CIVIL AVIATION GUIDANCE MATERIAL – 6008(II)

PERFORMANCE BASED NAVIGATION

PBN

CIVIL AVIATION AUTHORITY OF MALAYSIA

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Introduction

This Civil Aviation Guidance Material 6008 Part III (CAGM – 6008 (III)) is issued by the Civil Aviation Authority of Malaysia (CAAM) to provide guidance on the operational approval process in the context of performance-based navigation (PBN). It is intended for operators involved for the approval of PBN operations., pursuant to Civil Aviation Directives 6 Part 1 – Commercial Air Transport (CAD 6 Part 1 – CAT), Civil Aviation Directives 6 Part 2 – General Aviation (CAD 6 Part 2 – GA) and Civil Aviation Directives 6 Part 3 - Helicopters (collectively referred to as "CAD").

Organisations may use these guidelines to ensure compliance with the respective provisions of the relevant CAD's issued. Notwithstanding the Regulation 204 and Regulation 205 of the Malaysian Civil Aviation Regulations 2016 (MCAR 2016), when the CAGMs issued by the CAAM are complied with, the related requirements of the CAD's may be deemed as being satisfied and further demonstration of compliance may not be required.

(Captain Chester Voo Chee Soon)
Chief Executive Officer
Civil Aviation Authority of Malaysia

Civil Aviation Guidance Material components and Editorial practices

This Civil Aviation Guidance Material is made up of the following components and are defined as follows:

Standards: Usually preceded by words such as *"shall"* or *"must"*, are any specification for physical characteristics, configuration, performance, personnel or procedure, where uniform application is necessary for the safety or regularity of air navigation and to which Operators must conform. In the event of impossibility of compliance, notification to the CAAM is compulsory.

Recommended Practices: Usually preceded by the words such as "*should"* or "*may*", are any specification for physical characteristics, configuration, performance, personnel or procedure, where the uniform application is desirable in the interest of safety, regularity or efficiency of air navigation, and to which Operators will endeavour to conform.

Appendices: Material grouped separately for convenience, but forms part of the Standards and Recommended Practices stipulated by the CAAM.

Definitions: Terms used in the Standards and Recommended Practices which are not self-explanatory in that they do not have accepted dictionary meanings. A definition does not have an independent status but is an essential part of each Standard and Recommended Practice in which the term is used, since a change in the meaning of the term would affect the specification.

Tables and Figures: These add to or illustrate a Standard or Recommended Practice, and which are referred to therein, form part of the associated Standard or Recommended Practice and have the same status.

Notes: Included in the text, where appropriate, Notes give factual information or references bearing on the Standards or Recommended Practices in question but not constituting part of the Standards or Recommended Practices;

Attachments: Material supplementary to the Standards and Recommended Practices or included as a guide to their application.

The units of measurement used in this document are in accordance with the International System of Units (SI) as specified in CAD 5. Where CAD 5 permits the use of non-SI alternative units, these are shown in parentheses following the basic units. Where two sets of units are quoted it must not be assumed that the pairs of values are equal and interchangeable. It may, however, be inferred that an equivalent level of safety is achieved when either set of units is used exclusively.

Any reference to a portion of this document, which is identified by a number and/or title, includes all subdivisions of that portion.

Throughout this Civil Aviation Guidance Material, the use of the male gender should be understood to include male and female persons.

Record of Revisions

Revisions to this CAGM shall be made by authorised personnel only. After inserting the revision, enter the required data in the revision sheet below. The *'Initials'* has to be signed off by the personnel responsible for the change.

ISS/REV No.	Revision Date	Revision Details	Initials
ISS01/REV01	15th November 2021	Refer to Summary of Changes	CAAM

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Summary of Changes

ISS/REV No.	Item no.	Revision Details
ISS01/REV01	Attachment A	Removed and link provided.

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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 avigation (PBN) detailed in the Performance-based Navigation (PBN) Manual (ICAO Doc 9613), 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. This GM is intended to assist in improving this level of knowledge.

1.2 Definitions

Aircraft-based augmentation system (ABAS) is an augmentation system that augments and/or integrates the information obtained from the other GNSS elements with information available on board the aircraft.

Note.— The most common form of ABAS is receiver autonomous integrity monitoring (RAIM).

Airspace concept is an airspace concept describes the intended operations within an airspace. Airspace concepts are developed to satisfy explicit strategic objectives such as improved safety, increased air traffic capacity and mitigation of environmental impact. Airspace concepts can include details of the practical organization of the airspace and its users based on particular CNS/ATM assumptions, e.g. ATS route structure, separation minima, route spacing and obstacle clearance.

Airworthiness inspector (AWI) is a representative of the Civil Aviation Authority of Malaysia in charge of initial authorisation and/or continued oversight of the operator’s maintenance and engineering organisation and processes. The assessment performed by the AWI may include (but not be limited to):

a) the adequacy of maintenance facilities, equipment and procedures;

b) the adequacy of the training programmes and competence of employees;
c) the adequacy of the programme or schedule for periodic maintenance and overhauls; and
d) the airworthiness of the aircraft.

Approach procedure with vertical guidance (APV) is an instrument procedure which utilizes lateral and vertical guidance but does not meet the requirements established for precision approach and landing operations.

Area navigation defines a method of navigation which permits aircraft operation on any desired flight path within the coverage of ground or space-based navigation aids or within the limits of the capability of self-contained aids, or a combination of these.

Note.— Area navigation includes Performance-based Navigation as well as other RNAV operations that do not meet the definition of Performance-based Navigation.

Area navigation route is an ATS route established for the use of aircraft capable of employing area navigation.

ATS surveillance service is a term used to indicate a service provided directly by means of an ATS surveillance system.

ATS surveillance system is a generic term meaning variously, ADS-B, PSR, SSR or any comparable ground-based system that enables the identification of aircraft.

Note.— A comparable ground-based system is one that has been demonstrated, by comparative assessment or other methodology, to have a level of safety and performance equal to or better than monopulse SSR.

Cyclic redundancy check (CRC) refers to a mathematical algorithm applied to the digital expression of data that provides a level of assurance against loss or alteration of data.

Flight operations inspector (FOI) Is a representative of the Civil Aviation Authority of Malaysia in charge of initial authorisation and/or continued oversight of the operator's flight operations organisation and processes. The assessment performed by the FOI may include (but not be limited to):

a) the adequacy of flight operations facilities, equipment and procedures;
b) the adequacy of the training programmes and competence of employees; and
c) the adequacy of the programme to ensure safe operations of the aircraft.

Mixed navigation environment is an environment where different navigation specifications may be applied within the same airspace (e.g., RNP 10 routes and RNP 4 routes in the same airspace) or where operations using conventional navigation are allowed in the same airspace with RNAV or RNP applications.

Navigation aid (NAVAID) infrastructure refers to space-based and or ground-based NAVAIDs available to meet the requirements in the navigation specification.

Navigation application means the application of a navigation specification and the supporting NAVAID infrastructure, to routes, procedures, and/or defined airspace volume, in accordance with the intended airspace concept.

Note.— The navigation application is one element, along with communications, ATS surveillance and ATM procedures which meet the strategic objectives in a defined airspace concept.

Navigation function is the detailed capability of the navigation system (such as the execution of leg transitions, parallel offset capabilities, holding patterns, navigation databases) required to meet the airspace concept.

Note.— Navigational functional requirements are one of the drivers for the selection of a particular navigation specification. Navigation functionalities (functional requirements) for each navigation specification can be found in Volume II, Parts B and C.

Navigation specification are a set of aircraft and aircrew requirements needed to support Performance-based Navigation operations within a defined airspace. There are two kinds of navigation specification:

> RNAV specification. A navigation specification based on area navigation that does not include the requirement for on-board performance monitoring and alerting, designated by the prefix RNAV, e.g. RNAV 5, RNAV 1.
>
> RNP specification. A navigation specification based on area navigation that includes the requirement for on-board performance monitoring and alerting, designated by the prefix RNP, e.g. RNP 4, RNP APCH.
>
> Note.— Volume II of this manual contains detailed guidance on navigation specifications.

Performance-based navigation is defined as area navigation based on performance requirements for aircraft operating along an ATS route, on an instrument approach procedure or in a designated airspace.

Note.— Performance requirements are expressed in navigation specifications in terms of accuracy, integrity, continuity and functionality needed for the proposed operation in the context of a particular airspace concept. Availability of GNSS SIS or some other NAVAID infrastructure is considered within the airspace concept in order to enable the navigation application.

Procedural control refers to air traffic control service provided by using information derived from sources other than an ATS surveillance system.

Receiver autonomous integrity monitoring (RAIM) is a form of ABAS whereby a GNSS receiver processor determines the integrity of the GNSS navigation signals using only GPS signals or GPS signals augmented with altitude (baroaiding). This determination is achieved by a consistency check among redundant pseudo-range measurements. At least one additional satellite needs to be available with the correct geometry over and above that needed for the position estimation, for the receiver to perform the RAIM function.

RNAV operations refers to aircraft operations using area navigation for RNAV applications. RNAV operations include the use of area navigation for operations which are not developed in accordance with this manual.

RNAV system is defined as a navigation system which permits aircraft operation on any desired flight path within the coverage of station-referenced navigation aids or within the limits of the capability of self-contained aids, or a combination of these. An RNAV system may be included as part of a flight management system (FMS).

RNP operations refers to aircraft operations using an RNP system for RNP navigation applications. Explanation of Terms

RNP route is an ATS route established for the use of aircraft adhering to a prescribed RNP navigation specification.

RNP system is an area navigation system which supports on-board performance monitoring and alerting.

Satellite-based augmentation system (SBAS) is a wide coverage augmentation system in which the user receives augmentation information from a satellite-based transmitter.

Standard instrument arrival (STAR) is defined as a designated instrument flight rule (IFR) arrival route linking a significant point, normally on an ATS route, with a point from which a published instrument approach procedure can be commenced.

Standard instrument departure (SID) is defined as a designated instrument flight rule (IFR) departure route linking the aerodrome or a specified runway of the aerodrome with a specified significant point, normally on a designated ATS route, at which the en-route phase of a flight commences.

1.3 Abbreviations

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
AWI	=	Airworthiness Inspector
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)
CAT	=	Commercial air transport
CCF	=	Common cause failure
CDI	=	Course deviation indicator
CDU	=	Control display unit

CRC	=	Cyclic Redundancy Check
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
EHSI	=	Electronic Horizontal Situation Indicator
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
FAS	=	Final approach segment
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
FOI	=	Flight Operations Inspector
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
FTP	=	Fictitious threshold point
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
HIS	=	Horizontal situation indicator
IAF	=	Initial approach fix
IF	=	Initial fix
IFP	=	Instrument flight procedure
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
LOFT	=	Line Oriented Flight Training
LOI	=	Loss of integrity
LP	=	Localizer performance
LPV	=	Localizer performance with vertical guidance
LRNS	=	Long range navigation system
LTP	=	Landing threshold point
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 manuals
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 South American
SAM	=	Specific Approvals Manager
SB	=	Service bulletin
SBAS	=	Space-based augmentation system
SID	=	Standard instrument departure
SIS	=	Signal-in-space
SL	=	Service letter

SOP	=	Standard operating procedure
SPA	=	Specific approvals
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
VA	=	Heading to an altitude
VAE	=	Vertical angle error
V/DEV	=	Vertical deviation
VEB	=	Vertical error budget
VHF	=	Very high frequency
VI	=	Heading to a manual intercept
VM	=	Heading to a manual termination
VMC	=	Visual meteorological condition
VNAV	=	Vertical navigation
VOR	=	VHF omnidirectional radio range
VTF	=	Vector to final
WAAS	=	Wide area augmentation
WDM	=	Wiring diagram manual
WPR	=	Waypoint resolution error
WPT	=	Waypoint

1.4 PBN Overview

1.4.1 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.

1.4.2 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.

1.4.3 Area navigation systems are described in more detail in Appendix 1

1.5 RNAV and RNP

1.5.1 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.

1.5.2 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.

1.6 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[b]		2	2					2
RNAV 1[b]		1	1	1	1		1[c]	1
RNP 4	4							
RNP 2	2	2						
Advanced RNP[d]	2[e]	2 or 1	1	1	1	0.3	1[c]	1
RNP 1			1[f]	1	1		1[c]	1[e]
RNP 0.3[g]		0.3	0.3	0.3	0.3	–	0.3	0.3
RNP APCH				1	1	0.3[h]	1[c] or 0.3[i]	
RNP AR APCH				1-0.1	1-0.1	0.3-0.1	1-0.1[j]	

Notes:

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

b) *RNAV 1 and RNAV 2 are issued as a single approval.*

c) *Applies only once 50m (40 m CAT H) obstacle clearance has been achieved after the start of climb.*

d) *A-RNP also permits a range of scalable RNP lateral navigation accuracies*

e) *Optional; requires higher continuity.*

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

g) *The RNP 0.3 specification is primarily intended for helicopter operations.*

h) *The RNP APCH navigation specification is divided into two sections. RNP 0.3 is applicable to RNP APCH Section A (LNAV and LNAV/VNAV). Different angular performance requirements are applicable to RNP APCH Section B (LP and LPV).*

i) *This value applies during the initial straight-ahead missed approach segment for RNP APCH Section B (LP and LPV).*

j) *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*

1.7 PBN Applications

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

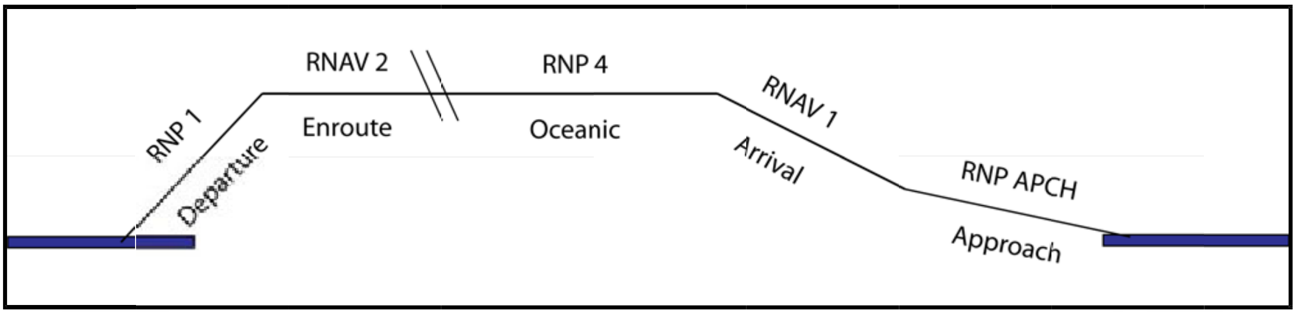

Figure 1-1. Navigation specifications to support a particular airspace concept

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 the 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 CAAM that the specific aircraft are in compliance with the relevant airworthiness standards 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

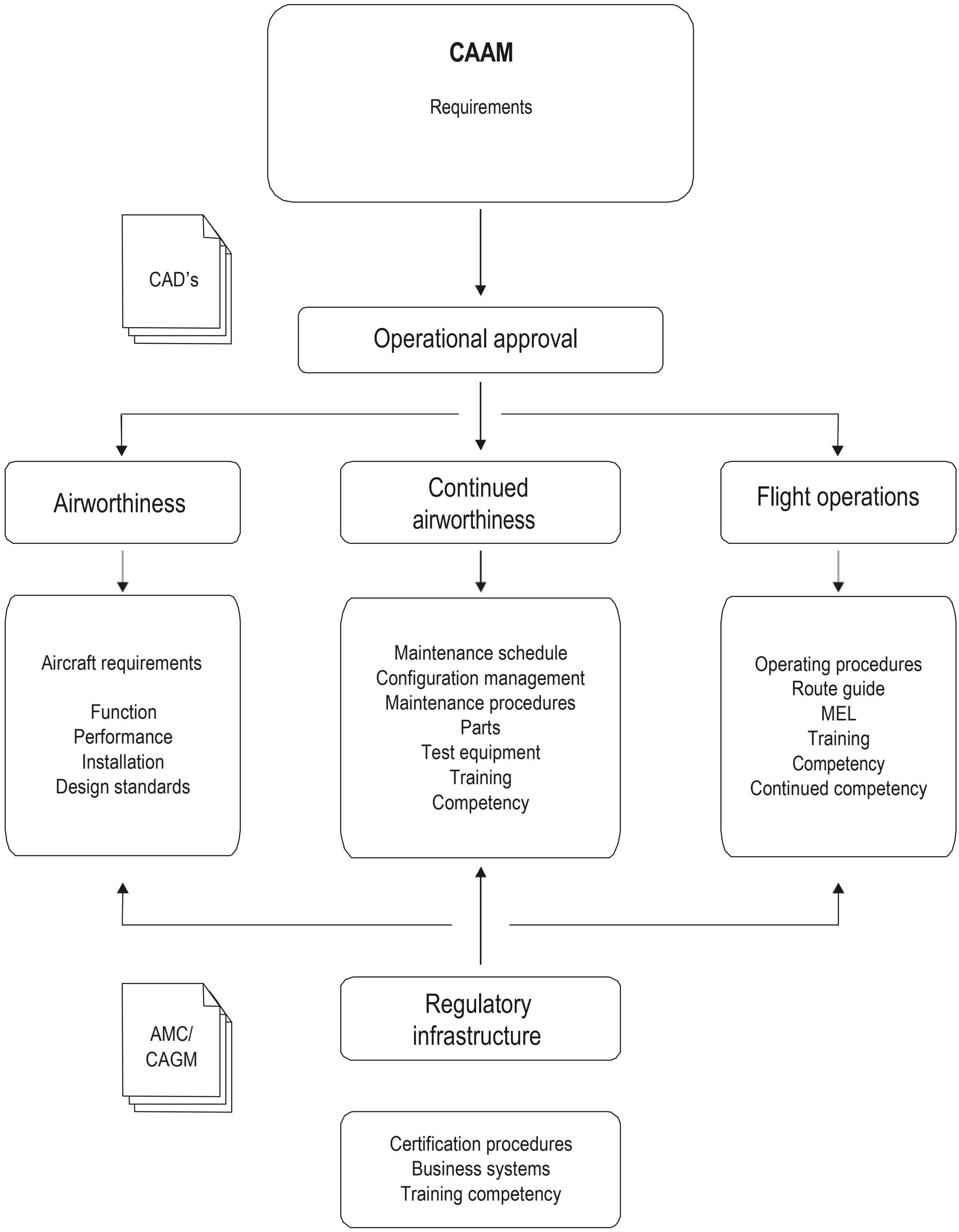

Figure 2-1. Overview of operational approval responsibilities

2.2 State regulatory responsibilities

2.2.1 Normally, individual States develop national regulatory material which address the PBN applications relevant to their airspace or relevant to operations conducted in another State by the operators and aircraft registered in that State. Therefore, prior to conducting PBN operations, the operator would require approval from the individual States.

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) usually 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.

Note1. – 2.2.3 describes general definitions of the different types of States.

Note 2. – For example, when a 9M registered aircraft is operated by a Malaysian AOC holder, the State of Registry and State of the Operator is the same.

2.2.3 Usually, the CAAM does 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 CAAM as its re-approving the data with respect to aircraft registered under its jurisdiction. When the CAAM does use technical data approved by another State, the CAAM will review the data, determine that the data are acceptable for use, 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 2.

2.3 Operational approval

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

2.3.2 The following factors usually influences CAAM'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 CAAM's decisions in this area are 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, CAAM 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 guidance is in place. The CAAM 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.

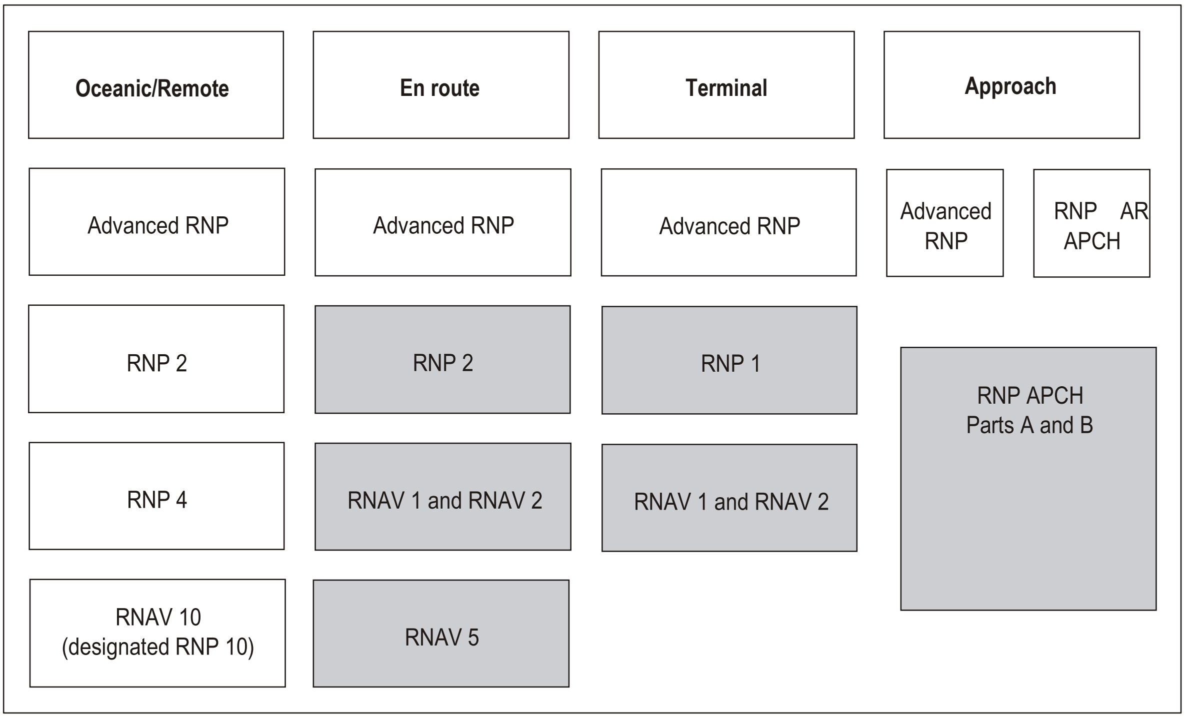

Figure 2-2: Bundling of navigation specifications

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, for example, approaches to operational approvals for commercial air transport and GA operations.

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 a 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 CAAM 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 CAAM 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 airworthiness, this is incorporated within the Certification Specification (CS) and Acceptable Means of Compliance (AMC) for Airborne Communications, Navigation and Surveillance (ACNS). Operational approval aspects are covered in Air-Ops Regulation Part ARO (authority requirements for air operations), Part ORO (organization requirements for air operations), Part CAT (commercial air transport), Part SPA (specific approvals), Part NCC (complex motor-powered aircraft). Part NCO (non-complex aircraft) and Part SPO (specialized operations). The Federal Aviation Administration (FAA), similarly, publishes advisory circulars (ACs) and orders for operations in United States 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 certification standards published by EASA and the FAA for PBN applications in 2012 (each document may reference additional standards including AC's, TSOs and RTCA/EUROCAE documents) and is subject to change*

Table 2-1. Approval scenarios

Scenario	***Aircraft certification status***	***Actions by the operator/owner***
1	Aircraft designed and type-certified 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 form the State of Registry (TC)

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

d) Actions to be taken in the event of a contingency, including the reporting to the operator and to the CAAM, 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, provided by the manufacturer, covering all these areas.

Table 2-2. EASA and FAA certification standards

Navigation specification	*EASA*	*FAA*
RNAV 10	CS-ACNS AMC 20-12	AC 90-105( )
RNAV 5	CS-ACNS AMC 20-4	AC 90-105( )
RNAV 1 and RNAV 2	JAA TGL-10	AC 90-100( )
RNP 4	Expected in 2015	AC 90-105( )
RNP 2	Expected in 2015	AC 90-105( )
RNP 1	Expected in 2015	AC 90-105( )
Advanced RNP	Expected in 2015	AC 90-105( )
RNP 0.3	Expected in 2015	AC 90-105( )
RNP APCH (LNAV)	CS-ACNS AMC 20-27	AC 90-105( )
RNP APCH (LNAV/VNAV)	CS-ACNS AMC 20-27	AC 90-105( )
RNP APCH (LPV)	CS-ACNS AMC 20-28	AC 90-107( )
RNP AR APCH	CS-ACNS AMC 20-26	AC 90-101( )
RF Attachment	Expected in 2015	AC 90-105( )

2.3.10 Control of operating procedures

2.3.10.1 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

2.3.11.1 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

2.3.12.1 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

2.3.13.1 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 of Ops Spec entries are provided in Appendix 3.

2.4.2 During the validity of the operational approval, the CAAM 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 CAAM PBN Operational Approval Process

2.5.1 General

2.5.1.1 In this CAGM, PBN operations mean all procedures applied for the purpose of ensuring safe aircraft operations in PBN airspace.

2.5.1.2 CAAM certification procedures are outlined in this manual.

2.5.1.3 The PBN approval process consists of both, an airworthiness approval and an operational approval.

2.5.1.4 The required information shall be provided to the CAAM by an air operator applying for PBN approval at least 60 working days prior to the intended start of PBN operations.

2.5.1.5 Any questions not covered herein, or any point of apparent conflict requiring resolution, should be referred to the CAAM.

2.5.2 The approval process should consist of the following phases:

2.5.2.1 ***Step 1 — <u>Pre-application phase:</u>*** Prior to initiating the approval process, the operator will review the requirements and guidelines outlined in the relevant regulations, CADs, and CAGMs which are published by the CAAM.

A pre-application usually commences when a prospective applicant makes his initial inquiries regarding application for an approval in the form of a letter or a personal visit to the CAAM. If the proposed application is complex, the operator may need to obtain advice and assistance from OEMs or other design organisations, training establishments, data providers, etc.
This Phase will include both Flight Operations and Airworthiness division to assist the applicant in queries and highlighting the requirements.

2.5.2.2 ***Step 2 — <u>Formal application phase:</u>*** The operator submits to the CAAM a formal, written application for approval, the CAAM will then appoint a Specific Approvals Manager (SAM) to oversee the application

Note. – An example application form is contained in Attachment A.

2.5.2.3 ***Step 3 — <u>Document evaluation phase:</u>*** The CAAM FOI and AWI evaluate the formal written application for approval to determine if all the requirements are being met. The FOI and AWI, may need to obtain advice and assistance from other departments within CAAM or organisations such as regional agencies or experts in other States.

2.5.2.4 ***Step 4 – <u>Demonstration and inspection phase:</u>*** During a formal inspection by the FOI and AWI (assisted as necessary by a team from the CAAM), the operator demonstrates how the requirements are being met.

2.5.2.5 ***Step 5 – <u>Approval phase:</u>*** Following a successful formal inspection by the CAAM, approval is given via:

e) an amendment to the OM; and

f) an Ops Spec associated with the AOC; or

g) a LOA

Note 1. – The demonstration and inspection phase may not be required depending upon the type of operation used, subject to the consideration of the CAAM.

Note 2. – The demonstration and inspection phase may not be required depending upon the area navigation system used and the type of operation used, subject to the consideration of the CAAM. For example, 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.

Table 2-2. Operational approval material

Navigation specification	ICAO (South American)	Australia	New Zealand	Canada
RNAV 10	AC 91-001	AC 91U-2( )		
RNAV 5	AC 91-002	DCAP B- RNAV-1		AC 700-015
RNAV 1 and RNAV2	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		
Advanced 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 International Operations

2.6.1 As stated in 2.2.1, 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 CAAM 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.

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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 ICAO PBN manual 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 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, and RNAV 1 and RNAV 2.

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 the CAAM 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 then be presented to the CAAM 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. 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.

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 has to be extremely thorough and ensure that the crew are able to manage all operations, including non-normal operations, safely. For example, crew without previous relevant experience (e.g., RNP APCH with baro-VNAV) would require a course in 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 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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4 Navigation Specification Job Aids

4.1 General

4.1.1 In order to facilitate a standardised approach to the process of applying for PBN approval, a structured form, known as a "job aid", has been developed.

4.1.2 These job aids can be used by the operator to detail the application for approval and to demonstrate that the specific requirements with respect to aircraft eligibility, operating procedures, training and database management have been met.

4.1.3 Much of the application process is common to all navigation specifications but each specification has specific elements that must be addressed. The following describes the process to complete an application for approval for a PBN navigation specification:

1) complete the PBN Application Form CAAM/BOP/SPA/PBN;

2) complete the job aid specific elements for the navigation specification, from sections 4.3 to 4.12 as applicable; and

3) combine the PBN Application Form CAAM/BOP/SPA/PBN and specific elements to form the complete approval application.

4.2 Job aid Guidance

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. Job aid specific elements

Part 1. 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 that the 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 LRNS maintenance practices, references to the maintenance document/programme.		
E	**Minimum equipment list** Showing provisions for LRNS.		
F	**Training** Part 91/GA operators or equivalent: • course completion records. Part 121/Part135/CAT operators or equivalent: • training programmes for flight crew, flight dispatchers and maintenance personnel.		
G	**Operating policies and procedures** Part 91/GA operators or equivalent: • extracts from the operations manual corresponding to the application. Part 121/Part135/CAT operators or equivalent: • operations manual and checklists.		
H	**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 2. Contents of the Operator application

#	Topic	*Specific ICAO reference*	*CAAM guidance/ reference*	*Operator compliance description*	*Inspector disposition/ comments*	*Follow-up by inspector (optional)*
		(ICAO Doc 9613, Volume II, …..)	*(CAD/CAGM, etc.)*	*(Document reference/ method*	*(Accepted/not accepted)*	*(Status and date)*

Note. – A detailed table is provided for each navigation specification.

Part 3. Operating procedures

#	Topic	*Specific ICAO reference*	*CAAM guidance/ reference*	*Operator compliance description*	*Inspector disposition/ comments*	*Follow-up by inspector (optional)*
		(ICAO Doc 9613, Volume II, …..)	*(CAD/CAGM, etc.)*	*(Document reference/ method*	*(Accepted/not accepted)*	*(Status and date)*

Note. – A detailed table is provided for each navigation specification.

Part 4. Contingency procedures

#	Topic	*Specific ICAO reference*	*CAAM guidance/ reference*	*Operator compliance description*	*Inspector disposition/ comments*	*Follow-up by inspector (optional)*
		(ICAO Doc 9613, Volume II, …..)	*(CAD/CAGM, etc.)*	*(Document reference/ method*	*(Accepted/not accepted)*	*(Status and date)*

Note. – A detailed table is provided for each navigation specification.

4.3 RNAV 10

4.3.1 General

4.3.1.1 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.

4.3.1.2 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 this document as RNAV 10.

4.3.1.3 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 this document will be known as RNAV 10.

4.3.2 System requirements

4.3.2.1 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.

4.3.2.2 The most common combinations of dual LRNSs are:

a) dual INS;

b) dual IRS;

c) dual GNSS;

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

4.3.2.3 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).

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

4.3.2.5 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.

4.3.2.6 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.

4.3.2.7 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.

4.3.3 Operating procedures

4.3.3.1 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 requirements of the CAAM should be sufficient to ensure compliance.

4.3.3.2 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.

4.3.3.3 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.

4.3.4 Pilot knowledge and training

4.3.4.1 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.

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

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

4.3.5 Job Aid – **RNAV 10** Specific Elements

Part 1. Operator application

Add following rows:

Annex	*Title*	*Inclusion by Operator*	*Comments by Inspector*
J	**Aircraft group** A statement by the operator of the method used to determine eligibility of the aircraft/LRNS combination		
K	**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.		
L	**Performance record** Evidence of previous problems, incidents or path-keeping errors, together with corrective action applied		
M	**Withdrawal of approval** The need for follow up action on navigation error reports, with the possibility of removal of approval.		

Part 2. Contents of the Operator application

#	Topic	Specific ICAO reference	CAAM guidance/ reference	Operator compliance description	Inspector disposition/ comments	Follow-up by inspector (optional)
		(ICAO Doc 9613, Volume II, Part B, Chapter 1)	*(CAD/CAGM, 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 (part 91 operators). Details of training programmes (part 121 and part 135 operators).	1.3.3.2.2.2 1.3.10				
6	**Operating policies and procedures** Extracts from the operations manual or other documentation (Part 91 operators).	1.3.3.2.2.3 1.3.5				

	Operations manual and checklists (part 121 and part 135 operators					
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				
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.	1.3.3.2.2.6				
10	**Withdrawal of RNP 10 authority**	1.3.12				
11	**Validation flight plan** If required					

Part 3. Operating procedures

#	Topic	*Specific ICAO reference*	*CAAM guidance/ reference*	*Operator compliance description*	*Inspector disposition/ comments*	*Follow-up by inspector (optional)*
		(ICAO Doc 9613, Volume II, Part B, Chapter 1)	*(CAD/CAGM, etc.)*	*(Document reference/ method*	*(Accepted/not accepted)*	*(Status and date)*
1	**Flight planning**					
1a	Verify that the aircraft is approved for RNP 10 operations.	1.3.7				
1b	Verify that two LRNSs are operational.	1.3.6				
1c	Verify that the RNP 10 time limit has been taken into account (INS/IRU only).	1.3.5.2				
1d	Verify that FDE is available (GNSS only).	1.3.5.2 1.3.8				
1e	Verify the FPL: “R” should appear in field 10 and PBN/A1 in field 18.	1.3.7				
1f	Verify operational restrictions as appropriate.	1.3.5.2				
1g	Verify the flight planned route including diversions.	1.3.7				
2	**Pre-flight**					
2a	Verify equipment conditions: • review flight technical records; • confirm that maintenance actions are complete.	1.3.5.3				
2b	Check the condition of navigation antennas and surrounding fuselage skin.	1.3.5.3				

2c	Review the emergency procedures for RNP 10 operations.	1.3.5.3				
3	**En route**					
3a	Verify that both LRNSs are RNP 10 capable at the oceanic point of entry.	1.3.9.1				
3b	Prior to the oceanic point of entry, the aircraft position must be independently checked and updated if necessary.	1.3.9.2				
3c	Other mandatory navigation.	1.3.9.3				
3d	ATC to be notified if unable to comply with RNP 10 requirements or of any deviation required for contingency procedures.	1.3.9.3				
3e	Follow route centre line within 5 NM	1.3.9.5				
4	**Update LRNS position**	1.3.9.7				

Part 4. Contingency procedures

#	Topic	*Specific ICAO reference*	*CAAM guidance/ reference*	*Operator compliance description*	*Inspector disposition/ comments*	*Follow-up by inspector (optional)*
		(Doc 4444, Chapters 5 and 15)	*(CAD/CAGM, etc.)*	*(Document reference/ method*	*(Accepted/not accepted)*	*(Status and date)*
1	**Contingencies**	15.2.1 and 15.2.2				
1a	Inability to comply with ATC clearance due to meteorological conditions, aircraft performance or pressurization failure.	15.2.1.1				
1b	Weather deviation.	15.2.3				
1c	Air-ground communications failure	5.4.2.6.3.2 15.3				

4.4 RNAV 5

4.4.1 General

4.4.1.1 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.

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

4.4.1.3 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.

4.4.2 System requirements

4.4.2.1 The RNAV 5 system requirements are not complex, as follows:

a) one single area navigation system is required;

b) the following sensors may be used:

   1) VOR/DME;

   2) DME/DME;

   3) 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;

   4) GNSS — receivers must be approved in accordance with ETSO-C129a, FAA TSO-C129a or later (ETSO-C129 or FAA TSO-C129 is also applicable provided it includes 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) an 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 field 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 less than or equal to ±5 NM for RNAV 5 — the maximum FTE permitted is 2.5 NM (1⁄2 FSD).

4.4.3 Operating procedures

4.4.3.1 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.

4.4.3.2 Because 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.

4.4.3.3 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 5 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 RNAV 5 operations with minimal additional training.

4.4.4.2 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.

4.4.5 Operational approval

4.4.5.1 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.

4.4.5.2 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.

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

4.4.6 Job Aid – **RNAV 5** Specific Elements

Part 2. Contents of the Operator application

#	*Topic*	*Specific ICAO reference*	*CAAM guidance/ reference*	*Operator compliance description*	*Inspector disposition/ comments*	*Follow-up by inspector (optional)*
		(ICAO Doc 9613, Volume II, Part B, Chapter 2)	*(CAD/CAGM, etc.)*	*(Document reference/ method*	*(Accepted/not accepted)*	*(Status and date)*
1	**Authorization request** Statement of intent to obtain authorization.					
2	**Aircraft/navigation system eligibility** Documents that establish eligibility.	2.3.2.1 2.3.2.2.1				
3	**Training** Details of courses completed (part 91 operators). Details of training programmes (part 121 and part 135 operators).	2.3.2.2.2 2.3.5				
4	**Operating policies and procedures** Extracts from the operations manual or other documentation (Part 91 operators). Operations manual and checklists (part 121 and part 135 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 3. Operating procedures

#	Topic	*Specific ICAO reference*	*CAAM guidance/ reference*	*Operator compliance description*	*Inspector disposition/ comments*	*Follow-up by inspector (optional)*
		(ICAO Doc 9613, Volume II, Part B, Chapter 2)	*(CAD/CAGM, etc.)*	*(Document reference/ method*	*(Accepted/not accepted)*	*(Status and date)*
1	**Flight planning**					
1a	Verify that the aircraft is approved for RNAV 5 operations.	2.3.4.2.1				
1b	Verify RAIM availability (GNSS only).	2.3.4.3				
1c	Verify the availability of NAVAIDS (non-GNSS)	2.3.4.2.4				
1d	Verify that the navigation database (if carried) is current and appropriate for the region.	2.3.4.2.3				
1e	Verify the FPL: "R" should appear in field 10 and 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 the flight planned route including diversions.	2.3.4.4.1				
2	**General operating procedures**					
2a	Advise ATC if unable to comply	2.3.4.4.1				
2b	Confirm that the navigation database is up to date (if appropriate).	2.3.4.4.4				

2c	Cross-check the chart with the RNAV system display.	2.3.4.4.5				
2d	Cross-check with conventional NAVAIDS to monitor for navigational reasonableness.	2.3.4.4.6				
2e	Follow route centre lines within 2.5 NM.	2.3.4.4.8				
2f	Do not modify the flight plan in the RNAV system after ATC heading assignment until a clearance is received to re-join the route or a new clearance is confirmed.	2.3.4.4.9				

Part 4. Contingency procedures

#	Topic	Specific ICAO reference	CAAM guidance/ reference	Operator compliance description	Inspector disposition/ comments	Follow-up by inspector (optional)
		*(ICAO Doc 9613, Volume II, Part B, Chapter 2)**	*(CAD/CAGM, etc.)*	*(Document reference/ method*	*(Accepted/not accepted)*	*(Status and date)*
1	**Contingencies**					
1a	Advise ATC if unable to meet the requirements for RNAV 5.	2.3.4.5.1				
1b	Air-ground communications failure.	2.3.4.5.2 (Doc 4444, Chapter 15, 15.3)				
1c	GNSS RAIM alert or loss of RAIM.	2.3.4.5.3				

** All references are to the PBN manual (ICAO Doc 9613), Volume II, Part B, Chapter 2, unless otherwise indicated.*

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4.5 RNAV 1 and RNAV 2

4.5.1 General

4.5.1.1 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 (U.S.-RNAV) requirements.

4.5.1.2 The RNAV 1 and RNAV 2 specifications apply to:

a) all ATS routes, including en-route;

b) standard instrument departures and arrivals (SIDs/STARs); and

c) instrument approach procedures up to the final approach fix (FAF)/final approach point (FAP).

4.5.1.3 Because 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.

4.5.1.4 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.

4.5.2 Operational approval

4.5.2.1 For operators holding either a P-RNAV approval or a U.S.-RNAV approval, the operational approval is relatively simple and minimal regulatory effort is required. Operators holding both P-RNAV and U.S.-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 U.S.-RNAV, and migration to RNAV 1 and RNAV 2 approval is not automatic unless the operator holds both U.S. and European approvals.

4.5.2.2 For operators holding only a P-RNAV approval or a U.S.-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, 3.3.2.4).

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

4.5.2.4 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 U.S.-RNAV airspace can continue to do so in accordance with a P-RNAV or U.S.-RNAV approval respectively.

4.5.3 System requirements

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

a) a single area navigation system;

b) the following sensors may be used:

1) DME/DME — accuracy is based upon TSO-C66c; the 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;

2) DME/DME/IRU — IRU performance in accordance with U.S. 14 CFR Part 121, Appendix G, automatic position updating from the DME/DME position and must not allow VOR inputs to affect position accuracy;

3) GNSS — receivers must be approved in accordance with ETSO-C129a, FAA TSO-C129a 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) an area navigation system failure indication;

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 field 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 less than or equal to ±1 NM for RNAV 1 or less than or equal to ±2 NM for RNAV 2 — the maximum FTE permitted is:

1) 0.5 NM for RNAV 1;

2) 1.0 NM for RNAV 2.

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

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

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

1) CA;

2) CF;
3) DF;
4) FM;
5) IF;
6) TF;
7) VA;
8) VI;
9) VM.

4.5.3.2 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 one-tenth of an 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.

4.5.3.3 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 or suitable position to allow either pilot to manoeuvre and adequately monitor cross-track deviation. 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 take-off 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 SID and STAR procedures.

4.5.4 Operating procedures

4.5.4.1 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.

4.5.4.2 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.

4.5.4.3 GNSS-based operations also require the prediction of fault detection (FD) RAIM 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 1 and RNAV 2 specific route prediction services are available from commercial sources.

4.5.4.4 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.

4.5.5 Pilot knowledge training

4.5.5.1 Most crews will already have some experience with 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.

4.5.5.2 Particular attention should be placed on:

a) the ability of the airborne equipment to fly the designed flight path. This may involve pilot intervention where the equipment functionality is limited;

b) management of changes;

c) turn management (turn indications, airspeed and bank angle, lack of guidance in turns);

d) route modification (insertion/deletion of waypoints, direct to waypoint);

e) intercepting a route from radar vectors.

4.5.5.3 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 programmes are available from a number of GPS manufacturers which provide a convenient method for familiarity with programming and operation of stand-alone GNSS systems.

4.5.5.4 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.

4.5.6 Job Aid – **RNAV 1 and RNAV 2** Specific Elements

Part 2. Contents of the Operator application

#	**Topic**	***Specific ICAO reference***	***CAAM guidance/ reference***	***Operator compliance description***	***Inspector disposition/ comments***	***Follow-up by inspector (optional)***
		(ICAO Doc 9613, Volume II, Part B, Chapter 3)	*(CAD/CAGM, etc.)*	*(Document reference/ method*	*(Accepted/not accepted)*	*(Status and date)*
1	**Authorization request** Statement of intent to obtain authorization.	3.3.2.1				
2	**Aircraft/navigation system eligibility** Documents that establish eligibility.	3.3.2.2 3.3.2.3.1				
3	**Training** Details of courses completed (part 91 operators). Details of training programmes (part 121 and part 135 operators).	3.3.2.3.2 3.3.5				
4	**Operating policies and procedures** Extracts from the operations manual or other documentation (Part 91 operators). Operations manual and checklists (part 121 and part 135 operators.	3.3.2.3.3				
5	**Maintenance practices** Document references for navigation database maintenance practices.	3.3.2.3.5 3.3.6				
6	**MEL update**	3.3.2.3.4				

Part 3. Operating procedures

#	Topic	*Specific ICAO reference*	*CAAM guidance/ reference*	*Operator compliance description*	*Inspector disposition/ comments*	*Follow-up by inspector (optional)*
		(ICAO Doc 9613, Volume II, Part B, Chapter 3)	*(CAD/CAGM, etc.)*	*(Document reference/ method*	*(Accepted/not accepted)*	*(Status and date)*
1	**Flight planning**					
1a	Verify that the aircraft is approved for RNAV 1 and RNAV 2 operations.	3.3.4.1				
1b	Verify RAIM availability (GNSS only).	3.3.4.3.1 3.3.4.3.2				
1c	Verify the availability of NAVAIDS (non-GNSS)	3.3.4.2.3 3.3.4.3.4				
1d	Verify that the navigation database (if carried) is current and appropriate for the region.	3.3.4.2.2 3.3.4.5.3				
1e	Verify the FPL: "R" should appear in field 10 and PBN/C1-D4 (as appropriate) in field 18.	3.3.4.2.1				
2	**General operating procedures**					
2a	Verify the flight-planned route.	3.3.4.5.3				
2b	Advise ATC if unable to comply with the requirements for RNAV 1/RNAV2	3.3.4.5.2				
2c	Confirm that the navigation database is up to date	3.3.4.5.3				
2d	Retrieve SIDs/STARs only from the database	3.3.4.5.4				

2e	Cross-check the chart with the RNAV system display.	3.3.4.5.3 3.3.4.5.6				
2f	Cross-check with conventional NAVAIDS to monitor for navigational reasonableness.	3.3.4.5.7				
2g	Use an appropriate display.	3.3.4.5.8 3.3.4.5.9				
2h	Use appropriate scaling.	3.3.4.5.10				
2i	Follow route centre line within 1 or 0.5 NM	3.3.4.5.11				
2j	Do not modify the flight plan in the RNAV system after ATC heading assignment until a clearance is received to re-join the route or a new clearance is confirmed.	3.3.4.5.12				
3	**RNAV SID requirements**					
3a	Prior to take-off, check the RNAV system, aerodrome and procedure loaded and the displayed position.	3.3.4.6.1				
3b	Engage LNAV no later than 153 m (500 ft) above aerodrome elevation.	3.3.4.6.2				
3c	If DME/DME only, do not use RNAV until within adequate DME coverage.	3.3.4.6.4				
3d	If DME/DME/IRU only, confirm navigation position within 0.17 NM of the start of the take-off roll.	3.3.4.6.5				
3e	If GNSS, acquire signal before start of take-off roll.	3.3.4.6.6				
4	**RNAV STAR requirements**					

4a	Verify that the correct STAR is loaded and displayed.	3.3.4.7.1				
4b	Contingency preparations	3.3.4.7.3				
4c	Procedure modification in response to ATC instructions.	3.3.4.7.4				
4d	Observance of speed and altitude constraints.	3.3.4.7.6				

Part 4. Contingency procedures

#	Topic	Specific ICAO reference	CAAM guidance/ reference	Operator compliance description	Inspector disposition/ comments	Follow-up by inspector (optional)
		*(ICAO Doc 9613, Volume II, Part B, Chapter 3)**	*(CAD/CAGM, etc.)*	*(Document reference/ method*	*(Accepted/not accepted)*	*(Status and date)*
1	**Contingencies**					
1a	Advise ATC if unable to meet the requirements for RNAV 1/RNAV 2.	3.3.4.8.1				
1b	Air-ground communications failure.	3.3.4.8.2 (Doc 4444, Chapter 15, 15.3)				

** All references are to the PBN manual (ICAO Doc 9613), Volume II, Part B, Chapter 3, unless otherwise indicated.*

4.6 RNP 4

4.6.1 General

4.6.1.1 RNP 4 supports 30 NM lateral and 30 NM 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 because the navigation specification is based upon U.S. FAA Order 8400.33.

4.6.2 System requirements

4.6.2.1 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;

d) an area navigation system failure indication;

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 field 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 ±4 NM — 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.

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 one-tenth of an NM. In some cases, a numeric indication of cross-track error may be provided outside the primary field of view (e.g., CDU).

4.6.2.2 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 with reference to the flight-planned track. This type of unit in en- route mode (nominally outside 30 NM from departure and destination airports) defaults to a CDI/HSI full-scale display of ±5 NM, with RAIM alerting defaulting to 2 NM, 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.

4.6.2.3 The default method for area navigation systems to manage turns at the intersection of "straight" route segments is to compute, based on ground speed 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 to 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.

4.6.3 Operating procedures

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

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

a) the aircraft is serviceable for RNP 4 operations;

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.

4.6.3.3 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 programmes 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.

4.6.4 Pilot knowledge and training

4.6.4.1 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.

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

4.6.5 Job Aid – **RNP 4** Specific Elements

Part 1. Operator application

Add following rows:

Annex	***Title***	***Inclusion by Operator***	***Comments by Inspector***
J	**Aircraft group** Statement by the operator as to which eligibility group the aircraft/RNP system combinations belong.		

Part 2. Contents of the Operator application

#	Topic	Specific ICAO reference	CAAM guidance/ reference	Operator compliance description	Inspector disposition/ comments	Follow-up by inspector (optional)
		(ICAO Doc 9613, Volume II, Part C, Chapter 1)	(CAD/CAGM, etc.)	(Document reference/ method	(Accepted/not accepted)	(Status and date)
1	**Authorization request** Statement of intent to obtain authorization.					
2	**Aircraft/navigation system eligibility** Documents that establish eligibility. For RNP 4, the eligibility group(s) used, and a list of the airframes included in each group.	1.3.2.2				
3	**Training** Details of courses completed (part 91 operators). Details of training programmes (part 121 and part 135 operators).	1.3.2.3.2 1.3.5				
4	**Operating policies and procedures** Extracts from the operations manual or other documentation (Part 91 operators). Operations manual and checklists (part 121 and part 135 operators.	1.3.2.3.3				
5	**Maintenance practices** Document references for RNP 4 maintenance practices.	1.3.2.3.5				
6	**MEL update**	1.3.2.3.4				

Part 3. Operating procedures

#	Topic	Specific ICAO reference (ICAO Doc 9613, Volume II, Part C, Chapter 1)	CAAM guidance/ reference (CAD/CAGM, 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 that the aircraft is approved for RNP 4 operations.	1.3.4.1				
1b	Verify that the navigation database is current.	1.3.4.2.1				
1c	Verify the availability of FDE (if applicable)	1.3.4.3				
1d	Verify the FPL: "R" should appear in field 10 and PBN/L1 in field 18.	1.3.4.2.1				
1e	Verify equipment conditions: • Review flight technical records; • Confirm that maintenance actions are complete.	1.3.4.2.2				
2	**En-route**					
2a	Two LRNSs must be RNP 4 capable at the oceanic point of entry.	1.3.4.4.1				
2b	Other mandatory navigation cross-checks.	1.3.4.4.2				
2c	ATC notified if unable to comply with the requirements for RNP or of any deviation required for a contingency.	1.3.4.4.3				

2d	Follow route centre line within 2 NM.	1.3.4.4.4				

Part 4. Contingency procedures

#	*Topic*	*Specific ICAO reference*	*CAAM guidance/ reference*	*Operator compliance description*	*Inspector disposition/ comments*	*Follow-up by inspector (optional)*
		(Doc 4444, Chapter 15)	*(CAD/CAGM, etc.)*	*(Document reference/ method*	*(Accepted/not accepted)*	*(Status and date)*
1	**Contingencies**					
1a	Inability to comply with ATC clearance due to meteorological conditions, aircraft performance or pressurization failure.	15.2.1.1				
1b	Weather deviation.	15.2.3				
1c	Air-ground communications failure	15.3				

4.7 RNP 2

4.7.1 General

4.7.1.1 RNP 2 is a navigation specification primarily intended to provide a means to develop routes in areas with little or no ground-based navigation aid (NAVAID) infrastructure.

4.7.1.2 The RNP 2 navigation specification is applicable to fixed or flexible routes in Continental En-route and Oceanic/Remote flight phases.

4.7.1.3 RNP 2 requires Global Navigation Satellite System (GNSS) as the primary navigation sensor, either as a stand-alone aviation system or as part of a multi-sensor system. Where multi-sensor systems incorporating GNSS are used, positioning data from non-GNSS navigation sensors may be integrated with the GNSS data provided the non-GNSS data do not cause position errors exceeding the total system error budget. Otherwise, a means should be provided to deselect the non-GNSS navigation sensor types.

4.7.1.4 RNP 2 operations in Oceanic and Remote airspace require dual independent long-range navigation systems. RNP 2 operations in Continental En-route airspace may use a single GNSS area navigation system providing an alternate means of navigation is available if required by the category of operation.

4.7.1.5 The standards applicable to RNP 2 oceanic / remote also meet the requirements for:

a) RNP 4; and

b) RNAV 5; and

c) RNAV 1 and RNAV 2.

Note. – RNP 2 is applicable to area navigation routes defined by straight segments. Fixed Radius Transitions may be applied to RNP 2 routes.

4.7.2 Aircraft eligibility

4.7.2.1 An aircraft is eligible for a RNP 2 navigation authorization if:

a) The AFM, an AFM supplement, or OEM service letter states that the aircraft navigation system is approved for RNP 2 operations; or

b) The aircraft is equipped with GNSS stand-alone system certified by the manufacturer for en-route operations in accordance with AC 21-36(0) (utilizing either TSO-C129 Class A1 or A2 or TSO-C146 / ETSO-C146 Class Gamma and Operational Class 1, 2 or 3) or equivalent;

c) The aircraft is equipped with a multi-sensor system (e.g. FMS) with GNSS equipment certified by the manufacturer for en-route operations in accordance with AC 21-37 (0) (utilizing either TSO/ETSO-C129(a) sensor

Class B or C, TSO/ETSO-C145 Class 1, 2 or 3 or TSO-C196) and the requirements of ETSO-C115b FMS or equivalent.

d) The aircraft is demonstrated to comply with the requirements for RNP 2 contained in ICAO ICAO Doc 9613 PBN Manual, Volume II, Part C, Chapter 2, Implementing RNP 2.

4.7.3 System performance, monitoring and alerting

System performance, monitoring and alerting requirements for RNP 2 operations are as stated in ICAO ICAO Doc 9613 PBN Manual, Volume II, Part C, Chapter 2, Implementing RNP 2.

4.7.4 System functionality

System functionality requirements for RNP 2 operations are as stated in ICAO ICAO Doc 9613 PBN Manual, Volume II, Part C, Chapter 2, Implementing RNP 2.

4.7.5 Operating standards

4.7.5.1 Flight planning
Prior to flight, consider conditions that may affect RNP 2 operations, including:

a) verifying that the aircraft and operating crew are approved for RNP 2;

b) confirming that the aircraft can be operated in accordance with the RNP 2 requirements for the planned route(s) including the route(s) to any alternate aerodrome(s) and minimum equipment requirements;

c) checking availability of the NAVAID infrastructure required for the intended routes, including any non-RNAV contingencies, for the period of the intended operation;

d) confirming that the navigational database is current and appropriate for the region of intended operation and includes the NAVAIDs and waypoints required for the route; and

e) considering any operating restrictions, including time limits if applicable. Insert the appropriate identifier in the flight plan to indicate RNP 2 as set out in the Aeronautical Information Publication.

4.7.5.2 GNSS Integrity Availability

a) GNSS navigation systems are equipped with a means of monitoring the integrity of the position solution. Integrity may be assured by a number of methods including Receiver Autonomous Integrity Monitor and proprietary hybrid inertial / GNSS systems.

b) The availability of the integrity monitoring function can be predicted and can be obtained from a variety of sources such as Notice to Airmen (NOTAM), and prediction services. Operators should be familiar with the prediction information available for the intended route. Prediction services are available from Air Navigation Service Provider (ANSPs), avionic manufacturers, other entities or through an on-board prediction capability.

c) Integrity availability prediction should take into account the latest satellite constellation NOTAM and the integrity system used by the aircraft avionics.

d) In the event of a predicted, continuous loss of the integrity function more than 5 minutes for any part of the RNP 2 operation, the flight plan should be revised (i.e. delaying the departure or planning a different route).

Note. – Some RNP systems, typically multi-sensor systems with tightly coupled GNSS/IRS, provide a global RNP capability based on a minimum number of available GPS satellites and IRS coasting capability, for example "For instrument approach procedures requiring GPS PRIMARY...GPS PRIMARY is available worldwide if 24 satellites or more are operative. If the number of satellites is 23 or less check GPS PRIMARY availability using an approved ground based prediction software". This equates to a global RNP capability of RNP 0.3 provided there is a minimum number of 24 serviceable GPS satellites. In such cases a prediction is not required unless operations below the stated RNP value are planned or the minimum number of serviceable satellites is reached.

e) Operators, pilots and ANSPs need to be aware, that a prediction of integrity availability, an unplanned failure of GNSS elements can result in a loss of integrity monitoring capability, and in some cases a complete loss of the navigation function whilst airborne, which may require reversion to an alternative means of navigation. Pilots should, therefore, assess their capability to navigate (potentially to an alternate destination) in the case of failure of GNSS navigation.

f) For aircraft navigating with Space Based Augmentation System (SBAS) receivers (all TSO-C145/C146), check GPS INTEGRITY availability in areas where SBAS is unavailable.

4.7.5.3 Flight procedures

a) Comply with any instructions or procedures identified by the manufacturer as being necessary to comply with the performance requirements of the navigation specification.

b) At system initialization, confirm the navigation database is current and verify that the aircraft position has been entered correctly. Verify proper entry of the Air Traffic Control (ATC) assigned route upon initial clearance from ATC to conduct the relevant RNAV route. Ensure the waypoints sequence, depicted by the navigation system, matches the route depicted on the appropriate chart/s and the assigned route.

c) Cross-check the cleared flight plan by comparing charts or other applicable resources with the navigation system textural display and the aircraft map display, if applicable. If required, confirm the exclusion of specific navigation aids.

Note. – Small differences between charted navigation information and displayed navigation data may be noted. Differences of 3 degrees or less due to the equipment manufacturer's application of magnetic variation and are operationally acceptable.

d) During flight, where feasible, confirm navigation reasonableness by cross-reference to available data from ground-based aids.

e) For RNP 2 routes, a lateral deviation indicator, navigation map display, flight director or autopilot in the lateral navigation mode is recommended.

f) In lieu of a lateral deviation indicator, a navigation map display with equivalent functionality to a lateral deviation indicator, as described in ICAO ICAO Doc 9613, Volume II, Part C, Chapter 2, Implementing RNP 2 is acceptable for RNP 2 operations.

g) Select lateral deviation display scaling suitable for the navigation accuracy associated with the route (e.g., full scale deflection ±2 NM for RNP 2 or ± 5 NM for TSO-C129 equipment).

h) Select navigation map scale to enable monitoring of tracking accuracy applicable to RNP 2.

Note. – Map scaling selection is dependent upon a number of factors including display size, resolution, any numeric cross-track indications and route complexity. Typically, a 10 NM display scaling may be used.

i) Maintain route centrelines, as depicted by lateral deviation indicators and/or flight guidance, unless authorized to deviate by ATC or under emergency conditions.

j) The standard for limitation of cross-track error/deviation (the difference between the computed path and the displayed aircraft position) is ½ the navigation accuracy (i.e. 1 NM for RNP 2).

Note. – Brief deviations from this standard during and immediately after turns, are normally considered acceptable. As accurate cross-track information may not be provided during turns, crew procedures and training need to emphasize observance of turn anticipation commands and management of rate of turn.

k) If ATC issues a heading assignment taking the aircraft off a route, do not modify the flight plan until clearance is received to re-join the route or the controller confirms a new clearance.

l) Manually selecting aircraft bank-limiting functions may reduce the aircraft's ability to maintain its desired track and is therefore not recommended. Pilots should recognise that manually selectable aircraft bank-limiting functions might reduce their ability to satisfy ATC flight path expectations, especially when executing large angle turns. This should not be construed as a requirement to deviate from approved aircraft flight manual procedures; rather pilots should be encouraged to limit the selection of such functions within accepted procedures.

4.7.5.4 Contingency procedures

Notify ATC when the RNP performance ceases to meet RNP 2 requirements.

4.7.6 Flight crew knowledge and training

4.7.6.1.1 Flight crew knowledge elements include:

a) The meaning and proper use of aircraft equipment/navigation suffixes;

b) The capabilities and limitations of the RNP system installed;

c) The operations and airspace for which the RNP system is approved to operate;

d) The NAVAID limitations with respect to the RNP system to be used for RNP 2 operations; Required navigation equipment for operation on RNP 2 routes;

e) The flight planning requirements for the RNP 2 operation;

f) The radio/telephony phraseology for the airspace, in accordance with ICAO Doc 4444 - Procedures for Air Navigation Services – Air Traffic Management (PANS/ATM) and Doc 7030 – Regional supplementary procedures, as appropriate;

g) Contingency procedures for RNP system failures;

h) RNP system-specific information, including:

   1) Levels of automation, mode annunciations, changes, alerts, interactions, reversions and degradation;

   2) Functional integration with other aircraft systems;

   3) Types of navigation sensors (e.g. Distance Measuring Equipment, Inertial Reference Unit and GNSS) utilized by the RNP system and associated system prioritization/weighting/logic;

   4) Aircraft configuration and operational conditions required to support RNP2 operations i.e. appropriate selection of lateral deviation display scaling;

   5) Pilot procedures consistent with the operation;

   6) The meaning and appropriateness of route discontinuities and related flight crew procedures;

   7) Monitoring procedures for each phase of the flight (e.g. monitor PROG or LEGS page);

   8) Turn anticipation with consideration to speed and altitude effects; and

   9) Interpretation of electronic displays and symbols.

4.7.6.2 Flight crew training elements include:

a) Verify that the aircraft navigation data is current and valid;

b) Verify the successful completion of RNP system self-tests;

c) Initialize RNP system position;

d) Perform a manual or automatic update (with take-off point shift, if applicable);

e) Verify waypoints and flight plan programming;

f) Resolve route discontinuities;

g) Fly direct to waypoint;

h) Fly a course/track to waypoint;

i) Intercept a course/track;

j) Vector off track and re-join a procedure;

k) Fly radar vectors and re-joining an RNP 2 route from a 'heading' mode;

l) Determine cross-track error/deviation;

m) Determine allowable deviation limits and maintain flight within those limits;

n) Remove and reselect navigation sensor input;

o) Perform gross navigation error checks using conventional aids;

p) Confirm exclusion of a specific navigation aid or navigation aid type;

q) Change arrival airport and alternate airport;

r) Perform parallel offset function if capability exists. Advise ATC if this functionality is not available; and

s) Contingency procedures for RNP 2 failures.

Note. – Where crews have the required standard of knowledge based on previous training or experience a separate training course may not be necessary, provided the applicant details the relevant knowledge and training elements that are contained in other training programmes.

4.7.7 Minimum equipment list

The operator's MEL must identify any unserviceability that affects the conduct of a RNP 2 operation.

4.7.8 Navigation Data Base

4.7.8.1 A navigation database should be obtained from a supplier that complies with Radio Technical Commission for Aeronautics DO-200A/ European Organization for Civil Aircraft Equipment document ED-76, Standards for Processing Aeronautical Data and should be compatible with the intended function of the equipment (see ICAO Annex 6, Part 1, Chapter 7). A Letter of

Acceptance (LOA), issued by an appropriate regulatory authority to each of the participants in the data chain, demonstrates compliance with this requirement. (e.g. Federal Aviation Administration (FAA) LOA issued in accordance with FAA AC 20-153 or European Aviation Safety Agency (EASA) LOA issued in accordance with EASA Implementing Rule 21 subpart G).

Note. – While a LOA provides assurance of minimum standards for the supply of a navigation data, errors may still occur, and all operators should consider the need to conduct periodic checks to ensure database integrity.

4.7.8.2 Any discrepancy in data is to be reported to the navigation database supplier and resolved prior to operational use by:

a) re-issue of the navigation database;

b) prohibition of the route; or

c) instructions to flight crew.

4.7.9 Navigation errors

4.7.9.1 It is the responsibility of the operator to take immediate action to rectify any condition that has led to navigation error.

4.7.9.2 A report to the CAAM, including an initial analysis of the causal factors and the measures being taken to prevent a recurrence is due within 72 hours.

4.7.9.3 Navigation errors exceeding the following limits are reportable:

a) a lateral navigational error of at least 2 NM for RNP 2;

b) a longitudinal navigational error of at least 2 NM for RNP 2; or

c) a navigation system failure. A navigation system failure is defined as meaning that the aircraft cannot meet the required performance for the current route.

4.7.10 Job Aid – **RNP 2** Specific Elements

Part 2. Contents of the Operator application

#	*Topic*	***Specific ICAO reference*** *(ICAO Doc 9613, Volume II, Part C, Chapter 2)*	***CAAM guidance/ reference*** *(CAD/CAGM, 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 eligibility.	2.3.2.2 2.3.2.3.1				
3	**Training** Details of courses completed (part 91 operators). Details of training programmes (part 121 and part 135 operators).	2.3.2.3.2 2.3.5				
4	**Operating policies and procedures** Extracts from the operations manual or other documentation (Part 91 operators). Operations manual and checklists (part 121 and part 135 operators.	2.3.2.3.3				
5	**Maintenance practices** Document navigation database maintenance practices.	2.3.2.3.5 2.3.6				
6	**MEL update**	2.3.2.3.4				

Part 3. Operating procedures

#	Topic	Specific ICAO reference (ICAO Doc 9613, Volume II, Part C, Chapter 2)	CAAM guidance/ reference (CAD/CAGM, 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 that the aircraft and crew are approved for RNP 2 operations.	2.3.4.1				
1b	Verify RAIM availability.	2.3.4.2.3 2.3.4.3				
1c	Verify that the navigation database is current.	2.3.4.2.2				
1d	Verify the FPL: "R" should appear in field 10 and PBN/TBD in field 18.	2.3.4.2.1				
2	**General operating procedures**					
2a	Comply with the manufacturer's instructions/procedures.	2.3.4.4.1				
2b	Advise ATC if unable to comply with the requirements for RNP 2.	2.3.4.4.2				
2c	Verify aircraft position and entry of assigned route.	2.3.4.4.3				
2d	Retrieve RNP 2 route from the database or build route using waypoints from the database.	2.3.4.4.4				
2e	Cross-check the chart with the RNAV system display.	2.3.4.4.4				
2f	Use an appropriate display.	2.3.4.4.6				

2g	Use appropriate scaling	2.3.4.4.6				
2h	Follow route centre line within 1 NM.	2.3.4.4.7				
2i	Do not use bank limiting functions.	2.3.4.4.8				
2j	Do not modify the fight plan in the RNAV system after ATC heading assignment until a clearance is received to re-join the route or a new clearance is confirmed.	2.3.4.4.9				
2k	If RNP input is required, select RNP 2 or lower.	2.3.4.4.10				

Part 4. Contingency procedures

#	Topic	Specific ICAO reference	CAAM guidance/ reference	Operator compliance description	Inspector disposition/ comments	Follow-up by inspector (optional)
		*(ICAO Doc 9613, Volume II, Part C, Chapter 2)**	*(CAD/CAGM, etc.)*	*(Document reference/ method*	*(Accepted/not accepted)*	*(Status and date)*
1	**Contingencies**					
1a	Advise ATC if unable to meet the requirements for RNP 2.	2.3.4.5				

** All references are to the PBN manual (ICAO Doc 9613), Volume II, Part C, Chapter 2, unless otherwise indicated.*

4.8 RNP 1

4.8.1 General

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

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

4.8.2 Maintaining 1 NM scaling

4.8.2.1 Stand-alone basic GNSS receiver

4.8.2.1.1 The most basic qualifying system is a stand-alone GNSS receiver (TSO C129(a) or equivalent) which should be 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.

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

a) a cross-track deviation display scaling is automatically set at ±1 NM full-scale deflection;

b) alert is automatically set to 1 NM (RAIM alert limit).

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

4.8.2.1.4 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 30 NM from the departure ARP. If the RNP 1 SID extends past 30 NM, the CDI scaling will no longer be adequate to support the required FTE limit (±0.5 NM), and flight crew action will be necessary to manually select ±1 NM CDI scaling.

4.8.2.1.5 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 30 NM from the ARP. If the STAR commences at a distance greater than 30 NM radius from the destination, then en-route CDI scaling of ±5 NM is inadequate for RNP 1 and must be manually selected to ±1 NM.

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

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

4.8.2.2 FMS systems

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

4.8.2.2.2 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.

4.8.2.2.3 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.

4.8.3 De-selection of radio updating

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.

4.8.4 Job Aid – **RNP 1** Specific Elements

Part 2. Contents of the Operator application

#	*Topic*	***Specific ICAO reference***	***CAAM guidance/ reference***	***Operator compliance description***	***Inspector disposition/ comments***	***Follow-up by inspector (optional)***
		(ICAO Doc 9613, Volume II, Part C, Chapter 3)	*(CAD/CAGM, etc.)*	*(Document reference/ method*	*(Accepted/not accepted)*	*(Status and date)*
1	**Authorization request** Statement of intent to obtain authorization.					
2	**Aircraft/navigation system eligibility** Documents that establish eligibility.	3.3.2.2 3.3.2.3.1				
3	**Training** Details of courses completed (part 91 operators). Details of training programmes (part 121 and part 135 operators).	3.3.2.3.2 3.3.5				
4	**Operating policies and procedures** Extracts from the operations manual or other documentation (Part 91 operators). Operations manual and checklists (part 121 and part 135 operators.	3.3.2.3.3				
5	**Maintenance practices** Document navigation database maintenance practices.	3.3.2.3.5 3.3.6				
6	**MEL update**	3.3.2.3.4				

Part 3. Operating procedures

#	Topic	*Specific ICAO reference*	*CAAM guidance/ reference*	*Operator compliance description*	*Inspector disposition/ comments*	*Follow-up by inspector (optional)*
		(ICAO Doc 9613, Volume II, Part C, Chapter 3)	*(CAD/CAGM, etc.)*	*(Document reference/ method*	*(Accepted/not accepted)*	*(Status and date)*
1	**Flight planning**					
1a	Verify that the aircraft is approved for RNP 1 operations.	3.3.4.1				
1b	Verify RAIM availability.	3.3.4.2.3 3.3.4.3				
1c	Verify that the navigation database is current.	3.3.4.2.2				
1d	Verify the FPL: "R" should appear in field 10 and PBN/O2 in field 18.	3.3.4.2.1				
2	**General operating procedures**					
2a	Comply with the manufacturer's instructions/procedures.	3.3.4.4.1				
2b	Advise ATC if unable to comply with the requirements for RNP 1.	3.3.4.4.2				
2c	Verify aircraft position and entry of assigned route.	3.3.4.4.3				
2d	Retrieve SIDs/STARs only from the database	3.3.4.4.4				
2e	Cross-check the chart with the RNAV system display.	3.3.4.4.5				
2f	Cross-check with conventional NAVAIDS to monitor for navigational reasonableness.	3.3.4.4.6				

2g	Use an appropriate display.	3.3.4.4.7				
2h	Use appropriate scaling.	3.3.4.4.7				
2i	Follow route centre line within 0.5 NM	3.3.4.4.8				
2j	Do not modify the flight plan in the RNAV system after ATC heading assignment until a clearance is received to re-join the route or a new clearance is confirmed.	3.3.4.4.9				
2k	If RNP input is required, select RNP 1 or lower.	3.3.4.5				
3	**RNP 1 SID requirements**					
3a	Prior to take-off, check the RNAV system, the aerodrome and procedure loaded and the displayed position.	3.3.4.6.1				
3b	Engage LNAV no later than 153 m (500 ft) above aerodrome elevation.	3.3.4.6.2				
3c	Use an authorized method to achieve RNP 1 (AP / FD / Map / L/DEV indicator)	3.3.4.6.3 3.3.4.6.5				
3d	If GNSS, signal must be acquired before start of take-off roll.	3.3.4.6.4				
4	**RNP 1 STAR requirements**					
4a	Verify that the correct STAR is loaded and displayed.	3.3.4.7.1				
4b	Contingency preparations	3.3.4.7.3				
4c	Procedure modification in response to ATC instructions.	3.3.4.7.4				
4d	Verify the correct operation of the	3.3.4.7.5				

	navigation system and that the correct procedure, transition and runway are loaded.					
4e	Observance of speed and altitude constraints.	3.3.4.7.6				
4f	If the procedure is more than 30 NM from ARP use FD/AP or set FSD to 1 NM.	3.3.4.7.7				

Part 4. Contingency procedures

#	Topic	Specific ICAO reference	CAAM guidance/ reference	Operator compliance description	Inspector disposition/ comments	Follow-up by inspector (optional)
		*(ICAO Doc 9613, Volume II, Part C, Chapter 3) **	*(CAD/CAGM, etc.)*	*(Document reference/ method*	*(Accepted/not accepted)*	*(Status and date)*
1	**Contingencies**					
1a	Advise ATC if unable to meet the requirements for RNP 1.	3.3.4.8.1				
1b	Air-ground communications failure.	3.3.4.8.2 (Doc 4444, Chapter 15, 15.3)				

** All references are to the PBN manual (ICAO Doc 9613), Volume II, Part C, Chapter 3, unless otherwise indicated.*

4.9 RNP APCH

4.9.1 General

4.9.1.1 RNP APCH is the general designator for PBN approach procedures that are not authorization required operations

4.9.1.2 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 — lateral and vertical positioning with SBAS;

d) RNP APCH – LP — lateral positioning with SBAS.

4.9.1.3 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.

4.9.1.4 Operators currently approved to conduct RNAV(GNSS) approaches should qualify for RNP APCH LNAV without further examination.

4.9.2 Aircraft requirements for RNP APCH to LNAV minima

4.9.2.1 On-board performance monitoring and alerting.

4.9.2.1.1 Accuracy: During operations on the initial and intermediate segments and for the RNAV missed approach of an RNP APCH, the lateral TSE must be within ± 1NM for at least 95% of the total flight time. The along-track error must also be within ± 1NM for at least 95% of the total flight time.

4.9.2.1.2 During operations on the FAS of an RNP APCH down to LNAV or LNAV/VNAV minima, the lateral TSE must be within ±0.3 NM for at least 95% of the total flight time. The along-track error must also be within ±0.3NM for at least 95% of the total flight time.

4.9.2.1.3 To satisfy the accuracy requirement, the 95% FTE should not exceed 0.5 NM on the initial and intermediate segments, and for the RNAV missed approach of an RNP APCH. The 95% FTE should not exceed 0.25 NM on the FAS of an RNP APCH.

Note. – The use of a deviation indicator with 1 NM full-scale deflection on the initial and intermediate segments, and for the RNAV missed approach and 0.3 NM full-scale deflection on the FAS, is an acceptable means of compliance. The use of an autopilot or flight director is an acceptable means of compliance (roll stabilization systems do not qualify).

4.9.2.1.4 Integrity: Malfunction of the aircraft navigation equipment is classified as a major failure condition under airworthiness regulations (i.e. 10^{-5} per hour).

4.9.2.1.5 Continuity: Loss of function is classified as a minor failure condition if the operator can revert to a different navigation system and proceed to a suitable airport.

4.9.2.1.6 On-board performance monitoring and alerting: During operations on the initial and intermediate segments and for the RNAV missed approach of an RNP APCH, the RNP system, or the RNP system and pilot in combination, shall provide an alert if the accuracy requirement is not met, or if the probability that the lateral TSE exceeds 2 NM is greater than 10^{-5}. During operations on the FAS of an RNP APCH down to LNAV or LNAV/VNAV minima, the RNP system, or the RNP system and pilot in combination, shall provide an alert if the accuracy requirement is not met, or if the probability that the lateral TSE exceeds 0.6 NM is greater than 10^{-5}.

4.9.2.1.7 SIS: During operations on the initial and intermediate segments and for the RNAV missed approach of an RNP APCH, the aircraft navigation equipment shall provide an alert if the probability of SIS errors causing a lateral position error greater than 2 NM exceeds 10^{-7} per hour. During operations on the FAS of an RNP APCH down to LNAV or LNAV/VNAV minima, the aircraft navigation equipment shall provide an alert of the probability of SIS errors causing a lateral position error greater than 0.6 NM exceeds 10^{-7} per hour.

Notes:

1. *There are no RNP APCH requirements for the missed approach if it is based on conventional means (VOR, DME, NDB) or on dead reckoning.*

2. *Compliance with the on-board performance monitoring and alerting requirement does not imply automatic monitoring of an FTE. The on-board monitoring and alerting function should consist at least of a NSE monitoring and alerting algorithm and a lateral deviation display enabling the crew to monitor the FTE. To the extent operational procedures are used to monitor FTE, the crew procedure, equipment characteristics, and installation are evaluated for their effectiveness and equivalence as described in the functional requirements and operating procedures. PDE is considered negligible due to the navigation database quality assurance process.*

3. *The following systems meet the accuracy, integrity and continuity requirements of these criteria:*

   a) *GNSS stand-alone systems, equipment should be approved in accordance with TSO-C129a/ ETSO-C129a Class A, E/TSO-C146() Class Gamma and operational class 1, 2 or 3, or TSO C-196();*

   b) *GNSS sensors used in multi-sensor system (e.g. FMS) equipment should be approved in accordance with TSO C129 ( )/ ETSO-C129 ( ) Class B1, C1, B3, C3 or E/TSO C145() class 1, 2 or 3, or TSO C-196(). For GNSS receiver* *approved in accordance with E/TSO-C129(), capability for satellite FDE is recommended to improve continuity of function; and*

c) *multi-sensor systems using GNSS should be approved in accordance with AC20-130A or TSO-C115b, as well as having been demonstrated for RNP APCH capability.*

4. *For RNP procedures, the RNP system may only use DME updating when authorized by the State. The manufacturer should identify any operating constraints (e.g. manual inhibit of DME) in order for a given aircraft to comply with this requirement. This is in recognition of States where a DME infrastructure and capable equipped aircraft are available. Those States may establish a basis for aircraft qualification and operational approval to enable use of DME. It is not intended to imply a requirement for implementation of DME infrastructure or the addition of RNP capability using DME for RNP operations. This requirement does not imply an equipment capability must exist providing a direct means of inhibiting DME updating. A procedural means for the pilot to inhibit DME updating or executing a missed approach if reverting to DME updating may meet this requirement.*

4.9.2.2 Criteria for specific navigation systems

4.9.2.2.1 RNP APCH is based on GNSS positioning. Positioning data from other types of navigation sensors may be integrated with the GNSS data provided the other positioning data do not cause position errors exceeding the TSE budget, or if means are provided to deselect the other navigation sensor types.

4.9.2.3 Functional requirements

4.9.2.3.1 Navigation displays and required functions

4.9.2.3.1.1 Navigations data, including a to/from indication, and a failure indication, must be displayed on a lateral deviation display (CDI, EHSI) and/or a navigation map display. These must be used as primary flight instruments for the navigation of the aircraft, for manoeuvre anticipation and for failure/status/integrity indication:

a) the displays must be visible to the pilot and located in the primary field of view (±15 degrees from the pilot’s normal line of sight) when looking forward along the flight path;

b) the lateral deviation display scaling should agree with any alerting and annunciation limits;

c) the lateral deviation display must also have a full-scale deflection suitable for the current phase of flight and must be based on the TSE requirement. Scaling is ±1 NM for the initial and intermediate segments and ±0.3 NM for the final segment;

d) the display scaling may be set automatically by default logic or set to a value obtained from a navigation database. The full-scale deflection value must be known or must be available for display to the pilot commensurate with approach values;

e) as an alternate means, a navigation map display must give equivalent functionality to a lateral deviation display with appropriate map scales (scaling may be set manually by the pilot). To be approved, the navigation map display must be shown to meet the TSE requirements;

f) it is highly recommended that the course selector of the deviation display is automatically slaved to the RNAV computed path;

Note. – This does not apply for installation where an electronic map display contains graphical display of the flight path and path deviation.

g) a flight director and/or autopilot is not required for this type of operation, however, if the lateral TSE cannot be demonstrated without these systems, it becomes mandatory. In this case, coupling to the flight director and/or automatic pilot from the RNP system must be clearly indicated at the cockpit level; and

h) enhanced navigation display (e.g. electronic map display or enhanced EHSI) to improve lateral situational awareness, navigation monitoring and approach verification (flight plan verification) could become mandatory if the RNAV installation doesn't support the display of information necessary for the accomplishment of these crew tasks.

4.9.2.3.1.2 The following system functions are required as a minimum:

a) The capability to continuously display to the pilot flying, on the primary flight instruments for navigation of the aircraft (primary navigation display), the RNAV computed desired path and aircraft position relative to the path. For aircraft where the minimum flight crew is two pilots, the means for the pilot not flying to verify the desired path and the aircraft position relative to the path must also be provided;

b) A navigation database, containing current navigation data officially promulgated for civil aviation, which can be updated in accordance with the AIRAC cycle and from which approach procedures can be retrieved and loaded into the RNP system. The stored resolution of the data must be sufficient to achieve the required track-keeping accuracy. The database must be protected against pilot modification of the stored data;

c) The means to display the validity period of the navigation data to the pilot;

d) The means to retrieve and display data stored in the navigation database relating to individual waypoints and NAVAIDs, to enable the pilot to verify the procedure to be flown;

e) Capacity to load from the database into the RNP system the whole approach to be flown. The approach must be loaded from the data base, into the RNP system, by its name;

f) The means to display the following items, either in the pilot's primary field of view, or on a readily accessible display page:

   1) the identification of the active (To) waypoint;

   2) the distance and bearing to the active (To) waypoint; and

   3) the ground speed or time to the active (To) waypoint;

g) The means to display the following items on a readily accessible display page:

   1) the display of distance between flight plan waypoints;

   2) the display of distance to go;

   3) the display of along-track distances; and

   4) the active navigation sensor type, if there is another sensor in addition to the GNSS sensor;

h) The capability to execute a "Direct to" function;

i) The capability for automatic leg sequencing with the display of sequencing to the pilot;

j) The capability to execute procedures extracted from the on-board database, including the capability to execute fly-over and fly-by turns;

k) The capability to automatically execure leg transition and maintain tracks consistent with the following ARINC 424 path terminators, or their equivalent:

   1) ARINC 424 path terminators

   2) IF

   3) TF

   4) DF

Note. – Path terminators are defined in ARINC 424, and their application is described in more detail in RTCA/EUROCAE documents DO 236B/ED-75B and DO-201A/ED-77.

l) The capability to display an indication of the RNP system failure, including the associated sensors, in the pilot's primary field of view;

m) The capability to indicate to the crew when the NSE alert limit is exceeded (alert provided by the "on-board performance monitoring and alerting function"); and

n) The capability to automatically load numeric values for courses and tracks from the RNP system database.

4.9.3 Aircraft requirements for RNP APCH to LNAV/VNAV minima

4.9.3.1 In addition to the requirements stated in 4.9.2, the following requirements need to be met for the aircraft to be eligible to conduct RNP APCH down to VNAV minima. Eligibility may be established by recognizing the qualities and qualifications of the aircraft and equipment and determining the acceptability for operations. The determination of eligibility for existing systems should consider acceptance of manufacturer documentation of compliance.

4.9.3.2 This approach operation is based upon the use of RNAV equipment that automatically determines aircraft position in the vertical plane using inputs from equipment that can include:

a) FAA-TSO-C106, Air Data Computer;

b) air data system, ARINC 706, Mark 5 Air Data System;

c) barometric altimeter system, DO-88 Altimetry, ED-26 MPS for Airborne Altitude Measurements and Coding Systems, ARP-942 Pressure Altimeter Systems, ARP-920 Design and Installation of Pitot Static Systems for Transport Aircraft; and

d) type certified integrated systems providing an air data system capability comparable to item b)

Note. – Further information on these requirements are detailed in the PBN manual ICAO Doc 9613 in Attachment A to Volume II.

4.9.4 Aircraft requirements for RNP APCH to LP and LPV minima

4.9.4.1 On-board performance monitoring and alerting

4.9.4.1.1 Accuracy: Along the FAS and the straight continuation of the final approach in the missed approach, the lateral and vertical TSE is dependent on the NSE, PDE and FTE:

a) NSE: the accuracy itself (the error bound with 95% probability) changes due to different satellite geometries. Assessment based on measurements within a sliding time window is not suitable for GNSS. Therefore, GNSS accuracy is specified as a probability for each and every sample. NSE requirements are fulfilled without any demonstration of the equipment computes three dimensional positions using linearized, weighted least square solution in accordance with RTCA DO 229C (or subsequent version) appendix J.

b) FTE: FTE performance is considered acceptable if the lateral and vertical display full-scale deflection is compliant with the non-numeric lateral cross-track and vertical deviation requirements of RTCA DO 229 C (or subsequent version) and if the crew maintains the aircraft within one-third the full scale deflection for the lateral deviation and within one-half the full scale deflection for the vertical deviation.

c) PDE: PDE is considered negligible based upon the process of path specification to data specification and associated quality assurance that is included in the FAS data-block generation process which is a standardized process. The responsibilities for FAS Data Block generation lies with the ANSP.

Note.— FTE performance is considered acceptable if the approach mode of the FGS is used during such approach.

4.9.4.1.2 Integrity: Simultaneously presenting misleading lateral and vertical guidance with misleading distance data during an RNP APCH operation down to LPV minima is considered a hazardous failure condition (extremely remote). Simultaneously presenting misleading lateral guidance with misleading distance data during an RNP APCH operation down to LP minima is considered a hazardous failure condition (extremely remote).

4.9.4.1.3 Continuity: Loss of approach capability is considered a minor failure condition if the operator can revert to a different navigation system and proceed to a suitable airport. For RNP APCH operations down to LP or LPV minima at least one system is required.

4.9.4.1.4 On-board performance monitoring and alerting: Operations on the FAS of an RNP APCH operation down to LP and LPV minima, the on-board performance monitoring and alerting function is fulfilled by:

a) NSE monitoring and alerting (see the SIS section below);

b) FTE monitoring and alerting: LPV approach guidance must be displayed on a lateral and vertical deviation display (HIS, EHSI, CDI/VDI) including a failure indicator. The deviation display must have a suitable full-scale deflection based on the required track-keeping accuracy. The lateral and vertical full scale deflection are angular and associated to the lateral and vertical definitions of the FAS contained in the FAS Data Block; and

c) Navigation database: once the FAS Data Block has been decoded, the equipment shall apply the CRC to the Data Block to determine whether the data is valid. If the FAS Data Block does not pass the CRC test, the equipment shall not allow activation of the LP or the LPV approach operation.

4.9.4.1.5 SIS

4.9.4.1.5.1 At a position between 2 NM from the FAP and the FAP, the aircraft navigation equipment shall provide an alert within 10 seconds if the SIS errors causing a lateral position error are greater than 0.6 NM, with a probability of $1\text{-}10^{-7}$ per hour.

4.9.4.1.5.2 After sequencing the FAP and during operations on the FAS of an RNP APCH operation down to LP or LPV minima:

a) the aircraft navigation equipment shall provide an alert within 6 seconds if the SIS errors causing a lateral position error are greater than 40 m, with a probability of $1\text{-}2.10^{-7}$ in any approach; and

b) the aircraft navigation equipment shall provide an alert within 6 seconds if the SIS errors causing a vertical position error is greater than 50 m (or 35 m for LPV minima down to 200 ft), with a probability of $1\text{-}2.10^{-7}$ in any approach.

Notes:

1. *There are no RNP APCH requirements for the missed approach if it is based on conventional means (VOR, DME, NDB) or on dead reckoning. The requirements for the straight continuation of the final approach, in the missed approach, are in accordance with RTCA DO 229C (or subsequent version).*

2. *Compliance with the performance monitoring and alerting requirement does not imply an automatic monitor of FTE. The on-board monitoring and alerting function should consist at least of a NSE monitoring and alerting algorithm and a lateral and vertical deviation display enabling the crew to monitor the FTE. To the extent operational procedures are used to monitor FTE, the crew procedure, equipment characteristics, and installation are evaluated for their effectiveness and equivalence as described in the functional requirements and operating procedures. PDE is considered negligible due to the navigation database quality assurance process and the operating procedures.*

3. *The following systems meet the accuracy, integrity and continuity requirements of these criteria:*

   a) *GNSS SBAS stand-alone equipment approved in accordance with E/TSO C146a (or subsequent version). Application of this standard guarantees that the equipment is at least compliant with RTCA DO 229C. The equipment should be a class gamma, operational class 3;*

   b) *for an integrated navigation system (e.g. FMS) incorporating a GNSS SBAS sensor, E/TSO C115b and AC 20-130A provide an acceptable means of compliance for the approval of this navigation system when augmented by the following guidelines:*

      i) *the performance requirements of E/TSO-C146a (or subsequent version) that apply to the functional class gamma, operational class 3 or delta 4 is demonstrated; and*

      ii) *The GNSS SBAS sensor is approved in accordance with E/TSO C145a class beta, operational class 3;*

c) *approach system incorporating a class delta GNSS SBAS equipment approved in accordance with E/TSO C146a (or subsequent version). This standard guarantees that the equipment is at least compliant with RTCA DO 229C. The equipment should be a class delta 4; and*

d) *future augmented GNSS systems are also expected to meet these requirements.*

4.9.4.2 Criteria for specific navigation systems

RNP APCH operations down to LP or LPV minima are based on augmented GNSS positioning. Positioning data from other types of navigation sensors may be integrated with the GNSS data provided it does not cause position errors exceeding the TSE budget, or if means are provided to deselect the other navigation sensor types.

4.9.4.3 Functional requirements

4.9.4.3.1 Navigation displays and required functions

4.9.4.3.1.1 Approach guidance must be displayed on a lateral and vertical deviation display (HIS, EHSI, CDI/VDI) including a failure indicator and must meet the following requirements:

a) this display must be used as primary flight instruments for the approach;

b) the display must be visible to the pilot and located in the primary field of view (± 15° from the pilot's normal line of sight) when looking forward along the flight path; and

c) the deviation display must have full-scale deflection based on the required track-keeping accuracy.

The lateral and vertical full-scale deflection are angular and associated to the lateral and vertical definitions of the FAS contained in the FAS Data Block.

4.9.4.3.1.2 The following system functions are required as a minimum:

a) The capability to display the GNSS approach mode (e.g. LP, LPV, LNAV/VNAV, lateral navigation) in the primary field of view. This annunciation indicates to the crew the active approach mode in order to correlate it to the corresponding line of minima on the approach chart. It can also detect a level of service degradation (e.g. downgrade from LPV to lateral navigation). The airborne system should automatically provide the highest "level of service" available for the annunciation of the GNSS approach mode when the approach is selected;

b) The capability to continuously display the distance to the LTP/FTP;

c) The navigation database must contain all the necessary data/information to fly the published approach procedure (FAS). Although data may be stored or transmitted in different ways, the data has to be organized in Data Blocks for the purpose of computing the CRC. This format provides integrity protection for the data it contains. Consequently, each FAS is defined by a specific “FAS Data Block” containing the necessary lateral and vertical parameters depicting the approach to be flown. Once the FAS Data Block has been decoded, the equipment shall apply the CRC to the Data Block to determine whether the data is valid. If the FAS Data Block does not pass the CRC test, the equipment shall not allow activation of the approach operation;

d) The capacity to select from the database into the installed system the whole approach procedure to be flown (SBAS channel number and/or approach name);

e) The indication of the loss of navigation (e.g. system failure) in the pilot’s primary field of view by means of a navigation warning flag or equivalent indicator on the vertical and/or lateral navigation display);

f) The indication of the LOI function in the pilot’s normal field of view (e.g. by means of an appropriately located annunciator); and

g) The capability to immediately provide track deviation indications relative to the extended FAS, in order to facilitate the interception of the extended FAS from a radar vector (e.g. VTF function).

Note. – There requirements are limited to the FAS, the straight continuation of the final approach in the missed approach, and the interception of the extended FAS. If the installed system is also able to fly the initial, intermediate and missed approach segments of the approach, the corresponding requirement applies.

4.9.5 Operating procedures

Most manufacturers have developed recommended procedures for RNAV(GPS)/RNAV(GNSS) procedures. Although the manufacturer’s 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 minimize any human factors elements associated with the introduction of PBN operations.

4.9.5.1 Pre-flight planning

4.9.5.1.1 Operators and pilots intending to conduct operations using an RNP APCH procedure must file the appropriate flight plan suffixes and the on-board navigation data must be current and include appropriate procedures.

Note.— Navigation databases are expected to be current for the duration of the flight. If the AIRAC cycle is due to change during flight, operators and pilots should establish procedures to ensure the accuracy of navigation data, including the suitability of navigation facilities used to define the routes and procedures for the flight.

4.9.5.1.2 In addition to the normal pre-flight planning checks, the following must be included:

a) the pilot must ensure that approaches which may be used for the intended flight (including alternate aerodromes) are selected from a valid navigation database (current AIRAC cycle), have been verified by the appropriate process (navigation database integrity process) and are not prohibited by a company instruction or NOTAM;

b) subject to a State's regulations, during the pre-flight phase, the pilot should ensure sufficient means are available to navigate and land at the destination or at an alternate aerodrome in the case of loss of RNP APCH airborne capability;

c) operators and pilots must take account of any NOTAMs or operator briefing material that could adversely affect the aircraft system operation, or the availability or suitability of the procedures at the airport of landing, or any alternate airport; and

d) for missed approach procedures based on conventional means (VOR, NDB), operators and pilots must ensure that the appropriate airborne equipment required for this procedure is installed in the aircraft and is operational and that the associated ground-based NAVAIDs are operational.

4.9.5.1.3 The availability of the NAVAID infrastructure, required for the intended routes, including any non-RNAV contingencies, must be confirmed for the period of intended operations using all available information. Since GNSS integrity (RAIM or SBAS signal) is required by Annex 10, Volume I, the availability of these should also be determined as appropriate. For aircraft navigating with SBAS receivers (all TSO-C145()/C146()), operators should check appropriate GPS RAIM availability in areas where the SBAS signal is unavailable.

4.9.5.2 GNSS availability

4.9.5.2.1 ABAS availability

4.9.5.2.1.1 RAIM levels required for RNP APCH down to LNAV or LNAV/VNAV minima can be verified either through NOTAMs (where available) or through prediction services. The operating authority may provide specific guidance on how to comply with this requirement (e.g. if sufficient satellites are available, a prediction may not be necessary). Operators should be familiar with the prediction information available for the intended route.

4.9.5.2.1.2 RAIM availability prediction should take into account the latest GPS constellation NOTAMs and avionics model (when available). The service may be provided by the ANSP, avionics manufacturer, and other entities, or through an airborne receiver RAIM prediction capability.

4.9.5.2.1.3 In the event of a predicted, continuous loss of appropriate level of fault detection of more than five minutes for any part of the RNP APCH operation, the flight planning should be revised (e.g., delaying the departure or planning a different departure procedure).

4.9.5.2.1.4 RAIM availability prediction software does not guarantee the service, rather they are tools to assess the expected capability of meeting the RNP. Because of unplanned failure of some GNSS elements, pilots/ANSPs should realize that RAIM or GPS navigation altogether may be lost while airborne which may require reversion to an alternative means of navigation. Therefore, pilots should assess their capability to navigate (potentially to an alternate destination) in case of failure of GPS navigation.

4.9.5.2.2 SBAS and other augmented GNSS availability

4.9.5.2.2.1 Section B of this chapter contains criteria to assess GNSS SBAS vertical guidance availability.

4.9.5.2.2.2 If the aircraft uses other GNSS augmentations, or enhancements to a basic GNSS capability (i.e., use of multiple constellations, dual frequency), the RNP APCH operation must be supported by a prediction capability based on the specific characteristics of these other augmentations.

4.9.5.3 Prior to commencing the procedure

4.9.5.3.1 In addition to the normal procedure prior to commencing the approach (before the IAF and in compatibility with crew workload), the pilot must verify the correct procedure was loaded by comparison with the approach charts. This check must include:

a) the waypoint sequence; and

b) reasonableness of the tracks and distances of the approach legs, and the accuracy of the inbound course and length of the FAS.

Note.— As a minimum, this check could be a simple inspection of a suitable map display that achieves the objectives of this paragraph.

4.9.5.3.2 The pilot must also check using the published charts, the map display or CDU, which waypoints are fly-by, and which are fly-over.

4.9.5.3.3 For multi-sensor systems, the pilot must verify, during the approach, that the GNSS sensor is used for position computation.

4.9.5.3.4 For an RNP system with ABAS requiring barometric corrected altitude, the current airport barometric altimeter setting should be input at the appropriate time and location, consistent with the performance of the flight operation.

4.9.5.3.5 When the operation is predicated on the availability of ABAS, the pilot should perform a new RAIM availability check if ETA is more than 15 minutes different from the ETA used during the pre-flight planning. This check is also processed automatically 2 NM before the FAF for an E/TSO-C129a Class A1 receiver.

4.9.5.3.6 ATC tactical interventions in the terminal area may include radar headings, “direct to” clearances which bypass the initial legs of an approach, interception of an initial or intermediate segment of an approach, or the insertion of waypoints loaded from the database. In complying with ATC instructions, the pilot should be aware of the implications for the RNP system:

a) the manual entry of coordinates into the RNP system by the pilot for operation within the terminal area is not permitted; and

b) “direct to” clearances may be accepted to the IF provided that the resulting track change at the IF does not exceed 45 degrees.

Note.— “Direct to” clearance to FAF is not acceptable.

4.9.5.3.7 The lateral definition of the flight path between the FAF and the MAPt must not be revised by the pilot under any circumstances.

4.9.5.4 During the procedure

4.9.5.4.1 The aircraft must be established on the final approach course no later than the FAF before starting the descent (to ensure terrain and obstacle clearance).

4.9.5.4.2 The crew must check the approach mode annunciator (or equivalent) is properly indicating approach mode integrity within 2 NM before the FAF.

Note.— This will not apply for certain RNP systems (e.g. aircraft already approved with demonstrated RNP capability). For such systems, other means are available including electronic map displays, flight guidance mode indications, etc., which clearly indicate to the crew that the approach mode is activated.

4.9.5.4.3 The appropriate displays must be selected so that the following information can be monitored:

a) the RNAV-computed desired path (DTK); and

b) the aircraft position relative to the path (cross-track deviation) for FTE monitoring.

4.9.5.4.4 The procedure must be discontinued:

a) if the navigation display is flagged invalid; or

b) in case of LOI alerting function; or

c) if integrity alerting function is annunciated not available before passing the FAF; or

Note.— Discontinuing the procedure may not be necessary for a multi-sensor RNP system that includes demonstrated RNP capability without GNSS. Manufacturer documentation should be examined to determine the extent the system may be used in such configuration.

d) if FTE is excessive.

4.9.5.4.5 The missed approach must be flown in accordance with the published procedure. Use of the RNP system during the missed approach is acceptable, provided:

a) the RNP system is operational (e.g. no loss of function, no NSE alert, no failure indication); and

b) the whole procedure (including the missed approach) is loaded from the navigation database.

4.9.5.4.6 During the RNP APCH procedure, pilots must use a lateral deviation indicator, flight director and/or autopilot in lateral navigation mode. Pilots of aircraft with a lateral deviation indicator (e.g. CDI) must ensure that lateral deviation indicator scaling (full-scale deflection) is suitable for the navigation accuracy associated with the various segments of the procedure (i.e. ±1.0 NM for the initial and intermediate segments, ±0.3 NM for the FAS down to LNAV or LNAV/VNAV minima, and ±1.0 NM for the missed approach segment). All pilots are expected to maintain procedure centre lines, as depicted by on-board lateral deviation indicators and/or flight guidance during the whole approach procedure, unless authorized to deviate by ATC or under emergency conditions. For normal operations, cross-track error/deviation (the difference between the RNP system computed path and the aircraft position relative to the path) should be limited to ±½ the navigation accuracy associated with the procedure (i.e. 0.5 NM for the initial and intermediate segments, 0.15 NM for the FAS, and 0.5 NM for the missed approach segment). Brief deviations from this standard (e.g. overshoots or undershoots) during and immediately after turns, up to a maximum of one-times the navigation accuracy (i.e. 1.0 NM for the initial and intermediate segments), are allowable.

Note.— Some aircraft do not display or compute a path during turns but are still expected to satisfy the above standard during intercepts following turns and on straight segments.

4.9.5.4.7 When Barometric VNAV is used for vertical path guidance during the FAS, deviations above and below the Barometric VNAV path must not exceed +22 m/–22 m (+75 ft/–75 ft), respectively.

4.9.5.4.8 Pilots must execute a missed approach if the lateral deviations or vertical deviations, if provided, exceed the criteria above, unless the pilot has in sight the visual references required to continue the approach.

4.9.5.5 General operating procedures

4.9.5.5.1 Operators and pilots must not request an RNP APCH procedure unless they satisfy all the criteria in the relevant State documents. If an aircraft not meeting these criteria receives a clearance from ATC to conduct an RNP APCH procedure, the pilot must advise ATC that he/she is unable to accept the clearance and must request alternate instructions.

4.9.5.5.2 The pilot must comply with any instructions or procedures identified by the manufacturer as necessary to comply with the performance requirements in this navigation specification.

4.9.5.5.3 If the missed approach procedure is based on conventional means (e.g. NDB, VOR, DME), related navigation equipment must be installed and be serviceable.

4.9.5.5.4 Pilots are encouraged to use flight director and/or autopilot in lateral navigation mode, if available.

4.9.5.6 Contingency procedures

4.9.5.6.1 The pilot must notify ATC of any loss of the RNP APCH capability, together with the proposed course of action. If unable to comply with the requirements of an RNP APCH procedure, pilots must advise ATS as soon as possible. The loss of RNP APCH capability includes any failure or event causing the aircraft to no longer satisfy the RNP APCH requirements of the procedure. The operator should develop contingency procedures in order to react safely following the loss of the RNP APCH capability during the approach.

4.9.5.6.2 In the event of communications failure, the pilot must continue with the RNP APCH in accordance with the published lost communications procedure.

4.9.6 Flight crew knowledge and training

Successful RNP APCH 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 provided as a guide.

4.9.6.1 Ground training

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

4.9.6.2 Simulator training

Simulator 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 simulator session of 2 to 4 hours 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-around, 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.

4.9.7 Navigation database

4.9.7.1 RNP APCH operations are critically dependent on valid data.

4.9.7.2 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.

4.9.7.3 It should be noted that despite the requirement for the database supplier to comply with RTCA DO- 200A/EUROCAE ED-76, data errors will still occur.

4.9.8 Job Aid – **RNP APCH** Specific Elements

Part 2. Contents of the Operator application

#	Topic	Specific ICAO reference	CAAM guidance/ reference	Operator compliance description	Inspector disposition/ comments	Follow-up by inspector (optional)
		(ICAO Doc 9613, Volume II, Part C, Chapter 5 Sections A&B)	*(CAD/CAGM, etc.)*	*(Document reference/ method*	*(Accepted/not accepted)*	*(Status and date)*
1	**Authorization request** Statement of intent to obtain authorization.					
2	**Aircraft/navigation system eligibility** Documents that establish eligibility.	5.3.2.2 5.3.2.3.1				
3	**Training** Details of courses completed (part 91 operators). Details of training programmes (part 121 and part 135 operators).	5.3.2.3.2 5.3.5				
4	**Operating policies and procedures** Extracts from the operations manual or other documentation (Part 91 operators). Operations manual and checklists (part 121 and part 135 operators.	5.3.2.3.3				
5	**Maintenance practices** Document navigation database maintenance practices.	5.3.2.3.5 5.3.6(Section A) 5.3.6(Section B)				
6	**MEL update**	5.3.2.3.4				

Part 3. Operating procedures

#	Topic	*Specific ICAO reference*	*CAAM guidance/ reference*	*Operator compliance description*	*Inspector disposition/ comments*	*Follow-up by inspector (optional)*
		(ICAO Doc 9613, Volume II, Part C, Chapter 5 Sections A&B)	*(CAD/CAGM, etc.)*	*(Document reference/ method*	*(Accepted/not accepted)*	*(Status and date)*
1	**Flight planning**					
1a	Verify that the aircraft and crew are approved for RNP APCH operations to LNAV, and/or LNAV/VNAV and/or LP and/or LPV minima.	5.3.4 (LNAV/VNAV) 5.3.4.1 (LP and/or LPV)				
1b	Verify RAIM and/or SBAS availability.	5.3.4.1.3 (Section A) 5.3.4.2. (Section A) 5.3.4.3 (Section B)				
1c	Verify that the navigation database is current.	5.3.4.1.1 (Section A) 5.3.4.1.2 a) (Section A) 5.3.4.2.1 (Section B) 5.3.4.2.2 (Section B)				
1d	Verify the FPL: “R” and “B” (LPV only) should appear in field 10 and PBN/S1 or PBN/S2 (LNAV/VNAV only) in field 18.	5.3.4.1.1 (Section A) 5.3.4.2.1 (Section B)				
2	**Prior to commencing procedure**					
2a	Verify that the correct procedure is loaded	5.3.4.3.1 (Section A) 5.3.4.4.1 (Section B)				

2b	Cross-check the chart with the RNAV system display.	5.3.4.3.1 (Section A) 5.3.4.4.1 (Section B)				
2c	Verify the GNSS sensor in use (only multi-sensor systems).	5.3.4.3.3 (Section A)				
2d	Input the barometric altimeter setting (only LNAV/VNAV required barometric input).	5.3.4.3.4 (Section A)				
2e	Perform a RAIM availability check if ETA is more than 15 minutes different from the FPL ETA (only for ABAS)	5.3.4.3.5 (Section A)				
2f	Do not modify the flight plan in the RNAV system after ATC heading assignment until a clearance is received to re-join the route or a new clearance is confirmed. Manual entry of coordinates within the terminal area is not permitted. “Direct to” clearances accepted up to IF, provided that the resulting track change at the IF does not exceed 45°.	5.3.4.3.6 (Section A) 5.3.4.4.2 (Section B)				
2g	Do not modify the final approach segment.	5.3.4.3.7 (Section A)				
2h	Use VTF to respect ATC clearances when appropriate	5.3.4.4.3 (Section B)				
3	**During procedure**					
3a	Establish the aircraft on the final approach course before starting descent.	5.3.4.4.1 (Section A) 5.3.4.5.4 (Section B)				
3b	Verify that the approach mode is activated 2NM prior to FAF/FAP.	5.3.4.4.2 (Section A) 5.3.4.5.3 (Section B)				

3c	Use an appropriate display.	5.3.4.4.3 (Section A) 5.3.4.5.5 (Section B)				
3d	Discontinue the approach if: • the navigation display is flagged invalid; • loss of integrity alert; • loss of integrity alerting function prior to the FAF; • FTE is excessive.	5.3.4.4.4 (Section A) 5.3.4.5.7 5.3.4.5.8 (Section B)				
3e	Do not use the RNP system in missed approach if the: • RNP system is not operational; or • Missed approach is not loaded from the database.	5.3.4.4.5 (Section A)				
3f	Follow the route centre line within 0.5/0.15/0.5 NM.	5.3.4.4.6 (Section A)				
3g	If baro-VNAV is used, follow vertical path ±22m (±75ft)	5.3.4.4.6 (Section A)				
3h	Execute a missed approach if the lateral or vertical deviations exceed the limits in 3f and 3g above (LNAV and LNAV/VNAV0 or if excessive deviations are encountered and cannot be corrected in time (LP and LPV)	5.3.4.4.8 (Section A) 5.3.4.5.9 (Section B)				
4	**General operating procedures**					
4a	Advise ATC if unable to meet the requirements for an RNP APCH.	5.3.4.5.1 (Section A) 5.3.4.6.1 (Section B)				
4b	Comply with the manufacturer's instructions/procedures.	5.3.4.5.2 (Section A)				

4c	If the missed approach is based on conventional means, appropriate navigation equipment must be installed and serviceable.	5.3.4.5.3 (Section A) 5.3.4.6.3 (Section B)				
4d	Use FD or AP if available	5.3.4.5.4 (Section A) 5.3.4.6.4 (Section B)				

Part 4. Contingency procedures

#	Topic	*Specific ICAO reference*	*CAAM guidance/ reference*	*Operator compliance description*	*Inspector disposition/ comments*	*Follow-up by inspector (optional)*
		*(ICAO Doc 9613, Volume II, Part C, Chapter 5) **	*(CAD/CAGM, etc.)*	*(Document reference/ method*	*(Accepted/not accepted)*	*(Status and date)*
1	**Contingencies**					
1a	Advise ATC if unable to comply with the requirements for an RNP APCH	5.3.4.6.1 (Section A) 5.3.4.7.2 (Section B)				
1b	Air-ground communications failure.	5.3.4.6.2 (Section A) 5.3.4.7.3 (Section B) (Doc 4444 Chapter 15, 15.3)				

** All references are to the PBN manual (ICAO Doc 9613), Volume II, Part C, Chapter 5, unless otherwise indicated.*

4.10 RNP 0.3

4.10.1 General

RNP 0.3 is primarily intended to support helicopter operations – en-route, arrivals, departures and approaches. However, it does not exclude fixed wing operations where the demonstrated performance is sufficient to meet the functional and accuracy requirements for all phases of flight.

4.10.2 System requirements

4.10.2.1 The following systems meet the accuracy, integrity and continuity requirements of these criteria;

a) Aircraft with E/TSO-C145a and the requirements of E/TSO-C115B FMS, installed for IFR use in accordance with FAA AC 20-130A;

b) Aircraft with E/TSO-C146a equipment installed for IFR use in accordance with FAA AC 20-138 or AC 20-138A; and

c) Aircraft with RNP 0.3 capability certified or approved to equivalent standards (e.g. TSO-C193).

4.10.2.2 General

4.10.2.2.1 On-board performance monitoring and alerting is required. This section provides the criteria for a TSE form of performance monitoring and alerting that will ensure a consistent evaluation and assessment of compliance for RNP 0.3 applications.

4.10.2.2.2 The aircraft navigation system, or aircraft navigation system and the pilot in combination, is required to monitor the TSE, and to provide an alert if the accuracy requirement is not met or if the probability that the lateral TSE exceeds two times the accuracy value is larger than 10–5. To the extent operational procedures are used to satisfy this requirement, the crew procedure, equipment characteristics, and installation should be evaluated for their effectiveness and equivalence. Examples of information provided to the pilot for awareness of navigation system performance include “EPU”, “ACTUAL”, “ANP” and “EPE”. Examples of indications and alerts provided when the operational requirement is or can be determined as not being met include “UNABLE RNP”, “Nav Accur Downgrade”, GNSS alert limit, loss of GNSS integrity, TSE monitoring (real time monitoring of NSE and FTE combined), etc. The navigation system is not required to provide both performance and sensor-based alerts, e.g. if a TSE based alert is provided, a GNSS alert may not be necessary.

4.10.2.3 On-board performance monitoring and alerting

4.10.2.3.1 *Accuracy:* During operations in airspace or on ATS routes designated as RNP 0.3, the lateral TSE must be within ±0.3 NM for at least 95% of the total flight time. The along-track error must also be within ±0.3 NM for at least 95% of the total flight time. To meet this performance requirement, an FTE of 0.25 NM (95%) may be assumed.

Note.— For all RNP 0.3 operations, the use of a coupled FGS is an acceptable means of complying with this FTE assumption (see RTCA DO-208, Appendix D, Table 1). Any alternative means of FTE bounding, other than coupled FGS, may require FTE substantiation through an airworthiness demonstration.

4.10.2.3.2 *Integrity:* Malfunction of the aircraft navigation equipment is classified as a Major failure condition under airworthiness regulations (i.e. 1×10^{-5} per hour).

4.10.2.3.3 *Continuity:* For the purpose of this specification, loss of function is a major failure condition for remote continental and offshore operations. The carriage of dual independent long-range navigation systems may satisfy the continuity requirement. Loss of function is classified as a minor failure condition for other RNP 0.3 operations if the operator can revert to a different available navigation system and proceed to a suitable airport.

4.10.2.3.4 SIS: The aircraft navigation equipment shall provide an alert if the probability of SIS errors causing a lateral position error greater than 0.6 NM exceeds 1×10^{-7} per hour.

4.10.2.4 Bounding FTE for equipment not monitoring TSE performance.

4.10.2.4.1 RNP 0.3 operations require coupled FGS to meet the allowable FTE bound unless the manufacturer demonstrates and obtains airworthiness approval for an alternate means of meeting the FTE bound. The following may be considered as one operational means to monitor the FGS FTE.

a) FTE should remain within half-scale deflection (unless there is other substantiated FTE data);

b) Pilots must manually set systems without automatic CDI scaling to not greater than 0.3 NM full-scale prior to commencing RNP 0.3 operations; and

c) Aircraft with electronic map display, or another alternate means of flight path deviation display, must select appropriate scaling for monitoring FTE.

4.10.2.4.2 Automatic monitoring of FTE is not required if the necessary monitoring can be achieved by the pilot using available displays without excessive workload in all phases of flight. To the extent that compliance with this specification is achieved through operational procedures to monitor FTE, an evaluation of the pilot procedures, equipment characteristics, and installation must ensure their effectiveness and equivalence, as described in the functional requirements and operating procedures.

4.10.2.4.3 PDE is considered negligible if the quality assurance process is applied at the navigation database level and if operating procedures are applied.

4.10.2.5 Functional requirements

The following navigation displays and functions (installed per AC 20-130A and AC 20-138A or equivalent airworthiness installation advisory material) are required.

Paragraph	*Functional requirement*	*Explanation*
a)	Navigation data, including a failure indicator, must be displayed on a lateral deviation display (CDI, EHSI) and/or a navigation map display. These must be used as primary flight instruments for the navigation of the aircraft, for manoeuvre anticipation and for failure/status/integrity indication.	Non-numeric lateral deviation display (e.g. CDI, EHSI), with a to/from indication and a failure annunciation, for use as primary flight instruments for navigation of the aircraft, for manoeuvre anticipation, and for failure/status/integrity indication, with the following six attributes: 1) The capability to continuously display to the pilot flying, on the primary flight instruments for navigation of the aircraft (primary navigation display), the computed path and aircraft position relative to the path. For operations where the required minimum flight crew is two pilots, the means for the pilot not flying to verify the desired path and the aircraft position relative to the path must also be provided. 2) Each display must be visible to the pilot and located in the primary field of view (±15° from the pilot's normal line of sight) when looking forward along the flight path. 3) The lateral deviation display scaling should agree with any implemented alerting and annunciation limits. 4) The lateral deviation display must also have a full-scale deflection suitable for the current phase of flight and must be based on the required track-keeping accuracy. 5) The display scaling may be set automatically by default logic: automatically to a value obtained from a navigation database, or manually by pilot procedures. The full-scale deflection value must be known or must be available for display to the pilot commensurate with the required track-keeping accuracy. 6) The lateral deviation display must be automatically slaved to the computed path. The course selector of the deviation display should be automatically slewed to the computed path.

		As an alternative means of compliance, a navigation map display can provide equivalent functionality to a lateral deviation display as described in 1 to 6 above, with appropriate map scales and giving equivalent functionality to a lateral deviation display. The map scale should be set manually to a value appropriate for the RNP 0.3 operation.
b)	The following system functions are required as minimum within any RNP 0.3 equipment.	1) The capability to continuously display to the pilot flying, on the primary flight instruments for navigation of the aircraft (primary navigation display), the computed path and aircraft position relative to the path. For operations where the required minimum flight crew is two pilots, the means for the pilot not flying to verify the desired path and the aircraft position relative to the path must also be provided. 2) A navigation database, containing current navigation data officially promulgated for civil aviation, which can be updated in accordance with the AIRAC cycle and from which IFR procedures and ATS routes or waypoint data corresponding to the coordinates of significant points on ATS routes, can be retrieved and loaded into the RNP system. The stored resolution of the data must be sufficient to achieve negligible PDE. The database must be protected against pilot modification of the stored data. 3) The means to display the validity period of the navigation data to the pilot. 4) The means to retrieve and display data stored in the navigation database relating to individual waypoints and NAVAIDs, to enable the pilot to verify the ATS route to be flown. 5) Capacity to load from the database into the RNP system the entire IFP and the ATS route to be flown.
c)	The means to display the following items, either in the pilot's primary field of view, or on a readily accessible display page.	1) The active navigation sensor type. 2) The identification of the active (To) waypoint. 3) The ground speed or time to the active (To) waypoint. 4) The distance and bearing to the active (To) waypoint.
d)	The capability to execute a "Direct to" function.	

e)	The capability for automatic leg sequencing with the display of sequencing to the pilot.	
f)	The capability to execute RNP 0.3 terminal procedures extracted from the on-board navigation database, including the capability to execute fly-over and fly-by turns.	
g)	The capability to automatically execute leg transitions and maintain tracks consistent with the following ARINC 424 path terminators, or their equivalent. — IF — CF — CA — DF — TF	
h)	The capability to automatically execute leg transitions consistent with VA, VM, and VI ARINC 424 path terminators, or must be able to be manually flown on a heading to intercept a course or to go direct to another fix after reaching a procedure-specified altitude.	
i)	The capability to automatically execute leg transitions consistent with CA and FM ARINC 424 path terminators, or the RNAV system must permit the pilot to readily designate a waypoint and select a desired course to or from a designated waypoint.	
j)	The capability to load an ATS route from the database, by name.	
k)	The capability to display an indication of the RNP 0.3 system failure, in the pilot's primary field of view.	
l)	The system shall be capable of loading numeric values for courses and tracks from the	

	on-board navigation database.	

4.10.3 Operating procedures

4.10.3.1 Airworthiness certification and recognition of RNP 0.3 aircraft qualification alone does not authorize RNP 0.3 operations. Operational approval is also required to confirm the adequacy of the operator's normal and contingency procedures for the particular equipment installation applied to an RNP 0.3 operation.

4.10.3.2 Pre-flight planning
Operators and pilots intending to conduct operations on RNP 0.3 ATS routes, including SIDs and STARs, initial and intermediate approach, should file the appropriate flight plan suffixes. The on-board navigation data must be current and include appropriate procedures.

Note.— Navigation databases are expected to be current for the duration of the flight. If the AIRAC cycle is due to change during flight, operators and pilots should establish procedures to ensure the accuracy of navigation data, including suitability of navigation facilities used to define the ATS routes.

4.10.3.3 RNP 0.3 availability prediction

4.10.3.3.1 RAIM prediction is not required where the equipment uses SBAS augmentation and the planned operations are within the service volume of the SBAS system. In areas and regions where SBAS is not usable or available, RAIM availability for the intended route should be checked prior to flight. Operators can verify the availability of RAIM to support RNP 0.3 operations via NOTAMs (where available) or through GNSS prediction services. The operating authority may provide specific guidance on how to comply with this requirement. Operators should be familiar with the prediction information available for the intended ATS route. RAIM availability prediction should take into account the latest GNSS constellation NOTAMs and avionics model (when available). The ANSP, avionics manufacturer, or the RNP system may provide this service. In the event of a predicted, continuous loss of RNP 0.3 of more than 5 minutes for any part of the RNP 0.3 operation, the flight planning should be revised (e.g. delaying the departure or planning a different ATS route). If the prediction service is temporarily unavailable, ANSPs may still allow RNP 0.3 operations to be conducted.

4.10.3.3.2 RAIM availability prediction software does not guarantee the availability of GNSS. Rather, prediction tools simply assess the expected capability to meet the RNP. Because of potential unplanned failures of some GNSS elements, pilots/ANSPs must consider the loss of RAIM (or GNSS navigation altogether) while airborne may require reversion to an alternative means of navigation. Therefore, pilots should assess their capability to navigate in case of failure of GNSS navigation and consider the actions necessary to successfully divert to an alternate destination.

4.10.3.4 General operating procedures

4.10.3.4.1 The pilot must comply with any instructions or procedures the manufacturer identifies necessary to comply with the performance requirements in this chapter.

Note.— Pilots are expected to adhere to all AFM/RFM limitations or operating procedures required to maintain RNP 0.3 performance for the ATS route. This shall include any speed restrictions needed to ensure maintenance of RNP 0.3 navigation accuracy.

4.10.3.4.2 Operators and pilots should not request or file RNP 0.3 procedures unless they satisfy all the criteria in the relevant CADs and documents. If an aircraft not meeting these criteria receives a clearance from ATC to conduct an RNP 0.3 operation, the pilot must advise ATC that he/she is unable to accept the clearance and must request alternate instructions.

4.10.3.4.3 The operator must confirm the availability of GNSS for the period of intended operations along the intended ATS route using all available information and the availability of NAVAID infrastructure required for any (non-RNAV) contingencies.

4.10.3.4.4 At system initialization, the pilot must confirm the navigation database is current and verify that initial position of the aircraft is entered correctly. The pilot must also verify proper entry of their desired ATS route and any ATC changes to that ATS route upon initial clearance and any subsequent change of ATS route. The pilot must ensure the waypoints sequence depicted by their navigation system matches the ATS route depicted on the appropriate chart(s) and their assigned ATS route.

Note.— The pilot may notice a slight difference between the navigation information portrayed on the chart and their primary navigation display. Differences of 3° or less may result from the equipment manufacturer's application of magnetic variation and are operationally acceptable.

4.10.3.4.5 The pilot must not attempt to fly an RNP 0.3 Instrument Flight Procedure unless it is retrievable by name from the on-board navigation database and conforms to the charted procedure. However, the pilot may subsequently modify a procedure by inserting or deleting specific waypoints in response to ATC clearances. The pilot may select the ATS route to be flown for the en-route section of the flight from the database or may construct the ATS route by means of selection of individual en-route waypoints from the database. The manual entry or creation of new waypoints, by manual entry of latitude and longitude or rho/theta values is not permitted. Additionally, pilots must not change any SID or STAR database waypoint type from a fly-by to a fly-over or vice versa.

4.10.3.4.6 The pilot should cross-check the flight plan clearance by comparing charts or other applicable resources with the navigation system textual display and the aircraft/rotorcraft map display, if applicable. If required, the pilot should also confirm exclusion of specific NAVAIDs in compliance with NOTAMs or other pilot procedures.

4.10.3.4.7 There is no pilot requirement to cross-check the navigation system's performance with conventional NAVAIDs as the absence of an integrity alert is considered sufficient to meet the integrity requirements. However, the pilot should monitor the reasonableness of the navigation solution and report any loss of RNP 0.3 capability to ATC. In addition, the pilot must continuously monitor the lateral deviation indicator (or equivalent navigation map display) during all RNP 0.3 operations.

4.10.3.4.8 The pilot is expected to maintain centre line, as depicted by on-board lateral deviation indicators, during all RNP operations unless authorized to deviate by ATC or under emergency conditions. For normal operations on straight segments or FRTs, cross-track error/deviation (the difference between the RNP system computed path and the aircraft position relative to the path) should be limited to ±½ the navigation accuracy associated with the procedure (0.15 NM). Brief deviations from this standard (e.g., overshoots or undershoots) during track changes (fly-by and fly-over turns), up to a maximum of one times the navigation accuracy (i.e., 0.3 NM for RNP 0.3), are allowable.

Note.— Some systems do not display or compute a path during track changes (fly-by and fly-over turns). As such, the pilots of these aircraft may not be able to adhere to the lateral navigation accuracy requirement (e.g. 0.15 NM) during these turns. However, the pilot is expected to satisfy the operational requirement during intercepts following turns and on straight segments.

4.10.3.4.9 If ATC issues a heading assignment taking the aircraft/rotorcraft off an ATS route, the pilot should not modify the flight plan in the RNAV system until receiving a new ATC clearance to re-join the ATS route or the controller confirms a new ATS route clearance. When the aircraft is following an ATC heading assignment, the specified accuracy requirement does not apply.

4.10.3.4.10 Manually selecting aircraft bank limiting functions may reduce the aircraft's ability to maintain its desired track and is not recommended. The pilot should recognize manually selectable aircraft bank-limiting functions might reduce their ability to satisfy path requirements of the procedure, especially when executing large angle turns. This should not be construed as a requirement to deviate from flight manual procedures; rather, pilots should be encouraged to avoid the selection of such functions except where needed for flight safety reasons.

4.10.3.5 Aircraft/rotorcraft with RNP selection capability

The pilot of an aircraft/rotorcraft with a manual RNP input selection capability should select RNP 0.3 for all RNP 0.3 ATS routes.

4.10.3.6 RNP 0.3 SID specific requirements

4.10.3.6.1 Prior to commencing take-off, the pilot must verify the aircraft RNP system is available, operating correctly, and the correct airport/heliport and departure data are loaded and properly depicted (including the aircraft's initial position). A pilot assigned an RNP 0.3 departure procedure and subsequently issued a change to the procedure or a transition from the procedure must verify that the appropriate changes are entered and available for navigation prior to take-off. A final check of proper departure entry and correct route depiction, shortly before take-off, is recommended.

Note.— As a minimum, the arrival checks can be a simple inspection of a suitable map display that achieves the objectives of this paragraph.

4.10.3.6.2 The creation of new waypoints by manual entry into the RNP 0.3 system by the pilot would not create a valid ATS route and is unacceptable at all times.

4.10.3.6.3 Where the contingency procedures require reversion to a conventional IFP, the pilot must complete all necessary preparation for such reversion (e.g. manual selection of NAVAID) before commencing any portion of the IFP.

4.10.3.6.4 Procedure modifications in the terminal area may take the form of ATC-assigned radar headings or "direct to" clearances, and the pilot must be capable of reacting in a timely fashion. This may include a requirement for the pilot to insert tactical waypoints loaded from the on-board navigation database. The pilot must not make manual entries or modify and create temporary waypoints or fixes that are not provided in the on-board navigation database.

4.10.3.6.5 The pilot must verify their aircraft navigation system is operating correctly, and the correct arrival procedure (including any applicable transition) is entered and properly depicted. Although a particular method is not mandated, the pilot must adhere to any published altitude and speed constraints associated with an RNP 0.3 operation.

4.10.3.7 Contingency procedures

The pilot must notify ATC of any loss of the RNP 0.3 capability (integrity alerts or loss of navigation) together with the proposed course of action. If unable to comply with the requirements of an RNP 0.3 ATS route for any reason, the pilot must advise ATC as soon as possible. The loss of RNP 0.3 capability includes any failure or event causing the aircraft to no longer satisfy the RNP 0.3

requirements of the desired ATS route. In the event of communications failure, the pilot should continue with the published lost communications procedure.

4.10.4 Pilot knowledge and training

The training programme should provide sufficient training (e.g. simulator, training device, or aircraft) on the aircraft RNP system to the extent that the pilot is familiar with the following:

a) The information in this chapter;

b) The meaning and proper use of aircraft/helicopter equipment/navigation suffixes;

c) Procedure characteristics as determined from chart depiction and textual description;

d) Depiction of waypoint types (fly-over and fly-by) and path terminators as well as associated aircraft/helicopter flight paths;

e) Required navigation equipment and MEL for operation on RNP 0.3 ATS routes;

f) RNP system-specific information:

1) Levels of automation, mode annunciations, changes, alerts, interactions, reversions, and degradation;
2) Functional integration with other aircraft systems;
3) The meaning and appropriateness of route discontinuities as well as related flight crew procedures;
4) Pilot procedures consistent with the operation (e.g. monitor PROG or LEGS page);
5) Types of navigation sensors utilized by the RNP system and associated system prioritization/weighting/logic/limitations;
6) Turn anticipation with consideration for airspeed and altitude effects;
7) Interpretation of electronic displays and symbols used to conduct an RNP 0.3 operation; and
8) Understanding of the aircraft configuration and operational conditions required to support RNP 0.3 operations (i.e. appropriate selection of CDI scaling/lateral deviation display scaling);

g) RNP equipment operating procedures, as applicable, including how to perform the following actions:

1) Verifying currency and integrity of aircraft navigation data;
2) Verifying successful completion of RNP system self-tests;
3) Entry of and update to the aircraft navigation system initial position;
4) Retrieving and flying an IFP with appropriate transition;
5) Adhering to speed and/or altitude constraints associated with an RNP 0.3 IFP;
6) Impact of pilot selectable bank limitations on aircraft/rotorcraft ability to achieve the required accuracy on the planned route;

7) Selecting the appropriate STAR or SID for the active runway in use and be familiar with flight crew procedures required to deal with a runway change;
8) Verifying waypoint in the flight plan programming;
9) Flying direct to a waypoint;
10) Flying a course/track to a waypoint;
11) Intercepting a course/track;
12) Following vectors and re-joining an RNP ATS route from “heading” mode;
13) Determining cross-track error/deviation. More specifically, the maximum deviations allowed to support RNP 0.3 must be understood and respected;
14) Inserting and deleting route discontinuities;
15) Removing and reselecting navigation sensor inputs;
16) When required, confirming exclusion of a specific NAVAID or NAVAID type;
17) Changing the arrival airport/heliport and the alternate airport;
18) Performing a parallel offset function, if the capability exists. The pilot should know how to apply offsets within the functionality of their particular RNP system and the need to advise ATC if this functionality is not available; and
19) Performing a conventional holding pattern;

h) Operator-recommended levels of automation for phase of flight and workload, including methods to minimize cross-track error to maintain route centre line;

i) R/T phraseology for RNAV/RNP applications; and

j) Contingency procedures for RNAV/RNP failures.

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

4.10.5 Job Aid – **RNP 0.3** Specific Elements

Part 2. Contents of the Operator application

#	Topic	Specific ICAO reference	CAAM guidance/ reference	Operator compliance description	Inspector disposition/ comments	Follow-up by inspector (optional)
		(ICAO Doc 9613, Volume II, Part C, Chapter 7)	*(CAD/CAGM , etc.)*	*(Document reference/ method*	*(Accepted/not accepted)*	*(Status and date)*
1	**Authorization request** Statement of intent to obtain authorization.					
2	**Aircraft/navigation system eligibility** Documents that establish eligibility.	7.3.2.2 7.3.2.3.1				
3	**Training** Details of courses completed (part 91 operators). Details of training programmes (part 121 and part 135 operators).	7.3.2.3.2 7.3.5				
4	**Operating policies and procedures** Extracts from the operations manual or other documentation (Part 91 operators). Operations manual and checklists (part 121 and part 135 operators.	7.3.2.3.3				
5	**Maintenance practices** Document navigation database maintenance practices.	7.3.2.3.5 7.3.6				
6	**MEL update**	7.3.2.3.4				

Part 3. Operating procedures

#	Topic	*Specific ICAO reference*	*CAAM guidance/ reference*	*Operator compliance description*	*Inspector disposition/ comments*	*Follow-up by inspector (optional)*
		(ICAO Doc 9613, Volume II, Part C, Chapter 7)	*(CAD/CAGM, etc.)*	*(Document reference/ method*	*(Accepted/not accepted)*	*(Status and date)*
1	**Flight planning**					
1a	Verify that the aircraft and crew are approved for RNP 0.3 operations.	7.3.4.1				
1b	Verify RAIM and/or SBAS availability.	7.3.4.3 7.3.4.4.3				
1c	Verify that the navigation database is current.	7.3.4.2				
1d	Verify the FPL: “R” should appear in field 10 and PBN/TBD in field 18.	7.3.4.2				
2	**General operating procedures**					
2a	Comply with the manufacturer’s instructions/procedures.	7.3.4.4.1				
2b	Advise ATC if unable to meet the requirements for RNP 0.3.	7.3.4.4.2				
2c	Verify aircraft position and entry of assigned route.	7.3.4.4.4				
2d	Retrieve SID/STAR/APP from the database; retrieve ATS route from database or construct route with waypoints from database	7.3.4.4.5				
2e	Cross-check the chart with the RNAV system display.	7.3.4.4.6				

2f	Follow route centre line within 0.15 NM	7.3.4.4.8				
2g	Do not modify the flight plan in the RNAV system after ATC heading assignment until a clearance is received to re-join the route or a new clearance is confirmed.	7.3.4.4.9				
2h	Do not select bank limiting functions.	7.3.4.4.10				
2i	If manual selection, set RNP 0.3 for all loaded RNP 0.3 routes.	7.3.4.5				
3	**RNP 0.3 SID requirements**					
3a	Prior to take-off, check the RNAV system, the aerodrome and procedure loaded and the displayed position.	7.3.4.6.1				
3b	If GNSS, signal must be acquired before start of take-off roll.	7.3.4.6.2				
3c	Engage FGS before first waypoint.	7.3.4.6.3				
4	**RNP 0.3 STAR requirements**					
4a	Verify that the correct STAR is loaded and displayed.	7.3.4.7.1				
4b	Manual entry of waypoints not authorized.	7.3.4.7.2				
4c	Contingency preparations.	7.3.4.7.3				
4d	Procedure modifications in response to ATC instructions.	7.3.4.7.4				
4e	Verify the correct operation of the navigation system and that the correct	7.3.4.7.5				

	procedure, transition and runway are loaded.					

Part 4. Contingency procedures

#	Topic	***Specific ICAO reference***	***CAAM guidance/ reference***	***Operator compliance description***	***Inspector disposition/ comments***	***Follow-up by inspector (optional)***
		*(ICAO Doc 9613, Volume II, Part C, Chapter 7) **	*(CAD/CAGM, etc.)*	*(Document reference/ method*	*(Accepted/not accepted)*	*(Status and date)*
1	**Contingencies**					
1a	Advise ATC if unable to comply with the requirements for RNP 0.3.	7.3.4.8				
1b	Air-ground communications failure.	7.3.4.8 (Doc 4444 Chapter 15, 15.3)				

** All references are to the PBN manual (ICAO Doc 9613), Volume II, Part C, Chapter 7, unless otherwise indicated.*

4.11 Advanced RNP (A-RNP)

4.11.1 General

A-RNP is intended to support operations in oceanic airspace and en-route continental airspace, on SIDs, on STARs and on approaches. It is intended to provide a single assessment of aircraft eligibility covering a range of accuracy requirements across all phases of flight. It incorporated RNAV 5, RNAV 2, RNAV 1, RNP 2, RNP 1, and RNP APCH (A and/or B). Fixed radius turn functionality within terminal airspace (RF) is a requirement while fixed radius turn functionalities in the en-route (FRT) is an option. RNP scalability, time of arrival control (TOAC) and Baro-VNAV functionalities are all optional. Higher continuity requirements are applied for RNP 2 in oceanic/remote airspace. The navigation specification does not specifically address the oceanic and remote applications RNAV 10 and RNP 4, and an operator would need to obtain separate approval before operating with an A-RNP approved aircraft in such airspace. It is not anticipated that this additional application will represent a significant burden to the operator particularly if the aircraft already meets the RNP 2 oceanic criteria.

4.11.2 Aircraft requirements

4.11.2.1 This section describes the aircraft performance and functional criteria for aircraft to qualify for applications requiring A-RNP. Aircraft eligible for A-RNP operations must meet all of the requirements of this chapter. The significant functional and performance requirements for A-RNP described herein are for RF legs, parallel offsets, RNAV holding, and the options for scalability, higher continuity, FRTs and TOAC.

4.11.2.2 Approved RNP AR systems are considered to meet the system performance monitoring and alerting requirements without further examination. However, this navigation specification contains additional functional requirements that are not included with the RNP AR APCH navigation specification, e.g. RF, RNAV holding, parallel offset and FRT. If such capabilities have been demonstrated and are contained in an approved RNP AR system, documentation of compliance may be all that is necessary. If such capabilities are added to an RNP AR system or part of a new RNP system, they will be subject to typical regulatory reviews, demonstrations, tests and approval.

4.11.2.3 Communications and ATS surveillance equipment must be appropriate for the navigation application.

4.11.2.4 Some features/requirements may be required in one flight phase and optional or unnecessary in another. No distinctions are made regarding this flight phase association in providing a general set of criteria spanning all phases and navigation applications. Where such differences are deemed important, or the operational need is for one application, a more application-specific navigation specification, e.g. RNP 1 should be used instead.

4.11.2.5 On-board performance monitoring and alerting

4.11.2.5.1 General

4.11.2.5.1.1 On-board performance monitoring and alerting is required. This section provides the criteria for a TSE form of performance monitoring and alerting that will ensure a consistent evaluation and assessment of compliance that can be applied across all of the possible applications.

4.11.2.5.1.2 The aircraft navigation system, or aircraft navigation system and flight crew in combination, is required to monitor the TSE, and to provide an alert if the accuracy requirement is not met or if the probability that the TSE exceeds two times the accuracy value is larger than 10^{-5}. To the extent operational procedures are used to satisfy this requirement, the crew procedure, equipment characteristics, and installation should be evaluated for their effectiveness and equivalence. Examples of information provided to the flight crew for awareness of navigation system performance include “EPU”, “ACTUAL”, “ANP”, and “EPE”. Examples of indications and alerts provided when the operational requirement is or can be determined as not being met include “UNABLE RNP”, “Nav Accur Downgrade”, GNSS alert, loss of GNSS integrity, TSE monitoring (real time monitoring of NSE and FTE combined), etc. The navigation system is not required to provide both performance and sensor-based alerts, e.g. if a TSE-based alert is provided, a GNSS alert may not be necessary.

4.11.2.5.2 System performance

4.11.2.5.2.1 *Accuracy:* During operations in airspace or on routes or procedures designated as RNP, the lateral TSE must be within the applicable accuracy (±0.3 NM to ±2.0 NM) for at least 95% of the total flight time. The along-track error must also be within ± the applicable accuracy for at least 95% of the total flight time. To satisfy the accuracy requirement, the 95% FTE should not exceed one half of the applicable accuracy except for a navigation accuracy of 0.3 NM where the FTE is allocated to be 0.25.

Note.— The use of a deviation indicator is an acceptable means of compliance for satisfying the FTE part of the lateral TSE with the scaling commensurate with the navigation application.

4.11.2.5.2.2 *Integrity:* Malfunction of the aircraft navigation equipment is classified as a major failure condition under airworthiness guidance material (i.e. 1×10^{-5} per hour).

4.11.2.5.2.3 *Continuity:* Loss of function is classified as a minor failure condition for applications predicated on this navigation specification. Where a State or application establishes a classification of major, the continuity requirement may be typically satisfied by carriage of dual independent navigation systems.

4.11.2.5.2.4 *SIS*: For GNSS RNP system architectures, the aircraft navigation equipment shall provide an alert if the probability of SIS errors causing a lateral position error greater than two times the applicable accuracy (2 × RNP) exceeds 1×10^{-7} per hour.

Notes:

1. *The lateral TSE includes positioning error, FTE, PDE and display error. For procedures extracted from the on-board navigation database, PDE is considered negligible due to the navigation database requirements, and pilot knowledge and training.*
2. *For RNP systems where the architecture is an integrated, multi-sensor capability and where GNSS integrity is incorporated into a 2 × RNP integrity alert consistent with RTCA/EUROCAE DO-236/ED-75 when performance cannot be met, a separate GNSS integrity alert is not required.*

4.11.2.6 Criteria for specific navigation services

4.11.2.6.1 This section identifies unique issues for the navigation sensors.

4.11.2.6.2 *GNSS:* The sensor must comply with the guidelines in FAA AC 20-138() or FAA AC 20-130A. For systems that comply with FAA AC 20-138(), the following sensor accuracies can be used in the total system accuracy analysis without additional substantiation: GNSS sensor accuracy is better than 36 metres (95%), and augmented GNSS (GBAS or SBAS) sensor accuracy is better than 2 metres (95%). In the event of a latent GNSS satellite failure and marginal GNSS satellite geometry, the probability the TSE remains within the procedure design obstacle clearance volume must be greater than 95%.

Note.— GNSS-based sensors output a HIL, also known as a HPL (see FAA AC 20-138() and RTCA/DO-229D for an explanation of these terms). The HIL is a measure of the position estimation error assuming a latent failure is present. In lieu of a detailed analysis of the effects of latent failures on the TSE, an acceptable means of compliance for GNSS-based systems is to ensure the HIL remains less than twice the navigation accuracy, minus the 95% of FTE, during the RNP operation.

4.11.2.6.3 *IRS:* An IRS must satisfy the criteria of US 14 CFR Part 121, Appendix G, or equivalent. While Appendix G defines the requirement for a 2 NM per hour drift rate (95%) for flights up to 10 hours, this rate may not apply to an RNP system after loss of position updating. Systems that have demonstrated compliance with Part 121, Appendix G, can be assumed to have an initial drift rate of 8NM/hour for the first 30 minutes (95 minutes) without further substantiation. Aircraft manufacturers and applicants can demonstrate improved inertial performance in accordance with the methods described in Appendix 1 or 2 of FAA Order 8400.12A.

Note. – Integrated GPS/INS position solutions reduce the rate of degradation after loss of position updating. For “tightly coupled” GPS/IRUs, RTCA/DO-229C, Appendix R, provides additional guidance.

4.11.2.6.4 *DME:* For RNP procedures and routes, the RNP system may only use DME updating when authorized by the State. The manufacturer should identify any operating constraints (e.g. manual inhibit of DME) in order for a given aircraft to comply with this requirement.

Notes:

1. *This is in recognition of States where a DME infrastructure and capable equipped aircraft are available, those States may establish a basis for aircraft qualification and operational approval to enable use of DME. It is not intended to imply a requirement for implementation of DME infrastructure or the addition of RNP capability using DME for RNP operations.*
2. *This does not imply an equipment capability must exist providing a direct means of inhibiting DME updating. A procedural means for the flight crew to inhibit DME updating or executing a missed approach if reverting to DME updating may meet this requirement.*

4.11.2.6.5 *VHF VOR station:* For RNP procedures, the RNAV system must not use VOR updating. The manufacturer should identify any operating constraints (e.g. manual inhibit of VOR) in order for a given aircraft to comply with this requirement.

Note.— This does not imply an equipment capability must exist providing a direct means of inhibiting VOR updating. A procedural means for the flight crew to inhibit VOR updating or executing a missed approach if reverting to VOR updating may meet this requirement.

4.11.2.6.6 For multi-sensor systems, there must be automatic reversion to an alternate RNAV sensor if the primary RNAV sensor fails. Automatic reversion from one multi-sensor system to another multi-sensor system is not required.

4.11.2.7 Functional requirements

4.11.2.7.1 Displays – guidance, situation and status

Item	*Function/Feature*	*Description*
a)	Continuous display of deviation.	1. The navigation system must provide the capability to continuously display to the pilot flying, on the primary flight instruments for navigation of the aircraft, the aircraft position relative to the RNP defined path. 2. For operations where the required minimum flight crew is two pilots, the means for the pilot not flying to verify the desired path and the aircraft position relative to the path must also be provided. 3. The display must allow the pilot to readily distinguish whether the cross-track deviation exceeds the navigation accuracy (or a smaller value).

		4. The numeric display of deviation on a map display with an appropriately scaled deviation indicator is generally considered acceptable for monitoring deviation. 5. Moving map displays without an appropriately scaled deviation indicator may be acceptable depending on the task, flight crew workload, display characteristics, flight crew procedures and training.
b)	Identification of the active (To) waypoint.	The navigation system must provide a display identifying the active waypoint either in the pilot's primary optimum field of view, or on a readily accessible and visible display to the flight crew.
c)	Display of distance and bearing.	The navigation system must provide a display of distance and bearing to the active (To) waypoint in the pilot's primary optimum field of view. Where not viable, a readily accessible page on a control display unit, readily visible to the flight crew, may display the data.
d)	Display of groundspeed and time.	The navigation system must provide the display of groundspeed and time to the active (To) waypoint in the pilot's primary optimum field of view. Where not viable, a readily accessible page on a control display unit, readily visible to the flight crew, may display the data.
e)	Desired track display.	The navigation system must have the capability to continuously display to the pilot flying the aircraft desired track. This display must be on the primary flight instruments for navigation of the aircraft.
f)	Display of aircraft track.	The navigation system must provide a display of the actual aircraft track (or track angle error) either in the pilot's primary optimum field of view, or on a readily accessible and visible display to the flight crew.
g)	Failure annunciation.	The aircraft must provide a means to annunciate failures of any aircraft component of the RNP system, including navigation sensors. The annunciation must be visible to the pilot and located in the primary optimum field of view.
h)	Slaved course selector.	The navigation system must provide a course selector automatically slaved to the RNP computed path.
i)	Display of distance to go.	The navigation system must provide the ability to display distance to go to any waypoint selected by the flight crew.

j)	Display of distance between flight plan waypoints.	The navigation system must provide the ability to display the distance between flight plan waypoints.
k)	Display of deviation.	The navigation system must provide a numeric display of the lateral deviation with a resolution of 0.1 NM or less.
l)	Display of active sensors.	The aircraft must display the current navigation sensor(s) in use. It is recommended that this display be provided in the primary optimum field of view. *Note.— This display is used to support operational contingency procedures. If such a display is not provided in the primary optimum field of view, crew procedures may mitigate the need for this display if the workload is determined to be acceptable.*

4.11.2.7.2 Path definition and flight planning

Item	*Function/Feature*	*Description*
a)	Maintaining tracks and leg transitions.	The aircraft must have the capability to execute leg transitions and maintain tracks consistent with the following ARINC 424 path terminators: *ARINC 424 path terminators* IF CF DF TF RF CA course from an FA VA VM VI HM Where approval is sought for FRT in association with this navigation specification, the RNP system must have the capability to create FRTs between route segments, based upon the data contained in the aircraft navigation system database. *Notes:* *1. Path terminators and the FRT are defined in ARINC 424, and their application is described in more detail in RTCA/EUROCAE documents DO-236B/ED-75B and DO-201A/ED-77.*

		2. *The list of path terminators includes a number that introduce variability in the flight path to be flown by the aircraft. For all RNP applications, the preferred path terminators are IF, DF, TF, and RF. Other path terminators may be used on the understanding that they will introduce less repeatability, predictability and reliability of aircraft lateral path performance.* 3. *For the VA, VM and VI path terminators, if the aircraft is unable to automatically execute these leg transitions, they should be able to be manually flown on a heading to intercept a course or to go direct to another fix after reaching a procedure-specified altitude.*
b)	Leg transition.	Fly-by and fly-over fixes. The aircraft must have the capability to execute fly-by and fly-over fixes. For fly-by turns, the navigation system must limit the path definition within the theoretical transition area defined in EUROCAE ED-75B/ RTCA DO-236B. The fly-over turn is not compatible with RNP flight tracks and will only be used when there is no requirement for repeatable paths. FRTs: Where approval is sought for FRTs, the aircraft must have the capability to execute the function.
c)	Intercepts.	The RNP system should provide the ability to intercept the final approach at or before the FAF. This functional capability must provide the pilot with the ability to re-join the published final approach track following a period when the aircraft has been flown manually, or in AFCS heading mode, following ATC vectors to support final approach sequencing. The implementation method and visual information (MCDU and primary displays (map display/EHSI)) shall be sufficient to enable the correct re-acquisition of the track with a minimum of manual intervention on the MCDU. Due account must be taken of the workload associated with the re-acquisition and the impact of errors in leg sequencing.
d)	Holding.	A holding procedure will only normally be required at defined holding points on entry to terminal airspace. However, holding may be required by ATC at any point. A hold shall be defined by a point, the turn direction, an inbound track and an outbound distance. This data may be extracted from

		the database for published holds or may be manually entered for ad hoc ATC holds. *Note.— It is highly desirable that the RNP system provide a holding capability that includes the computation of the hold flight path, guidance and/or cues to track the holding entry and path.* The system with the minimum of crew intervention must be capable of initiating, maintaining and discontinuing holding procedures at any point and at all altitudes.
e)	Parallel offset	Parallel offsets provide a capability to fly offset from the parent track, as defined by the series of waypoints. The turn defined for the parent track (fly-by or FRT) shall be applied in the offset track. Parallel offsets are applicable only for en-route segments and are not foreseen to be applied on SIDs, STARs or approach procedures. The activation of an offset shall be clearly displayed to the flight crew and the cross-track deviation indication during the operation of the offset will be to the offset track.
f)	Offset execution	The system should be capable of flying tracks offset by up to 20 NM from the parent track. The presence of an offset should be continuously indicated; Tracks offset from the parent track shall be continued for all ATS route segments and turns until either: - Removed by the crew; or - Automatically cancelled following: • Amendment of the active flight plan by executing a “Direct-To”; • Commencement of a terminal procedure; • Where a course change exceeds 90°, the RNP system may terminate the offset at the fix where the course change occurs. The offset may also be terminated if the route segment ends at a hold fix. The flight crew shall be given advance notice of this cancellation.

		The cross-track offset distance should be manually entered into the RNP system to a resolution of 1 NM or better. Where parallel offsets are applied, the lateral track-keeping requirement of RNP must be maintained referenced to the offset track. Where FRTs are applied, the offset track must be flown with the same turn radius as the parent track.
g)	Entry and recovery from offsets.	Transitions to and from the offset track must maintain an intercept angle of between 30° and 45°.
h)	Capability for a “direct-to” function.	The navigation system must have a “direct-to” function the flight crew can activate at any time. This function must be available to any fix. The navigation system must also be capable of generating a geodesic path to the designated “To” fix without “S-turning” and without undue delay.
i)	Altitudes and/or speeds associated with published terminal procedures.	Altitudes and/or speeds associated with published terminal procedures must be extracted from the navigation database.
j)	Capability to load procedures from the navigation database.	The navigation system must have the capability to load the entire procedure(s) to be flown into the RNP system from the on-board navigation database. This includes the approach (including vertical angle), the missed approach and the approach transitions for the selected airport and runway.
k)	Means to retrieve and display navigation data.	The navigation system must provide the ability for the flight crew to verify the procedure to be flown through review of the data stored in the on-board navigation database. This includes the ability to review the data for individual waypoints and for NAVAIDs.
l)	Magnetic variation.	For paths defined by a course (e.g. CF and FA path terminators), the navigation system should use the appropriate magnetic variation value in the navigation database.
m)	Changes in navigation accuracy.	The RNP system should automatically retrieve and set the navigation accuracy for each leg segment of a route or procedure from the on-board navigation database. When a change occurs to a smaller navigation accuracy, e.g. from RNP 1.0 to RNP 0.3, the change must be complete by the first fix defining the leg with the smaller navigation accuracy requirement. The timing of this change must also consider any latency in alerting from the RNP system.

		When the RNP system cannot automatically set the navigation accuracy for each leg segment, any operational procedures necessary to accomplish this must be identified. *Note.— One acceptable means to meet this requirement may be to require the flight crew to manually set the smallest navigation accuracy the route or procedure uses before commencing the route or procedure (i.e. prior to the IAF).* If the navigation accuracy for the RNP system has been set manually by the flight crew and following an RNP system change to the navigation accuracy required (e.g. the next flight path segment contains a different navigation accuracy), the RNP system should provide an alert to the flight crew.
n)	Automatic leg sequencing.	The navigation system must provide the capability to automatically sequence to the next leg and display the sequencing to the flight crew in a readily visible manner.

4.11.2.7.3 System

Item	*Function/Feature*	*Description*
a)	Design assurance	The system design assurance must be consistent with at least a major failure condition for the display of misleading lateral or vertical guidance in RNP applications.
b)	Navigation database.	The aircraft navigation system must use an on-board navigation database, containing current navigation data officially promulgated for civil aviation, which can be updated in accordance with the AIRAC cycle; and allow retrieval and loading of procedures into the RNP system. The stored resolution of the data must be sufficient to achieve negligible PDE. The on-board navigation database must be protected against flight crew modification of the stored data. When a procedure is loaded from the database, the RNP system must fly the procedure as published. This does not preclude the flight crew from having the means to modify a procedure or route already loaded into the RNP system. However, the procedures stored in the navigation database must not be modified and must remain intact

		within the navigation database for future use and reference. The aircraft must provide a means to display the validity period for the on-board navigation database to the flight crew. The equipment should not permit the flight crew to either manually or automatically select a route that is not supported. A route is not supported if it incorporates an FRT and the equipment does not provide FRT capability. The RNP system should also restrict pilot access to routes requiring FRTs if the equipment can support the route, but the aircraft is not otherwise equipped (e.g. the aircraft does not have the required roll steering autopilot or flight director installed). *Note. – An alternate means of satisfying this requirement is to remove such routes from the navigation database.*

4.11.2.7.4 Optional capability

Item	*Function/Feature*	*Description*
a)	RNP scalability	The RNP system must be capable of manual or automatic entry and display of navigation accuracy requirements in tenths of NM between 0.3 and 1.0 NM. The RNP system must provide lateral deviation displays and alerting appropriate to the selected navigation accuracy and application. *Notes:* *1. One means by which this can be achieved is as described in RTCA MOPS DO-283A. Another means is to develop lateral deviation displays and alerting as per RTCA/EUROCAE MASPS DO-236B/ED-75B.* *2. It is recognized that aircraft and equipment that are based upon GNSS standards such as RTCA DO-208() and DO-229() have RNP capabilities for lateral deviation and alerting that are generally associated with navigation accuracies of 0.3, 1.0, and 2.0 NM only. Such capability exists in a large portion of the aircraft fleet but may not be extended to other navigation accuracies or the means of compliance specified herein. Additionally, some of this fleet does provide the capability to select other navigation accuracies. Therefore, before a manufacturer implements or an*

		operator applies this functional capability, it is recommended that they determine the effects of the resolution of a number of issues including: *a) How their aircraft and systems will be affected or accommodated operationally when different navigation accuracy requirements are needed;* *b) Is there a basis for implementing improved functionality or operating procedures; and* *c) How such systems will need to be qualified, used by the flight crew and operationally approved.*

4.11.3 Operating procedures

Airworthiness certification alone does not authorize RNP operations. Operational approval is also required to confirm the adequacy of the operator's normal and contingency procedures for the particular equipment installation.

4.11.3.1 Pre-flight planning

4.11.3.1.1 Operators and pilots intending to conduct RNP operations requiring A-RNP capability should indicate appropriate application in the flight plan.

4.11.3.1.2 The on-board navigation data must be current and appropriate to the route being flown and for potential diversions. Navigation databases are expected to be current for the duration of the flight. If the AIRAC cycle is due to change during flight, operators and pilots should establish procedures to ensure the accuracy of navigation data, including suitability of navigation facilities used to define the routes and procedures for flight.

4.11.3.1.3 Operators using GNSS equipment should confirm the availability of RAIM by using RAIM availability prediction software taking account of the latest GNSS NOTAMs. Operators using SBAS augmentation should also check the relevant SBAS NOTAMs to determine the availability of SBAS. Notwithstanding pre-flight analysis results, because of unplanned failure of some GNSS or DME elements (or local interference), pilots must realize that integrity availability (or GNSS/DME navigation altogether) may be lost while airborne which may require reversion to an alternate means of navigation. Therefore, pilots should assess their capability to navigate in case of failure of the primary sensor or the RNP system.

4.11.3.2 General operating procedures

4.11.3.2.1 Operators and pilots should not request or file RNP routes, SIDs, STARs or approaches unless they satisfy all the criteria in the relevant State documents. The pilot should comply with any instructions or procedures identified by the manufacturer, as necessary, to comply with the performance requirements.

Note.— Pilots are expected to adhere to any AFM limitations or operating procedures required to maintain the RNP for the operation.

4.11.3.2.2 At system initialization, pilots must confirm the navigation database is current and verify that the aircraft position has been entered correctly. Pilots must not fly an RNP route, SID, STAR or approach unless it is retrievable by name from the on-board navigation database and conforms to the chart. An RNP route, SID, STAR or approach should not be used if doubt exists as to the validity of the procedure in the navigation database.

Note.— Flight crew may notice a slight difference between the navigation information portrayed on the chart and their primary navigation display. Differences of 3° or less may result from equipment manufacturer's application of magnetic variation and are operationally acceptable.

4.11.3.2.3 Cross-checking with conventional NAVAIDs is not required as the absence of integrity alert is considered sufficient to meet the integrity requirements. However, monitoring of navigation reasonableness is suggested, and any loss of RNP capability shall be reported to ATC. While operating on RNP Routes, SIDs, STARs or approaches, pilots are encouraged to use flight director and/or autopilot in lateral navigation mode, if available. Flight crew should be aware of possible lateral deviations when using raw path steering data or Navigation Map Displays for lateral guidance in lieu of flight director. When the dispatch of a flight into RNP operations is predicated on use of the autopilot/flight director at the destination and/or alternate, the dispatcher/flight crew must determine that the autopilot/flight director is installed and operational.

4.11.3.3 Manual entry of RNP

If the navigation system does not automatically retrieve and set the navigation accuracy from the on-board navigation database for each leg segment of a route or procedure, the fight crew’s operating procedures should ensure the smallest navigation accuracy for the route or procedure is manually entered into the RNP system.

4.11.3.4 SID specific requirements

4.11.3.4.1 Prior to flight, pilots must verify their aircraft navigation system is operating correctly and the correct runway and departure procedure (including any applicable en-route transition) are entered and properly depicted. Pilots who are assigned an RNP departure procedure and subsequently receive a change of runway, procedure or transition must verify the appropriate changes are entered and available for navigation prior to take-off. A final check of proper runway entry and correct route depiction, shortly before take-off, is recommended.

4.11.3.4.2 *Engagement altitude:* The pilot must be able to use RNP equipment to follow flight guidance for lateral navigation no later than 153 m (500 ft) above the airport elevation. The altitude at which guidance begins on a given route may be higher (e.g. climb to 304 m (1 000 ft) then direct to …).

4.11.3.4.3 Pilots must use an authorized method (lateral deviation indicator/navigation map display/flight director/autopilot to achieve appropriate level of performance.

4.11.3.4.4 *GNSS aircraft*: When using GNSS, the signal must be acquired before the take-off roll commences. For aircraft using FAA TSO-C129a equipment, the departure airport must be loaded into the flight plan in order to achieve the appropriate navigation system monitoring and sensitivity. For aircraft using FAA TSO-C145a/C146a equipment, if the departure begins at a runway waypoint, then the departure airport does not need to be in the flight plan to obtain appropriate monitoring and sensitivity.

4.11.3.5 STAR specific requirements

4.11.3.5.1 Prior to the arrival phase, the flight crew should verify that the correct terminal route has been loaded. The active flight plan should be checked by comparing the charts with the map display (if applicable) and the MCDU. This includes confirmation of the waypoint sequence, reasonableness of tracks and distances, any altitude or speed constraints, and, where possible, which waypoints are fly-by, and which are fly-over. If required by a route, a check will need to be made to confirm that updating will exclude a particular NAVAID. A route must not be used if doubt exists as to the validity of the route in the navigation database.

Note.— As a minimum, the arrival checks could be a simple inspection of a suitable map display that achieves the objectives of 4.11.3.5.1.

4.11.3.5.2 The creation of new waypoints by manual entry into the RNP system by the flight crew would invalidate the route and is not permitted.

4.11.3.5.3 Where the contingency procedure requires reversion to a conventional arrival route, necessary preparations must be completed before commencing the RNP route.

4.11.3.5.4 Route modifications in the terminal area may take the form of headings or “direct to” clearances and the flight crew must be capable of reacting in a timely fashion. This may include the insertion of tactical waypoints loaded from the database. Manual entry or modification by the flight crew of the loaded route, using temporary waypoints or fixes not provided in the database, is not permitted.

4.11.3.5.5 Pilots must verify their aircraft navigation system is operating correctly, and the correct arrival procedure and runway (including any applicable transition) are entered and properly depicted.

4.11.3.5.6 Although a particular method is not mandated, any published altitude and speed constraints must be observed. Approaches using temporary waypoints or fixes not provided in the navigation database are not permitted.

4.11.3.6 *Contingency procedures*

4.11.3.6.1 The pilot must notify ATC of any loss of the RNP capability (integrity alerts or loss of navigation), together with the proposed course of action. If unable to comply with the requirements of an RNP SID or STAR, pilots must advise ATS as soon as possible. The loss of RNP capability includes any failure or event causing the aircraft to no longer satisfy the A-RNP requirements of the route.

4.11.3.6.2 In the event of communications failure, the flight crew should continue with the A-RNP SID or STAR in accordance with the published lost communications procedure.

4.11.4 Pilot knowledge and training

The training programme should provide sufficient training (e.g. simulator, training device, or aircraft) on the aircraft's RNP system to the extent that the pilots are familiar with the following:

a) The meaning and proper use of aircraft equipment/navigation suffixes;

b) Procedure characteristics as determined from chart depiction and textual description:

   1) Depiction of waypoint types (fly-over, fly-by, RF and FRT), altitude and speed restrictions and path terminators as well as associated aircraft flight paths; and
   2) Required navigation equipment for operation on RNP routes, SIDs, and STARs;

c) RNP system-specific information:

   1) Levels of automation, mode annunciations, changes, alerts, interactions, reversions, and degradation;
   2) Functional integration with other aircraft systems;
   3) The meaning and appropriateness of route discontinuities as well as related flight crew procedures;
   4) Monitoring procedures for each phase of flight (for example, monitor PROG or LEGS page);
   5) Types of navigation sensors (GNSS) used by the RNP system and associated system prioritization/weighting/logic;
   6) Turn anticipation with consideration to speed and altitude effects;

7) Interpretation of electronic displays and symbols; and
8) Automatic and/ or manual setting of the required navigation accuracy;

d) Understand the performance requirement to couple the autopilot/flight director to the navigation system's lateral guidance on RNP procedures, if required;

e) The equipment should not permit the flight crew to select a procedure or route that is not supported by the equipment, either manually or automatically (e.g. a procedure is not supported if it incorporates an RF leg and the equipment does not provide RF leg capability). The system should also restrict pilot access to procedures requiring RF leg capability or FRTs if the system can select the procedure, but the aircraft is not otherwise equipped (e.g. the aircraft does not have the required roll steering autopilot or flight director installed);

f) RNP equipment operating procedures, as applicable, including how to perform the following actions:

1) Verify currency and integrity of aircraft navigation data;
2) Verify successful completion of RNP system self-tests;
3) Initialize navigation system position;
4) Retrieve and fly a SID or a STAR with appropriate transition;
5) Adhere to speed and/or altitude constraints associated with a SID or STAR;
6) Select the appropriate STAR or SID for the active runway in use and be familiar with procedures to deal with a runway change;
7) Verify waypoints and flight plan programming;
8) Perform a manual or automatic runway update (with take-off point shift, if applicable);
9) Fly direct to a waypoint;
10) Fly a course/track to a waypoint;
11) Intercept a course/track. (Fly vectors, and re-join an RNP route/procedure from the "heading" mode);
12) Determine cross-track error/deviation. More specifically, the maximum deviations allowed to support A-RNP must be understood and respected;
13) Where applicable, the importance of maintaining the published path and maximum airspeeds while performing RNP operations with RF legs or FRTs;
14) Insert and delete route discontinuity;
15) Remove and reselect navigation sensor input;
16) When required, confirm exclusion of a specific NAVAID or NAVAID type;
17) When required by the State aviation authority, perform gross navigation error check using conventional NAVAIDs;
18) Change arrival airport and alternate airport;
19) Perform parallel offset function if capability exists. Pilots should know how offsets are applied, the functionality of their particular RNP system and the need to advise ATC if this functionality is not available;
20) Perform RNAV holding function;

21) Flight crew contingency procedures for a loss of RNP capability; and
22) Manual setting of the required navigation accuracy;

Note. – Operators are strongly encouraged to use manufacturer recommended training and operating procedures.

g) Operator-recommended levels of automation for phase of flight and workload, including methods to minimize cross-track error to maintain route centre line; and

h) R/T phraseology for RNAV/RNP applications.

4.11.5 Job Aid – **A-RNP** Specific Elements

Part 2. Contents of the Operator application

#	Topic	*Specific ICAO reference*	*CAAM guidance/ reference*	*Operator compliance description*	*Inspector disposition/ comments*	*Follow-up by inspector (optional)*
		(ICAO Doc 9613, Volume II, Part C, Chapter 4)	*(CAD/CAGM , etc.)*	*(Document reference/ method*	*(Accepted/not accepted)*	*(Status and date)*
1	**Authorization request** Statement of intent to obtain authorization.					
2	**Aircraft/navigation system eligibility** Documents that establish eligibility.	4.3.2.5 4.3.2.6.6				
3	**Training** Details of courses completed (part 91 operators). Details of training programmes (part 121 and part 135 operators).	4.3.2.6.2 4.3.6				
4	**Operating policies and procedures** Extracts from the operations manual or other documentation (Part 91 operators). Operations manual and checklists (part 121 and part 135 operators.	4.3.2.6.3				
5	**Maintenance practices** Document navigation database maintenance practices.	4.3.2.6.5 4.3.5				
6	**MEL update**	4.3.2.6.4				

Part 3. Operating procedures

#	Topic	*Specific ICAO reference*	*CAAM guidance/ reference*	*Operator compliance description*	*Inspector disposition/ comments*	*Follow-up by inspector (optional)*
		(ICAO Doc 9613, Volume II, Part C, Chapter 4)	*(CAD/CAG M, etc.)*	*(Document reference/ method*	*(Accepted/not accepted)*	*(Status and date)*
1	**Flight planning**					
1a	Verify that the aircraft and crew are approved for A-RNP operations.	4.3.4				
1b	Verify RAIM/SBAS availability.	4.3.4.1.3				
1c	Verify that the navigation database is current.	4.3.4.2.2				
1d	If dispatch predicated on procedure with RF leg, verify AP/FD is operational.	Appendix 1 to Part C 5.5.3				
1e	Verify the FPL: “R” should appear in field 10 and PBN/TBD in field 18.	4.3.4.1.1				
2	**General operating procedures**					
2a	If system does not set RNP automatically, smallest navigation accuracy value must be entered manually for loaded route.	4.3.4.3				
3	**A-RNP SID requirements**					
3a	Prior to take-off, check the RNAV system, the runway and procedure loaded and the displayed position.	4.3.4.4.1				
3b	Engage LNAV no later than 153 m (500 ft) above aerodrome elevation.	4.3.4.4.2				

3c	Use an authorized method to achieve appropriate RNP performance (AP/FD/Map/ L/DEV indicator.	4.3.4.4.3				
3d	If GNSS, signal must be acquired before start of take-off roll.	4.3.4.4.4				
4	**A-RNP STAR requirements**					
4a	Verify that the correct STAR is loaded and displayed.	4.3.4.5.1				
4b	Contingency preparations.	4.3.4.5.3				
4c	Verify the correct operation of the navigation system and that the correct procedure, transition and runway are loaded.	4.3.4.5.5				
4d	Route modification in response to ATC instructions.	4.3.4.5.4				
4e	Observance of speed and altitude constraints.	4.3.4.5.6				
5	**RF requirements**					
5a	Be established on procedure prior to RF leg.	Appendix 1 to Part C 5.5.5				
5b	Cross-track deviation not to exceed ½ RNP.	Appendix 1 to Part C 5.5.6				
5c	Do not exceed maximum airspeed associated with design.	Appendix 1 to Part C 5.5.7				

Part 4. Contingency procedures

#	Topic	*Specific ICAO reference*	*CAAM guidance/ reference*	*Operator compliance description*	*Inspector disposition/ comments*	*Follow-up by inspector (optional)*
		*(ICAO Doc 9613, Volume II, Part C, Chapter 4) **	*(CAD/CAGM, etc.)*	*(Document reference/ method*	*(Accepted/not accepted)*	*(Status and date)*
1	**Contingencies**					
1a	Advise ATC if unable to comply with the requirements for A-RNP	4.3.4.6.1				
1b	Air-ground communications failure.	4.3.4.6.2 (Doc 4444 Chapter 15, 15.3)				
1c	If unable to follow RF turn due to system failure, maintain bank and roll out on charted exit course. Inform ATC.	Appendix 1 to Part C 5.5.8				

** All references are to the PBN manual (ICAO Doc 9613), Volume II, Part C, Chapter 4, unless otherwise indicated.*

4.12 RNP AR

4.12.1 General

4.12.1.1 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 the Required Navigation Performance Authorization Required (RNP AR) Procedure Design Manual (ICAO Doc 9905), there are a number of RNP AR APCH procedures in commercial use which have been designed according to private, proprietary criteria.

4.12.1.2 GNSS, an inertial reference system and a VNAV system are 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.

4.12.2 System requirements

This section describes the aircraft performance and functional criteria for aircraft to qualify for RNP AR APCH. In addition to the specific guidance in this chapter, the aircraft must comply with FAA AC 20-129 and either FAA AC 20-130 or AC 20-138, or equivalent.

4.12.2.1 On-board performance monitoring and alerting

4.12.2.1.1 This section defines the general performance requirements for aircraft qualification. The requirements for RNP AR APCH are unique due to the reduced obstacle clearance and advanced functionality, therefore the requirements in this section do not use the same structure as for other navigation specifications, e.g. RNP 4, RNP 1 and RNP APCH.

4.12.2.1.2 *Path definition:* Aircraft performance is evaluated around the path defined by the published procedure and RTCA/DO-236B Section 3.2; EUROCAE ED-75B. All vertical paths used in conjunction with the FAS will be defined by a flight path angle (RTCA/DO 236B, section 3.2.8.4.3) as a straight line emanating to a fix and altitude.

4.12.2.1.3 *Lateral accuracy*: All aircraft operating on RNP AR APCH procedures must have a cross-track navigation error no greater than the applicable accuracy value (0.1 NM to 0.3 NM) for 95% of the flight time. This includes positioning error, FTE, PDE and display error. Also, the aircraft along-track positioning error must be no greater than the applicable accuracy value for 95% of the flight time.

4.12.2.1.4 *Vertical accuracy:* The vertical system error includes altimetry error (assuming the temperature and lapse rates of the International Standard Atmosphere), the effect of along-track error, system computation error, data resolution error, and FTE. The 99.7% of system error in the vertical direction must be less than the following (in feet):

$$\sqrt{((6076.115)(1.225)RNP \cdot \tan\theta)^2 + (60\tan\theta)^2 + 75^2 + \left((-8.8 \cdot 10^{-8})(h+\Delta h)^2 + (6.5 \cdot 10^{-3})(h+\Delta h) + 50\right)^2}$$

where θ is the VNAV path angle, h is the height of the local altimetry reporting station and □h is the height of the aircraft above the reporting station.

Note.— VNAV systems compliant with the performance specification for RNP APCH operations down to LPV minima meet or exceed this vertical accuracy performance criteria.

4.12.2.1.5 *System monitoring*: A critical component of RNP is the ability of the aircraft navigation system to monitor its achieved navigation performance, and to identify, for the pilot, whether the operational requirement is or is not being met during an operation (e.g., “Unable RNP”, “Nav Accur Downgrade”). It should be noted that the monitoring system may not provide warnings of FTE. The management of FTE must be addressed as a pilot procedure.

4.12.2.1.6 *GNSS updating:* A crew alert is required when GNSS updating is lost unless the navigation system provides an alert when the selected RNP no longer meets the requirements for continued navigation.

4.12.2.1.7 Airspace containment:

a) RNP and baro-VNAV aircraft. This chapter provides a detailed acceptable means of compliance for aircraft that use an RNP system based primarily on GNSS, and a VNAV system based on barometric altimetry. Aircraft and operations complying with this navigation specification provide the requisite airspace protection through a variety of monitoring and alerting systems and pilot procedures. Aircraft and operations complying with this navigation specification provide the requisite performance and assurance to satisfy the airspace requirements and safety margins through a variety of monitoring and alerting (e.g. “Unable RNP”, GNSS alert limit, and path deviation monitoring); and

b) Other systems or alternate means of compliance. For other systems or alternate means of compliance to a), the probability of the aircraft exiting the lateral and vertical extent of the obstacle clearance volume of the procedure must not exceed 10^{-7} per approach (including the missed approach). This requirement may be satisfied by an operational safety assessment applying:

1) appropriate quantitative numerical methods;

2) qualitative operational and procedural considerations and mitigations; or

3) an appropriate combination of both quantitative and qualitative methods.

Notes:

1. *This requirement applies to the total probability of excursion outside the obstacle clearance volume, including events caused by latent conditions (integrity) and by detected conditions (continuity) if the aircraft does not remain within the obstacle clearance volume after the failure is annunciated (considering the aircraft wingspan). The monitor limit of the alert, the latency of the alert, the crew reaction time, and the aircraft response should all be considered when ensuring that the aircraft does not exit the obstacle clearance volume. The requirement applies to a single approach, considering the exposure time of the operation and the NAVAID geometry and navigation performance available for each published approach.*

2. *This containment requirement is derived from the operational requirement which is notably different than the containment requirement specified in RTCA/DO 236B (EUROCAE ED-75B). The requirement in RTCA/DO-236B (EUROCAE ED-75B) was developed to facilitate airspace design and does not directly equate to obstacle clearance.*

4.12.2.2 Criteria for specific navigation services

4.12.2.2.1 This section identifies unique issues for the navigation sensors within the context of RNP AR APCH operations.

4.12.2.2.2 ABAS and other GNSS augmentations based on GPS

a) The sensor must comply with the guidelines in AC 20-138() or AC 20-130 A. For systems that comply with AC 20-138(), the following sensor accuracies can be used in the total system accuracy analysis without additional substantiation: GPS (ABAS) sensor lateral accuracy is better than 36 m (119 ft) (95%), and augmented GPS (GBAS or SBAS) sensor lateral accuracy is better than 2 m (7 ft) (95%).

b) In the event of a latent GPS satellite failure and marginal GPS satellite geometry (e.g. HIL) equal to the horizontal alert limit), 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).

Notes:

1. *Other GNSS systems meeting or exceeding the accuracy of GPS can use the criteria in a) and b) above.*

2. *GNSS-based sensors output a HIL, also known as a HPL (see AC 20-138A, Appendix 1 and RTCA/DO-229C for an explanation of these terms). The HIL is a measure of the position estimation error assuming a latent failure is present. In lieu of a detailed analysis of the effects of latent failures on the TSE, an acceptable means of compliance for GNSS-based systems is to ensure the HIL remains less than twice the navigation accuracy, minus the 95% of FTE, during the RNP AR APCH operation.*

4.12.2.2.3 *IRS:* An IRS must satisfy the criteria of US 14 CFR part 121, Appendix G, or equivalent. While Appendix G defines the requirement for a 2 NM per hour drift rate (95%) for flights up to 10 hours, this rate may not apply to an RNP system after loss of position updating. Systems that have demonstrated compliance with Part 121, Appendix G, can be assumed to have an initial drift rate of 8 NM/hour for the first 30 minutes (95%) without further substantiation. Aircraft manufacturers and applicants can demonstrate improved inertial performance in accordance with the methods described in Appendix 1 or 2 of FAA Order 8400.12A.

Note.— Integrated GPS/INS position solutions reduce the rate of degradation after loss of position updating. For "tightly coupled" GPS/IRUs, RTCA/DO-229C, Appendix R, provides additional guidance.

4.12.2.2.4 *DME:* GNSS-updating is the basis for initiating all RNP AR APCH procedures. When authorized by the State, the aircraft may use DME/DME-updating as a reversionary navigation mode during an approach or during the missed approach when the navigation system continues to comply with the required navigation accuracy. The aircraft manufacturer should identify any requirements for the DME infrastructure or any necessary operational procedures and limitations when conducting a procedure through use of DME/DME updating of the aircraft's position.

4.12.2.2.5 *VHF omnidirectional range (VOR) station:* The aircraft's RNP system may not use VOR-updating when conducting RNP AR APCH procedures. The aircraft manufacturer should identify any pilot procedures or techniques for an aircraft to comply with this requirement.

Note.— This does not imply a requirement for a direct means of inhibiting VOR updating. An operational procedure requiring the pilot to inhibit VOR updating or a procedure requiring the pilot to execute a missed approach when the navigation system reverts to VOR-updating may satisfy this requirement.

4.12.2.2.6 For multi-sensor systems, there must be automatic reversion to an alternate area navigation sensor if the primary area navigation sensor fails. Automatic reversion from one multi-sensor system to another multi-sensor system is not required.

4.12.2.2.7 The 99.7% aircraft ASE for each aircraft (assuming the temperature and lapse rates of the International Standard Atmosphere) must be less than or equal to the following with the aircraft in the approach configuration:

$$\mathrm{ASE} = -8.8 \cdot 10^{-8} \cdot \mathrm{H}^2 + 6.5 \cdot 10^{-3} \cdot \mathrm{H} + 50(\mathrm{ft})$$

Where H is the true altitude of the aircraft.

4.12.2.2.8 *Temperature compensation systems:* Systems that provide temperature-based corrections to the barometric VNAV guidance must comply with RTCA/DO-236B, Appendix H.2. This applies to the FAS. Manufacturers should document compliance to this standard to allow the operator to conduct RNP approaches when the actual temperature is below or above the published procedure design limit. Appendix H also provides guidance on operational issues associated with temperature compensated systems, such as intercepting the compensated path from uncompensated procedure altitudes.

4.12.2.3 Functional requirements

Note.— Additional guidance and information concerning many of the required functions are provided in EUROCAE ED-75A/ RTCA DO-236B.

4.12.2.3.1 General requirements

4.12.2.3.1.1 Path definition and flight planning:

a) *Maintaining track and leg transitions:* The aircraft must have the capability to execute leg transitions and maintain tracks consistent with the following paths:

1) a geodesic line between two fixes;

2) a direct path to a fix;

3) a specified track to a fix, defined by a course; and

4) a specified track to an altitude.

Notes:

1. *Industry standards for these paths can be found in EUROCAE ED-75A/ RTCA DO-236B and ARINC 424, which refer to them as TF, DF, CF, and FA path terminators. Also, certain procedures require RF legs. EUROCAE ED-75A/ RTCA DO-236B and ED 77/ DO-201A describe the application of these paths in more detail.*

2. *The navigation system may accommodate other ARINC 424 path terminators (e.g. heading to manual terminator (VM)), and the missed approach procedure may use these types of paths when there is no requirement for RNP containment.*

b) *Fly-by and fly-over fixes:* The aircraft must have the capability to execute fly-by and fly-over fixes. For fly-by turns, the navigation system must limit the path definition within the theoretical transition area defined in EUROCAE ED-75B/ RTCA DO-236B and under the wind conditions identified in Doc 9905. The fly-over turn is not compatible with RNP flight tracks and will only be used when there is no requirement for repeatable paths.

c) *Waypoint resolution error:* The navigation database must provide sufficient data resolution to ensure the navigation system achieves the required accuracy. The waypoint resolution error must be less than or equal to 60 ft, including both the data storage resolution and the RNP system computational resolution used internally for construction of flight plan waypoints. The navigation database must contain vertical angles (flight path angles) stored to a resolution of hundredths of a degree, with computational resolution such that the system-defined path is within 1.5 m (5 ft) of the published path.

d) *Capability for a "direct-to" function:* The navigation system must have a "direct-to" function that the pilot can activate at any time. This function must be available to any fix. The navigation system must also be capable of generating a geodesic path to the designated "To" fix, without "S-turning" and without undue delay.

e) *Capability to define a vertical path:* The navigation system must be capable of defining a vertical path by a flight path angle to a fix. The system must also be capable of specifying a vertical path between altitude constraints at two fixes in the flight plan. Fix altitude constraints must be defined as one of the following:

   1) an "AT" or "ABOVE" altitude constraint (e.g. 2400A may be appropriate for situations where bounding the vertical path is not required);

   2) an "AT" or "BELOW" altitude constraint (e.g. 4800B may be appropriate for situations where bounding the vertical path is not required);

   3) an "AT" altitude constraint (e.g. 5200); or

   4) a "WINDOW" constraint (e.g. 2400A, 3400B).

Note.— For RNP AR APCH procedures, any segment with a published vertical path will define that path based on an angle to the fix and the altitude.

f) Altitudes and/or speeds associated with published terminal procedures must be extracted from the navigation database.

g) The system must be able to construct a path to provide guidance from the current position to a vertically constrained fix.

h) *Capability to load procedures from the navigation database:* The navigation system must have the capability to load the entire procedure(s) to be flown into the RNP system from the on-board navigation database. This includes the approach (including vertical angle), the missed approach and the approach transitions for the selected airport and runway.

i) *Means to retrieve and display navigation data:* The navigation system must provide the ability for the pilot to verify the procedure to be flown through review of the data stored in the on-board navigation database. This includes the ability to review the data for individual waypoints and for NAVAIDs.

j) *Magnetic variation:* For paths defined by a course (CF and FA path terminators), the navigation system must use the magnetic variation value for the procedure in the navigation database.

k) *Changes in navigation accuracy:* RNP changes to lower navigation accuracy must be completed by the fix defining the leg with the lower navigation accuracy, considering the alerting latency of the navigation system. Any operational procedures necessary to accomplish this must be identified.

l) *Automatic leg sequencing:* The navigation system must provide the capability to automatically sequence to the next leg and display the sequencing to the pilot in a readily visible manner.

m) A display of the altitude restrictions associated with flight plan fixes must be available to the pilot. If there is a specified navigation database procedure with a flight path angle associated with any flight plan leg, the equipment must display the flight path angle for that leg.

4.12.2.3.1.2 *Demonstration of path steering performance:* The demonstration of path steering performance (FTE) must be completed in a variety of operational conditions, i.e. rare-normal conditions and non-normal conditions (e.g. see FAA AC 120-29A, 5.19.2.2 and 5.19.3.1). Realistic and representative procedures should be used (e.g. number of waypoints, placement of waypoints, segment geometry, leg types, etc.). The non-normal assessment should consider the following:

a) Criteria for assessing probable failures during the aircraft qualification will demonstrate that the aircraft trajectory is maintained within a 1 × RNP corridor, and 22 m (75 ft) vertical. Proper documentation of this demonstration in the 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; and

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

Recommended operating procedures (relevant to sections 4.12.3 and 4.12.4) resulting from the above demonstration (e.g. one engine inoperative performance) should be documented in the AFM, AFM extension, or appropriate aircraft operational support document.

4.12.2.3.1.3 Displays

a) *Continuous display of deviation:* The navigation system must provide the capability to continuously display to the pilot flying, on the primary flight instruments for navigation of the aircraft, the aircraft position relative to the RNP defined path (both lateral and vertical deviation). The display must allow the pilot to readily distinguish if the cross-track deviation exceeds the lateral navigation accuracy (e.g. 1 × RNP) or a smaller value, and if the vertical deviation exceeds 22 m (75 ft) (or a smaller value) during RNP AR APCH operations.

Note.— The aircraft manufacturer may allocate a lateral deviation limit smaller than 1 × RNP to ensure lateral containment during RNP AR APCH operations. Likewise, the manufacturer may require a vertical deviation limit smaller than 22 m (75 ft) to ensure compliance with the vertical error budget in the procedure design.

It is recommended that an appropriately scaled non-numeric deviation display (i.e. lateral deviation indicator and vertical deviation indicator) be located in the pilot's primary optimum field of view. A fixed-scale CDI is acceptable as long as the CDI demonstrates appropriate scaling and sensitivity for the intended navigation accuracy and operation. With a scalable CDI, the scale should be derived from the selection of the lateral navigation accuracy, and not require the separate selection of a CDI scale. Alerting and annunciation limits must also match the scaling values. If the equipment uses default navigation accuracy to describe the operational mode (e.g. en route, terminal area and approach), then displaying the operational mode is an acceptable means from which the pilot may derive the CDI scale sensitivity.

Numeric display of deviation or graphic depiction on a map display, without an appropriately scaled deviation indicator, is generally not considered acceptable for monitoring deviation. The use of a numeric display or a map display may be feasible depending on the pilot workload, the display characteristics, and the pilot procedures and training. Additional initial and recurrent pilot training (or line experience) may be necessary.

b) *Identification of the active (To) waypoint:* The navigation system must provide a display identifying the active waypoint either in the pilot's primary optimum field of view, or on a readily accessible and visible display to the pilot.

c) *Display of distance and bearing:* The navigation system must provide a display of distance and bearing to the active (To) waypoint in the pilot's primary optimum field of view. Where not viable, a readily accessible page on a control display unit, readily visible to the pilot, may display the data.

d) *Display of ground speed and time to the active (To) waypoint:* The navigation system must provide the display of ground speed and time to the active (To) waypoint in the pilot's primary optimum field of view. Where not viable, a readily accessible page on a control display unit, readily visible to the pilot, may display the data.

e) *Display of To the active fix:* The navigation system must provide a To display in the pilot's primary optimum field of view.

f) *Desired track display:* The navigation system must have the capability to continuously display to the pilot flying the desired aircraft track. This display must be on the primary flight instruments for navigation of the aircraft.

g) *Display of aircraft track:* The navigation system must provide a display of the actual aircraft track (or track angle error) either in the pilot's primary optimum field of view, or on a readily accessible and visible display to the pilot.

h) *Failure annunciation:* The aircraft must provide a means to annunciate failures of any aircraft component of the RNP system, including navigation sensors. The annunciation must be visible to the pilot and located in the primary optimum field of view.

i) *Slaved course selector*: The navigation system must provide a course selector automatically slaved to the RNP computed path.

j) *RNP path display:* The navigation system must provide a readily visible means for the pilot monitoring to verify the aircraft's RNP-defined path and the aircraft's position relative to the defined path.

k) *Display of distance to go:* The navigation system must provide the ability to display distance to go to any waypoint selected by the pilot.

l) *Display of distance between flight plan waypoints:* The navigation system must provide the ability to display the distance between flight plan waypoints.

m) *Display of deviation:* The navigation system must provide a numeric display of the vertical and lateral deviation. Vertical deviation must have a resolution of 3 m (10 ft) or less for RNP AR APCH operations. Lateral deviation resolution must be:

1) 0.1NM or less for RNP operations not less than 0.3; or

2) 0.01 NM or less for RNP operations below 0.3.

n) *Display of barometric altitude:* The aircraft must display barometric altitude from two independent altimetry sources, one in each of the pilot's primary optimum field of view.

Notes:

1. *This display supports an operational cross-check (comparator monitor) of altitude sources. If the aircraft altitude sources are automatically compared, the output of the independent altimetry sources, including independent aircraft static air pressure systems, is expected to be analysed to ensure that they can provide an alert in the pilot's primary optimum field of view when deviations between the sources exceed 30 m (±100 ft). This comparator monitor function should be documented as it may eliminate the need for an operational mitigation.*

2. *When barometric vertical guidance is used, the altimeter setting input is expected to be used simultaneously by the aircraft altimetry system and by the RNP system. A single input is necessary to prevent possible crew error. Separate altimeter settings for the RNP system are prohibited.*

o) *Display of active sensors:* The aircraft must either display the current navigation sensor(s) in use or indicate sensor loss/degradation in navigation system performance. It is recommended that this display be provided in the primary optimum field of view.

Note.— This display is used to support operational contingency procedures. If such a display is not in the primary optimum field of view, pilot procedures may mitigate the requirement provided the workload is acceptable.

4.12.2.3.1.4 *Design assurance:* The system design assurance must be consistent with at least a major failure condition for the display of misleading lateral or vertical guidance on an RNP AR APCH procedure.

Note.— The display of misleading lateral or vertical RNP guidance is considered a hazardous (severe-major) failure condition for RNP AR APCHs with a navigation accuracy less than RNP-0.3. Systems designed consistent with this effect should be documented as it may eliminate the need for some operational mitigations for the aircraft.

The system design assurance must be consistent with at least a major failure condition for the loss of lateral guidance and a minor failure condition for loss of vertical guidance on an RNP AR APCH procedure.

Note.— Loss of vertical guidance is considered a minor failure condition because the pilot can take action to stop descending or climb when guidance is lost.

4.12.2.3.1.5 *Navigation database:* The aircraft navigation system must use an on-board navigation database which can receive updates in accordance with the AIRAC cycle and allow retrieval and loading of RNP AR APCH procedures into the RNP system. The RNP system must not allow the pilot to modify the data stored in the on-board navigation database.

Note.— When a procedure is loaded from the on-board navigation database, the RNP system is expected to execute the procedure as published. This does not preclude the pilot from having the means to modify a procedure already loaded into the navigation system.

4.12.2.3.1.6 The aircraft must provide a means to display the validity period of the on-board navigation database to the pilot.

4.12.2.3.2 Requirements for RNP AR approaches with RF legs

4.12.2.3.2.1 The navigation system must have the capability to execute leg transitions and maintain tracks consistent with an RF leg between two fixes/

4.12.2.3.2.2 The aircraft must have an electronic map display of the selected procedure.

4.12.2.3.2.3 The RNP system, the flight director system and autopilot must be capable of commanding a bank angle up to 25° above 121 m (400 ft) AGL and up to 8° below 121 m (400 ft) AGL.

4.12.2.3.2.4 Upon initiating a go-around or missed approach (through activation of TOGA or other means), the flight guidance mode should remain in lateral navigation to enable continuous track guidance during an RF leg.

4.12.2.3.2.5 When evaluating an FTE on RF legs, the effect of rolling into and out of the turn should be considered. The procedure is designed to provide a 5° manoeuvrability margin, to enable the aircraft to get back on the desired track after a slight overshoot at the start of the turn.

4.12.2.3.3 Requirements for RNP AR approaches to less than RNP 0.3

4.12.2.3.3.1 *No single point of failure:* No single point of failure can cause the loss of guidance compliant with the navigation accuracy associated with the approach. Typically, the aircraft must have at least the following equipment: dual GNSS sensors, dual FMS, dual air data systems, dual autopilots, and a single IRU.

Note.— For RNP AR APCH operations requiring less than 0.3 to avoid obstacles or terrain, the loss of the display of lateral guidance is considered a hazardous (severe-major) failure condition. The AFM should document systems designed consistent with this effect. This documentation should describe the specific aircraft configuration or mode of operation that achieves navigation accuracy less than 0.3. Meeting this requirement can substitute for the general requirement for dual equipment described above.

4.12.2.3.3.2 *Design assurance:* The system design assurance must be consistent with at least a major failure condition for the loss of lateral or vertical guidance on an RNP AR APCH where RNP less than 0.3 is required to avoid obstacles or terrain while executing the procedure.

4.12.2.3.3.3 *Go-around guidance:* Upon initiating a go-around or missed approach (through activation of TOGA or other means), the flight guidance mode should remain in lateral navigation to enable continuous track guidance during an RF leg. If the aircraft does not provide this capability, the following requirements apply:

a) If the aircraft supports RF legs, the lateral path after initiating a go-around (TOGA), (given a minimum 50-second straight segment between the RF end point and the DA), must be within 1° of the track defined by the straight segment through the DA point. The prior turn can be of arbitrary angular extent and radius as small as 1 NM, with speeds commensurate with the approach environment and the radius of the turn.

b) The pilot must be able to couple the autopilot or flight director to the RNP system (engage lateral navigation) by 121 m (400 ft) AGL.

4.12.2.3.3.4 *Loss of GNSS:* After initiating a go-around, or missed approach following loss of GNSS, the aircraft must automatically revert to another means of navigation that complies with the navigation accuracy.

4.12.2.3.4 Requirements for approaches with missed approach less than RNP 1.0

4.12.2.3.4.1 *Single point failure:* No single point of failure can cause the loss of guidance compliant with the navigation accuracy associated with a missed approach procedure. Typically, the aircraft must have at least the following equipment: dual GNSS sensors, dual FMS, dual air data systems, dual autopilots, and a single IRU.

4.12.2.3.4.2 *Design assurance:* The system design assurance must be consistent with at least a major failure condition for the loss of lateral or vertical guidance on an RNP AR APCH where RNP less than 1.0 is required to avoid obstacles or terrain while executing a missed approach.

Note.— For RNP AR APCH missed approach operations requiring less than 1.0 to avoid obstacles or terrain, the loss of the display of lateral guidance is considered a hazardous (severe-major) failure condition. The AFM should document systems designed consistent with this effect. This documentation should describe the specific aircraft configuration or mode of operation that achieves navigation accuracy less than 1.0. Meeting this requirement can substitute for the general requirement for dual equipment described above.

4.12.2.3.4.3 *Go-around guidance:* Upon initiating a go-around or missed approach (through activation of TOGA or other means), the flight guidance mode should remain in lateral navigation to enable continuous track guidance during an RF leg. If the aircraft does not provide this capability, the following requirements apply:

a) If the aircraft supports RF legs, the lateral path after initiating a go-around (TOGA) (given a minimum 50-second straight segment between the RF end point and the DA) must be within 1° of the track defined by the straight segment through the DA point. The prior turn can be of arbitrary angular extent and the radius as small as 1 NM, with speeds commensurate with the approach environment and the radius of the turn.

b) The pilot must be able to couple the autopilot or flight director to the RNP system (engage lateral navigation) by 121 m (400 ft) AGL.

4.12.2.3.4.4 *Loss of GNSS:* After initiating a go-around or missed approach following loss of GNSS, the aircraft must automatically revert to another means of navigation that complies with the navigation accuracy.

4.12.3 Operating Procedures

Most manufacturers have developed recommended procedures for RNP AR APCH procedures. Although the manufacturer's 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 minimize any human factors elements associated with the introduction of PBN operations.

4.12.3.1 Pre-flight considerations

4.12.3.1.1 *MEL:* The operator's MEL should be developed/revised to address the equipment requirements for RNP AR instrument procedures. Guidance for these equipment requirements is available from the aircraft manufacturer. The required equipment may depend on the intended navigation accuracy and whether the missed approach requires an RNP less than 1.0. For example, GNSS and autopilot are typically required for high navigation accuracy. Dual equipment is typically required for approaches when using a line of minima less than RNP 0.3 and/or where the missed approach has an RNP less than 1.0. An operable Class A TAWS is required for all RNP AR APCH procedures. It is recommended that the TAWS use an altitude that compensates for local pressure and temperature effects (e.g., corrected barometric and GNSS altitude), and includes significant terrain and obstacle data. The TAWS must not utilize the captain's altimeter subscale setting as the sole reference to help militate against a dual QNH setting error by the pilot. The pilot must be cognizant of the required equipment.

4.12.3.1.2 *Autopilot and flight director:* RNP AR APCH procedures with a lateral navigation accuracy of less than RNP 0.3 or with RF legs require the use of an autopilot or flight director driven by the RNP system in all cases. Thus, the autopilot/flight director must be operable and able to track the lateral and vertical paths defined by the procedure. When the dispatch of a flight is predicated on flying an RNP AR APCH procedure requiring the autopilot at the destination and/or alternate, the dispatcher must determine that the autopilot is operational.

4.12.3.1.3 *Dispatch RNP availability prediction*: The operator must have a predictive performance capability which can forecast whether or not the specified RNP will be available at the time and location of a desired RNP AR APCH procedure. This capability can be a ground service and need not be resident in the aircraft's avionics equipment. The operator must establish procedures requiring use of this capability as both a pre-flight dispatch tool and as a flight-following tool in the event of reported failures. The RNP assessment must consider the specific combination of the aircraft capability (sensors and integration).

a) RNP assessment when GNSS updating. This predictive capability must account for known and predicted outages of GNSS satellites or other impacts on the navigation system's sensors. The prediction programme should not use a mask angle below 5 degrees, as operational experience indicates that satellite signals at low elevations are not reliable. The prediction must use the actual GNSS constellation with the integrity monitoring algorithm (RAIM, AAIM, etc.) identical to that used in the actual equipment. For RNP AR APCH operations with high terrain, use a mask angle appropriate to the terrain; and

b) RNP AR APCH operations must have GNSS updating available prior to the commencement of the procedure.

4.12.3.1.4 *NAVAID exclusion:* The operator must establish procedures to exclude NAVAID facilities in accordance with NOTAMs (e.g. DMEs, VORs, localizers).

4.12.3.1.5 *Navigation database currency:* During system initialization, pilots of aircraft equipped with an RNP capable system, must confirm that the navigation database is current. Navigation databases are expected to be current for the duration of the flight. If the AIRAC cycle changes during flight, operators and pilots must establish procedures to ensure the accuracy of the navigation data, including the suitability of the navigation facilities used to define the routes and procedures for the flight. An outdated database must not be used to conduct the RNP AR APCH operation unless it has been established that any amendments to the database have no material impact on the procedure. If an amended chart is published for the procedure, the database must not be used to conduct the operation.

4.12.3.2 In-flight considerations

4.12.3.2.1 *Modification of the flight plan:* Pilots are not authorized to fly a published RNP AR APCH procedure unless it is retrievable by the procedure name from the aircraft navigation database and conforms to the charted procedure. The lateral path must not be modified, with the exception of:

a) Accepting a clearance to go direct to a fix in the approach procedure that is before the FAF and that does not immediately precede an RF leg.

b) Changing the altitude and/or airspeed waypoint constraints on the initial, intermediate, or missed approach segments of an approach (e.g. to apply cold temperature corrections or comply with an ATC clearance/instruction).

4.12.3.2.2 *Required list of equipment*: The pilot must have a required list of equipment for conducting RNP AR APCH operations or alternate methods to address in-flight equipment failures prohibiting RNP AR APCH procedures (e.g. a quick reference handbook).

4.12.3.2.3 *RNP management:* The pilot's operating procedures must ensure the navigation system uses the appropriate navigation accuracy throughout the approach. If multiple lines of minima associated with a different navigation accuracy are shown on the approach chart, the crew must confirm that the desired navigation accuracy is entered in the RNP system. If the navigation system does not extract and set the navigation accuracy from the on-board navigation database for each leg of the procedure, then the pilot's operating procedures must ensure that the smallest navigation accuracy required to complete the approach or missed approach is selected before initiating the procedure (e.g. before the IAF and before take-off roll). Different segments may have a different navigation accuracy, which are annotated on the approach chart.

4.12.3.2.4 *GNSS updating:* All RNP AR instrument procedures require GNSS updating of the navigation position solution. The pilot must verify that GNSS updating is available prior to commencing the RNP AR procedure. During an approach, if at any time GNSS updating is lost and the navigation system does not have the performance to continue the approach, the pilot must abandon the RNP AR APCH unless the pilot has in sight the visual references required to continue the approach.

4.12.3.2.5 *Radio updating:* Initiation of all RNP AR APCH procedures is based on the availability of GNSS updating. Except where specifically designated on a procedure as "Not Authorized", DME/DME updating can be used as a reversionary mode during the approach or missed approach when the system complies with the navigation accuracy. VOR updating is not authorized at this time. The pilot must comply with the operator's procedures for inhibiting specific facilities.

4.12.3.2.6 *Procedure confirmation:* The pilot must confirm that the correct procedure has been selected. This process includes confirmation of the waypoint sequence, reasonableness of track angles and distances, and any other parameters that can be altered by the pilot, such as altitude or speed constraints. A procedure must not be used if the validity of the navigation database is in doubt. A navigation system textual display or navigation map display must be used.

4.12.3.2.7 *Track deviation monitoring:* Pilots must use a lateral deviation indicator and/or flight director in lateral navigation mode on RNP AR APCH procedures. Pilots of aircraft with a lateral deviation indicator must ensure that lateral deviation indicator scaling (full-scale deflection) is suitable for the navigation accuracy associated with the various segments of the RNP AR APCH procedure. All pilots are expected to maintain procedure centre lines, as depicted by on-board lateral deviation indicators and/or flight guidance during all RNP operations described in this manual, unless authorized to deviate by ATC or under emergency conditions. For normal operations, cross-track error/deviation (the difference between the RNP system computed path and the aircraft position relative to the path) should be limited to ±½ the navigation accuracy associated with the procedure segment. Brief lateral deviations from this standard (e.g., overshoots or undershoots) during and immediately after turns, up to a maximum of one-times the navigation accuracy of the procedure segment are tolerable.

4.12.3.2.8 The vertical deviation must be within 22 m (75 ft) during the FAS noting that transients in excess of 75 ft above the vertical path are acceptable (e.g. configuration changes or energy management actions). Vertical deviation should be monitored above and below the vertical path; while being above the vertical path provides margin against obstacles on the final approach, continued intentional flight above the vertical path can result in a go-around decision closer to the runway and reduce the margin against obstacles in the missed approach.

4.12.3.2.9 Pilots must execute a missed approach if the lateral deviation exceeds 1 x RNP or the vertical deviation exceeds -22m (-75 ft), unless the pilot has in sight the visual references required to continue the approach.

a) Some aircraft navigation displays do not incorporate lateral and vertical deviations scaled for each RNP AR APCH operation in the primary optimum field of view. Where a moving map, low-resolution vertical deviation indicator (VDI), or numeric display of deviations are to be used, pilot training and procedures must ensure the effectiveness of these displays. Typically, this involves the demonstration of the procedure with a number of trained crews and inclusion of this monitoring procedure in the recurrent RNP AR APCH training programme.

b) For installations that use a CDI for lateral path tracking, the AFM or aircraft qualification guidance should state which navigation accuracy and operations the aircraft supports and the operational effects on the CDI scale. The pilot must know the CDI full-scale deflection value. The avionics may automatically set the CDI scale (dependent on the phase of flight) or the pilot may manually set the scale. If the pilot manually selects the CDI scale, the operator must have procedures and training in place to assure the selected CDI scale is appropriate for the intended RNP operation. The deviation limit must be readily apparent given the scale (e.g. full-scale deflection).

4.12.3.2.10 *System cross-check:* For approaches with a navigation accuracy less than RNP 0.3, the pilot must monitor the lateral and vertical guidance provided by the navigation system by ensuring it is consistent with other available data and displays that are provided by an independent means.

Note.— This cross-check may not be necessary if the lateral and vertical guidance systems have been developed consistent with a hazardous (severe-major) failure condition for misleading information and if the normal system performance supports airspace containment.

4.12.3.2.11 *Procedures with RF legs:* An RNP AR APCH procedure may require the ability to execute an RF leg to avoid terrain or obstacles. This requirement will be noted on the chart. As not all aircraft have this capability, pilots must be aware of whether or not they can conduct these procedures. When flying an RF leg, pilots must not exceed the maximum airspeeds shown in Table II-C-6-1 throughout the RF leg segment. For example, a Category C A320 must slow to 160 KIAS at the FAF or may fly as fast as 185 KIAS if using Category D minima. A missed approach prior to DA may require the segment speed for that segment be maintained.

Indicated airspeed (knots)						
Segment	*Indicated airspeed by aircraft category*					
	Cat H	*Cat A*	*Cat B*	*Cat C*	*Cat D*	*Cat E*
Initial and intermediate (IAF to FAF)	120	150	180	240	250	250
Final (FAF to DA)	90	100	130	160	185	As specified
Missed approach (DA to MAHF)	90	110	150	240	265	As specified
Airspeed restriction*	As specified					
**RNP AR APCH procedure design may use airspeed restriction to reduce the RF turn radius regardless of aircraft category. Operators therefore need to ensure they comply with the limiting speed for planned RNP AR APCH operations under all operating configurations and conditions.*						

Table II-C-6-1. Maximum airspeed by segment and category

4.12.3.2.12 *Temperature compensation:* For aircraft with temperature compensation capabilities, approved operating procedures may allow pilots to disregard the temperature limits on RNP AR APCH procedures if the operator provides pilot training on the use of the temperature compensation function. Temperature compensation by the system is applicable to the baro-VNAV guidance and is not a substitute for the pilot compensating for the cold temperature effects on minimum altitudes or the DA. Pilots should be familiar with the effects of the temperature compensation on intercepting the compensated path described in *EUROCAE-ED075B/ RTCA DO-236B Appendix H.*

Note. – When using GNSS vertical guidance on RNP AR operations (e.g. SBAS or GBAS), the temperature limits for the procedure do not apply. However, the pilot may still need to compensate for the cold temperature effects on minimum altitudes or the DA.

4.12.3.2.13 *Altimeter setting:* RNP AR APCH IAPs use barometric data to derive vertical guidance. The pilot must ensure that the current local QNH is set prior to the FAF. Remote altimeter settings are not permitted.

4.12.3.2.14 *Altimeter cross-check*: The pilot must complete an altimetry cross-check ensuring both pilots' altimeters agree within 30 m (±100 ft) prior to the FAF but no earlier than the IAF on approach. If the altimetry cross-check fails then the procedure must not be continued. If the avionics systems provide a comparator warning system for the pilots' altimeters, the pilot procedures should address actions to take if a comparator warning for the pilots' altimeters occurs while conducting an RNP AR APCH procedure.

Notes:

1. This operational cross-check is not necessary if the aircraft automatically compares the altitudes to within 30 m (100 ft) (see also 4.12.2.3.1.3, Displays, (n) Display of barometric altitude).
2. This operational check is not necessary when the aircraft uses GNSS vertical guidance (e.g. SBAS or GBAS).

4.12.3.2.15 *VNAV altitude transitions:* The aircraft barometric VNAV system provides fly-by vertical guidance and may result in a path that starts to intercept the vertical path of the procedure prior to the FAF. The small vertical displacement which may occur at a vertical constraint (e.g. the FAF is considered operationally acceptable, providing a smooth transition to the next flight path vertical segment. This momentary deviation below the published minimum procedure altitude is acceptable provided the deviation is limited to no more than 30 m (100 ft) and is a result of a normal VNAV capture. This applies to both "level off" or "altitude acquire" segments following a climb or descent, or vertical climb or descent segment initiation, or joining of climb or descent paths with different gradients.

4.12.3.2.16 *Non-standard climb gradient:* When an approach procedure specifies a non-standard climb gradient, the operator must ensure the aircraft is capable of complying with the published climb gradient at the aircraft landing weight under ambient atmospheric conditions.

4.12.3.2.17 *Go-around or missed approach:* Where possible, the missed approach will require a navigation accuracy of RNP 1.0. The missed approach portion of these procedures is similar to a missed approach of an RNP APCH approach. Where necessary, navigation accuracy less than RNP 1.0 will be used in the missed approach. Approval to conduct these approaches, equipage and procedures must meet criteria in 4.12.2.3.4 "Requirements for approaches with missed approach less than RNP 1.0".

4.12.3.2.18 In some aircraft, activating TOGA during the initiation of a go-around or missed approach may cause a change in lateral navigation mode or functionality, (i.e. TOGA disengages the autopilot and flight director from lateral navigation guidance) and track guidance may revert to track-hold derived from the inertial system. In such cases, lateral navigation guidance to the autopilot and flight director should be re-engaged as quickly as possible.

4.12.3.2.19 The pilot procedures and training must address the impact on navigation capability and flight guidance if the pilot initiates a go-around while the aircraft is in a turn. When initiating an early go-around, the pilot must ensure adherence to the published track unless ATC has issued a different clearance. The pilot should also be aware that RF legs are designed for a maximum ground speed. Initiating an early go-around at speeds higher that those considered in the design, may cause the aircraft to diverge throughout the turn and require pilot intervention to maintain the path.

4.12.3.2.20 *Contingency procedures — failure while en route:* The aircraft RNP capability is dependent on operational aircraft equipment and GNSS. The pilot must be able to assess the impact of equipment failure on the anticipated RNP AR APCH procedure and take appropriate action. As described in 6.3.4.1.3, "Dispatch RNP availability prediction", the pilot also must be able to assess the impact of changes in the GNSS constellation and take appropriate action.

4.12.3.2.21 *Contingency procedures — failure on approach:* The operator's contingency procedures need to address the following conditions: Failure of the RNP system components, including those affecting lateral and vertical deviation performance (e.g. failures of a GPS sensor, the flight director or automatic pilot); and loss of navigation SIS (loss or degradation of external signal).

4.12.4 Flight crew/dispatcher knowledge and training

4.12.4.1 The operator must provide training for key personnel (e.g. flight crew and dispatchers) in the use and application of RNP AR APCH procedures. A thorough understanding of the operational procedures and best practices is critical to the safe operation of aircraft during RNP AR APCH operations. This programme shall provide sufficient detail on the aircraft's navigation and flight control systems to enable the pilots to identify failures affecting the aircraft's RNP capability and the appropriate abnormal/emergency procedures. Training shall include both knowledge and skill assessments of the crew members' and dispatchers' duties. The amount of training will vary depending on the flight crew's previous area navigation experience; however, the following guidelines are provided:

a) *Ground training:* Ground training including computer-based training and classroom briefing shall include all required elements of the syllabus detailed in 4.12.4.3

b) *Simulator training:* Briefings and simulator sessions should cover all elements of the intended operation or the minimum number of approaches stipulated in 4.12.4.4. 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-around, 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 APCH simulator training is listed in Appendix D.

4.12.4.2 Operator responsibilities

a) Each operator is responsible for the training of pilots for the specific RNP AR APCH operations exercised by the operator. The operator must include training on the different types of RNP AR APCH procedures and required equipment. Training must include discussion of RNP AR APCH regulatory requirements. The operator must include these requirements and procedures in their flight operations and training manuals (as applicable). This material must cover all aspects of the operator's RNP AR APCH operations including the applicable operational authorization. An individual must have completed the appropriate ground and or flight training segment before engaging in RNP AR APCH operations.

b) Flight training segments must include training and checking modules representative of the type of RNP AR APCH procedures the operator conducts during line-oriented flying activities. Many operators may train for RNP AR APCH procedures under the established training standards and provisions for advanced qualification programmes. They may conduct evaluations in LOFT scenarios, selected event training scenarios or in a combination of both. The operator may conduct required flight training modules in flight training devices, aircraft simulators, and other enhanced training devices as long as these training devices accurately replicate the operator's equipment and RNP AR APCH operations.

c) Operators must address initial RNP AR APCH training and qualifications during initial, transition, upgrade, recurrent, differences, or stand-alone training and qualification programmes in the respective qualification category. The qualification standards assess each pilot's ability to properly understand and use RNP AR procedures (RNP AR APCH initial evaluation). The operator must also develop recurrent qualification standards to ensure their pilots maintain appropriate RNP AR APCH operations knowledge and skills (RNP AR APCH recurrent qualification).

d) Operators may address RNP AR APCH operation topics separately or integrate them with other curriculum elements. For example, an RNP AR APCH pilot qualification may focus on a specific aircraft during transition, upgrade, or differences courses. General training may also address RNP AR APCH qualification, e.g. during recurrent training or checking events such as recurrent proficiency check/proficiency training, line-oriented evaluation or special purpose operational training. A separate, independent RNP AR APCH operations qualification programme may also address RNP AR APCH training, e.g. by completion of an applicable RNP AR APCH curriculum at an operator's training centre or at designated crew bases.

e) Operators intending to receive credit for RNP training, when their proposed programme relies on previous training (e.g. special RNP IAPs), must receive specific authorization from their principal operations inspector/flight operations inspector. In addition to the current RNP training programme, the air carrier will need to provide differences training between existing training programme and the RNP AR APCH training requirements.

f) Training for flight dispatchers must include: the explanation of the different types of RNP AR APCH procedures, the importance of specific navigation equipment and other equipment during RNP AR APCH operations and the RNP AR APCH regulatory requirements and procedures. Dispatcher procedure and training manuals must include these requirements (as applicable). This material must cover all aspects of the operator's RNP AR operations including the applicable authorizations (e.g. Operations specifications, OM, MSpecs or LOA). An individual must have completed the appropriate training course before engaging in RNP AR APCH operations. Additionally, the dispatchers' training must address how to determine: RNP AR APCH availability (considering aircraft equipment capabilities), MEL requirements, aircraft performance, and navigation signal availability (e.g. GPS RAIM/predictive RNP capability tool) for destination and alternate airports.

4.12.4.3 Ground training segments content

4.12.4.3.1 Ground training segments must address the following subjects, as training modules, in an approved RNP AR APCH training programme during the initial introduction of a crew member to RNP AR APCH systems and operations. For recurrent programmes, the curriculum need only review initial curriculum requirements and address new, revised, or emphasized items.

4.12.4.3.2 General concepts of RNP AR APCH operation. RNP AR APCH training must cover RNP AR APCH systems theory to the extent appropriate to ensure proper operational use. The pilot must understand basic concepts of RNP AR APCH systems operation, classifications, and limitations. The training must include general knowledge and operational application of RNP AR procedures. This training module shall address the following specific elements:

a) definition of RNP AR APCH;

b) the differences between RNAV and RNP;

c) the types of RNP AR APCH procedures and familiarity with the charting of these procedures;

d) the programming and displaying of RNP and aircraft specific displays (e.g. actual navigation performance (ANP display));

e) how to enable and disable the navigation updating modes related to RNP;

f) the navigation accuracy appropriate for different phases of flight and RNP AR APCH procedures and how to select the navigation accuracy, if required;

g) the use of GPS RAIM (or equivalent) forecasts and the effects of RAIM availability on RNP AR APCH procedures (pilot and dispatchers);

h) when and how to terminate RNP navigation and transfer to traditional navigation due to loss of RNP and/or required equipment;

i) how to determine database currency and whether it contains the navigational data required for use of GNSS waypoints;

j) explanation of the different components that contribute to the TSE and their characteristics (e.g. effect of temperature on baro-VNAV and drift characteristics when using IRU with no radio updating); and

k) temperature compensation — pilots operating avionics systems with compensation for altimetry errors introduced by deviations from ISA may disregard the temperature limits on RNP AR APCH procedures, if pilot training on the use of the temperature compensation function is provided by the operator and the compensation function is utilized by the crew. However, the training must also recognize the temperature compensation by the system is applicable to the VNAV guidance and is not a substitute for the pilot compensating for the cold temperature effects on minimum altitudes or the DA.

4.12.4.3.3 *ATC communications and coordination for use of RNP AR APCH:* Ground training must instruct the pilots on proper flight plan classifications and any ATC procedures applicable to RNP AR APCH operations. The pilots must receive instructions on the need to advise ATC immediately when the performance of the aircraft's navigation system is no longer suitable to support continuation of an RNP AR APCH procedure. Pilots must also know what navigation sensors form the basis for their RNP AR APCH compliance, and they must be able to assess the impact of a failure of any avionics or a known loss of ground systems on the remainder of the flight plan.

4.12.4.3.4 *RNP AR APCH equipment components, controls, displays, and alerts:* Academic training must include a discussion of RNP terminology, symbology, operation, optional controls, and display features including any items unique to an operator's implementation or systems. The training must address applicable failure alerts and equipment limitations. The pilots and dispatchers should achieve a thorough understanding of the equipment used in RNP operations and any limitations on the use of the equipment during those operations.

4.12.4.3.5 *AFM information and operating procedures:* The AFM or other aircraft eligibility evidence must address normal and abnormal flight crew operating procedures, responses to failure alerts, and any equipment limitations, including related information on RNP modes of operation. Training must also address contingency procedures for loss or degradation of RNP capability. The flight operations manuals approved for use by the pilots (e.g. FOM or POH) should contain this information.

4.12.4.3.6 *MEL operating provisions:* Pilots must have a thorough understanding of the MEL requirements supporting RNP AR APCH operations.

4.12.4.4 Flight training segments – content

4.12.4.4.1 Training programmes must cover the proper execution of RNP AR APCH procedures in concert with the OEM's documentation. The operational training must include: RNP AR APCH procedures and limitations; standardization of the set-up of the cockpit's electronic displays during an RNP AR APCH procedure; recognition of the aural advisories, alerts and other annunciations that can impact compliance with an RNP AR APCH procedure; and the timely and correct responses to loss of RNP AR APCH capability in a variety of scenarios, embracing the scope of the RNP AR APCH procedures which the operator plans to complete. Such training may also use approved flight training devices or simulators. This training must address the following specific elements:

a) Procedures for verifying that each pilot's altimeter has the current setting before beginning the final approach of an RNP AR APCH procedure, including any operational limitations associated with the source(s) for the altimeter setting and the latency of checking and setting the altimeters approaching the FAF;

b) The use of aircraft radar, TAWS, GPWS, or other avionics systems to support the pilot's track monitoring and weather and obstacle avoidance;

c) The effect of wind on aircraft performance during RNP AR APCH procedures and the need to remain within RNP containment area, including any operational wind limitation and aircraft configuration essential to safely complete an RNP AR procedure;

d) The effect of ground speed on compliance with RNP AR APCH procedures and bank angle restrictions impacting the ability to remain on the course centre line. For RNP AR APCH procedures, aircraft are expected to maintain the standard speeds associated with the applicable category;

e) The relationship between RNP and the appropriate approach minima line on an approved published RNP AR APCH procedure and any operational limitations noted on the chart, e.g. temperature limits, RF leg requirements or loss of GNSS updating on approach;

f) Concise and complete pilot briefings for all RNP AR APCH procedures and the important role CRM plays in successfully completing an RNP AR APCH procedure;

g) Alerts from the loading and use of improper navigation accuracy data for a desired segment of an RNP AR procedure;

h) The performance requirement to couple the autopilot/flight director to the navigation system's lateral and vertical guidance on RNP AR APCH procedures requiring an RNP of less than RNP 0.3;

i) The importance of aircraft configuration to ensure the aircraft maintains any required speeds during RNP AR procedures;

j) The events triggering a missed approach when using the aircraft's RNP capability;

k) Any bank angle restrictions or limitations on RNP AR APCH procedures;

l) The potentially detrimental effect on the ability to comply with an RNP AR APCH procedure when reducing the flap setting, reducing the bank angle or increasing airspeed;

m) Pilot knowledge and skills necessary to properly conduct RNP AR APCH operations;

n) Programming and operating the FMC, autopilot, auto throttles, radar, GPS, INS, EFIS (including the moving map), and TAWS in support of RNP AR APCH procedures;

o) The effect of activating TOGA while in a turn;

p) FTE monitoring and impact on go-around decision and operation;

q) Loss of GNSS during a procedure;

r) Performance issues associated with reversion to radio updating and limitations on the use of DME and VOR updating; and

s) Flight crew contingency procedures for a loss of RNP capability during a missed approach. Due to the lack of navigation guidance, the training should emphasize the flight crew contingency actions that achieve separation from terrain and obstacles. The operator should tailor these contingency procedures to their specific RNP AR APCH procedures.

4.12.4.5 Evaluation module

4.12.4.5.1 *Initial evaluation* of RNP AR APCH operations knowledge and procedures. The operator must evaluate each individual pilot's knowledge of RNP AR APCH procedures prior to employing RNP AR APCH procedures as appropriate. As a minimum, the review must include a thorough evaluation of pilot procedures and specific aircraft performance requirements for RNP AR APCH operations. An acceptable means for this initial assessment includes one of the following:

a) an evaluation by an authorized instructor/evaluator or check-airman using an approved simulator or training device;

b) an evaluation by an authorized instructor/evaluator or check-airman during line operations, training flights, proficiency checks, practical tests events, operating experience, route checks, and/or line checks; or

c) LOFT/LOE programmes using an approved simulator that incorporates RNP operations that employ the unique RNP AR APCH characteristics (i.e. RF legs, RNP missed approach) of the operator's approved procedures.

4.12.4.5.2 *Evaluation content.* Specific elements that must be addressed in this evaluation module are:

a) demonstrate the use of any RNP limits that may impact various RNP AR APCH procedures;

b) demonstrate the application of radio-updating procedures, such as enabling and disabling ground-based radio updating of the FMC (i.e. DME/DME and VOR/DME updating) and knowledge of when to use this feature. If the aircraft's avionics do not include the capability to disable radio updating, then the training must ensure the pilot is able to accomplish the operational actions that mitigate the lack of this feature;

c) demonstrate the ability to monitor the actual lateral and vertical flight paths relative to the programmed flight path and complete the appropriate flight crew procedures when exceeding a lateral or vertical FTE limit;

d) demonstrate the ability to read and adapt to a RAIM (or equivalent) forecast, including forecasts predicting a lack of RAIM availability;

e) demonstrate the proper set-up of the FMC, the weather radar, TAWS, and moving map for the various RNP AR APCH operations and scenarios the operator plans to implement;

f) demonstrate the use of pilot briefings and checklists for RNP AR APCH operations, as appropriate, with emphasis on CRM;

g) demonstrate knowledge of and ability to perform an RNP AR APCH missed approach procedure in a variety of operational scenarios (e.g. loss of navigation or failure to acquire visual conditions);

h) demonstrate speed control during segments requiring speed restrictions to ensure compliance with an RNP AR APCH procedures;

i) demonstrate competent use of RNP AR APCH procedure plates, briefing cards, and checklists;

j) demonstrate the ability to complete a stable RNP AR APCH operation including bank angle, speed control, and remain on the procedure's centre line; and

k) knowledge of the operational limit for deviation below the desired flight path on an RNP AR APCH procedure and how to accurately monitor the aircraft's position relative to the vertical flight path.

4.12.4.6 Recurrent training

4.12.4.6.1 The operator should incorporate recurrent RNP training that employs the unique AR characteristics of the operator's approved procedures as part of the overall programme.

4.12.4.6.2 A minimum of two RNP AR APCHs, as applicable, 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.

Note. – Equivalent RNP approaches may be credited toward this requirement.

4.12.5 Navigation database

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

4.12.5.2 Any RNP AR APCH in the database shall 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) comparing subsequent database updates with the validated master to ensure that there are no discrepancies.

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

4.12.5.4 Even qualified database suppliers who comply with RTCA DO-200A/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.

4.12.5.5 The procedure stored in the navigation database defines the lateral and vertical path. Navigation database updates occur every 28 days, and the navigation data in every update are critical to the integrity of every RNP AR APCH procedure. Given the reduced obstacle clearance associated with these procedures, validation of navigation data warrants special consideration. This section provides guidance for the operator's procedures for validating the navigation data associated with RNP AR APCH procedures.

4.12.5.5.1 Data process

4.12.5.5.1.1 The operator must identify the responsible manager for the data updating process within their procedures.

4.12.5.5.1.2 The operator must document a process for accepting, verifying and loading navigation data into the aircraft.

4.12.5.5.1.3 The operator must place their documented data process under configuration control.

4.12.5.5.1.4 *Initial data validation:* The operator shall validate every RNP AR procedure before flying the procedure in instrument meteorological conditions (IMC) to ensure compatibility with their aircraft and to ensure the resulting path matches the published procedure. As a minimum, the operator must:

a) compare the navigation data for the procedure(s) to be loaded into the RNP system with the published procedure;

b) validate the loaded navigation data for the procedure, either in a simulator or in the actual aircraft in visual meteorological conditions (VMC). The depicted procedure on the map display must be compared to the published procedure. The entire procedure must be flown to ensure the path does not have any apparent lateral or vertical path disconnects, and is consistent with the published procedure; and

c) once the procedure is validated, retain and maintain a copy of the validated navigation data for comparison to subsequent data updates.

4.12.5.5.1.5 *Data updates:* Upon receipt of each navigation data update, and before using the navigation data in the aircraft, the operator must compare the update to the validated procedure. This comparison must identify and resolve any discrepancies in the navigation data. If there are significant changes (any change affecting the approach path or performance) to any portion of a procedure and source data verifies the changes, the operator must validate the amended procedure in accordance with initial data validation.

4.12.5.5.1.6 *Data suppliers:* Data suppliers must have an LOA for processing navigation data (e.g., FAA AC 20 153, EASA Conditions for the issuance of Letters of Acceptance for navigation database Suppliers by the Agency, or equivalent). An LOA recognizes the data supplier as one whose data quality, integrity and quality management practices are consistent with the criteria of DO-200A/ED-76. The operator's supplier (e.g. the FMS company) must have a Type 2 LOA, and their respective suppliers must have a Type 1 or 2 LOA.

4.12.5.5.1.7 *Aircraft modifications:* If an aircraft system required for RNP AR APCH operations is modified (e.g. software change), the operator is responsible for validating of RNP AR APCH procedures using the navigation database and the modified system. This may be accomplished without any direct evaluation if the manufacturer verifies that the modification has no effect on the navigation database or path computation. If no such assurance from the manufacturer is available, the operator must conduct an initial data validation using the modified system noting that flight control computers, FMS OPS and display software changes are particularly critical.

4.12.6 TAWS database

The procedure validation process should include a compatibility check with the installed TAWS. The TAWS data should only be obtained from a qualified source and operators should have procedures in place for the management of the TAWS data.

4.12.7 Safety assessments

4.12.7.1 The RNP AR procedure design criteria in assume that any event leading the aircraft to exit the lateral (2 x RNP) 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 *(refer section 4.12.2.1.7 and 4.12.2.3.1.2*).

4.12.7.2 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.

4.12.7.3 Operators should ensure that the aircraft compliance documented in the airworthiness approval or the demonstrated compliance performed during the operational approval properly satisfies the 10^{-7} RNP AR lateral and vertical airspace containment limits. The operator shall 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 the CAAM decides 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.

4.12.7.4 The operator shall provide a clear statement as to whether the aircraft State of Design approval has included the demonstration of compliance in the airworthiness approval of the aircraft or whether demonstration of compliance will be the operator's responsibility to be satisfied during the operational approval.

a) If the published RNP AR value in the operator'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 operator is able to give evidence through documentation obtained from the aircraft manufacturer qualification dossier.

b) If the published RNP AR value in the operator'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 CAAM requires a demonstration from the operator, 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 programme.

4.12.8 Flight operational safety assessment (FOSA)

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 Appendix 4.

4.12.9 Documentation supporting the application for approval

4.12.9.1 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.

4.12.9.2 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.

4.12.10 Oversight of operators

4.12.10.1 The CAAM considers any anomaly reports in determining remedial action. Repeated navigation error occurrences attributed to a specific piece of navigation equipment may result in the cancellation of the approval for use of that equipment.

4.12.10.2 Information that indicates the potential for repeated errors may require modification of an operator's training programme. Information that attributes multiple errors to a particular pilot crew may necessitate remedial training or licence review.

4.12.10.3 Operators must have an RNP monitoring programme to ensure continued compliance with the guidance of this chapter and to identify any negative trends in performance. At a minimum, this programme must address the following information. During the interim approval, operators must submit the following information every 30 days to the authority granting their authorization. Thereafter, operators must continue to collect and periodically review these data to identify potential safety concerns, as well as maintain summaries of these data:

a) total number of RNP AR APCH procedures conducted;

b) number of satisfactory approaches by aircraft/system (satisfactory if completed as planned without any navigation or guidance system anomalies);

c) reasons for unsatisfactory approaches, such as:

   1) UNABLE REQ NAV PERF, NAV ACCUR DOWNGRAD, or other RNP messages during approaches;

   2) excessive lateral or vertical deviation;

   3) TAWS warning;

   4) autopilot system disconnect;

   5) navigation data errors; and

   6) pilot report of any anomaly;

d) crew comments.

4.12.11 Job Aid – **RNP AR** Specific Elements

Part 1. Operator application

Amend rows:

Annex	***Title***	***Inclusion by Operator***	***Comments by Inspector***
C	**Aircraft eligibility – modifications (if applicable)** Maintenance records documenting installation or modification of aircraft systems to achieve eligibility. *Note: If aircraft were not delivered in an RNP AR operations compliant state, provide details as to how each aircraft was modified to become RNP AR compliant. Where possible, reference should be made to aircraft OEM documentation.*		
D	**Continuing Airworthiness** Navigation database and RNP AR APCH system maintenance practices. Provide details of procedures for: — Revising the electrical load analysis for each aircraft when it is modified, and the electrical load is changed. — Assessing modification documentation and managing the aircraft configuration; including procedures to modify any affected synthetic training devices (aircraft simulators or other training systems). — Software configuration management to an individual aircraft level. Aircraft operational data updating procedures e.g. navigation, terrain, SATCOM calling databases.		
I	**Navigation database** Validation programme and procedures		
J	**Withdrawal of approval** Possibility of withdrawal of approval following navigation error reports.		
K	**Monitoring programme** Data collection plan		

L	**Flight operational safety assessment (FOSA)** An established methodology for a formal safety assessment of the proposed operation.		

Part 2. Contents of the Operator application

#	Topic	Specific ICAO reference	CAAM guidance/ reference	Operator compliance description	Inspector disposition/ comments	Follow-up by inspector (optional)
		(ICAO Doc 9613, Volume II, Part C, Chapter 6)	(CAD/CAGM , etc.)	(Document reference/ method	(Accepted/not accepted)	(Status and date)
1	**Authorization request** Statement of intent to obtain authorization.					
2	**Aircraft/navigation system eligibility** Documents that establish eligibility.	6.3.2.5				
3	**Training** Details of courses completed (part 91 operators). Details of training programmes (part 121 and part 135 operators).	6.3.2.6.2 6.3.5				
4	**Operating policies and procedures** Extracts from the operations manual or other documentation (Part 91 operators). Operations manual and checklists (part 121 and part 135 operators.	6.3.2.6.3				
5	**Maintenance practices** Document navigation database maintenance practices.	6.3.2.6.5 6.3.6				
6	**MEL update**	6.3.2.6.4				

Part 3. Operating procedures

#	Topic	Specific ICAO reference	CAAM guidance/ reference	Operator compliance description	Inspector disposition/ comments	Follow-up by inspector (optional)
		(ICAO Doc 9613, Volume II, Part C, Chapter 6)	(CAD/CAGM, etc.)	(Document reference/ method	(Accepted/not accepted)	(Status and date)
1	**Flight planning**					
1a	Verify that the aircraft and crew are approved for RNP AR operations.	6.3.2				
1b	If dispatch predicated on procedure with RF leg, verify AP/FD is operational.	Appendix 1 to Part C 5.5.3				
1c	Verify MEL.	6.3.4.1.1				
1d	Verify RNP availability	6.3.4.1.3				
1e	Verify procedures for NAVAID exclusion.	6.3.4.1.4				
1f	Verify that the navigation database is current.	6.3.4.1.5				
1g	Review contingency procedures/options.	6.3.4.2.20 6.3.4.2.21				
1h	Verify FPL: "R" should appear in field 10 and PBN/T1 or T2 in field 18.					
2	**Prior to commencing procedure**					
2a	Verify that the correct procedure is 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 the chart with the RNAV system display.	6.3.4.2.1 6.3.4.2.6				
2d	Verify the GNSS sensor in use (only for multi-sensor systems).	6.3.4.2.4				

2e	Input specific NAVAIDS as required.	6.3.4.2.5				
2f	Modify only 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 that the aircraft is capable of complying with the missed approach climb gradient.	6.3.4.2.16				
3	**During procedure**					
3a	Maintain centre line; monitor track deviation; lateral deviation limited to ± ½ navigation accuracy (up to 1xRNP in fly-by turns). Execute missed approach if 1xRNP is exceeded.	6.3.4.2.7				
3b	Maintain vertical path; monitor vertical deviation – limited to -22 m (-75 ft). Execute a missed approach if -22 m (-75 ft) is exceeded.	6.3.4.2.8 6.3.4.2.9				
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 legs.	6.3.4.2.11				
3e	Apply temperature compensation as appropriate.	6.3.4.3.12				
3f	Ensure that the local QNH is set before FAF.	6.3.4.2.13				
3g	Cross-check altimeters after IAF and before FAF ±30 m (±100 ft).	6.3.4.2.14				

3h	Do not exceed 30 m (100 ft) vertical deviation at VNAV capture.	6.3.4.2.15				
3i	If LNAV is disengaged at TOGA, re-engage 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 the manufacturer's instructions/procedures.	6.3.4.2.5				
3l	Use FD and/or AP.	6.3.4.2.7				
4	**RF requirements**					
4a	Be established on procedure prior to RF leg.	Appendix 1 to Part C 5.5.5				
4b	Cross-track deviation not to exceed ½ RNP.	Appendix 1 to Part C 5.5.6				
4c	Do not exceed maximum airspeed associated with design.	Appendix 1 to Part C 5.5.7				

Part 4. Contingency procedures

#	Topic	Specific ICAO reference	CAAM guidance/ reference	Operator compliance description	Inspector disposition/ comments	Follow-up by inspector (optional)
		(Doc 4444, Chapter 15)	*(CAD/CAGM, etc.)*	*(Document reference/ method*	*(Accepted/not accepted)*	*(Status and date)*
1	**Contingencies**					
1a	Advise ATC if unable to comply with the requirements for an RNP AR APCH.	15.2.1.1				
1b	Air-ground communications failure.	15.3				
1c	If unable to follow RF turn due to system failure, maintain bank and roll out on charted exit course. Inform ATC.	ICAO Doc 9613, Volume II, Appendix 1 to Part C 5.5.8				

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5 Appendices

5.1 Appendix 1 – Area Navigation Systems

1 General

1.1 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 has a direct impact on 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.

1.2 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.

1.3 Area navigation enables the aircraft to fly a path, or "leg", between points, called "waypoints", which are not necessarily co-located with ground-based navigation aids. If a navigation database is included in the area navigation system then the data in the database are specific to an operator's requirements. These data are 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.

1.4 The intended flight path is displayed to the pilot. Lateral and, where available, vertical guidance are 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).

1.5 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, utilizing 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.

2 Guidance and control

2.1 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.

2.2 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.

3 Navigation database

3.1 Operators purchase the navigation data from third-party companies, known as data houses, which 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 databases 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.

3.2 If the data in the dataset are 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.

4 RNAV waypoints

4.1 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 use only significant points that are defined by geographic coordinates in WGS-84 and data houses convert fixes into “computer navigation fixes” with associated coordinates. Fixes are associated only 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.

4.2 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) flyover;

b) fly-by;

c) fixed radius.

4.3 A flyover waypoint requires that the turn is initiated when the aircraft passes overhead the waypoint. All area navigation systems are capable of a flyover 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 ground speed 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.

4.4 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 are not available on many older RNAV systems.

5 RNAV Performance

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

5.1 Accuracy

5.1.1 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).

5.1.2 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 one-half 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.

5.1.3 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.

5.1.4 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 appropriate only 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 ± 1 NM 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.

5.1.5 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.

5.2 Integrity

5.2.1 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.

5.2.2 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.

5.2.3 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 pre-set threshold value (horizontal alert limit (HAL)). This is known as fault detection (FD) and requires a minimum of five 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 six 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 centred 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 pre-set threshold values are breached. SBAS detects GPS satellite signal errors and broadcasts corrections to all users.

5.3 Availability and continuity

5.3.1 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.

5.3.2 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 an NSE monitoring and alerting algorithm, which generates an alert, and displays FTE via a lateral deviation indicator, which is monitored by the crew.

5.3.3 Functionality

5.3.3.1 The following 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 field 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.

5.3.3.2 Each navigation specification identifies additional functionalities which may include:

a) non-numeric lateral and vertical deviation displays in the primary field of view, automatically saved to the area navigation computed path and with full-scale deflection based upon the required TSE;

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, flyover, turn at altitude);

g) execute leg transitions and maintain tracks consistent with ARINC 4241 path terminators (CA, CF, DF, FA, FM, HA, HF, HM, IF, RF, VA, VI and VM);

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.

5.3.4 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 and 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 and V/DEV, together with FD and/or AP, are required for low RNP accuracy values.

5.2 Appendix 2 – Example Regulatory text

XXX.001 APPLICATION FOR A SPECIFIC APPROVAL

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

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

b) An applicant for a specific approval shall provide evidence to the Civil Aviation Authority of Malaysia that:

   1) the applicant complies with the requirements;
   2) the aircraft and required equipment fulfil the applicable airworthiness requirements, are maintained according to the approved maintenance programme and are approved when required;
   3) a training programme has been established for flight crew and, as applicable, personnel involved in these operations; and
   4) 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 procedure's 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 CHANGER 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 Civil Aviation Authority of Malaysia and obtain prior approval for the change to operation, documented by an amendment to the approval document 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 be operated only 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 Civil Aviation Authority of Malaysia.

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 database integrity requirements can be found in this CAD, ICAO PBN manual (ICAO Doc 9613) 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	×								AC 91-001	EASA AMC 20-12 FAA AC 90-105( )
RNAV 5		×							AC 91-002	EASA AMC 20-4 FAA AC 90-105( )
RNP 4	×								AC 91-004	FAA AC 90-105( )
RNP 2		×	×						TBD	FAA AC 90-105( )
RNAV 2		×	×						AC 91-003	EASA TBA FAA AC 90-100( )
RNP 1			×	×	×		×	×	AC 91-006	EASA TBA FAA AC 90-105( )
RNAV 1			×	×	×		×	×	AC 91-003	EASA JAA TGL10 FAA AC 90-100( )
A-RNP		×	×	×	×	×	×	×	TBD	FAA AC 90-105( )
RNP APCH (LNAV)				×	×	×	×		AC 91-008	EASA AMC 20-27 FAA AC 90-105( )
RNP APCH (LNAV/VNAV)				×	×	×	×		AC 91-010	
RNP APCH (LP/LPV)						×	×		TBD	EASA AMC 20-28 FAA AC 90-107
RNP AR			×	×	×	×	×	×	AC 91-009	EASA AMC 20-26 FAA AC 90-101
RF			×	×	×		×	×	TBD	FAA AC 90-105( )
Electronic data management		×	×	×	×	×	×	×	TBD	EASA Part 21, Subpart G FAA AC 20-153

XXX.PBN.002 PBN OPERATIONAL APPROVAL

To be issued a PBN operational approval by the Civil Aviation Authority of Malaysia, 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:

1) the equipment to be carried, including its operating limitations and appropriate entries in the minimum equipment list (MEL);
2) flight crew composition and experience requirements;
3) normal procedures;
4) contingency procedures;
5) monitoring and incident reporting; and
6) 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 be used only once the Civil Aviation Authority of Malaysia has approved the operator's procedure 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.

5.3 Appendix 3 – Example of PBN Operations Specifications (OPS SPEC) entries

A full example of the OPS SPEC and entry details can be found in the CADXX – AOC.

Example entries for PBN are illustrated below:

SPECIFIC APPROVAL	YES	NO	DESCRIPTION	REMARKS
AR navigation specifications for PBN operations	☐	☐	RNAV 10	Primary sensor GNSS
			RNAV 5	Also valid for B-RNAV routes. Approval based upon GNSS and DME/DME.
			RNAV 1 AND 2	Also valid for P-RNAV routes/procedures.
			RNP 1	Authorized for RF legs.
			RNP APCH (LPV)	Approval based upon SBAS. Authorized for approaches to LPV, LNAV/VNAV or LNAV minima
			RNP AR APCH	RNP 0.15 Authorized for RF legs. RNP 0.2 in missed approach AP required. Dual FMS/IRS required.

5.4 Appendix 4 – Flight Operational Safety Assessments (FOSAs)

1 FOSA OVERVIEW

1.1 Why is FOSA needed?

1.1.1 In some cases, the operational needs of stakeholders lead to procedure designs which may or may not comply with Required Navigation Performance Authorization Required (RNP AR) Procedure Design Manual (ICAO Doc 9905) but which require the aircraft to be operated in a manner that was not considered in its airworthiness approval.

1.1.2 A FOSA is intended to address this nominal mismatch.

1.1.3 When RNP AR APCH is being implemented it is for a specific reason, e.g. improved access, safety, efficiency. 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.

1.2 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 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.

1.3 How should a FOSA be carried out?

1.3.1 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.

1.3.2 The functional areas presented in Figure E-1 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.

2 REQUIRED DEPTH OF A FOSA

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

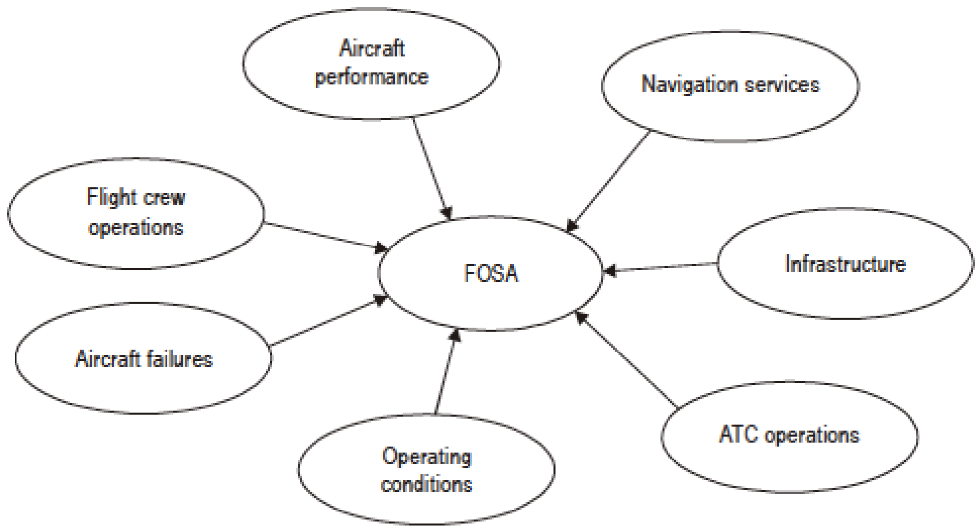

Figure E-1. Elements to consider in a FOSA

a) how challenging the proposed procedure design is relative to the airworthiness approval/qualification;
b) the operational and obstacle environment; and
c) the previous experience of stakeholders and the availability of appropriate previous safety assessments.

2.2 Airworthiness approval/qualification

2.2.1 In order to meet the RNP AR eligibility requirements, the manufacturer needs to establish that the criteria for assessing probable failures during the aircraft qualification demonstrated that the aircraft trajectory is maintained:

a) within 1 x RNP of the lateral track, 95% of the flight time; and
b) within the vertical path, 99.7% of flight time.

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

2.2.2 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.

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

Aircraft performance in the event of failures, as well as in normal conditions, should therefore be available in the AFM or an equivalent document.

2.3 Operational and obstacle environment

2.3.1 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.

2.3.2 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).

2.4 Previous experience stakeholders and availability of appropriate previous FOSAs

2.4.1 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:

a) a new procedure is being developed, or one already exists, that is flown by other carriers and/or by other aircraft types;
b) relevant FOSAs exist for the procedure or for other similar applications;
c) a carrier with an RNP-certified aircraft already has the manufacturer's 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;
d) the ANSP and regulator(s) have previous experience with RNP AR approaches and FOSA at this airport or similar locations.

2.4.2 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".

3 HOW TO CONDUCT A FOSA

3.1 Overview of the 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 Figure E-2 was 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.

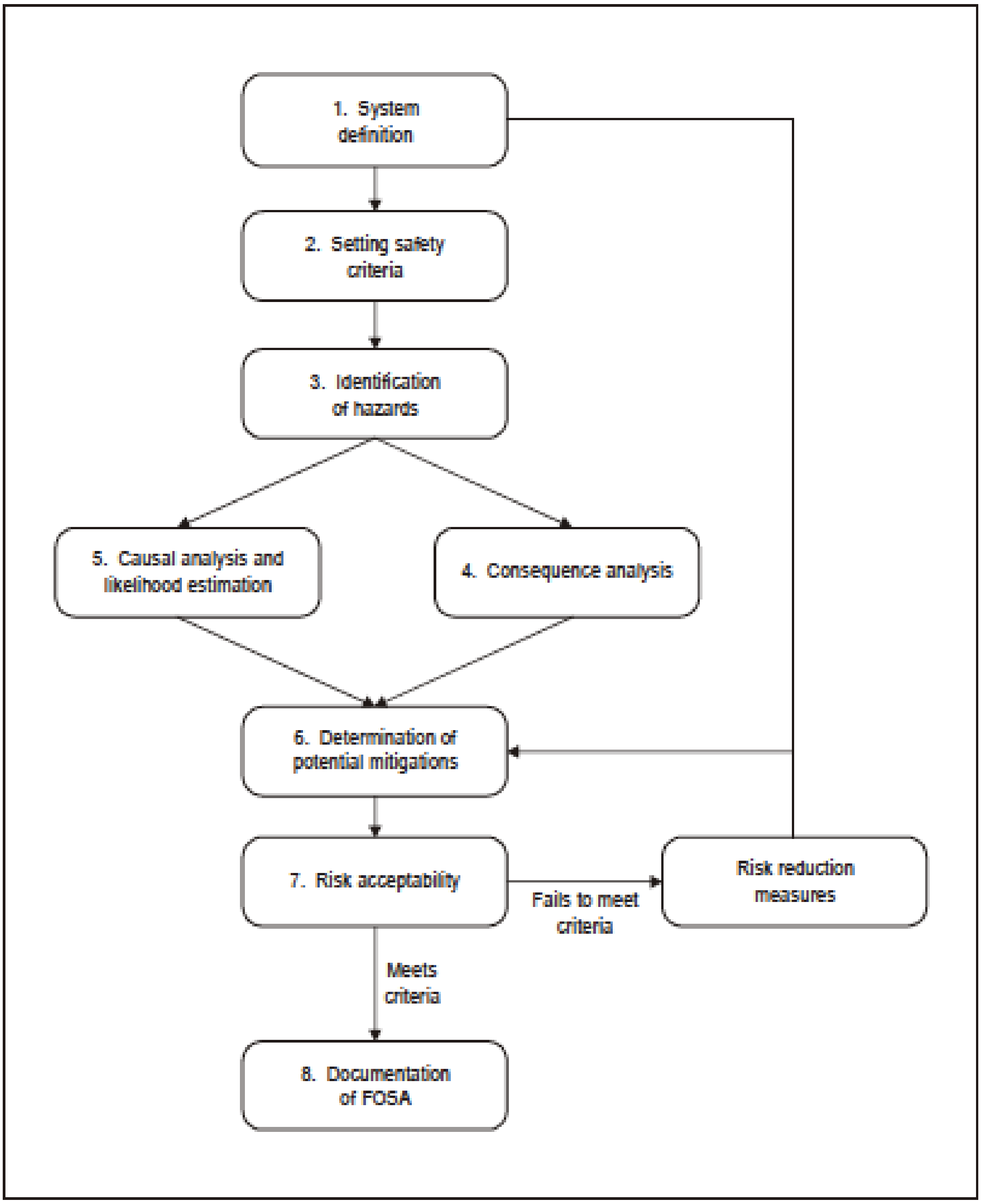

Figure E-2. Main steps in a FOSA

3.2 Details of each step

Step 1 – System definition

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

a) the proposed procedure design and details of the proposed operations including FMS coding issues;

b) 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;

c) flight crew procedures and training;
d) dispatch procedures and training;
e) proposed minimum equipment list (or RNP AR required equipment list);
f) any special maintenance requirements;
g) airport and airspace environment;
h) navigation infrastructure;
i) ATC facilities (including surveillance and communications), procedures and intended training with respect to RNP AR operations; and
j) monitoring programme.

3.2.2 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.

3.2.3 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

3.2.4 Safety criteria can be quantitative or qualitative. This CAD and the ICAO 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:

a) *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.

b) *Risk reduced as far as reasonably practicable (AFARP)*: This criterion is commonly used in aviation. It is sometimes referred to as the ALARP criterion, reducing risk as low as 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. the system as a whole has reduced the 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.

c) *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:

1) Sometimes it is very difficult even for aviation experts to compare the risks from different approach types.
2) 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.
3) Some regulations require that the ATM risk should decrease 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 from 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

3.2.5 There are a range of techniques that have been used in aviation to identify hazards. 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.

3.2.6 The following points can help maximize the effectiveness of group-based hazard identification:

a) ensure use of an experienced facilitator to guide the group;

b) gather the required mix of skills and knowledge, i.e.:

1) procedure designers;

2) aircraft and avionics manufacturers, if available;

3) technical support experts;

4) pilots (from relevant aircraft operators and test pilots if available);

5) AIM experts;

6) ATCOs and ATC representatives with knowledge of airspace planning and technical facilities; and

7) Regulators.

Representatives from other disciplines which could be useful in a FOSA include flight operations, dispatch, maintenance and safety and quality. 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

3.2.7 The manner in which the consequences 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 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.

3.2.8 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

3.2.9 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.

3.2.10 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:

a) identify and document the relevant causes of the hazard;

b) map the causal mitigations (see Step 6) to these causes;

c) consider the likelihood of these causes implicitly when judging whether the mitigations are sufficient.

3.2.11 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

3.2.12 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.

3.2.13 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) occurring at various critical locations (e.g. in the RF leg, early in the procedure potentially requiring long extraction, at DA/ DH).

3.2.14 It is usually helpful to identify mitigations that are already in place 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

3.2.15 For aircraft failure hazards, the normal airworthiness criteria from 14 CFR 25.1309 will be used along with section 4.12.2 of this CAD, i.e.:

a) Criteria for assessing probable failures during the aircraft qualification will demonstrate that the aircraft trajectory is maintained within a 1 x RNP corridor, and 22 m (75 ft) vertical. Proper documentation of this demonstration in the 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 judgement.

3.2.16 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.

5.5 Appendix 5 – Flight Simulation Training Device Functionality and Qualification for RNP AR APCH

1. 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 manufacturers (OEM) or aircraft manufacturer's design data. A statement of compliance template should be made available by the regulatory authority.

2. While there are no requirements for airport-specific models (e.g. FAA 14 CFR 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.

3. 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 programme.

4. 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 navigation 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 discrepancies
— Dual loss of GPS sensors
— FMS/GPS position disagreements
— FMS failures or downgrades

Visuals

— Ability to add airports to the visual database
— Use of generic airport with TAWS (possibility to set a generic visual with "flat terrain" in a way so as 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 does not cause spurious TAWS alerts (or flat terrain option in visual settings)

Navigation database considerations

— Procedure service provider/developer test databases and loading media
— Coordination required with multiple parties associated with process
  - Aircraft OEM
  - FMS/FGS vendor
  - Operator
  - FSTD vendor
  - Navigation 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 TAWS identical to the aircraft
- Dual FMSs, dual GPSs, dual autopilots and at least a single IRU and all must be operable
- Statement of compliance with the OEM systems included in the eligible configuration of RNP AR aircraft qualification
- Ability to load the entire RNP/AR approach procedure to be flown from the on-board 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 an 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. If the aircraft cannot remain in LNAV after TOGA is selected, then procedures to re-engage LNAV while remaining within 1 x RNP must be demonstrated and verified in the FSTD. The FSTD must permit re-engagement of LNAV by 400 ft AGL.

— Non-normal performance and functionality:
- The 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 an RNP AR APCH (e.g. FMS failure, GPS failure, AP failure, loss of guidance, loss of FD/FDE, engine failure, extreme wind/turbulence). 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 in 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 radio navigation update
  - High/low temperature impact on non-compensated baro-VNAV FPA

- Loss of GPS, GPS primary lost, navigation accuracy downgraded
- IRS drift effect.

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6 Attachments

6.1 Attachment A – PBN Application Form

6.1.1 The Latest Application form (CAAM/BOP/SPA/PBN) may be obtained from the CAAM Website. https://www.caam.gov.my/e-services-forms/air-operations/