REPUBLIC OF KENYA

KENYA CIVIL AVIATION AUTHORITY

PERFORMANCE-BASED NAVIGATION (PBN) OPERATIONS MANUAL

CAA-M-GEN021

May 2018

FOREWORD

The purpose of this manual is to provide guidance on approval and operations' requirements of performance-based navigation (PBN). It is intended for use by Kenyan aircraft operators and owners seeking approval to operate in PBN airspace. The manual is also intended for use by the Authority inspectors involved in the regulation of PBN operations.

This manual supplements the existing guidance material on certification and operational approval found in the Flight Operations Inspector Manual. The manual is based on ICAO Doc 9613 as well as Doc 9997 on Performance Based Navigation Operations. The manual should therefore be read in conjunction with these two other documents.

Comments on this manual will be appreciated from all parties involved in the regulation and issuance of approvals for PBN applications.

Because of the wide scope of operations involved and the many variables that can be encountered, it is impossible to anticipate all situations; therefore, users of this manual must exercise common sense and good judgment in the application of these PBN policies and procedures. As a minimum all regulatory requirements must be met.

DIRECTOR AVIATION SAFETY, SECURITY AND REGULATION

REFERENCES

a) ICAO Doc 9613 Performance Based Navigation Manual
b) ICAO Doc 9997 PBN Operational Approval Manual
c) Civil Aviation (Operation of Aircraft) Regulations as amended
d) Civil Aviation (Instrument & Equipment) Regulations as amended

KCAA DOCUMENTS

a) FORM: KCAA/FOPS/PBN – Application Form
b) FORM: KCAA/FOPS/PBN Evaluation Approval
c) FLIGHT OPERATINS INSPECTOR MANUAL - FOIM

DOCUMENT CONTROL

Summary of Change

Edition Number	Brief Description of Change	Prepared by	Effective Date
1.0	First Edition - issued as part of the Performance-Based Navigation Operational Approval Manual.	OPS	May 2018

NOTE:
When amended, this document will be re-issued in full. Each will indicate the edition number and the effective date. The edition number should be the same on each .
When printed this document is uncontrolled. Check the Authority docushare for the current release edition.

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NO	REV. NO	EFFECTIVE DATE
1	Rev 000	May 2018
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231	Rev 000	May 2018
232	Rev 000	May 2018
233	Rev 000	May 2018
234	Rev 000	May 2018
235	Rev 000	May 2018
236	Rev 000	May 2018

TABLE OF CONTENT

OUTLINE **NO.**

ABBREVIATIONS

ABAS	Aircraft-based augmentation system
ADC	Air Data Computer
ADS-B	Automatic dependent surveillance — broadcast
ADS-C	Automated dependent surveillance — contract
AFCS	Automatic Flight Control System
AFM	Aircraft flight manual
AHRS	Attitude Heading Reference System
AIP	Aeronautical information publication
ANSP	Air navigation service provider
AOC	Air operator certificate

APCH	Approach
AP/FD	Autopilot/Flight Director
APV	Approach procedure with vertical guidance
A-RNP	Advanced Required Navigation Performance
ASE	Altimetry System Error
ATC	Air traffic control
ATM	Air traffic management
ATS	Air traffic service
AWI	Airworthiness Inspector
CAA	Civil aviation authority
CCO	Continuous climb operations
CDI	Course deviation indicator
CDO	Continuous descent operations

CDU	Control and display unit
CFIT	Controlled flight into terrain
CMM	Component Maintenance Manual
CNS	Communications, navigation and surveillance
CPDLC	Controller-Pilot Data Link Communication
DCPC	Direct Controller-Pilot Communication
DME	Distance measuring equipment
EASA	European Aviation Safety Agency
ECAC	European Civil Aviation Conference
EFIS	Electronic Flight Instrument System
EGNOS	European Global Navigation Overlay System
EPE	Estimated Position Error
EPU	Estimated Position Error
ETSO	European Technical Standard Order
EUROCAE	European Organisation for Civil Aviation Equipment
FAA	Federal Aviation Administration
FAS	Final Approach Segment
FCC	Flight Control Computer
FDE	Fault Detection and Exclusion
FGS	Flight guidance system
FMS	Flight management system
FOI	Flight Operations Inspector
FOM	Figure of Merit
FOSA	Flight Operations Safety Assessment
FRT	Fixed radius transition
FTE	Flight technical error
GA	General aviation
GBAS	Ground-based augmentation system
GLONASS	Global Navigation Satellite System

GLS	GBAS landing system
GNSS	Global navigation satellite system
GPS	Global positioning system
HF	High frequency
HAL	Horizontal Alert Limit
HDOP	Horizontal Dilution of Precision
IAF	Initial Approach Fix
IAP	Instrument approach procedure
IFP	Instrument flight procedure
ILS	Instrument landing system
INS	Inertial navigation system
IRS	Inertial reference system
IRU	Inertial reference unit
JAA	Joint Aviation Authorities
KCAA	Kenya Civil Aviation Authority
LOA	Letter of authorization/letter of acceptance
LNAV	Lateral Navigation
VNAV	Vertical Navigation
LP	Localiser Performance
LPV	Localiser Performance with Vertical Guidnace
LTP	Landing Threshold Point
LRNS	Long Range Navigation System
MAHF	Missed Approach Holding Fix
MAPt	Missed Approach Point
MCDU	Multifunction control and display unit
MDA	Minimum Descent Altitude
MEL	Minimum equipment list
MLS	Microwave landing system
MMEL	Master minimum equipment list
MMR	Multi Mode Receiver
MNPS	Minimum navigation performance specification
MSA	Minimum sector altitude
MSL	Mean sea level
NAA	National airworthiness authority
NAT	North Atlantic
NAVAID	Navigation aid
NSE	Navigation system error
OEM	Original equipment manufacturer

OM	Operations manual
PBN	Performance-based Navigation
PDE	Path Definition Error
PFD	Primary Flight Display
PinS	Point-in-Space
PSE	Position Steering Error
PSR	Primary surveillance radar
RAIM	Receiver autonomous integrity monitoring
RF	Radius to fix
RNAV	Area navigation
RNP	Required navigation performance
RNP AR	Required Navigation Performance Authorisation Required
SB	Service bulletin
SBAS	Satellite-based augmentation system
SID	Standard instrument departure
SIS	Signal-in-space
SOP	Standard operating procedures
SSR	Secondary surveillance radar
STAR	Standard Terminal Instrument Arrival Route
STC	Supplemental type certificate
TC	Type certificate
TCDS	Type Certificate Data Sheet
TCH	Threshold Crossing Height
TLS	Target level of safety
TSE	Total system error
TSO	Technical standard order
UHF	Ultra high frequency
VDOP	Vertical Dilution of Precision
VFR	Visual flight range
VHF	Very high frequency
VNAV	Vertical navigation
VOR	VHF omnidirectional radio range
VSD	Vertical Situation Display
WAAS	Wide Area Augmentation System
WGS-84	World Geodetic System – 1984
XTK	Cross Track Error / Deviation

EXPLANATION OF TERMS

Aircraft-based augmentation system (ABAS). 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.
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.

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

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

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

ATS surveillance system. 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.

Mixed navigation environment. 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. NAVAID infrastructure refers to space-based and or ground-based NAVAIDs available to meet the requirements in the navigation specification.

Navigation application. 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. 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. 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

Note.— Volume II of this manual contains detailed guidance on navigation specifications.

Performance-based navigation. 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. Air traffic control service provided by using information derived from sources other than an ATS
surveillance system.

Receiver autonomous integrity monitoring (RAIM). 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 (baro- aiding). 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. 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. 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. Aircraft operations using an RNP system for RNP navigation applications

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

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

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

Standard instrument arrival (STAR). 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). 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.

SECTION A

PBN OPERATIONAL APPROVAL

CHAPTER 1

1.1 PBN OVERVIEW

1.1.1 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.

1.1.2 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 laysout the aircraft system performance requirements but also the aircrew requirements in terms of crew procedures and training, as well as any appropriate maintenance requirements, such as the provision of navigation databases.

1.2 RNAV AND RNP

1.2.1 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.

1.2.2 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.

1.3 NAVIGATION SPECIFICATIONS

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 30 NM and above MSA.

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

c) Applies only once 50 m (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.

1.4 PBN APPLICATIONS

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

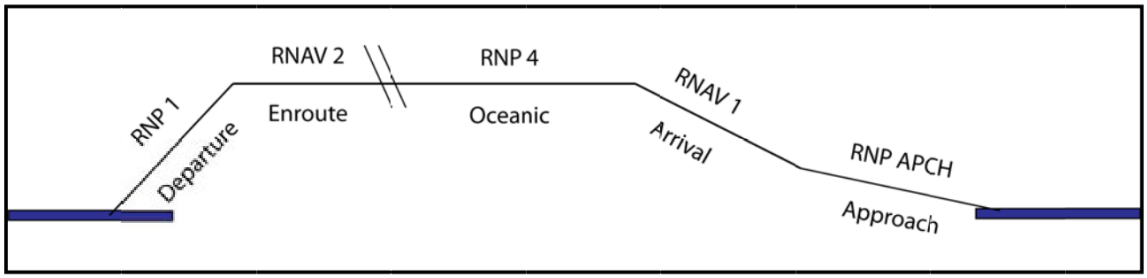


Figure 1-1. Navigation specifications to support a particular airspace concept

CHAPTER 2

2.0 CERTIFICATION AND OPERATIONAL APPROVAL

2.1 OVERVIEW

2.1.1 The PBN concept requires that the aircraft meets certain airworthiness certification standards, including the necessary navigation system performance and functionality, to be eligible for a particular application and that the operator has operational approval from an appropriate regulatory body before the system can be used.

2.1.2 A PBN navigation specification operational approval is an approval that authorizes an operator to carry out defined PBN operations with specific aircraft in designated airspace. The operational approval for an operator may be issued when the operator has demonstrated to the regulatory authority of the State of Registry/State of the Operator that the specific aircraft are in compliance with the relevant airworthiness standard and that the continued airworthiness and flight operations requirements are satisfied.

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

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

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

This is illustrated in Figure 2-1 next page.

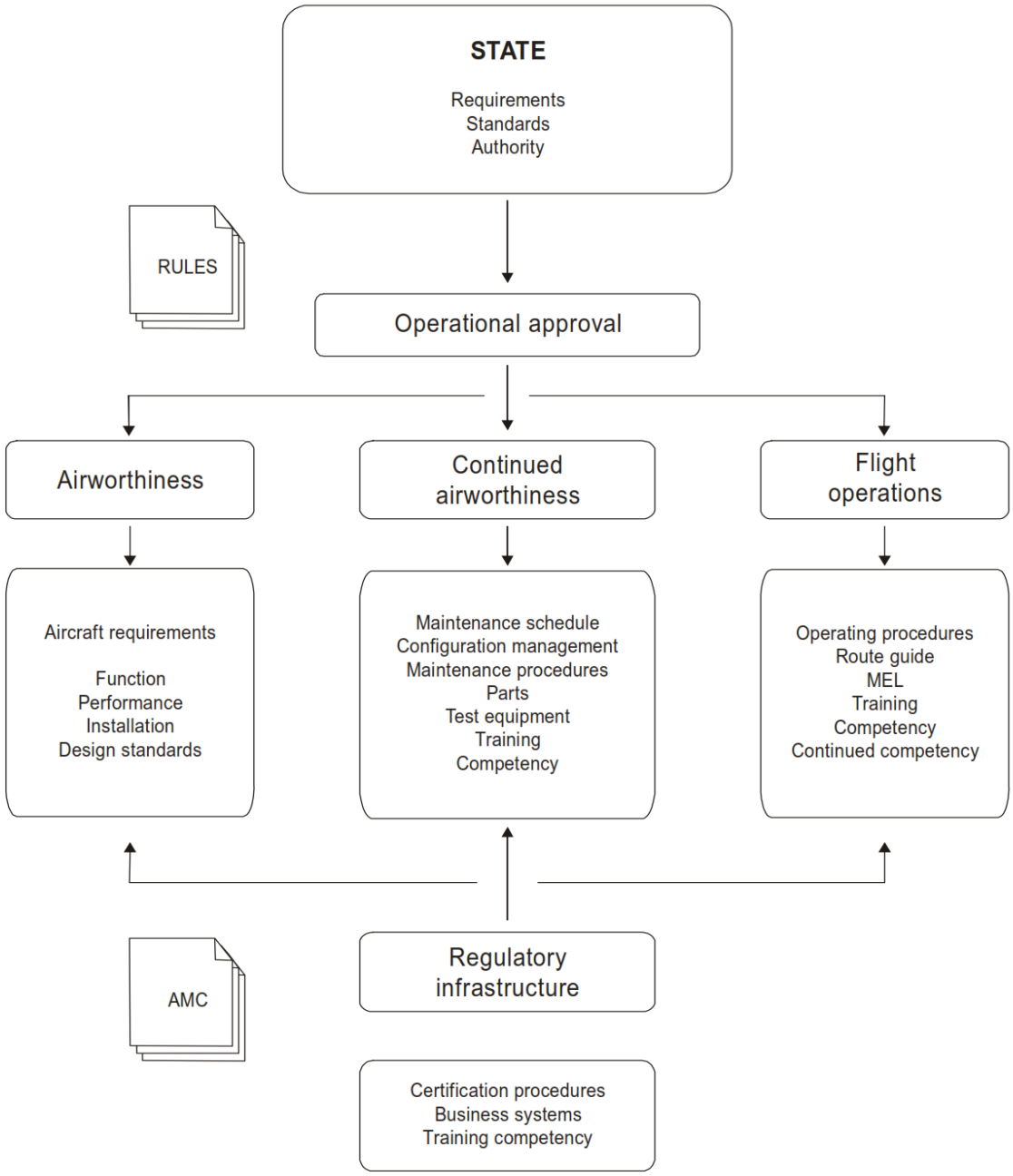


Figure 2-1. Overview of operational approval responsibilities

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

a) ***State of Design/Manufacture***. The organization which has designed the aircraft applies for a type certificate (TC) from the State of Design. The State of Design also approves the master minimum equipment list (MMEL), the mandatory maintenance tasks and intervals, and the aircraft flight manual (AFM) and its amendments, which determine the PBN capabilities and limitations of the aircraft. A State of Design, which may be different from the State which issued the original TC, may issue a design change approval for an aircraft as a supplemental type certificate (STC).

b) ***State of Registry.*** The State of Registry is the State in which the aircraft is registered. The State of Registry is responsible for the airworthiness of the aircraft. It approves the aircraft maintenance programme, in accordance with its regulations, and issues the certificate of airworthiness. It also approves aircraft repairs and modifications (as stand-alone modifications or as STCs). For general aviation, the State of Registry approves the minimum equipment list(MEL) and the conduct of specified PBN operations.

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

2.2 PBN APPROVAL OVERVIEW

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

2.2.2 The following factors shall influence the decision by the Authority to require a PBN 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.

2.2.3 The Authority's decisions in this area are be based on 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.

2.2.4 In order to facilitate expedited approvals, provided all airworthiness and operational requirements are satisfied, the Authority has developed a Worksheet which assists in "bundling" certain operations, particularly by flight phase, thereby allowing for leveraging of an operator's higher-level capabilities (see Figure below).

2.2.5 For example, an operator approved for RNP 1 operations might be readily approved for RNAV1 operations. The Authority also approaches 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.

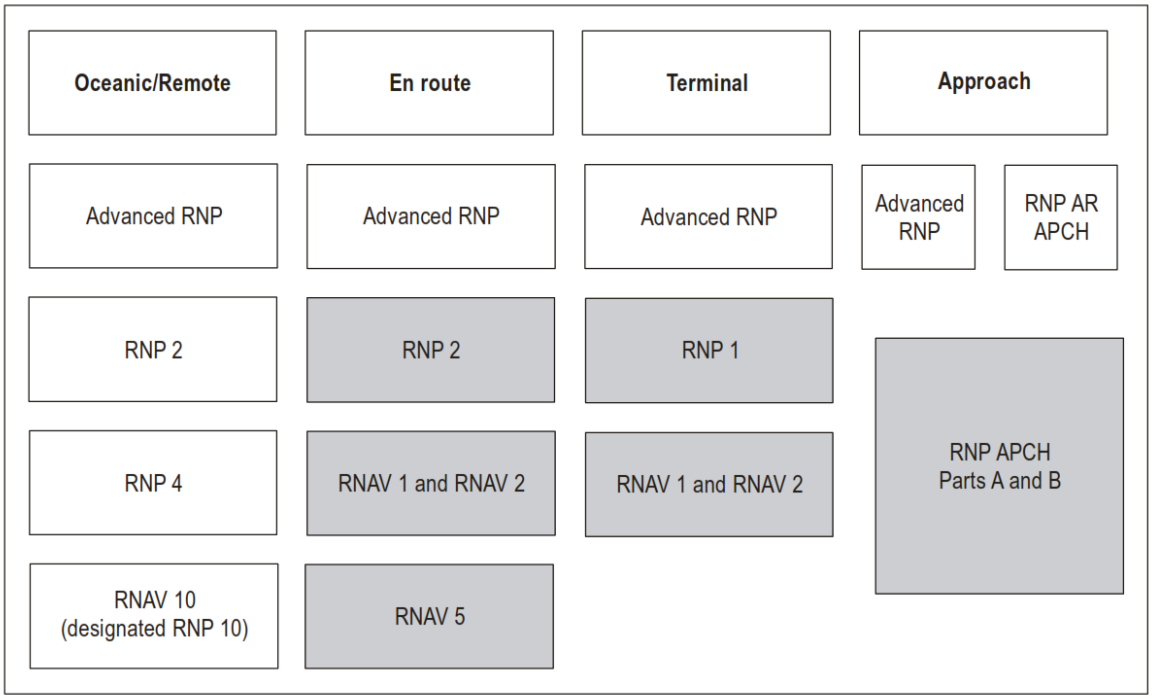


Figure 2-2. Bundling of navigation specifications

2.2.5 Inspector Coordination of the Operational Approval

2.2.5.1 Inspectors from Flight Operations and Airworthiness must coordinate their activities during the approval process. This will ensure that the final decision on approval meets all requirements. The following factors influence the Inspectors from both departments in making the 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, meets airworthiness requirements 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 by the operator;
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 flight operations officer 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.

2.2.5.2 Decisions by the Inspectors must be based upon balancing the efficient use of available regulatory resources to ensure proper initial operator compliance and to promote ongoing operational safety, while also enabling the use of new technologies and operations in the interest of enhanced safety and efficiency.

2.2.5.3 Operational approvals shall be endorsed in the applicable section of the AOC Operations Specifications template issued to the operator for the specific type of aircraft. The entries shall include the applicable navigation specifications and include any conditions or limitations in the remarks section.

2.2.5.4 General aviation (GA) operators may not be required to follow the same authorization model as commercial operators although a letter of authorisation (LOA) should be issued. Alternatively, the Inspector 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.

2.2.5.5 The coordinated 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.

2.2.5.6 Where a navigation database is required, inspectors shall ensure that operators 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 OPERATING PROCEDURES

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 Authority of significant incidents such as:
e) navigation errors not associated with transitions from an inertial navigation mode to a radio navigation mode;
f) unexpected deviations in lateral or vertical flight path attributed to incorrect navigation data;
g) significant misleading information without failure warning;
h) total loss or multiple failures of the PBN navigation equipment; or
i) problems with ground navigation facilities leading to significant navigation errors.

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 Authority.

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

2.3.1 Control of operating procedures

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

2.3.2 Flight crew and dispatch training and competency

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

2.3.3 Control of navigation database procedures

Navigation databases are required for all PBN navigation specifications except RNAV 10 and RNAV 5. The procedures for maintaining currency, checking for errors and reporting errors to the navigation database supplier must be documented in the operations and maintenance manual.

2.3.4 Performance record

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

2.4 AIRCRAFT ELIGIBILITY

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

a) the TC; or
b) the STC; or
c) the associated documentation — AFM or equivalent document; or
d) a compliance statement from the manufacturer, which has been approved by the State of Design and accepted by the State of Registry or the State of the Operator, if different.

Table 2-1. Approval scenarios

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

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

2.4.3 The Type Certificate (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 State of Registry either approves such changes through a modification approval process or STC, or accepts technical data defining a design change that has been approved by another State.

2.4.4 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).

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

2.4.5 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.

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.

2.5 ACTIONS FOR THE INSPECTOR AND OPERATOR

(all navigation specifications)

2.5.1 The Flight Operations Inspector (FOI) in coordination with the Airworthiness Inspector (AWI) will take the following steps to ensure the necessary actions are accomplished before issuing any navigation specifications approvals.

a) At the pre-application meeting, the inspector reviews with the operator the approval process events, establishes the form and content of the approval application, and provides the PBN application form KCAAFOPSPBN001 including the FORM: KCAA/FOPS/PBN Evaluation Approval and the KCAA PBN Manual.

b) The operator compiles required information/documents and records references to material in company documents for each relevant paragraph in the job aid (PBN FORM: KCAA/FOPS/PBN Evaluation Approval).

c) The operator submits to the inspector the completed Worksheet and the required documentation with the application. This may be submitted in hard copy Word or Excel format.

d) The flight operations inspector, in coordination with the airworthiness inspector, records his/her findings for each relevant part in the Evaluation Approval indicating compliance or necessary corrective action.

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

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

g) The Authority provides the operator with the operations specifications (Ops Specs), or a letter of authorization (LOA) as applicable, when the tasks and documents have been completed.

2.6 APPLICATION DOCUMENTS TO BE SUBMITTED BY THE OPERATOR

The following document are expected to be submitted to by the operator for PBN approval;

a) compliance documentation for the aircraft/navigation systems;
b) operating procedures and policies;
c) sections of the maintenance manual related to relevant navigation equipment and navigation databases (as applicable);
d) Minimum equipment list covering PBN applicable equipment;
e) PBN training programmes for flight crew, operations officers and where applicable maintenance personnel.

2.7 DOCUMENTATION OF OPERATIONAL APPROVAL

2.7.1 Operational approval shall be documented through:

a) an amendment to the operations manual (OM), where an OM 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.

2.7.2 During the validity of the operational approval, the Authority shall consider any navigation 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.

2.8 PBN REGULATORY AND GUIDANCE MATERIAL

Kenya Civil Aviation (Operation of Aircraft) regulations require the following:

A person shall not operate an aircraft in defined portions of airspace or on routes where a required navigation performance, (RNP) type has been prescribed, unless -

a) the aircraft is provided with navigation equipment which will enable it to operate in accordance with the prescribed RNP type(s); and
b) he is authorized by the State of the Registry for operations in such airspace.

The Authority has subsequently published the following:
1. PBN Operations Manual (this manual) for detailed guidance to both the Authority Inspectors and the Operator on the approval process;
2. PBN Application Form; and

3. PBN Evaluation Approval.

PBN Approvals for commercial operators are special authorizations and the applicable processes detailed in this manual require to be met..

2.9 APPROVAL PROCESS

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

a) meets the requirements established in the applicable air navigation regulations;
b) is adequately equipped; and
c) is capable of conducting the proposed operation in a safe and efficient manner.

2.9.1 Approval Phases Process

a) Approval process for all the navigation specifications consists of two components to the approval, airworthiness and operational. Although the two have different requirements, they must be considered in one single process.
b) Each process is an orderly method used by the Authority to make sure that the applicants meet the established requirements.
c) The approval process is made up by the following phases:
   1) Phase one: Pre-application
   2) Phase two: Formal application
   3) Phase three: Documentation evaluation
   4) Phase four: Inspection and demonstration
   5) Phase five: Approval

d) In *Phase one - Pre-application*, the Authority calls the applicant or operator to a pre-application meeting. At this meeting, the Authority informs the applicant or operator of all the operational and airworthiness requirements that it must meet during the approval process, including the following:
   1) the contents of the formal application;
   2) the review and evaluation of the application by the Authority;
   3) the limitations (if any) applicable to the approval; and
   4) conditions under which the navigation specification(s) applied for could be cancelled.
e) In *Phase two – Formal Application*, the applicant or operator submits the formal application along with all the relevant documentation, as established in the applicable advisory circular.

f) In Phase three – *Documentation evaluation*, the Authority evaluates all the documentation and the navigation system to determine their eligibility and the approval method to be followed in connection with the aircraft. As a result of this analysis and evaluation, the Authority may accept or reject the formal application along with the documentation.

g) In *Phase four – Inspection and demonstration*, the operator will provide training to its personnel and will carry out the validation flight, if required.

h) In *Phase five* – Approval. The Authority issues the operations specifications for the applicable navigation specification once the operator has met the airworthiness and operational requirements. For commercial air operators the Authority will issue an amended OpSpecs for the particular aircraft type. For General Aviation operators (private), a letter of authorisation (LOA) will be issued for RNP AR APCH operations. It may also be issued for other navigation specifications as determined by the CAA.

CHAPTER 3

3.0 OPERATIONAL APPROVAL GUIDELINES

3.1 AIRCRAFT ELIGIBILITY

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

3.1.2 The PBN manual and the associated State regulatory material have been issued in recent years 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. 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 their regulatory authority as early as possible.

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

a. qualification standard and fully understand the associated shortfall in the qualification of the navigation specification;

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

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

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

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

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

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

See Appendix 3: Approved GNSS Equipment for PBN Applications Chart

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 (OEM) and the air navigation service provider (ANSP) in whose airspace the PBN operations occur. The SOPs must be adequately documented in the OM. Pilots must therefore be instructed to comply with these SOPs so as to meet any instructions and procedure the manufacturer of the aircraft or navigation system specify.

3.2.2 *Preflight planning requirements*

a) the ICAO flight plan should contain the appropriate entries in items 10 and 18 showing the capability and approval 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 can not 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 and flight crew must ensure that FTE is limited to ±½ the navigation accuracy associated with the route or procedure;

c) crew must monitor flight progress and navigation reasonableness;

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

e) altitude and speed constraints must be observed;

f) 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:

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

II. where possible, documented procedures should be followed for:

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

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

c) significant misleading information without failure warning;

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

e) problems with ground navigation facilities leading to significant navigation errors; or

f) a communications failure.

3.2.6 *After-flight procedures*

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

See Appendix 4: Sample Operator Form for Reporting Navigation Errors

3.2.7 Operations with ABAS (RAIM) and SBAS

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 ICAO Annex 10, Volume I for certain navigation specifications, 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 SBAS signal is unavailable.

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

RAIM availability prediction software is a tool used to assess the expected capability of meeting the navigation performance. Due to unplanned failure of some GNSS elements, pilots/ANSP must realize that RAIM or GPS navigation may be lost altogether 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.

(E)TSO C145 and C146 GNSS receivers are capable of receiving and using SBAS information from the various SBAS systems now in service in certain parts of the world. RTCA DO-229 standards for GPS Wide Area Augmentation System requires SBAS capable GNSS receivers to be able to transit into and out of SBAS coverage areas and service volumes and automatically select and utilise the available SBAS messages without any pilot input.

On rare occasions the transmitted SBAS message may be corrupted. In some cases there has been no apparent effect, in others the corrupted transmission has interfered with SBAS capable GNSS even when outside the SBAS service volume.

When an SBAS capable GNSS receiver is operating within SBAS coverage but not within the SBAS service volume, it will receive the SBAS message but not utilise the differential corrections. However the receiver will still utilise the additional ranging signal transmitted from the geo-stationary SBAS satellite. The problem of large

position estimation errors due to this was corrected by equipment manufacturers issuing Service Bulletins to modify receivers and revising RTCA DO-229.
Operators need to ensure that all capable GNSS receivers in their aircraft have incorporated these modifications.

Operator procedures should include their policy for operations outside SBAS service volume areas. If the aircraft regularly operates into and out of SBAS service volume areas it is recommended that the SBAS function remains selected on. However flight crew training and operating procedures should ensure that in case of anomalous behaviour the flight crew deselect the SBAS function as an initial step in the GNSS failure contingency procedures.

3.3 TRAINING

3.3.1 General

3.3.1 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 enroute 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 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.

See Appendix 2: Flight Crew Knowledge and Training Requirements Summary

3.4 NAVIGATION DATABASES

3.4.1 Database Procedures

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.

3.4.2 Navigation Data Validation Programme

The information stored in the navigation database defines the lateral and longitudinal guidance of the aircraft for the applicable PBN operations. Navigation database updates are carried out every 28 days. The navigation data used in each update are critical to the integrity of every applicable RNAV/RNP procedure and route. This appendix provides guidance on operator procedures to validate the navigation data associated with the applicable operations.

DATA PROCESSING
The operator shall identify in its procedures the person responsible for the navigation data updating process.
The operator must document a process for accepting, verifying, and loading navigation data into the aircraft.
The operator must place its documented data process under configuration control.

INITIAL DATA VALIDATION

The operator must validate every applicable RNAV/RNP procedure and route, before flying under instrument meteorological conditions (IMC) to ensure compatibility with the aircraft and to ensure that the resulting paths are consistent with the published procedures.

As a minimum, the operator is required to:

a) compare the navigation data of the RNAV/RNP procedures and routes to be loaded into the FMS with valid charts and maps containing the published procedures.
b) validate the navigation data loaded for RNAV/RNP procedures and routes, either on the flight simulator or on the aircraft, under visual meteorological conditions (VMC).

The procedures and routes outlined on a map display must be compared to the published procedures and routes. The procedures and routes must be flown in order to ensure that the paths can be used, that they have no apparent lateral or longitudinal discrepancies, and that they are consistent with the published routes.

Once the RNAV/RNP procedures and routes are validated, a copy of the validated navigation data shall be kept and maintained in order to compare them with subsequent data updates.

DATA UPDATING

Upon receiving a navigation data update and before using such data on the aircraft, the operator must compare the update with the validated procedures and routes. This comparison must identify and resolve any discrepancy in the navigation data. If there are significant changes (any change affecting the path or the performance of the procedures or routes) and if those changes are verified through the initial data, the operator must validate the amended route in accordance with the initial validation data.

NAVIGATION DATA SUPPLIERS

Navigation data suppliers must have a letter of acceptance (LOA) in order to process these data (*e.g.*, FAA AC 20-153 or the document on the conditions for the issuance of letters of acceptance to navigation data suppliers by the European Aviation Safety Agency – EASA (EASA IR 21 Subpart G) or equivalent documents). A LOA recognises the data supplier as one whose data quality, integrity and quality management practices are consistent with the criteria of DO-200A/ED-76. The database supplier of an operator must have a Type 2 LOA and its respective suppliers must have a Type 1 or 2 LOA. The Authority may accept a LOA issued to navigation data suppliers or issue its own LOA.

CHAPTER 4

4.0 PBN APPLICATION AND EVALUATION APPROVAL FORMS

4.1 GENERAL

4.1.1 In order to facilitate a standardized approach to the process of applying for PBN approval, structured forms have been developed..

4.1.2 The forms are 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 The forms and documentation will 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)

4.1.4 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:

a) complete the PBN Approval Application Form KCAAFOPSPBN: PBN Application Job Aid Part A(see sample in Appendix 1);

b) complete the PBN Operational Evaluation Approval elements for the applicable navigation specifications FORM KCAAFOPSPBN: PBN Application Job Aid Part B (Evaluation Approval) ; and

c) attach the required documentation as a complete PBN approval application package (see documents required below)..

CHAPTER 5

5.0 PBN APPROVAL DOCUMENTS

5.1 DOCUMENTS REQUIRED

PBN Operations Approval requires documentation that demonstrates compliance with relevant requirements. Commonly required documents are as detailed below.

a) PBN Compliance Statement

This is a statement by the operator that they have assessed the following:

a. the aircraft;
b. their contuining airworthiness programme and procedures;
c. their flight operations procedures; and
d. found that all relevant and applicable PBN requirements have been complied with.

b) Airworthiness

a. aircraft equipment list – make/model/part number (applicable hardware and software);
b. aircraft Flight Manual or other manufacturer document that defines the approved PBN airworthiness capabilities of the aircraft;
c. installation compliance evaluation report;
d. a brief description of the aircraft's system and the installation of major components; and
e. previous PBN Approvals.

c) Continuing Airworthiness

a. identification of maintenance organisation responsible for maintaining the aircraft and operator oversight procedures of the maintenance provider(s);
b. maintenance schedule reference for the relevant systems;
c. aircraft configuration and management procedures (specifying references for ELA and software configuration);
d. aircraft maintenance manual or detailed references to relevant sections thereof;
e. parts management
f. test equipment required and management; and
g. maintenance personnel training and competency.

d) Flight Operations

a. flight operations procedures;
b. route guide document (Part C sections showing applicable areas and routes);
c. procedures for reporting of navigation errors and system failures;
d. flight crew training syllabus;
e. training means of delivery;
f. synthetic training devices to be used (if applicable);
g. flight crew competency assessment and continued competency;
h. a copy of the navigation database supplier's letter of acceptance (LOA);
i. navigation database validation and updating procedures; and
j. operators aircraft MEL (covering applicable PBN items).

Note: If the operator currently holds PBN Ops Approvals, a copy of the approval(s) should be included in the documentation package.

5.2 OPERATOR ASSESSMENT

5.2.1 Each PBN Operations Approval application must be evaluated for compliance with all relevant requirements. The formal evaluation cannot commence until the application is complete and all substantiating documentation has been completed and compiled.

5.2.2 Following the initial compliance evaluation by CAA inspectors, comments will be provided to the applicant to provide revised information where compliance cannot be met.

5.2.3 After completion of the initial assessment, the inspectors will conduct further document evaluation and determine any further activities needed to complete the approval. These activities will include any or all of the following;

a. site visits;
b. interviews with personnel;
c. observation of ground training sessions;
d. analysis of test data;
e. observation of flights; or
f. witness test flights.

CHAPTER 6

6.0 CARRYING OUT AN ASSESSMENT

6.1 ASSESSMENT PROCESS AND PROCEDURES

6.1.1 This section describes the procedures needed to complete a PBN Ops Approval. Form KCAAFOPSPBN: PBN Application Job Aid is in 2 parts. Part A is the Operator Application Form. Part B is the Evaluation Approval Form that provides a checklist for the various navigation specifications, with guidance to lead the applicant and the inspector through the Ops Approval assessment and provide a record of the assessment and the findings made. The form is available in Word format. However an Excel Worksheet is also available. The operator is not required to use the Excel worksheet, however it provides a more comprehensive job aid with some interactive guidance and is intended to provide an electronic means of recording PBN Operations Approval assessments for both the operator and the Authority inspectors.

6.1.2 The overall assessment process is shown in the PBN Approval Process Chart (Para 6.5 below). For reasons of practicality, it is divided into two parts:

a. a preliminary review [Steps 1 through 10]; and
b. a final assessment process [Steps 11 through 16];

The operator should normally complete the preliminary review process. Where the operator needs further guidance in this review the Authority Inspectors will assist the Operator in completing this phase.. The final assessment should be accomplished by the applicable FOI and/or AWI Authority in a coordinated manner with the information provided by the Operator as required. The operator should where possible, complete final check prior to submitting the completed application to the Authority's CPM/FOI. The Authority inspectors should complete the final assessment process to step 16 where before issuance of the PBN approval

Each of the steps is detailed from Paragraphs 6.6 to 6.22 below.

6.2 OPERATOR PBN PRELIMINARY REVIEW

6.2.1 Steps 1 through 10 listed below, and the PBN Approval Process Chart shown comprise a summary of the PBN Ops Approval review that should normally be undertaken by the operator. Where the operator is unable to manage this process the FOI and/or AWI may assist the Operator in conducting steps 1 through 10.
While some steps will by necessity, be sequential, other steps can be carried out as parallel activities. This is particularly relevant for the airworthiness and flight operations specialist areas.

6.2.2 It is recommended that the PBN Evaluation Approval Form be used to help with this task and record the assessment findings. Where the Excel spreadsheet is not available, or the operator opts not to use it then the assessment shall be accomplished using the Word version.

6.3 APPROVAL ASSESSMENT

6.3.1 The approval assessment is similar to the preliminary review except that it is primarily a detailed examination of the evidence presented to demonstrate compliance with the relevant and applicable requirements. The approval assessment is carried out by the Authority Inspectors. Steps 11 through 16 , and the process chart comprise a summary of the Approval Assessment.

6.4 SMALL AIRCRAFT AND NON-COMMERCIAL OPERATORS

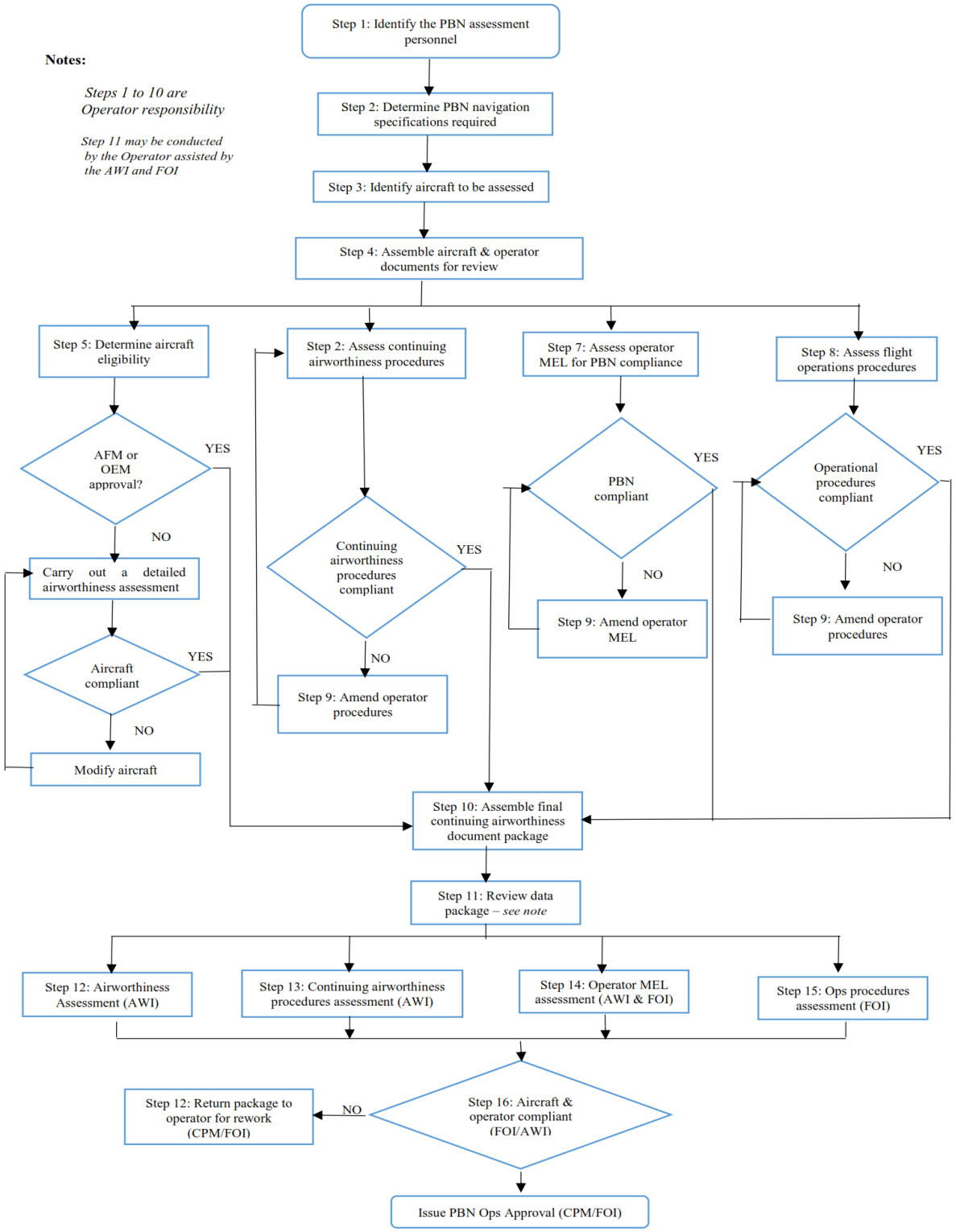
6.4.1 Small aircraft and Non-commercial (General Aviation) operators have a number of diverse operating scenarios ranging from commercial operations using aircraft with 3 Maximum Certificated Take-off Weight (MCTOW) below 5,700 Kg, to sport and recreational flying. Small aircraft commercial operators and GA operators are similar in that they are small enterprises that usually do not have in-house maintenance or specialist support.

6.4.2 Small aircraft typically have relatively simple GNSS-based navigation systems that are TSO approved stand-alone or integrated avionics systems. These systems are commonly approved for en-route, terminal and possibly approach operations using GNSS.

6.4.3 With less complex aircraft and pilot licencing that includes GNSS based PBN, simplified procedures can be used to reduce the burden of PBN Ops Approvals on small aircraft operators.

6.5 PBN APPROVAL PROCESS CHART

PBN Approval Process Chart



6.6 The Step-by-Step Operations Approval Process

6.6.1 The following steps are designed for the Operators of large commercial aircraft, typically with a MCTOW 5,700 Kg.

6.6.2 Steps 1 through 10 form the operator preliminary review. Steps 11 through 16 form the final assessment process.

See PBN Approval Process Chart above

6.7 Step 1: Identifying the PBN Assessment Personnel (Operator)

6.7.1 PBN Ops Approvals require Operator personnel from maintenance and and flight operations departments who are conversant with PBN requirements and the Operations Approval process. The assessments are best carried out with both specialities working together as a single team since there are many items that have both airworthiness and flight operations considerations.

6.8 Step 2: Determining the Required PBN Navigation Specifications

6.8.1 Operators should then assess their operations and determine the navigation specifications that are required. In carrying out this assessment, the operator should consider planned future developments in the area of their operations rather than just the immediate needs.

6.8.2 This operational requirements review needs to consider the en-route (continental or oceanic / remote continental), terminal procedures (arrivals and departures), and approach requirements. Further consideration must include the NAVAID infrastructure needed to support current operations and any planned future developments. For example, with many States transitioning to GNSS based navigation structures, some conventional NAVAIDs are being withdrawn from service in some regions. The withdrawal of these NAVAIDs may affect an operator's operations through the availability of alternates, when required.

6.8.3 Developing the operational requirements and identifying all the navigation specifications needed enables the required approvals to be obtained in a single cohesive application. Section B of this manual contains details of the PBN navigation specifications and their intended application

6.8.4 The applicant should identify the capabilities of TSO approved GNSS for the navigation specifications required as applicable.

See Appendix 3: Approved GNSS Equipment for PBN Applications Chart

6.8.5 The limitations of not being compliant with FAA AC 90-100A and other similar requirements will significantly limit the PBN capability of the listed systems and will exclude approach operations.

Worksheet Action: The navigation specifications required should be selected in the worksheet under the Certification Sheet tab.

6.9 Step 3: Identify the Aircraft to be Assessed and Approved

6.9.1 To assess aircraft eligibility the operator needs to identify each aircraft to be approved by its make and model, registration mark and serial number plus any other means used to identify the aircraft in the documentation (eg. OEM Line Number or Variable Number).

6.9.2 The exact configuration of each aircraft to be assessed must also be known and available. The aircraft modification status is important since the aircraft capability is often determined by the modification embodied (STC, OEM SB. etc)

6.9.3 In identifying the aircraft to be assessed and aproved, the operator needs to verify that the aircraft have a current Certificate of Airworthiness (C of A). If the aircraft does not have a current C of A, the assessment can proceed but the assessors must be confident that the Configuration being assessed will be the exact configuration when the aircraft is issued with its C of A. Any PBN Ops Approvals issued will not be valid until the C of A is issued.

6.9.4 For aircraft that do not operate with a C of A (e.g a Permit to Fly or other equivalent document) the same provisos apply as for aircraft that have a C of A.

Worksheet Action: The operator's details and the details ' of the aircraft to be assessed and approved should be entered into the relevant places in the worksheet under the Certification Sheet tab. Complete Section 1 under the a, worksheet PBN Ops Approval Assessment tab.

6.10 Step 4: Assemble the Documents Required

6.10.1 Having identified the PBN navigation specifications required for the operator's operations, the operator's team needs to gather the required documents with the exception of compliance reports (these will be completed later). These documents form the basis upon which any Ops Approval may be issued. Many of the items required for a PBN Approval will require references to these documents in order to demonstrate compliance with the requirements.

6.10.2 If the operator already has some PBN Approvals, a copy of these should be included in the document package. This information will enable the assessors to identify items that are already approved and may not need re-examination.

6.10.3 Having assembled the documents and verified that they are applicable to the aircraft to be included in the Ops Approval, the operator is required to make a detailed list of them, including the revision status of each document.

Worksheet Action: Complete Section 2 of the worksheet PBN Ops Approval Assessment tab.

6.11 Step 5 Preliminary Aircraft Airworthiness Review

Worksheet Action: Complete Section 3 of the worksheet PBN Ops Approval Assessment tab during this step. If a detailed airworthiness assessment is required, as indicated below, complete the assessment per worksheet Detailed Airworthiness Assessment tab.

6.11.1 The preliminary aircraft review is primarily an operator activity. The operator should also ensure interaction with the Authority Inspectors in determining acceptable means of compliance during this phase.

6.11.2 The purpose of the preliminary aircraft review is to determine its eligibility for the issue of a PBN Approval for the required navigation specifications. If the required navigation specifications are listed in the AFM, AFM Supplement or other aircraft OEM document then it is likely to be compliant provided that the aircraft has not been modified and the modification(s) have not compromised the PBN navigation specification compliance. Reference shall be made to the aircraft elegibility. Operator assessors should be familiar with the detailed information in this section prior to commencing the airworthiness review.

6.11.3 The assessment does not necessarily require a detailed examination of the aircraft for each navigation specification if its eligibility has already been determined. The assessment process is to commence the examination by reviewing the AFM to determine if the navigation specifications being sought are included in an OEM's airworthiness approval. AFMs commonly have a statement that the aircraft complies

with the airworthiness require~ merits of the navigation specification with an additional statement that the AFM entry does not constitute an operational approval.

6.11.4 When the AFM has an entry that states that the aircraft is compliant with one or more PBN navigation specification, it should specify the document that was used to determine compliance (e.g FAA AC 20-138D or EASA CS-ACNS). If the AFM does not specify the document used to determine compliance, clarification should be sought from the OEM or installation designer, as applicable.

6.11.5 The navigation capability statements in the aircraft AFM are often not up to date with the correct ICAO terminology compliance may not be a simple clear statement. In some cases, the AFM will use legacy navigation specification terminology such as RNP 10, B-RNAV, P-RNAV, etc. in other cases. the AFM compliance statement may specify combinations of aircraft serial numbers with certain Service Bulletins embodied as being compliant with the requirements for certain navigation specifications. Different serial numbers and Service Bulletin combinations can have quite different navigation capabilities.

6.11.6 The operator may use the airworthiness compliance statement as a means of demonstrating compliance with the navigation specification airworthiness requirements but must still obtain an Ops Approval to address the continuing airworthiness and flight operations aspects of the approval.

6.11.7 If the AFM does not contain the required PBN navigation specification airworthiness approval, an approval in an AFM Supplement or other acceptable OEM document will be an acceptable means of demonstrating compliance for the navigation specifications listed in the relevant documents.

6.11.8 Where the PBN compliance is not included in the AFM or other acceptable OEM document, an aircraft examination will be required. It is recommended that the operator assesses the aircraft using the Evaluation Approval form. A detailed assessment will enable the operator to identify the actual compliance status of the aircraft.

6.11.9 If a detailed examination of the aircraft is required, the complete installation is subject to examination and not just the primary navigation computer systems. Many of the requirements in each of the PBN navigation specifications 'are addressed under equipment TSO approvals such as TSO C146 for stand-alone GNSS based navigation systems or TSO C115 for flight management systems with GNSS sensors being addressed under TSO C145.

Appendix 3 lists the TSO requirements for the various PBN navigation specifications.

6.11.10 If the aircraft is not compliant with the requirements for the needed PBN navigation specifications, the operator needs to undertake a detailed study of the means of achieving compliance and the associated costs. Updating aircraft is expensive and complex. The installation of new navigation systems may be a major design change and

requires the modification to be subject to major design change procedures (typically 3 Supplemental Type Certificate (STC) approval process). Further advice on upgrading aircraft is beyond the scope of this manual.

Note: Modifying legacy aircraft for PBN compliance needs to be a well-considered decision since there is more to the PBN Ops Approval than just the immediate aircraft considerations. When installing new systems into older aircraft, it is common for the new systems to not interface to the old systems already installed. This flow-on effect can mean that a simple navigation system upgrade can easily become a major cockpit refurbishment with costs to match.

A further complication with upgrading aircraft is that any synthetic training devices (e.g flight simulators) must accurately replicate the actual aircraft. Installing a modern "glass cockpit" into an aircraft will also require any simulator to be upgraded to the same standard. Upgrading legacy aircraft may initially appear to be a cost-effective solution to meet PBN requirements. However, when all aspects are considered, just the opposite is often the reality.

6.11.11 If the aircraft require(s) modification to become compliant with the PBN navigation specification airworthiness requirements, advice should be sought from the Authority on the certification requirements for the change. If the change needed is minor, the Authority may accept a local modification, but equally the Authority may determine the change is a major design change and require a STC. Seeking Authority advice at this early stage is important if later complications are to be avoided.

Note: Status of TSO C129 Equipment

a) On 13'October 2011, the US cancelled TSO C129 and T50 €129a. Since these TSOs have been cancelled, no new approvals under TSO C129 or TSO C129a will be issued. Although these TSOs have been cancelled, TSO approval holders are still able to manufacture equipment under any approvals they may hold. Similarly, TSO C129 and T80 C129a equipment may still be installed in aircraft and used. However, since TSO C145, C146 and C196 equipment have a number of significant enhancements incorporated through the later TSO approval, it is recommended that operators install either (E)TSO C145, C146 or C196 GNSS equipment, as applicable to the intended application.

b) The impact for PBN Ops Approvals is that TSO C129 equipment is eligible for applications where the PBN navigation specification performance and functional requirements are met. However, since the TSO 129 equipment on-board performance monitoring and alerting function [usually RAIM] addresses only fault detection under the T80 approval, unless there is an additional aircraft level approval. TSO C129 equipped aircraft will be required to carry an alternate means of navigation suitable to the intended route that is not GNSS.

c) Under the TSO C129 approval, the equipment is qualified for only fault detection RAIM. Therefore, there is the potential for the aircraft to lose the area navigation function though a single satellite failure (e.g. a single point of failure where all TSO C129 systems will fail because of the single satellite failure). This single point of failure risk is mitigated by the aircraft being equipped with an alternate means of navigation suitable to the intended route (typically VOR or ADF)

d) TSO C129 equipment used for oceanic / remote continental operations must be TSO C129a approved and also have supplemental approval under FAA Notice 8110.60 or AC 20-138A Appendix 1 (or later version).

6.12 Step 6: Preliminary Continuing Airworthiness Review

Worksheet Action: Complete Section 4 (and the subsections) of the worksheet PBN Ops Approval Assessment tab during this step.

6.12.1 The preliminary continuing airworthiness review is primarily an operator activity to determine that all the continuing airworthiness requirements are addressed.

6.12.2 A key underlying principle of continuing airworthiness is that the aircraft operator is responsible for the overall maintenance of the aircraft, which also includes configuration management. Therefore, the operator's maintenance management procedures need to reflect this important aspect of their operation.

6.12.3 The continuing airworthiness assessment is a multi-faceted task that addresses not only the aircraft configuration management and maintenance tasks but also the interfaces to flight Operations and training systems.

6.12.4 A substantial part of the continuing airworthiness assessment involves a detailed review of the operator's procedures. Common problems found in these assessments stem from procedures that were developed earlier that, while adequate at the time, do not reflect the requirements for the management and assurance of continuing airworthiness of modern aircraft with software-based highly integrated systems.

6.12.5 For each of the continuing airworthiness requirements, the assessor should be able to locate an operator procedure that addresses, in detail, how the operator accomplishes the required objectives.

6.12.6 Within the assessment checklist/worksheet, the assessor must record the specific document reference to the operator's procedures where each of the requirements is specified. Generic statements such as "per SOPS" are not acceptable.

6.12.7 Historically the following continuing airworthiness items have held up Ops Approvals:

a) Maintenance Programme: The operator must have a maintenance programme for the aircraft that includes the PBN navigation systems within it.

b) Maintenance documentation: The operator must have the maintenance documentation to ensure that the aircraft is maintained compliant with its type design.
c) Aircraft Configuration Management: The operator must have procedures to manage the configuration of each aircraft and to ensure that design changes are not made to the aircraft without specific authorization from the operator.
d) Software Configuration Management: Software changes quite often in aircraft to the extent that the normal parts listings are unable to keep u with changes. The operator needs to have processes to manage the software installed in each aircraft and ensure that the software configuration is compatible and compliant
e) Synthetic Training Devices Configuration Management: Synthetic training devices, typically flight simulators, must be maintained so that they accurately replicate the actual aircraft. The operator's procedures need to ensure that when aircraft are modified, any changes needed to synthetic training devices are also made so the that simulator continues to accurately replicate the actual aircraft.
f) Electrical Load Analysis: Each aircraft must have a current ELA that accurately reflects the aircraft configuration and is compliant. The operator must have procedures for revising the ELA when the aircraft is modified.
g) Sub-contractor Oversight: Since the operator is responsible for all maintenance activity related to their aircraft, operator's need to have detailed procedures to ensure that all sub-contractors are qualified for the work undertaken and that only work authorized by the operator is carried out.
h) Manufacturer Service Information: Manufacturers provide operators with service information related to the operation and maintenance of the equipment they manufacture. While some of this information is purely engineering related [modifications], manufacturers also distribute information related to the operational use of equipment. Operator's therefore need to have procedures to routinely obtain this information and ensure that it is formally distributed to all relevant parts of the organization.
i) Maintenance Training: The operator must have a training programme so that personnel maintaining the aircraft and its PBN systems are qualified and competent to do so.

6.12.8 Airworthiness Compliance Review

6.12.8.1 As part of the continuing airworthiness review, the operator needs to verify that all inspections, tests and calibration required in accordance With the aircraft maintenance programme to maintain the aircraft compliant with its type design have been accomplished. When the required work has been accomplished, the work record reference should be noted in the assessment record as part of the compliance demonstration.

6.13 Step 7: Operator MEL

Worksheet Action: Complete Section 5 of the worksheet PBN Ops Approval Assessment tab during this step.

6.13.1 The operator MEL must be approved by the Authority. To be approved for PBN operations, the operator 5 MEL will require revision and then approval by the Authority. Revising the operator MEL is best accomplished through both the Operator aircraft maintenance and flight operations personnel working closely together.

6.13.2 Early PBN implementations identified that there are latent issues in the Master MEL for a number of aircraft, particularly legacy aircraft. Items that are required for certain navigation specifications may not be adequately covered in some MMELs. The operator MEL needs to be revised to address these latent concerns and to include PBN relevant information into the MEL.

6.14 Step 8: Preliminary Flight Operations Review

Worksheet Action: Complete Sections 6, 7 and 8 (and their sub-sections) of the worksheet PBN Ops Approval Assessment tab during this step.

6.14.1 The flight operations review will be quite extensive for an operator obtaining their first PBN Ops Approval since all elements require examination. Section B contains specific information on the operational procedures required for Approvals of the applicable navigation specifications. In many cases. operators will already have procedures that address the required topics. In these instances, the review needs to ensure that all items required for a PBN Ops Approval have been addressed.

It is recommended that the PBN Evaluation Approval form is used.

6.14.2 For non-AOC holders, the topics addressed in this section will mostly be still applicable and need to be addressed within the operator's operating environment.

6.14.3 Flight operations items that have historically caused approval delays are:

a) Third Party Training Service Providers: The operator is responsible for ensuring that their flight crew are trained and competent to conduct the intended operations. When training is provided by a third party service provider, the operator must have procedures to ensure that the training provided by the training service provider meets the Authority requirements. Where there are differences between the training provided and State requirements, the Authority may approve an alternate means of compliance.

b) Flight Crew Training Devices: All training devices need to accurately reflect the actual aircraft installation and have their configuration managed so that changes to the aircraft are also incorporated into training devices. When an operator uses third party synthetic training devices, routes and airports used should be for the operator's

area of operations. Similarly, and navigation database used should be that used in the operator's actual aircraft.

c) Navigation Database Management: Operators may not have had adequate procedures suitable to their operation to validate each new navigation database prior to installation in aircraft. The intent of the navigation database validation requirements is for the operator to carry out sufficient checks that for their operation, the database is unlikely to contain major errors. The amount of validation required will be a function of the size of the operator and the operations being undertaken. Detailed requirements for the management of navigation databases are documented in the applicable chapters of this manual.

6.15 Step 9: Develop Procedure Amendments

6.15.1 Having completed the preliminary review, the operator must then address each of the non-compliant items identified in the review using their standard internal processes.

6.16 Step 10: Assemble the Final Document Package for Assessment

6.16.1 Having completed the preliminary review, the operator's assessment team should assemble the document package that will be assessed in the final assessment and be submitted to the Authority for review and approval. Some OEM documents may not need to be included if the Authority has direct access to the OEM document library (eg. maintenance documents and the Aircraft Flight Manual).

6.16.2 As part of this activity, any compliance reports required should be prepared (i.e the Statement of Compliance, installation compliance reports etc)

6.16.3 Once the final document package has been assembled, the Operator should review the package to ensure that all required documents and information have been included. When submitting the data package, an inventory of the documents included should to be provided so that the Authority can readily ascertain that all submitted information has been received.

6.16.3.1 Operators should retain a copy of the submitted documentation package. The final package on approval should be retained as an auditable document so long as they have the relevant aircraft in their fleet.

6.17 Step 11: Data Package Review (Operator and Inspectors)

Worksheet Action: Complete Section 9 of the worksheet PBN Ops Approval Assessment tab during this step.

6.17.1 The data package review should be conducted by the Operator. The process is finalized when the Operator assessment team meet with the Authority inspectors to review the submission. The purpose of the review of the PBN Ops Approval data package is to check that:

a) All required documents are included.

b) The details of the aircraft being assessed are complete and correct.

c) The PBN navigation specifications being included in the assessment have been correctly identified

d) The PBN Ops Approval Job Aid worksheet have been completed

6.18 Step 12: Airworthiness Assessment (AWI)

Worksheet Action: Complete the relevant parts of Section 10 of the worksheet PBN Ops Approval Assessment tab during this step.

6.18.1 The purpose of the airworthiness compliance assessment is to determine that the aircraft complies with the requirements of each navigation specification for which approval is being sought and that compliance has been satisfactorily demonstrated.

6.18.2 The Airworthiness Inspector is required to make an assessment using the Evaluation Approval form Section 3 and determine that, for each item, the evidence presented is valid and that compliance has been demonstrated. The assessment can be accomplished through a document review, aircraft examination or a combination of these.

6.19 Step 13: Continuing Airworthiness Assessment (AWI)

Complete the relevant parts of Section 10 of the Evaluation Approval Form during this step.

6.19.1 The continuing airworthiness compliance assessment will focus on reviewing the operator's procedures to verify that they adequately address all the continuing airworthiness topics included in this manual and the Evaluation Approval Form and determine that, for each item, the evidence presented is valid and that compliance has been demonstrated. Where evidence of continuing airworthiness compliance is required, the assessment will review the evidence provided by the operator.

6.20 Step 14: Operator MEL Assessment (FOI and AWI)

Worksheet Action: Complete the relevant parts of Section 10 of the worksheet PBN Ops Approval Assessment tab during this step.

6.20.1 The operator MEL compliance assessment will determine that all entries pertaining to PBN operations have been addressed and that the relevant topics addressed in this Chapter have been addressed. Operator MEL compliance is assessed in the PBN Evaluation Approval Form.

6.21 Step 15: Flight Operations Assessment (FOI)

Complete the relevant parts of section 10 of the Evaluation Approval Form during this step.

6.21.1 The flight operations inspector review is to determine that the operator complies with the operational and training requirements of each navigation specification for which approval is being sought and that compliance has been satisfactorily demonstrated.

Refer to applicable sections of this manual and each relevant item in the Evaluation Approval Form.

6.22 Step 16: Completion (CPM/FOI and AWI)

Complete Section 11 of the worksheet Evaluation Approval Form and then complete the Certification Sheet recommending or not recommending approval and the issuance of the PBN requested PBN Ops Approvals.

6.22.1 Having completed their assessments, the Authority Inspectors must determine whether or not the operator has demonstrated compliance with all the relevant and applicable PBN requirements. Since there are elements that involve both airworthiness and flight operations, the determination of compliance should be the joint view of the assessors rather than being isolated airworthiness and flight operations decisions.

6.22.2 If the Inspectors determine that rework is required, this needs to be communicated to the operator with the reason the operator's means of compliance is unsatisfactory. The operator then needs to correct the deficiency and submit the revised information to the Authority for assessment.

6.22.3 When the Authority Inspectors are satisfied that compliance has been demonstrated, a PBN Ops Approval can be issued to the operator in accordance with the Authority's standard procedures. This is the responsibility of the CPM or FOI as applicable and the Manager Flight Operations.

6.22.4 Each aircraft assessed for a PBN Ops Approval needs to have the assessment and the findings recorded as an auditable document.

6.22.5 The assessment records need to detail the specific references to the documents that were used to demonstrate compliance with the PBN navigation specification requirements. To avoid the need to store large numbers of documents, it is acceptable to record the references only provided that the documents referred to, at the specific revision status used in the assessment, will remain available. If there is no assurance that superseded versions will be available, a copy of the version used needs to be archived.

6.23 Aircraft Approval Status Pilot Information

6.23.1 Many AFMs do not have clear statements of the navigation specifications for which the aircraft meets the airworthiness requirements. Given the manner in which some AFMs have been written, it is very difficult for pilots to interpret the flight manual information and correctly determine the navigation specifications that the aircraft complies with. While recommendations on the content of AFMs have been made, there are many legacy aircraft that are operating with AFMs written prior to PBN.

6.23.2 Common problems are that the navigation specifications are not specifically mentioned or the AFM creates a "logic puzzle" that a pilot may have to solve. Detailed equipment information is often not available to pilots and may not be carried in the aircraft during operations.

6.23.3 Aircraft tend to have long production runs; the manufacturers therefore incorporate incremental changes to the aircraft throughout its production life. Consequently, aircraft of ostensibly the same make/model can have quite different operational capabilities.

6.23.4 Pilots must know exactly what operations the particular aircraft they are flying is approved to carry out. Given the lack of clarity in many AFMs, it is recommended that operators ensure that an authoritative document is carried in each aircraft that clearly states its capability without further interpretation being needed. If the aircraft's operational capability is changed, this document must be revised to reflect the change.

In most cases the Operations Specifications showing the approved PBN specifications together with well documented PBN information in the Operations Manual will be sufficient.

SECTION B

APPROVAL OF NAVIGATION SPECIFICATIONS

CHAPTER 1

RNAV 10 OPERATIONS (DESIGNATED AND AUTHORIZED AS RNP 10)

1.0 OPERATIONS AND APPROVAL PROCESS

2.0 REFERENCES

KCARS Operation of Aircraft Regulations
KCARS Instrument and Equipment Regulations
Form KCAAFOPSPBN: Application Job Aid Part A (Application Form)
Form KCAAFOPSPBN: Evaluation Approval Form

ICAO Doc 9613 Performance-based Navigation (PBN) manual
ICAO Doc 8168 Procedures for air navigation services:
Volume I – Aircraft operations
Volume II – Parts I and III – General criteria
ICAO Doc 7030 Regional Supplementary Procedures
FAA Order 8400.12A Required navigation performance 10 (RNP 10) operational approval
EASA AMC 20-12 Recognition of FAA Order 8400.12A for RNP-10 operations
EASA Part SPA (GM1 SPA.PBN.100)

3.0 PURPOSE

This Chapter identifies the airworthiness and operational requirements for RNP 10 operations. It addresses only the lateral part of the navigation system. It establishes RNP 10 approval requirements for aircraft and operations in oceanic or remote airspace.

4.0 APPROVAL PROCESS

Aircraft are certified by their State of manufacture. Operators are approved in accordance with their national operating rules. The navigation specification provides the technical and operational criteria, and does not imply a need for recertification.

The operator who intends to seek for authorization/approval of RNAV-10 (designated and authorized as RNP 10) shall present to the authority a statement of intent to start the process of obtaining the authorization. A letter accompanying the application form shall be acceptable.

4.1 Contents of an application for an RNP 10 operational approval

a) Aircraft eligibility

Many aircraft and navigation systems currently in use in oceanic or remote area operations will qualify for RNP 10 based on one or more provisions of the existing certification criteria. Thus, additional aircraft certification action may not be necessary for the majority of RNP 10 operational approvals. Additional aircraft certification will only be necessary if the operator chooses to claim additional performance beyond that originally certified or stated in the AFM but cannot demonstrate the desired performance through data collection. Three methods of determining aircraft eligibility have been defined.

Method 1 — RNP certification

Method 1 can be used to approve aircraft that have been formally certificated and approved for RNP operations. RNP compliance is documented in the flight manual and is typically not limited to RNP 10. The flight manual addresses RNP levels that have been demonstrated to meet the certification criteria and any related provisions applicable to their use (e.g. NAVAID sensor requirements). Operational approval will be based upon the performance stated in the flight manual.

Airworthiness approval specifically addressing RNP 10 performance may be obtained. Sample wording that could be used in the flight manual, when an RNP 10 approval is granted for a change in the INS/IRU certified performance, is as follows:

"The XXX navigation system has been demonstrated to meet the criteria of [State's guidance material document] as a primary means of navigation for flights up to YYY hours' duration without updating. The determination of flight duration starts when the system is placed in navigation mode. For flights which include airborne updating of navigation position, the operator must address the effect that updating has on position accuracy and any associated time limits for RNP operations pertinent to the updating NAVAID facilities used and the area, routes or procedures to be flown. Demonstration of performance in accordance with the provisions of [State's guidance material document] does not constitute approval to conduct RNP operations."

Note.— The above wording is based upon performance approval by the aviation authority and is only one element of the approval process. Aircraft with this wording in their flight manual will be eligible for approval through issuance of Operations specifications or an LOA, if all other criteria are met. The YYY hours specified in the flight manual do not include updating. When the operator proposes a credit for updating, the proposal must address the effect the updating has on the position accuracy and any associated time limits for RNP operations pertinent to the updating of the NAVAID facilities used and the area, routes or procedures to be flown.

Method 2 — Aircraft eligibility through prior navigation system certification

Method 2 can be used to approve aircraft whose level of performance, under other/previous standards, can be equated to the RNP 10 criteria. The standards listed in 1.3.4 can be used to qualify an aircraft. Other standards may also be used if they are sufficient to ensure that the RNP 10 requirements are met. If other standards are to be used, the applicant must propose an acceptable means of compliance.

Method 3 — Aircraft eligibility through data collection

Method 3 requires that operators collect data to gain an RNP 10 approval for a specified period of time. The data collection programme must address the appropriate navigational accuracy requirements for RNP 10. The data collection must ensure that the applicant demonstrate to the aviation authority that the aircraft and the navigation system provide the pilot with navigation situational awareness relative to the intended RNP 10 route. The data collection must also ensure that a clear understanding of the status of the navigation system is provided and that failure indications and procedures are consistent with maintaining the navigation performance.

Relevant documentation for the selected qualification method must be available to establish that the aircraft is equipped with LRNSs which meet the requirements of RNP 10 (e.g. the flight manual). The applicant must provide a configuration list that details pertinent components and equipment to be used for long-range navigation and RNP 10 operations. The applicant's proposed RNP 10 time limit for the specified INS or IRU must be provided. The applicant must consider the effect of headwinds in the area in which RNP 10 operations are intended to be carried out (see 1.3.4) to determine the feasibility of the proposed operation.

4.2 Operational approval

This navigation specification does not in itself constitute regulatory guidance material against which either the aircraft or the operator will be assessed and approved. Aircraft are certified by their State of Manufacture. Operators are approved in accordance with their national operating rules. This navigation specification provides the technical and operational criteria, and does not necessarily imply a need for recertification.

Notes:

Detailed information on operational approvals is provided in Doc 9613, Volume I, Attachment C.

Where appropriate, States may refer to previous operational approvals in order to expedite this process for individual operators where performance and functionality are applicable to the current request for operational approval.

a) Aircraft eligibility

The aircraft eligibility must be determined through demonstration of compliance against the relevant airworthiness criteria and the requirements of 1.3.4. The OEM or the holder of installation approval for the aircraft, e.g. STC holder, will demonstrate compliance to their NAA (e.g. EASA, FAA) and the approval can be documented in manufacturer documentation (e.g. service letters). AFM entries are not required provided the State accepts manufacturer documentation.

b) Description of aircraft equipment

The operator must have a configuration list and, if necessary, a MEL detailing the required aircraft equipment for RNAV 10 operations.

c) Training documentation

Commercial operators must have a training programme addressing the operational practices, procedures and training items related to RNAV 10 operations (e.g. initial, upgrade or recurrent training for pilots, dispatchers or maintenance personnel).

Note.— Operators need not establish a separate training programme or regimen if they already integrate RNAV training as an element of their training programme. However, the operator should be able to identify the aspects of RNAV 10 covered within their training programme.

Private operators must be familiar with the practices and procedures identified in this section, “Pilot knowledge and training”.

d) OMs and checklists

OMs and checklists for commercial operators must address information/guidance on the SOP detailed in

The appropriate manuals should contain navigation operating instructions and contingency procedures, where specified. When required by the State of the

Operator/Registry, the operator must submit their manuals and checklists for review as part of the application process.

Private operators should operate using the practices and procedures in "Pilot knowledge and training" paragraphs.

e) MEL considerations

Any MEL revisions necessary to address RNAV 10 provisions must be approved. Operators must adjust the MEL, or equivalent, and specify the required dispatch conditions.

f) Continuing airworthiness

The operator must submit the continuing airworthiness instructions applicable to the aircraft's configuration and the aircraft's qualification for this navigation specification. Additionally, there is a requirement for the operator to submit their maintenance programme, including a reliability programme for monitoring the equipment.

Note.— The operator should confirm with the OEM, or the holder of installation approval for the aircraft, that acceptance of subsequent changes in the aircraft configuration, e.g. SBs, does not invalidate current operational approvals.

g) Past performance

An operating history of the operator must be included in the application. The applicant must address any events or incidents related to navigation errors for that operator (e.g. as reported on a State's navigation error investigation form), that have been covered by training, procedures and maintenance, or the aircraft/navigation system modifications which are to be used.

h) Aircraft requirements

RNP 10 requires that aircraft operating in oceanic and remote areas be equipped with at least two independent and serviceable LRNSs comprising an INS, an IRS FMS or a GNSS, with an integrity such that the navigation system does not provide an unacceptable probability of misleading information.

i) On-board performance monitoring and alerting

Accuracy: during operations in airspace or on routes designated as RNP 10, the lateral TSE must be within ±10 NM for at least 95 per cent of the total flight time. The along-track error must also be within ±10 NM for at least 95 per cent of the total flight time.

Notes:

For RNP 10, operational approval of aircraft capable of coupling the area navigation (RNAV) system to the flight director or autopilot, a navigational positioning error is considered to be the dominant contributor to cross-track and along-track error. FTE, PDE and display errors are considered to be insignificant for the purposes of RNP 10 approval.

When the data collection method described in Appendix 1 of FAA Order 8400.12A (as amended) is used as the basis for an RNP 10 operational approval, these error types are included in the analysis. However, when the data collection method described in Appendix 6 of FAA Order 8400.12A is used, these errors are not included since that method is more conservative. The Appendix 6 method uses radial error instead of cross-track and along-track error.

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

Continuity: loss of function is classified as a major failure condition for oceanic and remote navigation. The continuity requirement is satisfied by the carriage of dual independent LRNSs (excluding SIS).

SIS: if using GNSS, the aircraft navigation equipment shall provide an alert if the probability of SIS errors causing a lateral position error greater than 20 NM exceeds 10^{-7} per hour.

4.3 Criteria for specific navigation services

a) Aircraft incorporating dual GNSS

Aircraft approved to use GNSS as a primary means of navigation for oceanic and remote operations, in accordance with the appropriate aviation authority's requirements, also meet the RNP 10 requirements without time limitations.

Multi-sensor systems integrating GNSS with FDE that are approved using the guidance contained in United States FAA Advisory Circular AC 20-130A, or its equivalent, also meet RNP 10 requirements without time limitations.

FAA Advisory Circular AC 20-138A provides an acceptable means of complying with installation requirements for aircraft that use GNSS but do not integrate it with other sensors. FAA AC 20-130A describes an acceptable means of compliance for multi-sensor navigation systems that incorporate GNSS. Aircraft that intend to use GNSS as the only navigation system (e.g. no INS or IRS) on RNP 10 routes or in RNP 10 airspace must also comply with the regulations and related advisory documentation of the relevant aviation authority, except for specific GNSS requirements described in this guidance material. This includes use of GNSS approved for primary oceanic/remote performance.

The flight manual must indicate that a particular GNSS installation meets the appropriate aviation authority's requirements. Dual TSO-approved GNSS equipment must be fitted and an approved FDE availability prediction programme must be used. The maximum allowable time for which FDE capability is projected to be unavailable is 34 minutes for any one occasion. The maximum outage time must be included as a condition of the RNP 10 approval.

Note.— If predictions indicate that the maximum FDE outage time for the intended RNP 10 operation will be exceeded, then the operation must be rescheduled when FDE is available, or RNP 10 must be predicated on an alternate means of navigation.

b) Aircraft incorporating dual INS or IRUs — standard time limit

Aircraft equipped with dual INS or IRU systems approved in accordance with any of the following standards have been determined to meet RNP 10 requirements for up to 6.2 hours of flight time:

- United States 14 CFR, Part 121, Appendix G (or a State's equivalent);
- MNPS; and approved for RNAV operations in Australia.

The timing starts from when the systems are placed in navigation mode or at the last point at which the systems are updated.

Note.— The 6.2 hours of flight time are based on an inertial system with a 95 per cent radial position error rate (circular error rate) of 3.7 km/h (2.0 NM/h), which is statistically equivalent to individual 95 per cent cross-track and 95 per cent along-track position error rates (orthogonal error rates) of 2.9678 km/h (1.6015 NM/h) each, and 95 per cent cross-track and 95 per cent along-track position error limits of 18.5 km (10 NM) each (e.g. 18.5 km (10 NM)/2.9678 km/h (1.6015 NM/h) = 6.2 hours)).

If the systems are updated en route, the operator must show the effect that the accuracy of the update has on the time limit (see FAA Order 8400.12.A, 12.e for information on the adjustment factors for systems that are updated en route).

Note.— FAA Order 8400.12.A, 12.d provides information on acceptable procedures for operators who wish to increase the 6.2 hour time limitation specified.

Aircraft incorporating dual INS or IRUs — extended time limit

For aircraft with INS certified under United States 14 CFR, Part 121, Appendix G, additional certification is only necessary for operators who choose to certify INS accuracy to better than 3.7 km (2 NM) per hour radial error (2.9678 km (1.6015 NM) per hour cross-track error). However, the following conditions apply:

- the certification of INS performance must address all issues associated with maintaining the required accuracy, including accuracy and reliability, acceptance test procedures, maintenance procedures and training programmes; and

- the operator must identify the standard against which the INS performance is to be demonstrated. This standard may be a regulatory (i.e. Appendix G), an industry or an operator-unique specification. A statement must be added to the flight manual identifying the accuracy standard used for certification (see FAA Order 8400.12.A, 12.a.2).

Aircraft equipped with a single INS or IRU and a single GPS approved for primary means of navigation in oceanic and remote areas

Aircraft equipped with a single INS or IRU and a single GNSS meet the RNP 10 requirements without time limitations. The INS or IRU must be approved to 14 CFR, Part 121, Appendix G. The GNSS must be TSO-C129a-authorized and must have an approved FDE availability prediction programme. The maximum allowable time for which the FDE capability is projected to be unavailable is 34 minutes on any one occasion. The maximum outage time must be included as a condition of the RNP 10 approval. The flight manual must indicate that the particular INS, IRU or GPS installation meets the appropriate aviation authority's requirements.

c) Operating procedures

To satisfy the requirements for RNP 10 operations in oceanic and remote areas, an operator must also comply with the relevant requirements of Annex 2 — *Rules of the Air*.

d) Flight planning

During flight planning, the pilot should pay particular attention to conditions affecting operations in RNP 10 airspace (or on RNP 10 routes), including:

i. verifying that the RNP 10 time limit has been accounted for;

ii. verifying the requirements for GNSS, such as FDE, if appropriate for the operation; and

iii. accounting for any operating restriction related to RNP 10 approval, if required for a specific navigate on system.

e) Preflight procedures

The following actions should be completed during preflight:

review maintenance logs and forms to ascertain the condition of the equipment required for flight in RNP 10 airspace or on an RNP 10 route. Ensure that maintenance action has been taken to correct defects in the required equipment;

during the external inspection of an aircraft, if possible check the condition of the navigation antennas and the condition of the fuselage skin in the vicinity of each of these antennas (this check may be accomplished by a qualified and authorized person other than the pilot, e.g. a flight engineer or maintenance person); and

review the emergency procedures for operations in RNP 10 airspace or on RNP 10 routes. These are no different than normal oceanic emergency procedures with one exception — crews must be able to recognize when the aircraft is no longer able to navigate to its RNP 10 approval capability and ATC must be advised.

4.4 Navigation equipment

All aircraft operating in RNP 10 oceanic and remote airspace must be fitted with two fully serviceable independent LRNSs with integrity such that the navigation system does not provide misleading information.

A State authority may approve the use of a single LRNS in specific circumstances (e.g. North Atlantic MNPS and 14 CFR 121.351(c) refer). An RNP 10 approval is still required.

4.5 Flight plan designation

Operators should use the appropriate ICAO flight plan designation specified for the RNP route flown. The letter “R” should be placed in block 10 of the ICAO flight plan to indicate the pilot has reviewed the planned route of flight to determine RNP requirements and the aircraft and operator have been approved on routes where RNP is a requirement for operation. Additional information needs to be displayed in the remarks section that indicates the accuracy capability, such as RNP 10 versus RNP 4.

4.6 Availability of NAVAIDs

At dispatch or during flight planning, the operator must ensure that adequate NAVAIDs are available en route to enable the aircraft to navigate to RNP 10 for the duration of the planned RNP 10 operation.

For GNSS systems, the operator should ensure during dispatch or flight planning that adequate navigation capability is available en route for the aircraft to navigate to RNP 10, including the availability of FDE, if appropriate for the operation.

4.7 En route

4.7.1 At least two LRNSs capable of satisfying this navigation specification must be operational at the oceanic entry point. If this is not the case, then the pilot should consider an alternate route which does not require that particular equipment or having to make a diversion for repairs.

4.7.2 Before entering oceanic airspace, the position of the aircraft must be checked as accurately as possible by using external NAVAIDs. This may require DME/DME and/or VOR checks to determine NSEs through displayed and actual positions. If the system must be updated, the proper procedures should be followed with the aid of a prepared checklist.

4.7.3 Operator in-flight operating drills must include mandatory cross-checking procedures to identify navigation errors in sufficient time to prevent aircraft from inadvertent deviation from ATC-cleared routes.

4.7.4 Crews must advise ATC of any deterioration or failure of the navigation equipment below the navigation performance requirements or of any deviations required for a contingency procedure.

4.7.5 Pilots should use a lateral deviation indicator, flight director, or autopilot in lateral navigation mode on RNP 10 operations. All pilots are expected to maintain route 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 RNAV system computed path and the aircraft position relative to the path) should be limited to ±½ the navigation accuracy associated with the route (i.e. 5 NM). Brief deviations from this standard (e.g. overshoots or undershoots) during and immediately after route turns, up to a maximum of one times the navigation accuracy (i.e. 10 NM), are allowable.

Note.— Some aircraft do not display or compute a path during turns. Pilots of these aircraft may not be able to adhere to the ±½ accuracy standard during route turns, but are still expected to satisfy the standard during intercepts following turns and on straight segments.

4.8 Route evaluation for RNP 10 time limits for aircraft equipped only with INS or IRU

An RNP 10 time limit must be established for aircraft equipped only with INS or IRU. When planning operations in areas where RNP 10 is applied, the operator must establish that the aircraft will comply with the time limitation on the routes that it intends to fly.

In making this evaluation, the operator must consider the effect of headwinds and, for aircraft not capable of coupling the navigation system or flight director to the autopilot, the operator may choose to make this evaluation on a one-time basis or on a per-flight basis. The operator should consider the points listed in the following subsections in making this evaluation.

4.8.1 Route evaluation

The operator must establish the capability of the aircraft to satisfy the RNP 10 time limit established for dispatch or departure into RNP 10 airspace.

4.8.2 Start point for calculation

The calculation must start at the point where the system is placed in navigation mode or the last point at which the system is expected to be updated.

4.8.3 Stop point for calculation

The stop point may be one of the following:

the point at which the aircraft will begin to navigate by reference to ICAO standard NAVAIDs (VOR,
DME, NDB) and/or comes under ATS surveillance; or

the first point at which the navigation system is expected to be updated.

4.8.4 Sources of wind component data

The headwind component to be considered for the route may be obtained from any source acceptable to the aviation authority. Acceptable sources for wind data include: the State's Bureau of Meteorology, National Weather Service, Bracknell, industry sources such as Boeing Winds on World Air Routes, and historical data supplied by the operator.

4.8.5 One-time calculation based on 75 per cent probability wind components

Certain sources of wind data establish the probability of experiencing a given wind component on routes between city pairs on an annual basis. If an operator chooses to make a one-time calculation of RNP 10 time limit compliance, the operator may use the annual 75 per cent probability level to calculate the effect of headwinds (this level has been found to be a reasonable estimation of wind components).

4.8.6 Calculation of time limit for each specific flight

The operator may choose to evaluate each individual flight using flight plan winds to determine whether the aircraft will comply with the specified time limit. If it is determined that the time limit will be exceeded, then the aircraft must fly an alternate route or delay the flight until the time limit can be met. This evaluation is a flight planning or dispatch task.

4.9 Effect of en-route updates

Operators may extend their RNP 10 navigation capability time by updating. Approvals for various updating procedures are based upon the baseline for which they have been approved minus the time factors shown below:

a) automatic updating using DME/DME = baseline minus 0.3 hours (e.g. an aircraft that has been approved for 6.2 hours can gain 5.9 hours following an automatic DME/DME update);

b) automatic updating using DME/DME/VHF omnidirectional radio range (VOR) = baseline minus 0.5 hours; and

c) manual updating using a method similar to that contained in FAA Order 8400.12A (as amended), Appendix 7 or approved by the aviation authority = baseline minus 1 hour.

4.10 Automatic radio position updating

Automatic updating is any updating procedure that does not require the pilot to manually insert coordinates. Automatic updating is acceptable provided that:

a) procedures for automatic updating are included in an operator's training programme; and
b) pilots are knowledgeable of the updating procedures and of the effect of the update on the navigation solution.

An acceptable procedure for automatic updating may be used as the basis for an RNP 10 approval for an extended time as indicated by data presented to the aviation authority. This data must present a clear indication of the accuracy of the update and the effect of the update on the navigation capabilities for the remainder of the flight.

4.11 Manual radio position updating

If manual updating is not specifically approved, manual position updates are not permitted in RNP 10 operations. Manual radio updating may be considered acceptable for operations in airspace where RNP 10 is applied provided that:

a) the procedures for manual updating are reviewed by the aviation authority on a case-by-case basis. An acceptable procedure for manual updating is described in FAA Order 8400.12A (as amended), Appendix 7 and may be used as the basis for an RNP 10 approval for an extended time when supported by acceptable data;

b) operators show that their updating and training procedures include measures/cross-checking to prevent Human Factors errors and the pilot qualification syllabus is found to provide effective pilot training; and

c) the operator provides data that establish the accuracy with which the aircraft navigation system can be updated using manual procedures and representative NAVAIDs. Data should show the update accuracy achieved in in-service operations. This factor must be considered when establishing the RNP 10 time limit for INS or IRU.

4.12 Pilot knowledge and training

The following items should be standardized and incorporated into training programmes and operating practices and procedures. Certain items may already be adequately standardized in existing operator programmes and procedures. New technologies may also eliminate the need for certain crew actions. If this is found to be the case, then the intent of this attachment can be considered to have been met.

Note.— This guidance material has been written for a wide variety of operator types, therefore, certain items that have been included may not apply to all operators.

Commercial operators should ensure that pilots have been trained so that they are knowledgeable of the topics contained in this guidance material, the limits of their RNP 10 navigation capabilities, the effects of updating, and RNP 10 contingency procedures.

Non-commercial operators should show the aviation authority that their pilots are knowledgeable of RNP 10 operations. However, some States might not require non-commercial operators to have formal training programmes for some types of operations (e.g. FAA Order 8700.1, General Aviation Operations Inspector's Handbook). The aviation authority, in determining whether a non-commercial operator's training is adequate, might:

(a) accept a training centre certificate without further evaluation;

(b) evaluate a training course before accepting a training centre certificate from a specific centre;

(c) accept a statement in the operator's application for an RNP 10 approval that the operator has ensured and will continue to ensure that pilots are knowledgeable of the RNP 10 operating practices and procedures; or

(d) accept an operator's in-house training programme.

4.13 Navigation database

If a navigation database is carried, it must be current and appropriate for the operations and must include the NAVAIDs and waypoints required for the route.

4.14 Oversight of operators

An aviation authority may consider any navigation error reports in determining remedial action. Repeated navigation error occurrences attributed to a specific piece of navigation equipment or operational procedure may result in cancellation of the operational approval, pending replacement or modifications to the navigation equipment or changes in the operator's operational procedures.

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

4.15 Contingencies Procedures

The operator will outline contingency procedures fo dealing with the following;

a) Inability to comply with ATC clearance due to meteorological conditions, aircraft performance or pressurization failure
b) Weather deviations
c) Air-Ground communication failure

CHAPTER 2

RNAV 5 OPERATIONS

1.0 OPERATIONS AND APPROVAL PROCESS

1.0.1 INTRODUCTION

This chapter provides guidance on operational implementation of RNAV 5 in the en-route phase of flight.

2.0 PURPOSE

It provides the operator with criteria to enable operation in airspace where the carriage of RNAV meeting 5 NM lateral accuracy is already required. It avoids the need for further approvals in other regions or areas needing to implement RNAV with the same lateral accuracy and functional requirements.

While primarily addressing requirements of RNAV operation in an ATS surveillance environment, RNAV 5 implementation has occurred in areas where there is no ATS surveillance. This has required an increase in route spacing commensurate with the assurance of meeting the SSR.

The RNAV 5 specification does not require an alert to the pilot in the event of excessive navigation errors. Since the specification does not require the carriage of dual RNAV systems, the potential for loss of RNAV capability requires an alternative navigation source.

RNAV 5 systems permit aircraft navigation along any desired flight path within the coverage of station referenced NAVAIDs (space or terrestrial) or within the limits of the capability of self-contained aids, or a combination of both methods.

3.0 REFERENCES

3.1 KCARS Operations of Aircraft Regulations
KCARS Instrument and Equipment Regulations
Form KCAAFOPSPBN: Application Job Aid Part A (Application Form)
Form KCAAFOPSPBN: Evaluation Approval

3.2 Other References

a) EASA AMC 25-11 electronic display systems
b) EASA AMC 20-5 acceptable means of compliance for airworthiness approval and operational criteria for the use of the NAVSTAR global positioning system (GPS)
c) EASA Part SPA (GM1 SPA.PBN.100)
d) FAA AC 25-4 Inertial Navigation Systems (INS)

e) FAA AC 25-15 Approval of FMS in Transport Category Airplanes
f) FAA AC 90-45 A Approval of Area Navigation Systems for use in the U S. National Airspace System
g) TSO/ETSO-C115b Airborne Area Navigation Equipment Using Multi Sensor Inputs
h) TSO/ETSO-C129a Airborne Supplemental Navigation Equipment Using the Global Positioning System (GPS)
i) TSO/ETSO-C145 Airborne Navigation Sensors Using the Global Positioning System (GPS) Augmented by the Wide Area Augmentation System (WAAS)
j) TSO/ETSO-C146 Stand-Alone Airborne Navigation Equipment Using the Global Positioning System (GPS) Augmented by the Wide Area Augmentation System (WAAS)

4.0 RNAV 5 Operational Requirements

This section identifies the operational requirements for RNAV 5 operations. Operational compliance with these requirements should be addressed through national operational regulations, and may require specific operational approval in some cases.

5.0 Approval process

5.0.1 The operator who intends to seek for authorization/approval of RNAV-5 shall present to the authority a statement of intent to start the process of obtaining the authorization. A letter accompanying the application form shall be acceptable.

5.0.2 The equivalence of the technical requirements of RNAV 5 and B-RNAV means that equipment approved against existing national rules for B-RNAV will not normally require further technical approval.

5.0.3 RNAV 5 does not require the carriage of a navigation database. Because of the specific limitations (e.g. workload and potential for data input errors) associated with manual insertion of waypoint coordinate data, RNAV 5 operations should be restricted to the en-route phase of flight.

Notes:

1. *Detailed information on operational approvals is provided in Volume I, Attachment C.*
2. *Where appropriate, States may refer to previous operational approvals in order to expedite this process for individual operators where performance and functionality are applicable to the current request for operational approval.*

5.1 Aircraft eligibility

The aircraft eligibility must be determined through demonstration of compliance against the relevant airworthiness criteria and the requirements this Chapter. The OEM or the holder of installation approval for the aircraft, e.g. STC holder, will demonstrate compliance to their NAA (e.g. EASA, FAA) and the approval can be documented in manufacturer documentation (e.g. service letters). AFM entries are not required provided the State accepts manufacturer documentation.

5.2 Operational approval

Description of aircraft equipment
The operator must have a configuration list and, if necessary, an MEL detailing the required aircraft equipment for RNAV 5 operations.

5.2.1 Training documentation

Commercial operators must have a training programme addressing the operational practices, procedures and training items related to RNAV 5 operations (e.g. initial, upgrade or recurrent training for pilots, dispatchers or maintenance personnel).

Note.— Operators need not establish a separate training programme or regimen if they already integrate RNAV training as an element of their training programme. However, the operator should be able to identify the aspects of RNAV 5 covered in their training programme.

Private operators must be familiar with the practices and procedures identified the Pilot knowledge and training sections of this manual.

5.2.2 Operations Manuals and checklists

OMs and checklists for commercial operators must address information/guidance on the SOP detailed in this Chapter. The appropriate manuals should contain navigation operating instructions and contingency procedures, where specified. When required by the State of the Operator/Registry, the operator must submit their manuals and checklists for review as part of the application process.

5.2.3 MEL considerations

Any MEL revisions necessary to address RNAV 5 provisions must be approved. Operators must adjust the MEL, or equivalent, and specify the required dispatch conditions.

5.2.4 Continuing airworthiness

The operator must submit the continuing airworthiness instructions applicable to the aircraft's configuration and the aircraft's qualification for this navigation specification. Additionally, there is a requirement for the operator to submit their maintenance programme, including a reliability programme for monitoring the equipment.

Note.— The operator should confirm with the OEM, or the holder of installation approval for the aircraft, that acceptance of subsequent changes in the aircraft configuration, e.g. SBs, does not invalidate current operational approvals.

6.0 *Migration path to RNAV 5*

The requirements of B-RNAV are identical to RNAV 5. National regulatory material is expected to take this equivalence into account. No additional migration path is required. This does not relieve the operator of the responsibility, in relation to all operations, to consult and comply with regional and national specific procedures or regulations.

7.0 Aircraft requirements

RNAV 5 operations are based on the use of RNAV equipment which automatically determines the aircraft position using input from one or a combination of the following types of position sensors, together with the means to establish and follow a desired path:

a) VOR/DME;

b) DME/DME;

c) INS or IRS; and

d) GNSS.

8.0 *On-board performance monitoring and alerting*

a. *Accuracy*: During operations in airspace or on routes designated as RNAV 5, the lateral TSE must be within 5 NM for at least 95 per cent of the total flight time. The along-track error must also be within ±5 NM for at least 95 per cent of the total flight time.

b. *Integrity*: Malfunction of the aircraft navigation equipment is classified as a major failure condition under airworthiness regulations (i.e. 10–5 per hour).

c. *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.

d. *SIS*: If using GNSS, the aircraft navigation equipment shall provide an alert if the probability of SIS errors causing a lateral position error greater than 10 NM exceeds 10–7 per hour.

Note.— The minimum level of integrity and continuity required for RNAV 5 systems for use in airspace designated for RNAV 5 would normally be met by a single installed system comprising one or more sensors, an RNAV computer, a control display unit and navigation display(s) (e.g. ND, HSI or CDI), provided that the system is monitored by the pilot and that in the event of a system failure the aircraft retains the capability to navigate relative to ground-based NAVAIDs (e.g. VOR/DME or NDB).

9.0 *Criteria for specific navigation services*

INS/IRS
Inertial systems may be used either as a stand-alone INS or an IRS acting as part of a multi-sensor RNAV system, where inertial sensors provide augmentation to the basic position sensors, as well as a reversionary position data source when out of cover of radio navigation sources.
INS without automatic radio updating of aircraft position, but approved in accordance with AC 25-4, and when complying with the functional criteria of this specification, may be used only for a maximum of 2 hours from the last alignment/position update performed on the ground. Consideration may be given to specific INS configurations (e.g. triple mix) where either equipment or the aircraft manufacturer's data justify extended use from the last position update.

INS with automatic radio updating of aircraft position, including those systems where manual selection of radio channels is performed in accordance with flight crew procedures, should be approved in accordance with AC-90-45A, AC 20-130A or equivalent material.

VHF VOR
VOR accuracy can typically meet the accuracy requirements for RNAV 5 up to 60 NM (75 NM for Doppler VOR) from the NAVAID. Specific regions within the VOR coverage may experience larger errors due to propagation effects (e.g. multipath). Where such errors exist, this can be resolved by prescribing areas where the affected VOR may not be used.

Alternative action could be to take account of lower VOR performance in the setting up of the proposed RNAV routes by, for example, increasing additional route spacing. Account must be taken of the availability of other NAVAIDs that can provide coverage in the affected area and that not all aircraft may be using the VOR concerned and may therefore not exhibit the same track-keeping performance.

DME
DME signals are considered sufficient to meet the requirements of RNAV 5 whenever the signals are received and there is no closer DME on the same channel, regardless of the published coverage volume. When the RNAV 5 system does not take account of published "Designated Operational Coverage" of the DME, the RNAV system must execute data integrity checks to confirm that the correct DME signal is being received. The individual components of the NAVAID infrastructure must meet the performance requirements detailed in Annex 10, Volume I. NAVAIDs that are not compliant with Annex 10 should not be published in the State AIP.

GNSS
The use of GNSS to perform RNAV 5 operations is limited to equipment approved to ETSO-C129(), ETSOC145(), ETSO-C146(), FAA TSO-C145(), TSO-C146(), and TSO-C129() or equivalent, and include the minimum system functions specified in this Chapter.

Integrity should be provided by SBAS GNSS or RAIM or an equivalent means within a multi-sensor navigation system. In addition, GPS stand-alone equipment should include the following functions:

a. pseudo-range step detection; and
b. health word checking.

Note.— These two additional functions are required to be implemented in accordance with TSOC129a/ ETSO-C129a or equivalent criteria.

Where approval for RNAV 5 operations requires the use of traditional navigation equipment as a back-up in the event of loss of GNSS, the required NAVAID capability, as defined in the approval (i.e. VOR and DME), will need to be installed and be serviceable.

Positioning data from other types of navigation sensors may be integrated with the GNSS data provided other positioning data do not cause position errors exceeding the track-keeping accuracy requirements.

10.0 *Functional requirements*

The following system functions are the minimum required to conduct RNAV 5 operations:

a. continuous indication of aircraft position relative to track to be displayed to the pilot flying the aircraft, on a navigation display situated in his/her primary field of view;
b. where the minimum flight crew is two pilots, indication of the aircraft position relative to track to be displayed to the pilot not flying the aircraft, on a navigation display situated in his/her primary field of view;
c. display of distance and bearing to the active (to) waypoint;
d. display of ground-speed or time to the active (to) waypoint;
e. storage of waypoints; minimum of 4; and
f. appropriate failure indication of the RNAV system, including the sensors.

RNAV 5 navigation displays

Navigation data must be available for display either on a display forming part of the RNAV equipment or on a lateral deviation display (e.g. CDI, (EHSI, 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. They should meet the following requirements:

a. the displays must be visible to the pilot when looking forward along the flight path;
b. the lateral deviation display scaling should be compatible with any alerting and annunciation limits, where implemented; and
c. the lateral deviation display must have a scaling and full-scale deflection suitable for the RNAV 5 operation.

11.0 OPERATING PROCEDURES

11.1 *General*

Airworthiness certification alone does not authorize flights in airspace or along routes for which RNAV 5 approval is required. Operational approval is also required to confirm the adequacy of the operator's normal and contingency procedures for the particular equipment installation.

11.2 *Pre-flight planning*

11.2.1 Operators and pilots intending to conduct operations on RNAV 5 routes should file the appropriate flight plan suffixes indicating their approval for operation on the routes.

11.2.2 During the preflight planning phase, 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. The pilot must also confirm availability of the on-board navigation equipment necessary for the operation.

11.2.3 Where a navigation database is used, it should be current and appropriate for the region of intended operation and must include the NAVAIDs and waypoints required for the route.

11.2.4 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 SBAS signal is unavailable.

11.3 *ABAS availability*

En-route RAIM levels are required for RNAV 5 and can be verified either through NOTAMs (where available) or through prediction services. The operating authority may provide specific guidance on ow 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.

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

In the event of a predicted, continuous loss of appropriate level of fault detection of more than five minutes for any part of the RNAV 5 operation, the flight planning should be revised (i.e. delaying the departure or planning a different departure procedure).

RAIM availability prediction software is a tool used to assess the expected capability of meeting the navigation performance. Due to unplanned failure of some GNSS elements, pilots/ANSP must realize that RAIM or GPS navigation may be lost altogether 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.

11.4 *General operating procedures*

11.4.1 Operators and pilots should not request or file RNAV 5 routes unless they satisfy all the criteria in the relevant documents. If an aircraft not meeting these criteria receives a clearance from ATC to conduct an RNAV procedure, the pilot must advise ATC that he/she is unable to accept the clearance and must request alternate instructions.

11.4.2 The pilot should comply with any instructions or procedures identified by the manufacturer as being necessary to comply with the performance requirements in this manual.

11.4.3 Pilots of RNAV 5 aircraft must adhere to any AFM limitations or operating procedures required to maintain the navigation accuracy specified for the procedure.

11.4.4 Where installed, pilots must confirm that the navigation database is up to date.

11.4.5 The pilots should cross-check the cleared flight plan by comparing charts or other applicable resources with the navigation system textual display and the aircraft map display, if applicable. If required, the exclusion of specific NAVAIDs should be confirmed.

11.4.6 During the flight, where feasible, the flight progress should be monitored for navigational reasonableness, by cross-checks with conventional NAVAIDs using the primary displays in conjunction with the RNAV CDU.

11.4.7 For RNAV 5, pilots should use a lateral deviation indicator, flight director or autopilot in lateral navigation mode. Pilots may use a navigation map display without a flight director or autopilot. Pilots of aircraft with a lateral deviation display must ensure that lateral deviation scaling is suitable for the navigation accuracy associated with the route/procedure (e.g. full-scale deflection: ±5 NM).

11.4.8 All pilots are expected to maintain route centre lines, as depicted by on-board lateral deviation indicators and/or flight guidance, during all RNAV 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 RNAV system-computed path and the aircraft position relative to the path) should be limited

to ±½ the navigation accuracy associated with the procedure or route (i.e. 2.5 NM). Brief deviations from this standard (e.g. overshoots or undershoots) during and immediately after procedure/route turns, up to a maximum of one times the navigation accuracy (i.e. 5 NM), are allowable.

Note.— Some aircraft do not display or compute a path during turns; pilots of these aircraft may not be able to adhere to the ±½ accuracy standard during route turns, but are still expected to satisfy the standard during intercepts of the final track following the turn and on straight segments.

11.4.9 If ATS issues a heading assignment taking the aircraft off a route, the pilot should not modify the flight plan in the RNAV system until a clearance is received to rejoin the route or the controller confirms a new clearance. When the aircraft is not on the published route, the specified accuracy requirement does not apply.

12.0 Contingency procedures

12.1 The pilot must notify ATC when the RNAV performance ceases to meet the requirements for RNAV 5. The communications to ATC must be in accordance with the authorized procedures (Doc 4444 or Doc 7030, as appropriate).

12.2 In the event of Air-Ground communication failure, the pilot should continue with the flight plan in accordance with the published "lost communications" procedure.

12.3 Where stand-alone GNSS equipment is used:

a. In the event of that there is a loss of the RAIM detection function, the GNSS position may continue to be used for navigation. The pilot should attempt to cross-check the aircraft position, with other sources of position information, (e.g. VOR, DME and/or NDB information) to confirm an acceptable level of navigation performance. Otherwise, the pilot should revert to an alternative means of navigation and advise ATC.
b. In the event that the navigation display is flagged invalid due to a RAIM alert, the pilot should revert to an alternative means of navigation and advise ATC.

13.0 PILOT KNOWLEDGE AND TRAINING

The pilot training programme should address the following items:

a) the capabilities and limitations of the RNAV system installed;
b) the operations and airspace for which the RNAV system is approved to operate;
c) the NAVAID limitations with respect to the RNAV system to be used for the RNAV 5 operation;
d) contingency procedures for RNAV failures;
e) the radio/telephony phraseology for the airspace, in accordance with Doc 4444 and Doc 7030, as appropriate;
f) the flight planning requirements for the RNAV operation;
g) RNAV requirements as determined from chart depiction and textual description;
h) RNAV system-specific information, including:
   i. levels of automation, mode annunciations, changes, alerts, interactions, reversions, and degradation;
   ii. functional integration with other aircraft systems;
   iii. monitoring procedures for each phase of the flight (e.g. monitor PROG or LEGS);
   iv. types of navigation sensors (e.g. DME, IRU, GNSS) utilized by the RNAV system and associated system prioritization/weighting/logic;
   v. turn anticipation with consideration to speed and altitude effects; and
   vi. interpretation of electronic displays and symbols;
   vii. RNAV equipment operating procedures, as applicable, including how to perform the following actions:
      a) verify that the aircraft navigation data is current;
      b) verify the successful completion of RNAV system self-tests;
      c) initialize RNAV system position;
      d) fly direct to a waypoint;
      e) intercept a course/track;
      f) be vectored off and rejoin a procedure;
      g) determine cross-track error/deviation;
      h) remove and reselect navigation sensor input;
      i) when required, confirm exclusion of a specific NAVAID or NAVAID type; and
      j) perform gross navigation error checks using conventional NAVAIDs.

14.0 NAVIGATION DATABASE

Where a navigation database is carried and used, it must be current and appropriate for the region of intended operation and must include the NAVAIDs and waypoints required for the route.

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 the navigation data, including the suitability of navigation facilities used to define the routes for the flight. Traditionally, this has been accomplished by verifying electronic data against paper products.

15.0 OVERSIGHT OF OPERATORS

A process needs to be established whereby navigation error reports can be submitted and analysed in order to establish the need for remedial action. Repeated navigation error occurrences attributed to a specific piece of navigation equipment need to be followed up and action taken to remove the causal factor(s).

The nature of the error cause will determine the remedial action which could include the need for remedial training, restrictions in the application of the system, or requirements for software changes in the navigation system.

The nature and severity of the error may result in temporary cancellation of the approval for use of that equipment until the cause of the problem has been identified and rectified.

CHAPTER 3

RNAV 1 AND 2

1.0 OPERATIONS AND APPROVAL PROCESS

1.1 INTRODUCTION

For legacy systems, compliance with both P-RNAV (TGL-10) and U.S. RNAV (FAA AC 90-100) assures automatic compliance with this ICAO specification. Operators with compliance to only TGL-10 or AC 90-100 should refer to further details in this Chapter to confirm whether their system gives automatic compliance to this specification. Compliance with ICAO RNAV 1 and 2 through either of the above obviates the need for further assessment beyond checking entries in AFM documentation where applicable. In addition, an operational approval to this specification allows an operator to conduct RNAV 1 and/or 2 operations globally.

2.0 PURPOSE

This chapter provides guidance for the implementation of RNAV 1 and 2 navigation specification, and references to the applicable guidance material that supports the implementation of RNAV 1 and RNAV 2.

3.0 REFERENCES AND RELATED DOCUMENTS

KCARS Operation of Aircraft Regulations
KCARS Instrument and Equipment Regulations
PBN Application Form
PBN Evaluation Approval form

Annex 6 Operation of aircraft
Part I – International commercial air transport – Aeroplanes
Part II – International general aviation - Aeroplanes
ICAO Doc 9613 Performance-based navigation (PBN) manual
ICAO Doc 8168 Aircraft operations
Volume I: Flight procedures
Volume II: Construction of visual and instrument flight procedures
EASA Part SPA (GM1 SPA.PBN.100)
FAA AC 90-100A U.S. Terminal and en route area navigation (RNAV) operations
FAA AC 90-96A Approval of U.S. operators and aircraft to operate under instrument flight rules (IFR) in European airspace designated for basic area navigation (B-RNAV) and precision area navigation (P-RNAV)

4.0 NAVAID infrastructure

The RNAV 1 and 2 specification is applicable to all ATS routes, including routes in the en-route domain, SIDs and STARS. It also applies to IAPs up to the FAF.

The RNAV 1 and 2 specification is primarily developed for RNAV operations in a radar environment (for SIDs, radar coverage is expected prior to the first RNAV course change). The RNP 1 specification is intended for similar operations outside radar coverage.

However, RNAV 1 and RNAV 2 may be used in a non-radar environment or below minimum vectoring altitude if the implementing State ensures appropriate system safety and accounts for lack of on-board performance monitoring and alerting.

RNAV 1 and RNAV 2 routes are intended to be conducted in Direct Controller-Pilot Communication (DCPC) environments.

The route design should take account of the navigation performance, which can be achieved with the available NAVAID infrastructure, and the functional capabilities required by this document. While the aircraft's navigation equipment requirements for RNAV 1 and RNAV 2 are identical, NAVAID infrastructure impacts the achievable performance. Accommodation of existing user equipment should be considered a primary goal.

The following navigation criteria are defined: GNSS, DME/DME and DME/DME/IRU. Where DME is the only navigation service used for position updates, gaps in DME coverage can prevent position update. Integration of IRUs can permit extended gaps in coverage.

Note.— Based on evaluated IRU performance, the growth in position error after reverting to IRU can be expected to be less than 2 NM per 15 minutes.

If an IRU is not carried, then the aircraft can revert to dead reckoning. In such cases, additional protection, in accordance with PANS-OPS (Doc 8168, Volume II), will be needed to cater for the increased error. GNSS should be authorized whenever possible and limitations on the use of specific system elements should be avoided.

Note.— Most modern RNAV systems prioritize input from GNSS and then DME/DME positioning. Although VOR/DME positioning is usually performed within a flight management computer when DME/DME positioning criteria cannot be met, avionics and infrastructure variability pose serious challenges to standardization. Therefore, the criteria in this document only cover GNSS, DME/DME and DME/DME/IRU. This does not preclude the conduct of operations by systems that also use VOR provided they satisfy the criteria above

4.1 Communications and ATS surveillance

Where reliance is placed on the use of radar to assist contingency procedures, its performance should be adequate for that purpose i.e. radar coverage, its accuracy, continuity and availability should be adequate to ensure separation on the RNAV 1 and RNAV 2 ATS route structure and provide contingency in cases where several aircraft are unable to achieve the navigation performance prescribed in this navigation specification.

4.2 Publication

The AIP should clearly indicate whether the navigation application is RNAV 1 or RNAV 2. The route should rely on normal descent profiles and identify minimum segment altitude requirements. The navigation data published in the State AIP for the routes and supporting NAVAIDs must meet the requirements of Annex 15. All routes must bebased upon WGS-84 coordinates.

The available NAVAID infrastructure should be clearly designated on all appropriate charts (e.g. GNSS, DME/DME or DME/DME/IRU).

Any DME facilities that are critical to RNAV 1 or RNAV 2 operations should be identified in the relevant publications.

5.0 NAVIGATION SPECIFICATION

5.1 Background

This section identifies the aircraft requirements and operating procedures for RNAV 1 and RNAV 2 operations.

5.2 Approval process

This navigation specification does not in itself constitute regulatory guidance material against which either the aircraft or the operator will be assessed and approved. Aircraft are certified by their State of Manufacture. Operators are approved in accordance with their national operating rules. This navigation specification provides the technical and operational criteria, and does not necessarily imply a need for recertification.

The operator who intends to seek for authorization/approval of RNAV-5 shall present to the authority a statement of intent to start the process of obtaining the authorization. A letter accompanying the application form shall be acceptable.

5.2.1 *Aircraft eligibility*

The aircraft eligibility must be determined through demonstration of compliance against the relevant airworthiness criteria and the requirements of this Chapter. The OEM or the holder of installation approval for the aircraft, e.g. STC holder, will demonstrate compliance to their NAA (e.g. EASA, FAA) and the approval can be documented in manufacturer documentation (e.g. service letters). AFM entries are not required provided the State accepts manufacturer documentation.

5.3 *Operational approval*

a) Description of aircraft equipment

The operator must have a configuration list and, if necessary, an MEL detailing the required aircraft equipment for RNAV 1 and/or RNAV 2 operations.

5.3.1 Training documentation

Commercial operators must have a training programme addressing the operational practices, procedures and training items related to RNAV 1 and/or RNAV 2 operations (e.g. initial, upgrade or recurrent training for pilots, dispatchers or maintenance personnel).

Note.— Operators need not establish a separate training programme if they already integrate RNAV training as an element of their training programme. However, the operator should be able to identify the aspects of RNAV 1 and/or RNAV 2 covered within their training programme.

Private operators must be familiar with the practices and procedures identified this Chapter (Pilot knowledge and training).

5.3.2 Operations Manuals and checklists

OMs and checklists for commercial operators must address information/guidance on their SOPs. The appropriate manuals should contain navigation operating instructions and contingency procedures, where specified. When required by the State of Operator/Registry, operators must submit their manuals and checklists for review as part of the application process.

5.3.3 MEL considerations

Any MEL revisions necessary to address RNAV 1 and/or RNAV 2 provisions must be approved. Operators must adjust the MEL, or equivalent, and specify the required dispatch conditions.

5.3.4 Continuing airworthiness

The operator must submit the continuing airworthiness instructions applicable to the aircraft configuration and the aircraft qualification for this navigation specification. Additionally, there is a requirement for operators to submit their maintenance programme, including a reliability programme for monitoring the equipment.

Note.— The operator should confirm with the OEM, or the holder of installation approval for the aircraft, that acceptance of subsequent changes in the aircraft configuration, e.g. SBs, does not invalidate current operational approvals.

6.0 Achieving RNAV 1 and RNAV 2 Approval

Operator holding no approval

An operator wishing to fly into RNAV 1 or RNAV 2 designated airspace:

a. First, establish the aircraft eligibility. This may be accomplished through prior documentation of compliance to the requirements of this navigation specification (e.g. compliance with AC 90-100A, TGL No. 10 or AC 90-100) and, second, establish the differences to achieve an acceptable means of compliance to RNAV 1 and RNAV 2. Having evidence of aircraft eligibility, the operator will then be required to obtain the necessary operational approval from their State authority who should again refer to the existing material and the deltas that satisfy the RNAV 1 or RNAV 2 standard.
b. An operator approved against the criteria for RNAV 1 and RNAV 2 operations is eligible to operate on US-RNAV RNAV 1 and RNAV 2 and European P-RNAV routes; no further approval is required.

Note.— In many cases, the OEMs have already made an airworthiness assessment of their systems against both the TGL No. 10 and AC 90-100 standards and can provide supporting evidence of compliance through service letters or AFM statements. The operational differences are limited to the navigation database being obtained from an accredited source. In this way, the regulatory effort of migrating from one approval to another should be minimized, avoiding the need for time-consuming reinvestigation and costly assessment.

6.1 Summary of RNAV 1/TGL-10/AC 90-100 insignificant differences

The appendix to this chapter contains a list of insignificant differences between RNAV 1, TGL-10 and AC 90-100.

6.2 Aircraft requirements

RNAV 1 and RNAV 2 operations are based upon the use of RNAV equipment that automatically determines the aircraft position in the horizontal plane using input from the following types of position sensors (no specific priority):

a) GNSS in accordance with FAA TSO-C145(), TSO-C146(), or TSO-C129(). Positioning data from other types of navigation sensors may be integrated with the GNSS data provided other position data do not cause position errors exceeding

the total system accuracy requirements. The use of GNSS equipment approved to TSO-C129 () is limited to those systems which include the minimum functions specified in this Section. As a minimum, integrity should be provided by an ABAS. In addition, TSO-C129 equipment should include the following additional functions:

i. pseudo-range step detection;
ii. health word checking;

b) DME/DME RNAV equipment complying with the criteria listed in this Section; and
c) DME/DME/IRU RNAV equipment complying with the criteria listed in this Section.

6.3 On-board performance monitoring and alerting

Accuracy: During operations in airspace or on routes designated as RNAV 1, the lateral TSE must be within ±1 NM for at least 95 per cent of the total flight time. The along-track error must also be within ±1 NM for at least 95 per cent of the total flight time. During operations in airspace or on routes designated as RNAV 2, the lateral TSE must be within ±2 NM for at least 95 per cent of the total flight time. The along-track error must also be within ±2 NM for at least 95 per cent of the total flight time.

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

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.

SIS: During operations in airspace or on routes designated as RNAV 1 if using GNSS, 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 in airspace or on routes designated as RNAV 2 if using GNSS, the aircraft navigation equipment shall provide an alert if the probability of SIS errors causing a lateral position error greater than 4 NM exceeds 10–7 per hour.

6.4 *Criteria for specific navigation services*

Criteria for GNSS

The following systems meet the accuracy requirements of these criteria:

a) aircraft with TSO-C129/C129a sensor (Class B or C) and the requirements in a TSO-C115b FMS, installed for IFR use in accordance with FAA AC 20-130A;
b) aircraft with TSO-C145() sensor and the requirements in a TSO-C115b FMS, installed for IFR use IAW FAA AC 20-130A or AC 20-138B;
c) aircraft with TSO-C129/C129a Class A1 (without deviating from the functionality described in this section), installed for IFR use IAW FAA AC 20-138 or AC 20-138A; and
d) aircraft with TSO-C146() (without deviating from the functionality described in 3.3.3.3 of this document), installed for IFR use IAW AC 20-138A.
e) For routes and/or aircraft approvals requiring GNSS, if the navigation system does not automatically alert the pilot to a loss of GNSS, the operator must develop procedures to verify correct GNSS operation.
f) Positioning data from other types of navigation sensors may be integrated with the GNSS data provided other positioning data do not cause position errors exceeding the TSE budget. Otherwise, means should be provided to deselect the other navigation sensor types.

TABLE 1

6.5 CRITERIA FOR THE APPROVAL OF RNAV SYSTEMS THAT USE DME

(DME/DME RNAV SYSTEM)

PURPOSE

The Authority is responsible for assessing DME coverage and availability in accordance with the minimum standards of the DME/DME RNAV system for each route and procedure. Detailed criteria are needed to define DME/DME RNAV system performance, since that system is related to DME infrastructure. This Appendix describes the minimum DME/DME RNAV system performance and functions required to support the implementation of RNAV 1 and RNAV 2 routes, SIDs, and STARs. These criteria must be used for the airworthiness approval of new equipment or can be used by manufacturers for the certification of their existing equipment.

MINIMUM REQUIREMENTS FOR DME/DME RNAV SYSTEMS

Paragraph	Criteria	Explanation
a)	Accuracy is based on the performance standards set forth in TSO-C66c	
b)	Tuning and updating position of DME facilities	The DME/DME RNAV system must: update its position within 30 seconds of tuning on DME navigation facilities; auto-tune multiple DME facilities; and provide continuous DME/DME position updating. If a third DME facility or a second pair has been available for at least the previous 30 seconds, there must be no interruption in DME/DME positioning when the RNAV system switches between DME stations/pairs.

c)	Use of facilities contemplated in State AIPs	DME/DME RNAV systems must only use the DME facilities identified in the State AIPs. Systems must not use the facilities that States list in their AIPs as not appropriate for RNAV 1 and/or RNAV 2 operations, or facilities associated to an ILS or MLS that uses a range offset. This can be done through: Excluding specific DME facilities which are known to have a deleterious effect on the navigation solution from the aircraft navigation database when RNAV routes are within the reception range of said DME facilities. the use of an RNAV system that conducts reasonableness checks to detect errors in all of the DME facilities and excludes those facilities from the navigation position solution as appropriate.
d)	DME facilities relative angles	When it is necessary to generate a DME/DME position, the RNAV system must use, as a minimum, DMEs with a relative angle between 30° and 150°.
e)	Use of DMEs through the RNAV system	The RNAV system may use any valid (listed in the AIP) DME facility, regardless of its location. A valid DME facility: issues a precise signal that identifies the facility; meets the minimum signal intensity requirements; and is protected against interference from other DME signals, in accordance with co-channel and adjacent channel requirements. When needed to generate a DME/DME position, as a minimum, the RNAV system must use an available and valid low altitude and/or high altitude DME anywhere within the following region around the DME facility: greater than or equal to 3 NM from the facility; and less than 40° above the horizon when viewed from the DME facility and at a distance of 160 NM.
f)	No requirement to use VOR, NDB, LOC, IRU or AHRS	There is no requirement to use VOR, non-directional radio beacon (NDB), localizer (LOC), IRU or attitude and heading reference system (AHRS) during normal operation of the DME/DME RNAV system.
g)	Position estimation error (PEE)	When using a minimum of two DME facilities that meet the criteria contained in Paragraph e) above and any other valid facility that does not meet such criteria, the position estimation error during 95% of the time must be better than or equal to the specified standard.

h)	Preventing erroneous guidance from other facilities	The RNAV system must ensure that the use of facilities outside the service volume (where field intensity and common or adjacent interference requirements cannot be met) do not cause misguidance. This could be achieved by including reasonableness checks when initially tuning on a DME facility, or by excluding a DME facility when there is a co-channel DME within line-of-sight.
i)	Preventing erroneous VOR signals-in-space	The RNAV system can use a VOR. However, the RNAV system must make sure that an erroneous VOR signal-in-space does not affect the position error when the system is within DME/DME coverage. This can be achieved by monitoring the VOR signal with DME/DME to make sure that it does not mislead position results.
j)	Ensuring RNAV systems use operational facilities	The RNAV system must use operational DME facilities. DME facilities listed in the NOTAMs as inoperative (for example, being tested or undergoing maintenance) could still reply to on-board interrogation. Consequently, inoperative facilities must not be used.
k)	Operational mitigation	Operational mitigations, such as the monitoring by pilots of the sources to update the RNAV navigation system, or time scheduling, or the exclusion of multiple DME facilities, should be performed before any period of intensive workload or any critical flight phase. *Note.- The exclusion of individual facilities listed in the NOTAMS as out of service and/or the programming of a route/procedure defined as critical DME is acceptable when such mitigation does not require action by the pilot during a critical phase of the flight.*
l)	Reasonableness checks	Many RNAV systems perform reasonableness checks to verify the validity of DME measurements.- Reasonableness checks are very effective against database errors or erroneous system inputs (such as, inputs from co-channel DME facilities) and normally can be divided into two classes: the ones the RNAV system uses after a new DME has been captured, where the system compares the aircraft's position before using the DME with the range of the aircraft to that DME; and

		the ones the RNAV system continuously uses, based on redundant information (for example, additional DME signals or IRU information). General requirements Reasonableness checks are intended to prevent navigation aids from being used for navigation updating in areas where data can lead to errors in the radio position fix due to co-channel interference, multipath, and direct signal screening. Assumptions.- Under certain conditions, reasonableness checks can be invalid. A DME signal will not remain valid just because it was valid when captured. *Additional DME signals might not be available.* The intent of this specification is to support operations where infrastructure is minimal (for example, when only two DMEs are available for en-route segments).

TABLE 2

6.6 CRITERIA FOR APPROVAL OF RNAV SYSTEMS THAT USE DME AND IRU

(DME/DME/IRU RNAV SYSTEM)

PURPOSE

This TABLE defines the minimum performance for the DME/DME/IRU (D/D/I) RNAV system. Performance standards for DME/DME positioning are detailed in Appendix 1. The minimum requirements set forth in Appendix 1 are applicable to this appendix and, thus, are not repeated, unless additional performance is required.

MINIMUM REQUIREMENTS FOR DME/DME/IRU RNAV SYSTEMS (INERTIAL SYSTEM PERFORMANCE)

Para	Criteria	Explanation
a)	Inertial system performance must meet the criteria set forth in Appendix G to Part 121 or equivalent.	
b)	Automatic position updating capability is required from the DME/DME solution.	*Note.- Operators/pilots must contact manufacturers to discern if any annunciation of inertial coasting is suppressed following loss of radio updating.*
c)	Since some aircraft systems revert to VOR/DME-based navigation before reverting to inertial coasting, the impact of VOR radial accuracy when the VOR is greater than 40 NM from the aircraft, must not affect aircraft position accuracy.	A method to comply with this objective is to exclude from the RNAV system the VORs that are more than 40 NM away from the aircraft

TABLE 3

6.7 FUNCTIONAL REQUIREMENTS – NAVIGATION FUNCTIONS AND DISPLAYS

Para	Functional requirements	Explanation
	Navigation data, including the to/from indication and a failure indicator, must be shown on a lateral deviation display [*e.g.*, a course deviation indicator (CDI), an enhanced horizontal situation indicator (E)HSI) and/or a navigation chart display]. These lateral deviation displays will be used as primary means of navigation of the aircraft, for manoeuvre anticipation, and for indication of failure/status/integrity. They shall meet the following requirements:	Non-numeric lateral deviation displays (*e.g.*, CDI, (E)HSI), with to/from indication and failure warning, for use as primary means of navigation of the aircraft, manoeuvre anticipation, and indication of failure/status/integrity, with the following five attributes: Displays will be visible to the pilot and will be located in the primary field of view (± 15 degrees from the normal line of sight of the pilot) when looking forward along the flight path; The lateral deviation display scale must be consistent with all alerting and advisory limits, if implemented; The lateral deviation display must also have a full-scale deflection suitable for the flight phase and must be based on the total system precision required; The display scale may be automatically adjusted by default logic, or set to a value obtained from the navigation database. The full-scale deflection value must be known or must be available for display to the pilot, and must be consistent with the values for en-route, terminal, and approach operations; and The lateral deviation display must be automatically slaved to the RNAV calculated path. The course selector of the lateral deviation display shall be automatically adjusted to the RNAV calculated path. *Note.- The normal functions of the stand-alone GNSS meet this requirement.* As an alternate means, a navigation chart display must provide a function equivalent to a lateral deviation display, as described in Paragraph a) 1) from (a) to (e), with appropriate chart scales; which may be manually adjusted by the pilot.

	The following RNAV 1 and RNAV 2 system functions are required as a minimum:	The capability to continuously display to the pilot flying (PF), on the primary flight navigation instruments, the calculated desired RNAV path and the position of the aircraft relative to that path. For operations where the minimum flight crew is two pilots, means will be provided for the monitoring pilot (PM) to check the desired path and the aircraft position; A navigation database with current nav data officially issued for civil aviation, which can be updated in accordance with the AIRAC cycle and from which routes can be retrieved and loaded into the RNAV system; The means to display to the flight crew the period of validity of the navigation database; The means to retrieve and display the data stored in the navigation database relating to individual waypoints and NAVAIDs, to enable the flight crew to verify the route to be flown; and The capability to load on the RNAV system, from the navigation database, the complete RNAV segment of the SIDs or STARs to be flown.
	The means to show the following items, either on the primary field of view of the pilots, or on a readily accessible display [*e.g.*, on a multi-function control display unit (MCDU)]:	The active navigation sensor type; The identification to the active (TO) waypoint; The ground speed or time to the active (TO) waypoint; and The distance and bearing to the active (TO) waypoint. *Note.- When the CDU/MCDU is used to support precision checks by the pilot, said CDU/MCDU must have the capability of displaying lateral deviation with a resolution of at least 0.1 NM.*
	The capability to execute the "direct to" function.	
	The capability for automatic leg sequencing, displaying the sequence to the flight crew.	

	The capability of executing ATS routes retrieved from the on-board database, including the capability of performing fly-by and flyover turns.	
	The aircraft must have the capability to automatically execute leg transitions and maintain tracks consistent with the following ARINC 424 path terminators or their equivalent: Initial fix (IF); Course to a fix (CF); Direct to a fix (DF); and Track to a fix (TF).	*Note 1.- Path terminators are defined in ARINC 424 specification, and their application is described in more detail in RTCA documents DO-236B and DO-201A and in EUROCAE ED-75B and ED-77* *Note 2.- Numeric values for courses and tracks must be automatically loaded from the RNAV system database.*
	The aircraft must have the capability to automatically execute leg transitions consistent with ARINC 424 path terminators: heading to an altitude (VA), heading to a manual termination (VM), and heading to an intercept (VI), or must be capable of being manually flown on a heading to intercept a course or to fly direct to another fix after reaching an altitude of a specified procedure.	
	The aircraft must have the capability to automatically execute leg transitions consistent with the following ARINC 424 path terminators: course to an altitude (CA) and course from a fix to a manual termination (FM), or the RNAV system must permit the pilot to readily designate a waypoint and select a desired course to or from a designated waypoint.	
	The capability to load an RNAV ATS route from the database into the RNAV	

	system by its name is a recommended function.	
	The capability of indicating an RNAV system failure, including the associated sensors, in the primary field of view of the pilots.	
	For multi-sensor systems, the capability for automatic reversion to an alternate RNAV sensor if the primary RNAV sensor fails. This does not preclude the provision of a means for manual selection of the navigation source.	
	Database integrity	Navigation database suppliers must comply with RTCA DO-200/EUROCAE document ED 76 - Standards for processing aeronautical data. A Letter of acceptance (LOA) issued by the appropriate regulatory authority to each of the participants in the data chain shows compliance with this requirement. Discrepancies that invalidate a route must be reported to database providers, and the affected routes must be prohibited through a notice from the operator to its flight crews. Aircraft operators should conduct periodic checks of the databases in order to meet safety requirements.

6.8 Operating procedures

Airworthiness certification alone does not authorize flight in airspace or along routes for which RNAV 1 or RNAV 2 approval is required. Operational approval is also required to confirm the adequacy of the operator's normal and contingency procedures for the particular equipment installation.

6.8.1 Preflight planning

6.8.1.1 Operators and pilots intending to conduct operations on RNAV 1 and RNAV 2 routes should file the appropriate flight plan suffixes.

6.8.1.2 The on-board navigation data must be current and appropriate for the region of intended operation and must include the NAVAIDs, waypoints, and relevant coded ATS routes for departure, arrival, and alternate airfields.

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 the navigation data, including the suitability of navigation facilities used to define the routes and procedures for flight.

6.8.1.3 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 the SBAS receivers (all TSO-C145/C146), operators should check appropriate GPS RAIM availability in areas where the SBAS signal is unavailable.

6.8.2 ABAS availability

6.8.2.1 RAIM levels required for RNAV 1 and RNAV 2 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.

6.8.2.2 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, other entities or through an airborne receiver RAIM prediction capability.

6.8.2.3 In the event of a predicted, continuous loss of appropriate level of fault detection of more than five minutes for any part of the RNAV 1 or RNAV 2 operation, the flight

plan should be revised (e.g. delaying the departure or planning a different departure procedure).

6.8.2.4 RAIM availability prediction software does not guarantee a service; such tools assess the RNAV system's ability to meet the navigation performance. Because of unplanned failure of some GNSS elements, pilots/ANSP must 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.

6.8.3 DME availability

For navigation relying on DME, NOTAMs should be checked to verify the condition of critical DMEs. Pilots should assess their capability to navigate (potentially to an alternate destination) in case of failure of critical DME while airborne.

6.8.4 General operating procedures

6.8.4.1 The pilot should comply with any instructions or procedures identified by the manufacturer as necessary to comply with the performance requirements in this chapter.

6.8.4.2 Operators and pilots should not request or file RNAV 1 and RNAV 2 routes 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 RNAV route, the pilot must advise ATC that he/she is unable to accept the clearance and must request alternate instructions.

6.8.4.3 At system initialization, pilots must confirm the navigation database is current and verify that the aircraft position has been entered correctly. Pilots must verify proper entry of their ATC assigned route upon initial clearance and any subsequent change of route. Pilots must ensure the waypoints sequence, depicted by their navigation system, matches the route depicted on the appropriate chart(s) and their assigned route.

6.8.4.4 Pilots must not fly an RNAV 1 or RNAV 2 SID or STAR unless it is retrievable by route name from the on-board navigation database and conforms to the charted route. However, the route may subsequently be modified through the insertion or deletion of specific waypoints in response to ATC clearances. 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 RNAV SID or STAR database waypoint type from a fly-by to a fly-over or vice versa.

6.8.4.5 Whenever possible, RNAV 1 and RNAV 2 routes in the en-route domain should be extracted from the database in their entirety, rather than loading individual waypoints from the database into the flight plan. However, it is permitted to select and insert individual, named fixes/waypoints from the navigation database, provided all fixes along the published route to be flown are inserted. Moreover, the route may

subsequently be modified through the insertion or deletion of specific waypoints in response to ATC clearances. The creation of new waypoints by manual entry of latitude and longitude or rho/theta values is not permitted.

6.8.4.6 Pilots should cross-check the cleared flight plan by comparing charts or other applicable resources with the navigation system textual display and the aircraft map display, if applicable. If required, the exclusion of specific NAVAIDs should be confirmed.

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

6.8.4.7 During the flight, where feasible, the pilot should use available data from ground-based NAVAIDs to confirm navigational reasonableness.

6.8.4.8 For RNAV 2 routes, pilots should use a lateral deviation indicator, flight director or autopilot in lateral navigation mode. Pilots may use a navigation map display with equivalent functionality as a lateral deviation indicator, as described above in 3.3.3.), without a flight director or autopilot.

6.8.4.9 For RNAV 1 routes, pilots must use a lateral deviation indicator, flight director, or autopilot in lateral navigation mode.

6.8.4.10 Pilots of aircraft with a lateral deviation display must ensure that lateral deviation scaling is suitable for the navigation accuracy associated with the route/procedure (e.g. full-scale deflection: ±1 NM for RNAV 1, ±2 NM for RNAV 2, or ±5 NM for TSO-C129() equipment on RNAV 2 routes).

6.8.4.11 All pilots are expected to maintain route centre lines, as depicted by on-board lateral deviation indicators and/or flight guidance during all RNAV 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 RNAV system computed path and the aircraft position relative to the path, i.e. FTE) should be limited to ±½ the navigation accuracy associated with the procedure or route (i.e. 0.5 NM for RNAV 1, 1.0 NM for RNAV 2).

6.8.4.12 Brief deviations from this standard (e.g. overshoots or undershoots) during and immediately after procedure/route turns, up to a maximum of one times the navigation accuracy (i.e. 1.0 NM for RNAV 1, 2.0 NM for RNAV), are allowable.

Note.— Some aircraft do not display or compute a path during turns, therefore, pilots of these aircraft may not be able to adhere to the ±½ lateral navigation accuracy during

procedural/route turns, but are still expected to satisfy the standard during intercepts following turns and on straight segments.

6.8.4.13 If ATC issues a heading assignment taking the aircraft off a route, the pilot should not modify the flight plan in the RNAV system until a clearance is received to rejoin the route or the controller confirms a new route clearance.

6.8.4.14 When the aircraft is not on the published route, the specified accuracy requirement does not apply.

6.8.4.15 Manually selecting aircraft bank limiting functions may reduce the aircraft's ability to maintain its desired track and are not recommended. Pilots should recognize that manually selectable aircraft bank-limiting functions might reduce their ability to satisfy ATC path expectations, especially when executing large angle turns.

6.8.4.16 This should not be construed as a requirement to deviate from aeroplane flight manual procedures; rather, pilots should be encouraged to limit the selection of such functions within accepted procedures.

6.9 *RNAV SID specific requirements*

6.9.1 Prior to commencing take-off, the pilot must verify the aircraft's RNAV system is available, operating correctly, and the correct airport and runway data are loaded. 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 RNAV 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.

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

6.9.3 Pilots must use an authorized method (lateral deviation indicator/navigation map display/flight director/autopilot) to achieve an appropriate level of performance for RNAV 1.

6.9.4 DME/DME aircraft. Pilots of aircraft without GPS, using DME/DME sensors without IRU input, cannot use their RNAV system until the aircraft has entered adequate DME

coverage. The ANSP will ensure adequate DME coverage is available on each RNAV (DME/DME) SID at an acceptable altitude. The initial legs of the SID may be defined based on heading.

6.9.5 DME/DME/IRU (D/D/I) aircraft. Pilots of aircraft without GPS, using DME/DME RNAV systems with an IRU (DME/DME/IRU), should ensure the aircraft navigation system position is confirmed, within 304 m (1 000 ft) (0.17 NM) of a known position, at the starting point of the take-off roll. This is usually achieved by the use of an automatic or manual runway update function.

6.9.6 A navigation map may also be used to confirm aircraft position, if the pilot procedures and the display resolution allow for compliance with the 304 m (1 000 ft) tolerance requirement.

Note.— Based on evaluated IRU performance, the growth in position error after reverting to IRU can be expected to be less than 2 NM per 15 minutes.

6.9.7 GNSS aircraft. When using GNSS, the signal must be acquired before the take-off roll commences. For aircraft using TSO-C129/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 TSO-C145a/C146a avionics, 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.

6.10 *RNAV STAR specific requirements*

6.10.1 Prior to the arrival phase, the pilot 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 track angles 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 this paragraph.

6.10.2 The creation of new waypoints by manual entry into the RNAV system by the pilot would invalidate the route and is not permitted.

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

6.10.4 Route modifications in the terminal area may take the form of radar headings or “direct to” clearances and the pilot 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 pilot of the loaded route, using temporary waypoints or fixes not provided in the database, is not permitted.

6.10.5 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.

6.10.6 Although a particular method is not mandated, any published altitude and speed constraints must be observed.

6.11 Contingency procedures

6.11.1 The pilot must notify ATC of any loss of the RNAV capability, together with the proposed course of action. If unable to comply with the requirements of an RNAV route, pilots must advise ATS as soon as possible. The loss of RNAV capability includes any failure or event causing the aircraft to no longer satisfy the RNAV requirements of the route.

6.11.2 In the event of communications failure, the pilot should continue with the RNAV route in accordance with established lost communications procedures.

6.12 Pilot knowledge and training

The following items should be addressed in the pilot training programme (e.g. simulator, training device, or aircraft) for the aircraft's RNAV system:

a) the information in this chapter;
b) the meaning and proper use of aircraft 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 (see ARINC 424 path terminators) and any other types used by the operator, as well as associated aircraft flight paths;
e) required navigation equipment for operation on RNAV routes/SIDs/STARs, e.g. DME/DME, DME/DME/IRU, and GNSS;
f) RNAV system-specific information:

i. levels of automation, mode annunciations, changes, alerts, interactions, reversions, and degradation;
ii. ii) functional integration with other aircraft systems;
iii. iii) the meaning and appropriateness of route discontinuities as well as related flight crew procedures;
iv. iv) pilot procedures consistent with the operation;
v. v) types of navigation sensors (e.g. DME, IRU, GNSS) utilized by the RNAV system and associated system prioritization/weighting/logic;
vi. vi) turn anticipation with consideration to speed and altitude effects;

vii. vii) interpretation of electronic displays and symbols;
viii. viii) understanding of the aircraft configuration and operational conditions required to support RNAV operations, i.e. appropriate selection of CDI scaling (lateral deviation display scaling);

g) RNAV equipment operating procedures, as applicable, including how to perform the following actions:
   i. verify currency and integrity of the aircraft navigation data;
   ii. verify the successful completion of RNAV system self-tests;
   iii. initialize navigation system position;
   iv. retrieve and fly a SID or a STAR with appropriate transition;
   v. adhere to speed and/or altitude constraints associated with a SID or STAR;
   vi. select the appropriate STAR or SID for the active runway in use and be familiar with procedures to deal with a runway change;
   vii. perform a manual or automatic update (with take-off point shift, if applicable);
   viii. verify waypoints and flight plan programming;
   ix. fly direct to a waypoint;
   x. fly a course/track to a waypoint;
   xi. intercept a course/track;
   xii. following vectors and rejoining an RNAV route from "heading" mode;
   xiii. determine cross-track error/deviation. More specifically, the maximum deviations allowed to support RNAV must be understood and respected;
   xiv. resolve route discontinuities;
   xv. remove and reselect navigation sensor input;
   xvi. when required, confirm exclusion of a specific NAVAID or NAVAID type;
   xvii. when required by the State aviation authority, perform gross navigation error checks using conventional NAVAIDs;
   xviii. change arrival airport and alternate airport;
   xix. perform parallel offset functions if capability exists. Pilots should know how offsets are applied, the functionality of their particular RNAV system and the need to advise ATC if this functionality is not available;
   xx. perform RNAV holding functions;

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 applications; and
j) contingency procedures for RNAV applications.

6.13 Navigation database

The navigation database should be obtained from a supplier that complies with RTCA DO 200A/EUROCAE document ED 76, Standards for Processing Aeronautical Data and should be compatible with the intended function of the equipment (Annex 6, Part 1, Chapter 7). An LOA, issued by the appropriate regulatory authority to each of the participants in the data chain, demonstrates compliance with this requirement (e.g. FAA LOA issued in accordance with FAA AC 20-153 or EASA LOA issued in accordance with EASA Opinion Nr. 01/2005.

Discrepancies that invalidate a route must be reported to the navigation database supplier and affected routes must be prohibited by an operator's notice to its pilots.

Aircraft operators should consider the need to conduct periodic checks of the operational navigation databases in order to meet existing quality system requirements. DME/DME RNAV systems must only use DME facilities identified in State AIPs. Systems must not use facilities indicated by the State as inappropriate for RNAV 1 and RNAV 2 operations in the AIP or facilities associated with an ILS or MLS that uses a range offset. This may be accomplished by excluding specific DME facilities, which are known to have a deleterious effect on the navigation solution, from the aircraft's navigation database, when the RNAV routes are within reception range of these DME facilities.

6.14 Oversight of operators

A regulatory authority may consider any navigation error reports in determining remedial action. Repeated navigation error occurrences attributed to a specific piece of navigation equipment may result in cancellation of the approval for use of that equipment.

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.

CHAPTER 4

RNP 4 OPERATIONS

1.0 PURPOSE.

This chapter provides ICAO guidance for implementing RNP 4. The operational approval process described herein is limited to aircraft which have received airworthiness certification indicating the installed navigation systems meet the performance requirements for RNP 4. This certification may have been issued at the time of manufacture, or where aircraft have been retrofitted in order to meet the requirements for RNP 4, by the granting of an appropriate STC.

This chapter does not address all requirements that may be specified for particular operations. These requirements are specified in other documents, such as national operating rules, AIPs and the *Regional Supplementary Procedures* (Doc 7030). While operational approval primarily relates to the navigation requirements of the airspace, operators and pilots are still required to take account of all operational documents relating to the airspace, which are required by the appropriate State authority, before conducting flights into that airspace.

2.0 REFERENCES.

The following materials were referred to for the development of this Chapter:

(a) Form KCAAFOPSPBN: Application Job Aid Part A (Application Form)
(b) Form KCAAFOPSPBN: Evaluation Approval Form
(c) ICAO PBN Manual Document 9613 AN/937
(d) FAA Order 8400.33
(e) FAA TSOs C129
(f) FAA C146(),
(g) EASA ETSOs C129A
(h) EASA ETSO C146()

3.0 RNP 4 NAVAID AND COMMUNICATION CONSIDERATIONS

RNP 4 was developed for operations in oceanic and remote airspace, therefore, it does not require any ground-based NAVAID infrastructure. GNSS is the primary navigation sensor to support RNP 4, either as a stand-alone navigation system or as part of a multi-sensor system.

In order to ensure the magnitude and frequency of gross lateral errors are kept within acceptable limits, and to manage contingency and emergency events, consideration should be given to the use of DCPC (voice) or CPDLC (Controller-Pilot Data Link Communication), plus ADS-C surveillance, utilizing waypoint/periodic reporting and lateral deviation event contracts.

In respect of longitudinal separation, communications and ATS surveillance requirements for distance based longitudinal separation utilizing RNP 4 are specified in PANS-ATM.

Note: An existing application of 30 NM lateral and 30 NM longitudinal separation minimum requires a communications capability of DCPC or CPDLC and an ATS surveillance capability by an ADS system in which an event contract must be set that includes a lateral deviation event report whenever a deviation from track centre line greater than 9.3 km (5 NM) occurs.

4.0 APPROVAL REQUIREMENTS

This section identifies the airworthiness and operational requirements for RNP 4 operations.

The operator who intends to seek for authorization/approval of RNP 4 shall present to the authority a statement of intent to start the process of obtaining the authorization.

4.1 *Aircraft eligibility*

The aircraft eligibility must be determined through demonstration of compliance against the relevant airworthiness criteria and the requirements of this Chapter. The OEM or the holder of installation approval for the aircraft, e.g. STC holder, will demonstrate compliance to their NAA (e.g. EASA, FAA) and the approval can be documented in manufacturer documentation (e.g. service letters). AFM entries are not required provided approved manufacturer documentation is available.

4.1.1 Aircraft eligibility groups:

a) Group 1: RNP certification:
Group 1 aircraft are those with formal certification and approval of RNP integration in the aircraft. RNP compliance is documented in the aircraft's flight manual.

The certification will not necessarily be limited to a specific RNP specification. The flight manual must address the RNP levels that have been demonstrated and any related provisions applicable to their use (e.g. NAVAID sensor requirements). Operational approval is based upon the performance stated in the flight manual.

This method also applies in cases where certification is received through an STC issued to cover retrofitting of equipment, such as GNSS receivers, to enable the aircraft to meet RNP 4 requirements
in oceanic and remote area airspace.

b) Group 2: Prior navigation system certification:

Group 2 aircraft are those that can equate their certified level of performance, given under previous standards, to RNP 4 criteria. Those standards listed in i) to iii) can be used to qualify aircraft under Group 2:

i) GNSS. Aircraft fitted with GNSS only as an approved long-range navigation system for oceanic and remote airspace operations must meet the technical requirements specified in this Chapter. The flight manual must indicate that dual GNSS equipment approved under an appropriate standard is required. Appropriate standards are FAA TSOs C129A or C146(), and JAA JTSOs C129A or C146(). In addition, an approved dispatch FDE availability prediction programme must be used.

The maximum allowable time for which FDE capability is projected to be unavailable on any one event is 25 minutes. This maximum outage time must be included as a condition of the RNP 4 operational approval. If predictions indicate that the maximum allowable FDE outage will be exceeded, the operation must be rescheduled to a time when FDE is available.

ii) Multi-sensor systems integrating GNSS with integrity provided by RAIM. Multi-sensor systems incorporating GPS with RAIM and FDE that are approved under FAA AC20-130a, or other equivalent documents, meet the technical requirements. Note that there is no requirement to use dispatch FDE availability prediction programmes when multi-sensor systems are fitted and used.

iii) Aircraft autonomous integrity monitoring (AAIM). AAIM uses the redundancy of position estimates from multiple sensors, including GNSS, to provide integrity performance that is at least equivalent to RAIM. These airborne augmentations must be certified in accordance with TSO C-115b, JTSO C-115b or other equivalent documents. An example is the use of an INS or other navigation sensors as an integrity check on GNSS data when RAIM is unavailable but GNSS positioning information continues to be valid.

c) Group 3: New technology:

This group has been provided to cover new navigation systems that meet the technical requirements
for operations in airspace where RNP 4 is specified.

4.2 *Operational approval*

4.2.1 Description of aircraft equipment

The operator must have a configuration list and, if necessary, an MEL detailing the required aircraft equipment for RNP 4 operations.

4.2.2 Training documentation

Commercial operators must have a training programme addressing the operational practices, procedures and training items related to RNP 4 operations (e.g. initial, upgrade or recurrent training for pilots, dispatchers or maintenance personnel).

Note.— Operators need not establish a separate training programme or regimen if they already integrate RNAV training as an element of their training programme. However, the operator should be able to identify the aspects of RNP 4 covered within their training programme.

Private operators must be familiar with the practices and procedures identified in "Pilot knowledge and training" section of this manual.

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4.2.3 OMs and checklists

OMs and checklists for commercial operators must address information/guidance on the SOP detailed in this Chapter. The appropriate manuals should contain navigation operating instructions and contingency procedures, where specified. When required by the State of the Operator/Registry, the operator must submit their manuals and checklists for review as part of the application process.

4.2.4 MEL considerations

Any MEL revisions necessary to address RNP 4 provisions must be approved. Operators must adjust the MEL, or equivalent, and specify the required dispatch conditions.

4.2.5 Continuing airworthiness

The operator must submit the continuing airworthiness instructions applicable to the aircraft's configuration and the aircraft's qualification for this navigation specification. Additionally, there is a requirement for the operator to submit their maintenance programme, including a reliability programme for monitoring the equipment.

Note.— The operator should confirm with the OEM, or the holder of installation approval for the aircraft, that acceptance of subsequent changes in the aircraft configuration, e.g. SBs, does not invalidate current operational approvals.

4.3 APPROVAL REQUIREMENTS

4.3.1 Aircraft Installation Requirements

For RNP 4 operations in oceanic or remote airspace, at least two fully serviceable independent LRNSs, with integrity such that the navigation system does not provide misleading information, must be fitted to the aircraft and form part of the basis upon which RNP 4 operational approval is granted. GNSS must be used and can be used as either a stand-alone navigation system or as one of the sensors in a multi-sensor system.

United States FAA Advisory Circular AC 20-138A, or equivalent documents, provides an acceptable means of complying with installation requirements for aircraft that use, but do not integrate, the GNSS output with that of other sensors. FAA AC 20-130A describes an acceptable means of compliance for multi-sensor navigation systems that incorporate GNSS.

The equipment configuration used to demonstrate the required accuracy must be identical to the configuration specified in the MEL or flight manual.

The design of the installation must comply with the design standards that are applicable to the aircraft being modified and changes must be reflected in the flight manual prior to commencing operations requiring an RNP 4 navigation approval.

4.3.2 On-board performance monitoring and alerting

Accuracy: During operations in airspace or on routes designated as RNP 4, the lateral TSE must be within ±4 NM for at least 95 per cent of the total flight time. The along-track error must also be within ±4 NM for at least 95 per cent of the total flight time.

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

Continuity: Loss of function is classified as a major failure condition for oceanic and remote navigation. The continuity requirement is satisfied by the carriage of dual independent long-range navigation systems (excluding SIS).

On-board performance monitoring and alerting: 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 8 NM is greater than 10–5.

Signal-in-Space: If using GNSS, the aircraft navigation equipment shall provide an alert if the probability of SIS errors causing a lateral position error greater than 8 NM exceeds 10–7 per hour.

Note.— Compliance with the on-board 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 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 quality assurance process and crew procedures.

4.3.3 Functional requirements

4.3.3.1 The on-board navigation system must have the following functionalities:

a) display of navigation data;
b) TF;
c) DF;
d) direct to function;
e) CF;
f) parallel offset;
g) fly-by transition criteria;
h) user interface displays;
i) flight planning path selection;
j) flight planning fix sequencing;
k) user defined CF;
l) path steering;
m) alerting requirements;
n) navigation database access;
o) wgs-84 geodetic reference system; and
p) automatic radio position updating.

4.3.3.3 Explanation of required functionalities

Display of navigation data

The display of navigation data must use either a lateral deviation display (see a) below) or a navigation map display (see b) below) that meets the following requirements:

a) a non-numeric lateral deviation display (e.g. CDI, EHSI), with a to/from indication and failure annunciation, for use as a primary flight instrument for navigation of the aircraft, for manoeuvre anticipation, and for failure/status/integrity indication, with the following attributes:

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

ii. lateral deviation scaling must agree with any alerting and annunciation limits, if implemented;

iii. lateral deviation display must be automatically slaved to the RNAV computed path. The lateral deviation display also must have full-scale deflection suitable for the current phase of flight and must be based on the required track-keeping accuracy. The course selector of the lateral deviation display should be automatically slewed to the RNAV computed path, or the pilot must adjust the CDI or HSI selected course to the computed desired track;

Note.— The normal function of stand-alone GNSS equipment meets this requirement.

iv. display scaling may be set automatically by default logic or set to a value obtained from the navigation database. The full-scale deflection value must be known or must be available to the pilot and must be commensurate with en-route, terminal or approach phase values;

b) a navigation map display, readily visible to the pilot, with appropriate map scales (scaling may be set manually by the pilot), and giving equivalent functionality to a lateral deviation display.

4.3.3.4 *Parallel offset*

The system must have the capability to fly parallel tracks at a selected offset distance. When executing a parallel offset, the navigation accuracy and all performance requirements of the original route in the active flight plan must be applicable to the offset route. The system must provide for entry of offset distances in increments of 1 NM, left or right of course. The system must be capable of offsets of at least 20 NM. When in use, system offset mode operation must be clearly indicated to the pilot.

When in offset mode, the system must provide reference parameters (e.g. cross-track deviation, distance-to-go, time-to-go) relative to the offset path and offset reference points. An offset must not be propagated through route discontinuities, unreasonable path geometries, or beyond the ÍAF. Annunciation must be given to the pilot prior to the end of the offset path, with sufficient time to return to the original path.

Once a parallel offset is activated, the offset must remain active for all flight plan route segments until removed automatically, until the pilot enters a direct-to routing, or until pilot (manual) cancellation. The parallel offset function must be available for en-route TF and the geodesic portion of DF leg types.

4.3.3.5 Fly-by transition criteria

The navigation system must be capable of accomplishing fly-by transitions. No predictable and repeatable path is specified because the optimum path varies with airspeed and bank angle. However, boundaries of the transition area are defined. PDE is defined as the difference between the defined path and the theoretical transition area. If the path lies within the transition area, there is no PDE. Fly-by transitions must be the default transition when the transition type is not specified. The theoretical transition area requirements are applicable for the following assumptions:

a) course changes do not exceed 120 degrees for low altitude transitions (aircraft barometric altitude is less than FL 195); and
b) course changes do not exceed 70 degrees for high altitude transitions (aircraft barometric altitude is equal to or greater than FL 195).

4.3.3.6 *User interface displays*

General user interface display features must clearly present information, provide situational awareness, and be designed and implemented to accommodate human factors considerations. Essential design considerations include:

a) minimizing reliance on pilot memory for any system operating procedure or task;
b) developing a clear and unambiguous display of system modes/sub-modes and navigational data with emphasis on enhanced situational awareness requirements for any automatic mode changes, if provided;
c) the use of context-sensitive help capability and error messages (e.g. invalid input or invalid data entry messages should provide a simple means to determine how to enter "valid" data);
d) fault-tolerant data entry methods rather than rigid rule-based concepts;
e) placing particular emphasis on the number of steps and minimizing the time required to accomplish flight plan modifications to accommodate ATS clearances, holding procedures, runway and instrument approach changes, missed approaches and diversions to alternate destinations; and
f) minimizing the number of nuisance alerts so the pilot will recognize and react appropriately, when required.

4.3.3.7 *Displays and controls*

Each display element used as a primary flight instrument in the guidance and control of the aircraft, for manoeuvre anticipation, or for failure/status/integrity annunciation, must be located where it is clearly visible to the pilot (in the pilot's primary field of view) with the least practicable deviation from the pilot's normal position and line of vision when looking forward along the flight path. For those aircraft meeting the requirements of FAR/CS/JAR 25, compliance with the provisions of certification documents, such as AC 25-11, AMJ 25-11 and other applicable documents, should be met.

All system displays, controls and annunciations must be readable under normal cockpit conditions and expected ambient light conditions. Night lighting provisions must be compatible with other cockpit lighting.

All displays and controls must be arranged to facilitate pilot accessibility and usage. Controls that are normally adjusted in flight must be readily accessible with standardized labelling as to their function. System controls and displays must be designed to maximize operational suitability and minimize pilot workload. Controls intended for use during flight must be designed to minimize errors, and when operated in all possible combinations and sequences, must not result in a condition that would be detrimental to the continued performance of the system. System controls must be arranged to provide adequate protection against inadvertent system shutdown.

4.3.3.8 *Flight planning path selection*

The navigation system must provide the crew the capability to create, review and activate a flight plan. The system must provide the capability for modification (e.g. deletion and addition of fixes and creation of along-track fixes), review and user acceptance of changes to the flight plans. When this capability is exercised, guidance output must not be affected until the modification(s) is activated. Activation of any flight plan modification must require positive action by the pilot after input and verification by the pilot.

4.3.3.9 Flight planning fix sequencing

The navigation system must provide the capability for automatic sequencing of fixes.

4.3.3.10 User-defined CF

The navigation system must provide the capability to define a user-defined course to a fix. The pilot must be able to intercept the user-defined course.

4.3.3.11 *FTE*

The system must provide data to enable the generation of command signals for autopilot/flight director/CDI, as applicable. In all cases, an FTE must be defined at the time of certification, which will meet the requirements of the desired RNP operation in combination with the other system errors. During the certification process, the ability of the crew to operate the aircraft within the specified FTE must be demonstrated. Aircraft type, operating envelope, displays, autopilot performance, and leg transitioning guidance (specifically between arc legs) should be accounted for in the demonstration of FTE compliance. A measured value of FTE may be used to monitor system compliance to RNP requirements. For operation on all leg types, this value must be the distance to the defined path. For cross-track containment compliance, any inaccuracies in the cross-track error computation (e.g. resolution) must be accounted for in the TSE.

4.3.3.12 Alerting requirements - The system must also provide an annunciation if the manually entered navigation accuracy is larger than the navigation accuracy associated

with the current airspace as defined in the navigation database. Any subsequent reduction of the navigation accuracy must reinstate this annunciation. When approaching RNP airspace from non-RNP airspace, alerting must be enabled when the cross-track to the desired path is equal to or less than one-half the navigation accuracy and the aircraft has passed the first fix in the RNP airspace.

4.3.3.13 *Navigation database access*

The navigation database must provide access to navigation information in support of the navigation systems reference and flight planning features. Manual modification of the data in the navigation database must not be possible. This requirement does not preclude the storage of "user-defined data" within the equipment (e.g. for flex-track routes). When data are recalled from storage they must also be retained in storage. The system must provide a means to identify the navigation database version and valid operating period.

4.3.3.14 Geodetic reference system

The World Geodetic System — 1984 (WGS-84) or an equivalent Earth reference model must be the reference Earth model for error determination. If WGS-84 is not employed, any differences between the selected Earth model and the WGS-84 Earth model must be included as part of the PDE. Errors induced by data resolution must also be considered.

4.3.4 Operating procedures

4.3.4.1 Airworthiness certification alone does not authorize RNP 4 operations. Operational approval is also required to confirm the adequacy of the operator's normal and contingency procedures for the particular equipment installation.

4.3.4.2 *Preflight planning*

4.3.4.2.1 Operators should use the appropriate ICAO flight plan designation specified for the RNP route. The letter "R" should be placed in block 10 of the ICAO flight plan to indicate the pilot has reviewed the planned route of flight and determined the RNP requirements and the aircraft and operator approval for RNP routes. Additional information should be displayed in the remarks section indicating the accuracy capability, such as RNP 4 versus RNP 10. It is important to understand that additional requirements will have to be met for operational authorization in RNP 4 airspace or on RNP 4 routes. CPDLC and ADS-C systems will also be required when the separation standard is 30 NM lateral and/or longitudinal. 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 routes and procedures for flight.

4.3.4.2.2 The pilot must:

a) review maintenance logs and forms to ascertain the condition of the equipment required for flight in RNP 4 airspace or on routes requiring RNP 4 navigation capability;
b) ensure that maintenance action has been taken to correct defects in the required equipment;
c) review the contingency procedures for operations in RNP 4 airspace or on routes requiring an RNP 4 navigation capability. These are no different than normal oceanic contingency procedures with one exception: crews must be able to recognize, and ATC must be advised, when the aircraft is no longer able to navigate to its RNP 4 navigational capability.

4.3.4.3 *Availability of GNSS*

At dispatch or during flight planning, the operator must ensure that adequate navigation capability is available en route to enable the aircraft to navigate to RNP 4 and to include the availability of FDE, if appropriate for the operation.

4.3.4.4 *En route*

4.3.4.4.1 At least two LRNSs, capable of navigating to RNP 4, and listed in the flight manual, must be operational at the entry point of the RNP airspace. If an item of equipment required for RNP 4 operations is unserviceable, then the pilot should consider an alternate route or diversion for repairs.

4.3.4.4.2 In flight operating procedures must include mandatory cross-checking procedures to identify navigation errors in sufficient time to prevent inadvertent deviation from ATC-cleared routes.

4.3.4.4.3 Crews must advise ATC of any deterioration or failure of the navigation equipment that cause navigation performance to fall below the required level, and/or any deviations required for a contingency procedure.

4.3.4.4.4 Pilots should use a lateral deviation indicator, flight director, or autopilot in lateral navigation mode on RNP 4 routes. Pilots may use a navigation map display with equivalent functionality to a lateral deviation indicator as described in this Chapter. Pilots of aircraft with a lateral deviation indicator must ensure that the lateral deviation indicator scaling (full-scale deflection) is suitable for the navigation accuracy associated with the route (i.e. ±4 NM).

4.3.4.4.5 All pilots are expected to maintain route centre lines, as depicted by on-board lateral deviation indicators and/or flight guidance duringall RNP operations described in this manual unless authorized to deviate by ATC or under emergency conditions.

4.3.4.4.6 For normal operations, cross-track error/deviation (the difference between the RNAV system computed path and the aircraft position relative to the path) should be limited to ±½ the navigation accuracy associated with the route (i.e. 2 NM). Brief deviations from this standard (e.g. overshoots or undershoots) during and immediately after route turns, up to a maximum of one-times the navigation accuracy (i.e. 4 NM), are allowable.

4.3.5 Pilot knowledge and training

Operators/owners must ensure that pilots are trained and have appropriate knowledge of the topics contained in this guidance material, the limits of their RNP 4 navigation capabilities, the effects of updating, and RNP 4 contingency procedures.

In determining whether training is adequate, an approving Authority shall evaluate a training course before accepting a training centre certificate from a specific centre. The Authority may accept a statement by the operator that it has conducted or will conduct an RNP 4 training programme utilizing the guidance contained in this chapter.

4.3.6 Navigation database

The navigation database should be obtained from a supplier that complies with RTCA DO 200A/EUROCAE document ED 76, Standards for Processing Aeronautical Data. An LOA issued by the appropriate regulatory authority demonstrates compliance with this requirement (e.g. FAA LOA issued in accordance with FAA AC 20-153 or EASA LOA issued in accordance with EASA Opinion Nr. 01/2005.

Discrepancies that invalidate the route must be reported to the navigation database supplier and the affected route must be prohibited by an operator's notice to its pilots.

Aircraft operators should consider the need to conduct periodic checks of the operational navigation databases in order to meet existing quality system requirements.

Note.— To minimize PDE, the database should comply with DO-200A/ED-76, or an equivalent operational means must be in place to ensure database integrity for the RNP 4.

4.3.7 Oversight of operators

1.3.7.1 The Authority shall consider any navigation error reports in determining remedial action.
Repeated navigation error occurrences attributed to a specific piece of navigation equipment or operational procedure may result in cancellation of the operational approval pending replacement or modifications on the navigation equipment or changes in the operator's operational procedures.

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

4.3.8 Contingencies

An operator will ensure that the follo9wing contingency procedures are in place and reported;

a) Inability to comply with ATC clearance due to meteorological conditions, aircraft performance or pressurization failure.
b) Weather deviation.
c) Air-ground communications failure.

CHAPTER 5

RNP 2 OPERATIONS

APPROVAL PROCESS

1.0 PURPOSE

This Chapter establishes RNP 2 approval requirements for aircraft and operations in oceanic or remote airspace.

2.0 REFERENCES AND RELATED DOCUMENTS

KCARS Operation of Aircraft Regulations
KCARS Instrument and Equipment Regulations
KCAA Form XX: PBN Operations Application Form
KCAA Form PBN Evaluation Approval Form

ICAO Doc 9613 Performance-based Navigation (PBN) manual
ICAO Doc 9997 PBN Operational Approval manual
EASA AMC Part SPA.PBN (as amended) Subpart B: PBN Operations
FAA AC 20-138 (as amended) Airworthiness Approval of Positioning and Navigation Systems

3.0 INTRODUCTION

3.1 Background

3.1.1 RNP 2 is primarily intended for a diverse set of en-route applications, particularly in geographic areas with little or no ground NAVAID infrastructure, limited or no ATS surveillance, and low to medium density traffic. Use of RNP 2 in continental applications requires a lower continuity requirement than used in oceanic/remote applications. In the latter application, the target traffic is primarily transport category aircraft operating at high altitude, whereas, continental applications may include a significant percentage of GA aircraft.

3.1.2 This navigation specification can be applied for applications in oceanic, continental and in airspace considered by a State to be remote. Such remote airspace may require different considerations for aircraft eligibility based on whether the remote areas support suitable landing airports for the target aircraft population, or support reversion to an alternate means of navigation. Thus for remote airspace applications, a State may choose to designate either continental or oceanic/remote aircraft eligibility.

3.2 Purpose

3.2.1 This chapter provides guidance for approval of RNP 2 for en-route airspace. While operational approval primarily relates to the navigation requirements of the airspace, operators and pilots are still required to take account of all other operational documents relating to the airspace, which are required by the applicable State, before conducting flights into that airspace. RNP 2 can be associated with FRT.

3.3 IMPLEMENTATION CONSIDERATIONS

3.3.1 NAVAID infrastructure considerations

3.3.2 The RNP 2 specification is based upon GNSS. Operators relying on GNSS are required to have the means to predict the availability of GNSS fault detection (e.g. ABAS RAIM) to support operations along the RNP 2 ATS route. The on-board RNP system, GNSS avionics, the ANSP or other entities may provide a prediction capability. RNP 2 shall not be used in areas of known GNSS signal interference.

3.4 NAVIGATION SPECIFICATION

3.4.1 Background

Operational compliance with the requirements in this Chapter shall require specific operational approval from the Authority for commercial and non-commercial operations, as applicable. This navigation specification provides the technical and operational criteria and does not necessarily imply a need for recertification.

Note: Where appropriate, previous operational approvals may be used in order to expedite this process for individual operators where performance and functionality are applicable to the current request for operational approval.

3.4.2 Aircraft eligibility

The aircraft eligibility must be determined through demonstration of compliance against the relevant airworthiness criteria and the requirements in this manual. The OEM or the holder of installation approval for the aircraft, e.g. STC holder, will demonstrate compliance to their National Aviation Authority (e.g. EASA, FAA) and the approval can be documented in manufacturer documentation (e.g. service letters). AFM entries are may not be required where the necessary manufacturer documentation is availed.

In this navigation specification, the continuity requirements for oceanic/remote and continental applications are different. Where an aircraft is eligible for continental applications only, such a limitation must be clearly identified to support operational approvals. Aircraft meeting the oceanic/remote continuity requirement also meet the continental continuity requirement.

A-RNP systems are considered as qualified for RNP 2 continental applications without further examination, and for RNP 2 oceanic/remote applications provided the oceanic/remote continuity requirement has been met.

Note: Requests for approval to use optional functionality (e.g. RF legs, FRT) should address the aircraft and operational requirements.

3.5 Operational approval

Description of aircraft Operation and related equipment

3.5.1 Training documentation

Commercial operators must have a training programme addressing the operational practices, procedures and training items related to RNP 2 operations (e.g. initial, upgrade or recurrent training for pilots, dispatchers or maintenance personnel).

Note: Operators need not establish a separate training programme if they already integrate RNAV training as an element of their training programme. However, the operator should be able to identify the aspects of RNP 2 covered within their training programme.

Private operators must be familiar with the practices and procedures identified in "Pilot knowledge and training" section of this Chapter.

3.5.2 OMs and checklists

OMs and checklists for commercial operators must address information/guidance on the SOP detailed in the appropriate manuals should contain navigation operating instructions and contingency procedures, where specified. When required by the State of the Operator/Registry, the operator must submit their manuals and checklists for review as part of the application process.

3.5.3 MEL considerations

The operator must have a configuration list and an MEL (unless not applicable) detailing the required aircraft equipment for RNP 2 operations.
Any MEL revisions necessary to address RNP 2 provisions must be approved. Operators must adjust the MEL, or equivalent, and specify the required dispatch conditions.

3.6 Continuing airworthiness

The operator must submit the continuing airworthiness instructions applicable to the aircraft's configuration and the aircraft's qualification for this navigation specification. Additionally, there is a requirement for the operator to submit their maintenance programme, including a reliability programme for monitoring the equipment.

Note: The operator should confirm with the OEM, or the holder of installation approval for the aircraft, that acceptance of subsequent changes in the aircraft configuration, e.g. SBs, does not invalidate current operational approvals.

3.7 Aircraft Requirements

3.7.1 General

On-board performance monitoring and alerting is required. The criteria for a TSE form of performance monitoring and alerting that will ensure a consistent evaluation and assessment of compliance for RNP 2 applications is required.

The aircraft navigation system, or aircraft navigation system and 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 1 × 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 Downgrad", 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.

3.7.2 Accuracy and Integrity Requirements

The following systems meet the accuracy and integrity requirements of these criteria:

a) aircraft with E/TSO-C129a sensor (Class B or C), E/TSO-C145() and the requirements of E/TSO- C115b FMS, installed for IFR use in accordance with FAA AC 20-130A;
b) aircraft with E/TSO-C129a Class A1 or E/TSO-C146() equipment installed for IFR use in accordance with FAA AC 20-138A or AC 20-138B;

3.7.3 On-board performance monitoring and alerting

Accuracy: During operations in airspace or on routes designated as RNP 2, the lateral TSE must be within ±2 NM for at least 95 per cent of the total flight time. The along-track error must also be within ±2 NM for at least 95 per cent of the total flight time. To satisfy the accuracy requirement, the 95 per cent FTE should not exceed 1 NM.

Note: The use of a deviation indicator with 2 NM full-scale deflection is an acceptable means of compliance.

Integrity: Malfunction of the aircraft navigation equipment is classified as a major failure condition under airworthiness guidance material (i.e. 10–5 per hour).

Continuity: For RNP 2 oceanic/remote continental airspace applications, loss of function is a major failure condition.

For RNP 2 continental operations, loss of function is a minor failure condition if the operator can revert to a different navigation system and proceed to a suitable airport. If a single aircraft configuration is to support all potential applications of RNP 2, the more stringent continuity requirement applies. The AFM limitations section must reflect restrictions in capability to aid in operational approvals.

For oceanic/remote continental RNP 2 operations will require dual independent GPS long-range navigation systems with FDE to meet the continuity requirement. Integration of positioning data from other sensors may be allowed provided that this does not cause the TSE to be exceeded. Manual entry/creation of waypoints using latitude and longitude values should be permitted to support flexible track ATS systems (e.g. in some MNPS airspace).

Signal-in-Space: The aircraft navigation equipment shall provide an alert if the probability of Signal-In-Space errors causing a lateral position error greater than 4 NM exceeds 1 × 10–7 per hour.

3.7.4 FTE

During the aircraft certification process, the manufacturer must demonstrate the ability of the pilot to operate the aircraft within the allowable FTE. The demonstration of FTE should account for the aircraft type, the operating envelope, aircraft displays, autopilot performance, and flight guidance characteristics. When this is done, the pilot may use the demonstrated value of FTE to monitor compliance to the RNP requirements. This value must be the cross-track distance to the defined path. For cross-track containment compliance, the demonstration should account for any inaccuracies in the cross-track error computation (e.g. resolution) in the TSE.

PDE is considered negligible because a quality assurance process is applied at the navigation database level.

3.8 RNP 2 Functional requirements

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

Note: These functional requirements, while consistent with the equivalent requirements in the RNAV and the other RNP specifications, have been customized for the en-route application and editorially revised for clarification.

Item	RNP 2 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), 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: 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; 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; The lateral deviation display scaling should agree with any implemented alerting and annunciation limits;

		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;
		The display scaling may be set automatically by default logic, automatically to a value obtained from a navigation database, or manually by flight crew 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; and 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 or the pilot must adjust the CDI or HSI selected course to the computed desired track. As an alternate means of compliance, a navigation map display can provide equivalent functionality to a lateral deviation display as described in 1–6 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 2 operation.
b)	The RNP 2 operation requires the following minimum system and equipment functions:	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 RNP 2 routes can be retrieved and loaded into the RNP system. The stored resolution of the data must be sufficient to achieve negligible PDE. Database protections must prevent pilot modification of the on-board stored data; A means to display the validity period of the navigation data to the pilot; A means to retrieve and display data stored in the navigation database relating to individual waypoints and NAVAIDs (when applicable), to enable the pilot to verify the RNP 2 route to be flown; and

		For RNP 2 tracks in oceanic/remote continental airspace using flexible (e.g. organized) tracks, a means to enter the unique waypoints required to build a track assigned by the ATS provider.
c)	The means to display the following items, either in the pilot's primary field of view, or on a readily accessible display:	The active navigation sensor type; The identification of the active (To) waypoint; The groundspeed or time to the active (To) waypoint; and 4) The distance and bearing to the active (To) waypoint.
d)	The capability to execute a "direct to" function.	The aircraft and avionics manufacturers should identify any limitations associated with conducting the "direct to" function during RNP 2 operations in the manufacturer's documentation.
e)	The capability for automatic leg sequencing with the display of sequencing to the pilot.	
f)	The capability to automatically execute waypoint transitions and maintain track consistent with the RNP 2 performance requirements.	
g)	The capability to display an. indication of RNP 2 system failure in the pilot's primary field of view.	
h)	Parallel offset function (optional)	If implemented: The system must have the capability to fly parallel tracks at a selected offset distance; When executing a parallel offset, the navigation accuracy and all performance requirements of the original route in the active flight plan apply to the offset route; The system must provide for entry of offset distances in increments of 1 NM, left or right of course;

		The system must be capable of offsets of at least 20 NM; When in use, the system must clearly annunciate the operation of offset mode; When in offset mode, the system must provide reference parameters (e.g. cross-track deviation, distance-to-go, time-to-go) relative to the offset path and offset reference points; The system must annunciate the upcoming end of the offset path and allow sufficient time for the aircraft to return to the original flight plan path; and Once the pilot activates a parallel offset, the offset must remain active for all flight plan route segments until the system deletes the offset automatically; the pilot enters a new direct-to routing, or the pilot manually cancels the offset.

3.9 Operating procedures

3.9.1 Airworthiness certification and recognition of RNP 2 aircraft qualification together do not authorize RNP 2 operations. Operational approval is also required to confirm the adequacy of the operator's normal and contingency procedures for the particular equipment installation.

3.9.2 Preflight planning

Operators and pilots intending to conduct operations on RNP 2 routes must file the appropriate flight plan suffixes.

The on-board navigation data must be current and include appropriate procedures. Navigation databases should 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 the navigation data, including the suitability of navigation facilities defining the routes and procedures for flight.

The operator must confirm the availability of the NAVAID infrastructure, required for the intended routes, including those for use in a non-GNSS contingency, for the period of intended operations using all available information. Since Annex 10 requires GNSS integrity (RAIM or SBAS signal), the procedures should determine the availability of these services and functions as appropriate. For aircraft navigating with SBAS capability (all TSO-C145()/C146()), operators should check appropriate GNSS RAIM availability in areas where the SBAS signal is unavailable.

ABAS availability

Operators can verify the availability of RAIM to support RNP 2 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 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 appropriate level of fault detection of more than five (5) minutes for any part of the RNP 2 operation, the operator should revise the flight plan (e.g. delay the departure or plan a different route).

RAIM availability prediction software does not guarantee the service; rather, RAIM prediction tools assess the expected capability to meet the RNP. Because of unplanned failure of some GNSS elements, pilots and ANSPs must realize that RAIM or GNSS navigation may be lost while airborne, and this may require reversion to an alternative means of navigation. Therefore, pilots should prepare to assess their capability to navigate (potentially to an alternate destination) in case of failure of GNSS navigation.

3.9.3 General operating procedures

The pilot should comply with any instructions or procedures the manufacturer of the aircraft or avionics identifies as necessary to comply with the RNP 2 performance requirements. Pilots must adhere to any AFM limitations or operating procedures the manufacturer requires to maintain RNP 2 performance.

Operators and pilots should not request or file for RNP 2 routes unless they satisfy all the criteria in the relevant State documents. If an aircraft does not meet these criteria and receives a clearance from ATC to operate on an RNP 2 route, the pilot must advise ATC that they are unable to accept the clearance and must request an alternate clearance.

At system initialization, pilots must confirm the navigation database is current and verify proper aircraft position. Pilots must also verify proper entry of their ATC assigned route upon initial clearance and any subsequent change of route. Pilots must then ensure that the waypoint sequence depicted by their navigation system matches the route depicted on the appropriate chart(s) and their assigned route.

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

Pilots must not fly a published RNP 2 route unless they can retrieve the route by name from the on-board navigation database and confirm it matches the charted route. However, pilots may subsequently modify the route through the insertion or deletion of specific waypoints in response to ATC requests and clearances. Pilots must not make manual entries or create new waypoints by manual entry of latitude and longitude or rho/theta values for fixed, published routes. Additionally, pilots must not change any route database waypoint type from a fly-by to a fly-over or vice versa. For flexible route structures, entry of latitude and longitude may also be permitted provided the potential for entry error by pilots is accounted for during associated safety analyses.

Note.— When the waypoints that make up an RNP 2 route are available by name in the aircraft's on-board navigation database, the operational authority may permit pilots to make a manual entry of the waypoints to define a published RNP 2 route in their navigation system.

The pilot need not cross-check the lateral navigation guidance with conventional NAVAIDs, as the absence of an integrity alert is sufficient to meet the integrity requirements.

For RNP 2 routes, pilots must use a lateral deviation indicator, flight director, or autopilot in lateral navigation mode. Pilots of aircraft with a lateral deviation display

must ensure that the lateral deviation scaling is suitable for the navigation accuracy associated with the route (e.g. full-scale deflection: ±2 NM for RNP 2 or ±5 NM in the case of some TSO-C129a equipment) and know their allowable lateral deviation limits.

Note.— An appropriately scaled map display may also be used.

All pilots must maintain a centre line, as depicted by on-board lateral deviation indicators and/or flight guidance during all RNP 2 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 system computed path and the aircraft position relative to the path, i.e. FTE) should be limited to ±½ the navigation accuracy associated with the route (i.e. 1 NM for RNP 2). 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. 2 NM for RNP 2) are allowable. Some aircraft do not display or compute a path during turns, therefore, pilots of these aircraft may not be able to confirm adherence to the ±½ lateral navigation accuracy during turns, but must satisfy the standard during intercepts following turns and on straight segments.

Manually selecting or use of default aircraft bank limiting functions may reduce the aircraft's ability to maintain desired track and the pilot should not use these functions. Pilots should understand manually selecting aircraft bank-limiting functions may reduce their ability to satisfy ATC path expectations, especially when executing large angle turns. However, pilots should not deviate from AFM procedures and should limit the use of such functions within accepted procedures that meet the requirements for operation on an RNP 2 route.

If ATC issues a heading assignment that takes an aircraft off a route, the pilot should not modify the flight plan in the RNP system until they receive a clearance to rejoin the route or the controller confirms a new route clearance. When the aircraft is not on the RNP 2 route, the RNP 2 performance requirements do not apply.

Pilots of aircraft with RNP input selection capability should select a navigation accuracy value of 2 NM, or lower. The selection of the navigation accuracy value should ensure the RNP system offers appropriate lateral deviation scaling permitting the pilot to monitor lateral deviation and meet the requirements of the RNP 2 operation.

3.9.4 Contingency procedures

The pilot must notify ATC of any loss of the RNP 2 capability (integrity alerts or loss of navigation). If unable to comply with the requirements of an RNP 2 route for any reason, pilots must advise ATC as soon as possible. The loss of RNP 2 capability includes any failure or event causing the aircraft to no longer satisfy the RNP 2 requirements.

4.0 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 information in this chapter;
b) the meaning and proper use of aircraft equipment/navigation suffixes;
c) route and airspace characteristics as determined from chart depiction and textual description;
d) required navigation equipment on RNP 2 operations;
e) RNP system-specific information:

   i. levels of automation, mode annunciations, changes, alerts, interactions, reversions, and degradation;
   ii. functional integration with other aircraft systems;
   iii. the meaning and appropriateness of route discontinuities as well as related flight crew procedures;
   iv. pilot procedures consistent with the operation;
   v. types of navigation sensors utilized by the RNP system and associated system prioritization/ weighting/logic/limitations;
   vi. turn anticipation with consideration to speed and altitude effects;
   vii. interpretation of electronic displays and symbols used to conduct an RNP 2 operation; and
   viii. understanding of the aircraft configuration and operational conditions required to support RNP 2 operations, e.g. appropriate selection of CDI scaling (lateral deviation display scaling);

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

   i. verify currency and integrity of the aircraft navigation data;
   ii. verify the successful completion of RNP system self-tests;
   iii. initialize navigation system position;
   iv. retrieve/manually enter and fly an RNP 2 route;
   v. adhere to speed and/or altitude constraints associated with an RNP 2 route;
   vi. verify waypoints and flight plan programming;

vii. fly direct to a waypoint;
viii. fly a course/track to a waypoint;
ix. intercept a course/track (flying assigned vectors and rejoining an RNP 2 route from "heading" mode);
x. determine cross-track error/deviation. More specifically, the maximum deviations allowed to support RNP 2 must be understood and respected;
xi. resolve route discontinuities;
xii. remove and reselect navigation sensor input; and
xiii. perform parallel offset function during RNP 2 operations 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;

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

h) R/T phraseology for RNP applications; and
i) contingency procedures for RNP failures.

5.0 Navigation database

Navigation data management is addressed in Annex 6, Part 1, Chapter 7. In support of this, the operator must obtain the navigation database from a supplier complying with RTCA DO 200A/EUROCAE document ED 76, Standards for Processing Aeronautical Data, and the database must be compatible with the intended function of the equipment. Regulatory authorities recognize compliance to the referenced standard using a LOA or other equivalent document.

The operator must report any discrepancies invalidating an ATS route to the navigation database supplier, and the operator must take actions to prohibit their pilots from flying the affected ATS route.

Aircraft operators should consider the need to conduct periodic checks of the operational navigation databases in order to meet existing quality system requirements.

6.0 Oversight of operators

The Authority shall consider any navigation error reports in determining remedial action for an operator. Repeated navigation error occurrences attributed to specific navigation equipment shall result in cancellation of the operational approval permitting use of that equipment during RNP 2 operations.

Information indicating the potential for repeated errors may require modification of an operator's training programme. Information attributing multiple errors to a particular pilot may necessitate remedial training or licence review.

CHAPTER 6

RNP 1 OPERATIONS

APPROVAL PROCESS

This Chapter establishes RNP 1 approval requirements for aircraft and operators. The future tense of the verb or the term "shall" apply to operators who choose to meet the criteria set forth in this Chapter.

1.0 REFERENCE

KCARs Operation of Aircraft Regulation
KCARS Instrument and Equipment Regulation
Form KCAAFOPSPBN: Application Job Aid Part A (Application Form)
Form KCAAFOPSPBN: Evaluation Approval Form

2.0 RELATED DOCUMENTS

ICAO Doc 9613 Performance based navigation (PBN) manual
ICAO Doc 9997 PBN Operational Approval manual
ICAO Doc 8168 Aircraft operations Volume I: Flight procedures
FAA AC 90-105 Appendix 2 Qualification criteria for RNP 1 (terminal) operations
EASA Part SPA (GM1 SPA.PBN.100)

3.0 INTRODUCTION

According to Doc 8168 – Procedures for Air Navigation Services – Aircraft Operations (PANS-OPS) Volume II, the RNP 1 navigation specification is used in standard instrument departures and arrivals (SIDs and STARs) and in approaches to the final approach fix (FAF)/final approach point (FAP) with or without air traffic service (ATS) surveillance.

Although the operational approval is normally related to airspace requirements, the operators and flight crews must consider the operational documents required by the Authority before conducting flights in RNP 1 airspace.

The material described in this Chapter has been developed based on the ICAO Doc 9613, Volume II, Part C, Chapter 3 – Implementing RNP 1.

4.0 NAVAID, COMMUNICATION AND SURVEILLANCE CONSIDERATIONS

The RNP 1 specification is based upon GNSS. While DME/DME-based RNAV systems are capable of RNP 1 accuracy, this navigation specification is primarily intended for environments where the DME infrastructure cannot support DME/DME area navigation to the required performance. The increased complexity in the DME

infrastructure requirements and assessment means it is not practical or cost-effective for widespread application.
RNP 1 shall not be used in areas of known navigation signal (GNSS) interference.

This navigation specification is intended for environments where ATS surveillance is either not available or limited. RNP 1 SIDs/STARs are primarily intended to be conducted in DCPC environments.

For procedure design and infrastructure evaluation, the normal FTE limit of 0.5 NM defined in the operating procedures is assumed to be a 95 per cent value.
The default alerting functionality of a TSO-C129a sensor (stand-alone or integrated), switches between terminal alerting (±1 NM) and en-route alerting (±2 NM) at 30 miles from the ARP.

4.1 The operator who intends to seek for authorization/approval of RNP 1 shall present to the authority a statement of intent to start the process of obtaining the authorization.

4.2 OMs and checklists

OMs and checklists for commercial operators must address information/guidance on the SOP detailed in

- The appropriate manuals should contain navigation operating instructions and contingency procedures, where specified. When required by the State of the Operator/Registry, the operator must submit their manuals and checklists for review as part of the application process.

- Private operators should operate using the practices and procedures in “Pilot knowledge and training” paragraphs.

4.3 MEL considerations

Any MEL revisions necessary to address RNP 1 provisions must be approved. Operators must adjust the MEL, or equivalent, and specify the required dispatch conditions.

4.4 Maintenance Practices

The operator must submit the continuing airworthiness instructions applicable to the aircraft’s configuration and the aircraft’s qualification for this navigation specification. The maintenance document should include instructions on document navigation database maintenance practices.

5.0 AIRCRAFT ELIGIBILITY REQUIREMENTS

5.1 The aircraft eligibility must be determined through demonstration of compliance against the relevant airworthiness criteria. The OEM or the holder of installation approval for the aircraft, e.g. STC holder, will demonstrate compliance to their NAA (e.g. EASA, FAA), and the approval can be documented in manufacturer documentation (e.g. service letters). AFM entries are not required, where approved manufacturer documentation supports the navigation specification.

5.2 The following systems meet the accuracy, integrity and continuity requirements of these criteria:

a) aircraft with E/TSO-C129a sensor (Class B or C), E/TSO-C145() and the requirements of E/TSOC115b FMS, installed for IFR use in accordance with FAA AC 20-130A;
b) aircraft with E/TSO-C129a Class A1 or E/TSO-C146() equipment installed for IFR use in accordance with FAA AC 20-138 or AC 20-138A; and
c) aircraft with RNP capability certified or approved to equivalent standards.

Note.— 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 pilots to inhibit DME updating or executing a missed approach if reverting to DME updating may meet this requirement.

5.3 On-board performance monitoring and alerting

Accuracy: During operations in airspace or on routes designated as RNP 1, the lateral TSE must be within ±1 NM for at least 95 per cent of the total flight time. The along-track error must also be within ±1 NM for at least 95 per cent of the total flight time. To satisfy the accuracy requirement, the 95 per cent FTE should not exceed 0.5 NM.

Note.— The use of a deviation indicator with 1 NM full-scale deflection has been found to be an acceptable means of compliance. The use of an autopilot or flight director has been found to be an acceptable means of compliance (roll stabilization systems do not qualify).

Integrity: Malfunction of the aircraft navigation equipment is classified as a major failure condition under airworthiness regulations (i.e. 1 × 10–5 per hour).

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.

On-board performance monitoring and alerting: 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 1 NM is greater than 1 × 10–5.

Signal-in-Space: If using GNSS, the aircraft navigation equipment shall provide an alert if the probability of SIS errors causing a lateral position error greater than 2 NM exceeds 1 × 10–7 per hour.

Note.— Compliance with the on-board performance monitoring and alerting requirements does not imply automatic monitoring of FTEs. The on-board monitoring and alerting function should at least consist of an 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 quality assurance process and crew procedures.

5.4 Criteria for specific navigation systems

RNP 1 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. Otherwise, means should be provided to deselect the other navigation sensor types.

Note.— 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.

5.5 Functional requirements

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

Paragraph	Functional requirement	Explanation
a)		The lateral deviation display scaling should agree with any implemented alerting and annunciation limits; 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; 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; and 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, or the pilot must adjust the CDI or HSI selected course to the computed desired track. As an alternate means of compliance, a navigation map display can provide equivalent functionality to a lateral deviation display as described in 1-6 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 1 operation.

b)	The following system functions are required as a minimum within any RNP 1 equipment:	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 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; The means to display the validity period of the navigation data to the pilot; 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 route to be flown; and
c)		4) The capacity to load from the database into the RNP 1 system the entire segment of the SID or STAR to be flown. Note.— Due to variability in systems, this document defines the RNAV segment from the first occurrence of a named waypoint, track, or course to the last occurrence of a named waypoint, track, or course. Heading legs prior to the first named waypoint or after the last named waypoint do not have to be loaded from the database. The entire SID will still be considered an RNP 1 procedure.
d)	The means to display the following items, either in the pilot's primary field of view, or on a readily accessible display :	the active navigation sensor type; the identification of the active (To) waypoint; the ground speed or time to the active (To) waypoint; and the distance and bearing to the active (To) waypoint.
e)	The capability to execute a "direct to" function.	
f)	The capability for automatic leg sequencing with the display of sequencing to the pilot.	

g)	The capability to load and execute an RNP 1 SID or STAR from the on-board database, by procedure name, into the RNP system.	
h)	The aircraft must have the capability to automatically execute leg transitions and maintain tracks consistent with the following ARINC 424 path terminators, or their equivalent: IF CF DF TF	Note 1.— Path terminators are defined in ARINC 424, and their application is described in more detail in RTCA documents DO-236B/EUROCAE ED-75B and DO-201A/EUROCAE ED-77. Note 2.— Numeric values for courses and tracks must be automatically loaded from the RNP system database.
i)	The aircraft must have the capability to automatically execute leg transitions consistent with VA, VM	
j)	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.	
k)	The aircraft must have the capability to automatically execute leg transitions consistent with CA and FM ARINC 424 path terminators, or the RNP system must permit the pilot to readily designate a waypoint and select a desired course to or from a designated waypoint.	

l)	The capability to display an indication of the RNP 1 system failure, in the pilot's primary field of view.	

6.0 Operating procedures

Airworthiness certification alone does not authorize RNP 1 operations. Operational approval is also required to confirm the adequacy of the operator's normal and contingency procedures for the particular equipment installation.

6.1 Preflight planning

6.1.1 Operators and pilots intending to conduct operations on RNP 1 SIDs and STARs should file the appropriate flight plan suffixes.

6.1.2 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 the navigation data, including the suitability of navigation facilities used to define the routes and procedures for flight.

6.1.3 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, 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.

6.2 *ABAS availability*

6.2.1 RAIM levels required for RNP 1 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.

6.1.2 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, other entities or through an airborne receiver RAIM prediction capability.

6.1.3 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 1 operation, the flight planning should be revised (e.g. delaying the departure or planning a different departure procedure).

6.1.4 RAIM availability prediction software does not guarantee the service, rather, they are tools to assess the expected capability to meet the RNP. Because of unplanned failure

of some GNSS elements, pilots/ANSP must 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.

6.2 *General operating procedures*

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

Operators and pilots should not request or file RNP 1 procedures 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 1 procedure, the pilot must advise ATC that he/she is unable to accept the clearance and must request alternate instructions.

6.2.2 At system initialization, pilots must confirm that the aircraft position has been entered correctly. Pilots must verify proper entry of their ATC assigned route upon initial clearance and any subsequent change of route. Pilots must ensure that the waypoint sequence depicted by their navigation system matches the route depicted on the appropriate chart(s) and their assigned route.

6.2.3 Pilots must not fly an RNP 1 SID or STAR unless it is retrievable by procedure name from the on-board navigation database and conforms to the charted procedure. However, the procedure may subsequently be modified through the insertion or deletion of specific waypoints in response to ATC clearances. 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.

6.2.4 Pilots should cross-check the cleared flight plan by comparing charts or other applicable resources with the navigation system textual display and the aircraft map display, if applicable. If required, the exclusion of specific NAVAIDs should be confirmed.

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

6.2.5 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.

6.2.6 For RNP 1 routes, pilots must use a lateral deviation indicator, flight director, or autopilot in lateral navigation mode. Pilots of aircraft with a lateral deviation display must ensure that lateral deviation scaling is suitable for the navigation accuracy associated with the route/procedure (e.g. full-scale deflection: ±1 NM for RNP 1).

All pilots are expected to maintain centre lines, as depicted by on-board lateral deviation indicators and/or flight guidance during all RNP 1 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 system computed path and the aircraft position relative to the path, i.e. FTE) should be limited to ±½ the navigation accuracy associated with the procedure (i.e. 0.5 NM for RNP 1). 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 RNP 1) 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.

6.2.7 If ATC issues a heading assignment that takes an aircraft off of a route, the pilot should not modify the flight plan in the RNP system until a clearance is received to rejoin the route or the controller confirms a new route clearance. When the aircraft is not on the published RNP 1 route, the specified accuracy requirement does not apply.

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

6.2.9 Pilots of aircraft with RNP input selection capability should select RNP 1 or lower, for RNP 1 SIDs and STARs.

6.3 RNP 1 SID specific requirements

6.3.1 Prior to commencing take-off, the pilot must verify that the aircraft's RNP 1 system is available, operating correctly, and that the correct airport and runway data are loaded. 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 1 departure procedure and subsequently receive a change of runway, procedure or transition must verify that 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.

6.3.2 Engagement altitude. The pilot must be able to use RNP 1 equipment to follow flight guidance for lateral navigation, e.g. lateral navigation no later than 153 m (500 ft) above airport elevation.

6.3.3 Pilots must use an authorized method (lateral deviation indicator/navigation map display/flight director/autopilot) to achieve an appropriate level of performance for RNP 1.

6.3.4 GNSS aircraft. When using GNSS, the signal must be acquired before the take-off roll commences. For aircraft using TSO-C129a avionics, the departure airport must be loaded into the flight plan in order to achieve the appropriate navigation system monitoring and sensitivity. For aircraft using TSO-C145()/C146() avionics, 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. If the RNP 1 SID extends beyond 30 NM from the ARP and a lateral deviation indicator is used, its full-scale sensitivity must be selected to not greater than 1 NM between 30 NM from the ARP and the termination of the RNP 1 SID.

6.3.5 For aircraft using a lateral deviation display (i.e. navigation map display), the scale must be set for the RNP 1 SID, and the flight director or autopilot should be used.

6.4 *RNP 1 STAR specific requirements*

6.4.1 Prior to the arrival phase, the pilot 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 track angles 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 this paragraph.

6.4.2 The creation of new waypoints by manual entry into the RNP 1 system by the pilot would invalidate the route and is not permitted.

6.4.3 Where the contingency procedure requires reversion to a conventional arrival route, necessary preparations must be completed before commencing the RNP 1 procedure.

6.4.4 Procedure modifications in the terminal area may take the form of radar headings or "direct to" clearances and the pilot 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 pilot of the loaded route using temporary waypoints or fixes not provided in the database is not permitted.

6.4.5 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.

6.4.6 Although a particular method is not mandated, any published altitude and speed constraints must be observed.

6.4.7 Aircraft with TSO-C129a GNSS RNP systems: If the RNP 1 STAR begins beyond 30 NM from the ARP and a lateral deviation indicator is used, then full scale sensitivity should be manually selected to not greater than 1 NM prior to commencing the STAR. For aircraft using a lateral deviation display (i.e. navigation map display), the scale must be set for the RNP 1 STAR, and the flight director or autopilot should be used.

7.0 Contingency procedures

7.1 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 1 SID or STAR for any reason, 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 RNP 1 requirements of the route.

7.2 In the event of communications failure, the pilot should continue with the published lost communications procedure.

8.0 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 information in this chapter;
b. the meaning and proper use of aircraft 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 (provided in 3.3.3.4 g), AIRINC 424 path terminators) and any other types used by the operator), as well as associated aircraft flight paths;
e. required navigation equipment for operation on RNP 1 SIDs, and STARs;
f. RNP system-specific information:
    i. levels of automation, mode annunciations, changes, alerts, interactions, reversions, and degradation;
    ii. functional integration with other aircraft systems;
    iii. the meaning and appropriateness of route discontinuities as well as related pilot procedures;
    iv. pilot procedures consistent with the operation;
    v. types of navigation sensors utilized by the RNP system and associated system prioritization/weighting/logic;
    vi. turn anticipation with consideration to speed and altitude effects;
    vii. interpretation of electronic displays and symbols; and
    viii. understanding of the aircraft configuration and operational conditions required to support RNP 1 operations, i.e. appropriate selection of CDI scaling (lateral deviation display scaling);

g. RNP system operating procedures, as applicable, including how to perform the following actions:
    i. verify currency and integrity of the aircraft navigation data;
    ii. verify the successful completion of RNP system self-tests;
    iii. initialize navigation system position;
    iv. retrieve and fly an RNP 1 SID or a STAR with appropriate transition;
    v. adhere to speed and/or altitude constraints associated with an RNP 1 SID or STAR;
    vi. select the appropriate RNP 1 SID or STAR for the active runway in use and be familiar with procedures to deal with a runway change;
    vii. verify waypoints and flight plan programming;
    viii. fly direct to a waypoint;
    ix. fly a course/track to a waypoint;
    x. intercept a course/track;
    xi. following vectors and rejoining an RNP 1 route from “heading” mode;
    xii. determine cross-track error/deviation. More specifically, the maximum deviations allowed to support RNP 1 must be understood and respected;
    xiii. resolve route discontinuities;
    xiv. remove and reselect navigation sensor input;
    xv. when required, confirm exclusion of a specific NAVAID or NAVAID type;
    xvi. change arrival airport and alternate airport;

xvii. 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; and
xviii. perform RNAV holding function;

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.

9.0 Navigation database

The navigation database must be obtained from a supplier that complies with RTCA DO 200A/EUROCAE document ED 76, Standards for Processing Aeronautical Data. An LOA issued by the appropriate regulatory authority to each of the participants in the data chain demonstrates compliance with this requirement (e.g. FAA LOA issued in accordance with FAA AC 20-153 or EASA LOA issued in accordance with EASA Opinion Nr. 01/2005.

Discrepancies that invalidate a SID or STAR must be reported to the navigation database supplier, and the affected SID or STAR must be prohibited by an operator's notice to its pilots.

Aircraft operators should consider the need to conduct periodic checks of the operational navigation databases in order to meet existing quality system requirements.

Note.— To minimize PDE, the database should comply with DO 200A, or an equivalent operational means must be in place to ensure database integrity for the RNP 1 SIDs or STARs.

10.0 Oversight of operators

The Authority shall consider any navigation error reports in determining remedial action.
Repeated navigation error occurrences attributed to a specific piece of navigation equipment may result in cancellation of the approval for use of that equipment.

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.

CHAPTER 7

RNP APCH OPERATIONS

1.0 APPROVAL PROCESS

This Advisory Circular (AC) establishes RNP APCH approval requirements for aircraft and operators. This includes operations down to LNAV and LNAV/VNAV minima in Part A of the circular.

The requirements of aircraft and operators approval for RNP APCH operations down to LP (localizer performance) and LPV (localizer performance with vertical guidance) minima, using the global navigation satellite system (GNSS) augmented by the satellite-based augmentation systems (SBAS), are established in Part B of this circular.

1.1 REFERENCE

KCARS Operation of Aircraft Regulations
KCARS Instrument and Equipment Regulations
Form KCAAFOPSPBN: Application Job Aid Part A (Application Form)
Form KCAAFOPSPBN: Evaluation Approval Form

RELATED DOCUMENTS (as amended)

ICAO Doc 9613 Performance based navigation (PBN) manual
ICAO Doc 9997 PBN Approval
ICAO Doc 8168 Aircraft operations Volume I: Flight procedures
EASA Part SPA (GM1 SPA.PBN.100)
EASA AMC 20-27 Airworthiness approval and operational criteria for RNP APCH operations including APV BARO-VNAV operations
EASA AMC 20-28 Approval related to Area Navigation for GNSS approach operation to Localiser Performance with Vertical guidance minima using Satellite Based Augmentation
FAA AC 90-107 Guidance for Localizer Performance with Vertical Guidance and Localizer Performance without Vertical Guidance Approach Operations in the U.S. National Airspace System
FAA AC 90-105 Approval guidance for RNP operations and barometric vertical navigation in the U.S. National Airspace System
FAA AC 90-107 Guidance for Localizer Performance with Vertical Guidance and Localizer Performance without Vertical Guidance Approach Operations in the U.S. National Airspace System
FAA AC 20-138B Airworthiness approval of positioning and navigation systems

PART A – LNAV / VNAV

2.0 INTRODUCTION

This Chapter addresses approach applications based on GNSS which are classified as RNP APCH in accordance with the PBN concept and give access to minima designated as LNAV or LNAV/VNAV.

The guidance material of this Part of the Chapteraddresses the requirements for the lateral navigation (2D navigation) of RNP APCH approaches designed with straight segments down to LNAV minima. This navigation specification includes present RNAV (GNSS) or GPS approaches.

RNP APCH approaches based on GNSS may include barometric vertical navigation. Baro-VNAV systems are optional capabilities that do not constitute a minimum requirement to fly RNP APCH approaches using an LNAV line of minima.

This document also provides general considerations on the approval of stand-alone and multi-sensor aircraft systems, including their requirements of functionality, accuracy, integrity, continuity of function, and limitations, together with operational considerations.

Stand-alone and multi-sensor RNP systems that use GNSS and that comply with EASA AMC 20-27 and with the FAA ACs 90-105, 20-138A, 20-130A, 20-138B or TSO C 115b/ETSO C 115b, as amended, meet the ICAO RNP APCH (LNAV) navigation specification.

Note: Part B of this Chapter describes requirements RNP APCH operations with LP and LPV minima

3.0 GENERAL CONSIDERATIONS

Navaid infrastructure
The global navigation satellite system (GNSS) is the primary navigation system that supports RNP APCH procedures down to LNAV or LNAV/VNAV minima.
The missed approach segment may be based upon the conventional navaid (e.g., VOR or DME)

For baro-VNAV RNP APCH operations, the procedure design is based upon the use of a barometric altimetry by an airborne RNP system whose capabilities support the required operation. The procedure design must take into account the performance and functional capabilities required in the aircraft eligibility part of this Circular for APV/baro-VNAV operations or in equivalent documents.

The acceptability of the risk of loss of RNP APCH capability for multiple aircraft due to satellite failure or loss of on-board monitoring and alerting functions (for example, spaces with RAIM holes), must be considered by the responsible airspace authority.

3.1 Obstacle clearance

3.1.1 RNP APCH operations without baro-VNAV guidance

Detailed guidance on obstacle clearance is provided in ICAO Doc 8168 (PANS-OPS), Volume II – Construction of visual and instrument flight procedures; the general criteria in Parts I and III apply.
The missed approach procedures may be supported by either RNAV or by conventional segments (*e.g.*, segments based on VOR or DME.

Procedure design must take into account of the absent of vertical navigation (VNAV) capability on the aircraft.

3.1.2 RNP APCH operations with baro-VNAV guidance

Baro-VNAV is applied where vertical guidance and information is provided to the flight crew during instrument approach procedures containing a vertical path defined by a vertical path angle (VPA).

Detailed guidance on obstacle clearance is provided in Doc 8168 (PANS-OPS), Volume II – Construction of visual and instrument flight procedures. Missed approach procedures may be supported by RNAV or conventional segments (*e.g.*, segments based on VOR, DME, NDB).

3.2 Approach Charts/Publications

a. The instrument approach charts will clearly identify the RNP APCH application as RNP APCH or $RNAV_{(GNSS)}$ RWY *XX*. The Navigation Specification being used, RNP APCH, will be clearly identified in the PBN Box on the chart.
b. ICAO Circular 336 published in 2015 now requires charts in future to progressively identify the charts as RNP RWY *XX* and use a suffix for the exceptional circumstances e.g. RNP RWY 08 (LNAV/VNAV only).
c. For RNP APCH operations without baro-VNAV (down to LNAV minima only), the procedure design will be based on normal descent profiles, and the chart minima box will identify minimum altitude requirements for each segment, including a lateral navigation obstacle clearance altitude/height (LNAV OCA/H).
d. For RNP APCH operations with baro-VNAV (down to LNAV/VNAV minima), the charts will follow the standards of ICAO Annex 4 section on the designation of an RNAV procedure where the vertical path is specified by a glide path angle. The chart designation will be consistent with said Annex and a lateral and vertical navigation obstacle clearance altitude/height will be issued (LNAV/VNAV OCA/H).

e. When the missed approach segment is based on conventional means, the navaid facilities or the airborne navigation means that are necessary to conduct the missed approach will be identified in the relevant publications.
f. The navigation information published in the applicable aeronautical information publication (AIP) for the procedures and the supporting NAVAIDs will meet the requirements of ICAO Annexes 15 and 4 as appropriate. Procedure charts will provide sufficient data to support navigation database checking by the flight crew (including waypoint names (WPT), tracks, distances for each segment and the VPA).
g. All procedures will be based on the 1984 World Geodetic Coordinates (WGS 84).

3.3 Communications and Air traffic service (ATS) surveillance

RNP APCH operations do not include specific requirements for communication or ATS surveillance. An adequate obstacle clearance is achieved through aircraft performance and operating procedures. Where reliance is placed on the use of radar to assist contingency procedures, it must be demonstrated that its performance is adequate for this purpose. The radar service requirement will be identified in the AIP.

3.4 Navigation accuracies associated with the flight phases of a RNP APCH approach

Navigation accuracies associated with the flight phases of a RNP APCH approach are the following:

1)	initial segment:	RNP 1.0
2)	middle segment:	RNP 1.0
3)	final segment:	RNP 0.3
4)	missed approach segment:	RNP 1.0

3.5 Additional considerations

Most aircraft have the capability to execute a holding pattern manoeuvre using their RNP system.

3.6 AIRWORTHINESS AND OPERATIONAL APPROVAL

3.6.1 In order to get an RNP APCH authorization, an operator shall comply with the following:
a) an aircraft eligibility review by airworthiness inspectorate; and
b) an operational approval from flight operations inspectorate.

3.6.2 For general aviation operators, the Authority will determine if the aircraft meets the applicable RNP APCH requirements and will issue the operational authorisation (*e.g.*, a letter of authorization – LOA).

3.6.3 Before submitting the application, operators shall review all the aircraft qualification requirements. Compliance with airworthiness requirements or the installation of the equipment, by themselves does not constitute operational approval.

3.6.4 The operator who intends to seek for authorization/approval of RNP 1 and has complied to the above aircraft requirement shall present to the authority a statement of intent to start the process of obtaining the authorization. A letter accompanying the application form shall be acceptable.

3.7 AIRCRAFT ELIGIBILITY

3.7.1 General

The following aircraft airworthiness criteria and aircraft requirements are applicable to the installation of RNP systems required for RNP APCH operations:

a) This AC uses FAA AC 20-138/AC 20-138A/AC 20-138B (GPS stand-alone system) or FAA AC 20-130A/AC 20-138B (multi-sensors systems) as a basis for the airworthiness approval of an RNP system based on GNSS.
b) For APV/baro-VNAV operations, FAA AC 20-129/AC 20-138B may be referenced.

3.7.2 Aircraft and system requirements

Aircraft approved to conduct RNP APCH approaches meet the performance and functional requirements of this Chapter for RNP APCH instrument approaches without radius to fix segments (without RF segments).

i. Aircraft that have a statement of compliance with respect to the criteria contained in this Chapter or equivalent documents in their flight manual (AFM), AFM supplement, pilot operations handbook (POH), or the operating manual for their avionics meet the performance and functional requirements of this Chapter.
ii. Aircraft that have a statement from the manufacturer documenting compliance with the criteria of this Chapter or equivalent documents meet the performance and functional requirements of this document. This statement will include the airworthiness basis for such compliance. Compliance with the sensor requirements will have to be determined by the equipment or aircraft manufacturer, while compliance with the functional requirements may be determined by the manufacturer or through an inspection by the operator.
iii. If the RNP installation is based on GNSS stand-alone system, the equipment must be approved in accordance with technical standard order (TSO) C129a/ETSO-C129a Class A1 (or subsequent revisions) or with TSO-C146a/ETSO-C146a Class Gamma, Operational Class 1, 2, or 3 (or subsequent revisions) and meet the functionality requirements of this document.
iv. If the RNP installation is based on GNSS sensor equipment used in a multi-sensor system (*e.g.*, FMS, the GNSS sensor must be approved in accordance with TSO-C129 ()/ETSO-C129 () Class B1, C1, B3, C3 (or subsequent

revisions) or TSO-C145 ()/ETSO-C145 () Class Beta, Operational Class 1, 2 or 3 (or subsequent revisions) and meet the functionality requirements of this document.

v. Multi-sensor systems using GNSS must be approved in accordance with AC 20-130A/CA 20-138B or TSO-C115b/ETSO-C115b and meet the functionality requirements of this document.

Note 1.- *The GNSS equipment approved in accordance with TSO-C129a/ETSO-C129a must meet the system functions specified in this document. In addition, integrity should be provided through an aircraft-based augmentation system (ABAS). It is recommended that GNSS receivers include the capability of fault detection and exclusion (FDE) to improve continuity of function.*

Note 2.- *Multi-sensor systems that use DME/DME or DME/DME/IRU as the only means of RNP compliance are not authorised to conduct RNP APCH operations.*

3.7.2.1 Performance and functional requirements for RNP APCH systems Accuracy

The total system error (TSE) in the lateral and longitudinal dimensions of the on-board navigation equipment must be within:

a) ± 1 NM for at least 95 percent of the total flight time in the initial and intermediate approach segments and for the missed approach of a RNP APCH procedure.
b) Note.- There is no specific RNP accuracy requirement for the missed approach if this segment is based on conventional NAVAIDs (e.g. VOR, DME) or on dead reckoning.
c) ± 0.3 NM for at least 95 percent of the total flight time in the final approach segment of the procedure.
d) To satisfy the accuracy requirement, the 95 % FTE shall not exceed:
e) 0.5 NM on the initial, intermediate, and missed approach segments of a RNP APCH procedure; and
f) 0.25 NM on the final approach segment of the procedure.

Note .- *The use of a deviation indicator with 1 NM full-scale deflection (FSD) on the initial, intermediate and missed approach segments and 0.3 NM FSD on the final approach segment is considered to be an acceptable means of compliance. The use of an autopilot or flight director is considered to be an acceptable means of compliance (roll stabilization systems do not meet the necessary conditions).*

An acceptable means of compliance with the accuracy requirements described in the previous paragraphs is to have an RNP system approved for RNP APCH approaches down to LNAV minima, in accordance with the 2D navigation accuracy criteria of FAA AC 20-138, AC 20-130A or AC 20-138B.

Integrity.- Malfunction of the aircraft navigation equipment that causes the TSE to exceed 2 times the RNP value is classified as a major failure condition under airworthiness regulations. In the horizontal plane (lateral and longitudinal), the system

must provide an alert if the accuracy requirement is not met, or if the probability that the TSE exceeds 2 NM for initial, intermediate and missed approach segments or 0.6 NM for the final approach segment.

Continuity.- Loss of the RNP APCH function is classified as a minor failure condition if the operator can revert to a different navigation system and safely proceed to a suitable airport. If the missed approach procedure is based on conventional NAVAIDs (e.g., VOR, DME, NDB), the associated navigation equipment must be installed and operational. For RNP APCH operations, at least one RNP navigation system is required.

Note.- *From an operational point of view, the operator must develop contingency procedures in case of loss of the RNP APCH capability during approach.*

3.7.2.2 On-board performance monitoring and alerting.- During operations on the initial, intermediate and the missed approach segments of a RNP APCH procedure, 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. During operations on the final approach segment 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.

Signal-in-space.- During operations on the initial, intermediate, and missed approach segments of an RNP APCH procedure, the aircraft navigation equipment shall provide an alert if the probability of signal-in-space errors causing a lateral position error greater than 2 NM exceeds. During operations on the final approach segment of an RNP APCH down to LNAV or LNAV/VNAV minima, the aircraft navigation equipment shall provide an alert if the probability of signal-in-space errors causing a lateral position error greater than 0.6 NM.

Note.- *Compliance with the on-board performance monitoring and alerting requirement does not imply automatic monitoring of FTE. The on-board monitoring and alerting function must consist at least of a navigation system error (NSE) monitoring and alerting algorithm, and a lateral deviation display enabling the flight crew to monitor the FTE. To the extent operational procedures are used to monitor the FTE, the flight crew procedure, equipment characteristics and installation are evaluated for their effectiveness and equivalence as described in the functional requirements and operational procedures.*

Path definition.- Aircraft performance is evaluated around the path defined by the published procedure and by document RTCA/DO-236B Sections 3.2.

Functional requirements of navigation displays.- The following navigation displays and functions are required. Navigation data, including a to/from indication and a failure indicator must be displayed on a lateral deviation display (course deviation indicator (CDI), enhanced horizontal situation indicator (EHSI)) and/or a navigation map display. These displays must be used as primary flight instruments for the navigation of the aircraft, manoeuvre anticipation and for failure/status/integrity indication. The

aforementioned non-numerical lateral deviation displays must have the following attributes:

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 must agree with any alerting and annunciation limits.
c) the lateral deviation display must also have an Full Scale Deflection (FSD) 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 must be set automatically by default or set to a value obtained from a navigation database. The FSD 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 provide equivalent functionality to a lateral deviation display with appropriate map scales (scales may be set manually by the pilot). To be approved, the navigation map display must be shown to meet TSE requirements.
f) the lateral deviation display must be automatically slaved to the RNP computed path. It is recommended that the course selector of the deviation display is automatically slaved to the RNP computed path.

Note.- *This does not apply for installations where an electronic map display contains a graphical display of the flight path and path deviation.*

g) enhanced navigation displays (*e.g., electronic map displays* or EHSI) to improve lateral situational awareness, navigation surveillance and approach verification (flight plan verification) could be mandatory if the RNP installation does not support the display of information necessary for the accomplishment of these crew tasks.

System capabilities.- The following system capabilities are required as a minimum:

a) the capability to continuously display to the pilot flying (PF) the aircraft, on the primary flight instruments for navigation of the aircraft (primary navigation display), the RNP 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 (PNF) the aircraft 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 by the Authority, which can be updated in accordance with the aeronautical information regulation and control (AIRAC) cycle and from which approach procedures can be retrieved and entered in 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 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) the capability to load from the database into the RNP system, the whole approach to be flown. The approach must be loaded from the database, 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 :
g) the identification of the active (to) WPT;
h) the distance and bearing to the active (to) WPT; and
i) the ground speed or time to the active (to) WPT.
j) the means to display the following items on a readily accessible display :
k) the display of distance between the WPTs of the operational flight plan;
l) the display of distance to go;
m) the display of along-track distances; and
n) the active navigation sensor type, if there is another sensor in addition to the GNSS sensor.
o) the capability to execute the "direct to" function.
p) the capability for automatic leg sequencing with the display of sequencing to the pilot.
q) the capability to execute procedures extracted from the on-board database, including the capability to execute fly-over and fly-by turns.
r) the capability to automatically execute leg transitions and maintain tracks consistent with the following ARINC 424 path terminators or their equivalent:
    i. ARINC 424 path terminators
    ii. initial fix (IF)
    iii. track to fix (TF)
    iv. direct to fix (DF)

Note.- *Path terminators are defined in ARINC Specification 424 and their application is described in more detail in RTCA documents DO-236B and DO-201A.*

Note.- *Numerical values for tracks must be automatically entered from the RNP system database.*

s) the capability to display an indication of the RNP system failure, including the associated sensors, in the primary field of view of the pilot.
t) the capability to indicate to the flight crew when the NSE alert limit is exceeded (alert provided by the on-board performance monitoring and alerting function).

Flight director/autopilot.- A flight director and/or autopilot is not required for this type of operation, however, it is recommended that the flight director (FD) and/or autopilot (AC) remain coupled for RNP approaches. 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.

Database integrity.- The navigation database suppliers must comply with RTCA DO-200A. A letter of acceptance (LOA), issued by the appropriate regulatory authority to each one of the participants in the data chain, demonstrates compliance with this requirement. Positive compliance with this requirement will be considered for those LOAs issued prior to the publication of this Chapter.

3.7.3 Eligibility and approval of the system for RNP APCH operations down to LNAV and LNAV/VNAV minima

a) **Introduction.-** The original equipment manufacturer (OEM) or the holder of installation approval for the aircraft (*e.g.*, the holder of the supplementary type certificate (STC)), must demonstrate to the CAA of State of registry or manufacture that it complies with the appropriate provisions. The approval can be recorded in the documentation of the manufacturer (*e.g.*, service letters (SL), etc.). In this case the approval need not be recorded in the AFM.

b) **Eligibility for RNP APCH operations down to LNAV and LNAV/VNAV minima.-** Systems that meet the requirements of this Chapter are eligible for RNP APCH operations down to LNAV minima. Systems that meet the requirements of this Chapter and APV/baro-VNAV or equivalent are eligible for RNP APCH operations down to LNAV/VNAV minima. Aircraft qualified in accordance with requirements with RNP AR APCH, (*e.g.*, FAA AC 90-101 or EASA AMC 20-26) are considered qualified for RNP APCH operations down to LNAV and LNAV/VNAV minima without further examination.

c) System eligibility for RNP APCH operations down to LNAV or LNAV/VNAV minima

1. **Lines of minima.-** RNP APCH approaches supported by GNSS normally include at least two lines of minima: LNAV and LNAV/VNAV. The LNAV line of minima is based on the use of systems that meet the performance criteria in 2) below and LNAV/VNAV criteria in 3) below.
2. LNAV Line of minima qualification

i. **Stand-alone systems.-** Stand-alone systems that comply with TSO-C129/ETSO-C129 Class A1 or TSO-C146/ETSO-C146 Classes 1, 2, or 3 meet the aircraft qualification requirements for RNP APCH operations using the LNAV line of minima, provided the IFR equipment installations have been performed in accordance with FAA AC 20-138. RNP systems must be approved in accordance with FAA AC 20-138 or equivalent.

Note.- *it is considered that these systems meet the functional and performance requirements set out in this Chapter in the aspects that correspond.*

ii. Multi-sensor systems.-

a) Multi-sensor systems that use TSO-C129/ETSO-C129 Classes B1, B3, C1, or C3 sensors meet the aircraft qualification requirements for RNP APCH operations using the LNAV line of minima, provided:

- the equipment installations meet the criteria of this Chapter; and

- the associated flight management system (FMS) complies with TSO-C115b/ETSO-C115b and is installed in accordance with FAA AC 20-130 or FAA AC 20-138B or subsequent.

b) Multi-sensor systems that use TSO-C145/ETSO-C145 Classes 1, 2, or 3 sensors meet the aircraft qualification requirements for RNP APCH operations using the LNAV line of minima, provided:
- the equipment installations meet the criteria of this Chapter; and
- are installed in accordance with FAA AC 20-138.

Note.- *it is considered that these systems meet the functional and performance requirements set out in this Chapter in the aspects that correspond.*

d) LNAV/VNAV Line of minima qualification

(a) **Stand-alone systems**

i. Stand-alone TSO-C146/ETSO-C146 Classes 2 or 3 systems meet the aircraft qualification requirements for RNP APCH operations using the LNAV/VNAV line of minima, provided that the installations meet at least the performance and functional requirements of this Chapter..

ii. The systems that meet TSO-C129/ETSO-C129 can be used for RNP APCH operations using the LNAV/VNAV line of minima if they meet the criteria of this Chapter.

iii. RNP systems must be approved in accordance with FAA AC 20-138 or equivalent, and those systems that utilize conventional baro-VNAV must provide vertical navigation system performance that meets or exceeds the criteria of APV-baro-VNAV requirements.

(b) **Multi-sensor systems**

i. Multi-sensor systems that use TSO-C129/ETSO-C129 Classes B1, B3, C1, or C3 sensors or TSO-C145/ETSO-C145 Classes 1, 2, or 3 sensors meet the aircraft qualification requirements for RNP APCH operations using the LNAV/VNAV line of minima, provided the installations meet the requirements of this Chapter.

ii. RNP systems that utilize conventional baro-VNAV must provide a vertical navigation system performance that meets or exceeds the criteria of APV-baro-VNAV requirements.

iii. RNP systems must be installed in accordance with FAA AC 20-138 or equivalent and/or the associated FMS must comply with TSO-C115b/ETSO-C115b and must be installed in accordance with FAA AC 20-130 or AC 20-138B or equivalent.

3.8 Aircraft modification

a) If any system required for RNP APCH operations is modified (*e.g.*, changes in the software or hardware), the aircraft modification must be approved.
b) The operator must obtain a new operational approval that is supported by updated aircraft operational and qualification documentation including the updated MEL.

3.9 Continued airworthiness

a) The operators of aircraft approved to perform RNR APCH operations down to LNAV or LNAV/VNAV minima, must ensure the continuity of the technical capacity of them, in order to meet technical requirements established in this Chapter.
b) Each operator who applies for RNP APCH operational approval down to LNAV or LNAV/VNAV minima shall submit to the Authority, a maintenance and inspection program that includes all those requirements of maintenance necessary to ensure that navigation systems continue fulfilling the approval criteria for RNP APCH operations down to LNAV or LNAV/VNAV minima.
c) The following maintenance documents must be revised, as appropriate, to incorporate aspects concerning RNP APCH operations down to LNAV or LNAV/VNAV minima:
    i. Maintenance control manual (MCM);
    ii. Illustrated parts catalogs (IPC); and
    iii. Maintenance program.
d) The approved maintenance program for the affected aircrafts should include maintenance practices listed in maintenance manuals of the aircraft manufacturer and its components, and must consider:
    i. that equipment involved in the RNP APCH operation down to LNAV or LNAV/VNAV minima should be maintained according to directions given by manufacturer's components;
    ii. that any amendment or change of navigation system affecting in any way RNP APCH initial approval down to LNAV or LNAV/VNAV minima, must be forwarded and reviewed by the Authority for its acceptance or approval of such changes prior to its implementation; and
    iii. that any repair that is not included in the approved/accepted maintenance documentation, and that could affect the integrity of navigation performance, should be forwarded to the Authority for acceptance or approval thereof.
e) Within the RNP APCH maintenance documentation should be presented the training program of maintenance personnel, which inter alia, should include:
    i. PBN concept;

ii. application of RNP APCH down to LNAV or LNAV/VNAV minima;

iii. equipment involved in an RNP APCH operation down to LNAV or LNAV/VNAV minima; and

iv. MEL use.

3.10 OPERATIONAL APPROVAL

The airworthiness approval, by itself, does not authorise the operator to conduct RNP APCH operations down to LNAV or LNAV/VNAV minima. In addition to the airworthiness approval, the operator must obtain an operational approval confirming that the installation of the specific equipment is consistent with normal and contingency procedures.

3.10.1 Operational approval requirements

To obtain the authorisation for RNP APCH operations down to LNAV or LNAV/VNAV minima, the operator will take the following steps, taking into account the criteria established in this Circular and in FORM KCAA-FOPS-RNP APCH: Application Job Aid RNP APCH operations.

3.10.2 Description of the aircraft equipment

a) The operator must establish and have available a configuration list detailing the components and equipment to be used for RNP APCH operations down to LNAV or LNAV/VNAV minima.

b) The list of required equipment shall be established during the operational approval process, taking into account the AFM. This list shall be used for updating the MEL for each type of aircraft that the operator intends to operate.

c) The details of the equipment and its use in accordance with the approach characteristics appear in this Chapter.

3.10.3 Aircraft qualification documentation

a) *For aircraft currently conducting GNSS approaches under FAA AC 90-94 or equivalent*.- Documentation is not required for aircraft that have an AFM or AFM supplement which states the aircraft is approved to fly RNAV (GPS), or equivalent GPS approaches, to the LNAV line of minima.

b) *For aircraft without approval to fly GNSS instrument approach procedures*.- Operators will submit to the Authority the RNP qualification documentation showing compliance with this Chapter, provided the equipment is properly installed and operated.

Note.- Before requesting an authorisation to conduct RNP APCH operations down to LNAV or LNAV/VNAV minima, operators shall review all equipment performance requirements. Equipment installation by itself does not guarantee operational approval nor permit its operational use.

3.10.4 RNP APCH operational documentation

a) The operator will develop the operational documentation for using the equipment for RNP APCH operations down to LNAV or LNAV/VNAV minima, based on the aircraft or avionics manufacturer documentation.

b) The operational documentation of the aircraft or avionics manufacturer will consist of recommended operational procedures and training programmes for the flight crew, in order to assist operators meet the requirements of this Chapter.

3.10.4.1 Acceptance of documentation

a) New aircraft/equipment (aircraft/equipment in the process of being manufactured or recently manufactured).- The aircraft/equipment qualification documentation can be approved as part of an aircraft certification project and be reflected in the AFM and related documents.

b) Aircraft/equipment in service (capacity achieved in service).- Previous approvals issued to conduct GNSS or GPS instrument approaches according to FAA AC 90-94 or equivalent do not require further evaluations. For installations/equipment not eligible to conduct GNSS or GPS instrument approaches, the operator will submit aircraft or avionics qualification documentation to the Authority.

c) The Authority's inspectors will review the application package for RNP APCH operations down to LNAV or LNAV/VNAV minima.

3.10.4.2 Training documentation

Commercial operators must have a training programme addressing the operational practices, procedures and training items related to RNP APCH, Section A of this chapter, operations (e.g. initial, upgrade or recurrent training for pilots, dispatchers or maintenance personnel).

Note.— Operators need not establish a separate training programme if they already integrate RNAV training as an element of their training programme. However, the operator should be able to identify the aspects of RNP

APCH operations to LNAV and/or LNAV/VNAV minima covered within their training programme.

Private operators must be familiar with the practices and procedures identified in Section A, 5.3.5, "Pilot knowledge and training".

3.10.4.3 OMs and checklists

OMs and checklists for commercial operators must address information/guidance on the SOP detailed in Section A, 5.3.4. The appropriate manuals should contain navigation operating instructions and contingency procedures, where specified. When required by the State of the Operator/Registry, the operator must submit their manuals and checklists for review as part of the application process.

Private operators should operate using the practices and procedures identified in Section A, 5.3.5, "Pilot knowledge and training".

3.10.4.4 MEL considerations

Any MEL revisions necessary to address provisions for RNP APCH operations to LNAV and/or LNAV/VNAV minima must be approved. Operators must adjust the MEL, or equivalent, and specify the required dispatch conditions.

3.10.5 Operating procedures

Airworthiness certification alone does not authorize an operator to conduct an RNP APCH operation down to LNAV or LNAV/VNAV minima. Operational approval is also required to confirm the adequacy of the operator's normal and contingency procedures for the particular equipment installation.

a) *Pre-flight planning*

3.10.5.1 Operators and pilots intending to conduct RNP APCH operations down to LNAV or LNAV/VNAV minima must file the appropriate flight plan suffixes, and on board navigation data must be current and include the appropriate procedures.

3.10.5.2 At system initialization, pilots must confirm the navigation database is current and includes appropriate procedures. Likewise, pilots must also verify that the aircraft position is correct.

Note.- *Navigation databases are expected to be current for the duration of the flight. If the AIRAC cycle is due to change during the flight, the operators and pilots shall 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. If an amended letter for the procedure is published, the database must not be used for conducting the operation.*

3.10.5.3 Pilots must verify the proper entry of their ATC assigned route once they have received the initial clearance and following any subsequent changes of the route. Likewise, pilots must ensure the WPT sequence depicted by their navigation system matches their assigned route and the route depicted on the appropriate charts.

Note.- *Pilots may notice a slight difference between the navigation information portrayed on the chart and the heading shown on the primary navigation display. A difference of 3 degrees or less may be due to a magnetic variation applied by the equipment manufacturer and may be operationally acceptable.*

Note.- *Manual selection of functions that limit the aircraft bank angle can reduce the aircraft's ability to maintain the desired track and is not recommended.*

3.10.5.4 The aircraft RNP capability depends on the aircraft operational equipment. The flight crew must be able to assess the impact of equipment failure on the anticipated RNP APCH operation and take appropriate action. When a flight dispatch is predicated on flying an RNP APCH procedure that requires the use of the AP or FD at the destination and/or alternate aerodrome, the operator must determine that the AP and/or FD are installed and operational.

3.10.5.5 Pilots must ensure that the approaches that can be used for the intended flight (including alternate aerodromes):

a) have been selected from a valid navigation data base (current AIRAC cycle);
b) have been verified through an appropriate process (navigation database integrity process); and
c) are not prohibited by an operational instruction of the company or NOTAM.

3.10.5.6 Pilots must ensure that there are sufficient means available to fly and land at the destination or alternate aerodrome in case of loss of on board RNP APCH capability.

3.10.5.7 Operators and flight crews must take account of all NOTAMs or operator briefing material that could adversely affect the aircraft system operation or the availability or suitability of the procedures at the aerodrome of landing or at any alternate aerodromes.

3.10.5.8 For missed approach procedures based on conventional means (e.g. VOR, NDB), operators and flight crews must ensure that the appropriate airborne equipment required to fly these procedures is installed and operational in the aircraft, and that the associated ground-based navigation aids are operational.

3.10.5.9 The availability of the NAVAID infrastructure, required for the intended routes, including any non-RNP contingencies, must be confirmed for the period of intended operations, using all available information. Since GNSS integrity [receiver autonomous integrity monitoring (RAIM) or satellite-based augmentation system (SBAS) signal] is required by Annex 10, Volume I, the availability of these signals must also be determined as appropriate. For aircraft navigating with SBAS receivers [all TSO-C145()/C146()/ETSO-C145()/C146()], operators must check appropriate GPS RAIM availability in areas where the SBAS signal is unavailable.
GNSS availability.- RAIM prediction must be performed prior to departure.

3.10.6 ABAS availability

RAIM levels required for RNP APCH operations down to LNAV or LNAV/VNAV minima can be verified either through notices to airmen (NOTAMs) (if 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 shall be familiar with the prediction information available for the intended route.
RAIM availability prediction shall take into account the latest GPS constellation NOTAMs and use the identical algorithm to that used in the airborne equipment, or an algorithm based on RAIM prediction assumptions that give a more conservative result. The RAIM prediction service may be provided by ANSPs, avionics manufacturers, other entities or through an airborne receiver RAIM prediction capability. RAIM availability may be confirmed by using model specific RAIM prediction software.
In the event of a predicted, continuous loss of appropriate level of fault detection (FD) of more than five minutes for any part of the RNP APCH operation, the flight planning

must be revised (e.g., the flight must be delayed, cancelled, or re-routed where RAIM requirements can be met).
The RAIM availability prediction software does not guarantee the service; rather it is a tool to assess the expected capability of meeting the required navigation performance.
Because of unplanned failures of some GPS elements, pilots must realize that RAIM or GPS navigation may be lost while airborne which may require reversion to an alternative means of navigation. Therefore, pilots must assess their capability to navigate to an alternate aerodrome in case of failure of GPS navigation.
The predictive capability must account for known and predicted coverage gaps of GPS satellites or other effects on navigation system sensors.
The prediction programme shall not use a mask angle below 5 degrees, as operational experience indicates that satellite signals at low elevations are not reliable.
For aircraft navigating with SBAS receivers (all TSO-C145/C146/ ETSO-C145/C146 systems), operators shall take into account the latest NOTAMs of the GPS and SBAS constellation. If the NOTAMs indicate that the SBAS signal is not available over the intended flight route, operators shall check the appropriate GPS RAIM availability.
Availability of SBAS and other augmented GNSS systems

Aircraft and operators approval for RNP APCH operations down to LP and LPV minima using GNSS augmented by SBAS, contains the criteria to assess GNSS SBAS vertical guidance availability.

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

3.10.7 Prior to commencing the procedure

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

(a) the WPT sequence;
(b) the reasonableness of the tracks and distances of the approach legs, the accuracy of the inbound course, and the length of the final approach segment.

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

3.10.7.2 The flight crew must also check, using the published charts, the map display or the control and display unit (CDU), which WPTs are fly-by and which are flyover.

3.10.7.3 For multi-sensor systems, the flight crew must verify, during the approach, that the GNSS sensor is used for position computation.

3.10.7.4 For an RNP system with an aircraft-based augmentation system (ABAS) requiring barometric corrected altitude, the current aerodrome barometric altimeter setting must be input at the appropriate time and location, consistent with the performance of the flight operation.

3.10.7.5 When the operation is predicated on ABAS availability, the flight crew must perform a new RAIM availability check if the estimated time of arrival (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.

3.10.7.6 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 WPTs loaded from the database. In complying with ATC instructions, the flight crew must be aware of the following:

(a) the manual entry of coordinates into the RNP system by the flight crew for operations within the terminal area is not permitted; and

(b) "direct to" clearances may be accepted up to the intermediate fix (IF), provided that the resulting track change at the IF does not exceed 45º.

Note.- *"Direct to" clearance to the FAF is not acceptable.*

3.10.7.7 The lateral definition of the flight path between the FAF and the missed approach point (MAPt) must not be revised by the flight crew under any circumstances.

3.10.8 During the procedure

3.10.8.1 Pilots must comply with the instructions or procedures identified by the operator, as necessary, to meet the performance requirements of this Chapter.

3.10.8.2 Before starting the final descent, the aircraft must be established on the final approach course no later than the final approach fix (FAF) to ensure terrain and obstacle clearance.

3.10.8.3 The flight crew must check if the approach mode annunciator (or equivalent) is properly indicating the approach mode integrity within 2 NM prior to the FAF.

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

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

i. the RNP computed desired path (DTK); and

ii. the aircraft position relative to the path (cross-track deviation) for flight technical error (FTE) monitoring.

3.10.8.5 An RNP APCH procedure must be discontinued:

iii. if the navigation display is flagged invalid: or

iv. in case of loss of the integrity alerting function; or

v. if the integrity alerting function is annunciated not available before passing the FAF; or if the FTE is excessive

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

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

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

ii. the whole procedure (including the missed approach) has been loaded from the navigation data base.

3.10.8.7 During the RNP APCH procedure down to LNAV or LNAV/VNAV minima, pilots must use a lateral deviation indicator, FD and/or AP in the lateral navigation mode. Although the scale should change automatically, pilots of aircraft provided with a lateral deviation indicator (e.g., CDI) must ensure that the 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, intermediate, and missed approach segments, and ± 0.3 NM for the final approach segment down to LNAV or LNAV/VNAV minima).

3.10.8.8 All pilots are expected to maintain route centreline, as depicted by on-board lateral deviation and/or flight guidance indicators throughout the RNP APCH procedure unless authorized to deviate by ATC or under emergency conditions.

3.10.8.9 For normal operations, cross-track error/deviation (the difference between the RNP system computed path and the aircraft position relative to the path) must be limited to ± ½ of the navigation accuracy associated with the procedure (i.e., 0.5 NM for the initial, intermediate and missed approach segments and 0.15 NM for the final 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 (e.g., 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 standard during intercepts following turns and on straight segments.*

3.10.8.10 When barometric VNAV is used for vertical path guidance during the final approach segment, deviations above and below the barometric VNAV path must not exceed + 75/-75 ft respectively.

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

3.10.8.12 For aircraft requiring two pilots, the flight crew must verify that each pilot's altimeter has the current setting before beginning the final approach of an RNP APCH approach procedure down to LNAV or LNAV/VNAV minima. The flight crew must also observe any operational limitations related to altimeter setting sources and the verification and setting latency of altimeters when approaching the FAF.

3.10.8.13 RNP APCH procedures down to LNAV or LNAV/VNAV require flight crew monitoring of lateral and, if installed, vertical track deviations on the pilot's primary flight displays (PFD) to ensure the aircraft remains within the boundaries defined by the procedure.

3.10.10 General operating procedures

1. Operators and pilots must not request an RNP APCH procedure down to LNAV or LNAV/VNAV minima unless they satisfy all the criteria required by the Authority. If an aircraft not meeting these criteria receives a clearance from ATC to conduct an RNP APCH procedure down to LNAV or LNAV/VNAV minima, the pilot must advise ATC that he/she is unable to accept the clearance and must request alternate instructions.
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.
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. Pilots should use the flight director and autopilot in lateral navigation mode, whenever available.

3.10.11 Contingency procedures

1. The pilots must notify ATC of any loss of the RNP APCH capability, together with the proposed course of action.
2. If unable to comply with the requirements of an RNP APCH procedure down to LNAV or LNAV/VNAV minima, they must notify air traffic service (ATS) as soon as possible.
3. 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.
4. The operators must develop contingency procedures in order to react safely following the loss of the RNP APCH capability during the approach.
5. In the event of communication failure, the flight crew must continue with the RNP APCH procedure in accordance with the published lost communication procedure.
6. The operator's contingency procedures must address at least the following conditions:

(a) failure of the RNP system components, including those affecting lateral or vertical deviation performances (*e.g.*, failures of a GPS sensor, FD or AP); and
(b) loss of navigation signal-in-space (loss or degradation of the external signal).

7. The pilot must ensure the capability of navigating and landing at an alternate aerodrome if loss of RNP APCH capacity occurs.

3.10.12 Training programme

The training programme must provide sufficient training (*e.g.*, in simulator, training devices or aircraft) on the aircraft's RNP system to the extent that the pilots are not just task oriented. The training programme will cover at least the following aspects:

1. the information on this Chapter.
2. the meaning and proper use of RNP systems.
3. procedure characteristics as determined from chart depiction and textual description.
4. knowledge regarding depiction of WPT types (fly-by and flyover waypoints), required path terminators (IF, TF, and DF) and any other types used by the operator, as well as the associated aircraft flight paths.
5. knowledge on the required navigation equipment in order to conduct RNP APCH operations down to LNAV or LNAV/VNAV minima (at least one RNP system based on GNSS).
6. knowledge of RNP system-specific information:
   i. automation levels, mode annunciations, changes, alerts, interactions, reversions and degradation;
   ii. functional integration with other aircraft systems;
   iii. the meaning and appropriateness of route discontinuities as well as related flight crew procedures;
   iv. monitoring procedures for each phase of flight;
   v. types of navigation sensors utilized by the RNP system and associated system prioritization/weighting/logic;
   vi. turn anticipation with consideration to speed and altitude effects; and
   vii. interpretation of electronic displays and symbols.

7. knowledge of RNP equipment operating procedures, as applicable, including how to perform the following actions:
   i. verify currency of aircraft navigation data;
   ii. verify the successful completion of RNP system self-tests;
   iii. initialize RNP system position;
   iv. retrieve and fly an RNP APCH procedure;
   v. adhere to speed and/or altitude constraints associated with an approach procedure;
   vi. fly interception of an initial or intermediate segment of an approach following air traffic control (ATC) notification;
   vii. verify WPTs and flight plan programming;

viii. fly direct to a WPT;
ix. determine cross-track error/deviation;
x. insert and delete route discontinuity;
xi. when required by the Authority, perform gross navigation error checks using conventional NAVAIDs; and
xii. change arrival airport and alternate airport.

8. knowledge levels of automation recommended by the operator for each phase of flight and workload, including methods to minimize cross-track error to maintain procedure centreline.
9. knowledge of radio telephony phraseology for RNP applications.
10. ability to conduct contingency procedures following RNP system failures.

3.10.13 Navigation database

1. The operator must obtain the navigation databases from a qualified supplier that complies with RTCA DO 200A/EUROCAE document ED 76 – Standards for processing aeronautical data.
2. A letter of acceptance (LOA) issued by the appropriate regulatory authority demonstrates compliance with this requirement (e.g., FAA LOA issued in accordance with FAA AC 20-153 or EASA LOA issued in accordance with EASA OPINIO Nr. 01/2005.
3. The database supplier of an operator must have a Type 2 LOA and their respective suppliers must have a Type 1 or 2 LOA. The Authority will normally accept a LOA issued to the navigation data suppliers.
4. Discrepancies that invalidate a procedure must be reported to the navigation database supplier and affected procedures must be prohibited by an operator´s notice to its flight crew.
5. Aircraft operators should conduct periodic checks of the operational navigation database in order to meet existing quality system requirements.

3.10.14 OVERSIGHT OF OPERATORS – NAVIGATION ERRORS

The operator will establish a process to receive, analyse, and do the follow-up of navigation error reports in order to determine the appropriate corrective action.
The Authority may consider any navigation error reports in determining remedial action.
Repeated navigation error occurrences attributed to a specific piece of navigation equipment may result in cancelling of the approval for use of that equipment.
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 may necessitate remedial training or licence review.

CHAPTER 7 - PART B

RNP APCH LP / LPV OPERATIONS

1.0 Purpose

This part of the Chapter provides guidance for implementing RNP APCH operations down to Localiser Performance (LP) or Localiser Performance with Vertical Guidance (LPV) minima.

1.1 LP/LPV approach procedures.

At some airports, it may not be possible to meet the requirements to publish an approach procedure with LPV vertical guidance. This may be due to: obstacles and terrain along the desired final approach path, airport infrastructure deficiencies, or the inability of SBAS to provide the desired availability of vertical guidance (i.e. an airport located on the fringe of the SBAS service area). When this occurs, a State may provide an LP approach procedure based on the lateral performance of SBAS. The LP approach procedure is a non-precision approach procedure with angular lateral guidance equivalent to a localizer approach. As a non-precision approach, an LP approach procedure provides lateral navigation guidance to a MDA; however, the SBAS integration provides no vertical guidance. With the notable exception of material directly related to SBAS vertical guidance, this guidance material applies to both LPV and LP approach operations.

2.0 IMPLEMENTATION CONSIDERATIONS

2.1 NAVAID infrastructure

2.1.1 The RNP APCH specification is based on augmented GNSS to support RNP APCH operations down to LP or LPV minima.

2.1.2 The acceptability of the risk of loss of RNP APCH approach capability for multiple aircraft due to satellite failure and/or augmented GNSS system failure will be considered by the responsible airspace authority.

2.2 Communications and ATS surveillance

RNP APCH operation down to LP or LPV minima using augmented GNSS does not include specific requirements for communications or ATS surveillance. Adequate obstacle clearance is achieved through aircraft performance and operating procedures.

2.3 Obstacle clearance

2.3.1 Detailed guidance on obstacle clearance is provided in PANS-OPS (Doc 8168, Volume II). The general criteria in Parts I and III apply, together with the approach criteria from

Doc 8168, Volume II, Part III, Section 1, Chapter 5 and Section 3, Chapter 5, regarding SBAS. The criteria assume normal operations.

2.3.2 Missed approach procedure may be supported by either RNAV or conventional segments (e.g. based on NDB, VOR, DME).

2.4 Additional considerations

2.4.1 Each State is required to verify that the augmented GNSS system and that the service provider of the GNSS system, used to support RNP APCH operations, are approved according to the appropriate regulation.

2.5 Publication and Charting

2.5.1 The AIP should clearly indicate that the navigation application is RNP APCH. Charting will follow the standards of Annex 4 — Aeronautical Charts, for the designation of an RNAV procedure.

a. The instrument approach charts will clearly identify the RNP APCH application as $RNAV_{(GNSS)}$ RWY *XX*.
b. ICAO Circular 336 published in 2015 now requires charts in future to progressively identify the charts as RNP RWY XX and use a suffix for the exceptional circumstances e.g. RNP RWY 08 (LP only, or LP/LPV only).

The charting designation will be promulgated as an LP or LPV OCA(H).

2.5.2 If the missed approach segment is based on conventional means, NAVAID facilities that are necessary to conduct the approach will be identified in the relevant publications.

2.5.3 The navigation data published in the State AIP for the procedures and supporting NAVAIDs will meet the requirements of Annex 4 and Annex 15 — Aeronautical Information Services (as appropriate).

2.5.4 All procedures will be based upon WGS-84 coordinates.

2.5.5 The Final Approach Segment (FAS) of RNP APCH operations down to LP or LPV minima is uniquely characterized by a geometrically defined FAS. The FAS will be promulgated using the FAS Data Base process. This FAS DB contains the lateral and vertical parameters, which define the approach to be flown.

2.5.6 The FAS may be intercepted by an approach transition (e.g. RNAV1), or initial and intermediate segments of an RNP APCH approach, or through vectoring (e.g. interception of the extended FAS).

2.8 ATS system monitoring

If an observation/analysis indicates that a loss of obstacle clearance has occurred, the reason for the apparent deviation from track or altitude should be determined and steps taken to prevent a recurrence.

3.0 NAVIGATION SPECIFICATION

3.1 Background

This section identifies the airworthiness and operational requirements for RNP APCH operations down to LP or LPV minima using augmented GNSS. Operational compliance with these requirements will require a specific operational approval.

3.2 Approval process

3.2.1 This navigation specification does not in itself constitute regulatory guidance material against which either the aircraft or the operator will be assessed and approved. Aircraft are certified by their State of Manufacture. Operators are approved in accordance with KCARS and this Chapter.

3.2.2 Aircraft eligibility

The aircraft eligibility must be determined through demonstration of compliance against the relevant airworthiness criteria and the requirements of this document. The Original Equipment Manufacturer (OEM) or the holder of installation approval for the aircraft, e.g. STC holder, will demonstrate compliance to their State authorities (e.g. EASA, FAA) and the approval can be documented in manufacturer documentation (e.g. service letters). AFM entries may not be required where the Operator provides approved manufacturer documentation.

3.2.3 Operational approval

Description of aircraft equipment

The operator must have a configuration list and, if necessary, an MEL detailing the required aircraft equipment for RNP APCH operations to LP or LPV minima.

3.2.4 Training documentation

(a) Commercial operators must have a training programme addressing the operational practices, procedures and training items related to RNP APCH operations to LP or LPV minima (e.g. initial, upgrade or recurrent training for pilots, dispatchers or maintenance personnel).

(b) Note: Operators need not establish a separate training programme or regimen if they already integrate RNAV training as an element of their training programme. However, the operator should be able to identify the aspects of RNP APCH operations to LP or LPV minima covered within their training programme.

(c) Private operators should show compliance with the practices and procedures identified in 5.3.5, “Pilot knowledge and training”.

(d) Operations Manuals and checklists

- OMs and checklists for commercial operators must address information/guidance on the SOP detailed in 3.4. The appropriate manuals should contain navigation operating instructions and contingency procedures, where specified. The operator

must submit their manuals and checklists for review as part of the application process.

- Private operators should operate using the practices and procedures identified in, 3.5, "Pilot knowledge and training".

3.2.5 MEL considerations

Any MEL revisions necessary to address provisions for RNP APCH operations to LP or LPV minima must be presented for approval. Operators must adjust the MEL, or equivalent, and specify the required dispatch conditions.

3.2.6 Continuing airworthiness

The operator must submit the continuing airworthiness instructions applicable to the aircraft's configuration and the aircraft's qualification for this navigation specification. Additionally, there is a requirement for operators to submit their maintenance programme, including a reliability programme for monitoring the equipment.

3.3 Aircraft requirements

3.3.1 On-board performance monitoring and alerting

Accuracy: Along the Final Approach Segment and the straight continuation of the final approach in the missed approach, the lateral and vertical Total System Error (TSE) is dependent on the Navigation System Error (NSE), Path Definition Error (PDE) and Flight Technical Error (FTE):

a. Navigation System Error (NSE): the accuracy itself (the error bound with 95 per cent 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 if the equipment computes three dimensional positions using linearized, weighted least square solution in accordance with RTCA DO 229C (or subsequent version) Appendix J.
b. Flight Technical Error: 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. Path Definition Error: 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 Flight Guidance System is used during such approach.

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).

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.

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 Signal in Space SIS section below);
(b) FTE monitoring and alerting: LPV approach guidance must be displayed on a lateral and vertical deviation display (HSI, 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 DB; and
(c) Navigation database: once the FAS DB has been decoded, the equipment shall apply the Cyclic redundancy check (CRC) to the Data Base to determine whether the data is valid. If the FAS DB does not pass the Cyclic redundancy check test, the equipment shall not allow activation of the LP or LPV approach operation.

3.3.2 Signal-in-Space (SIS)

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.

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; 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).

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.

3.3.3 Functional requirements

Navigation displays and required functions
Approach guidance must be displayed on a lateral and vertical deviation display (HSI, 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 degrees from the pilot's normal line of sight) when looking forward along the flight path; and
c. the deviation display must have a suitable full-scale deflection based on the required track-keeping accuracy.
d. 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 Base.

Note: Where the minimum flight crew is two pilots, it should be possible for the pilot not flying to verify the desired path and the aircraft position relative to the path.

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 Landing Threshold Point (LTP);
(c) The navigation database must contain all the necessary data/information to fly the published approach procedure (FAS). The format provides integrity protection for the data it contains. Consequently, each FAS is defined by a specific "FAS DB" containing the necessary lateral and vertical parameters depicting the approach to be flown. If the FAS DB does not pass the required 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 lateral offset indicator 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 Final Approach Segment (FAS), in order to facilitate the interception of the extended from a radar vector FAS (e.g. VTF function).

Note: These requirements are limited to the FAS, the straight continuation of the final approach in the missed approach, and to 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 (e.g. RNP APCH, Section A of this chapter, or RNAV1 criteria) applies.

3.3.4 Operating procedures

Airworthiness certification alone does not authorize an operator to conduct RNP APCH operations down to LP or LPV minima. Operational approval is also required to confirm the adequacy of the operator's normal and contingency procedures for the particular equipment installation.

3.3.5 Pre-flight planning

Operators and pilots intending to conduct RNP APCH operations down to LP or LPV minima must file the appropriate ATC flight plan suffixes. The on-board navigation data must be current and must include the 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 routes and procedures for flight.

In addition to the normal preflight planning, the following checks must be carried out:

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

(b) Subject to State's regulations, during the preflight 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 LP or LPV airborne capability;

(c) Operators and flight crews must take account of any NOTAMs (including SBAS 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) If the missed approach procedure is based on conventional means (e.g. VOR, NDB) the appropriate airborne equipment required to fly this procedure must be installed in the aircraft and must be operational. The associated ground-based NAVAIDs must also be operational. If the missed approach procedure is based on RNAV (no conventional or dead reckoning missed approach available) the appropriate airborne equipment required to fly this procedure must be installed in the aircraft and must be operational.

The availability of the NAVAID infrastructure, required for the intended routes, incluCCding any non-RNAV contingencies, must be confirmed for the period of

intended operations using all available information. Since GNSS integrity is required by Annex 10, the availability of these should also be determined as appropriate.

3.3.6 Augmented GNSS availability

Service levels required for RNP APCH operations down to LP or LPV 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. Operators should be familiar with the prediction information available for the intended route.

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

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).

Service availability prediction software does not guarantee the service, they are tools to assess the expected capability to meet the RNP. Because of unplanned failure of some GNSS or SBAS elements, pilots/ANSPs should realize that GPS or SBAS 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 plus SBAS navigation.

These availability prediction services are expected to be developed also for future GNSS systems with performances equivalent to SBAS.

3.3.7 Prior to commencing the procedure

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

(a) the waypoint sequence;
(b) reasonableness of the tracks and distances of the approach legs, and the accuracy of the inbound course and mileage of the FAS; and

Note.— As a minimum, this check could be a simple inspection of a suitable map display.

(c) the vertical path angle.

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 following implications for the navigation system:

(a) The manual entry of coordinates into the navigation system by the pilot for operation within the terminal area is not permitted; and
(b) "Direct to" clearances may be accepted to the Intermediate Fix (IF) provided that the resulting track change at the IF does not exceed 45 degrees.

Note: Direct to clearance to FAP is not acceptable.

The approach system provides the capability for the pilot to intercept the final approach track well before the Final Approach Point (FAP). This function should be used to respect a given ATC clearance.

3.3.8 During the procedure

The approach mode will be activated automatically by the RNP system. When a direct transition to the approach procedure is conducted (e.g. when the aircraft is vectored by the ATC to the extended Final Approach Segment (FAS) and the crew selects the VTF function or an equivalent function), the LP or LPV approach mode is also immediately activated.

The system provides lateral and/or vertical guidance relative to the LP or LPV FAS or to the extended FAS (for the direct transition).

The crew must check that the GNSS approach mode indicates LP or LPV (or an equivalent annunciation) 2 NM before the FAP.

The FAS should be intercepted no later than the FAP in order for the aircraft to be correctly established on the final approach course before starting the descent (to ensure terrain and obstacle clearance).

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

a) aircraft position relative to the lateral path;
b) aircraft position relative to the vertical path; and
c) absence of lateral offset indication alert.

The crew should respect all published altitude and speed constraints.

Prior to sequencing the FAP, the crew should abort the approach procedure if there is:

a) loss of navigation indicated by a warning flag (e.g. absence of power, equipment failure, …);
b) LOI monitoring, annunciated locally, or equivalent; and

c) low altitude alert (if applicable).

After sequencing the FAP, unless the pilot has the visual references required to continue the approach in sight, the procedure must be discontinued if:

a) loss of navigation is indicated by a warning flag (e.g. lateral flag, vertical flag or both flags);
b) Note.— Lateral offset indication monitoring after sequencing the Final Approach Point leads to a loss of navigation (warning flag).
c) loss of vertical guidance is indicated (even if lateral guidance is already displayed); and/or
d) FTE is excessive and cannot be corrected in a timely manner.

Pilots must execute a missed approach if excessive lateral and/or vertical deviations are encountered and cannot be corrected on time, unless the pilot has in sight the visual references required to continue the approach. The missed approach must be flown in accordance with the published procedure (e.g. conventional or RNAV).

3.3.9 General operating procedures

Operators and pilots must not request an RNP APCH operation down to LP or LPV minima 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 such an approach procedure, the pilot must advise ATC that he/she is unable to accept the clearance and must request alternate instructions.

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

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

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

3.3.10 Contingency procedures

The operator should develop contingency procedures in order to react safely following the loss of the approach capability during the approach.

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.

In the event of a communications failure, the pilot should continue with the procedure in accordance with published lost communications procedures.

3.4 Pilot knowledge and training

The pilot training programme should be structured to provide sufficient theoretical and practical training, using a simulator, training device, or line training in an aircraft, on the use of the aircraft's approach system to ensure that pilots are not just task-oriented. The following syllabus should be considered as a minimum amendment to the training programme to support these operations:

a. RNP approach concept containing LP or LPV minima:

i. theory of approach operations;
ii. approach charting;
iii. use of the approach system including:
    1) selection of the LP or LPV approach procedure; and
    2) ILS look alike principle;
iv. use of lateral navigation mode(s) and associated lateral control techniques;
v. use of VNAV mode(s) and associated vertical control techniques;
vi. R/T phraseology for LP or LPV approach operations; and
vii. the implication for LP or LPV approach operations of systems malfunctions which are not related to the approach system (e.g. hydraulic failure);

b. RNP approach operation containing LP or LPV minima:

i. definition of LP or LPV approach operations and its direct relationship with RNAV(GNSS) procedures;
ii. regulatory requirements for LP or LPV approach operations;
iii. required navigation equipment for LP or LPV approach operations:
    1) GPS concepts and characteristics;
    2) augmented GNSS characteristics; and
    3) MEL;
iv. procedure characteristics:
    1) chart depiction;
    2) aircraft display depiction; and
    3) minima;
v. retrieving an LP or LPV approach procedure from the database (e.g. using its name or the SBAS channel number);
vi. change arrival airport and alternate airport;
vii. flying the procedure:
    1. use of autopilot, autothrottle and flight director;
    2. flight guidance mode behaviour;
    3. lateral and vertical path management;
    4. adherence to speed and/or altitude constraints;
    5. fly interception of an initial or intermediate segment of an approach following ATC notification;
    6. fly interception of the extended FAS (e.g. using the VTF function);
    7. consideration of the GNSS approach mode indication (LP, LPV, LNAV/VNAV, lateral navigation); and

8. the use of other aircraft equipment to support track monitoring, weather and obstacle avoidance;

viii. ATC procedures;

ix. abnormal procedures; and

x. contingency procedures.

CHAPTER 8

RADIUS TO FIX (RF) PATH TERMINATOR

1.0 INTRODUCTION

1.1 Background

This chapter addresses ARINC 424 RF path terminator functionality when used in association with RNP 1, RNP 0.3, RNP APCH, and A-RNP specifications. RF legs are an optional capability for use with RNP 1 RNP 0.3 and RNP APCH rather than a minimum requirement. This functionality can be used in the initial and intermediate approach segments, the final phase of the missed approach, SIDs and STARs. The application of this chapter in the final approach or the initial or intermediate phases of the missed approach is prohibited. Such procedure segments wishing to apply RF would have to use the RNP AR specification.

1.2 Purpose

1.2.1 This chapter provides guidance for implementing Instrument Flight Procedures where RF legs are incorporated into terminal procedures.

1.2.2 For the operator, the Appendix provides training requirements. This chapter is intended to facilitate operational approval for existing RNP systems that have a demonstrated RF leg capability. An operational approval based upon this standard allows an operator to conduct operations on procedures containing RF legs globally.

1.2.3 This chapter also provides airworthiness and operational criteria for the approval of an RNP system incorporating an RF leg capability. Although the ARINC 424 RF leg functionality in this chapter is identical to that found in the RNP AR specification, the approval requirements when applied in association with RNP 1, RNP 0.3, RNP APCH and A-RNP are not as constraining as those applied to RNP AR. This is taken into account in the related obstacle protection and route spacing criteria.

2.0 IMPLEMENTATION CONSIDERATIONS

2.1 Application of RF legs

2.1.1 The RF leg should be used when there is a requirement for a specific fixed radius curved path in a terminal procedure. The RF leg is defined by the arc centre fix, the arc initial fix, the arc ending fix and the turn direction. The radius is calculated by the navigation computer as the distance from the arc centre fix to the arc ending fix. RNP systems

supporting this leg type provide the same ability to conform to the track-keeping accuracy during the turn as in the straight line segments. RF legs are intended to be applied where accurate repeatable and predictable navigation performance is required in a constant radius turn.

2.1.2 The RF leg may be associated as an optional requirement for proceures defined using the following RNP specifications:

- Implementing RNP 1
- Implementing RNP APCH
- Implementing RNP 0.3

In addition, the RF leg is a minimum requirement when approval is sought or terminal procedures are defined using the following RNP specification:

- Implementing Advanced RNP (A-RNP)

2.1.3 RF legs may be used on any segment of a terminal procedure except the (Final Approach Segment) FAS, the Initial missed approach phase or the intermediate missed approach phase.

Note.— Although the RF leg is designed to be applied within the extent of terminal procedures, during higher flight level/altitude segments aircraft may become bank angle limited.

3.0 GENERAL CONSIDERATIONS FOR USE OF RF LEGS

3.1 Benefits

RF legs provide a predictable and repeatable ground track during a turn and prevent the dispersion of tracks experienced in other types of turn construction due to varying aircraft speeds, turn anticipation, bank, roll rate, etc.

Therefore, RF legs can be employed where a specified path must be flown during a turn. Additionally, because an RF leg traverses a specified distance it can be used to maintain aircraft longitudinal spacing between aircraft having the same speed. This is not necessarily true with other turn constructions such as fly-by transitions, because of the varying turn paths aircraft execute.

3.2 ATC coordination

3.1.1 It is expected that ATC will be familiar with RF leg benefits and their limitations, e.g. speed. ATC shall not allocate a speed that exceeds a constraint associated with the (design) flyability of an RF leg.

3.1.2 Aircraft must be established on the inbound track to the RF leg prior to it being sequenced by the navigation system. ATC must therefore not issue a Direct To clearance to a waypoint beginning an RF leg or a vector to intercept an RF leg.

4.0 AIRCRAFT REQUIREMENTS

4.1 RNP system-specific information

4.1.1 The navigation system should not permit the pilot to select a procedure 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).

4.1.2 The navigation system should also prohibit pilot access to procedures requiring RF leg capability 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).

Notes:

1. One acceptable means to meet these requirements is to screen the aircraft's on-board navigation database and remove any routes or procedures the aircraft is not eligible to execute. For example, if the aircraft is not eligible to complete RF leg segments, then the database screening could remove all procedures containing RF leg segments from the navigation database.

2. Another acceptable means of compliance may be pilot training to identify and prohibit the use of procedures containing RF legs.

4.2 On-board performance monitoring and alerting

The navigation system must have the capability to execute leg transitions and maintain a track consistent with an RF leg between two fixes.

4.3 System failure modes/annunciations

4.3.1 The RNP system shall provide a visible alert within the pilot's primary field of view when loss of navigation capability and/or LOI is experienced.

4.3.2 Any failure modes that have the potential to affect the RF leg capability should be identified. Failure modes may include loss of electrical power, loss of signal reception, RNP system failure, including degradation of navigation performance resulting in a loss of RNP containment integrity.

4.3.3 The ability of the aircraft to maintain the required FTE after a full or partial failure of the autopilot and/or flight director should be documented.

Note.— If autopilot malfunction testing was performed for worst case failures, no further validation is required. In this case, the manufacturer is expected to provide a statement of confirmation.

4.4 Functional requirements

4.4.1 An autopilot or flight director with at least "roll-steering" capability that is driven by the RNP system is required. The autopilot/flight director must operate with suitable accuracy to track the lateral and, as appropriate, vertical paths required by a specific RNP procedure.

4.4.2 An electronic map display depicting the RNP computed path of the selected procedure is required.

4.4.3 The flight management computer, the flight director system, and the autopilot must be capable of commanding and achieving a bank angle up to 25 degrees above 400 ft AGL.

4.4.4 The flight guidance mode should remain in lateral navigation while on an RF leg, when a procedure is abandoned or a missed approach/go-around is initiated (through activation of TOGA or other means) to enable display of deviation and display of positive course guidance during the RF leg. As an alternative means, crew procedures may be used that ensure that the aircraft adheres to the specified flight path throughout the RF leg segment.

4.5 Compliance demonstration

4.5.1 In seeking an airworthiness approval for a navigation system implementing the RF path terminator, the compliance demonstration supporting such an approval should be scoped to the airspace operational concept and the boundaries to which the RF leg is likely to be applied.

4.5.2 Consideration should be given to evaluation of the navigation system on a representative set of procedure designs under all foreseen operating conditions. The evaluation should address maximum assumed crosswind and maximum altitude with the aircraft operating in the range of expected airspeeds for the manoeuvre and operating gross weights.
Procedure design constraints should include sequencing multiple, consecutive RF leg segments of varying turn radii, including consecutive RF leg segments reversing the direction of turn (i.e. reversing from a left-hand RF turn to a right-hand RF turn). Within the demonstration, the applicant should be seeking to confirm the FTE commensurate with the identified RNP navigation accuracy and that the RF turn entry and exit criteria are satisfied. Any limitations identified during the compliance demonstration should be documented.
Flight crew procedures should be assessed, including identification of any limitations which surround the use of pilot selectable or automatic bank angle limiting functions and confirmation of those related to go-around or missed approach from an RF leg segment.

5.0 OPERATIONAL REQUIREMENTS

5.1 Background

This section identifies the operational requirements associated with the use of RF legs as scoped in 1.1 of this chapter.

It assumes that the airworthiness approval of the aircraft and systems has been completed. This means that the basis for the RF leg function and the system performance has already been established and approved based upon appropriate levels of analysis, testing and demonstration. As part of this activity, the normal procedures, as well as any limitations for the function, will have been documented, as appropriate, in the aircraft flight and operations manuals. Compliance with this chapter shall meet approval requirements.

5.2 Approval process

5.2.1 The following steps must be completed before the use of the RF leg function in the conduct of an RNP terminal operation:

a) Aircraft equipment eligibility must be determined and documented;
b) Operating procedures must be documented;
c) Pilot training based upon the operating procedures must be documented;
d) The above material must be accepted by the Authority; and
e) Operational approval should then be issued in the PBN authorisations section of the OPSPECs. This will be captured as a remark.

Note.— The criteria applied in the approval process should be dependent on the navigation specification to which the RF leg is associated, e.g. during the approval process of the navigation specification with RF leg associated, it should be verified that the requirements valid for this navigation specification are also met when applying an RF leg.

5.2.2 Following the successful completion of the above steps, an operational approval for the use of RF legs with the navigation specification with which it is associated, a LOA or appropriate Operations specifications, or an amendment to the OM, if required, should then be issued by the State.

5.3 Aircraft eligibility

5.3.1 Relevant documentation must be presented to the Authority to establish that the aircraft is equipped with an RNP system with a demonstrated RF leg capability. Eligibility may be established in two steps:

a) first, recognizing the qualities and qualifications of the aircraft and equipment; and
b) second, determining the acceptability for operations.

The determination of eligibility for existing systems should consider acceptance of manufacturer documentation of compliance, e.g. FAA ACs 90-105, 90-101A, 20-138B, EASA AMC 20-26.

Note.— RNP systems demonstrated and qualified for RNP AR operations using RF leg functionality are considered qualified with recognition that the RNP operations are expected to be performed consistent with the operators RNP AR approval. No further examination of aircraft capability, operator training, maintenance, operating procedures, databases, etc. is necessary.

5.3.2 *Eligibility airworthiness documents*. The flight manual or referenced document should contain the following information:

a) A statement indicating that the aircraft meets the requirements for RNP operations with RF legs and has demonstrated the established minimum capabilities for these operations. This documentation should include the phase of flight, mode of flight (e.g. FD on or off, and/or AP on or off, and applicable lateral and vertical modes), minimum demonstrated lateral navigation accuracy, and sensor limitations, if any;
b) Any conditions or constraints on path steering performance (e.g. AP engaged, FD with map display, including lateral and vertical modes, and/or CDI/map scaling requirements) should be identified. Use of manual control with CDI only is not allowed on RF legs; and
c) The criteria used for the demonstration of the system, acceptable normal and non-normal configurations and procedures, the demonstrated configurations and any constraints or limitations necessary for safe operation should be identified.

5.4 Operational approval

5.4.1 The assessment of a particular operator is made by the Authority and in accordance with national operating rules supported through the material in this PBN Manual and guidance material found in documents such as FAA AC 90-105. The assessment should take into account:

a) Evidence of aircraft eligibility;
b) Assessment of the operating procedures for the navigation systems to be used;
c) Control of those procedures through acceptable entries in the OM;
d) Identification of pilot training requirements; and
e) Where required, control of the navigation database process.

5.4.2 The operational approval will likely be documented through AOC accompanying OPSPECs or through issue of an LOA as applicable.

5.4.3 Training documentation. Commercial operators must have a training programme addressing the operational practices, procedures and training related to RF legs in terminal operations (e.g. initial, upgrade or recurrent training for pilot, dispatchers or maintenance personnel).

Note.— It is not required to establish a separate training programme or regime if RNAV and RF leg training is already an integrated element of a training programme. However, it should be possible to identify what aspects of RF leg use are covered within a training programme. Private operators should be familiar with the practices and procedures identified in 5.6, "Pilot knowledge and training".

5.4.4 OMs and checklists. OMs and checklists for commercial operators must address information/guidance on the SOPs detailed in this manual. These SOP and practices

must clearly define any aircraft limitations associated with RF leg execution (e.g. if the aircraft is not capable of executing RF leg segments, then the instructions to pilots must prohibit an attempt to fly a procedure requiring RF leg capability).

5.5 Operating procedures

5.5.1 The pilot must use either a flight director or autopilot when flying an RF leg. The pilot should comply with any instructions or procedures identified by the manufacturer as necessary to comply with the performance requirements in this chapter.

5.5.2 Procedures with RF legs will be identified on the appropriate chart.

5.5.3 When the dispatch of a flight is predicated on flying an RNP procedure with an RF leg, the dispatcher/pilot must determine that the installed autopilot/flight director is operational.

5.5.4 The pilot is not authorized to fly a published RNP 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 complying with ATC clearances/instructions.

5.5.5 The aircraft must be established on the procedure prior to beginning the RF leg.

5.5.6 The pilot is expected to maintain the centre line of the desired path on RF legs. For normal operations, cross-track error/deviation (the difference between the displayed path and the displayed aircraft position relative to the displayed path (i.e. FTE) should be limited to half the navigation accuracy associated with the procedure (e.g. 0.5 NM for RNP 1).

5.5.7 Where published, the pilot must not exceed maximum airspeeds associated with the flyability (design) of the RF leg.

5.5.8 If an aircraft system failure results in the loss of capability to follow an RF turn, the pilot should maintain the current bank and roll out on the charted RF exit course. The pilot should advise ATC as soon as possible of the system failure.

5.6 Pilot knowledge and training

The training programme must include:

a) The information in this chapter;
b) The meaning and proper use of RF functionality in RNP systems;

c) Associated procedure characteristics as determined from the chart depiction and textual description;
d) Associated levels of automation, mode annunciations, changes, alerts, interactions, reversions, and degradation;

Note.— Manually selecting aircraft bank limiting functions may reduce the aircraft's ability to maintain its desired track and are not permitted. The pilots should recognize that manually selectable aircraft bank limiting functions may reduce their ability to satisfy ATC path expectations, especially when executing large angle turns.

e) Monitoring track-keeping performance;
f) The effect of wind on aircraft performance during execution of RF legs and the need to remain within the RNP containment area. The training programme should address any operational wind limitations and aircraft configurations essential to safely complete the RF turn;
g) The effect of ground speed on compliance with RF paths and bank angle restrictions impacting the ability to remain on the course centre line;
h) Interpretation of electronic displays and symbols; and
i) Contingency procedures.

5.7 Navigation database

Aircraft operators will be required to manage their navigation data base load either through the packing or through flight crew procedure, where they have aircraft systems capable of supporting the RF functionality, but as an operator they do not have an approval for its use.

CHAPTER 9

BAROMETRIC VNAV (BARO-VNAV)

1.0 INTRODUCTION

1.1 Background

This navigation specification addresses those systems based upon the use of barometric altitude and area navigation information in the definition of vertical flight paths, and vertical tracking to a path. The Final Approach Segments (FAS) of VNAV Instrument Flight Procedures can be performed using vertical guidance to a glide path computed by the on-board RNP system. The glide path is contained in the specification of the instrument procedure within the RNP system navigation database. For other phases of flight, Baro-VNAV provides vertical path information that can be defined by vertical angles or altitudes at fixes in the procedure.

1.2 Purpose

This chapter provides guidance where approval of Baro-VNAV is required for RNP APCH approaches and RNP AR APCH, where approved. It reflects airworthiness guidance material for constant descent operations that has existed over many years. This specification is intended to facilitate operational approval for existing Baro-VNAV systems that have demonstrated their capabilities and obtained regulatory approval for usage. An operational approval based upon this standard allows an operator to conduct Baro-VNAV operations globally.

This specification provides airworthiness and operational criteria for the approval of an RNP system using barometric altimetry as a basis for its VNAV capability.

2.0 IMPLEMENTATION CONSIDERATIONS

2.1 Application of Baro-VNAV

Baro-VNAV is intended to be applied where vertical guidance and information are provided to the pilot on approach procedures containing a vertical flight path defined by a vertical path angle. Baro-VNAV may also be defined by altitude constraints but only for flight phases other than approach. Guidance for operational use is provided in PANS-OPS (Doc 8168), Volume I.

2.2 Obstacle clearance

Detailed guidance on obstacle clearance for the Final Approach Segment (FAS) is provided in PANS-OPS (Doc 8168), Volume II; the general criteria in Parts I and III apply, and assume normal operations. The PANS-OPS criteria do not provide specific guidance for the design of a Baro-VNAV overlay to a conventional non-precision procedure CDFA. In such cases, many other considerations must be made to ensure continued obstacle clearance, flyability, charting consistency and compatibility with airborne systems.

3.0 GENERAL CONSIDERATIONS FOR DEVELOPMENT OF BARO-VNAV SPECIFICATION

3.1 NAVAID infrastructure considerations

The procedure design does not have unique infrastructure requirements.

Monitoring and investigation of navigation and system errors

If an observation/analysis indicates that a loss of separation or obstacle clearance has occurred, the reason for the apparent deviation from track or altitude should be determined and steps taken to prevent a recurrence.

3.2 Navigation error reports

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

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.

3.3 ATC coordination

It is expected that ATC will be familiar with aircraft Baro-VNAV capabilities, as well as issues associated with altimeter setting and temperature data required by the aircraft.

4.0 NAVIGATION SPECIFICATION

4.1 Background

This section identifies the operational requirements for Baro-VNAV in conjunction with RNP APCH operations. It assumes the airworthiness approval of the aircraft and systems have been completed. This means the basis for the Baro-VNAV function and performance have already been established and approved based upon appropriate levels of analysis, testing and demonstration. Additionally, as part of this activity, the normal procedures, as well as any limitations for the function, have been documented, as appropriate, in the aircraft flight and operations manuals. Compliance with the operational requirements herein should be addressed through national operational regulations, and may, in some cases, require a specific operational approval.

5.0 Approval process

The following steps must be completed before the use of Baro-VNAV in the conduct of RNP AR APCH operations:

a) aircraft equipment eligibility must be determined and documented;

b) operating procedures must be documented;

c) pilot training based upon the operating procedures must be documented;

d) the above material must be accepted by the State regulatory authority; and

e) operational approval should then be obtained in accordance with national operating rules.

Following the successful completion of the above steps, an operational approval for the use of Baro-VNAV, an LOA or appropriate Operations specifications, or an amendment to the OM, if required, should then be issued by the Authority.

5.1 Aircraft requirements

5.1.2 Aircraft eligibility

Relevant documentation acceptable to the State of operation must be available to establish that the aircraft is equipped with an RNP system with a demonstrated Baro-VNAV capability. Eligibility may be established in two steps, one recognizing the qualities and qualifications of the aircraft and equipment, and the second determining the acceptability for operations. The determination of eligibility for existing systems should consider acceptance of manufacturer documentation of compliance, e.g. AC20-129.

Note.— RNP AR systems: RNP systems demonstrated and qualified for RNP AR operations including VNAV are considered qualified with recognition that the RNP approaches are expected to be performed consistent with the operators RNP AR approval. No further examination of aircraft capability, operator training, maintenance, operating procedures, databases, etc. is necessary.

Description of aircraft equipment. The operator must have a configuration list detailing pertinent components and equipment to be used for approach operation.

Note.— Barometric altimetry and related equipment such as air data systems are a required basic capability and already subject to minimum equipment requirements for flight operations.

Training documentation. Commercial operators should have a training programme addressing the operational practices, procedures and training related to Baro-VNAV in approach operations (e.g. initial, upgrade or recurrent training for pilot, dispatchers or maintenance personnel).

Note.— It is not required to establish a separate training programme if RNAV and Baro-VNAV training is already an integrated element of a training programme. However, it should be possible to identify what aspects of Baro-VNAV are covered within a training programme.

OMs and checklists. OMs and checklists for commercial operators must address information/guidance on the SOP detailed in below. The appropriate manuals should contain navigation operating instructions and contingency procedures, where specified. Manuals and checklists must be submitted for review as part of the application process.

Private operators should operate using the practices and procedures identified in, “Pilot knowledge and training”.

5.1.3 MEL considerations

Any unique MEL revisions necessary to address Baro-VNAV for approach provisions must be approved. Operators must adjust the MEL, or equivalent, and specify the required dispatch conditions.

Note.— Barometric altimetry and related systems are minimum equipment for all operations. Any unique dispatch or operational assumptions should be documented.

5.2 Aircraft system requirements

5.2.1 Baro-VNAV system performance

Baro-VNAV approach operations are 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).

Notes:
Positioning data from other sources may be integrated with the barometric altitude information provided it does not cause position errors exceeding the track keeping accuracy requirements.

Altimetry system performance is demonstrated separately through the static pressure systems certification (e.g. FAR or CS 25.1325), where performance must be 30 ft per 100 KIAS. Altimetry systems meeting such a requirement will satisfy the ASE requirements for Baro-VNAV. No further demonstration or compliance is necessary.

5.2.2 System accuracy

For instrument approach operations, the error of the airborne Baro-VNAV equipment, excluding altimetry, should have been demonstrated to be less than that shown below on a 99.7 per cent probability basis:

	Level flight segments and climb/descent intercept altitude region of specified altitudes	*Climb/descent along specified vertical profile (angle)*
At or below 1 500 m (5 000 ft)	15 m (50 ft)	30 m (100 ft)
1 500 m to 3 000 m (5 000 ft to 10 000 ft)	15 m (50 ft)	45 m (150 ft)
Above 3 000 m (10 000 ft)	15 m (50 ft)	67 m (220 ft)

Notes:

Maximum operating altitudes to be predicated on a compliance with total accuracy tolerance.

Baro-VNAV guidance may be used in level flight en route as in the case of altitude hold control laws, which are integrated with speed control laws to provide an energy trade. The incremental error component contributed by the Baro-VNAV equivalent must be offset by a corresponding reduction in other error components, such as FTE, to ensure that the total error budget is not exceeded.

Altimetry error refers to the electrical output and includes all errors attributable to the aircraft altimetry installation including position effects resulting from normal aircraft flight attitudes. In high performance aircraft, it is expected that altimetry correction will be provided. Such a correction should be done automatically. In lower performance aircraft, upgrading of the altimetry system may be necessary.

Baro-VNAV equipment error includes all errors resulting from the vertical guidance equipment installation. It does not include errors of the altimeter system, but does include any additional errors resulting from the addition of the Baro-VNAV equipment. This error component may be zero in level en-route flight if the operation is limited to guidance by means of the altimeter only. It should not be disregarded in terminal and approach operations where the pilot is expected to follow the Baro-VNAV indications.

The vertical error component of an along track positioning error is bounded by the following equipment qualification requirements for Baro-VNAV, and is directly

reflected in the along-track tolerance offset used in Baro-VNAV procedure design criteria:

a) GNSS navigation systems certified for approach or multi-sensor systems using IRU in combination with GNSS; or

b) RNP systems approved for RNP 0.3 or less;

c) serviceable Baro-VNAV equipment;

d) VNAV system certified for Baro-VNAV approach operations;

e) Equipped with integrated LNAV/VNAV system with accurate source of barometric altitude; and

f) Baro-VNAV altitudes and procedure information from a navigation database with integrity through quality assurance.

Flight technical (pilotage) errors. With satisfactory displays of vertical guidance information, FTEs should have been demonstrated to be less than the values shown below on a three-sigma basis.

	Level flight segments and climb/descent intercept altitude region of specified altitudes	*Climb/descent along specified vertical profile (angle)*
At or below 1 500 m (5 000 ft)	45 m (150 ft)	60 m (200 ft)
1 500 m to 3 000 m (5 000 ft to 10 000 ft)	73 m (240 ft)	91 m (300 ft)
Above 3 000 m (10 000 ft)	73 m (240 ft)	91 m (300 ft)

Note.— Some applications (e.g. RNP APCH and RNP AR APCH operations) require truncation of the FTE error distribution through operational procedures.

Sufficient flight tests of the installation should have been conducted to verify that these values can be maintained. Smaller values for FTEs may be achieved especially in the cases where the Baro-VNAV system is to be used only when coupled to an autopilot or flight director. However, at least the total system vertical accuracy shown below should be maintained.

If an installation results in larger FTEs, the total vertical error of the system (excluding altimetry) may be determined by combining equipment and FTEs using the root sum

square (RSS) method. The result should be less than the values listed below.

	Level flight segments and climb/descent intercept altitude region of specified altitudes	***Climb/descent along specified vertical profile (angle)***
At or below 1 500 m (5 000 ft)	48 m (158 ft)	68 m (224 ft)
1 500 m to 3 000 m (5 000 ft to 10 000 ft)	74 m (245 ft)	102 m (335 ft)
Above 3 000 m (10 000 ft)	74 m (245 ft)	113 m (372 ft)

An acceptable means of complying with these accuracy requirements is to have an RNP system approved for Baro-VNAV approaches in accordance with the criteria of FAA AC20-129 and an altimetry system approved in accordance with FAR/CS 25.1325 or equivalent.

5.2.3 Continuity of function

For operations predicated on the use of Baro-VNAV capability, at least one RNP system is required.

5.2.4 VNAV functions

Path definition

The requirements for defining the vertical path are governed by the two general requirements for operation: allowance for aircraft performance, and repeatability and predictability in path definition. This operational relationship leads to the specifications in the following sections that are based upon specific phases of flight and flight operations.

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:

a) An "AT OR ABOVE" altitude constraint (e.g. 2400A, may be appropriate for situations where bounding the vertical path is not required);

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

c) An "AT" altitude constraint (e.g. 5200); or

d) A "WINDOW" constraint (e.g. 2400A3400B).

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

5.2.5 Vertical constraints

Altitudes and/or speeds associated with published procedures must be automatically extracted from the navigation database upon selecting the approach procedure.

5.2.6 Path construction

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

5.2.7 Capability to load procedures from the navigation database

The navigation system must have the capability to load and modify the entire procedure(s) to be flown, based upon ATC instructions, 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. The navigation system should preclude modification of the procedure data contained in the navigation database.

5.2.8 Temperature limits

For aircraft using Baro-VNAV without temperature compensation to conduct the approach, low temperature limits are reflected in the procedure design and identified along with any high temperature limits on the charted procedure. Cold temperatures reduce the actual GPA, while high temperatures increase the actual GPA. Aircraft using Baro-VNAV with temperature compensation or aircraft using an alternate means for vertical guidance (e.g. SBAS) may disregard the temperature restrictions.

5.2.9 Guidance and control

For the vertical performance requirements, the path steering error budget must reflect altitude reference as well as other factors, such as roll compensation and speed protection, as applicable.

5.3 User interface

5.3.1 Displays and control

The display resolution (readout) and entry resolution for VNAV information should be as follows:

Parameter	Display resolution (readout)	Entry resolution
Altitude	Flight level or (1 ft)	Flight level or (1 ft)

Vertical path deviation	10 ft	Not applicable
Flight path angle	0.1°	0.1°
Temperature	1°	1°

5.3.2 Path deviation and monitoring

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 vertically defined path. The display must allow the pilot to readily distinguish if the vertical deviation exceeds +22 m/–22 m (+75 ft/–75 ft). The deviation should be monitored, and action taken to minimize errors.

It is recommended that an appropriately-scaled non-numeric deviation display (i.e. vertical deviation indicator) be located in the pilot's primary optimum field of view. A fixed-scale deviation indicator is acceptable as long as it demonstrates appropriate scaling and sensitivity for the intended operation. Any alerting and annunciation limits must also match the scaling values.

Note.— Existing systems provide for vertical deviation scaling with a range of ±500 ft. Such deviation scaling should be assessed consistent with the above requirement on discernability.

a) In lieu of appropriately scaled vertical deviation indicators in the pilot's primary

optimum field of view, a numeric display of deviation may be acceptable depending on the pilot workload and the numeric display characteristics. A numeric display may require additional initial and recurrent pilot training.

b) Since vertical deviation scaling and sensitivity varies widely, eligible aircraft must also be equipped with and operationally using either a flight director or autopilot capable of following the vertical path.

5.4 Barometric altitude

The aircraft must display barometric altitude from two independent altimetry sources, one in each pilot's primary optimum field of view. Operator procedures should ensure current altimeter settings for the selected instrument procedure and runway.

5.5 Operating procedures

Airworthiness certification alone does not authorize operators to utilize Baro-VNAV capability during the conduct of flight operations. Operational approval is required to confirm the adequacy of the operator's normal and contingency procedures for the particular equipment installation. Pilots should use a flight director or autopilot when flying a vertical path based on Baro-VNAV.

5.2.1 General operating procedures

The pilot should comply with any instructions or procedures identified by the manufacturer as necessary to comply with the performance requirements in this chapter.

5.2.2 Altimeter setting

The pilots should take precautions to switch altimeter settings at appropriate times or locations and request a current altimeter setting if the reported setting may not be recent, particularly at times when pressure is reported or is expected to be rapidly decreasing. Remote altimeter settings are not allowed.

5.2.3 Cold temperature

When cold weather temperatures exist, the pilot should check the chart for the IAP to determine the limiting temperature for the use of Baro-VNAV capability. If the airborne system contains a temperature compensation capability, the manufacturer's instructions should be followed for the use of the Baro-VNAV function.

5.3 Contingency procedures

Where the contingency procedure requires reversion to a conventional procedure, necessary preparations should be completed before commencing the RNAV procedure, consistent with operator practices.

5.4 Pilot knowledge and training

The training programme should provide sufficient training (e.g. simulator, training device, or aircraft) on the aircraft's Baro-VNAV capability to the extent that the pilots are not just task-oriented, including:

a) the information in this chapter;

b) the meaning and proper use of aircraft systems; and

c) procedure characteristics, as determined from chart depiction and textual description:

i. depiction of waypoint types (fly-over and fly-by) and path terminators and any other types used by the operator) as well as associated aircraft flight paths;

ii. RNP system-specific information;

iii. levels of automation, mode annunciations, changes, alerts, interactions, reversions, and degradation;

iv. functional integration with other aircraft systems;

v. the meaning and appropriateness of vertical path discontinuities as well as related pilot procedures;

vi. monitoring procedures for each phase of flight (e.g. monitor "PROGRESS" or "LEGS");

vii. turn anticipation with consideration to speed and altitude effects; and

viii. interpretation of electronic displays and symbols.

Baro-VNAV equipment operating procedures, as applicable, including how to perform the following actions:

d) adhere to speed and/or altitude constraints associated with an approach procedure;

e) verify waypoints and flight plan programming;

f) fly direct to a waypoint;

g) determine vertical-track error/deviation;

h) insert and delete route discontinuity;

i) change arrival airport and alternate airport;

j) contingency procedures for Baro-VNAV failures;

k) there should be a clear understanding of crew requirements for comparisons to primary altimeter information, altitude cross-checks (e.g. altimetry comparisons of 30 m (100 ft), temperature limitations for instrument procedures using Baro-VNAV, and procedures for altimeter settings for approach; and

l) discontinuation of a procedure based upon loss of systems or performance and flight conditions, e.g. inability to maintain required path tracking, loss of required guidance.

5.5 Navigation database

The navigation database should be obtained from a supplier holding an EASA or FAA LOA. This LOA demonstrates compliance with EUROCAE/RTCA document ED-76/DO-200A, Standards for Processing Aeronautical Data. FAA AC 20-153/EASA IR 21 sub-part G provides additional guidance on Type 1 and Type 2 LOAs.

Discrepancies that invalidate a procedure must be reported to the navigation database supplier and affected procedures must be prohibited by an operator's notice to its pilot.

Aircraft operators should consider the need to conduct periodic checks of the operational navigation databases in order to meet existing quality system requirements.

APPENDICES

APPENDIX 1

PBN APPROVAL APPLICATION FORM

INFORMATION ON AIRCRAFT AND EQUIPMENT

Operator Name and AOC Number: _____
Aircraft Manufacturer, Model, and Series: _____
PBN Specifications applied for:

RNAV 10 ☐	**RNP 4** ☐
RNAV 5 ☐	**RNP 2** ☐
RNAV 1 & 2 ☐	**RNP 1** ☐
	RNP APCH ☐

Registration numbers	Aircraft Serial numbers	Area navigation systems and manufacturer	Model serial number

DATE OPERATOR INTENDS TO BEGIN PBN OPERATIONS
_____

DATE / SIGN BY RESPONSIBLE POST HOLDER
_____/_____

NAME OF RESPONSIBLE POST HOLDER
_____

For Official use

DATE OF PRE-APPLICATION MEETING _____

DATE APPLICATION WAS RECEIVED _____

NOTIFICATION DATE APPROPRIATE? YES ☐ NO ☐

INSPECTOR NAME & SIGNATURE: _____

Application Instructions:

1. The Operator should conduct an initial assessment so as to determine the navigation specifications required for intended operations using specific aircraft.

2. The application form shall be submitted after the pre-application meeting. It should be accompanied by an application letter signed by the responsible post holder or accountable manager.

3. A Configuration list of the pertinent equipment and software for each aircraft type/variant and navigation specification must be attached. The installed number of specific components should be indicated.

4. An applicant should submit the application 60 days before the date of PBN operations commencement.

5. At the pre-application meeting with the operator, the inspector shall review the basic events of the required PBN approval process in order to provide an overview of the approval process events.

APPENDIX 2

FLIGHT CREW KNOWLEDGE AND TRAINING REQUIREMENTS SUMMARY

Knowledge Requirement	RNP 10	RNAV 5	RNAV 1 & 2	RNP 4	RNP 2	RNP 1	RNP APCH	Baro-VNAV	RF legs	Fixed Radius Transitions
The capabilities and limitations of the navigation systemlsl installed.	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Knowledge of the each of the navigation specifications to be used by the aircraft.	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Theory of approach operations and the lLS look alike principle.							LPV			
The meaning and proper use of aircraft equipment/navigation suffixes and functionality.			Y	Y	Y	Y	Y	Y	Y	Y
Route, airspace and procedure characteristics as determined from chart depiction and textual description.	Y	Y	Y	Y	Y	Y		Y	Y	Y

Knowledge Requirement	RNP 10	RNAV 5	RNAV 1 & 2	RNP 4	RNP 2	RNP 1	RNP APCH	Baro-VNAV	RF legs	Fixed Radius Transitions
A Depiction of waypoint types [fly-over, fly~by and FRTi and AIRINC 424 path terminators (HF, TF, RF, CF, DF, FA, HA, HM, HF, CA, VA, FM. VM, VI) and any other types used by the operator, as well as associated aircraft / helicopter flight paths.						Y	Y	Y		
Knowledge of the required navigation equipment in order to conduct various RNAV and RNP operations including: GPS concepts and characteristics augmented GNSS characteristics Minimum Equipment List provisions.	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Navigation system-specific information.										
Levels of automation, mode annunciations, changes, alerts, interactions, reversions, and degradation.		Y	Y		Y	Y	Y	Y	Y	

Knowledge Requirement	RNP 10	RNAV 5	RNAV 1 & RNAV 2	RNP 4	RNP 2	RNP 1	RNP APCH	Baro-VNAV	RF legs	Fixed Radius Transitions
Use of autopilot, autothrottle and flight director.			Y		Y	Y	Y	Y		
Functional integration with other aircraft systems		Y								
Flight Guidance(FG) mode behaviour.			Y		Y	Y	Y	Y		
The meaning and appropriateness of lateral and vertical route discontinuities as well as related pilot procedures.			Y		Y	Y	Y	Y		
Pilot procedures consistent with the operation.			Y		Y	Y		Y		
Monitoring procedures for each phase of the flight [e.g. monitor PROG or LEGS].		Y	Y		Y	Y	Y	Y	Y	
Lateral and vertical path management.			Y		Y	Y	Y	Y		
Types of navigation sensors (e.g DME, IRU , GNSS) utilised by the navigation system and associated system prioritization /weighing/logic		Y	Y		Y	Y	Y			
Turn anticipation with consideration to speed and altitude effects		Y	Y		Y	Y	Y	Y		

Knowledge Requirement	RNP 10	RNAV 5	RNAV 1 & 2	RNP 4	RNP 2	RNP 1	RNP APCH	Baro-VNAV	RF legs	Fixed Radius Transitions
Interpretation of (electronic) displays and symbols		Y	Y		Y	Y	Y	Y	Y	
Understanding of the aircraft configuration and operational conditions required to support PBN operations i.e appropriate selection of CDI scaling (lateral deviation display scaling)			Y		Y	Y	Y			
Understand the performance requirement to couple the autopilot/flight director to the navigation systems laterla guidance on RNP procedures if required.			Y		Y	Y				

Knowledge Requirement	RNP 10	RNAV 5	RNAV 1 & 2	RNP 4	RNP 2	RNP 1	RNP APCH	Baro-VNAV	RF legs	Fixed Radius Transitions
The equipment should not permit the flight crew to select a procedure or route that is not supported by the equipment, either manually (e.g the procedure is not supported if it incorpoerate 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 fixed radius transitions 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)										
Automatic and/or manual setting of the required navigation accuracy			Y			Y				
RNP system operating procedures, as applicable including how to perform the following actions ;										

Knowledge Requirement	RNP 10	RNAV 5	RNAV 1 & 2	RNP 4	RNP 2	RNP 1	RNP APCH	Baro-VNAV	RF legs	Fixed Radius Transitions
Verify currency asnd integrity of the aircraft navigation data		Y	Y		Y	Y	Y			
Verify the successful completion of the RNP system self-tests		Y	Y		Y	Y	Y			
Initialise navigation system position		Y	Y		Y	Y	Y			
Retrive and fly a route SID or STAR or approach by name with appropriate transition			Y		Y	Y	Y			
Retrieve a LP or LPV approach procedure from the database (e.g using its name or the SBAS channel number) (LP and LPV only)							LPV			
Adhere to speed and/ or altitude constraints associated with routes and procedures			Y		Y	Y	Y	Y		
Where applicable, the impotance of maintaining the published path and maximum airspeeds while performing RNP operations with RF legs or fixed Rdius Transitions										

Knowledge Requirement	RNP 10	RNAV 5	RNAV 1 & RNAV 2	RNP 4	RNP 2	RNP 1	RNP APCH	Baro-VNAV	RF legs	Fixed Radius Transitions
Impact of pilot selectable bank limitations on aircraft/rotorcraft ability to achieve the required accuracy on the planned route.			Y			Y			Y	
The effect of wind on aircraft performance during execution of RF legs and the need to remain within the RNP containment area. The training programme should address any operational wind limitations and aircraft configurations essential to safely complete the RF turn.									Y	
The effect of ground speed on compliance with RF paths and bank angle restrictions impacting the ability to remain on the course centreline.									Y	
Select the appropriate RNP 1 SID or STAR for the active runway in use and be familiar with procedures to deal with a runway change [RNP1 and RNAV1 & RNAV 2 only].			Y		Y	Y	Y			

Knowledge Requirement	RNP 10	RNAV 5	RNAV 1 & 2	RNP 4	RNP 2	RNP 1	RNP APCH	Baro-VNAV	RF legs	Fixed Radius Transitions
Verify waypoints and flight plan programming.			Y		Y	Y	Y	Y		
Fly direct to a waypoint.		Y	Y		Y	Y	Y	Y		
Fly a course/track to a waypoint.			Y		Y	Y				
Intercept a course/track.		Y	Y		Y	Y				
Intercept a course/track. (Fly vectors, and re-join an RNP route/procedure from the 'heading' mode.)		Y	Y		Y	Y				
Intercept initial or intermediate segment of an approach following ATC notification.							Y			
Fly interception of the extended final approach segment [e.g. using the VTF function].							LPV			
Determine cross-track [vertical] error/deviation. More specifically, the maximum deviations allowed to support route / procedure must be understood and respected.		Y	Y		Y	Y	Y	Y	Y	
Resolve route discontinuities.			Y		Y	Y	Y			
Insert and delete route discontinuity.			Y		Y	Y	Y			

Knowledge Requirement	RNP 10	RNAV 5	RNAV 1 & 2	RNP 4	RNP 2	RNP 1	RNP APCH	Baro-VNAV	RF legs	Fixed Radius Transitions
Remove and reselect navigation sensor input.		Y	Y		Y	Y				
When required, confirm exclusion of a specific NAVAID or NAVAlD type.		Y	Y			Y				
Change arrival airport and alternate airport.			Y				Y	Y		
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.	Y		Y	Y	Y	Y				
Perform RNAV holding function.			Y				Y			
Perform a conventional holding pattern.			Y		Y	Y	Y			
Perform gross navigation error checks using conventional NAVAIDs.		Y					Y			
Perform a manual or automatic runway update {with take-off point shift, if applicable.			Y		Y	Y				

Knowledge Requirement	RNP 10	RNAV 5	RNAV 1 & 2	RNP 4	RNP 2	RNP 1	RNP APCH	Baro-VNAV	RF legs	Fixed Radius Transitions
Operator-recommended levels of automation for phase of flight and workload, including methods to minimize cross-track error to maintain route centreline.			Y		Y	Y	Y	Y		
The radio/telephony phraseology for the relevant airspace in accordance with the ATP for the State in which the aircraft is operating.			Y	Y		Y	Y			
Contingency procedures for RNAV/RNP failures.	Y	Y	Y	Y	Y	Y	Y	Y	Y	
The flight planning requirements forthe RNAV/ RNP operations;	Y	Y	Y	Y	Y	Y	Y	Y		
There should be a clear understanding of crew requirements for comparisons to primary altimeter information, altitude cross-checks [e.g. altimetry comparisons of 30 m [100 ft}, temperature limitations for instrument procedures using Barometric VNAV, and procedures for altimeter settings for approach; and										
Application and use of temperature compensation procedures, either manually or using FMS functions.										
Discontinuation of a procedure based upon loss of systems or performance and flight conditions. (e.g. inability to maintain required path tracking. loss of required guidance, etc.) [Baro-VNAV only]										

APPENDIX 3

APPROVED GNSS EQUIPMENT FOR PBN APPLICATIONS CHART

	RNAV 10 (RNP 10)	**RNAV 5**	**RNAV 2**	**RNAV 1**	**RNP 4**	**RNP 2**	**RNP 1**	**RNP APCH**[5]
TSO C129 [3,4]	Acceptable	Acceptable	Class A1 or Class B[2] or C[2]	Class A1 or Class B[2] or C[2]	Not Acceptable	Not Acceptable	Not Acceptable	Class B1,B3,C1 & C3
(E) TSO C129a[3]	Acceptable	Acceptable	Class A1 or Class B[2] or C[2]	Class A1 or Class B[2] or C[2]	Acceptable	Class A1 or Class B[2] or C[2]	Class A1 or Class B[2] or C[2]	Class A1,B1,B3,C1 & C3
(E) TSO C145 (AR)	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable	Class 1[2],2[2] or 3[2]	Class 1[2],2[2] or 3[2]	LNAV- Classes 1,2,3 LNAV/NNAV Classes 2,3 LP/LPV Class 3
(E) TSO C146 (AR)	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable	Class Gamma &Operational Class 1,2 or 3	Class Gamma &Operational Class 1,2 or 3	LNAV- Classes 1,2,3 LNAV/NNAV Classes 2,3 LP/LPV Class 3
(E) TSO C196 (AR)	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable	LNAV

Notes:

1 'Terminal' navigation is terminology is included to enable operators with equipment classified in that manner to identify its capability.
2 Also requires a E/TSO –C115b FMS installed IAW with FAA AC 20-138D
3 (E)TSO C129( ) equipment used in the oceanic /remote continental airspace (RNAV 10, RNP 4 or RNP 2) must have approved for FDE per FAA Notice 8110.60 or AC 20-138A Appendix 1 (or latera Version)
4 For RNAV 5, RNAV 2 and RNAV 1 operations, TSO C129 equipment requires pseudo-range step detection and health word checking ; thses functions must be implemented in accordance with TSO C129a
5 RNP APCH section B (LP/LPV approach) requires the use of (E)TSO C146a GNSS swensors

APPENDIX 4
SAMPLE OPERATOR FORM FOR REPORTING NAVIGATION ERRORS

NAVIGATION ERROR INVESTIGATION FORM				
Type of report PILOT – Flight: ATC CONTROLLER:				
Date/UTC time	Type of error LATERAL (A to G) (*) LATERAL (A to O)			
Reasons METEOROLOGY (see 2 G): Other (Specify):				
Conflict alerting systems:				
DATA	First aircraft		Second aircraft (only vertical error)	
Identification				
Operator				
Type				
Origin				
Destination				
Route segment				
Flight level	Assigned	Current	Assigned	Current
Magnitude and direction of the deviation (NM lateral; feet vertical)				
Duration				
Position where the error was observed (BGR/DIS to fix or LAT/LONG)				
Action by the crew/ATC				
Other comments				

(*) See deviation classification
Submit form to the Authority.

APPENDIX 2 (Continued)

INSTRUCTIONS FOR COMPLETING THE FORM

1. As many boxes as possible must be filled.
2. Complementary data may be attached to the form.
3. The navigation error notifications, as much as possible, will have the following classification:
4. Altitude (vertical) deviations
5. Contingency due to engine failure
6. Contingency due to pressurisation failure
7. Contingency due to other reasons
8. Failure in the assigned climb/descent
9. Climb/descent without ATC assignment
10. Entry into airspace at an incorrect flight level
11. ATC reallocation of flight level (FL) with loss of longitudinal/lateral separation
12. Deviation due to the airborne collision avoidance system (ACAS II/TCAS II)
13. Impossibility to maintain FL
14. Other

Lateral deviations

A. Aircraft without RNP approval
B. ATC system loop error
C1. Control equipment error, including unnoticed waypoint (WPT) error
C2. WPT insertion error due to incorrect position input
D. Other, with sufficient pre warning to ATC to receive corrective instructions
E. Other, without enough pre warning to ATC
F. Other, with failure reported/received by the ATC
G. Lateral deviations due to weather, with no possibility of receiving ATC authorisation.