

## ADVISORY CIRCULAR

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### **SUBJECT: AIRCRAFT AND OPERATORS APPROVAL FOR RNP APPROACH (RNP APCH) OPERATIONS DOWN TO LNAV AND LNAV/VNAV MINIMA**

#### **1. PURPOSE**

This advisory circular (AC) establishes the requirements of aircraft and operators approval for RNP APCH operations down to LNAV minima only (lateral navigation).

The requirements of aircraft and operators approval for RNP APCH operations down to VNAV minima only (barometric vertical navigation) are detailed on AC 91-010 of the Latin American Regional Safety Oversight Cooperation System (SRVSOP).

The guidance material contained in this AC and in AC 91-010 establishes the requirements of aircraft and operators approval for RNP APCH operations down to LNAV/VNAV minima (lateral navigation and barometric vertical navigation).

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 SRVSOP AC 91-011.

An operator may use other means of compliance, provided they are acceptable for the Civil Aviation Administration (CAA).

Use of the future tense of the verb or use of the term “must” applies to an operator that chooses to meet the criteria established in this AC.

#### **2. SECTIONS RELATED TO THE LATIN AMERICAN AERONAUTICAL REGULATIONS (LARs) OR EQUIVALENT**

LAR 91: Sections 91.1015 and 91.1640 or equivalents

LAR 121: Section 121.995 (b) or equivalent

LAR 135: Section 135.565 (c) or equivalent

#### **3. RELATED DOCUMENTS**

Annex 6 Aircraft operations

Annex 10 Aeronautical telecommunications

Volume I: Radio navigation aids

Doc 9613 Performance-based navigation manual (PBN)

Doc 8168 Aircraft operations

Volume I: Flight procedures

Volume II: Construction of visual and instrument flight procedures

AMC 20-27 Airworthiness approval and operational criteria for RNP APPROACH (RNP APCH)

	operations including APV BARO-VNAV operations
FAA AC 90-105	Approval guidance for RNP operations and barometric vertical navigation in the U.S. National Airspace System
FAA AC 20-138B	Airworthiness approval of positioning and navigation systems
SRVSOP AC 91-009	Aircraft and operators approval for RNP authorization required approach (RNP AR APCH) operations
SRVSOP AC 91-010	Aircraft and operators approval for approach operations with vertical guidance/barometric vertical navigation (APV/baro-VNAV)

## 4. DEFINITIONS AND ABBREVIATIONS

### 4.1 Definitions

- a) **Primary field of view.-** For the purposes of this AC, the primary field of view is within 15 degrees of the primary line of sight of the pilot.
- b) **Navigation specifications.-** A set of aircraft and flight crew requirements needed to support performance based navigation operations within a defined airspace. There are two kinds of navigation specifications:

*Required navigation performance (RNP) specification.-* A navigation specification based on area navigation that includes the requirement for on-board performance monitoring and alerting, designated by the prefix RNP, e.g., RNP 4, RNP APCH, RNP AR APCH.

*Area navigation (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 2, RNAV 1.

*Note 1. - The Performance-based Navigation (PBN) Manual (Doc 9613), Volume II, contains detailed guidance on navigation specifications.*

*Note 2.- The term RNP as previously defined as "a statement of the navigation performance, necessary for operation within a defined airspace", has been removed from the Annexes to the Convention on International Civil Aviation as the concept of RNP has been overtaken by the concept of PBN. The term RNP in such Annexes is now solely used in context of navigation specifications that require performance monitoring and alerting, e.g., RNP 4 refers to the aircraft and operating requirements, including a 4 NM lateral performance with on board performance monitoring and alerting that are detailed in the PBN Manual (Doc 9613).*

- c) **Performance based navigation (PBN).-** 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, availability and functionality needed for the proposed operation in the context of a particular airspace concept.*

- d) **Area navigation (RNAV).-** 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 capabilities of self-contained navigation 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.*

- e) **RNP operations.-** Aircraft operations using a RNP system for RNP applications.
- f) **Waypoint (WPT).-** A specified geographical location used to define an area navigation route or the flight path of an aircraft employing area navigation. Waypoints are identified as either:

*Fly-by waypoint.-* A waypoint that requires turn anticipation to allow tangential interception of the next segment of a route or procedure.

*Flyover waypoint.-* A waypoint at which a turn is initiated in order to join the next segment of a route or

procedure.

- g) **Initial approach fix (IAF).**- Fix that marks the beginning of the initial segment and the end of the arrival segment, if applicable. In RNAV application, this fix is normally defined as a “fly-by fix”.
- h) **Flight management system (FMS).**- An integrated system, consisting of an airborne sensor, receiver and computer with both navigation and aircraft performance databases, which provides performance and RNAV guidance to a display and automatic flight control system.
- i) **Global positioning system (GPS).**- The U.S. global navigation satellite system (GNSS) is a satellite based radio navigation system that uses precise distance measurements to determine the position, velocity and time anywhere in the world. The GPS is composed of space, control and user elements. The space element consists of at least 24 satellites in 6 orbiting planes. The control element consists of 5 monitoring stations, 3 ground antennas, and one main control station. The user element consists of antennas and receivers that provide the user with position, speed, and precise time information.
- j) **Global navigation satellite system (GNSS).**- Generic term used by ICAO to define any worldwide position, velocity and time determination system, which consists of one or more main satellite constellations, such as the GPS and the global orbital navigation satellite system (GLONASS), aircraft receivers, and several integrity monitoring systems, including aircraft-based augmentation systems (ABAS), satellite-based augmentation systems (SBAS), such as the wide area augmentation system (WAAS) and ground-based augmentation systems (GBAS), such as the local area augmentation system (LAAS).  
Distance information will be provided, at least in the immediate future, by GPS and GLONASS.
- k) **RNP system.**- An area navigation system which supports on-board performance monitoring and alerting.
- l) **RNP value.**- The RNP value designates the lateral performance requirement associated with a procedure. Examples of RNP values are: RNP 0.3 and RNP 0.15.
- m) **Receiver autonomous integrity monitoring (RAIM).**- Technique used in a GPS receiver/processor to determine the integrity of its navigation signals, using only GPS signals or GPS signals augmented with barometric altitude data. This determination is achieved by a consistency check among redundant pseudo-range measurements. At least one additionally satellite to those required must be available to obtain the navigation solution.

## 4.2 Abbreviations

- |    |               |   |
|----|---------------|---|
| a) | AAC           | Civil Aviation Administration   |
| b) | ABAS          | Aircraft-based augmentation system  |
| c) | AIP           | Aeronautical information publication                                      |
| d) | AP            | Autopilot   |
| e) | APCH          | Approach  |
| f) | APV           | Approach procedure with vertical guidance                                 |
| g) | APV/baro-VNAV | Approach operations with vertical guidance/Barometric vertical navigation |
| h) | AR            | Authorisation required  |
| i) | AIRAC         | Aeronautical information regulation and control                           |
| j) | AC            | Advisory circular (FAA)   |
| k) | AFM           | Aircraft flight manual  |
| l) | AMC           | Acceptable means of compliance  |
| m) | ANSP          | Air navigation service provider   |

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n)	ATC	Air traffic control
o)	ATS	Air traffic service
p)	baro-VNAV	Barometric vertical navigation
q)	CA	Advisory circular (SRVSOP)
r)	CDI	Course deviation indicator
s)	CDU	Control display unit
t)	DME	Distance measuring equipment
u)	DME/DME	Distance measuring equipment/distance measuring equipment
v)	DME/DME/IRU	Distance measuring equipment/distance measuring equipment/inertial reference unit
w)	DTK	Desired track
x)	EASA	European Aviation Safety Agency
y)	EHSI	Enhanced horizontal situation indicator
z)	ETA	Estimated time of arrival
aa)	FAA	United States Federal Aviation Administration
bb)	FAF	Final approach fix
cc)	FD	Flight director
dd)	FDE	Fault detection and exclusion
ee)	FMS	Flight management system
ff)	Fly-by WPT	Fly-by waypoint
gg)	Flyover WPT	Flyover waypoint
hh)	FSD	Maximum deflection
ii)	FTE	Flight technical error
jj)	GBAS	Ground-based augmentation system
kk)	GNSS	Global navigation satellite system
ll)	GLONAS	Global orbital navigation satellite system
mm)	GPS	Global positioning system
nn)	IAF	Initial approach fix
oo)	IAP	Instrument approach procedure
pp)	IFR	Instrument flight rules
qq)	IRU	Inertial reference unit
rr)	LAAS	Local area augmentation system
ss)	LAR	Latin American Aeronautical Regulations
tt)	LNAV	Lateral navigation
uu)	LOA	Letter of authorisation/letter of acceptance
vv)	LP	Localizer performance
ww)	LPV	Localizer performance with vertical guidance

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xx)	MAPt	Missed approach point
yy)	MEL	Minimum equipment list
zz)	NAVAIDS	Navigation aids
aaa)	2D navigation	2D area navigation that only uses the capabilities on the horizontal plane
bbb)	NDB	Non-directional beacon
ccc)	NPA	Non-precision approach
ddd)	NSE	Navigation system error
eee)	NOTAM	Notice to airmen
fff)	OACI	International Civil Aviation Organization
ggg)	OCA/H	Obstacle clearance altitude/height
hhh)	OEM	Original equipment manufacturer
iii)	OM	Operations manual
jjj)	OpSpecs	Operational specifications
kkk)	PANS-OPS	Procedures for air navigation services – Aircraft operations
lll)	PBN	Performance-based navigation
mmm)	PDE	Path definition error
nnn)	PF	Pilot flying the aircraft
ooo)	PFD	Primary flight display
ppp)	POH	Pilot operations handbook
qqq)	PM	Pilot monitoring the aircraft
rrr)	PNF	Pilot not flying the aircraft
sss)	RAIM	Receiver autonomous integrity monitoring
ttt)	RF	Constant radius arc to a fix
uuu)	RNAV	Area navigation
vvv)	RNAV <sub>(GNSS)</sub>	GNSS (GPS)-based RNP APCH approaches
www)	RNP	Required navigation performance
xxx)	RNP APCH	Required navigation performance approach
yyy)	RNP AR APCH	Required navigation performance authorization required approach
zzz)	SBAS	Satellite-based augmentation system
aaaa)	SL	Service letters
bbbb)	SOP	Standard operating procedures
cccc)	SRVSOP	Regional Safety Oversight Cooperation System
dddd)	STC	Supplemental type certificate
eeee)	TCDS	Type certificate data sheet
fff)	TSE	Total system error
gggg)	TSO	Technical standard order

hhhh)	VMC	Visual flight meteorological conditions
iiii)	VNAV	Vertical navigation
jjjj)	VOR	VHF omnidirectional radio range
kkkk)	VPA	Vertical path angle
llll)	WAAS	Wide area augmentation system
mmmm)	WGS	World geodetic system
nnnn)	WPT	Waypoint
oooo)	XTK	Cross-track

## 5. INTRODUCTION

5.1 This AC 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.

5.2 The guidance material of this AC addresses only 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<sub>(GNSS)</sub> or GNSS approaches.

5.3 The requirements for approaches with curved segments or *published arcs*, also known as segments with constant radius arc to a fix (*RF segments*), are specified in AC 91-009 of the Regional Safety Oversight Cooperation System (SRVSOP) – Aircraft and operators approval for RNP authorization required approach operations (RNP AR APCH).

5.4 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 RNAV (GNSS) or GNSS approaches using a LNAV line of minima.

5.5 The criteria for barometric vertical navigation (baro-VNAV) of a RNP APCH approach down to VNAV minima are described in SRVSOP AC 91-010 – Aircraft and operators approval for approach operations with vertical guidance/barometric vertical navigation (APV/baro-VNAV).

5.6 The guidance material of this AC together with the guidance material of AC 91-011 addresses the requirements for RNP APCH operations down to LNAV/VNAV minima.

5.7 If the system is approved for an approach procedure with vertical guidance (APV) with GNSS augmented with SBAS, the installation must satisfy the requirements of SRVSOP AC 91-011.

5.8 Operations with localizer performance (LP) and localizer performance with vertical guidance (LPV) are not covered by this AC and are addressed in the SRVSOP AC 91-011.

5.9 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.

5.10 Stand-alone and multi-sensor RNP systems that use GNSS (GPS) and that comply with AMC 20-27 of the European Aviation Safety Agency (EASA) and with the advisory circulars (AC) of the United States Federal Aviation Administration (FAA): AC 90-105, AC 20-138A, AC 20-130A, AC 20-138B or TSO C 115b/ETSO C 115b, meet the ICAO RNP APCH navigation specification.

**Note.-** The multi-sensor systems may use other sensors combinations, such as distance measuring equipment/distance measuring equipment (DME/DME) or distance measuring equipment/distance measuring equipment/inertial reference unit (DME/DME/IRU), that provide the navigation performance acceptable for RNP APCH operations; however, such cases are limited due to the growing complexity of navigation aid (NAVAID) infrastructure requirements and assessment, and their extended application is not practical nor cost effective.

5.11 The material described in this AC has been developed based on the following document:

- ✓ ICAO Doc 9613, Volume II, Part C, Chapter 5 – Implementing RNP APCH: Part A -

RNP APCH operations down to LNAV and LNAV/VNAV minima.

5.12 Where possible, this AC has been harmonised with the following guidance documents:

- ✓ EASA AMC 20-27 - Airworthiness approval and operational criteria for RNP APPROACH (RNP APCH) operations including APV BARO-VNAV operations; and
- ✓ FAA AC 90-105 - Approval guidance for RNP operations and barometric vertical navigation in the U.S. National Airspace System.

*Note.* - Notwithstanding harmonisation efforts, operators shall note the differences between this AC and the aforementioned documents when requesting an authorisation from the corresponding Administrations.

## 6. GENERAL CONSIDERATIONS

### 6.1 Navaid infrastructure

- a) The global navigation satellite system (GNSS) is the primary navigation system that supports RNP APCH procedures down to LNAV or LNAV/VNAV minima.
- b) The missed approach segment may be based upon the conventional navaid (e.g., VOR, DME, NDB)
- c) 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 SRVSOP AC 91-010 – Aircraft and operators approval for APV/baro-VNAV operations or in equivalent documents.
- d) 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.

### 6.2 Obstacle clearance

#### 6.2.1 RNP APCH operations without baro-VNAV guidance

- a) 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.
- b) The missed approach procedures may be supported by either RNAV or by conventional segments (e.g., segments based on VHF omnidirectional radio range (VOR), distance measuring equipment (DME), or non-directional radio beacon (NDB)).
- c) Procedure design must take into account of the absent of vertical navigation (VNAV) capability on the aircraft.

#### 6.2.2 RNP APCH operations with baro-VNAV guidance

- a) 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).
- b) 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).

### 6.3 Publications

- a) The instrument approach charts will clearly identify the RNP APCH application as RNAV<sub>(GNSS)</sub>.
- b) For RNP APCH operations without baro-VNAV (down to LNAV minima only), the procedure design will be based on normal descent profiles, and the charts will identify minimum altitude requirements for each segment, including a lateral navigation obstacle clearance altitude/height (LNAV OCA/H).
- c) For RNP APCH operations with baro-VNAV (down to LNAV/VNAV minima), the charts will follow the standards of Annex 4 to the Convention on International Civil Aviation for 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).

- d) 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.
- e) The navigation information published in the applicable aeronautical information publication (AIP) for the procedures and the supporting NAVAIDs will meet the requirements of Annexes 15 and 4 to the Convention on International Civil Aviation (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).
- f) All procedures will be based on the 1984 World Geodetic Coordinates (WGS 84).

#### 6.4 **communications and Air traffic service (ATS) surveillance**

- a) 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.
- b) Appropriate radio phraseology will be published for RNP APCH operations.
- c) It is expected that Air traffic control (ATC) to be familiar with aircraft VNAV capabilities, as well as with aspects concerning altimetry setting and the effect of temperature that could potentially affect the integrity of baro-VNAV RNP APCH operations (down to LNAV/VNAV minima).
- d) The particular hazards of a terminal and approach area and the impact of contingency procedures following a multiple loss of RNP APCH capability must be assessed.

#### 6.5 **Navigation accuracies associated with the flight phases of a RNP APCH approach**

- a) According to ICAO Doc 9613, 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

#### 6.6 **Additional considerations**

- a) Many aircraft have the capability to execute a holding pattern manoeuvre using their RNP system.

### 7. **DESCRIPTION OF THE NAVIGATION SYSTEM**

- a) **Lateral navigation (LNAV).**- In LNAV, the RNP equipment enables the aircraft to be navigated in accordance with appropriate routing instructions along a path defined by WTP held in an on-board navigation database.

**Note.**- LNAV is typically a flight guidance systems mode, where the RNP equipment provides path steering commands to the flight guidance system, which then controls flight technical error (FTE) through either manual pilot control with a path deviation display or through coupling to the FD or AP.

### 8. **AIRWORTHINESS AND OPERATIONAL APPROVAL**

- 8.1 In order to get an RNP APCH authorization, a commercial air transport operator shall obtain two types of approval:



- a) an airworthiness approval from the State of registry; and
- b) an operational approval from the State of the Operator.

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

8.3 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.

## **9. AIRWORTHINESS APPROVAL**

### **9.1 General**

- a) The following airworthiness criteria are applicable to the installation of RNP systems required for RNP APCH operations:
  - 1) This AC uses FAA AC 20-138/AC 20-138A/AC 20-138B (GPS stand-alone system) or AC 20-130A/AC 20-138B (multi-sensors systems) as a basis for the airworthiness approval of an RNP system based on GNSS.
  - 2) For APV/baro-VNAV operations, AC 20-129/AC 20-138B will be used, as established in SRVSOP AC 91-010.

### **9.2 Aircraft and system requirements**

- a) Aircraft approved to conduct RNAV<sub>(GNSS)</sub> or GNSS approaches meet the performance and functional requirements of this AC for RNP APCH instrument approaches without radius to fix segments (without RF segments).
- b) Aircraft that have a statement of compliance with respect to the criteria contained in this AC 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 AC.
- c) Aircraft that have a statement from the manufacturer documenting compliance with the criteria of this AC 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.
- d) 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.
- e) If the RNP installation is based on GNSS sensor equipment used in a multi-sensor system (e.g., flight management system (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.
- f) 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.

### 9.3 Performance and functional requirements for RNP APCH systems

#### a) Accuracy

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

- (a)  $\pm 1$  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.

**Note.-** There is no specific RNP accuracy requirement for the missed approach if this segment is based on conventional NAVAIDs (VOR, DME, NDB) or on dead reckoning.

- (b)  $\pm 0.3$  NM for at least 95 percent of the total flight time in the final approach segment of the procedure.

- 2) To satisfy the accuracy requirement, the 95 % FTE shall not exceed:

- (a) 0.5 NM on the initial, intermediate, and missed approach segments of a RNP APCH procedure; and
  - (b) 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).

- 3) 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.

- b) **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 (*i.e.*,  $10^{-5}$  per hour). 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 is greater than  $10^{-5}$  per hour.

- c) **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.

- d) **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 is greater than  $10^{-5}$ . 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 is greater than  $10^{-5}$ .

- e) **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  $10^{-7}$  per hour (Annex 10, Volume I, Table 3.7.2.4-1). 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 exceeds  $10^{-7}$  per hour (Annex 10, Volume I, Table 3.7.2.4-1).

**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. The path definition error (PDE) is considered negligible due to the quality assurance process and flight crew procedures.

f) **Path definition.-** Aircraft performance is evaluated around the path defined by the published procedure and by document RTCA/DO-236B Sections 3.2.5.4.1 and 3.2.5.4.2

g) **Functional requirements of navigation displays.-** The following navigation displays and functions are required, according to FAA AC 20-130 and AC 20-138 or equivalent advisory material. 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:

- 1) the displays must be visible to the pilot and located in the primary field of view ( $\pm 15$  degrees from the pilot's normal line of sight) when looking forward along the flight path.
- 2) the lateral deviation display scaling must agree with any alerting and annunciation limits.
- 3) the lateral deviation display must also have an FSD suitable for the current phase of flight and must be based on the TSE requirement. Scaling is  $\pm 1$  NM for the initial and intermediate segments and  $\pm 0.3$  NM for the final segment.
- 4) 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.
- 5) 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.
- 6) 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.

- 7) 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.

h) **System capabilities.-** The following system capabilities are required as a minimum:

- 1) 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.
- 2) a navigation database containing current navigation data officially promulgated by the CAA, 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.

- 3) the means to display the validity period of navigation data to the pilot.
- 4) the means to retrieve and display data stored in the navigation database relating to individual waypoints and NAVAIDs, to enable the pilot to verify the procedure to be flown.
- 5) 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.
- 6) the means to display the following items, either in the pilot's primary field of view or on a readily accessible display page:
  - (a) the identification of the active (to) WPT;
  - (b) the distance and bearing to the active (to) WPT; and
  - (c) the ground speed or time to the active (to) WPT.
- 7) the means to display the following items on a readily accessible display page:
  - (a) the display of distance between the WPTs of the operational flight plan;
  - (b) the display of distance to go;
  - (c) the display of along-track distances; and
  - (d) the active navigation sensor type, if there is another sensor in addition to the GNSS sensor.
- 8) the capability to execute the "direct to" function.
- 9) the capability for automatic leg sequencing with the display of sequencing to the pilot.
- 10) the capability to execute procedures extracted from the on-board database, including the capability to execute fly-over and fly-by turns.
- 11) the capability to automatically execute leg transitions and maintain tracks consistent with the following ARINC 424 path terminators or their equivalent:
  - (a) ARINC 424 path terminators
  - (b) initial fix (IF)
  - (c) track to fix (TF)
  - (d) 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.

- 12) the capability to display an indication of the RNP system failure, including the associated sensors, in the primary field of view of the pilot.
  - 13) 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).
- i) **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 (AP) 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.

- j) **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 Laos Type 2 issued prior to the publication of this AC.

#### 9.4 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 of this AC. The approval can be recorded in the documentation of the manufacturer (e.g., service letters (SL), etc.). Provided the CAA accepts manufacturer documentation, 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 AC are eligible for RNP APCH operations down to LNAV minima. Systems that meet the requirements of this AC and SRVSOP AC 91-010 (APV/baro-VNAV) or equivalent are eligible for RNP APCH operations down to LNAV/VNAV minima. Aircraft qualified in accordance with SRVSOP AC 91-009 or equivalent, 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 of this AC and AC 91-010 (APV/baro-VNAV).
  - 2) **LNAV Line of minima qualification**
    - (a) **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 AC 20-138 or equivalent.  
  
*Note.- it is considered that these systems meet the functional and performance requirements set out in Paragraph 9.3 of this AC in the aspects that correspond.*
    - (b) **Multi-sensor systems.-**
      - (1) 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 AC; and
        - the associated flight management system (FMS) complies with TSO-C115b/ETSO-C115b and is installed in accordance with FAA AC 20-130 or AC 20-138B or subsequent.
      - (2) 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 AC; 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 Paragraph 9.3 of this AC in the aspects that correspond.*
- 3) **LNAV/VNAV Line of minima qualification**

(a) **Stand-alone systems**

- (1) 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 AC and AC 91-010 or equivalent.
- (2) 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 AC and AC 91-010 or equivalent.
- (3) 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 AC 91-010 or equivalent.

(b) **Multi-sensor systems**

- (1) 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 AC and AC 91-010 or equivalents.
- (2) RNP systems that utilize conventional baro-VNAV must provide a vertical navigation system performance that meets or exceeds the criteria of AC 91-010 or equivalent.
- (3) 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 AC 20-130 or AC 20-138B or equivalent.

## **9.5 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.

## **9.6 Continued airworthiness**

- a) The operators of aircraft approved to perform RNP 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 AC.
- b) Each operator who applies for RNP APCH operational approval down to LNAV or LNAV/VNAV minima shall submit to the CAA of State of registry, 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:
  - 1) Maintenance control manual (MCM);
  - 2) Illustrated parts catalogs (IPC); and
  - 3) 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:

- 1) 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;
  - 2) 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 CAA for its acceptance or approval of such changes prior to its implementation; and
  - 3) 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 CAA 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:
- 1) PBN concept;
  - 2) application of RNP APCH down to LNAV or LNAV/VNAV minima;
  - 3) equipment involved in an RNP APCH operation down to LNAV or LNAV/VNAV minima; and
  - 4) MEL use.

## 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.

### 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 paragraph and in Paragraphs 10.2 to 10.10 of this AC.

- a) *Airworthiness approval.*- Aircraft shall have the corresponding airworthiness approvals as established in Paragraph 9 of this AC.
- b) *Application.*- The operator will submit the following documentation to the CAA:
  - 1) *the application to obtain the authorization for RNP APCH operations down to LNAV or LNAV/VNAV minima;*
  - 2) *Aircraft eligibility and qualification documentation.*- Airworthiness documentation showing that the aircraft and system proposed meet the requirements of this AC, as described in Paragraphs 9 and 10.3. To avoid unnecessarily regulatory activity, the determination of eligibility for existing systems should consider acceptance of manufacturer documentation of compliance. Systems qualified for RNP AR APCH operations are considered qualified for RNP APCH operations down to LNAV or LNAV/VNAV minima without further examination.
  - 3) *Type of aircraft and description of the aircraft equipment to be used.* - The operator will provide a configuration list describing in detail the relevant components and the equipment to be used in the operation. The list shall include each manufacturer, model and version of the GNSS equipment and the FMS software installed.
  - 4) *Operational procedures and practices.*- Operator manuals shall properly indicate the navigation operating practices and procedures identified in Paragraphs 10.4, 10.6, and 10.7 of this AC. LAR 91 operators shall confirm that they will operate using identified practices and procedures.
  - 5) *Navigation data validation programme.* - Details of the navigation data validation programme are provided in Appendix 1 to this AC.
  - 6) *Training programmes for the flight crew and flight dispatchers*

- (a) Commercial operators (e.g. LAR 121 and 135 operators) must provide a training programme addressing the operational practices, procedures and training items related to RNP APCH operations down to LNAV or LNAV/VNAV minima (e.g. initial, upgrade or recurrent training for flight crew and dispatchers).
 

*Note. - It is not required to establish a separate training program or regime if RNP APCH operations down to LNAV or LNAV/VNAV minima training, identified in Paragraph 10.8, is already integrated in the operator's training program. However, it must be possible to identify what aspects of RNP APCH operations down to LNAV or LNAV/VNAV minima are covered within a training program.*
- (b) Private operators (e.g. LAR 91 operators) must be familiar with the practices and procedures identified in Paragraph 10.8 "training program" of this AC.
- 7) Training programme for maintenance personnel.- Operators will send instruction syllabus corresponding to maintenance personnel.
- 8) *Operations manual (OM) and checklists*
  - (a) Operations manual and checklists of commercial operators (e.g. LAR 121 and 135 operators) must address information and guidance on the standard operating procedures (SOP) detailed in Paragraph 10.6. The appropriate manuals should contain navigation operating instructions and contingency procedures described in Paragraph 10.7 of this AC, where specified. Manuals and checklists must be submitted for review as part of the approval process.
  - (b) Private operators (e.g. LAR 91 operators) must operate using the practices and procedures identified in Paragraphs 10.6 and 10.7 "operating procedures and contingency procedures" of this AC.
- 9) *Maintenance procedures.*- The operator will submit the maintenance procedures containing airworthiness and maintenance instructions for the systems and equipment to be used in the operation in accordance with Paragraph 9.6. The operator will provide a procedure to remove and restore RNP APCH operational capability in the aircraft.
- 10) *Minimum equipment list (MEL).*- The operator will submit any revision to the MEL needed to conduct RNP APCH operations down to LNAV or LNAV/VNAV minima.
- c) *Training.*- Once the amendments to manuals, programmes and documents submitted have been accepted or approved and before starting RNP APCH operations down to LNAV or LNAV/VNAV minima, the operator will provide the necessary training to its personnel.
- d) *Validation flights.*- The CAA may conduct validation flights if it deems it necessary for safety purposes. Validation flights will be conducted according to Chapter 13, Volume II, Part II of the SRVSOP Operation Inspector Manual (MIO).
- e) *Issuance of the authorisation to conduct RNP APCH operations down to LNAV or LNAV/VNAV minima.*- Once the operator has successfully completed the operational approval process, the CAA will issue, as appropriate, the authorisation to the operator to conduct RNP APCH operations down to LNAV or LNAV/VNAV minima.
  - 1) *LAR 91 operators.*- For operators LAR 91, the CAA will issue a letter of authorisation (LOA).
  - 2) *LAR 121 and/or 135 operators.*- For LAR 121 and/or LAR 135 operators, the CAA will issue the corresponding operational specifications (OpSpecs) reflecting the authorisation to conduct RNP APCH operations down to LNAV or LNAV/VNAV minima.

## 10.2 Description of the aircraft equipment

- c) 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.
- d) 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.

- e) The details of the equipment and its use in accordance with the approach characteristics appear in this AC and in AC 91-010.

### 10.3 Aircraft qualification documentation

- a) *For aircraft currently conducting RNAV (GPS) or GPS 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 GPS approaches, to the LNAV line of minima.
- b) *For aircraft without approval to fly RNAV (GPS) or GPS instrument approach procedures.*- Operators will submit to the CAA the RNP qualification documentation showing compliance with this AC, 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.

### 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 AC.

### 10.5 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 RNAV (GPS) or GPS instrument approaches according to AC 90-94 or equivalent do not require further evaluations. For installations/equipment not eligible to conduct RNAV (GPS) or GPS instrument approaches, the operator will submit aircraft or avionics qualification documentation to the CAA.
- c) The relevant CAA organisation will review the application package for RNP APCH operations down to LNAV or LNAV/VNAV minima. Acceptance will be documented by means of a letter to the operator.

### 10.6 Operating procedures

#### a) Pre-flight planning

- 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.
- 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. Traditionally, this has been done by comparing electronic data with printed documents. An acceptable method is to compare aeronautical charts (new and old) in order to verify navigation fixes before dispatch. If an amended letter for the procedure is published, the database must not be used for conducting the operation.

- 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.

- 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.
- 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.
- 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.
- 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.
- 8) For missed approach procedures based on conventional means (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.
- 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.
- 10) GNSS availability.- RAIM prediction must be performed prior to departure.
  - (a) ABAS availability
    - (1) 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.
    - (2) 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.
    - (3) 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.

- (4) 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).
  - (5) 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.
  - (6) 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.
  - (7) The predictive capability must account for known and predicted coverage gaps of GPS satellites or other effects on navigation system sensors.
  - (8) 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.
- 11) 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.
- 12) Availability of SBAS and other augmented GNSS systems
- (a) AC 91-011 - 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.
  - (b) 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.

**b) Prior to commencing the procedure**

- 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.*
- 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) For multi-sensor systems, the flight crew must verify, during the approach, that the GNSS sensor is used for position computation.
- 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.

- 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.
- 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 implications of the RNP system.
  - (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 45°.

**Note.-** "Direct to" clearance to the FAF is not acceptable.

- 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.

c) **During the procedure**

- 1) Pilots must comply with the instructions or procedures identified by the operator, as necessary, to meet the performance requirements of this AC.
- 2) Before starting the 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) 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 does 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.

- 4) The appropriate displays must be selected so that the following information can be monitored:
  - (a) the RNP computed desired path (DTK); and
  - (b) the aircraft position relative to the path (cross-track deviation) for flight technical error (FTE) monitoring.
- 5) An RNP APCH procedure must be discontinued:
  - (a) if the navigation display is flagged invalid; or
  - (b) in case of loss of the integrity alerting function; or
  - (c) if the integrity alerting function is annunciated not available before passing the FAF; or

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

- (d) if the FTE is excessive.
- 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:
  - (a) the RNP system is operational (e.g., there is no loss of function, no NSE alert, no failure indication, etc.); and
  - (b) the whole procedure (including the missed approach) has been loaded from the navigation data base.
- 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.,  $\pm 1.0$  NM for the initial, intermediate, and missed approach segments, and  $\pm 0.3$  NM for the final approach segment down to LNAV or LNAV/VNAV minima).

- 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.
- 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  $\pm \frac{1}{2}$  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.

- 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.
- 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.
- 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.
- 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.

#### **10.7 General operating procedures**

- a) Operators and pilots must not request an RNP APCH procedure down to LNAV or LNAV/VNAV minima unless they satisfy all the criteria in the relevant CAA documents. 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 is unable to accept the clearance and must request alternate instructions.
- b) 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.
- c) If the missed approach procedure is based on conventional means (e.g., NDB, VOR, DME), related navigation equipment must be installed and be serviceable.
- d) Pilots are encouraged to use flight director and/or autopilot in lateral navigation mode, if available.

#### **10.8 Contingency procedures**

- a) The pilots must notify ATC of any loss of the RNP APCH capability, together with the proposed course of action.
- b) 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.

- c) 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.
- d) The operators must develop contingency procedures in order to react safely following the loss of the RNP APCH capability during the approach.
- e) In the event of communication failure, the flight crew must continue with the RNP APCH procedure in accordance with the published lost communication procedure.
- f) The operator's contingency procedures must address at least the following conditions:
  - 1) 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
  - 2) loss of navigation signal-in-space (loss or degradation of the external signal).
- g) The pilot must ensure the capability of navigating and landing at an alternate aerodrome if loss of RNP APCH capacity occurs.

### 10.9 Training programme

- a) 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 about this AC.
  - 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:
    - (a) automation levels, mode annunciations, changes, alerts, interactions, reversions and degradation;
    - (b) functional integration with other aircraft systems;
    - (c) the meaning and appropriateness of route discontinuities as well as related flight crew procedures;
    - (d) monitoring procedures for each phase of flight;
    - (e) types of navigation sensors utilized by the RNP system and associated system prioritization/weighting/logic;
    - (f) turn anticipation with consideration to speed and altitude effects; and
    - (g) interpretation of electronic displays and symbols.
  - 7) knowledge of RNP equipment operating procedures, as applicable, including how to perform the following actions:
    - (a) verify currency of aircraft navigation data;
    - (b) verify the successful completion of RNP system self-tests;
    - (c) initialize RNP system position;
    - (d) retrieve and fly an RNP APCH procedure;

- (e) adhere to speed and/or altitude constraints associated with an approach procedure;
  - (f) fly interception of an initial or intermediate segment of an approach following air traffic control (ATC) notification;
  - (g) verify WPTs and flight plan programming;
  - (h) fly direct to a WPT;
  - (i) determine cross-track error/deviation;
  - (j) insert and delete route discontinuity;
  - (k) when required by the CAA, perform gross navigation error checks using conventional NAVAIDs; and
  - (l) 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.

#### **10.10 Navigation database**

- a) 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.
- b) 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).
- c) 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 CAA may accept a LOA issued to the navigation data suppliers or issue its own LOA.
- d) 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.
- e) Aircraft operators should consider the need to conduct periodic checks of the operational navigation database in order to meet existing quality system requirements.

#### **11. OVERSIGHT OF OPERATORS**

- a) 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.
- b) A regulatory authority may consider any navigation error reports in determining remedial action.
- c) Repeated navigation error occurrences attributed to a specific piece of navigation equipment may result in cancelling of the approval for use of that equipment.
- d) Information that indicates the potential for repeated errors may require modification of an operator's training programme.
- e) Information that attributes multiple errors to a particular pilot may necessitate remedial training or licence review.

## APPENDIX 1

### NAVIGATION DATA VALIDATION PROGRAMME

#### 1. INTRODUCTION

The procedure stored in the navigation database defines the aircraft lateral and vertical guidance. The navigation database is updated every 28 days. The navigation data used in each update are critical for the integrity of each RNP APCH procedure. Bearing in mind the reduced obstacle clearance associated to these approaches, the validation of navigation data requires special consideration. This appendix provides guidance on the procedures to be followed by the operator to validate navigation data associated with RNP APCH procedures.

#### 2. DATA PROCESSING

- a) In its procedures, the operator will identify the person responsible for the navigation data updating process.
- b) The operator must document a process for accepting, verifying, and loading navigation data into the aircraft.
- c) The operator must place their documented data process under configuration control.

#### 3. INITIAL DATA VALIDATION

The operator must validate each RNP APCH procedure before flying the procedure in instrument meteorological conditions (IMC) to ensure compatibility with their aircraft and to ensure the resulting paths matches the published procedure. As a minimum, the operator must:

- a) compare the navigation data of the procedure or procedures to be loaded on the FMS with a published procedure.
- b) validate the loaded navigation data for the procedure, either in a flight simulator or in the aircraft in visual meteorological conditions (VMC). The depicted procedure on the map display must be compared to the published procedure. The entire procedure must be flown to ensure the path can be used, does not have any apparent lateral or vertical path disconnections, and is consistent with the published procedure.
- c) once the procedure is validated, a copy of the validated navigation data must be kept and maintained to be compared with subsequent data updates.

#### 4. DATA UPDATING

Whenever the operator receives a navigation data update and before using such data on the aircraft, the update must be compared with the validated procedure. This comparison must identify and resolve any discrepancy in the navigation data. If there are any significant changes (any changes affecting the approach path or performance) to any part of a procedure, or if such changes are verified through initial information data, the operator must validate the amended procedure in accordance with the initial validation of the data.

#### 5. NAVIGATION DATA SUPPLIERS

Navigation data suppliers must have a letter of acceptance (LOA) to process these data (e.g., FAA AC 20-153 or document on the conditions for the issuance of letters of acceptance for navigation data suppliers by the European Aviation Safety Agency – EASA (EASA IR 21 Sub-part G) or equivalent document). A LOA recognises the data supplier as one whose data quality, integrity, and quality



management practices are consistent with the criteria of document DO-200A/ED-76. 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 CAA may accept a LOA issued to the navigation data suppliers or issue its own LOA.

## **6. AIRCRAFT MODIFICATIONS (UP DATE OF THE DATA BASE)**

If an aircraft system required for RNP APCH operations is modified (e.g., a change in the software), the operator is responsible for validation of RNP APCH procedures with the navigation database and the modified system. This may be accomplished without any direct evaluation if the manufacturer verifies that the modification has no effect on the navigation database or path computation. If this verification is not done by the manufacturer, the operator must carry out an initial validation of the navigation data with the modified system.

## APPENDIX 2

### RNP APCH APPROVAL PROCESS

- a) The RNP APCH approval process consists of two types of approvals: the airworthiness and the operational approval. Although the two have different requirements, they must be considered within a single process.
- b) This process constitutes an orderly method used by the CAAs to ensure that applicants meet the established requirements.
- c) The approval process consists of the following phases:
  - 1) Phase one: Pre-application
  - 2) Phase two: Formal application
  - 3) Phase three: Analysis of the documentation
  - 4) Phase four: Inspection and demonstration
  - 5) Phase five: Approval
- d) In *Phase one - Pre-application*, the CAA meets with the applicant or operator (pre-application meeting), who is advised of all the requirements it must meet during the approval process.
- e) In *Phase two - Formal application*, the applicant or operator submits the formal application, accompanied by all the relevant documentation, as established in Paragraph 10.1 of this AC.
- f) In *Phase three – Analysis of the documentation*, the CAA evaluates the documentation and the navigation system to determine their eligibility and the approval method to be applied with respect to the aircraft. As a result of this review and evaluation, the CAA may accept or reject the formal application together with the documentation.
- g) In *Phase four - Inspection and demonstration*, the operator will train its personnel and conduct validation flights, if required.
- h) In *Phase five - Approval*, the CAA issues the RNP APCH authorisation once the operator has met the airworthiness and operational requirements. For LAR 121 and 135 operators, the CAA will issue the OpSpecs, and for LAR 91 operators, it will issue a LOA.