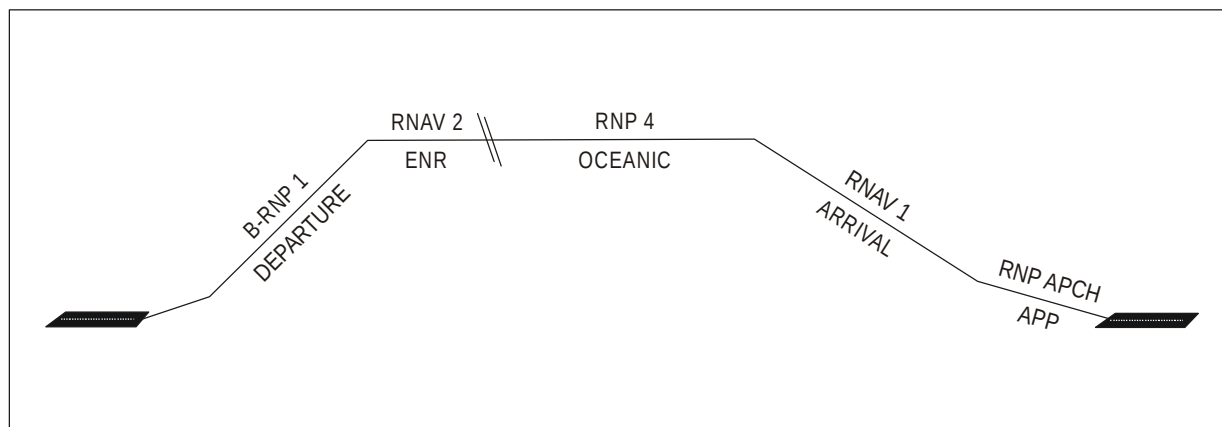


Figure 1-1. Navigation specifications to support a particular airspace concept

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Chapter 2

CERTIFICATION AND OPERATIONAL APPROVAL

2.1 OVERVIEW

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 authorizes 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 regulatory authority of the State of Registry/State of the Operator that the specific aircraft are in compliance with the relevant airworthiness standard and that the continued airworthiness and flight operations requirements are satisfied.

- a) 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. U.S. 14 CFR Part 25/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.
- b) 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. U.S. 14 CFR 25.1529/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.
- c) 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.

This is illustrated in Figure 2-1.

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 organizations. In line with current practice, small or less capable States may elect to adopt or even adapt, as an acceptable means of compliance, the national regulatory material of certification States that have a relevant developed regulatory framework.

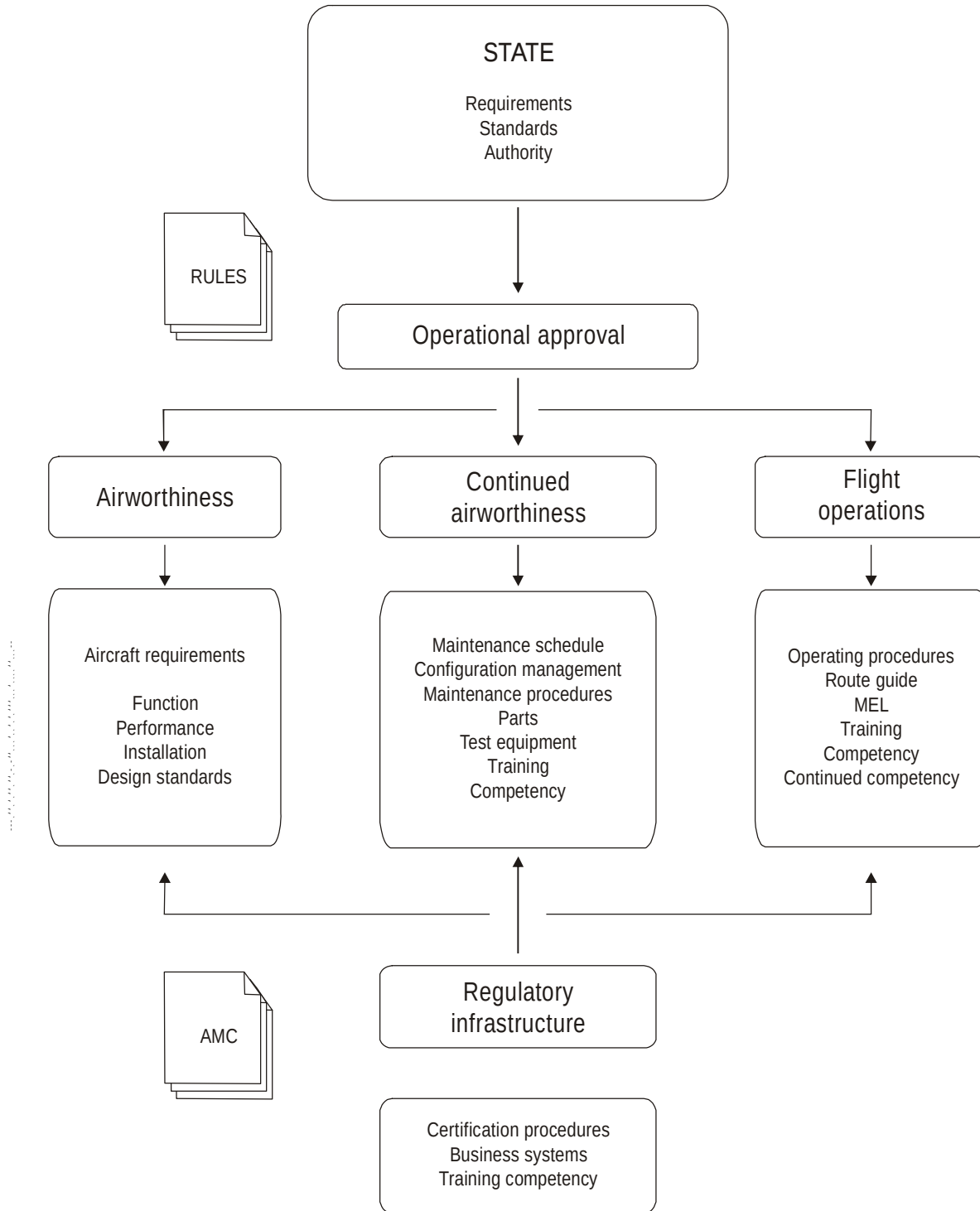


Figure 2-1. Overview of operational approval responsibilities

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

- a) *State of Design/Manufacture.* The organization 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).
- b) *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 stand-alone modifications or as STCs). For general aviation, the State of Registry approves the minimum equipment list (MEL) and the conduct of specified PBN operations.
- c) *State of the Operator.* The State of the Operator (which may be different from the State of Registry for commercial air transport operations) 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, determine that the data are acceptable for use in that 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 Appendix B.

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's 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. whether the aircraft, including its RNAV or RNP navigation system, has 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 operations 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, and 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 TCs 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 2-2). 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 shown in the shaded area of Figure 2-2, as having less operational risk if adequate control mechanisms are implemented overall.

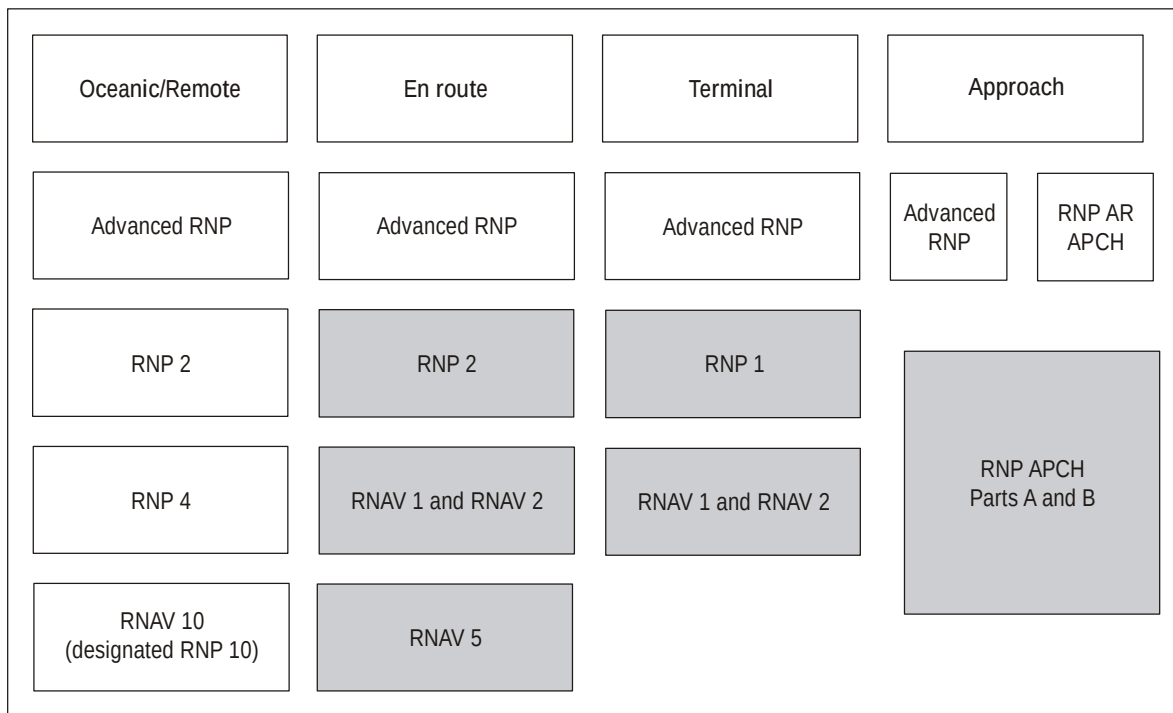


Figure 2-2. Bundling of navigation specifications

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 a letter of authorization (LOA) is also necessary for general aviation (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 of 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 <http://www.icao.int/safety/PBN/Pages/default.aspx> for example approaches to operational approvals for commercial air transport and GA operators.

Note 1.— RNP 0.3 has not been included because it primarily deals with helicopter operations with specific applications.

Note 2.— An 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 the databases 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, which 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 or STC, or accepts technical data defining a design change that has been approved by another State.

2.3.8.3 An alternate method 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, FAA Form 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 an 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 an 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 2-1 lists the possible scenarios facing an operator who wishes to obtain approval for a PBN application, together with the appropriate courses of action.

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 (ACs) and orders for operations in U.S. airspace. The ACs, orders and AMCs usually reference appropriate technical standard orders (TSOs) and European TSOs (ETSOs). TSOs/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 in 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 “harmonized” 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 2-2 lists the certification standards published by EASA and the FAA for PBN applications in 2012 (each document may reference additional standards including ACs, TSOs and RTCA/EUROCAE documents) and is subject to change.

2.3.9 Operating procedures

2.3.9.1 Standard operating procedures (SOPs) 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

Table 2-1. Approval scenarios

Scenario	Aircraft certification status	Actions by the operator/owner
1	Aircraft designed and type-certificated for PBN application. Documented in the AFM, TC or STC.	No action required; aircraft eligible for PBN application.
2	Aircraft equipped for PBN application but not certified. No statement in the AFM. SB available from the aircraft manufacturer.	Obtain the SB (and associated amendment pages to the AFM) from the aircraft manufacturer.
3	Aircraft equipped for PBN application. No statement in the 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 the AFM. SB not available. Statement of compliance from the aircraft manufacturer not available.	Develop a detailed submission to the 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's 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).

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:

- 1) navigation errors not associated with transitions from an inertial navigation mode to a radio navigation mode;
- 2) unexpected deviations in lateral or vertical flight path attributed to incorrect navigation data;
- 3) significant misleading information without failure warning;
- 4) total loss or multiple failures of the PBN navigation equipment; or
- 5) problems with ground navigation 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.

Table 2-2. EASA and FAA certification standards

<i>Navigation specification</i>	<i>EASA</i>	<i>FAA</i>
RNAV 10	AMC 20-12	Order 8400.12()
RNAV 5	AMC 20-4	AC 90-96()
RNAV 1 and RNAV 2	TGL 10 (expected to change to a CS)	AC 90-100()
RNP 4	Expected in 2015	Order 8400.33
RNP 2	Expected in 2015	TBA
RNP 1	Expected in 2015	AC 90-105
Advanced RNP	Expected in 2015	TBA
RNP 0.3	Expected in 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 in 2015	AC 90-105

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 training programme and, if applicable, a dispatcher training programme must cover all the tasks associated with the PBN operation as well as provide 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 an LOA in accordance with EASA Opinion Nr. 01/2005.

2.3.13 Performance record

Navigation error reports should be recorded and analysed 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 certificate (AOC); or
- c) a letter of authorization (LOA) for general aviation aircraft.

Example Ops Spec entries are provided at Appendix C.

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 cancellation 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

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 Appendix B.

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 ACs 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 2-3 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).

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.

Table 2-3. Operational approval material

<i>Navigation Specification</i>	<i>ICAO (SAM)</i>	<i>Australia</i>	<i>New Zealand</i>	<i>Canada</i>
RNAV 10	AC 91-001	AC 91U-2()		
RNAV 5	AC 91-002	CAAP B-RNAV-1		AC 700-015
RNAV 1 and RNAV 2	AC 91-003	AC 91U-II-B-3		
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		—		

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

Note.— An example application form is contained in Appendix 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 OM; and
- b) an Ops Spec associated with the AOC; or
- c) an 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 stand-alone ETSO/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 of the Convention, to ensure 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 of 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 Doc 8335. Such evaluation is necessary in order for the State, under the terms of Article 33 of 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 intends 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 are 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 Operators 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 operators should assess the:

- a) qualification standard and fully understand the associated shortfall in the qualification of the navigation specification;
- b) procedures that have been established by the State with respect to the area of operation. 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, operators should review their operational procedures and identify possible changes or additional procedures/requirements that could mitigate the identified deficiencies and hazards. The proposed changes should be presented to their regulatory authority for authorization/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. It is anticipated that in the future 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 because 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 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 STANDARD OPERATING PROCEDURES

3.2.1 Standard operating procedures (SOPs) 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 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 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 the 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) the 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 a proposed course of action;
- b) where possible, documented procedures should be followed for:
 - 1) navigation errors not associated with transitions from an inertial navigation mode to a radio navigation mode;
 - 2) unexpected deviations in lateral or vertical flight path attributed to incorrect navigation data;
 - 3) significant misleading information without failure warning;
 - 4) total loss or multiple failures of the PBN navigation equipment;
 - 5) problems with ground navigation facilities leading to significant navigation errors; or
 - 6) a 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 will vary 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, desktop simulation training is normally sufficient. Arrival and departure operations and approach operations, in particular, also require the use of flight simulation training devices 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 with area navigation operations may not be familiar with some of the more advanced features such as radius to fix (RF) legs, fixed radius transitions, required time of arrival 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 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 *Performance 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 *Operating 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

3.3.3.1 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.

3.3.3.2 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 a knowledge training curriculum.

3.3.3.3 *En-route (oceanic, remote and continental).* In general flight training is not required for en-route operations.

3.3.3.4 *Arrival and departure.* Because arrival and departure 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.

3.3.3.5 *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 because the 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.

3.3.3.6 *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, 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 in ground training plus simulator flight training in order to achieve competency.

3.4 NAVIGATION DATABASES

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 that:

- 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 being loaded 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.
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Chapter 4

NAVIGATION SPECIFICATIONS

4.1 RNAV 10

4.1.1 General

4.1.1.1 RNAV 10 supports a 50 NM lateral and 50 NM 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. Because the requirements for RNP 10 did not include a requirement for on-board performance monitoring and alerting, RNP 10 is more correctly described as an RNAV operation and hence is included 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 application in the PBN Manual 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 (LRNSs). 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 hours, but this may be extended by updating or by demonstration of reduced drift rate (less than 2 NM per hour).

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-C145()/146() 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 programmes 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 *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 to the inspector the completed job aid with the application.
- d) The inspector records his/her 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 operations specifications (Ops Specs) or a letter of authorization (LOA), as applicable, when the tasks and documents have been completed.

<i>Part</i>	<i>Topic</i>	<i>Page</i>
1	General information	
2	Aircraft and operator identification	
3	Operator application	
4	Contents of the operator application	
5	Basic pilot procedures	
6	Contingency procedures	

4. Reference documents

<i>Publisher</i>	<i>Reference</i>	<i>Title</i>
ICAO	Annex 2	Rules of the Air
	Annex 6	Operation of Aircraft
	Doc 4444	Procedure for Air Navigation Services — Air Traffic Management
	Doc 7030	Regional Supplementary Procedures
	Doc 9613	Performance-based Navigation (PBN) Manual
FAA	Order 8400.12()	Required Navigation Performance 10 (RNP 10) Operational Approval
	AC 20-130	Airworthiness Approval of Navigation or Flight Management Systems Integrating Multiple Navigation Sensors
	AC 20-138()	Airworthiness Approval of Global Navigation Satellite System (GNSS) Equipment
	14 CFR Part 121, Subpart 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 Authorisation
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**

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

PART 2. IDENTIFICATION OF AIRCRAFT AND OPERATORS

Name of Operator: _____

<i>Aircraft manufacturer, model and series</i>	<i>Registration number</i>	<i>Serial number</i>	<i>Long-range navigation system manufacturer, model and number</i>	<i>PBN specification</i>

Date of pre-application meeting: _____

Date when application received by CAA: _____

Date when operator intends to begin RNAV 10 operations: _____

Is the CAA notification date appropriate?

Yes ☐No ☐

PART 3. OPERATOR APPLICATION

<i>Annex</i>	<i>Title</i>	<i>Inclusion by Operator</i>	<i>Comments by Inspector</i>
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 that the 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 the aircraft is eligible.		
F	Maintenance For aircraft with established LRNS maintenance practices, references to the maintenance document/programme. For recently installed LRNSs, details of the full maintenance practices.		
G	Minimum equipment list Showing provisions for LRNS.		

<i>Annex</i>	<i>Title</i>	<i>Inclusion by Operator</i>	<i>Comments by Inspector</i>
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.		
I	Operating policies and procedures xxx91/GA operators or equivalent: • extracts from the operations manual corresponding to the application. xxx121/xxx135/CAT operators or equivalent: • operations manual and checklists.		
J	Performance record Evidence of previous problems, incidents or path-keeping errors, together with corrective action applied.		
K	Withdrawal of approval The need for follow-up action on navigation error reports, with the possibility of removal of approval.		
L	Validation flight plan As required.		

Contents of the application to be submitted by the operator

- compliance documentation for 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 documents.

PART 4. CONTENTS OF THE OPERATOR APPLICATION

#	Topic	Specific ICAO reference	Specific State guidance reference	Operator compliance description	Inspector disposition/ comments	Follow-up by inspector (Optional)
		(Doc 9613, Volume II, Part B, Chapter 1)	(AC/AMC/CA, etc.)	(Document reference/ method)	(Accepted/ not accepted)	(Status and date)
1	Authorization request Statement of intent to obtain authorization.	1.3.3.2				
2a	Aircraft/navigation system eligibility Documents that establish 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 LRNSs 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 reference	Specific State guidance reference	Operator compliance description	Inspector disposition/ comments	Follow-up by inspector (Optional)
		(Doc 9613, Volume II, Part B, Chapter 1)	(AC/AMC/CA, etc.)	(Document reference/ method)	(Accepted/ not accepted)	(Status and date)
6	Operating policies and procedures Extracts from the 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 Applicable only to operations requiring a 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.					